FINAL REPORT

FOUNDATION INVESTIGATION AND DESIGN REPORT

Otasawian River Bridge, Highway 11 (Site No. 39W-002)
Township of Kohler – New Liskeard (Cochrane) Area, ON

Prepared for:

Ontario Ministry of Transportation
Regional Director's Office -NE Region
447 McKeown Avenue, Suite 301
North Bay, ON P1B 9S9
Attn: J.P. Perron

Ontario Ministry of Transportation
Pavements and Foundations Section
Foundations Group
Building 'C', Room 223
1201 Wilson Avenue
Downsview, ON M3M 1J8
Attn: T.C. Kim

exp services Inc.
October 19, 2011

Ministry of Transportation

Foundation Investigation and Design Report

Type of Document:
FINAL

Project Name:
Otasawian River Bridge, Highway 11 (Site No. 39W-002)
Township of Kohler – New Liskeard (Cochrane) Area, ON
GEOCRES No. 42F-23

Project Number:
ADM-00201207-AO
THB-00011156-AG

Prepared By:
Demetri N. Georgiou, MASc., P.Eng.

Reviewed By:
Stan E. Gonsalves, M.Eng. P.Eng.

exp Services Inc.
56 Queen St, East, Suite 301
Brampton, ON L6V 4M8
Canada

Demetri N. Georgiou, MASc., P.Eng.
Principal Engineer
Thunder Bay Branch Manager

Stan E. Gonsalves, M.Eng., P.Eng.
Principal Engineer
Designated MTO Foundation Contact

Date Submitted:
10/19/2011

Legal Notification

This report was prepared by **exp** Services Inc. for the account of the **Ontario Ministry of Transportation.**

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. **Exp** Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this project.

Table of Contents

List of Appendices

1 Part I: FOUNDATION INVESTIGATION

1.1 Introduction

This report presents the results of a geotechnical investigation completed by **exp** Services Inc. (**exp**) for the Otasawian River Bridge Rehabilitation (Site No. 39W-002), on Highway 11, in the Township of Kohler, about 40.2 km west of the Highway 631 junction, in New Liskeard (Cochrane) Area, Ontario; see Figure 1 – Site Location Plan.

The work was undertaken under Agreement # 5006-E-0060, Assignment No. 5. The terms of reference were as presented by MTO in a letter dated June 13, 2011.

The purpose of the foundation investigation was to examine the existing subsurface conditions within the area of the existing bridge and foundation supports as well as to evaluate the capacity of the existing timber piles (in Part II – Engineering Discussion and Recommendations). The site specific geotechnical investigation consisted of test borings, borehole logging, and field and laboratory testing. This foundation investigation report has been prepared specifically and solely for the project described herein. It contains the factual results of the field investigation and the associated laboratory testing.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The site is located on Highway 11, in the Township of Kohler, about 40.2 km west of the Highway 631 junction, in New Liskeard (Cochrane) Area, Ontario. Based on information provided by the MTO, the Otasawian River bridge consists of a three-span supported, reinforced concrete slab on steel girder bridge. The length of the bridge is about 49 m and the individual span lengths are about 16.3 m, 16.5 m and 16.3 m. Based on the MTO records, the bridge was constructed in 1956 and rehabilitated in 1982. The rehabilitation in 1982 was limited to the replacement of expansion joints, deck drain modification, patching of the concrete deck surface, waterproofing and paving. It is understood that the proposed structural rehabilitation will include the replacement of the bridge deck superstructure, which is to be supported on the existing bridge substructure and existing foundations.

Highway 11 runs in an east/west direction and the Otasawian River is generally located in a north/south direction; the river flow direction is to the north. The area is generally forested with mature trees and shrubs and the roadway structure is elevated from the natural topography. Immature vegetation was observed on the slopes/embankments (appears to be vegetated erosion blankets/grids), and beneath the bridge on both sides of the river, blast rock / boulders were observed around the piers. North of the bridge, within the river, 20 timber plies were noted.

The site plan is as shown on the drawings in Appendix A.

1.2.2 Geological Setting

According to the Ontario Ministry of Natural Resources (MNR), Map 5082 and 5083, the regional surficial geology in the area of the river consists of alluvial plain deposits with mainly low local relief and wet surface conditions. In addition, sand alluvial plain deposits with mainly low local relief, channelled and dry surface conditions with a high water table were noted.

According to Bedrock Geology of Ontario Map 2543 (Ministry of Northern Development and Mines, Ontario), the bedrock at the site is from the Paleoproterozoic (1.6 to 2.5 Ga), mafic and ultramafic intrusive rock consisting of Matachewan and Hearst swarms (2454 Ma); diabase dikes.

1.3 Investigation Procedures

1.3.1 Site Description

On July 2, 2011, **exp** personnel visited the site to conduct a site assessment of the existing topographic conditions, accessibility, and to locate possible borehole locations.

To assess the subsurface soil conditions at the site for the bridge rehabilitation, **exp** geotechnical personnel returned to the site between July 12 and 20, inclusive, and monitored the advancement of four (4) boreholes (BH1 to BH4), at the locations shown on Figure 2. The boreholes were advanced near the east and west abutments and east and west piers; drill rig access based on the site topography generally determined the borehole locations. Site photographs of borehole locations are provided in Appendix B.

The drilling was conducted by Thunder Bay Testing & Engineering, an MOE licensed well contractor, using a sub-contracted CME 55 track mounted drill rig, equipped with hollow stem continuous flight augers, a 50 mm outside diameter split spoon sampler, *in situ* shear vane testing equipment and rock coring equipment. The boreholes were advanced to auger and/or split spoon refusal, ranging between about 20.0 m and 37.5 m below ground surface. Upon refusal at BH2 and BH4, rock coring techniques (NQ core size) were used to advance the boreholes about an additional 3.4 m and 3.2 m, respectively. In addition, rock coring techniques were used at BH3 at about 19.4 m to 19.7 m depth to advance the borehole.

During the drilling, soil samples were obtained using a split-spoon sampler with automatic trip hammer, in accordance with Standard Penetration Test (SPT) procedures (ASTM D 1586), at intervals shown on the attached borehole logs (Appendix C). The SPT “N” values were recorded and used to provide an assessment of in-situ consistency or compactness of the non-cohesive soils. *In situ* shear vane tests were performed in the cohesive soil at BH1 and BH2 at about 7.2 m and 8.7 m below ground surface.

Representative samples of the various soil strata encountered in the boreholes were taken to our laboratory in Thunder Bay for further examination by a geotechnical engineer and for laboratory classification testing.

After completion, the boreholes were backfilled with the soil cuttings, generally to about 2.0 m below ground surface and then backfilled with bentonite hole plug material to about 0.3 m below ground surface. The remaining 0.3 m was backfilled with soil cuttings.

Groundwater level measurements were obtained using an electric tape, prior to fully backfilling the boreholes. Following the fieldwork, ground surface elevations at the boreholes and the top of surface water at the Otasawian River were surveyed. The boreholes were measured to local structures/features and using a handheld GPS unit. The ground surface elevations were referenced to a local benchmark; highway centerline at deck on concrete expansion joint at the east end of the bridge (assumed elevation 100.00 m). The elevation and location of the benchmark are detailed on Figure 2.

The locations of the existing timber piles just north of the bridge (assumed to be an abandoned pile bent) were measured to local structures/features and the diameter, stick-up from river bottom and distance below top of river water were measured.

The fieldwork was supervised by a member of **exp'**s geotechnical personnel, Mr. Elwin Farkas, who directed the drilling and sampling operation, logged borehole data in accordance with MTO Soils Classification System, and retrieved soil samples for subsequent laboratory testing and identification.

1.3.2 Laboratory Testing

Following the field investigation representative soil samples were selected for laboratory Atterberg Limit testing (10 samples – LS703/704), hydrometer (5 samples – LS702) and grain size analyses (24 samples – LS602) and natural moisture content determinations (all samples – LS701) for soil type classification purposes as well as to allow estimation of the geotechnical properties. The results are provided in the Appendix A and C, and are discussed herein. Samples remaining after the testing will be stored for one year from issue date of report, after which they may be discarded unless we are requested otherwise.

1.4 Subsurface Conditions

Details of the subsurface conditions encountered at the borehole locations are provided on the Borehole Logs included in Appendix C of this report. The general subsurface soil conditions are summarized in the following sections.

1.4.1 Sand and Silt

Sand and silt was generally encountered surfacing the boreholes. The sand and silt soils were generally described as very loose to loose, brown, moist to wet at depth containing trace to

some gravel and roots and rootlets (upper 0.3 m). Occasional cobbles were noted at BH1 and BH4 and trace to some clay was noted at BH1 (3.8 m depth) and BH2 (4.6 m depth). At BH1, a sheet metal piece was noted at about 0.6 m depth; at BH2, wood pieces were noted at about 3.1 m depth; and at BH4, asphalt and wood pieces were noted within the upper 0.1 m. In addition, trace organics were noted at BH1 (3.8 m depth) and BH2 (3.1 to 3.8 m depth). The sand and silt extended to depths ranging between about 0.1 m and 9.2 m below ground surface.

Eight grain size analyses were performed on representative samples of the sand and silt (BH1-S3, BH1-S6, BH1-S9, BH2-S2, BH2-S3, BH2-S5, BH2-S6, BH2-S8); the results are presented on Figure 4A and 4B. In addition, one hydrometer analysis was performed of the sand and silt (BH2-8); the results are presented on Figure 4B.

All samples within the sand and silt stratum were submitted for moisture contents determinations. The moisture contents ranged between about 4.2 % and 29.6 %.

Based on the saturated moisture contents, unit weights are estimated to range from about 20 kN/m^3 to 23 kN/m^3.

1.4.2 Silty Clay to Clayey Silt

A cohesive stratum, ranging generally between silty clay and clayey silt was encountered beneath the sand and silt. This cohesive complex was generally described as firm to very stiff, grey, moist to wet, containing trace to some gravel and trace to some sand. Occasional cobbles were noted during augering at BH1 at depths of about 10.4 m to 10.7 m and 12.8 m to 13.1 m below ground surface. At BH2, the soil was described as hard at about 10.7 m to 13.7 m depth as well as at BH3 at about 13.7 m to 15.2 m depth. Two i*n situ* shear vane tests were performed and the results were > 100 kPa at BH1 (7.2 m depth) and 20 kPa at BH2 (8.5 m depth). This cohesive soil extended to depths ranging between about 13.7 m and 15.2 m below ground surface.

Two grain size and two hydrometer analyses were performed on representative samples (BH3-S10, BH3-S14); the results are presented on Figure 4C.

All samples within the silty clay and clayey silt were submitted for moisture contents determinations. The moisture contents ranged between about 10.7 % and 21.1 %.

Based on the saturated moisture contents, unit weights are estimated to range from about 20.5 kN/m^3 to 23 kN/m^3.

At BH4, a mixture of sand, silt and clay layers were encountered underlying the sand and silt upper layer. The sand, silt and clay layers were generally described as brown to grey at depth, moist to wet at depth. The cohesionless soils were described as very loose to compact and the cohesive soils were described as stiff to soft. Trace organics, and roots and rootlets were noted

at 1.5 m and 2.3 m depth, respectively and occasional cobbles were noted during augering at about 2.1 m to 2.3 m depth. The sand, silt and clay layers extended to about 9.2 m below ground surface. It is considered that the soil in the upper 4 m to 5 m may be fill from the construction of the embankment.

Four grain size analyses were performed on representative samples of the sand, silt and clay layers (BH4-S3, BH4-S6B, BH4-S7, BH4-S9); the results are presented on Figure 4D. In addition, one hydrometer analysis was performed of the sand, silt and clay (BH4-S3); the results are presented on Figure 4D.

All samples within the sand, silt and clay were submitted for moisture contents determinations. The moisture contents ranged between about 4.1 % and 33.2 %.

Based on the saturated moisture contents, unit weights are estimated to range from about 18.5 kN/m^3 to 22.5 kN/m^3.

Atterberg limit testing was performed on ten representative samples of the silt and/or clay and indicated that the soil is of low to medium plasticity. The natural moisture contents of the silt and clay were generally below the liquid limits, except at BH4-11B where they were equal. The data is shown on the Plasticity Charts, Figures 5A to 5D, and summarized in the following Table 1-1.

Table 1-1: Summary of Atterberg Limit Testing

Borehole / Sample	**BH1 S10**	**BH1 S12**	**BH2 S11**	**BH3 S3**	**BH3 S6**	**BH3 S9**	**BH3 S15**	**BH4 S4**	**BH4 S11A**	**BH4 S11B**
Depth	6.6 m	9.6 m	9.5 m	1.1 m	3.4 m	5.7 m	14.0 m	1.8 m	7.8 m	8.1 m
Liquid Limit, w_L	24	16	16	23	27	16	19	18	36	21
Plastic Limit, w_P	15	13	12	16	15	14	14	15	18	13
Plasticity Index, I_P	9	3	4	7	12	2	5	3	18	8
Moisture Content (%)	18.4	12.0	12.7	14.8	16.8	12.0	13.3	13.1	33.2	21.3

1.4.3 Silt and Sand

Silt and sand was encountered underlying the cohesive soils at BH3 and BH4. The silt and sand was generally described loose to compact, grey, wet containing trace gravel and trace to some clay. The silt and sand extended to 17.2 m at BH3 and 15.6 m at BH4.

Two grain size analyses were performed on representative samples of the silt and/or sand (BH4-S12, BH4-S14); the results are presented on Figure 4D.

All samples within the silt and/or sand were submitted for moisture contents determinations. The moisture contents ranged between about 7.7 % and 18.1 %.

Based on the saturated moisture contents, unit weights are estimated to range from about 21 kN/m^3 to 23.5 kN/m^3.

Sand and gravel was generally encountered beneath the silt and sand depth at BH3 and was generally described as compact to very dense, grey, wet, containing trace to some silt and some cobbles. A boulder, about 300 mm, was encountered beneath the sand and gravel. The sand and gravel, including the boulder, extended to about 19.7 m below ground surface.

Two grain size analyses were performed on representative samples of the sand and gravel (BH3-S17B, BH3-S18); the results are presented on Figure 4C.

All samples within the sand and gravel were submitted for moisture contents determinations. The moisture contents ranged between about 7.5 % and 9.8 %.

Based on the saturated moisture contents, unit weights are estimated to range from about 23 kN/m^3 to 24 kN/m^3.

1.4.4 Sand and Silt Till

Sand and silt till was generally encountered beneath all of the above noted overlying soils. The till was generally described as very dense, grey, moist, containing trace gravel to gravelly and trace to some clay. During augering, cobbles were noted at BH1 (18.0 m and 26.2 m depth), BH2, (23.8 m) and BH4 (18.3 m). The till extended to depths of about 20.0 m and 37.5 m below ground surface.

Six grain size analyses were performed on representative samples of the till (BH1-S15, BH1-S18, BH2-S14, BH3-S20, BH4-S16B, BH4-S17); the results are presented on Figures 4A, 4B, 4C and 4E. In addition, one hydrometer analysis was performed of the till (BH1-S18); the results are presented on Figure 4A.

All samples within the till were submitted for moisture contents determinations. The moisture contents ranged between about 4.5 % and 16.9 %.

Based on the saturated moisture contents, unit weights are estimated to range from about 21 kN/m^3 to 24.5 kN/m^3.

1.4.5 Refusal and Bedrock

Refusal to further augering and/or split spoon penetration was encountered at depths ranging between about 20.0 m and 37.5 m below ground surface. Rock coring techniques (NQ size) were used at BH2, BH3 and BH4; however, bedrock was only proven at BH2. At BH3, rock coring techniques indicated the presence of a boulder, about 300 mm, and till beneath the boulder. At BH4, rock coring was used to advance the borehole 3.2 m (25.2 m below ground surface) but only indicated the presence of cobbles and boulders.

The bedrock that was cored in BH2 was described as medium strong rock (25 MPa to 50 MPa compressive strength), very severely fractured to fractured at depth, greenish grey, coarse grained with pink stringers, some quartz pockets and stringers. The gross recovery ranged between about 89% and 100% and the Rock Quality Designation (RQD), which is a modified core recovery ranged between 18% and 64% (very severely fractured to fractured). The RQD increased at depth. Borehole BH2 was advanced about 3.4 m into the bedrock and was terminated at about 40.9 m below ground surface.

1.5 Groundwater Conditions

Groundwater measurements were taken prior to backfilling the boreholes. Groundwater levels are shown on the Borehole Logs in Appendix C and are summarized in Table 1-2, below.

It must be noted that the depth to the groundwater table may fluctuate seasonally, or after periods of extended precipitation or drought, and as such may differ at other times.

Table 1-2: Groundwater Data

Borehole (UTM Coordinates – NAD 83)	Date Borehole Completed	Date Measured	Ground Surface Elevation[2]	Depth to Water[3]	Groundwater Elevation
BH1 (16 U 639240 5513544)	July 15/11	July 17/11	94.59	4.12	90.47
BH2 (16 U 639251 5513544)	July 13/11	July 14/11	92.27	1.90	90.37
BH3 (16 U 639278 5513525)	July 17/11	July 17/11	94.16	2.64	91.52
BH4 (16 U 639291 5513541)	July 19/11	July 20/11	98.95	6.41	92.54
River	N/A	July 14/11	N/A	N/A	90.57
River	N/A	July 17/11	N/A	N/A	90.44

Notes:
1) All units in meters.
2) Elevations surveyed are referenced to highway centerline at deck on concrete expansion joint at the east end of the bridge with assumed elevation (100.00 m).
3) Depths are relative to ground surface.
4) UTM Coordinates from handheld GPS unit and are approximate.

1.6 Existing Timber Piles

Existing timber piles (20) were noted in the river, north of the bridge. These are assumed to be from an abandoned pile bent at the time of original construction. The piles were located in two rows (i.e. pairs) in north / south direction and the lengths separating the piles in the east / west direction and north / south direction ranged between about 1.1 m and 1.4 m, and 0.6 m and 1.8 m, respectively. In addition, the pile located furthest north and furthest south were single piles (i.e. not paired). Details of the timber piles are shown on Figure 7 and are summarized in Table 1-3 below:

Table 1-3: Existing Timber Piles

Timber Pile No.	Diameter (mm)	Stick-Up (mm)
1	300	350
2	350	300
3	280	650
4	350	350
5	350	750
6	350	350
7	350	800
8	300	500
9	280	850
10	350	700
11	270	850
12	350	900
13	320	900
14	290	900
15	300	900
16	300	900
17	300	950
18	300	900
19	250	950
20	250	950

There were 20 timber piles noted and ranged in diameter between about 250 mm and 350 mm and the stick-ups ranged between about 300 mm and 950 mm above the river bottom.

2 Part II: ENGINEERING DISCUSSION AND RECOMMENDATIONS

2.1 Introduction

The purpose of the following subsections is to provide evaluation of the existing timber piles at the Otasawian River bridge. The bridge consists of a three-span supported, reinforced concrete slab on steel girder bridge. The length of the bridge is about 49 m and the individual span lengths are about 16.3 m, 16.5 m and 16.3 m. According to a construction drawing[1] provided by the MTO, the bridge abutments are supported on 16.8 m (55 ft) long timber piles, while the length of the piles supporting the piers is about 13.7 m (45 ft). It is understood that the proposed structural rehabilitation will include the replacement of the bridge deck superstructure, which is to be supported on the existing bridge substructure and existing foundations.

It is understood that the project is expected to be delivered through a design-build model. It is also understood that the inspection for the integrity of the existing timber piles will be supervised by the NER Structural Section.

This report addresses the geotechnical design of the piles for the bridge by providing geotechnical design parameters at the Ultimate Limit State (ULS) and Serviceability Limit States (SLS) in accordance with the *Canadian Highway Bridge Design Code (CHBDC)* (November 2006), the *Canadian Foundation Engineering Manual (CFEM)* (2006), and good practice. The design parameters and recommendations presented are based on our current understanding of the project.

At the time of the field work, an established benchmark was unknown. As discussed previously, a local benchmark, established on the roadway centreline at the east abutment expansion joint, was used and assigned an elevation of 100.00 m. Review of the previously mentioned construction drawing suggests that this point had an approximate elevation of 813.5 ft. (247.95 m, assuming straight conversion to metric). This data can be used for approximations of the current metric geodetic elevations.

2.2 Geotechnical Design Considerations for Foundations

2.2.1 General

The geotechnical investigation and its findings pertaining to the subsurface soil characteristics have been covered in Part I - Foundation Investigation Report which contains details of the field and laboratory aspects of the investigation. In general, the natural stratigraphic sequence at the site typically consists of a deposit of sand and silt, overlying silt and clay, overlying till, overlying bedrock.

[1] Otasawian River Bridge, General Plan and Details. Drawing Number D3737-1, WP 206-55. March 23, 1955.

In the context of pile foundations, a suitable end-bearing soil stratum, that being the dense to very dense till, was encountered at depths ranging from about 14 m to 22 m below ground surface at the borehole locations. These depths correspond to elevations (local datum) of between about 81 m and 76 m. Bedrock was proven only near the west pier, at a depth of about 37.5 m (el. 54.7 m). The thickness of the dense to very dense till overlying the bedrock at this location was about 24 m.

2.2.2 Existing Timber Piles

It has been stated that the existing bridge abutments and piers are supported by timber piles. The abutment piles are understood to be about 16.8 m long, while the pier piles are about 13.7 m long. The species is unknown, but assumed to be Jackpine, which should yield conservative results in the following discussion.

Based on the field measurements of the (abandoned) pile bent in the centre of the river channel to the north of the bridge, the butt diameters range from about 250 mm to 350 mm, with an average of about 310 mm, for the 20 piles. There are no diameters specified on the aforementioned construction drawing, therefore the measured average of 310 mm is used in subsequent calculations for the piles supporting the piers and abutments.

Based on values recommended in the CHBDC, using a compressive strength of 14.2 MPa for Jackpine piles, the above noted pile dimensions, and a resistance factor of 0.8, the factored structural resistance would be in the order of 857 kN. Elastic shortening of a 15 m long pile under this load, however, would be about 55 mm, using an elastic modulus (E_{05}) of 5,000 MPa. Conversely, for an elastic shortening of 25 mm, the required structural load would be about 390 kN.

The geotechnical resistance of these timber piles has been calculated based on the following conservative assumptions and subsurface information.

- Pile embedment = 13.2 m and 16.3 m, bearing in the dense till
- Butt diameter = 310 mm, tip diameter = 180 mm
- SPT average N-value = 10 in the loose soil and 38 in the till

The factored (0.4) geotechnical resistance at the ULS has been calculated to be about 275 kN and 380 kN for embedment lengths of 13.2 m and 16.3 m, at the piers and abutments, respectively. Elastic shortening under these loads is calculated to be about 15 mm and 25 mm, respectively.

The SLS bearing reaction (geotechnical) for such piles for a given vertical displacement is difficult to specify. However, given that the ultimate skin friction is mobilized after only a few millimetres of pile movement and the ultimate base resistance is mobilized at about 10% of the

tip diameter (18 mm), it can be inferred that the SLS reaction is much greater than the factored ULS resistance. Accordingly, the ULS will likely govern design.

2.2.3 **Driven Steel Piles**

If the bridge foundations are to be replaced or supplemented, consideration should be given to the use of driven steel piles. Piles can consist of steel (minimum 350 MPa) pipe (open or closed) or HP sections. Such piles, driven to, or into, the dense to very dense till (with average N-values of between 38 and 45) can be designed using the factored resistance values in the following Table 2-1. These values are based on a static analysis. The elastic compression at ULS should be less than 15 mm in all cases.

Table 2-1. Geotechnical Resistance Values for Driven Steel Piles

Closed End Pipe Size or HP Section	Factored ULS (kN) for embedment		
	15 m	17 m	19 m
273 mm x 12.7 mm	445	600	800
298 mm x 12.7 mm	545	740	990
324 mm x 12.7 mm	655	900	1210
HP310 x 79	310	460	650
HP310 x 110	370	560	800

The values given in Table 2-1, above, are based on driving the piles to various depths below the underside of the pile cap, at the approximate levels that presently exist. Hard driving and refusal to pile penetration may be encountered prior to achieving the above-noted penetration, due to obstacles such as cobbles and boulders, or conversely, piles may be driven further than 18 m if weak zones in the till are encountered. HP sections will likely penetrate deeper than pipe sections.

In view of the possible presence of cobbles and boulders in the till soils, a pre-fabricated driving shoe should be provided at the pile toe to protect the tip from.

Prior to driving piles, a wave equation (WEAP) analysis should be performed in order to assess the driving stresses and the anticipated penetration resistance required to develop the required pile capacity. This analysis considers the complete driving system. Dynamic testing (PDA testing) on a number of piles with the Pile Driving Analyser must be performed near the beginning of the pile driving phase of construction to confirm the pile capacities.

In addition, all piles should be visually monitored by experienced personnel during installation to check for plumbness, set, internal damage, etc. This is especially important at this site due to the presence of cobbles and boulders in the till. All damaged piles should be rejected and if the damage is considered to be minor, the pile can be dynamically tested to determine the available pile capacity.

The required penetration resistance will vary depending on the pile driving hammer, pile cross section and design loads. For preliminary purposes, a diesel pile hammer with a rated energy of at least 58 kJ (42,000 ft-lbs) is recommended. Final penetration resistance is expected to be between 10 and 15 blows per 25 mm of penetration, depending on the pile size and hammer used, for three consecutive sets of blows. This would be confirmed with the WEAP analysis and PDA testing. A drop hammer may also be considered to install the piles.

Piles in groups should be spaced no closer than 3 pile diameters. All piles in a group should be checked for heaving during the driving of the adjacent piles.

2.2.4 Frost Protection

The potential frost depth at this site is about 2.6 m. Consequently, all pile caps exposed to seasonal freezing conditions should be protected from frost action by at least 2.6 m of soil cover or equivalent insulation.

2.3 Closure

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the works, should, in this light, decide on their own investigations as well as their own interpretations of the factual borehole results so that they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation and Design Report has been prepared by Ahileas Mitsopoulos, P.Eng. and Demetri N. Georgiou, P.Eng., and reviewed by S.E. Gonsalves, P.Eng., Designated MTO Foundations Contact for **exp**.

We trust that these comments provide you with sufficient information to proceed with design. Should you have any questions, please do not hesitate to contact this office.

Yours truly,

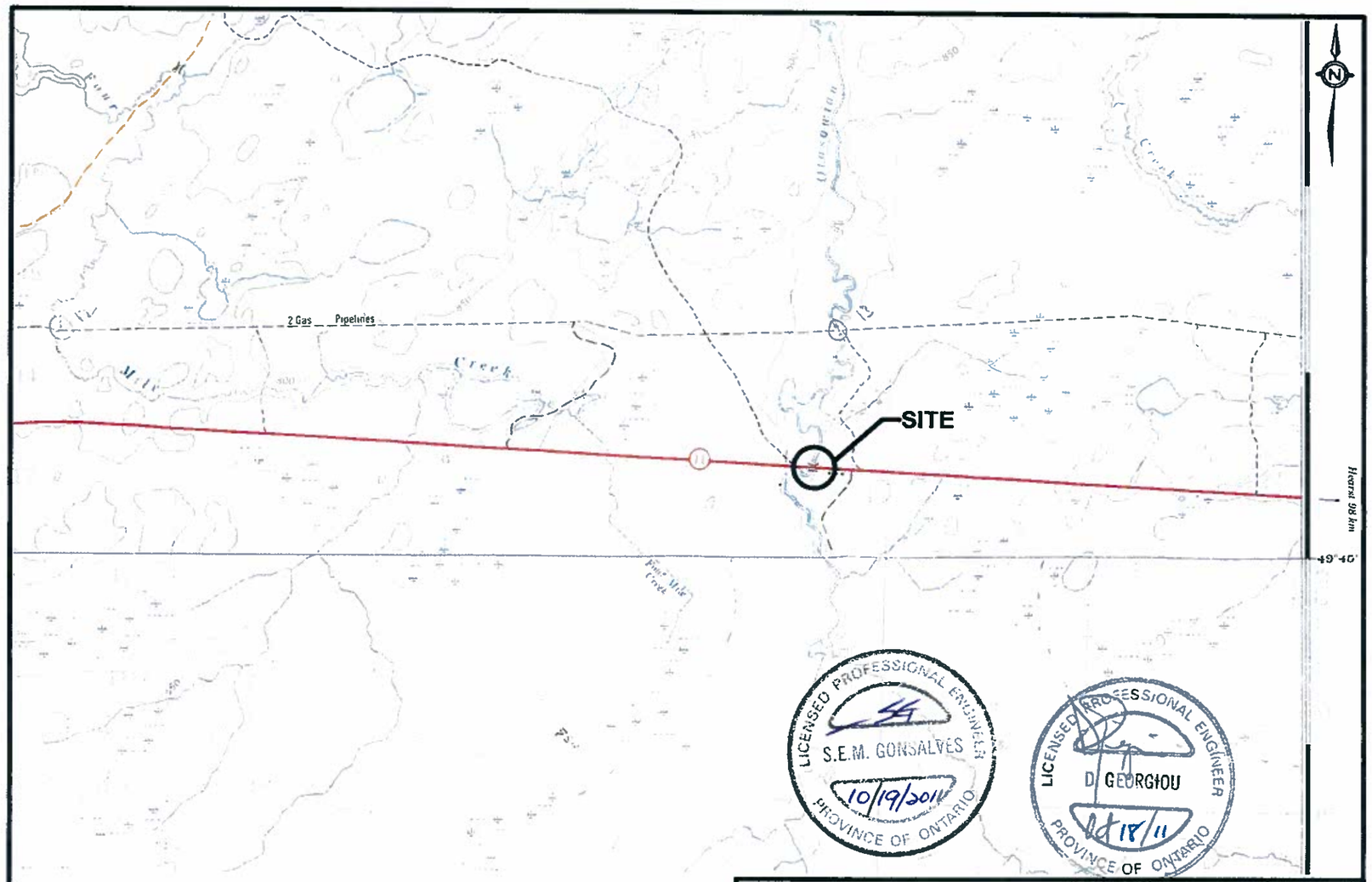
exp Services Inc.

Ahileas Mitsopoulos, P.Eng.
Project Engineer

Demetri N. Georgiou, MASc., P.Eng.
Principal Engineer
Thunder Bay Branch Manager

S.E. Gonsalves, M.Eng., P.Eng.
Principal Engineer
Designated MTO Foundations Contact

Appendix A – Figures



NOTES:

1. REFERENCE: SURVEY AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES. NATIONAL TOPOGRAPHIC SYSTEM, 1:50,000 MAP SHEETS 42 F/14 (EUREKA LAKE) AND 42 F/11 (OSAWIN RIVER).

500 0 500 1000
IN METRES

LICENSED PROFESSIONAL ENGINEER
S.E.M. GONSALVES
10/19/2011
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
D. GEORGIOU
OCT 18/11
PROVINCE OF ONTARIO

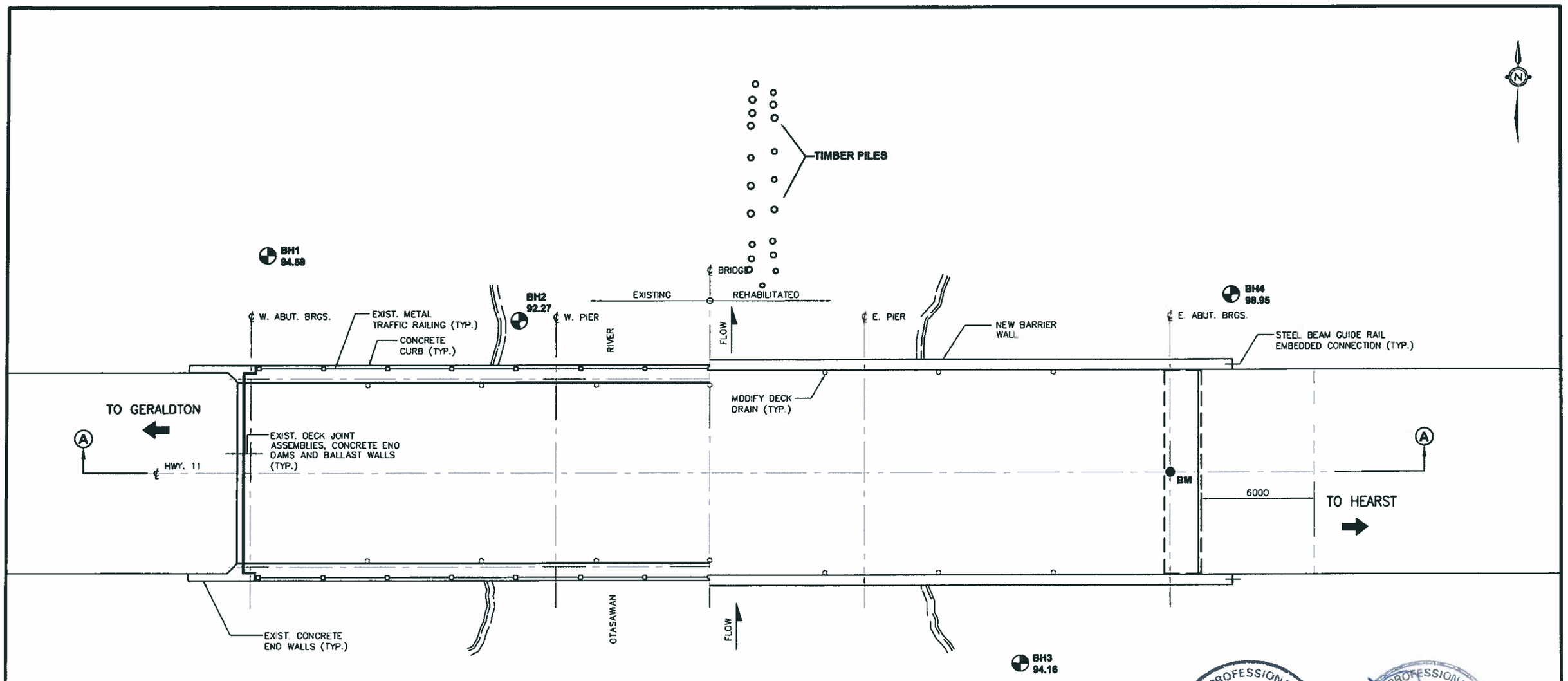
exp. The new Identity of Trow

FIGURE 1

SITE LOCATION PLAN

Geotechnical Investigation
Otasawian River Bridge - Site No. 39W-002
GWP No. 5236-06-00
Ontario Ministry of Transportation
GEOCRES No. 42F-23

PROJECT NO.:	ADM-000201207-AO
SCALE:	1:50,000
DRAWN BY:	DT/AM
CHECKED BY:	DG
DATE:	AUG. 16, 2011



LICENSED PROFESSIONAL ENGINEER
S.E.M. GONSALVES
10/19/2011
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
D. GEORGIOU
Oct 19/11
PROVINCE OF ONTARIO

LEGEND:

BH1 94.59	BOREHOLE LOCATION ELEVATION IN METRES
BM 100.00m	BENCHMARK LOCATION ELEVATION IN METRES

NOTES:

1. REFERENCE: BASE PLAN PROVIDED BY CLIENT.
2. BENCHMARK (BM): CENTRE LINE OF HWY 11 OF CONCRETE BRIDGE DECK AT EXPANSION JOINT AT EAST ABUTMENT. ASSUMED LOCAL ELEVATION OF 100.000m.

2.5 0 2.5 5
IN METRES

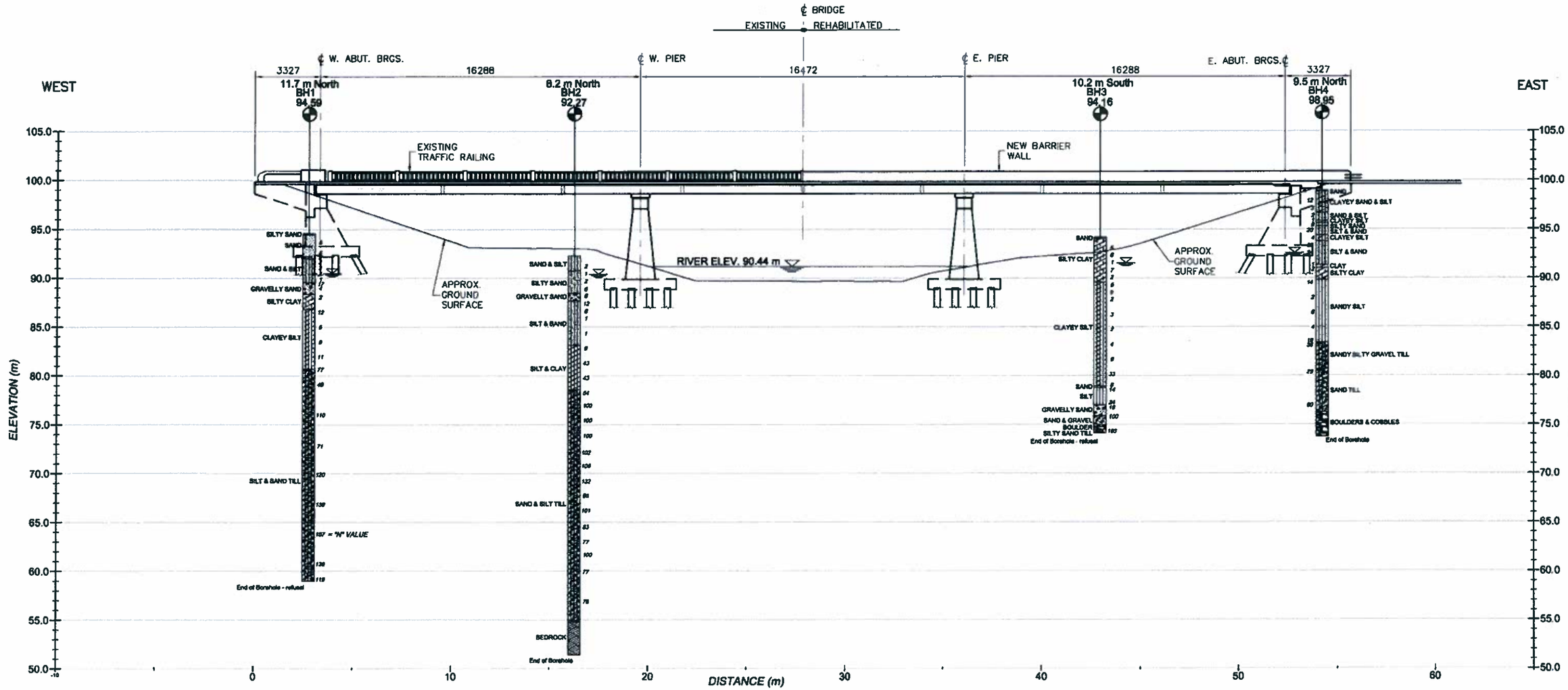
exp. The new identity of Trow

FIGURE 2

BOREHOLE LOCATION PLAN

Geotechnical Investigation
Otasawian River Bridge - Site No. 39W-002
GWP No. 5236-06-00
Ontario Ministry of Transportation
GEOCRES No. 42F-23

PROJECT NO.:	ADM-000201207-A0
SCALE:	1:200
DRAWN BY:	DT/AM
CHECKED BY:	DG
DATE:	AUG. 16, 2011



LICENSED PROFESSIONAL ENGINEER
S.E.M. GONSALVES
10/19/2011
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
D. GEORGIOU
OCT 18/11
PROVINCE OF ONTARIO

LEGEND:

BH1 / 94.59 — BOREHOLE LOCATION / ELEVATION IN METRES

NOTES:

1. REFERENCE: BASE PLAN PROVIDED BY CLIENT.
2. BENCHMARK (BM): CENTRE LINE OF HWY 11 OF CONCRETE BRIDGE DECK AT EXPANSION JOINT AT EAST ABUTMENT. ASSUMED LOCAL ELEVATION OF 100.000m.
3. RIVER ELEVATION SURVEYED ON JULY 17, 2011.
4. GROUNDWATER ELEVATIONS AT BH1, BH2, BH3 AND BH4 WERE MEASURED ON JULY 17, 14, 17 AND 20, 2011, RESPECTIVELY.

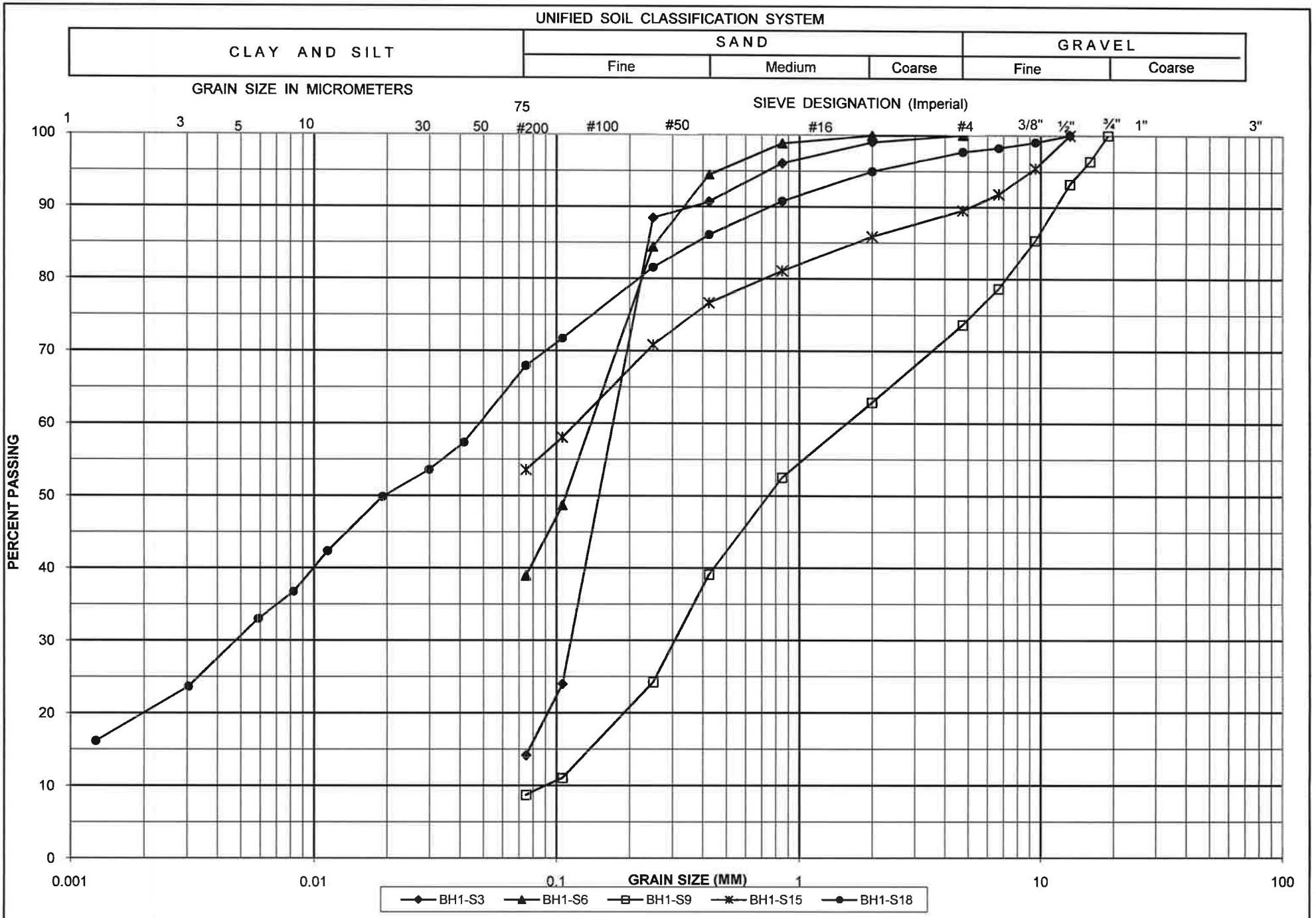
exp. The new identity of Trow

FIGURE 3

STRATIGRAPHIC SECTION A-A

Geotechnical Investigation
Otasawian River Bridge - Site No. 39W-002
GWP No. 5236-06-00
Ontario Ministry of Transportation
GEOCRES No. 42F-23

PROJECT NO.:	ADM-000201207-AO
SCALE:	1:200H / 1:400V
DRAWN BY:	DT/AM
CHECKED BY:	DG
DATE:	AUG. 24, 2011



exp.

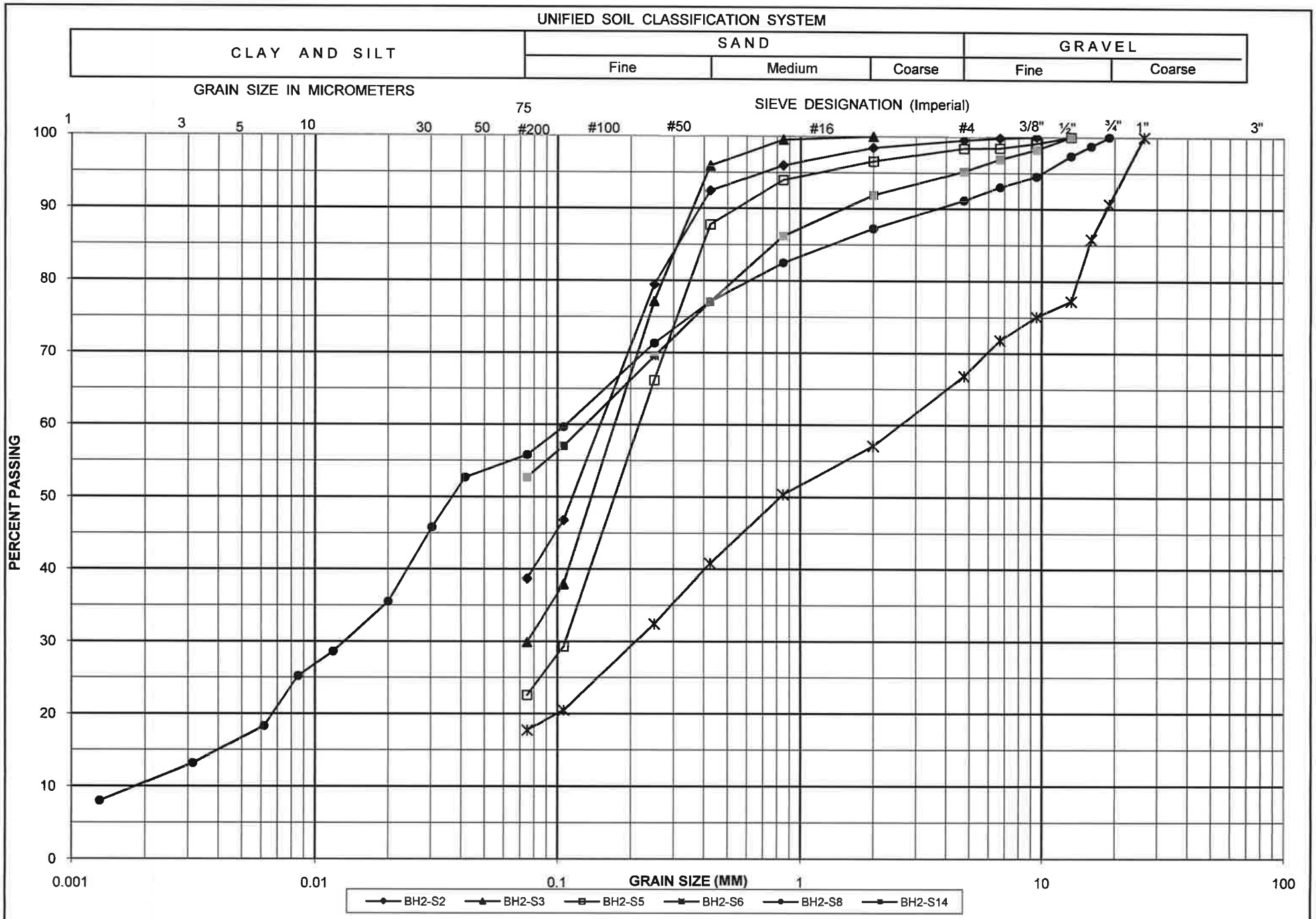
GRAIN SIZE DISTRIBUTION - BH1

Otasawian River Bridge - Site No. 39W-002 - GEOCRES No. 42F-23

FIGURE No. 4A

Ref. No. ADM-00201207-AO

DATE August 19, 2011



exp.

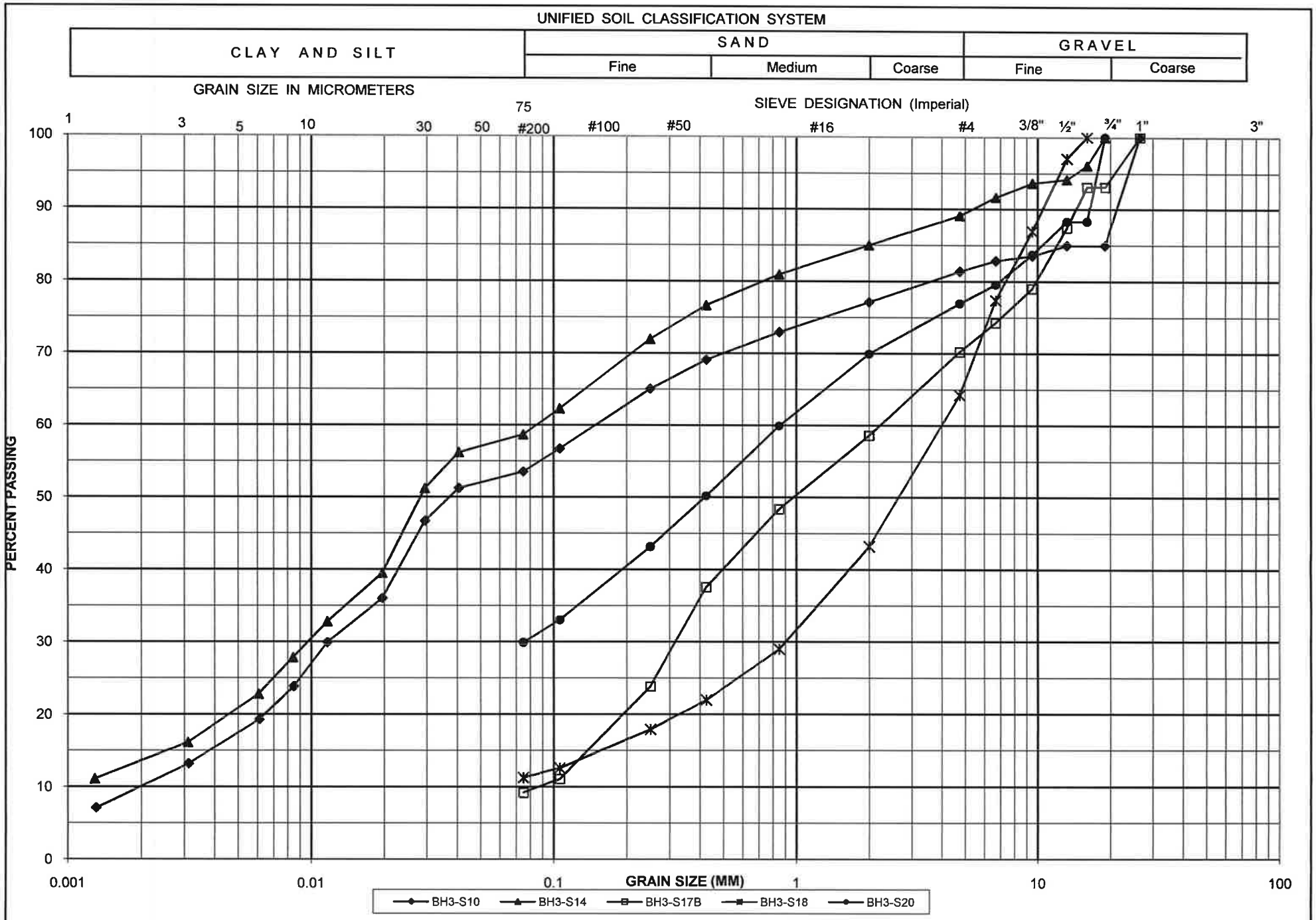
GRAIN SIZE DISTRIBUTION - BH2

Otasawian River Bridge - Site No. 39W-002 - GEOCRES No. 42F-23

FIGURE No. 4B

Ref. No. ADM-00201207-AO

DATE August 19, 2011



exp.

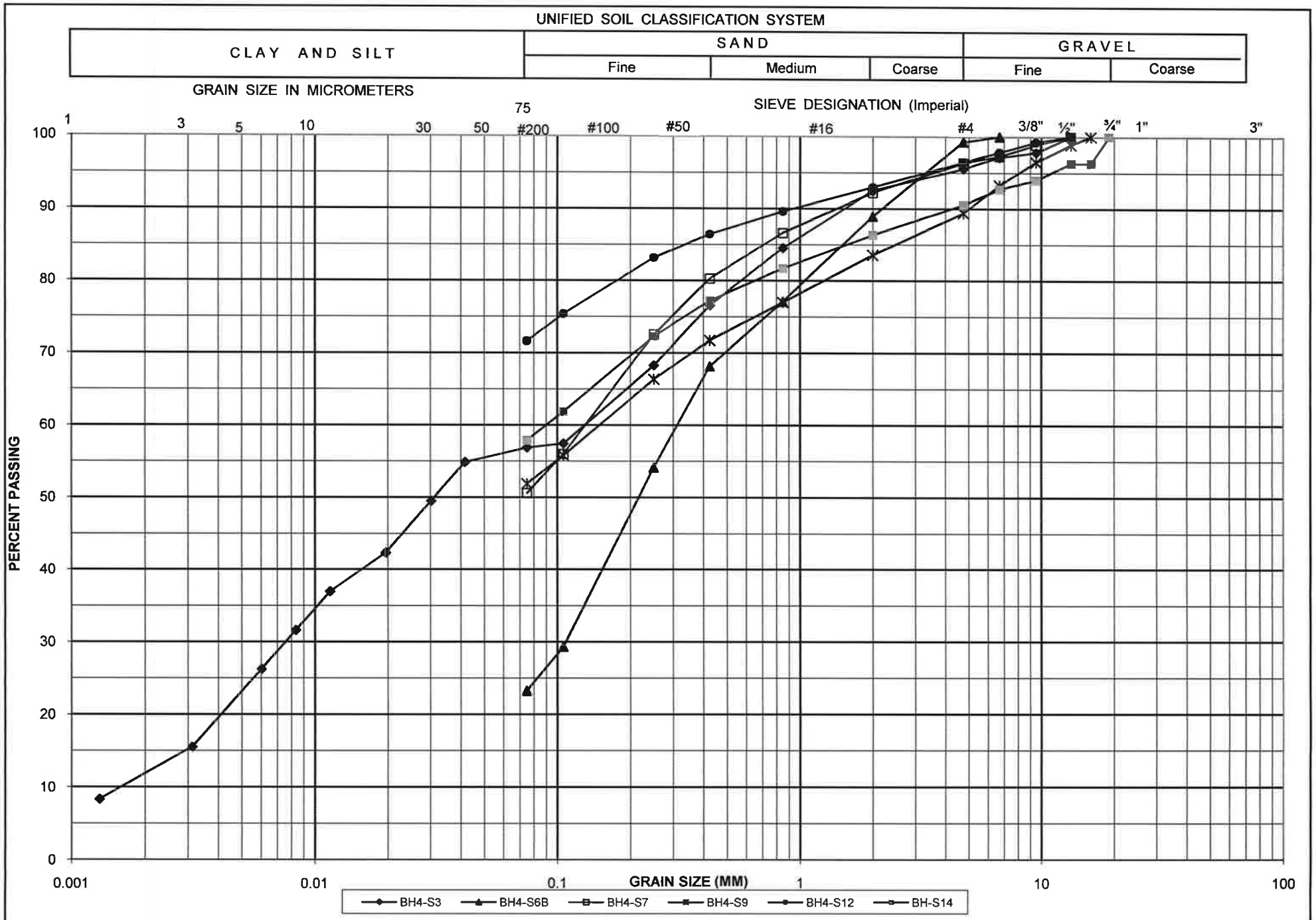
GRAIN SIZE DISTRIBUTION - BH3

Otasawian River Bridge - Site No. 39W-002 - GEOCRES No. 42F-23

FIGURE No. 4C

Ref. No. ADM-00201207-AO

DATE August 19, 2011



exp.

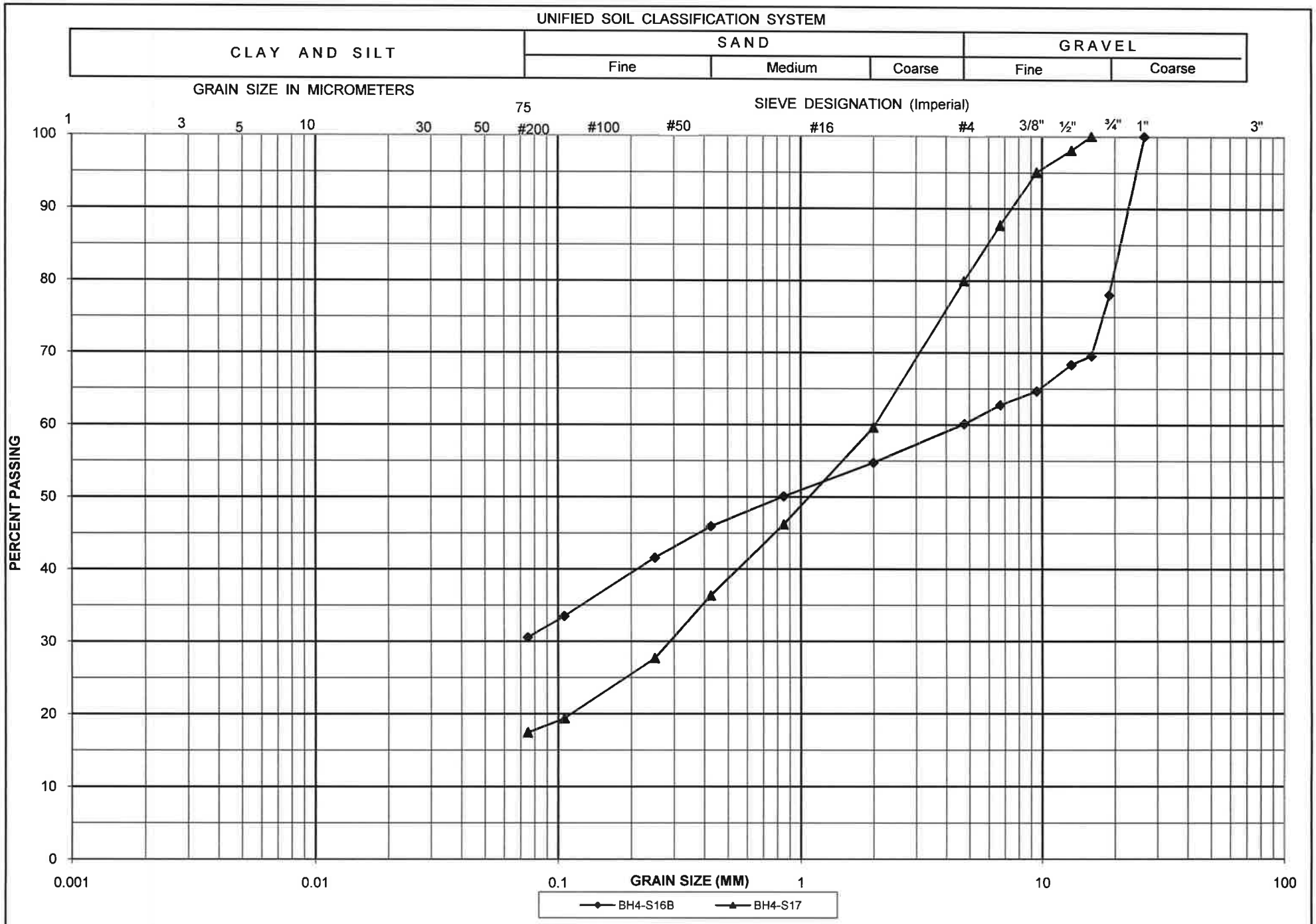
GRAIN SIZE DISTRIBUTION - BH4

Otasawian River Bridge - Site No. 39W-002 - GEOCRES No. 42F-23

FIGURE No. 4D

Ref. No. ADM-00201207-AO

DATE August 19, 2011



exp.

GRAIN SIZE DISTRIBUTION - BH4 (CONTINUED)

Otasawian River Bridge - Site No. 39W-002 - GEOCRES No. 42F-23

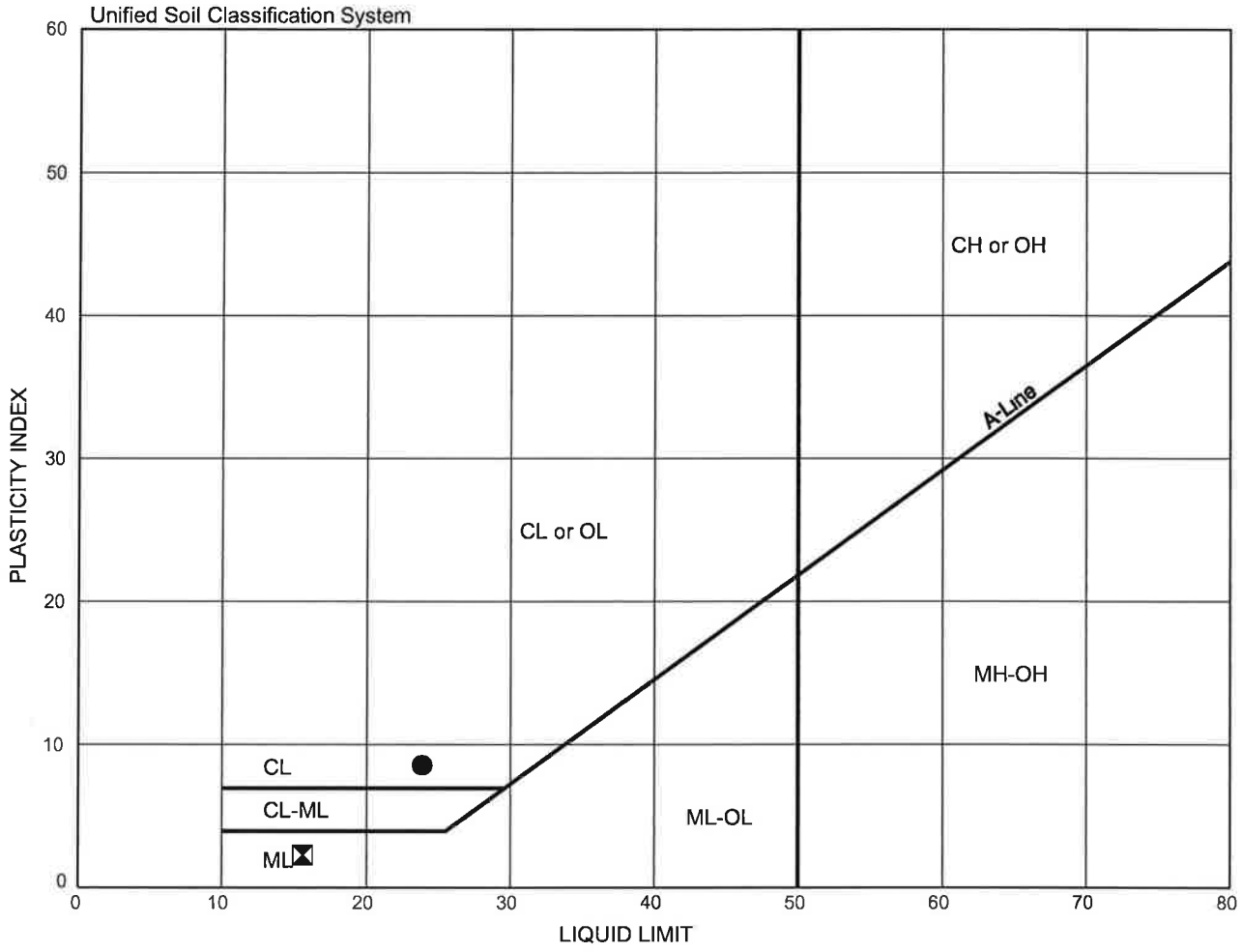
FIGURE No. 4E

Ref. No. ADM-00201207-AO

DATE August 19, 2011

Plasticity Chart

Figure 5A

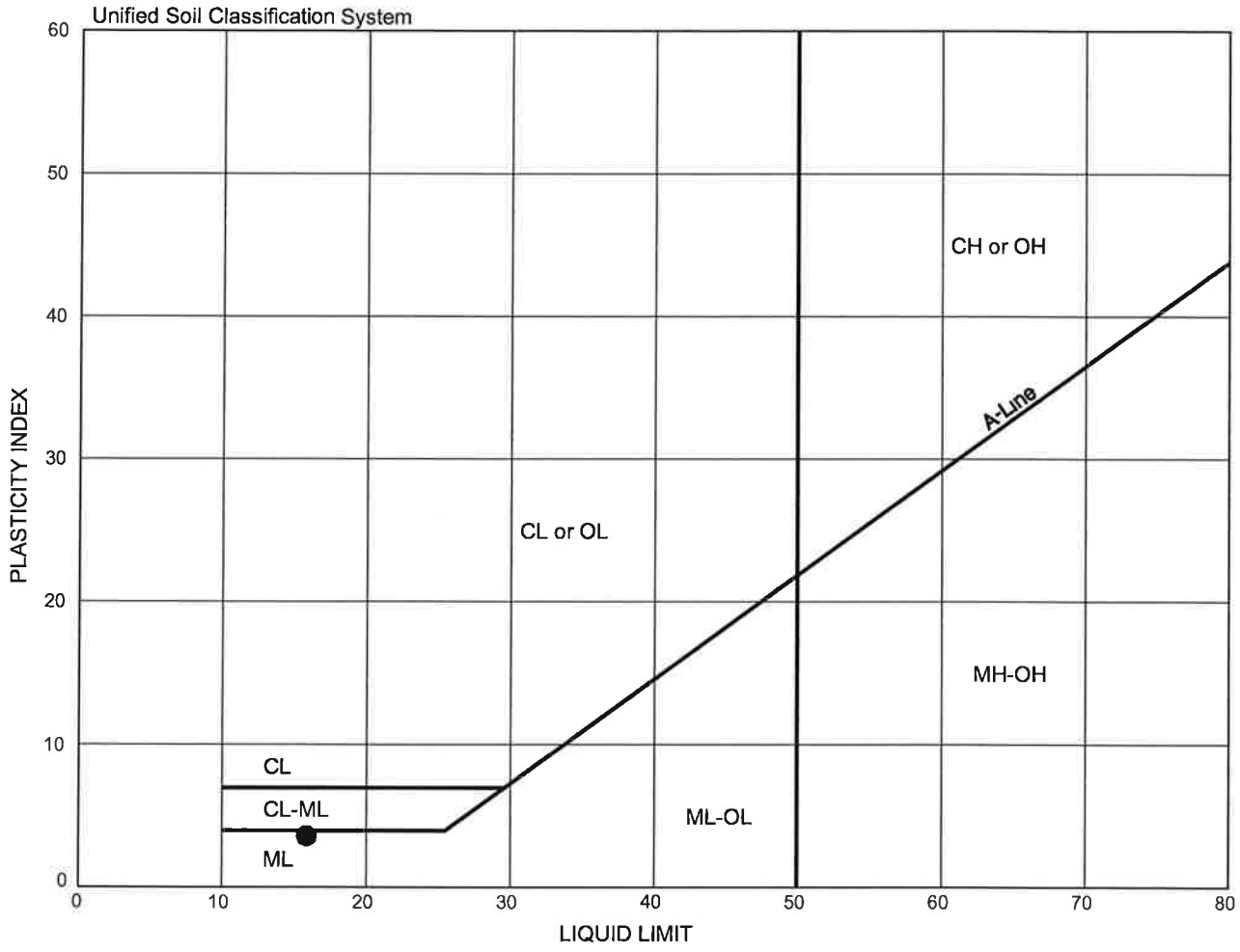


Symbol	Location	Sample No.	Depth (m)	Elevation (m)	W	W_P	W_L	PI
●	BH1	S10	6.56	88.03	18.4	15.3	23.9	8.6
⊠	BH1	S12	9.61	84.98	12.0	13.3	15.6	2.3

Project: Otasawian River Bridge - Site No. 39W-002 - GWP No. 5236-06-00 - GEOCRES No. 42F-23 - BH1
Project No. ADM-00201207-AO

Plasticity Chart

Figure 5B

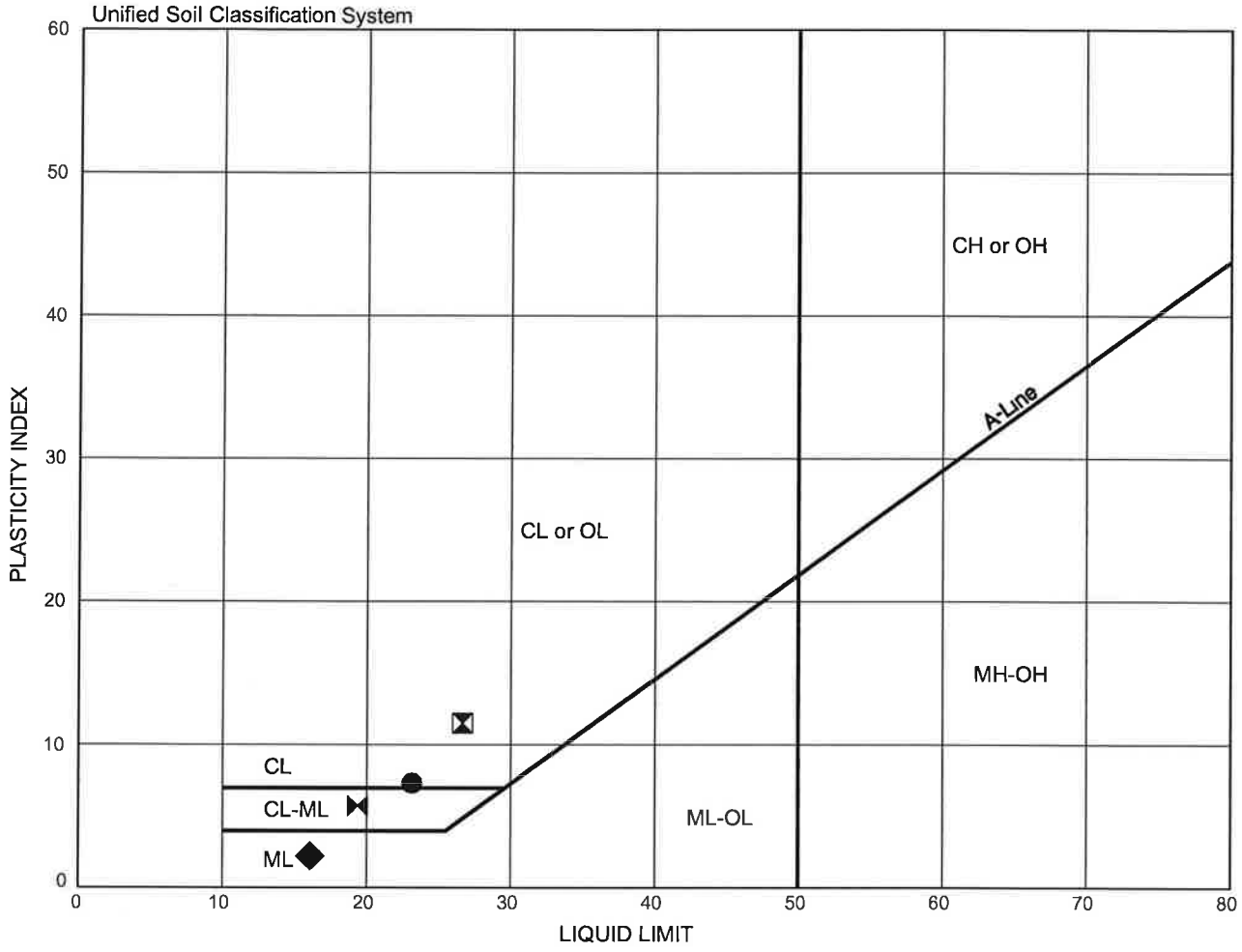


Symbol	Location	Sample No.	Depth (m)	Elevation (m)	W	W_P	W_L	PI
●	BH2	11	9.46	82.81	12.7	12.3	15.9	3.6

Project: Otasawian River Bridge - Site No. 39W-002 - GWP No. 5236-06-00 - GEOCRES No. 42F-23 - BH2
Project No. ADM-00201207-AO

Plasticity Chart

Figure 5C

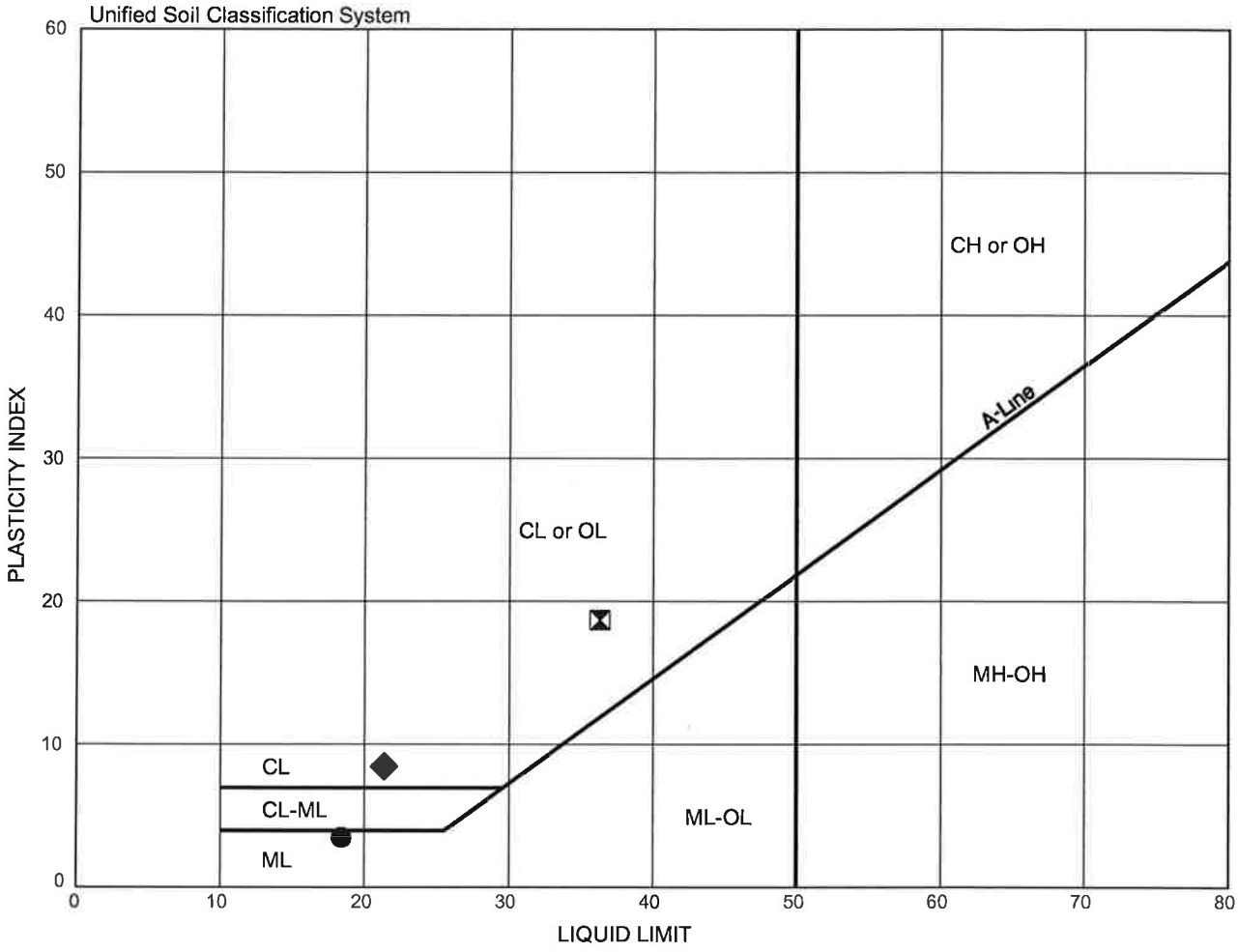


Symbol	Location	Sample No.	Depth (m)	Elevation (m)	W	W_P	W_L	PI
●	BH3	S3	1.07	93.09	14.8	15.9	23.2	7.3
⊠	BH3	S6	3.41	90.75	16.8	15.2	26.7	11.5
◆	BH3	S9	5.66	88.50	12.0	13.9	16.1	2.2
⋈	BH3	S15	14.03	80.13	13.3	13.7	19.4	5.7

Project: Otasawian River Bridge - Site No. 39W-002 - GWP No. 5236-06-00 - GEOCRES No. 42F-23 - BH3
Project No. ADM-00201207-AO

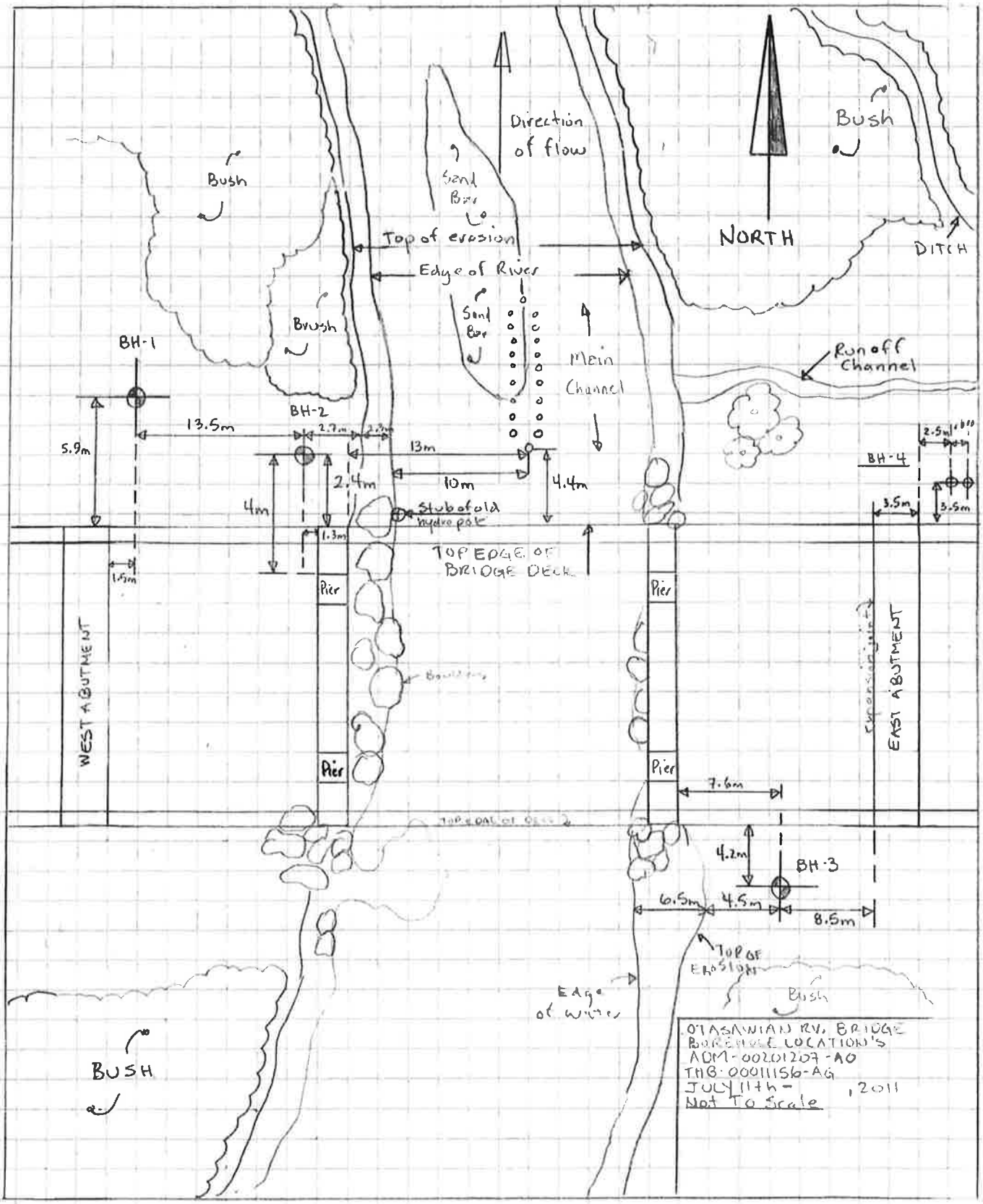
Plasticity Chart

Figure 5D



Symbol	Location	Sample No.	Depth (m)	Elevation (m)	W	W_P	W_L	PI
●	BH4	S4	1.84	97.11	13.1	14.9	18.4	3.5
⊠	BH4	S11A	7.78	91.17	33.2	17.6	36.3	18.7
◆	BH4	S11B	8.09	90.86	21.3	12.8	21.3	8.5

Project: Otasawian River Bridge - Site No. 39W-002 - GWP No. 5236-06-00 - GEOCRES No. 42F-23 - BH4
Project No. ADM-00201207-AO



Notes:

1. REFERENCE: Field sketch prepared by **exp** personnel.

exp. The new identity of Trow

Thunder Bay, Ontario

FIGURE 6

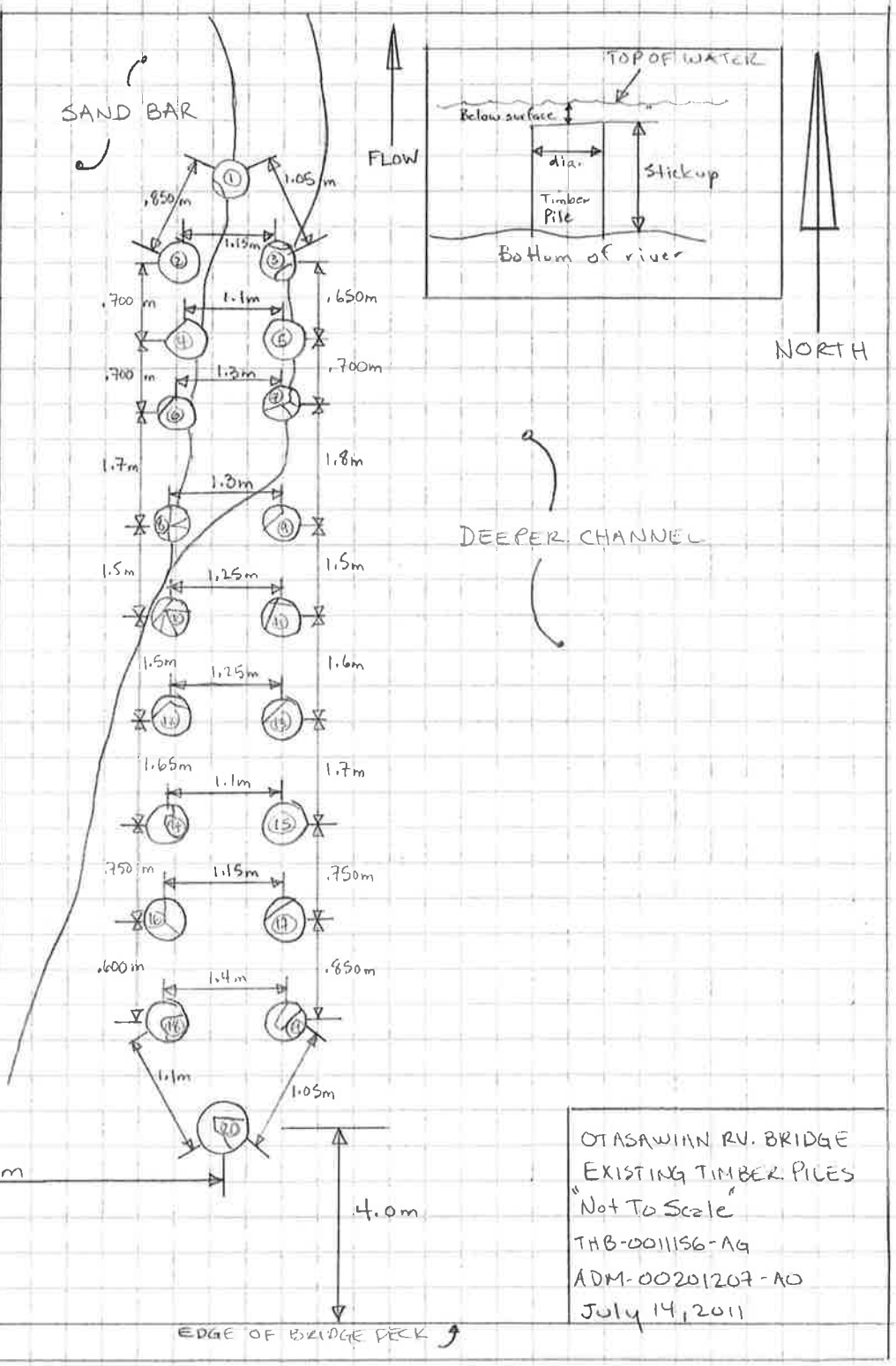
BOREHOLE LOCATION & SURROUNDING FEATURES FIELD SKETCH

Geotechnical Investigation
Otawasian River Bridge - Site No. 39W-002
Ontario Ministry of Transportation
GWP No. 5236-06-00 / GEOCRES No. 42F-23

PROJECT NO.:	ADM-00201207-AO
SCALE:	NOT TO SCALE
DRAWN BY:	DMT
CHECKED BY:	DG
DATE:	Aug. 25, 2011

OTASAWIAN RV. BRIDGE ADM-00201207-AO THB-0011156-AG
JULY 14, 2011, EXISTING TIMBER PILE DETAILS

TIMBER PILES	
①	.300 dia .070 below surface .350m Stickup
②	.350m dia .070 below surface .300 Stickup
③	.280m dia .060m below surface .650 Stickup
④	.350m dia .070m below surface .350 Stickup
⑤	.350 dia .050m below surface .750 Stickup
⑥	.350 dia .050 below surface .350 Stickup
⑦	.350 dia. .050 below surface .800 Stickup
⑧	.300 dia. .070 below surface .500 Stickup
⑨	.280 dia. .050 below surface .850 Stickup
⑩	.350 dia .050 below surface. .700 Stickup
⑪	.270 dia. .070 below surface .850 Stickup
⑫	.350 dia. .050 below surface .900 Stickup
⑬	.320 dia. .050 below surface .900 Stickup
⑭	.290 dia. .050 below surface .900 Stickup
⑮	.300 dia. .030 below surface .900 Stickup
⑯	.300 dia. .060 below surface .900 Stickup
⑰	.300 dia. .050 below surface .950 Stickup
⑱	.300 dia. .060 below surface .900 Stickup
⑲	.250 dia .050 below surface .950 Stickup
⑳	.250 dia .040 below surface .950 Stickup



OTASAWIAN RV. BRIDGE
EXISTING TIMBER PILES
"Not To Scale"
THB-0011156-AG
ADM-00201207-AO
July 14, 2011

Notes:

1. REFERENCE: Field sketch prepared by **exp** personnel.

exp. The new identity of Trow — Thunder Bay, Ontario

FIGURE 7

EXISTING TIMBER PILE FIELD SKETCH

Geotechnical Investigation
Otawasian River Bridge - Site No. 39W-002
Ontario Ministry of Transportation
GWP No. 5236-06-00 / GEOCRES No. 42F-23

PROJECT NO.:	ADM-00201207-AO
SCALE:	NOT TO SCALE
DRAWN BY:	DMT
CHECKED BY:	DG
DATE:	Aug. 25, 2011

Appendix B – Photographs

Photograph 1: Looking west at the bridge. East pier shown.	
	**Photograph 2**: Looking southwest under the bridge. East and west piers shown. BH2 location is located across river on right side (north) of bridge.
Photograph 3: Looking north from on top of bridge. The existing timber piles (11 or 20) are noted in river.	

Photograph 4: Looking south from on top of bridge.	
	**Photograph 5**: Looking east at east pier. BH3 location located on right side (south).
Photograph 6: Looking south at BH4 (located on east side of bridge and north side of Hwy 11).	

Appendix C – Borehole Logs

RECORD OF BOREHOLE No BH1 1 OF 2 METRIC

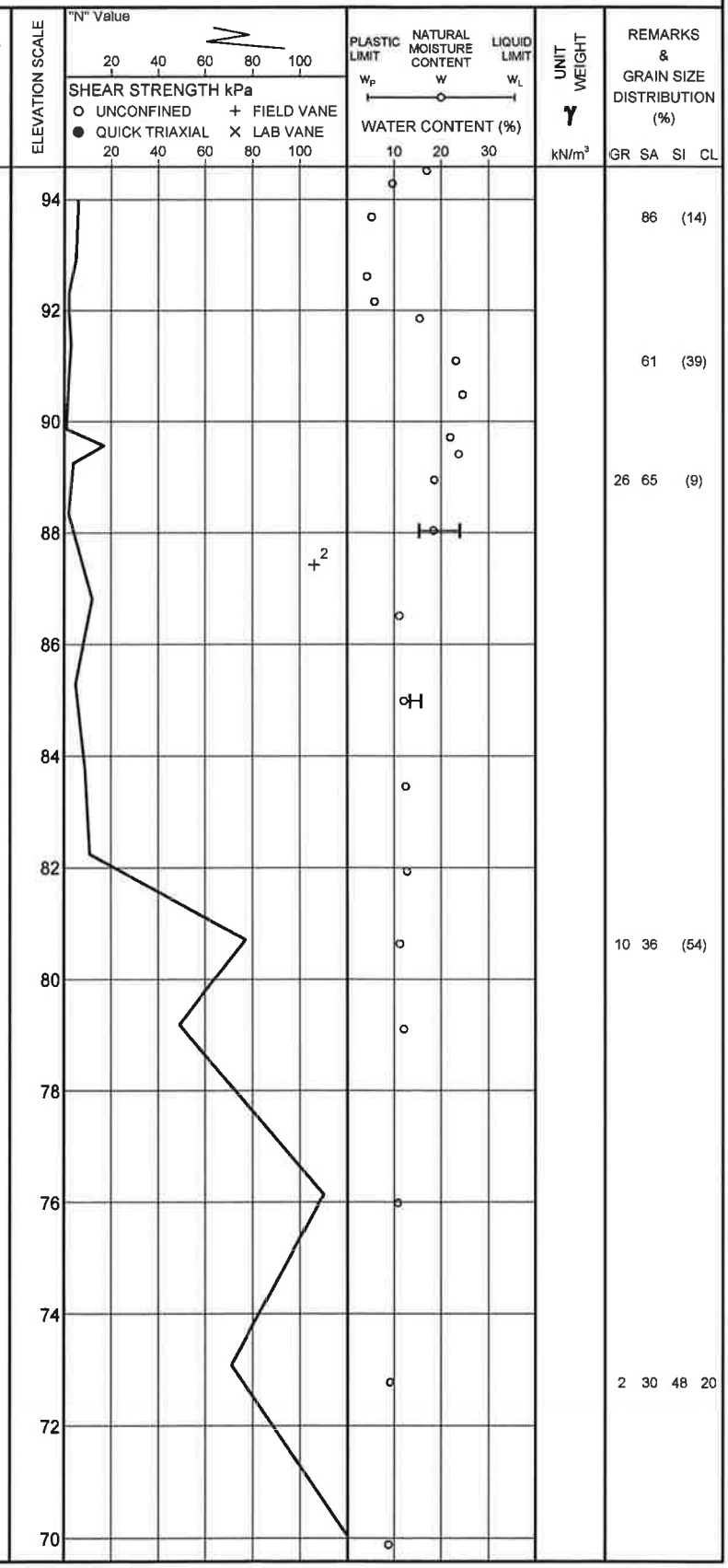
W.P. GWP No. 5236-06-00 LOCATION Otasawian River Bridge (Site No. 39W-002) - GEOCRES No. 42F-23 ORIGINATED BY EF

DIST Twp Kohler HWY 11 BOREHOLE TYPE CME 55 Trailer Mount / HSA COMPILED BY DMT

DATUM Local DATE 7.13.11 - 7.17.11 CHECKED BY AM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
94.6	Silty Sand					
94.4 / 0.2	**SILTY SAND** - loose, brown, moist, some gravel, occasional cobbles, roots and rootlets		S1	AUGER		
			S2	AUGER		
	SAND - loose, light brown, moist, some silt, occasional cobbles, fine grained		S3	SS	6	
	- sheet metal piece at about 0.6 m depth		S4	SS	5	
92.0	- becoming very loose, damp, trace silt at about 1.7 m depth		S5A	SS	2	
2.6			S5B	SS	2	
	SAND & SILT - very loose, brown, moist		S6	SS	3	
	- becoming wet at about 3.2 m depth		S7	SS	2	▽
	- trace clay, trace organics at about 3.8 m depth					
89.6			S8A	SS	1	
5.0	**GRAVELLY SAND** - compact, grey, wet, trace silt		S8B	SS	17	
	- becoming very loose to loose at about 5.3 m depth		S9	SS	4	
88.3						
6.3	**SILTY CLAY** - very stiff, grey, moist, trace to some gravel, trace sand		S10	SS	2	
86.8						
7.8	**CLAYEY SILT** - stiff, grey, moist, trace gravel, trace to some sand		S11	SS	12	
	- becoming firm, wet at about 8.4 m depth		S12	SS	5	
	- cobbles noted during augering from about 10.4 m to 10.7 m depth		S13	SS	9	
			S14	SS	11	
	- cobbles noted during augering from about 12.8 m to 13.1 m depth					
80.7			S15	SS	77	
13.9	**SILT & SAND TILL** - very dense, grey, moist, trace to some gravel					
	- becoming dense, wet, occasional interbedded 50 mm clay seams at about 15.4 m depth		S16	SS	49	
	- cobbles noted during augering at about 18.0 m depth					
	- becoming very dense, some clay at about 18.5 m depth		S17	SS	110	
	- becoming sandy, some clay to clayey at about 21.8 m depth		S18	SS	71	
	- trace clay at about 24.6 m depth		S19	SS	120	

Continued Next Page



UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
		86		(14)
		61		(39)
		26	65	(9)
		10	36	(54)
		2	30	48	20

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH1 2 OF 2 METRIC

W.P. GWP No. 5236-06-00 LOCATION **Otasawian River Bridge (Site No. 39W-002) - GEOCRES No. 42F-23** ORIGINATED BY EF

DIST Twp Kohler HWY 11 BOREHOLE TYPE CME 55 Trailer Mount / HSA COMPILED BY DMT

DATUM **Local** DATE 7.13.11 - 7.17.11 CHECKED BY AM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	"N" Value / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT & SAND TILL continued - cobbles noted during augering at about 26.2 m depth		S20	SS	139		68				
			S21	SS	107		66				
			S22	SS	138		64				
			S23	AUGER			62				
59.0			S24	SS	119		60				
35.6	**End of Borehole** - refusal to auger and SPT Notes: - borehole caved below about 7.0 m depth - borehole backfilled with cuttings to about 2.1 m depth - borehole backfilled with bentonite between about 0.3 m and 2.1 m depth - borehole backfilled with cuttings from ground surface to 0.3 m depth										

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

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2 1 OF 2 METRIC

W.P. GWP No. 5236-06-00 LOCATION Otasawian River Bridge (Site No. 39W-002) - GEOCRES No. 42F-23 ORIGINATED BY EF

DIST Twp Kohler HWY 11 BOREHOLE TYPE CME 55 Trailer Mount / HSA / NQ COMPILED BY DMT

DATUM Local DATE 7.12.11 - 7.14.11 CHECKED BY AM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.3	Sand & Silt				
0.0	**SAND & SILT** - very loose, light brown, wet, trace gravel, fine grained, roots and rootlets	S1	AUGER		
90.7	- becoming dark brown at about 0.5 m depth	S2	SS	2	61 (39)
1.5	- becoming brown, trace organics at about 0.8 m depth	S3	SS	1	70 (30)
	SILTY SAND - very loose to loose, brown, wet, trace organics	S4	SS	2	
88.5	- becoming dark brown, trace gravel, wood pieces at about 3.1 m depth	S5	SS	6	2 75 (23)
3.8	**GRAVELLY SAND** - loose, brown, wet, some silt	S6	SS	9	33 49 (18)
87.7					
4.6	**SILT & SAND** - compact, grey, wet, trace gravel, trace to some clay	S7	SS	12	
	- becoming loose at about 5.3 m depth	S8	SS	6	9 35 46 10
	- becoming very loose at about 6.1 m depth	S9	SS	1	
		S10	SS	1	
83.1					
9.2	**SILT & CLAY** - firm, grey, wet, trace to some sand	S11	SS	6	
	- becoming hard at about 10.7 m depth	S12	SS	43	
	- becoming wet, occasional seams of hard clay at about 12.2 m depth	S13	SS	43	
78.5					
13.7	**SAND & SILT TILL** - very dense, grey, moist, trace gravel, some clay	S14	SS	54	5 42 (53)
	- difficult drilling, some soft interbedded layers noted at about 14.3 m depth	S15	SS	100	
		S16	SS	100	
		S17	SS	100	
	- trace to some gravel at about 19.8 m depth	S18	SS	102	
	- difficult drilling, some soft interbedded layers noted at about 20.4 m depth	S19	SS	106	
		S20	SS	132	
	- cobbles noted during augering from about 23.8 m to 24.1 m depth				
	- 130 mm very dense interbedded silt seam at about 24.4 m depth	S21	SS	95	

Continued Next Page

"N" Value 20 40 60 80 100

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

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

ELEVATION SCALE 92 90 88 86 84 82 80 78 76 74 72 70 68

GROUND WATER CONDITIONS

$+^3, \times^3$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No BH2 2 OF 2 METRIC

W.P. GWP No. 5236-06-00 LOCATION Otasawian River Bridge (Site No. 39W-002) - GEOCRES No. 42F-23 ORIGINATED BY EF

DIST Twp Kohler HWY 11 BOREHOLE TYPE CME 55 Trailer Mount / HSA / NQ COMPILED BY DMT

DATUM Local DATE 7.12.11 - 7.14.11 CHECKED BY AM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	"N" Value / SHEAR STRENGTH kPa / WATER CONTENT (%)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND & SILT TILL continued		S22	SS	101		66				
			S23	SS	83		64				
			S24	SS	77		62				
			S25	SS	100						
			S26	SS	77		60				
			S27	SS	78		58				
54.7	- refusal to auger and SPT at about 37.5 m depth						56				
37.5	**BEDROCK** - medium strong, severely fractured (RQD = 18%), greenish grey, coarse grained, pink stringers, some quartz pockets and stringers, recovery = 89%		S28	CORE			54				
	- becoming severely fractured to fractured (RQD = 50%), recovery = 100% at about 38.7 m depth		S29	CORE							
51.4	- becoming fractured (RQD = 64%), recovery = 100% at about 39.8 m depth		S30	CORE			52				
40.9	**End of Borehole**										

Notes:
- borehole backfilled with cuttings to about 2.0 m depth
- borehole backfilled with bentonite between about 0.3 m and 2.0 m depth
- borehole backfilled with cuttings from ground surface to 0.3 m depth

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

$+^3$, $\times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH3 1 OF 1 METRIC

W.P. GWP No. 5236-06-00 LOCATION Otasawian River Bridge (Site No. 39W-002) - GEOCRES No. 42F-23 ORIGINATED BY EF

DIST Twp Kohler HWY 11 BOREHOLE TYPE CME 55 Trailer Mount / HSA / NQ COMPILED BY DMT

DATUM Local DATE 7.16.11 - 7.17.11 CHECKED BY AM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.2	Sand						
94.0 / 0.2	**SAND** - very loose, brown, damp, trace gravel, some silt, roots and rootlets		S1	AUGER			
			S2	AUGER			
	SILTY CLAY - firm, brown, moist, trace gravel, trace sand		S3	SS	5		
	- becoming brown to grey, trace organics in upper 2.3 m at about 0.8 m depth		S4	SS	6		
	- becoming soft, moist to wet at about 2.3 m depth		S5	SS	1	▽	
	- becoming firm at about 3.1 m depth		S6	SS	7		
	- becoming soft, varved, fine grey sand seams at about 3.8 m depth		S7	SS	2		
89.6 / 4.6	**CLAYEY SILT** - firm to stiff, grey, wet, trace gravel, trace to some sand		S8	SS	6		
			S9	SS	9		
	- becoming soft, some gravel, sandy at about 6.1 m depth		S10	SS	2		19 27 44 10
	- becoming soft at about 7.6 m depth		S11	SS	3		
			S12	SS	2		
			S13	SS	4		
	- becoming firm at about 12.2 m depth		S14	SS	5		11 30 46 13
	- becoming hard, moist at about 13.7 m depth		S15	SS	33		
78.9 / 15.3	**SAND** - loose, grey, wet, trace to some silt, fine grained		S16A	SS	8		
15.4			S16B	SS	14		
	SILT - compact, grey, wet, trace gravel, trace sand, some clay						
77.0	- 80 mm seam of hard grey clay at about 16.8 m depth		S17A	SS	24		
17.2			S17B	SS	18		30 61 (9)
	GRAVELLY SAND - compact, grey, wet, trace silt						
75.9 / 18.3	**SAND & GRAVEL** - very dense, grey, wet, some silt, some cobbles at about 18.3 m depth		S18	SS	100		36 53 (11)
74.8 / 19.4	**BOULDER** - about 300 mm		S19	CORE			
74.7 / 19.5	**SILTY SAND TILL** - very dense, grey, moist, gravelly		S20	SS	193		23 47 (30)
20.0	**End of Borehole** - refusal to SPT						

Notes:
- borehole backfilled with cuttings to about 2.0 m depth
- borehole backfilled with bentonite between about 0.3 m and 2.0 m depth
- borehole backfilled with cuttings from ground surface to 0.3 m depth

ELEVATION SCALE: 94, 92, 90, 88, 86, 84, 82, 80, 78, 76

"N" Value: 20 40 60 80 100

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

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

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity

O^3%: STRAIN AT FAILURE

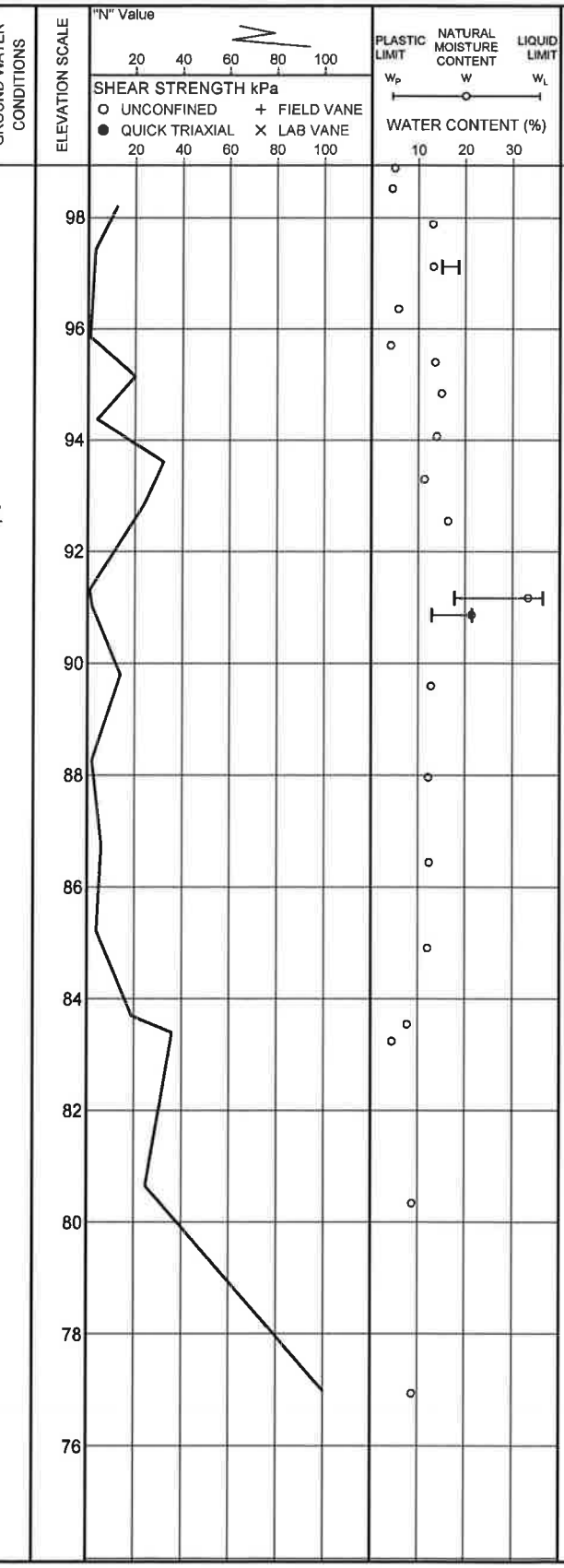
RECORD OF BOREHOLE No BH4 1 OF 2 METRIC

W.P. GWP No. 5236-06-00 LOCATION Otasawian River Bridge (Site No. 39W-002) - GEOCRES No. 42F-23 ORIGINATED BY EF

DIST Twp Kohler HWY 11 BOREHOLE TYPE CME 55 Trailer Mount / HSA / NQ COMPILED BY DMT

DATUM Local DATE 7.18.11 - 7.20.11 CHECKED BY AM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES
98.9	Sand			
98.7 / 0.1	**SAND** - very loose, brown, damp, trace to some gravel, some silt, occasional cobbles, roots and rootlets, asphalt pieces, wood pieces	S1	AUGER	
		S2	AUGER	
		S3	SS	12
	CLAYEY SAND & SILT - stiff, brown, moist, trace gravel - cobbles noted during augering from about 1.4 to 1.6 m depth	S4	SS	3
96.7 / 2.3	- trace organics at about 1.5 m depth	S5	SS	2
95.8 / 3.2	- cobbles noted during augering from about 2.1 m to 2.3 m depth	S6A	SS	1
		S6B	SS	9
95.2 / 3.7	**SAND & SILT** - very loose, brown, wet, trace gravel, trace clay, roots and rootlets	S7	SS	20
94.4 / 4.6	**CLAYEY SILT** - firm, brown, moist, trace gravel, some sand, wood pieces	S8	SS	4
93.8 / 5.2	**SILTY SAND** - compact, brown, wet, trace gravel	S9	SS	32
	SILT & SAND - compact, brown, wet, trace gravel, interbedded silt layers	S10	SS	24
91.3	**CLAYEY SILT** - firm, grey, moist, trace gravel, trace sand			
91.0 / 7.9	**SILT & SAND** - dense, grey, moist, some gravel, trace to some clay - becoming compact, wet at about 6.1 m depth	S11A	SS	1
		S11B	SS	2
89.8 / 9.2	**CLAY** - soft, grey, moist, trace gravel, trace sand, some silt			
	SILTY CLAY - soft, grey, moist, trace gravel, some sand - cobbles noted during augering at about 8.4 m depth	S12	SS	14
	SANDY SILT - compact, grey, wet, trace gravel, trace to some clay - becoming very loose at about 10.7 m depth	S13	SS	2
	- becoming loose at about 9.1 m depth	S14	SS	6
	- becomng very loose to loose at about 13.7 m depth	S15	SS	4
83.4 / 15.6	**SANDY SILTY GRAVEL TILL** - very dense, grey, moist	S16A	SS	19
		S16B	SS	36
80.6 / 18.3	**SAND TILL** - compact, grey, wet, some gravel to gravelly, some silt - cobbles and boulders noted during augering from 18.3 m to 22.0 m depth	S17	SS	25
77.0 / 22.0	**BOULDERS & COBBLES**	S18	SS	100
		S19	CORE	
		S20	CORE	
		S21	CORE	



GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
		4	40	45	11
		1	76	(23)	
		4	45	(51)	
		11	37	(52)	
▽					
		4	24	(72)	
		9	33	(58)	
		40	29	(31)	
		20	63	(17)	

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

O3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH4 2 OF 2 METRIC

W.P. GWP No. 5236-06-00 LOCATION **Otasawian River Bridge (Site No. 39W-002) - GEOCRES No. 42F-23** ORIGINATED BY EF

DIST Twp Kohler HWY 11 BOREHOLE TYPE CME 55 Trailer Mount / HSA / NQ COMPILED BY DMT

DATUM **Local** DATE 7.18.11 - 7.20.11 CHECKED BY AM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	"N" Value / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	w_P w w_L	γ kN/m³	GR SA SI CL
73.7 / 25.2	**End of Borehole**						72				

Notes:
- borehole caved below about 11.1 m depth
- borehole backfilled with cuttings to about 7.0 m depth
- borehole backfilled with bentonite between about 5.8 m and 7.0 m depth
- borehole backfilled with cuttings to about 1.5 m depth
- borehole backfilled with bentonite between about 0.3 m and 1.5 m depth
- borehole backfilled with cuttings from ground surface to 0.3 m depth

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

WATER CONTENT (%): 10 20 30

$+^3$, $\times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE