FINAL REPORT

Foundation Investigation and Design Report (Part 1 & Part 2)

Total Project Management (TPM) Assignment Detail Design
Four (4) Culvert Replacements
HWY 26, 15 km West of Nottawasaga River Crossing
Simcoe County, Ontario
Agreement Number: 2011-E-0032
GWP 2341-09-00 Hwy 26

GEOCRES # 41A-222

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Part 1 Foundation Investigation

1.1 Introduction

This project is part of the overall Total Project Management (TPM) Assignment Detail Design and preparation of six (6) individual Contract Packages for Pavement Rehabilitation, carried out by **exp** Services Inc. (exp), the new identity of Trow Associates Inc., for Ainley and Associates (Ainley), on behalf of the Ministry of Transportation (MTO), Agreement No. 2011-E-0032. Specifically, this project is part of the Hwy 26 – GWP 2341-09-00 assignment for the rehabilitation of Highway 26 in Simcoe County. This Foundation Investigation Report presents the results of four (4) separate geotechnical investigations at four (4) separate existing culvert sites located along Highway 26, which have been identified as potentially requiring replacement or rehabilitation by the MTO.

The existing culverts consist of one CSP and three concrete box culverts with varying spans/diameters underlying the two lane highway. The culverts sites are identified in the following Table 1.1 and their locations shown on the respective key plans on Sheets 1 to 4, inclusive:

Table 1.1 Site Numbers and Corresponding MTO Culvert Identification Numbers

Site	MTO Culvert ID	Hwy	Township	Type
1	30-577/C; East of Klondike Park Rd Culvert	26	Medonte	Concrete Box
2	30-524/C; Hwy 26, Sunnidale Corners Culvert	26	Sunnidale	Concrete Box
3	30-522/C; McIntyre Creek Culvert	26	Sunnidale	CSP Arch Pipe
4	30-425/C; Lamont Creek Culvert	26	Nottawasaga	Concrete Box

The site numbers designated 1 to 4 were arbitrarily established to simplify the field locations and reporting. Both the Site numbers and the corresponding MTO Culvert Identification numbers will be used in this report.

The purpose of these geotechnical investigations was to determine the existing soil and groundwater conditions within the proposed construction limits at each culvert site by field investigation and laboratory testing.

1.2 Site Description and Geological Setting

1.2.1 Site Descriptions

Site 1 - Culvert 30-577/C

The culvert at Site 1 (Culvert 30-577/C) is located on Highway 26 approximately 450 m east of Klondike Park Road in Medonte Township in Simcoe County. The highway runs in an east-west orientation with the culvert skewed in a southeast-northwest alignment. Flow through the culvert is from the flat lying agricultural lands to the south via adjacent ditches and creek on the south side of the highway into a creek on the north side of the highway. The culvert consists of a cast-in-place reinforced concrete rigid frame box culvert. The culvert has a length of 30.5 m, a width of 4.2 m and a height of 2.0 m according to information provided by the MTO. There is approximately 0.75 m of fill overlying the culvert. Photographs of the site are provided in Appendix A-1. The site plan and cross section profile of the culvert are approximately as shown on Sheet 1 in Appendix B.

Site 2 – Culvert #30-524/C; Sunnidale Corners Culvert

The culvert at Site 2 (Culvert #30-524/C - Sunnidale Corners Culvert) is located on Highway 26 just to the west of the service station at Sunnidale Corners, which is on the northside of the road immediately to the west of the intersection with Hwy 10. On the south side of the highway, there is a widening for a turning lane onto Hwy 10 southbound. Photographs of the site are provided in Appendix A-2. The approximate site plan and cross section profile of the culvert are as shown on Sheet 2 in Appendix B.

The culvert consists of a cast-in-place reinforced concrete rigid frame box culvert. The culvert has a length of 28.1 m, a width of 3.2 m and a height of 1.5 m according to inspection reports provided by the MTO. There is approximately 1.2 m of fill overlying the culvert. The existing concrete box culvert crosses the highway embankment at a skewed alignment, oriented approximately southeast to northwest, and conveys collected surface water from the creek from the flat lying agricultural lands to the south to the creek flowing northwards along the north side of the embankment.

Site 3 – Culvert #30-522/C; McIntyre Creek Culvert

The culvert at Site 3 (Culvert #30-522/C; McIntyre Creek Culvert) is located on Highway 26 approximately 150 m to the east of the 3rd & 4th Sunnidale Sideroad intersection. The skewed CSP ellipse culvert has a length of 43 m, a width of 5.1 m, and a height of 3.0 m

according to inspection reports provided by the MTO. There is approximately 4.0 m of fill overlying the culvert, which conveys the water of McIntyre Creek towards the north, ultimately joining the Nottawasaga River. Photographs of the site are provided in Appendix A-3. The approximate site plan and cross section profile of the culvert are as shown on Sheet 3 in Appendix B.

Site 4 – Culvert #30-425/C; Lamont Creek Culvert

The culvert at Site 4 (Culvert #30-425/C; Lamont Creek Culvert) is located on Highway 26 North within the Town of Stayner, approximately 350 m to the north of the intersection with Hwy 26 West/Hwy 91 W. The cast-in-place reinforced concrete box culvert has open footings (non-rigid frame) with a length of 16.5 m, a width of 5.8 m, a height of 1.5 m, and has approximately 0.8 m of fill overtop. The culvert conveys the water of Lamont Creek from the urban/town area to the west of the highway towards the east, ultimately joining the Nottawasaga River. Photographs of the site are provided in Appendix A-4. The approximate site plan and cross section profile of the culvert are as shown on Sheet 4 in Appendix B.

1.2.2 Geological Setting

According to mapping on the Ontario Geological Survey Map 2556 (Quaternary Geology of Ontario, Southern Sheet), all four culvert sites are located in an area known as the Simcoe Lowlands with the soils in the vicinity of Highway 26 consisting of undifferentiated fine grained glacial tills and glaciolacustrine deposits of sand, gravelly sand and gravel, and deposits of finer grained deposits of silt and clay with minor sand. The bedrock geology is indicated as being limestone, dolostone, shale of the Simcoe Group for all 4 sites according to the Ministry of Northern Development and Mines Map 2544 (Bedrock Geology of Ontario, Southern Sheet).

1.3 Investigation Procedures

1.3.1 Field Program

The fieldwork for this investigation was performed between November 30 and December 7, 2011. The fieldwork consisted of drilling two (2) or three (3) sampled boreholes at each of the culvert sites with the boreholes numbered as follows:

Table 1.2 Borehole Numbering System

Site	Culvert ID	Boreholes
Site 1	Culvert 30-577/C	BH 1-1, BH 1-2
Site 2	Culvert 30-524/C – Sunnidale Corners	BH 2-1, BH 2-2 and BH 2-3
Site 3	Culvert 30-522/C - McIntyre Creek	BH 3-1, BH 3-2
Site 4	Culvert #30-425/C - Lamont Creek Culvert	BH 4-1, BH 4-2

The boreholes were typically advanced from the shoulder of the existing highway embankment adjacent to the underlying culvert and where accessible, from either the roadside ditches or adjacent to the creek. Due to the proximity of overhead hydro lines and buried gas lines located along the shoulder of the highway at some sites, borehole locations varied somewhat from site to site. The borehole depths at each site typically ranged from 15.8 m to 19.7 m, with one borehole (BH 2-3) terminated at 12.8 m depth.

The boreholes at all four sites were advanced using a Bombardier mounted CME-55 drill rig, equipped with both solid auger (4-1/4" SSA) and hollow stem augers and standard soil sampling equipment. The boreholes were drilled by our drilling subcontractor, Ontario Soil Drilling.

From the drilling program, soil samples were obtained using a 51 mm OD split-spoon sampler in conjunction with Standard Penetration Tests at 0.75 m intervals within the foundation zone of the culvert (about 5 m below the culvert invert) and at 1.5 m intervals at deeper depths. Sampling and testing procedures were in general accordance with ASTM D1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter OD split-spoon sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 300 mm was recorded as the SPT 'N' value of the sampled soil and this gives an indication of the consistency or the relative density of the soil deposit. Where very dense material was encountered, the number of hammer blows was occasionally terminated at 50 and the depth of penetration (less than 300 mm) was noted.

All fieldwork was supervised by a member of **exp's** engineering staff, who directed the drilling and sampling operations, logged the factual borehole data in accordance with the MTO Soils Classification System for foundation reports, and retrieved soil samples for subsequent laboratory testing and identification. All of the recovered soil samples were placed in moisture-proof bags and returned to **exp's** Barrie laboratory for additional visual, textural and olfactory examination and for selected laboratory testing.

Following completion of the boreholes, the boreholes were backfilled with auger cuttings and sealed with bentonite pellets. With the exception of Site 1, fifty (50) mm diameter pvc standpipes with a 1.5 m well screen were installed in one borehole at each site to enable long term groundwater level measurements and follow-on hydrogeological testing.

Details of the soil strata encountered in the boreholes are included in the attached Record of Borehole sheets in Appendix C, and plotted on the profiles included on Sheets 1, 2, 3, and 4 in Appendix B. The elevations indicated are based on temporary local datums established by our field staff whereby the centerline of the pavement above each culvert was assumed to have an elevation of 100.00 m.

1.3.2 Laboratory Testing

All samples returned to the laboratory were subjected to detailed visual examination and classification. The laboratory testing program included moisture content determinations of all samples (LS-701/ASTM D2216) and routine classification testing of approximately 25% of the selected soil samples. As the recovered samples were predominantly glacial till materials and typically non-cohesive or partially cohesive, the routine testing included predominantly grain size distribution analyses (LS-702/ASTM D422 and ASTM D1140), along with one (1) Atterberg Limits test (LS-703 and LS 704) carried out on a more cohesive sample.

The laboratory test results are provided on the attached Record of Borehole sheets in Appendix C. The results of the grain size analyses and the Atterberg Limits tests are presented in Appendix D.

1.4 Subsurface Conditions

1.4.1 General

The subsurface conditions encountered during the field investigation are summarized on the attached borehole logs in Appendix C for each site. Figures 1A and 1B, "Notes on Sample Descriptions", preceding the borehole logs (Appendix C) form an integral part of and should be read in conjunction with this report.

A borehole location plan and a strata plot of the soils encountered in the boreholes at Sites 1 through 4 are provided on Sheets 1, 2, 3 and 4, respectively, in Appendix B.

Summaries of the soil and groundwater conditions encountered in the boreholes at each site are provided below. The predominant soil types at all 4 locations typically consisted of a layer of highway embankment fill comprising sand & gravel and sand materials and native deposits of glacial till material consisting of clayey silt till and silty sand to sandy silt till, with random layers of silt, sand, and sand and gravel.

1.4.2 Soil Stratigraphy and Groundwater

1.4.2.1 Site 1 (Culvert 30-577/C)

The culvert at Site 1 (Culvert 30-577/C) is located on Highway 26 approximately 450 m east of Klondike Park Road in Medonte Township in Simcoe County. The highway runs in an east-west orientation with the culvert skewed in a southeast-northwest alignment. Flow through the concrete box culvert is from the flat lying agricultural lands to the south via adjacent ditches and the creek on the south side of the highway into the creek on the north side of the highway. The site plan and cross section profile of the culvert are approximately as shown on Sheet 1 in Appendix B.

Borehole BH 1-1 was located approximately 3 m from the edge of pavement along the south shoulder of the highway and approximately 12 m west of the centerline of the culvert. Borehole BH 1-2 was located along the north shoulder approximately 2.5 m from the edge of pavement and approximately 3.5 m east of the centerline of the culvert. Boreholes BH 1-1 and BH 1-2 were advanced to depths of 19.7 m and 15.8 m, respectively.

The embankment fill materials consisted of a layer of sand and gravel fill overlying glacial tills consisting of two alternating deposits of sandy silt to silty sand till and clayey silt till. The groundwater level is estimated to be at or slightly above the creek level, which was about 2.4 m below the top of pavement on January 26, 2012. The soil materials encountered are described in further detail below.

1.4.2.1.1 Fill (Sand and Gravel)

Both Boreholes BH 1-1 and BH 1-2 encountered a 0.7 m thick layer of brown sand and gravel fill, with a trace of silt. Based on the two "N" values from the Standard Penetration Tests (SPT) of 15 and 16 blows per 300 mm of penetration, the compactness of the fill material was assessed as compact.

Laboratory testing performed on selected samples of the fill material consisted of two moisture content tests. The test results are as follows:

Moisture content:

- 6% and 22%

The results of the moisture content tests are provided on the Record of Borehole sheets in Appendix C.

1.4.2.1.2 Silty Sand to Sandy Silt Till

Two separate deposits of silty sand to sandy silt till were encountered in both boreholes. The upper deposit was encountered at 0.7 m depth directly beneath the sand & gravel fill layer and extended to depths of approximately 1.1 m in Borehole BH 1-1 and to 2.2 m in Borehole BH 1-2. The sandy silt till in BH 1-1 and the silty sand till encountered in BH 1-2 contained some gravel and a trace of clay. Measured SPT "N" values in the upper deposit ranged from 7 to 12, indicating a loose to compact compactness condition.

The lower deposit of silty sand to sandy silt till was encountered between depths of 3.8 m and 10.2 m in BH 1-1 and from 3.8 m to 11.0 m in BH 1-2. In both boreholes, the two separate silty sand to sandy silt till deposits were separated by a layer of clayey silt till (described below).

Laboratory testing performed on selected samples of the silty sand to sandy silt till materials consisted of moisture content tests on all samples and four (4) grain size distribution tests. The test results are as follows:

Moisture content range:

- 10% to 18% (upper till deposit)
- 9% to 18% (lower till deposit)

Grain Size Distribution:

- 0 to 13% gravel;
- 38 to 80% sand;
- 20 to 62% silt; and
- 3% clay.

The results of the moisture content and grain size distribution tests are provided on the Record of Borehole sheets in Appendix C. The results of the grain size distribution tests on the silty sand to sandy silt till are provided on Figures D1 and D2 in Appendix D.

1.4.2.1.3 Clayey Silt Till

Two deposits of clayey silt till were encountered in both Boreholes BH 1-1 and BH 1-2. The upper clayey silt till deposit was encountered between overlying and underlying silty sand to sandy silt till layers at depths of 1.1 m to 2.2 m and extended to 3.8 m depth in both boreholes. The lower clayey silt till layer was encountered at a depth of 10.2 m in BH 1-1 and at 11.0 m in BH 1-2. Both boreholes were terminated within the clayey silt till stratum at depths of 19.7 m and 15.8 m, respectively.

The upper clayey silt till deposit contained some sand and a trace of gravel, was brown in colour, and was in a moist to wet condition. SPT "N" values within the upper clayey silt till material ranged from 3 to 7 inferring a soft to firm consistency.

The lower clayey silt till deposit also contained some sand and a trace of gravel, was grey in colour, and was in a moist to wet condition. SPT "N" values within the lower clayey silt till deposit ranged from 12 to 48, inferring a stiff to hard consistency.

Laboratory testing performed on selected samples consisted of moisture content tests on each recovered sample, two grain size distribution tests, and an Atterberg Limits test. The test results are as follows:

Moisture content range:

- 24% to 25% (Upper deposit)

- 10% to 14% (Lower deposit)

Grain Size Distribution:

- 1% gravel;
- 20 to 22% sand;
- 47 to 56% silt; and
- 21 to 32% clay.

Atterberg Limits:

- Liquid Limit: 24%
- Plastic limit: 16%
- Plasticity Index: 8%

The results of the moisture content, grain size distribution and Atterberg Limits tests are provided on the Record of Borehole sheets in Appendix C. The results of the grain size distribution tests on the clayey silt till are provided on Figure D3 in Appendix D. The results of the Atterberg Limits test, which indicates that the clayey silt till material behaves as a clay with low plasticity (CL), are provided on Figure D14 in Appendix D.

1.4.2.1.4 Groundwater

Information regarding the groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion of drilling. The measured groundwater levels, which are shown on the borehole logs, ranged from depths of approximately 3.0 m in BH 1-1 to 3.8 m in BH 1-2. The level of the creek was at about 1.9 m depth below the ground surface elevations at Boreholes BH 1-1 and BH 1-2 on January 26, 2012.

Seasonal variations in the water table should be anticipated, with higher levels occurring during wetter periods of the year (such as spring thaw and late fall) and lower levels during drier periods. The groundwater levels will also be influenced by the level of the creek.

1.4.2.2 Site 2 (Culvert 30-524/C; Sunnidale Corners)

The concrete box culvert at Site 2 (Culvert #30-524/C - Sunnidale Corners Culvert) is located on Highway 26 just to the west of the intersection with Highway 10. On the south side of the highway, there is a widening for a turning lane onto Highway 10 southbound. The approximate site plan and cross section profile of the culvert are approximately as shown on Sheet 2 in Appendix B.

Borehole BH 2-1 was located approximately 1.75 m from the edge of pavement along the north shoulder of the highway and approximately 8 m west of the centerline of the culvert. Borehole BH 2-2 was located adjacent to the creek on the south side of the highway approximately 12.75 m south of the edge of pavement and 4.5 m west of the centerline of the culvert. Borehole BH 2-3 was located along the south shoulder approximately 3 m from the edge of pavement and approximately 8.5 m east of the centerline of the culvert. Boreholes BH 2-2 and BH 2-3 were both advanced to depths of 12.8 m and BH 2-1 to 15.8 m depth below existing grade.

The embankment fill materials consisted of a layer of sand and gravel fill overlying native glacial till materials consisting of an upper deposit of clayey silt till and a lower deposit of silty sand to sandy till extending to the termination depth of the boreholes. The groundwater level measured in the standpipe installed in Borehole BH 2-2 was at a depth of 0.7 m on January 26, 2012. The soil materials encountered are described in further detail below.

1.4.2.2.1 Fill (Sand and Gravel)

Boreholes BH 2-1 and BH 2-3 encountered a 0.7 m and 1.0 m thick layer of brown sand and gravel fill, with a trace of silt. Based on the two "N" values from the Standard Penetration Tests (SPT) of 6 and 20 blows per 300 mm of penetration, the compactness of the fill material was assessed as loose to compact.

Laboratory testing performed on samples of the fill material consisted of two moisture content tests. The test results are as follows:

Moisture content:

- 4% to 8%

The results of the moisture content tests are provided on the Record of Borehole sheets in Appendix C.

1.4.2.2.2 Clayey Silt Till

A shallow deposit of clayey silt till was encountered beneath the highway embankment fill in Boreholes BH 2-1 and BH 2-3, and directly below ground surface in Borehole BH 2-2. The clayey silt till deposit extended to depths ranging from 1.5 m in both Boreholes BH 2-1 and BH 2-2 and to 2.3 m depth in Borehole BH 2-3.

The clayey silt till deposit contained a trace of sand, a trace of gravel, and a trace of rootlets (BH 2-2 only), was dark brown to brown to grey in colour, and was in a moist condition. SPT "N" values within the clayey silt till material ranged from 3 to 7 inferring a soft to firm consistency.

Laboratory testing performed on selected samples consisted of moisture content tests on each recovered sample. The test results are as follows:

Moisture content range:

- 20% to 30%

The results of the moisture content tests are provided on the Record of Borehole sheets in Appendix C.

1.4.2.2.3 Sandy Silt to Silty Sand Till

The predominant soil deposit at the site is a sandy silt to silty sand till, that was encountered in all 3 boreholes directly underlying the shallow clayey silt till deposit at depths ranging from 1.5 m to 2.2 m. The sandy silt to silty sand till extended to the termination depths of the three boreholes at 12.8 m (BH 2-2 and BH 2-3) and 15.8 m (BH 2-1). The sandy silt to silty sand till material, which contains a trace to some gravel and a trace to some clay, is brown to grey in colour and was in a moist to saturated condition. Some sandy seams were also encountered in Borehole BH 2-2. Measured SPT "N" values ranged widely from 3 to 94, indicating a very loose to very dense compactness condition. One "N" value of zero was obtained at approximately 6.1 m to 6.5 m depth in Borehole BH 2-2 due to a probable inflowing sand layer.

Laboratory testing performed on selected samples of the sandy silt to silty sand till materials consisted of moisture content tests on all samples and nine (9) grain size distribution tests. The test results are as follows:

Moisture content range:

- 2% to 16%

Grain Size Distribution:

- 0 to 7% gravel;
- 33 to 67% sand;
- 23 to 60% silt; and
- 3 to 16% clay.

The gradation of two samples from the coarser sized sand seams encountered in Borehole BH 2-2 are as follows:

- 0 to 10% gravel;
- 78 to 80% sand;
- 11 to 20% silt; and
- 0 to 1% clay.

The results of the moisture content and grain size distribution tests are provided on the Record of Borehole sheets in Appendix C. The results of the grain size distribution tests on the sandy silt to silty sand till are provided on Figures D4, D5 and D6 in Appendix D.

1.4.2.2.4 Groundwater

Information regarding the groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion of drilling. The measured groundwater levels, which are shown on the borehole logs, ranged from depths of approximately 4.9 m in BH 2-3 to 6.4 m in BH 2-1. The groundwater level measured in the standpipe installed in Borehole BH 2-2 was at a depth of 0.7 m on January 26, 2012.

Seasonal variations in the water table should be anticipated, with higher levels occurring during wetter periods of the year (such as spring thaw and late fall) and lower levels during drier periods. The groundwater levels will also be influenced by the level of the creek.

1.4.2.3 Site 3 (Culvert 30-522/C; McIntyre Creek)

The corrugated steel ellipse culvert at Site 3 (Culvert #30-522/C; McIntyre Creek Culvert) is located on Highway 26 approximately 150 m to the east of the 3rd & 4th Sunnidale Sideroad intersection. The culvert conveys the water of McIntyre Creek towards the north, ultimately joining the Nottawasaga River. The approximate site plan and cross section profile of the culvert are as shown on Sheet 3 in Appendix B.

Borehole BH 3-1 was located approximately 0.8 m from the edge of pavement along the south shoulder of the highway and approximately 11 m east of the centerline of the culvert. Borehole BH 3-2 was located along the north shoulder approximately 1 m from the edge of pavement and approximately 9.5 m west of the centerline of the culvert. Boreholes BH 3-1 and BH 3-2 were both advanced to a depth of 15.8 m below existing grade.

The embankment fill materials consisted of a layer of sand and gravel fill overlying a deposit of silty sand till and deposits of sand and gravel and silt. The groundwater level measured in the standpipe installed in Borehole BH 3-2 was at a depth of 5.6 m on January 26, 2012. The soil materials encountered are described in further detail below.

1.4.2.3.1 Fill (Sand and Gravel)

Boreholes BH 3-1 and BH 3-2 encountered a 1.3 m and a 2.2 m thick layer, respectively, of brown sand and gravel fill, with a trace of silt. Based on the "N" values from the Standard Penetration Tests (SPT), which ranged from 11 to 20 blows per 300 mm of penetration, the compactness of the fill material was assessed as being compact.

Laboratory testing performed on selected samples of the fill material consisted of five moisture content tests. The test results are as follows:

Moisture content range:

- 4% to 13%

The results of the moisture content tests are provided on the Record of Borehole sheets in Appendix C.

1.4.2.3.2 Silty Sand Till

A deposit of silty sand till was encountered directly beneath the highway embankment fill in Boreholes BH 3-1 and BH 3-2. The silty sand till deposit extended to depths ranging from approximately 5.6 m to 7.2 m in Boreholes BH 3-1 and BH 3-2, respectively.

The silty sand till deposit contained a trace to some gravel and some clay, with the material having a somewhat higher clay content in Borehole 3-1, grading to a more cohesive clayey sand till. The material was brown to grey in colour, and was in a moist condition. SPT "N" values within the silty sand till material typically ranged from 3 to 8 inferring a very loose to loose compactness condition.

Laboratory testing performed on selected samples of the silty sand till materials consisted of moisture content test on all samples and five (5) grain size distribution tests. The test results are as follows:

Moisture content range:

- 14% to 27%

Grain Size Distribution:

- 4 to 20% gravel;
- 43 to 55% sand;
- 18 to 33% silt; and
- 12 to 23% clay.

The results of the moisture content and grain size distribution tests are provided on the Record of Borehole sheets in Appendix C. The results of the grain size distribution tests on the silty sand till are provided on Figures D7 and D8 in Appendix D.

1.4.2.3.3 Sand and Gravel with Cobbles

A random layer of wet sand and gravel with cobbles was encountered in Borehole BH 3-2 from approximately 5.5 m to 7.2 m depth. One SPT "N" value of 19 was obtained indicating the material was in a compact condition.

Laboratory testing performed on the recovered sample of the sand and gravel consisted of one moisture content test and a grain size distribution test. The test results are as follows:

Moisture content:

- 23

Grain Size Distribution:

- 47% gravel;
- 43% sand;
- 10% silt.

The results of the moisture content and grain size distribution test are provided on the Record of Borehole sheets in Appendix C. The results of the grain size distribution test on the sand and gravel are provided on Figure D9 in Appendix D.

1.4.2.3.4 Silt

A deposit of predominantly silt was encountered in both boreholes directly underlying the silty sand till deposit at 5.6 m depth in Borehole BH 3-1 and the sand and gravel with cobbles layer at 7.2 m depth in Borehole BH 3-2. The silt material extended to the termination depth of both boreholes at 15.8 m. The silt material, which contains some sand and a trace of clay, is grey in colour and was in a wet condition. Measured SPT "N" values ranged from 34 to 54, indicating a dense to very dense compactness condition.

Laboratory testing performed on selected samples of the silt material consisted of moisture content test on all samples and three (3) grain size distribution tests. The test results are as follows:

Moisture content range:

- 14% to 21%

Grain Size Distribution:

- 0 % gravel;
- 13 to 20% sand;
- 78 to 79% silt; and
- 3 to 16% clay.

The results of the moisture content and grain size distribution tests are provided on the Record of Borehole sheets in Appendix C. The results of the grain size distribution tests on the silt are provided on Figure D10 in Appendix D.

1.4.2.3.5 Groundwater

Information regarding the groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion of drilling. The measured groundwater levels, which are shown on the borehole logs, ranged from depths of approximately 6.4 m in BH 3-1 to 3.5 m in BH 3-2. The groundwater level measured in the standpipe installed in Borehole BH 3-2 was at a depth of 5.6 m on January 26, 2012.

Seasonal variations in the water table should be anticipated, with higher levels occurring during wetter periods of the year (such as spring thaw and late fall) and lower levels during drier periods. The groundwater levels will also be influenced by the level of the creek.

1.4.2.4 Site 4 (Culvert #30-425/C; Lamont Creek Culvert)

The culvert at Site 4 (Culvert #30-425/C; Lamont Creek Culvert) is located on Highway 26 North within the Town of Stayner, approximately 350 m to the north of the intersection with Hwy 26 West. The concrete box culvert conveys the water of Lamont Creek from the urban/town area to the west of the highway towards the east, ultimately joining the Nottawasaga River. The approximate site plan and cross section profile of the culvert are as shown on Sheet 4 in Appendix B.

Borehole BH 4-1 was located approximately 2.75 m from the edge of the southbound lane pavement along the paved west shoulder of the highway and approximately 6 m south of the centerline of the culvert. Borehole BH 4-2 was located along the east shoulder approximately 2.5 m from the edge of pavement and approximately 10 m north of the centerline of the culvert. Boreholes BH 4-1 and BH 4-2 were both advanced to a depth of 15.8 m below existing grade.

The embankment fill materials consisted of a 50 mm thick layer of asphalt (Borehole BH 4-1 only) and then a layer of sand and gravel fill overlying sand fill followed by native deposits of sand and silty sand till to sandy silt till extending to the full depth of the boreholes. The groundwater level measured in the standpipe installed in Borehole BH 4-2 was at a depth of 0.8 m on January 26, 2012.

1.4.2.4.1 Fill (Asphalt, Sand and Gravel, Sand)

Borehole BH 4-1 encountered a thin 50 mm thick layer of asphalt at surface overlying granular fill while Borehole BH 4-2 encountered granular fill at surface. Both Boreholes BH 4-1 and BH 4-2 encountered similar granular fill materials consisting of brown sand and gravel, with a trace of silt, extending to 0.7 m depth, and then brown sand fill, with some gravel and a trace of silt, extending to 1.4 m depth in both boreholes. Based on the "N" values from the Standard Penetration Tests (SPT) of 20 and 38, the upper sand and

gravel fill is in a compact to dense state of compaction. The lower sand fill had "N" values of 6 and 14, indicating a loose to compact condition.

Laboratory testing performed on selected samples of the fill material consisted of four moisture content tests. The test results are as follows:

Moisture content:

- 3% to 4% (upper sand and gravel fill)
- 7% to 11% (lower sand fill)

The results of the moisture content tests are provided on the Record of Borehole sheets in Appendix C.

1.4.2.4.2 Sand

Both Boreholes BH 4-1 and BH 4-2 encountered a deposit of native sand directly underlying the fill materials that extended to depths of 3.0 m and 4.0 m, respectively. The sand material contained a trace to some silt, a trace of gravel, and a trace of wood pieces. The sand material was brown to grey in colour and in a moist to saturated condition. Based on the "N" values from the Standard Penetration Tests (SPT), which ranged from 1 to 98 blows per 300 mm of penetration, the sand stratum has a very wide range of compactness ranging from very loose to very dense.

Laboratory testing performed on selected samples of the sand material consisted of moisture content tests on all samples and three (3) grain size distribution tests. The test results are as follows:

Moisture content range:

- 13% to 26%

  (note: one higher value of 45% was obtained from Sample 4 from BH 4-1, which probably contained some organic matter)

Grain Size Distribution:

- 2 to 11% gravel;
- 79 to 89% sand;
- 9 to 13% silt; and
- 0% clay.

The results of the moisture content and grain size distribution tests are provided on the Record of Borehole sheets in Appendix C. The results of the grain size distribution tests on the sand are provided on Figures D11 in Appendix D.

1.4.2.4.3 Silty Sand to Sandy Silt Till

A deposit of silty sand to sandy silt till was encountered beneath the sand stratum in both Boreholes BH 4-1 and BH 4-2 that extended to the termination depths of both boreholes at 15.8 m. The silty sand to sandy silt till deposit contained a trace to some gravel and a trace to some clay, was grey in colour, and in a moist to wet condition. SPT "N" values within the silty sand to sandy silt till material typically ranged from 27 to 86, indicating a compact to very dense compactness condition. Two lower "N" values of 7 and 13 were obtained from the upper and lower portions, respectively, of the stratum in Borehole BH 4-1, indicating loose and compact conditions at these locations.

Laboratory testing performed on selected samples of the silty sand to sandy silt till materials consisted of moisture content test on all samples and four (4) grain size distribution tests. The test results are as follows:

Moisture content range:

- 6% to 16%
- (note: one higher value of 22% was obtained from Sample 5 from BH 4-1 in the upper portion of the stratum where the lower N value of 7 was also obtained)

Grain Size Distribution:

- 2 to 16% gravel;
- 38 to 83% sand;
- 12 to 50% silt; and
- 3 to 11% clay.

The results of the moisture content and grain size distribution tests are provided on the Record of Borehole sheets in Appendix C. The results of the grain size distribution tests on the silty sand till are provided on Figures D12 and D13 in Appendix D.

1.4.2.4.4 Groundwater

Information regarding the groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion of drilling. The measured groundwater levels, which are shown on the borehole logs, ranged from depths of approximately 3.9 m in BH 4-2 to 5.2 m in BH 4-1. The groundwater level in the standpipe installed in Borehole BH 4-2 was measured at a depth of approximately 0.8 m on January 26, 2012.

Seasonal variations in the groundwater table and creek level should be anticipated, with higher levels occurring during wetter periods of the year (such as spring thaw and late fall) and lower levels during drier periods.

1.5 Closure

A soil investigation is a limited sampling of a site. The information is collected at specific borehole locations and can be extrapolated to an approximate limited area around the borehole. The extent of the limited area depends on the variability of the soil and groundwater conditions as influenced by geological processes and previous construction activities. Should any conditions at the site be encountered, which differ from those reported at the test locations, **exp** should be notified immediately in order to allow reassessment of our evaluation. It may then be necessary to carry out additional field work and analyses.

Engineering discussion of the foundation investigation and recommendations for the proposed culvert replacements are provided in the following Section - Part 2 Engineering Discussion and Recommendations.

We trust this Foundation Investigation (Part 1) report is satisfactory for your immediate purposes. Should you have any questions, please do not hesitate to contact this office.

Yours truly,

exp Services Inc.

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Part 2 Engineering Discussion and Recommendations

2.1 Introduction

The following subsections address geotechnical design and construction considerations for the removal and replacement of four (4) existing culverts located beneath Highway 26 in Simcoe County. At the time of preparation of this report, it is understood that full replacement of the cast-in-place reinforced concrete box culvert at Site 2 - Culvert #30-524/C at Sunnidale Corners was being planned but has been deferred. It is also understood that only rehabilitation of the three (3) other culverts that are part of this current assignment is currently being planned. However, general recommendations for future culvert replacement are provided. Geotechnical recommendations for the culvert rehabilitation only will thus be limited.

The four culverts are identified in the following Table 2.1 and their locations shown on the respective key plans on Sheets 1 to 4, inclusive:

Table 2.1 Culvert Identification

Site	MTO Culvert ID	Hwy	Township	Type	Proposed Remedial Measures
1	30-577/C; East of Klondike Park Rd Culvert	26	Medonte	Concrete Box	Rehabilitate
2	30-524/C; Hwy 26, Sunnidale Corners Culvert	26	Sunnidale	Concrete Box	Replace
3	30-522/C; McIntyre Creek Culvert	26	Sunnidale	CSP Arch Pipe	Rehabilitate
4	30-425/C; Lamont Creek Culvert	26	Nottawasaga	Concrete Box	Rehabilitate

The site numbers designated 1 to 4 were arbitrarily established to simplify the field locations and reporting. Both the Site numbers and the corresponding MTO Culvert Identification numbers are used in this report. The elevations referred to at each site are

based on temporary local datums established by our field staff whereby the centerline of the pavement directly above each culvert was assumed to have an elevation of 100.00 m. Photographs of the 4 sites are included in Appendix A. The results of the boreholes are provided on the Record of Borehole sheets in Appendix C.

2.2 Culvert Replacements

The following recommendations are intended to address the culvert replacements at each site. Where only culvert rehabilitation is required, depending on the proposed rehabilitation measures, the following comments may not be applicable.

2.2.1 Site 1 - Culvert 30-577/C

The culvert at Site 1 (Culvert 30-577/C) is located on Highway 26 approximately 450 m east of Klondike Park Road in Medonte Township in Simcoe County. The highway runs in an east-west orientation with the culvert skewed in a southeast-northwest alignment. Flow through the culvert is from the flat lying agricultural lands to the south via adjacent ditches and creek on the south side of the highway into a creek on the north side of the highway. The culvert consists of a cast-in-place, reinforced concrete rigid frame box culvert. The culvert has a length of 30.5 m, a width of 4.2 m and a height of 2.0 m according to information provided by the MTO. There is approximately 0.75 m of fill overlying the culvert. The surveyed invert elevations of the inlet and outlet ends of the existing culvert were 97.11 m and 97.27 m, respectively (note: the inlet invert elevation was lower than the outlet invert elevation). Photographs of the site are provided in Appendix A-1. The site plan and cross section profile of the culvert are approximately as shown on Sheet 1 in Appendix B.

The embankment fill materials consist of a 0.7 m thick layer of sand and gravel fill overlying glacial tills consisting of two alternating deposits of sandy silt to silty sand till and clayey silt till. The upper layer of sandy silt to silty sand till was in a loose to compact condition while the lower deposit encountered at 3.8 m depth (Elevation 96.1 m) was in a compact to very dense condition. The upper clayey silt till, which extends to 3.8 m depth, had a firm to soft consistency, with soft conditions encountered at and below the existing culvert. The groundwater level is estimated to be at or slightly above the creek level, which was at about 2.1 m below the top of pavement (Elevation 97.9 m) on January 26, 2012.

It is assumed that the replacement culvert, when required, would consist of a similarly sized closed bottomed concrete box culvert, although the recommendations provided below would generally be applicable for other types of closed bottomed culverts. An "open-bottom" type of culvert could also be considered, if the bottom can be made erosion resistant. Based on the results of the geotechnical investigation and the existing culvert invert elevation of approximately 97.3 m, it is recommended that the proposed

replacement culvert be founded on the existing compact silty sand to sandy silt till located below Elevation 96.0 m, as indicated on the soil strata cross-section presented on Sheet 1, Appendix B, and the Record of Borehole Sheets in Appendix C. In order to provide uniform subgrade support, it is recommended that the existing culvert and any bedding material be removed and the new replacement culvert be founded either directly on the compact silty sand to sandy silt till (as encountered in Boreholes BH 1-1 and BH 1-2) or on compacted engineered fill placed over the compact silty sand to sandy silt till. A Factored Geotechnical Resistance at ULS of 200 kPa and a Geotechnical Reaction at SLS of 100 kPa are recommended for the above native soils and engineered fill (assumed to consist of well compacted Granular B, Type II material) in accordance with the Canadian Highway Bridge Design Code (C.H.B.D.C.), Section 6.7.

Based on a review of the existing creek and ditch alignment, it appears to be feasible to shift the new culvert alignment approximately 5 m to the east, such that the existing culvert could be used to divert creek water during construction. The existing culvert would be removed following completion of the new culvert installation.

2.2.2 Site 2 - Culvert #30-524/C Sunnidale Corners

The concrete box culvert at Site 2 (Culvert #30-524/C - Sunnidale Corners Culvert) is located on Highway 26 approximately 150 m to the west of the intersection with Highway 10. The culvert consists of a cast-in-place, reinforced concrete, rigid frame box culvert. The culvert has a length of 28.1 m, a width of 3.2 m and a height of 1.5 m according to inspection reports provided by the MTO. There is approximately 1.2 m of fill overlying the culvert. The existing concrete box culvert crosses the highway embankment at a slightly skewed alignment, oriented approximately southeast to northwest, and conveys collected surface water from the creek draining the flat lying agricultural lands to the south of the highway to the creek flowing northwards along the north side of the embankment. The invert elevations of the culvert inlet and outlet were measured at 97.51 m and 97.44 m, respectively. The approximate site plan and cross section profile of the culvert are as shown on Sheet 2 in Appendix B.

The embankment fill materials consist of a 0.7 m to 1.0 m thick layer of loose to compact sand and gravel fill. The native soils consist of glacial till materials consisting of a shallow upper deposit of soft to firm clayey silt till and a lower deposit of very loose to very dense silty sand to sandy silt till extending to the termination depth of the boreholes. The groundwater level measured in the standpipe installed in Borehole BH 2-2 was at a depth of 0.7 m (Elevation 97.5 m) on January 26, 2012, which was at approximately the invert level of the culvert inlet.

It is assumed that the replacement culvert would consist of a similarly sized, closed bottomed concrete box culvert, although the recommendations provided below would generally be applicable for other types of closed bottomed culverts. An "open-bottom" type of culvert is not recommended unless the bottom soil materials can be made erosion

resistant. Based on the results of the geotechnical investigation and the existing culvert invert elevation of approximately 97.4 m to 97.5 m, it is recommended that the proposed replacement culvert be founded on the existing compact silty sand to sandy silt till located below Elevation 96.7 m to 97.0 m, as indicated on the Record of Borehole Sheets in Appendix C and the soil strata cross-section presented on Sheet 2, Appendix B. In order to provide uniform subgrade support, it is recommended that the existing culvert and any bedding material be removed and the new replacement culvert be founded either directly on the compact silty sand to sandy silt till (as encountered in Boreholes BH 2-1 and BH 2-3) or on compacted engineered fill placed over the compact sandy silt till. A Factored Geotechnical Resistance at ULS of 250 kPa and a Geotechnical Reaction at SLS of 150 kPa are recommended for the above native soils and engineered fill (assumed to consist of well compacted granular Granular B, Type II material) in accordance with the Canadian Highway Bridge Design Code (C.H.B.D.C.), Section 6.7.

2.2.3 Site 3 (Culvert 30-522/C; McIntyre Creek)

The corrugated steel ellipse culvert at Site 3 (Culvert #30-522/C; McIntyre Creek Culvert) is located on Highway 26 approximately 150 m to the east of the 3rd & 4th Sunnidale Sideroad intersection. The culvert conveys the water of McIntyre Creek towards the north, ultimately joining the Nottawasaga River. The approximate site plan and cross section profile of the culvert are as shown on Sheet 3 in Appendix B.

As indicated on the Record of Borehole Sheets in Appendix C, the embankment fill materials consisted of a 1.3 m to 2.2 m thick layer of compact sand and gravel fill overlying a deposit of very loose to loose silty sand till that extended to depths of 5.5 m to 5.6 m in Boreholes BH 3-2 and BH 3-1, respectively. An approximately 1.7 m thick layer of compact sand & gravel with cobbles was encountered from Elevation 94.1 m to 92.5 m in Borehole BH 3-2. Dense to very dense silt was encountered at a depth of 5.6 m (Elevation 94.2 m) in BH 3-1 and at a depth of 7.2 m (Elevation 92.5 m) in BH 3-2. The groundwater level was measured at a depth of 5.6 m (Elevation 94.0 m) on January 26, 2012 in Borehole BH 3-2, which is at the approximate invert level of the culvert.

The existing skewed CSP ellipse culvert has a length of 43 m, a width of 5.1 m, and a height of 3.0 m according to inspection reports provided by the MTO. There is approximately 4.0 m of fill overlying the culvert. Although the MTO inspection reports indicate the culvert to be in good condition, replacement may be required in the future. It is assumed that a replacement culvert would consist of a similar type of closed bottom CSP culvert or alternatively, a closed bottom reinforced concrete box culvert.

Based on the results of the geotechnical investigation and the existing culvert invert Elevations of 94.09 at the inlet and 93.95 m at the outlet, a replacement culvert would likely be founded at an approximate Elevation of 93.0 m to 93.6 m, either on the native, dense to very dense silt or on the compact sand and gravel, as indicated on the soil strata cross-section presented on Sheet 3, Appendix B. It is recommended that the existing

culvert and any bedding material be removed. The new replacement culvert founded on the dense/very dense silt or on the compact silty sand till may be designed for a Factored Geotechnical Resistance at ULS of 250 kPa and a Geotechnical Reaction at SLS of 150 kPa.

2.2.4 Site 4 (Culvert #30-425/C; Lamont Creek Culvert)

The culvert at Site 4 (Culvert #30-425/C; Lamont Creek Culvert) is located on Highway 26 North within the Town of Stayner, approximately 350 m to the north of the intersection with Hwy 26 West. The concrete box culvert conveys the water of Lamont Creek from the urban/town area to the west of the highway towards the east, ultimately joining the Nottawasaga River. The cast-in-place reinforced concrete box culvert has open footings (non-rigid frame) with a length of 16.5 m, a width of 5.8 m, a height of 1.5 m, and has approximately 0.8 m of fill overtop. The creek bottom at the inlet end of the culvert was measured at approximately Elevation 97.09 m while the invert elevation at the outlet was at a significantly higher elevation of 97.58 m. This probably indicates that scouring of the invert at the inlet has occurred. The approximate site plan and cross section profile of the culvert are shown on Sheet 4 in Appendix B.

As indicated on the Record of Borehole Sheets in Appendix C, the highway embankment fill materials consisted of a 50 mm thick layer of asphalt (Borehole BH 4-1 only) and then a layer of compact sand and gravel fill overlying loose sand fill followed by native deposits of very loose to very dense sand extending to depths of 3.0 m to 4.0 m. Loose to very dense silty sand till to sandy silt till was then encountered extending to the full depth of both boreholes at 15.8 m. The dense to very dense till was encountered below a depth of 4.0 m or approximately Elevation 96.0 m in both boreholes. The groundwater level measured in the standpipe installed in Borehole BH 4-2 was at a depth of 0.8 m (Elevation 99.2 m) on January 26, 2012.

It is assumed that the replacement culvert would consist of a similarly sized closed bottomed concrete box culvert, although the recommendations provided below would generally be applicable for other types of closed bottomed culverts. An "open-bottom" type of culvert is not recommended because of the potential for erosion of the sand and silty sand till and sandy silt till strata. Based on the results of the geotechnical investigation and the existing culvert invert elevation of approximately 97.4 m, it is recommended that the proposed replacement culvert be founded on the existing very dense silty sand to sandy silt till located below Elevation 96.0 m, as indicated on the soil strata cross-section presented on Sheet 4, Appendix B. In order to provide uniform subgrade support, it is recommended that the existing culvert and any bedding material be removed and the new replacement culvert be founded either directly on the very dense silty sand or sandy silt till (as encountered in BH 4-1 and BH 4-2) or on compacted engineered fill placed over the compact sandy silt till. A Factored Geotechnical Resistance at ULS of 300 kPa and a Geotechnical Reaction at SLS of 200 kPa are

recommended for the very dense till below Elevation 96.0 m or on engineered fill (assumed to consisted of well compacted granular Granular B, Type II material) placed overtop of the undisturbed very dense till in accordance with the Canadian Highway Bridge Design Code (C.H.B.D.C.), Section 6.7.

2.3 Excavations

All excavations for the culvert replacements should be carried out in accordance with the Ontario Occupational Health and Safety Act (OHSA) and its regulations. For guidance, the soil materials encountered down to the assumed excavation depths at each site should be classified as follows:

Table 2.2 – OHSA Soil Classifications at Each Site

Site	Culvert ID	Soil Description	OHSA Classification
1	#30-577/C	Fill: Sand with Gravel, compact, above GWT	Type 2
		Sandy Silt-Silty Sand Till, loose, above GWT	Type 3
		Clayey Silt Till: firm to soft, below GWT	Type 4
		Silty Sand to Sandy Silt Till: loose, below GWT	Type 4
		Silty Sand to Sandy Silt Till: dense, below GWT	Type 3
2	#30-524/C	Fill: Sand and Gravel, loose, above GWT	Type 3
		Clayey Silt Till: firm, above GWT	Type 3
		Silty Sand to Sandy Silt Till: very loose to loose, below GWT	Type 4
		Silty Sand to Sandy Silt Till: dense, below GWT	Type 3
3	#30-522/C	Fill: Sand and Gravel, compact, above GWT	Type 2
		Silty Sand Till: very loose to loose, above GWT	Type 3
		Silty Sand Till: compact, below GWT	Type 3
		Silt: dense to very dense, below GWT	Type 3
4	#30-425/C	Fill: Sand with Gravel, compact, above GWT	Type 2
		Fill: Sand, loose to compact, above GWT	Type 3
		Sand, very loose to loose, saturated, below GWT	Type 4
		Silty Sand to Sandy Silt Till: loose, below GWT	Type 4
		Silty Sand to Sandy Silt Till: dense/very dense, below GWT	Type 3

Note: GWT refers to groundwater table.

Excavations are expected to be below the observed groundwater levels and the creek invert levels measured during this investigation. To avoid disturbance of the founding subgrade and to allow for placement of fill in dry conditions, the groundwater must be lowered and controlled to a level below the proposed excavation levels.

Diversion of the creeks at each site will be required during the course of the culvert replacements. MOE and DFO approvals are required and construction must be carried out in accordance with the approved schedules. As well, because daily groundwater withdrawals are expected to exceed 50 m^3 day, a Permit to Take Water (PTTW) will be required from the Ministry of the Environment (MOE).

Temporary excavation side slopes for Type 3 soil should not exceed 1H:1V. Temporary excavation side slopes for Type 4 soils should not exceed 3H:1V. There is a potential for sloughing to occur if the excavation remains open for an extended period of time (i.e. 24-48 hours) or during a rainfall event.

It is assumed that the contractor will be encouraged to construct the new culverts exposing one lane at a time such that one lane of traffic will be open at all times. The excavations and culvert installation in each lane are expected to be completed within several days. However, it is recommended that excavations be supported by a trench box if they are to be left open for an extended period of time or for rain events.

When excavations cannot be safely sloped to maintain stability during construction, temporary shoring suitably designed must be used. Section 2.7, which follows, addresses lateral earth pressures at the site. Support systems, such as steel sheet piles or steel "I" beam piles with timber lagging (soldier piles and lagging), can be employed for temporary excavations. Since the proposed work for culvert replacement is located in the vicinity of the highway embankment, it will be the Contractors responsibility to design a suitable temporary support system for the MTO review prior to installation. The Contractor is to follow OPSS 538 and SP No. 902S01 regarding excavations for structures, and OPSS 539 and SP No. 105S19, regarding temporary protection systems (e.g. braced sheet piles, or some other form of bracing such as a soldier pile and lagging system).

The Contractor should be responsible for the complete design, construction, monitoring and removal of any installed protection system that is required. The protection system should be designed to provide protection for excavations as required by the Occupational Health and Safety Act, at locations specified in the contract, and at any locations where the stability, safety or function of an existing structure and/or utility may be impaired by construction work.

Prior to placement of the culvert bedding layer, the exposed subgrade material must be cleared of fill, weak soils, organic or other deleterious material. In areas where excavations for the base of the trench experience loose and soft materials, the area should

be sub-excavated and replaced with Granular "A" or Granular "B" Type II material to stabilize the excavation base. The groundwater level needs to be controlled to at least 0.6 m below the excavation level to avoid disturbance. A non-woven geotextile separator may be required to be placed between the subgrade soils and the granular backfill material along the entire length of the new culverts. The geotextile separator should be a Class II non-woven material with an equivalent opening size of 75-150 μm.

2.4 Dewatering

The soils encountered below the groundwater table and within potential excavation depths typically consist of clayey silt till, sandy silt till, silty sand till, sand, and sand and gravel. The estimated hydraulic conductivity, "K", of these materials at the various sites is as follows:

Table 2.3. Material Types and Ranges of Hydraulic Conductivity

Site/Culvert No.	Soil Materials	Estimated Range of Hydraulic Conductivity K (cm/sec)
Site 1 – Culvert #30-577/C	Clayey Silt Till	$<1.0 \times 10^{-6}$
	Sandy Silt Till	$<1.0 \times 10^{-6}$ to 1.0×10^{-5}
	Silty Sand Till	1.0×10^{-5} to 5.0×10^{-4}
Site 2 – Culvert #30-524/C	Clayey Silt Till	$<1.0 \times 10^{-6}$
	Sandy Silt Till, trace-some clay	$<1.0 \times 10^{-6}$ to 1.0×10^{-5}
	Silty Sand Till, trace clay	1.0×10^{-5} to 1.0×10^{-4}
	Sand, some Silt (Sand seams)	1.0×10^{-4} to 1.0×10^{-3}
Site 3 – Culvert #30-522/C	Silty Sand Till, some clay	$< 1.0 \times 10^{-6}$
	Sand and Gravel	5.0×10^{-3} to 1.0×10^{-1}
	Silt, some sand	4.0×10^{-6} to 5.0×10^{-4}
Site 4 – Culvert #30-425/C	Fill – Sand and Gravel, trace silt	1.0×10^{-3} to 5.0×10^{-2}
	Sand, trace to some silt	1.0×10^{-3} to 5.0×10^{-2}
	Silty Sand Till, trace-some clay	1.0×10^{-6} to 5.0×10^{-5}

It is the responsibility of the Contractor to propose a suitable dewatering system based on the time of construction and groundwater levels and creek flow conditions for prior

approval of the MTO. The method used should not undermine the existing road. During construction, the upstream flow in the ditches should be directed away from the culvert.

2.5 Culvert Bedding

The culvert bedding at all four sites should consist of Granular "A" (OPSS 1010) with a minimum thickness of 150 mm beneath the replacement box culverts and extend a minimum of 500 mm horizontally on either side of the culvert edge and slope down at 1H:1V, as specified in OPSD 802.010, attached in Appendix E. The bedding material should be placed in layers not exceeding 200 mm in thickness, loose measurement, and compacted to at least 95% of the standard Proctor maximum dry density before a subsequent layer is placed in accordance with OPSS 514.

Bedding material placed in the haunches for CSP culverts should be compacted prior to placement of cover material. Bedding on each side of the pipe should be completed simultaneously. At no time should the levels on each side differ more than the 200 mm uncompacted layer.

For CSP culverts, the pipe bedding should also consist of Granular "A" material (OPSS 1010) with a minimum thickness of 150 mm beneath the flexible pipe. The bedding material is to be placed up to the pipe springline in lifts not exceeding 150 mm and each lift is to be compacted to 98% of its Standard Proctor Maximum Dry Density (SPMDD). Particular care should be taken when compacting beneath the pipe haunches. The cover material should consist of a minimum of 300 mm of Granular "A" (OPSS 1010).

Bedding thicknesses may be increased in areas where the founding subgrade is wet, or subject to disturbance. Where soft or loose base conditions are encountered below the water table, base stabilization may be required. This may include the placement of crushed stone sub-bedding, wrapped in a non-woven geotextile (such as Terrafix 270R or equivalent) to prevent base disturbance and to allow the removal of water through standard filtered sump and pump methods.

Prior to placing any fill material, the exposed native subgrade should be inspected according to SSP 902S01. The non-woven geotextile separator should be placed between the approved subgrade and the compacted engineered fill to assist in material placement and maintain the integrity of the founding soil along the entire length of the culvert replacement.

2.6 Culvert Backfill

The culvert backfill should consist of Granular "B", Type I or Granular "A" (OPSS 1010) placed in layers not exceeding 300 mm in thickness for the full width of the trench and each layer should be compacted to 95% standard Proctor maximum dry density before a subsequent layer is placed according to OPSS 514.

The culvert should be encased with a minimum of 300 mm of compacted material. Typical backfill diagrams are presented in Appendix E, OPSD 802.010 and 802.014. The minimum height of fill cover above the crown of the pipe before power operated tractors or rolling equipment should be 900 mm, unless otherwise noted by the structural engineer.

2.7 Lateral Earth Pressure

Culvert sidewalls and any temporary shoring that may be required for excavation should be designed to resist lateral earth pressure. The expression for calculating lateral earth pressure is given by:

$$p = K(\gamma h + q) + \gamma_w h_w$$

where p = Lateral earth pressure (kPa)

K = Coefficient of earth pressure

γ = Unit weight of backfill (kN/m^3)

γ_w = Unit weight of water (kN/m^3)

h = Depth to point of interest (m)

h_w = Depth of water above point of interest (m)

q = Surcharge load acting adjacent to the wall at the ground surface (kPa)

The culvert sidewalls should be designed assuming flood conditions where creek levels upstream of the culvert are backed up to the level of the top of the overlying roadway.

Table 2.4 below, lists various earth pressure properties for given materials.

Table 2.4 Material Types and Earth Pressure Properties

Material	Friction Angle ϕ' (unfactored)	Coefficient of Active Earth Pressure (K_a)	Coefficient of Passive Earth Pressure at Rest (K_p)	Coefficient of Earth Pressure at Rest (K_o)	Unit Weight γ (kN/m^3)
Granular A	35°	0.27	3.7	0.43	22
Granular B Type I	30°	0.31	3.3	0.5	21
Granular B Type II	35°	0.27	3.7	0.43	21
Sand Fill	30°	0.33	3.0	0.5	20
Silty Sand Till Fill	30°	0.33	3.0	0.5	21
Sandy Silt Till FillFillClay Fill	28°	0.36	2.77	0.53	20
Clayey Silt Till	28°	0.36	2.77	0.53	20
Silt	28°	0.36	2.77	0.53	20

Note: Values given for horizontal earth pressures are for horizontal backfill. For sloping backfill, the design requirements outlined in Sec C6.91(c) of the Canadian Highway Bridge Design Code should be used.

The mobilization of full active or passive resistance requires a measurable and perhaps significant wall movement or rotation. Therefore, unless the structural element can tolerate these deflections, the at-rest earth pressure should be used in design.

The effect of compaction surcharge should be taken into account in the calculations of active and at rest earth pressures. The lateral pressure due to compaction should be taken as at least 12 kPa at the surface, and its magnitude should be assumed to diminish linearly with depth to zero at the depth where the active (or at rest) pressure is equal to 12 kPa. This pressure distribution should be added to the calculated active (or at rest) pressure. Notwithstanding, lighter compaction equipment and smaller lifts should be used adjacent to walls to prevent overstressing.

2.8 Frost Protection

For the central area of Simcoe County where the 4 culvert sites are located, a frost penetration depth of approximately 1.6 m can occur in open, unheated areas without snow cover. Beneath the existing culverts, the native soils typically consist of clayey silt

till, and silty sand to sandy silt till. These materials generally have a low to moderate frost susceptibility based upon the MTO Frost Classification guidelines for percent particles between 5 to 75 μm in size. However, based upon the U.S. Corps of Engineering Frost Classification guideline, the clayey silt till, sandy silt till, silty sand till and silt soils would have a frost group rating of F4 (F1 lowest, F4 Highest) making it highly susceptible to frost movements.

For movements due to frost action to occur, the following must be present beneath a structure: (i) must have frozen conditions; (ii) must have access to free water; and (iii) the subgrade soils must be frost susceptible.

For these sites, the subgrade soils will certainly be subjected to frozen conditions. There will be water available in the creeks, ditches and from the groundwater table. Therefore, to minimize potential frost movements, the frost protection treatment as outlined in OPSD 803.030 and 803.31 included in Appendix E of this report may be applied.

If construction proceeds during the winter months, the base of the trench and all fill materials should not be allowed to freeze.

2.9 Slope Stability

For the soil conditions encountered at each of the 4 sites, embankment side slopes and creek channel sideslopes above the groundwater table should remain stable if graded no steeper than 2H:1V. The greatest embankment height is at Site 3 (Culvert#30-522/C), where the embankment height above the creek invert is approximately 6.0 m. At the other 3 sites, the embankment heights range from 2.4 m to 2.9 m above the culvert invert. Further topographic survey information would be required to enable more detailed site specific stability analyses to be carried out.

2.10 Erosion Control

Erosion and sediment control during culvert construction should be as per the MTO Drainage Manual, Volume 2. Silt fences and other sediment control measures should be included to protect the downstream environment from the construction activities.

The predominant native soil types encountered at the four culvert sites above the assumed excavation depths generally consist of clayey silt till, silty sand to sandy silt till, and sand (Site 4 only). The soil erodibility factor "K" is a measure of the ability of rainfall and runoff to detach and transport soil particles, with the two main factors governing a soil's susceptibility to erosion being particle size and plasticity. Values of the soil erodibility factor "K" range from a low of 0.02 to a high of 0.7. Based upon the gradation curves, organic content, soil structure and permeability of the different major soil types encountered, the estimated Wischmeier Nomograph 'K' factors ranged from 0.05 to 0.7, indicating that the native soils are relatively non-erodible to highly erodible.

Table 2.5. Material Types and Erodibility Factors

Site/Culvert No.	Soil Materials	Estimated Range of Soil Erodibility Factor "K"
Site 1 – Culvert #30-577/C	Clayey Silt Till	0.1 – 0.3
	Sandy Silt Till	0.4 to 0.6
	Silty Sand Till, trace clay	0.3 to 0.5
Site 2 – Culvert #30-524/C	Clayey Silt Till	0.1 – 0.3
	Sandy Silt Till, trace-some clay	0.4 to 0.6
	Silty Sand Till, trace clay	0.3 to 0.5
	Sand, some Silt (Sand seams)	0.1 to 0.3
Site 3 – Culvert #30-522/C	Silty Sand Till, some clay	0.1 – 0.3
	Sand and Gravel	0.05 to 0.1
	Silt, some sand	0.6 to 0.7
Site 4 – Culvert #30-425/C	Sand, trace to some silt	0.05 – 0.2
	Silty Sand Till, trace-some clay	0.1 – 0.3

Based on the above information, it is recommended that seeding and mulching of exposed earth slopes be applied as soon as practical to limit erosion and sedimentation problems.

For creek channel stability, the non-cohesive materials encountered above tend to have greater erodibility and scour potential. The till materials with some clay content are considered relatively stable. However, all of the above materials are susceptible to erosion at high creek flow velocities.

Rip-rap treatment for the culvert outlets should be provided as per OPSD 810.010, attached in Appendix E. Rip rap protection should also be provided for the culvert inlets to prevent scouring beneath and around the culvert structure.

2.11 Culvert Replacement Construction

The following is a brief chronology of the general sequence of construction events that will need to be performed to allow for the old box culvert or CSP culvert removal and new box culvert or CSP culvert installation:

- Divert surface water from the culvert watershed away from the culvert; install appropriate sediment control measures.
- Establish safe work areas on each side of the highway to be used for alternate lane construction activity.
- Install traffic control measures as per Ontario Book 7 (Ministry of Transportation Ontario Traffic Manual) to safely allow one lane to remain open for traffic during construction.
- Install dewatering system.
- Open cut excavate on the closed lane down through the embankment fill to allow for access to the existing culvert. It is estimated the excavations would need to be approximately 4.0 m to 6.0 m deep at the various culvert locations.
- Remove the existing culvert.
- Remove existing bedding, topsoil/organics as well as any loose or otherwise disturbed soil down to competent subgrade.
- Construct new engineered fill placed over the competent subgrade in subexcavated areas.
- Install compacted bedding material over prepared subgrade soils.
- Install the new culvert to the required grades.
- Backfill as specified herein.
- Provide temporary pavement structure for closed lane.
- Repeat procedures for the opposite lane; second culvert to be securely connected and sealed to first culvert as per structural engineer's requirements.
- Restore pavement for both lanes once completed.

2.12 Design Review and Inspection During Construction

The recommendations made in this report are in accordance with our present understanding of the project and are provided solely for the design team responsible for the project. If there are any changes, such as relocation of the structures, changes to the structure dimensions and/or material types, or other features which may affect our analysis, the information obtained during this investigation may be inadequate and additional field work, analysis and reporting may be required.

Prior to tendering the proposed culvert replacements, the geotechnical aspects of the design drawings/specifications should be reviewed by this office to confirm that the intent of this report has been met.

Construction quality control of the "earthworks" associated with the culvert replacements should be provided throughout the project by qualified personnel to verify all design assumptions, recommendations and confirmation of the subsurface soil conditions. This includes inspection of the excavations, side slopes and subgrade conditions prior to the placement of any structural fill and culverts to ensure that any and all deleterious materials have been removed and to ensure that the actual conditions are not markedly different than those on which the recommendations made herein are based. Compaction control of structural fill is also recommended as standard practice, as is sampling and testing of aggregates and concrete.

3.0 Closure

This report has been prepared by Mr. Andy Schell, M.Sc. (Eng.), P. Eng. and reviewed by Mr. Peter Chan, P. Eng., Alternate Designated MTO Foundation Contact and Mr. Eric Gonneau, P. Eng., Manager MTO Assignments. The field investigation was conducted by Mr. John Michael Brown.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Yours truly,

exp Services Inc.

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6/19/2012
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P T-L. CHAN
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Andy Schell, M.Sc. (Eng.), P. Eng.
Senior Geotechnical Engineer

Peter Chan, P. Eng.
Geotechnical Division Manager
Alternate Designated MTO Foundation Contact

Eric A. Gonneau, P. Eng., MBA
Manager MTO Assignments

APPENDIX A

Photographs

Appendix A-1 – Site 1 (Culvert #30-577/C) Photographs

Photo 1 – Looking along eastbound shoulder towards Culvert 30-577/C inlet.

Photo 2 – Looking across Hwy 26 at area downstream of culvert outlet.

Photo 3 – View looking at concrete box culvert inlet on south side of Hwy 26.

Photo 4 – View looking at culvert outlet and creek flowing to right towards the northwest.

Photo 1 – Looking east along westbound shoulder towards Culvert 30-524/C outlet.

Photo 2 – Looking southwest across Hwy 26 towards creek upstream of culvert inlet.

Photo 1 – Looking east along eastbound embankment towards Culvert 30-522/C inlet.

Photo 2 – Looking at CSP arch culvert inlet.

Photo 3 – View looking at retaining wall and drainage pipe on east side of inlet to culvert

Photo 4 – View looking at culvert inlet and cover above to top of embankment

Photo 1 – Looking west towards culvert outlet beneath Hwy 26 in Stayner.

Photo 2 – Looking at outlet of concrete box culvert.

Photo 3 – View looking south along northbound side of Hwy 26.

Photo 4 – View looking at culvert inlet

Photo 5 – View looking at culvert inlet and south bank of creek

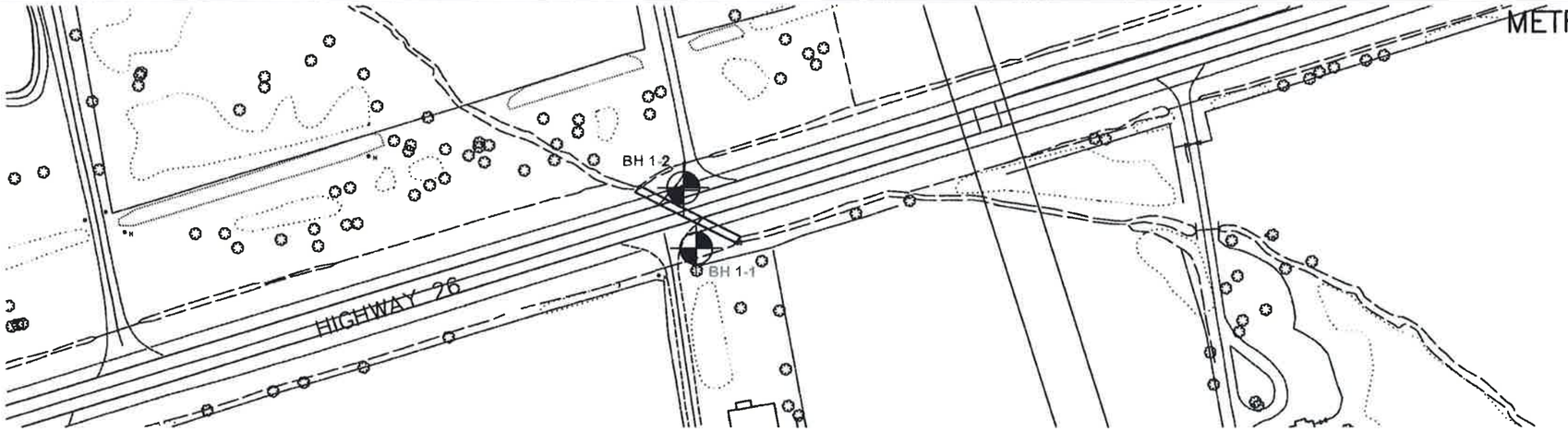
Photo 6 – View looking at culvert inlet and north bank of creek

APPENDIX B

Drawings

(Sheets 1 to 4)

METRIC



SITE 1 - CULVERT #30-577/C

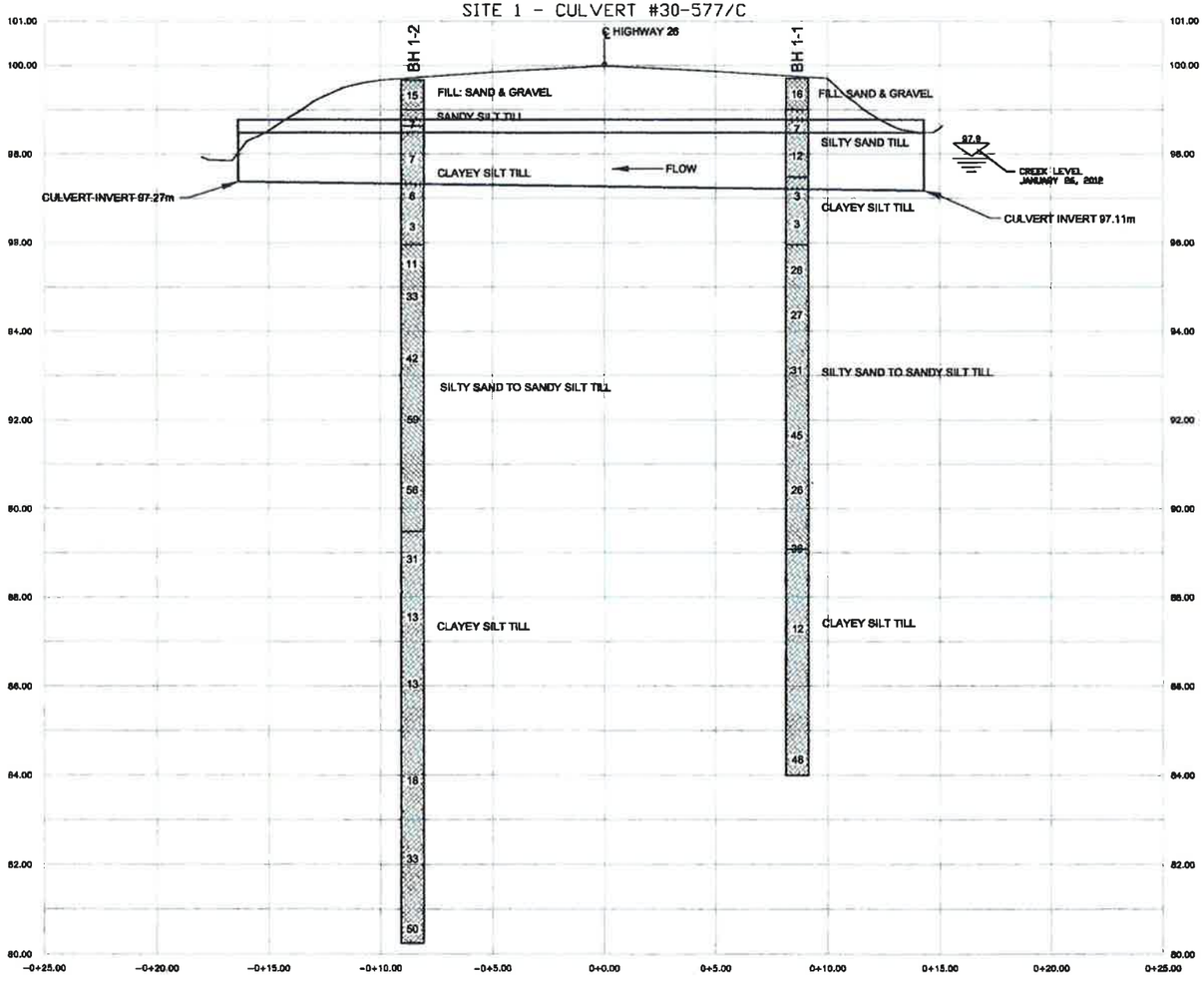


PLATE No
2011-E-0032
GWP 2341-09-00

BAR-00203602
CULVERT REPAIRS
SITE 1 - CULVERT #30-577/C
BOREHOLE LOCATION AND SOIL STRATA

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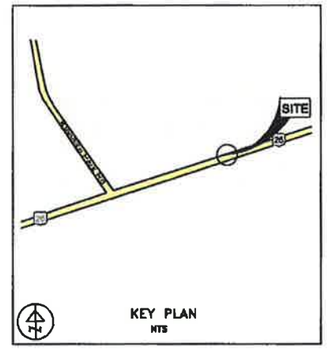

KEY PLAN
NTS

LEGEND

BOREHOLE - exp.

N Blows/0.3m
(Std. Pen Test, 475 J / blow)

TEMPORARY BENCH MARK
CENTRELINE OF PAVEMENT ALONG CULVERT ALIGNMENT
ASSUMED ELEV. OF 100.00m

XX.X GROUND WATER LEVEL

BH No	ELEVATION	COORDINATES NORTHINGS	EASTINGS
BH 1-1	99.84	4922173	265932
BH 1-2	99.84	4922184	265926

NOTES:
1) BOREHOLE ELEVATIONS ARE REFERENCED TO TOP OF PAVEMENT AT CENTRELINE OF HIGHWAY ABOVE CENTRELINE OF CULVERT; ASSUMED ELEVATION OF 100.00m.

2) BOREHOLE LOCATIONS WERE MEASURED IN THE FIELD RELATIVE TO THE CENTRELINE OF CULVERT AND OFFSET FROM EDGE OF PAVEMENT.

3) BOREHOLE COORDINATES ARE REFERENCED TO BASE PLAN PROVIDED BY MTO AND ARE APPROXIMATE ONLY.

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P T-L. CHAN
6/15/12
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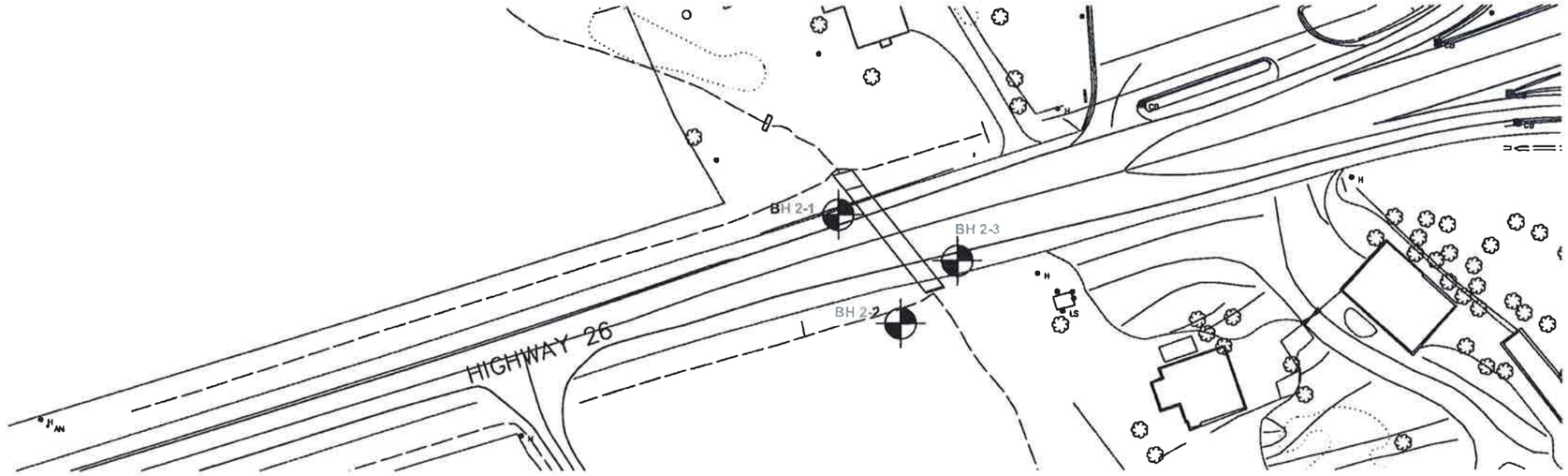
SOIL STRATA SYMBOLS

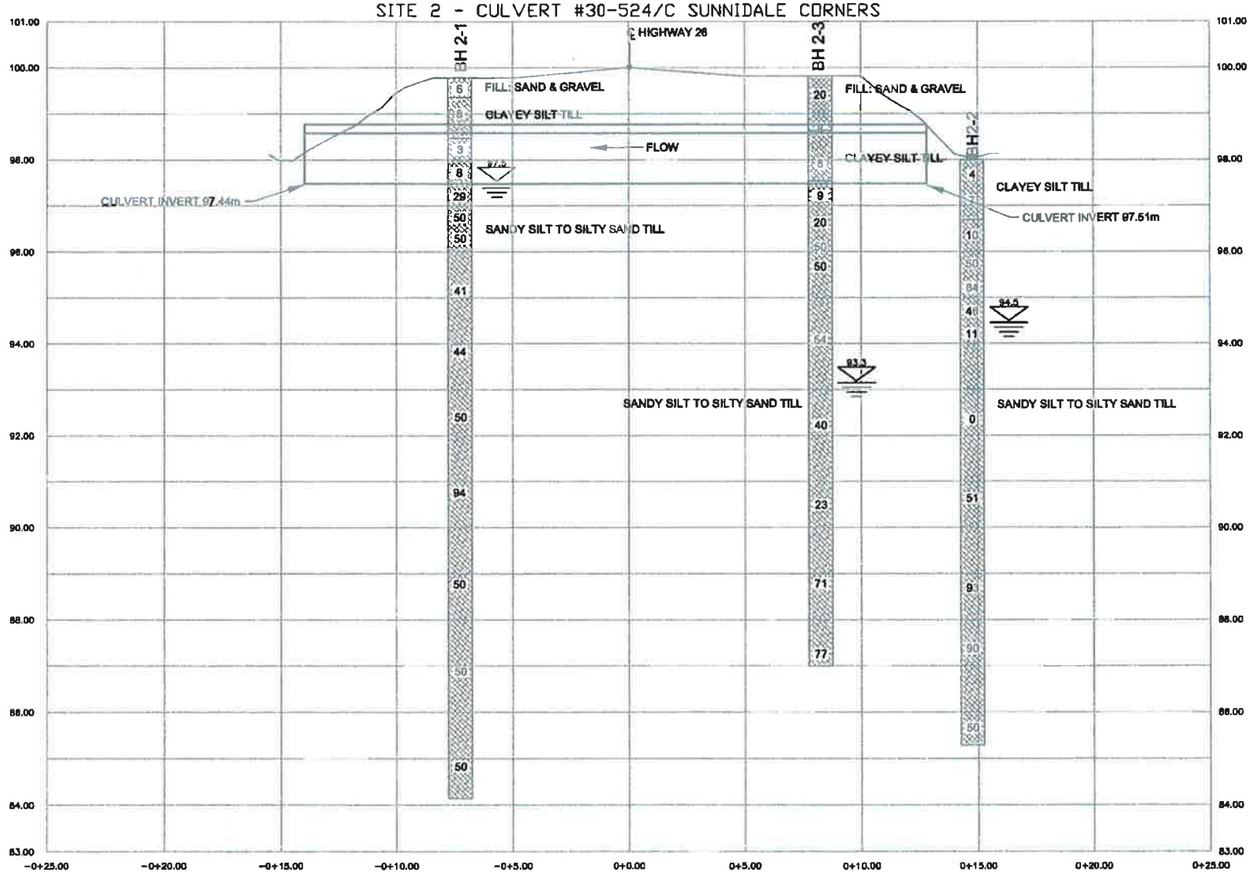
FILL
SAND
TILL
SILTY SAND

SCALE
HORI. 5 0 5 10
VERT. 2.5 0 2.5 5

MINISTRY OF TRANSPORTATION, ONTARIO PH-D-707 86-09



SITE 2 - CULVERT #30-524/C SUNNIDALE CORNERS



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SOIL STRATA SYMBOLS

- FILL
- TILL

PLATE No
2011-E-0032
GWP 2341-09-00

SHEET 2

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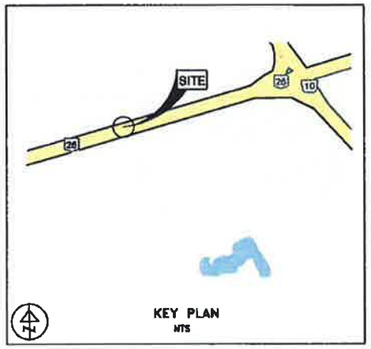


KEY PLAN
NTS

LEGEND

- BOREHOLE - exp.
- N — Blows/0.3m (Std. Pen Test, 475 J / blow)
- TEMPORARY BENCH MARK CENTRELINE OF PAVEMENT ALONG CULVERT ALIGNMENT ASSUMED ELEV. OF 100.00m
- XX.X — GROUND WATER LEVEL

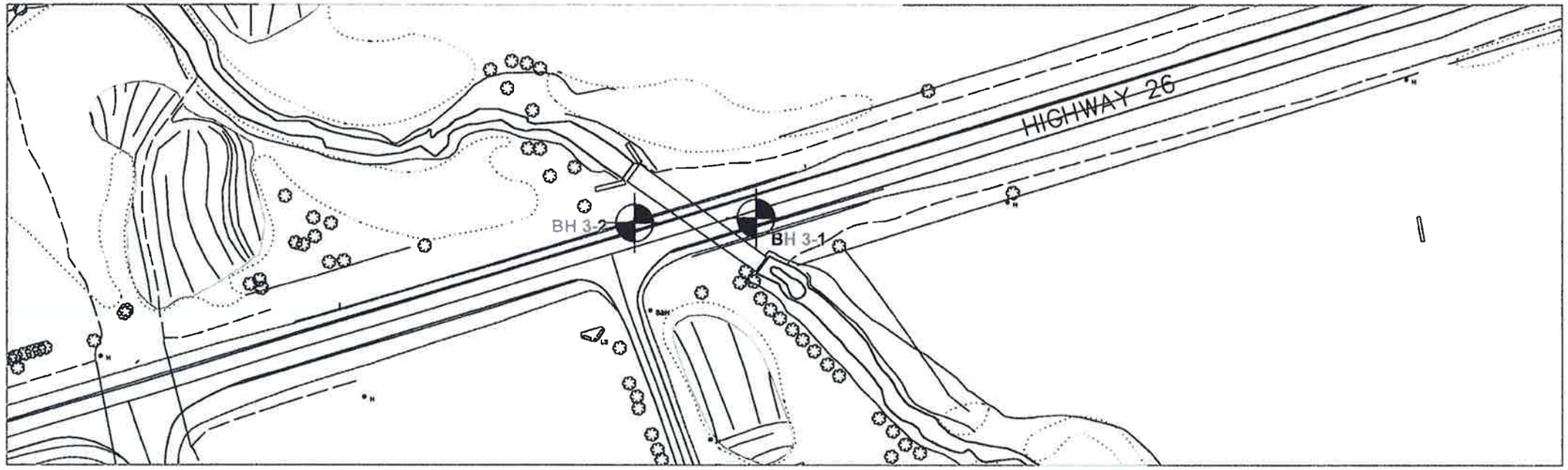
BH No	ELEVATION	COORDINATES NORTHINGS	EASTINGS
BH 2-1	100.03	4921547	263871
BH 2-2	99.23	4921529	263888
BH 2-3	99.75	4921538	263898

NOTES:
1) BOREHOLE ELEVATIONS ARE REFERENCED TO TOP OF PAVEMENT AT CENTRELINE OF HIGHWAY ABOVE CENTRELINE OF CULVERT; ASSUMED ELEVATION OF 100.00m.

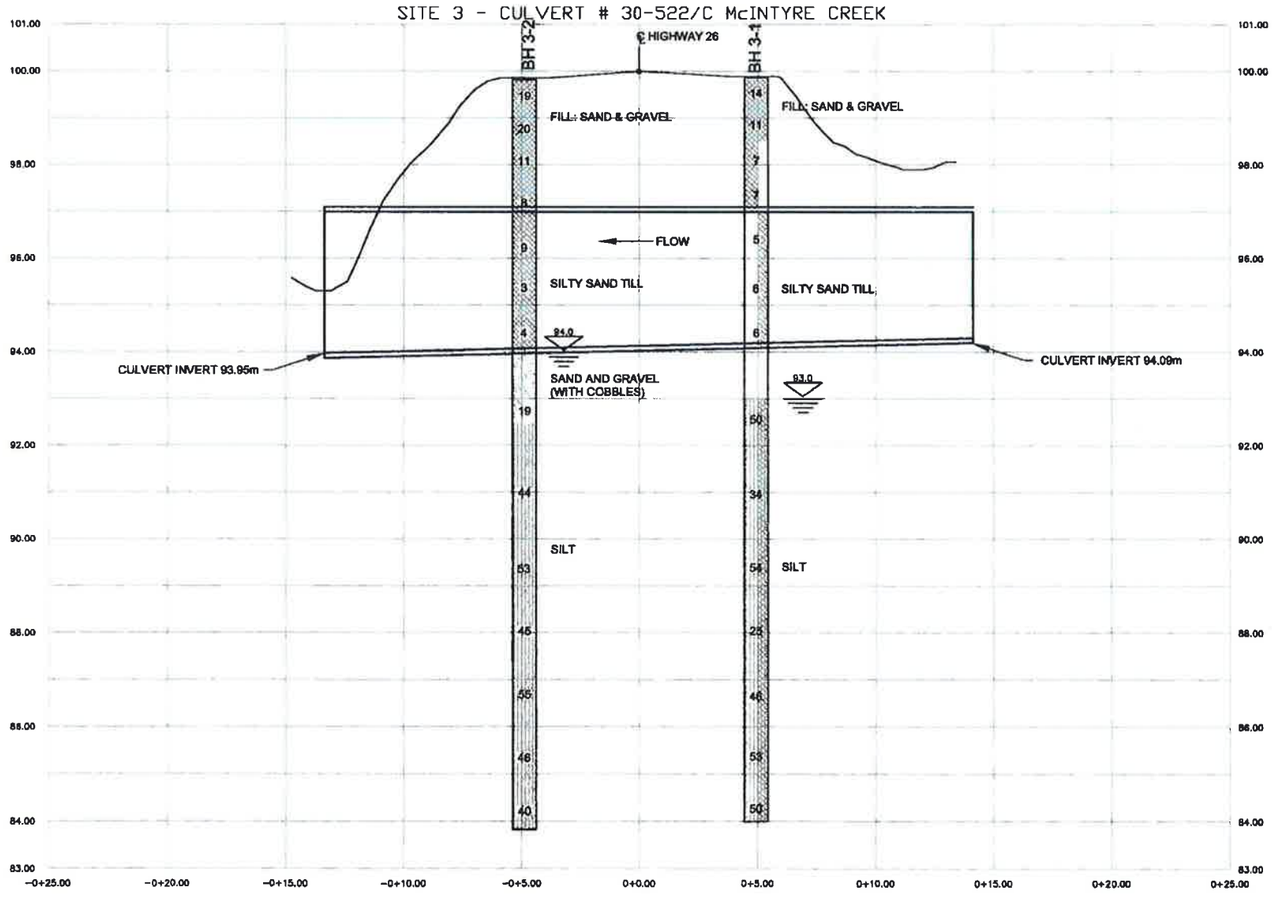
2) BOREHOLE LOCATIONS WERE MEASURED IN THE FIELD RELATIVE TO THE CENTRELINE OF CULVERT AND OFFSET FROM EDGE OF PAVEMENT.

3) BOREHOLE COORDINATES ARE REFERENCED TO BASE PLAN PROVIDED BY MTO AND ARE APPROXIMATE ONLY.

SCALE
HORI. 5 0 5 10
VERT. 2.5 0 2.5 5



SITE 3 - CULVERT # 30-522/C McINTYRE CREEK



ACTUAL CULVERT LENGTH IS 43m IN LENGTH, BUT IS NOT REPRESENTATIVE ON THE DRAWING BECAUSE THE CULVERT IS ON A SKEW TO THE ROAD

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SOIL STRATA SYMBOLS

- SILT
- SAND AND GRAVEL
- FILL
- TILL

PLATE No
2011-E-0032
GWP 2341-09-00

SHEET 3

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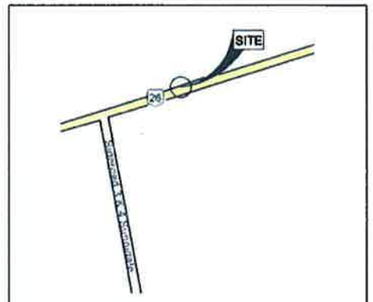


LEGEND

- BOREHOLE - exp.
- N Blows/0.3m (Std. Pen Test, 475 J / blow)
- TEMPORARY BENCH MARK CENTRELINE OF PAVEMENT ALONG CULVERT ALIGNMENT ASSUMED ELEV. OF 100.00m
- XX.X GROUND WATER LEVEL

BH No	ELEVATION	COORDINATES NORTHINGS	EASTINGS
BH 3-1	99.76	4920914	261854
BH 3-2	99.64	4920915	261827

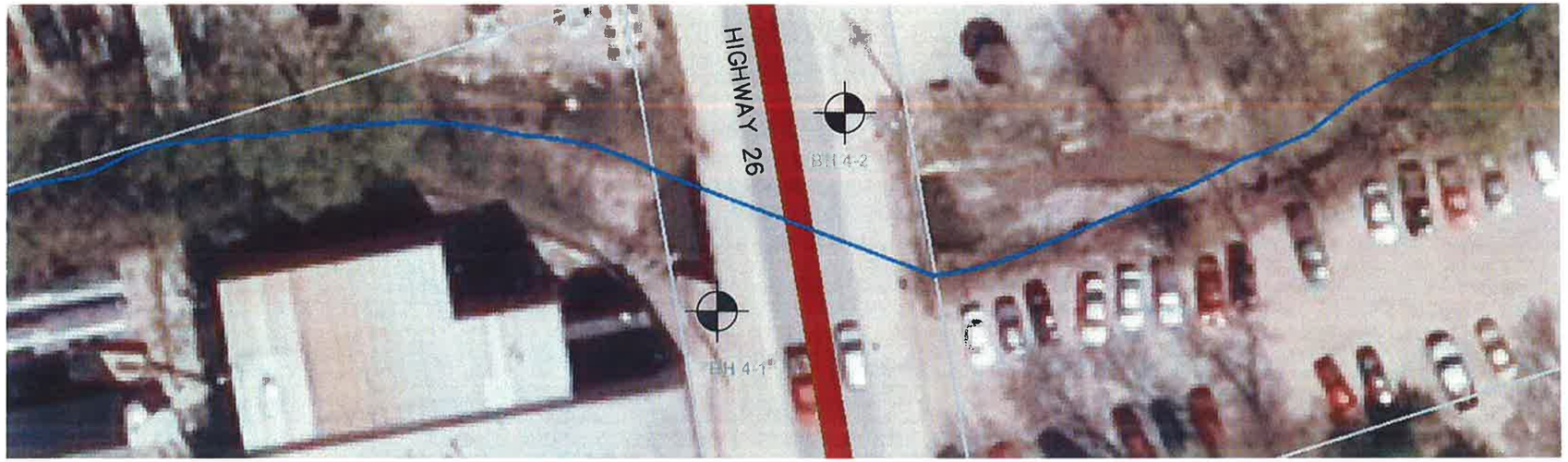
NOTES:
1) BOREHOLE ELEVATIONS ARE REFERENCED TO TOP OF PAVEMENT AT CENTRELINE OF HIGHWAY ABOVE CENTRELINE OF CULVERT; ASSUMED ELEVATION OF 100.00m.

2) BOREHOLE LOCATIONS WERE MEASURED IN THE FIELD RELATIVE TO THE CENTRELINE OF CULVERT AND OFFSET FROM EDGE OF PAVEMENT.

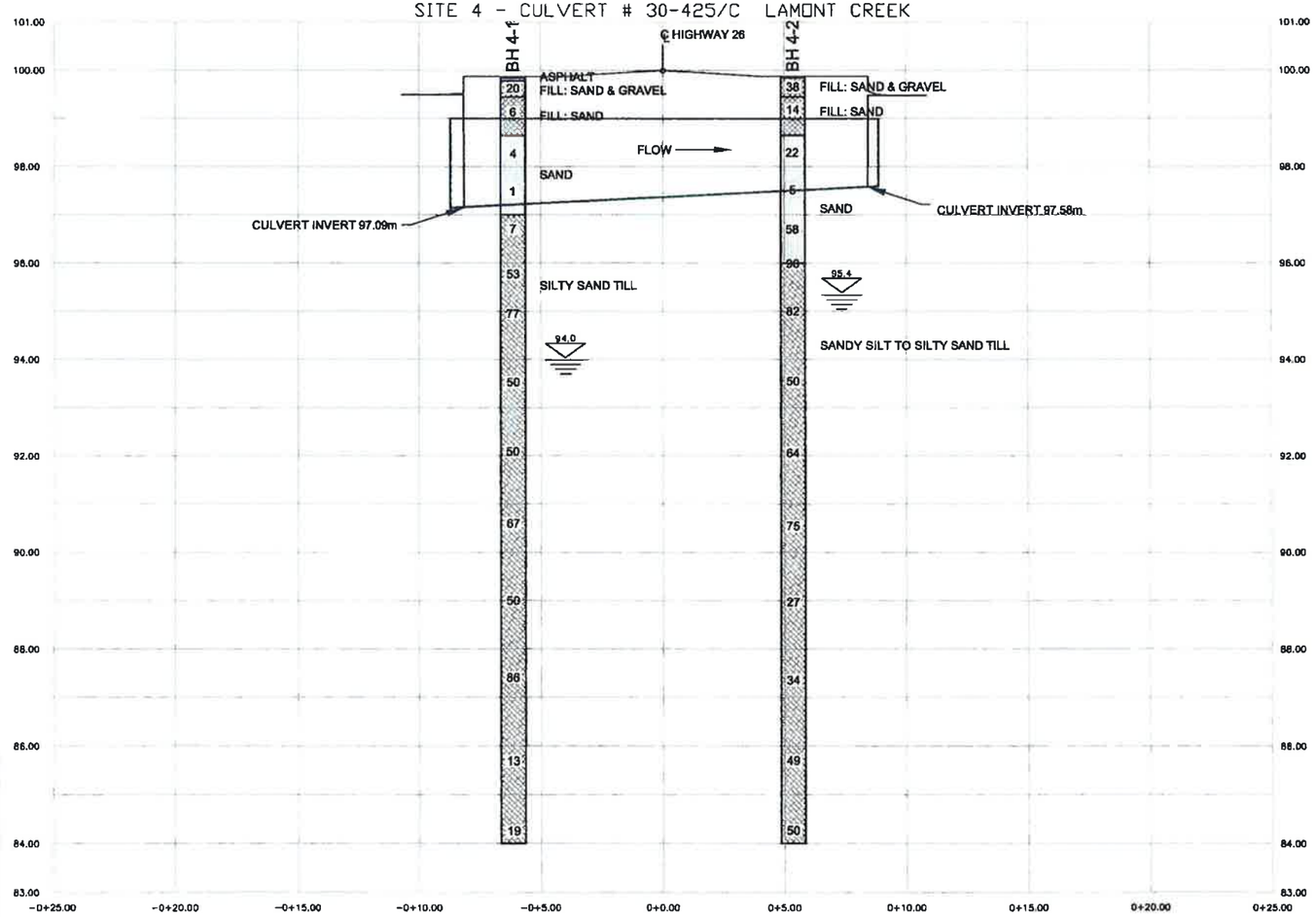
3) BOREHOLE COORDINATES ARE REFERENCED TO BASE PLAN PROVIDED BY MTO AND ARE APPROXIMATE ONLY.

SCALE
HORI. 5 0 5 10
VERT. 2.5 0 2.5 5

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-707 98-05



SITE 4 - CULVERT # 30-425/C LAMONT CREEK



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PROVINCE OF ONTARIO

SOIL STRATA SYMBOLS

FILL	ASPHALT
TILL	SAND

PLATE No
2011-E-0032
GWP 2341-09-00

SHEET 4

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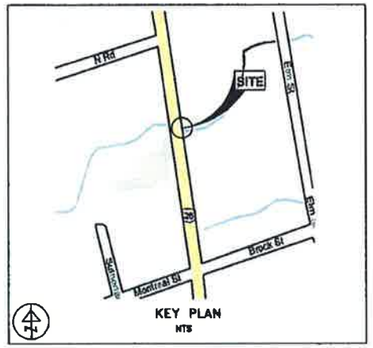

KEY PLAN
NTS

LEGEND

BOREHOLE - exp.

N Blows/0.3m (Std. Pen Test, 475 J / blow)

TEMPORARY BENCH MARK CENTRELINE OF PAVEMENT ALONG CULVERT ALIGNMENT ASSUMED ELEV. OF 100.00m

XX.X GROUND WATER LEVEL

BH No	ELEVATION	COORDINATES NORTHINGS	EASTINGS
BH 4-1	99.935	4919078	571902
BH 4-2	99.955	4919090	571912

NOTES:
1) BOREHOLE ELEVATIONS ARE REFERENCED TO TOP OF PAVEMENT AT CENTRELINE OF HIGHWAY ABOVE CENTRELINE OF CULVERT; ASSUMED ELEVATION OF 100.00m.

2) BOREHOLE LOCATIONS WERE MEASURED IN THE FIELD RELATIVE TO THE CENTRELINE OF CULVERT AND OFFSET FROM EDGE OF PAVEMENT.

3) BOREHOLE COORDINATES ARE REFERENCED TO COUNTY OF SIMCOE MAPS AND ARE APPROXIMATE ONLY.

SCALE
HORI. 5 0 5 10
VERT. 2.5 0 2.5 5

APPENDIX C

Record of Borehole Sheets

Notes On Sample Descriptions

1. All sample descriptions included in this report follow the Unified Soil Classification System (USCS) as outlined by the Ministry of Transportation. Different classification systems may be used by others; one such system is the International Society for Soil Mechanics and Foundation Engineering (ISSMFE), as outlined in the Canadian Foundation Engineering Manual. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

UNIFIED SOIL CLASSIFICATION

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS	FINE	COARSE
SILT (NONPLASTIC)		SAND		GRAVEL	

0.002	0.006	0.02	0.06	0.2	0.6	2.0	6.0	20	60	200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (75 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Notes On Sample Descriptions

4. The following table gives a description of the soil based on particle sizes. With the exception of those samples where grain size analyses have been performed, all samples are classified visually. The accuracy of visual examination is not sufficient to differentiate between this classification system or exact grain size.

Soil Classification		Terminology	Proportion
Clay and Silt	<0.075 mm		
Sand	0.075 to 4.75 mm	"trace" (e.g. Trace sand)	0% to 10%
Gravel	4.75 to 75 mm	"some" (e.g. Some sand)	10% to 20%
Cobbles	75 to 200 mm	with (e.g. with sand)	20% to 35%
Boulders	>200 mm	and (e.g. and sand)	35% to 50%

For a given material listed as an adjective (e.g. silty sand) means the predominant grain size is sand sized with 30 to 40% silt sized particles.

The compactness of Cohesionless soils and the consistency of the cohesive soils are defined by the following:

Cohesionless Soil		Cohesive Soil		
Compactness	**Standard Penetration Resistance "N" value Blows/ 0.3 m**	**Consistency**	**Undrained Shear Strength (kPa)**	**'N' Values**
Very Loose	0 to 4	Very soft	<12	<2
Loose	4 to 10	Soft	12 to 25	2 to 4
Compact	10 to 30	Firm	25 to 50	4 to 8
Dense	30 to 50	Stiff	50 to 100	8 to 15
Very Dense	Over 50	Very Stiff	100 to 200	15 to 30
		Hard	>200	>30

5. **ROCK CORING**

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundless of the rock mass. It is obtained from the rock cores by summing the length of the core covered, counting only those pieces of sound core that are 100 mm or more length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

RQD Classification	RQD (%)
Very Poor Quality	<25
Poor Quality	25 to 50
Fair Quality	50 to 75
Good Quality	75 to 90
Excellent Quality	90 to 100

Recovery Designation: $$\% \text{ Recovery} = \frac{\text{Length of Core Per Run}}{\text{Total Length of Run}} \times 100$$

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Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 1-1

SHEET 1 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 1 - Culvert #30-577/C, Hwy 26 | ORIGINATED BY MB

DIST Central | HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 12/6/2011 - 12/7/2011 | CHECKED BY AS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
99.8							
0.0	**FILL:** Sand and Gravel, Trace Silt, Brown, Moist		SA1	SS	15		
99.1 / 0.7	[Compact]						
98.8 / 1.1	**SANDY SILT TILL:** Trace to Some Gravel, Brown, Moist		SA2	SS	7		
	[Loose]						
	CLAYEY SILT TILL: Some Sand, Trace Gravel, Brown, Moist to Saturated		SA3	SS	7		
	[Firm to Soft]		SA4	SS	6		
			SA5	SS	3		
96.1 / 3.8	**SILTY SAND TO SANDY SILT TILL:** Trace Clay, Trace Gravel, Grey, Moist to Wet		SA6	SS	11		
	[Compact to Very Dense]		SA7	SS	33		
			SA8	SS	42		
			SA9A	SS	59		
			SA9B	SS			
			SA10	SS	56		
89.6 / 10.2	**CLAYEY SILT TILL:** Some Sand, Trace Gravel, Grey, Moist		SA11	SS	31		
	[Stiff to Hard]		SA12	SS	13		
			SA13	SS	13		

SPT TEST (N-Value) ●
DYNAMIC CONE PENETRATION 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
⊗ QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT PL | NATURAL WATER CONTENT w | LIQUID LIMIT LL
WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
SA4	1	2	47	32
SA6	1	57	39	3
SA7	0	38	62	
SA12	1	22	56	21

Continued Next Page

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

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 1-1

SHEET 2 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 1 - Culvert #30-577/C, Hwy 26 | ORIGINATED BY MB
DIST Central | HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO
DATUM Local | DATE 12/6/2011 - 12/7/2011 | CHECKED BY AS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) ● / DYNAMIC CONE PENETRATION 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ⊗ QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT PL / NATURAL WATER CONTENT w / LIQUID LIMIT LL / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			SA14	SS	18		84	●	○		
							83				
							82				
			SA15	SS	33		81	●	○		
80.2			SA16	SS	50			●	○		
19.7	END OF BOREHOLE										

+ ³, × ³: Numbers refer to Sensitivity O ³% STRAIN AT FAILURE

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 1-2

SHEET 1 OF 2 | METRIC

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 1 - Culvert #30-577/C, Hwy 26 | ORIGINATED BY MB

DIST Central | HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 12/7/2011 - 12/7/2011 | CHECKED BY AS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
99.8						
0.0	**FILL:** Sand and Gravel, Trace Silt, Brown, Moist		SA1	SS	16	
99.1	[Compact]					
0.7	**SILTY SAND TILL:** Some Gravel, Brown, Moist		SA2	SS	7	
	[Loose to Compact]		SA3	SS	12	
97.6						
2.2	**CLAYEY SILT TILL:** Some Sand, Brown, Wet		SA4	SS	3	
	[Soft]		SA5	SS	3	
96.1						
3.8	**SILTY SAND TO SANDY SILT TILL:** Trace Gravel, Grey, Moist		SA6	SS	26	
	[Compact to Dense]		SA7A	SS	27	
			SA7B	SS		
			SA8	SS	31	
			SA9	SS	45	
			SA10	SS	26	
88.9			SA11A	SS	36	
11.0	**CLAYEY SILT TILL:** Some Sand, Trace Gravel, Grey, Moist to Wet		SA11B	SS		
	[Stiff to Hard]		SA12	SS	12	
				VS		

SPT TEST (N-Value) ●
DYNAMIC CONE PENETRATION 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
⊗ QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

ELEVATION SCALE: 99, 98, 97, 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85

PLASTIC LIMIT PL | NATURAL WATER CONTENT w | LIQUID LIMIT LL
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
13	55	32	
0	80	20	

Continued Next Page

+3, ×3: Numbers refer to Sensitivity | O3% STRAIN AT FAILURE

ON_MTO BOREHOLE LOGS - HWY 26 FOUNDATIONS.GPJ ON_MOT.GDT 7/18/12

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 1-2

SHEET 2 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 1 - Culvert #30-577/C, Hwy 26 | ORIGINATED BY MB

DIST Central HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 12/7/2011 - 12/7/2011 | CHECKED BY AS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) ● / DYNAMIC CONE PENETRATION 20 40 60 80 100	PLASTIC LIMIT PL / NATURAL WATER CONTENT w / LIQUID LIMIT LL / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE; ⊗ QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100			
84.0			SA13	SS	48			●	○		
84							84				
15.9	END OF BOREHOLE										

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

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 2-1

SHEET 1 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 2 - Culvert#30-524/C, Hwy 26 | ORIGINATED BY MB
DIST Central | HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO
DATUM Local | DATE 12/5/2011 - 12/5/2011 | CHECKED BY AS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
100.0								
0.0	**FILL:** Sand and Gravel, Trace Silt, Brown, Moist to Wet							
99.3 / 0.7	[Loose]	SA1	SS	6				
	CLAYEY SILT TILL: Trace Sand, Brown to Grey, Moist to Damp	SA2	SS	8				
98.5 / 1.5	[Firm]	SA3	SS	3	7	54	23	16
	SILTY SAND TO SANDY SILT TILL: Trace Gravel, Trace to Some Clay, Brown to Grey, Damp to Wet	SA4	SS	8				
	[Very Loose to Very Dense]	SA5	SS	29				
		SA6	SS	50	1	34	60	5
		SA7	SS	50	3	34	55	8
		SA8	SS	41				
		SA9	SS	44				
		SA10	SS	50				
		SA11	SS	94				
		SA12	SS	50				
		SA13	SS	50				

GROUND WATER CONDITIONS

ELEVATION SCALE: 99, 98, 97, 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86

SPT TEST (N-Value) ●
DYNAMIC CONE PENETRATION 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
⊗ QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT PL | NATURAL WATER CONTENT w | LIQUID LIMIT LL
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

ON_MTO_BOREHOLE LOGS - HWY 26 FOUNDATIONS.GPJ ON_MOT GDT 7/18/12

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 2-1

SHEET 2 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 2 - Culvert#30-524/C, Hwy 26 | ORIGINATED BY MB

DIST Central HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 12/5/2011 - 12/5/2011 | CHECKED BY AS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) ● / DYNAMIC CONE PENETRATION 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ⊗ QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100	PLASTIC LIMIT PL / NATURAL WATER CONTENT w / LIQUID LIMIT LL; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES							GR	SA	SI	CL
84.2			SA14	SS	50			●	○						
15.8	END OF BOREHOLE														

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

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 2-2

SHEET 1 OF 1 **METRIC**

PROJECT NO. BAR-00203602-A0 **LOCATION** SITE 2 - Culvert#30-524/C, Hwy 26 **ORIGINATED BY** MB

DIST Central **HWY** 26 **BOREHOLE TYPE** Hollow Stem Augers **COMPILED BY** LO

DATUM Local **DATE** 12/6/2011 - 12/6/2011 **CHECKED BY** AS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) / DYNAMIC CONE PENETRATION / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ⊗ QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT PL / NATURAL WATER CONTENT w / LIQUID LIMIT LL / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
98.2														
0.0	**CLAYEY SILT TILL:** Trace Sand, Trace Rootlets, Dark Brown to Brown, Moist [Soft to Firm]		SA1	SS	4	▽	98							
			SA2	SS	7		97							
96.8														
1.5	**SANDY SILT TO SILTY SAND TILL:** Trace Gravel, Trace to Some Clay, With Some Sandy Seams, Brown to Grey, Moist to Saturated [Very Loose to Very Dense]		SA3	SS	10		96							
			SA4	SS	50						2	33	53	12
			SA5	SS	84		95							
			SA6	SS	46		94							
			SA7	SS	11		93							
	Sandy Seam		SA8	SS	0		92				0	80	20	
			SA9	SS	51		91							
			SA10	SS	93		90							
	Sandy Seam		SA11	SS	90		89				10	78	11	1
			SA12	SS	50		88							
85.4							87							
12.8	**END OF BOREHOLE**						86							

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

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 2-3

SHEET 1 OF 1 **METRIC**

PROJECT NO. BAR-00203602-A0 **LOCATION** SITE 2 - Culvert#30-524/C, Hwy 26 **ORIGINATED BY** MB

DIST Central **HWY** 26 **BOREHOLE TYPE** Hollow Stem Augers **COMPILED BY** LO

DATUM Local **DATE** 12/6/2011 - 12/6/2011 **CHECKED BY** AS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
99.8							
0.0	**FILL:** Sand and Gravel, Trace Silt, Brown, Moist [Compact]		SA1	SS	20		
98.8							
1.0	**CLAYEY SILT TILL:** Trace Sand, Trace Gravel, Brown, Moist [Firm]		SA2A	SS	8		
			SA2B	SS			
			SA3	SS	8		
97.5							
2.3	**SANDY SILT TO SILTY SAND TILL:** Trace Gravel, Trace to Some Clay, Brown to Grey, Moist to Wet [Loose to Dense]		SA4	SS	9		
			SA5	SS	20		
			SA6	SS	50		
			SA7	SS	50	▽	
			SA8	SS	64		
			SA9	SS	40		
			SA10	SS	23		
			SA11	SS	71		
			SA12	SS	77		
86.9							
12.8	**END OF BOREHOLE**						

SPT TEST (N-Value) ●
DYNAMIC CONE PENETRATION 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
⊗ QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT PL — NATURAL WATER CONTENT w — LIQUID LIMIT LL
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
SA4	0	34	50	16
SA8	2	45	45	8
SA11	0	67	30	3

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

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 3-1

SHEET 1 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 **LOCATION** SITE 3 - Culvert #30-522/C, Hwy 26 **ORIGINATED BY** MB

DIST Central **HWY** 26 **BOREHOLE TYPE** Hollow Stem Augers **COMPILED BY** LO

DATUM Local **DATE** 12/5/2011 - 12/5/2011 **CHECKED BY** AS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
99.8							
0.0	**FILL:** Sand and Gravel, Trace Silt, Brown, Moist [Compact]		SA1	SS	14		
			SA2	SS	11		
98.5							
1.3	**SILTY SAND TILL:** Some Clay, Trace to Some Gravel, Brown, Moist [Loose]		SA3	SS	7		
			SA4	SS	7		
			SA5	SS	5		
			SA6	SS	6		
			SA7	SS	8		
94.2							
5.6	**SILT:** Some Fine Sand, Trace Clay, Grey, Wet [Compact to Very Dense]		SA8	SS	50	▽	
			SA9	SS	34		
			SA10	SS	54		
			SA11	SS	25		
			SA12	SS	46		
			SA13	SS	53		

SPT TEST (N-Value) ●
DYNAMIC CONE PENETRATION 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
⊗ QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT PL — NATURAL WATER CONTENT w — LIQUID LIMIT LL
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
12	50	38	
9	55	18	18
4	50	23	23
0	20	78	2

Continued Next Page

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

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 3-1

SHEET 2 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 3 - Culvert #30-522/C, Hwy 26 | ORIGINATED BY MB

DIST Central | HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 12/5/2011 - 12/5/2011 | CHECKED BY AS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) ● / DYNAMIC CONE PENETRATION ~ (20 40 60 80 100)	PLASTIC LIMIT PL / NATURAL WATER CONTENT w / LIQUID LIMIT LL	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ⊗ QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	WATER CONTENT (%) (10 20 30)		GR SA SI CL
			SA14	SS	50			●	○		
83.9							84				
15.8	END OF BOREHOLE										

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

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 3-2

SHEET 1 OF 2 | METRIC

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 3 - Culvert #30-522/C, Hwy 26 | ORIGINATED BY MB

DIST Central | HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 12/2/2011 - 12/2/2011 | CHECKED BY AS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) / DYNAMIC CONE PENETRATION (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ⊗ QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT PL / NATURAL WATER CONTENT w / LIQUID LIMIT LL / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
99.6														
0.0	**FILL:** Sand and Gravel, Trace Silt, Brown, Moist [Compact]		SA1	SS	19		99							
			SA2	SS	20		98							
			SA3	SS	11									
97.4							97					4	49	33	14
2.2	**SILTY SAND TILL:** Trace to Some Gravel, Some Clay, Brown to Grey, Moist [Very Loose to Loose]		SA4	SS	8									
			SA5	SS	9		96							
			SA6	SS	3									
			SA7	SS	4		95					20	43	25	12
94.1						▽									
5.5	**SAND AND GRAVEL:** With Cobbles, Trace to Some Silt, Brown, Saturated [Compact]		SA8	SS	19		94					47	43	10	
92.5							93								
7.2	**SILT:** Some Sand, Trace Clay, Grey, Wet [Dense to Very Dense]		SA9	SS	44		92							
			SA10	SS	53		91					1	19	79	1
			SA11	SS	45		90							
			SA12	SS	55		89							
			SA13	SS	46		88					0	13	79	8
							87							
							86							
							85							

Continued Next Page

+³, ×³: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 3-2

SHEET 2 OF 2

METRIC

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 3 - Culvert #30-522/C, Hwy 26 | ORIGINATED BY MB

DIST Central HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 12/2/2011 - 12/2/2011 | CHECKED BY AS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) ● / DYNAMIC CONE PENETRATION 20 40 60 80 100	PLASTIC LIMIT PL / NATURAL WATER CONTENT w / LIQUID LIMIT LL	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE; ⊗ QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100	WATER CONTENT (%): 10 20 30		GR SA SI CL
83.8			SA14	SS	40		84	●	○		
15.8	END OF BOREHOLE										

+³, ×³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 4-1

SHEET 1 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 4 - Culvert #30-425/C, Hwy 26 | ORIGINATED BY MB

DIST Central | HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 11/30/2011 - 11/30/2011 | CHECKED BY AS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
99.9							
99.7	**ASPHALT:** 50 mm						
99.2 / 0.7	**FILL:** Sand and Gravel, Trace Silt, Brown, Moist		SA1	SS	20		
	[Compact]		SA2	SS	6		
	FILL: Sand, Some Gravel, Trace Silt, Brown, Moist						
98.5 / 1.4	[Loose]		SA3	SS	4		
	SAND: Trace to Some Silt, Trace to Some Gravel, Trace Wood Pieces, Brown, Wet						
	[Very Loose]		SA4	SS	1		
97.0 / 3.0	**SILTY SAND TILL:** Trace to Some Clay, Trace to Some Gravel, Grey, Moist to Wet		SA5	SS	7		
	[Loose to Very Dense]		SA6	SS	53		
			SA7	SS	77	▽	
			SA8	SS	50		
			SA9	SS	50		
			SA10	SS	67		
			SA11	SS	50		
			SA12	SS	86		
			SA13	SS	13		

SPT TEST (N-Value) ●
DYNAMIC CONE PENETRATION 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
⊗ QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT PL | NATURAL WATER CONTENT w | LIQUID LIMIT LL
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
11	79	10	
13	41	35	11
16	53	24	7

Continued Next Page

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

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 4-1

SHEET 2 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 4 - Culvert #30-425/C, Hwy 26 | ORIGINATED BY MB

DIST Central | HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 11/30/2011 - 11/30/2011 | CHECKED BY AS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) ● / DYNAMIC CONE PENETRATION 20 40 60 80 100	PLASTIC LIMIT PL / NATURAL WATER CONTENT w / LIQUID LIMIT LL	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE; ⊗ QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100	WATER CONTENT (%): 10 20 30		GR SA SI CL
84.1			SA14	SS	19			●	○		
15.8	END OF BOREHOLE						84				

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

ON_MTO_BOREHOLE LOGS - HWY 26 FOUNDATIONS.GPJ ON_MOT.GDT 7/18/12

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 4-2

SHEET 1 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 | LOCATION SITE 4 - Culvert #30-425/C, Hwy 26 | ORIGINATED BY MB

DIST Central | HWY 26 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY LO

DATUM Local | DATE 11/30/2011 - 11/30/2011 | CHECKED BY AS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
100.0						
0.0	**FILL:** Sand and Gravel, Trace Silt, Brown, Moist		SA1	SS	38	
99.3	[Dense]					
0.7	**FILL:** Sand, Trace Silt, Trave Gravel, Brown, Moist		SA2	SS	14	
98.5	[Compact]					
1.4	**SAND:** Trace to Some Silt, Trace Gravel, Brown to Grey, Moist to Saturated		SA3	SS	22	
	[Loose to Very Dense]		SA4	SS	5	
			SA5	SS	58	
96.0			SA6A	SS	96	
4.0	**SANDY SILT TO SILTY SAND TILL:** Some Gravel, Trace Clay, Grey, Moist to Wet		SA6B	SS		
	[Compact to Very Dense]		SA7	SS	82	
			SA8	SS	50	
			SA9	SS	64	
			SA10	SS	75	
			SA11	SS	27	
			SA12	SS	34	
			SA13A	SS	49	
			SA13B	SS		

ELEVATION SCALE: 99, 98, 97, 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86

SPT TEST (N-Value) ●
DYNAMIC CONE PENETRATION 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
⊗ QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT PL | NATURAL WATER CONTENT w | LIQUID LIMIT LL
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	8	79	13	
	2	89	9	
	12	38	50	
	2	83	12	3

Continued Next Page

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

ON_MTO_BOREHOLE LOGS - HWY 26 FOUNDATIONS.GPJ ON_MOT.GDT 7/18/12

exp. Services Inc.
561 Bryne Drive, Unit D
Barrie, ON L4N 9Y3

RECORD OF BOREHOLE No BH 4-2

SHEET 2 OF 2 **METRIC**

PROJECT NO. BAR-00203602-A0 LOCATION SITE 4 - Culvert #30-425/C, Hwy 26 ORIGINATED BY MB

DIST Central HWY 26 BOREHOLE TYPE Hollow Stem Augers COMPILED BY LO

DATUM Local DATE 11/30/2011 - 11/30/2011 CHECKED BY AS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	SPT TEST (N-Value) ● / DYNAMIC CONE PENETRATION; SHEAR STRENGTH kPa: ○ UNCONFINED, ⊗ QUICK TRIAXIAL, + FIELD VANE, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT PL / NATURAL WATER CONTENT w / LIQUID LIMIT LL; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
84.1			SA14	SS	50			●	○		
15.8	END OF BOREHOLE						84				

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

APPENDIX D

Laboratory Data

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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-577/C

Figure No.: D1

Project No.: BAR-00203602-A0

Date Tested: January 4, 2012

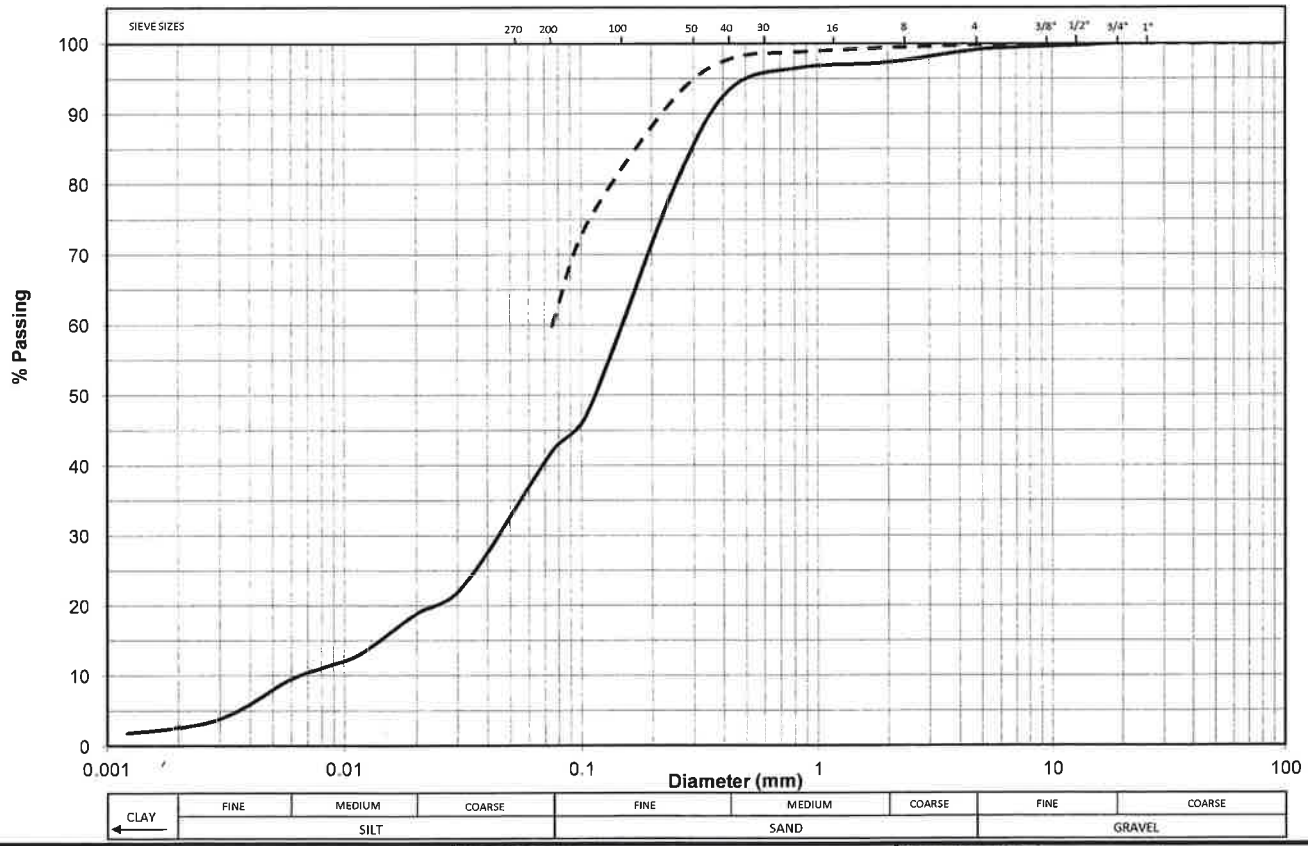
Client: Ainley Group

Date Sampled: December 6 & 7, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 1-1 SA6	3.8 - 4.4	Silty Sand Till	
2	BH 1-1 SA7	4.6 - 5.2	Sandy Silt Till	
3				

Sieve Analysis



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Lesley O'May

Checked By:
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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-577/C

Figure No.: D2

Project No.: BAR-000203602-A0

Date Tested: January 3 & 5, 2012

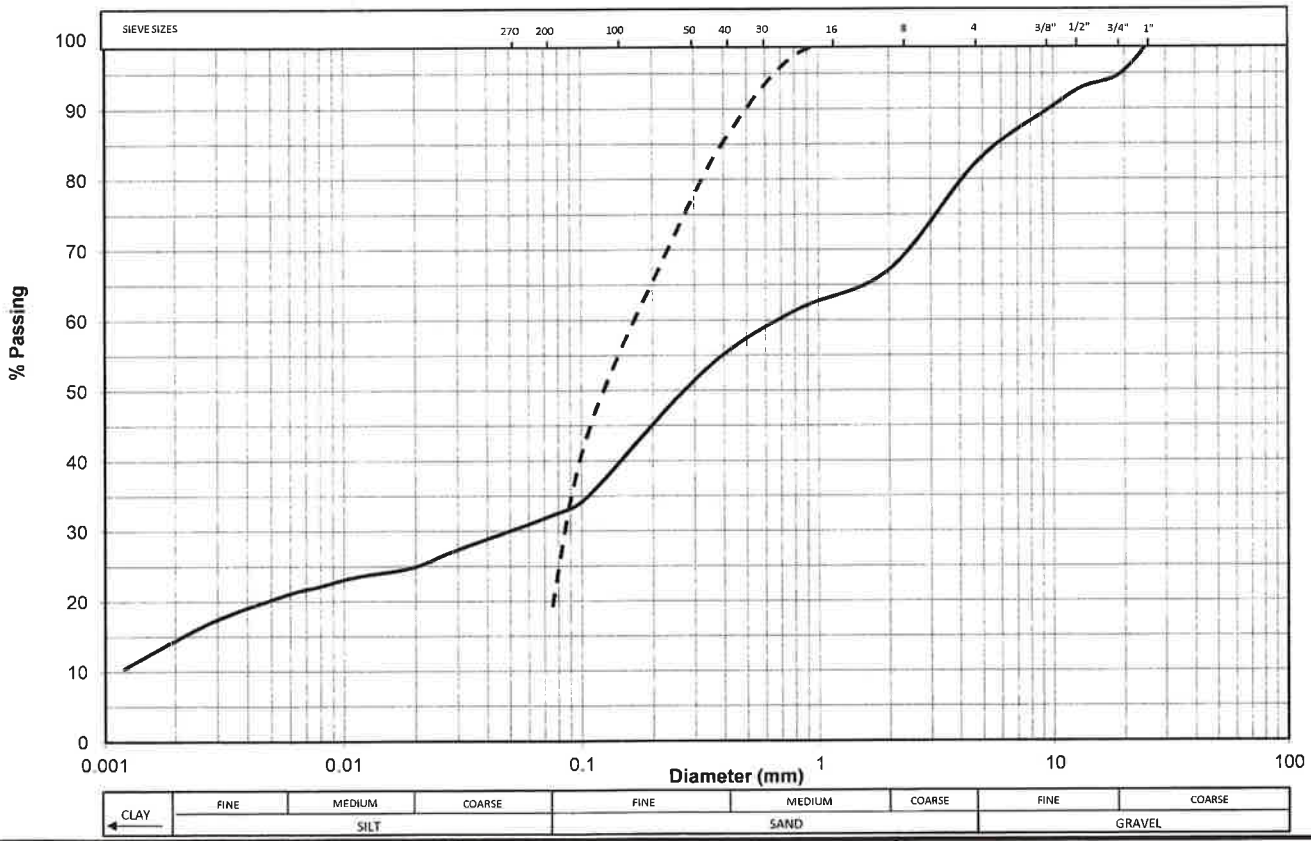
Client: Ainley Group

Date Sampled: December 6, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 1-2 SA3	1.5 - 2.1	Silty Sand Till	
2	BH 1-2 SA8	6.1 - 6.7	Silty Sand Till	
3				

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-577/C

Figure No.: D3

Project No.: BAR-000203602-A0

Date Tested: January 2012

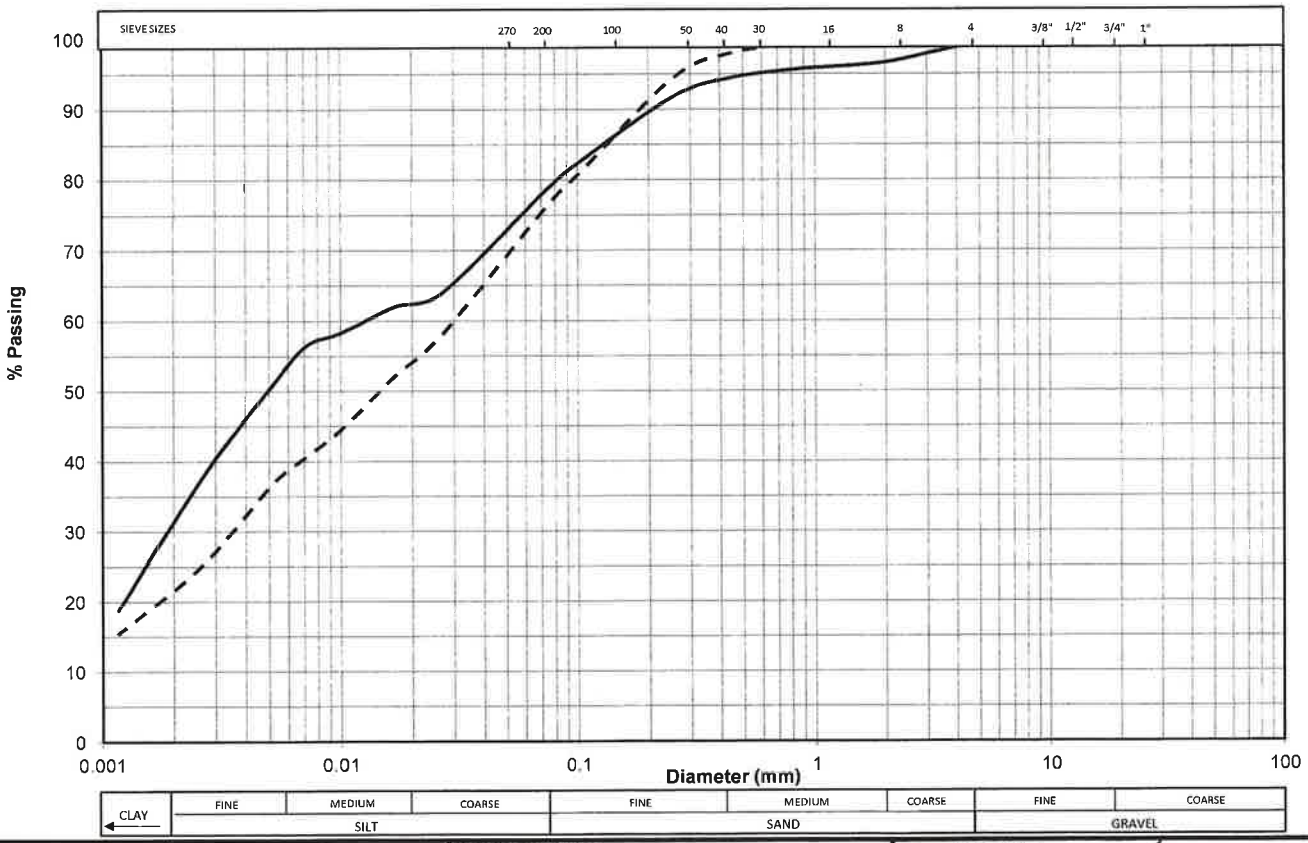
Client: Ainley Group

Date Sampled: December 6 & 7, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 1-1 SA4	2.3 - 2.9	Clayey Silt Till	
2	BH 1-1 SA13	13.7 - 14.3	Clayey Silt Till	
3				

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-524/C

Figure No.: D4

Project No.: BAR-000203602-A0

Date Tested: January 2012

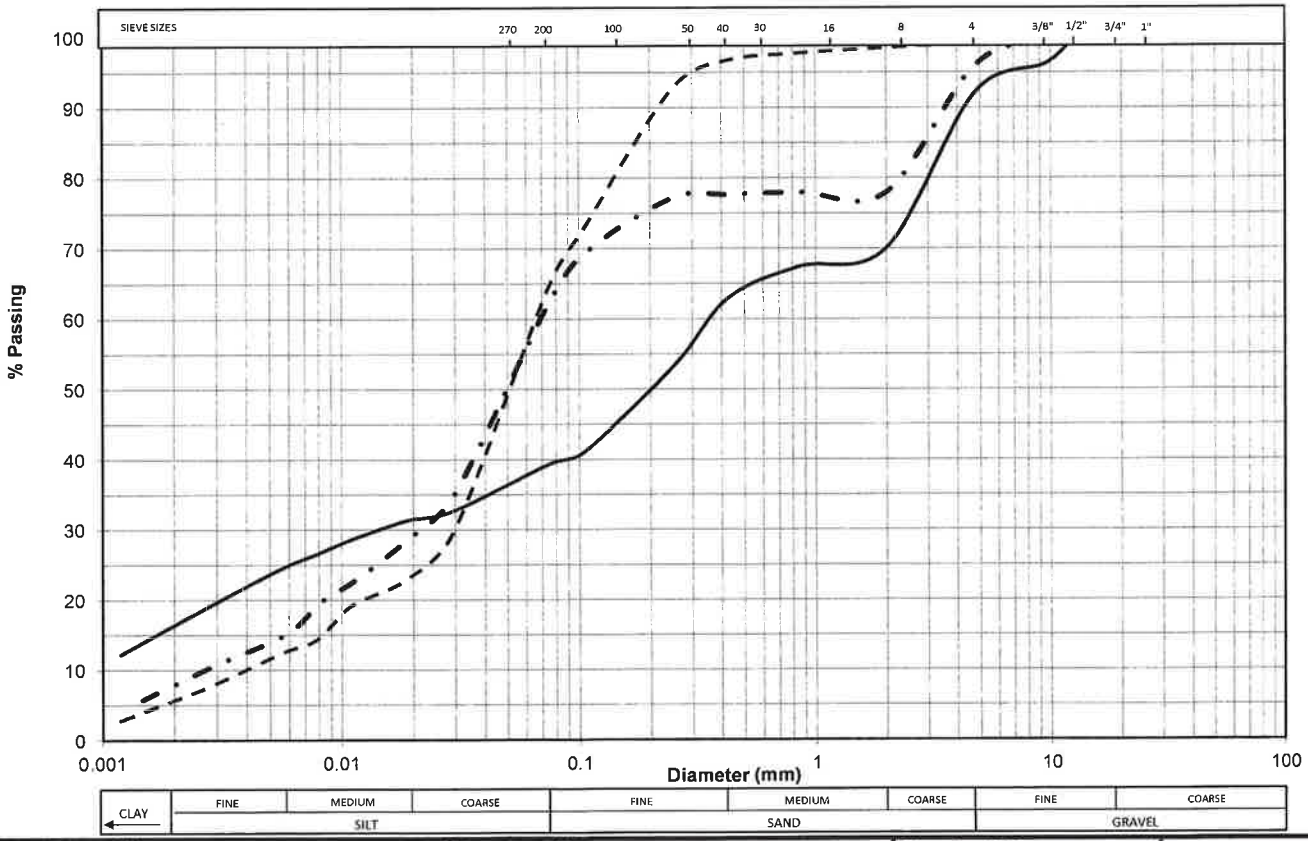
Client: Ainley Group

Date Sampled: December 5, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 2-1 SA3	1.5 - 2.1	Silty Sand Till, some Clay	
2	BH 2-1 SA6	3.8 - 4.4	Sandy Silt Till	
3	BH 2-1 SA9	7.6 - 8.2	Sandy Silt Till	

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-524/C

Figure No.: D5

Project No.: BAR-000203602-A0

Date Tested: January 2012

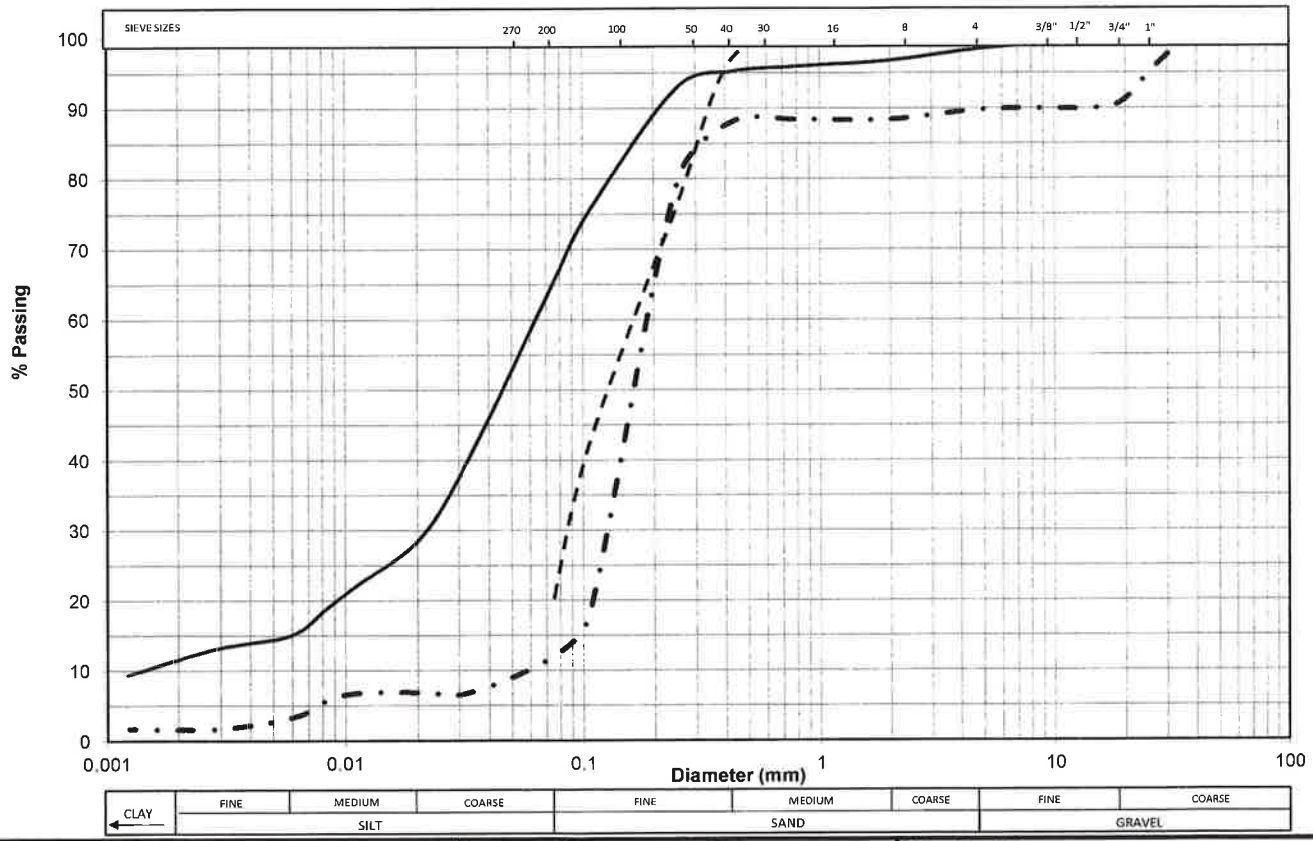
Client: Ainley Group

Date Sampled: December 6, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 2-2 SA4	2.3 - 2.9	Sandy Silt Till	
2	BH 2-2 SA8	6.1 - 6.7	Sand, some Silt	- - - - - - - -
3	BH2-2 SA11	10.7 - 11.3	Sand, some Silt	-·-·-·-·-·-

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-524/C

Figure No.: D6

Project No.: BAR-000203602-A0

Date Tested: January 2012

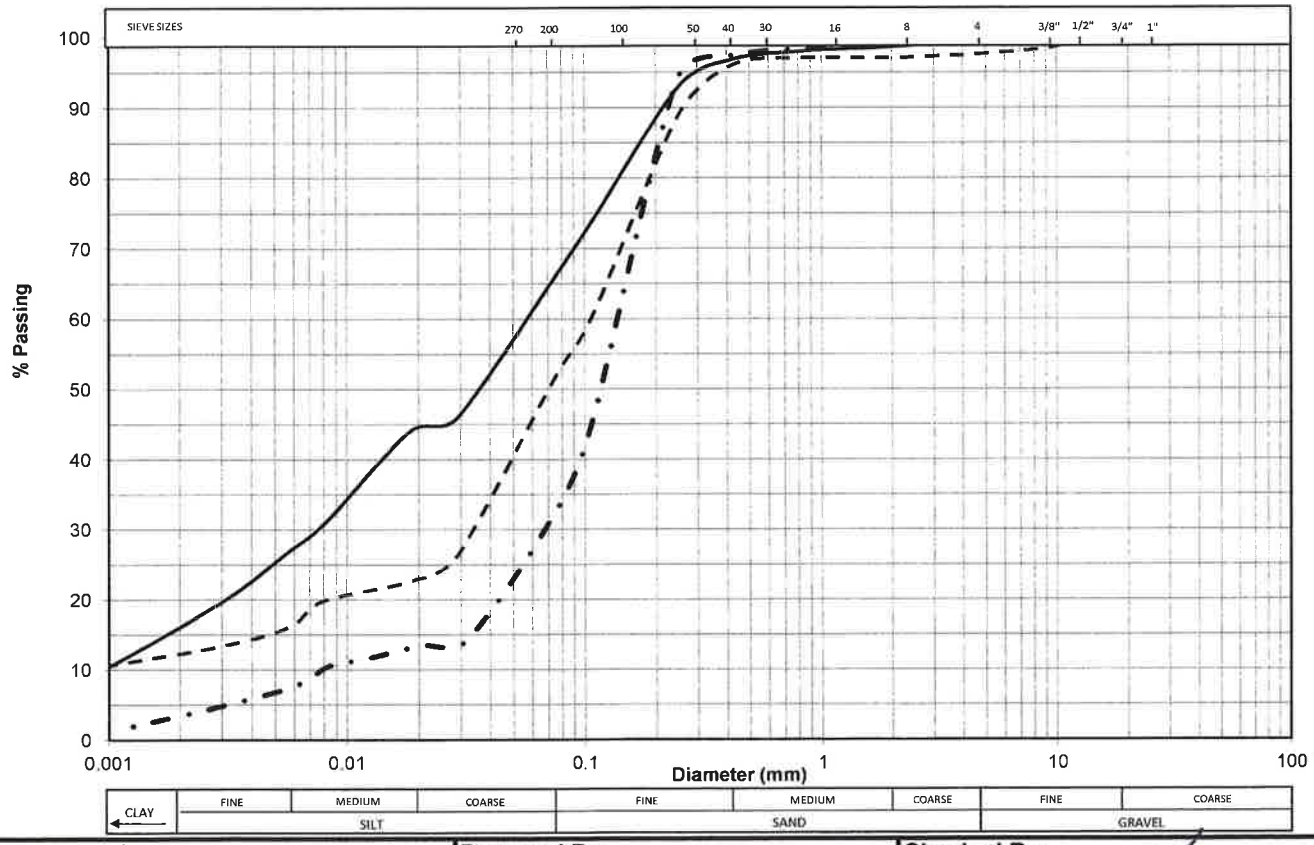
Client: Ainley Group

Date Sampled: December 6, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 2-3 SA5	3.0 - 3.7	Sandy Silt Till	
2	BH 2-3 SA8	6.1 - 6.7	Sandy Silt Till	
3	BH 2-3 SA11	10.7 - 11.3	Silty Sand Till	

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-522/C

Project No.: BAR-000203602-A0

Client: Ainley Group

Figure No.: D7

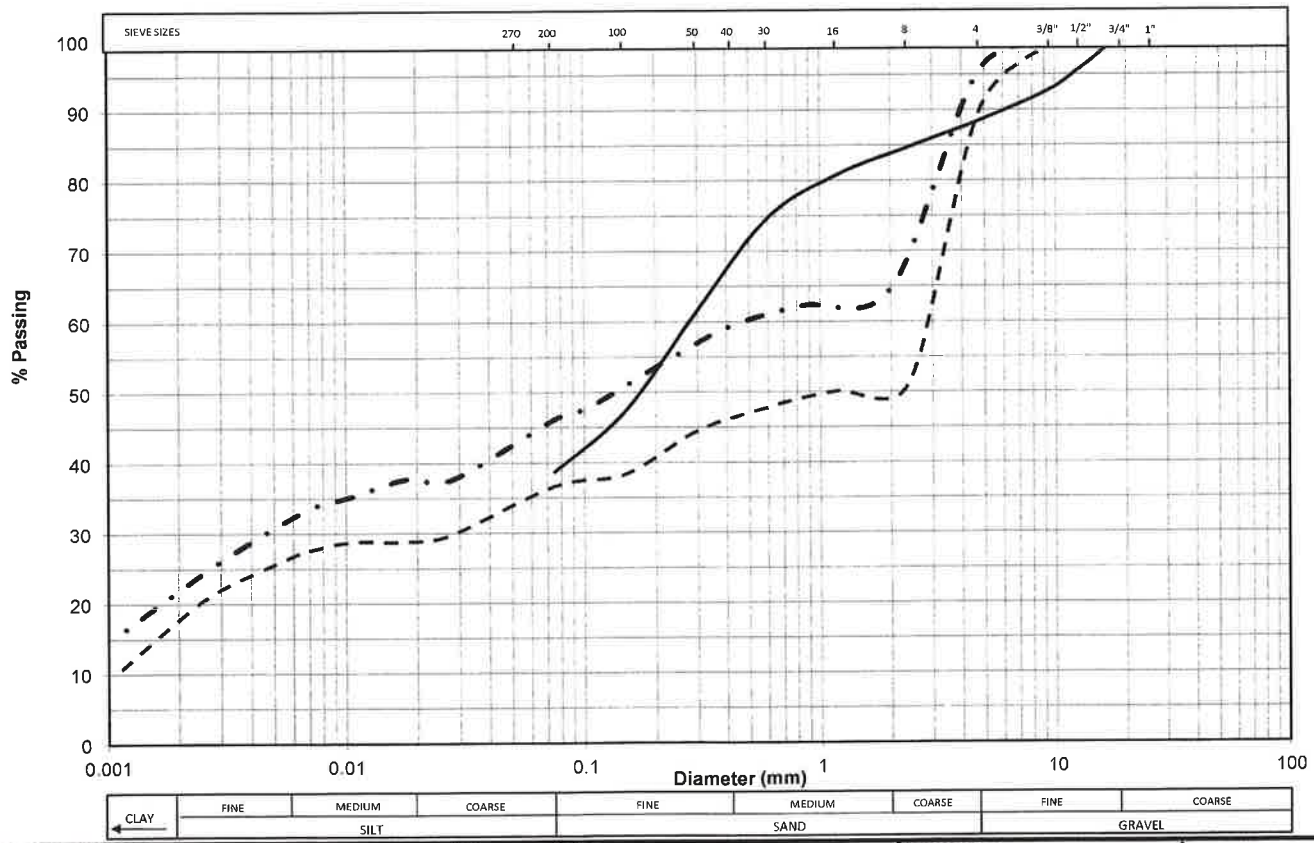
Date Tested: January 2012

Date Sampled: December 5, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 3-1 SA3	1.5 - 2.1	Silty Sand Till	
2	BH 3-1 SA5	3.0 - 3.7	Silty Sand Till	
3	BH 3-1 SA7	4.6 - 5.2	Silty Sand Till	

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-522/C

Figure No.: D8

Project No.: BAR-000203602-A0

Date Tested: January 2012

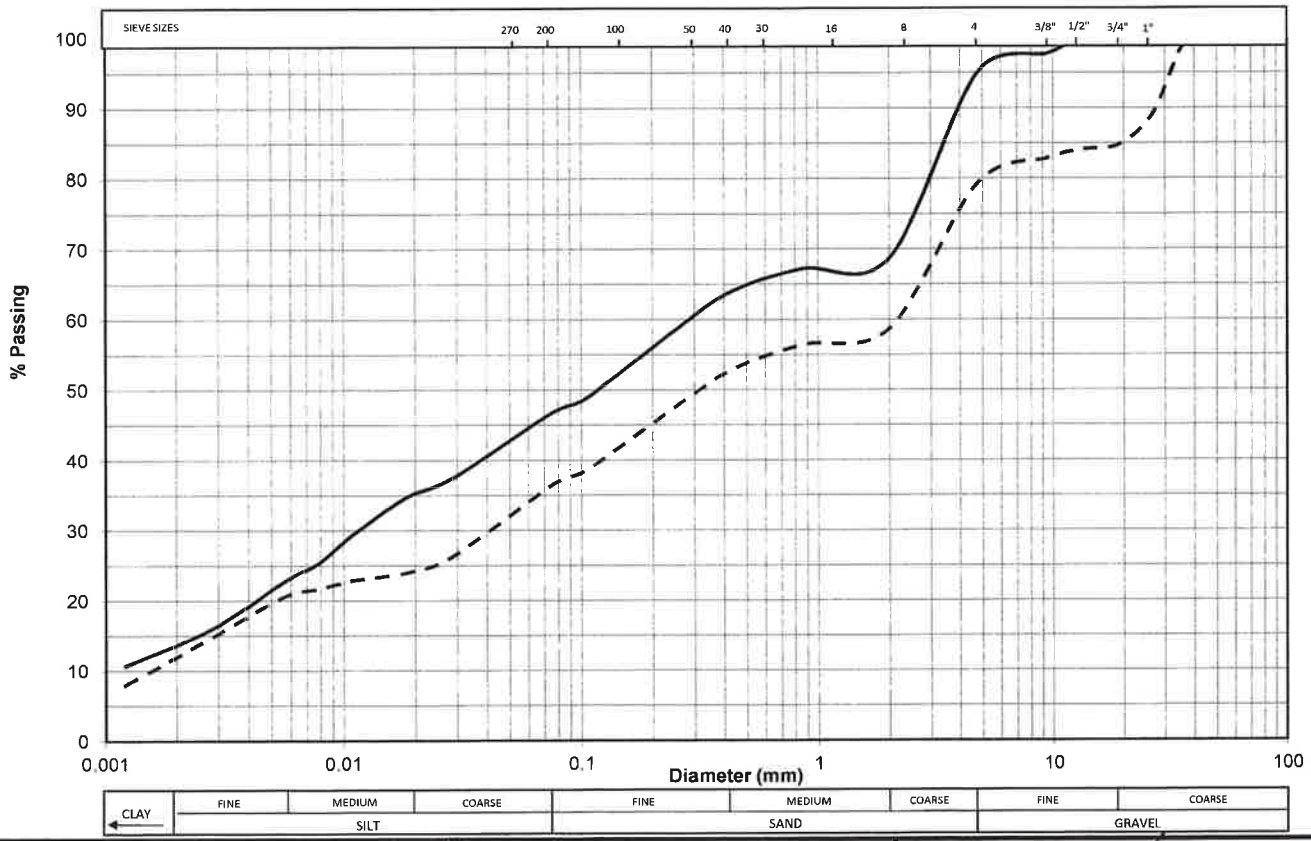
Client: Ainley Group

Date Sampled: December 2, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 3-2 SA4	2.3 - 2.9	Silty Sand Till	
2	BH 3-2 SA7	4.6 - 5.2	Silty Sand Till	
3				

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-522/C

Figure No.: D9

Project No.: BAR-000203602-A0

Date Tested: February 2012

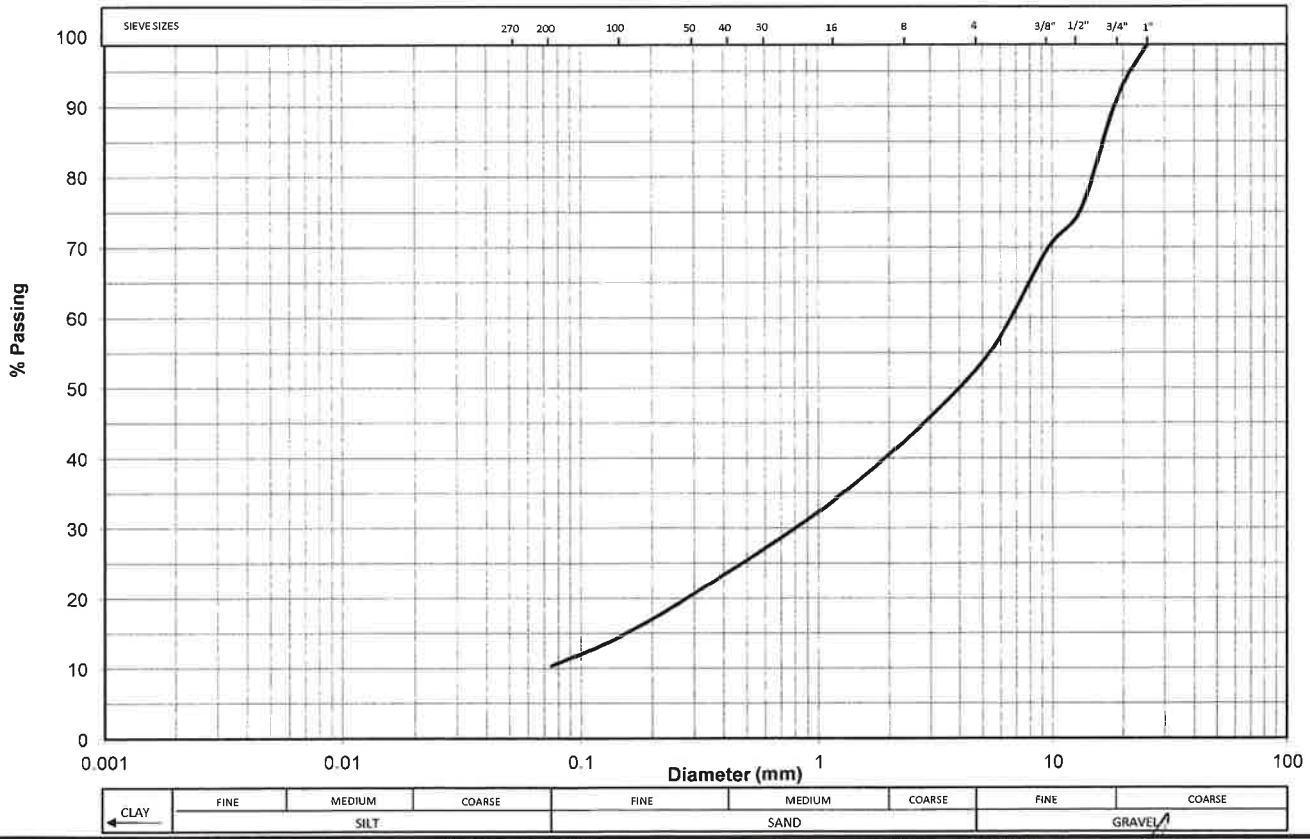
Client: Ainley Group

Date Sampled: December 2, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 3-2 SA8	6.1 - 6.9	Sand and Gravel, Trace to some Silt	
2				
3				

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-522/C

Figure No.: D10

Project No.: BAR-000203602-A0

Date Tested: January 2012

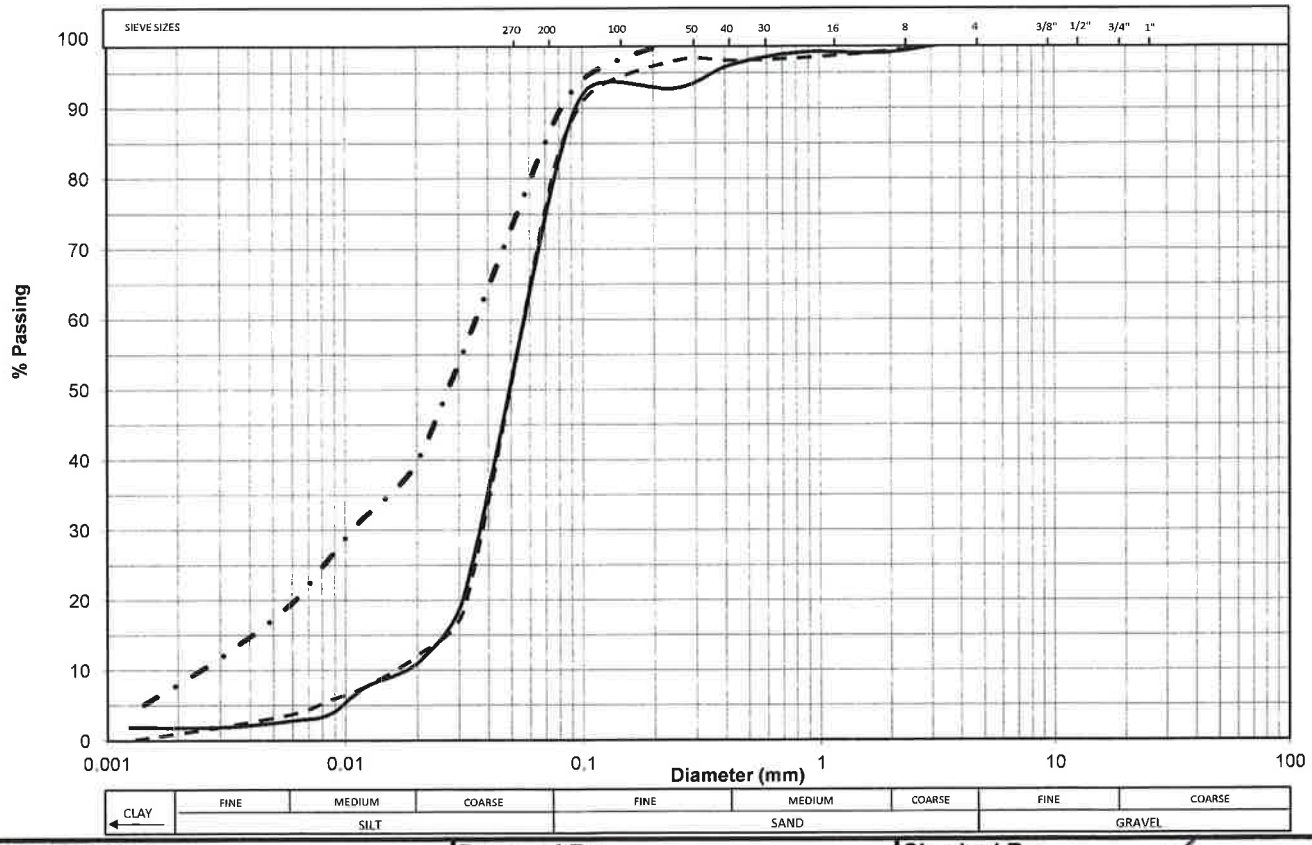
Client: Ainley Group

Date Sampled: December 2 & 5, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 3-1 SA10	9.1 - 9.8	Silt, some Sand	
2	BH 3-2 SA10	9.1 - 9.8	Silt, some Sand	
3	BH 3-2 SA13	13.7 - 14.3	Silt, some Sand	

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-425/C

Figure No.: D11

Project No.: BAR-000203602-A0

Date Tested: January 2012

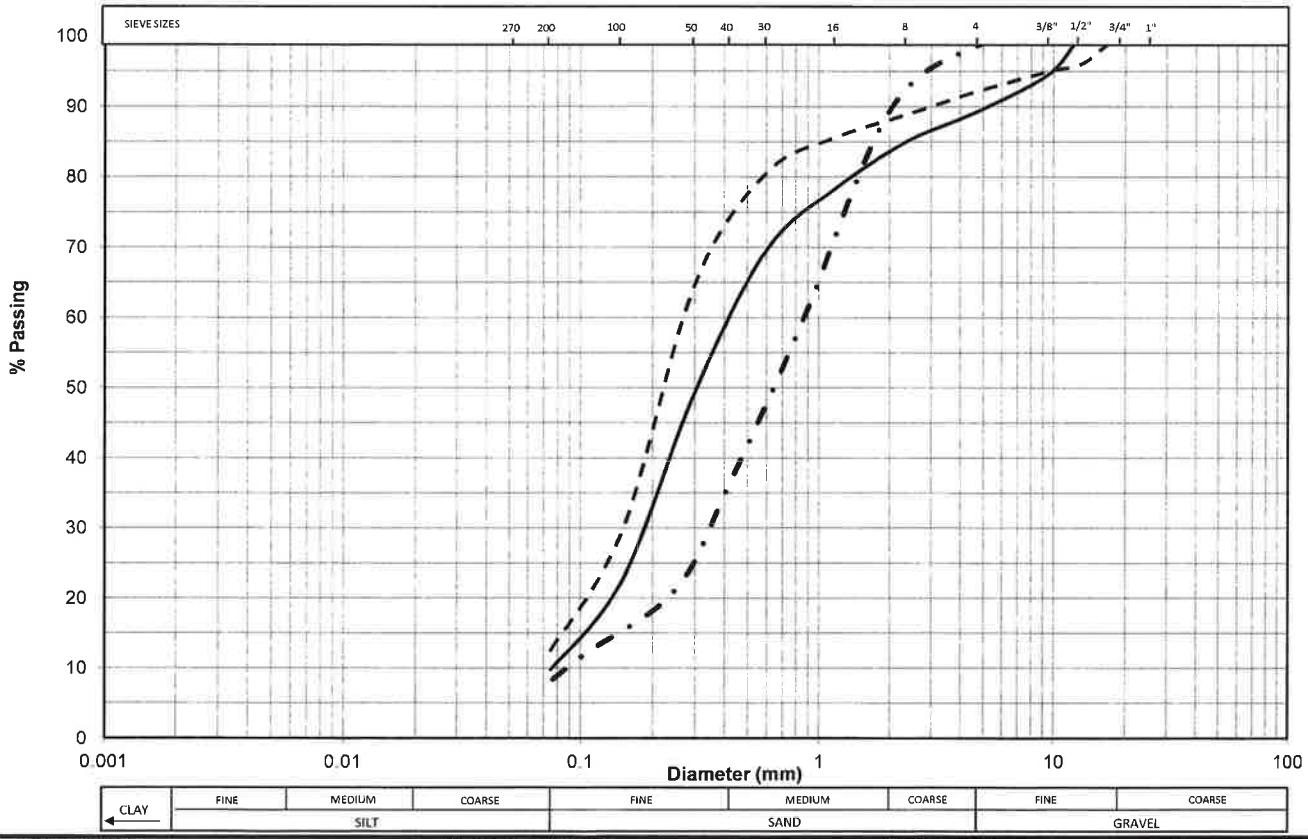
Client: Ainley Group

Date Sampled: November 30, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 4-1 SA4	2.3 - 2.9	Sand, some Silt	———
2	BH 4-2 SA4	2.3 - 2.9	Sand, some Silt	- - - - -
3	BH 4-2 SA6A	3.8 - 4.0	Sand, trace Silt	-·-·-·-

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-425/C

Figure No.: D12

Project No.: BAR-000203602-A0

Date Tested: January 2012

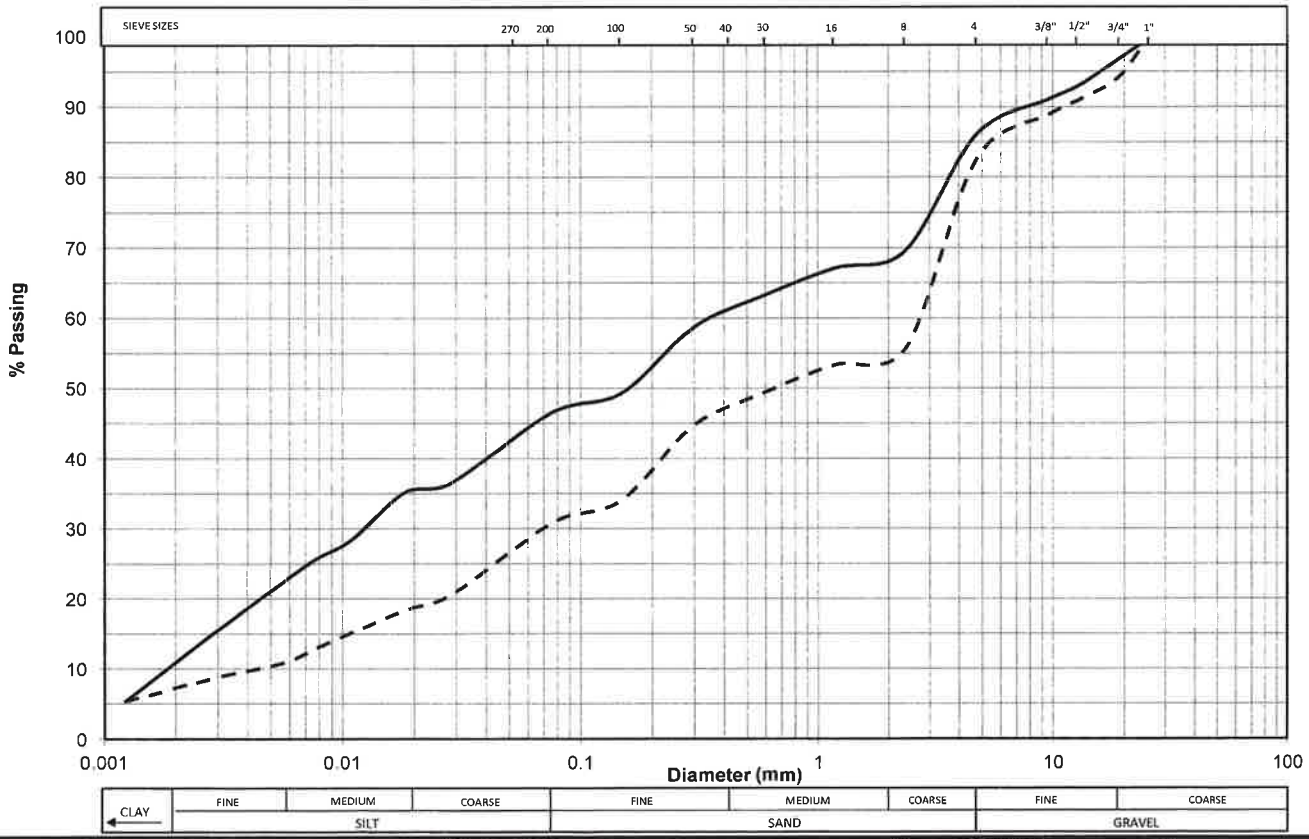
Client: Ainley Group

Date Sampled: November 30, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 4-1 SA6	3.8 - 4.4	Silty Sand Till	
2	BH 4-1 SA10	9.1 - 9.8	Silty Sand Till	
3				

Sieve Analysis



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Grain Size Analysis Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-425/C

Figure No.: D13

Project No.: BAR-000203602-A0

Date Tested: January 2012

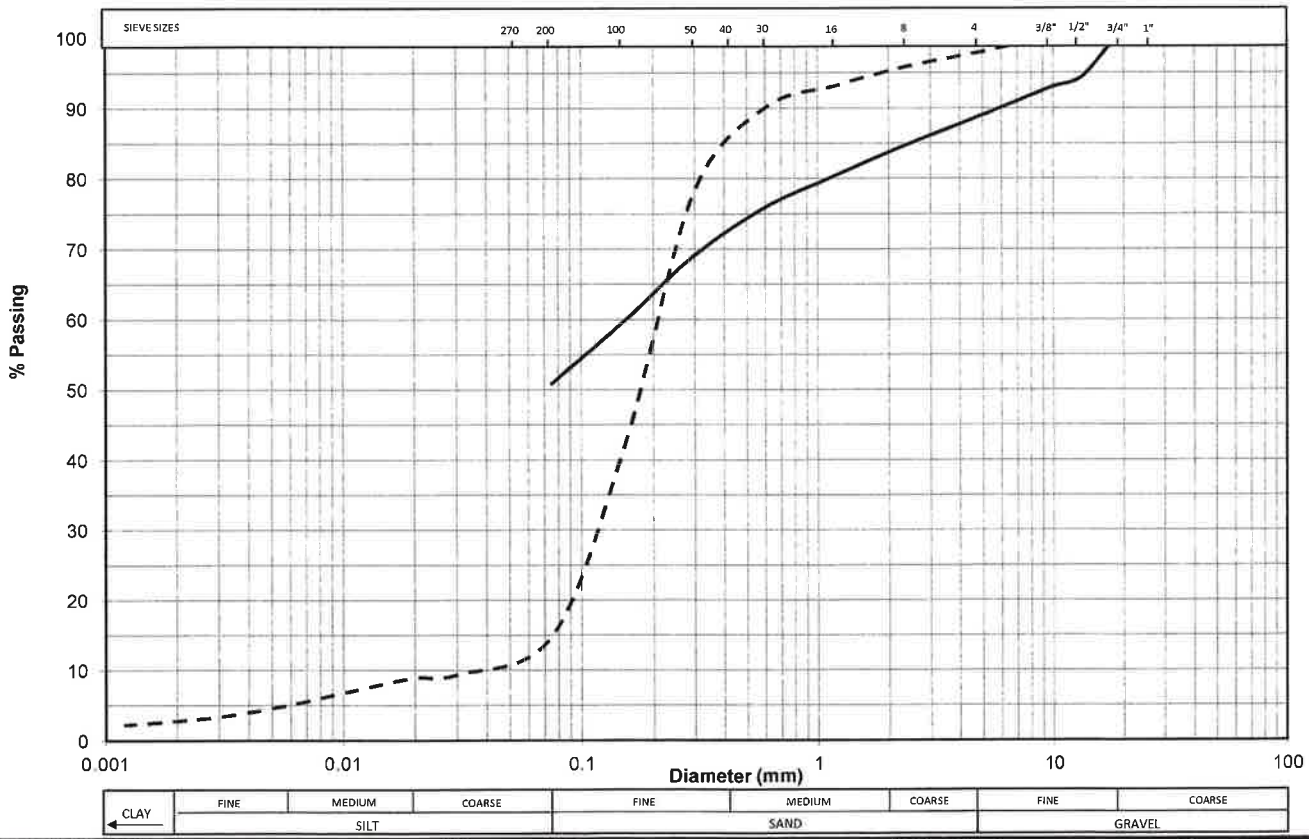
Client: Ainley Group

Date Sampled: November 30, 2011

SAMPLE INFORMATION

Material	Borehole No. and Sample No.	Sample Depth (m)	Material Description	Graph Line Type
1	BH 4-2 SA6B	4.0 - 4.2	Sandy Silt Till	
2	BH 4-2 SA8	6.1 - 6.5	Silty Sand Till	
3				

Sieve Analysis



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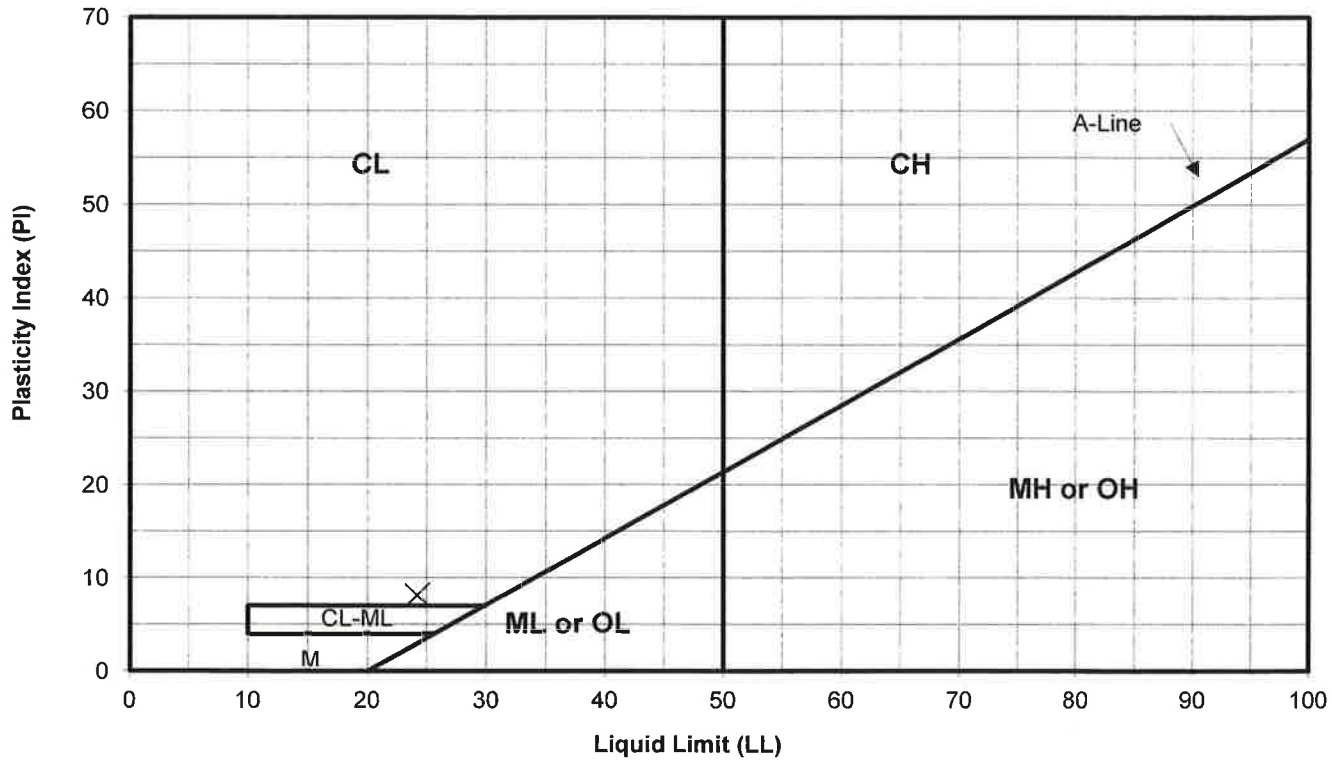
Atterberg Limits Report

Project Name: Foundation Investigation and Design - Highway 26 Culvert Replacements, Culvert #30-577/C
Project No.: BAR-00203602
Client: Ainley Group

Figure No.: D14
Date Tested: January 12, 2012
Date Sampled: December 7, 2011

SAMPLE INFORMATION								
SAMPLE ID	BH 1-2 - SA 5	LIQUID LIMIT (LL):	24.2	PLASTIC LIMIT (PL)	16.0	PLASTIC INDEX (PI)	8.2	X
SAMPLE ID		LIQUID LIMIT (LL):		PLASTIC LIMIT (PL)		PLASTIC INDEX (PI)		+
SAMPLE ID		LIQUID LIMIT (LL):		PLASTIC LIMIT (PL)		PLASTIC INDEX (PI)		□

Plasticity Chart



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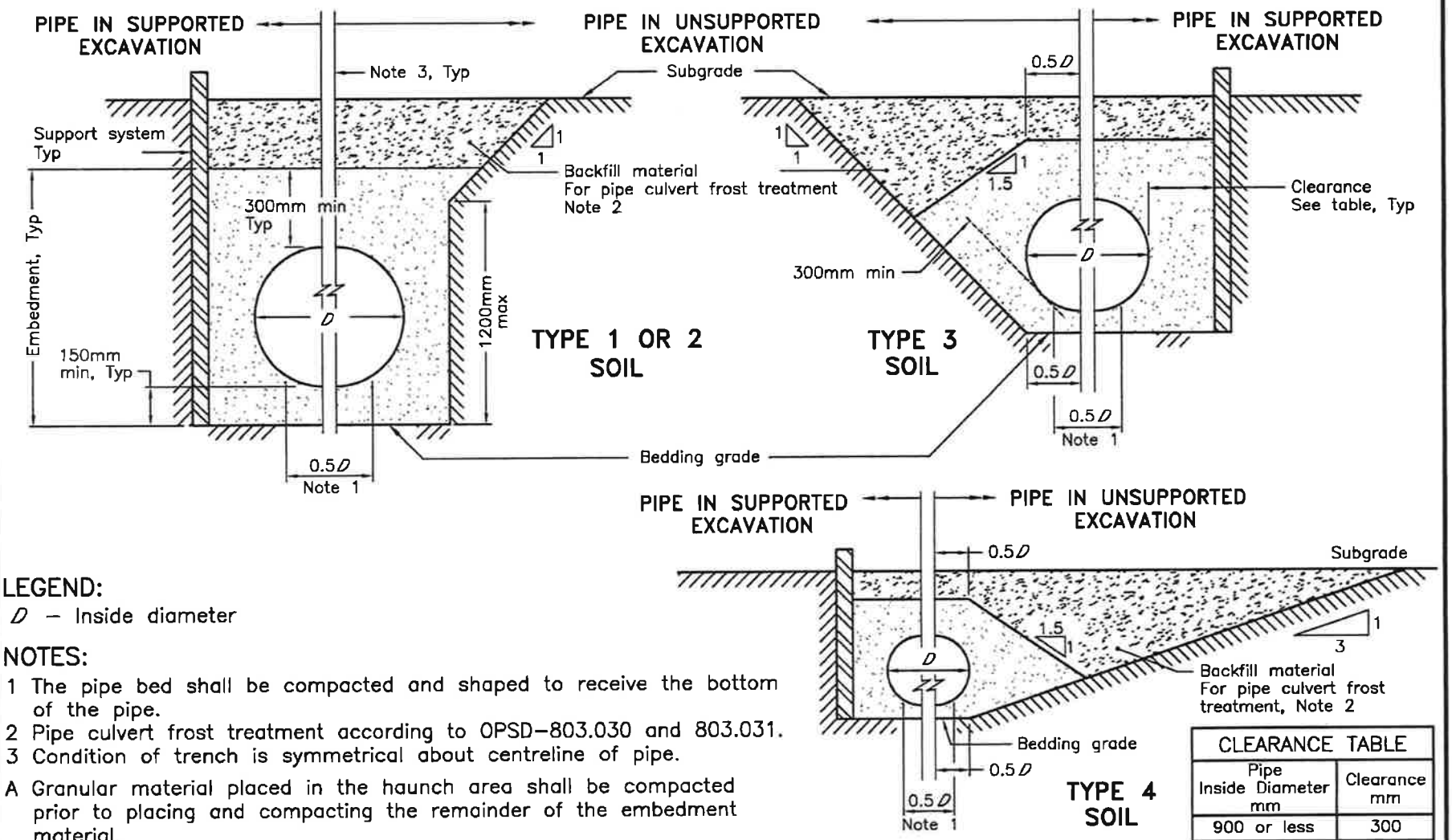
APPENDIX E

OPSD Specifications



LEGEND:

D – Inside diameter

NOTES:

1 The pipe bed shall be compacted and shaped to receive the bottom of the pipe.
2 Pipe culvert frost treatment according to OPSD–803.030 and 803.031.
3 Condition of trench is symmetrical about centreline of pipe.

A Granular material placed in the haunch area shall be compacted prior to placing and compacting the remainder of the embedment material.
B Soil types as defined in the Occupational Health and Safety Act and Regulations for Construction Projects.
C All dimensions are in metres unless otherwise shown.

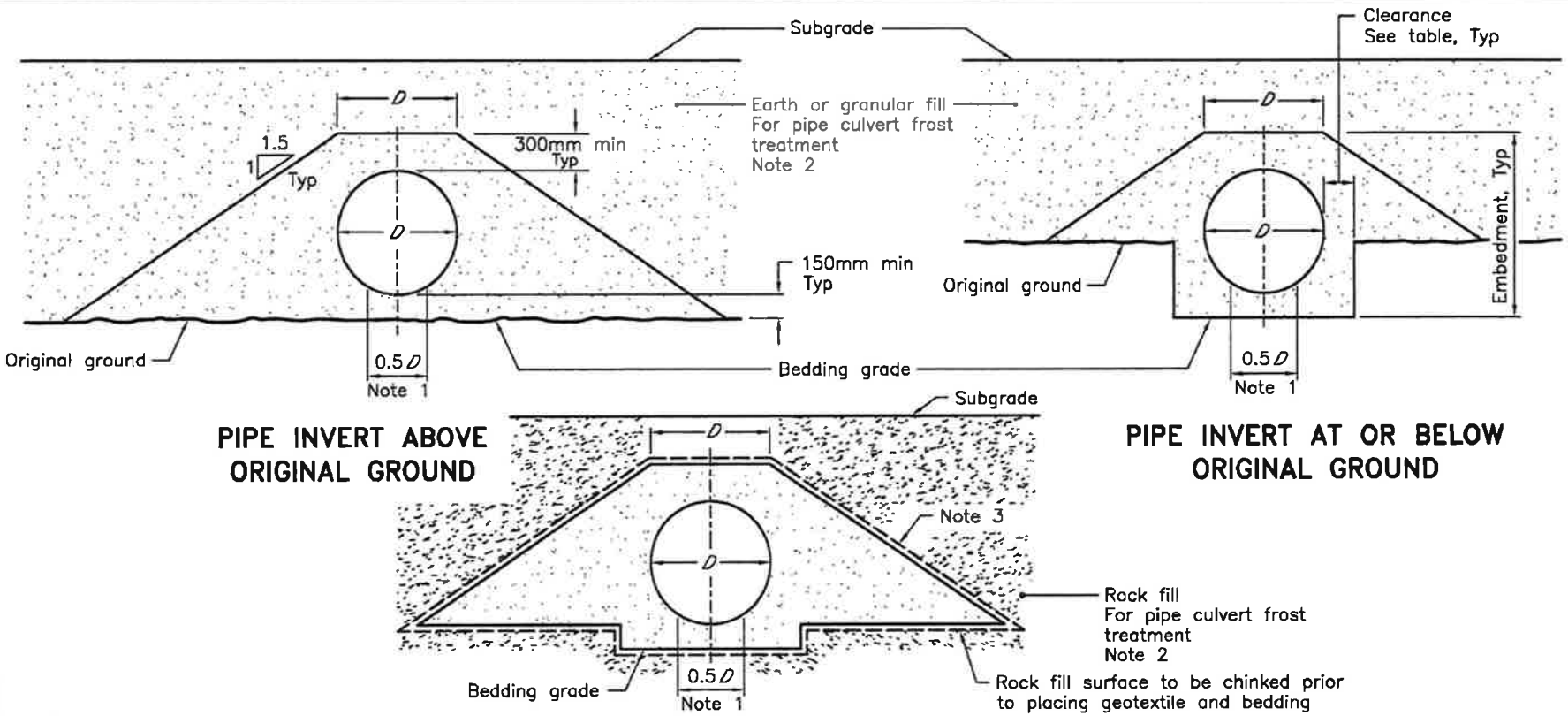
CLEARANCE TABLE	
Pipe Inside Diameter mm	Clearance mm
900 or less	300
Over 900	500

ONTARIO PROVINCIAL STANDARD DRAWING

FLEXIBLE PIPE EMBEDMENT AND BACKFILL EARTH EXCAVATION

Nov 2005 | Rev 1

OPSD – 802.010



PIPE EMBEDMENT
WITH ROCK FILL UNDER AND OVER THE PIPE

LEGEND:

D – Inside diameter

NOTES:

1 The pipe bed shall be compacted and shaped to receive the bottom of the pipe.

2 Pipe culvert frost treatment according to OPSD–803.030 and 803.031.

3 Embedment material to be wrapped in non–woven geotextile when specified.

A Granular material placed in the haunch area shall be compacted prior to placing and compacting the remainder of the embedment material.

B All dimensions are in metres unless otherwise shown.

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

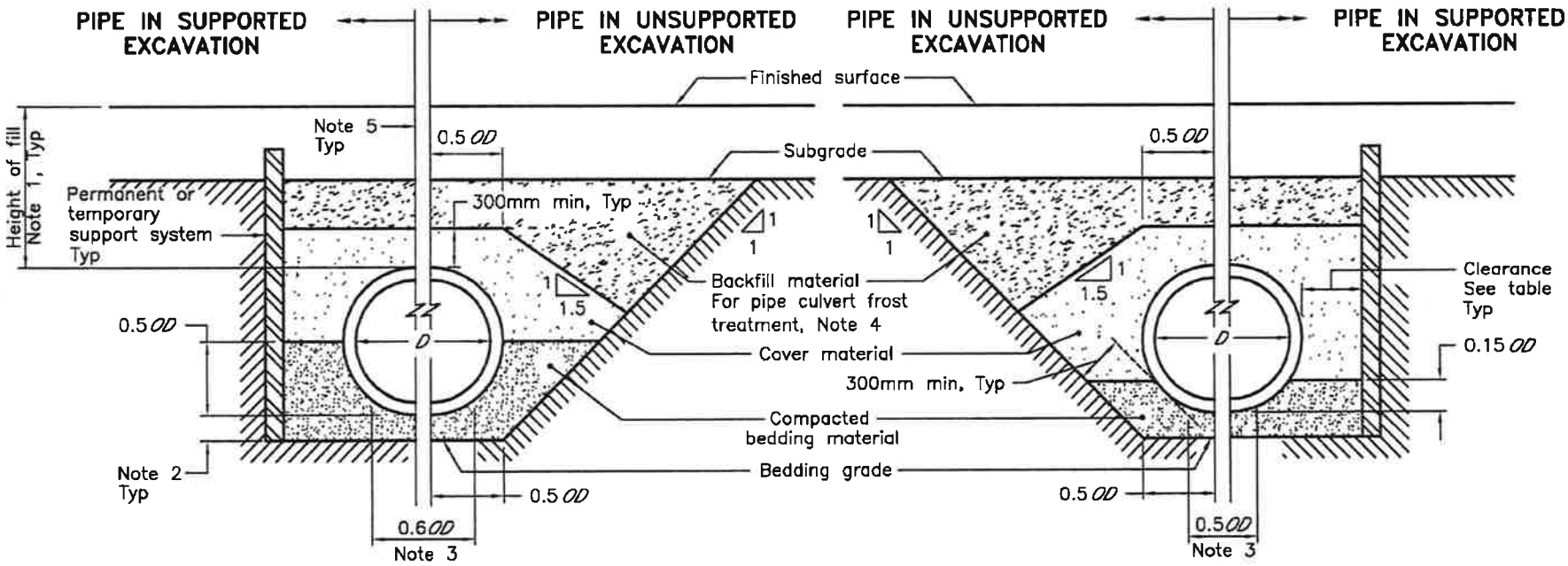
ONTARIO PROVINCIAL STANDARD DRAWING

FLEXIBLE PIPE EMBEDMENT IN EMBANKMENT ORIGINAL GROUND: EARTH OR ROCK

Nov 2005 | Rev 1

ONTARIO STANDARDS · MUNICIPAL – PROVINCIAL · OPSD

OPSD – 802.014



CLASS B BEDDING **CLASS C BEDDING**

NOTES:

1 Height of fill is measured from the finished surface to top of pipe.
2 The minimum bedding depth below the pipe shall be 0.15*D*. In no case shall this dimension be less than 150mm or greater than 300mm.
3 The pipe bed shall be compacted and shaped to receive the bottom of the pipe.
4 Pipe culvert frost treatment shall be according to OPSD 803.030 and 803.031.
5 Condition of excavation 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.

LEGEND:

D – Inside diameter
OD – Outside diameter

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

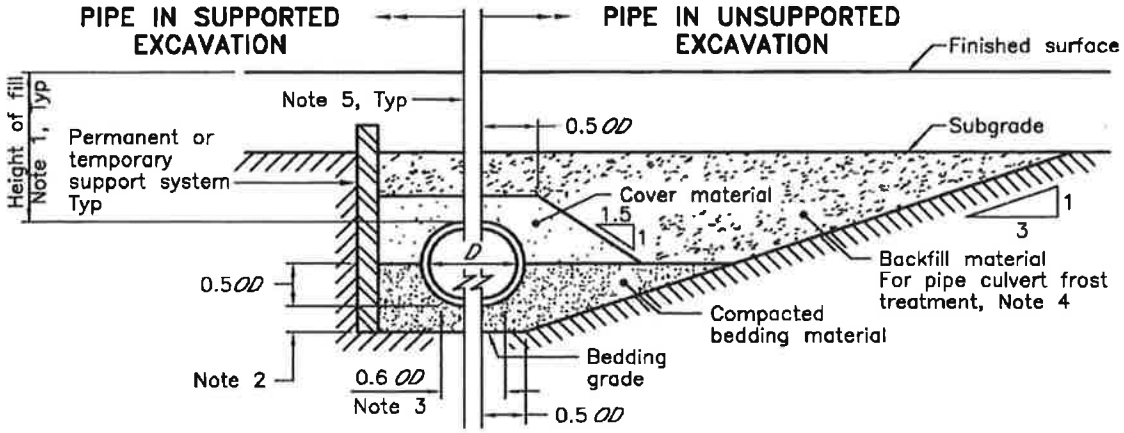
ONTARIO PROVINCIAL STANDARD DRAWING

RIGID PIPE BEDDING, COVER, AND BACKFILL TYPE 3 SOIL – EARTH EXCAVATION

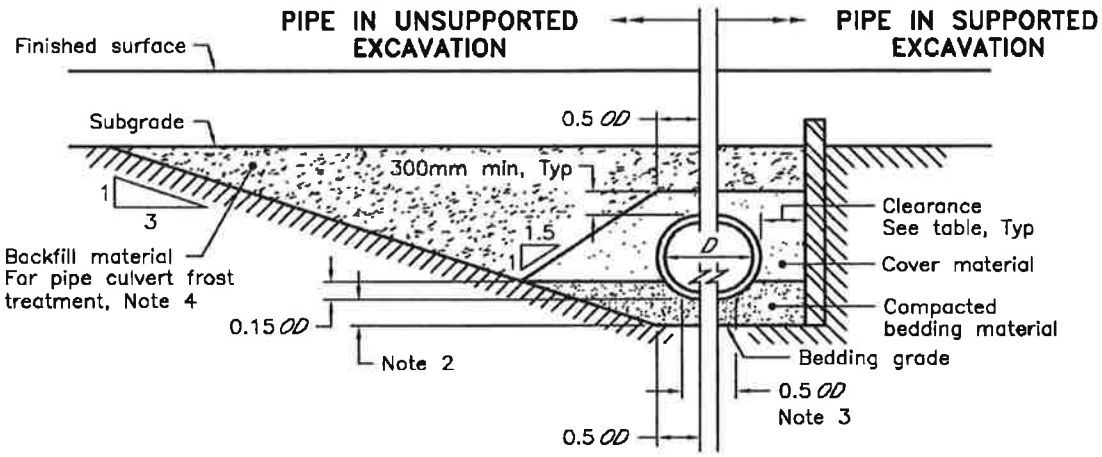
Nov 2010 | Rev 2

ONTARIO STANDARDS · MUNICIPAL – PROVINCIAL · OPS

OPSD 802.031



CLASS B BEDDING



CLASS C BEDDING

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

LEGEND:

D – Inside diameter

OD – Outside diameter

NOTES:

1 Height of fill is measured from the finished surface to top of pipe.

2 The minimum bedding depth below the pipe shall be 0.15*D*. In no case shall this dimension be less than 150mm or greater than 300mm.

3 The pipe bed shall be compacted and shaped to receive the bottom of the pipe.

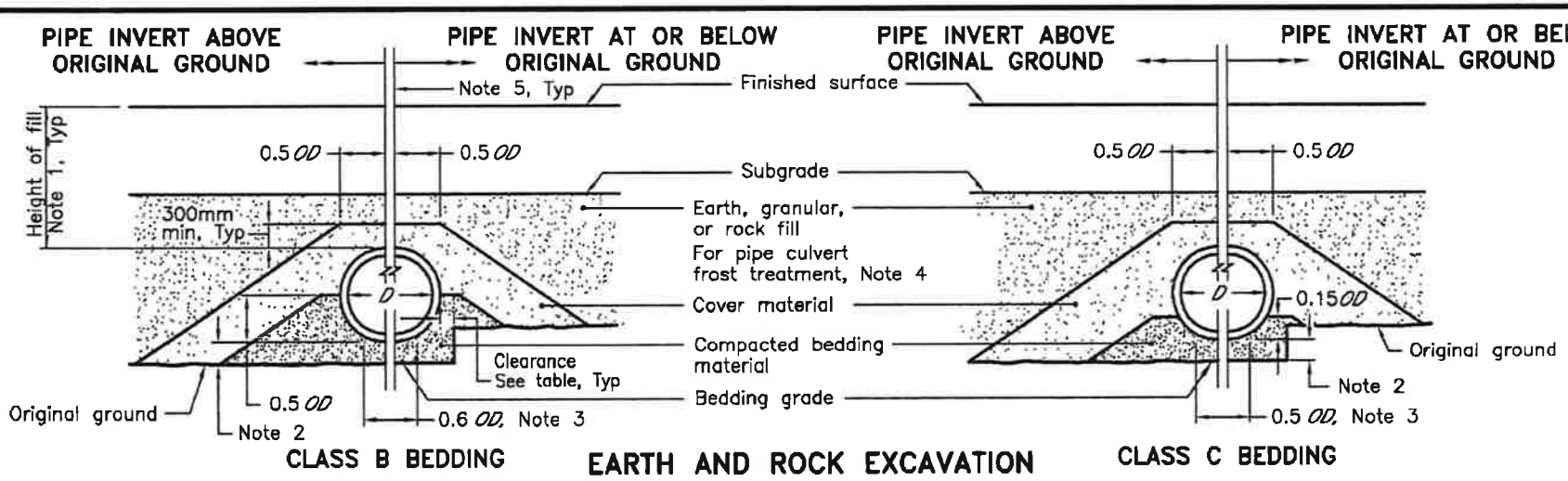
4 Pipe culvert frost treatment shall be according to OPSD 803.030 and 803.031.

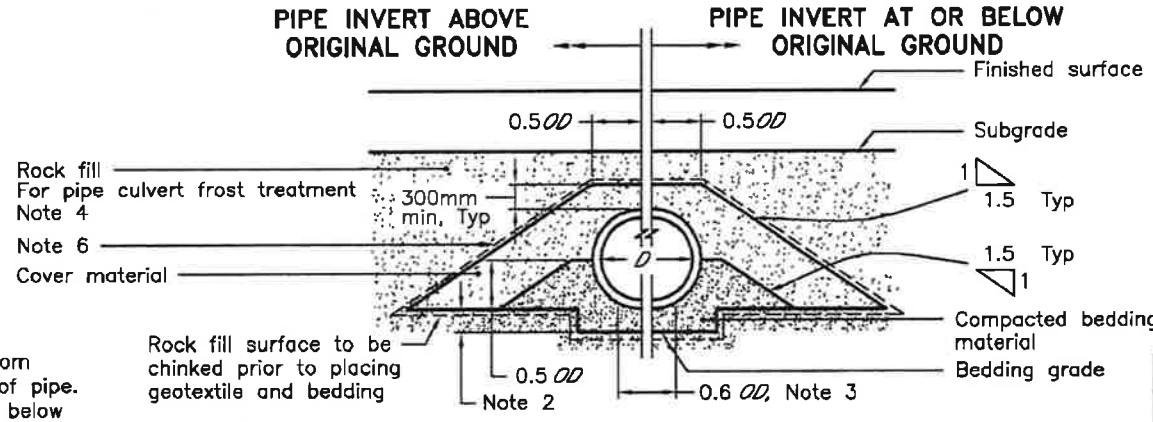
5 Condition of excavation is symmetrical about centreline of pipe.

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 2010	Rev 2
RIGID PIPE BEDDING, COVER, AND BACKFILL TYPE 4 SOIL – EARTH EXCAVATION		OPSD 802.032





PIPE BEDDING AND COVER WITH ROCK FILL UNDER AND OVER THE PIPE

LEGEND:

D – Inside diameter
OD – Outside diameter

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

NOTES:

1 Height of fill is measured from the finished surface to top of pipe.
2 The minimum bedding depth below the pipe shall be 0.15*D*, except on a rock foundation where the minimum bedding depth shall be 0.25*D*. In no case shall the minimum dimension be less than 150mm or the maximum dimension exceed 300mm.
3 The pipe bed shall be compacted and shaped to receive the bottom of the pipe.
4 Pipe culvert frost treatment shall be according to OPSD 803.030 and 803.031.
5 Condition of excavation is symmetrical about centreline of pipe.
6 Bedding and cover material shall be wrapped in non–woven geotextile when specified.

A All dimensions are in metres unless otherwise shown.

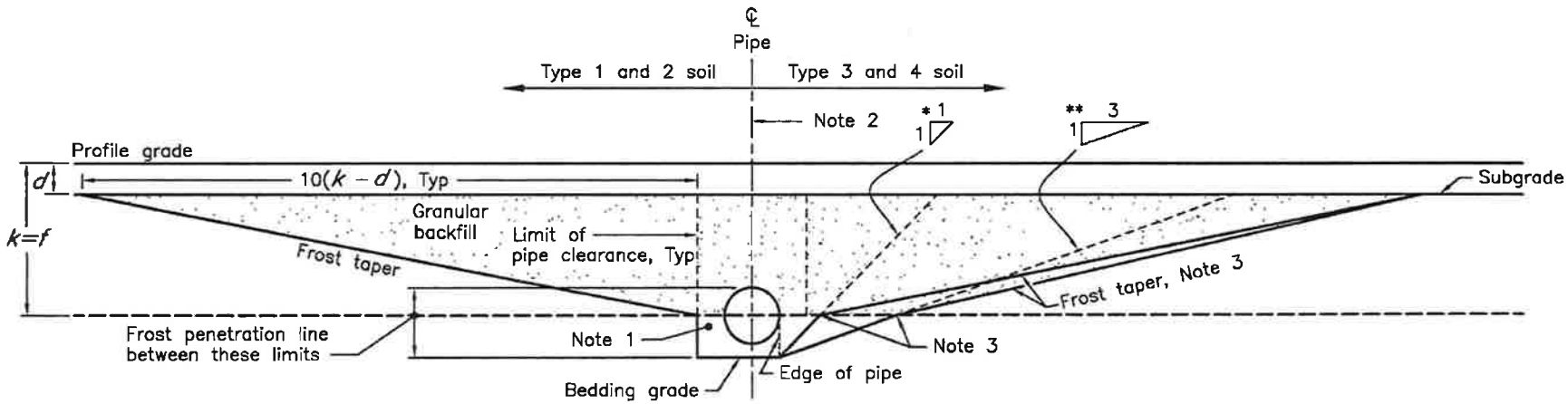
ONTARIO PROVINCIAL STANDARD DRAWING

RIGID PIPE BEDDING AND COVER IN EMBANKMENT ORIGINAL GROUND: EARTH OR ROCK

Nov 2010 | Rev 2

ONTARIO STANDARDS · MUNICIPAL – PROVINCIAL

OPSD 802.034



FROST TREATMENT – RIGID AND FLEXIBLE PIPE

NOTES:

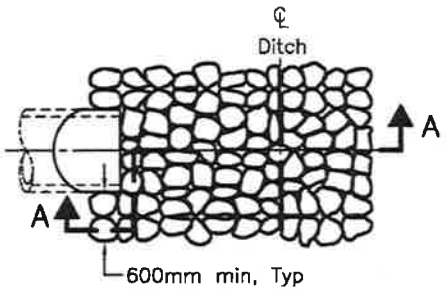
1 Pipe embedment or bedding, cover, and backfill according to:
   a) Flexible – OPSD–802.010, 802.013, 802.014, 802.020, 802.023 and 802.024
   b) Rigid – OPSD–802.030, 802.031, 802.032, 802.033, 802.034, 802.050, 802.051, 802.052, 802.053, and 802.054
2 Condition of frost treatment symmetrical about 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.

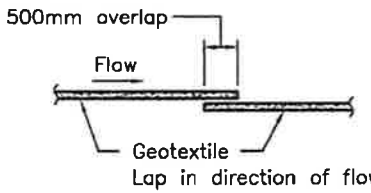
LEGEND:

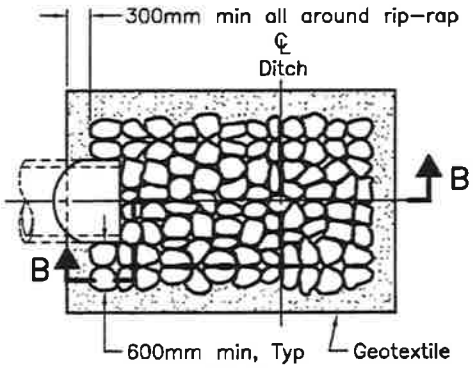
d – depth of roadbed granular
k – depth of frost treatment
f – depth of frost penetration
* – Type 3 soil
** – Type 4 soil

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2005	Rev 2
FROST TREATMENT – PIPE CULVERTS FROST PENETRATION LINE BETWEEN TOP OF PIPE AND BEDDING GRADE		
	OPSD – 803.031	

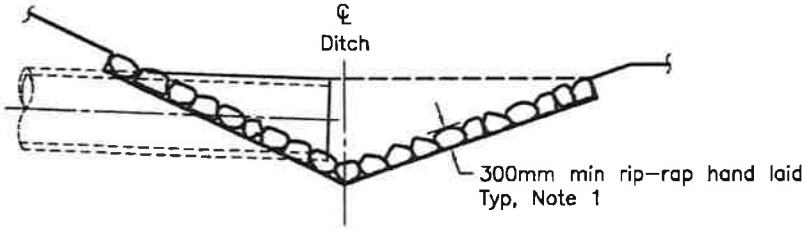


PLAN
CUT OR FILL

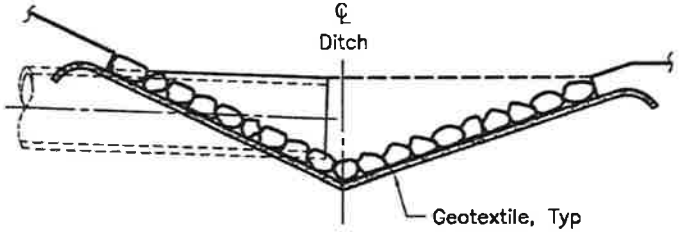




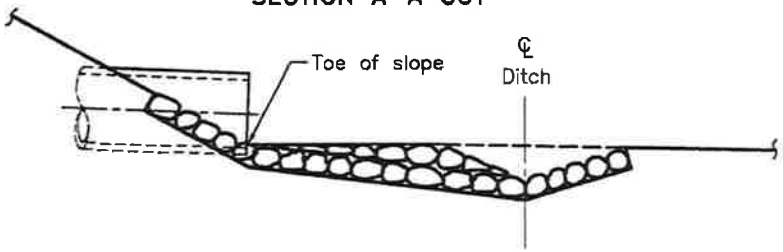
PLAN
CUT OR FILL



SECTION A–A CUT

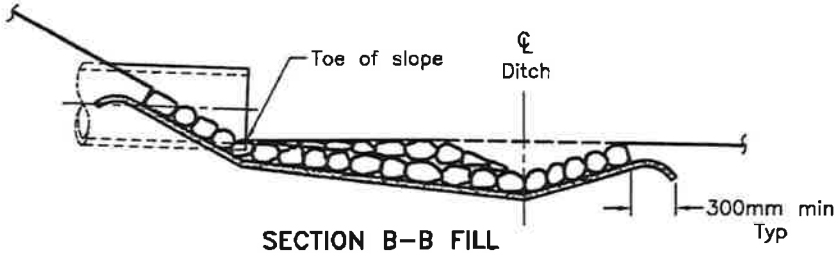


SECTION B–B CUT



SECTION A–A FILL

TYPE A – WITHOUT GEOTEXTILE



SECTION B–B FILL

TYPE B – WITH GEOTEXTILE

NOTES:

1 The thickness of the rip–rap layer shall be at least 1.5 times the rip–rap mean diameter.

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING

RIP–RAP TREATMENT FOR SEWER AND CULVERT OUTLETS

Nov 2007 | Rev 1

ONTARIO STANDARDS – MUNICIPAL – PROVINCIAL

OPSD 810.010