

**FOUNDATION INVESTIGATION AND DESIGN REPORT
STAGING AREAS FOR KENT STREET STRUCTURE RAPID REPLACEMENT
HIGHWAY 417 IMPROVEMENTS
OTTAWA, ONTARIO**

W.P. 4033-08-01

Geocres Number: 31G5-253

Report to

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Replacement\Kent Street Staging Areas - FINAL FIDR.doc

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Appendix E	Drawing titled “Borehole Locations Plan”

Appendices A and B include:

- Record of Borehole Sheets
- Laboratory Test Results
- Selected Photographs

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for two alternative staging areas for rapid replacement of the superstructures of the Highway 417 Kent Street Overpass in the City of Ottawa, Ontario. The proposed rapid replacement work is part of the Highway 417 operational improvements and infrastructure rehabilitation within the project limits, extending from Parkdale Avenue to the Rideau Canal.

The purpose of this investigation was to explore the subsurface conditions at the two sites and, based on the data obtained, to provide a borehole location plan, records of borehole sheets, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin, under the Ministry of Transportation Ontario (MTO) Agreement Number 4009-E-0007.

2 SITE DESCRIPTION

The Kent Street Overpass is located on Highway 417 directly south of the Ottawa city centre. The existing structures are single span voided slab bridges with a total span varying from approximately 18 to 30 m across Kent Street, a three lane roadway at the overpass (two northbound lanes from Highway 417 W-N Ramp to Kent Street and one northbound lane off Chamberlain Avenue). The overall width is approximately 35 m including four westbound lanes on the Highway 417 WB superstructure (19.1 m wide) and three eastbound lanes on the Highway 417 EB superstructure (15.4 m wide).

Two alternative locations were proposed to serve as a temporary staging area for prefabrication, assembly and storage of new superstructures as well as for storage of the decommissioned old superstructures.

Staging Area #1

Staging Area #1 is currently an urban park with a soccer field. The park is located at the southwest corner of the intersection of Lyon Street South and Chamberlain Avenue, approximately 50 m south of Highway 417 and 200 m west of Kent Street. The lands surrounding the park consist of mainly residential developments. Photographs of the site are presented in Appendix A.

Staging Area #2

Staging Area #2 is located adjacent to the south side of Highway 417 and is bounded by Chamberlain Avenue, Kent Street and Bank Street. The site comprises a vegetated fill slope along the side of the Highway 417 embankment. Development of the staging area will require excavation of the embankment slope, including provision of a protection system along Highway 417, to provide a level working area. Commercial and residential developments encompass the general area. A photograph adjacent to the site is presented in Appendix B.

The two staging area sites are geologically located in the physiographic region called Ottawa Valley Clay Plain, which comprises a clay plain interrupted by ridges of sand or rock outcrops. Based on The Geological Survey of Canada's Map 1508A, "Generalized Bedrock Geology, Ottawa-Hull, Ontario and Quebec", the Kent Street staging areas are located in an area underlain by bedrock of the Lindsay Formation, Ottawa Group (limestone with shale interbeds) and Billings Formation (dark brown to black shale) towards Bank Street.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between November 5 and 19, 2012 and consisted of drilling six boreholes (identified as Boreholes KSS-01 to KSS-06), three at each staging area. The boreholes were terminated in bedrock at depths of 7.6 to 21.5 m below the ground surface. In Staging Area #2, Boreholes KSS-04 and KSS-05 were drilled on Highway 417 at the crest of the highway embankment and Borehole KSS-06 was drilled on Chamberlain Avenue at the toe of the slope.

The approximate locations of the boreholes are shown on the Borehole Locations Plan Drawing included in Appendix E.

The borehole locations were marked in the field and utility clearances were obtained prior to commencement of drilling operations. A road cut permit was obtained for the borehole drilled on Chamberlain Avenue (Borehole KSS-06) and City of Ottawa consent was obtained for the boreholes drilled in the City Park at Lyon Street South and Chamberlain Avenue (Boreholes KSS-01 to KSS-03).

Boreholes KSS-01 to KSS-03 were drilled using a track-mounted drill rig and Boreholes KSS-04 to KSS-06 were drilled using a CME 75 truck-mounted drill rig. Hollow-stem augers were used to advance Boreholes KSS-01 to KSS-03 and KSS-06, and NW casing with wash-boring was used in Boreholes KSS-04 and KSS-05. The borehole sidewalls were supported by this equipment

throughout drilling. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

NQ coring equipment was used to recover cores of the underlying bedrock. A minimum 2.7 m length of bedrock core was recovered from each of the six boreholes. All rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Index (FI) were determined.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples and rock cores for transport to Thurber's laboratory for further examination and testing.

One standpipe piezometer, consisting of a 19 mm diameter PVC pipe with a minimum 3 m slotted screen, was installed in each of the proposed staging areas (Boreholes KSS-01 and KSS-04). The completion details of the piezometer installations and backfilling details for other boreholes are summarised in Table 3.1. Following the final water level readings, the piezometers will be decommissioned in general accordance with MOE Regulation 903.

Table 3.1 – Piezometer Installation and Borehole Backfill Details

Borehole	Tip Position (m)	Installation / Backfill Details
	Depth / Elev.	
KSS-01	6.7 / 60.7	Sand filter from 6.7 to 3.3 m, then bentonite from 3.3 m to surface. Flushmount protective casing installed at surface.
KSS-02	None installed	Borehole backfilled with bentonite holeplug and cuttings to surface.
KSS-03	None installed	Borehole backfilled with bentonite holeplug and cuttings to surface.
KSS-04	19.4 / 53.6	Sand filter from 19.4 to 15.1 m, bentonite from 15.1 to 14.2 m, then sand/bentonite mixture to surface. Flushmount protective casing installed at surface with asphalt patch.
KSS-05	None installed	Borehole backfilled with bentonite to 0.2 m, then asphalt cold patch to surface.
KSS-06	None installed	Borehole backfilled with bentonite and cuttings to 0.2 m, then asphalt cold patch to surface.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and moisture content determinations. Selected samples were also subjected to grain size distribution analysis (sieve and hydrometer) and Atterberg Limits testing, where appropriate. The results of this testing program are summarized on the Record of Borehole sheets and figures included in Appendices A and B.

Point load tests were carried out on selected samples of intact bedrock core to assist in evaluation of the compressive strength of the bedrock. Results of the point load tests are included in the Record of Borehole sheets in Appendix A and Appendix B (as average Unconfined Compressive Strength (UCS) per core run).

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A and Borehole Locations Plan Drawing included in Appendix E. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

More detailed descriptions of the individual strata encountered at the two proposed staging areas are presented below.

5.1 Staging Area #1 (Boreholes KSS-01 to KSS-03)

In general terms, the stratigraphy encountered at this site consists of a thin layer of topsoil overlying cohesionless fill (sandy silt to sand), underlain by layers of silty sand till and sandy silt to sand. Limestone bedrock with occasional shale interbeds was encountered below these soils.

5.1.1 Topsoil

A thin layer of topsoil was encountered at the surface in all three boreholes at this site. The thickness of the topsoil ranged from 50 to 200 mm. The topsoil thickness is anticipated to vary across the site.

5.1.2 Sandy Silt to Sand Fill

Cohesionless fill was encountered below the topsoil in all three boreholes. The cohesionless fill was generally brown in colour with occasional grey and black pockets. The fill varied from sandy silt to sand in the three boreholes. The fill contained trace gravel and trace clay, occasional wood pieces, and occasional glass fragments.

The thickness of the cohesionless fill ranged from 2.9 to 4.5 m, with the lower boundary of the cohesionless fill encountered at depths of 3.0 to 4.6 m (Elevations 64.7 to 62.3 m). In general, the fill was thickest at the northern portion of the site.

SPT 'N' values recorded in the fill ranged from 4 to greater than 100 blows for 0.3 m penetration, indicating a variable density ranging from loose to very dense. Typically, SPT 'N' values ranged from 4 to 33 blows for 0.3 m penetration (loose to dense). Higher 'N' values are generally indicative of obstructions within the fill.

The moisture content of samples of the cohesionless fill typically ranged from 5 to 21%. Higher moisture contents, of 35% and 43%, were measured in samples of the fill collected from Borehole KSS-01 where occasional wood pieces and peat were observed.

Two samples of the cohesionless fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figure A1, Appendix A.

Gravel %	0 to 6
Sand %	28 to 53
Silt %	31 to 67
Clay %	5 to 10

5.1.3 Silty Sand Till

Silty sand till was encountered below the cohesionless fill in Boreholes KSS-02 and KSS-03. The silty sand till was grey in colour and contained trace to some gravel, trace clay, and occasional cobbles.

The thickness of the silty sand till ranged from 1.5 to 3.1 m, with the lower boundary of the till encountered at a depth of 6.1 m in both boreholes (Elevations 61.6 and 60.8 m).

SPT 'N' values recorded in the silty sand till ranged from 10 blows for 0.3 m penetration to 50 blows for 0.125 m penetration, indicating a compact to very dense relative density. The high recorded 'N' values may reflect the presence of cobbles and boulders in the till.

Moisture contents of the till ranged from 6 to 15%.

Two samples of the till were selected for laboratory grain size analysis testing. The results of these tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figure A2, Appendix A.

Gravel %	10 to 18
Sand %	46 to 57
Silt %	25
Clay %	8 to 11

Glacial till inherently contains cobbles and boulders.

5.1.4 Sandy Silt to Sand

A layer of sandy silt was encountered below the till in Borehole KSS-02 while in Borehole KSS-03 a layer of sand was encountered below the till. The sandy silt to sand was grey in colour.

The layer of sandy silt in Borehole KSS-02 was 1.3 m thick, with the lower boundary encountered at a depth of 7.4 m (Elevation 59.5 m). The sand layer encountered in Borehole KSS-03 was 1.1 m thick, with the lower boundary encountered at a depth of 7.2 m (Elevation 60.6 m).

SPT 'N' values recorded in the sandy silt to sand were greater than 100 blows for 0.3 m penetration, indicating a very dense relative density.

Moisture contents of the sandy silt to sand ranged from 12 to 15%.

One sample of the sandy silt underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the corresponding Record of Borehole sheet included in Appendix A and the grain size distribution curve for this sample is plotted on Figure A3, Appendix A.

Gravel %	3
Sand %	31
Silt %	59
Clay %	7

5.1.5 Bedrock

Bedrock was encountered directly below the silty sand fill in Borehole KSS-01 and below the sandy silt to sand in Boreholes KSS-02 and KSS-03 and was proven by coring in all three boreholes. The depths and elevations at which bedrock was encountered are summarized in Table 5.1.1.

Table 5.1.1 – Depths and Elevations of Bedrock Surface

Borehole	Bedrock Surface	
	Depth (m)	Elevation (m)
KSS-01	4.6	62.8
KSS-02	7.4	59.5
KSS-03	7.2	60.6

The bedrock was described as light to dark grey, fine crystalline, nodular limestone. The limestone is slightly to moderately weathered with occasional shale interbeds/partings throughout. Highly fractured zones were noted near the bedrock surface.

Total Core Recovery (TCR) in the bedrock ranged from 42% to 100%, typically greater than 90%. The RQD values are between 36% and 95%, indicating poor to excellent quality rock. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 8.

The average estimated unconfined compressive strength per core run, interpreted from point load tests conducted on intact rock cores, ranged from 38 to 101 MPa, indicating a medium strong to strong rock strength classification.

5.1.6 Water Levels

Water levels were not observed in the open boreholes upon completion of drilling, since water was added to the boreholes during bedrock coring. One standpipe piezometer was installed at this site, in Borehole KSS-01. The groundwater depth and elevation measured in the piezometer are summarised in Table 5.1.2.

Table 5.1.2 – Groundwater Monitoring Data

Borehole	Date	Water Level (m)	
		Depth	Elevation
KSS-01	05-Nov-12	3.1	64.3
	21-Nov-12	3.2	64.2
	05-Dec-12	3.2	64.2

The groundwater level is susceptible to seasonal fluctuations. In particular, the groundwater level may be at higher elevations after spring snowmelt or after periods of heavy rainfall.

5.2 Staging Area #2 (Boreholes KSS-04 to KSS-06)

In general terms, the stratigraphy encountered at this site consists of asphalt pavement and sand fill overlying silty clay which is locally underlain by sand and silty sand till. Limestone bedrock with shale interbeds was encountered below the soil deposits.

5.2.1 Asphalt

A layer of asphalt was encountered at the surface in all three boreholes. Boreholes KSS-04 and KSS-05 were drilled on the south edge of the eastbound lanes of Highway 417 while Borehole KSS-06 was drilled on Chamberlain Avenue.

The thickness of the asphalt ranged from 200 to 300 mm.

5.2.2 Sand Fill

Sand fill was encountered below the asphalt in all three boreholes. The sand fill was brown or grey in colour and contained some silt to silty and trace to some gravel.

The thickness of the sand fill ranged from 1.1 m (on Chamberlain Avenue) to 7.0 m (on Highway 417), with the lower boundary encountered at depths of 1.4 to 7.2 m (Elevations 66.6 to 65.8).

SPT 'N' values recorded in the sand fill ranged from 8 to 78 blows for 0.3 m penetration, indicating a loose to very dense relative density. The SPT N-value of 8 (loose) was recorded in the thin layer of sand fill in Borehole KSS-06, drilled on Chamberlain Avenue while the Highway 417 embankment fill was typically compact to very dense.

Moisture contents of the sand fill typically ranged from 4 to 9%. Moisture contents of 17 and 26% were measured in Boreholes KSS-04 and KSS-05 near the lower boundary of the fill.

Three samples of the sand fill were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the corresponding Record of Borehole sheets, included in Appendix B. The grain size curves for these samples are plotted on Figure B1, Appendix B.

Gravel %	0 to 4
Sand %	63 to 74
Silt %	15 to 29
Clay %	7 to 8

5.2.3 Silty Clay

Silty clay was encountered below the sand fill in all three boreholes drilled at this staging area. The silty clay was brown to grey in colour and contained trace sand near the surface of the deposit.

The thickness of the silty clay ranged from 7.8 to 8.8 m, with the lower boundary of the silty clay encountered at depths of 9.2 to 16.0 m (Elevations 58.7 to 57.0).

SPT 'N' values recorded in the silty clay ranged from 0 to 8 blows for 0.3 m penetration, indicating a very soft to firm consistency. In general, the highest N-values were recorded near the upper boundary of the silty clay layer. In situ vane testing recorded undrained shear strengths ranging from 30 to 64 kPa, indicating a firm to stiff consistency.

Moisture contents of samples of the silty clay ranged from 34 to 76%.

Grain size distribution analyses were carried out on three samples of the silty clay. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. The grain size distribution curves for these samples are plotted on Figure B2, Appendix B. The results are presented below:

Gravel %	0
Sand %	0 to 2
Silt %	23 to 48
Clay %	52 to 75

These three samples also underwent Atterberg Limits testing, the results of which are summarized below. These results are also plotted on Figure B4, Appendix B.

Liquid Limit %	51 to 70
Plastic Limit %	23 to 29

The results of the Atterberg Limits tests indicate that the silty clay is high plastic with a group symbol of CH.

The measured sensitivity, expressed as the ratio of undisturbed vane strength to remoulded vane strength, ranged from 5 to 16, indicating that the clay is medium to highly sensitive.

5.2.4 Silty Sand

A layer of grey silty sand was encountered below the silty clay in Borehole KSS-05.

This sand layer was 2.1 m thick, with the lower boundary of the silty sand encountered at a depth of 17.0 m (Elevation 55.6).

An SPT N-value of 25 blows for 0.3 m penetration was recorded in the silty sand, indicating a compact relative density.

A moisture content of 22% was measured in one sample of the silty sand.

5.2.5 Silty Sand Till

Silty sand till was encountered below the silty clay in Borehole KSS-06. The silty sand till was grey and contained trace to some gravel, trace clay, and occasional cobbles.

The till was 3.8 m thick, with the lower boundary of the till encountered at a depth of 13.0 m (Elevation 55.0).

SPT 'N' values of 1 and 16 blows for 0.3 m penetration were recorded within the silty sand till, indicating a very loose to compact relative density. An SPT N-value of 50 blows for 0.075 m penetration was recorded at the till-bedrock interface.

Measured moisture contents ranged from 9 to 11%.

One sample of the silty sand till underwent laboratory grain size analysis testing. The results of this test are presented below and are summarized on the corresponding Record of Borehole sheet, included in Appendix B. The grain size distribution curve for this sample is plotted on Figure B3, Appendix B.

Gravel %	5
Sand %	62
Silt %	21
Clay %	12

Glacial tills inherently contain cobbles, boulders and shale slabs.

5.2.6 Bedrock

Bedrock was encountered below the silty clay in Borehole KSS-04, below the silty sand in Borehole KSS-05, and below the silty sand till in Borehole KSS-06. The bedrock was proven by coring in all three boreholes. The depths and elevations at which bedrock was encountered are summarised in Table 5.2.1.

Table 5.2.1 – Depths and Elevations of Bedrock Surface

Borehole	Bedrock Surface	
	Depth (m)	Elevation (m)
KSS-04	16.0	57.0
KSS-05	17.0	55.6
KSS-06	13.0	55.0

The bedrock core from Boreholes KSS-04 and KSS-05 is described as dark grey to black shale with calcareous siltstone interbeds. Occasional bituminous seams to 20 mm thick

were noted. The rock is highly to moderately weathered, becoming slightly weathered approximately 2.0 to 2.5 m below the bedrock surface.

The bedrock recovered from Borehole KSS-06 is described as light and dark grey, crystalline limestone. The upper 1.2 m of core was slightly to moderately weathered, with horizontal joints to 150 mm thick infilled with clay. The rock becomes slightly weathered below this depth.

Total Core Recovery (TCR) ranged from 31% to 100%, typically lower near the bedrock surface. The RQD values ranged from 14 to 100%, indicating variable rock quality ranging from very poor to excellent. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, generally ranged from 0 to 6, except where the rock core was highly fractured and the FI was greater than 10.

The average estimated unconfined compressive strength of the bedrock, interpreted from point load tests conducted on intact rock cores, ranged typically from 52 to 122 MPa, indicating a strong to very strong rock strength classification.

5.2.7 Water Levels

Water levels were not observed in the open boreholes upon completion of drilling due to the introduction of water into the borehole for bedrock coring. A standpipe piezometer was installed in Borehole KSS-04. The groundwater depths and elevations measured in the piezometer are summarised in Table 5.2.2.

Table 5.2.2 – Ground Water Monitoring Data

Borehole	Date	Water Level (m)	
		Depth	Elevation
KSS-04	15-Nov-12	9.9	63.1
	05-Dec-12	10.2	62.8

The groundwater level is susceptible to seasonal fluctuations. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. Surveyors from MMM Group Limited provided co-ordinates and the ground surface elevations for the completed boreholes.

Underground Service Locators Inc. obtained utility clearances on behalf of Thurber for the selected borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied both the track-mounted and truck-mounted CME 75 drill rigs and conducted the drilling, sampling and in-situ testing operations.

The field investigation was supervised by Ms. Gabrielle Marcotte, E.I.T. and Ms. Katrina Young, E.I.T., both of Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall planning and supervision of the field program was conducted by Ms. Lindsey Blaine, E.I.T. Interpretation of the data and preparation of the report were carried out by Ms. Lindsey Blaine, E.I.T. and Mr. M.R. Anderson, P.Eng.

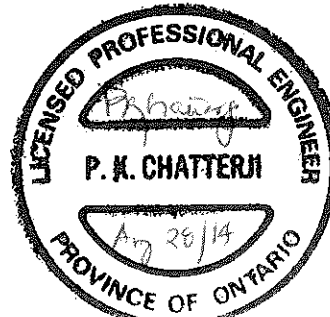
The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select the preferred staging area and design temporary supports for construction of the new Kent Street Overpass superstructures.

The Kent Street Overpass is located on Highway 417 directly south of the Ottawa city centre. The existing structures are single span voided slab bridges with a total span varying from approximately 18 to 30 m across Kent Street. The overall width is approximately 35 m including four westbound lanes on the Highway 417 WB superstructure and three eastbound lanes on the Highway 417 EB superstructure.

Rapid replacement of the superstructures will involve prefabrication of the new superstructures on temporary supports in the staging area, removal of the old superstructures and storage in the staging area, and transportation and installation of the new superstructures at the overpass site.

Two alternative sites are proposed for the staging area. One site (designated Staging Area #1 in this report) comprises a park located at the southwest corner of the intersection of Lyon Street South and Chamberlain Avenue, approximately 50 m south of Highway 417 and 200 m west of Kent Street. The other site (designated Staging Area #2) consists of the south slope of the Highway 417 embankment, bounded by Kent Street, Bank Street and Chamberlain Avenue. This site is under consideration due to utility clearance issues on Chamberlain Avenue to the west of Kent Street, and will require excavation of the highway embankment slope, including provision of a protection system along Highway 417, to provide a level working area.

Discussion and recommendations presented in this report are based on the information provided by McCormick Rankin and on the factual data obtained in the course of the investigation.

8 STAGING AREA FOUNDATIONS

The subsurface stratigraphy encountered at Staging Area #1 generally consists of loose to very dense sandy silt to sand fill extending to depths of 3.0 to 4.6 m, underlain by layers of silty sand till and sandy silt to sand, overlying limestone bedrock contacted at depths of 4.6 to 7.4 m (Elev. 59.5 to 62.8). At Staging Area #2, the stratigraphy consists of loose to very dense sand fill extending to depths of 1.4 to 7.2 m, overlying 7.8 to 8.8 m of soft to firm silty clay which is locally underlain by sand and silty sand till, overlying limestone and shale bedrock contacted at depths of 13.0 to 17.0 m (Elev. 55.0 to 57.0).

We understand that the maximum allowable differential settlement permitted for construction of the new structure within the staging area will be 10 mm between substructures and 5 mm across an individual substructure. To achieve these stringent settlement requirements, it is recommended that the temporary supports be constructed on augered caissons or driven piles extended to bedrock.

The use of deep foundations is recommended considering the following:

- The existing fills and native soils are considered unsuitable for support of temporary foundations due to the variable and/or low available geotechnical resistance and the potential for high differential settlements.
- In Staging Area #1, excavation depths of up to 6.1 m would be required to penetrate existing fill and native soils to found spread footings on very dense native soil or bedrock capable of achieving the tight settlement requirements.
- In Staging Area #2, foundations would need to be extended below the existing fill, soft to firm silty clay and very loose to compact sand/till to found on bedrock contacted at depths of 16.0 to 17.0 m below Highway 417 grade at the top of the embankment slope and 13.0 m below road grade on Chamberlain Avenue at the base of the slope.
- Construction of an engineered fill pad would require similar excavation depths as for spread footings on native soil or bedrock, as well as disposal of excavated soils and importation of select granular material.
- The use of deep foundations reduces excavation and disposal quantities, and achieves the differential settlement requirements.

Recommendations for design and construction of caissons socketed into bedrock and steel H-piles driven to bedrock are presented for both staging areas in the following sections. A comparison of the foundation alternatives, based on advantages and disadvantages of each, is provided in Appendix C. Shallow foundations are not considered suitable for the temporary supports.

A sample Special Provision provided by MMM Group for design and construction of the temporary structures, including the temporary foundations, is provided in Appendix D.

8.1 Caissons

8.1.1 Axial Capacity

It is recommended that caissons be socketed at least 1.5 m into the bedrock to found in sound limestone and shale below the level of fractured/weathered bedrock and clay seams, achieve the stringent settlement requirements, and enable extension of a caisson liner into the bedrock for groundwater control during construction. The factored axial geotechnical resistances at ULS recommended for typical caisson designs socketed 1.5 and 3.0 m into bedrock are provided in Table 8.1. These values include the geotechnical resistance factor of 0.4 specified in the CHBDC for axial compression.

Table 8.1- Axial Geotechnical Resistance of Caissons

Caisson Diameter (m)	Socket Length (m)	Factored Axial Resistance at ULS (kN)
0.6	1.5	1,500
	3.0	3,000
0.9	1.5	3,000
	3.0	5,500
1.2	1.5	4,500
	3.0	8,500

The factored axial resistances provided in the table were computed based on a factored shaft resistance of 400 kPa and factored end-bearing resistances of 2,500 and 4,000 kPa for 1.5 and 3.0 m deep sockets, respectively. The end-bearing resistance at 1.5 m depth has been reduced in consideration of fracturing/weathering/poorer quality rock in the upper part of the bedrock. The SLS condition will not govern for caissons founded in bedrock.

8.1.2 Caisson Installation

Caisson installation must be in accordance with OPSS 903.

At Staging Area #1, the caissons will be advanced through loose to very dense silty sand to sand fill, silty sand till and very dense sandy silt to sand. Groundwater was measured at depths of 3.1 to 3.2 m (Elev. 64.2 to 64.3) in a piezometer installed at this staging area, up to 4.8 m above the bedrock level.

At Staging Area #2, the caissons will be advanced through very dense to compact silty sand to sand fill, soft to firm silty clay and very loose to very dense silty sand till. Groundwater was measured at depths of 9.9 to 10.2 m (Elev. 62.8 to 63.1) in a piezometer installed at this staging area, up to 8.1 m above the bedrock level.

The caisson drilling equipment supplied by Contractor must be capable of advancing through the variable fill and native soils. The fill and till deposits may contain cobbles, boulders or other obstructions, and penetrating or pushing aside of these potential

obstructions may be required. Augering/coring equipment must also be able to penetrate the limestone bedrock. Blasting of the bedrock will not be permitted.

Construction of the caissons will require implementation of methods to support the sidewalls, minimize groundwater inflow, and enable machine-cleaning of the socket base. The construction method is the responsibility of the Contractor, but consideration could be given to temporary steel liners, mud drilling and tremie concrete techniques where conditions warrant.

Caisson concrete must be placed within 8 hours of excavation to minimize softening of the shale interbeds in the socket.

An NSSP notifying the Contractor of the specific subsurface conditions and installation requirements at this site should be included in the contract documents. Suggested wording is presented in Appendix D. Selection of the type of equipment and method of installation is the responsibility of the Contractor.

8.1.3 Lateral Resistance

The lateral resistance of the caisson may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) in the cohesionless soils as follows:

$$k_s = n_h \cdot z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \cdot \gamma \cdot z \cdot K_p \quad (\text{kPa})$$

Where: z = depth of embedment of caisson in metres

D = caisson diameter in metres

n_h = value from Table 8.2

γ = unit weight (Table 8.2)

K_p = passive earth pressure coefficient (Table 8.2)

In cohesive soils, the caisson lateral resistance may be calculated as follows:

$$k_s = 67 s_u / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 9 s_u \quad (\text{kPa})$$

Where: D = caisson diameter in metres

s_u = undrained shear strength (kPa)

The above equations and recommended parameters may be used to analyse the interaction between a caisson and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

Table 8.2 – Parameters for Lateral Caisson Resistance

Site No.	Top Elev.	Bottom Elev.	n_h (kN/m ³)	K_p	S_u (kPa)	Unit Weight (kN/m ³)	Soil Conditions
Staging Area #1	Surface	64.0	3500	3.0	-	20	Silty sand to sand fill
	64.0	62.5	2500	3.0	-	10*	Silty sand to sand fill
	62.5	61.0	3000	3.0	-	11*	Silty sand till
	61.0	60.0	5000	3.3	-	11*	Sandy silt to sand
Staging Area #2	Surface	66.5	5000	3.0	-	21	Silty sand to sand fill
	66.5	63.0	-	-	40	17	Silty clay
	63.0	57.0	-	-	40	7*	Silty clay
	57.0	55.0	5000	3.3	-	11*	Silty sand till

* Buoyant unit weight below groundwater table.

Caisson interaction should be considered with reference to CHBDC Clause 6.8.9.2. Where a caisson group is oriented *perpendicular* to the direction of loading, group action may be considered by reducing values for k_s by a reduction factor R as follows:

Caisson Spacing Perpendicular to Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
4 D*	1.00
1 D*	0.50

Where a caisson group is oriented *parallel* to the direction of loading, group action may be considered by reducing values for k_s by a reduction factor R as follows:

Caisson Spacing Parallel to Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
8 D*	1.00
6 D*	0.70
4 D*	0.40
3 D*	0.25

* D is the width of the caisson, and spacing is measured centre to centre

Intermediate values of reduction factors may be obtained by linear interpolation.

In bedrock, the caisson lateral resistance may be calculated using a coefficient of horizontal subgrade reaction (k_s) of 100 MN/m³ and an ultimate lateral resistance (p_{ult}) of 2,500 kPa.

The above equations and recommended parameters may be used to analyse the interaction between a caisson and the surrounding rock. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance. The lateral resistance of the caisson in bedrock will not be significantly affected by caisson spacing.

The spring constant, K, for analysis may be obtained by the expression, $K = k_s \cdot L \cdot D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m³), D is the caisson width (m) and L is the length (m) of the caisson segment or element used in the analysis. The ultimate lateral resistance on any one segment of caisson, P_{ult} , may be

obtained from the expression, $P_{ult} = p_{ult} * L * D$. This represents the ultimate load at which the caisson fails and will not support any additional load at greater displacements.

8.2 Steel H-Piles

The use of steel H-piles driven to refusal on bedrock may be considered to support the new superstructure in the staging area. The piles are expected to encounter refusal on bedrock near elevation Elev. 59.5 to 62.8 at Staging Area #1 and at Elev. 55.0 to 57.0 at Staging Area #2.

For HP 310x110 steel piles driven to bedrock, a factored axial geotechnical resistance at ULS of 2,000 kN per pile is recommended. The SLS condition will not govern for piles founded on bedrock.

Pile installation must be in accordance with OPSS 903. All pile tips should be fitted with H-Section driving shoes as per OPSD 3000.100. The appropriate pile driving note is "Piles to be driven to bedrock".

The Contractor must be prepared to drive piles through locally very dense fill, till and sand deposits potentially containing cobbles, boulders and shale slabs. The Contract Documents should contain a NSSP alerting the Bidders to these conditions. Suggested text for an NSSP is included in Appendix D.

Lateral resistance provided by the piles may be computed as outlined for augered caissons. Alternatively battered piles may be employed.

If driven piles are used, a preconstruction condition survey of existing structures and utilities within about 50 m of the site should be carried out prior to commencement of pile driving. Vibration monitoring should be carried out during pile driving to limit potential impacts on existing facilities, and conditions carefully monitored for signs of disturbance. In general, vibration levels should not exceed a peak particle velocity of 8 mm/s at ground level adjacent to any structure.

8.3 Recommended Foundation

From a geotechnical perspective and based on the subsurface conditions, steel H-piles driven to refusal on bedrock are the preferred foundation type for the temporary structure supports. Caissons socketed into bedrock are also considered feasible, however use of a caisson liner will be required to support the sidewalls of the caisson and allow for machine cleaning of the caisson base.

Based on the shallower depth to bedrock, Staging Area #1 (the park location) would be preferred from a foundations perspective to minimize the length and cost of deep foundations. Further, equipment mobilization would be more straightforward on the level parkland than on the sloped highway embankment. It is recognized however that use of this site requires a longer travel distance to the overpass site.

8.4 Frost Cover

The design depth of frost penetration at this site is 1.8 m.

Frost protection should be provided for all pile caps to be in use over the winter months, and should consist of a minimum of 1.8 m of soil cover or equivalent thermal insulation.

9 ROADWAY PROTECTION

Roadway protection will be required to maintain the Highway 417 eastbound lanes adjacent to the north side of Staging Area #2. Roadway protection should be supplied in accordance with OPSS 539 and designed for Performance Level 2. The protection systems should be designed by a licensed Professional Engineer experienced in design of shoring with consideration of adjacent traffic loads and any sloping retained surfaces.

It is the responsibility of the Contractor to design the roadway protection system and any dewatering system required. Use of a sheet pile or soldier pile and lagging system with driven H-piles is expected to be feasible.

Considering the height of the protection system (expected to be in the order of 5 m) and the presence of soft to firm clay forming the embankment foundation, additional lateral support will likely be required to limit movement of the protection system. The use of soil anchors installed within the existing compact to very dense sand embankment fill or rock anchors extended down to the underlying shale bedrock may be considered. The global stability of the excavation and shoring system will also need to be confirmed, and additional measures to improve the stability may be required.

Material and equipment should not be stockpiled adjacent to the excavation.

10 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to the issues discussed below.

- The fill and till deposits at the site may contain cobbles, boulders and other obstructions. In addition, very dense zones are present in these materials. Equipment selected to install caissons and piles must be capable of penetrating these materials.
- Equipment selected for extending the caissons into bedrock must be capable of penetrating limestone with shale interbeds and producing a rock socket without disturbing the sides or base of the excavation.
- Caisson sockets should be inspected, approved and protected with concrete within 8 hours of excavation to prevent softening of the shale beds in the bedrock.
- Use of a steel liner is recommended to advance caissons to the bedrock surface to support the sidewalls, minimize groundwater inflow, and enable machine-cleaning of the socket base.

- If driven piles are used, a preconstruction condition survey of existing structures and utilities within about 50 m of the site should be carried out prior to commencement of pile driving. Vibration monitoring should be carried out during pile driving to limit potential impacts on existing facilities, and conditions carefully monitored for signs of disturbance.

11 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Keli Shi, P.Eng. and Mr. M.R. Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Keli Shi, P.Eng.
Geotechnical Engineer



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Senior Foundations Engineer



P.K. Chatterji, P.Eng.
Review Principal



Appendix A
Staging Area #1

Record of Borehole Sheets
Laboratory Test Results
Site Photographs

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
	HIGHLY ORGANIC SOILS		Pt
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS






ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No KSS-01

1 OF 1

METRIC

W.P. 4033-08-01 LOCATION N 5 029 910.9 E 367 744.7 ORIGINATED BY GM
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.11.05 - 2012.11.05 CHECKED BY LRB

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									
67.4								20	40	60	80	100					
0.0	TOPSOIL: (200mm)																
0.2	Brown Damp		1	SS	30		67										
	Silty SAND, trace clay, trace gravel Compact to Loose Brown Damp (FILL) Occasional wood pieces		2	SS	24		66										6 53 31 10
			3	SS	4		65										
	Occasional glass fragments and wood pieces		4	SS	7		64										
	Occasional peat Black		5	SS	5		63										
62.8			6	SS	60		62										
4.6	LIMESTONE BEDROCK, fine crystalline, nodular, slightly weathered, occasional shale interbeds, light to dark grey		1	RUN	0.025		61										
			2	RUN			60										
			3	RUN													
59.8																	
7.6	END OF BOREHOLE AT 7.6m. WATER LEVEL AT 3.1m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov. 21/12 3.2 64.2 Dec. 05/12 3.2 64.2																

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Sensitivity 20
15 10 6 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No KSS-02

1 OF 2

METRIC

W.P. 4033-08-01 LOCATION N 5 029 952.7 E 387 813.8 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.11.06 - 2012.11.06 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)								
								○ UNCONFINED	+ FIELD VANE												
								● QUICK TRIAXIAL	× LAB VANE												
66.9							20	40	60	80	100										
0.0	TOPSOIL: (50mm)																				
0.1	SAND and SILT, trace gravel, trace clay, some rootlets Loose Brown Damp (FILL)		1	SS	9																
66.0																					
0.9	SAND, some gravel, trace silt, trace cobbles Very Dense Brown Damp (FILL)		2	SS	76/ 0.150																
64.6																					
2.3	SAND and SILT, trace gravel, occasional wood pieces Loose Brown/Grey Damp (FILL)		4	SS	10																
			5	SS	4																
62.3																					
4.6	Silty SAND, trace to some gravel, trace clay Loose/Compact Grey Wet (TILL)		6	SS	10																
60.8																					
6.1	Sandy SILT Very Dense Grey Saturated		7	SS	50/ 0.125																
	Auger refusal at 7.3m																				
59.5																					
7.4	LIMESTONE BEDROCK, fine crystalline, nodular, slightly weathered, occasional shale interbeds, light to dark grey		1	RUN																	
			2	RUN																	
																		</			

Continued Next Page

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Sensitivity

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(%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No KSS-02

2 OF 2

METRIC

W.P. 4033-08-01 LOCATION N 5 029 952.7 E 367 813.8 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.11.06 - 2012.11.06 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y kN/m ³	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 X LAB VANE					W _p	W	W _L		
	Continued From Previous Page							20	40	60	80	100					
			3	RUN			56										
55.5																	
11.4	END OF BOREHOLE AT 11.4m. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO SURFACE.																

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RECORD OF BOREHOLE No KSS-03

1 OF 2

METRIC

W.P. 4033-08-01 LOCATION N 5 029 885.7 E 367 796.9 ORIGINATED BY GM
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.11.05 - 2012.11.05 CHECKED BY LRB

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	x LAB VANE						
67.7							20	40	60	80	100						
0.0	TOPSOIL: (50mm)																
0.1	Sandy SILT, trace clay, some rootlets Compact Dark Brown Damp (FILL)		1	SS	13											0 28 67 5	
			2	SS	28												
	Dense to Very Dense Trace roots Wet		3	SS	33												
	Grey		4	SS	64												
64.7																	
3.0	Silty SAND, some gravel, trace clay, occasional cobbles Very Dense to Compact Grey (TILL)		5	SS	50/ 0.125												
			6	SS	22											18 46 25 11	
61.6																	
6.1	SAND, coarse grained, some gravel Very Dense Grey Wet		7	SS	50/ 0.125												
60.6																	
7.2	LIMESTONE BEDROCK, fine crystalline, nodular, moderately weathered, occasional shale interbeds, light to dark grey, highly fractured near surface		1	RUN												RUN #1 TCR=100% SCR=58% RQD=42% UCS=64MPa (Average)	
			2	RUN												RUN #2 TCR=42% SCR=42% RQD=36% UCS=72MPa (Average)	
			3	RUN												RUN #3 TCR=100% SCR=87% RQD=70%	

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10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No KSS-03

2 OF 2

METRIC

W.P. 4033-08-01 LOCATION N 5 029 885.7 E 367 796.9 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.11.05 - 2012.11.05 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT W _p W W _L			UNIT WEIGHT γ kN/m ³	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 X LAB VANE					WATER CONTENT (%) 20 40 60				
	Continued From Previous Page		4	RUN													
57.3																	
10.5	END OF BOREHOLE AT 10.5m. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO SURFACE.															UCS=43MPa (Average) RUN #4 TCR=93% SCR=85% RQD=70% UCS=43MPa (Average)	

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Sensitivity

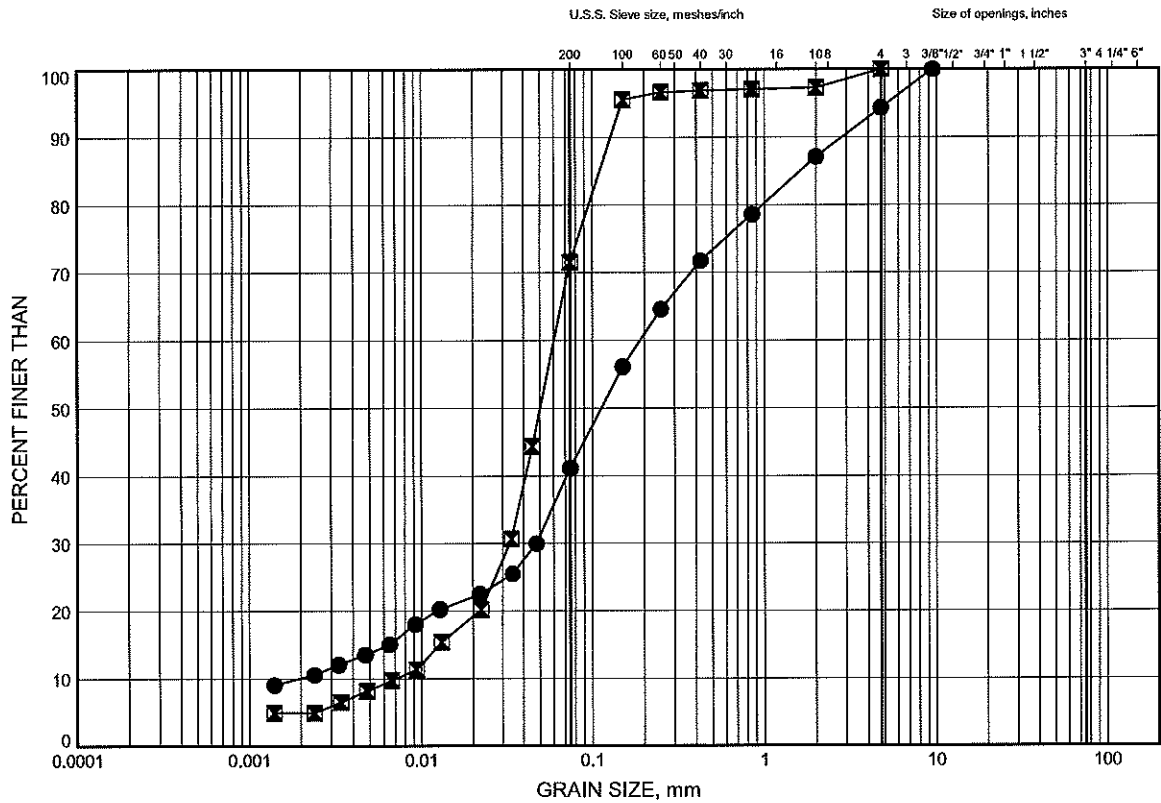
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15
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(%) STRAIN AT FAILURE

GRAIN SIZE DISTRIBUTION

FIGURE A1

SANDY SILT to SILTY SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND			GRAVEL		SIZE

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KSS-01	1.07	66.33
×	KSS-03	1.07	66.66

Date June 2013
W.P. 4033-08-01

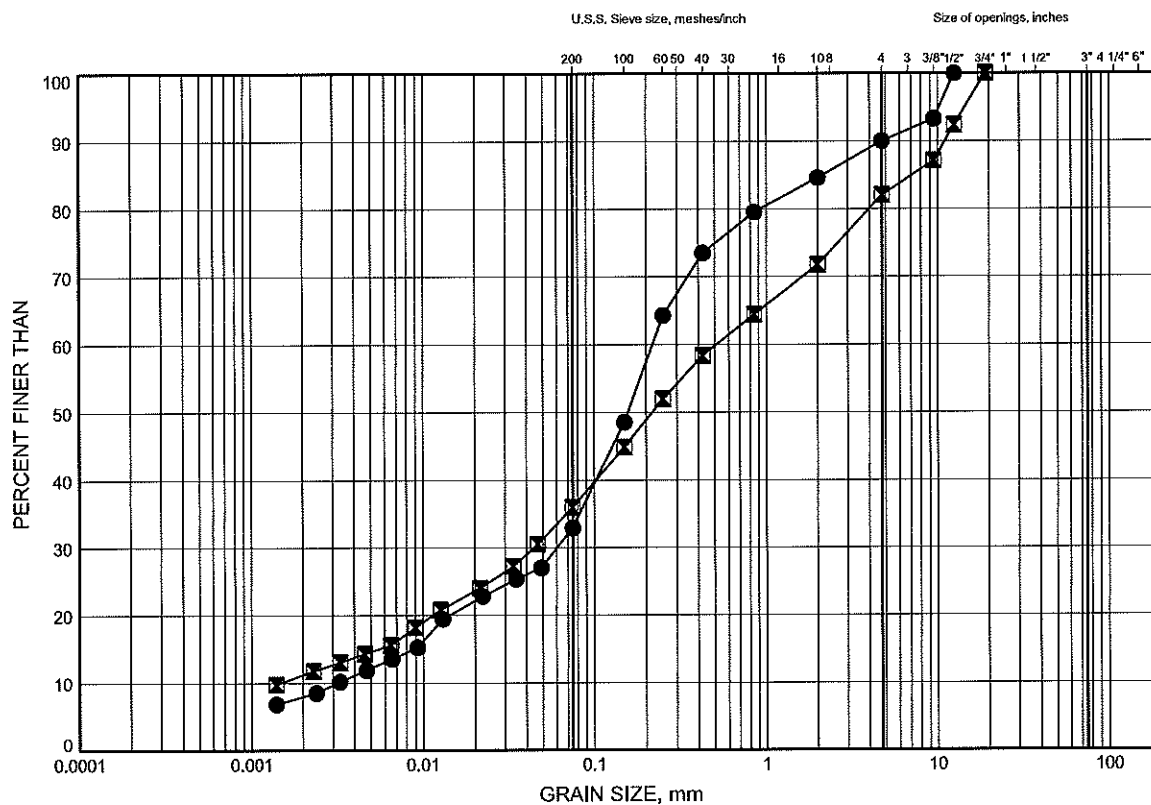


Prep'd AN
Chkd. LRB

GRAIN SIZE DISTRIBUTION

FIGURE A2

SILTY SAND TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KSS-02	4.88	62.02
×	KSS-03	4.88	62.85

GRAIN SIZE DISTRIBUTION - THURBER 1201F.GPJ 6/11/13

Date June 2013
W.P. 4033-08-01

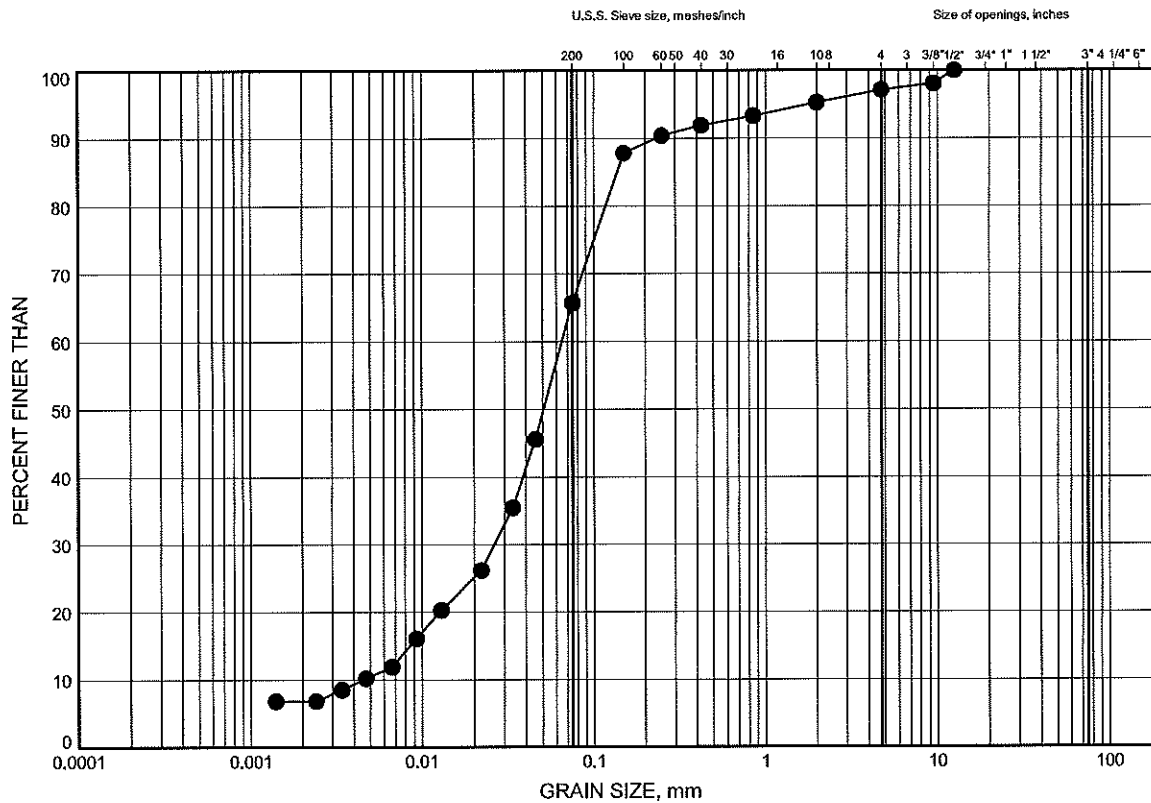


Prep'd AN
Chkd. LRB

GRAIN SIZE DISTRIBUTION

FIGURE A3

SANDY SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KSS-02	6.24	60.66

Date June 2013

W.P. 4033-08-01



Prep'd AN

Chkd. LRB

Staging Areas for Kent Street Structure Rapid Replacement
Highway 417 – Ottawa, Ontario



Photograph 1: Looking northeast across the City Park at Staging Area #1. The wall that can be seen in the top left corner is next to Highway 417.



Photograph 2: Looking southeast towards the residences adjacent to the City Park at Staging Area #1.

Appendix B
Staging Area #2

Record of Borehole Sheets
Laboratory Test Results
Site Photographs

RECORD OF BOREHOLE No KSS-04

1 OF 3

METRIC

W.P. 4033-08-01 LOCATION N 5 030 119.9 E 367 980.3 ORIGINATED BY GM
HWY 417 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.11.14 - 2012.11.15 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)						
73.0								20	40	60	80	100	W _P	W	W _L			
0.0	ASPHALT: (200mm)																	
0.2	SAND, some silt to silty, trace to some gravel Very Dense to Compact Brown Damp (FILL)																	
			1	SS	57		72											
			2	SS	61		71											4 71 17 8
			3	SS	72		70											
			4	SS	78		68											
			5	SS	15		67											0 63 29 8
65.8							66											
7.2	Silty CLAY, trace sand Soft to Firm Grey		6	SS	2		65											
							64											

ONTMT4S 1201F.GPJ 2012TEMPLATE(MTO).GDT 8/18/14

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5
(%) STRAIN AT FAILURE

METRIC

CHECKED BY _____ LRB

ONT\MT4S 1201F.GPJ 2012TEMPLATE(MTO).GOT 8/18/14

(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W _P W W _L ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE 20 40 60 80 100			
Continued From Previous Page												

+³, X³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No KSS-05

1 OF 3

METRIC

W.P. 4033-08-01 LOCATION N 5 030 155.6 E 368 036.3 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.11.18 - 2012.11.19 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
72.6							20 40 60 80 100					
0.0	ASPHALT: (300mm)						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE					
72.2							20 40 60 80 100					
0.3	SAND, trace to some gravel, some silt Very Dense to Compact Grey Damp (FILL)		1	SS	44		20 40 60 80 100					
			2	SS	65		20 40 60 80 100					
			3	SS	47		20 40 60 80 100					
			4	SS	12		20 40 60 80 100					
	Occasional clay pockets		5	SS	3		20 40 60 80 100					
66.5			6	SS	0		20 40 60 80 100					
6.1	Silty CLAY Soft to Firm Brown		7	SS	0		20 40 60 80 100					
	Grey						20 40 60 80 100					

ONTMT4S 1201F.GPJ 2012TEMPLATE(MTO).GDT 8/18/14

Continued Next Page

+³, X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

W.P.	4033-08-01	LOCATION	N 5 030 155.6 E 368 036.3	ORIGINATED BY	GM
HWY	417	BOREHOLE TYPE	Casing/NQ Coring	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.11.18 - 2012.11.19	CHECKED BY	LRB

[illegible]

+³, ×³: Numbers refer to Sensitivity


CONTMT4S 1201F.GPJ 2012TEMPLATE(MTO).GDT 8/18/14

RECORD OF BOREHOLE No KSS-05

3 OF 3

METRIC

W.P. 4033-08-01 LOCATION N 5 030 155.8 E 368 036.3 ORIGINATED BY GM
HWY 417 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.11.18 - 2012.11.19 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE				WATER CONTENT (%) w _p w w _L					
	Continued From Previous Page						20	40	60	80	100		20	40	60		
	Slightly weathered		3	RUN													RUN #3 TCR=77% SCR=77% RQD=67% UCS=43MPa (Average)
			4	RUN													
51.1																	
21.5	END OF BOREHOLE AT 21.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG WITH ASPHALT PATCH AT SURFACE.																

ONTMT4S 1201F.GPJ 2012TEMPLATE(MTO).GDT 8/18/14

+³, X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No KSS-06

1 OF 2

METRIC

W.P. 4033-08-01 LOCATION N 5 030 098.3 E 368 027.8 ORIGINATED BY KMY
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.11.08 - 2012.11.08 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
67.9								20 40 60 80 100						
0.0	ASPHALT: (275mm)							○ UNCONFINED + FIELD VANE						
67.6								● QUICK TRIAXIAL X LAB VANE						
0.3	SAND, some silt Loose Light Brown Moist (FILL)		1	SS	8		67							
66.6														
1.4	Silty CLAY, trace sand Firm to Soft Brown		2	SS	8		66							
			3	SS	3		65							
							64							
							63	14.0 +						
							62	6.0 +						
							61							
							60	13.0 +						
							59							
							58							
58.7														
9.2	Silty SAND, trace to some gravel, trace clay, occasional cobbles Very Loose to Compact Grey Wet													

ONTMT4S 1201F.GPJ 2012TEMPLATE(MTO).GDT 8/18/14

Continued Next Page

+³, X³; Numbers refer to
Sensitivity

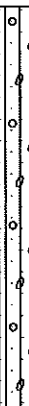
20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No KSS-06

2 OF 2

METRIC

W.P. 4033-08-01 LOCATION N 5 030 098.3 E 368 027.8 ORIGINATED BY KMY
HWY 417 BOREHOLE TYPE Hollow Stem Augers/INQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.11.08 - 2012.11.08 CHECKED BY LRB

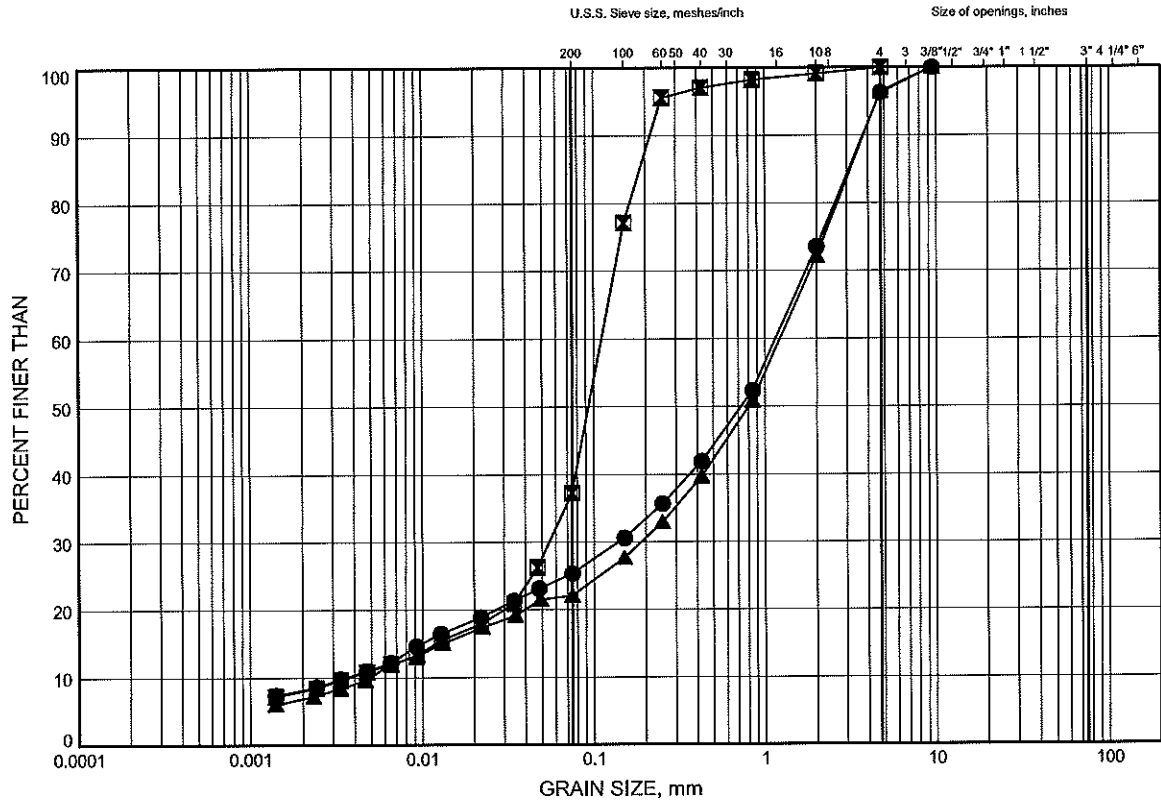
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	W _p	W	W _L			
	Continued From Previous Page						20	40	60	80	100	20	40	60		GR SA SI CL	
	Silty SAND, trace to some gravel, trace clay, occasional cobbles Very Loose to Compact Grey Wet (TILL)		7	SS	1											5 62 21 12	
															</		

ONTMT4S 1201F.GPJ 2012TEMPLATE(MTO).GDT 8/18/14

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND to SILTY SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KSS-04	1.83	71.18
■	KSS-04	6.40	66.61
▲	KSS-05	3.35	69.20

GRAIN SIZE DISTRIBUTION - THURBER 1201.F.GPJ 6/11/13

Date June 2013
W.P. 4033-08-01

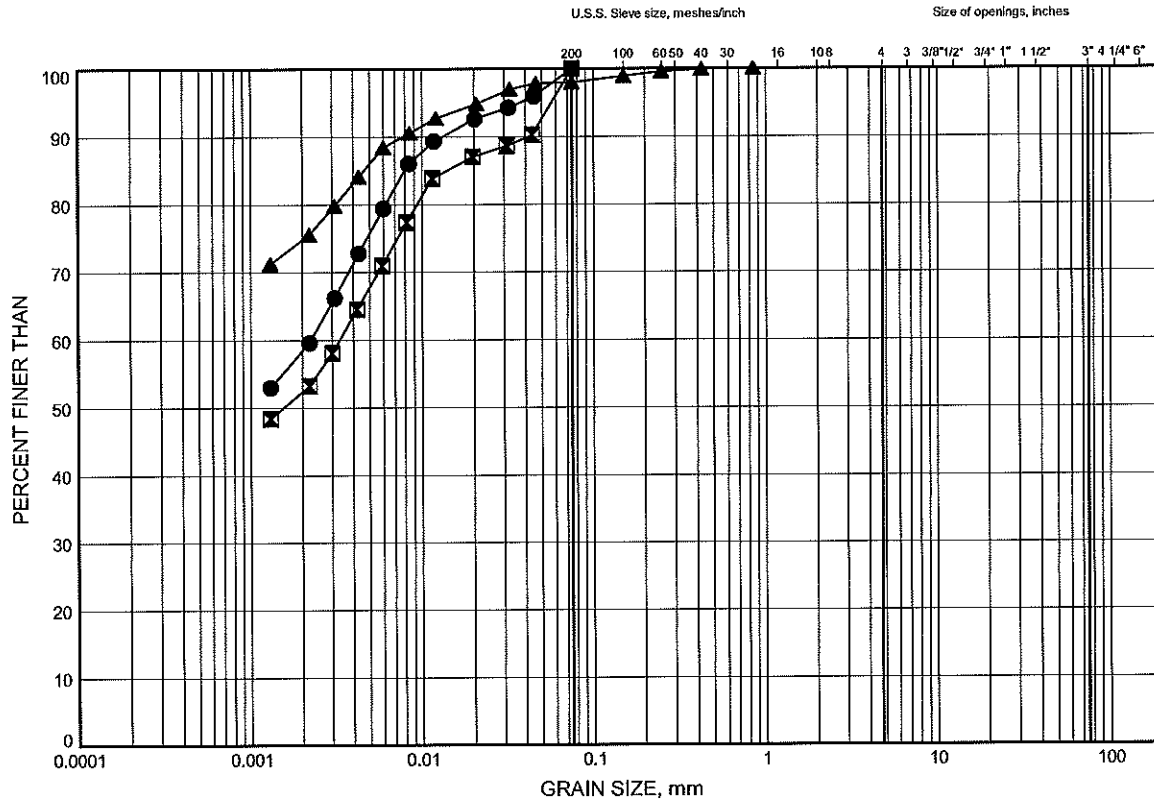


Prep'd AN
Chkd. LRB

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY CLAY



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KSS-04	10.97	62.04
⊠	KSS-05	7.92	64.63
▲	KSS-06	2.59	65.34

GRAIN SIZE DISTRIBUTION - THURBER 1201F.GPJ 6/11/13

Date June 2013
W.P. 4033-08-01

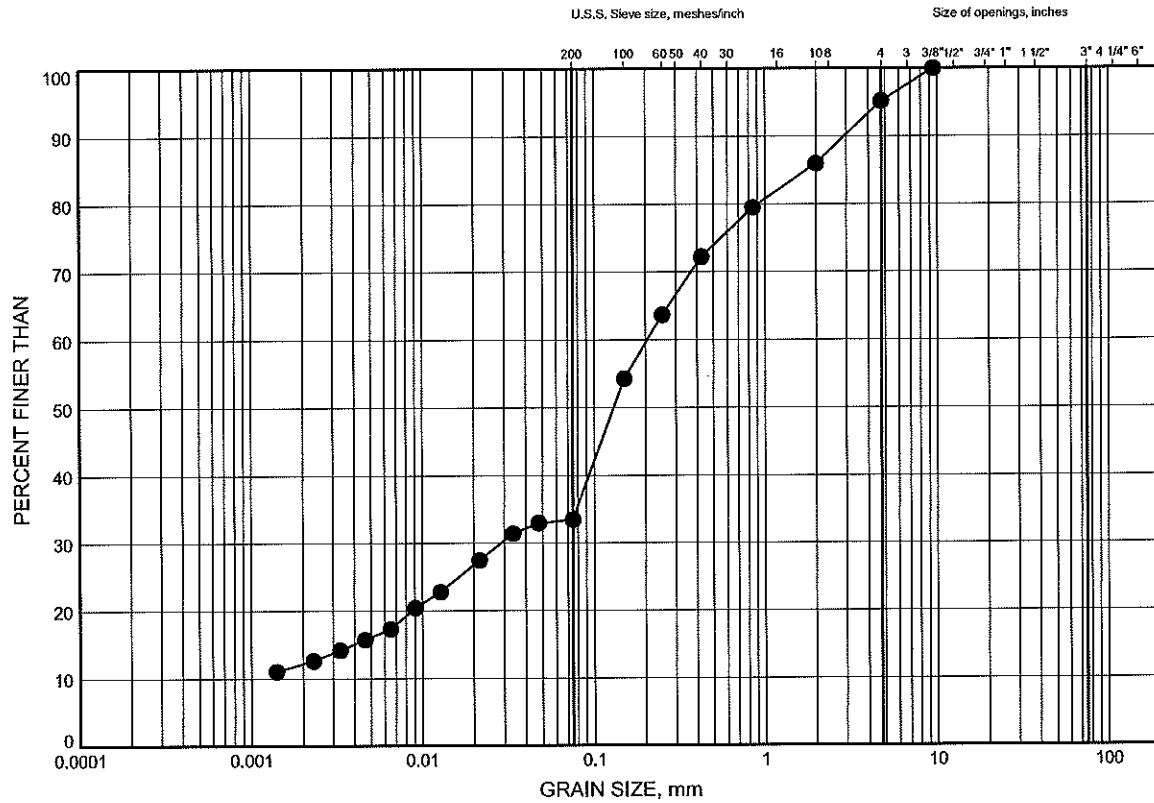


Prep'd AN
Chkd. LRB

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY SAND TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KSS-06	10.21	57.72

GRAIN SIZE DISTRIBUTION - THURBER 1201F.GPJ 6/11/13

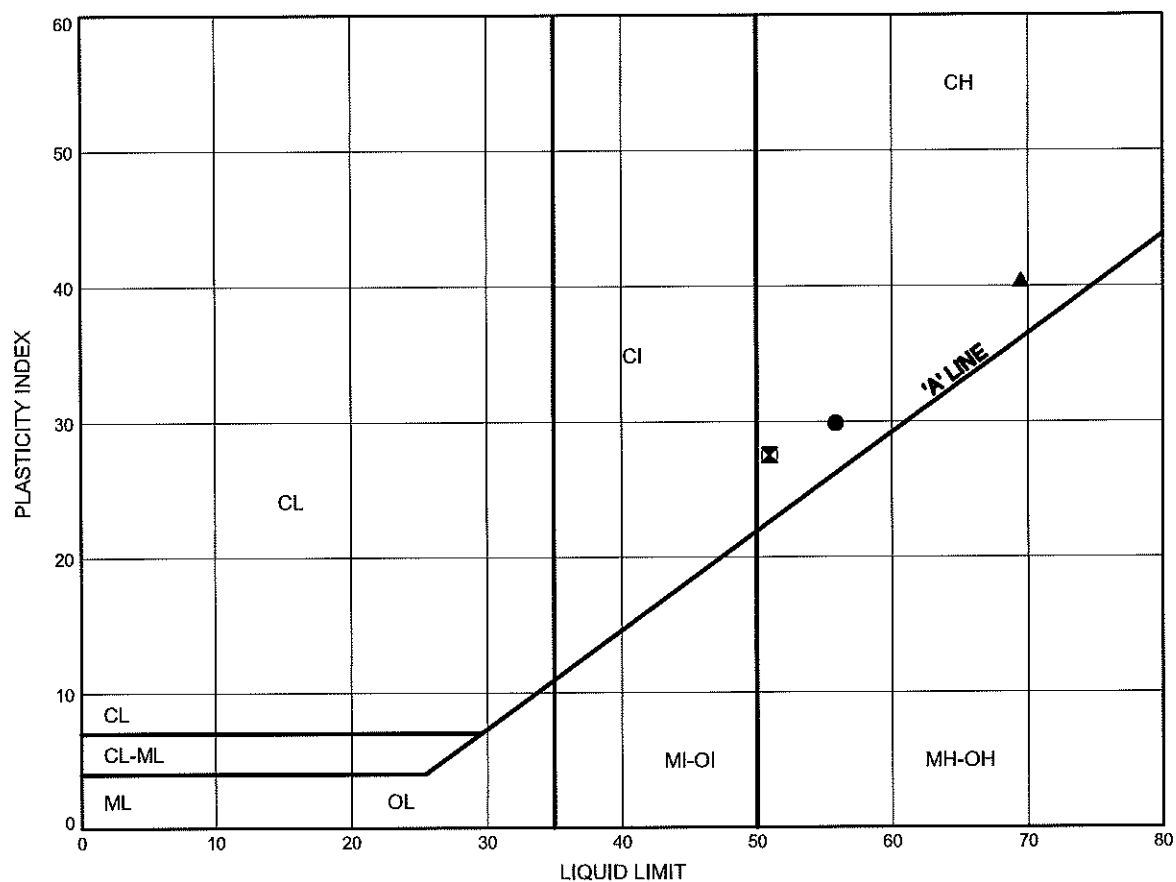
Date June 2013
W.P. 4033-08-01



Prep'd AN
Chkd. LRB

FIGURE B4

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KSS-04	10.97	62.04
■	KSS-05	7.92	64.63
▲	KSS-06	2.59	65.34

Date June 2013
W.P. 4033-08-01



Prep'd AN
Chkd. LRB

Staging Areas for Kent Street Structure Rapid Replacement
Highway 417 – Ottawa, Ontario



Photograph 3: Looking west along Chamberlain Avenue, south of proposed staging area. The proposed staging area is located behind the trees on the right.

Appendix C
Foundation Comparison

Staging Areas for Kent Street Structure Rapid Replacement
Highway 417 – Ottawa, Ontario

COMPARISON OF FOUNDATION ALTERNATIVES FOR STAGING AREA

Spread Footings	Caissons Socketed into Bedrock	Driven Steel H-Piles
<p>Advantages:</p> <ul style="list-style-type: none"> i. Typically straightforward and economical to construct. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance available by socketing caissons into bedrock. ii. Requires fewer foundation elements than piles. iii. Provides uplift and overturning resistance. iv. Reduced differential settlement. v. Construction of caissons could continue in freezing weather. vi. Subexcavation of fill and variable material not required. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance available by driving piles to bedrock. ii. Reduced differential settlement. iii. Readily installed. iv. Installation not impacted by cohesionless soils below water table. v. Subexcavation of fill and variable material not required.
<p>Disadvantages:</p> <ul style="list-style-type: none"> i. Existing fill and native soils are generally unsuitable for support of spread footings. ii. Deep excavation required to construct footings on suitable founding material (bedrock). iii. Excavation through cohesionless soils below the groundwater level would require prior dewatering. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> i. Difficulty in unwatering, cleaning and inspecting bases. ii. Possibility of cobbles and boulders impeding drilling. iii. Higher unit cost compared to footings. iv. Disposal of auger spoils required. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> i. Possibility of cobbles and boulders impeding driving. ii. Higher unit cost compared to footings.
NOT RECOMMENDED	FEASIBLE	RECOMMENDED

Appendix D

**List of SPs and OPSS, and Suggested
Text for Selected NSSP**

1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS 903
- OPSD 3000.100

2. Suggested Text for NSSP on Caisson Installation

The soils on site include very loose to very dense sand fill and silty sand till. The fill and till may contain cobbles, boulders and other obstructions. Further, caissons must be socketed into the underlying limestone or shale bedrock. These materials will potentially have an impact on the installation of caissons. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- The cobbles, boulders and other obstructions may impede the drilling for the caissons resulting in lower production and faster wear of drilling bits.
- Rock coring equipment must be provided in cases where augering cannot push aside or penetrate obstructions in the till, and as needed to construct the sockets in the limestone bedrock. Blasting is not permitted.
- The cobbles, boulders and other obstructions may impact the alignment of the caissons during drilling and accordingly drill advancement must be carefully controlled.

The Contractor is further advised that non-cohesive soils and high groundwater levels are present on site. Non-cohesive soil is susceptible to disturbance under conditions of unbalanced hydrostatic head. The Contractor is responsible for constructing the caisson excavation and rock socket without disturbing the sides or base of the excavation, and for cleaning of the socket base. The construction method is the responsibility of the Contractor, but consideration could be given to temporary liners, mud drilling and tremie concrete techniques where conditions warrant.

The rock socket must be constructed to the Contract dimensions and formed entirely within the bedrock below the level of any cobbles, boulders and rock slabs. Any length of caisson above the bedrock surface will not be considered part of the specified length of rock socket. The top of bedrock elevation and constructed socket length shall be approved through monitoring by the Quality Verification Engineer prior to placing concrete.

The shale in the caisson socket must be protected from deterioration by placement of concrete as soon as practical after completion of the excavation and in no case later than 8 hours after excavation.

3. Suggested Text for NSSP on Pile Driving

The Contractor is advised that the sand fill and silty sand till on site contain very dense zones and may contain cobbles, boulders or other obstructions. Pile driving equipment must be capable of pushing aside or penetrating these obstructions to reach the underlying bedrock.

TEMPORARY STRUCTURE – Item No.

Special Provision

SCOPE

Work under this item includes the design, construction and removal of three (3) temporary structures for the existing Kent Street westbound and eastbound and the new westbound and eastbound structures including foundations in the designated construction staging area required for the support and construction of the new superstructure steel girders, concrete deck, barriers and deck waterproofing systems and for dropping-off of the existing superstructures. It should be noted that one of the structures will need to be adaptable for both the existing EBL structure as well as the new WBL structure. Work shall include but not be limited to the following:

- Earth excavation, backfilling and reinstatement required for temporary structure foundations below the excavated level required to create a level staging area which requires excavation of the existing highway embankment.
- Supply, install and removal of protection systems as may be required. Protection systems as may be required shall meet the requirements of performance level 2 as specified elsewhere in the Contract. These protection system are in addition to those required to maintain the highway embankment when the staging area is excavated
- Supply and place temporary support foundations for temporary structural steel structure including all attachments and connections between foundations and steel structure.
- Supply and place reinforcing steel in temporary concrete support pads.
- Supply and install all plates, angles, bolts, fasteners, anchor rods and miscellaneous attachments (welded or bolted) as required to construct the temporary structure and foundation units.
- Supply and place high strength non-shrink grout between structural steel and concrete surfaces, if utilized, to ensure uniform bearing and support at all locations and at all times.
- Fabricate, supply, transport and erect the temporary structural steel structure required to support and construct the new bridge superstructure in the construction staging area complete with all the plates, angles, bolts, fasteners, anchor rods and miscellaneous attachments (welded and bolted).
- Supply and install bearings, blocking, shim plates, bevelled plates to facilitate the supporting the structure in a stable manner and to allow free thermal movement of the structure.
- Supply access to the work area required to complete all the work operations including placement and finishing of concrete deck, barrier walls and deck waterproofing system, and designed to accommodate concrete finishing equipment and all the equipment necessary to dismantle and dispose of the existing bridge superstructure.
- Remove and dispose of concrete foundation (and reinforcing steel) and temporary steel structure, shoring material and all other miscellaneous components listed above of structure foundation, temporary structure, shoring components and associated works.

The design and construction of the temporary support structure shall allow the removal and transportation of the bridge superstructures from the construction staging area to their final location utilizing Self-Propelled Modular Transporters (SPMT's) as defined elsewhere in the Contract and in accordance with the contract drawings. The Contractor shall coordinate the design and construction of the temporary support structures and their layout including elevation within the construction staging area with the organization responsible for the removal and transportation of the bridge superstructures utilizing SPMT's.

Three temporary structures and two temporary structures shall be provided in the designated construction staging area for the Highway 417 Kent Street Westbound and Eastbound structures (three temporary structures total). The temporary structures shall be designed and capable of supporting the new and existing Highway 417 Kent Street Westbound and Eastbound structures. The design and construction of the temporary support structure shall allow the removal and transportation of the bridge superstructures from the construction staging area to their final location utilizing Self-Propelled Modular Transporters (SPMT's) as defined elsewhere in the Contract and in accordance with the contract drawings. The Contractor shall coordinate the design and construction of the temporary support structures and their layout within the construction staging area with the organization responsible for the removal and transportation of the bridge superstructures.

Provide analysis of wind loads and other possible lateral forces on the bridge at its temporary location. The design of the temporary support structure shall consider the effects of wind loading on the temporary structure and the replacement superstructure during construction.

The temporary structure shall also be designed and constructed to support the existing bridge superstructures and attached ballast walls to be delivered to the staging area and to allow for their subsequent disposal.

The construction staging area shall also be designed and constructed to allow for the dropping-off and dismantling of the existing bridge superstructure either on the temporary support structure or elsewhere at another location inside the construction staging area.

REFERENCES

Ontario Provincial Standard Specifications, Construction

OPSS 539 Construction Specification for Temporary Protection Systems
OPSS 903 Construction Specification for Deep Foundations
OPSS 902 Construction Specification for Excavating and Backfilling – Structures
OPSS 904 Concrete Structures
OPSS 905 Steel Reinforcement for Concrete
OPSS 906 Structural Steel
OPSS 919 Formwork and Falsework
OPSS 922 Installation of Bearings

Ontario Provincial Standard Specifications, Materials

OPSS 1350 Concrete – Materials and Production

Canadian Standards Association

CAN/CSA-G40.21 – Structural Quality Steels

American Society for Testing and Materials Standards:

A325-M91 - High-Strength Bolts for Structural Steel Joints (Metric)

Ontario Ministry of Transportation Standard Special Provisions

109S42 Amendment to OPSS 905 and OPSS 1440

DEFINITIONS

Stamped:	Means drawings, details or reports that have been reviewed and stamped " Conforms with Contract Documents ". The stamp shall include the date and signature of the Quality Verification Engineer (QVE).
Signed and Sealed:	Means drawings or details that have been signed and sealed by a professional engineer licensed/registered in the province of Ontario and responsible for the work.
Quality Verification Engineer (QVE):	An Engineer licensed to practice in the Province of Ontario who has a minimum of five (5) years experience in the field of design and/or construction of bridges and structural steel fabrication and erection. The Quality Verification Engineer shall be retained by the Contractor to ensure conformance with the contract documents and issue certificate(s) of conformance.
Foundation Engineer:	An Engineer licensed to practice in the Province of Ontario who has a minimum of five (5) years experience in undertaking foundation investigations and preparation of Foundation Investigation and Design Reports for bridge structures of similar nature and scope to the required work. The Foundation Engineer cannot perform the role of the Foundation Checking Engineer.
Foundation Checking Engineer:	An Engineer licensed to practice in the Province of Ontario who has a minimum of five (5) years experience in undertaking foundation investigations and preparation of Foundation Investigation and Design Reports for bridge structures of similar nature and scope to the required work.
Design Engineer:	An Engineer licensed to practice in the Province of Ontario who has a minimum of five (5) years experience in undertaking design of bridge structures and/or temporary structures of similar nature and scope to the required work. The Design Engineer cannot perform the role of the Checking Engineer.
Checking Engineer:	An Engineer licensed to practice in the Province of Ontario who has a minimum of five (5) years experience in undertaking design of bridge structures and/or temporary structures of similar nature and scope to the required work.

SUBMISSION AND DESIGN REQUIREMENTS

At least three (3) weeks prior to the commencement of work under this item, the Contractor shall submit to the Contract Administrator for information purposes, a Foundation Design Report for the foundation components to temporary structures in the Construction Staging area. The Foundation Design Report shall be signed and sealed by a Foundation Engineer and Foundation Checking Engineer employed by a firm registered in RAQS – Geotechnical (Structures and Embankments) – medium complexity.

At least three (3) weeks prior to the commencement of work under this item, the Contractor shall submit to the Contract Administrator for information purposes, engineering design drawings for all components of the proposed temporary structures in the Construction Staging area. The design, construction, layout and elevation of components for the temporary structures in the Construction Staging Area shall be coordinated with the organization responsible for the removal and transportation of the bridge superstructures utilizing

SPMT's and proposed Movement Plans and Personnel Plans as specified elsewhere in the Contract. The engineering design drawings shall be signed and sealed by the Design Engineer and Checking Engineer. The engineering design drawings shall be stamped "reviewed for horizontal clearances, vertical clearances, access and bearing seat elevations" by the organization responsible for the removal and transportation of the bridge superstructures utilizing SPMT's.

Contractor submissions regarding excavations and backfilling shall be governed by OPSS 902.

Contractor submissions regarding protection systems shall be governed by OPSS 539.

Contractor submissions regarding piling shall be governed by OPSS 903.

The Contractor shall measure all components of the existing structure that will impact the fabrication and erection of the temporary supports. Shop drawings shall reflect as measured dimensions and elevations.

All structural steel fabrication, delivery and erection shall be governed by OPSS 906. Contractor submissions regarding structural steel fabrication, delivery and erection shall be governed by OPSS 906.

Contractor submissions regarding reinforcing steel fabrication and placement shall be governed by OPSS 905 as amended by Special Provision No. 109S42.

Contractor submissions regarding the construction of concrete support pads shall be governed by OPSS 904 and OPSS 919.

Contractor submissions regarding the falsework foundation design report shall be governed by OPSS 919.

Protection systems and piling as may be required shall be designed such that existing underground utilities and/or services are protected for the duration of the work.

CERTIFICATES OF CONFORMANCE

The Contractor shall submit to the Contract Administrator, Certificates of Conformance for protection systems as may be required. The Certificates of Conformance shall be in accordance with OPSS 539.

The Contractor shall submit to the Contract Administrator, Certificates of Conformance for excavation as may be required. Certificates of Conformance shall be in accordance with OPSS 902.

The Contractor shall submit to the Contract Administrator, Certificates of Conformance for construction of piling as may be required. The Certificates of Conformance shall be in accordance with OPSS 903.

The Contractor shall submit to the Contract Administrator, Certificates of Conformance for the fabrication of the structural steel temporary supports including all foundation work and components. The Certificates of Conformance shall be in accordance with Special Provision No. 109S42.

The Contractor shall submit to the Contract Administrator Certificates of Conformance for the erection of the structural steel temporary supports. The Certificates of Conformance will be in accordance with OPSS 906.

Certificates of Conformance related to reinforcing steel and concrete construction shall be as stipulated in the applicable OPS Specifications and Special Provisions noted above.

Following completion of the construction of temporary support structures and prior to constructing the new superstructures on temporary support structures in the construction staging area, the Contractor shall submit a final Certificate of Conformance for the overall construction of the temporary support structure.

MATERIALS

Proprietary shoring and patented accessories shall conform to the requirements of OPSS 539.

All structural steel shall conform to the requirements of OPSS 906 and CSA standard CAN3-G40.21, Grade 300W or 350W.

Concrete shall conform to all of the requirements of OPSS 904 and OPSS 1350.

Reinforcing steel shall conform to OPSS 905 as amended by SP 109S42.

All bolts shall be high tensile strength conforming to ASTM 325.

Mechanical and/or adhesive anchors and non-shrink grouts, as required, shall be supplied as per the Designated Sources Manual.

CONSTRUCTION

The Contractor shall locate all overhead and underground utilities and/or services as specified elsewhere in the Contract prior to proceeding with the work. All utilities and/or services shall be protected for the duration of the work. Any damage to existing utilities and/or services shall be repaired by the Contractor at no expense to the Owner. Protection systems and/or piling as may be required shall not interfere with existing underground utilities and/or services, and shall be bridged overtop of existing underground utilities and/or services.

Construction of the structural steel temporary support system shall be carried out in conformance with OPSS 906.

All formwork and/or falsework shall be carried out in accordance with OPSS 919.

All protection systems shall be carried out in accordance with OPSS 539.

All piling shall be carried out in accordance with OPSS 903.

Construction of concrete support pads or foundations shall be carried out in accordance with OPSS 904, OPSS 905 as amended by Special Provision No. 109S42, and OPSS 919.

The temporary supports located in the construction staging area shall have adequate foundation capacity to prevent settlement before, during and after the construction of the superstructure. The maximum permissible settlement at any point in the temporary structure shall be 4 mm and the maximum differential settlement between any two points in the temporary structure shall be 2 mm.

Monitoring shall be provided at each bearing location and at quarter points along the span of each girder to detect settlement and shall be monitored on a regular basis (twice per week) during all phases of the work. Until the day of the rapid lift operation The Contractor shall submit the results to the Contract Administrator after each monitoring operation.

The temporary support structures shall be constructed with girder bearing seats in the same location as the final support conditions including dimensions, cross-fall and grade of the structure in its final location. The girders should be supported in the same manner and at the same relative elevations and locations (e.g. centreline of bearings) as required in the permanent superstructure location.

The temporary supports must provide clear distance from ground surface to the underside of girders as necessary to allow SPMT's to move under the spans for lifting and to transport and set the new bridge superstructures in their final respective locations at the designated bridge site.

Submit details that address fit-up including steel shimming at bearing locations, preformed anchor bolt holes and anchor bolt installation with appropriate templates.

Provide adequate temporary construction bracing to prevent excessive distortion before, during and after placement of concrete in decks.

Tolerances for temporary supports/bearings shall be in accordance with OPSS 922.

MEASUREMENT FOR PAYMENT

There will be no measurement for this item.

BASIS OF PAYMENT

Payment at the contract price for the above tender item shall include full compensation for all labour, material and equipment required to do the work.

No separate payment shall be made for any additional granular materials over and above that required for the general construction staging area as specified elsewhere in the contract.

Appendix E

**Drawing
Borehole Locations Plan**



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

CONT No
WP No

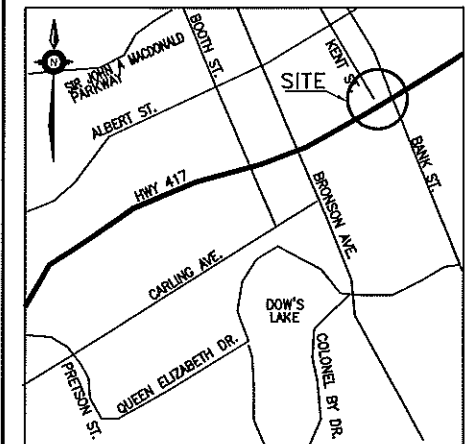
HIGHWAY 417
KENT STREET STRUCTURE
STAGING AREAS
BOREHOLE LOCATIONS PLAN



SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Borehole
- Borehole and Cone
- Blows /0.3m (Std Pen Test, 475J/blow)
- Blows /0.3m (60° Cone, 475J/blow)
- Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- Rock Quality Designation (RQD)
- Auger Refusal

NO	ELEVATION	NORTHING	EASTING
KSS-01	67.4	5 029 910.9	367 744.7
KSS-02	66.9	5 029 952.7	367 813.8
KSS-03	67.7	5 029 885.7	367 796.9
KSS-04	73.0	5 030 119.9	367 980.3
KSS-05	72.6	5 030 155.6	368 036.3
KSS-06	67.9	5 030 098.3	368 027.8

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-253

REVISIONS	DATE	BY	DESCRIPTION
DESIGN LRB	CHK LRB	CODE	LOAD
DRAWN AN	CHK MRA	SITE	STRUCT
			DWG 1
			DATE AUG 2014

