

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGH FILL APPROACH AND
RAMP EMBANKMENT SETTLEMENT
HIGHWAY 77 / 401 INTERCHANGE
TOWN OF LAKESHORE, ESSEX COUNTY
G.W.P. 3072-12-00**

GEOCRES No. 40J2-133

**Report
to
Ministry of Transportation Ontario**

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) to investigate the cause of embankment settlement and pavement cracking issues at the south approach to Bridge Site No. 6-104 and the eastbound off-ramp from Highway 401 to Highway 77 in the Town of Lakeshore, Essex County, Ontario. Thurber carried out the investigation as a consultant to the Ministry of Transportation Ontario (MTO) under the MTO Agreement Numbers 3012-E-007 and 3012-E-008.

The purpose of this investigation was to explore the subsurface conditions near the zones of settlement and pavement cracking and, based on the data obtained, to provide a borehole location and soil strata drawing, records of boreholes, laboratory test results and a written description of the subsurface conditions.

2 SITE DESCRIPTION

The site is located at the Highway 401 and Highway 77 interchange, about 35 km to 40 km east of Windsor, Ontario, as shown on the Key Plan on the Borehole Locations and Soil Strata Drawing included in Appendix C. Embankment settlement and pavement cracking has been observed at the south approach to Bridge Site No. 6-104 (south approach) and the eastbound off-ramp from Highway 401 to Highway 77 (W-N/S Ramp) in the Town of Lakeshore, Essex County, Ontario. A site reconnaissance visit was carried out by one of our senior foundations engineer in September 2015.

Three major areas of visible distress have been identified and are shown on the Plan View on the Borehole Locations and Soil Strata Drawing included in Appendix C. Area A is located above the 72-inch diameter concrete culvert that runs in a general north-south orientation under the W-N/S Ramp embankment just west of its intersection with Highway 77. Area B is located above the 36-inch diameter concrete culvert that runs in a general east-west orientation under the south approach embankment of the bridge which carries Highway 77 over Highway 401. Area C is situated further north on the south approach near the south abutment of the bridge.

From published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam, the site is located within the physiographic region known as the St. Clair Clay Plains which generally consists of deep deposits of glacial tills and depressions filled with clays. The site is situated in an area

underlain by Tavistock Till typically comprised of silty clay as delineated in *Quaternary Geology of Ontario*.

The land surrounding the interchange is gently undulating. The land use generally consists of agricultural and commercial activities.

3 INVESTIGATION PROCEDURES

The field investigation for this project was carried out between October 13 and 15, 2015, during which time six boreholes denoted as Boreholes 15-01 to 15-06 were advanced at selected locations within areas of settlement and cracking at the interchange of Highway 77 and Highway 401. Boreholes 15-01 and 15-02 were drilled along the roadway within the W-N/S Ramp, while Boreholes 15-03 to 15-06 were drilled along the roadway within the south approach. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing provided in Appendix C.

A track-mounted Diedrich D50T drill rig supplied and operated by London Soil Test Ltd. of London, Ontario was used. The boreholes were advanced using hollow stem augers to depths between 9.8 m and 12.8 m. In all boreholes, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT).

The field investigation was supervised on a full time basis by a member of Thurber's technical staff who marked/staked the boreholes in the field, arranged for the clearance of subsurface utilities, directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations. Standpipe piezometers were installed in two (2) of the boreholes (Boreholes 15-03 and 15-06) to permit monitoring of the groundwater levels at the site. Each standpipe piezometer consisted of a 19 mm diameter PVC pipe, with a slotted screen sealed at selected depths within the boreholes. The boreholes, in which no standpipe piezometers were installed, were backfilled in general accordance with Ontario Regulation 903.

Details of the piezometer installations and borehole completion are summarized as follows:

Borehole Number	Piezometer Installations			Completion Details
	Sand Screen Depth (m)	Sand Screen Elevation (m)	Sand Filter	
15-01	None Installed			Bentonite holeplug and cuttings to 0.2 m, then asphalt to surface
15-02	None Installed			Bentonite holeplug and cuttings to 0.1 m, then asphalt to surface
15-03	5.6 – 9.8	185.1 – 181.0	Silty Clay Fill/Silty Clay Till	Backfilled with filter sand from 9.8 to 5.6 m, bentonite holeplug from 5.6 to 0.3m, then grout to ground surface.
15-04	None Installed			Bentonite holeplug and cuttings to 0.1 m, then asphalt to surface
15-05	None Installed			Bentonite holeplug and cuttings to 0.1 m, then asphalt to surface

15-06	8.5 – 12.8	182.8 – 178.5	Silty Clay Till	Backfilled with filter sand from 12.8 to 8.5 m, bentonite holeplug from 8.5 to 0.3m, then grout to ground surface.
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4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (hydrometer and/or sieve) and Atterberg Limits testing, where appropriate. Laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions encountered in these boreholes consisted of asphalt and pavement granulars overlying varying thicknesses of silty clay embankment fill, which was in turn underlain by native silty clay till. Descriptions of the individual strata are presented below.

5.1 Asphalt

All six boreholes were drilled through the existing pavement shoulder at the interchange of Highway 77 and Highway 401 and encountered a surface layer of asphalt having an approximate thickness of 100 mm.

5.2 Fill

Fill materials were encountered below the asphalt in all the borehole locations.

Immediately below the asphalt was pavement granular material consisting of sand, some gravel and trace to some silt with a thickness between 0.9 m and 1.0 m. Moisture contents between 2% and 21% were measured in the cohesionless fill.

Below the pavement, the embankment fill material consisted of silty clay, some sand to sandy, trace gravel, asphalt fragments and trace organics. The cohesive fill had a thickness between 4.4 m and 7.0 m.

SPT 'N' values within the silty clay fill ranged from 5 to 21 blows per 0.3 m of penetration, indicating a firm to very stiff consistency. Measured moisture contents between 8% and 22% were measured in the cohesive fill.

The results of grain size distribution analyses and Atterberg Limits testing carried out on selected samples of the silty clay fill are presented on the Record of Borehole sheets included in Appendix A and on Figures B1 to B3 and B5 to B7 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0-3
Sand	17-31
Silt	32-45
Clay	33-45

The results of Atterberg Limits testing are summarized below:

Index Property	Percentage (%)
Plastic Limit	12-22
Liquid Limit	32-42

The results of the Atterberg Limits testing indicate the layer to be of low to intermediate plasticity with group symbol CL or CI.

A possible cobble or boulder was encountered at about 5 m depth in Borehole 15-06.

5.3 Silty Clay Till

A glacial till deposit of silty clay, trace sand to sandy, trace gravel, trace organics and occasional clay pockets was encountered below the fill at all the borehole locations. In Borehole 15-03, the cohesive till deposit had a thickness of 1.8 m and extended to a depth of 9.2 m (Elevation 181.5 m). The remaining boreholes were terminated within this till at depths ranging from 9.8 m to 12.8 m (Elevations 178.5 m to 181.4 m).

SPT 'N' values within the silty clay till deposit typically ranged from 11 to 25 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency. Occasional SPT 'N' values of greater than 30 blows per 0.3 m penetration were recorded, indicating the presence of hard zones. Measured moisture contents within the silty clay till deposit varied between 15% and 27%.

The results of grain size distribution analyses and Atterberg Limits testing carried out on selected samples of the silty clay till are presented on the Record of Borehole sheets included in Appendix A and on Figures B4 and B8 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	14-25
Silt	38-44
Clay	34-48

The results of Atterberg Limits testing are summarized below:

Index Property	Percentage (%)
Plastic Limit	11-21
Liquid Limit	30-42

The results of the Atterberg Limits testing indicate the layer to be of low to intermediate plasticity with group symbol CL or CI.

Glacial tills inherently contain cobbles and boulders.

5.4 Clayey Silt

A layer of clayey silt with some sand, occasional sand pockets, trace gravel and trace rootlets was encountered below the silty clay till deposit in Borehole 15-03, extending to the borehole termination depth of 9.8 m (Elevation 181.0 m).

An SPT 'N' value of 12 blows per 0.3 m penetration indicated that the clayey silt had a stiff consistency. The clayey silt had a measured moisture content of 26%.

5.5 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. Standpipe piezometers were installed in Boreholes 15-03 and 15-06 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and in the standpipe piezometers are summarized below.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
15-01	October 13, 2015	Dry	-	Open borehole
15-02	October 13, 2015	Dry	-	Open borehole
15-03	November 6, 2015	Dry	-	Standpipe piezometer
15-04	October 14, 2015	Dry	-	Open borehole
15-05	October 15, 2015	Dry	-	Open borehole
15-06	November 6, 2015	8.6	182.7	Standpipe piezometer

The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6 MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained subsurface utility clearances prior to drilling.

London Soil Test Ltd. of London, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full time basis by Ms. Eckie Siu of Thurber. Overall supervision of the field program was provided by Mr. Michael Eastman, EIT of Thurber.

The coordinates and ground surface elevations at the borehole locations were established by Thurber with a Trimble Pathfinder ProXRT differential GPS unit.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory. Interpretation of the field data and preparation of this report was carried out by Mr. Michael Eastman, EIT and Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.

Michael Eastman Jan 18/16

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This section of the report presents an interpretation of the geotechnical data in the factual report and provides foundation recommendations for remediation of the embankment distress and pavement cracking at Area A on the W-N/S Ramp, and Areas B and C on the south approach to the bridge at the Highway 401 and Highway 77 interchange in the Town of Lakeshore, Essex County, Ontario. Information from MTO indicated that cracks were first reported shortly after the completion of the interchange reconstruction more than 10 years ago.

A summary of field observations during our site visit and background information provided to us by MTO are presented below. Appendix D presents selected photographs of the observed site conditions for reference.

Area A

Along the W-N/S Ramp to the west of Highway 77, tension cracks that had reportedly been observed previously at the crest of the embankment above the culvert have been filled with asphalt. Since the time of the last patching of the cracks, it is understood that neither new significant cracks have appeared, nor have the previous cracks opened further. The most severe deformation and cracking were observed above the 72-inch diameter concrete culvert that runs below the ramp embankment. Near the north crest of the embankment, the tension cracks extended about 22 m west and about 18 m east of the culvert centreline. Near the south crest of the embankment, the tension cracks extended over a similar length. Less severe cracking extended for about 100 m west of the culvert centreline. From a foundation engineering standpoint, the 72-inch diameter concrete culvert was visually inspected and the culvert grade appeared to be straight and there was no visual evidence of distortion and/or differential settlement of the culvert at the time of the site visit.

Areas B and C

Along the south approach, there are two sections of pavement patching/overlay north of the W-N/S Ramp. The first patch section (Area B) is approximately 19 m long and is located above, and centred over, a 36-inch diameter concrete culvert that runs below the approach embankment. From a foundation engineering standpoint, this culvert was also visually inspected and showed no evidence of distortion and/or differential

settlement. Further to the north, a second section of pavement (Area C) appeared to have been repaired over two 16 m long lengths. While the timing of the repairs is not known, there was no visual evidence at the time of the site visit of significant further embankment settlement since completion of the repairs.

As per our proposal letter for Retainer Assignment No. 6, the field investigation carried out for this project consists of drilling and sampling six boreholes. One borehole was located within Area A, one borehole was located within Area B, two boreholes were located within Area C, one borehole was located to the west of Area A where no cracks were observed, and one borehole was located between Areas B and C where no cracks were observed. Approximate locations of these boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix C.

Selected embankment cross-sections provided by MTO and selected survey shots at the crest and toe of the slopes obtained by Thurber indicate that the existing slope surfaces have an inclination of 2H:1V. Visual inspection of the slope surfaces by Thurber revealed no evidence of surficial instability (no formation of gullies, seepage zones or lack of vegetation).

Based on the factual data obtained during this investigation, an understanding of the issues based on our site observations and background information provided by MTO, foundation comments on the possible cause(s) of the observed distress and recommendations on remedial measures are provided below.

8 POSSIBLE CAUSES OF SETTLEMENT/CRACKING

Boreholes 15-01 to 15-06 indicate the presence of up to about 1.1 m of loose pavement granular material consisting of sand and some gravel. The sand is underlain by stiff to very stiff silty clay embankment fill which contains some firm zones. Stiff to very stiff and occasionally hard, native silty clay till underlies the embankment fill. Piezometric measurements and visual observations during drilling indicate that the groundwater table is below the base of the embankment.

Initial consideration was given to the following mechanisms that may have caused the observed embankment distress and pavement cracking:

- Global instability of embankment slopes
- Foundation settlement
- Inadequate placement and compaction of pavement granular material, and the underlying clay fill
- Insufficient asphalt thickness

8.1 Global Stability

Slope stability analyses have been carried out for selected embankment sections using the commercially available program SLOPE/W produced by Geo-Slope International applying the Morgenstern-Price method of analysis. Results of the analyses are summarized in the following table.

Location	Factor of Safety (Long-Term)
Section A-A	1.6
Section B-B	1.7
Section C-C	1.6

Total stress (short-term) conditions result in factors of safety which are higher than those shown in the above table.

The above results indicate that the long-term conditions generally satisfy the minimum Factor of Safety (F.S.) of 1.5 acceptable to MTO. Figures E1 to E3 in Appendix E provide graphical presentations of the results summarized above.

Based on these results, our site observations and background information from MTO, global stability is not considered to be a contributing factor to the reported embankment distress and pavement cracking.

8.2 Foundation Settlement

Based on the borehole data, the underlying native silty clay till foundation is considered competent. Any post construction consolidation settlement that might have occurred under the embankment loading is anticipated to have completed.

Compression of the embankment fill itself after construction may have contributed to a portion of the surficial settlement. Given that the existing embankments were constructed more than 10 years ago, the embankment fill self-compression is considered completed for all practical purposes.

Since culverts underlie Areas A and B, it is possible that some of the observed surficial settlement is attributed to culvert settlement. Since there is no visual evidence of distortion and/or differential settlement, any culvert settlement that might have occurred was likely uniform along the culvert alignment. It is also anticipated that such settlement, if present, has completed over the years.

8.3 Pavement Granular Material

Based on the SPT 'N' values of 6 to 7 blows per 0.3 m of penetration (loose condition) measured in the sand fill in five of six boreholes advanced during this investigation, it is considered likely that the reported settlement and pavement cracking can be attributed, at least partially, to inadequate placement and compaction, and/or deterioration of the granular materials under the asphalt. There appears to be no significant difference between the results of Boreholes 15-02, 15-03, 15-05, 15-06 (located within the distress areas) and Boreholes 15-01 and 15-04 (located outside of distress areas).

8.4 Pavement Design

An asphalt thickness of 100 mm was encountered on the road shoulder within the distressed areas. There is no confirmation of the asphalt thickness on the travelled portion of the roadway and whether the asphalt thickness is sufficient to support the design traffic loading along the subject

roadways. The borehole data also indicates that the existing asphalt pavement is underlain by loose granular materials. It is recommended that MTO consider checking the existing pavement design in-house for the applicable traffic loading, or engaging a pavement designer to carry out this task. The pavement design should be checked for the existing loose granular base/subbase as well as a well compacted granular base/subbase.

Based on the information available to date, a preliminary assessment indicates that the asphalt thickness of 100 mm at the shoulder may not necessarily be sufficient to support frequently applied large wheel loadings such as those from heavily loaded trucks.

9 REMEDIAL MEASURES

The assessment discussed above indicates that the pavement cracking noted at this site is not related to any foundation issues, but may be due to issues associated with the pavement structure.

Based on the above assessment, the three recommended options of remedial measures at this site are as follows:

- Option 1 - Do nothing, observe and monitor pavement performance periodically.
- Option 2 - Remove existing asphalt, re-compact the exposed granular base/subbase and repave with possibly thicker asphalt based on pavement design checks.
- Option 3 - Remove existing asphalt and the underlying granular material to 0.5 m depth, re-compact the exposed granular subgrade, and backfill with well compacted granular material prior to repaving asphalt. This option may also require thicker asphalt based on pavement design checks and closing of the ramp during pavement reconstruction.

Option 1

Since the surface cracks on the pavement occurring over the years have been repaired, and that no new cracks have reportedly been observed to date since the last repairs, MTO may consider to continue monitoring the pavement and defer the consideration of any remedial measures for the time being.

Option 2

Consideration may be given to removing the existing asphalt to expose the underlying granular material, the surface of which should be re-compacted prior to re-paving with new asphalt. Subject to the pavement design checks which should consider a loose granular base/subbase, the asphalt thickness may need to be increased. Should this be the case, the granular thickness may need to be reduced accordingly to accommodate the extra asphalt, such that the top of road grade can be maintained.

The pavement material replacement should extend for the full width of the embankment at the W-N/S Ramp and at the south approach distress areas (Areas A, B and C). In the direction of the ramp and south approach centrelines, the extent of the replacement should cover all areas where asphalt patching and currently existing cracks, if any, can be seen. Based on our site observations outlined above, the recommended minimum extents of the remedial works are as follows:

- Area A – from 25 m west to 20 m east of 72-inch diameter culvert centreline (longitudinal)

- full width of ramp (transverse).
- Area B – from 10 m north to 10 m south of 36-inch diameter culvert centreline (longitudinal)
 - full width of south approach (transverse).
- Area C – 20 m long north to south to include two repaired cracks (longitudinal)
 - full width of south approach (transverse).

The above lengths are approximate and must be re-confirmed in the field.

Option 3

A third option is to remove the existing asphalt and sub-excavate the existing granular materials for a thickness of 0.5 m. The surface of the remaining granular fill should be re-compacted and the sub-excavation backfilled with new, imported OPSS.PROV 1010 Granular A material placed and compacted in thin lifts to 100% of the Standard Proctor Maximum Dry Density within 2% of its optimum moisture content. The new asphalt pavement may then be placed on the well compacted Granular A base. The asphalt thickness may have to be increased based on pavement design checks and the granular thickness may need to be reduced accordingly to accommodate the extra asphalt, such that the top of road grade can be maintained. The new granular fill must be appropriately transitioned into the existing granular fill near the longitudinal ends of the sub-excavation.

This option may require temporary ramp closure and possible replacement of the guide rails if they are affected by the sub-excavation.

10 EXCAVATION

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA) and in accordance with OPSS 902. For the purposes of the OHSA, the existing loose pavement granular materials may be classified as Type 3 soils. The adjacent pavement granular is free-draining. Perched water from the sidewalls and precipitation can be handled by perimeter ditches and pumping from filtered sumps. Surface run-off should be diverted away from the excavations.

Where there is space restrictions such as those due to the presence of buried utilities and if one lane of the road is to be kept open at all times during construction, staged construction involving roadway protection (shoring) may be required. Roadway protection (shoring) must be carried out in accordance with performance level II requirements as per OPSS.PROV 539.

11 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to, the following:

- Impact of excavation on the existing pavement surface
Daily visual inspection of the pavement surface must be carried out in the vicinity of the remedial works. If cracks form in the pavement or settlement is observed to occur, these matters must immediately be brought to the attention of the Contract Administrator for determining as to whether further action is required.
- Disturbance of the subgrade within the sub-excavation footprint.
- Confirmation that the backfill materials are adequately placed and compacted to specifications.

It is recommended that provision(s) be included in the contract requiring the Contractor to confirm that the above issues are adequately addressed. Should there be any doubts about issues such as depth of sub-excavation and subgrade conditions, these provisions should require the Contractor to retain qualified geotechnical personnel to assess the site conditions and to alert the Contract Administrator.

12 CLOSURE

Stability analysis was carried out by Mr. Michael Eastman, E.I.T. Engineering assessment and preparation of this report was carried out by Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.



Sydney Pang, P.Eng.
Associate, Senior Foundations Engineer



P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Appendix A

Record of Borehole Sheets

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	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No 15-01

1 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 677 961.1 E 300 377.8 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.13 - 2015.10.13 CHECKED BY MKE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			<div>PLASTIC LIMIT w_p</div> <div>NATURAL MOISTURE CONTENT w</div> <div>LIQUID LIMIT w_L</div> <div>WATER CONTENT (%)</div>	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 × LAB VANE													
188.5	GROUND SURFACE												
0.0	ASPHALT: (100 mm)												
0.1	SAND, some gravel, trace to some silt Loose Brown Moist (FILL)		1	GS			188						
187.4			1	SS	6								
1.1	Silty CLAY, some sand to sandy, trace gravel, trace organics Stiff to Very Stiff Brown to Grey Moist (FILL)		2	SS	8		187						
			3	SS	14								
			4	SS	21		186						
			5	SS	16								
			6	SS	15		185						
			7	SS	14		184						
			8	SS	14								
183.0			9	SS	11		183						
5.5	Silty CLAY, some sand, trace gravel Stiff to Hard Brown to Grey Moist (TILL)		10	SS	17		182						
			11	SS	21								
			12	SS	32		181						
							180						
			13	SS	22		179						
178.7													
9.8	END OF BOREHOLE AT 9.8 m.												

Continued Next Page

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

RECORD OF BOREHOLE No 15-01

2 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 677 961.1 E 300 377.8 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.13 - 2015.10.13 CHECKED BY MKE

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			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page																
	BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2 m, THEN ASPHALT TO SURFACE.																

ONTMT4S 6435.GPJ 2015TEMPLATE(MTO).GDT 12/10/15

RECORD OF BOREHOLE No 15-02

1 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 677 945.0 E 300 425.3 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.13 - 2015.10.13 CHECKED BY MKE

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							
189.5	GROUND SURFACE							20 40 60 80 100							
0.0	ASPHALT: (100 mm)							20 40 60 80 100							
0.1	SAND, some gravel, trace silt Loose Brown Moist (FILL)		1	GS			189	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
188.4			1	SS	7			20 40 60 80 100							
1.0	Silty CLAY, some sand to sandy, trace gravel Firm to Very Stiff Brown Moist (FILL)		2	SS	5		188								
			3	SS	11		187								
			4	SS	10		186							0 26 32 42	
			5	SS	18		185							0 18 37 45	
	Asphalt fragments at 3.7 m		6	SS	8		184								
			7	SS	13		183							0 17 41 42	
			8	SS	10		182								
			9	SS	13		181								
			10	SS	15		180								
			11	SS	19										
182.0	Silty CLAY, trace sand, trace gravel Very Stiff to Hard Brown to Grey Moist (TILL)		12	SS	29										
7.5			13	SS	37										
179.7	END OF BOREHOLE AT 9.8 m.														
9.8															

Continued Next Page

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

RECORD OF BOREHOLE No 15-02

2 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 677 945.0 E 300 425.3 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.13 - 2015.10.13 CHECKED BY MKE

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			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W P W W L 20 40 60					
	Continued From Previous Page																
	BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1 m, THEN ASPHALT TO SURFACE.																

ONTMT4S 6435.GPJ 2015TEMPLATE(MTO).GDT 12/10/15

RECORD OF BOREHOLE No 15-03

1 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 677 981.9 E 300 489.2 ORIGINATED BY ES
HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2015.10.14 - 2015.10.14 CHECKED BY MKE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		<div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div></div> <div><div>W_P</div><div>W</div><div>W_L</div></div> <div>WATER CONTENT (%)</div>	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
190.7	GROUND SURFACE							20 40 60 80 100				
0.0	ASPHALT: (100 mm)							20 40 60 80 100				
0.1	SAND, some gravel, trace to some silt Loose Brown Moist (FILL)		1	GS				○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
189.6			1	SS	7		190					
1.1	Silty CLAY, some sand to sandy with occasional sand pockets, trace gravel, trace organics Stiff Brown Moist (FILL)		2	SS	9		189					
			3	SS	9		188					0 22 35 43
			4	SS	12		187					
			5	SS	10		186					
			6	SS	11		185					0 22 39 39
			7	SS	14		184					
			8	SS	11		183					
			9	SS	10		182					
			10	SS	13		181					0 26 38 36
	Very Stiff		11	SS	20							
183.3	Silty CLAY, some sand, trace gravel Very Stiff Brown Moist (TILL)		12	SS	20							
7.4			13	SS	21							
	Possible cobble at 8.0 m		14	SS	15							
181.5	Clayey SILT, some sand with occasional sand pockets, trace gravel, trace rootlets Stiff Grey		15	SS	12							
9.2												
181.0												
9.8												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-03

2 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 677 981.9 E 300 489.2 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.14 - 2015.10.14 CHECKED BY MKE

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			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page																
	Moist																
	END OF BOREHOLE AT 9.8 m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 3.0 m slotted screen.																
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2015.11.06 Dry -																

ONTMT4S 6435.GPJ 2015TEMPLATE(MTO).GDT 12/10/15

RECORD OF BOREHOLE No 15-04

1 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 678 013.2 E 300 490.8 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.14 - 2015.10.14 CHECKED BY MKE

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			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
191.1	GROUND SURFACE											
0.0	ASPHALT: (100 mm)						191					
0.1	SAND, some gravel, trace to some silt Loose Brown Moist (FILL)		1	GS								
190.1			1	SS	6							
1.0	Silty CLAY, some sand to sandy, trace gravel, trace organics Firm to Very Stiff Brown to Grey Moist (FILL)		2	SS	10		190					
			3	SS	17		189					0 25 36 39
			4	SS	13							
			5	SS	10		188					
			6	SS	7							
			7	SS	8		187					0 19 41 40
			8	SS	12		186					
			9	SS	9							
			10	SS	17		185					0 19 44 37
			11	SS	16		184					
183.7			12	SS	17							
7.4	Silty CLAY, some sand, trace gravel, trace organics Very Stiff to Stiff Brown to Grey Moist (TILL)		13	SS	17		183					
			14	SS	15							
			15	SS	13		182					
181.4												
9.8	END OF BOREHOLE AT 9.8 m.											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-04

2 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 678 013.2 E 300 490.8 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.14 - 2015.10.14 CHECKED BY MKE

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	20 40 60	W _p W W _L				
	Continued From Previous Page													
	BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1 m, THEN ASPHALT TO SURFACE.													

ONTMT4S 6435.GPJ 2015TEMPLATE(MTO).GDT 12/10/15

RECORD OF BOREHOLE No 15-05

1 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 678 037.6 E 300 505.0 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.15 - 2015.10.15 CHECKED BY MKE

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			SHEAR STRENGTH kPa						
191.2	GROUND SURFACE							20 40 60 80 100						
0.0	ASPHALT: (100 mm)							20 40 60 80 100						
0.1	SAND, some gravel, trace to some silt Compact Brown Moist (FILL)		1	GS			191							
190.2			1	SS	11									
1.0	Silty CLAY, some sand to sandy, trace gravel, trace organics Stiff Brown Moist (FILL) 50 mm wet gravel seam at 1.6 m		2	SS	13		190							
			3	SS	16		189							0 26 41 33
			4	SS	10									
			5	SS	8		188							
			6	SS	12									
			7	SS	11		187							
			8	SS	12		186							3 19 38 40
			9	SS	13									
			10	SS	14		185							
184.5			11	SS	18		184							
6.7	Silty CLAY, some sand to sandy, trace gravel, trace rootlets, occasional wood fibres Very Stiff Brown to Grey Moist (TILL)		12	SS	15									0 22 43 35
							183							
			13	SS	23		182							
181.4														
9.8	END OF BOREHOLE AT 9.8 m.													

Continued Next Page

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

RECORD OF BOREHOLE No 15-05

2 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 678 037.6 E 300 505.0 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.15 - 2015.10.15 CHECKED BY MKE

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			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page																
	BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1 m, THEN ASPHALT TO SURFACE.																

ONTMT4S 6435.GPJ 2015TEMPLATE(MTO).GDT 12/10/15

RECORD OF BOREHOLE No 15-06

1 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 678 048.6 E 300 492.5 ORIGINATED BY ES
HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2015.10.14 - 2015.10.14 CHECKED BY MKE

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
191.3	GROUND SURFACE													
0.0	ASPHALT: (100 mm)													
0.1	SAND, some gravel, trace silt Loose Brown Moist (FILL)		1	GS										
190.2			1	SS	7									
1.1	Silty CLAY, some sand to sandy, trace gravel, occasional wood fibres Stiff to Very Stiff Brown to Grey Moist (FILL)		2	SS	12									
			3	SS	16									
			4	SS	8									
			5	SS	10									
			6	SS	10									
			7	SS	12									
			8	SS	50/ 0.025									
	Cobble or boulder at 5.0 m													
			9	SS	12									
			10	SS	9									
			11	SS	18									
			12	SS	18									
183.2			13	SS	14									
8.1	Silty CLAY, with occasional clay pockets, some sand to sandy, trace gravel, trace rootlets Stiff to Very Stiff Brown to Grey Moist (TILL)		14	SS	15									
			15	SS	23									

Continued Next Page

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

RECORD OF BOREHOLE No 15-06

2 OF 2

METRIC

GWP# 3072-12-00 LOCATION Hwy 77/401 Interchange N 4 678 048.6 E 300 492.5 ORIGINATED BY ES
 HWY 77/401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2015.10.14 - 2015.10.14 CHECKED BY MKE

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
	Silty CLAY , with occasional clay pockets, some sand, trace gravel, trace rootlets Stiff to Very Stiff Brown to Grey Moist (TILL)		16	SS	14		181							
							180							
			17	SS	25		179							
178.5														
12.8	END OF BOREHOLE AT 12.8 m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 3.0 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2015.11.06 8.6 182.7													

ONTMT4S 6435.GPJ 2015TEMPLATE(MTO).GDT 12/10/15

Appendix B

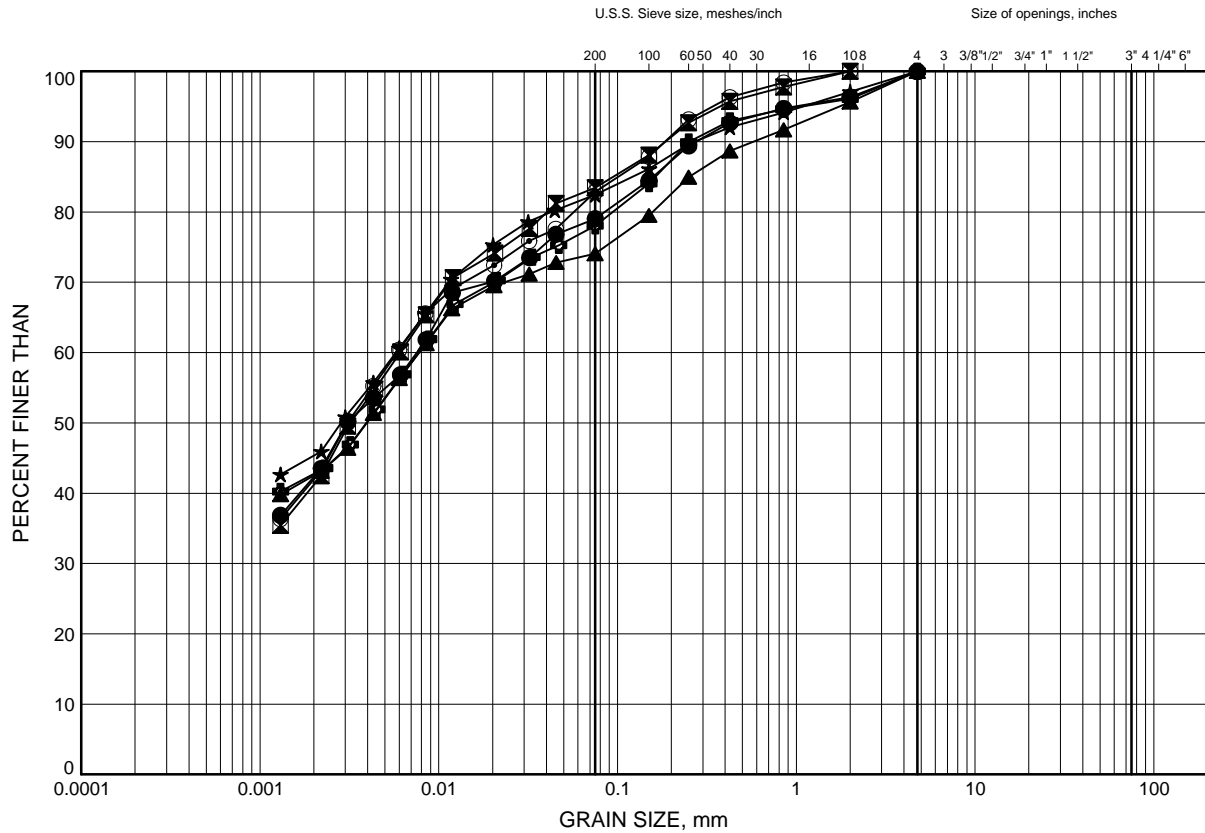
Laboratory Test Results

Hwy 77 / 401 Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	2.74	185.74
⊠	15-01	4.57	183.91
▲	15-02	2.74	186.71
★	15-02	4.57	184.88
⊙	15-02	6.40	183.05
⊕	15-03	2.13	188.58

Date November 2015
Project 15-64-35



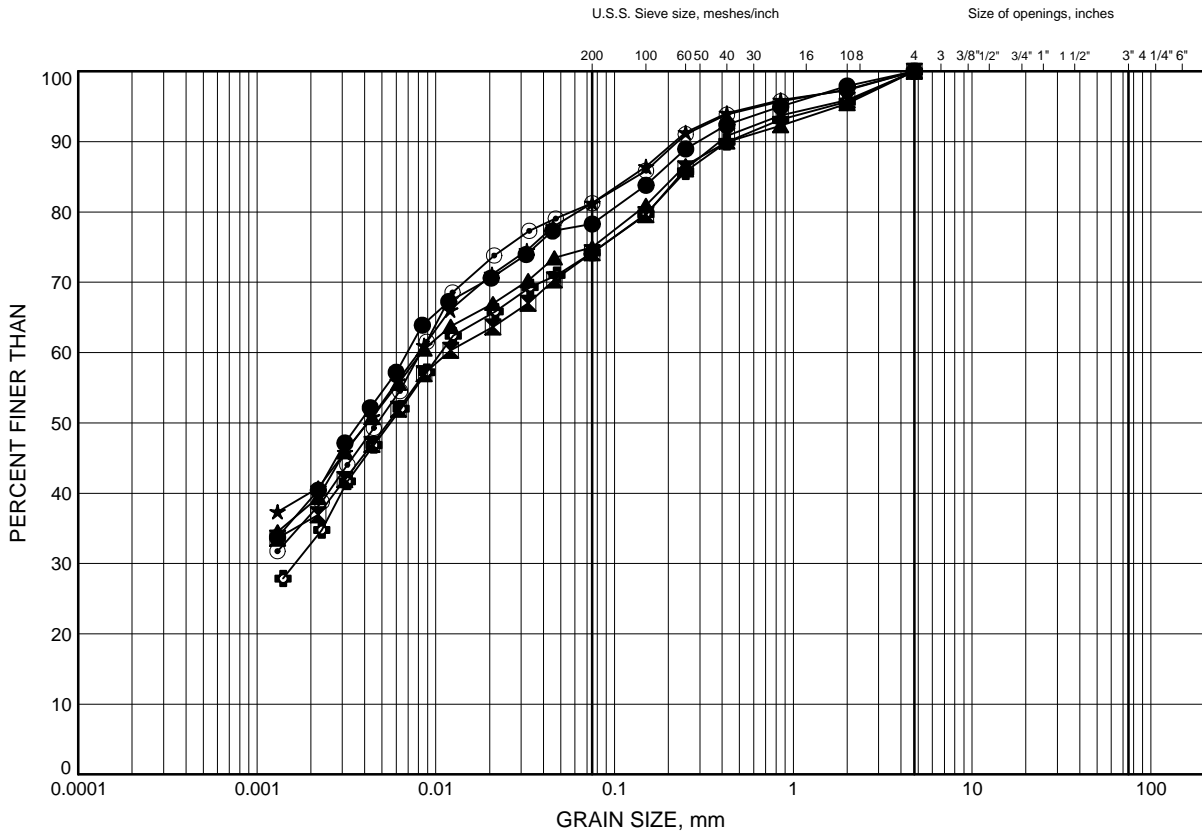
Prep'd AN
Chkd. MKE

Hwy 77 / 401 Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-03	3.96	186.75
⊠	15-03	6.40	184.31
▲	15-04	2.13	189.00
★	15-04	4.57	186.57
⊙	15-04	6.40	184.74
⊕	15-05	2.13	189.05

Date November 2015
Project 15-64-35



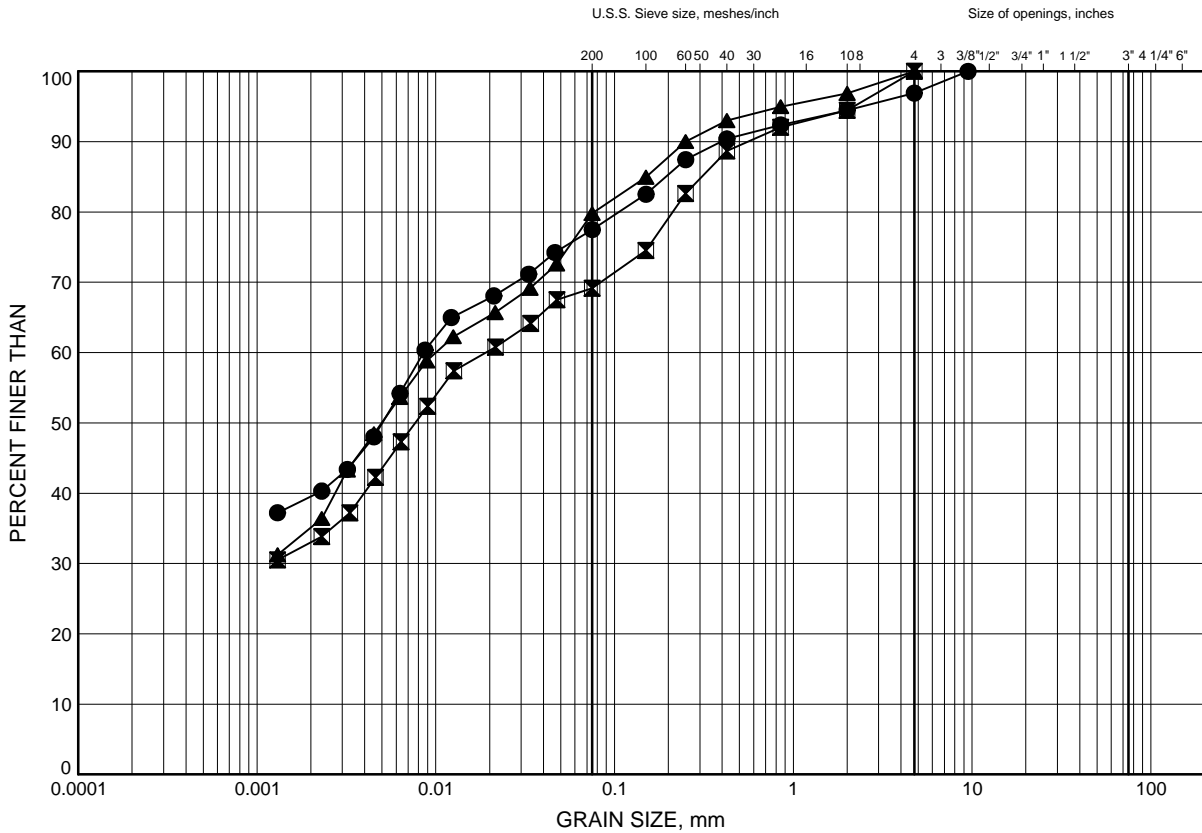
Prep'd AN
Chkd. MKE

Hwy 77 / 401 Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-05	5.18	186.00
⊠	15-06	3.35	187.93
▲	15-06	5.79	185.49

Date November 2015
Project 15-64-35

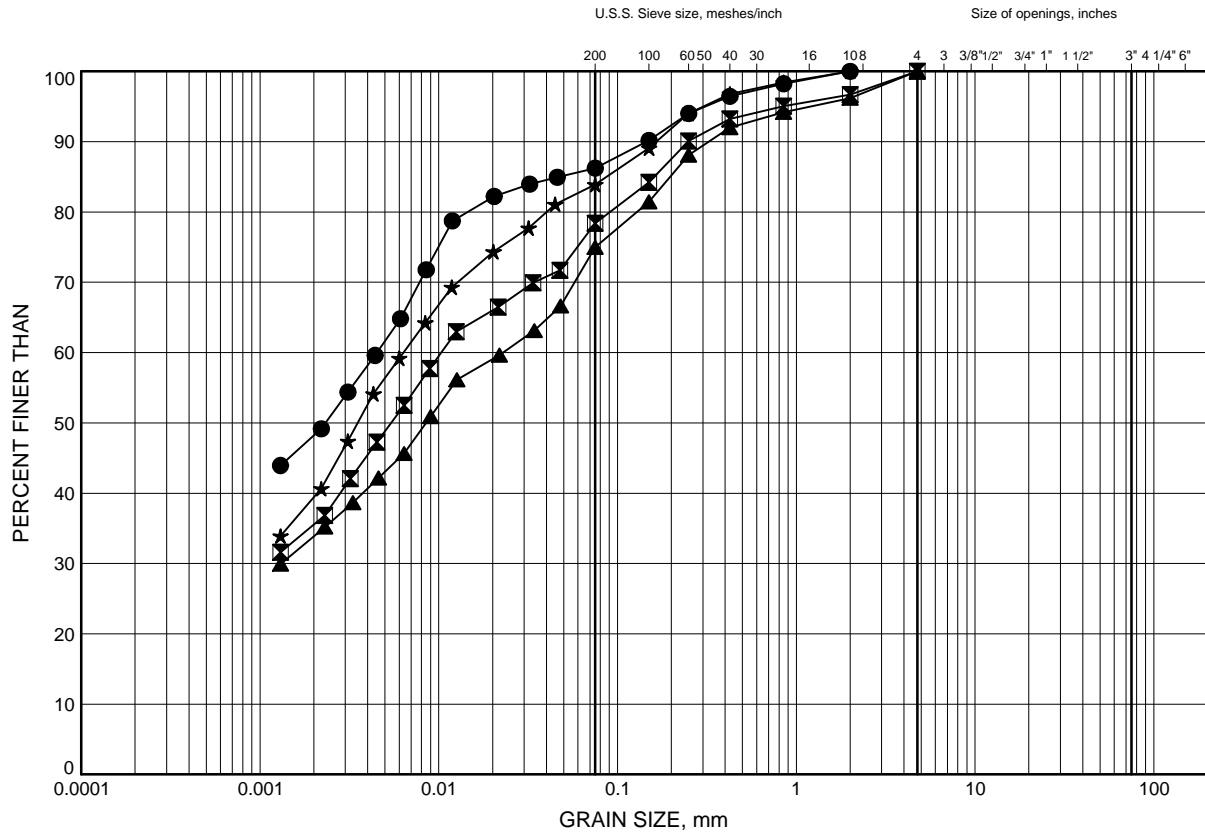


Prep'd AN
Chkd. MKE

Hwy 77 / 401 Interchange GRAIN SIZE DISTRIBUTION

FIGURE B4

Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	7.62	180.86
⊠	15-05	7.62	183.56
▲	15-06	8.23	183.06
★	15-06	10.97	180.31

Date November 2015
Project 15-64-35

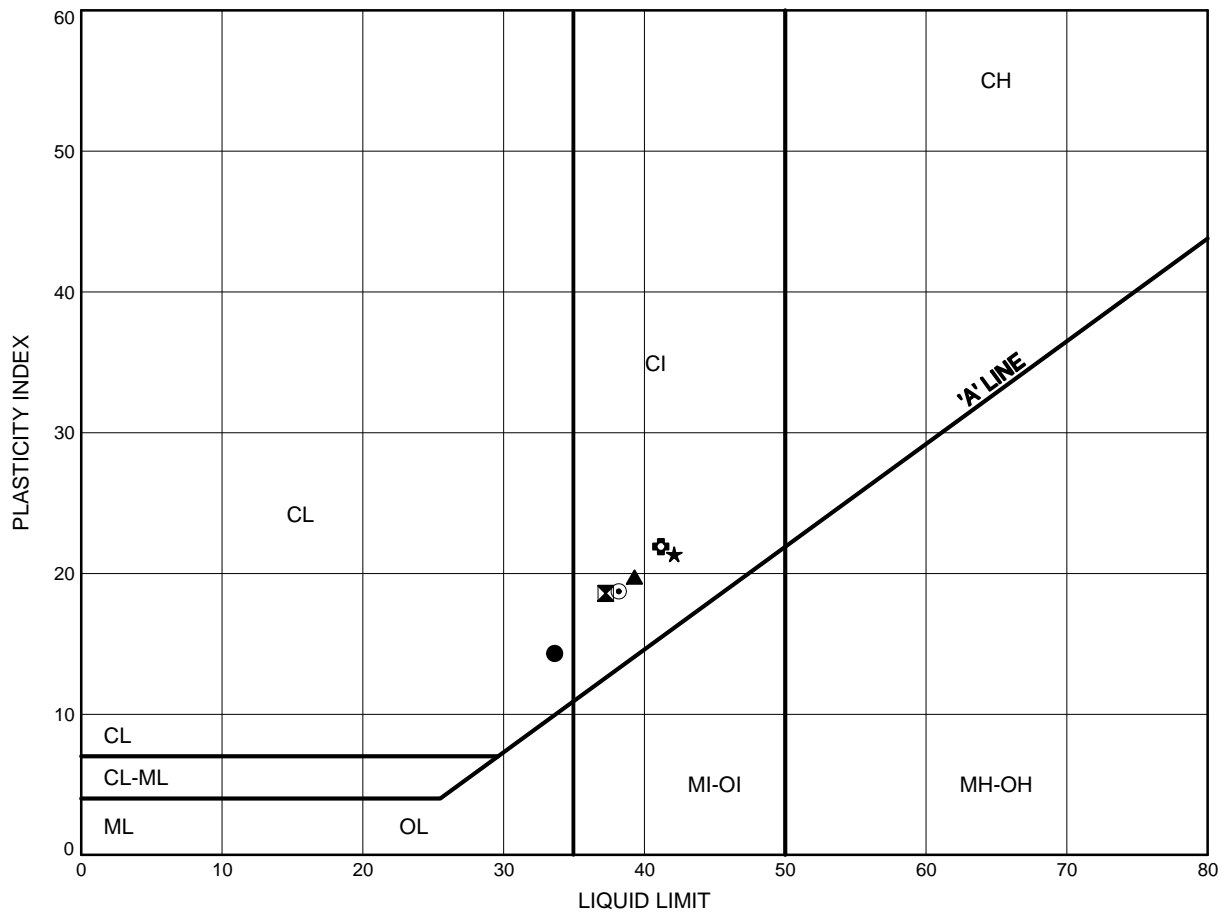


Prep'd AN
Chkd. MKE

Hwy 77 / 401 Interchange
ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	2.74	185.74
⊠	15-01	4.57	183.91
▲	15-02	2.74	186.71
★	15-02	4.57	184.88
⊙	15-02	6.40	183.05
⊕	15-03	2.13	188.58

Date November 2015
 Project 15-64-35

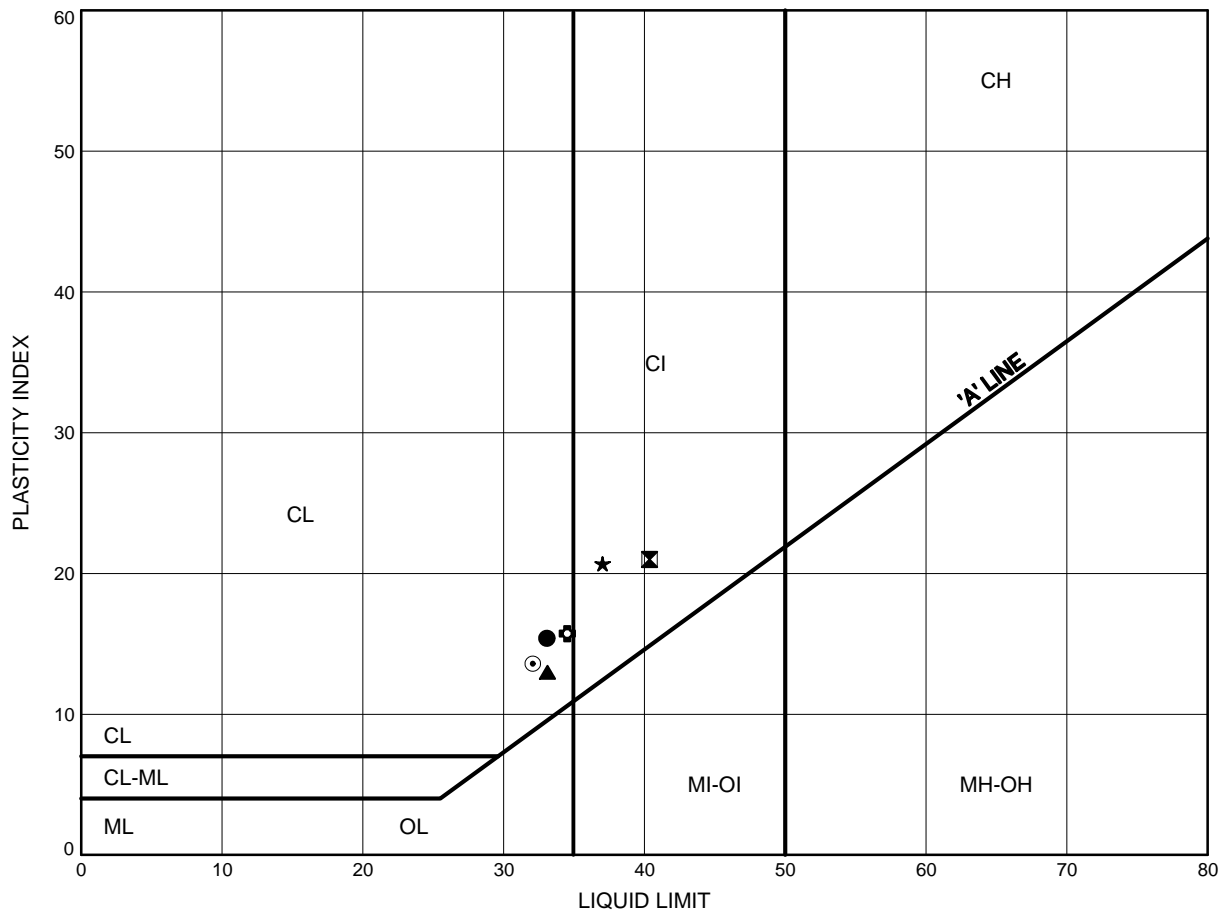


Prep'd AN
 Chkd. MKE

Hwy 77 / 401 Interchange
ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Silty CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-03	3.96	186.75
⊠	15-03	6.40	184.31
▲	15-04	2.13	189.00
★	15-04	4.57	186.57
⊙	15-04	6.40	184.74
⊕	15-05	2.13	189.05

Date November 2015
 Project 15-64-35

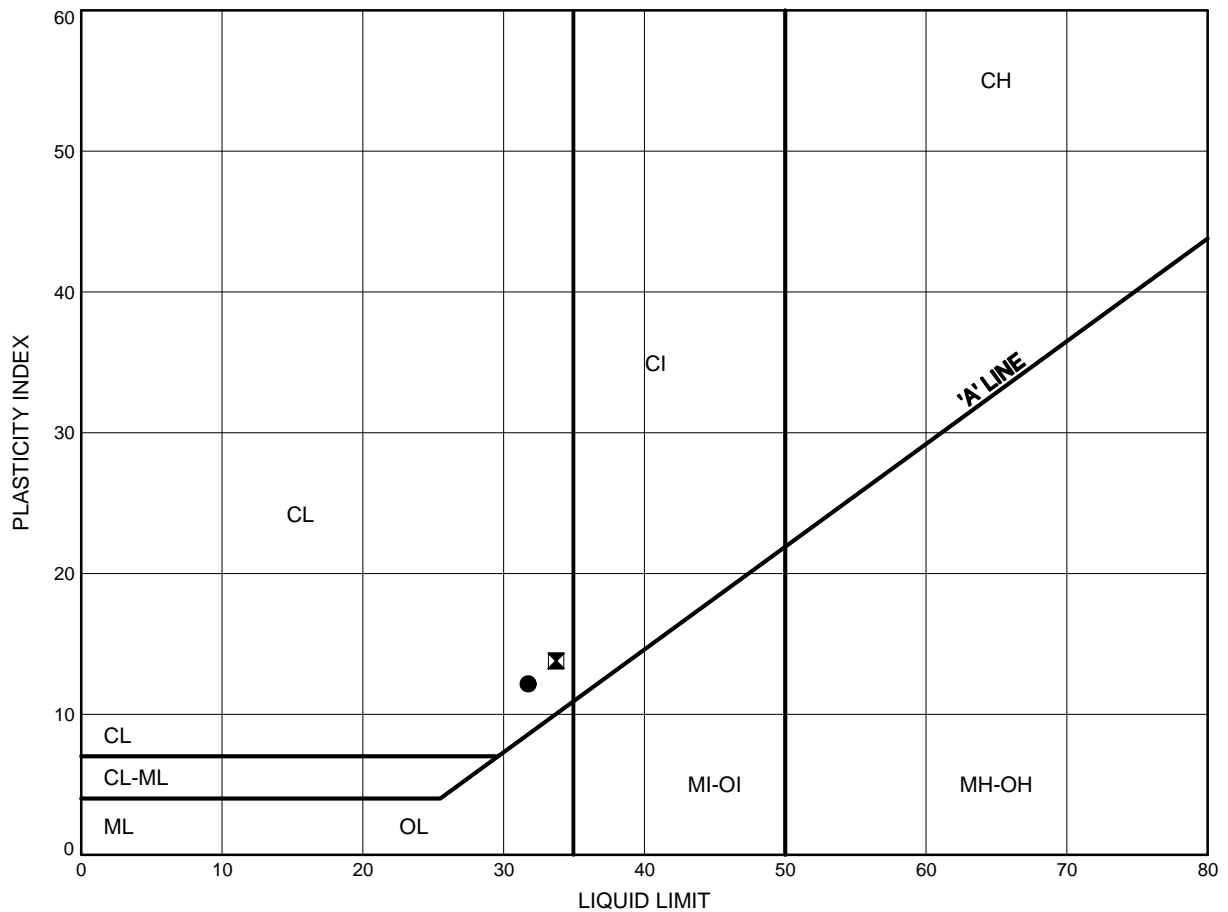


Prep'd AN
 Chkd. MKE

Hwy 77 / 401 Interchange
ATTERBERG LIMITS TEST RESULTS

FIGURE B7

Silty CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-05	5.18	186.00
⊠	15-06	3.35	187.93

Date November 2015
 Project 15-64-35

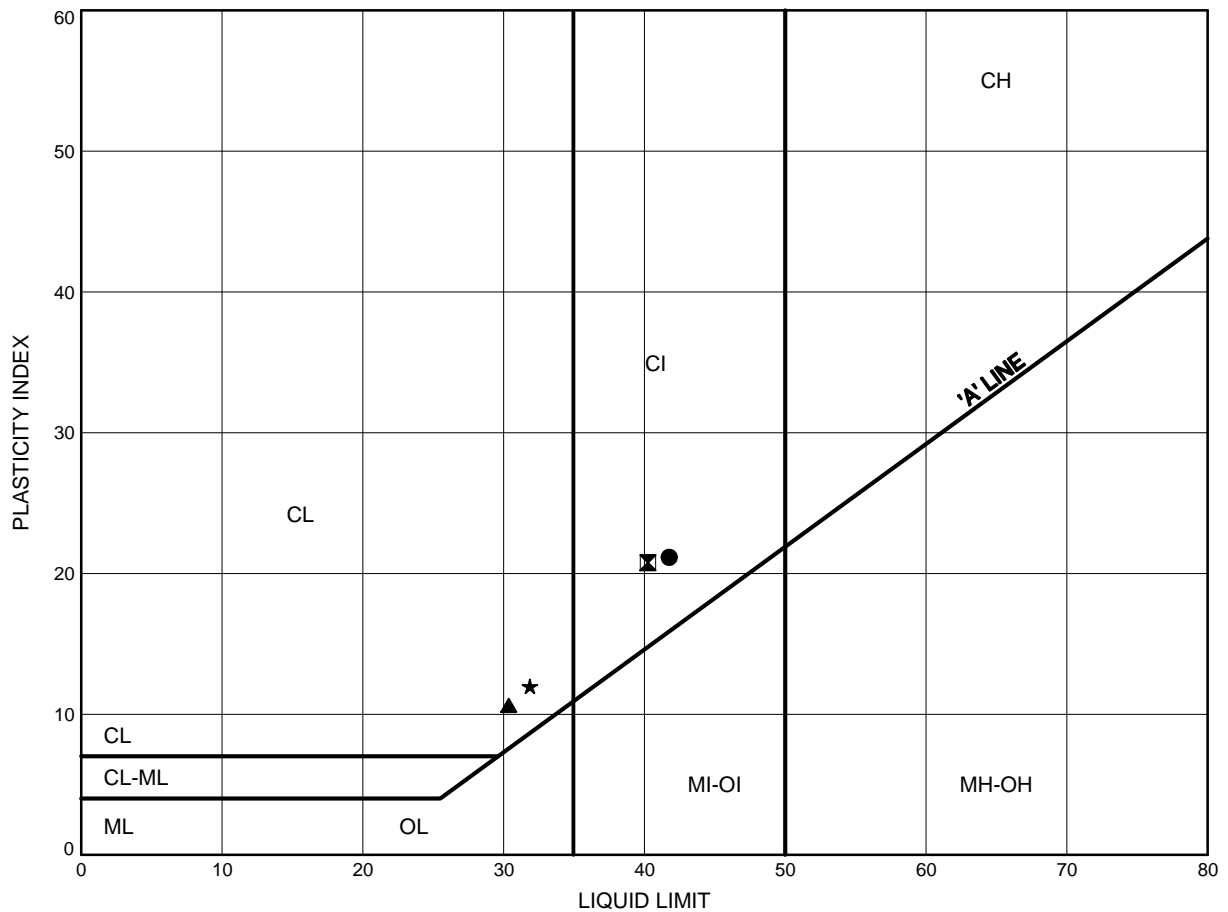


Prep'd AN
 Chkd. MKE

Hwy 77 / 401 Interchange
ATTERBERG LIMITS TEST RESULTS

FIGURE B8

Silty CLAY TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	7.62	180.86
⊠	15-05	7.62	183.56
▲	15-06	8.23	183.06
★	15-06	10.97	180.31

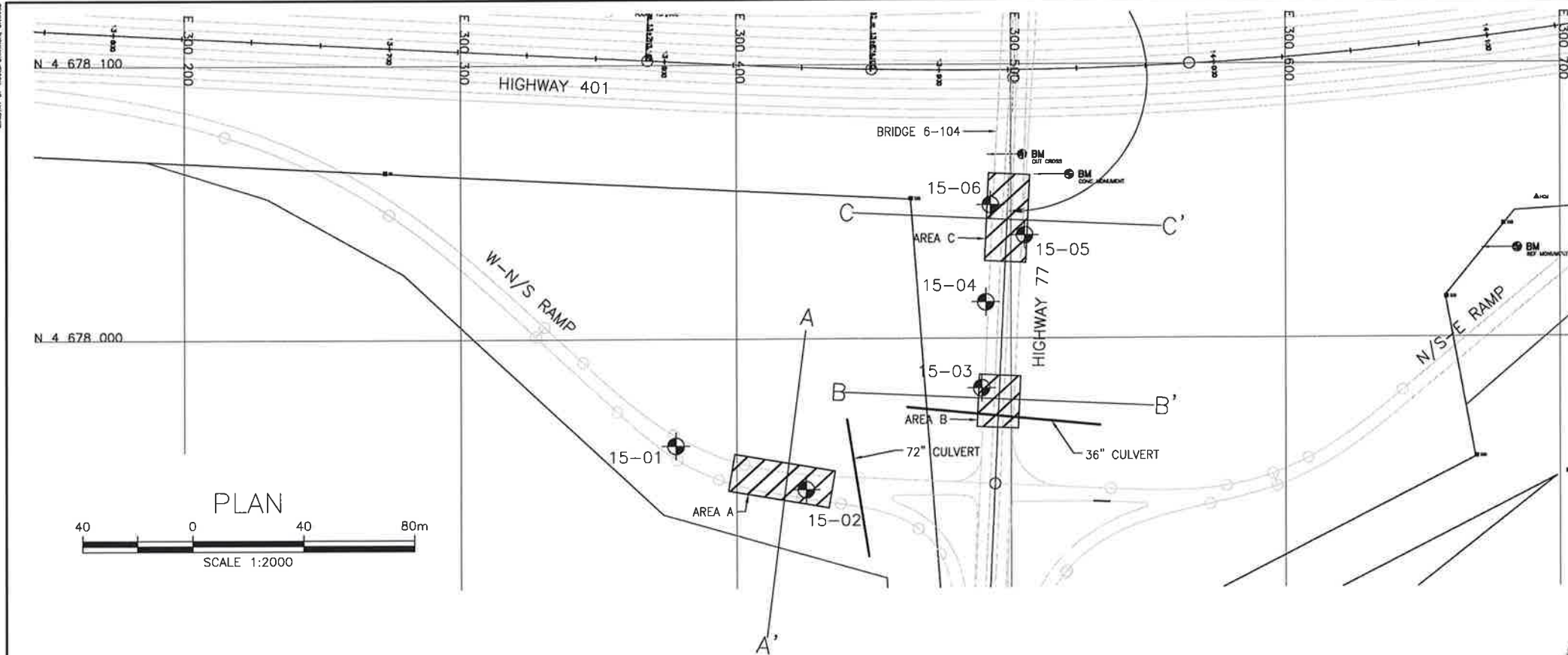
Date November 2015
 Project 15-64-35



Prep'd AN
 Chkd. MKE

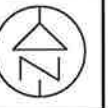
Appendix C

Borehole Locations and Soil Strata Drawing



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

CONT No
GWP No 3072-12-00

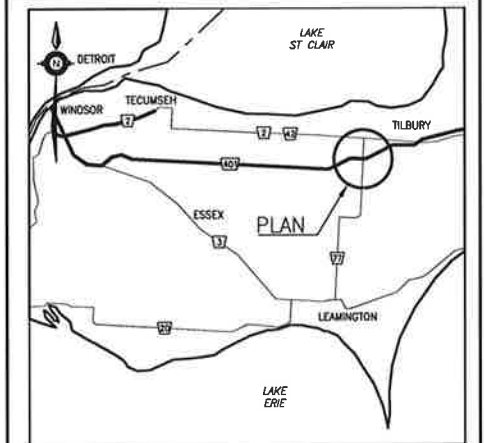


HIGHWAY 77/401
INTERCHANGE
SETTLEMENT & PAVEMENT CRACKING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

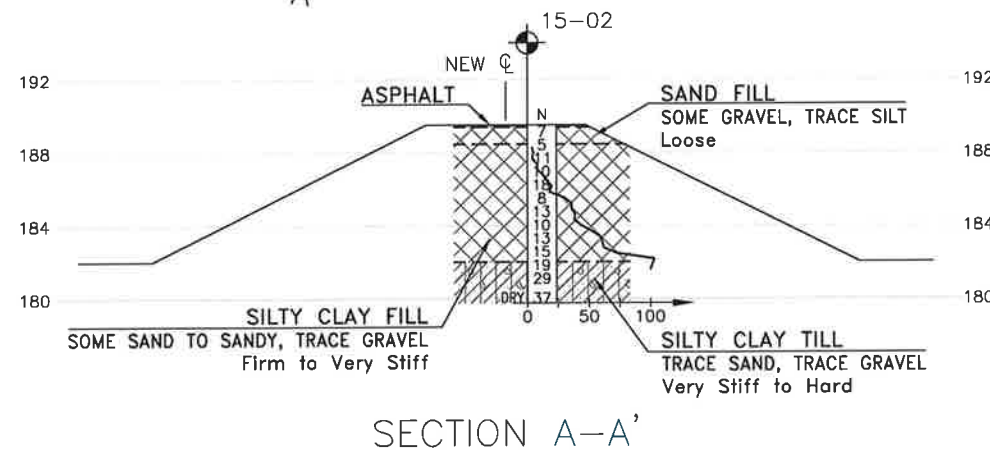
●	Borehole
⊙	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⊥	Head Artesian Water
⊥	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
15-01	188.5	4 677 961.1	300 377.8
15-02	189.5	4 677 945.0	300 425.3
15-03	190.7	4 677 981.9	300 489.2
15-04	191.1	4 678 013.2	300 490.8
15-05	191.2	4 678 037.6	300 505.0
15-06	191.3	4 678 048.6	300 492.5

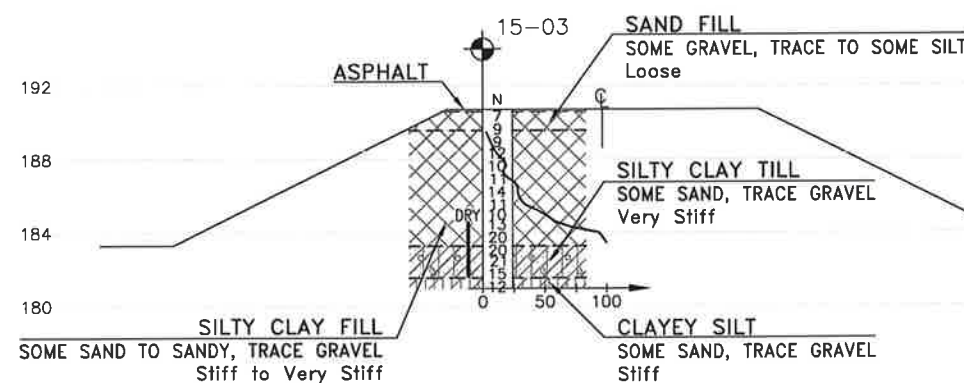
-NOTES-

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

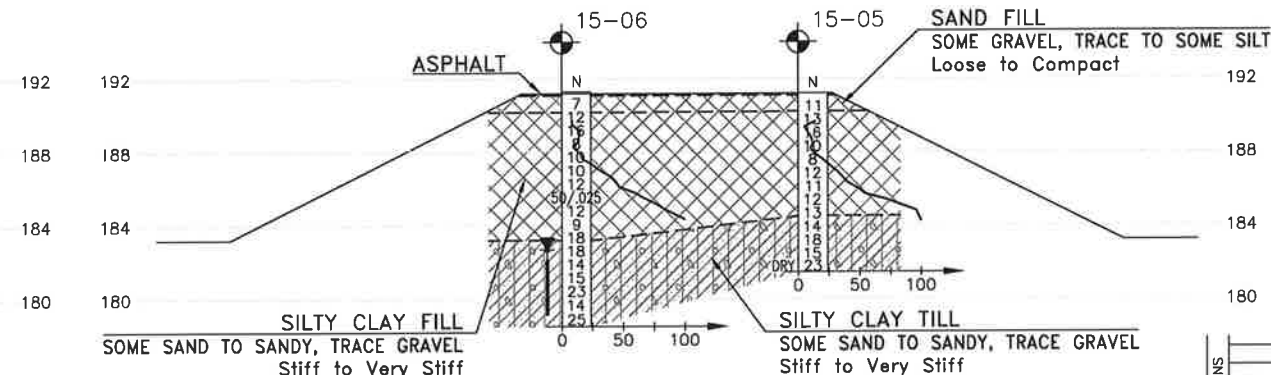
GEOCRES No. 40J2-133



SCALE 1:400



SECTION B-B'



SECTION C-C'

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MKE	CHK PKC	CODE
DRAWN	MFA	CHK MKE	SITE
			LOAD
			DATE
			JAN 2016
			DWG 1

Appendix D

Site Photographs

High Fill Approach and Ramp Embankment Settlement
Highway 77 / 401 Interchange



Looking east at south shoulder of eastbound off-ramp from Highway 401 to Highway 77
(August 17, 2015)

High Fill Approach and Ramp Embankment Settlement
Highway 77 / 401 Interchange



Looking east at north shoulder of eastbound off-ramp from Highway 401 to Highway 77
(August 17, 2015)



Looking south at north end of culvert below eastbound off-ramp from Highway 401 to Highway 77
(August 17, 2015)

High Fill Approach and Ramp Embankment Settlement
Highway 77 / 401 Interchange



Looking south at boundary of patches at south abutment along Highway 77
(August 17, 2015)

High Fill Approach and Ramp Embankment Settlement
Highway 77 / 401 Interchange



Looking north at patch above 36 inch diameter concrete culvert along Highway 77
(August 17, 2015)

Appendix E

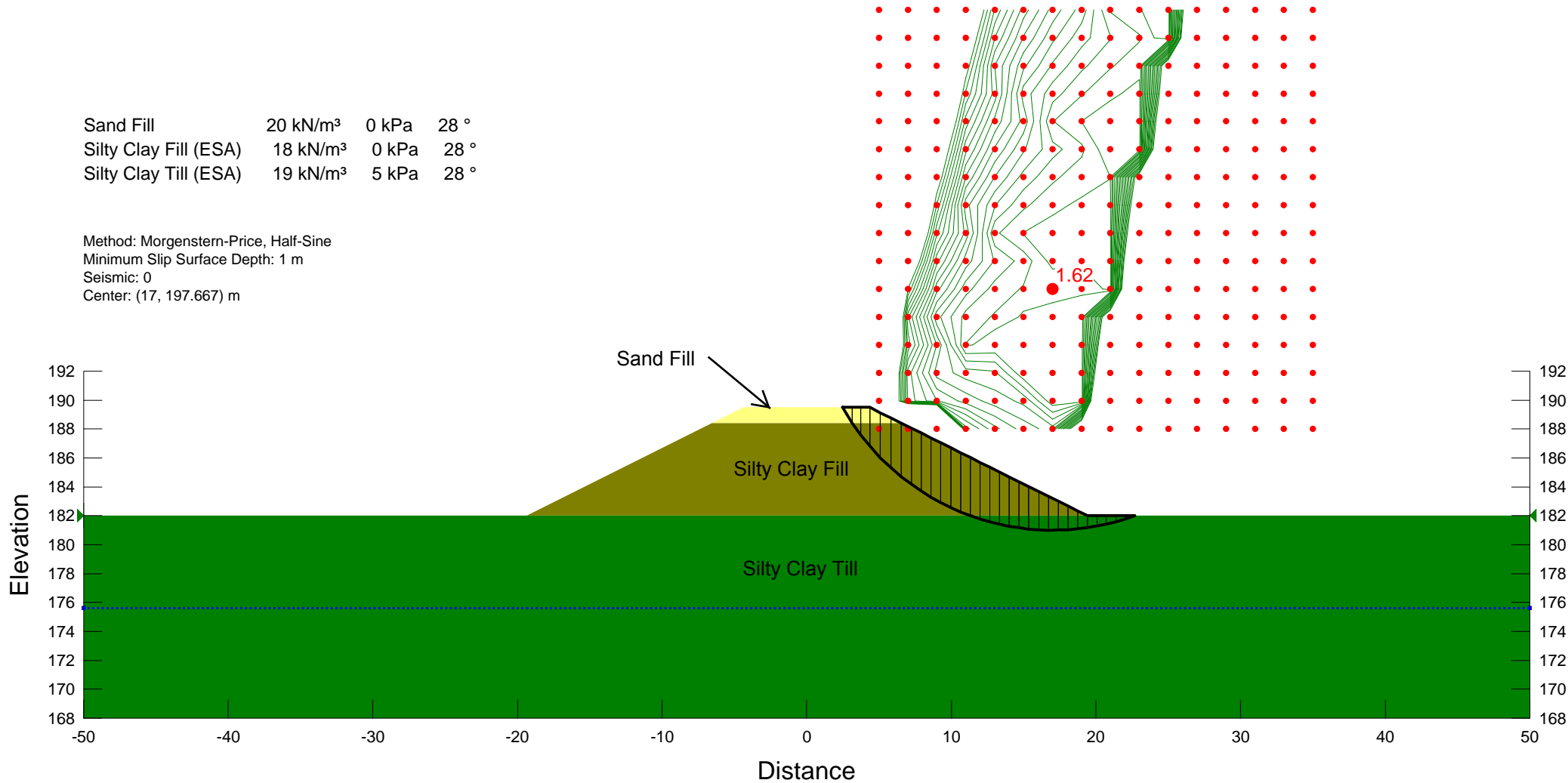
Global Stability Analyses

GLOBAL STABILITY – SECTION A-A (ESA) HIGH FILL APPROACH AND RAMP EMBANKMENT SETTLEMENT HIGHWAY 77 / 401 INTERCHANGE

FIGURE E1

Sand Fill	20 kN/m ³	0 kPa	28 °
Silty Clay Fill (ESA)	18 kN/m ³	0 kPa	28 °
Silty Clay Till (ESA)	19 kN/m ³	5 kPa	28 °

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1 m
Seismic: 0
Center: (17, 197.667) m

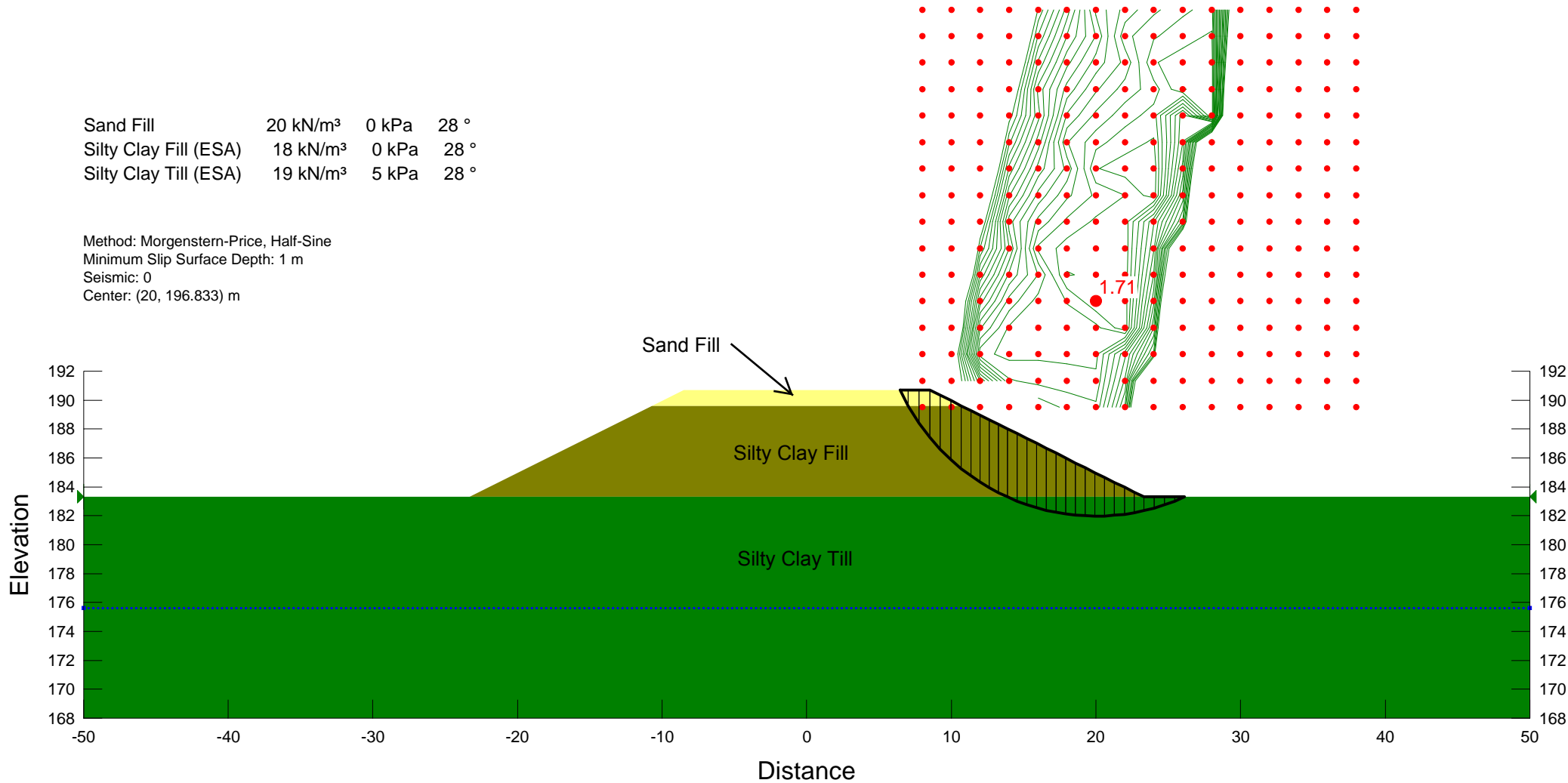


GLOBAL STABILITY – SECTION B-B (ESA) HIGH FILL APPROACH AND RAMP EMBANKMENT SETTLEMENT HIGHWAY 77 / 401 INTERCHANGE

FIGURE E2

Sand Fill	20 kN/m ³	0 kPa	28 °
Silty Clay Fill (ESA)	18 kN/m ³	0 kPa	28 °
Silty Clay Till (ESA)	19 kN/m ³	5 kPa	28 °

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1 m
Seismic: 0
Center: (20, 196.833) m



GLOBAL STABILITY – SECTION C-C (ESA) HIGH FILL APPROACH AND RAMP EMBANKMENT SETTLEMENT HIGHWAY 77 / 401 INTERCHANGE

FIGURE E3

Sand Fill	20 kN/m ³	0 kPa	28 °
Silty Clay Fill (ESA)	18 kN/m ³	0 kPa	28 °
Silty Clay Till (ESA)	19 kN/m ³	5 kPa	28 °

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1 m
Seismic: 0
Center: (22, 198.667) m

