



**Foundation Investigation and
Design Report**

Highway 8
Richardson Drain Culvert Replacement
Station 17+696
Township of Perth South
Site No. 25-319-C

G.W.P. 344-97-00
W.P. 3043-06-04

Geocres No. 40P6-21

Project No. 165000741

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FOUNDATION INVESTIGATION REPORT

For
G.W.P 344-97-00
W.P. 3043-06-04

Highway 8 – Richardson Drain Culvert Replacement
Station 17+696
Site No. 25-319-C
Township of Perth South

1.0 Introduction

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation, Ontario (MTO) to undertake the detailed design for the replacement of an existing centreline culvert for the Richardson Drain at approximately Station 17+696 on Highway 8, between Sebringville and Stratford, in the Township of Perth South, Ontario.

This Foundation Investigation Report has been prepared specifically and solely for the replacement of the centreline culvert for the following project:

Project Number: WP 344-97-00

Project Location: Highway 8, 1.6 km east of Perth County Road 135
Centreline Culvert Replacement, approximate Station 17+696

2.0 Site Description and Geology

Site Location

The site location is shown on the Key Plan inset to Drawing No. 1, provided in Appendix A. It is noted that for project orientation purposes, Highway 8 will be assumed to run east-west at this location, with chainage increasing from west to east.

General Site Description

Although within the project limits Highway 8 is classified as a two-lane Rural Arterial Undivided highway (see Photos 1 and 2 in Appendix A), the section in the immediate vicinity of the culvert is two lanes with curbs and gutter, and sidewalk on both sides. Drainage is provided via catchbasins.

At the culvert, an embankment approximately 2.2 m high with 2H:1V side slopes is present on both sides (see Photos 3 and 4 in Appendix A). On the north side, away from the culvert, the highway is at approximately the same grade as the adjacent properties. On the south side, the adjacent properties are slightly lower than the elevation of the highway.

Existing Culvert

The existing culvert is a concrete open footing culvert 3 m by 1.5 m by 20 m with a CSP extension at the north end comprised of two 1.8 m diameter Corrugated Steel Pipes (CSP) (Photos 3 and 4, Appendix A). The portion of the concrete culvert from the south end to approximately the north curb line has a skew of approximately 36° relative to a perpendicular from the road. Just behind the north curb line the concrete culvert bends to the north so that it is almost perpendicular to the road (approximately a 4° skew). The CSP extension on the north end is approximately 2 m in length and is aligned at a skew of approximately 20° relative to a perpendicular from the road (See Photo No. 5 in Appendix A). The approximate alignment of the existing culvert is shown on Dwg. 1 in Appendix A. Flow in the culvert is from north to south.

The east CSP on the north side is partially blocked with stones, soil and tree branches (see Photo 6, Appendix A).

The outlet of the culvert is visible at the base of the embankment on the east side, approximately 2.1 m below the pavement surface (see Photos 3 and 4 in Appendix A).

Physiographic Description

The site is located within a physiographic region known as the Stratford till plain (Chapman and Putnam, The Physiography of Southern Ontario, 3rd Edition, 1984). This region is situated on a broad clay plain and is characterized by ground moraines. The till is described as fairly uniform, consisting of calcareous silty clay. The silt and clay contents vary as does the stoniness of the till, however, it is seldom classified as a stony till.

Drainage within the Stratford till plain is generally toward the southwest. The site is within the Thames River Watershed. In the immediate vicinity of the site, drainage is provided via storm sewers.

3.0 Method of Investigation

3.1 DRILLING INVESTIGATION

The foundation field investigation required for the culvert replacement consisted of four (4) boreholes. The boreholes were designated BH10-1 to BH10-4 and their locations are shown on the Borehole Location Plan, Drawing No.1 in Appendix A.

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

The field drilling program was carried out from May 25th to 27th, 2010. The boreholes were advanced with hollow stem augers using a rubber track-mounted Diedrich D-50 equipped for soil and bedrock sampling. A Dynamic Cone Penetration Test was carried out in one borehole, BH10-2, from a depth of 6.1 m to refusal at 8.2 m. The drilling equipment was owned and operated by London Soil Test of London, Ontario.

The subsurface stratigraphy encountered in each borehole was recorded in the field by an experienced Stantec Field Technologist. Split spoon samples were collected at regularly spaced intervals (typically every 760 mm). All samples recovered were returned to our Ottawa laboratory for detailed classification and testing. Boreholes were backfilled with auger cuttings mixed with bentonite to match observed stratigraphy, and road holes were topped with cold patch asphalt.

One piezometer was installed in BH10-1 on the morning of May 25th, 2010. The water level was measured late in the day on May 26th and the piezometer was removed using the winch on the drilling rig. The remaining opening was filled with bentonite to surface. The water level in the culvert was surveyed on May 27th, 2010.

3.2 SURVEY

Borehole locations were established in the field by Stantec personnel relative to the centerline of the existing alignment and the existing culvert. The ground surface elevation at each borehole location was surveyed by Stantec personnel with reference to a Geodetic Benchmark provided by MTO. The benchmark was an iron bar at station 17+633.491, along the sidewalk north of Highway 8. The Geodetic elevation of this benchmark is reported to be 356.6 m.

Table 3.1: Borehole Summary

	Boreholes			
	BH10-1	BH10-2	BH10-3	BH10-4
MTM Zone 10 Coordinates				
Northing	4808047	4808033	4808039	4808023
Easting	422083	422082	422064	422069
Station	17+696	17+703	17+683	17+697
Offset	15.0 Lt	1.9 Lt	2.2 Rt	12.5 Rt
Ground Surface Elevation, m	356.3	356.2	356.1	355.9
Total Depth Drilled, m	14.0	8.2	14.0	9.5
End of Borehole Elevation, m	342.4	348.0	342.2	346.4
Depth Augered, m	14.0	6.1	14.0	9.5
Number of Soil Samples	16	8	16	13
Depth Cored, m	0	0	0	0

3.3 LABORATORY TESTING

All samples were taken to our Ottawa laboratory where they were subjected to a detailed visual examination by a Geotechnical Engineer. Selected soil samples underwent plasticity testing (6 samples), gradation analysis (13 samples) and moisture content testing (16 samples).

It is noted that a nominal size of 0.005 mm has been utilized to distinguish between silt and clay sized particles.

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

4.0 Subsurface Conditions

4.1 SUBSURFACE PROFILE

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

In general, the subsurface stratigraphy consists of a pavement structure over a sandy clay to silty sand fill material overlying a sandy silty clay to silty clayey sand till material with gravel.

Borehole location plans and stratigraphic sections of the soils encountered within the boreholes are provided on Drawing No. 1 in Appendix A. An explanation of the symbols and terms used for these Borehole Records has been included in Appendix B.

4.1.1 Pavement Structure

The pavement structure was observed in Boreholes BH10-2 and BH10-3 and consists of 110 to 120 mm asphalt over about 180 mm of granular base and approximately 600 mm of granular subbase.

Grain size analysis (see Figure 1 in Appendix C) and moisture content testing on three samples of the material beneath the asphalt yielded the following results:

- 38% to 42% Gravel
- 44% to 49% Sand
- 12 to 14% Fines (silt and clay size particles)
- Moisture Content 2% to 3%

Based on the grain size distribution, the material may be classified as silty sand with gravel.

4.1.2 Sandy Clay Fill

A sandy clay fill layer was observed beneath the pavement structure in Boreholes BH10-2 and BH10-3, at ground surface in BH10-1 and beneath a 610 mm sandy topsoil in Borehole BH10-4. The fill layer was between 0.9 m and 1.6 m thick, with a base elevation of 353.6 m and 354.1 m.

The results of the gradation analyses on one sample indicates that the fill deposit contained 14% gravel, 31% sand, 37% silt and 18% clay size particles. The results of the gradation analyses are shown on Figure 2 in Appendix C. Atterberg Limit tests were performed on Sample BH10-3, SS3 from this deposit. It was found to have a liquid limit of 26 and a plastic limit of 16; the moisture content of the tested sample was 21%. (see Figure 5 in Appendix C).

This material is classified as sandy clay (CL). Trace organic material was observed in Borehole BH10-4. Pieces of wood were observed within the fill strata in Borehole BH10-2.

4.1.3 Sandy Silty Clay to Silty Clayey Sand Till

Sandy silty clay to silty clayey sand till with varying gravel content was found in all boreholes. All boreholes were terminated in this layer at depths ranging from 8.2 to 14.0 m below ground surface (El. 348.0 m to 342.2 m).

Standard Penetration Testing in this unit yielded N-values ranging from 12 to greater than 100 blows per 0.3 m, indicating compact to very dense material. It is noted that blow counts typically increased with depth.

The gradation of the till material varied with the coarse fraction generally increasing with depth.

Gradation tests were carried out on nine samples and the results are presented on Figures 3 and 4 in Appendix C. Atterberg Limit Tests were carried out on five samples and the results presented on Figure 5 in Appendix C. The test results are summarized as follows.

- 1% to 30% Gravel
- 9% to 39% Sand
- 42% to 90% Fines (silt and clay size particles)
- 15 to 19 Liquid Limit
- 10 to 12 Plastic Limit
- 7% to 18% Moisture Content

The till unit varies in classification from a CL-ML to SC-SM to GC-GM. Cobbles may be present within the till layer.

One sample of the till was submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis results are provided in Table 4.1.

Table 4.1: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
BH10-2	SS5	3.1 to 3.7	7.99	102	22	50.0

4.2 BEDROCK

Bedrock was not encountered within the depth of exploration during this investigation.

4.3 GROUNDWATER

The water level at the culvert outlet was surveyed on May 27, 2010, and was found to be at 354.6 m geodetic. This corresponded to a depth of water of approximately 500 mm in the stream channel.

A monitoring well was installed in BH10-1 on the morning of May 25, 2010. The water level was measured on the afternoon of May 26, 2010, to be at 1.65 m below ground surface, corresponding to an elevation of 354.6 m.

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

5.0 Closure

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

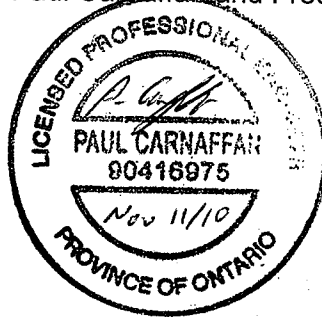
This report has been prepared by Paul Carnaffan and Fred Griffiths. A technical review was carried out by Raymond Haché.

Respectively Submitted;

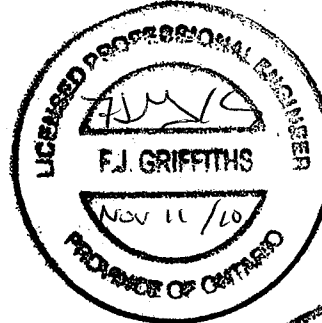
STANTEC CONSULTING LTD.



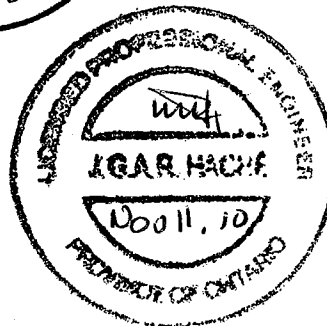
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FOUNDATION DESIGN REPORT

For

G.W.P. 344-97-00

W.P. 3043-06-04

Highway 8 – Richardson Drain Culvert Replacement

Station 17+696

Site No. 25-319-C

Township of Perth South

6.0 Discussion**6.1 PROJECT DESCRIPTION & BACKGROUND**Project Purpose/Justification

The Preliminary Design Report for GWP 344-97-00 indicates that, based on recent structural inspections, the existing Richardson Drain culvert structure is nearing the end of its useful service life and requires replacement. Deficiencies identified in the Preliminary Design Report include:

- Noticeable settlement at the sidewalks over both ends of the culvert indicating loss of fines.
- Pedestrian railings in poor condition.
- Extensive leachate stained pattern cracking in the structure under the roadway platform.
- Significant pattern cracking of the asphalt.

Performance of Existing Foundations

With the exception of the short CSP extension at the north end, the existing culvert is an open concrete culvert. No contract documents or foundation investigation and design reports were available for the existing structure to confirm the geometry of the existing foundations, however, based on the borehole data, it appears likely that the culvert is supported on strip footings bearing on the sandy silty clay with gravel (till) deposit.

An inspection of the existing culvert from a geotechnical perspective identified the following issues:

- Settlement and cracking of the sidewalks (see Photo 7 in Appendix A).
- Minor erosion of the west bank of the drain at the south end of the culvert (see Photo 8 in Appendix A).

The geotechnical inspection did not reveal any indications of problems associated with bearing capacity, settlement or scour of the existing culvert foundations.

Proposed Structure

It is understood that the proposed replacement culvert will have internal dimensions of 3.0 m x 2.1 m x 24.4 m and that the two bends in the existing culvert will be eliminated with a straight culvert alignment. The width of the base of the culvert will be 3.5 m. Due to the skew, the end sections of the culvert will likely be cast-in-place together with the retaining walls.

The Preliminary Design Report indicates that a precast concrete box culvert should be considered to minimize impacts to traffic and the community of Sebringville. It is understood that a rigid frame open footing culvert is also an option.

Key elevations associated with the proposed culvert replacement are as follows:

Pavement Elevation	356.3 m (approximate near C/L)
Invert Elevation:	353.9 m North End (approx) – inlet 353.4 m South End (approx) – outlet
Water Elevation:	354.6 m at time of Foundation Investigation (May 27, 2010) 355.09 m High water level (25-year storm event)
Founding Elevation	≥ 353.15 m Precast Concrete Box Culvert ≥ 352.0 m Rigid Frame Open Footing Culvert

The founding elevation for the precast concrete box culvert has been determined based on the assumption that the base of the culvert will be 300 mm thick and that 500 mm of natural substrate material will be required inside the box to meet environmental requirements. Cast-in-place cut-off walls will be provided at both ends of the culvert.

It is anticipated that cast-in-place retaining walls will be required on both sides of both ends of the culvert to retain the road embankment. The length of the four retaining walls is anticipated to be between 3 m and 4 m and the height of retained soil is anticipated to be up to 2 m.

Construction Staging & Detours

The existing platform width is approximately 16 m from sidewalk to sidewalk in the area of the culvert.

Two options are being considered for the construction staging:

- 1) Half and half construction using single-lane, traffic signal controlled or continual flagging staging (see Preliminary Design Staging Plans in Appendix D). This method requires temporary roadway protection as there is insufficient room for a 1:1 excavation slope from the back of the Jersey Barrier to the toe of the slope.

2) Short term local road detours.

The feasibility of a short term local road detour has not been confirmed at this point and the remainder of this report has been prepared assuming that half and half construction will be carried out with the use of temporary roadway protection.

6.2 SOIL SUMMARY

The soil conditions at this site generally consist of fill over compact to very dense glacial till.

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

Table 6.1: Geotechnical Model

Elevation (m)		Soil Type	Design Properties
From	To		
356.0	355.0	FILL: Sand with silt and gravel	Total Unit Weight = 22.0 kN/m ³ Friction Angle, $\phi = 35^\circ$
355.0	353.6	FILL: Sandy clay	Total Unit Weight = 19.0 kN/m ³ Friction Angle, $\phi = 30^\circ$
353.6	351.0	Sandy silty clay with gravel (CL-ML), compact to dense, (TILL)	Total Unit Weight = 21.5 kN/m ³ Friction Angle, $\phi = 36^\circ$ $E' = 50$ MPa
351.0	<342.2	Silty clayey sand with gravel (SC-SM), compact to very dense (TILL)	Total Unit Weight = 22.0 kN/m ³ Friction Angle, $\phi = 38^\circ$ $E' = 150$ MPa

The 25-year design flood elevation of 355.09 m will be used as the design groundwater elevation.

6.3 SEISMIC DESIGN CONSIDERATIONS

It is recommended that a Soil Profile I as defined in CHBDC Section 4.4.6 be used in the seismic design of this site.

Table A3.1.1 of the CHBDC indicates that the Zonal Acceleration Ratio for Stratford is 0.0. Although the Zonal Acceleration Ratio for this site is 0.0, minimum seismic design forces may need to be considered as per Section 4.4.10 of the CHBDC, depending on the design of the structure.

Seismically induced lateral earth pressures are not considered applicable for this project as the Zonal Acceleration Ratio is 0.0.

Liquefaction of the foundation soils is not a concern for this project due to the compact to very dense soil conditions and the Zonal Acceleration Ratio is 0.0.

7.0 Structure Foundations

7.1 STRUCTURE/FOUNDATION OPTIONS

Both a concrete Rigid Frame Open Footing culvert and a precast concrete box culvert are being considered by the design team for replacement of the existing structure. Both of these structures would be founded within the compact to dense silty clay with gravel till deposit. The soil conditions offer more than adequate bearing resistance for both culvert types.

The following table compares the structure options from a foundations design and constructability perspective:

Table 7.1: Foundation Comparison for Replacement Culvert

Option	Advantages	Disadvantages	Relative Cost	Risk/Consequences
Rigid Frame Open Footing		<ul style="list-style-type: none">▪ Slower construction process▪ Deeper excavation required▪ More extensive (deeper and longer duration) unwatering required	Medium	<ul style="list-style-type: none">▪ increased risk of dewatering problems/construction delays
Precast Concrete Box	<ul style="list-style-type: none">▪ Use of precast sections minimizes construction period▪ Wide bottom increases the ultimate bearing resistance and distributes load over a wider area resulting in a more conservative foundation design.		Low	<ul style="list-style-type: none">▪ If not properly installed, leakage and loss of backfill could occur at joints/settlement of roadway platform

Although the foundation soils are generally good and will provide adequate support for both options, the use of pre-cast concrete box culvert sections will allow for a shorter construction period which offers the following benefits:

- Minimized impacts to traffic and the community of Sebringville.
- Reduced efforts for flow diversion and excavation unwatering. The volume of water to be pumped will be greatly reduced by the shorter construction period.
- Reduced risk of softening of the subgrade surface

Based on the advantages presented above, the use of a closed box culvert supported by the native soils is the recommended foundation approach.

7.2 FOUNDATION RECOMMENDATIONS

7.2.1 Bearing Resistance

It is recommended that the new culvert consist of a precast concrete box culvert founded on the silty clay with gravel (till). A 200 mm layer of OPSS Granular A should be placed and compacted beneath the culvert for bedding purposes.

The geotechnical resistances provided in Table 7.2 may be used in the design provided the footings are placed on undisturbed native till or granular bedding over undisturbed native till as described above. Geotechnical resistances are also provided for cast in place head walls and the open footing rigid frame culvert option.

Table 7.2: Recommended Spread Footing Design Parameters

Founding Element	Founding Elev. (m)	Footing Size (m x m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS (kPa)
Box culvert on Till	353.65 north end 353.15 south end	3.5 x 24.4	700	350
Retaining Walls on Till	352.5 north end 352.0 south end	1.0 x 4.0 1.5 x 4.0 2.0 x 4.0 2.5 x 4.0	470 545 610 670	470* 545* 550 500
Open Footing Culvert on Till	352.5 north end 352.0 south end	0.5 x 24.0 0.6 x 24.0 0.9 x 24.0	370 380 420	370* 380* 420*

In accordance with Section 6.6.1 of the CHBDC, a resistance factor of 0.5 has been applied to calculate the factored geotechnical resistance at ULS.

The geotechnical reaction at SLS typically corresponds to a maximum settlement of 25 mm. Geotechnical reaction at SLS values marked with an asterisk (*) correspond to conditions where the factored geotechnical resistance at ULS is reached prior to undergoing 25 mm of total settlement. These foundation conditions have been assigned a geotechnical reaction at SLS equal to the factored geotechnical resistance at ULS.

7.2.2 Sliding Resistance

The unfactored horizontal resistance of spread footings may be calculated using the following unfactored coefficients of friction:

- 0.35 between OPSS Granular A and pre-cast concrete
- 0.25 between silty clay with gravel (till) and cast-in-place concrete

7.2.3 Frost Protection

The design frost penetration depth for foundations, f , at the culvert site is 1.4 m based on OPSD 3090.101. Spread footings should be provided with 1.4 m of earth cover or equivalent insulation for frost protection.

This depth of frost penetration should also be used in the design of frost tapers for the culvert backfill.

7.2.4 Lateral Earth Pressures

Earth pressures will need to be considered in the design of the culvert walls, retaining walls, as well as for roadway protection systems.

The culvert should be backfilled in accordance with OPSD 803.010. The retaining walls should be backfilled with granular material in accordance with OPSD 3120.150.

Computation of earth pressures should be in accordance with Section 6.9 of the CHBDC. For retaining walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied and unyielding structures, the at-rest earth pressure should be used for design. For a closed box culvert and a Rigid Frame Open Footing, the walls are considered to be unyielding and the at-rest earth pressure should be used for design. The unfactored soil parameters provided in Table 7.3 may be used for design of walls with a horizontal backfill. The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6.6 of the CHBDC.

The total active (P_A) and passive (P_P) thrusts can be calculated using the following equations

$$P_A = \frac{1}{2} K_a \gamma H^2$$

$$P_P = \frac{1}{2} K_p \gamma H^2$$

Where H is the height of the wall. Values for K_a , K_p , K_o and γ are provided in Table 7.3 below. The thrust acts at a point one third up the height of the wall.

Table 7.3: Recommended Earth Pressure Parameters

Parameter	OPSS Gran B Type I	OPSS Gran A and Gran B Type II	Existing Road Embankment Fill	Silty Clay with Gravel (till)
Bulk Unit Weight, γ (kN/m ³)	21.2	22.0	19.0	21.5
Effective Friction Angle	32°	35°	30°	36°
Coefficient of Earth Pressure at Rest (K_o)	0.47	0.43	0.5	0.41
Coefficient of Active Earth Pressure (K_a)	0.31	0.27	0.33	0.26
Coefficient of Passive Earth Pressure (K_p)	3.2	3.7	3.0	3.85

7.2.5 Retaining Walls - Global Stability

Global stability of a typical retaining wall section for this project was analyzed using commercially available two-dimensional limit equilibrium based slope stability software (Slope/W).

The retaining wall geometry for the cross section that was analyzed is summarized as follows:

Top of wall elevation =	356.0 m
Founding elevation =	352.0 m
Top of soil in front of wall =	354.2 m
Footing Width =	1.5 m

It has been assumed that granular backfill will be provided within the 45 degree wedge from the vertical back face of the wall. Outside of this backfill wedge, the soil conditions have been assumed to correspond to the soil model presented in Section 6.2 of this report. To represent the worst case scenario, the piezometric surface has been assumed to be at the 25-year high water level (elevation 355.09 m) behind the retaining wall and at ground surface in front of the retaining wall.

Dynamic loading due to traffic has been accounted for in the analysis by considering an equivalent static load equivalent to 0.8 m of additional fill, as per Section 6.9.5 of the CHBDC. The traffic loading was applied to the worst case piezometric scenario.

Seismic loading was not included in the analysis as the zonal acceleration ratio is 0.0 for this site.

The soil conditions and assumed retaining wall geometry are shown on the slope stability modeling results provided in Appendix E. The results of the analysis indicate a Factor of Safety of 1.7 against global instability, which is considered acceptable under static loading conditions.

8.0 Construction Considerations

8.1 CONSTRUCTION STAGING

The option of closing the road for a short duration by using local road detours is being considered. This option would allow for replacement of the culvert in a single stage.

The staging concept carried forward in the preliminary design involves two stage construction as shown on the Preliminary Staging Plans provided in Appendix D. This option would require the use of temporary roadway protection near the centerline of the highway. Further discussion regarding temporary protection systems is provided in Section 9.3.

8.2 EXCAVATION, BEDDING AND BACKFILLING

Excavation and backfill for the new culvert should be carried out in accordance with OPSS 902 Construction Specification for Excavation and Backfilling – Structures, including requirements for QVE inspections.

Side slopes for open cut excavations should conform to Occupational Health and Safety Act regulations for Construction Projects. The existing highway embankment fill and native till are considered Type 3 soil above the water level. Above the stream and groundwater level, temporary cut slopes should be no steeper than 1 horizontal to 1 vertical from the base of the excavation. For excavations below stream and/or groundwater levels, the soils should be considered as Type 4 soils and slopes no steeper than 3H:1V will be required. Flatter side slopes or supported excavations may be required.

Benching of earth slopes should be carried out in accordance with OPSD 208.010.

All vegetation, fill, organic soils and other deleterious materials must be removed from beneath the proposed box culvert foundation. Where deleterious materials are encountered, the material should be excavated, wasted and replaced. The lateral extent of such excavation should include all deleterious material within the influence zone of the foundations.

Compaction of bedding and backfill should be carried out in accordance with SP105S10.

Construction of frost tapers at the new culvert should be considered as a part of the pavement design.

Grading work for reinstatement of the highway embankment along the existing culvert alignment should be carried out in accordance with OPSS-206 Construction Specification for Grading and SP 206S03 using OPSS Select Subgrade Material.

8.3 TEMPORARY PROTECTION SYSTEMS

Two options for holding back the retained soil were considered – a steel sheet pile (SSP) wall, and a soldier pile with timber lagging wall. Due to the limited depth of excavation, cantilevering is likely feasible if a steel sheet pile system is used.

The roadway protection for the culvert replacement will necessitate excavation below the waterline. As such, dewatering will be required for the culvert replacement, and may also be required during installation of the roadway protection system.

The following table compares the available roadway protection options considered for the culvert replacement:

Table 8.1: Comparison of Roadway Protection Systems

Option	Advantages	Disadvantages	Relative Cost	Risk & Consequences
Steel sheet pile; soil anchors	<ul style="list-style-type: none"> easier to install below waterline (no dewatering required during roadway protection installation) 	<ul style="list-style-type: none"> will require removal and re-installation of soil anchors during staging 	High	
Steel sheet pile; cantilevered	<ul style="list-style-type: none"> easier to install below waterline (no dewatering required during roadway protection installation) can be used for two both stages 		High	<ul style="list-style-type: none"> disturbance during extraction after second stage – could loosen soils and cause settlement
H-Piles with timber lagging; soil anchors	<ul style="list-style-type: none"> simple installation 	<ul style="list-style-type: none"> will require removal and re-installation of soil anchors during staging dewatering required prior to excavation portion of system often left in place beneath pavement 	Low	<ul style="list-style-type: none"> seepage or flow of retained material/ possibility of settlement
H-Piles with timber lagging; rakers	<ul style="list-style-type: none"> simple installation 	<ul style="list-style-type: none"> rakers can act in both tension and compression, avoiding need to re-install support system dewatering required prior to excavation portion of system often left in place beneath pavement 	Low	<ul style="list-style-type: none"> seepage or flow of retained material/ possibility of settlement

Given that the roadway protection system is required to support the roadway during both stages of the culvert replacement, the use of a cantilevered steel sheet pile system is recommended. The contractor will ultimately be responsible to develop and implement a roadway protection

system meeting the requirements of OPSS 539, including establishing appropriate geotechnical design parameters.

A conceptual sketch showing the location of the roadway protection is provided as Drawing No. 2 in Appendix D.

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

8.4 UNWATERING

The underside of the proposed box culvert is approximately 1 m lower than the observed groundwater and stream water levels. The founding elevation for the cast-in-place retaining walls is 2.4 m below the observed groundwater and stream water levels and 2.9 m lower than the 25-year high water level.

Control of the water flow in the stream will require a cofferdam to prevent stream flow into the excavations. It is anticipated that flow will be diverted using pumps to allow construction of the replacement culvert.

The native soils within the anticipated depth of excavation have a low to moderate hydraulic conductivity. Unwatering of the structure excavation using conventional sump and pump techniques should be adequate.

A draft NSSP is provided in Appendix E which notifies the contractor of the groundwater conditions and the requirements for dewatering to facilitate excavations.

8.5 EROSION AND SCOUR PROTECTION

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes and adjacent stream banks. All slopes within 3 m of the culvert inlet and outlet should be surfaced with rip-rap at least 300 mm thick placed on a Class II non-woven filter fabric. Where embankment construction includes earth fill, normal slope vegetation should be established as soon as possible after completion of the embankment fills in order to control surficial erosion.

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

8.6 CEMENT TYPE AND CORROSION PROTECTION

One sample of the native soil was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The testing was completed to determine the potential for degradation of the concrete in the presence of

soluble sulphates and the potential for corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in the Table 4.1.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The soluble sulphate results was 22 µg/g. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU (General Use) Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH was 7.99 which is within what is considered the normal range for soil pH of 5.5 to 9.0. The pH levels of the tested soil do not indicate a highly corrosive environment. The test results provided in the Table 4.1 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

9.0 Specifications

The following specifications are referenced in this report:

Table 9.1: Specifications Referenced in Report

Document	Title
OPSD 3090.101	Foundation Frost Depths for Southern Ontario
OPSD 803.010	Backfill and Cover for Concrete Culverts
OPSD 3120.150	Walls – Retaining, Backfill – Minimum Granular Requirement
OPSS902	Construction Specification for Excavation and Backfilling – Structures
OPSS 206	Construction Specification for Grading
SP 206S03	Earth Excavation, Grading
SP105S10	Construction Specification for Compaction
OPSD 208.010	Benching of Earth Slopes
OPSS 539	Construction Specification for Temporary Protection System

10.0 References

ASTM 4.08. Standard D1586-99: Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM 4.08. Standard D2216-98: Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

ASTM 4.08. Standard D2487-00: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

ASTM 4.08. Standard D422-63: Standard Test Method for Particle-Size Analysis of Soils.

Canadian Geotechnical Society. Canadian Foundation Engineering Manual, 4th Edition. Richmond: BiTech Publisher Ltd, 2006.

Canadian Standards Association. Concrete Materials and Methods of Concrete Construction.: CSA Standards A23.1-04. Mississauga, Ontario: Canadian Standards Association, 2004.

Chapman, L.J., and Putnam, D.F. The physiography of southern Ontario; Ontario Geological Survey, Special Volume 2. Toronto: Ontario Research Foundation, Ontario Geological Survey, 1984.

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

Ministry of Labour. Occupational Health and Safety Act and Regulations for Construction Projects. Toronto, Ontario: Publications Ontario, 2002.

Ministry of Transportation. Ontario Provincial Standards for Roads and Municipal Services. Downsview, Ontario: Ministry of Transportation, 1998.

Mononobe, N. "Earthquake-Proof Construction of Masonry Dams," Proceedings of the World Engineering Conference, 9: 1929.

NAVFAC DM-7.2. Foundation and Earth Structures. Department of the Navy Naval Facilities Engineering Command, Alexandria, VA, 1982.

Okabe, S. "General Theory of Earth Pressure," Journal of the Japanese Society of Civil Engineers. 12(1): 1926.

Highway 8 Preliminary Design Report, Ministry of Transportation West Region Planning and Design G.W.P. 344-97-00. March 2009.

11.0 Closure

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

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

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

Respectfully submitted,

STANTEC CONSULTING LTD.



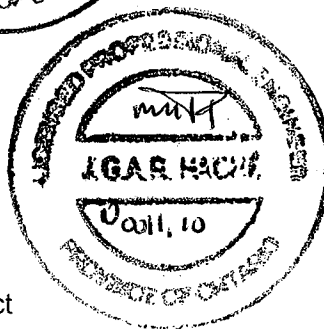
Paul Carnaffan, M.Eng., P.Eng.
Associate



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

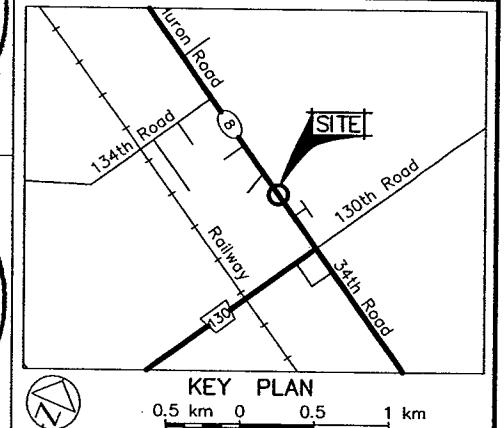
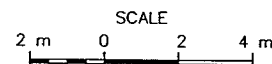
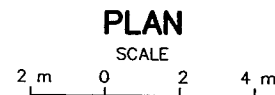






Raymond Haché, M.Sc., P.Eng.
Designated Principal MTO Foundation Contact



APPENDIX A

Drawing No. 1 – Borehole Location Plan and Soil Strata
Site Photos



 Bore Hole
 Borehole and Cone
 N Blows/0.3m (Std Pen Test, 475 J/blow)
 WL at time of investigation May 2010
 Benchmark, HCP 125, Elev. 356.57 m

No	ELEVATION	MTM ZONE 10 COORDINATES	
		NORTH	EAST
10-1	356.3	4 808 047.2	422 083.2
10-2	356.2	4 808 033.0	422 081.6
10-3	356.1	4 808 038.8	422 063.6
10-4	355.9	4 808 023.4	422 069.1

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

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

REVISIONS			DESCRIPTION
	DATE	BY	

GEOCRES. No 40P6-21

HWY No 8		DIST	
SUBM'D PC	CHECKED	DATE 2010-11-08	SITE 25-319-C
DRAWN GBB	CHECKED	APPROVED	DWG 1



Photo No. 1: Highway 8 looking east over culvert.



Photo No. 2: Highway 8 looking west towards culvert.



Photo No. 3: North end of culvert.



Photo No. 4: South end of culvert looking north.



Photo No. 5: North end of culvert, west CSP.



Photo No. 6: North end of culvert, east CSP with rock and tree debris.



Photo No. 7: Settlement and cracking of sidewalk at south end of culvert.



Photo No. 8: Erosion of west bank at south end of culvert covered by logs.

APPENDIX B

Symbols and Terms Used on Borehole Records
Borehole Records

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Topsoil</i>	- mixture of soil and humus capable of supporting vegetative growth
<i>Peat</i>	- mixture of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

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

Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

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

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

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

Terminology describing compactness of cohesionless soils:

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

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

Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistency	Undrained Shear Strength	
	kips/sq.ft.	kPa
<i>Very Soft</i>	<0.25	<12.5
<i>Soft</i>	0.25 - 0.5	12.5 - 25
<i>Firm</i>	0.5 - 1.0	25 - 50
<i>Stiff</i>	1.0 - 2.0	50 - 100
<i>Very Stiff</i>	2.0 - 4.0	100 - 200
<i>Hard</i>	>4.0	>200



ROCK DESCRIPTION

Terminology describing rock quality:

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

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

Terminology describing rock mass:

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

Terminology describing rock strength:

Strength Classification	Unconfined Compressive Strength (MPa)
<i>Extremely Weak</i>	< 1
<i>Very Weak</i>	1 – 5
<i>Weak</i>	5 – 25
<i>Medium Strong</i>	25 – 50
<i>Strong</i>	50 – 100
<i>Very Strong</i>	100 – 250
<i>Extremely Strong</i>	> 250

Terminology describing rock weathering:

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



STRATA PLOT


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


Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta- morphic Bedrock	Sedi- mentary Bedrock

SAMPLE TYPE

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

WATER LEVEL MEASUREMENT

 measured in standpipe, piezometer, or well

 inferred

RECOVERY

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

N-VALUE





Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N value corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

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

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



RECORD OF BOREHOLE No BH10-1

1 OF 1

METRIC

W.P. 344-97-00 LOCATION 17+696 15.0 m Lt CL (County of Perth) N: 4 808 047 E: 422 083 ORIGINATED BY AS
 DIST HWY 8 BOREHOLE TYPE Splittings, Hollow Stem Augers COMPILED BY AS
 DATUM Geodetic DATE 5.25.10 - 5.25.10 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
356.3 0.0	Silty sand with gravel, brown, FILL		1	SS	14		356							
355.7 0.6	Sandy clay, dark brown, FILL		2	SS	2		355							
			3	SS	13		354							
354.1 2.2	Sandy silty clay with gravel (CL-ML), compact to very dense, brown, TILL		4	SS	19		354							17 28 35 20
			5	SS	18		353							
			6	SS	52		352							
			7	SS	47		351							
			8	SS	75		350							
			9	SS	100/ 130 mm		349							
			10	SS	72		348							
351.1 5.3	Silty clayey sand with gravel (SC-SM), dense to very dense, grey brown, TILL		11	SS	30		347						24 30 31 15	
			12	SS	33		346							
			13	SS	75		345							
			14	SS	100/ 130 mm		344							
			15	SS	100/ 100 mm		343							
			16	SS	100/ 90 mm									
342.4 14.0	End of Borehole 50 mm dia. PVC Standpipe Installed													17 36 (47)

ONTARIO MTO STANTEC 165000741 HWY 8 STRATFORD.GPJ ONTARIO MTO.GDT 10/29/10

RECORD OF BOREHOLE No BH10-2

1 OF 1

METRIC

W.P. 344-97-00 LOCATION 17+703 1.9 m Lt CL (County of Perth) N: 4 808 033 E: 422 082 ORIGINATED BY AS
 DIST HWY 8 BOREHOLE TYPE Splitterspoons, Hollow Stem Augers, Dynamic Cone Test COMPILED BY AS
 DATUM Geodetic DATE 5.25.10 - 5.25.10 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	× FIELD VANE	● QUICK TRIAXIAL							× LAB VANE	
356.2	110 mm ASPHALT							20	40	60	80	100						
356.1	Silty sand with gravel, FILL		1	SS	55												38 48 (14)	
355.9	Poorly-graded sand with silt and gravel, brown, FILL		2	SS	10													39 49 (12)
354.7	Sandy clay with wood, brown, FILL		3	SS	27													
353.8	Sandy silty clay with gravel (CL-ML), compact to dense, brown, TILL		4	SS	12													
			5	SS	28													
			6	SS	45													
			7	SS	46													
351.0	Silty clayey sand with gravel (SC-SM), dense brownish grey, TILL		8	SS	35													
350.1	Dynamic Cone Penetration Test																	
	- Inferred: Silty clayey sand with gravel (SC-SM), dense to very dense, TILL																	
348.0	End of Borehole																	
8.2																		

ONTARIO MTO STANTEC 165000741 HWY 8 STRATFORD.GPJ ONTARIO.MOT.GDT 10/29/10

RECORD OF BOREHOLE No BH10-3

1 OF 1

METRIC

W.P. 344-97-00 LOCATION 17+683 2.2 m Rt CL (County of Perth) N: 4 808 039 E: 422 064 ORIGINATED BY AS
 DIST HWY 8 BOREHOLE TYPE Splittings, Hollow Stem Augers COMPILED BY AS
 DATUM Geodetic DATE 5.26.10 - 5.26.10 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								○ UNCONFINED	× FIELD VANE								
								● QUICK TRIAXIAL	× LAB VANE								
356.1	120 mm ASPHALT						20	40	60	80	100						
356.0	Silty sand with gravel, brown, FILL		1	SS	61												42 44 (14)
355.3	Poorly-graded sand with silt and gravel, brown, FILL																
355.2	Sandy clay, brown, FILL		2	SS	9												
0.9																	
			3	SS	4												14 31 37 18
353.6	Sandy silty clay with gravel (CL-ML), compact to dense, brown, TILL		4	SS	11												
2.5																	
			5	SS	14												
			6	SS	21												
			7	SS	31												
			8	SS	40												
			9	SS	29												
349.4	Silty clayey sand with gravel (SC-SM), compact to very dense, grey, TILL																
6.7			10	SS	22												1 9 (90)
			11	SS	30												
	- trace gravel		12	SS	23												
			13	SS	51												
			14	SS	100/ 125 mm												
			15	SS	116												27 31 28 14
342.2	End of Borehole		16	SS	100/ 80 mm												
14.0																	

ONTARIO MTO STANTEC 165000741 HWY 8 STRATFORD.GPJ ONTARIO MOT.GDT 10/29/10

RECORD OF BOREHOLE No BH10-4

1 OF 1

METRIC

W.P. 344-97-00 LOCATION 17+697 12.5 m Rt CL (County of Perth) N: 4 808 023 E: 422 069 ORIGINATED BY AS
 DIST HWY 8 BOREHOLE TYPE Splitterspoons, Hollow Stem Augers COMPILED BY AS
 DATUM Geodetic DATE 5.26.10 - 5.26.10 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)																																																	
355.9 0.0	610 mm sandy TOPSOIL		1	SS	7		355		20	40	60	80	100	10	20	30	GR SA SI CL																																																
355.3 0.6	Sandy clay, trace organic matter, brown, FILL		2	SS	7																																																												
			3	SS	7																																																												
353.8 2.1	Silty clayey gravel with sand (GC-GM), compact to dense, brown, TILL		4	SS	17													354	353		20	40	60	80	100	10	20	30	30 24 (46)																																				
			5	SS	37																																																												
			6	SS	24																																																												
352.3 3.7	Silty clay with sand (CL-ML), compact to dense, grey, TILL		7	SS	38																									352	351		20	40	60	80	100	10	20	30	4 13 52 31																								
			8	SS	27																																																												
			9	SS	25																																																												
350.7 5.3	Sandy silty clay with gravel (CL-ML), compact to very dense, grey, TILL		10	SS	100/ 80 mm																																					350	349		20	40	60	80	100	10	20	30	20 24 36 20												
			11	SS	98																																																												
			12	SS	71																																																												
	- becomes silty clayey sand (SC-SM), TILL		13	SS	102																																																	348	347		20	40	60	80	100	10	20	30	14 39 (47)
346.4 9.5	End of Borehole																																																																

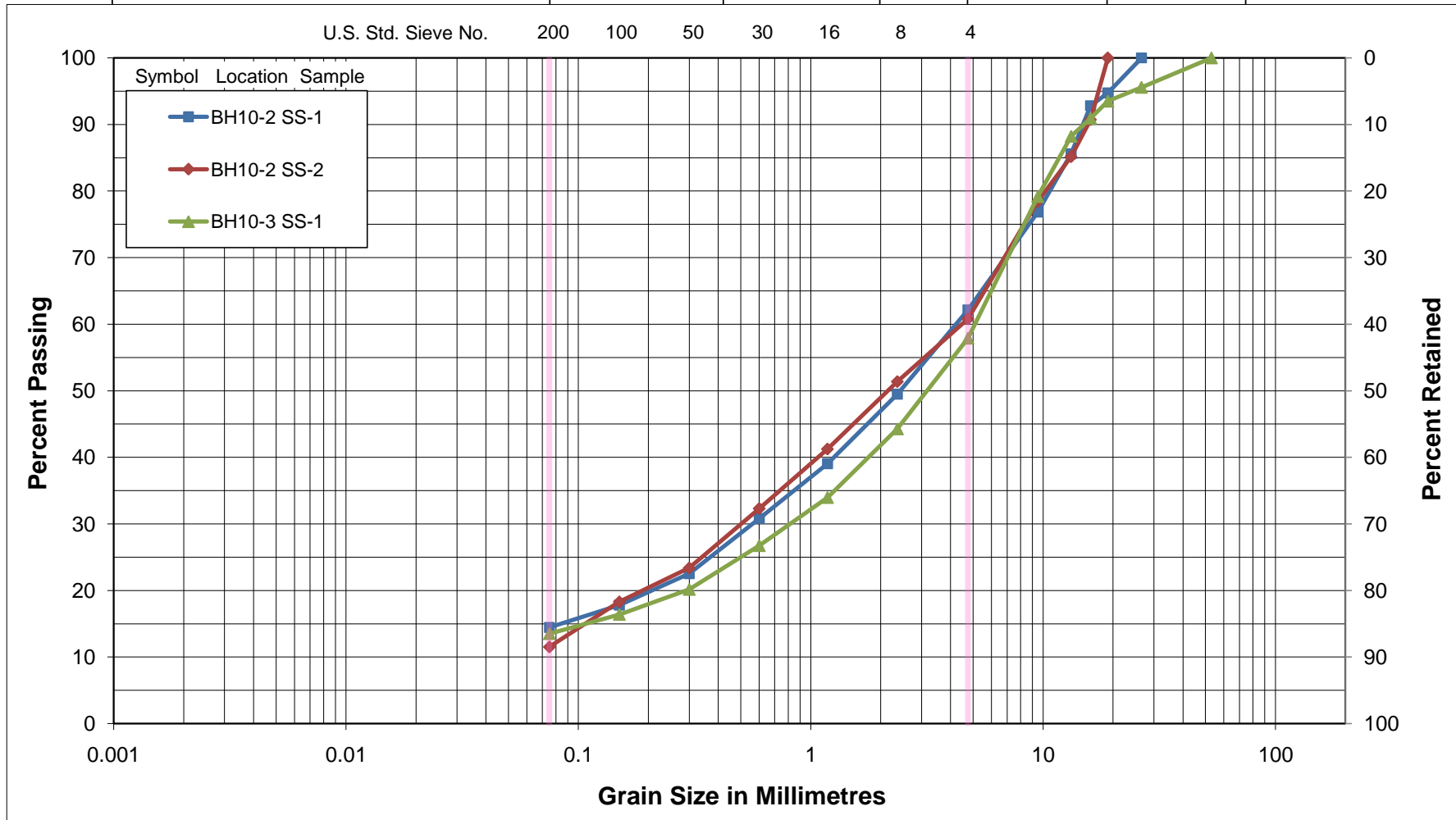
ONTARIO MTO STANTEC 165000741 HWY 8 STRATFORD GPJ ONTARIO MOT GDT 10/29/10

APPENDIX D

Construction Staging Plans
Drawing No. 2 – Roadway Protection System Location

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

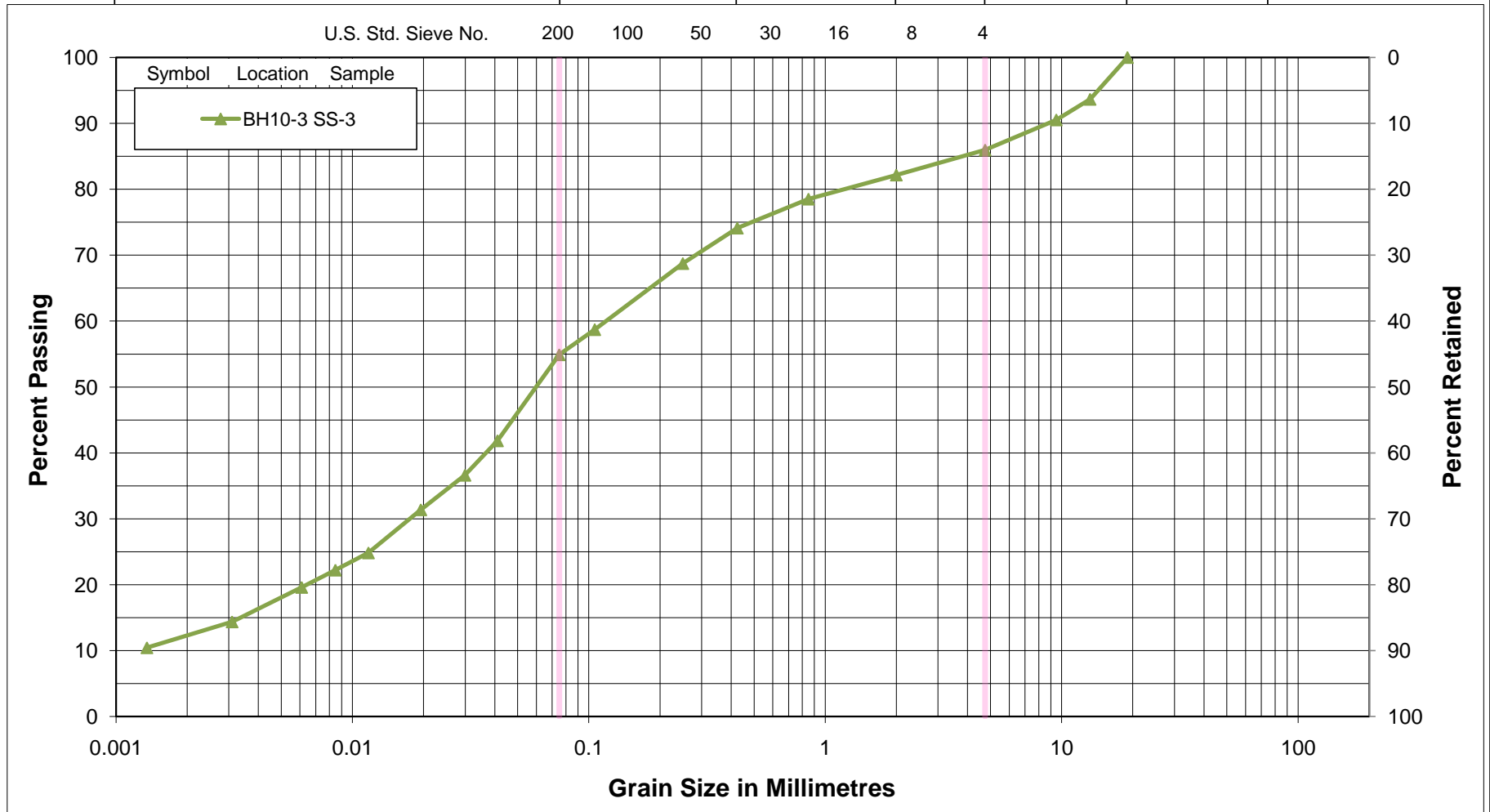
Pavement Structure Granulars

Figure No. 1

Project No. 165000741

Unified Soil Classification System

	SAND			Gravel	
CLAY & SILT	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

Sandy Clay Fill

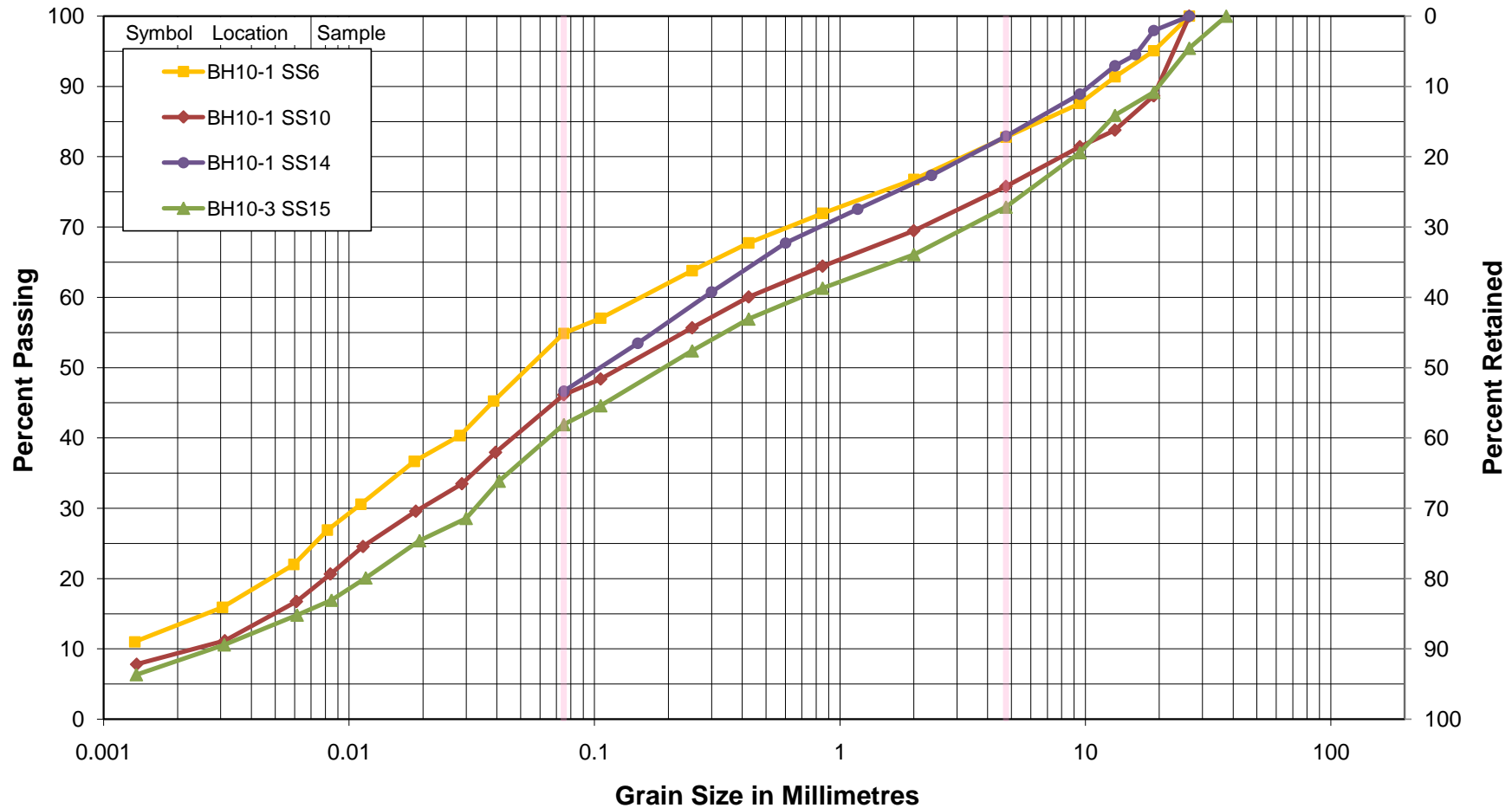
Figure No. 2

Project No. 165000741

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

U.S. Std. Sieve No. 200 100 50 30 16 8 4



GRAIN SIZE DISTRIBUTION

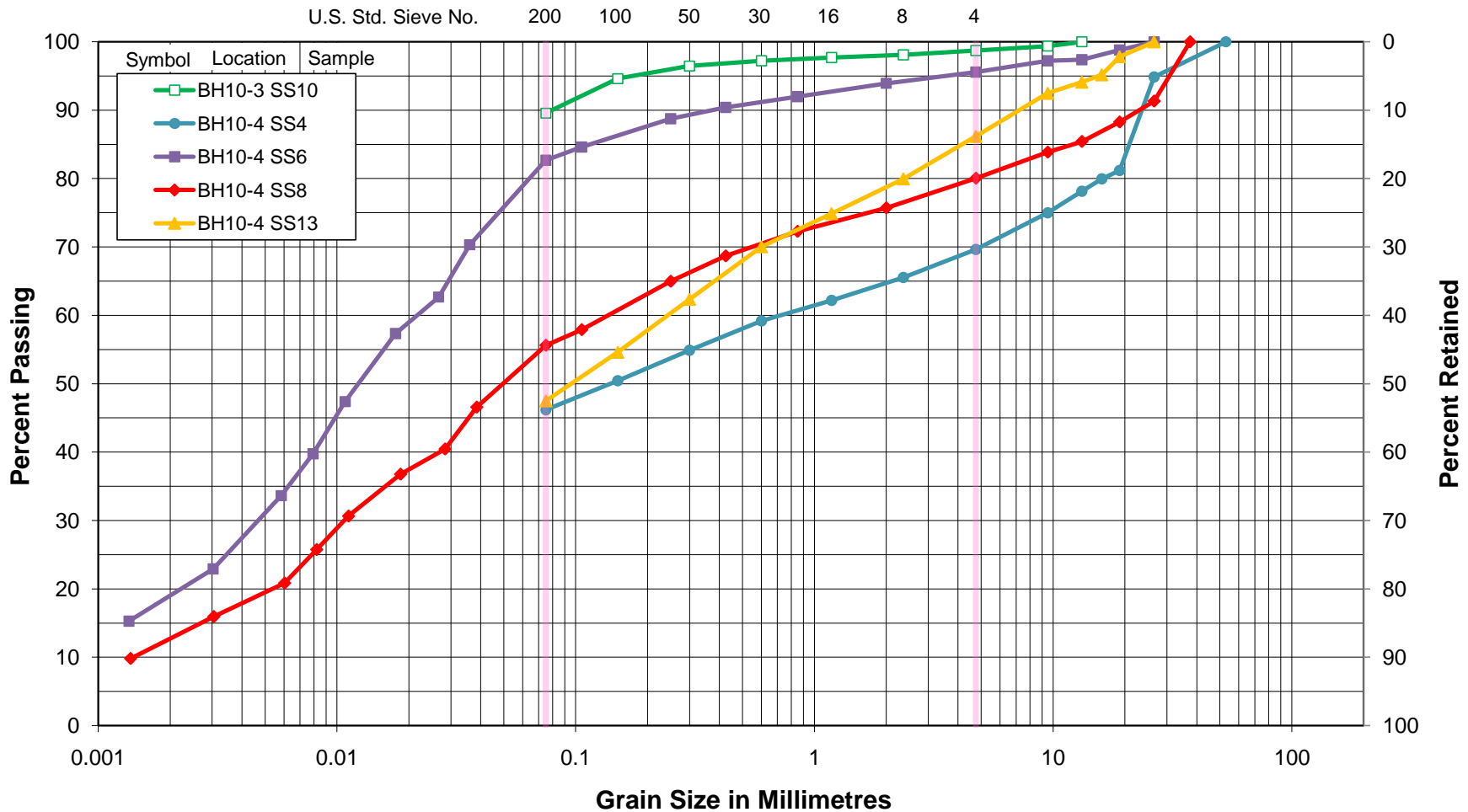
Till

Figure No. 3

Project No. 165000741

Unified Soil Classification System

	SAND			Gravel	
CLAY & SILT	Fine	Medium	Coarse	Fine	Coarse

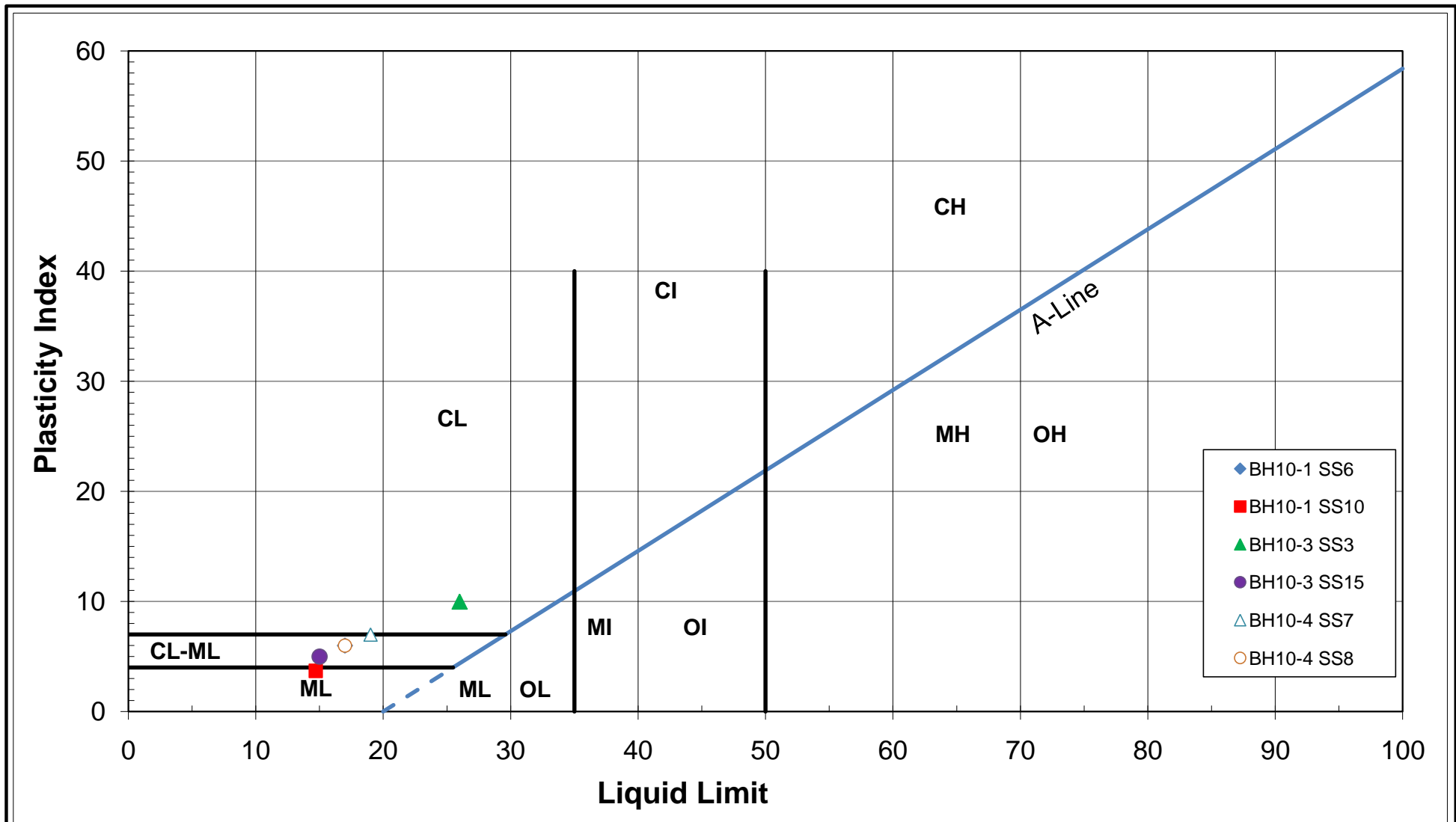


GRAIN SIZE DISTRIBUTION

Till

Figure No. 4

Project No. 165000741



PLASTICITY CHART

Figure No. 5

Project No. 165000741

APPENDIX D

Construction Staging Plans
Drawing No. 2 – Roadway Protection System Location

PLATE No 167-8/20-0
CONT No
WP No 344-97-00
PRELIMINARY-DESIGN
STA 17+500 TO STA 17+850

SHEET
38

REGISTERAR'S COMPILED PLAN 511

17+500 17+600 17+700 17+800 17+850

BOLGERS RD

R EX HYDRO POLE LINE

EX 3.65 m LANE

EX 3.65 m LANE

EX HYDRO POLE LINE

CL HWY 8

3.50m LANE

0.6m 0.5m 0.5m 0.6m 1.45

TEMPORARY TRAFFIC SIGNALS TO BE INSTALLED FOR STAGING

UNDER CONSTRUCTION

SCALE

20 9 3

Minutes


MINISTRY OF TRANSPORTATION, ONTARIO
P.L.D. 397 88-53

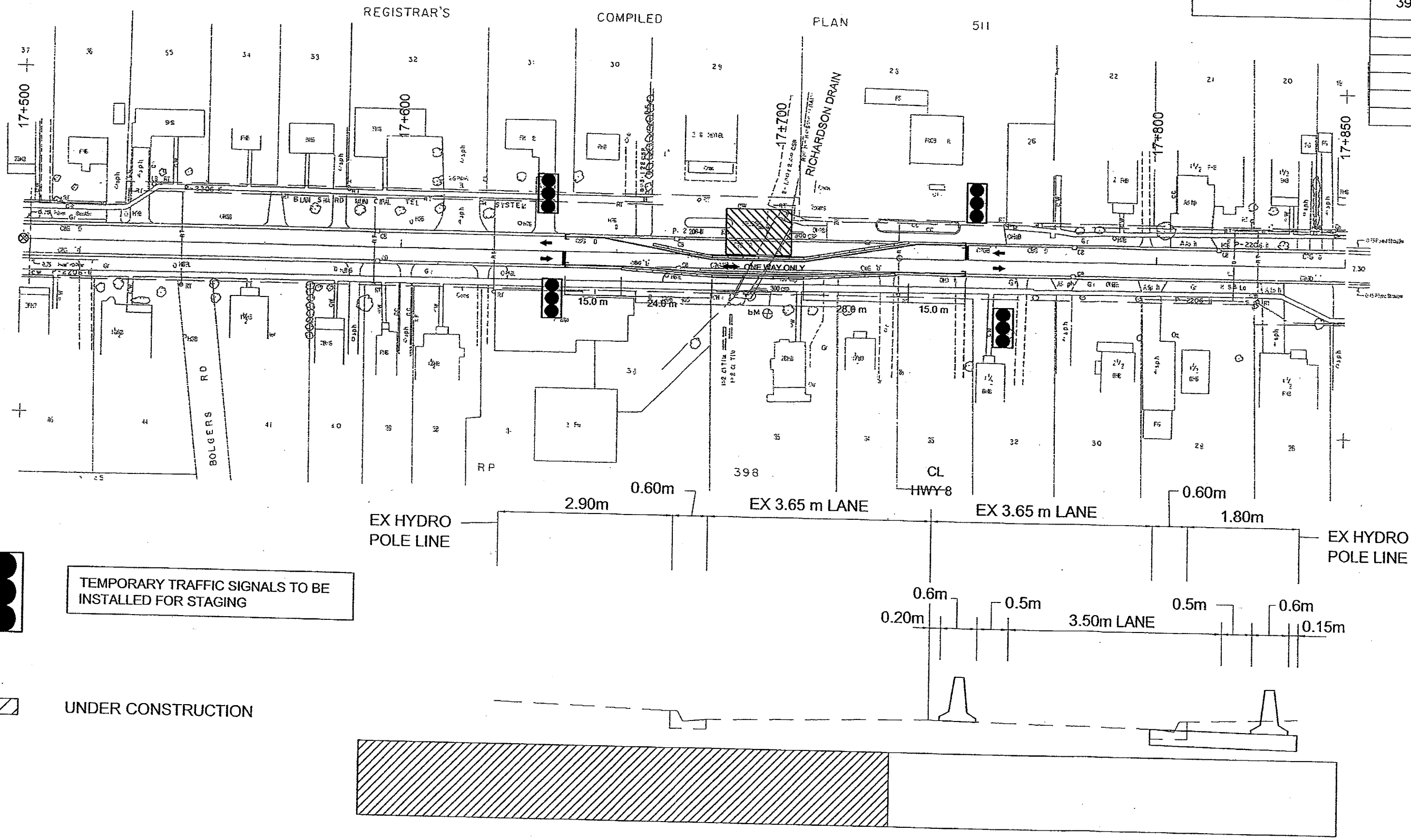
STAGE 2

DETOUR DESIGN SPEED 50 km/hr

METRIC

PLATE No	167-8/20-0
CONT No	WP No 344-97-00
PRELIMINARY-DESIGN	
STA 17+500 TO STA 17+850	


SHEET
39



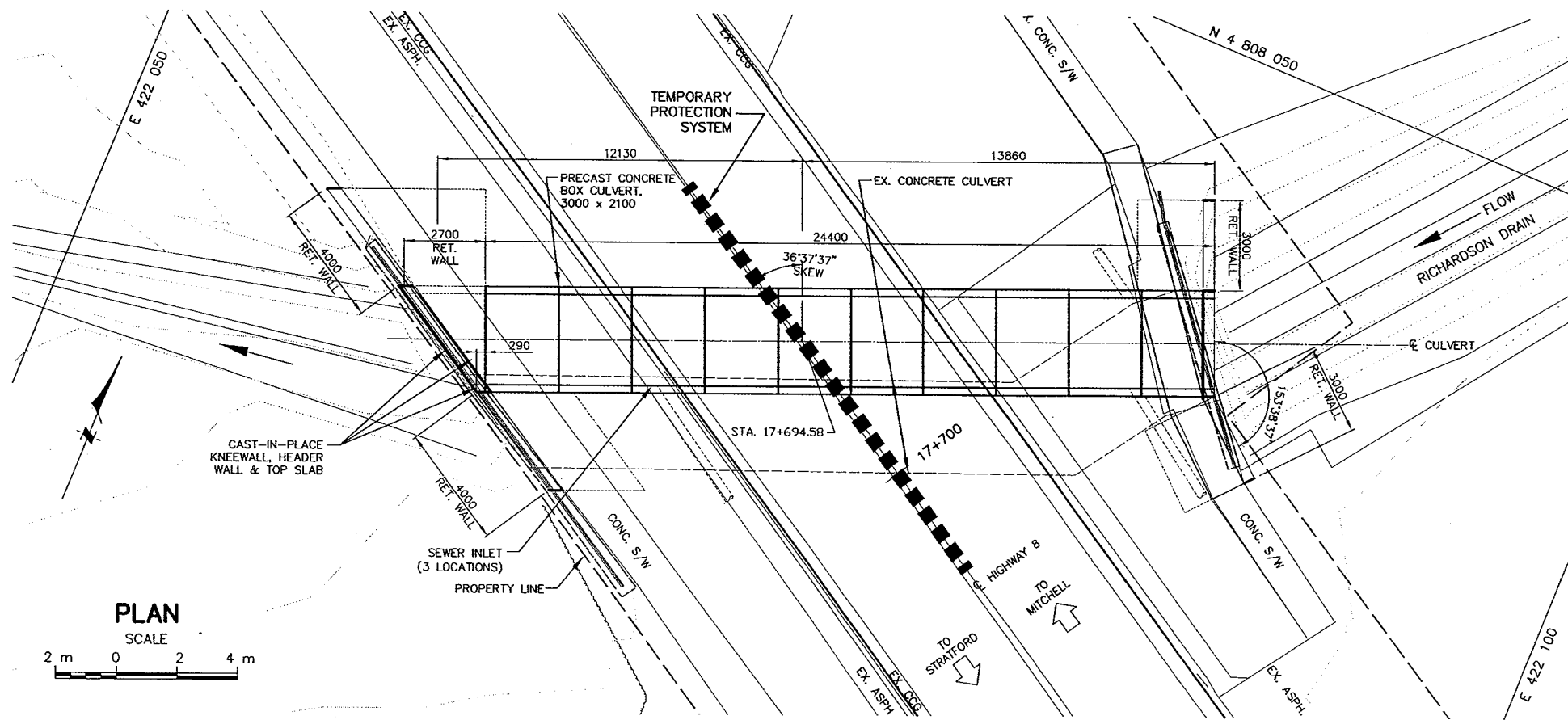
TEMPORARY TRAFFIC SIGNALS TO BE INSTALLED FOR STAGING



UNDER CONSTRUCTION

N.T.S.

SCALE
1:500



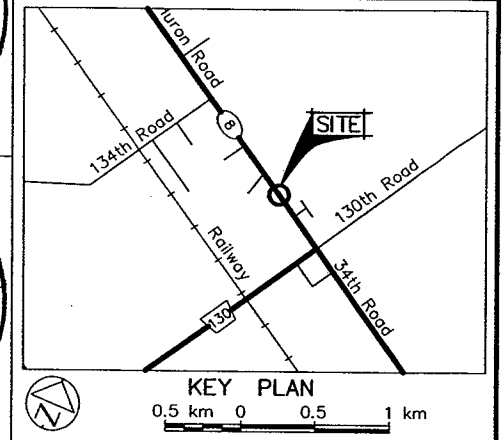
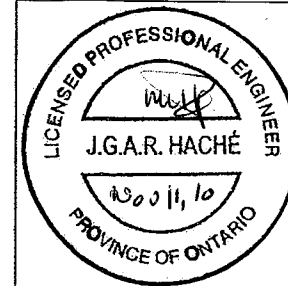
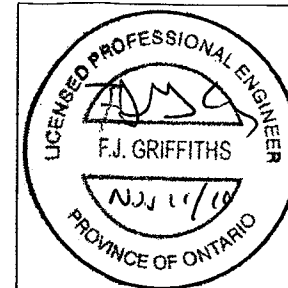
PLAN
SCALE
2 m 0 2 4 m

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

PLATE No
CONT
WP 344-97-00
RICHARDSON DRAIN REPLACEMENT
HIGHWAY 8, SEBRINGVILLE
ROADWAY PROTECTION SYSTEM LOCATION



SHEET



KEY PLAN
0.5 km 0 0.5 1 km

=NOTE=
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

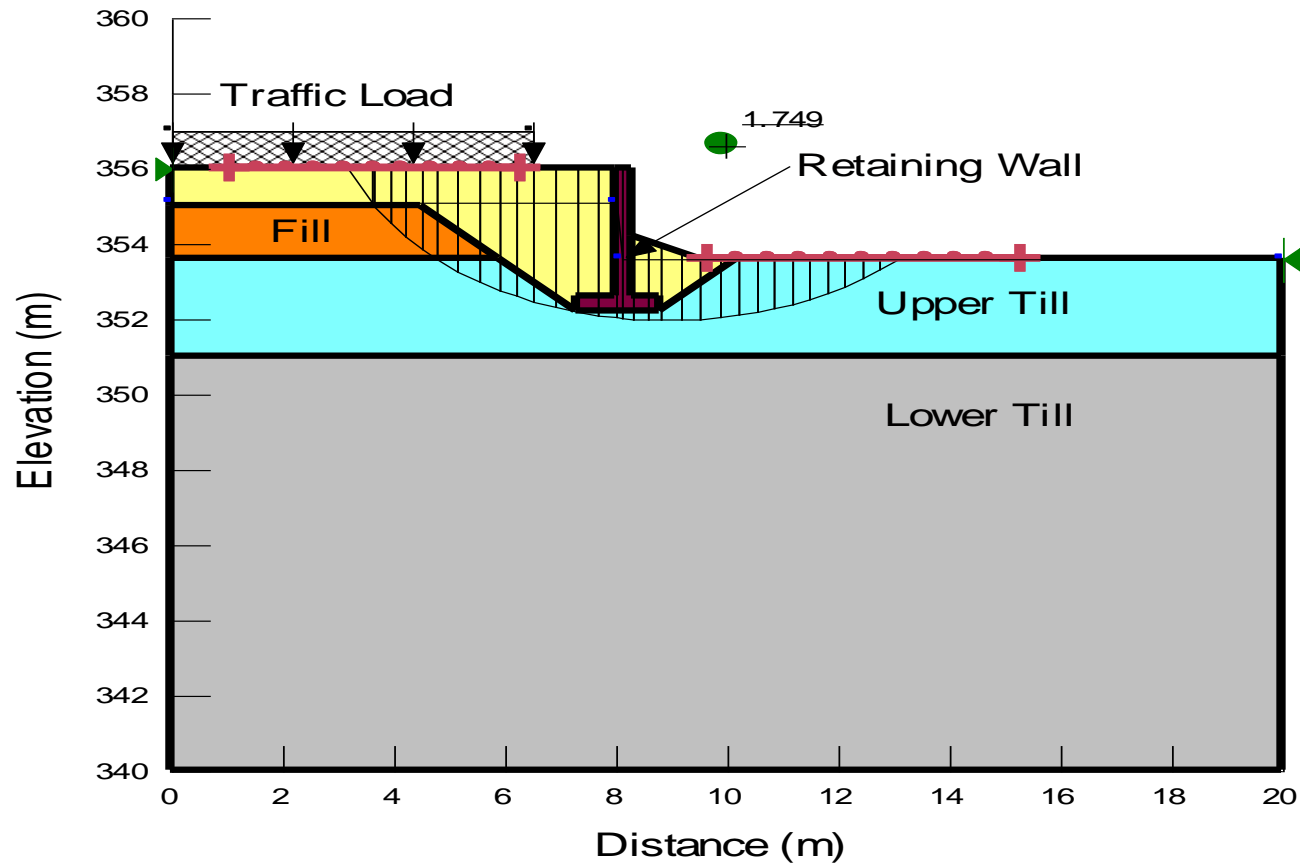
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2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

REVISIONS		DATE		BY	DESCRIPTION
GEOCRES No 40P6-21					
HWY No 8					DIST
SUBMIT PC	CHECKED	DATE 2010-11-08	SITE	25-319-C	
DRAWN GBB	CHECKED	APPROVED	DWG	2	

APPENDIX E

Global Stability Analysis Results
NSSP – Excavation Unwatering

Name: Concrete Wall Unit Weight: 24 kN/m³ Cohesion: 3e+00
 Name: Lower Till Unit Weight: 22 kN/m³ Cohesion: 0 kPa Ph
 Name: Upper Till Unit Weight: 21.5 kN/m³ Cohesion: 0 kPa I
 Name: Granular Fill Unit Weight: 22 kN/m³ Cohesion: 0 kPa
 Name: Fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °



Slope Stability Analysis

Richardson Drain Culvert Replacement

Highway 8 - W.P. 3043-06-04

Drawing No. 3

Dewatering Structure Excavations – Item No. **

Special Provision

October 2010

This special provision is to highlight the fact that:

- The water flow through the existing Richardson Drain culvert will need to be diverted to allow for the culvert replacement.
- The excavation for the new structures will extend below the level of the groundwater and the level of the surface water flowing through the culvert.
- Excavation for foundations for the retaining walls will extend to a lower elevation than the underside of the culvert.
- The contractor shall consider the site conditions and sequence of work when designing the excavation dewatering scheme in accordance with OPSS 902.