

**FOUNDATION INVESTIGATION REPORT
GRANDVIEW CREEK CULVERT – EBL
HIGHWAY 11/17 - FOUR LANING
FROM 0.36 km EAST OF HIGHWAY 527 EASTERLY 12.6 km
TO 1 km WEST OF MACKENZIE STATION ROAD
G.W.P. 623-89-00, SITE 48C-349/C1**

Geocres Number: 52A-157

Report to

McCormick Rankin Corporation

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the location of the Grandview Creek culvert under existing Highway 11/17 in the Township of MacGregor, District of Thunder Bay. Replacement of the existing culvert is planned as part of the proposed Highway 11/17 four-laning project extending from 0.36 km east of Highway 527 to 1 km west of MacKenzie Station Road. The existing Highway 11/17 will become the new eastbound lanes of the four-lane divided highway.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic sections, laboratory test results and written descriptions 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 Corporation, under the Ministry of Transportation Ontario (MTO) Agreement Number 6009-E-0017.

2 SITE DESCRIPTION

The proposed Grandview Creek culvert is located approximately 14 km east of Thunder Bay, Ontario and approximately 10.5 km east of Highway 527. The new culvert will be situated at the location of the existing culvert under the existing Highway 11/17 alignment. The existing roadway embankment is approximately 5 to 6 m in height.

The existing culvert comprises a 1.4 m diameter corrugated steel pipe (CSP) with a length of 34.8 m. The invert level of the existing culvert ranges from approximate elevation 239.5 at the inlet (north end) to elevation 238.5 at the outlet (south end).

Lands surrounding the culvert site consist of forested areas with bedrock outcrops. Cobbles and boulders are present in the creek channel at the inlet, and rock fill exists on the south facing embankment slope.

Photographs in Appendix C show the general nature of the site.

The site lies near the border of the Superior and Southern Geological Provinces of the Canadian Shield. According to bedrock geology maps produced by the Ontario Geological Survey, the culvert site lies near a boundary between massive granodiorite to granite rocks and metasedimentary rocks. Bedrock core samples confirm that the site is underlain by fine grained metasedimentary rocks. Locally, the overburden consists of cohesionless deposits of gravelly sand to silty sand containing occasional cobbles and boulders.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out in several stages between October 22, 2011 and February 1, 2012. Six boreholes, identified as GCE-1 to GCE-6, were drilled and sampled at the site.

Boreholes GCE-1 and GCE-4 were located near the proposed culvert inlet, Boreholes GCE-2 and GCE-5 were located on the existing highway embankment, and Boreholes GCE-3 and GCE-6 were located near the culvert outlet. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata drawing included in Appendix D.

The boreholes were advanced to depths of 2.9 m to 13.0 m (elevations 235.7 to 228.3). Bedrock was proven by coring 2.7 m to 3.7 m in all boreholes except Borehole GCE-3.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling. Clearing and access preparation were required prior to commencement of the borehole drilling. Silt fencing was installed between the drill area and the creek to prevent migration of core water sediment into the adjacent creek.

A track mounted CME 45 drill rig was used to drill all boreholes except Borehole GCE-3, and a combination of hollow-stem augers, casing and NQ coring techniques were used to advance the boreholes. Borehole GCE-3 was advanced with a portable tripod rig using solid-stem augers. Overburden samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (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.

Groundwater conditions were observed in the open boreholes during and upon completion of the drilling operations. Groundwater conditions observed after completion of coring were not

representative of site conditions as water was introduced into the borehole during coring. Standpipe piezometers were installed in two boreholes for subsequent monitoring of groundwater levels. The completion details of the piezometers and boreholes are summarized in Table 3.1. The piezometers were decommissioned in general accordance with MOE Regulation 903 in late July 2012.

Table 3.1 – Piezometer and Borehole Completion Details

| Borehole | Borehole Depth/ Elevation (m) | Completion Details |
|-----------------|--|--|
| GCE-1 | - | Backfilled with a mixture of bentonite and auger cuttings to surface. |
| GCE-2 | - | Backfilled with bentonite holeplug to 1.8 m, auger cuttings from 1.8 m to 0.07 m, then asphalt to surface. |
| GCE-3 | - | Backfilled with holeplug to surface. |
| GCE-4 | 8.5 / 232.0 | Holeplug from 12.2 m to 8.5 m. Piezometer installed at 8.5 m. Filter sand from 8.5 m to 4.6 m and holeplug from 4.6 m to surface. |
| GCE-5 | 9.1 / 235.3 | Holeplug from 13.0 m to 9.1 m. Piezometer installed at 9.1 m. Filter sand from 9.1 m to 5.6 m, holeplug from 5.6 m to 1.0 m, sand from 1.0 m to 0.03 m, then asphalt to surface. |
| GCE-6 | - | Backfilled with holeplug to 0.9 m, then cuttings to surface. |

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 gradation analysis. The results of these tests are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

Point load tests were carried out on selected samples of intact bedrock upon arrival at the laboratory to evaluate the unconfined compressive strength (UCS) of the bedrock. The UCS values of the rock assessed from the point load data are reported on the borehole logs.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing included in Appendix D. 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.

In general, the subsurface stratigraphy encountered at the site consisted of sand and gravel embankment fill overlying native deposits of gravelly sand and silty sand, underlain by bedrock. Localized units of silt and sandy silt were also encountered. More detailed descriptions of the individual strata are presented below.

5.1 Topsoil

Topsoil was encountered at the surface in Boreholes GCE-1 and GCE-4 drilled near the culvert inlet. The topsoil is dark brown and described as sandy with some silt. The topsoil was 500 mm thick in Borehole GCE-1 and 200 mm thick in Borehole GCE-4.

An SPT N-value of 4 blows for 0.3 m penetration was recorded in Borehole GCE-1, indicating a loose relative density. A moisture content of 13% was measured.

5.2 Asphalt

Asphalt was encountered surficially in Boreholes GCE-2 and GCE-5 drilled on the shoulders of Highway 11/17. The asphalt was 100 mm and 125 mm thick.

5.3 Sand and Gravel Fill

Sand and gravel fill was encountered below the asphalt in Boreholes GCE-2 and GCE-5, and at the ground surface in Borehole GCE-6. The sand and gravel fill was brown and contained trace silt and clay and occasional cobbles and/or boulders.

The sand and gravel fill was 4.5 m thick in Boreholes GCE-2 and GCE-5 drilled through the existing highway embankment, and 0.5 m thick in Borehole GCE-6 drilled at the embankment toe. The lower boundary of the fill was encountered at depths varying from 0.5 m to 4.6 m (elevation 239.8 to 239.7).

SPT N-values recorded in the fill typically ranged from 33 to 46 blows for 0.3 m penetration, indicating a dense relative density. An SPT 'N' value of 67 blows per 0.275 m was obtained on probable cobbles in Borehole GCE-2. In Borehole GCE-6, an N-value of 11 blows per 0.3 m penetration was recorded, indicating a compact condition.

The moisture content of samples of the sand and gravel fill typically ranged from 7% to 10%. A value of 20% was measured in Borehole GCE-6 which may be attributed to the presence of organics in the sample.

Two samples of the sand and gravel fill underwent laboratory gradation analysis. The results of these tests are summarized on the Record of Borehole sheets in Appendix A and the grain size distribution curves are plotted on Figure B1, Appendix B. The results of the gradation analyses are as follows.

| | |
|----------------|----------|
| Gravel% | 30 to 40 |
| Sand% | 54 to 62 |
| Silt and Clay% | 6 to 8 |

5.4 Gravelly Sand

Native gravelly sand was encountered below the topsoil in Boreholes GCE-1 and GCE-4, beneath the sand and gravel fill in Borehole GCE-5, and below sand and silt layers in Borehole GCE-3. The gravelly sand was brown, dark brown or grey and contained trace to some silt and cobbles. A 400 mm thick layer of sandy silt was encountered within the gravelly sand in Borehole GCE-4. The use of coring methods was required to advance the boreholes through cobbles and possible boulders within the gravelly sand in Boreholes GCE-1 and GCE-4.

The gravelly sand layer was 0.6 to 3.9 m thick. The base of the gravelly sand layer was encountered at depths of 1.7 m to 6.1 m (elevations 238.8 to 235.7).

SPT N-values recorded in the native gravelly sand typically ranged from 9 to 35 blows for 0.3 m penetration, indicating a loose to dense relative density. In Boreholes GCE-1 and GCE-4, N-values of 50 blows per 0.05 m penetration and 102 blows per 0.3 m penetration were recorded on probable cobbles.

The moisture content of samples of the gravelly sand ranged from 7% to 13%.

5.5 Silty Sand

Silty sand was encountered at the ground surface in Borehole GCE-3 and below the sand and gravel fill or native gravelly sand in all other boreholes. The silty sand was brown to grey and contained trace to some gravel and occasional cobbles and boulders. Layers of silt, 150 mm and 700 mm thick, were encountered within the silty sand in Boreholes GCE-1 and GCE-3. Coring was required to advance Boreholes GCE-1, GCE-4 and GCE-6 through the silty sand, indicating the presence of cobbles and boulders.

The thickness of the silty sand ranged from 2.3 m to 5.3 m, with the lower boundary of the silty sand encountered at depths of 2.3 m to 9.4 m (elevations 237.4 to 231.1).

SPT N-values recorded in the native silty sand typically ranged from 31 blows for 0.3 m penetration to 46 blows for 0.025 m penetration, indicating a dense to very dense relative density and/or the presence of cobbles and boulders. Lower SPT N-values of 5 blows to 26 blows for 0.3 m penetration were recorded in Boreholes GCE-2 and GCE-3, indicating loose to compact conditions.

The moisture content of samples of the silty sand ranged from 9% to 21%, with single values of 25% and 34% measured near the upper boundary of this layer in Boreholes GCE-1 and GCE-3.

Five samples of the silty sand underwent laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A and are plotted on Figure B2, Appendix B.

| | |
|---------|----------|
| Gravel% | 0 to 16 |
| Sand% | 40 to 63 |
| Silt% | 22 to 46 |
| Clay% | 2 to 9 |

5.6 Silt to Sandy Silt

A 0.7 m thick layer of silt was encountered locally within the silty sand in Borehole GCE-3. The silt was brown and contained some sand. An SPT N-value of 18 blows for 0.3 m penetration was recorded, indicating a compact condition. A moisture content of 23% was measured.

A 0.4 m thick layer of grey sandy silt was encountered at a depth of 1.7 m within the gravelly sand in Borehole GCE-4. An SPT N-value of 11 blows for 0.3 m penetration was recorded in the sandy silt, indicating a compact condition. The moisture content of a sample of the sandy silt was 20%.

A sample of the sandy silt underwent laboratory gradation analysis, the results of which are summarized below. The results of this test are also presented on the Record of Boreholes sheets in Appendix A and the grain size distribution curve for this sample is plotted on Figure B3, Appendix B.

| | |
|---------|----|
| Gravel% | 8 |
| Sand% | 32 |
| Silt% | 56 |
| Clay% | 4 |

5.7 Bedrock

Bedrock was proven below the silty sand in all boreholes except Borehole GCE-3, where auger refusal was met on probable bedrock or boulders below the gravelly sand. The depths to bedrock proven by coring or inferred by auger refusal are summarized in Table 5.1.

The bedrock recovered in the cores was described as fine grained metasedimentary bedrock with occasional quartz veins and quartz interbeds. The bedrock is greenish grey to dark grey in colour with occasional white bands.

Table 5.1 – Depth to Bedrock or Probable Bedrock/Boulders at Borehole Locations

| Borehole | Depth to Bedrock (m) | Top of Bedrock Elevation (m) | Method |
|----------|----------------------|------------------------------|---------------|
| GCE-1 | 4.9 | 235.6 | Cored |
| GCE-2 | 7.0 | 237.4 | Cored |
| GCE-3 | 2.9 | 235.7 | Auger refusal |
| GCE-4 | 9.4 | 231.1 | Cored |
| GCE-5 | 9.3 | 235.1 | Cored |
| GCE-6 | 2.8 | 237.4 | Cored |

Core recovery ranged from 61% to 100%. RQD values ranged from 0% to 23% in the initial core run at the bedrock surface in Boreholes GCE-1, GCE-2, GCE-4 and GCE-5, indicating very poor rock quality. RQD values in subsequent runs and in Borehole GCE-6 ranged from 47% to 100%, indicating poor to excellent rock quality, typically good to excellent. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was generally less than 5, with many values over 5 in Boreholes GCE-2 and GCE-5.

The unconfined compressive strength of the rock, estimated from the results of point load tests conducted on the rock core samples, ranged from 130 to 204 MPa, indicating a strong to very strong intact rock. The results are summarized on the Record of Borehole sheets in Appendix A (as average per run).

5.8 Water Levels

Groundwater was measured at 0.8 m depth (elevation 237.8) in Borehole GCE-3 upon completion of the drilling. Water was added to the boreholes during coring operations and therefore natural water levels were not recorded in the remaining boreholes upon completion.

Standpipe piezometers were installed in Boreholes GCE-4 and GCE-5 following completion of drilling. The ground water depths and levels measured in the piezometers and in open Borehole GCE-3 upon completion are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

| Borehole | Date | Water Level (m) | | Comment |
|----------|---------------|-----------------|-----------|-----------------|
| | | Depth | Elevation | |
| GCE-3 | Feb. 01, 2012 | 0.8 | 237.8 | Upon completion |
| GCE-4 | Jan. 30, 2012 | 1.8 | 238.7 | Piezometer |
| GCE-5 | Dec. 02, 2011 | 7.2 | 237.2 | Piezometer |

The water level in the creek at the time of the fieldwork was in the order of 0.2 m above the culvert invert level. Based on this observation and the culvert invert levels shown on the preliminary design drawings, the creek water level is estimated to be between elevation 239.7 at the inlet and 238.7 at the outlet.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall, and will reflect the water level in the creek.

6 MISCELLANEOUS

The borehole locations were selected by Thurber Engineering Ltd. and staked in the field by McCormick Rankin Corporation (MRC). The co-ordinates and ground surface elevations at the boreholes were surveyed by MRC. Where boreholes required relocation from the staked location, field measurements were recorded and the surveyed coordinates and elevations adjusted accordingly.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied a track mounted CME 45 drill rig and conducted the drilling, sampling and in-situ testing operations. Thunder Bay Testing from Thunder Bay, Ontario supplied the portable tripod rig and conducted the drilling, sampling and in-situ testing operation for one borehole.

The field program was supervised on a full time basis by Ms. Eckie Siu and Mr. Ryan Kromer, E.I.T. of Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

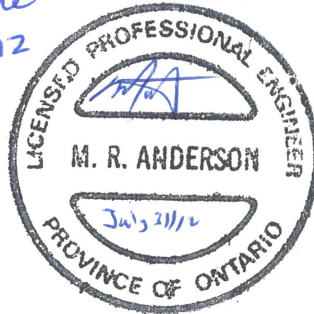
Overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng. Interpretation of the data and preparation of this report were carried out by Ms. Lindsey Blaine, E.I.T.

The report was reviewed by Mr. Murray R. Anderson, M.Eng., P.Eng. and Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations Projects.

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July 31/12



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Review Principal

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 |

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


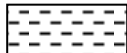



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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 | | | |

EXPLANATION OF ROCK LOGGING TERMS

| <u>ROCK WEATHERING CLASSIFICATION</u> | | <u>SYMBOLS</u> | |
|---------------------------------------|---|---|-------------------|
| Fresh (FR) | No visible signs of weathering. | | |
| Fresh Jointed (FJ) | Weathering limited to the surface of major discontinuities. |  | CLAYSTONE |
| Slightly Weathered (SW) | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material. |  | SILTSTONE |
| Moderately Weathered (MW) | Weathering extends throughout the rock mass, but the rock material is not friable. |  | SANDSTONE |
| Highly Weathered (HW) | Weathering extends throughout the rock mass and the rock is partly friable. |  | COAL |
| Completely Weathered (CW) | Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved. |  | Bedrock (general) |

| <u>DISCONTINUITY SPACING</u> | | <u>STRENGTH CLASSIFICATION</u> | | | |
|------------------------------|-----------------------|--------------------------------|---|---------------------|---|
| Bedding | Bedding Plane Spacing | Rock Strength | Approximate Uniaxial Compressive Strength | | Field Estimation of Hardness* |
| | | | (MPa) | (psi) | |
| Very thickly bedded | Greater than 2m | Extremely Strong | Greater than 250 | Greater than 36,000 | Specimen can only be chipped with a geological hammer |
| Thickly bedded | 0.6 to 2m | | | | |
| Medium bedded | 0.2 to 0.6m | Very Strong | 100-250 | 15,000 to 36,000 | Requires many blows of geological hammer to break |
| Thinly bedded | 60mm to 0.2m | Strong | 50-100 | 7,500 to 15,000 | Requires more than one blow of geological hammer to break |
| Very thinly bedded | 20 to 60mm | | | | |
| Laminated | 6 to 20mm | Medium Strong | 25.0 to 50.0 | 3,500 to 7,500 | Breaks under single blow of geological hammer. |
| Thinly Laminated | Less than 6mm | | | | |



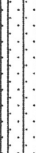

| <u>TERMS</u> | | | | | |
|-------------------------------------|--|-----------------------|-------------|--------------|--|
| Total Core Recovery: (TCR) | Core recovered as a percentage of total core run length. | Weak | 5.0 to 25.0 | 750 to 3,500 | Can be peeled by a pocket knife with difficulty |
| Solid Core Recovery: (SCR) | Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run. | Very Weak | 1.0 to 5.0 | 150 to 750 | Can be peeled by a pocket knife, crumbles under firm blows of geological pick. |
| Rock Quality Designation: (RQD) | Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length. | Extremely Weak (Rock) | 0.25 to 1.0 | 35 to 150 | Indented by thumbnail |
| 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 GCE-1

1 OF 1

METRIC

W.P. 623-89-00 LOCATION N 5 376 238.7 E 378 262.8 Grandview Creek EBL ORIGINATED BY RK
HWY 11/17 BOREHOLE TYPE HW and NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.11.14 - 2011.11.14 CHECKED BY RPR

| 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | WATER CONTENT (%) w _p w w _L | | | | |
| 240.5 | | | | | | | | 20 40 60 80 100 | | | | | | | |
| 0.0 | TOPSOIL, sandy Dark Brown Moist |  | 1 | SS | 4 | | | | | | | ○ | | | |
| 240.0 | | | | | | | | | | | | | | | |
| 0.5 | Gravelly SAND, some cobbles Very Dense Dark Brown Wet Cored through gravel and cobbles (possible boulders) from 0.5m to 1.5m |  | 2 | SS | 50/ 0.050 | | | | | | | ○ | | | |
| 238.8 | | | | | | | | | | | | | | | |
| 1.7 | Silty SAND, trace clay Dense to Very Dense Brown Wet Layer of silt (150mm) at 2.0m Cored through cobbles and boulders from 2.1m to 3.0m |  | 3 | SS | 31 | | | | | | | ○ | | | 0 51 46 3 |
| | | | 4 | SS | 54 | | | | | | | ○ | | | |
| | Some gravel Cored through cobbles and boulders from 3.0m to 4.7m Grey | | 5 | SS | 80 | | | | | | | ○ | | | 16 40 37 7 |
| | | | | | | | | | | | | | | | |
| | Moist | | 6 | SS | 46/ 0.025 | | | | | | | ○ | | | |
| 235.6 | | | | | | | | | | | | | | FI | |
| 4.9 | METASEDIMENTARY BEDROCK, moderately to slightly weathered, dark greenish grey, occasional quartz veins |  | 1 | RUN | | | | | | | | | | 2 | RUN #1 TCR=92% SCR=42% RQD=23% UCS=170MPa (Average) |
| | | | | | | | | | | | | | | 3 | |
| | | | | | | | | | | | | | | 3 | |
| | | | | | | | | | | | | | | 2 | |
| | Rubble zone (100mm) at 6.0m | | | | | | | | | | | | | 1 | |
| | | | | | | | | | | | | | | 3 | RUN #2 TCR=98% SCR=82% RQD=47% UCS=154MPa (Average) |
| | | | 2 | RUN | | | | | | | | | | 3 | |
| | | | | | | | | | | | | | | 1 | |
| | | | | | | | | | | | | | | 5 | |
| 232.7 | | | | | | | | | | | | | | | |
| 7.8 | END OF BOREHOLE AT 7.8m. BOREHOLE BACKFILLED WITH MIXTURE OF BENTONITE AND AUGER CUTTINGS TO SURFACE. | | | | | | | | | | | | | | |

ONTMT4S 1182.GPJ 1/27/12

METRIC

[illegible]

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GCE-3

1 OF 1

METRIC

W.P. 623-89-00 LOCATION N 5 376 205.8 E 378 277.5 Grandview Creek EBL ORIGINATED BY GA
 HWY 11/17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.02.01 - 2012.02.01 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 | | | 20 40 60 80 100 | PLASTIC LIMIT W _P | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | |
| 238.6 | | | | | | | | | | | | |
| 0.0 | Silty SAND , trace clay, trace gravel, occasional blast rock, occasional rootlets Compact Brown Damp | | 1 | SS | 26 | | 238 | | | o | | 6 63 22 9 |
| 237.8 | | | | | | | | | | | | |
| 0.8 | SILT , some sand Compact Brown Wet | | 2 | SS | 18 | | | | | o | | |
| 237.1 | | | | | | | 237 | | | o | | 15 51 32 2 |
| 1.5 | Silty SAND , trace gravel Compact Grey Wet | | 3 | SS | 20 | | | | | | | |
| 236.3 | | | | | | | | | | | | |
| 2.3 | Gravelly SAND , trace silt Dense Grey Wet | | 4 | SS | 35 | | 236 | | | o | | |
| 235.7 | | | | | | | | | | | | |
| 2.9 | END OF BOREHOLE AT 2.9m UPON AUGER REFUSAL. WATER LEVEL AT 0.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE. | | | | | | | | | | | |

RECORD OF BOREHOLE No GCE-4

1 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 376 243.7 E 378 272.1 Grandview Creek EBL ORIGINATED BY RK
HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.11.17 - 2011.11.17 CHECKED BY RPR

| 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | WATER CONTENT (%) w _p w w _L | | | | | | |
| 240.5 | | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | |
| 0.0 | TOPSOIL: (200mm) | | | | | | | | | | | | | | | | | | | |
| 0.2 | Gravelly SAND , some silt, occasional cobbles Loose to Very Dense Brown Moist to Wet Cored through occasional cobbles from 0.2m to 1.5m | | 1 | SS | 9 | | 240 | | | | | | | | | | | | | |
| | | | 2 | SS | 102 | | | | | | | | | | | | | | | |
| 238.8 | | | | | | | 239 | | | | | | | | | | | | | |
| 1.7 | Layer of sandy silt (400mm) Trace clay | | 3 | SS | 11 | | | | | | | | | | | | 8 | 32 | 56 | 4 |
| 238.4 | | | | | | | | | | | | | | | | | | | | |
| 2.1 | Compact | | 4 | SS | 29 | | 238 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | No recovery | | 5 | SS | 18 | | 237 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| 236.4 | | | | | | | 236 | | | | | | | | | | | | | |
| 4.1 | Silty SAND , trace gravel, trace clay Very Dense Grey Wet Cored through gravel and occasional cobbles from 4.6m to 9.1m | | 6 | SS | 50/ 0.150 | | | | | | | | | | | | | | | |
| | | | | | | | 235 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | 7 | SS | 61/ 0.150 | | 234 | | | | | | | | | | 3 | 59 | 35 | 3 |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | 233 | | | | | | | | | | | | | |
| | | | 8 | SS | 50/ 0.075 | | | | | | | | | | | | | | | |
| | | | | | | | 232 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| 231.1 | | | | | | | 231 | | | | | | | | | | | | | |
| 9.4 | METASEDIMENTARY BEDROCK, slightly weathered to fresh, dark greenish grey, occasional quartz veins | | | | | | | | | | | | | | | | | | | |
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Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No GCE-5

1 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 376 221.7 E 378 280.1 Grandview Creek EBL ORIGINATED BY ES
HWY 11/17 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.10.22 - 2011.10.22 CHECKED BY RPR

| 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 | 20 40 60 80 100 | 20 40 60 80 100 | | |
| 244.4 | | | | | | | | | | | | |
| 0.0 | ASPHALT: (125mm) | | | | | | | | | | | |
| 0.1 | SAND and GRAVEL, trace silt and clay, occasional cobbles and boulders Dense Brown Moist (FILL) Cored through boulders from 0.1m to 0.8m | | 1 | SS | 34 | | 244 | | | | | |
| | | | 2 | SS | 33 | | 243 | | | | | |
| | | | 3 | SS | 46 | | 242 | | | | | |
| | | | 4 | SS | 46 | | 241 | | | | | |
| 239.8 | | | | | | | 240 | | | | | |
| 4.6 | Gravelly SAND, occasional cobbles Loose Brown Moist | | 5 | SS | 9 | | 239 | | | | | |
| 238.3 | | | | | | | | | | | | |
| 6.1 | Silty SAND, trace gravel, occasional cobbles Very Dense Grey Wet | | 6 | SS | 57 | | 238 | | | | | |
| | | | 7 | SS | 50/ 0.125 | | 237 | | | | | |
| | | | 8 | SS | 50/ 0.100 | | 236 | | | | | |
| 235.1 | | | | | | | 235 | | | | | |
| 9.3 | METASEDIMENTARY BEDROCK, moderately to slightly weathered, grey, occasional quartz interbeds | | 1 | RUN | | | | | | | | |

Continued Next Page


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

RECORD OF BOREHOLE No GCE-5

2 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 376 221.7 E 378 280.1 Grandview Creek EBL ORIGINATED BY ES
HWY 11/17 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.10.22 - 2011.10.22 CHECKED BY RPR

| 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 (%) | | | |
| | Continued From Previous Page | | | | | | | 20 40 60 80 100 | | | | | | | GR SA SI CL | | | | |
| | METASEDIMENTARY BEDROCK , moderately to slightly weathered, grey, occasional quartz interbeds Sub-vertical fractures (50mm to 100mm) at 10.0m, 10.1m, 10.3m, 11.1m and 11.3m |  | 2 | RUN | | | 234 | | | | | | | | 2 | RUN #2 TCR=100% SCR=88% RQD=88% UCS=177MPa (Average) | | | |
| | Quartz interbeds: 300mm at 9.9m 75mm at 10.3m 100mm at 11.3m 225mm at 11.4m 50mm at 12.5m Vertical fracture at: 150mm at 11.4m 225mm at 12.7m | | | | | | 233 | | | | | | | | | | | >5 | |
| | Sub-horizontal fracture at 11.5m, 11.8m, 12.7m, 12.8m and 12.9m | | 3 | RUN | | | 232 | | | | | | | | | | | 1 | |
| | | | | | | | | | | | | | | | | | | | 1 |
| | | | | | | | | | | | | | | | | | | | >5 |
| 231.4 | | | | | | | | | | | | | | | | | | | |
| 13.0 | END OF BOREHOLE AT 13.0m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec. 02/11 7.2 237.2 | | | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No GCE-6

1 OF 1

METRIC

W.P. 623-89-00 LOCATION N 5 376 214.6 E 378 282.8 Grandview Creek EBL ORIGINATED BY ES
 HWY 11/17 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.11.23 - 2011.11.23 CHECKED BY RPR

| 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 | | | 20 40 60 80 100 | W _P W W _L | WATER CONTENT (%) | | | | | |
| 240.2 | | | | | | | | | | | | | | | |
| 0.0 | SAND and GRAVEL , trace organics Compact Brown Moist (FILL) Silty SAND , trace gravel, occasional organics Very Dense Brown Moist Cored through cobbles and boulders from 0.5m to 1.3m | | 1 | SS | 11 | | | | | | | | | | |
| 239.7 | | | | | | | | | | | | | | | |
| 0.5 | | | | | | | | | | | | | | | |
| | | | 2 | SS | 50/ 0.125 | | | | | | | | | | |
| | | | 3 | SS | 50/ 0.050 | | | | | | | | | | |
| 237.4 | | | | | | | | | | | | | | | |
| 2.8 | METASEDIMENTARY BEDROCK , slightly weathered, occasional quartz interbeds, grey with white bands Sub-vertical fracture (between 25mm to 100mm) at 2.8m, 3.3m, 3.7m, 4.8m 300mm at 4.0m Vertical fracture (25mm to 75mm) at 3.8m, 3.9m Quartz interbed (25mm to 100mm) at 2.7m, 3.0m, 3.4m, 4.7m | | 1 | RUN | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | 2 | RUN | | | | | | | | | | | |
| 234.7 | | | | | | | | | | | | | | | |
| 5.5 | END OF BOREHOLE AT 5.5m. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.9m THEN CUTTINGS TO SURFACE. | | | | | | | | | | | | | | |

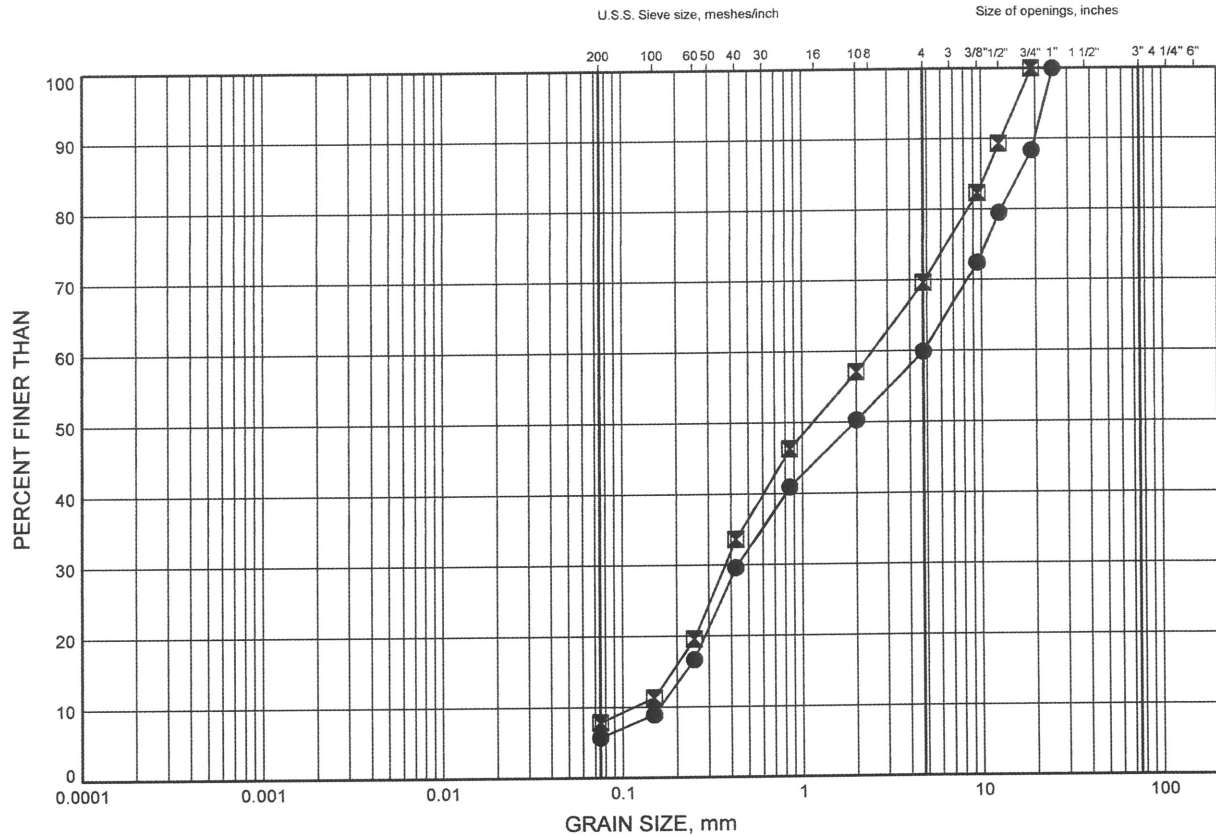
Appendix B

Laboratory Test Results

Grandview Creek - EBL GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & GRAVEL FILL



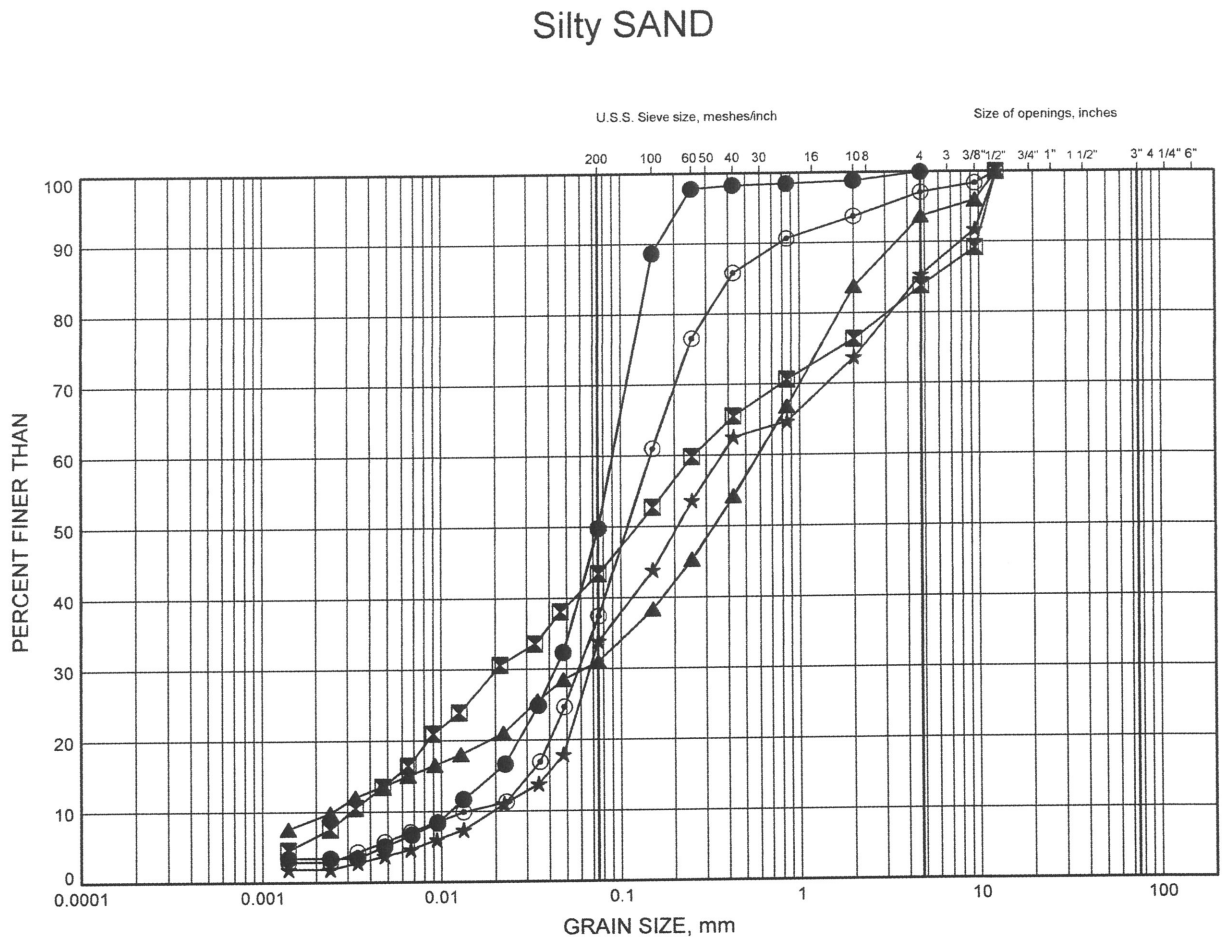
| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | GCE-2 | 2.59 | 241.81 |
| ■ | GCE-5 | 1.83 | 242.57 |

Grandview Creek Culvert - EBL GRAIN SIZE DISTRIBUTION

FIGURE B2



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

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | GCE-1 | 1.83 | 238.67 |
| ⊠ | GCE-1 | 3.35 | 237.15 |
| ▲ | GCE-3 | 0.30 | 238.30 |
| ★ | GCE-3 | 1.83 | 236.77 |
| ⊙ | GCE-4 | 6.40 | 234.10 |

GRAIN SIZE DISTRIBUTION - THURBER 1182.GPJ 6/22/12

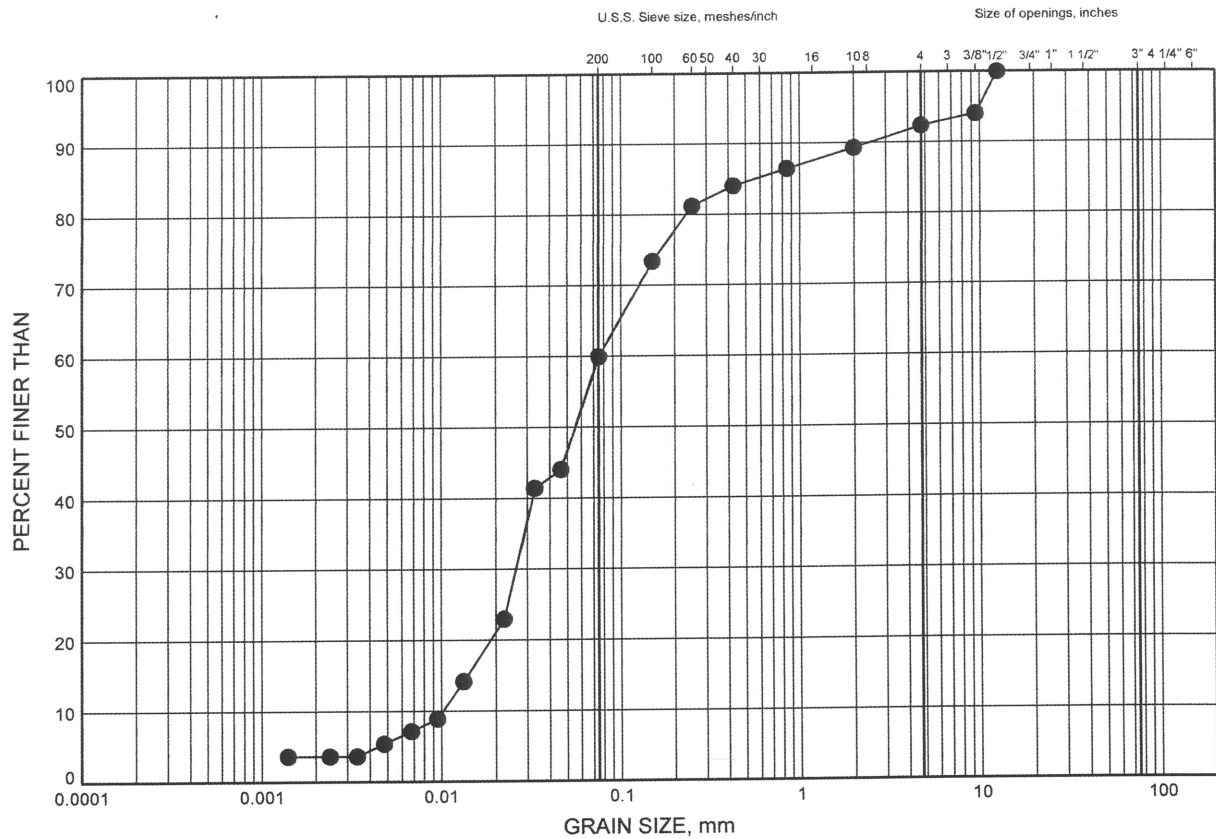
W.P.# 623-89-00
Prepared By AN
Checked By LRB



Grandview Creek Culvert - EBL GRAIN SIZE DISTRIBUTION

FIGURE B3

Sandy SILT



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

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | GCE-4 | 1.83 | 238.67 |



W.P.# 623-89-00
Prepared By AN
Checked By LRB

Appendix C

Site Photographs



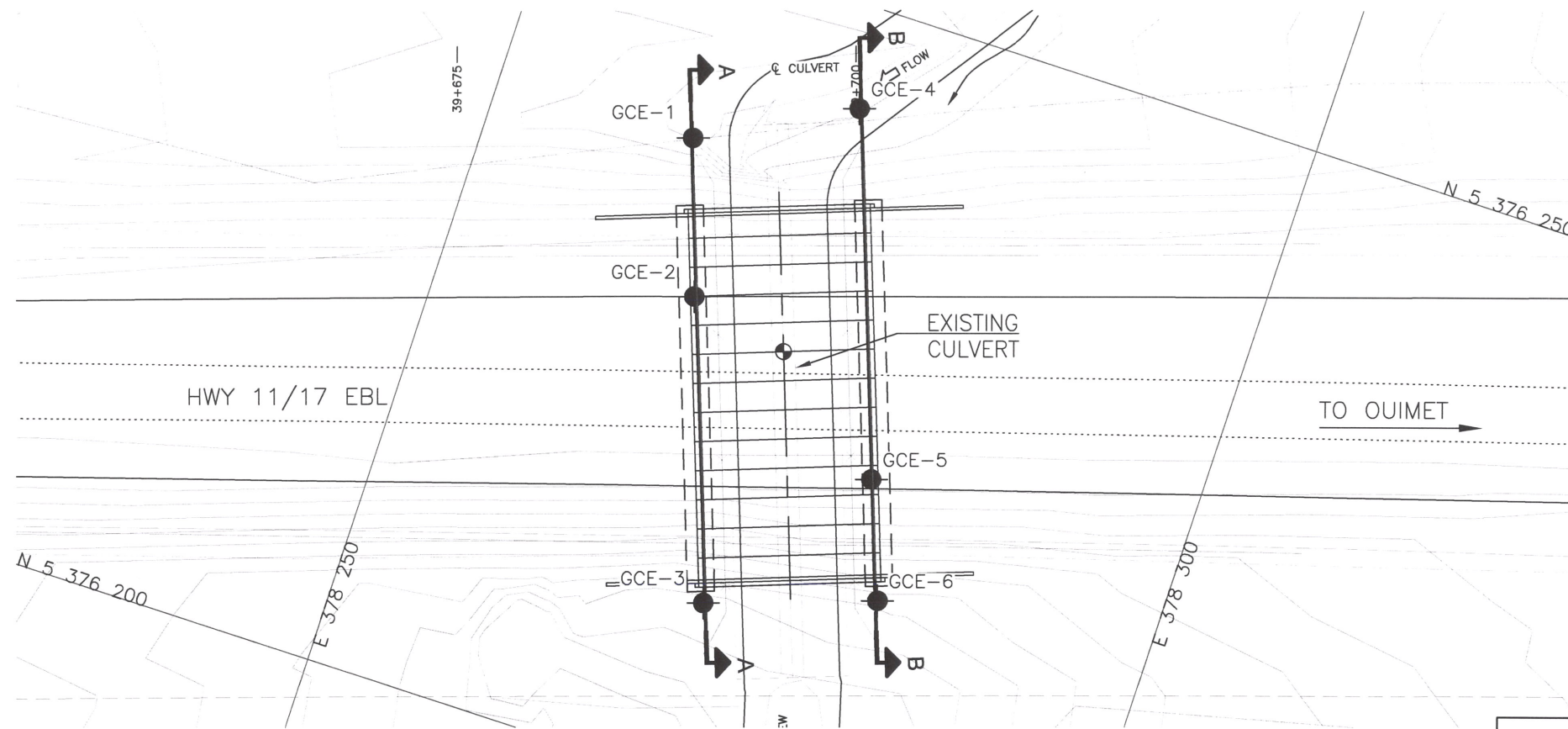
Photograph 1 – Grandview Creek EBL Culvert Inlet



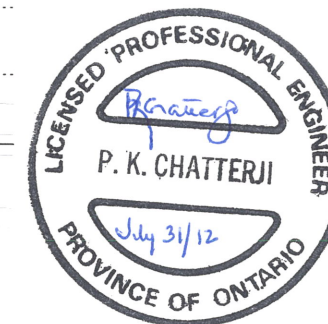
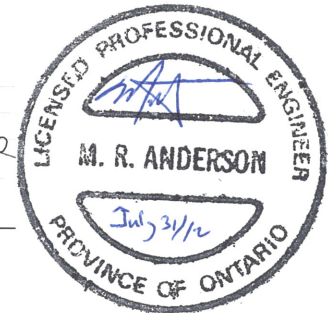
Photograph 2 – Grandview Creek EBL Culvert Outlet

Appendix D

Borehole Locations and Soil Strata Drawing



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



CONT No 2012-6010
WP No 623-89-00

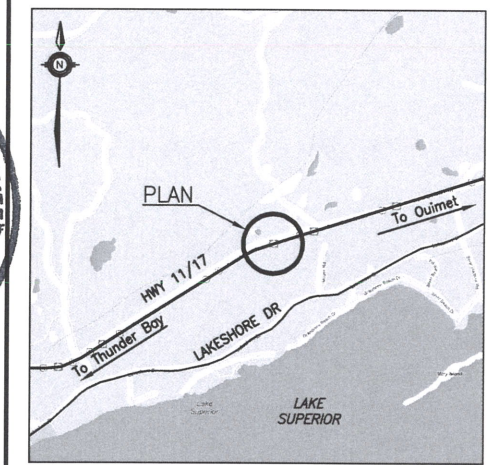
HIGHWAY 11/17
GRANDVIEW CREEK - EBL
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

Hatch Mott MacDonald

THURBER ENGINEERING LTD.



SHEET
255



KEYPLAN

LEGEND

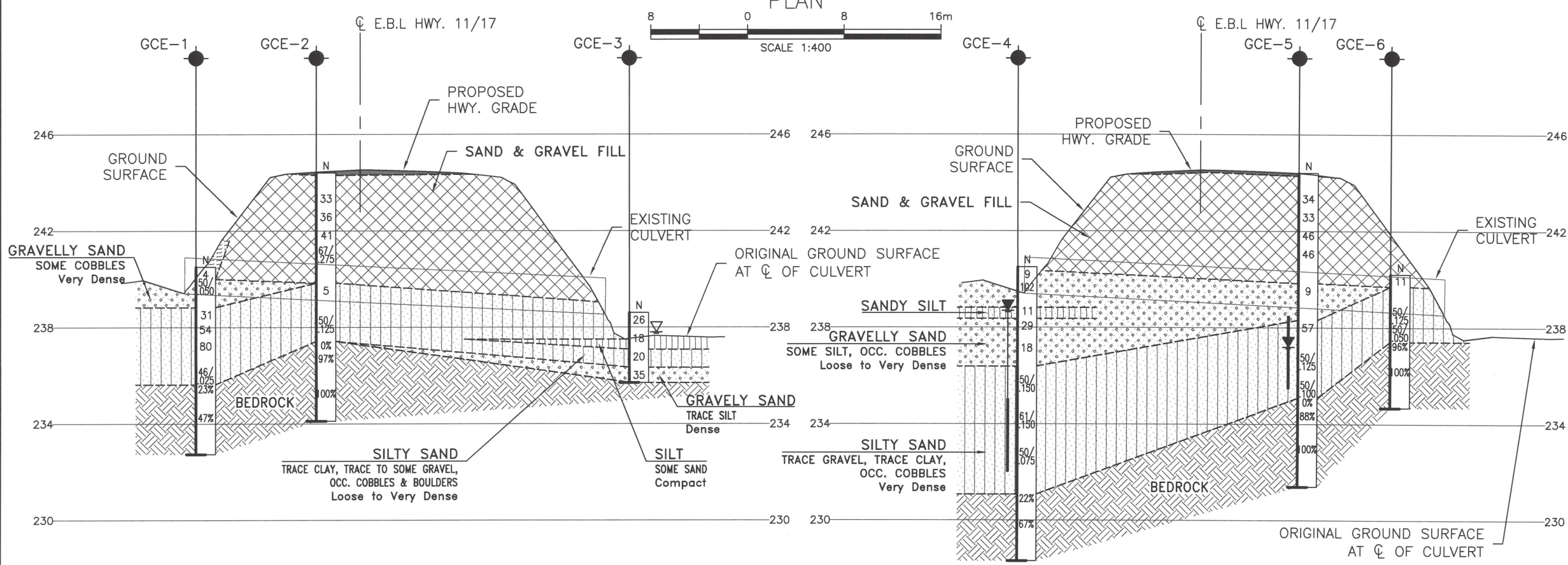
- Borehole
- ⊕ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- P Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

| NO | ELEVATION | NORTHING | EASTING |
|-------|-----------|-------------|-----------|
| GCE-1 | 240.5 | 5 376 238.7 | 378 262.8 |
| GCE-2 | 244.4 | 5 376 229.2 | 378 265.9 |
| GCE-3 | 238.6 | 5 376 205.8 | 378 277.5 |
| GCE-4 | 240.5 | 5 376 243.7 | 378 272.1 |
| GCE-5 | 244.4 | 5 376 221.7 | 378 280.1 |
| GCE-6 | 240.2 | 5 376 214.6 | 378 282.8 |

-NOTES-

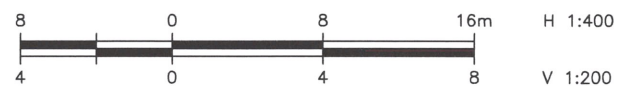
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 52A-157



SECTION A-A

SECTION B-B



| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|---------|---|
| DESIGN | LRB | CHK LRB | CODE CAN/CSA S6-06/LOAD CL-625-ONT/DATE JUL. 2012 |
| DRAWN | MFA | CHK AEG | SITE 48C-349/C1/STRUCT DWG 2 |