



**Foundation Investigation and  
Design Report**  
Culvert Replacements  
Highway 7 - Norwood to Havelock  
Township of Dummer and Belmont  
W.P. 67-99-00

AECOM

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**FOUNDATION INVESTIGATION REPORT**

For

W.P. 67-99-00

Culvert Replacements  
Highway 7 - Norwood to Havelock  
Townships of Dummer and Belmont

**1.0 Introduction**

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This report was prepared as part of the Total Project Management (TPM) assignment for the Detailed Design of the pavement rehabilitation and widening to accommodate one eastbound passing lane and one westbound passing lane on Highway 7 between Norwood and Havelock, Ontario. The work is being carried out under MTO W.P. 67-99-00.

The work was carried out in general accordance with our Proposal No. 1041692 dated July 2008. Authorization to proceed was provided by the Ministry of Transportation of Ontario (MTO) under Agreement Number 4007-E-0024 with AECOM, the Detailed Design Consultant for this project. It is noted that during the course of this assignment, Stantec Consulting Ltd. (Stantec) acquired Jacques Whitford Limited (JWL).

This report has been prepared specifically and solely for the culvert extension and/or replacement work described herein. It contains factual information pertaining to the subsurface conditions which was obtained as part of this investigation.

**2.0 Site Description and Geology**

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**Site Location**

The project is located within the Townships of Dummer and Belmont in Eastern Ontario. The project limits are shown on Drawing No. 1 in Appendix A. It is noted that for project orientation purposes, Highway 7 is assumed to run east-west with chainage increasing from west to east.

The project limits are defined as follows:

Start:	22+450 Dummer Township
Chainage Equation:	27+157.508 Dummer Township = 10+000 Belmont Township
End:	13+095 Belmont Township

The RFP for this assignment identified four culvert locations within the limits of the proposed passing lanes where buried organic material was suspected of being present beneath the existing highway embankment. A Foundation Investigation was deemed to be warranted for the proposed extension or replacement of these culverts. The location of these four culverts is shown on Drawing No. 1 in Appendix A and summarized in Table 2.1.

**Table 2.1: Culvert Locations and Construction Program**

<b>Culvert #</b>	<b>Culvert Location</b>	<b>Existing Culvert Size (mm)</b>	<b>Existing Culvert Length (m)</b>
13	27+139	1219 x 914	18.40
15	10+937	1219 x 914	18.67
18	11+963	914 x 914	16.00
19	12+387	1219 x 1219	17.52

The culvert numbers provided in Table 2.1 are the culvert numbers identified on the contact drawings.

#### General Site Description

Within the project limits Highway 7 is classified as a two-lane Rural Collector Undivided (RCU) highway. The existing highway section typically includes two 3.35 m lanes with 2.0 m wide shoulders. The highway alignment passes through several muskeg sections.

#### Physiographic Description

Based on the Physiography of Southern Ontario by Chapman and Putnam (1984) the culvert structures are situated in the physiographic region known as the Dummer Moraines. This is an area of rough stony land bordering the Canadian Shield. The soils in this region consist of a morainic mantle and drumlinized till plain.

Based on Geology Map No. 2544 published by the Ministry of Mines and Northern Development, the bedrock in the area consists of Middle Ordovician Limestone.

#### Culvert Locations

In general, there is evidence of settlement of the culverts and surrounding highway embankments in the form of very thick asphalt layering, buried asphalt at one location and water levels which are very high within the culverts. It is noted however, that there are currently no pavement performance issues associated with the culverts. The existing conditions at the four existing culverts are described as follows:

**Culvert # 13 – 27+139 Dummer**

The existing culvert consists of a cast-in-place open footed concrete culvert measuring 1219 mm x 914 mm.

The centerline of the existing highway is approximately 2.0 m above the existing grades in the adjacent swamp. The upstream and downstream invert elevations for the existing culvert are 219.54 m and 219.50 m respectively. The direction of the stream flow is from south to north.

Photo 1 in Appendix B shows the general condition of the highway and the adjacent swamp. Photo 2 in Appendix B shows the general condition at the end of the existing culvert.

**Culvert # 15 – 10+937 Belmont**

The existing culvert consists of a cast-in-place open footed concrete culvert measuring 1219 mm x 914 mm.

The centerline of the existing highway is approximately 1.8 to 2.1 m above the existing grades in the adjacent swamp. The downstream and upstream invert elevations for the existing culvert are 216.41 m and 216.29 m respectively. The direction of the stream flow is from south to north.

Photo 3 in Appendix C shows the general condition of the highway and the adjacent swamps. Photo 4 in Appendix C shows the general condition at the south end of the existing culvert.

**Culvert #18 – 11+963 Belmont**

The existing culvert consists of a cast-in-place open footed concrete culvert measuring 914 mm x 914 mm.

The centerline of the existing highway is approximately 1.3 m above the existing grades in the adjacent swamp. The upstream and downstream invert elevations for the existing culvert are 213.22 m and 213.03 m respectively. The direction of the stream flow is from south to north.

Photo 5 in Appendix D shows the general condition of the highway and the adjacent swamps. Photo 6 in Appendix D shows the general condition at the end of the existing culvert.

**Culvert #19 – 12+387 Belmont**

The existing culvert consists of a cast-in-place open footed concrete culvert measuring 1219 mm x 1219 mm.

The centerline of the existing highway is approximately 1.6 m above the existing grades in the adjacent swamp. The upstream and downstream invert elevations for the existing culvert are 212.17 m and 211.83 m respectively. The direction of the stream flow is from south to north.

Photo 7 in Appendix E shows the general condition of the highway and the adjacent swamp. Photo 8 in Appendix E shows the general condition at the end of the existing culvert.

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### 3.0 Method of Investigation

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#### 3.1 DRILLING INVESTIGATION

The field investigation at the culvert locations consisted of thirteen (13) boreholes. Where culvert extensions were proposed, the investigation included one borehole near the end of the proposed extension and one borehole through the existing embankment at the edge of pavement offset from the existing culvert. Where culvert replacement was proposed, the investigation included one borehole near each end of the proposed culvert and one borehole through the edge of pavement near the proposed alignment of the new culvert. Where the new culvert is to be replaced on the same alignment as the existing it was necessary to offset the embankment borehole.

The designation of the boreholes drilled at each culvert location is outlined in Table 3.1 below. The locations of the boreholes are shown on the borehole location plans in Appendices B through E.

**Table 3.1: Boreholes Advanced at Each Culvert Location**

<b>Culvert #</b>	<b>Culvert Location</b>	<b>Boreholes Advanced at the Culvert Locations</b>
13	27+139	09-1, 09-11
15	10+937	09-2, 09-3, 09-10
18	11+963	09-4, 09-9, 10-8, 10-9
19	12+387	09-5, 09-6, 09-7, 09-8

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

The field drilling program was carried out between May 27<sup>th</sup>, 2009, and July 16<sup>th</sup>, 2010.

The boreholes located at the ends of the culverts were advanced using portable drilling equipment and a one-third weight or full weight hammer for advancing the split spoon samplers and an electric core drill for advancing the casing and coring the bedrock. It was necessary to utilize portable equipment as the surface conditions at the inlets and outlets consisted of either shallow water or saturated peat deposits which would not support a CME drill. The portable drilling equipment was owned and operated by OGS Drilling Inc. of Almonte, Ontario. The Standard Penetration Test (SPT) N-values reported on the borehole records have been divided by three for those that were advanced using the one-third weight hammer.

The boreholes located at the edge of pavement were advanced using a truck mounted CME 75 drill rig equipped for soil and bedrock sampling. The CME drilling equipment was owned and operated by George Downing Estate Drilling Ltd of Hawkesbury, Ontario.



The subsurface stratigraphy encountered in each borehole was recorded in the field by experienced Stantec Field Technologists. Split spoon samples were collected at regularly spaced intervals ranging from 760 mm to 1500 mm. It is noted that sample recovery from the split spoon sampler was poor at some intervals due to the presence of large gravel, boulders and cobbles within the overburden. Portions of the overburden were cored with NQ or BQ coring equipment in order to penetrate through cobbles and boulders. All samples recovered were returned to our Ottawa laboratory for detailed classification and testing.

The boreholes were backfilled with the auger cuttings and sealed with bentonite. For the boreholes advanced within the roadway the surface was reinstated with 300 mm of cold patch asphalt.

The depth to groundwater was observed and documented in the open boreholes at the time of drilling. Piezometers were not installed as the boreholes were drilled within swamps where water was present either at or slightly above ground surface.

### **3.2 SURVEY**

Borehole locations were established in the field by Stantec personnel relative to the centerline of the existing alignment. The location (MTM Zone 9 northing and easting) and ground surface elevation at each borehole location was surveyed by Stantec Geomatics Limited personnel with reference to MTO Geodetic Benchmark 00819668559. The benchmark is located at approximate Station 13+000 and is reported to have a geodetic elevation of 213.801 m.

### **3.3 LABORATORY TESTING**

All samples were taken to our Ottawa laboratory where they were subjected to a detailed visual examination by a Geotechnical Engineer. Selected soil samples underwent a gradation analysis and moisture content testing. Samples of the organic material also underwent organic content and consolidation testing. Samples of the bedrock underwent unconfined compression testing to determine the strength characteristics of the rock.

Five soil samples were submitted to Paracel Laboratories in Ottawa, Ontario, for determination of pH, chloride content, soluble sulphate content and resistivity.

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 the client.

## **4.0 Subsurface Conditions**

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An explanation of the symbols and terms used to describe the Borehole Records is provided in Appendix A.

#### **4.1 CULVERT #13 - STATION 27+139**

In general, a layer of peat was encountered beside and beneath the existing roadway embankment. The peat was underlain by a thin layer of silty gravel with sand (Till) over limestone bedrock. The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix B. A stratigraphic cross-section is provided in Drawing No. 2 in Appendix B.

##### **4.1.1 Pavement Structure & Embankment Fill**

Borehole 09-11 was drilled through the edge of pavement beside the existing culvert. The pavement structure was observed to consist of 250 mm of asphalt over granular base/subbase over embankment fill. The embankment fill extended down to a depth of 2.3 m below ground surface (Elev. 219.1 m) in Borehole 09-11.

A sieve analysis on a sample of the embankment fill indicated that it contained 28% gravel, 56% sand and 16% fines. The results of the sieve analysis are provided on Figure No. 1 in Appendix B. The material is classified as silty sand with gravel (SM) in accordance with the MTO soil classification system. The moisture content of the sample tested was 7%.

SPT 'N' values were 8 and 52 indicating that the fill varied from a loose to very dense state. It is noted that the 'N' value of 8 was recorded within a zone located below the groundwater level and directly above the underlying peat deposit.

##### **4.1.2 Organic Material (Peat)**

An organic deposit that ranged from dark brown to black amorphous to fibrous peat was identified directly beneath the existing embankment fill and at surface in the borehole beyond the end of the existing culvert.

The base of the peat ranged from elevation 218.3 m to 218.9 m. The thickness of the peat was 800 mm beneath the existing embankment and 1.1 m beyond the end of the existing culvert.

The moisture contents of the two samples of peat tested were 340% and 442%. The measured organic content of a sample from Borehole 09-1 was 72%.

##### **4.1.3 Silty Gravel with Sand (Till)**

A glacial till deposit was observed beneath the peat in both boreholes. The thickness of the till layer ranged from 1.7 m to 2.6 m. The base of the till varied from elevation 216.3 m to 216.5 m (geodetic).

The moisture contents of two samples tested were both 8%. Sieve analyses on two samples of the till material indicated that it contained 49% gravel, 29% to 37% sand and 14% to 22% fines. The results of the sieve analyses are provided on Figure No. 2 in Appendix B. The material is classified as silty gravel with sand (GM) in accordance with the MTO soil classification system. It is noted that frequent cobbles and boulders were identified within the till. SPT 'N' values within

the till deposit were all greater than 50 indicating that the till is in a dense state. Rock coring techniques were used to penetrate cobbles or boulders in Borehole 09-1.

#### **4.1.4 Limestone Bedrock**

Bedrock was encountered at depths of 4.8 m below the top of existing pavement and 3.7 m below the top of the adjacent swamp. The surface of the bedrock varied from elevation 216.3 m to 216.5 m.

Both boreholes were advanced approximately 3 m into bedrock by coring with NQ-size diamond coring equipment. The core recovery ranged from 85% to 100% with an average of 97%. The rock quality designation (RQD) ranged from 0% to 61% with an average of 28%, indicating very poor to fair quality rock mass. The RQD generally increased with depth. Photographs of the recovered bedrock cores are provided in Appendix B.

The recovered rock core consisted of grey limestone bedrock with shale partings. The rock ranged from slightly weathered to unweathered. Joint spacing ranged from very close to moderate with dipping orientation typically flat (0 to 20° from horizontal). A detailed description of the rock cores is provided in the Field Core Logs in Appendix B.

Unconfined compressive strength tests were carried out on two sample of the recovered bedrock core. The tests results are presented in Table 4.1.

**Table 4.1: Unconfined Compressive Strength of Bedrock**

<b>Borehole No.</b>	<b>Ground Surface Elevation (m)</b>	<b>Test Elevation (m)</b>	<b>Unconfined Compressive Strength (MPa)</b>	<b>Rock Strength Classification</b>
09-1	220.0	216.2	107	Very Strong
09-11	221.3	217.5	170	Very Strong

#### **4.1.5 Groundwater**

Groundwater was measured in the open boreholes at the time of drilling to be 200 mm below ground surface in Borehole 09-1 within the swamp and 1.5 m below the top of pavement in Borehole 09-11. The groundwater depths correspond to geodetic elevation 219.8 m. The water elevation in the ditch at the north end of the culvert was surveyed to be 219.84 m a few weeks after completion of the drilling.

## **4.2 CULVERT #15 - STATION 10+937**

In general, a thin layer of peat was encountered at surface in the muskeg section at the south end of the culvert alignment. Within the existing roadway, the stratigraphy consists of granular embankment fill over a thin deposit of glacial till over shallow limestone bedrock.

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix C. A stratigraphic cross-section is provided in Drawing No. 3 in Appendix C.

#### **4.2.1 Pavement Structure & Embankment Fill**

Borehole 09-10 was drilled through the edge of pavement beside the existing culvert. The pavement structure was observed to consist of 270 mm of asphalt over granular base/subbase over embankment fill. The embankment fill beneath the pavement structure extended down to a depth of 2.3 m below ground surface (Elev. 216.1 m) in Borehole 09-10.

A sieve analysis on a sample of the pavement structure base/subbase indicated that it contained 27% gravel, 56% sand and 17% fines. The results of the sieve analysis are provided on Figure No. 3 in Appendix C. The material is classified as silty sand with gravel (SM) in accordance with the MTO soil classification system. The moisture content of the sample tested was 3%.

SPT 'N' values were 31 and 7 indicating that the fill varied from a loose to compact state. It is noted that the 'N' value of 7 was recorded within a zone located below the groundwater level.

#### **4.2.2 Organic Material (Peat)**

An organic deposit was identified at ground surface on the south side of the highway in Borehole 09-3. The material consisted of dark brown to black coarse fine fibrous peat with woody matter and some roots. The thickness of the peat was 900 mm and the base was identified as elevation 216.0 m

A layer of topsoil and rootmat approximately 100 mm thick was encountered in Borehole 09-2 on the north side of the highway.

#### **4.2.3 Silty Sand with Gravel (Till)**

A glacial till deposit was observed beneath the topsoil, peat and embankment fill in all boreholes. The thickness of the till layer ranged from 700 mm to 1.7 m. The base of the till varied from elevation 214.3 m to 215.3 m (geodetic).

The moisture contents of five samples tested ranged from 12% to 24% with an average of 17%. Sieve analyses on five samples of the till material indicated that it contained 2 to 34% gravel, 25 to 66% sand and 12 to 71% fines. Four of the five sample tested are classified as silty sand or silty sand with gravel (SM). The other sample is classified as sandy silt (ML). The results of the sieve analyses are provided on Figure No. 4 in Appendix C. The presence of cobbles and boulders within the till was noted during drilling.

SPT 'N' values within the till deposit ranged from 16 to greater than 50, indicating that the till is compact to dense.

#### **4.2.4 Limestone Bedrock**

Bedrock was encountered at depths of 1.4 m and 2.6 m below ground surface at the north and south ends of the culvert alignment and at a depth of 3.0 m below top of pavement at the north edge of pavement. The elevation of the bedrock surface ranged from 214.3 m to 215.3 m.

All three boreholes were advanced into bedrock by coring with NQ and/or BQ-size diamond coring equipment. The core recovery ranged from 22% to 100%. The rock quality designation (RQD) ranged from 0% to 67%, indicating very poor to fair quality rock mass. Photographs of the recovered bedrock cores are provided in Appendix C.

The recovered rock core consisted of grey limestone bedrock with shale partings. The rock ranged from slightly weathered to unweathered. Joint spacing ranged from very close to moderate with dipping orientation typically flat (0 to 20° from horizontal). A detailed description of the rock cores is provided in the Field Core Logs in Appendix C.

Unconfined compressive strength tests were carried out on two sample of the recovered bedrock core. The tests results are presented in Table 4.2.

**Table 4.2: Unconfined Compressive Strength of Bedrock**

Borehole No.	Ground Surface Elevation (m)	Test Elevation (m)	Unconfined Compressive Strength (MPa)	Rock Strength Classification
09-03	216.9	212.7	160	Very Strong
09-10	218.3	212.4	83	Strong

#### **4.2.5 Groundwater**

Groundwater was measured in the open boreholes at the time of drilling to be approximately 300 mm below ground surface in Borehole 09-3 within the swamp and 1.7 m below the top of pavement in Borehole 09-10. The groundwater depths correspond to geodetic elevation 216.6 m. The water elevation in the ditch at the south end of the culvert was surveyed to be 216.61 m a few weeks after completion of the drilling.

#### **4.3 CULVERT #18 - STATION 11+963**

In general, a layer of peat was encountered beside and beneath the existing roadway embankment. The peat was underlain by a thin layer of silty gravel with sand (Till) over limestone bedrock. A thin layer of marl was identified beneath the peat in the swamp near the north end of the culvert alignment and in one of the roadway boreholes. The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix D. A stratigraphic cross-section is provided in Drawing No. 4 in Appendix D.

##### **4.3.1 Pavement Structure & Embankment Fill**

Boreholes 09-9 and 10-8 were drilled through the edge of pavement beside the existing culvert. The pavement structure was observed to consist of 300 mm and 220 mm of asphalt over granular base/subbase over embankment fill. The embankment fill extended down to a depth of 2.3 m below ground surface (Elev. 212.8 m) in Borehole 09-9 and 2.4 m below ground surface (El 212.7 m) in Borehole 10-8.

The embankment fill is classified as silty sand with gravel (SM) in accordance with the MTO soil classification system.

SPT 'N' values were from 21 to 6 indicating that the fill varied from a loose to compact state. It is noted that the 'N' value of 6 was recorded within a zone located below the groundwater level and directly above the underlying peat deposit.

#### **4.3.2 Organic Material (Peat)**

An organic deposit consisting of dark brown to black fine fibrous peat was identified directly beneath the existing embankment fill and at surface in the boreholes beyond the ends of the existing culvert.

The base of the peat ranged from elevation 211.2 m to 211.6 m. The thickness of the peat was 1.5 m to 0.9 m beneath the existing embankment and 2.3 m to 2.8 m beyond the end of the existing culvert. A layer of sand with silt was observed within the peat in Borehole 10-9. Gradation testing on that material yielded 1% gravel, 91% sand and 8% fines.

The moisture content of the six samples of peat tested ranged from 86% to 507% with an average of 298%. The organic content of a sample from Borehole 09-4 was 72%; three samples from Borehole 10-9 had organic contents of 7%, 27% and 19%.

#### **4.3.3 Organic Material (Marl)**

A thin deposit of soft whitish grey marl was identified beneath the peat deposit in Boreholes 09-4 and 10-8. The top of the marl was at a depth of 2.3 m and 3.5 m below ground surface respectively and the thickness of the layer was approximately 400 mm and 500 mm. The base of the marl was at elevation 211.2 m in both boreholes.

#### **4.3.4 Silty Sand (SM)**

A thin deposit of very loose to loose grey silty sand was identified beneath the peat deposit in Borehole 09-9, 10-8, and 10-9. The top of the sand was at a depth of 3.8 m, 4.0 m and 2.8 m below ground surface respectively and the thickness of the layer was approximately 600 mm, 1100 mm and 1300 mm. The base of the sand was at elevation 210.7 m, 210.0 m and 209.9 m.

The moisture content of the two samples tested of the silty sand was 23% and 19%. Sieve analysis on two samples indicated they contained no gravel, 80% and 87% sand, and 20% and 13% silt and clay sized particles, see Figure 5 in Appendix D. The material is classified as an SM in accordance with the MTO soil classification system. SPT N-values within the silty sand deposit ranged from 3 to 13 for 0.3 m of penetration indicating a very loose to compact deposit.

#### **4.3.5 Silty Sand with Gravel (Till)**

A glacial till deposit was observed beneath the peat/marl and silty sand in all boreholes. The thickness of the till layer ranged from 0.5 m to 1.9 m. The base of the till varied from elevation 209.2 m to 209.4 m (geodetic).

The moisture contents of two samples tested were 8% and 16%. Sieve analysis on a sample of the till material indicated that it contained 40% gravel, 45% sand and 15% fines. The results of the sieve analyses are provided on Figure No. 5 in Appendix D. The material is classified as silty sand with gravel (SM) in accordance with the MTO soil classification system. It is noted that frequent cobbles and boulders were identified within the till. SPT 'N' values within the till deposit ranged from 12 to greater than 100 blows for 150 mm of penetration indicating that the till is compact to dense.

#### **4.3.6 Limestone Bedrock**

Bedrock was encountered at depths of 5.7 m to 6.0 m below the top of existing pavement and 4.6 m to 4.7 m below the top of the adjacent swamp. The surface of the bedrock varied from elevation 209.2 m to 209.4 m.

Boreholes 09-4, 09-9 and 10-8 were advanced approximately 3 m into bedrock by coring with NQ or BQ-size diamond coring equipment. The core recovery ranged from 70% to 100% with an average of 96%. The rock quality designation (RQD) ranged from 0% to 85%, indicating very poor to good quality rock mass. The RQD generally increased with depth. Photographs of the recovered bedrock cores are provided in Appendix D.

The recovered rock core consisted of grey limestone bedrock with shale partings. The rock ranged from slightly weathered to unweathered. Joint spacing ranged from very close to moderate with dipping orientation typically flat (0 to 20° from horizontal). A detailed description of the rock cores is provided in the Field Core Logs in Appendix D.

Unconfined compressive strength tests were carried out on two sample of the recovered bedrock core. The tests results are presented in Table 4.3.

**Table 4.3: Unconfined Compressive Strength of Bedrock**

<b>Borehole No.</b>	<b>Ground Surface Elevation (m)</b>	<b>Test Elevation (m)</b>	<b>Unconfined Compressive Strength (MPa)</b>	<b>Rock Strength Classification</b>
09-04	213.9	207.7	198	Very Strong
09-09	215.1	209.6	162	Very Strong

#### **4.3.7 Groundwater**

Groundwater was measured in the open boreholes at the time of drilling. The water in the swamp beside the existing highway embankment (Boreholes 09-4 and 10-9) was at ground surface at the time of drilling. The water level in Boreholes 09-9 and 10-8 was approximately 1.1 m below top of pavement. The groundwater depths correspond to geodetic elevation 213.9 m to 214.0 m. The water elevation in the ditch at the north end of the culvert was surveyed to be 214.06 m a few weeks after completion of the 2009 drilling.

#### **4.4 CULVERT #19 - STATION 12+387**

In general, a layer of peat was encountered beside and beneath the existing roadway embankment. The peat was underlain by marl, a thin layer of silty sand and glacial till (silty sand with gravel) over limestone bedrock. The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix E. A stratigraphic cross-section is provided in Drawing No. 5 in Appendix E.

##### **4.4.1 Pavement Structure & Embankment Fill**

Boreholes 09-7 and 09-8 were drilled beside the existing culvert through the south and north edges of pavement, respectively. The pavement structure was observed to consist of 230 to 250 mm of asphalt over granular base/subbase over embankment fill. The embankment fill beneath the pavement structure extended down to a depth of 2.3 m below ground surface (Elev. 212.5 m to 212.7 m).

A sieve analysis on a sample of the embankment fill indicated that it contained 34% gravel, 52% sand and 14% fines. The results of the sieve analysis are provided on Figure No. 6 in Appendix E. The material is classified as silty sand with gravel (SM) in accordance with the MTO soil classification system. The moisture content of the sample tested was 8%.

SPT 'N' values ranged from 6 to 34 with an average of 19, indicating that the fill varied from a loose to dense state. It is noted that the lower 'N' values were recorded within a zone located below the groundwater level and directly above the underlying peat deposit.

##### **4.4.2 Organic Material (Peat)**

An organic deposit that ranged from dark brown to black amorphous to coarse fibrous peat was identified directly beneath the existing embankment fill and at surface in the boreholes beyond the ends of the existing culvert.

The base of the peat ranged from elevation 211.3 m to 211.5 m. The thickness of the peat was 1.2 m in both boreholes drilled through the existing highway embankment and 1.1 to 1.7 m in the adjacent swamps.

The moisture content of the six samples of peat tested ranged from 97% to 387% with an average of 254%. The organic content of a sample from Borehole 09-6 was 26%.

##### **4.4.3 Organic Material (Marl)**

A soft whitish grey deposit of marl was encountered beneath the peat at all borehole locations.

The thickness of the marl deposit ranged from 600 mm to 1.2 m. The base of the marl ranged from elevation 210.2 m to 210.8 m.

The moisture content of the four samples of marl tested ranged from 139% to 283% with an average of 233%. The organic content of a sample from Borehole 09-7 was 5%.



The SPT 'N' values ranged from zero to 1.

#### **4.4.4 Silty Sand**

A silty sand deposit was observed beneath the marl in all boreholes. The thickness of the silty sand layer ranged from 800 mm to 1.7 m. The base of the silty sand ranged from elevation 208.6 m to 209.5 m (geodetic).

The moisture content of the four samples tested ranged from 16% to 24% with an average of 20%. Sieve analyses on four samples of the silty sand indicated that it contained 0 to 2% gravel, 78 to 84% sand and 16 to 22% fines. The results of the sieve analyses are provided on Figure No. 7 in Appendix E. The material is classified as silty sand (SM) in accordance with the MTO soil classification system. SPT 'N' values within the silty sand deposit ranged from 1 to 31 with an average of 12, indicating that the silty sand is compact on average but varies from very loose to dense.

#### **4.4.5 Silty Sand with Gravel (Till)**

A glacial till deposit was observed beneath the silty sand in all boreholes. The thickness of the till layer ranged from 700 mm to 1.5 m. The base of the till varied from elevation 207.6 m to 208.2 m (geodetic).

The moisture contents of two samples tested were 14% and 16%. Sieve analyses on two samples of the till material indicated that it contained 7 to 21% gravel, 51 to 83% sand and 10 to 28% fines. The results of the sieve analyses are provided on Figure No. 8 in Appendix E. The material is classified as silty sand to silty sand with gravel (SM) in accordance with the MTO soil classification system. It is noted that frequent cobbles and boulders were identified within the till in two of the boreholes. SPT 'N' values within the till deposit ranged from 14 to greater than 50, indicating that the till is compact to dense. Rock coring techniques were used to penetrate cobbles or boulders at some locations.

#### **4.4.6 Limestone Bedrock**

Bedrock was encountered at depths of 6.6 m to 7.3 m below the top of existing pavement and 5.5 m to 5.8 m below the top of the swamps. The surface of the bedrock varied from elevation 207.6 m to 208.2 m.

All boreholes were advanced into bedrock by coring with BQ and/or NQ-size diamond coring equipment. The core recovery ranged from 20% to 100% with an average of 78%. The rock quality designation (RQD) ranged from 0% to 100%, with an average of 27% indicating very poor to excellent quality rock mass. The RQD generally increased with depth. Photographs of the recovered bedrock cores are provided in Appendix E.

The recovered rock core consisted of grey limestone bedrock with shale partings. The rock ranged from slightly weathered to unweathered. Joint spacing ranged from very close to moderate with dipping orientation typically flat (0 to 20° from horizontal). A detailed description of the rock cores is provided in the Field Core Logs in Appendix E.

Unconfined compressive strength tests were carried out on four samples of the recovered bedrock core. The tests results are presented in Table 4.4.

**Table 4.4: Unconfined Compressive Strength of Bedrock**

<b>Borehole No.</b>	<b>Ground Surface Elevation (m)</b>	<b>Test Elevation (m)</b>	<b>Unconfined Compressive Strength (MPa)</b>	<b>Rock Strength Classification</b>
09-05	213.8	208.2	162	Very Strong
09-06	213.1	205.3	156	Very Strong
09-07	214.8	207.4	184	Very Strong
09-08	214.9	207.5	96	Strong

#### **4.4.7 Groundwater**

Surface water was encountered at elevation 213.7 m on the south side of Highway 7 at the time of drilling as indicated on Borehole 09-6. Groundwater was observed at a similar elevation in the all the open boreholes.

## 5.0 Closure

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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.

This report has been prepared by Paul Carnaffan and Fred Griffiths. A technical review was carried out by Raymond Haché.

Respectfully submitted,

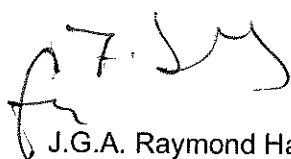
**STANTEC CONSULTING LTD.**



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**FOUNDATION DESIGN REPORT**

For

W.P. 67-99-00

Culvert Replacements  
Highway 7 - Norwood to Havelock  
Townships of Dummer and Belmont

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**6.0 General Comments**

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It is understood that it is proposed to widen the embankments for the proposed passing lanes on Highway 7 between Norwood and Havelock. The RFP identified four locations where culvert extensions or replacements were planned within muskeg sections. Although the existing culverts are not classified as structures, foundation investigations were completed to assess the potential for differential settlement of the culverts due to the proposed embankment widening and to assess the stability of the culverts and excavation slopes during the excavation work required for embankment widening, and culvert extension or replacement.

The four culvert locations investigated as part of this Foundation Investigation are summarized in Table 6.1.

**Table 6.1: Culvert Station Locations and Construction Program**

<b>Culvert #</b>	<b>Culvert Location</b>	<b>Existing Culvert Size (mm)</b>	<b>Proposed Construction Program</b>
13	27+139	1219 x 914	No works proposed
15	10+937	1219 x 914	No works proposed
18	11+963	914 x 914	Culvert extension or culvert replacement with one 855 x 1355 mm elliptical concrete culvert, existing culvert to be removed
19	12+387	1219 x 1219	Culvert replacement with one 1500 mm diameter concrete culvert Existing culvert to be removed

Each culvert location has been assessed independently in the sections that follow. Foundation recommendations have been provided for each culvert location.

## **7.0 Culvert #13 - Station 27+139, Dummer**

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### **7.1 PROPOSED WORK**

Based on the preliminary design, the culvert at Station 27+139 was located within an area where the embankment was to be widened to the north to accommodate the proposed EBL passing lane. This would have required extending the culvert at the north end.

The limits of the EBL passing lane were shortened during the detailed design process and this culvert is no longer within the limits of the passing lane. As a result, no modifications to this culvert are proposed as part of this contract. No further discussion or recommendations are provided for this culvert location.

## **8.0 Culvert #15 - Station 10+937, Belmont**

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### **8.1 PROPOSED WORK**

The culvert at Station 10+937 is located just west of the west limit of the proposed westbound passing lane. No embankment widening is currently proposed at this location.

Based on the preliminary design, it was proposed to replace this culvert. The updated drainage study carried out as part of the detailed design process, indicates that no modifications to this culvert are proposed as part of this contract. No further discussion or recommendations are provided for this culvert location.

## **9.0 Culvert #18 - Station 11+963, Belmont**

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### **9.1 PROPOSED WORK**

The culvert at Station 11+963 is located within the limits of the proposed westbound passing lane. Embankment widening to the north is proposed at this location. There is a CPR railway embankment located south of Highway 7 at this location.

Based on the updated drainage study carried out as part of the detailed design process, it is proposed to extend the existing culvert by 5 m to the north or replace the existing culvert with a new elliptical pipe on the same alignment.

The existing culvert is identified as a 914 x 914 mm NRFO with invert elevations of 213.03 m and 213.22 m at the left and right ends, respectively. The culvert extension would consist of a 1000 mm diameter circular concrete culvert connected to the existing concrete box culvert with a cast in place joint. Alternatively, the existing culvert would be replaced with a new 855 x 1355 mm elliptical concrete culvert with a design invert elevation of approximately 213.4 m.

## 9.2 SOIL SUMMARY

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

In general, the subsurface stratigraphy through the existing embankment consists of the pavement structure and granular embankment fill, over a peat deposit, overlying a silty sand, over glacial till (silty sand with gravel) over limestone bedrock. Outside the existing embankment, the subsurface stratigraphy consisted of organic material including peat and marl, over silty sand/glacial till (silty sand with gravel) over limestone bedrock.

The elevation of the asphalt at this location is approximately 215.1 m.

The bottom of the organic layer was at elevation 211.3 m to 211.2 m; approximately 2.2 m below the invert of the proposed culvert or culvert extension, and 3.9 m below the asphalt.

The railway embankment is at approximately the same elevation as Highway 7, ie. 215.0 m and 215.1 m, respectively. There is approximately 8 m horizontal distance between the toe of the Highway 7 embankment and the toe of the railway embankment to the south. The limit of the highway right-of-way is approximately 1.7 m south of the toe of the highway embankment slope.

Based on the in-situ testing and laboratory test results, the geotechnical parameters presented in Table 9.1 were used for assessing the stability of embankment and excavation side slopes at this culvert location.

**Table 9.1: Summary of Soil Parameters for Culvert at Station 11+963**

Soil Parameter	Soil Type				
	Granular Fill	Rock Fill	Peat	Marl	Till
Total Unit Weight (kN/m <sup>3</sup> )	21	18	10.6	12.8	20.5
Undrained Shear Strength (kPa)	0	0	27	12	0
Friction Angle	34°	48°	0°	0°	35°

For design and analysis purposes, the groundwater level has been assumed to be at the top of the swamp, approximately elevation 214 m.

### **9.3 DESIGN/CONSTRUCTION CONSIDERATIONS & ASSESSMENT**

The following issues are deemed to be significant from a geotechnical perspective for the design and construction at this site:

Organic deposits were identified beneath both the existing highway embankment and on either side. Therefore, in order to minimize settlement issues, the organic material will need to be removed from beneath new culverts using the standard construction practices such as swamp excavation, bedding and backfill shown on OPSD 203.040. Given the depth of excavation required to achieve this, construction staging and the potential for impact to the adjacent CPR railway embankment need to be considered.

Due to the flow volumes in the ditches and muskeg areas, construction dewatering will be required to facilitate excavations and installations of the proposed culverts.

### **9.4 DESIGN OPTIONS**

#### **9.4.1 Culvert Extension vs Replacement**

Based on the preliminary design, it was proposed to construct an extension at the north end of the existing culvert. The investigations at this site revealed that the embankment is underlain by peat and marl. The construction of an extension was reviewed from a foundation engineering perspective. There were several significant disadvantages:

- Swamp removal would be carried out below the extension but not below the existing culvert. The swamp replacement material could migrate laterally into the adjacent swamp that will remain, resulting in loss of support and settlement near the connection.
- The existing culvert would be undermined during swamp excavation for the extension, necessitating the need for roadway protection.
- The northern portion of the culvert which is currently under the shoulder and slope would remain. The grades would increase at this location to achieve the required cross-section. As the peat and marl would also remain under the existing culvert, there would be settlement of the existing culvert for that portion beneath the existing slope. The settlement would have a significant differential component with the maximum occurring very close to the proposed joint between the existing culvert and the extension.

Given that the culvert extension option would result in significant settlement beneath a portion of the existing culvert, it is recommended that the culvert at 11+963 be replaced.

#### **9.4.2 Excavation Side Slopes and Construction Staging**

Sub-excavation is required to remove the organic deposits from beneath the footprint of the proposed culvert to an approximate elevation of 211.2 m which corresponds to approximately 3.9 m below the centreline of Highway 7. A slope stability analysis was carried out using the

soil parameters provided in Table 9.1 for a 4.7 m high temporary cut. The output from the stability analysis is provided in Appendix G. The analysis was carried out in accordance with the Section 3.8 of the 2006 edition of the CHBDC. A surcharge load of 20 kPa was used to model truck loads. (Section 6.9.5 indicates that a uniformly distributed load of 17.6 kPa is equivalent to the idealized truck load.) The analysis indicates that a 3H:1V slope is required to maintain stability. While a 3H:1V slope geometry may be possible for the edge of the excavation perpendicular to the centerline, there is clearly insufficient room to complete a half and half culvert replacement and maintain traffic through the work area.

Two options to resolve the construction staging issue are to construct a detour widening in the area to increase the embankment width or to use a temporary protection system to protect the existing roadway during the installation of the culvert. The following table compares the available staging options considered for the installation of the new culvert.

**Table 9.2: Construction Staging Options for Culvert at Station 11+963**

Option	Advantages	Disadvantages	Relative Cost	Risk & Consequences
Building temporary detour widening	Ease of construction Remains in place throughout the day Already constructing a widening in this area	Increased costs and construction time Detour will be in muskeg area, increasing extent of swamp excavation. Significant increase in quantities for swamp backfill and embankment materials. Increased quantities of swamp excavated material for disposal. The culvert lengths will need to be increased to accommodate the widening Possible implications to fauna.	Moderate to high	Longer construction time
Temporary roadway protection	Able to use existing shoulder to detour traffic around construction activities Protection system can assist in control of dewatering efforts.	Increased costs Removal of protection system may damage roadway Rock anchors will likely be required due to the shallow rock depth	High	May not be able to use rock fill for backfill material which may increase side slopes

Given the extent of the work required for the construction of the widened embankment platform and tapers, as well as the potential environmental impact, the detour solution is not considered



practical. It is recommended that the replacement be constructed using a temporary roadway protection system.

In order to minimize the excavation volumes, control groundwater and surface water flow, and minimize risks associated with leaving organic deposits within a cut slope, it is recommended that the excavation for the culvert replacement be carried out within a closed or boxed roadway protection system. The closed or boxed roadway protection system would support the travelled traffic lanes, the CPR property to the south, and the pavement immediately to the east and west of the staged excavations. The roadway protection system should be designed by the contractor to achieve the excavation limits shown on OPSD 203.040.

Given that it is proposed to use roadway protection to support the pavement perpendicular to the centreline of the roadway, it will be necessary to construct a granular taper upon removal of the roadway protection. The taper should be constructed as per OPSD 803.030 or 803.031.

#### **9.4.3 CP Railway**

It is a design objective to minimize construction beyond the ROW. In order to mitigate risks of construction induced movements to the railway, the southern limit of the swamp removal excavation will need to include roadway protection. Furthermore the extent of the swamp removal beyond the end of the culvert will be reduced from that shown on OPSD 203.040. There is a risk that the newly placed swamp replacement backfill will push into the adjacent swamp material. This could result in a lack of support to the culvert bedding. The following table presents four options to address this concern:

**Table 9.3: Railway Protection Details, Culvert at Station 11+963**

Option	Advantages	Disadvantages	Relative Cost	Risks/Consequences
Leave RWP in place below culvert level permanently	Simple Easily constructed	Maintenance. May influence RWP type to ensure durability. May influence anchor types to ensure durability Protection system needs to be designed as a permanent feature capable of supporting permanent loads in a direction that is reversed from those supported during the temporary construction. Due to the shallow depth to bedrock, a simple cantilevered sheet pile approach would not be feasible.	Moderate	
Construct a gabion system with a geotextile separator	Can retrieve RWP	Requires dewatering to base of swamp during gabion construction	High	Possible damage to geotextile during retrieval of RWP
Move RWP to at least 2 m from end of culvert	Can retrieve RWP No dewatering below bedding	Additional work on railway ROW	Low	Increase in risk to railway
Pour tremie concrete plug at end of culvert	Can retrieve RWP No dewatering below bedding Reduces risk to CPR embankment		Low	

Due to the ease of construction and low cost, it is recommended that a tremied concrete plug be constructed beneath the end of the culvert. The tremied concrete plug should include the following dimensions:

- Should extend vertically from the bottom of the peat removal to 300 mm below the pipe invert.
- Along the axis of the culvert, the plug should extend from 1.0 m north of the end of the pipe (beneath the pipe), southerly to the south limit of the protection system where the CPR property is to be supported.
- Perpendicular to the culvert axis, the tremied concrete plug should extend to the east and west walls of the protection system
- The area immediately above the tremied concrete plug should be covered with uncompacted pipe bedding material.
- Where the protection system is to be removed, a bond breaker should be provided so that the protection system can be removed without disturbing the tremied concrete plug and without leaving large voids in the adjacent soil.

#### **9.4.4 Dewatering**

It is noted that a swamp is present on both sides of Highway 7 at this culvert location. The drainage study noted that the existing culvert is fully submerged and offers limited hydraulic capacity. It is noted that the existing culvert is to be removed and replaced and will therefore be unavailable to convey water across the site during all of the construction period. It is anticipated that water will need to be pumped across the highway through a temporary conduit.

The excavation of the swamp material and subsequent backfilling does not require dewatering provided Granular B Type II or rock fill is used as swamp backfill material.

Dewatering will be required to achieve compaction of the culvert bedding layer and during placement of the new culvert and its backfill. This will require control of approximately 1 m head of water. It is noted that the rock fill that will be used as backfill where peat removal is carried out beneath embankment widening and culvert replacements will be highly permeable. Dewatering volumes could be very high if the closed or boxed protection system around the excavation is not designed to cut off flow from the surrounding area. Sump and pump techniques are anticipated to be suitable provided a relatively water tight closed or boxed protection system is provided. A draft non standard special provision red-flagging the potential hydraulic connection to the highly permeable rock fill is included in Appendix F.

## **9.5 RECOMMENDATIONS**

A closed or boxed temporary roadway protection system will be required to facilitate staging. The system may be designed and installed as per OPSS 539 Construction Specifications for Temporary Protection Systems. A protection system with a performance level 2 would be adequate for roadway protection, however a performance level 1a will be required for the southern portion adjacent to the CPR Property.

The proposed culvert may be designed and constructed using conventional pipe culvert techniques as per OPSD 203.040 Embankments over Swamp at Pipe Culverts  $\leq 1500$  mm. The south limit of the excavation will be reduced from that shown on the OPSD to limit encroachment of the excavation into the CP Railway right-of-way.

Drawing No. 6 in Appendix F shows the approximate location of the protection system.

Ongoing monitoring of the CPR Railway embankment may be required while construction work is being carried out on the Railway Right-of-Way. The CPR Railway may have other requirements that can include having a CPR inspector onsite while working within their right-way. The monitoring requirements of OPSS 539 should be invoked.

General construction considerations are presented in Section 11.

## **10.0 Culvert #19 - Station 12+387, Belmont**

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### **10.1 PROPOSED WORK**

The culvert at Station 12+387 is located within the limits of the proposed westbound passing lane. An embankment widening to the north of Highway 7 is proposed at this location.

Based on the updated drainage study, it is proposed to replace the existing culvert with a new circular pipe. It is understood that the replacement culvert is to be on the same alignment as the existing to facilitate flow patterns with the nearby culvert beneath the CP Rail.

The existing culvert has been identified as a 1219 mm x 1219 mm NRFO with invert elevations of 211.83 m and 212.17 m at the left and right ends, respectively. The proposed culvert is to be a 1500 mm diameter concrete culvert with a design invert elevation of approximately 212.3 m.

### **10.2 SOIL SUMMARY**

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

In general, the subsurface stratigraphy through the existing embankment consists of the pavement structure and granular embankment fill, over an organic deposit, including peat and

marl, overlying a silty sand, over glacial till (silty sand with gravel) over limestone bedrock. Within the areas north and south of the existing culvert the subsurface stratigraphy consisted of organic material including peat and marl, overlying a silty sand, over glacial till (silty sand with gravel) over limestone bedrock.

The elevation of the asphalt at this location is approximately 214.9 m. Organic deposits were identified beneath both the existing highway embankment in Borehole 09-7 and 09-8 and within the areas north and south of the existing culvert in Borehole 09-5 and 09-6. The bottom of the organic layer was at an elevation of 210.2 m and 210.8 m; approximately 2.1 m below the invert of the proposed culvert and 4.7 m below the asphalt.

The railway embankment is at approximately the same elevation as Highway 7, ie 214.4 and 214.9 m respectively. There is approximately 8 m horizontal distance between the toe of the Highway 7 embankment and the toe of the railway embankment to the south. The limit of the highway Right-of-Way (ROW) is approximately 1.2 m south of the toe of the highway embankment slope.

Based on the in-situ testing and laboratory test results, the geotechnical parameters presented in Table 10.1 were used for assessing the stability of embankment and excavation side slopes at this culvert location.

**Table 10.1: Summary of Soil Parameters for Culvert at Station 12+387**

Soil Parameter	Soil Type				
	Granular Fill	Rock Fill	Peat	Marl	Till
Total Unit Weight (kN/m <sup>3</sup> )	21	18	10.6	12.8	20.5
Undrained Shear Strength (kPa)	0	0	27	12	0
Friction Angle	34°	48°	0°	0°	35°

### **10.3 DESIGN/CONSTRUCTION CONSIDERATIONS & ASSESSMENT**

The following issues are deemed to be significant from a geotechnical perspective for the design and construction of the new culvert at this site.

In order to minimize settlement issues, the organic material will need to be removed from beneath the new culvert using standard construction practices such as swamp excavation, bedding and backfill shown on OPSD 203.040. Given the depth of excavation required to achieve this, construction staging and the potential for impact to the adjacent CPR railway embankment need to be considered.

Due to the flow volumes in the ditches and muskeg areas construction dewatering will be required to facilitate excavations and installations of the proposed culvert. There is open water between the MTO and CPR culvert crossings at this location.

## 10.4 DESIGN OPTIONS

### 10.4.1 Excavation Side Slopes and Construction Staging

Sub-excavation is required to remove the organic deposits from beneath the footprint of the proposed culvert to an approximate elevation of 210.2 m which corresponds to approximately 4.7 m below the centreline of Highway 7. A slope stability analysis was carried out using the soil parameters provided in Table 10.1. The output from the stability analysis is provided in Appendix G. The analysis was carried out in accordance with the Section 3.8 of the 2006 edition of the CHBDC. A surcharge load of 20 kPa was used to model truck loads. (Section 6.9.5 indicates that a uniformly distributed load of 17.6 kPa is equivalent to the idealized truck load.) The analysis indicates that a 3H:1V slope is required to maintain stability. While a 3H:1V slope geometry may be possible for the edge of the excavation perpendicular to the centerline, there is clearly insufficient room to complete a half and half culvert replacement and maintain traffic through the work area.

Two options to resolve the construction staging issue are to construct a detour widening in the area to increase the embankment width or to use a temporary protection system to protect the existing roadway during the installation of the culvert. The following table compares the available staging options considered for the installation of the new culvert.

**Table 10.2: Construction Staging Options for Culvert at Station 12+387**

Option	Advantages	Disadvantages	Relative Cost	Risk & Consequences
Building temporary detour widening	Ease of construction Remains in place throughout the day Already constructing a widening in this area	Increased costs and construction time Detour will be in muskeg area, increasing extent of swamp excavation. Significant increase in quantities for swamp backfill and embankment materials. Increased quantities of swamp excavated material for disposal. The culvert lengths will need to be increased to accommodate the widening Possible implications to fauna.	Moderate to high	Longer construction time
Temporary roadway protection	Able to use existing shoulder to detour traffic around construction activities Protection system can assist in control of dewatering efforts.	Increased costs Removal of protection system may damage roadway Rock anchors will likely be required due to the shallow rock depth	High	May not be able to use rock fill for backfill material which may increase side slopes

Given the extent of the work required for the construction of the widened embankment platform and tapers, as well as the potential environmental impact, the detour solution is not considered practical. It is recommended that the replacement be constructed using a temporary roadway protection system.

In order to minimize the excavation volumes, control groundwater and surface water flow, and minimize risks associated with leaving organic deposits within a cut slope, it is recommended that the excavation for the culvert replacement be carried out within a closed or boxed roadway protection system. The closed or boxed roadway protection system would support the travelled traffic lanes, the CPR property to the south, and the pavement immediately to the east and west of the staged excavations. The roadway protection system should be designed by the contractor to achieve the excavation limits shown on OPSD 203.040.

Given that it is proposed to use roadway protection to support swamp excavations with the crest of the slope perpendicular to the centreline of the roadway, it will be necessary to construct a granular taper upon removal of the roadway protection. The taper should be constructed as per OPSD 803.030 or 803.031.

#### **10.4.2 CP Railway**

It is a design objective to minimize construction beyond the ROW. In order to mitigate risks of construction induced movements to the railway, the southern limit of the swamp removal excavation will need to include roadway protection. Furthermore the extent of the swamp removal beyond the end of the culvert will be reduced from that shown on OPSD 203.040. There is a risk that the newly placed swamp replacement backfill will push into the adjacent swamp material. This could result in a lack of support to the culvert bedding. The following table presents four options to address this concern:

**Table 10.3: Railway Protection Details, Culvert at Station 12+387**

Option	Advantages	Disadvantages	Relative Cost	Risks/Consequences
Leave RWP in place below culvert level permanently	Simple Easily constructed	Maintenance. May influence RWP type to ensure durability. May influence anchor types to ensure durability Protection system needs to be designed as a permanent feature capable of supporting permanent loads in a direction that is reversed from those supported during the temporary construction. Due to the shallow depth to bedrock, a simple cantilevered sheet pile approach would not be feasible.	Moderate	
Construct a gabion system with a geotextile separator	Can retrieve RWP	Requires dewatering to base of swamp during gabion construction	High	Possible damage to geotextile during retrieval of RWP
Move RWP to at least 2 m from end of culvert	Can retrieve RWP No dewatering below bedding	Additional work on railway ROW	Low	Increase in risk to railway
Pour tremie concrete plug at end of culvert	Can retrieve RWP No dewatering below bedding Reduces risk to CPR embankment		Low	

Due to the ease of construction and low cost, it is recommended that a tremied concrete plug be constructed beneath the end of the culvert. The tremied concrete plug should include the following dimensions:

- Should extend vertically from the bottom of the peat removal to 300 mm below the pipe invert.



- Along the axis of the culvert, the plug should extend from 1.0 m north of the end of the pipe (beneath the pipe), southerly to the south limit of the protection system where the CPR property is to be supported.
- Perpendicular to the culvert axis, the tremied concrete plug should extend to the east and west walls of the protection system
- The area immediately above the tremied concrete plug should be covered with uncompacted pipe bedding material.
- Where the protection system is to be removed, a bond breaker should be provided so that the protection system can be removed without disturbing the tremied concrete plug and without leaving large voids in the adjacent soil.

#### **10.4.3 Dewatering**

It is noted that a swamp is present on both sides of Highway 7 at this culvert location. The drainage study noted that the existing culvert is fully submerged and offers limited hydraulic capacity. It is noted that the existing culvert is to be removed and replaced and will therefore be unavailable to convey water across the site during all of the construction period. It is anticipated that water will need to be pumped across the highway through a temporary conduit.

The excavation of the swamp material and subsequent backfill does not require dewatering provided Granular B Type II or rock fill is used as swamp backfill material.

Dewatering will be required to achieve compaction of the culvert bedding layer and during placement of the new culvert and its backfill. This will require control of approximately 1 m head of water. It is noted that the rock fill that will be used as backfill where peat removal is carried out beneath embankment widening and culvert replacements will be highly permeable. Dewatering volumes could be very high if the closed or boxed protection system around the excavation is not designed to cut off flow from the surrounding area. Sump and pump techniques are anticipated to be suitable provided a relatively water tight closed or boxed protection system is provided. A draft non standard special provision red-flagging the potential hydraulic connection to the highly permeable rock fill is included in Appendix F.

#### **10.5 RECOMMENDATIONS**

A temporary roadway protection system will be required to facilitate staging. The protection system may be designed and installed using the techniques as per OPSS 539 Construction Specifications for Temporary Protection Systems. A protection system with a performance level 2 would be adequate for roadway protection, however, a performance level 1a will be required for the southern portion adjacent to the CPR property.

The proposed culvert may be designed and constructed using conventional pipe culvert techniques as per OPSD 203.040 Embankments over Swamp at Pipe Culverts  $\leq 1500$  mm. The south limit of the excavation will be reduced from that shown on the OPSD to limit encroachment of the excavation onto the CPR Railway Right-of-Way.

1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in the Table 11.2 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

---

## 12.0 Closure

---

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

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.

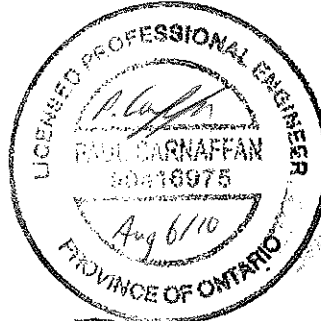
This report has been prepared by Paul Carnaffan and Fred Griffiths. A technical review was carried out by Raymond Haché.

Respectfully submitted,

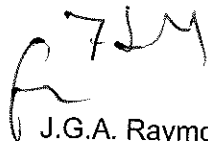
**STANTEC CONSULTING LTD.**



Paul Carnaffan, M.Eng., P.Eng.  
Associate



Fred J. Griffiths, Ph.D., P.Eng.  
Principal



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

## **APPENDIX A**

Drawing No. 1 – Culvert Location Plan  
Symbols and Terms Used on Borehole and Test Pit Records

## ROCK DESCRIPTION

### Terminology describing rock quality:

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

Rock quality classification is based on a modified core recovery percentage (RQD) in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures. The terminology describing rock mass quality based on RQD is subjective and is underlain by the presumption that sound strong rock is of higher engineering value than fractured weak rock.

### Terminology describing rock mass:

Spacing (mm)	Joint Classification	Bedding, Laminations, Bands
> 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	Unconfined Compressive Strength (MPa)
<i>Extremely Weak</i>	< 1
<i>Very Weak</i>	1 – 5
<i>Weak</i>	5 – 25
<i>Medium Strong</i>	25 – 50
<i>Strong</i>	50 – 100
<i>Very Strong</i>	100 – 250
<i>Extremely Strong</i>	> 250

### Terminology describing rock weathering:

Term	Description
<i>Fresh</i>	No visible signs of rock weathering. Slight discolouration along major discontinuities
<i>Slightly Weathered</i>	Discolouration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
<i>Moderately Weathered</i>	Less than half the rock is decomposed and/or disintegrated into soil.
<i>Highly Weathered</i>	More than half the rock is decomposed and/or disintegrated into soil.
<i>Completely Weathered</i>	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.



## 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.



Boulders  
Cobbles  
Gravel



Sand



Silt



Clay



Organics



Asphalt



Concrete



Fill



Bedrock

## 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
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

## WATER LEVEL MEASUREMENT



measured in standpipe, piezometer, or well



inferred

## 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 (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. 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 value 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 (305 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
γ	Unit weight
G <sub>s</sub>	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 <sub>u</sub>	Unconfined compression
I <sub>p</sub>	Point Load Index (I <sub>p</sub> on Borehole Record equals I <sub>p</sub> (50) in which the index is corrected to a reference diameter of 50 mm)



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	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

## **APPENDIX B**

Culvert #13 - Station 27+139

Site Photographs

Borehole Location Plan and Stratigraphic Sections

Borehole Records

Laboratory Test Results

Field Core Logs

Photos of Rock Cores



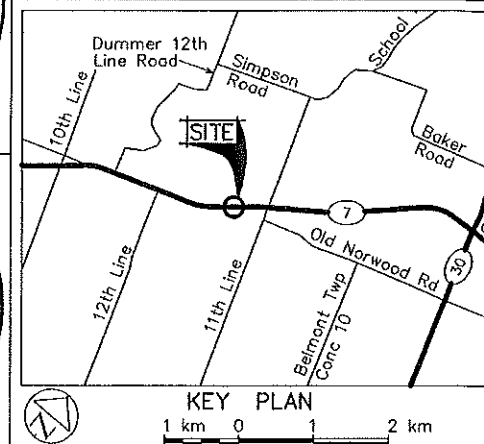
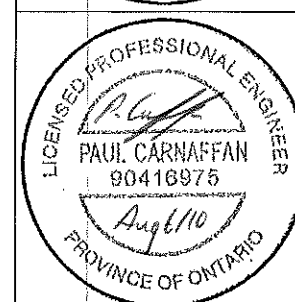
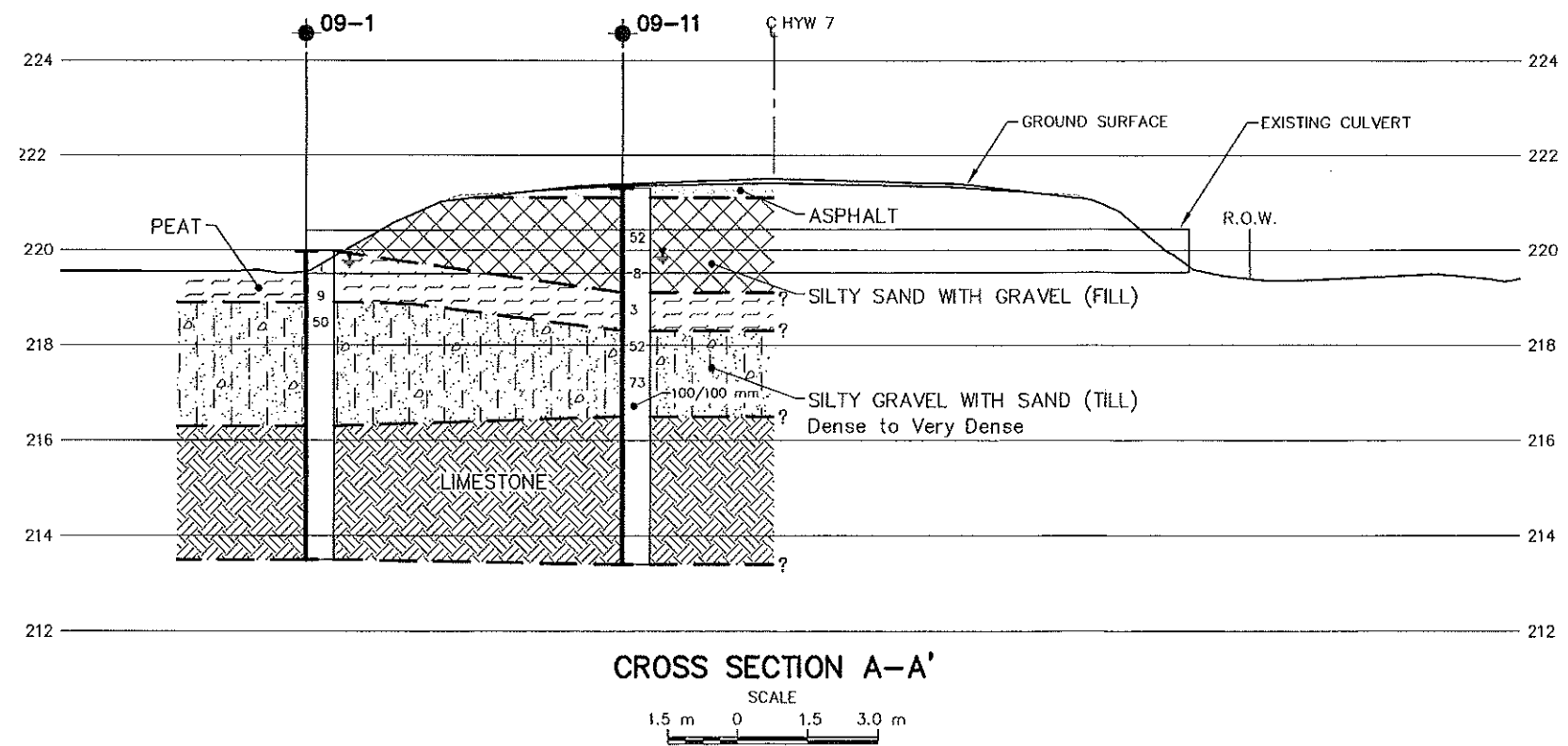
**Photo 1:** 27+139 – View of road and adjacent land in vicinity of culvert.



**Photo 2:** 27+139 – End of existing culvert.

p:\2009\122410158 - 1047243- hwy 7 havelock\foundation\report\culverts\draft\site photos 27+139.doc





**≡NOTE≡**

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

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.

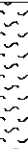
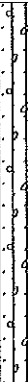

REVISIONS					
DATE		BY		DESCRIPTION	
GEORES No		31C--199			
HWY No 7				DIST	
SUBM'D KP	CHECKED	DATE 2010-04-28		SITE	
DRAWN GBB	CHECKED	APPROVED <i>Be</i>		DWG 2	

# RECORD OF BOREHOLE No 09-1

1 OF 1

METRIC

W.P. 67-99-00 LOCATION 27+139 O/S CL 13.8 LT N: 4 920 599 E: 191 198 ORIGINATED BY ZP  
 DIST HWY 7 BOREHOLE TYPE Portable Drilling Equipment, 1/3 Weight Hammer, Spitspoons, NQ Coring Equipment COMPILED BY ZP  
 DATUM Geodetic DATE 5.27.09 - 5.27.09 CHECKED BY PC

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 (%)	
220.0								20 40 60 80 100								
0.0	Fine fibrous organic matter, soft, dark brown to black, (PEAT)		1	SS	1	▽	219							440	49 29 (22)	
218.9			2	SS	9											360
1.1	Silty gravel (GM) with sand dense to very dense, grey, TILL  - frequent cobbles and boulders - boulder frequency increasing with depth		3	SS	50											
			4	NQ					218							
			5	NQ					217							
			6	NQ												
			7	NQ												
216.3																
3.7	Grey LIMESTONE bedrock with shale partings - poor to fair quality - slightly weathered - flat orientation (0 - 20°) - very close to close joint spacing - rough planar		8	NQ			216									
			9	NQ			215									
			10	NQ												
			11	NQ			214									
213.5																
6.4	End of Borehole															

ONTARIO MTO STANTEC 1047243 HWY 7 GPJ ONTARIO MOT.GDT 8/3/10



**Client:** AECOM Canada Ltd.  
**Project:** Highway 7 - Norwood to Havelock, W.P. 67-99-00  
**Contractor:** George Downing Estate Drilling Ltd. - (CME75)

Project No.:	122410158
Date:	June 5, 2009
Borehole No.:	09-1
Logger:	Kenton C. Power

<u>STRENGTH (MPa)</u>		<u>DISCONTINUITY TYPE</u>	<u>ORIENTATION</u>	<u>FILLING</u>
EH = Extremely Strong = > 250	VW = Very Weak = 1-5	B = Bedding Joint	F = Flat = 0-20°	T = Tight, Hard
VS = Very Strong = 100-250	EW = Extremely Weak = < 1	J = Cross Joint	D = Dipping = 20-50°	O = Oxidized
S = Strong = 50-100		F = Fault	V = n-Vertical = >50°	SA = Slightly Altered, Clay Free
MS = Medium Strong = 25-50		S = Shear Plane		S = Sandy, Clay Free
W = Weak = 5 - 25				Si = Sandy, Silty, Minor Clay
				NC = Non-softening Clay
				SC = Swelling, Soft Clay
<u>WEATHERING</u>		<u>SPACING</u>	<u>ROUGHNESS</u>	
U = Unweathered = No Signs		VW = Very Wide = >3m	RU = Rough Undulating	
S = Slightly = Oxidized		W = Wide = 1-3 m	RP = Rough Planar	
M = Moderately = Discoloured		M = Moderate = 0.3-1 m	SU = Smooth Undulating	
H = Highly = Friable		C = Close = 5-30 cm	SP = Smooth Planar	
C = Completely = Soil-like		VC = Very Close = <5 cm	LU = Slickensided Undulating	
			LP = Slickensided Planar	



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# Field Core Log

Client: AECOM Canada Ltd.  
 Project: Highway 7 - Norwood to Havelock, W.P. 67-99-00  
 Contractor: George Downing Estate Drilling Ltd. - (CME75)

Project No.: 122410158  
 Date: June 5, 2009  
 Borehole No.: 09-11  
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
4.82	8	85	0	5.13	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC	RP		T		
5.13	9	100	0	5.71	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC	RP		T		
5.71	10	95	10	6.94	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC	RP		T		
9.64	11	100	55	7.94	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC/C	RP		T		

**STRENGTH (MPa)**  
 EH = Extremely Strong = > 250  
 VS = Very Strong = 100-250  
 S = Strong = 50-100  
 MS = Medium Strong = 25-50  
 W = Weak = 5 - 25

**WEATHERING**  
 U = Unweathered = No Signs  
 S = Slightly = Oxidized  
 M = Moderately = Discoloured  
 H = Highly = Friable  
 C = Completely = Soil-like

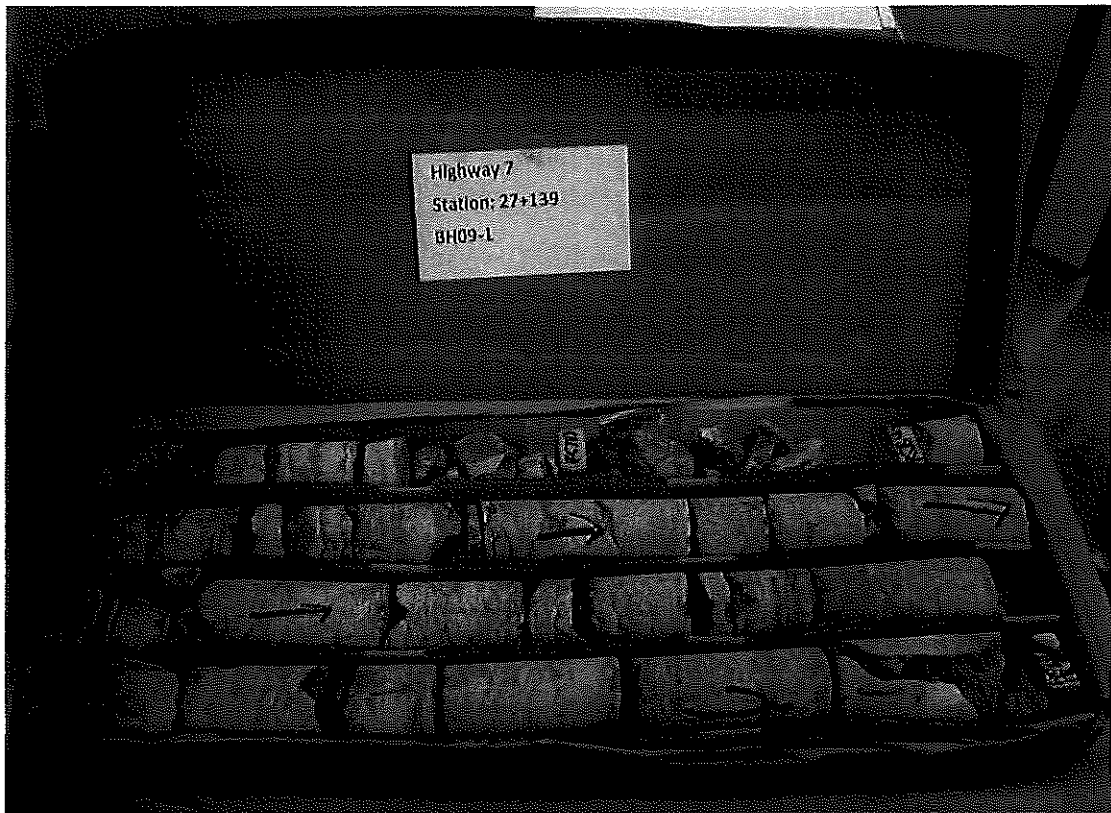
**DISCONTINUITY TYPE**  
 B = Bedding Joint  
 J = Cross Joint  
 F = Fault  
 S = Shear Plane

**SPACING**  
 VW = Very Wide = >3m  
 W = Wide = 1-3 m  
 M = Moderate = 0.3-1 m  
 C = Close = 5-30 cm  
 VC = Very Close = <5 cm

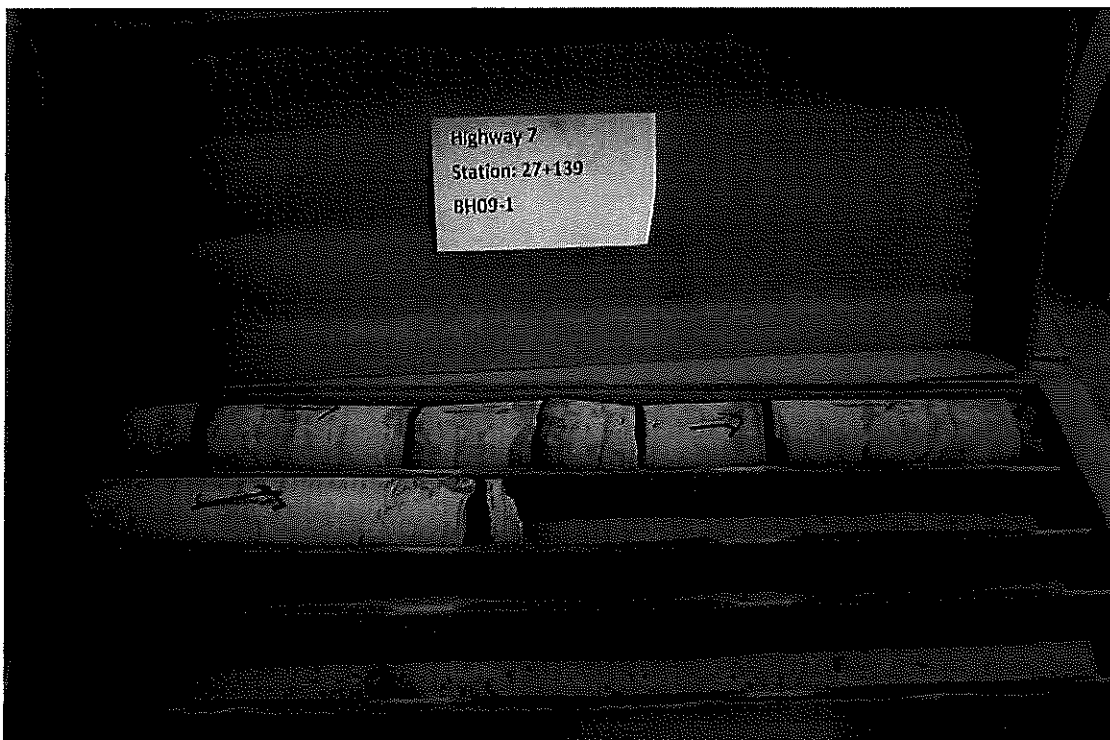
**ORIENTATION**  
 F = Flat = 0-20°  
 D = Dipping = 20-50°  
 V = n-Vertical = >50°

**ROUGHNESS**  
 RU = Rough Undulating  
 RP = Rough Planar  
 SU = Smooth Undulating  
 SP = Smooth Planar  
 LU = Slickensided Undulating  
 LP = Slickensided Planar

**FILLING**  
 T = Tight, Hard  
 O = Oxidized  
 SA = Slightly Altered, Clay Free  
 S = Sandy, Clay Free  
 Si = Sandy, Silty, Minor Clay  
 NC = Non-softening Clay  
 SC = Swelling, Soft Clay



**Photo No. 9: 27+139 BH09-1**



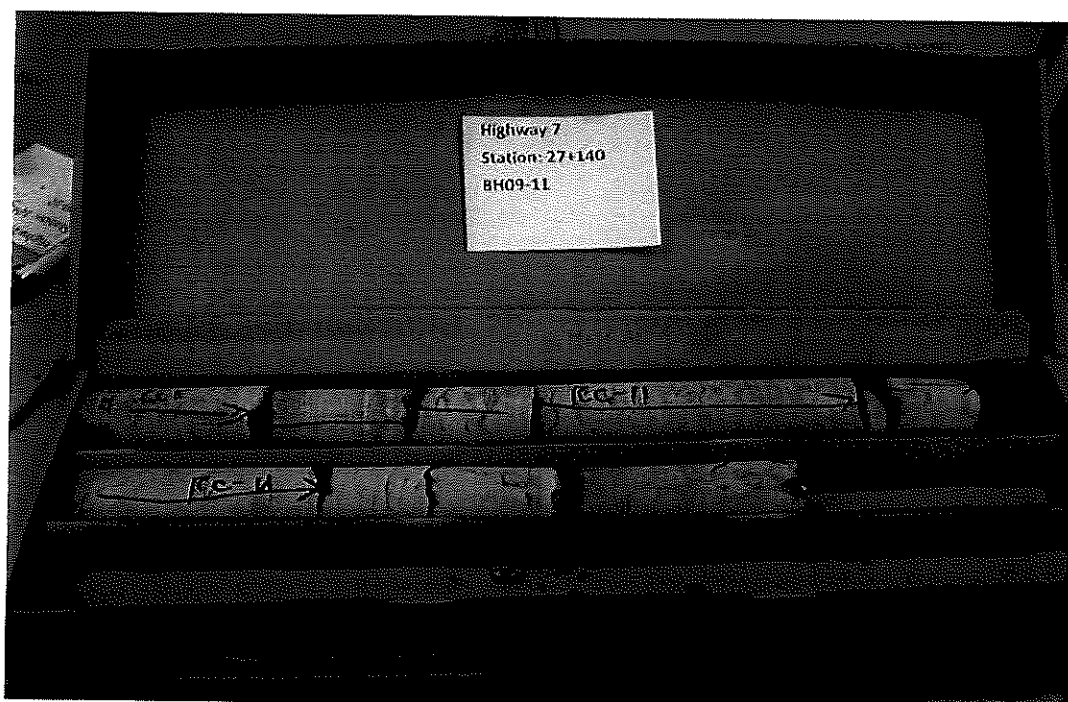
**Photo No. 10: 27+139 BH09-1**



**Stantec**



**Photo No. 11: 27+140 BH09-11**



**Photo No. 12: 27+140 BH09-11**

P:\2009\122410158 - 1047243- Hwy 7 Havelock\Foundation\Report\Culverts\Draft\BR Core Photos 27+139.Doc



**Stantec**

## **APPENDIX C**

Culvert #15 - Station 10+937

Site Photographs

Borehole Location Plan and Stratigraphic Sections

Borehole Records

Laboratory Test Results

Field Core Logs

Photos of Rock Cores



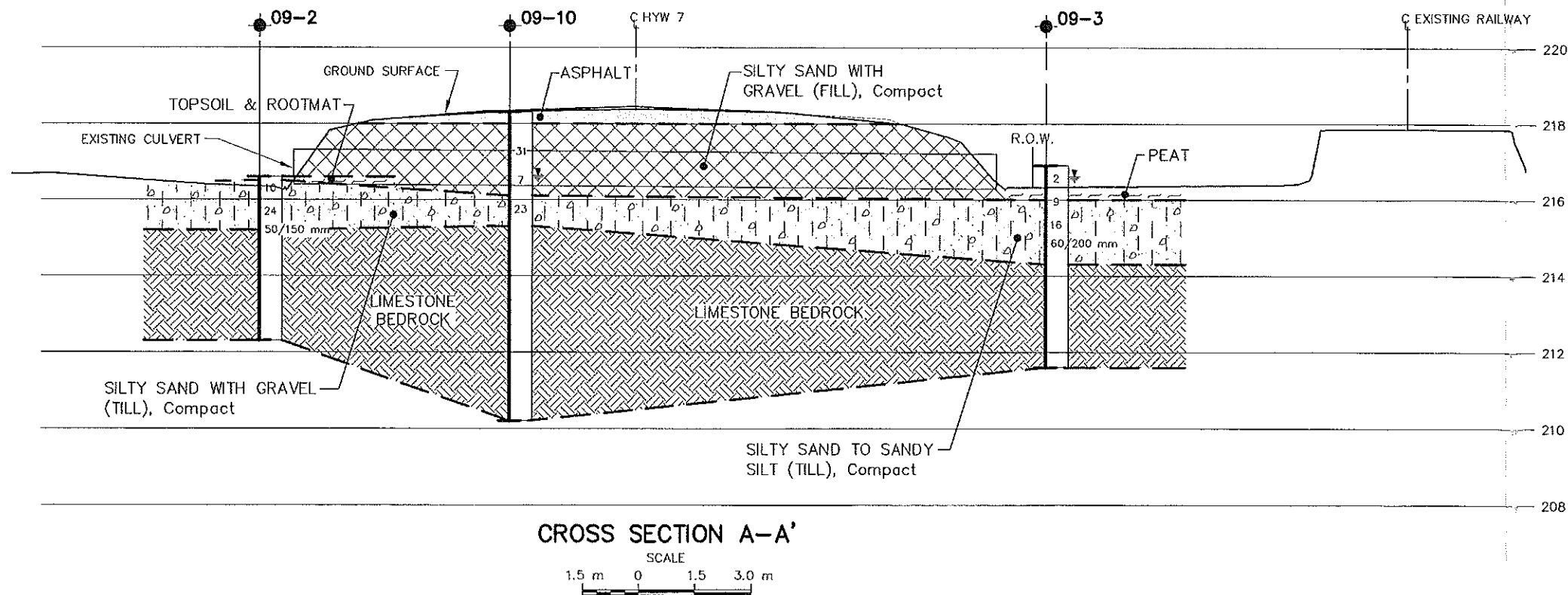
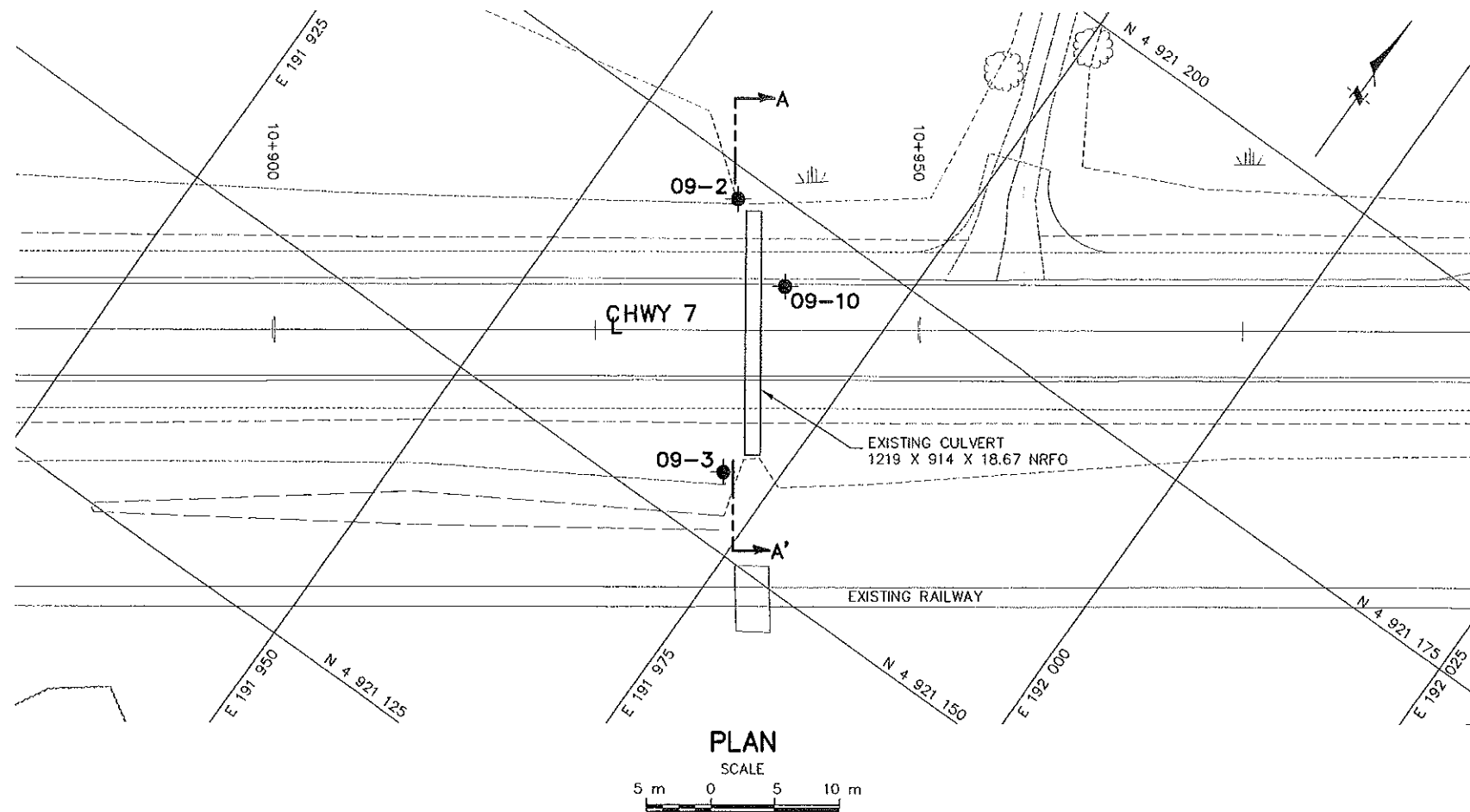
**Photo 3: 10+937 – View of general conditions in vicinity of culvert.**



**Photo 4: 10+937 – End of existing culvert.**



DRAWING NAME: 122410158-2\_8\_Cu  
CREATED: 2010-07-23  
C:\DOCUMENTS\LOCALS\1\Temp\AcPublish\_3424\122410158-2\_8\_Cu.dwg  
Printed: Aug 05, 2010



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

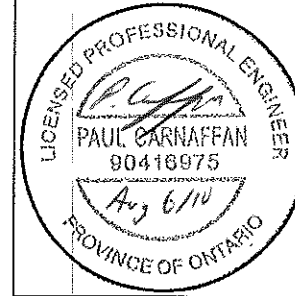
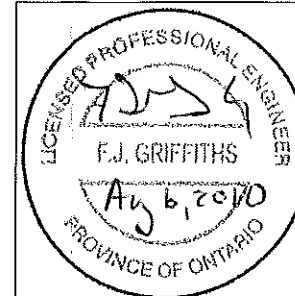
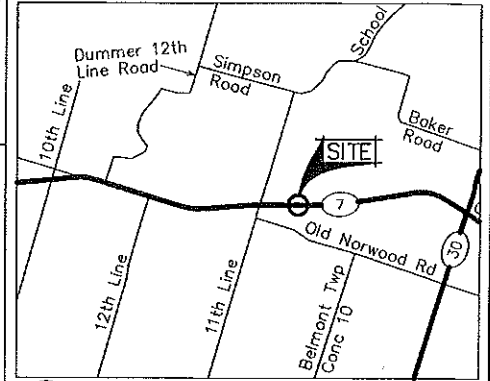


PLATE No  
CONT  
WP 67-99-00

HIGHWAY 7  
CULVERT AT STA. 10+937  
BOREHOLE LOCATIONS & SOIL STRATA



KEY PLAN  
1 km 0 1 2 km

- LEGEND
- Borehole
  - Dynamic Cone Penetration Test (Cone)
  - 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 (June 2009)
  - WL in Piezometer
  - Piezometer

No	ELEVATION	MTM ZONE 9 COORDINATES NORTH	EAST
09-2	216.6	4 921 172.9	191 960.0
09-3	216.9	4 921 155.2	191 971.2
09-10	218.3	4 921 169.6	191 966.9

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

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.

DATE	BY	DESCRIPTION
GEOCRE No 31C-199		
HWY No 7	CHECKED	DIST
SUBMIT KP	CHECKED	DATE 2010-05-07 SITE
DRAWN GBB	CHECKED	APPROVED [Signature] DWG 3

# RECORD OF BOREHOLE No 09-2

1 OF 1

METRIC

W.P. 67-99-00 LOCATION 10+938 O/S CL 11.8 LT N: 4 921 173 E: 191 980 ORIGINATED BY ZP  
 DIST HWY 7 BOREHOLE TYPE Portable Drilling Equipment, Splitspoons, NQ and BQ Coring Equipment COMPILED BY ZP  
 DATUM Geodetic DATE 5.28.09 - 5.28.09 CHECKED BY PC

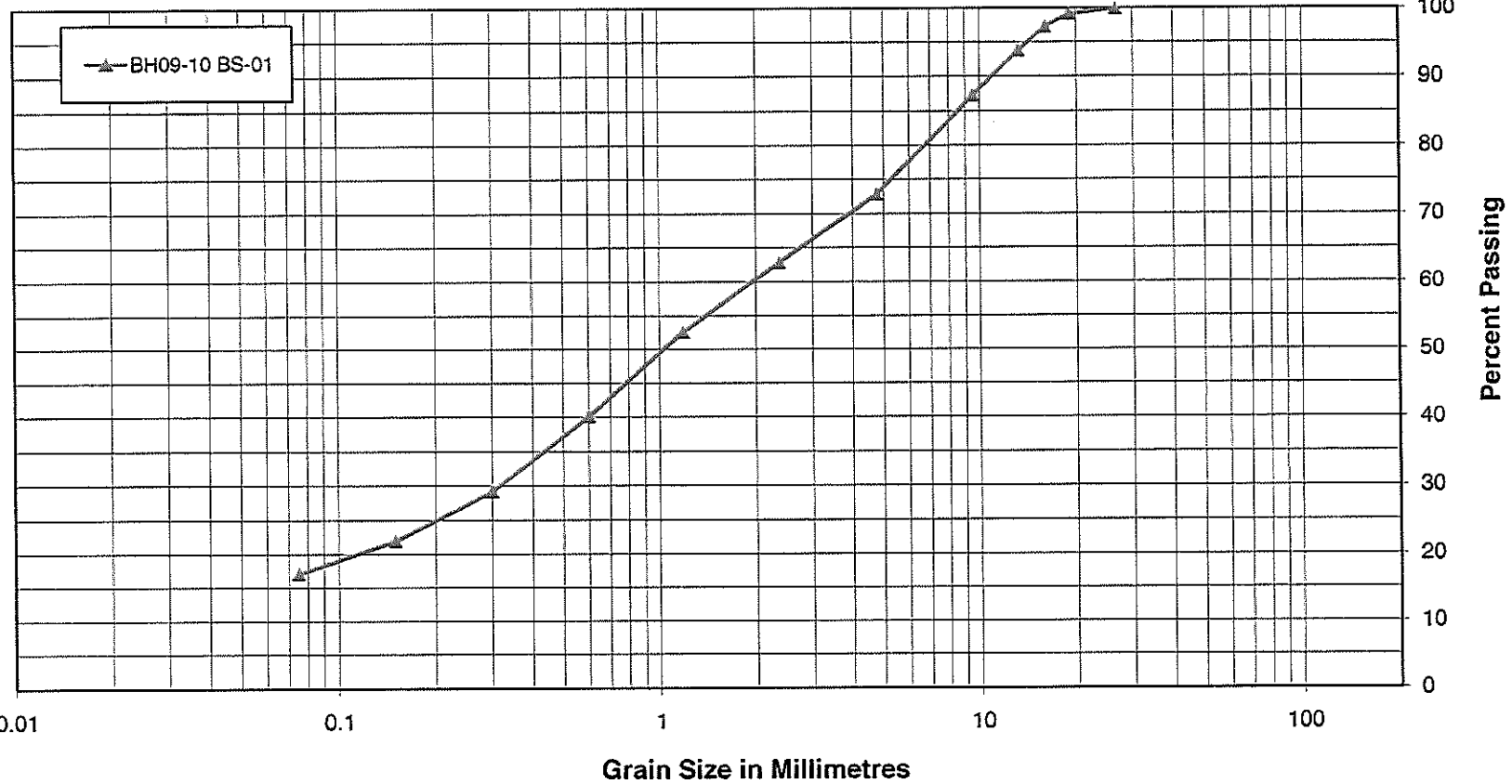
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
216.6								20	40	60	80	100						
216.0	Dark brown to black TOPSOIL & ROOTMAT		1	SS	10													
0.1	Silty sand (SM) with gravel, compact, brown Till.		2	SS	24													34 54 (12)
215.2			3	SS	50/ 150mm													
1.4	Grey LIMESTONE bedrock with shale partings - very poor to poor quality - slightly to moderately weathered - flat orientation (0 - 20°) - very close joint spacing - rough planar		4	NQ														
			5	NQ														
			6	NQ														
			7	NQ														
			8	NQ														
			9	NQ														
			10	BQ														
212.3			11	BQ														
4.3	End of Borehole																	

ONTARIO MTO STANTEC 1047243 HWY 7.GPJ ONTARIO MOT.GDT 8/3/10

# Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

200 100 50 30 16 8 4 U.S. Std. Sieve



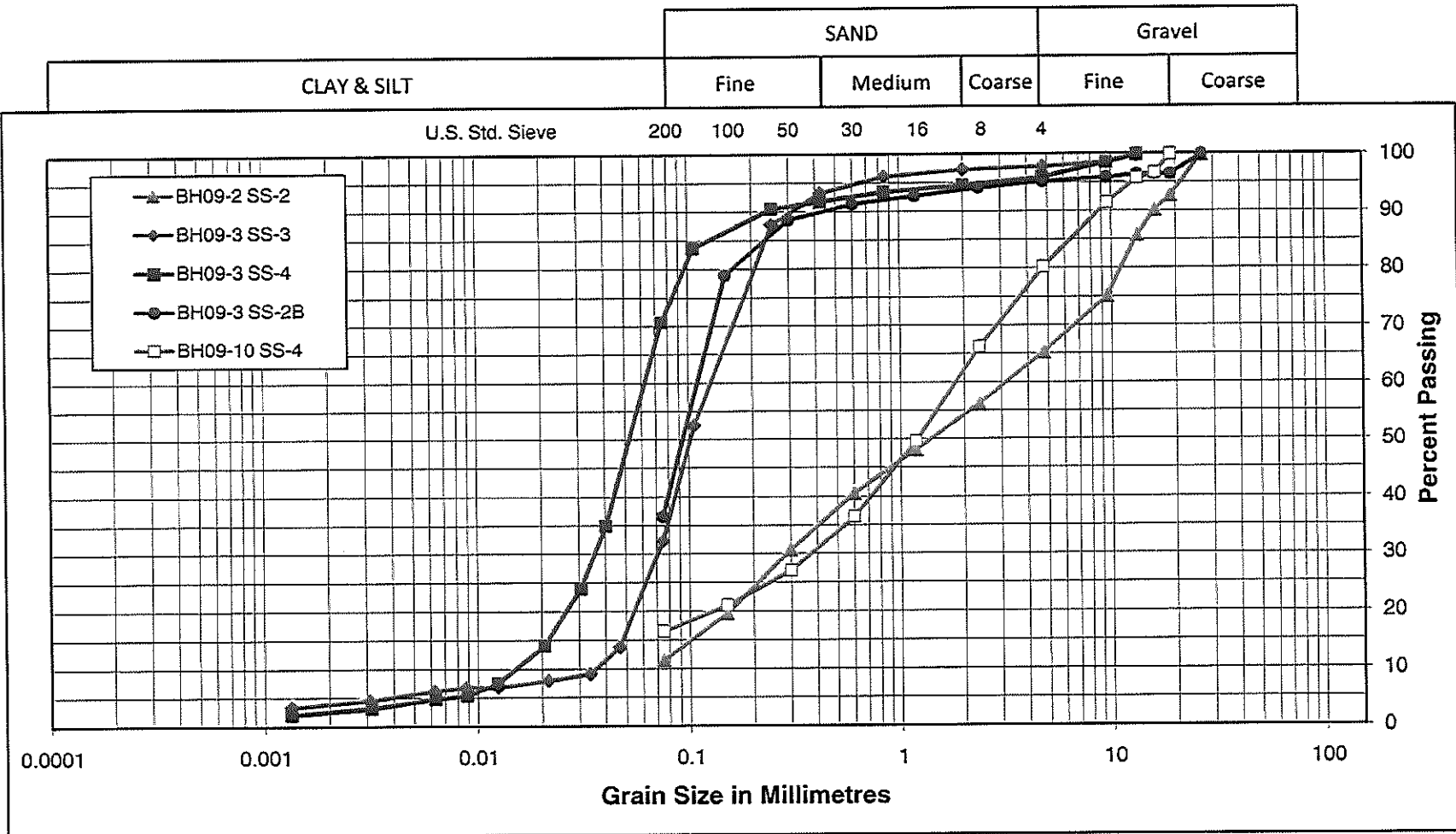
## GRAIN SIZE DISTRIBUTION

FILL: Silty Sand with Gravel  
Culvert 2: 10+937

Figure No. 3

Project No. 122410158

## Unified Soil Classification System



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**GRAIN SIZE DISTRIBUTION**  
 TILL: Silty Sand with Gravel to Silt with Sand  
 Culvert 2: 10+937

Figure No. 4

Project No. 122410158



**Stantec**

# Field Core Log

Client: AECOM Canada Ltd.-  
 Project: Highway 7 - Norwood to Havelock, W.P. 67-99-00  
 Contractor: OGS Drilling Inc. (portable drilling equipment)

Project No.: 122410158  
 Date: June 5, 2009  
 Borehole No.: 09-2  
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1.37	4	33	21	1.83	Grey LIMESTONE bedrock with shale partings	S	S		B	F	VC	PR		T		
1.83	5 and 6	33 and 58	0 and 0	2.13	Grey LIMESTONE bedrock with shale partings	S	S		B	F	VC	PR		T		
2.44	7 and 8	88 and 64	28 and 28	3.13	Grey LIMESTONE bedrock with shale partings	S	S		B	F	VC	PR		T		
3.13	9 and 10	81 and 30	0 and 0	4.04	Grey LIMESTONE bedrock with shale partings	S	S		B	F	VC	PR		T		
<div> <p><b>STRENGTH (MPa)</b>            EH = Extremely Strong = &gt; 250            VS = Very Strong = 100-250            S = Strong = 50-100            MS = Medium Strong = 25-50            W = Weak = 5 - 25</p> <p><b>WEATHERING</b>            U = Unweathered = No Signs            S = Slightly = Oxidized            M = Moderately = Discoloured            H = Highly = Friable            C = Completely = Soil-like</p> </div> <div> <p><b>DISCONTINUITY TYPE</b>            B = Bedding Joint            J = Cross Joint            F = Fault            S = Shear Plane</p> <p><b>SPACING</b>            VW = Very Wide = &gt;3m            W = Wide = 1-3 m            M = Moderate = 0.3-1 m            C = Close = 5-30 cm            VC = Very Close = &lt;5 cm</p> </div> <div> <p><b>ORIENTATION</b>            F = Flat = 0-20°            D = Dipping = 20-50°            V = n-Vertical = &gt;50°</p> <p><b>ROUGHNESS</b>            RU = Rough Undulating            RP = Rough Planar            SU = Smooth Undulating            SP = Smooth Planar            LU = Slickensided Undulating            LP = Slickensided Planar</p> </div> <div> <p><b>FILLING</b>            T = Tight, Hard            O = Oxidized            SA = Slightly Altered, Clay Free            S = Sandy, Clay Free            Si = Sandy, Silty, Minor Clay            NC = Non-softening Clay            SC = Swelling, Soft Clay</p> </div>																



**Stantec**

# Field Core Log

Client: AECOM Canada Ltd.  
 Project: Highway 7 - Norwood to Havelock, W.P. 67-99-00  
 Contractor: OGS Drilling Inc. (portable drilling equipment)

Project No.: 122410158  
 Date: June 5, 2009  
 Borehole No.: 09-2  
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
4.04	11	22	0	4.42	Grey LIMESTONE bedrock with shale partings	RENG	S		B	F	VC	PR		T		

<b>STRENGTH (MPa)</b> EH = Extremely Strong = > 250 VS = Very Strong = 100-250 S = Strong = 50-100 MS = Medium Strong = 25-50 W = Weak = 5 - 25				<b>DISCONTINUITY TYPE</b> B = Bedding Joint J = Cross Joint F = Fault S = Shear Plane				<b>ORIENTATION</b> F = Flat = 0-20° D = Dipping = 20-50° V = n-Vertical = >50°				<b>FILLING</b> T = Tight, Hard O = Oxidized SA = Slightly Altered, Clay Free S = Sandy, Clay Free Si = Sandy, Silty, Minor Clay NC = Non-softening Clay SC = Swelling, Soft Clay			
<b>WEATHERING</b> U = Unweathered = No Signs S = Slightly = Oxidized M = Moderately = Discoloured H = Highly = Friable C = Completely = Soil-like				<b>SPACING</b> VW = Very Wide = >3m W = Wide = 1-3 m M = Moderate = 0.3-1 m C = Close = 5-30 cm VC = Very Close = <5 cm				<b>ROUGHNESS</b> RU = Rough Undulating RP = Rough Planar SU = Smooth Undulating SP = Smooth Planar LU = Slickensided Undulating LP = Slickensided Planar							



**Stantec**

# Field Core Log

Client: AECOM Canada Ltd.  
 Project: Highway 7 - Norwood to Havelock, W.P. 67-99-00  
 Contractor: OGS Drilling Inc.

Project No.: 122410158  
 Date: June 5, 2009  
 Borehole No.: 09-3  
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS	
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE			FILLING
2.59	5	71	35	3.2	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC	RP		T		
3.2	6	75	0	3.4	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC	RP		T		
3.4	7	86	0	3.76	Grey LIMESTONE bedrock with shale partings	VS	U		B	F	VC	RP		T		
3.76	8	79	0	4.16	Grey LIMESTONE bedrock with shale partings	VS	U		B	F	C	RP		T		

STRENGTH (MPa)

EH = Extremely Strong = > 250

VS = Very Strong = 100-250

S = Strong = 50-100

MS = Medium Strong = 25-50

W = Weak = 5 - 25

WEATHERING

U = Unweathered = No Signs

S = Slightly = Oxidized

M = Moderately = Discoloured

H = Highly = Friable

C = Completely = Soil-like

DISCONTINUITY TYPE

B = Bedding Joint

J = Cross Joint

F = Fault

S = Shear Plane

SPACING

VW = Very Wide = >3m

W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm

VC = Very Close = <5 cm

ORIENTATION

F = Flat = 0-20°

D = Dipping = 20-50°

V = n-Vertical = >50°

ROUGHNESS

RU = Rough Undulating

RP = Rough Planar

SU = Smooth Undulating

SP = Smooth Planar

LU = Slickensided Undulating

LP = Slickensided Planar

FILLING

T = Tight, Hard

O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free

Si = Sandy, Silty, Minor Clay

NC = Non-softening Clay

SC = Swelling, Soft Clay



**Client:** AECOM Canada Ltd.  
**Project:** Highway 7 - Norwood to Havelock, W.P. 67-99-00  
**Contractor:** OGS Drilling Inc.

Project No.:	122410158
Date:	June 5, 2009
Borehole No.:	09-3
Logger:	Kenton C. Power

Page 4 of 5





**Stantec**

# Field Core Log

Client: AECOM Canada Ltd.  
 Project: Highway 7 - Norwood to Havelock, W.P. 67-99-00  
 Contractor: George Downing Estate Drilling Ltd. - (CME75)

Project No.: 122410158  
 Date: June 5, 2009  
 Borehole No.: 09-10  
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
2.99	5 and 6	-	-	5.21	Grey LIMESTONE bedrock with shale partings	S	S		B	F	VC	RP		T		
5.21	7	100	0	5.57	Grey LIMESTONE bedrock with shale partings	S	S		B	F	VC	RP		T		
5.57	8	78	20	7.09	Grey LIMESTONE bedrock with shale partings	S	U		B	F	VC/C	RP		T		
7.09	9	100	67	8.09	Grey LIMESTONE bedrock with shale partings	S	U		B	F	C/M	RP		T		

## STRENGTH (MPa)

EH = Extremely Strong = > 250  
 VS = Very Strong = 100-250  
 S = Strong = 50-100  
 MS = Medium Strong = 25-50  
 W = Weak = 5 - 25  
 VW = Very Weak = 1-5  
 EW = Extremely Weak = < 1

## WEATHERING

U = Unweathered = No Signs  
 S = Slightly = Oxidized  
 M = Moderately = Discoloured  
 H = Highly = Friable  
 C = Completely = Soil-like

## DISCONTINUITY TYPE

B = Bedding Joint  
 J = Cross Joint  
 F = Fault  
 S = Shear Plane

## SPACING

VW = Very Wide = >3m  
 W = Wide = 1-3 m  
 M = Moderate = 0.3-1 m  
 C = Close = 5-30 cm  
 VC = Very Close = <5 cm

## ORIENTATION

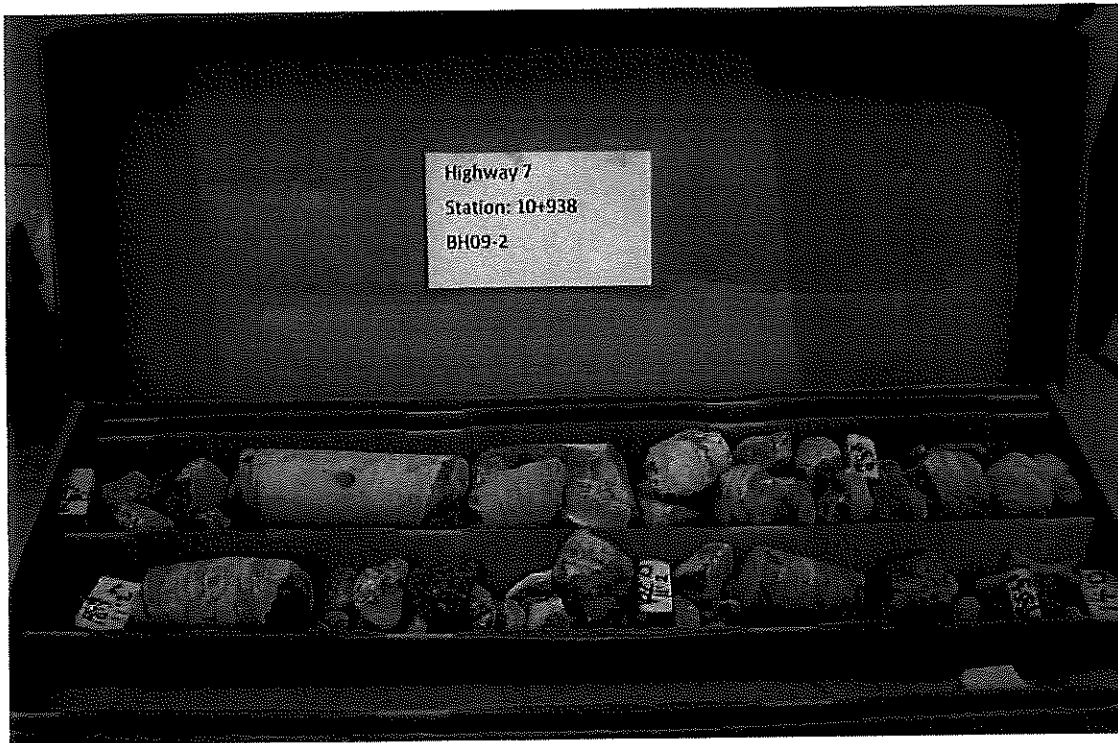
F = Flat = 0-20°  
 D = Dipping = 20-50°  
 V = n-Vertical = >50°

## ROUGHNESS

RU = Rough Undulating  
 RP = Rough Planar  
 SU = Smooth Undulating  
 SP = Smooth Planar  
 LU = Slickensided Undulating  
 LP = Slickensided Planar

## FILLING

T = Tight, Hard  
 O = Oxidized  
 SA = Slightly Altered, Clay Free  
 S = Sandy, Clay Free  
 Si = Sandy, Silty, Minor Clay  
 NC = Non-softening Clay  
 SC = Swelling, Soft Clay



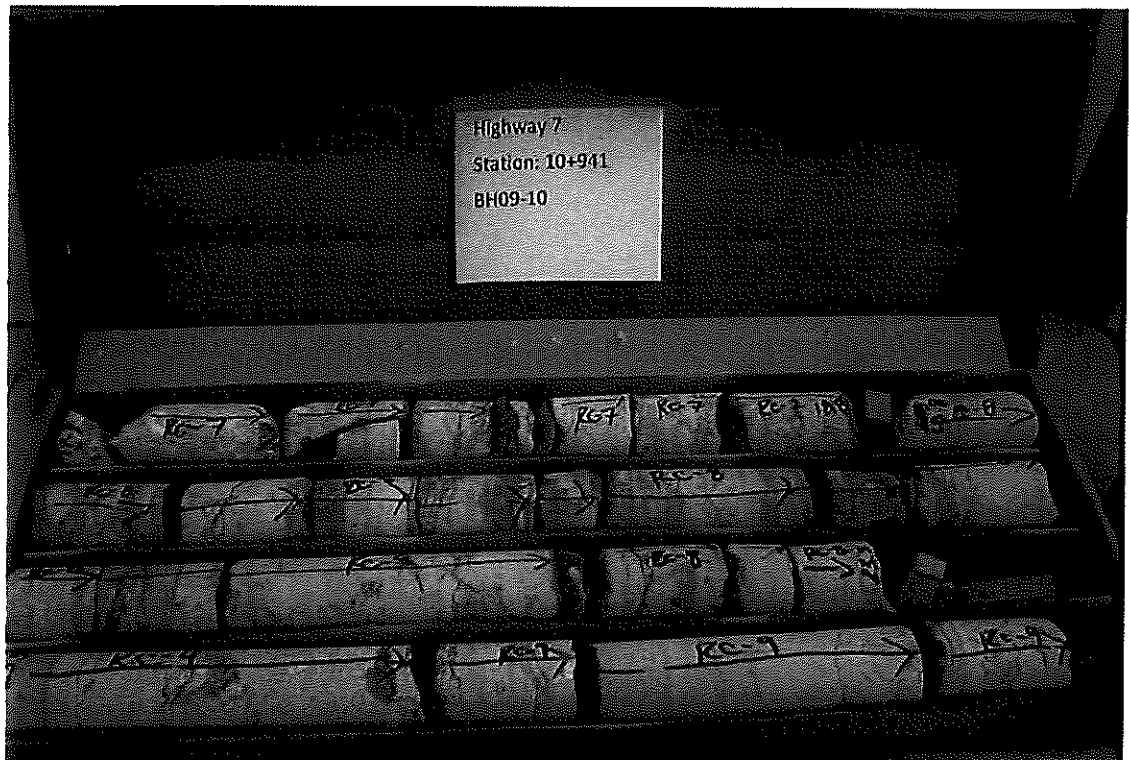
**Photo No. 13: 10+938 BH09-2**



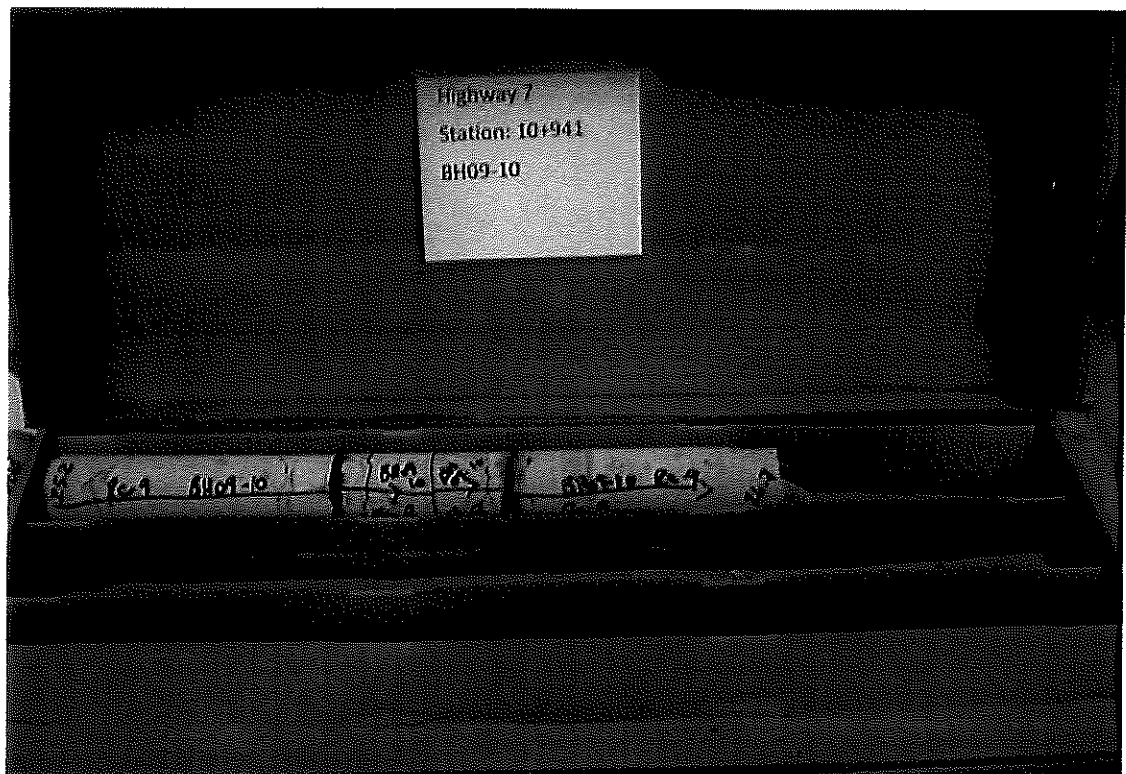
**Photo No. 14: 10+938 BH09-3**



**Stantec**



**Photo No. 15: 10+941 BH09-10**



**Photo No. 16: 10+941 BH09-10**

P:\2009\122410158 - 1047243- Hwy 7 Havelock\Foundation\Report\Culverts\Draft\BR Core Photos 10+937.Doc



**Stantec**

## **APPENDIX D**

Culvert #18 - Station 11+963

Site Photographs

Borehole Location Plan and Stratigraphic Sections

Borehole Records

Laboratory Test Results

Field Core Logs

Photos of Rock Cores



**Photo 5: 11+963 – View of general conditions in vicinity of culvert.**



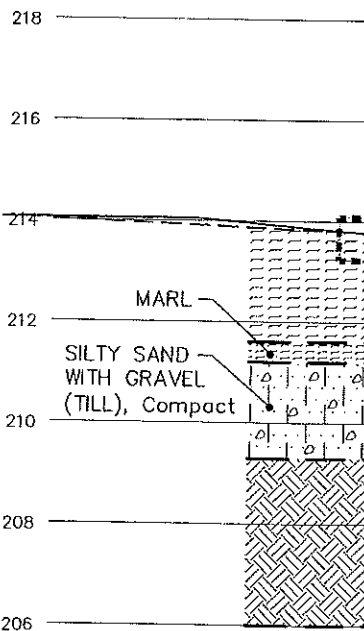
**Photo 6: 11+963 – End of existing culvert.**

PR-0-107 68-00

DIRECTOR OF PROFESSIONAL ENGINEERING

Printed: Aug 05, 2010

DRAWING NAME: 122410158-2.8 Cu  
 CREATED: GBB  
 MODIFIED: 2010-07-30  
 C:\DOCUMENTS\1\p\ones\LOCALS-1\Temp\AcPublish\_3424\122410158-2.8 Cu.dwg



ETRIC  
 UNITS ARE IN METRES  
 OR MILLIMETRES  
 OTHERWISE SHOWN

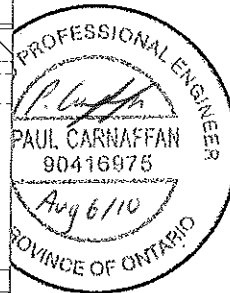
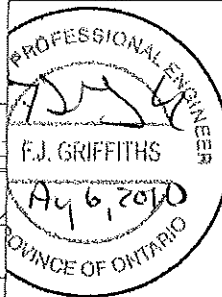


PLATE No

CONT  
 WP

67-99-00

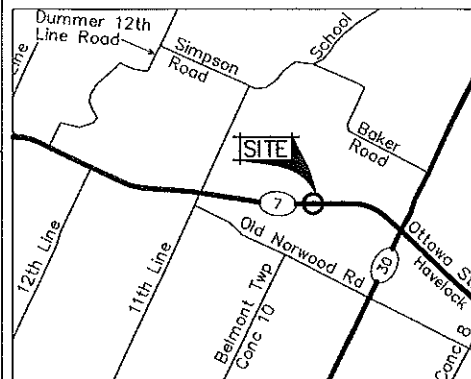


HIGHWAY 7  
 CULVERT AT STA. 11+963  
 BOREHOLE LOCATIONS & SOIL STRATA

SHEET



Stantec



KEY PLAN



### LEGEND

- Borehole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ 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 (June 2009)
- ⬇ WL in Piezometer
- ⬇ Piezometer

No	ELEVATION	MTM ZONE 9 COORDINATES	
		NORTH	EAST
09-4	213.9	4 921 833.1	192 741.2
09-9	215.1	4 921 825.7	192 746.2
10-8	215.1	4 921 820.3	192 748.0
10-9	214	4 921 816.6	192 756.0

### NOTE

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

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

GEOCRETS No 31C-199

HWY No 7	CHECKED	DATE 2010-04-28	DIST
SUBM'D KP	CHECKED	APPROVED	SITE
DRAWN GBB	CHECKED	APPROVED	DWG 4



# RECORD OF BOREHOLE No 10-9

1 OF 1

METRIC

W.P. 67-99-00 LOCATION 11+962 O/S CL 10.1 RT N: 4 921 817 E: 192 756 ORIGINATED BY JF  
 DIST HWY 7 BOREHOLE TYPE Portable Drilling Equipment, 1/3 Weight Hammer, Spillspoons COMPILED BY JF  
 DATUM Geodetic DATE 7.7.10 - 7.7.10 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
214.0	Cattails													
0.0	Fine fibrous organic matter, soft, dark brown, (PEAT)		1	SS	1									
212.9			2	SS	1		213							
1.1	Sand with silt, brown, FILL		3	SS	2									1 90 (8)
212.3			4	SS	2		212							
1.8	Fine fibrous organic matter, soft, dark brown, (PEAT)		5	SS	4									
211.2			6	SS	13		211							0 80 (20)
2.8	Silty sand (SM), compact, grey		7	SS	34		210							0 87 (13)
209.9														
209.7	Silty sand (SM), compact, TILL													
4.3	Inferred TILL - start of dynamic cone penetration test													
209.4														
4.7	End of Borehole													
	Dynamic Cone Refusal on Inferred Bedrock													

×<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity

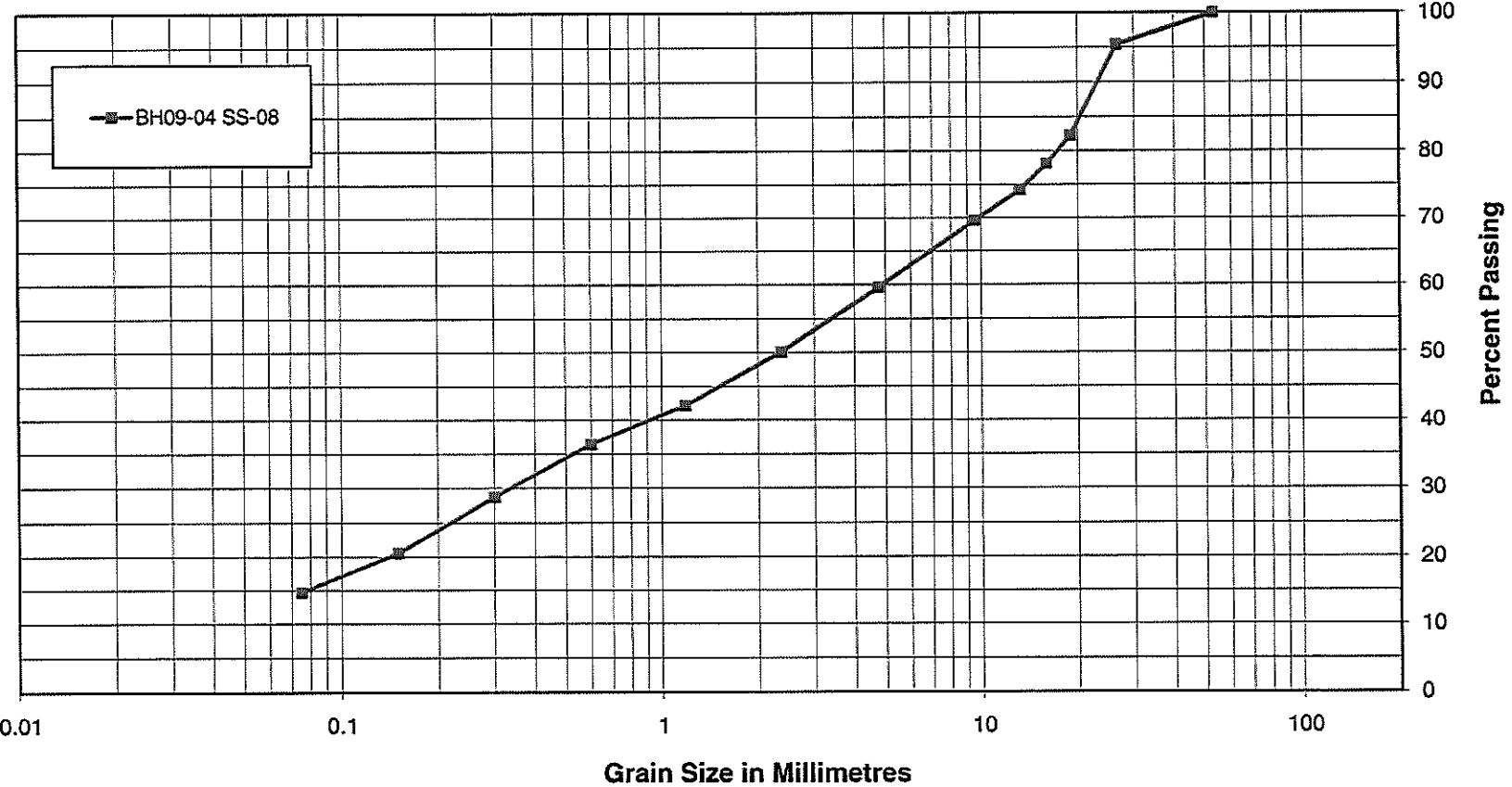
○ 3% STRAIN AT FAILURE



# Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

200 100 50 30 16 8 4 U.S. Std. Sieve



Stantec

## GRAIN SIZE DISTRIBUTION

TILL: Silty Sand with Gravel  
Culvert 3: 11+963

Figure No. 5

Project No. 122410158



**Stantec**

# Field Core Log

Client: AECOM Canada Ltd.  
 Project: Highway 7 - Norwood to Havelock, W.P. 67-99-00  
 Contractor: OGS Drilling Inc.

Project No.: 122410158  
 Date: June 5, 2009  
 Borehole No.: 09-4  
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS	
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE			FILLING
4.62	9 and 10	100 and 100	0 and 0	5.59	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC/C	RP		T		
5.59	11 and 12	100 and 100	100 and 45	6.04	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC/C	RP		T		
6.04	13	100	25	7.37	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC/C	RP		T		
7.37	14	100	43	7.97	Grey LIMESTONE bedrock with shale partings	VS	U		B	F	C	RP		T		

<p><b>STRENGTH (MPa)</b></p> <p>EH = Extremely Strong = &gt; 250          VS = Very Strong = 100-250          S = Strong = 50-100          MS = Medium Strong = 25-50          W = Weak = 5 - 25</p> <p><b>WEATHERING</b></p> <p>U = Unweathered = No Signs          S = Slightly = Oxidized          M = Moderately = Discoloured          H = Highly = Friable          C = Completely = Soil-like</p>	<p><b>DISCONTINUITY TYPE</b></p> <p>B = Bedding Joint          J = Cross Joint          F = Fault          S = Shear Plane</p> <p><b>SPACING</b></p> <p>VW = Very Wide = &gt;3m          W = Wide = 1-3 m          M = Moderate = 0.3-1 m          C = Close = 5-30 cm          VC = Very Close = &lt;5 cm</p>	<p><b>ORIENTATION</b></p> <p>F = Flat = 0-20°          D = Dipping = 20-50°          V = n-Vertical = &gt;50°</p> <p><b>ROUGHNESS</b></p> <p>RU = Rough Undulating          RP = Rough Planar          SU = Smooth Undulating          SP = Smooth Planar          LU = Slickensided Undulating          LP = Slickensided Planar</p>	<p><b>FILLING</b></p> <p>T = Tight, Hard          O = Oxidized          SA = Slightly Altered, Clay Free          S = Sandy, Clay Free          Si = Sandy, Silty, Minor Clay          NC = Non-softening Clay          SC = Swelling, Soft Clay</p>
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# Stantec

Project No.:	122410158
Date:	June 5, 2009
Borehole No.:	09-9
Logger:	Kenton C. Power

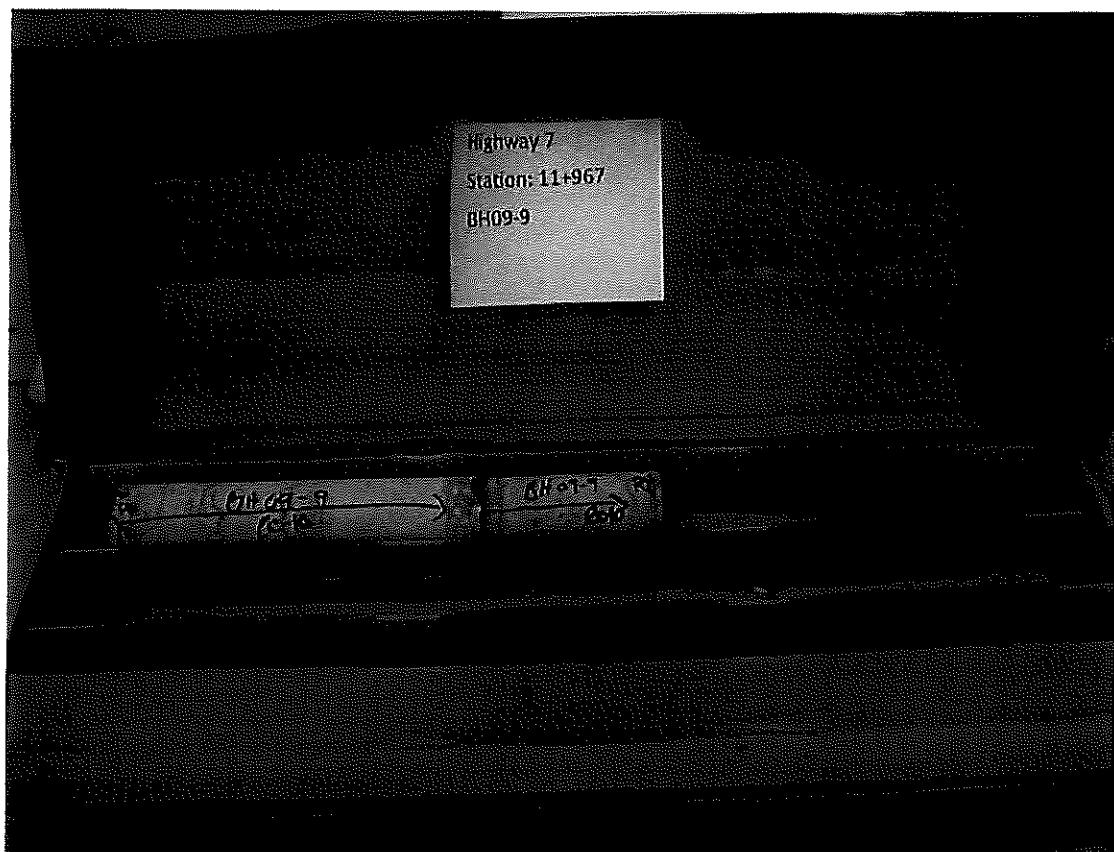
Page 2 of 2 P:\2009\122410158 - 1047243- Hwy 7 Havelock\Foundation\Bedrock Cores\1047243 Bedrock Core Logs.xlsx



**Photo No. 17: 11+963 BH09-4**



**Photo No. 18: 11+967 BH09-9**



**Photo No. 19: 11+967 BH09-9**

P:\2009\122410158 - 1047243- Hwy 7 Havelock\Foundation\Report\Culverts\DRAFT\BR Core Photos 11+963.Doc

## **APPENDIX E**

Culvert #19 - Station 12+387

Site Photographs

Borehole Location Plan and Stratigraphic Sections

Borehole Records

Laboratory Test Results

Field Core Logs

Photos of Rock Cores

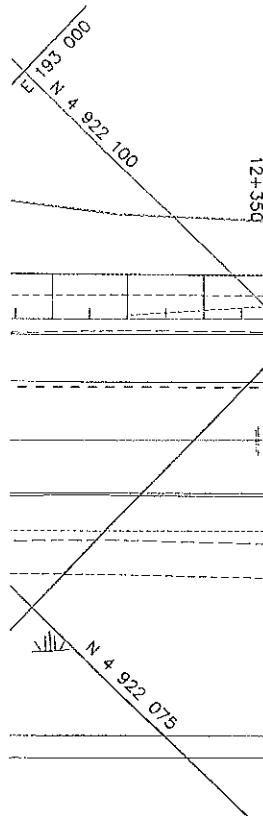


**Photo 7: 12+387 – View of general conditions in vicinity of culvert.**



**Photo 8: 12+387 – Water at end of existing culvert.**

DRAWING NAME: 122410158-2.B Cu  
 CREATED: 2010-07-23  
 C:\DOCUMENTS\1\gbriones\LOCALS-1\Temp\AcfPublish\_3424\122410158-2.B Cu.dwg Printed: Aug 05, 2010



**METRIC**  
 UNITS ARE IN METRES  
 OR MILLIMETRES  
 OTHERWISE SHOWN

PLATE No

CONT  
WP

67-99-00

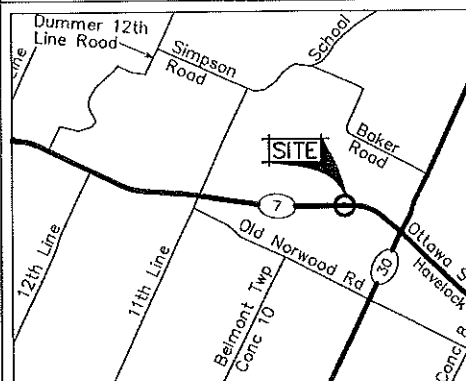


SHEET

**HIGHWAY 7**  
**CULVERT AT STA. 12+387**  
**BOREHOLE LOCATIONS & SOIL STRATA**



Stantec



KEY PLAN

1 km 0 1 2 km

## LEGEND

- Borehole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊗ 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 (June 2009)
- ↓ WL in Piezometer
- ⊥ Piezometer

No	ELEVATION	MTM ZONE 9 NORTH	COORDINATES EAST
09-5	213.8	4 922 126.8	193 045.6
09-6	213.7	4 922 112.3	193 060.9
09-7	214.8	4 922 115.3	193 055.4
09-8	214.9	4 922 120.4	193 051.2

## NOTE

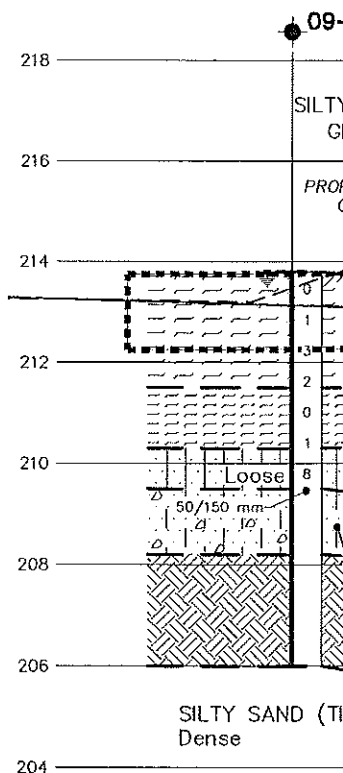
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

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

GEOCRETS No 31C-199

HWY No 7	CHECKED	DATE 2010-05-10	DIST
SUBM'D KP	CHECKED	APPROVED	SITE
DRAWN GBB	CHECKED	APPROVED	DWG 5





# RECORD OF BOREHOLE No 09-5

1 OF 1

METRIC

W.P. 67-99-00 LOCATION 12+387 O/S CL 13.6 LT N: 4 922 127 E: 193 046 ORIGINATED BY ZP  
 DIST HWY 7 BOREHOLE TYPE Portable Drilling Equipment, 1/3 Weight Hammer, Splispoons, BQ Coring Equipment COMPILED BY ZP  
 DATUM Geodetic DATE 6.1.09 - 6.2.09 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								20 40 60 80 100											
								20 40 60 80 100											
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT												
							v <sub>p</sub> w w <sub>L</sub>					WATER CONTENT (%)							
							○ UNCONFINED × FIELD VANE												
							● QUICK TRIAXIAL × LAB VANE												
							20 40 60 80 100					10 20 30							
213.8																			
0.0	Amorphous organic matter, soft, brown to black (PEAT)		1	SS	0														
			2	SS	1														
212.5																			
1.2	Fine fibrous organic matter, soft, dark brown to black, (PEAT)		3	SS	3														
			4	SS	2														
211.5																			
2.3	MARL, soft, whitish grey		5	SS	0														
			6	SS	1														
210.3																			
3.6	Silty sand (SM), loose, grey to brown		7	SS	8														
			8	SS	50/150mm														
209.5																			
4.3	Silty sand (SM), dense, grey to brown, TILL  - frequent cobbles and boulders - boulder frequency increasing with depth		9	BQ															
			10	BQ															
208.2																			
5.5	Grey LIMESTONE bedrock with shale partings - very poor to poor quality - slightly weathered - flat orientation (0 - 20°) - very close joint spacing - rough planar		11	BQ															
			12	BQ															
			13	BQ															
			14	BQ															
			15	BQ															
			16	BQ															
			17	BQ															
			18	BQ															
			19	BQ															
206.0																			
7.7	End of Borehole																		

# RECORD OF BOREHOLE No 09-6

1 OF 1

METRIC

W.P. 67-99-00 LOCATION 12+387 O/S CL 10.2 RT N: 4 922 112 E: 193 060 ORIGINATED BY ZP  
 DIST HWY 7 BOREHOLE TYPE Portable Drilling Equipment, Spillspoons, NQ Coring Equipment COMPILED BY ZP  
 DATUM Geodetic DATE 6.2.09 - 6.3.09 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT 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			SHEAR STRENGTH kPa		WATER CONTENT (%)				
213.7 0.0	610mm WATER 610 mm WATER							20 40 60 80 100	20 40 60 80 100	10 20 30				
213.1 0.6	Coarse fibrous organic matter, soft, dark brown to black, (PEAT) - trace wood		1	SS	1		213							
			2	SS	0		212							
211.4 2.3	MARL, soft, whitish grey		3	SS	2									
210.8 2.9	Silty sand (SM), loose to compact, brown		4	SS	1/ 450mm		211							
			5	SS	10		210							
209.4 4.3	Silty sand (SM) with gravel, dense, brown, TILL		7	SS	33		209							
			8	SS	34									
207.9 5.8	Gray LIMESTONE bedrock with shale partings - poor to excellent quality - slightly weathered - flat orientation (0 - 20°) - very close to moderate joint spacing - rough planar		9	NQ			208							
			10	NQ			207							
			11	NQ										
			12	NQ			206							
204.7 9.0	End of Borehole		13	NQ			205							

# RECORD OF BOREHOLE No 09-7

1 OF 1

METRIC

W.P. 67-99-00 LOCATION 12+392 O/S CL 3.2 RT N: 4 922 115 E: 193 055 ORIGINATED BY AB  
 DIST HWY 7 BOREHOLE TYPE Splitterspoons, Hollow Stem Augers, NQ Coring Equipment COMPILED BY ZP  
 DATUM Geodetic DATE 6.22.09 - 6.22.09 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	× FIELD VANE	● QUICK TRIAXIAL							× LAB VANE	
214.8	250 mm ASPHALT						20	40	60	80	100	10	20	30				
0.0																		
214.6																		
0.3	Silty sand with gravel, grey, FILL		1	BS	-													
			2	SS	34													
			3	SS	12													
212.5																		
2.3	Fine fibrous organic matter, soft, dark brown to black, (PEAT)		4	SS	4													
			5	SS	1/600mm													
211.3																		
3.5	MARL, soft, whitish grey		6	SS	1/450mm													
210.2																		
4.6	Silty sand (SM), compact to dense, greyish brown		7	SS	18													
			8	SS	31													
208.9																		
5.9	Silty sand (SM), compact, brown, TILL		9	SS	14													
208.2																		
6.6	Grey LIMESTONE bedrock with shale partings - very poor to poor quality - slightly weathered - flat orientation (0 - 20°) - very close to close joint spacing - rough planar		10	NQ														
			11	NQ														
			12	NQ														
204.5																		
10.3	End of Borehole																	

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

# RECORD OF BOREHOLE No 09-8

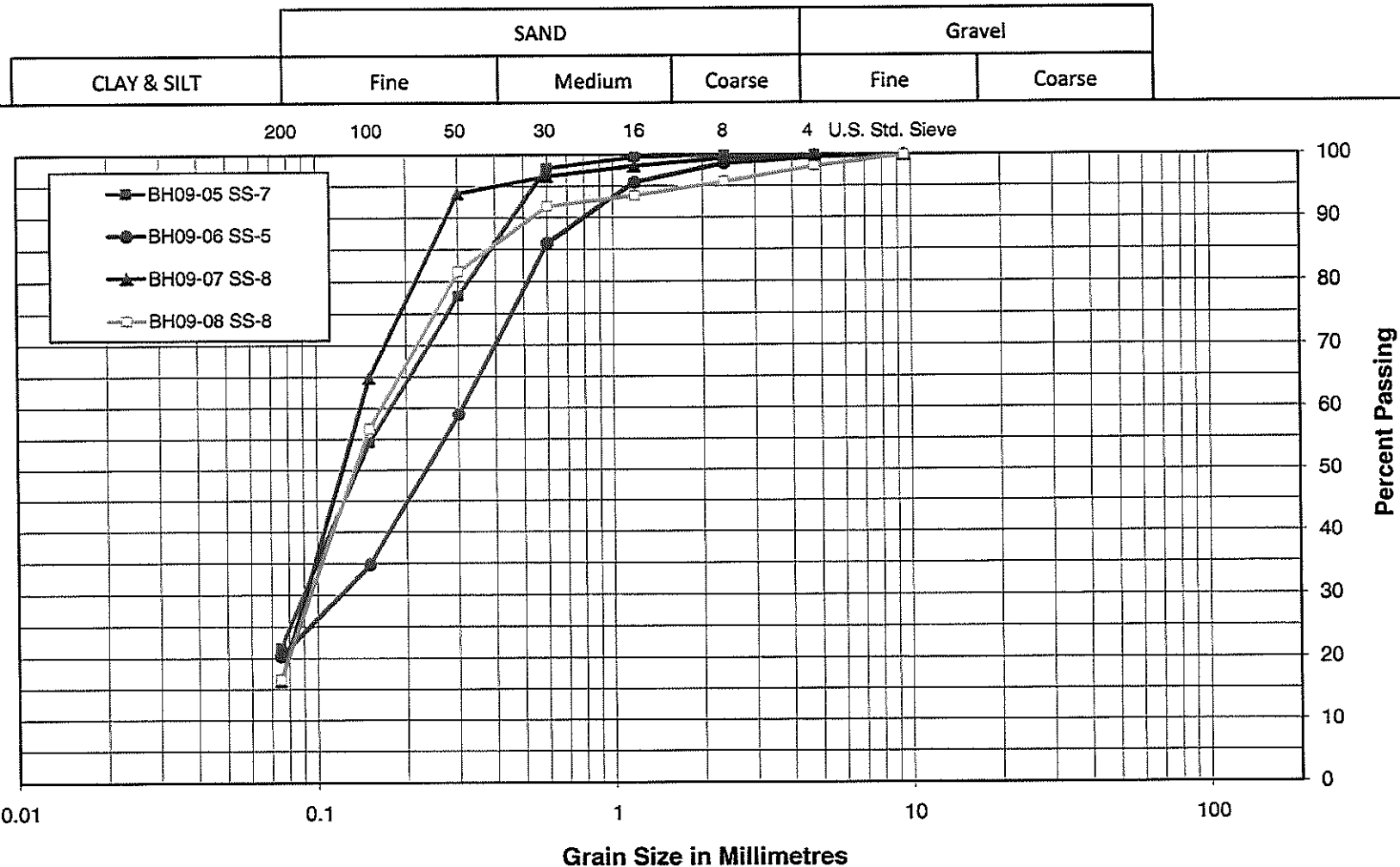
1 OF 1

METRIC

W.P. 67-99-00 LOCATION 12+393 O/S CL 3.2 LT N: 4 922 120 E: 193 051 ORIGINATED BY AB  
 DIST HWY 7 BOREHOLE TYPE SplitSpoons, Hollow Stem Augers, NQ Coring Equipment COMPILED BY ZP  
 DATUM Geodetic DATE 6.22.09 - 6.22.09 CHECKED BY PC

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 (%)
214.9	230 mm ASPHALT							20 40 60 80 100							
0.0 214.7	Silty sand with gravel, grey, FILL		1	BS	-			○ UNCONFINED      × FIELD VANE							
0.2			2	SS	24			● QUICK TRIAXIAL      × LAB VANE							
			3	SS	6										
212.7	Fine fibrous organic matter, soft, dark brown to black, (PEAT)														
2.3			4	SS	2										
211.5	MARL, soft, whitish grey		5	SS	1										
3.5			6	SS	1										
210.4	Silty sand (SM), very loose to loose, brown														
4.6			7	SS	1										
			8	SS	7										
208.6	Silty sand (SM), dense, brown, TILL  - frequent cobbles and boulders - boulder frequency increasing with depth		9	SS	75/ 130mm									2 81 (17)	
6.3			10	SS	75/ 130mm										
207.6			11	NQ	80mm										7 83 (10)
7.3	Grey LIMESTONE bedrock with shale partings - poor quality - slightly weathered - flat orientation (0 - 20°) - very close to close joint spacing - rough planar		12	NQ											
			13	NQ											
			14	NQ											
204.6 10.4	End of Borehole														

# Unified Soil Classification System



## GRAIN SIZE DISTRIBUTION

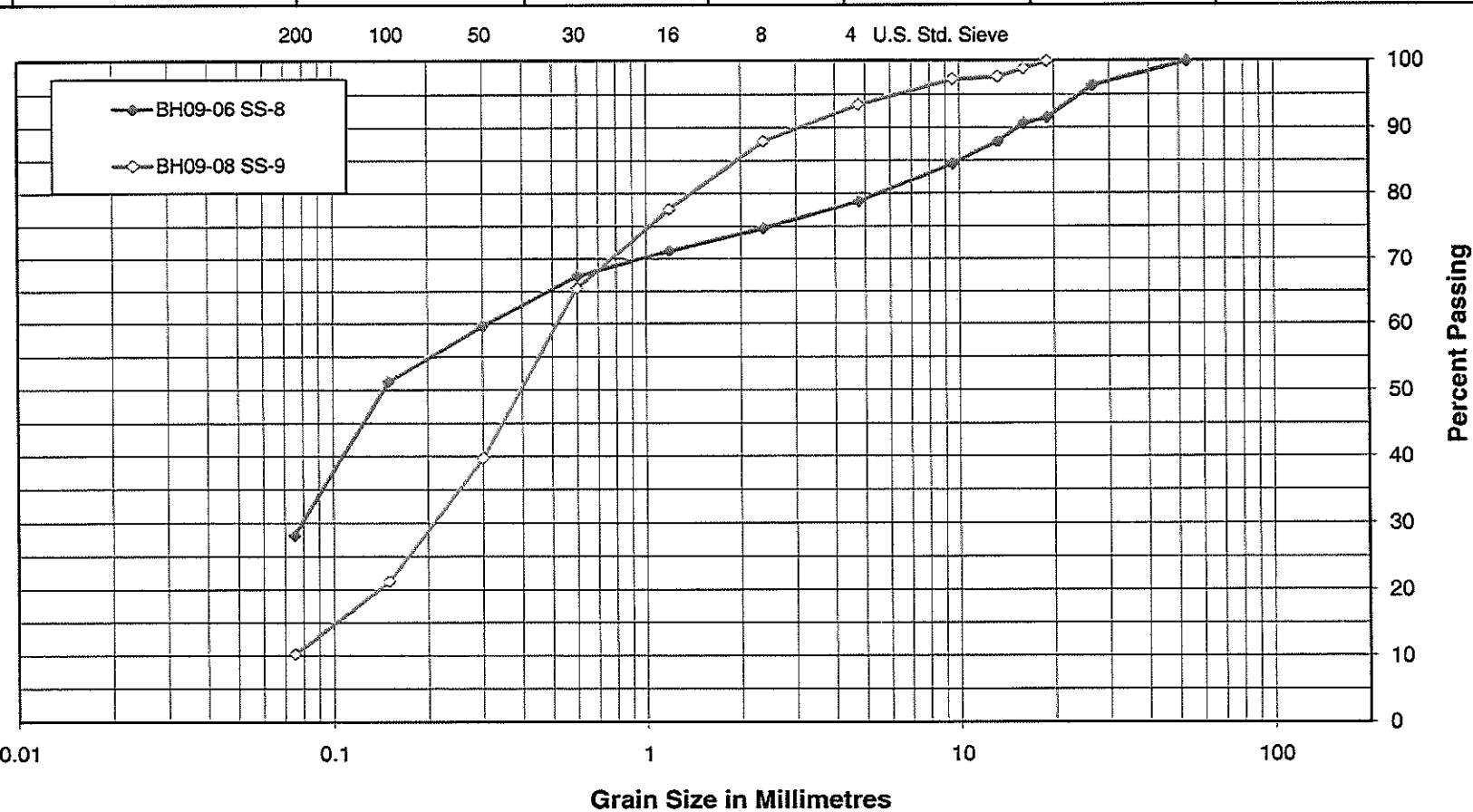
Silty Sand with Gravel  
Culvert 4: 12+387

Figure No. 7

Project No. 122410158

# Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse



Stantec

## GRAIN SIZE DISTRIBUTION

TILL: Silty Sand with Gravel to Silty Sand  
Culvert 4: 12+387

Figure No. 8

Project No. 122410158



**Client:** AECOM Canada Ltd.  
**Project:** Highway 7 - Norwood to Havelock, W.P. 67-99-00  
**Contractor:** OGS Drilling Inc.

Project No.:	122410158
Date:	June 5, 2009
Borehole No.:	09-5
Logger:	Kenton C. Power

P:\2009\122410158 - 1047243- Hwy 7 Havelock\Foundation\Bedrock Cores\1047243 Bedrock Core Logs.xlsx



**Stantec**

# Field Core Log

Client: AECOM Canada Ltd.  
 Project: Highway 7 - Norwood to Havelock, W.P. 67-99-00  
 Contractor: OGS Drilling Inc.

Project No.: 122410158  
 Date: June 5, 2009  
 Borehole No.: 09-6  
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS	
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE			FILLING
5.77	9	67	100	5.92	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC/C	RP		T		
5.92	10	96	48	6.53	Grey LIMESTONE bedrock with shale partings	VS	U		B	F	C	RP		T		
6.53	11	96	43	7.14	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC/C	RP		T		
7.14	12	92	54	7.8	Grey LIMESTONE bedrock with shale partings	VS	U		B	F	C	RP		T		

**STRENGTH (MPa)**

EH = Extremely Strong = > 250  
VS = Very Strong = 100-250  
S = Strong = 50-100  
MS = Medium Strong = 25-50  
W = Weak = 5 - 25

**WEATHERING**

U = Unweathered = No Signs  
S = Slightly = Oxidized  
M = Moderately = Discoloured  
H = Highly = Friable  
C = Completely = Soil-like

**DISCONTINUITY TYPE**

B = Bedding Joint  
J = Cross Joint  
F = Fault  
S = Shear Plane

**SPACING**

VW = Very Wide = >3m  
W = Wide = 1-3 m  
M = Moderate = 0.3-1 m  
C = Close = 5-30 cm  
VC = Very Close = <5 cm

**ORIENTATION**

F = Flat = 0-20°  
D = Dipping = 20-50°  
V = n-Vertical = >50°

**ROUGHNESS**

RU = Rough Undulating  
RP = Rough Planar  
SU = Smooth Undulating  
SP = Smooth Planar  
LU = Slickensided Undulating  
LP = Slickensided Planar

**FILLING**

T = Tight, Hard  
O = Oxidized  
SA = Slightly Altered, Clay Free  
S = Sandy, Clay Free  
Si = Sandy, Silty, Minor Clay  
NC = Non-softening Clay  
SC = Swelling, Soft Clay





**Client:** AECOM Canada Ltd.  
**Project:** Highway 7 - Norwood to Havelock, W.P. 67-99-00  
**Contractor:** OGS Drilling Inc.

Project No.:	122410158
Date:	June 5, 2009
Borehole No.:	09-6
Logger:	Kenton C. Power

STRENGTH (MPa)

EH = Extremely Strong = > 250  
VS = Very Strong = 100-250  
S = Strong = 50-100  
MS = Medium Strong = 25-50  
W = Weak = 5 - 25

VW = Very Weak = 1-5  
EW = Extremely Weak = < 1

## WEATHERING

U = Unweathered = No Signs  
S = Slightly = Oxidized  
M = Moderately = Discoloured  
H = Highly = Friable  
C = Completely = Soil-like

## DISCONTINUITY TYPE

B = Bedding Joint  
J = Cross Joint  
F = Fault  
S = Shear Plane

## SPACING

VW = Very Wide = >3m  
W = Wide = 1-3 m  
M = Moderate = 0.3-1 m  
C = Close = 5-30 cm  
VC = Very Close = <5 cm

## ORIENTATION

F = Flat = 0-20°  
D = Dipping = 20-50°  
V = n-Vertical = >50°

## ROUGHNESS

- RU = Rough Undulating
- RP = Rough Planar
- SU = Smooth Undulating
- SP = Smooth Planar
- LU = Slicksided Undulating
- LP = Slicksided Planar

## FILLING

T = Tight, Hard  
O = Oxidized  
SA = Slightly Altered, Clay Free  
S = Sandy, Clay Free  
Si = Sandy, Silty, Minor Clay  
NC = Non-softening Clay  
SC = Swelling, Soft Clay



**Stantec**

# Field Core Log

Client: AECOM Canada Ltd.  
 Project: Highway 7 - Norwood to Havelock, W.P. 67-99-00  
 Contractor: George Downing Estate Drilling Ltd. - (CME75)

Project No.: 122410158  
 Date: June 5, 2009  
 Borehole No.: 09-7  
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
6.64	10	83	0	7.23	Grey LIMESTONE bedrock with shale partings	VS	S		B	F	VC/C	RP		T		
7.23	11	96	48	8.75	Grey LIMESTONE bedrock with shale partings	VS	U		B	F	VC/C	RP		T		
8.75	12	93	36	10.27	Grey LIMESTONE bedrock with shale partings	VS	U		B	F	VC/C	RP		T		

<b>STRENGTH (MPa)</b>		<b>DISCONTINUITY TYPE</b>		<b>ORIENTATION</b>		<b>FILLING</b>	
EH = Extremely Strong = > 250	VW = Very Weak = 1-5	B = Bedding Joint	F = Flat = 0-20°			T = Tight, Hard	
VS = Very Strong = 100-250	EW = Extremely Weak = < 1	J = Cross Joint	D = Dipping = 20-50°			O = Oxidized	
S = Strong = 50-100		F = Fault	V = n-Vertical = >50°			SA = Slightly Altered, Clay Free	
MS = Medium Strong = 25-50		S = Shear Plane				S = Sandy, Clay Free	
W = Weak = 5 - 25						Si = Sandy, Silty, Minor Clay	
						NC = Non-softening Clay	
						SC = Swelling, Soft Clay	
<b>WEATHERING</b>		<b>SPACING</b>		<b>ROUGHNESS</b>			
U = Unweathered = No Signs		VW = Very Wide = >3m		RU = Rough Undulating			
S = Slightly = Oxidized		W = Wide = 1-3 m		RP = Rough Planar			
M = Moderately = Discoloured		M = Moderate = 0.3-1 m		SU = Smooth Undulating			
H = Highly = Friable		C = Close = 5-30 cm		SP = Smooth Planar			
C = Completely = Soil-like		VC = Very Close = <5 cm		LU = Slickensided Undulating			
				LP = Slickensided Planar			



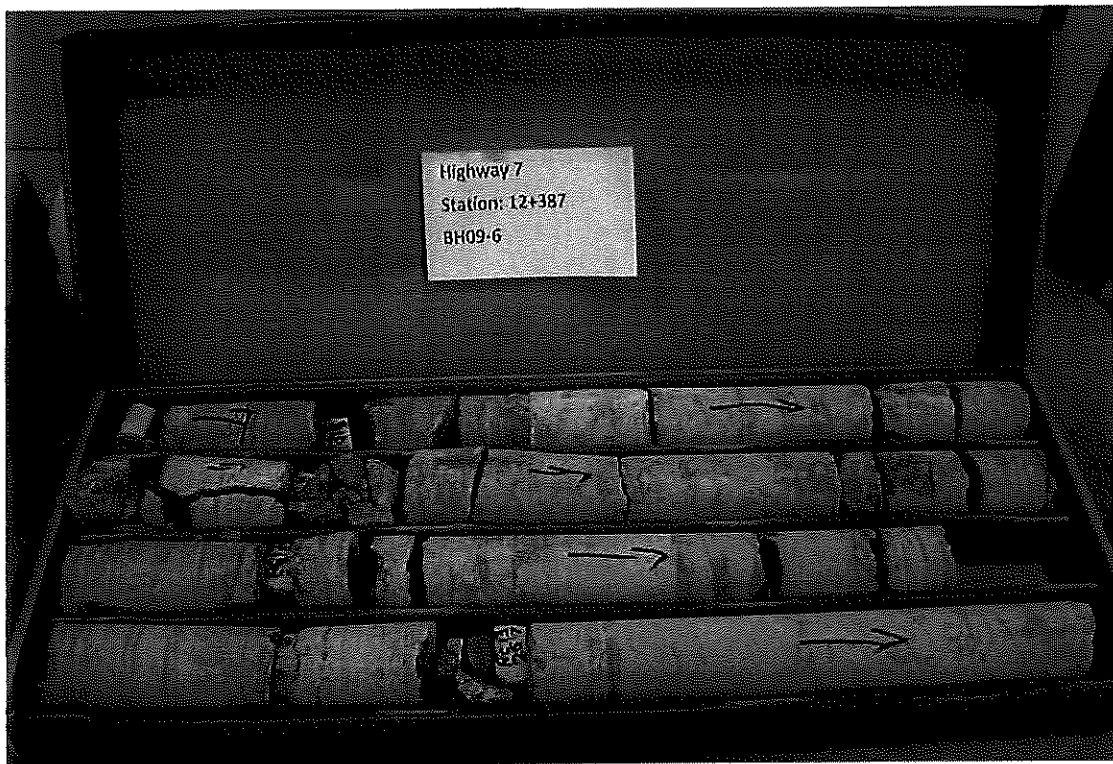
**Stantec**

# Field Core Log

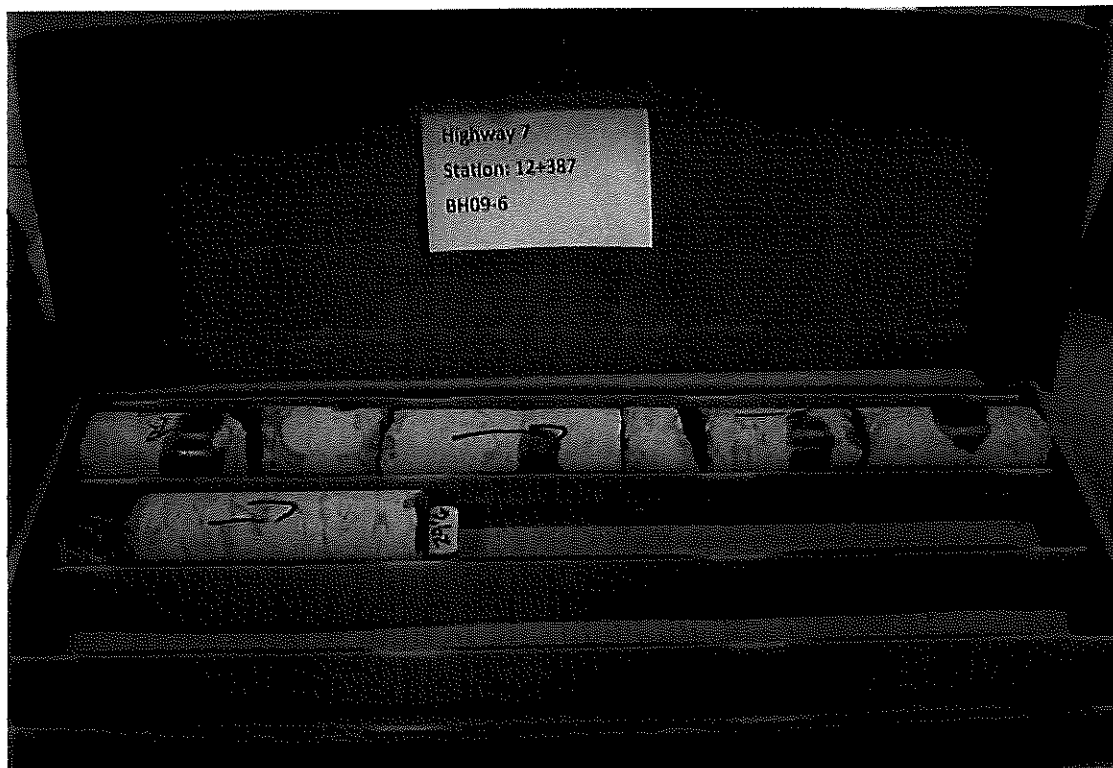
Client: AECOM Canada Ltd.  
Project: Highway 7 - Norwood to Havelock, W.P. 67-99-00  
Contractor: George Downing Estate Drilling Ltd. - (CME75)

Project No.: 122410158  
Date: June 5, 2009  
Borehole No.: 09-8  
Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS	
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE			FILLING
6.91	11	-	-	7.32	Boulders											
7.32	12	48	0	8.0	Grey LIMESTONE bedrock with shale partings	S	S		B	F	VC	RP		T		
8.0	13	93	31	8.84	Grey LIMESTONE bedrock with shale partings	S	U		B	F	VC/C	RP		T		
8.84	14	100	26	10.36	Grey LIMESTONE bedrock with shale partings	S	U		B	F	VC/C	RP		T		
<div><div><div><div><div><u>STRENGTH (MPa)</u></div><div>EH = Extremely Strong = &gt; 250</div><div>VS = Very Strong = 100-250</div><div>S = Strong = 50-100</div><div>MS = Medium Strong = 25-50</div><div>W = Weak = 5 - 25</div></div><div><div><u>WEATHERING</u></div><div>U = Unweathered = No Signs</div><div>S = Slightly = Oxidized</div><div>M = Moderately = Discoloured</div><div>H = Highly = Friable</div><div>C = Completely = Soil-like</div></div></div><div><div><div><u>DISCONTINUITY TYPE</u></div><div>B = Bedding Joint</div><div>J = Cross Joint</div><div>F = Fault</div><div>S = Shear Plane</div></div><div><div><u>SPACING</u></div><div>VW = Very Wide = &gt;3m</div><div>W = Wide = 1-3 m</div><div>M = Moderate = 0.3-1 m</div><div>C = Close = 5-30 cm</div><div>VC = Very Close = &lt;5 cm</div></div></div><div><div><div><u>ORIENTATION</u></div><div>F = Flat = 0-20°</div><div>D = Dipping = 20-50°</div><div>V = n-Vertical = &gt;50°</div></div><div><div><u>ROUGHNESS</u></div><div>RU = Rough Undulating</div><div>RP = Rough Planar</div><div>SU = Smooth Undulating</div><div>SP = Smooth Planar</div><div>LU = Slickensided Undulating</div><div>LP = Slickensided Planar</div></div></div><div><div><u>FILLING</u></div><div>T = Tight, Hard</div><div>O = Oxidized</div><div>SA = Slightly Altered, Clay Free</div><div>S = Sandy, Clay Free</div><div>Si = Sandy, Silty, Minor Clay</div><div>NC = Non-softening Clay</div><div>SC = Swelling, Soft Clay</div></div></div></div>																

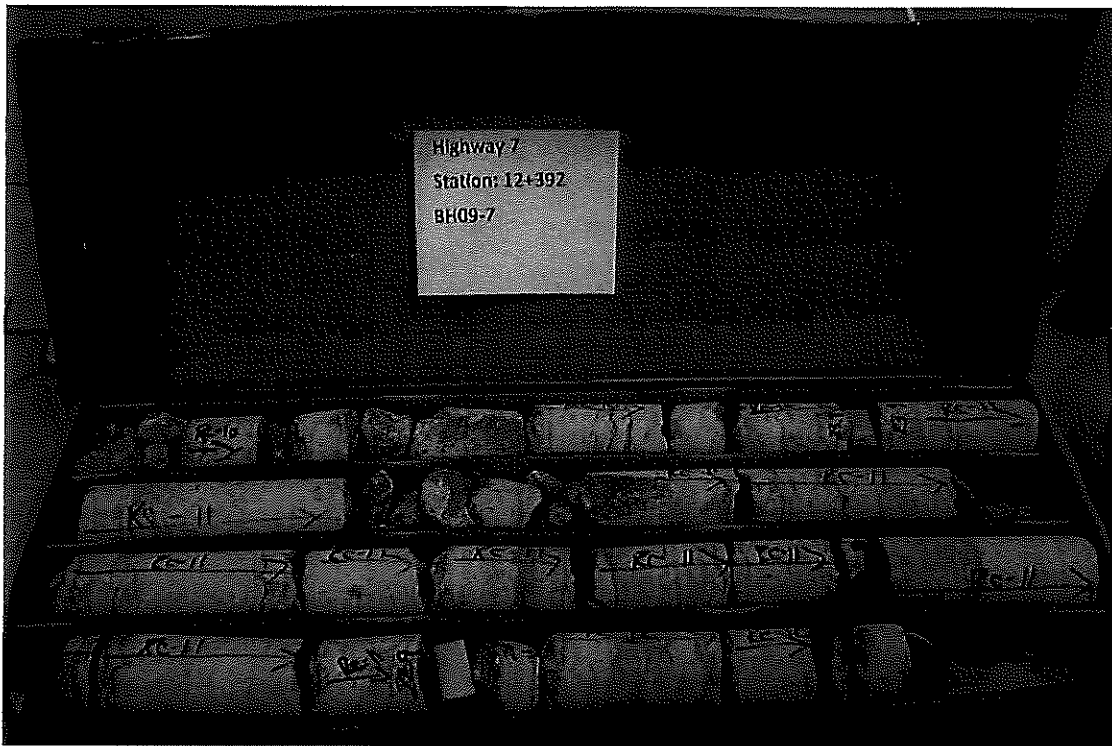


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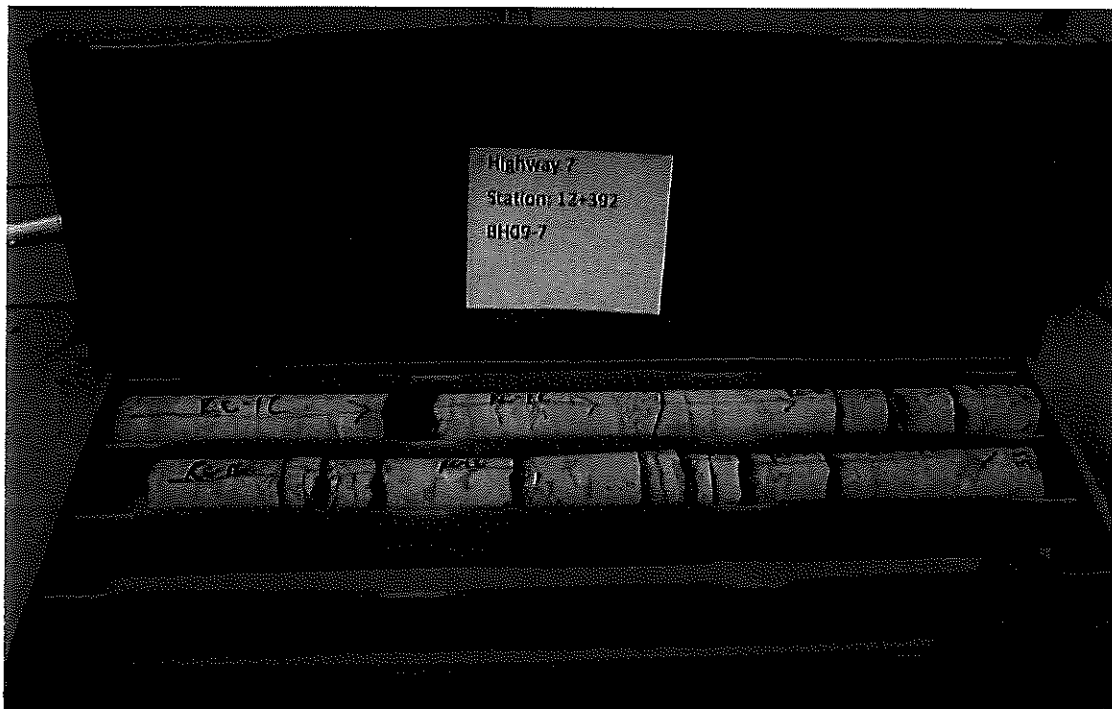


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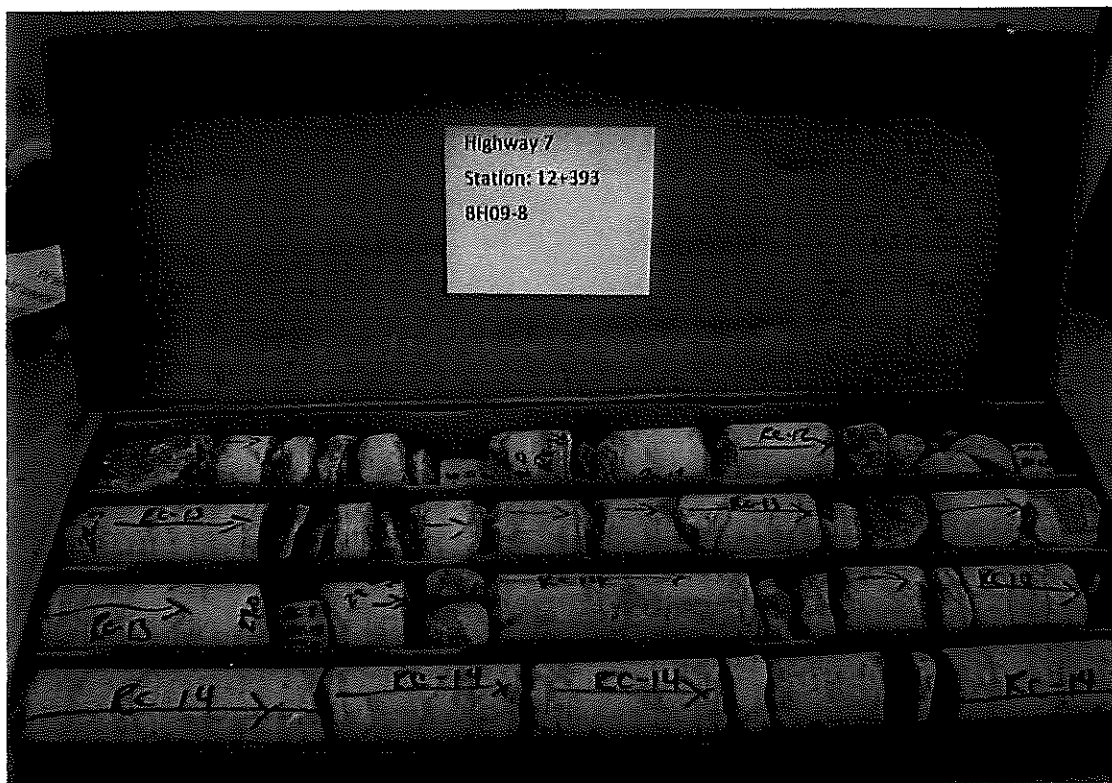




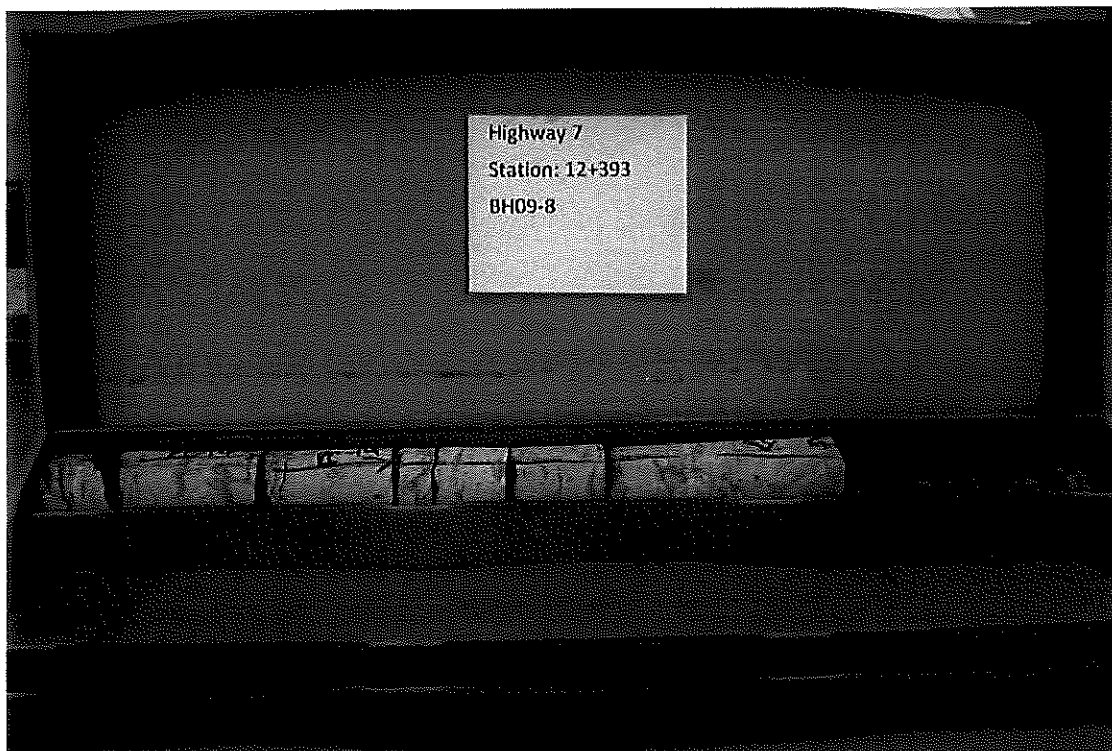
**Photo No. 22: 12+392 BH09-7**



**Photo No. 23: 12+392 BH09-7**



**Photo No. 24: 12+393 BH09-8**

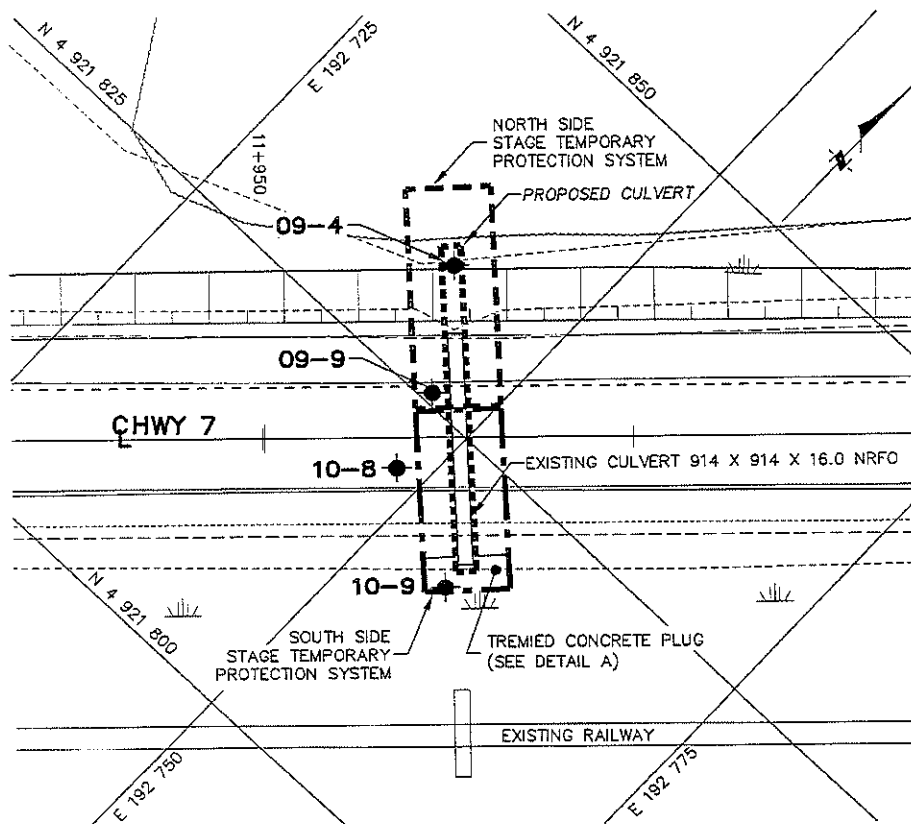


**Photo No. 25: 12+393 BH09-8**

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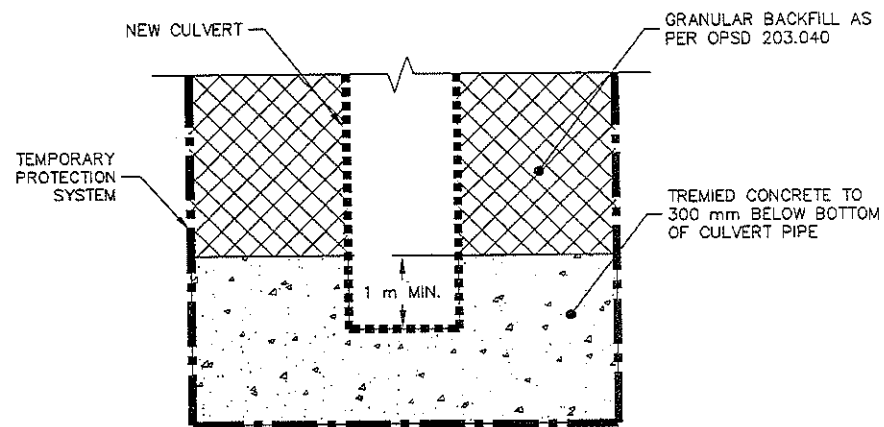
**APPENDIX F**

Typical Details  
OPSD References  
Non Standard Special Provisions

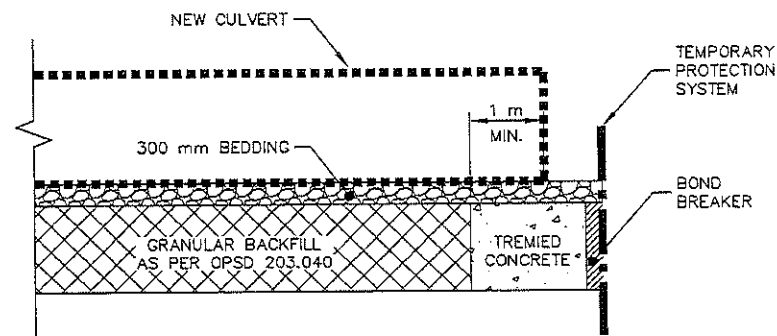


STATION 11+963

SCALE  
5 m 0 5 10 m



PLAN



PROFILE

DETAIL A

SCALE  
1 m 0 1 2 m

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

## SWAMP EXCAVATION AND TEMPORARY PROTECTION SYSTEM DETAIL

FOUNDATION INVESTIGATION - WP 67-99-00  
HIGHWAY 7, NORWOOD TO HAVELOCK, ONTARIO

Client:

AECOM CANADA LTD.

Job No.: 122410158  
Scale: AS SHOWN  
Date: 10/08/03  
Dwn. By: GBB  
App'd By: *PC*

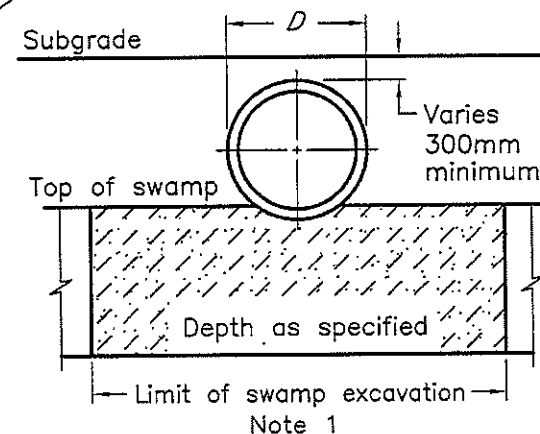
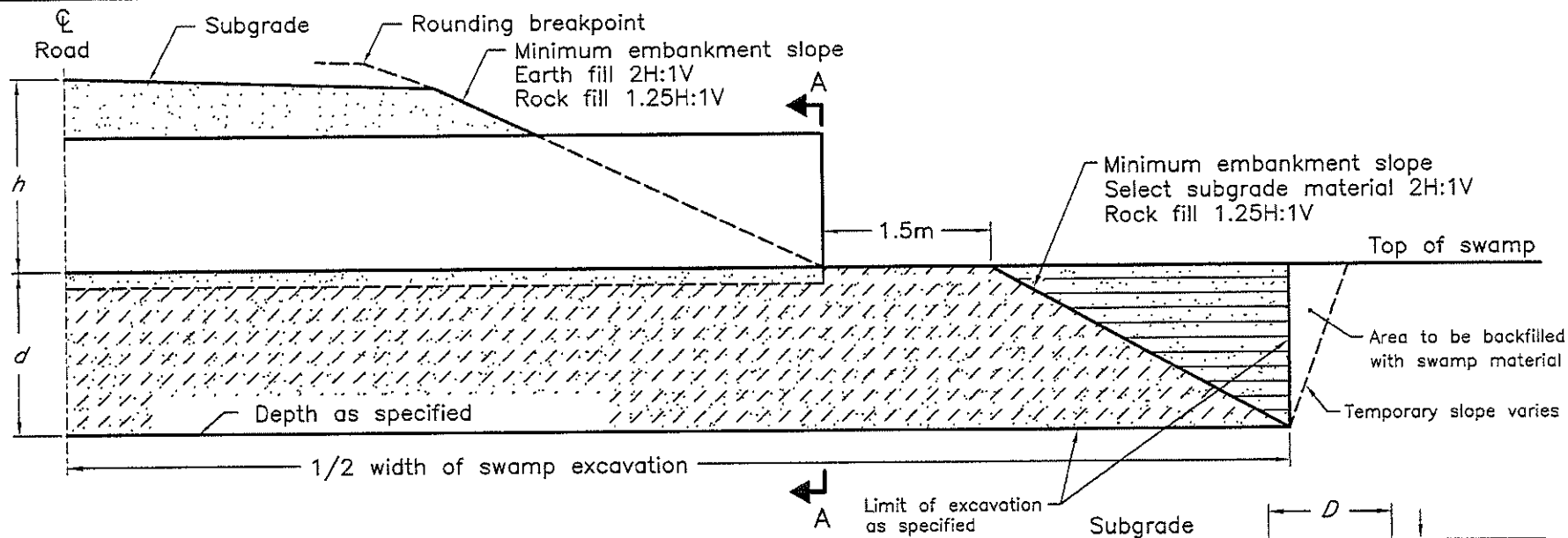
Dwg. No.:

6



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SECTION A-A

# NOTES:

1 Width of excavation shall be  $D + 1.0\text{m}$  for pipes  $\leq 1000\text{mm}$  min diameter and  $2D$  for pipes  $> 1000\text{mm}$  in diameter.

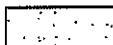
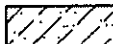
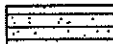
A For this OPSD,  $h$  must be  $\leq 4.5\text{m}$  and  $d$  must be  $\leq 6.0\text{m}$ .

B Height of fill is the vertical difference between top of subgrade and top of swamp elevation measured at new road centreline.

C All dimensions are in millimetres unless otherwise shown.

# LEGEND:

$h$  - Height of fill  
 $d$  - Depth of sub-excitation  
 $D$  - Nominal pipe diameter

 Embankment materials as specified  
 Excavate and backfill as specified  
 Excavate and backfill with swamp material

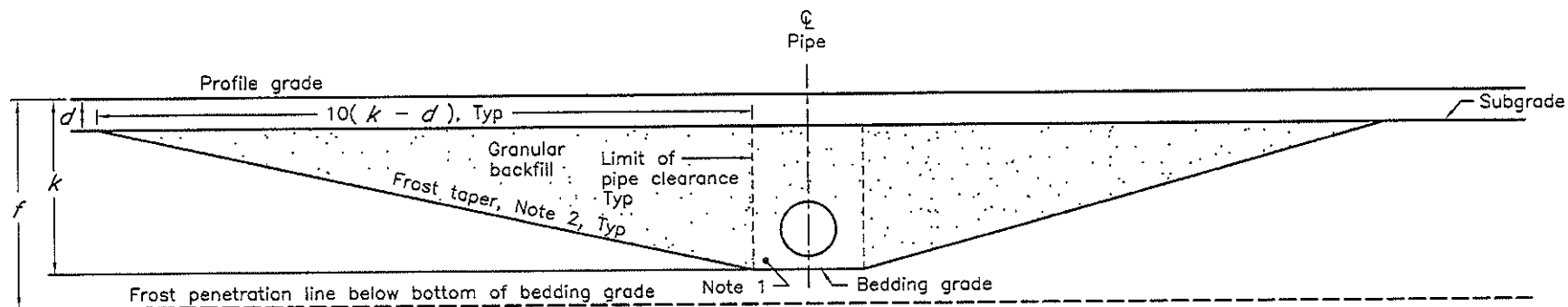
ONTARIO PROVINCIAL STANDARD DRAWING

EMBANKMENTS OVER SWAMP  
 AT PIPE CULVERTS  $\leq 1500\text{mm}$

Nov 2005 Rev 2



OPSD - 203.040



## FROST TREATMENT – RIGID AND FLEXIBLE PIPE

### NOTES:

- 1 Pipe embedment or bedding, cover, and backfill according to:
  - a) Flexible – OPSD–802.010, 802.013, 802.014, 802.020, 802.023, and 802.024
  - b) Rigid – OPSD–802.030, 802.031, 802.032, 802.033, 802.034, 802.050, 802.051, 802.052, 802.053, and 802.054.
- 2 Frost tapers start at bedding grade.
- A Frost tapers are not required in rock embankment.

### LEGEND:

- $d$  –depth of roadbed granular  
 $k$  –depth of frost treatment  
 $f$  –depth of frost penetration

ONTARIO PROVINCIAL STANDARD DRAWING

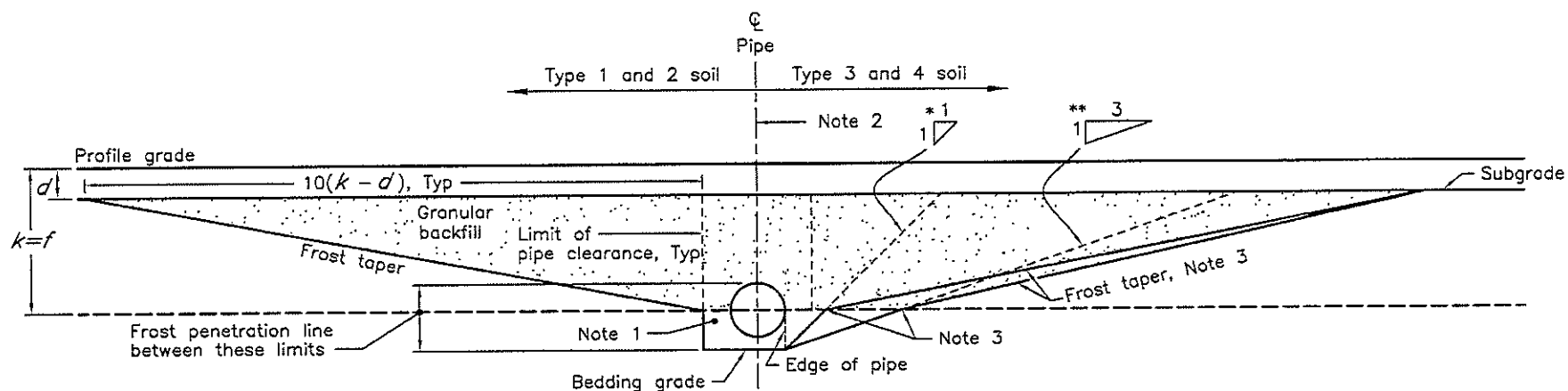
FROST TREATMENT – PIPE CULVERTS  
FROST PENETRATION LINE BELOW  
BEDDING GRADE

Nov 2005

Rev 1



OPSD – 803.030



## FROST TREATMENT – RIGID AND FLEXIBLE PIPE

### NOTES:

- 1 Pipe embedment or bedding, cover, and backfill according to:
  - a) Flexible – OPSD–802.010, 802.013, 802.014, 802.020, 802.023 and 802.024
  - b) Rigid – OPSD–802.030, 802.031, 802.032, 802.033, 802.034, 802.050, 802.051, 802.052, 802.053, and 802.054
- 2 Condition of frost treatment symmetrical about centreline of pipe.
- 3 Frost tapers start at the intersection of the 1H:1V or 3H:1V slope and the frost penetration line.
- A Frost tapers are not required in rock embankment.
- B Frost tapers not required when frost line is above the top of pipe.
- C Soil types as defined in the Occupational Health and Safety Act and Regulations for Construction Projects.

### LEGEND:

- $d$  – depth of roadbed granular  
 $k$  – depth of frost treatment  
 $f$  – depth of frost penetration  
 $*$  – Type 3 soil  
 $**$  – Type 4 soil

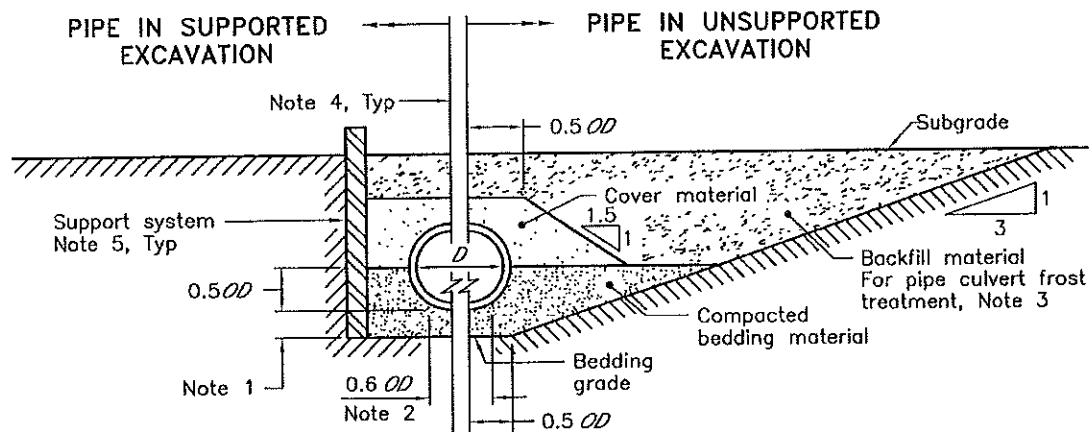
ONTARIO PROVINCIAL STANDARD DRAWING

FROST TREATMENT – PIPE CULVERTS  
FROST PENETRATION LINE BETWEEN  
TOP OF PIPE AND BEDDING GRADE

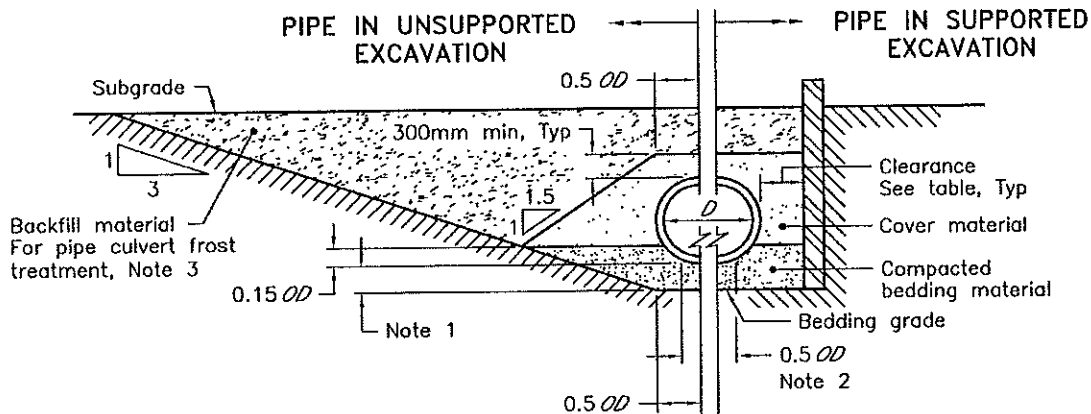
Nov 2005 Rev 2



OPSD – 803.031



**CLASS B BEDDING**



**CLASS C BEDDING**

**LEGEND:**

$D$  - Inside diameter  
 $OD$  - Outside diameter

CLEARANCE TABLE	
Pipe Inside Diameter mm	Clearance mm
900 or less	300
Over 900	500

**NOTES:**

- 1 The minimum bedding depth below the pipe shall be  $0.15D$ . In no case shall this dimension be less than 150mm or greater than 300mm.
  - 2 The pipe bed shall be compacted and shaped to receive the bottom of the pipe.
  - 3 Pipe culvert frost treatment according to OPSD-803.030 and 803.031.
  - 4 Condition of trench is symmetrical about centreline of pipe.
- A Soil types as defined in the Occupational Health and Safety Act and Regulations for Construction Projects.
- B All dimensions are in metres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING

Nov 2005 Rev 1

**RIGID PIPE BEDDING,  
 COVER, AND BACKFILL  
 TYPE 4 SOIL - EARTH EXCAVATION**

**OPSD - 802.032**





**1500 mm Pipe Culvert - Item No. 26**  
**1100 mm Non-circular Pipe Culvert - Item No. 29**  
**Dewatering Structure Excavations – Item No. 67**  
**Temporary Protection Systems – Item No. \*\***

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Special Provision

August 2010

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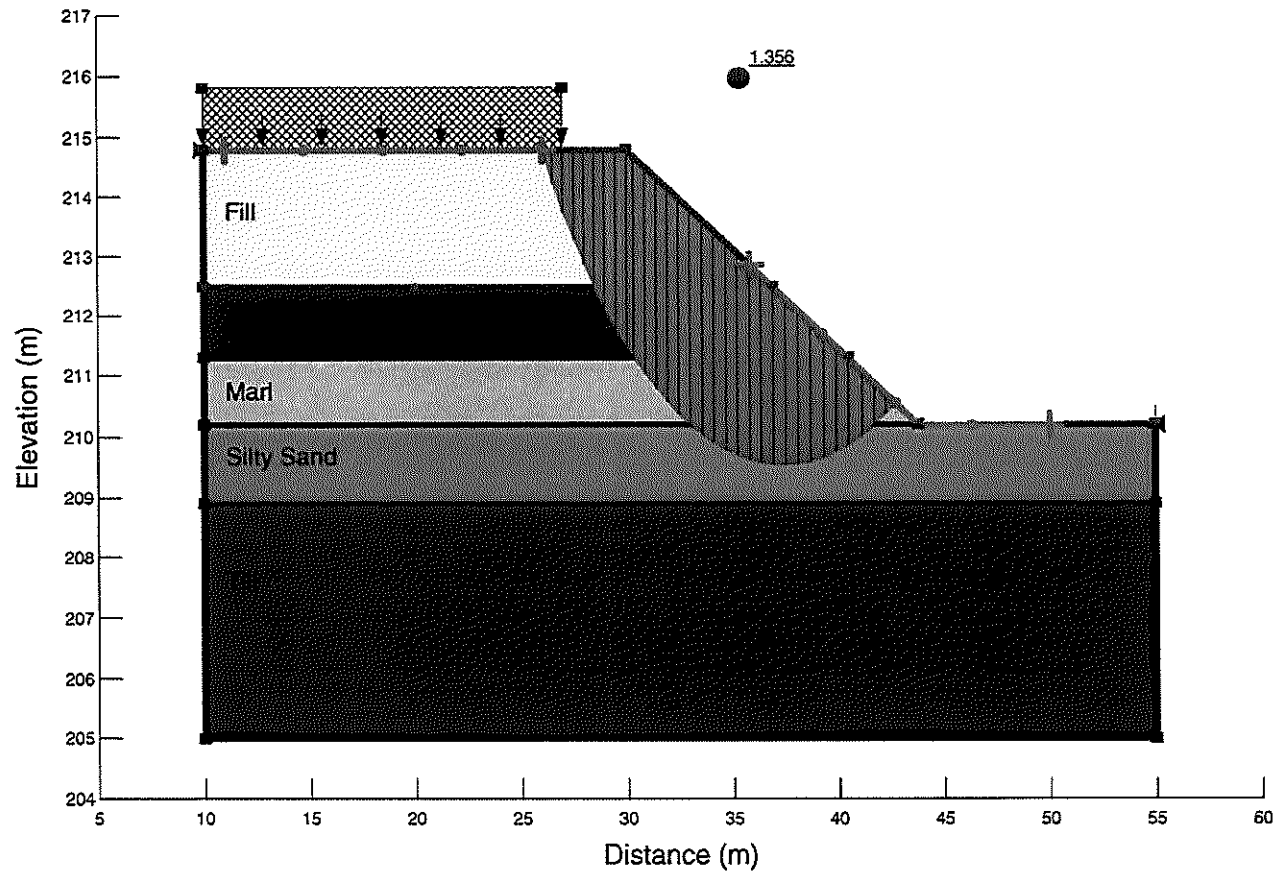
This special provision is to highlight the fact that:

- Organic deposits will be removed from beneath embankment widening and culvert installations in accordance with OPSS 209, OPSD 203.020, OPSD 203.040 or other project specific details as identified in the contract documents and backfilled with granular materials. The granular backfill may have a high hydraulic conductivity and may store a significant volume of water.
- Some culvert locations are adjacent to muskeg areas with wide areas of open water at certain times of the year.
- A hydraulic connection between temporary excavations requiring dewatering and areas with open water or the backfilled areas as described above could result in large volumes of water entering temporary excavations.
- The contractor shall consider the site conditions and sequence of work when assessing and selecting dewatering methods, the design of temporary protection systems, and need for cofferdams.

**APPENDIX G**

Outputs from Slope Stability Studies

Name: Fill Unit Weight: 21 kN/m<sup>3</sup> Cohesion: 2 kPa Phi: 34 °  
 Name: Peat Unit Weight: 10.6 kN/m<sup>3</sup> Cohesion: 27 kPa Phi: 0 °  
 Name: Marl Unit Weight: 12.8 kN/m<sup>3</sup> Cohesion: 12 kPa Phi: 0 °  
 Name: Silty Sand Unit Weight: 21 kN/m<sup>3</sup> Cohesion: 0 kPa Phi: 32 °  
 Name: Till Unit Weight: 20.5 kN/m<sup>3</sup> Cohesion: 0 kPa Phi: 35 °



Stantec

## Slope Stability Analysis

### Temporary Excavation

Highway 7 - W.P. 67-99-00  
Norwood to Havelock

Figure No. 9



