Submitted To AECOM Canada Ltd.
189 Wyld Street Suite 103, North Bay, Ontario P1B 1Z2
On Behalf of the Ontario Ministry of Transportation

Highway 144 Rehabilitation
Bridge Rehabilitation – Site No. 46-237
Bailey Creek Bridge
Twp. of Ulster
GWP 5046-05-00

Highway 144
From Cartier West Entrance (Centre Street),
Northerly 24.8 km

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

Date: September 21, 2012
Ref. Nº: 11/06/11101-F4

Geocres No. 42I-288

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1.0 INTRODUCTION

LVM | MERLEX has been retained by AECOM Canada Ltd., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation to supply subsurface data for the design of a protection system to be implemented at the Bailey River Bridge during the proposed rehabilitation. This bridge is located on Highway 144, some 20.6 km north of Cartier, in the Township of Ulster. The existing bridge is a 25.2 m single span concrete girder bridge with a width of 10.4 m.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5010-E-0012. The terms of reference for the scope of work are outlined in MEL's proposal P-10-177, dated January, 2011. The purpose of this investigation was to determine the subsurface conditions in the areas of the bridge approaches in order to provide design recommendations for a protection system to be implemented during rehabilitation activities to convert to semi-integral abutments. LVM | MERLEX investigated the foundation areas by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on select samples.

2.0 SITE DESCRIPTION

The Bailey Creek Bridge is located on Highway 144, between Stations 18+262.5 to 18+287.7, Township of Ulster (Site No. 46-237). The topography at the site is generally of low relief. The existing highway embankment currently supports two undivided lanes of highway, running in a north south direction. Bailey Creek flows from west to east at the bridge location. A visual review of the highway at the north and south approaches indicates that, in general, the approaches are in fair condition. Cobble and boulder size rock is present in the existing stream bed.

The existing 25.2 m single span concrete deck bridge was constructed in 1967 and rehabilitated in 1984 on the original highway alignment. The structure is in fair condition with deterioration of the concrete in some elements, including the wing walls and abutments.

Infrastructure at the bridge location consists of overhead communication wires on the east (right) side of the highway.

2.1 Site Physiography and Surficial Geology

This project is located in the Geomorphic Sub-province known as the Eastern Sandy Uplands. The topography on this section of Highway 144 is generally rolling. There are exposed bedrock ridges. At many locations, significant layers of earth overlay the bedrock. Organic terrain was also observed. Within the project area overburden consists primarily of sand and gravel containing varying amounts of silt and clay.

Bedrock in the area, as indicated on OGS Map 2506, is of the Early Precambrian Era. At the location of this bridge foundation investigation, the bedrock comprises of Felsic Igneous and Metamorphic Rocks including: granitic rocks, syenite, pegmatite, and unsubdivided migmatite.

3.0 INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out between September 18th and October 17th, 2011, during which four (4) sampled boreholes were advanced. Two boreholes were advanced at each end of the bridge: one through the existing approach slab and the second a short distance beyond the end of the approach slab. Additionally, pre-coring of the approach slabs at both ends of the bridge, directly behind the abutments, was undertaken to allow boreholes to be advanced at a future date. However, work at the abutments, by the Regional MTO Contractor, was carried out between the time of pre-coring the approach slabs and the investigation with the

auger drill, during which the approach slabs, left of centerline (southbound lane), were in the process of reconstruction. As such Boreholes Nos. 5 and 6 were not advanced through the newly replaced approach slab.

The field investigation was carried out using a truck mounted CME drilling rig equipped with hollow stem augers, standard augers, and routine geotechnical sampling equipment. Prior to mobilizing the auger drill to the site, the concrete approach slabs were core drilled, where required, with an electric core drill. Soil samples were obtained at the borehole locations at regular intervals of depth using the standard 50 mm O.D. split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures (ASTM D-1586). The SPT method involves advancing a 50 mm O.D. split spoon sampler with the force of a 63.5 kg hammer freely dropping 760 mm mounted in a trip (automatic) hammer. The number of blows per 300 mm penetration was recorded as the “N” value. At the boreholes, a Dynamic Cone Penetration Test (DCPT) was carried out to give a continuous plot of the soil resistance with depth. When cohesive deposits were encountered, the in-situ strength was measured using an “N” size field vane, vane collar, and calibrated torque meter. All samples taken during this investigation were stored in labeled airtight containers for transport to our North Bay laboratory for visual examination and select laboratory testing.

Groundwater conditions in the open boreholes were observed during the advancement of, and immediately following, completion of the individual boreholes. All open boreholes were backfilled upon completion with compacted auger cuttings in the general order they were removed and the upper portion of the hole, where necessary, was backfilled with an asphalt cold patch to seal the existing asphalt surface. The field work for this investigation was under the full time direction of a senior member of our engineering staff, who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations,

logging of the boreholes, labeling and preparation of samples for transport to our North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in our laboratory. Laboratory testing of select samples included routine testing for natural moisture content determination and particle size analysis. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix B), with a summary of results presented on the laboratory sheets in Appendix C (Figure No. L-1).

The location of the individual boreholes were determined in the field using highway chainage (established by others) and offset relative to highway centerline. The MTO co-ordinates, northing and easting, were then established for the boring locations. Elevations contained in this report are referenced to a geodetic datum.

4.0 SUBSURFACE CONDITIONS

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Appendix B) and on Figure No. 2 (Appendix C). Please note that stratigraphic delineation presented on the borehole logs and soil strata plot are the results of non-continuous sampling, response to drilling progress, the results of SPT and Dynamic Cone Penetration Test (DCPT), plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of a specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location, and are shown on the drawings for illustration purposes only.

4.1 Bailey Creek Bridge, TWP of Ulster – Site No. 46-237

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Figure No. 2, Appendix C. During the course of the exploration program, four (4) sampled

boreholes were put down at this site, with Borehole No. 1 advanced to the south of the south approach slab right of centerline. Borehole No. 2 was advanced behind the south abutment right of centerline. Borehole No. 3 was advanced behind the north abutment to the right of centerline, and Borehole No. 4 was advanced to the north of the north approach slab, left of centerline. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 4 were recorded at 408.5, 408.6, 408.7, and 408.7 m, respectively.

4.1.1 Pavement Structure

At surface at Borehole Nos. 1 and 4, a surficial pavement structure consisting of 100 to 125 mm of asphalt overlying 125 to 150 mm of crushed gravel was encountered. At surface at Borehole Nos. 2, 3, 5, and 6, a pavement structure consisting of 50 to 100 mm of asphalt overlying a 275 to 350 mm thick concrete approach slab, overlying 150 to 200 mm of crushed gravel was penetrated.

4.1.2 Fill

Underlying the pavement structure and approach slab at each borehole, a deposit of fill consisting of brown gravel and sand trace silt was penetrated. Numerous cobbles and boulder size rock was encountered in the lower reaches of this deposit, as such the fill was identified as rock fill. The natural moisture content measured on samples of this deposit was in the order of 1 to 9%. Gradation analyses were carried out on four (4) samples of the granular portion of this deposit, the results of which indicated 43 to 66% gravel size particles, 26 to 53% sand size particles, and 4 to 9% silt and clay size particles (Figure No. L-1, Appendix C). Based on SPT ‘N’ values of 11 to 65 blows per 300 mm penetration, the compactness of this deposit was described as compact to very dense, generally compact. Auger refusal was encountered on cobble/boulder size rock in this deposit at depths of 2.5, 2.0, 1.4, and 1.4 m below grade at Borehole Nos. 1 to 4, respectively (elevations 406.0, 406.6, 407.3, and 407.3 m, respectively).

DCPT refusal was encountered in this deposit at depths of 0.6, 3.9, 2.9, and 5.3 m below existing grade at Borehole Nos. 1 to 4, respectively (elevations 407.9, 404.7, 405.8, 403.4 m, respectively).

4.1.3 Previous Investigations

Based on information obtained from Contract No. 67-98 and Foundation Investigation Report W.J. 66-F-60, dated July 11, 1960, the overburden at this site generally consisted of boulders overlying a mix of sand, gravel and boulders with bedrock at an approximate elevation of 396.5 m. The original ground surface was at approximately elevations 404.5 and 403.5 m to the south and north of the stream channel. The embankment was constructed over the boulder bed using rock fill. The Bailey Creek contract drawings, from Contract No. 67-98 have been included, for general information, as Enclosure Nos. 6 and 7 in Appendix D.

4.2 Groundwater Conditions

During this investigation, the water level in the river was measured at an elevation of 403.4 m, based on the survey by exp. Measurements of the groundwater table and cave-in levels were undertaken, where possible, in the open boreholes during the advance of the individual borings and upon completion. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix B). Borehole Nos. 1 to 4 were dry upon completion and were backfilled immediately upon completion of sampling. The groundwater levels will fluctuate seasonally.

5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

A foundation investigation was carried out for the design of a protection system for the proposed bridge rehabilitation and conversion to semi-integral abutment at the Bailey Creek Bridge, as identified in the RFP. The bridge is located between Stations 18+262.5 to 18+287.7, in the Township of Ulster, and is identified as Site No. 46-237. The existing bridge is a 25.2 m single span, precast concrete girder structure with a reinforced concrete deck.

The existing highway, at the bridge location, supports two undivided lanes of traffic, running in a north-south direction. A visual review of the highway embankment at the north and south approaches indicates that, in general, the bridge approaches have performed well. Based on data from this foundation investigation, the embankment supporting the existing pavement structure at this site has been constructed using granular materials (pavement structure) over rock fill. Contract 67-98 indicates the bridge abutments are supported on rock fill overlying the native heterogeneous deposit of boulders, cobbles, gravels, and sands with bedrock at an elevation of 396.5 m.

Based on Contract No. 67-98, the Bailey Creek Bridge abutments are founded on a shallow foundation supported on rock fill at approximately elevation 405.8 m. The conversion to semi integral abutments will require the removal of the ballast walls. It is anticipated that, to carry out the bridge rehabilitation and convert the Bailey Creek Bridge to a semi-integral abutment an excavation some 1 m deep will be required behind the existing abutments. As such, a protection system will be required at the north and south abutments of the bridge to support an excavation some 1 m deep behind the abutments and maintain an active lane of traffic. Based on data from this foundation investigation, the fill behind the abutments supporting the approach slabs and pavement structure generally consist of granular soils with rock fill. Auger refusal was

encountered at depths of approximately 1.4 to 2.5 m below grade (elevations 407.3 to 406.0 m). The deeper auger penetration was achieved directly behind the abutments where granular backfill was to have been placed during construction (based on contract documents).

5.2 Excavation and Dewatering

The fill below the pavement structure and approach slabs is considered a Type 3 soil in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. As such, to remain stable above the water table, side walls of temporary open excavations would have to be cut back to a angle of 1H:1V. A 1 m deep excavation (i.e. to elevations 407.5 to 407.7 m) will be required to the rear of the abutments to allow the rehabilitation work to be carried out on the ballast wall. The existing width of the approach is insufficient to allow the construction of a 1H:1V slope parallel to the active traffic lane. As such, a vertical excavation adjacent to the active traffic lane will be required and a protection system, installed perpendicular to the abutments, will be needed to support the active traffic lane. Conceptual shoring locations are illustrated on Figure No. SK-3, Appendix E.

Excavations must be maintained in a dewatered condition during excavation and foundation construction. The water level in the river was recorded at elevation 403.4 m. This level is below the anticipated depth of excavation (elevations 407.5 to 407.7 m), as such, it is not anticipated that the groundwater table will be encountered during the shallow excavations at the abutments. If a dewatered deeper excavation is required to be advanced below the prevailing groundwater table (estimated at elevation 403.4 m), then groundwater control in accordance with OPSS 517 will have to be carried out.

5.3 Protection System

The results of this investigation indicated that, underlying the pavement structure and approach slabs, a rock fill was encountered, with auger refusal at approximately depths of 1.4 to 2.5 m at Boreholes Nos. 1 to 4 (elevations 407.3 to 406.0 m). DCPT refusal was also encountered at depths of 0.6 to 5.3 m at Borehole Nos. 1 to 4 (elevation 407.9 to 403.4 m).

Directly behind the abutments at Borehole Nos. 2 and 3, granular fills, consisting of sands and gravels trace silt, were encountered to depths of 2.0 and 1.4 m below grade (elevations 406.6 and 407.3 m), respectively. At Borehole Nos. 1 and 4, located some 9 m beyond the abutments, cobbles and boulder size rock fill was encountered at shallow depth, with DCPT refusal encountered at 0.6 m below grade at Borehole No. 1 and auger refusal encountered at 1.4 m below grade at Borehole No. 4.

The required depth of anticipated excavation, directly behind the abutments to remove the existing ballast walls for conversion to a semi integral abutment, will be relatively shallow, in the order of 1.0 m (elevations 407.6 to 407.7 m). As discussed in Section 5.2, a protection system will be required to carry out this excavation. A table outlining the possible protection systems and their relative advantages, disadvantages, and costs, as well as comments on the viability of the methods is provided in Table A, Appendix E.

In consideration of the soil conditions within the depth of the anticipated excavation, steel sheet piles of sufficiently robust cross section or timber sheeting may be considered for use as the protection system once the approach slab has been removed. The steel sheet piles or timber sheeting can be advanced vertically to the required depth below the base of the excavation to provide adequate support. If refusal is met before the required penetration depth, then the excavation would have to be locally advanced to remove the obstruction. A system of walers

and rakers would have to be installed as the depth of the excavation progresses. Once the excavation has reached a sufficient depth to allow work on the ballast wall, the sheets can be tied into the existing approach slab and final waler and raker installed.

Upon completion of the first side (lane), a system of buried anchors could be installed as the backfilling operation progresses to tie in the steel sheet piles or timber sheeting to allow the use of the same protection system while carrying out the excavation for the second side (lane).

It is not anticipated that an excavation greater than 1 m depth will be required. However, should a deeper excavation be required, penetration of the rock fill would have to be undertaken. Successfully driving steel sheet piles or timber sheeting through these obstructions is probably not possible. As such, a system of H piles (soldier piles) with lagging installed by predrilling, or micropiles with a reinforced shotcrete face, would be required. Additional lateral restraint can be supplied by drilling in tie-back anchors. Significant problems could develop in attempting to remove pieces of rock fill, which could be as large as up to one third of the height of the fill in size, without destabilizing the surrounding fill. It may be necessary to locally grout around a large piece of rock fill and tie the protruding piece into the protection system. Once the first side of the ballast wall has been removed and backfilling operations commenced, sacrificial deadman anchors with tiebacks could be installed in the backfill, with the tieback ends exiting at the area of the excavation face to allow reconnection and stressing during advance of the opposite/second side (section) of the excavation. If micropiles with a reinforced shotcrete face are used, it is likely that additional reinforced shotcrete will have to be applied as the second side of the excavation progresses.

If tiebacks are required, the resistance (R) for grouted anchors, located outside the active failure wedge, in cohesionless soils can be estimated from the following equation as supplied in the Canadian Foundation Manual (4th Edition):

$\mathbf{R = \sigma_z' A_s L_s \alpha_g}$ Where: $\mathbf{\sigma_z'}$ = effective vertical stress at the midpoint of the load carrying length

$\mathbf{A_s}$ = effective unit surface area of the anchor

$\mathbf{L_s}$ = effective embedment length of the anchor

α_g = anchorage coefficient
use 1.0 for granular backfill

Unless the pull-out resistance (capacity) of the anchor is proven with a load test program, the allowable anchor load (as suggested by the Canadian Foundation Engineering Manual, 4th Edition), is commonly obtained by dividing the computed capacity of the anchor by a factor of safety of 3. Alternatively, proprietary anchor systems can be used.

Lateral earth pressures for the protection system can be designed using the following parameters:

Elevation (m)	Soil Type	Unit weight (KN/m^3) γ	Angle of Internal Friction (degrees)	Active earth pressure (Ka)	At-rest earth pressure (Ko)
South Abutment 408.6 – 406.6 North Abutment 408.7 – 407.3	Fill – Sand and Gravel trace Silt	20	30	0.33	0.50
South Abutment 406.6 – 404.7 North Abutment 407.3 – 405.8	Fill – Rock fill	18.5	43	0.19	0.32

For flexible retaining structures, deflection can occur, such the “active” condition (Ka) applies. Considering the cohesionless nature of the fill (granular pavement structure over granular fill), it is recommended that the apparent lateral earth pressure be calculated as a rectangular

pressure distribution. As such, the apparent lateral pressure per linear metre of wall is equal to $0.65*K_a*\gamma*H^2$, where:

Ka = active earth pressure,
γ = unit weight, and
H = height of wall above the base of excavation.

The temporary protection system should be designed and constructed in accordance with OPSS 539. In consideration of the location of the protection system, a performance level 2 is considered appropriate.

5.4 Backfill and Compaction

Prior to backfilling the excavation, the exposed surface of the granular backfill to the abutments should be proofrolled with a minimum of five overlapping passes of a hand operated vibratory compactor with a minimum weight of 400 kg (or a centrifugal force of 50 kN). Backfilling should be carried out in accordance with OPSS 902 and compaction should be carried out in accordance with OPSS 501.

5.5 Construction Concerns

Considering the relatively shallow depth of expected excavations, no major construction concerns are anticipated if carried out in general conformance to that discussed above.

6.0 CLOSURE

Information provided in this report is valid only at the locations described above. Any assumptions of continuity of soil stratigraphy between boreholes, as shown on the enclosed cross-sections, is intended as an aid for design purposes only and does not constitute a statement of existing conditions for contractual or construction purposes. Field investigation was carried out using a CME drill rig mounted on a Bombardier carrier owned by Chrisdamat Management Ltd. The report was prepared by Mr. J. R. Berghamer, P. Eng and reviewed by the firm's principal and MTO designate Mr. M. A. Merleau, P. Eng.

Details of the investigation, the material analysis and recommendation in this report are considered to be complete. However, should any questions arise, please do not hesitate to contact the undersigned.

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M. A. Merleau, P. Eng.
Principal Engineer
MTO Designate

J. R. Berghamer, P. Eng.
Regional Manager

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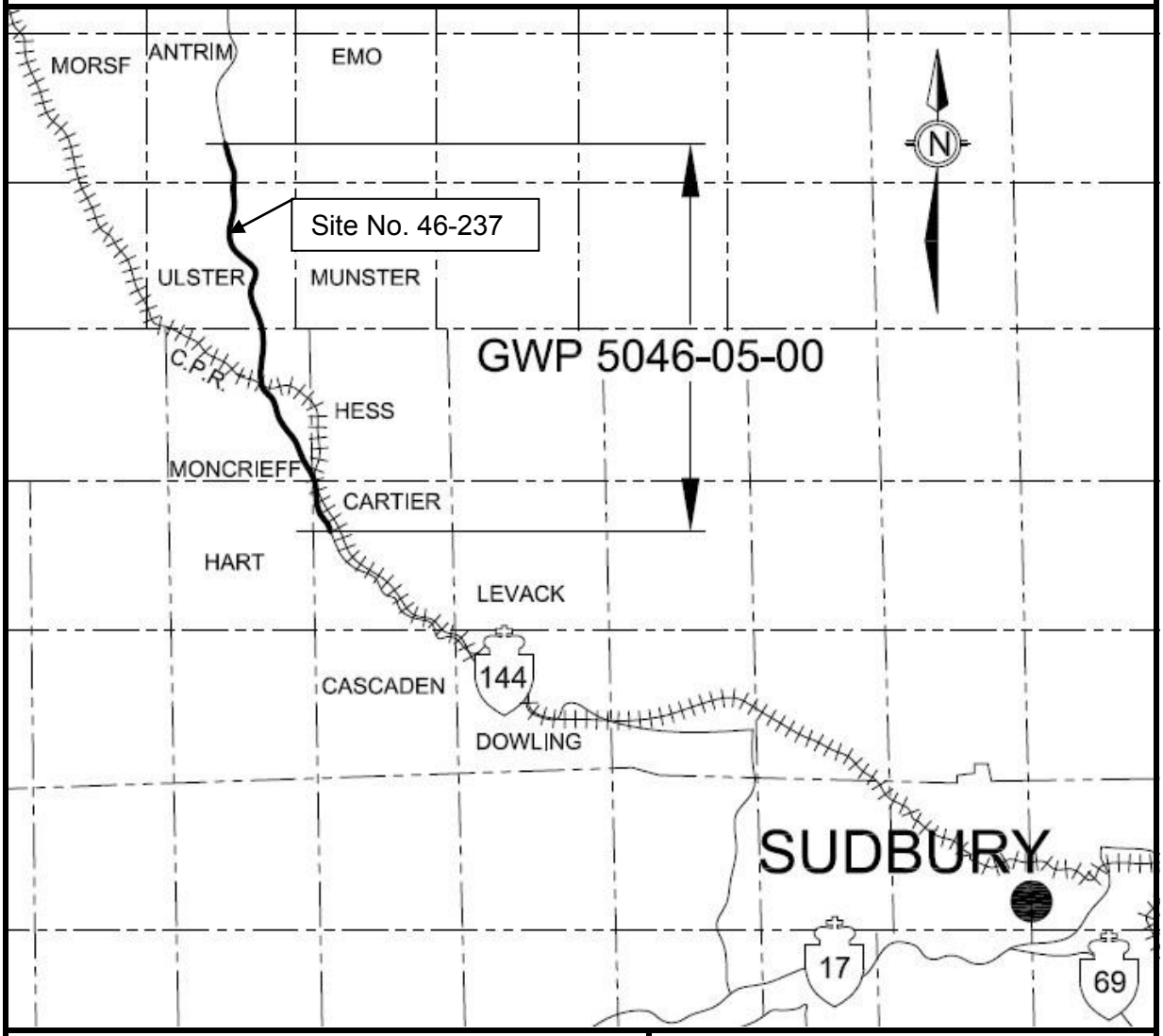
Appendix A Key Plan

Figure No. 1: Key Plan

KEY PLAN

Figure No. 1

NOT TO SCALE



FINAL
FOUNDATION INVESTIGATION
AND DESIGN REPORT
GWP 5046-05-00

Highway 144

From Cartier West Entrance (Centre Street)
Northerly 24.8 km

Ref. No.: 11/06/11101-F4 September 2012

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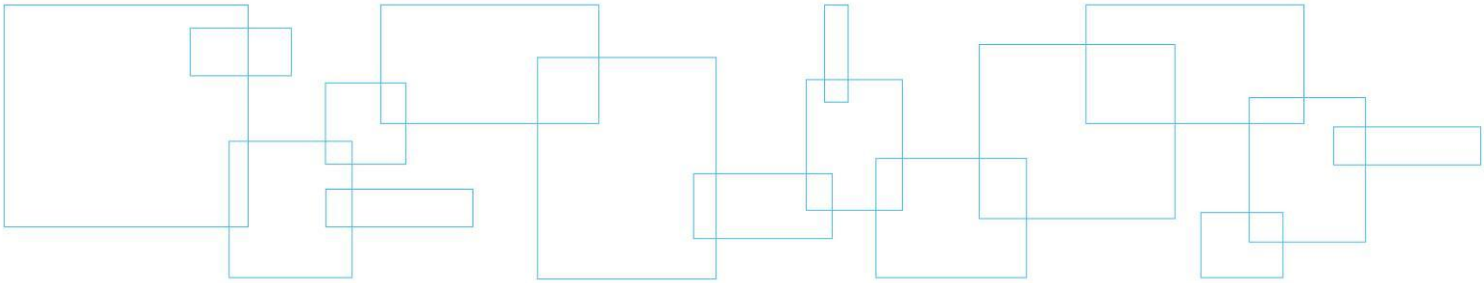
Appendix B Abbreviations
Record of Borehole Sheets

Enclosure No. 1: List of Abbreviations and Symbols

Enclosure Nos. 2 to 7: Record of Borehole Sheets



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LIST OF ABBREVIATIONS & DESCRIPTION OF TERMS

The abbreviations and terms, used to describe retrieved samples and commonly employed on the borehole logs, on the figures and in the report are as follows:

1. ABBREVIATIONS

AS Auger Sample
CS Chunk Sample
DS Denison type sample
FS Foil Sample
NFP No Further Progress
PH Sampler advanced by hydraulic pressure
PM Sampler advanced by manual pressure
RC Rock core with size & percentage of recovery
SS Split Spoon
ST Slotted Tube
TO Thin-walled, open
TP Thin-walled, piston
WS Wash Sample

2. PENETRATION RESISTANCE/"N"

Dynamic Cone Penetration Test (DCPT):

A continuous profile showing the number of blows for each 300 mm of penetration of a 50 mm diameter 60° cone attached to AW rod driven by a 63 kg hammer falling 760 mm.

Plotted as —•—•—•—•

Standard Penetration Test (SPT) or "N" Values

The number of blows of a 63 kg hammer falling 760 mm required to advance a 50 mm O.D. drive open sampler 300 mm.

3. SOIL DESCRIPTION

a) *Cohesionless Soils:*

"N" (blows/0.3 m)	*Relative Density*
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

b) *Cohesive Soils:*

Undrained Shear Strength (kPa)	*Consistency*
Less than 12	very soft
12 to 25	soft
25 to 50	firm
50 to 100	stiff
100 to 200	very stiff
over 200	hard

3. SOIL DESCRIPTION (Cont'd)

c) *Method of Determination of Undrained Shear Strength of Cohesive Soils:*

+ 3.2 - Field Vane test in borehole. The number denotes the sensitivity to remoulding.

D - Laboratory Vane Test

¨ - Compression test in laboratory

For a saturated cohesive soil the undrained shear strength is taken as one-half of the undrained compressive strength.

4. TERMINOLOGY

Terminology used for describing soil strata is based on the proportion of individual particle sizes present in the samples (please note that, with the exception of those samples subject to a grain-size analysis, all samples were classified visually and the accuracy of visual examination is not sufficient to determine exact grain sizing):

Trace, or occasional	Less than 10%
Some	10 to 20%
With	20 to 30%
Adjective (i.e. silty or sandy)	30 to 40%
And (i.e. sand and gravel)	40 to 60%

Terminology for cobbles and boulders is based on auger response and field observations:

Occasional	Obstructions encountered in borehole, however advance is not impeded
Numerous	Obstructions are essentially continuous over drilled length

5. LABORATORY TESTS

P Standard Proctor Test
A Atterberg Limit Test
GS Grain Size Analysis
H Hydrometer Analysis
C Consolidation

SAMPLE DESCRIPTION NOTES:

1. **FILL:** The term fill is used to designate all man-made deposits of natural soil and/or waste materials. The reader is cautioned that fill materials can be very heterogeneous in nature and variable in depth, density and degree of compaction. Fill materials can be expected to contain organics, waste materials, construction materials, shot rock, rip-rap, and/or larger obstructions such as boulders, concrete foundations, slabs, abandoned tanks, etc.; none of which may have been encountered in the borehole. The description of the material penetrated in the borehole therefore may not be applicable as a general description of the fill material on the site as boreholes cannot accurately define the nature of fill material. During the boring and sampling process, retrieved samples may have certain characteristics that identify them as 'fill'. Fill materials (or possible fill materials) will be designated on the Borehole Logs. If fill material is identified on the site, it is highly recommended that testpits be put down to delineate the nature of the fill material. However, even through the use of testpits defining the true nature and composition of the fill material cannot be guaranteed. Fill deposits often contain pockets or seams of organics, organically contaminated soils or other deleterious material that can cause settlement or result in the production of methane gas. It should be noted that the origins and history of fill material is frequently very vague or non-existent. Often fill material may be contaminated beyond environmental guidelines and the material will have to be disposed of at a designated site (i.e. registered landfill). Unless requested or stated otherwise in this report, fill material on this site has not been tested for contaminants however, environmental testing of the fill material can be carried out at your request. Detection of underground storage tanks cannot be determined with conventional geotechnical procedures.

2. **TILL:** The term till indicates a material that is an unstratified, glacial deposit, heterogeneous in nature and, as such, may consist of mixtures and pockets of clay, silt, sand, gravel, cobbles and/or boulders. These heterogeneous deposits originate from a geological process associated with glaciation. It must be noted that due to the highly heterogeneous nature of till deposits, the description of the deposit on the borehole log may only be applicable to a very limited area and therefore, caution must be exercised when dealing with a till deposit. When excavating in till, contractors may encounter cobbles/boulders or possibly bedrock even if they are not indicated on the borehole logs. It must be appreciated that conventional geotechnical sampling equipment does not identify the nature or size of any obstruction.

3. **BEDROCK:** Auger refusal may be due to the presence of bedrock, but possibly could also be due to the presence of very dense underlying deposits, boulders or other large obstructions. Auger refusal is defined as the point at which an auger can no longer be practically advanced. It must be appreciated that conventional geotechnical sampling equipment does not differentiate between nature and size of obstructions that prevent further penetration of the boring below grade. Bedrock indicated on the borehole logs will be labeled 'possibly' or 'probable' etc. based on the response of the boring and sampling equipment, surrounding topography, etc. Bedrock can be proven at individual borehole locations, at your request, by diamond core drilling operations or, possibly, by testpits. It must also be appreciated that bedrock surfaces can be, and most times are, very erratic in nature (i.e. sheer drops, isolated rock knobs, etc.) and caution must be used when interpreting subsurface conditions between boreholes. A bedrock profile can be more accurately estimated, at the clients' request, through a series of closely positioned unsampled auger probes combined with core drilling.

4. **GROUNDWATER:** Although the groundwater table may have been encountered during this investigation and the elevation noted in the report and/or on the record of boreholes, it must be appreciated that the elevation of the groundwater table will fluctuate based upon seasonal conditions, localized changes, erratic changes in the underlying soil profile between boreholes, underlying soil layers with highly variable permeabilities, etc. These conditions may affect the design and type and nature of dewatering procedures. Cave-in levels recorded in borings give a general indication of the groundwater level in cohesionless soils however, it must be noted that cave-in levels may also be due to the relative density of the deposit, drilling operations etc.

ENCLOSURE NO.:2 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 1

REFERENCE 11/06/11101-F4 DATUM Geodetic LOCATION N5191666.6 E256459.5 - Ulster Township ORIGINATED BY JL

PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-237 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) October 17, 2011 TIME (Completed) 1:15:00 PM CHECKED BY MAM

DATE (Completed) October 17, 2011

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
408.5	Ground Surface										
0.0 / 407.9	100 mm Asphalt 125 mm Crushed Gravel		1	AS	N/A		408				
0.6	DCPT Refusal FILL - gravel with sand to sandy trace silt numerous cobbles/boulders (rock fill) (compact)		2	SS	19						66 26 (8)
			3	SS	11		407				
406.0			4	SS	30/ 175mm		406				55 40 (5)
2.5	Auger Refusal End of Borehole										

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3$, $\times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

$\circ^{3\%}$ STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 10/17/11 1:15:00 PM	DRY	0.7
2)	-	-
3)	-	-

MEL-GEO 11101 - AREA 9 - BOREHOLE LOGS - BAILEY CREEK.GPJ MEL-GEO.GDT 5/14/12

L|V|M
120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

ENCLOSURE NO.:3 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 2

REFERENCE 11/06/11101-F4 DATUM Geodetic LOCATION N5191675.3 E256458.9 - Ulster Township ORIGINATED BY JL

PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-237 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) October 17, 2011 TIME (Completed) 2:15:00 PM CHECKED BY MAM

DATE (Completed) October 17, 2011

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
408.6	Ground Surface						
0.0	50 mm Asphalt 350 mm Concrete 150 mm Crushed Gravel		1	AS	N/A		
	FILL - sand and gravel trace silt		2	SS	24		
	(compact/dense)		3	SS	36		
406.6							
2.0	Auger Refusal						
404.7							
3.9	DCPT Refusal End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

ELEVATION SCALE: 408, 407, 406, 405

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%)
20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA (SI CL)

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3, \times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ $^{3\%}$ STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 10/17/11 2:15:00 PM	DRY	1.1
2)	-	-
3)	-	-

MEL-GEO 11101 - AREA 9 - BOREHOLE LOGS - BAILEY CREEK.GPJ MEL-GEO.GDT 5/14/12

L|V|M
120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

ENCLOSURE NO.:4 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 3

L|V|M

REFERENCE 11/06/11101-F4 DATUM Geodetic LOCATION N5191703.2 E256458.6 - Ulster Township ORIGINATED BY JL

PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-237 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) October 17, 2011 TIME (Completed) 3:15:00 PM CHECKED BY MAM

DATE (Completed) October 17, 2011

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
408.7	Ground Surface										
0.0	100 mm Ashpalt 300 mm Concrete 200 mm Crushed Gravel		1	AS							43 53 (4)
407.3	FILL - sand and gravel trace silt (compact)		2	SS	15		408				
1.4	Auger Refusal						407				
405.8							406				
2.9	DCPT Refusal End of Borehole										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

WATER CONTENT (%): 20 40 60

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3$, $\times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

$\circ$ $^{3\%}$ STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 10/17/11 3:15:00 PM	DRY	0.9
2)	-	-
3)	-	-

MEL-GEO 11101 - AREA 9 - BOREHOLE LOGS - BAILEY CREEK.GPJ MEL-GEO.GDT 5/14/12

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120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

ENCLOSURE NO.:5 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 4

REFERENCE 11/06/11101-F4 DATUM Geodetic LOCATION N5191712.4 E256454.9 - Ulster Township ORIGINATED BY JL

PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-237 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) October 17, 2011 TIME (Completed) 4:10:00 PM CHECKED BY MAM

DATE (Completed) October 17, 2011

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%) (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)
408.7	Ground Surface										
0.0	125 mm Ashpalt 150 mm Crushed Gravel		1	AS							
	FILL - gravel and sand trace silt numerous cobbles/boulders (rock rill)		2	SS	65						51 40 (9)
407.3											
1.4	(very dense) Auger Refusal										
403.4											
5.3	DCPT Refusal End of Borehole										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

WATER CONTENT (%): 20 40 60

ELEVATION SCALE: 408 407 406 405 404

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3$, $\times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

$\circ$ $^{3\%}$ STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 10/17/11 4:10:00 PM	DRY	1
2)	-	-
3)	-	-

MEL-GEO 11101 - AREA 9 - BOREHOLE LOGS - BAILEY CREEK.GPJ MEL-GEO.GDT 5/14/12

L|V|M
120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

ENCLOSURE NO.:6 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 5

L|V|M

REFERENCE 11/06/11101-F4 DATUM Geodetic LOCATION N5191675.3 E256455.1 - Ulster Township ORIGINATED BY JL

PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-237 BOREHOLE TYPE Coring COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) September 7, 2011 TIME (Completed) CHECKED BY MAM

DATE (Completed) September 7, 2011

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
408.6	Ground Surface										
0.0	63 mm Asphalt 343 mm Concrete										

COMMENTS

Due to construction of a new slab, after coring and prior to advancing the borehole, the borehole was not advanced further.

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3$, $\times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ $^{3\%}$ STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1)	-	-
2)	-	-
3)	-	-

MEL-GEO 11101 - AREA 9 - BOREHOLE LOGS - BAILEY CREEK.GPJ MEL-GEO.GDT 5/14/12

L|V|M
120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

ENCLOSURE NO.:7 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 6

L|V|M

REFERENCE 11/06/11101-F4 DATUM Geodetic LOCATION N5191703.2 E256455.0 - Ulster Township ORIGINATED BY JL

PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-237 BOREHOLE TYPE Coring COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) September 7, 2011 TIME (Completed) CHECKED BY MAM

DATE (Completed) September 7, 2011

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
408.7	Ground Surface										
0.0	100 mm Asphalt 275 mm Concrete										

COMMENTS

Due to construction of a new slab, after coring and prior to advancing the borehole, the borehole was not advanced further.

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3$, $\times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1)	-	-
2)	-	-
3)	-	-

MEL-GEO 11101 - AREA 9 - BOREHOLE LOGS - BAILEY CREEK.GPJ MEL-GEO.GDT 5/14/12

L|V|M
120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

Appendix C Borehole Location Plan Labwork

Figure No. 2: Borehole Location and Soil Strata
Figure No. L-1: Summary Grain Size Analysis Graph
Figure No. L-2: Lab Test Summary Sheet

LVM | MERLEX

METRIC

Dimensions are in meters and/or millimeters unless otherwise shown. Stations are in kilometers + meters.

SITE No	46–237
WP No	5046–05–00
Geocres	42I–288

N

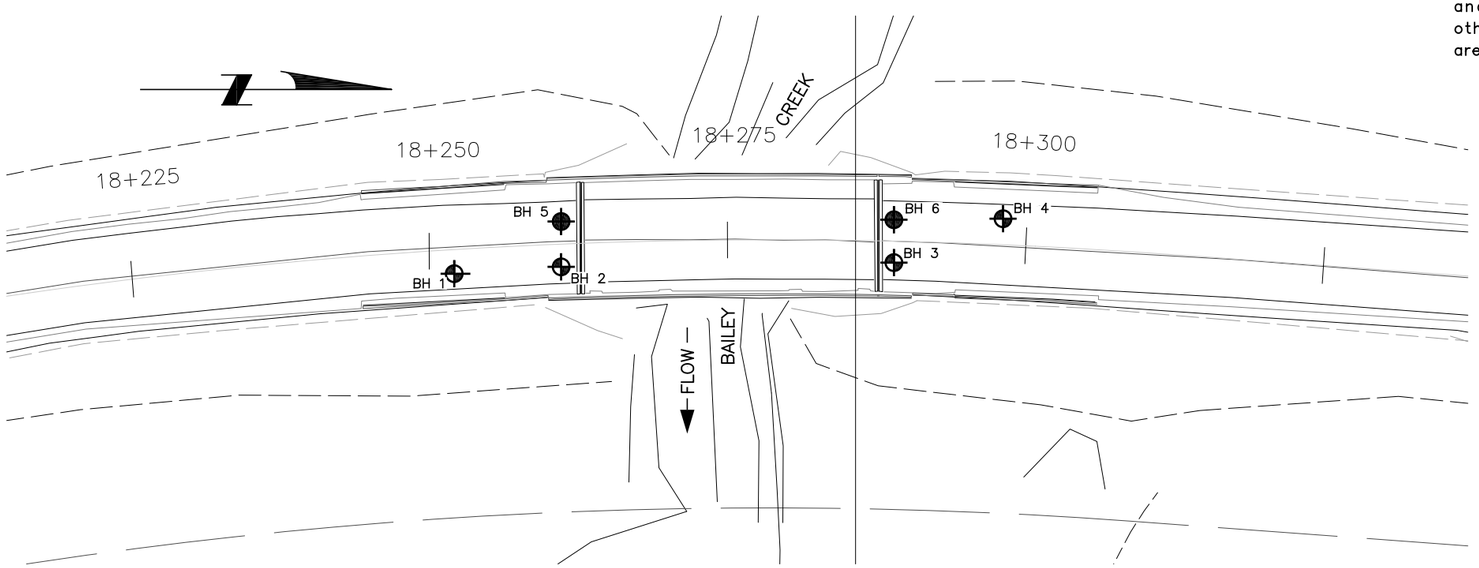
HWY NO. 144 – Township of Ulster

Bailey Creek Bridge
Protection System

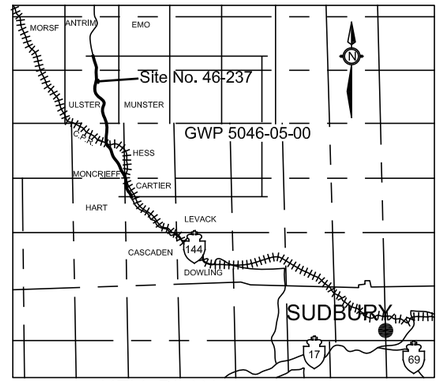
BOREHOLE LOCATIONS & SOIL STRATA

Figure 2

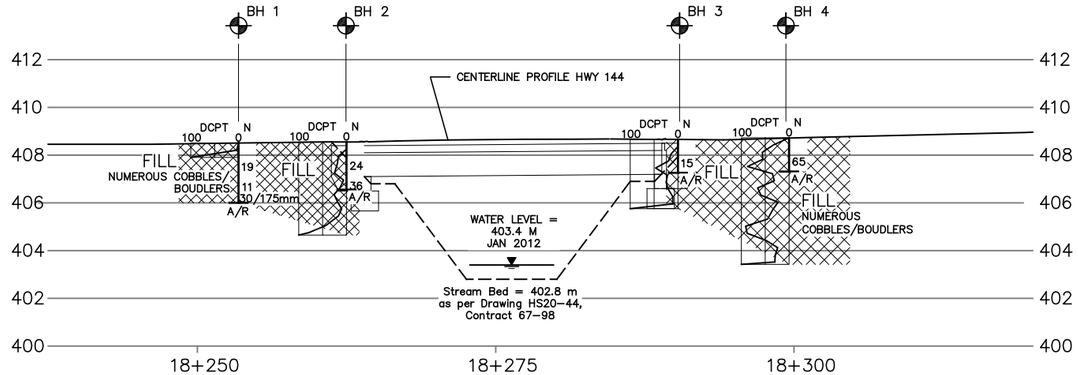
L|V|M | MERLEX



PLAN
SCALE
5m 5m



KEY PLAN – NOT TO SCALE



℄ PROFILE
SCALE
5m 5m HOR
2.5m 2.5m VER

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole and DCPT
- N — Blows/0.3 m (Std Pen Test, 475 J/blow)
- DCPT — Blows/0.3 m (60° Cone, 475 J/blow)
- Water Level at Time of Investigation
- A/R — Auger Refusal at Elevation
- E/S — End of Sampling

Borehole No.	Elev.	O/S	Co–ordinates Northerly	Co–ordinates Easterly
Borehole No. 1	408.5	2.0m Rt	5191666.4	256459.5
Borehole No. 2	408.6	1.9m Rt	5191675.3	256458.9
Borehole No. 3	408.7	1.8m Rt	5191703.2	256458.6
Borehole No. 4	408.7	2.2m Lt	5191712.4	256454.9
Borehole No. 5	408.6	1.9m Lt	5191675.3	256455.1
Borehole No. 6	408.7	1.8m Lt	5191703.2	256455.0

NOTE 1:
The boundaries between soil strata have been established at the borehole locations only. The boundaries illustrated and stratigraphy between boreholes on this drawing are assumed based on borehole data and may vary. They are intended for design only.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration. The proposed structure location is shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contract Documents.

REVISIONS

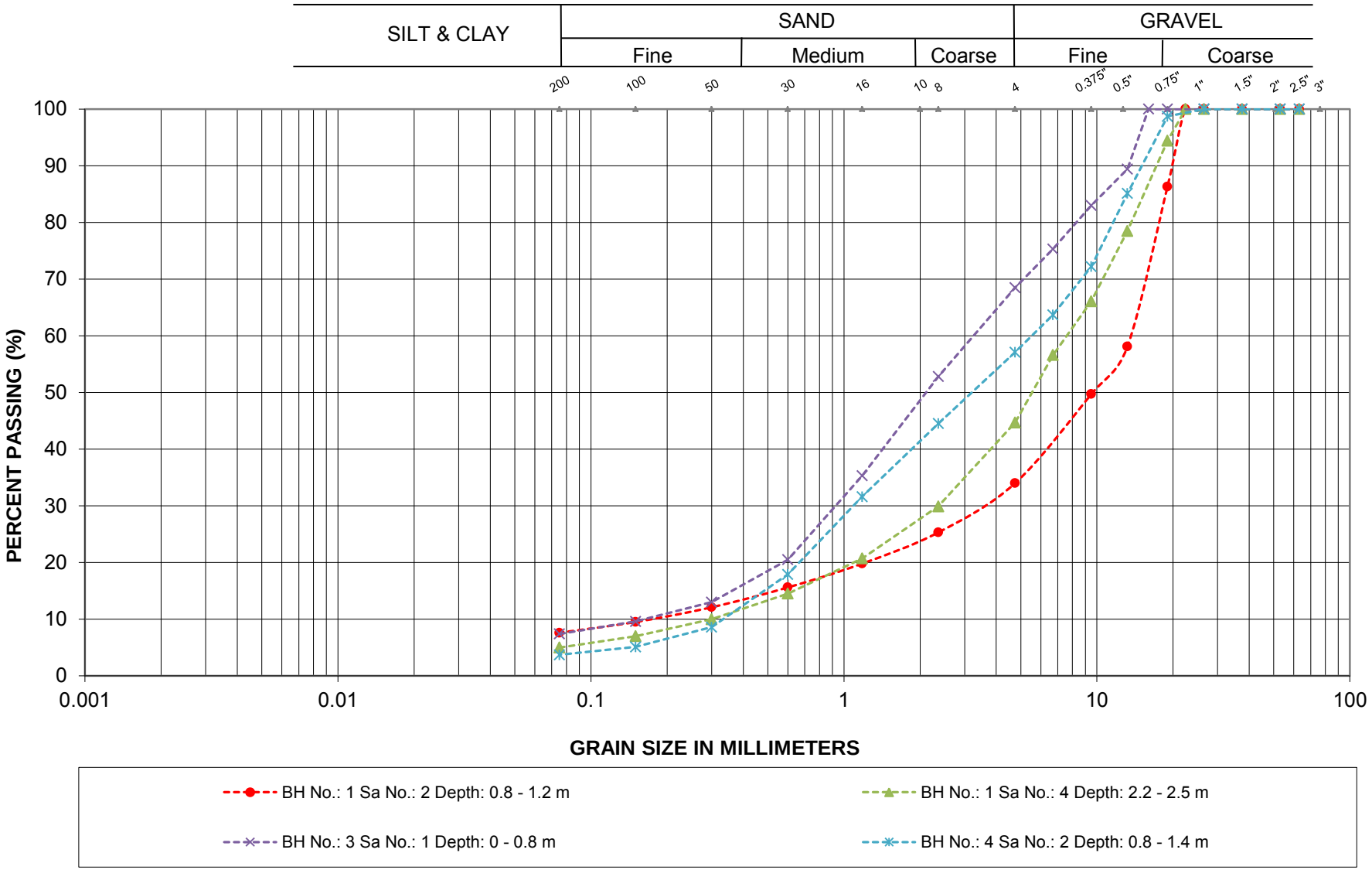
DATE	BY	DESCRIPTION
Jan 2012	RG	DRAFT
Aug 2012	RG	FINAL

HWY No. 144 – Ulster Twp – Bailey Creek Bridge			REF 11101
SUBM'D			SITE 47–237
DRAWN RG	CHK MAM	DATE January 2012	FIG 2

Reference No.: 11/06/11101-F4
Date: September 2012

LVM | MERLEX

GRAIN SIZE ANALYSIS



G.W.P.: 5046-05-00
LOCATION: Hwy 144
SITE: 46-237

FILL

LVM | MERLEX

FIGURE L-1

LVM | MERLEX

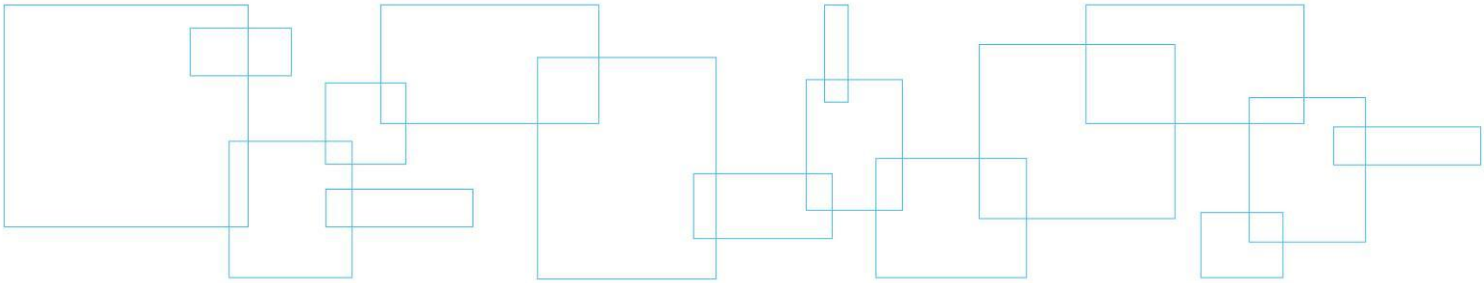
Laboratory Tests - Summary Sheet

Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m3)	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
1	1	0.0					2.2				N/A			
	2	0.8	66	26	8		1.2				19			
	3	1.5					1.7				11			
	4	2.3	55	40	5		2.0				30/ 175mm			
2	1	0.0					4.8				N/A			
	2	0.8					6.4				24			
	3	1.5									36			
3	1	0.0	43	53	4		4.9				N/A			
	2	0.8					8.6				15			
4	1	0.0					2.0				N/A			
	2	0.8	51	40	9		2.9				65			

Appendix D Historical Information

Enclosure No. 8: Contract No. 67-98, Bailey Creek Stratigraphy

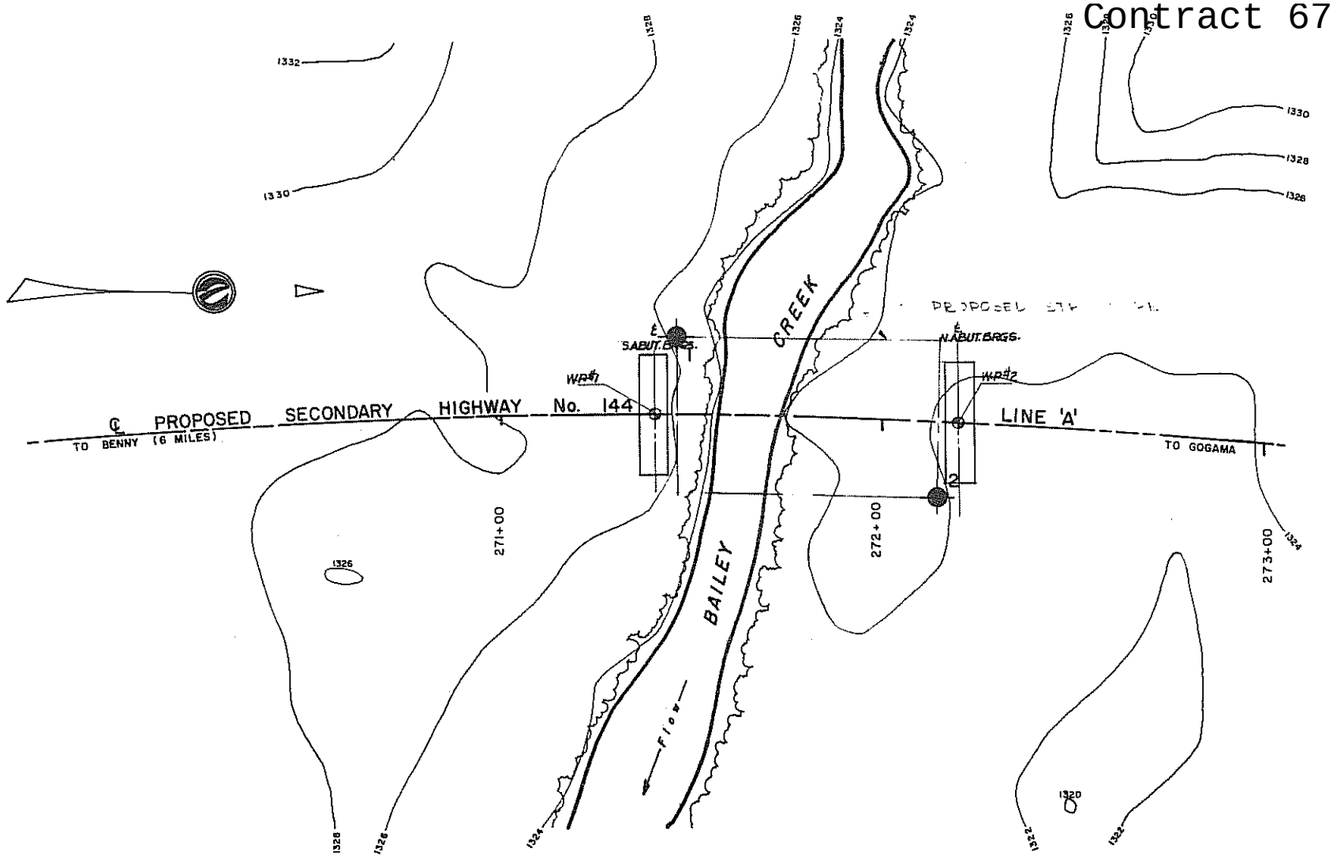
Enclosure No. 9: Contract No. 67-98, Bailey Creek Bridge



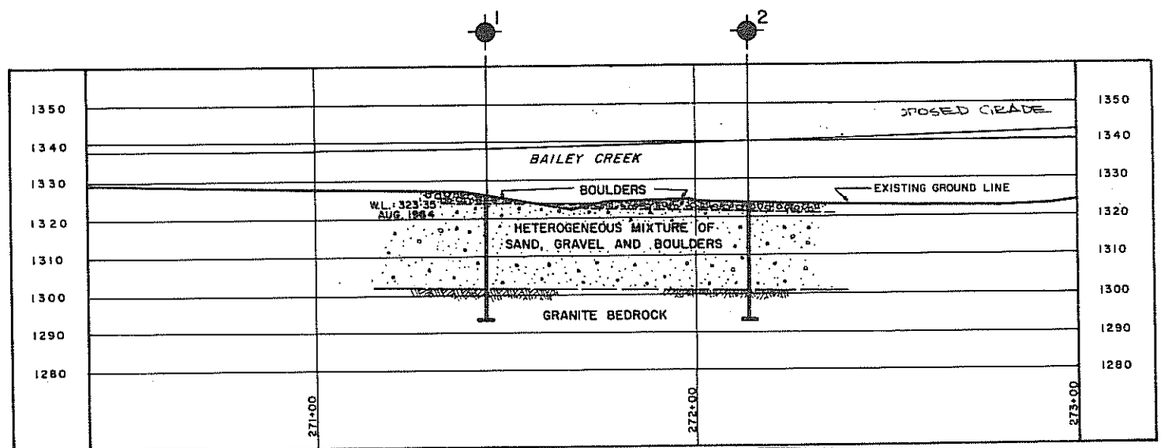
LVM | MERLEX

LVM | MERLEX
Reference No.: 11/06/11101-F4
Hwy 144, Bailey Creek

Enclosure No. 8
Contract 67-98



PLAN
SCALE
20 10 0 20 40 FT.



PROFILE
SCALE
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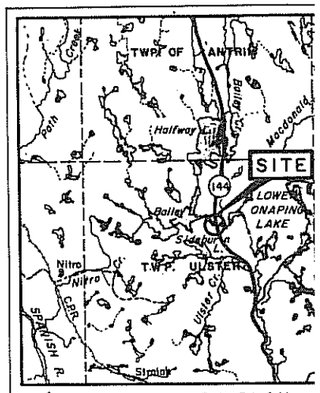


KEY PLAN
SCALE IN MILES
1 0.5 0 2

LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetratio
- Water Levels established of field investigation. (J

NO.	ELEVATION	STATION
1	1326·0	271+45
2	1325·0	272+15

— NOTE —
The boundaries between soil strata have be
Bore Hole locations. Between Bore Holes the
from geological evidence and may be subjec

REVISIONS			
	DATE	BY	DESCRIP

DEPARTMENT OF HIGHWAYS
MATERIALS & TESTING DIVISION – FO

BAILEY CR

KING'S HIGHWAY NO. 144 LINE 'A'
DIST. SUDBURY
TWP. ULSTER LOT

BORE HOLE LOCATIONS

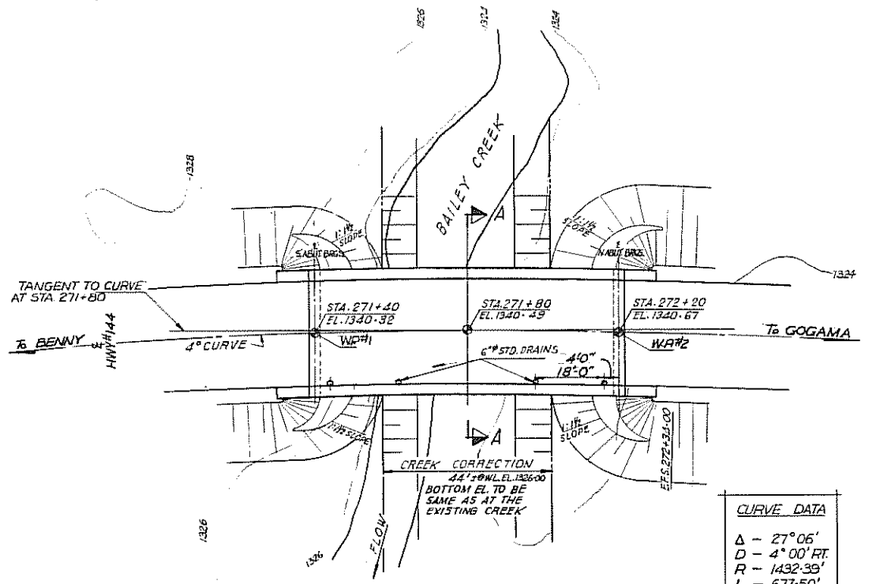
SUBM'D. P.P.	CHECKED [illegible]	W.P. NO. 262-64
DRAWN P.G.O.	CHECKED [illegible]	JOB NO. 66-F-60
DATE JULY 25, 1966		SITE NO 46-237
APPROVED [signature] PRINCIPAL FOUNDATION ENGINEER		CONT NO. 67-98

—NOTE—
The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the Sudbury District Office.

REF. NO. E-4410-1

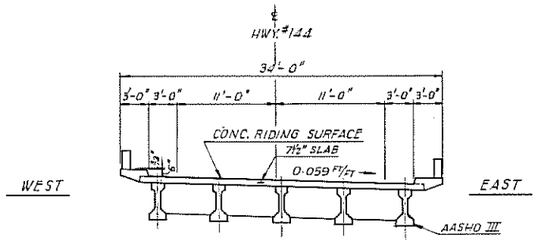
LVM | MERLEX
Reference No.: 11/06/11101-F4
Hwy 144, Bailey Creek

Enclosure No. 9
Contract 67-98

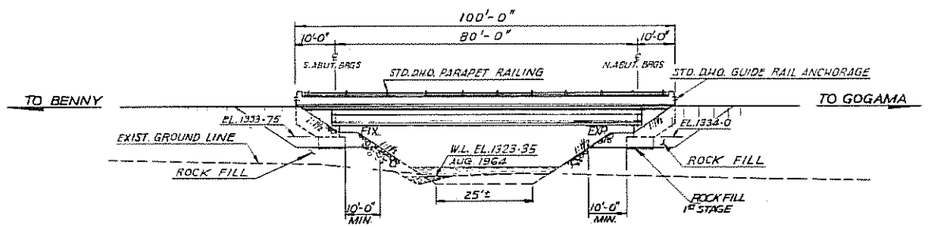


PLAN
SCALE: 1" = 20'

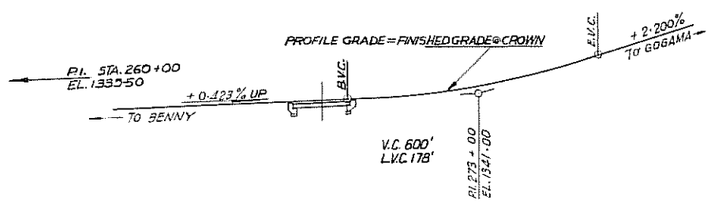
CURVE DATA
Δ – 27°06'
D – 4°00' RT.
R – 1432.39'
L – 677.50'
T – 345.21'
E – 41.01'



SECTION A-A
SCALE: ⅛"=1'-0"



ELEVATION
SCALE: 1" = 20'



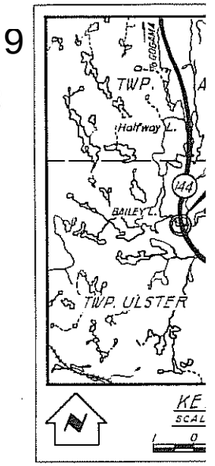
GRADE PROFILE @ ℄ HWY. # 144
N.T.S.

B.M. EL. 1352.72
N. ℄ W. IN 1' N. ROOT OF 0.6' POPLAR
82' RIGHT OF STA. 277+55

LIST OF DRAWINGS

D-6032-1	GENERAL LAYOUT
-2	BORE HOLE LOCATIONS & SOIL STRATA
-3	FOOTINGS & ABUTMENTS
-4	PRESTRESSED GIRDERS & BEARINGS
-5	DECK, DIAPHRAGMS & SCREED ELEVATIONS
-6	PARAPET WALL DETAILS
-7	STANDARD STEEL PARAPET RAIL
-8	STANDARD DETAILS

REGISTERED PROFESSIONAL ENGINEER — CIVIL — K. Z. STOLARSKI — PROVINCE OF ONTARIO



CLASS OF CONCRETE
DECK, CURBS & PARAPET WALL — 400
REMAINDER — 300
FOR PRESTRESSED GIRDERS SEE DWG

CLEAR COVER ON REINFORCING STEEL
FOOTINGS — 3"
ABUTMENTS — 3"
DECK TOP — 1½"
BOTTOM — 1"
DIAPHRAGMS & CURBS — 2"
AND/OR AS NOTED ON DRAWINGS

CONSTRUCTION NOTES
THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LE TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF ± 1/8 INCH.

NO CONCRETE SHALL BE PLACED ABOV ABUTMENT BEARING SEATS UNTIL TH CONCRETE IN THE DECK HAS BEEN

REVISIONS			
	DATE	BY	DESCRIPT

DEPARTMENT OF HIGHWAY
BRIDGE DIVISION

BAILEY CREEK BRI
5.8 MI. NORTH OF BENNY

KING'S HIGHWAY No. 144
DIST. OF SUDBURY
TWP. ULSTER — LOT

GENERAL LAYOU

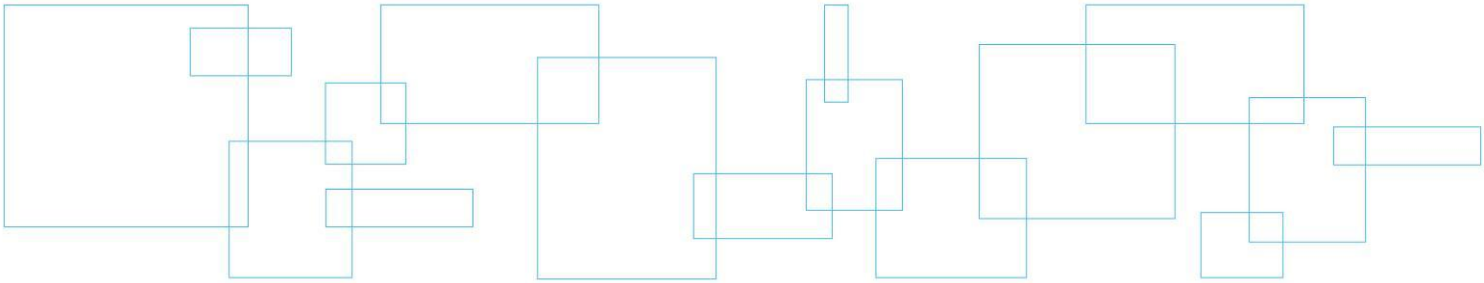
APPROVED — BRIDGE ENGINEER

DESIGN	K.Z.S.	CHECK	P.O.L.	SITE No.
DRAWING	L.S./F.R.	CHECK	K.Z.S.	CONTRACT No.
DATE	JAN. 1967	LOADING	HS20-44	DRAWING No.

Appendix E Design Data

Sketch Nos. SK-3: Conceptual Shoring Sketch

Table A: Comparison of Shoring Alternatives



LVM | MERLEX

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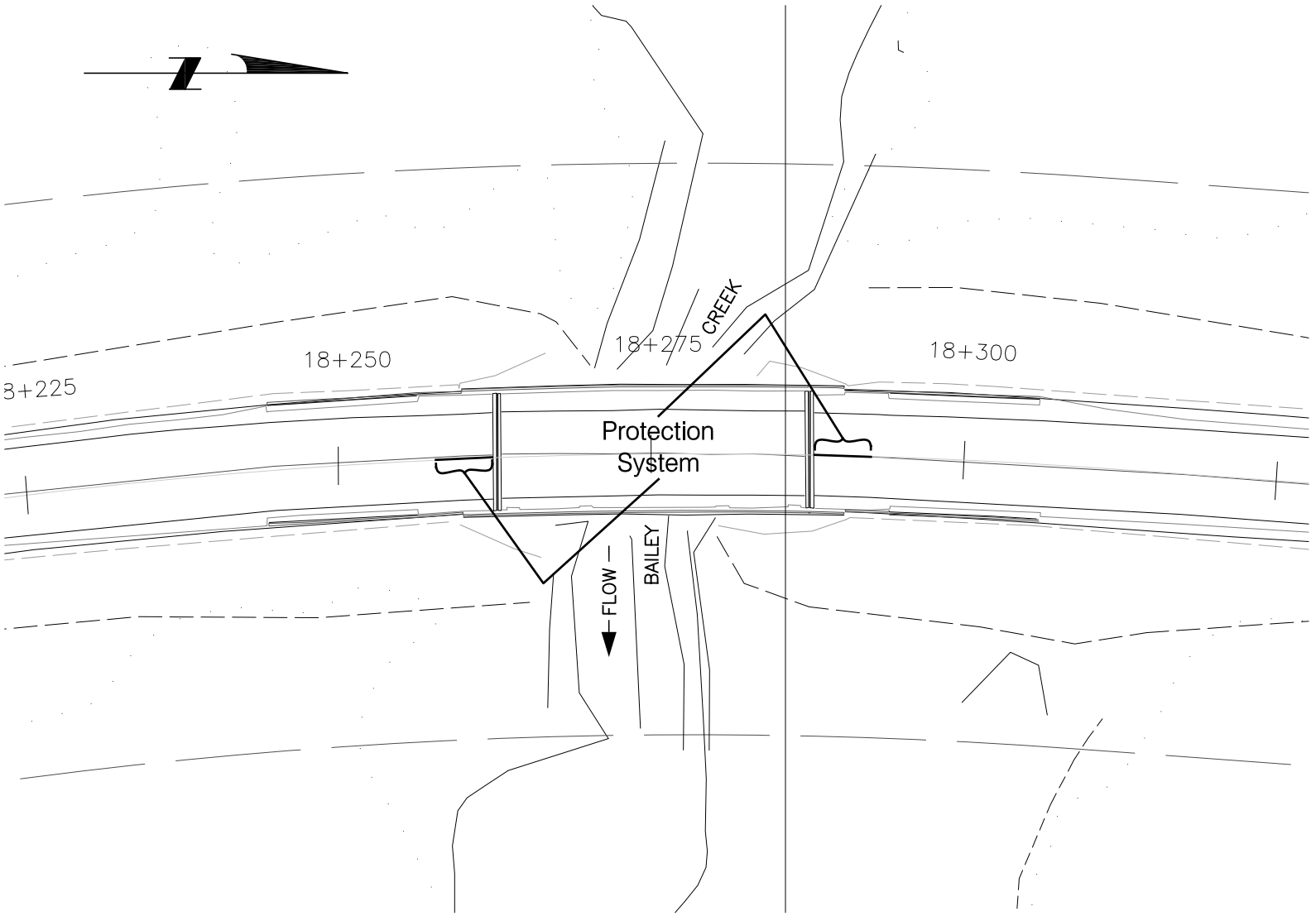

HWY 144 - Township of Ulster - Site 46-237
Conceptual Shoring Locations - Baily Creek Bridge

FIGURE SK-3

Table A – Protection Systems

Retaining System	Depth Range (m)	Advantages	Disadvantages	Remarks	Estimated Costs
Wood Sheeting	1.5 – 5	-Low cost, -Easily installed in good ground conditions	-Limited by soil conditions, -Limited depth of installation, -Low strength, -discontinuous	Recommended for shallow excavations at this site	$ 650
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Recommended for shallow excavations at this site	$ 650
Pre-cast concrete panels	3 – 10	-Durable -Assists in minimizing seepage	-Limited depths -Can be damaged by driving -Limited by soil conditions (i.e. obstructions)	Not considered due to limited depth required and higher costs	
Soldier piles With lagging	5 – 25	-Easy installation -Readily available -Adaptable to various ground conditions	-Pre-drilling may be required -Possible ground loss	Recommended for deep excavations at this site.	$ 725/m^2
Tangent/ Secant/ Staggered Drilled Piles	10 – 18	-Readily available -Adaptable to various ground conditions	-Possible ground loss and/or seepage -Poor alignment tolerance	Not Considered due to limited depths required and higher costs	
Concrete Diaphragm	10 – 30	-High Strength -Durable -Can be permanent	-High cost -Requires specialized equipment/control	Not Considered due to limited depths required and higher costs	
Micropiles with reinforced shotcrete face		-Can be installed in various ground conditions -High strength -Good tolerance	-High Cost -Requires specialized equipment	Considered for deep excavations at this site.	$ 900/m^2