



**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
for**

**BAUDETTE - RAINY RIVER BRIDGE REPLACEMENT
MNDOT BRIDGE NO. 39016 / MTO SITE NO. 45-110
MN TH 72 / HIGHWAY 11
MNDOT PROJECT NO. SP 3905-09
MNDOT CONTRACT NO. 02047
GWP 6046-08-00
RAINY RIVER, ONTARIO**

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PML Ref.: 14TF020
Index No.: 039FIR and 040FDR
GEOCRES No.: 52D-28
December 21, 2016



PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

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PART A- PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

Baudette - Rainy River Bridge Replacement
MnDOT Bridge No. 39016 / MTO Site No. 45-110
MN TH 72 / Highway 11
MnDOT Project No. SP 3905-09
MnDOT Contract No. 02047, GWP 6046-08-00
Rainy River, Ontario

1. INTRODUCTION

Peto MacCallum Ltd. (PML) has been retained by Stantec Consulting Services Inc. (Stantec) on behalf of the Minnesota Department of Transportation (MnDOT) and Ministry of Transportation of Ontario (MTO) to conduct a foundation investigation for a bridge replacement over the Rainy River, located at the border crossing of Baudette, Minnesota, United States of America (US), and Rainy River, Ontario, Canada. The Baudette-Rainy River Bridge, known as MnDOT Bridge No. 39016 or MTO Site No. 45-110, connects the Minnesota Trunk Highway (MN TH) 72 and the Ontario Provincial Highway 11 (Kings Highway).

The Baudette - Rainy River Bridge is located at the confluence of the Baudette River and the Rainy River, and is aligned in the southwest-northeast direction. The southwest portion of the bridge is situated within the limits of the Town of Baudette in Lake of the Woods County, Minnesota, while the northeast portion is part of the Township of Rainy River, Ontario. Currently, this bridge provides access to and from the Town of Baudette and the Town of Rainy River. It also serves as one of the land links between the US and Canada, with border patrol facilities located at each end of the bridge. It is understood that the bridge is owned and maintained by the State of Minnesota and the Province of Ontario under a joint ownership agreement.

The location of the existing bridge is given on a site plan provided on Drawing RR-1 in Appendix A.

The contract agreement for this project requires that foundation investigations for the proposed replacement bridge need to be undertaken separately on the US and Canadian sides. Based on this, a foundation investigation consisting of three (3) boreholes was completed by others on the US side of the bridge in 2013, and a Technical Memorandum was issued on April 13, 2016.

The purpose of the foundation investigation by PML was to identify the subsurface conditions on the Canadian side of the proposed bridge alignment, and provide geotechnical recommendations



for the preliminary design of the bridge based on the interpretation of the borehole information and laboratory test results. The investigation consisted of advancing boreholes adjacent to the proposed pier locations and abutment, as well as at the approach embankment.

2. SITE DESCRIPTION

At the bridge location, the Rainy River flows from southeast to northwest, and is about 350 m (1148.3 ft.) wide. The water level in the river during fieldwork in August 2016 was at El. 322.9 m (1059.4 ft.). The top of the approach embankment on the Canadian side was about at El. 328 m (1076.1 ft.). Both the north and south slopes of this approach embankment were at 2H:1V, and were moderately vegetated with grass, shrubs and few trees. On the south side, access to the lower part of the approach embankment and abutment area was through private properties. At the toe of the embankment, a drainage ditch existed, discharging into the Rainy River.

The banks of the Rainy River at the bridge location are approximately 3 m (10 ft.) high with relatively gentle slopes. Vegetation along the banks mainly consists of grass, small shrubs and trees. There are no rock outcrops, and the terrain near the bridge is relatively flat.

A railway bridge that stretches along the same southwest-northeast direction is located approximately 85 m (280 ft.) north of the existing bridge.

Photographs (Photographs P1 – P6) of the site and existing bridge are provided in Appendix B.

3. FIELD INVESTIGATION PROCEDURES

The fieldwork for the foundation investigation consisted of drilling six (6) boreholes during the period of August 3, 2016 to August 11, 2016. Boreholes 16-1, 16-2 and 16-3 were drilled in the river to depths in the range of 20.5 m (67.3 ft.) to 31.1 m (102 ft.) below the top of the drilling platform. The other three (3) boreholes (16-4, 16-5 and 16-6) were drilled at the top and near the toe of the approach embankment, to depths between 3.7 m (12.1 ft.) and 12.8 m (42 ft.) from the existing grade. Drawings RR-1 and RR-2 in Appendix A present the location of boreholes relative to piers and the abutment. Table 1 provides the depth of boreholes and conditions at termination.

Attempt was made to locate the boreholes in the river as close as to the pier locations of the proposed bridge. However, anchoring the barge at the planned borehole locations was difficult due



to the presence of strong currents. In addition, access to location of Borehole 16-3 at the bridge abutment was difficult and the borehole was moved to the river as shown on Drawings RR-1 and RR-2 (Appendix A). Borehole locations were established and staked out in the field by PML staff.

TABLE 1 - BOREHOLE LOCATIONS, DEPTH AND TERMINATION CONDITIONS

BOREHOLE NO.	BOREHOLE LOCATION	RIVER BOTTOM / GROUND SURFACE (m)	DEPTH FROM DRILLING PLATFORM / EXISTING GRADE (m)	REMARK
16-1	In the River, Near Proposed Pier	316.2 (1037.4 ft.)	31.1 (102 ft.)	Refusal
16-2	In the River, Near Proposed Pier	316.3 (1037.7 ft.)	20.5 (67.3 ft.)	Refusal
16-3	In the River, Near the Abutment	321.9 (1056.1 ft.)	22 (72.2 ft.)	Refusal
16-4	Top of the Approach Embankment	328.3 (1077.1 ft.)	12.8 (42 ft.)	Competent Soil
16-5	Toe of the Approach Embankment	324.4 (1064.3 ft.)	8.2 (26.9 ft.)	Competent Soil
16-6	On Abandoned Road	325.0 (1066.3 ft.)	3.7 (12.1 ft.)	Below Fill

All three boreholes located in the river were advanced using a CME-750 all-terrain drill rig, mounted on a spud barge and directed by a tugboat. These boreholes were advanced by wash boring and tri-coning with 75 mm (2.95 in.) diameter (NW) casing. NQ size diamond coring was used to advance the boreholes through hard layers containing cobbles and boulders.

Boreholes located at the top and toe of the approach embankment were drilled using a hollow stem auger powered by a track-mounted CME-55 drill rig. Both CME-750 and CME-55 drill rigs were supplied and operated by RPM Drilling Inc. (RPM), a specialist-drilling contractor based in Thunder Bay, Ontario. LTL Contracting Ltd. under contract to RPM supplied the barge and tugboat. The fieldwork was completed under the full time supervision of a PML field staff.

Soil samples were obtained at selected intervals using a split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedures described in ASTM D1586. The drilling rigs were equipped with a 63.5 kg (140 lb) cathead hammer calibrated to fall freely through 760 mm (30 ft.).



In-situ vane tests were carried out using an MTO 'N'-size vane according to the procedures outlined in ASTM D2573 (Standard Test Method for Field Vane Shear Test), to assess the strength of cohesive soils. Thin wall (Shelby) tube samples of cohesive soils were also obtained in Boreholes 16-2 and 16-3 by pushing hydraulically in accordance with ASTM D1587.

Soil samples were visually examined as they were retrieved from boreholes, and placed in moisture-proof bags and transported to the PML laboratory in Toronto.

The groundwater conditions in boreholes located at the approach embankment were observed during drilling by visual examination of soil samples, sampler and drill rods as the samples were retrieved. The groundwater level upon completion of drilling was measured in open boreholes.

Upon completion of drilling, the boreholes at the approach embankment (Boreholes 16-4, 16-5, and 16-6) were backfilled with drill cuttings and sealed with a bentonite/cement mixture in accordance with the MTO guidelines and MOE Reg. 903 for borehole abandonment. All three boreholes located in the river (Boreholes 16-1, 16-2, and 16-3) were grouted to the full depth upon completion of drilling.

Exp Services Inc. (exp) of North Bay, Ontario, under contract to PML, conducted the surveying of the as-drilled borehole locations, and provided the coordinates in UTM NAD 83 northing and easting. These coordinates were later converted to MTM NAD 83 for use on Record of Borehole Sheets. All the elevations given in this report are orthometric and refer to the height above a reference geoid. A description of the methodology as well as the results of surveying are provided in Appendix C.

4. LABORATORY TESTS

All the soil samples were transported to the PML laboratory, located in Toronto for detailed visual examination and testing. The laboratory tests included the following:

- Natural Moisture Content Determination (73)
- Atterberg Limit Tests (14)
- Grain Size Distribution (13)
- Consolidation (1)

Generally, more than 25% of the recovered samples were submitted for routine (index) laboratory tests such as moisture content determinations, Atterberg limits, and grain size analyses.



Laboratory tests were performed on representative samples of each stratigraphic layer encountered in boreholes. All the laboratory tests were conducted in accordance with MTO procedures, which follow ASTM guidelines with the exception of hydrometer testing (LS-702).

In addition to index tests, a consolidation test was conducted on an undisturbed Shelby tube sample from BH 16-3, at a depth of 7.1 m (23.5 ft.), El. 315.6 m (1035.4 ft.), to determine the consolidation characteristics of clayey soils encountered at the site. The test was carried out according to ASTM D 2435 using one load cycle to a maximum consolidation pressure of 1,600 kPa (232 psi).

Moreover, chemical tests were carried out on three (3) representative soil samples to determine the corrosivity characteristics. The tests were conducted by AGAT Laboratories located in Mississauga, Ontario. These tests included the determination of sulphate, sulphide and chloride contents, pH value, and resistivity. The soil samples were taken from Boreholes 16-1, 16-2 and 16-4.

All laboratory test results are provided on Record of Borehole Sheets given in Appendix D. Results of the grain size distribution tests are presented on Figures GS-1 to GS-6. Atterberg limit test results are provided on Figures PC-1 and PC-2, and the result of the consolidation test is provided on Figure RR-C-1. Results of chemical corrosivity tests are provided in Appendix E.

5. SITE GEOLOGY

Based on the Quaternary Geology map of Fort Frances - Rainy River area published in 2001 by Ontario Geological Survey, the site is located within the Superior Province of the Precambrian bedrock formation. Rock outcrops are reported to be less common, but regional mapping and stratigraphic correlation indicate that the bedrock in the region contains mafic meta-volcanic rocks. In the Rainy River area, these rocks are overlain by glacio-lacustrine tills and glacio-fluvial deposits. The map indicates that the river channel contains alluvial deposits made up of pebbly fine to medium sand. The overburden is primarily clay and silt with occasional sand and gravel.

The thickness of Quaternary sediment containing clay, silt and sand, tend to be greatest adjacent to the river and diminish rapidly to the north-northeast direction. Depths to bedrock of 40 m (131 ft.) to about 50 m (164 ft.) are common along the river's course between Fort Frances and Emo and decrease to 25 m (82 ft.) to 35 m (114 ft.) between Emo and Lake of the Woods.



6. SUBSURFACE CONDITIONS

The subsurface conditions encountered on the Canadian side of the bridge during the course of investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets provided in Appendix D. The site plan and borehole locations are shown on Drawings RR-1 and RR-2 (Appendix A), and a profile along the proposed bridge alignment is provided on Drawing RR-2. The boundaries between the soil strata shown on Drawing RR-2 are established at borehole locations only. The boundaries between and beyond the boreholes, are assumed and may vary from location to location. For complete understanding of the subsurface conditions, the Records of Boreholes 100, 101, and 102 drilled on the US side of the bridge at locations shown on Drawing RR-1, are provided in Appendix F.

In summary, the subsurface at the approach embankment on the Canadian side consisted of 3.5 m (11.5 ft.) to 4.5 m (14.8 ft.) thick fill made up of sand and gravel, clayey silt and silty sand. In Borehole 16-4, the fill is underlain by 800 mm (2.6 ft.) thick layer of buried topsoil and organic materials. Beneath these materials, a silty clay deposit was encountered to the full depth of investigation.

In the river, the upper part of the subsurface consisted of 1.0 m (3.3 ft.) to 6 m (19.7 ft.) thick sand layer. This sand layer was underlain by a silty clay to a depth of 14.0 m (40.7 ft.). Beneath the silty clay, a sand to silty sand deposit was encountered up to the maximum depth of investigation. For classification purposes, the soils at the site are divided into the following soil units.

- a) Topsoil
- b) Silty Sand, Some Gravel (Granular Fill)
- c) Clayey Silt, Some Sand (Embankment Fill)
- d) Organic Deposits
- e) Silty Clay, Some Sand
- f) Sand, Trace Silt
- g) Sand to Silty Sand, Trace Gravel, Trace Clay

6.1. Topsoil

A layer of topsoil was encountered at the ground surface in Boreholes 16-4 and 16-5. The thickness of this topsoil was in the range of 100 mm (0.3 ft.) to 300 mm (1 ft.).



6.2. Silty Sand, Some Gravel (Granular Fill)

The granular fill in Boreholes 16-5 and 16-6, was composed of silty sand with varying proportions of gravel and clay. The fill was also mixed with organics, and was dark brown and moist. The thickness ranged from 2.2 m (7.2 ft.) to 2.8 m (9.2 ft.), extending to El. 322.2 m (1057.1 ft.).

The SPT "N"-values in the silty sand fill varied from 2 to 9 blows/300 mm (blows/foot), indicating very loose to loose state of compaction.

The moisture content of samples from this fill varied between 21.2% and 27.6%. The grain size analysis performed on a sample from Borehole 16-6 resulted in 13% gravel, 57% sand, 25% silt, and 5% clay. The grain size distribution curve is provided on Figure GS-2, in Appendix D.

6.3. Clayey Silt, Some Sand (Embankment Fill)

A sand and gravel fill underlain by a layer of clayey silt fill was encountered in Borehole 16-4 drilled at the top of the approach embankment. The sand and gravel layer in the upper part was grey to dark brown in color and very loose. The clayey silt underneath contained some sand, trace gravel, and organic inclusions. The bottom part consisted of sand and gravel with cobbles. The total thickness of the fill was 4.4 m (14.4 ft.), extending to El. 323.8 m (1062.3 ft.).

The moisture content of samples from this fill was in the range of 11.8% to 18.5%. Atterberg limit tests of a sample of the clayey silt fill taken from Borehole 16-4 provided a liquid limit of 32 and a plastic limit of 13, resulting in a plasticity index of 19. Based on these results, the clayey silt may be classified as inorganic clays of low plasticity (CL) in the Unified Soil Classification System (USCS). The plasticity chart is provided on Figure PC-1, in Appendix D.

A grain size analysis was conducted on a sample of clayey silt fill taken from Borehole 16-4, at a depth of 1.8 m (5.9 ft.), El. 326.5 m (1071.2 ft.). The results indicated 7% gravel, 30% sand, 44% silt and 19% clay. The grain size distribution curve is provided on Figure GS-1, in Appendix D.

6.4. Organic Deposits, Topsoil

A layer of buried topsoil and organic deposits was encountered in Borehole 16-4 beneath the sand and gravel, and clayey silt fill. The depth to this layer was 4.5 m (14.8 ft.), extending to EL. 323.0 m



(1062.3 ft.), and its thickness was 800 mm (2.6 ft.). Organic inclusions and rootlets were also obtained in BH 16-5 and Borehole 16-6 within the silty sand fill, and in Borehole 16-3.

The SPT-“N” value measured within the topsoil in Borehole 16-4 was 8 blows/300mm (blows/foot), indicating stiff consistency. The moisture content of a sample from this layer was 47.9%.

6.5. Sand, Trace Silt

In the river, a sand deposit with varying proportions of gravel and trace silt was encountered below the 800 mm (2.62 ft.) to 900 mm (2.95 ft.) thick alluvial deposit. This sand deposit was encountered in Boreholes 16-1 and 16-2. The depth to this layer from the water surface varied from 8.1 m (26.6 ft.) in Borehole 16-1 to 8.2 m (26.9 ft.) in Borehole 16-2, extending to El. 315.3 m (1034.4 ft.) in both boreholes. The thickness of the sand in Borehole 16-2 was 900 mm (2.95 ft.). However, the thickness of this layer in Borehole 16-1 was observed to be 5.2 m (17 ft.).

The SPT-“N” values measured within the sand layer were in the range of 4 to 12 blows/300mm (blows/foot), indicating a loose to compact state of denseness.

The results of sieve analyses performed on samples taken from Borehole 16-1 and 16-2 indicated that the sand layer was composed of 0% -15% gravel, 83% – 97% sand, and 2% - 3% fines. The results of sieve analyses are presented on Figure GS-3, in Appendix D.

6.6. Silty Clay, Trace to Some Sand

The topsoil in Borehole 16-4 and the silty sand fill in Borehole 16-5 were underlain by a silty clay layer with varying proportions of sand, and trace gravel. In Borehole 16-2, the silty clay layer was found below the sand deposit, and in Borehole 16-3, it was encountered immediately below the riverbed. The depth to this deposit in these boreholes ranged from 2.2 m (7.2 ft.) to 5.3 m (17.4 ft.), extending to El. 322.2 m (1057.1 ft.) and El. 323.0 m (1059.7 ft.). In Borehole 16-3, occasional rounded cobbles were encountered within this deposit. The silty clay was fully penetrated in Boreholes 16-2 and 16-3, and the thickness ranged from 4.4 m (14.4 ft.) to 12.4 m (40.7 ft.). However, drilling on land in Boreholes 16-4 and 16-5 was terminated within this deposit.

The SPT “N”-values ranged from 1 to 30 blows/300 mm (blows/foot) penetration, indicating very soft to very stiff consistency. The high blow counts were observed in Borehole 16-4, and the low



blow counts correspond to the upper part Borehole 16-3. The in-situ vane shear test conducted within this layer in Boreholes 16-3 and 16-5 provided an undrained shear strength (C_u) ranging from 84 kPa (12.2 psi) to 100 kPa (14.5 psi). This indicates a stiff to very stiff consistency.

The moisture content of samples from the silty clay deposit was in the range of 16.6% to 29.5%. The liquid limit values ranged from 33 to 43 and the plastic limits varied from 15 to 20, resulting in plasticity index of 18 to 23. Based on the results of Atterberg limit tests, the silty clay, except Sample SS8 from Borehole 16-4, may be classified as inorganic clays of medium plasticity (CI) in the Unified Soil Classification System (USCS). Sample SS8 may be classified as clay of low plasticity (CL). The corresponding plasticity chart is provided on Figure PC-2, in Appendix D.

The grain size analyses of samples taken from the silty clay deposit indicated the presence of 1% - 8% gravel, 26% - 32% sand, 41% - 53% silt and 20% - 30% clay. The grain size distribution curves are provided on Figure GS-4, in Appendix D.

The result of the consolidation test conducted to determine the compressibility characteristics of the silty clay is given on Figure RR-C-1, in Appendix D. The test result indicated a pre-consolidation pressure of 146 kPa (21 psi) compared to the effective overburden pressure of about 70 kPa (14.5 psi). The computed initial void ratio (e_o) was 0.304 and the compression index (C_c) was 0.153.

During detail design stage, additional consolidation test should be carried out to confirm the consolidation characteristics of soils.

Borehole 16-6 was advanced to a maximum depth of 3.7 m (12.1 ft.) and terminated in a silt layer underlying the fill. This silty layer was mottled grey to brown, wet, compact, and contained trace to some clay and trace sand. The grain size analysis indicated 0% gravel, 10% sand, 80% silt and 10% clay. The grain size distribution curve is provided on Figure GS-4, in Appendix D.



6.7. Sand to Silty Sand

The sand to silty sand deposit was encountered below the sand layer in Borehole 16-1 and underneath the silty clay deposit in Boreholes 16-2 and 16-3. It was intercepted at depths ranging from 13.3 m (43.6 ft.) to 14.0 m (45.9 ft.) and extends to the maximum depth of investigation of 31.1 m (102 ft.), El. 292.3 m (959 ft.). Occasional gravel and cobble layers were intercepted in this sandy deposit. Coring was used below the depth of 18.7 m (61.35 ft.), El. 304.8 m (1000 ft.) to advance Borehole 16-2 through 1.5 m (4.9 ft.) thick hard layer of cobbles and boulders.

The SPT-"N" values in the upper part of the sand to silty sand deposit to approximately El. 309.5 m (1015.4 ft.), were in the range of 11 to 33 blows/300 mm (blows/foot), indicating a "compact" to "dense" state of denseness. Below El. 308.5 m (1012.1 ft.), this sandy deposit was found to be very dense with refusal to drive the split spoon in all boreholes drilled in the river.

The moisture content of the sand to silty sand deposit was in the range of 7.5% to 25.4%. The soil samples were found to be moist to wet and grey in color while they were retrieved.

The grain size analysis of samples from all three boreholes resulted in 0% - 15% gravel, 30% - 93% sand, 26% - 29% silt and 3% clay. However, the test result of a sample from Borehole 16-1 taken at a depth of 13.6 m (44.6 ft.), El. 309.6 m (1015.7 ft.), indicated presence of higher proportion of gravel (41%). The grain size distribution curves are provided on Figure GS-5, in Appendix D.

7. GROUNDWATER

The groundwater level in Borehole 16-1, 16-2 and 16-3 was observed to be at the same level as the river, El. 322.9 m (1059.3 ft.). Groundwater was not encountered in Boreholes 16-4 and 16-6 drilled on the approach embankment. The groundwater level measured immediately after the completion of drilling of Borehole 16-5 was at a depth of 1.5 m (4.9 ft.), El. 322.9 m (1059.4 ft.).

The groundwater level at this site will be influenced by the water level in the river and it may be expected to fluctuate due to seasonal changes and precipitation.



8. CHEMICAL TEST RESULTS

A summary of the corrosivity test results conducted on sand to silty sand and silty clay samples is provided in Table 2. The samples were taken from Borehole 16-1, at El. 295.4 m (969.2 ft.), from Borehole 16-2, at El. 312 m (1023.6 ft.) and Borehole 16-4, at El. 318.8 m (1045.9 ft.). The details of these results and a description of the test method are given in Appendix E.

Table 2 – A Summary of Corrosivity Test Results

BOREHOLE NO.	ELEVATION (m)	SOIL TYPE	SULPHIDE (%)	SULPHATE (µg/g, ppm)	CHLORIDE (µg/g, ppm)	pH	RESISTIVITY (Ohm-cm)
16-1	295.4 (969.2 ft.)	Sand to Silty Sand	<0.05	24	6	9.12	10800
16-2	312 (1023.6 ft.)	Silty Clay	0.53	1160	<4	7.82	909
16-4	318.8 (1045.9 ft.)	Silty Clay	0.34	365	9	8.06	2110



9. CLOSURE

The drilling work was supervised by Mr. Shane Aziz under the direction of Lulseged Yimam, PhD, P.Eng of PML. The drilling equipment was supplied and operated by RPM Drilling Inc. of Thunder Bay, Ontario. The barge and the tugboat were contracted by RPM from LTL Contracting Ltd., based in Thunder Bay, Ontario. The laboratory tests were conducted at the PML laboratory in Toronto. Chemical tests were carried out by AGAT Laboratories of Mississauga, Ontario. Surveying of borehole locations was performed by exp Services Inc. (exp) of North Bay, Ontario.

This report was prepared by Lulseged Yimam, PhD, P.Eng., and reviewed by M. Vasavithasan, M.Sc. Eng., P. Eng., Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



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Senior Engineer, Geotechnical Services



Carlos M.P. Nascimento, P.Eng.
Project Manager and
MTO Designated Principal Contact

LY/MV/CN:nk

Part A – Preliminary Foundation Investigation Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 039FIR

PML Ref.: 14TF020, December 21, 2016



APPENDIX A

Site Plan

Borehole Locations and Soil Strata

G.W.P. No. 6046-08-00
MnDOT Contract No. 02047
MnDOT Project No. SP 3905-09
**BAUDETTE – RAINY RIVER
BRIDGE REPLACEMENT
SITE PLAN**



SHEET

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS



KEY PLAN
250m 0 250m 500m 750m 1km 1.25km

LEGEND

- Borehole
- Borehole by Others

BH No	ELEVATION	NORTHINGS	EASTINGS
16-1	323.5	5 398 800.7	408 532.3
16-2	323.4	5 398 847.0	408 601.9
16-3	323.5	5 398 878.2	408 642.0
16-4	328.3	5 398 915.9	408 681.4
16-5	324.4	5 398 892.0	408 689.4
16-6	325.0	5 398 884.0	408 688.6
Boreholes by Others			
B100	324.3	5 398 713.9	408 393.1
B101	324.4	5 398 746.7	408 442.1
B102	324.3	5 398 777.5	408 488.0

— NOTE —
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

DATE	BY	DESCRIPTION

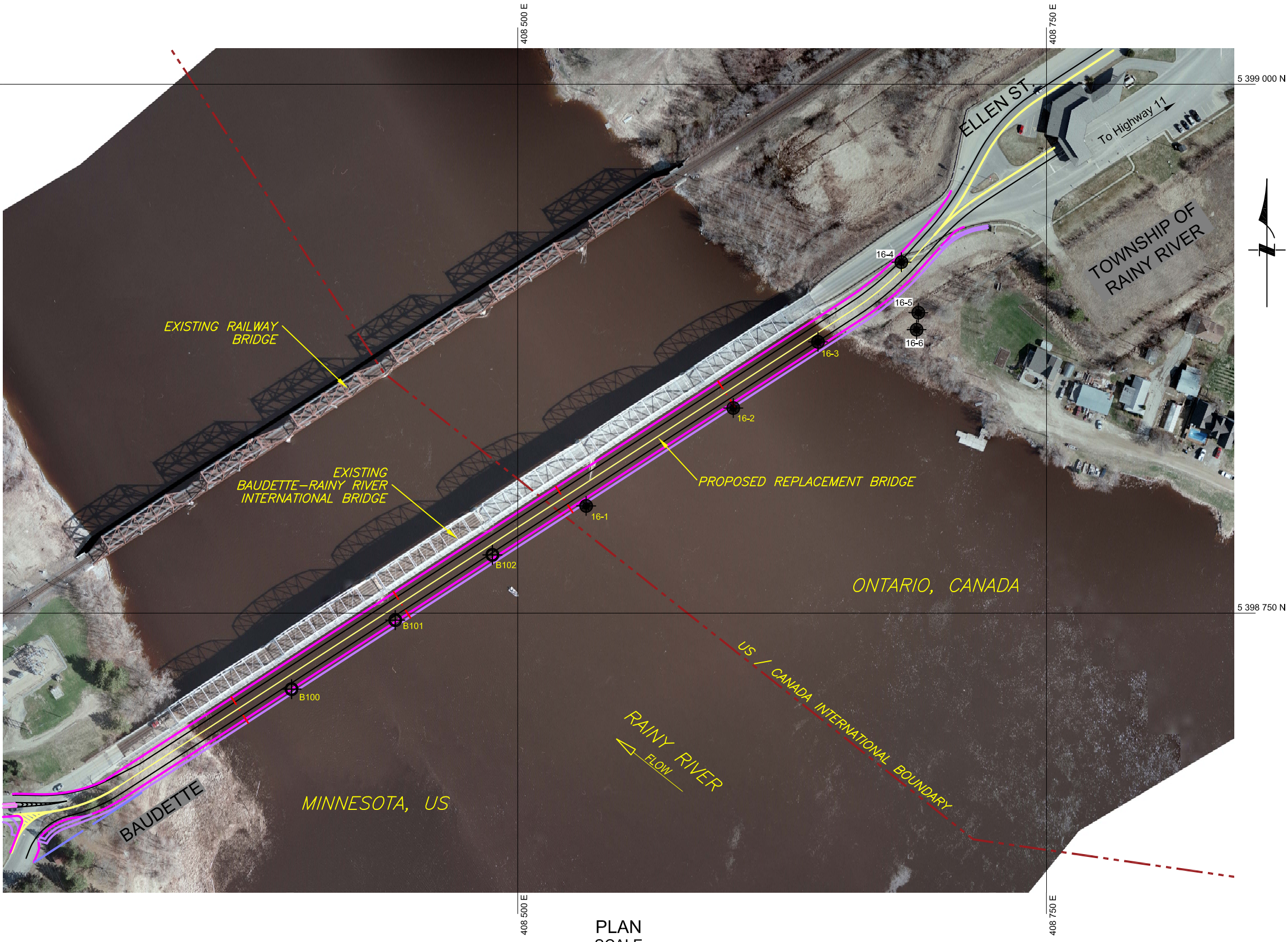
Geocres No. 52D-28			
HWY No.	11	DIST.	THUNDER BAY
SUBMD	NA	CHECKED	LY
DATE	DEC. 20, 2016	MTD	SITE No. 45-110
DRAWN	NA	CHECKED	MV
APPROVED	CN	DWG	RR-1

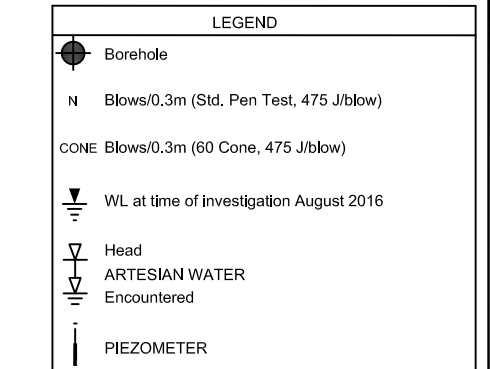


REF Drawing: cd3905-009_gm1c_mtmnad83.dwg Undated

NOTES:

- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.
- ELEVATION OF BOREHOLES 16-1, 16-2 AND 16-3 ARE MEASURED AT THE CENTRE OF THE PLATE INSTALLED ON DRILLING PLATFORM OVER THE BOREHOLE LOCATION.

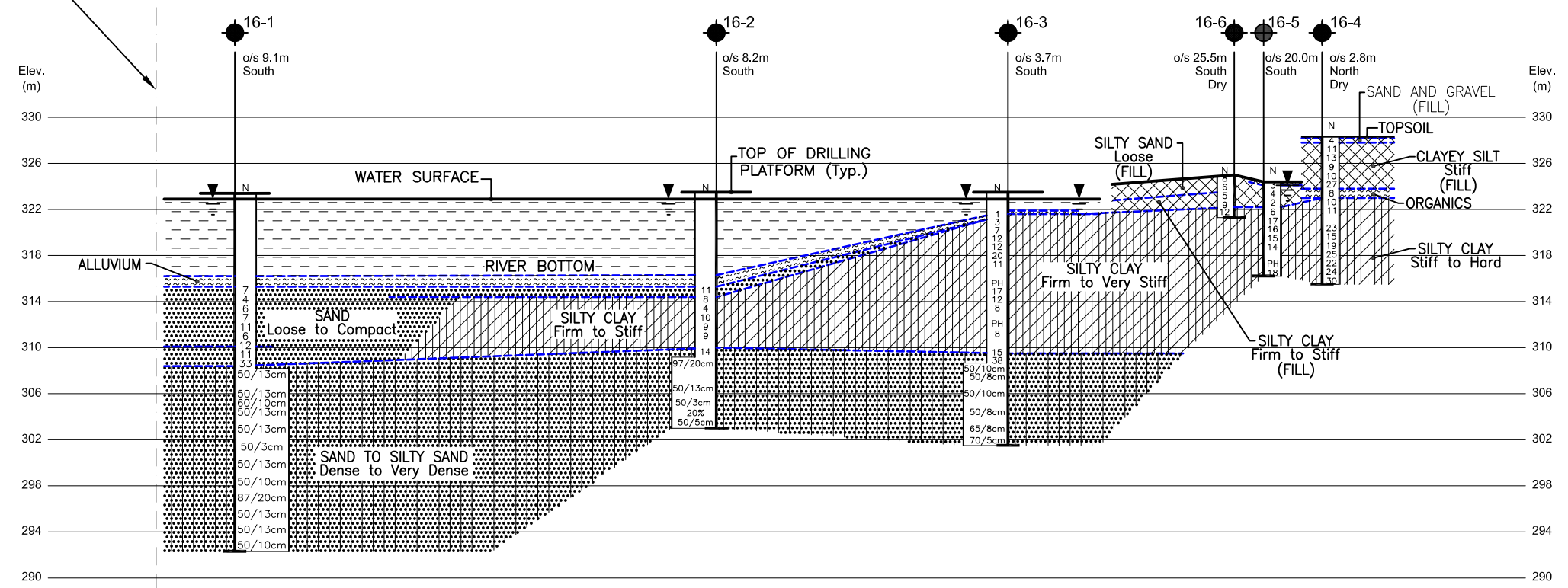




- NOTE -

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

Geocres No. 52D-28



SCALE
HORIZONTAL

10 0 10 20m

VERTICAL

5 0 5 10m

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

Part A – Preliminary Foundation Investigation Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 039FIR

PML Ref.: 14TF020, December 21, 2016



APPENDIX B

Site Photographs

Part A – Preliminary Foundation Investigation Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 039FIR

PML Ref.: 14TF020, December 21, 2016



Photograph P1 – Looking North at the Canadian Side of the Baudette – Rainy River Bridge (August 3, 2016).



Photograph P2 – Looking East at Drilling Set-up of Borehole 16-2 (August 3, 2016).



Photograph P3 – Drilling Borehole 16-2 (August 3, 2016).

Part A – Preliminary Foundation Investigation Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 039FIR

PML Ref.: 14TF020, December 21, 2016



Photograph P4 – Looking West at Drilling of Borehole 16-4, Located at the top of the Approach Embankment (August 11, 2016).

Part A – Preliminary Foundation Investigation Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 039FIR

PML Ref.: 14TF020, December 21, 2016



Photograph P5 – Looking East from the Bridge at the Abutment area and the South Side of the Approach Embankment Slope (August 11, 2016).

Part A – Preliminary Foundation Investigation Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 039FIR

PML Ref.: 14TF020, December 21, 2016



Photograph 6 – Drilling Setup of Borehole 16-5, Toe of the Approach Embankment (August 10, 2016).

Part A – Preliminary Foundation Investigation Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 039FIR

PML Ref.: 14TF020, December 21, 2016



APPENDIX C

Borehole Surveying Methodology Description



Peto MacCullum Ltd- Boreholes in Rainy River, ON

Methodology:

To determine the position of the borehole locations with a horizontal and vertical accuracy of 0.003 meters (m) Real time Kinetic (RTK) GPS observations were recorded using dual frequency GNSS receivers. To geo-reference the measured borehole locations Static GPS observations were recorded at benchmarks by using two GNSS receivers simultaneously collecting static data at two different Benchmarks. The data files were processed using the Canada Spatial Reference System-Precise Point Positioning service (CSRS-PPP) online application for GNSS data post-processing on the NRCan website. The Static data was further compared to the published survey benchmark data of the Minnesota Ministry of transportation geodetic monuments for benchmarks "Shoemaker-2011" and "Mann-2011".

Equipment:

- Two Dual frequency Trimble GPS Recievers-R8-4069, R8-7770
- TDS Ranger data logger with survey pro (SS71026294)

Project summary:

Linear Unit: Meters (m)

Projection: NAD 83(CSRS) 1997 UTM North –Zone_15

Geoid: CGDV28 (HTv2.0)

The Coordinates and the elevations of the borehole locations are in meters are as follows:

Water surface Elevation: 322.886m

Boreholes on the River:

Benchmark	Grid Northing (m)	Grid Easting (m)	Orthometric Elevation (m)	Description
1	5397485.173	383116.619	323.376	Borehole 1*
2	5397441.670	383045.297	323.466	Borehole 2
3	5397514.823	383157.851	323.462	Borehole 3

* Measured on the center of the plate over the borehole location before the drilling began.

Boreholes on Land:

Benchmark	Grid Northing (m)	Grid Easting (m)	Orthometric Elevation (m)	Description
4	5397550.920	383198.732	328.333	BH 16-4*
5	5397526.762	383205.818	324.386	BH 16-5
6	5397518.735	383204.681	325.042	BH 16-6

*The borehole was not yet drilled when the location was measured.



APPENDIX D

Explanation of Terms used in the Report
Record of Borehole Sheets
Grain Size Distribution - Figures GS-1 to GS-6
Plasticity Charts - Figures PC-1 and PC-2
Consolidation Test Result - Figure RR-C-1

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S SPLIT SPOON	T P THINWALL PISTON
W S WASH SAMPLE	O S OSTERBERG SAMPLE
S T SLOTTED TUBE SAMPLE	R C ROCK CORE
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY
T W THINWALL OPEN	F S FOIL SAMPLE
F V FIELD VANE	

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	e_{max}	1, %	VOID RATIO IN LOOSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	e_{min}	1, %	VOID RATIO IN DENSEST STATE
ρ_w	kg/m ³	DENSITY OF WATER	S_r	%	DEGREE OF SATURATION	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
γ_w	kN/m ³	UNIT WEIGHT OF WATER	w_L	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_p	%	PLASTIC LIMIT	D_n	mm	n PERCENT - DIAMETER
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_s	%	SHRINKAGE LIMIT	C_u	1	UNIFORMITY COEFFICIENT
ρ_d	kg/m ³	DENSITY OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m ³ /s	RATE OF DISCHARGE
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	j	kN/m ³	SEEPAGE FORCE
e	1, %	VOID RATIO						

RECORD OF BOREHOLE No 16-1

1 of 3

METRIC

G.W.P. 6046-08-00

LOCATION

MnDOT No. 02047

Coords: 5 398 800.7 N; 408 532.3 E

ORIGINATED BY S.A.

DIST Thunder Bay

BOREHOLE

TYPE Wash Boring + NW Casing and NQ Coring + Tricone

COMPILED BY L.Y.

DATUM OrthometricHWY

DATE _____

August 05, 2016

CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)					
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL						× LAB VANE					
								20	40	60	80	100						20	40	60			
323.4 0.0	Top of Drilling Platform					▽* ▼	323																
322.9 0.5	Water surface Water						322																
							321																
							320																
							319																
							318																
							317																
316.2 7.2	River bottom Alluvium						316																
315.3 8.1	Sand trace silt, trace gravel Loose to Grey/ Moist compact black to wet		1	SS	7		315					○				0 97 (3)							
			2	SS	4		314					○											
			3	SS	6		313					○											
			4	SS	7		312					○				3 95 (2)							
			5	SS	11		311					○											
			6	SS	6		310					○											
			7	SS	12		309					○											
310.1 13.3	gravel, cobbles		8	SS	11		308					○				41 30 26 3							
	Sand to silty sand trace clay, trace gravel		9	SS	33		307					○											
308.4	Compact to Grey Moist very dense to wet						306					○											
	Cont'd						305					○											

RECORD OF BOREHOLE No 16-1


2 of 3

METRIC

G.W.P. 6046-08-00 LOCATION MnDOT No. 02047 Coords: 5 398 800.7 N; 408 532.3 E ORIGINATED BY S.A.

DIST Thunder Bay BOREHOLE TYPE Wash Boring + NW Casing and NQ Coring + Tricone COMPILED BY L.Y.

DATUM Orthometric HWY 11 DATE August 05, 2016 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa										WATER CONTENT (%)		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
308.4							20	40	60	80	100								
15.0	Sand to silty sand trace clay, trace gravel		10	SS	50/13cm														
	Very dense Grey Moist to wet (Cont'd)																		
			11	SS	50/13cm														

RECORD OF BOREHOLE No 16-1

3 of 3

METRIC

G.W.P. 6046-08-00 LOCATION MnDOT No. 02047 Coords: 5 398 800.7 N; 408 532.3 E ORIGINATED BY S.A.
 DIST Thunder Bay BOREHOLE TYPE Wash Boring + NW Casing and NQ Coring + Tricone COMPILED BY L.Y.
 DATUM Orthometric HWY 11 DATE August 05, 2016 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								<div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE</div>												
293.4								20	40	60	80	100								
30.0	Sand to silty sand trace clay, trace gravel	•					293													
	Very dense Grey Moist to wet (Cont'd)	•																		
292.3		•	20	SS	50/10cm															
31.1	End of borehole	•																		
	<div>* 2016 08 05</div> <div>▽ Water level observed during drilling</div> <div>▼ Water level measured after drilling</div> <div>Bentonite slurry mud used to stabilize borehole from 7.6m to 31.1m depth.</div> <div>Difficult drilling conditions and slow progress from a depth of 16.8m (El. 306.6m) to 31.1m (El. 292.3m).</div> <div>Delay in drilling due to a sand blow at 25.9m (El. 297.5m).</div>																			

RECORD OF BOREHOLE No 16-2

1 of 2

METRIC

G.W.P. 6046-08-00 LOCATION MnDOT No. 02047 Coords: 5 398 847.0 N; 408 601.9 E ORIGINATED BY S.A.
DIST Thunder Bay BOREHOLE TYPE Wash Boring + NW Casing and NQ Coring COMPILED BY L.Y.
DATUM Orthometric HWY 11 DATE August 03, 2016 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
323.5	Top of Drilling Platform							20	40	60	80	100							
0.0						▽* ▽*	323												
322.9	Water surface																		
0.6	Water																		

RECORD OF BOREHOLE No 16-2

2 of 2

METRIC

G.W.P. 6046-08-00

LOCATION

MnDOT No. 02047

Coords: 5 398 847.0 N: 408 601.9 E

ORIGINATED BY S.A.

DIST Thunder Bay

BOREHOLE

TYPE Wash Boring + NW Casing and NQ Coring

COMPILED BY L.Y.

DATUM OrthometricHWY

DATE _____

August 03, 2016

CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
308.5																				
15.0	Sand to silty sand some gravel, trace clay cobbles																			
	Very dense Grey Wet (Cont.d)																			
			9	SS	50/13cm								o							
			10	SS	50/3cm															
	cobbles and boulders		10A	RC HQ	REC 20%															
303.0			11	SS	50/5cm															
20.5	End of borehole Refusal on boulders																			
	 <																			

RECORD OF BOREHOLE No 16-3

1 of 2

METRIC

G.W.P. 6046-08-00 LOCATION MnDOT No. 02047 Coords: 5 398 878.2 N; 408 642.0 E ORIGINATED BY S.A.
 DIST Thunder Bay BOREHOLE TYPE Wash Boring and NW Casing COMPILED BY L.Y.
 DATUM Orthometric HWY 11 DATE August 06, 2016 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× LAB VANE	
323.5	Top of Drilling Platform							20	40	60	80	100						
0.0																		
322.9	Water surface					▽* ▼*	323											
0.6	Water																	
321.9	River bottom						322											
1.6	rootlets, organics wood debris		1	SS	1													
	Very soft Dark Wet to soft brown/ black		2	SS	3		321											
	Silty clay trace sand, trace garvel																	
	Firm to Dark Wet very stiff brown/ black		3	SS	7		320											
			4	SS	12											3 28 44 25		
			5	SS	12		319											
			6	SS	20		318											
			7	SS	11		317											
				FV														
			7A	TW	PH		316									5 27 42 26		
			8	SS	17		315											
			9	SS	12		314											
313.8	rounded cobbles		10	SS	8		313											
9.7				FV														
			10A	TW	PH		312											
			11	SS	8		311									2 13 54 31		
				FV														
				FV			310											
309.5			12	SS	15		309											
14.0	Sand to silty sand trace clay, trace gravel																	
	Dense to Grey Wet Very dense		13	SS	38											8 60 29 3		
308.5																		

RECORD OF BOREHOLE No 16-3

2 of 2

METRIC

G.W.P.	6046-08-00	LOCATION
--------	------------	----------

MnDOT No. 02047

Coords: 5 398 878.2 N; 408 642.0 E

ORIGINATED BY S.A.

DIST Thunder Bay

BOREHOLE TYPE Wash Boring and NW Casing

COMPILED BY L.Y.

DATUM OrthometricHWY

DATE August 06, 2016

CHECKED BY M.V.

[illegible]

RECORD OF BOREHOLE No 16-4

1 of 1

METRIC

G.W.P. 6046-08-00

LOCATION

MnDOT No. 02047

Coords: 5 398 915.9 N; 408 681.4 E

ORIGINATED BY S.A.

DIST Thunder Bay

BOREHOLE TYPE

Continuous Flight Hollow Stem Augers

COMPILED BY L.Y.

DATUM Orthometric HWY 11

DATE

August 11, 2016

CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
					WATER CONTENT (%)												
328.3	Ground Surface						20	40	60	80	100						
0.0	Topsoil																
328.2	Sand and gravel		1	SS	4								○				
0.1	Very loose Grey/ Moist dark brown																
	Clayey silt with sand, trace gravel organic inclusions rootlets, wood debris		2	SS	11								○				
	Stiff Grey/ dark brown		3	SS	13								○			7 30 44 19	
	(FILL)																
			4	SS	9								○				
			5	SS	10								○				
	Sand and gravel, cobbles																
	Compact Grey/ Moist brown		6	SS	27								○				
323.8	Topsoil, rootlets peat inclusions																
4.5	Stiff Dark brown/ Moist black to wet		7	SS	8									○			
323.0																	
5.3	Silty clay with sand, trace gravel cobbles,		8	SS	10								○			8 30 42 20	
	Stiff to Grey/ Moist hard brown		9	SS	11								○				
			10	SS	23								○			1 29 46 24	
			11	SS	15								○				
			12	SS	19								○				
			13	SS	25								○			3 26 46 25	
			14	SS	22								○				
			15	SS	24								○				
			16	SS	30								○				
315.5																	
12.8	End of borehole																
	* Borehole dry																

RECORD OF BOREHOLE No 16-5

1 of 1

METRIC

G.W.P. 6046-08-00 LOCATION MnDOT No. 02047 Coords: 5 398 892.0 N; 408 689.4 E ORIGINATED BY S.A.
 DIST Thunder Bay BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY L.Y.
 DATUM Orthometric HWY 11 DATE August 10, 2016 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										○		
								● QUICK TRIAXIAL × LAB VANE												
324.4	Ground Surface						20	40	60	80	100									
0.0	Topsoil																			
324.1			1	SS	3		324													
0.3	Silty sand, some clay rootlets, organics																			
	Very loose Dark brown/ brown		2	SS	4		323													
	(FILL)		3	SS	2															
322.2																				
2.2	Silty clay with sand, trace gravel		4	SS	6		322													
	Firm to Grey Moist very stiff to wet																			
			5	SS	17		321													
			6	SS	16		320													
			7	SS	15															
			8	SS	14		319													
				FV																
			8A	TW	PH		318													
			9	SS	18		317													
316.2																				
8.2	End of borehole																			
<div>* 2016 08 10</div> <div>▽ Water level observed during drilling</div> <div>▼ Water level measured after drilling</div> <div>PH Pushed hydraulically</div>																				

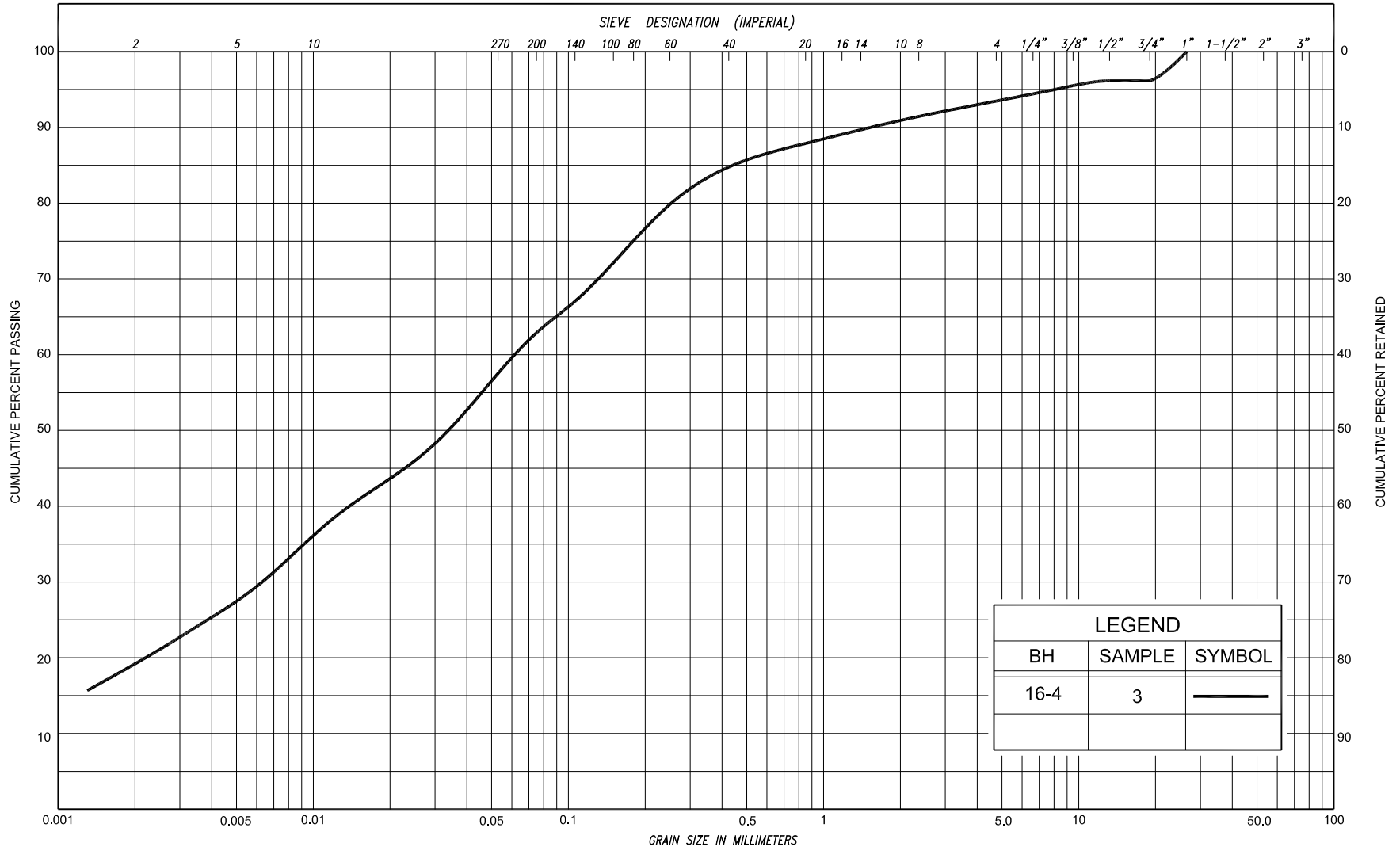
RECORD OF BOREHOLE No 16-6

1 of 1

METRIC

G.W.P. 6046-08-00 LOCATION MnDOT No. 02047 Coords: 5 398 884.0 N; 408 688.6 E ORIGINATED BY S.A.
 DIST Thunder Bay BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY L.Y.
 DATUM Orthometric HWY 11 DATE August 10, 2016 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W _P	W	W _L		GR	SA	SI	CL
325.0	Ground Surface							20	40	60	80	100								
0.0	Silty sand some gravel, trace clay organics, rootlets topsoil inclusions		1	SS	8		324							○					13 57 25 5	
	Loose Grey/ Moist dark brown		2	SS	6										○					
	Silty clay rootlets, topsoil and organic inclusions		3	SS	5										○					
	Firm to Grey/ Moist stiff brown																			
322.2	(FILL)		4	SS	9										○					
2.8	Silt trace sand, trace clay						322												0 10 80 10	
321.3	Compact Mottled Wet grey/brown		5	SS	12										○					
3.7	End of borehole																			
	* Borehole dry																			



SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL		COBBLES	UNIFIED		
				SAND										
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE	GRAVEL	COBBLES	M.I.T.
	SILT													
CLAY		SILT			V. FINE		FINE		MED.		COARSE	GRAVEL		U.S. BUREAU
				SAND										



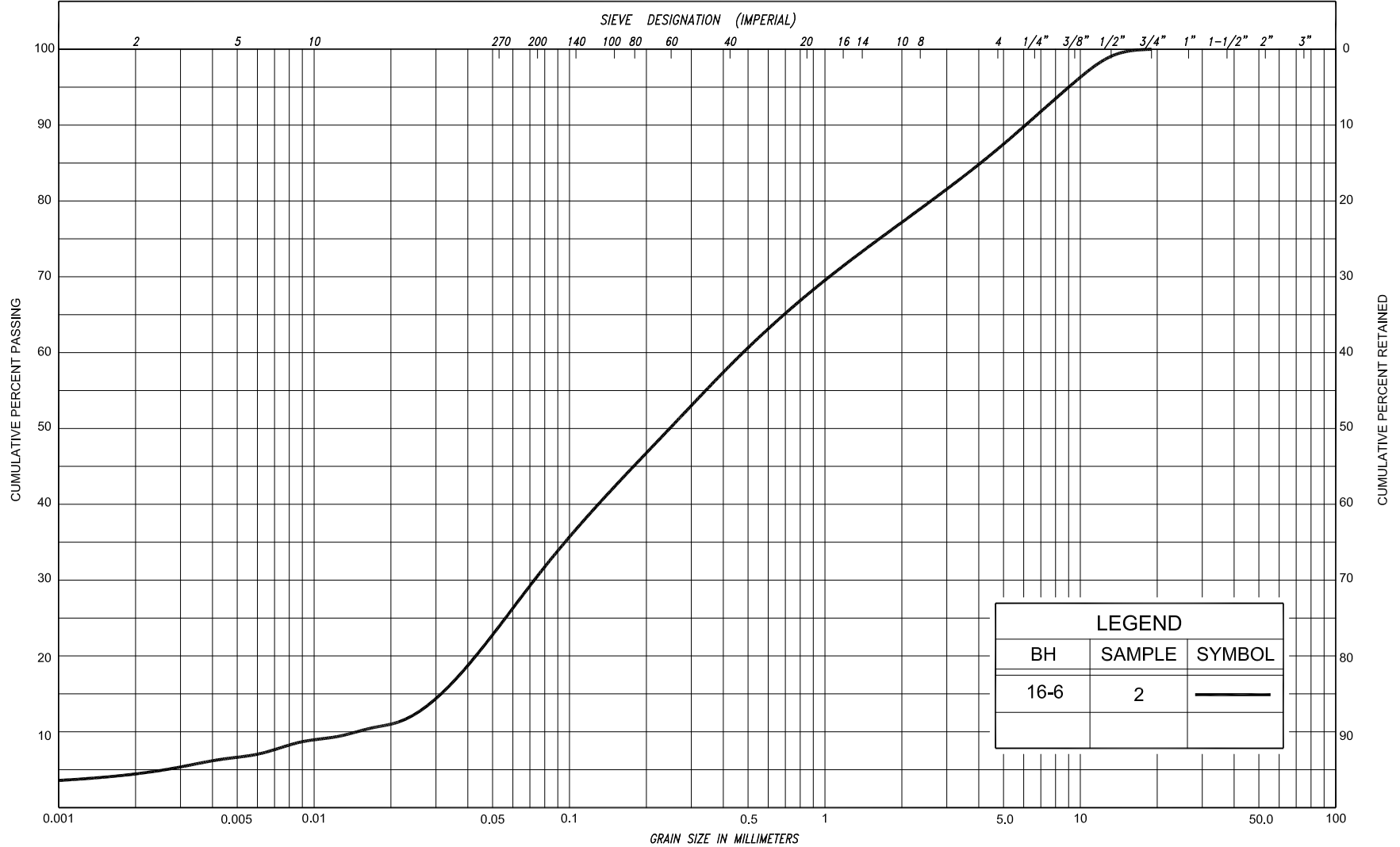
GRAIN SIZE DISTRIBUTION CLAYEY SILT, some sand (CL) (FILL)

FIG No. GS-1

HWY 11

MnDOT No. 02047

G.W.P. No. 6046-08-00

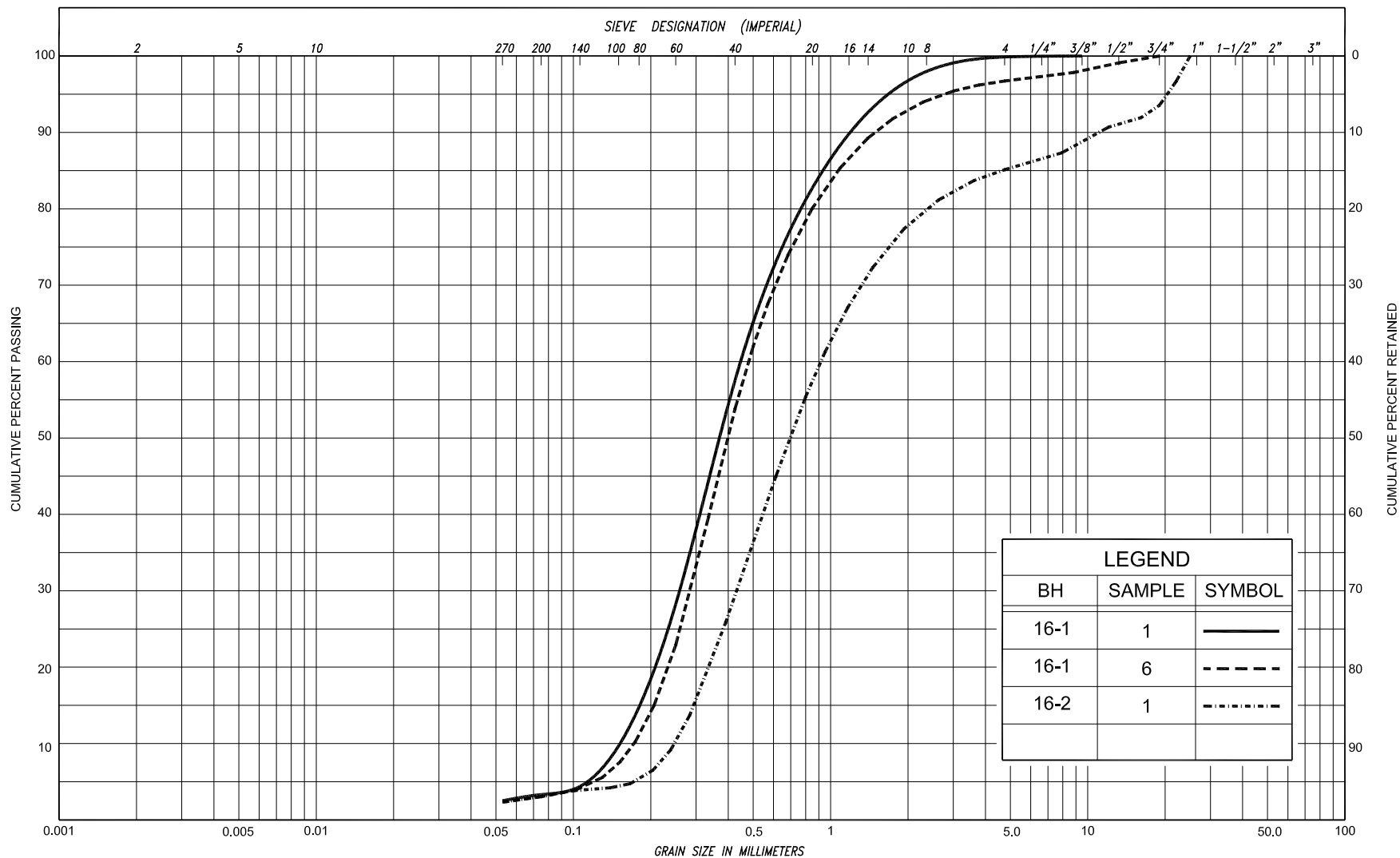


SILT & CLAY				SAND			GRAVEL		COBBLES	UNIFIED
				FINE	MEDIUM	COARSE				
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL		COBBLES	M.I.T.
				SILT						
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL		U.S. BUREAU
				SAND						



GRAIN SIZE DISTRIBUTION SILTY SAND, some gravel (FILL)

FIG No.	GS-2
HWY	11
MnDOT No. 02047	G.W.P. No. 6046-08-00



SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COBBLES	UNIFIED			
					SAND													
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.	
	SILT																	
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL							U.S. BUREAU	
					SAND													

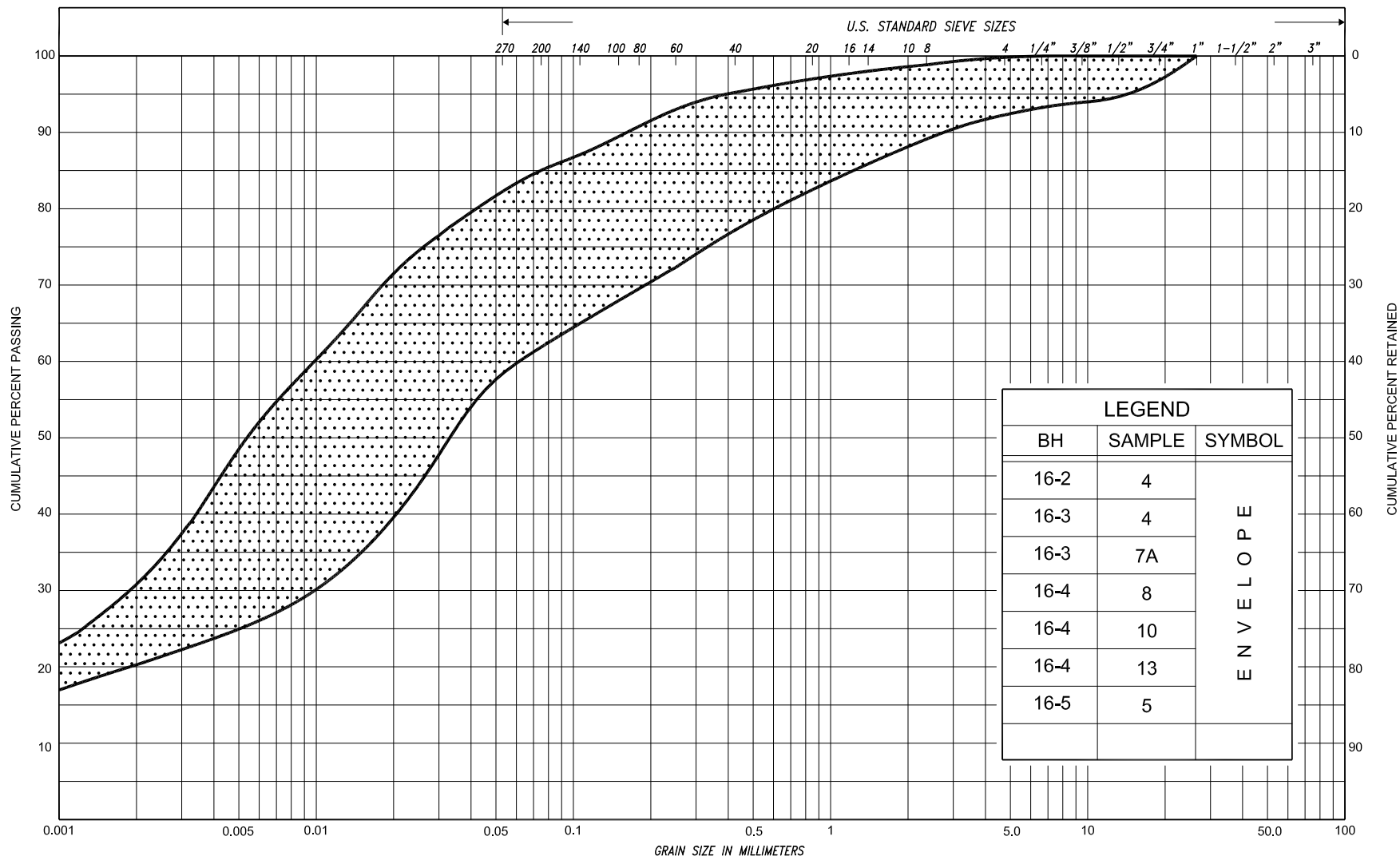


GRAIN SIZE DISTRIBUTION SAND, trace to some gravel, trace silt

FIG No. GS-3

HWY 11

MnDOT No. 02047 G.W.P. No. 6046-08-00



SILT & CLAY					FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED		
					SAND						GRAVEL			COBBLES	M.I.T.	
CLAY	FINE		MEDIUM	COARSE		FINE		MEDIUM		COARSE						
	SILT															
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL						U.S. BUREAU
					SAND											



GRAIN SIZE DISTRIBUTION

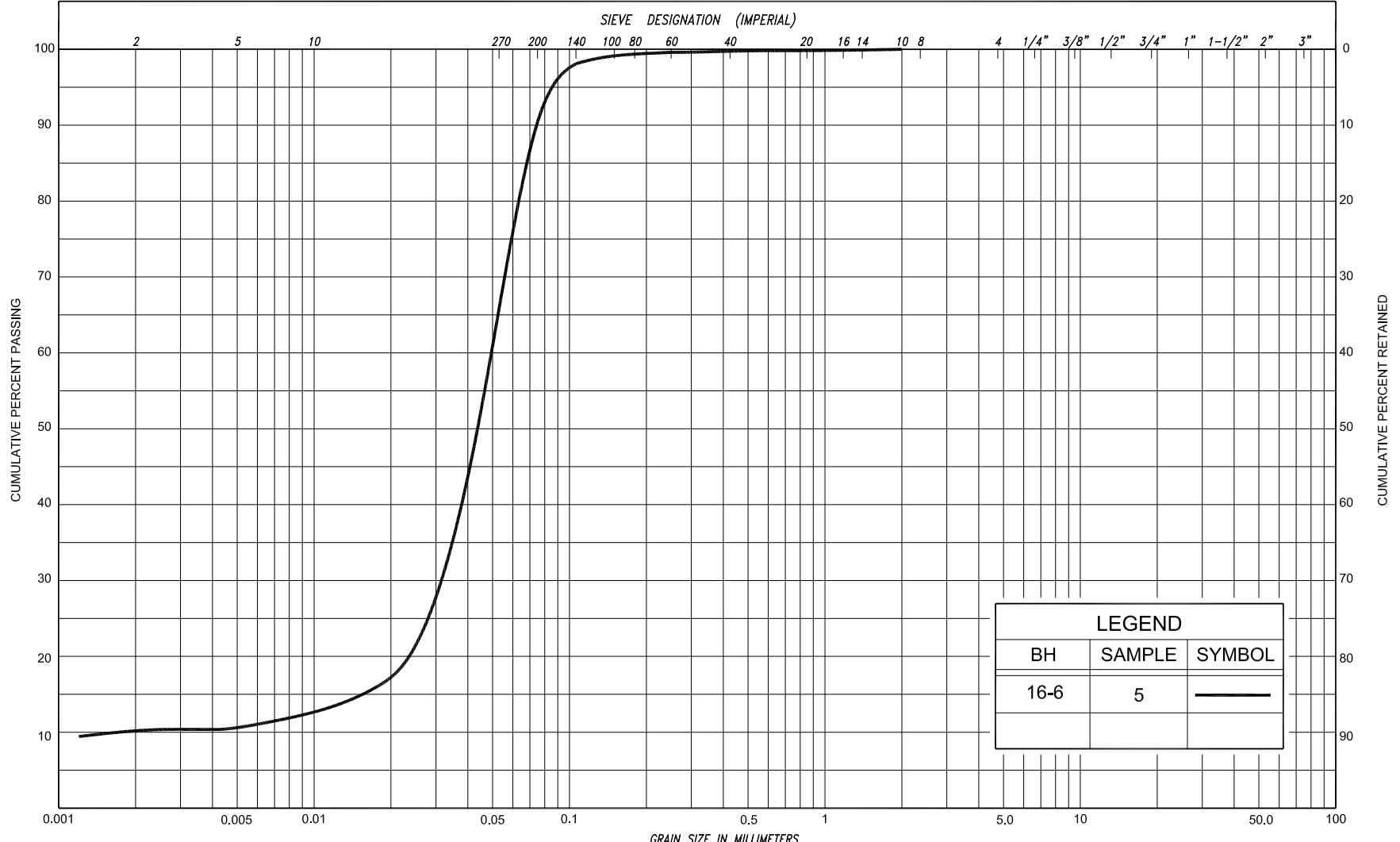
SILTY CLAY, trace to some sand (CI)

FIG No. GS-4

HWY 11

MnDOT No. 02047

G.W.P. No. 6046-08-00



LEGEND		
BH	SAMPLE	SYMBOL
16-6	5	—

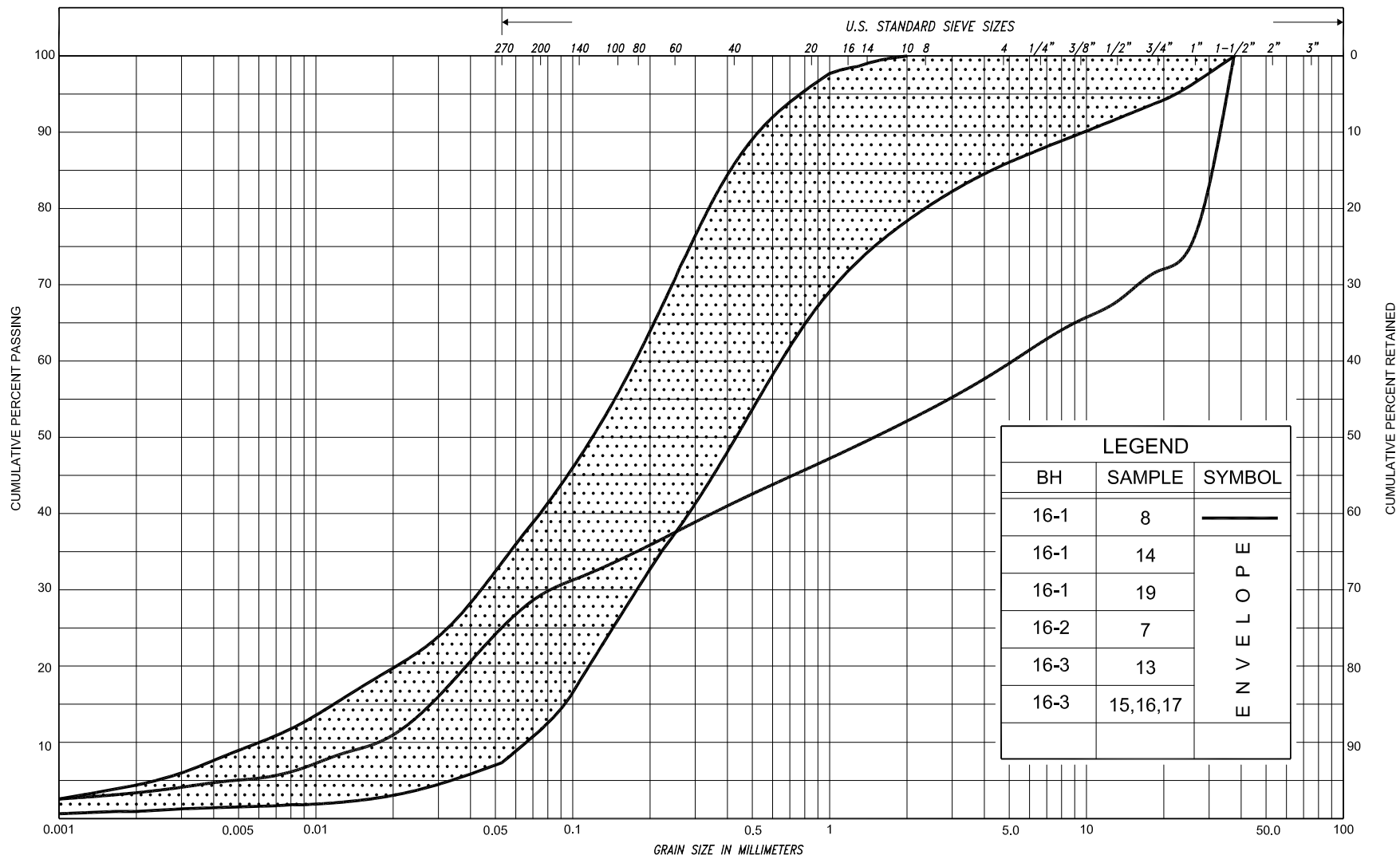
SILT & CLAY					FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED	
CLAY	FINE		MEDIUM		COARSE	FINE		MEDIUM		COARSE	GRAVEL			COBBLES	M.I.T.
CLAY			SILT			V. FINE	FINE	MED.	COARSE	GRAVEL					U.S. BUREAU



GRAIN SIZE DISTRIBUTION

SILT, trace to some clay, trace sand

FIG No.	GS-5
HWY	11
MnDOT No. 02047	G.W.P. No. 6046-08-00



SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COBBLES	UNIFIED		
					SAND												
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT																
CLAY			SILT			V. FINE		FINE		MED.		COARSE		GRAVEL			U.S. BUREAU
						SAND											



GRAIN SIZE DISTRIBUTION

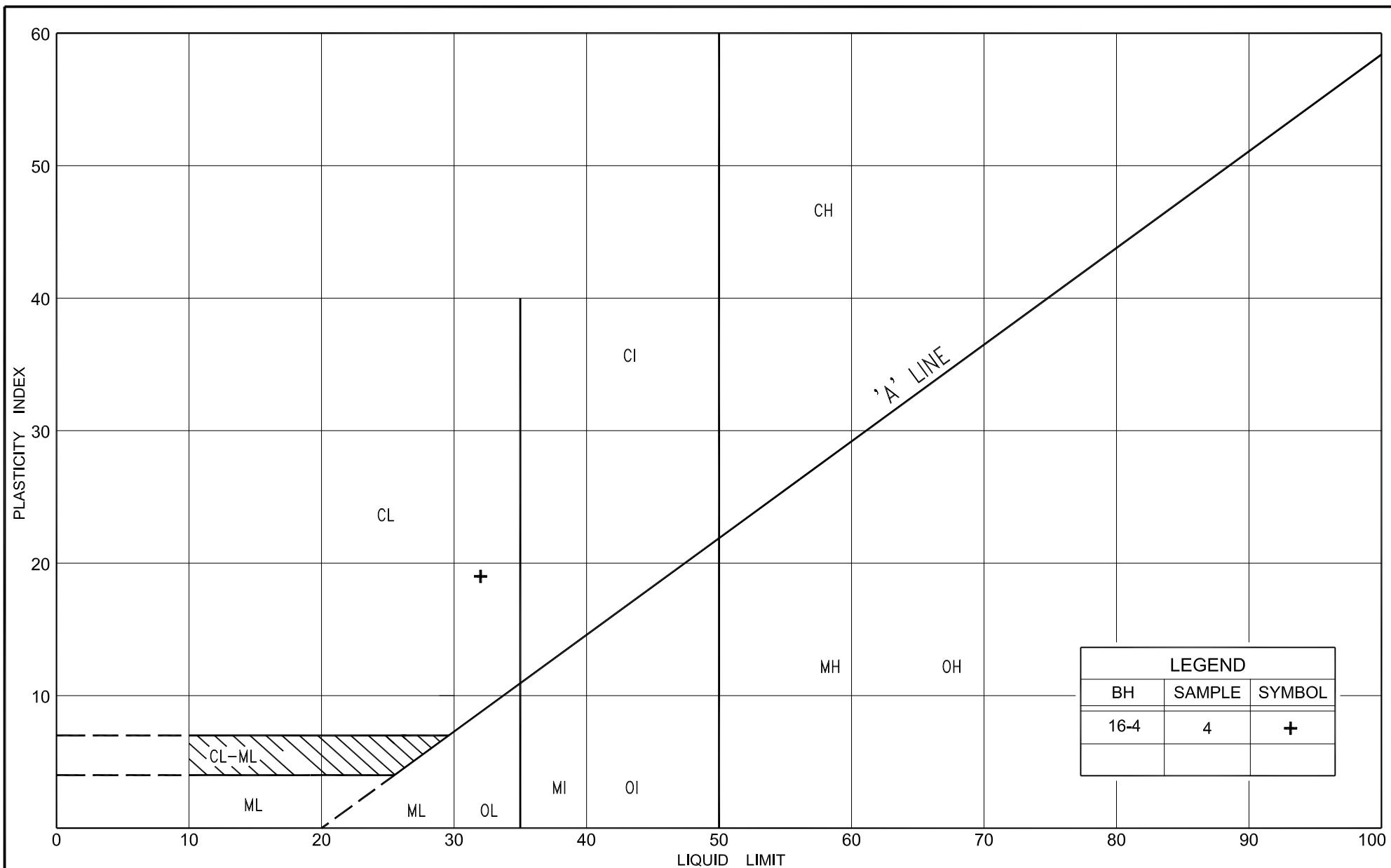
SAND TO SILTY SAND, trace to some gravel, trace clay

FIG No. GS-6

HWY 11

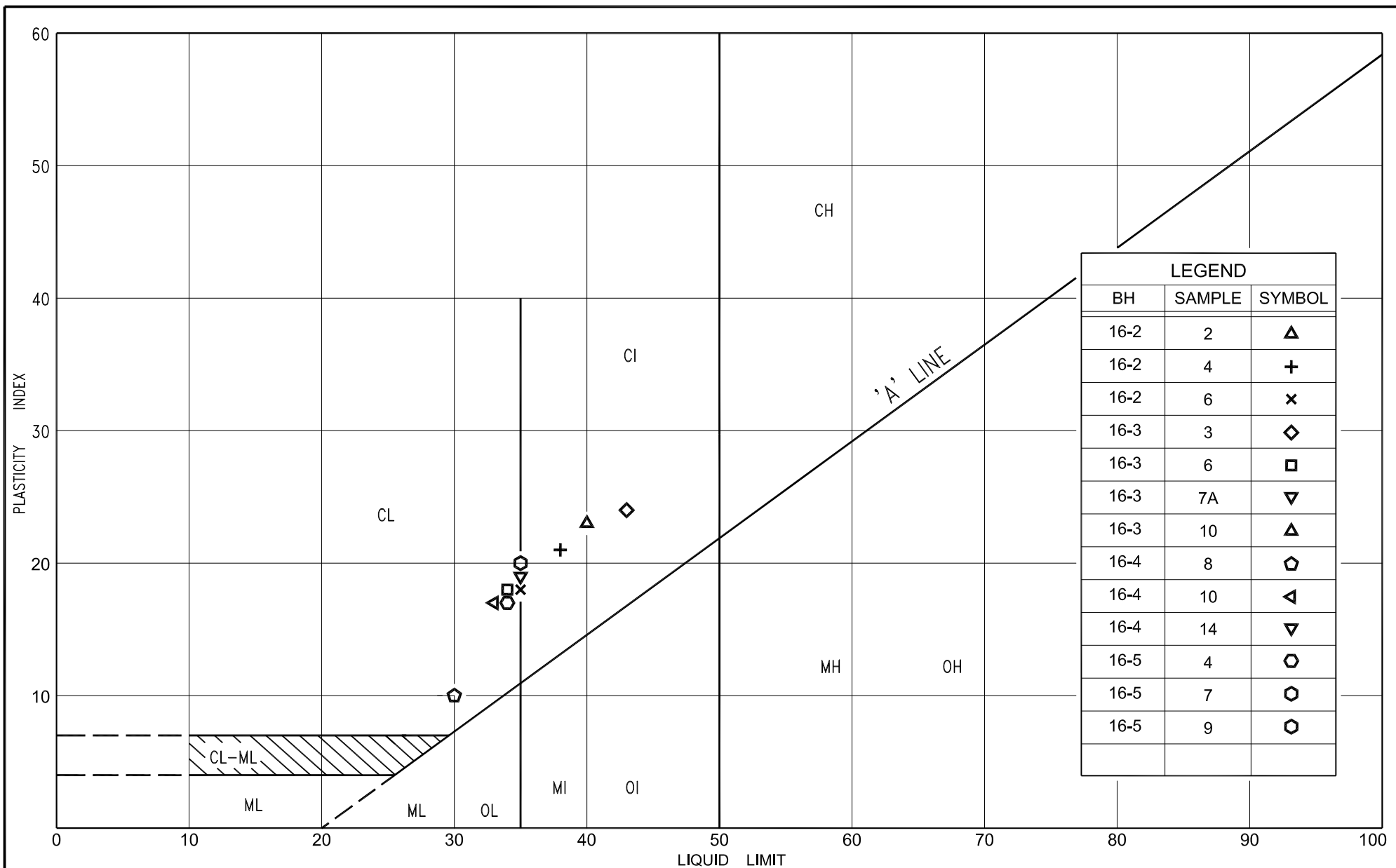
MnDOT No. 02047

G.W.P. No. 6046-08-00



PLASTICITY CHART
CLAYEY SILT, some sand (CL)
(FILL)

FIG No.	PC-1
HWY	11
MnDOT No. 02047	G.W.P. No. 6046-08-00



PLASTICITY CHART

SILTY CLAY, trace to some sand (CL / CI)

FIG No. PC-2

HWY 11

MnDOT No. 02047

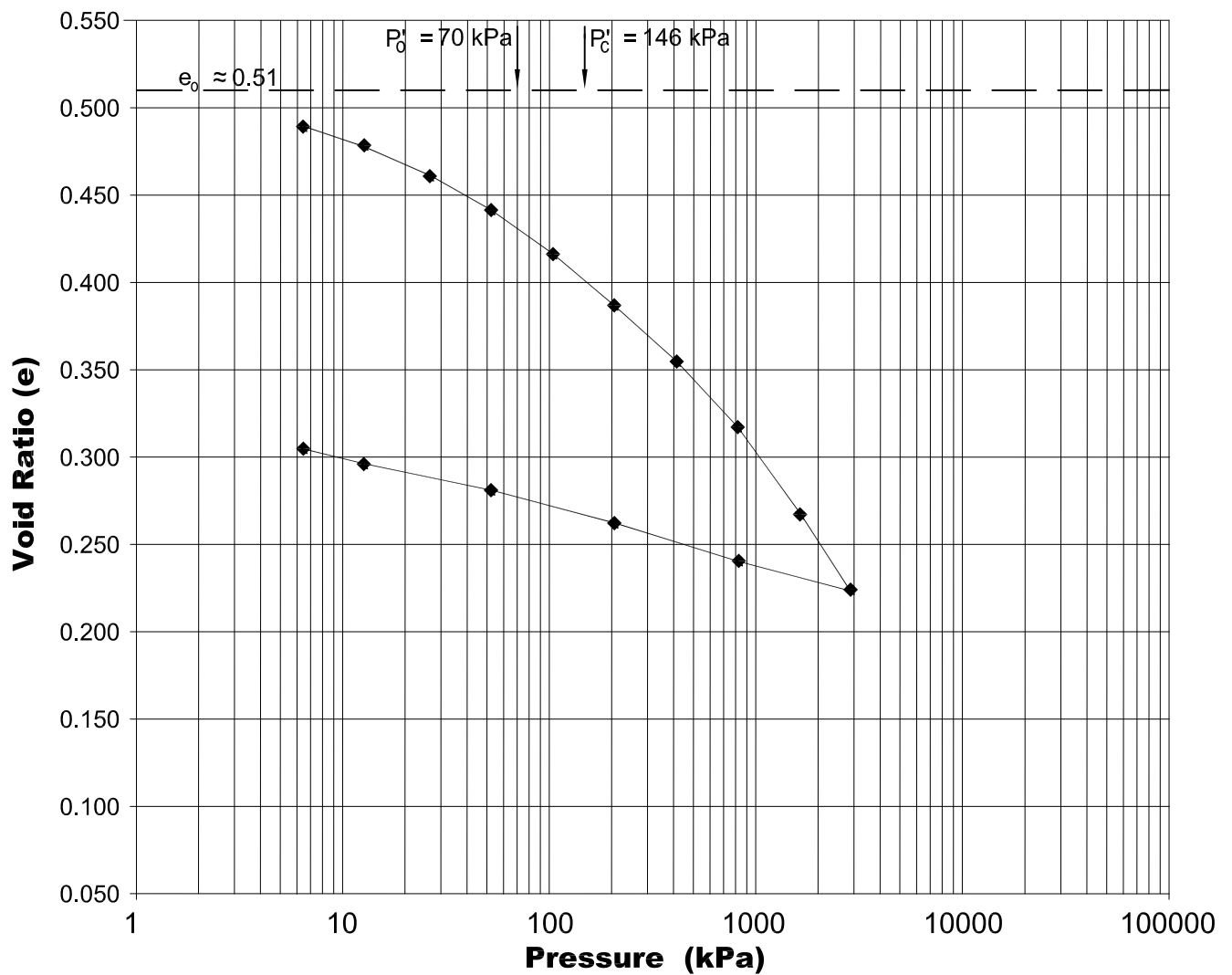
G.W.P. No. 6046-08-00

Laboratory Consolidation Test Results

Highway 11
Baudette - Rainy River Bridge Replacement
MnDOT Contract No. 02047
District Thunder Bay, Ontario

Borehole 16-3, Sample 7A, Depth 7.6 to 8.2 m

Void Ratio versus Log of Pressure



SOIL TYPE: SILTY CLAY, with sand

$e_0 \approx 0.51$

$C_c = 0.153$

$\gamma = 26.2 \text{ kN/m}^3$

$P'_0 = 70 \text{ kPa}$

$P'_c = 146 \text{ kPa}$

$W_L = 35$

$W_P = 16$

$PI = 19$

FIGURE No: RR-C-1

HIGHWAY: 11

DISTRICT THUNDER BAY

G.W.P. No. 6046-08-00

Part A – Preliminary Foundation Investigation Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 039FIR

PML Ref.: 14TF020, December 21, 2016



APPENDIX E

Results of Chemical Corrosivity Tests



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 16T134170

PROJECT: 14TF020

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: PETO MACCALLUM LIMITED

ATTENTION TO: Lul Yimam

SAMPLING SITE:

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2016-09-02

DATE REPORTED: 2016-09-09

		SAMPLE DESCRIPTION: BH 16-1 SS18				BH 16-2 SS5		BH 16-4 SS12	
		SAMPLE TYPE: Soil				Soil		Soil	
		DATE SAMPLED: 8/5/2016				8/3/2016		8/11/2016	
Parameter	Unit	G / S	RDL	7823683	RDL	7823684	RDL	7823685	
Sulphide	%		0.05	<0.05	0.05	0.53	0.05	0.34	
Chloride (2:1)	µg/g		2	6	4	<4	2	9	
Sulphate (2:1)	µg/g		2	24	4	1160	2	365	
pH (2:1)	pH Units		NA	9.12	NA	7.82	NA	8.06	
Electrical Conductivity (2:1)	mS/cm		0.005	0.093	0.005	1.10	0.005	0.475	
Resistivity (2:1)	ohm.cm		1	10800	1	909	1	2110	
Redox Potential (2:1)	mV		5	209	5	222	5	220	

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

7823683 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Please note that sample was analyzed past hold time.

7823684 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Elevated RDL indicates the degree of sample dilution prior to the analysis for Anions in order to keep analytes within the calibration range of the instrument and to reduce matrix interference. Please note that sample was analyzed past hold time.

7823685 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By:

Amanjot Bhela

Quality Assurance

CLIENT NAME: PETO MACCALLUM LIMITED

PROJECT: 14TF020

SAMPLING SITE:

AGAT WORK ORDER: 16T134170

ATTENTION TO: Lui Yimam

SAMPLED BY:

Soil Analysis

RPT Date: Sep 09, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Corrosivity Package

Sulphide	7823683	7823683	< 0.05	< 0.05	NA	< 0.05	100%	80%	120%	NA			NA		
Chloride (2:1)	7823685	7823685	9	9	NA	< 2	91%	80%	120%	104%	80%	120%	106%	70%	130%
Sulphate (2:1)	7823685	7823685	365	366	0.3%	< 2	96%	80%	120%	105%	80%	120%	106%	70%	130%
pH (2:1)	7823685	7823685	8.06	8.05	0.1%	NA	101%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	7823685	7823685	0.475	0.475	0.0%	< 0.005	100%	90%	110%	NA			NA		
Redox Potential (2:1)	7823685	7823685	220	221	0.5%	< 5	103%	70%	130%	NA			NA		

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By:



Method Summary

CLIENT NAME: PETO MACCALLUM LIMITED

AGAT WORK ORDER: 16T134170

PROJECT: 14TF020

ATTENTION TO: Lui Yimam

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulphide	MIN-200-12025	ASTM E1915-09	GRAVIMETRIC
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B, SSA #5 Part 3	CALCULATION
Redox Potential (2:1)		McKeague 4.12 & SM 2510 B	REDOX POTENTIAL ELECTRODE



PART B - PRELIMINARY FOUNDATION DESIGN REPORT

for

**BAUDETTE - RAINY RIVER BRIDGE REPLACEMENT
MNDOT BRIDGE NO. 39016 / MTO SITE NO. 45-110
MN TH 72 / HIGHWAY 11
MNDOT PROJECT NO. SP 3905-09
MNDOT CONTRACT NO. 02047
GWP 6046-08-00
RAINY RIVER, ONTARIO**

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

Distribution:

- 2 cc: Stantec Consulting Services Inc. for
distribution to MTO, Project Manager
+ 1 Digital Copy (pdf)**
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distribution to MTO, Foundations Section
+ 1 Digital Copy (pdf)**
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+ 1 Digital Copy (pdf)**
- 1 cc: PML Toronto**

**PML Ref.: 14TF020
Index No.: 040FDR
GEOCRES No.: 52D-28
December 21, 2016**

Part B – Preliminary Foundation Design Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 040FDR

PML Ref.: 14TF020, December 21, 2016, TOC 1 of 2



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Appendix F – Records of Previous Boreholes Drilled on the US Side of the Bridge

Appendix G – Existing Baudette – Rainy River Bridge Drawings

Appendix H – List of Ontario Provincial Standard Specifications (OPSS) and List of Ontario Provincial Standard Drawings (OPSD) Mentioned in the Report

**PART B – PRELIMINARY FOUNDATION DESIGN REPORT
for**

Baudette - Rainy River Bridge Replacement
MnDOT Bridge No. 39016, MTO Site No. 45-110
MN TH 72 / Highway 11
MnDOT Project No. SP 3905-09
MnDOT Contract No. 02047, GWP 6046-08-00
Rainy River, Ontario

10. INTRODUCTION

This Preliminary Foundation Design Report provides foundation design recommendations based on the interpretation of the Preliminary Foundation Investigation Report (Part A). The objective of the report is to assist the design team in the selection and preliminary design of a suitable type of foundation for the Baudette - Rainy River bridge replacement.

This report is for preliminary design and planning purposes only. Additional foundation investigation and analysis will be required at the detail design stage of the project to finalize the design, and to develop construction documents and specifications.

This report is intended for the use of Stantec Consulting Services Inc. (Stantec) on behalf of the Ministry of Transportation of Ontario (MTO) for the preliminary design and planning of the proposed Baudette - Rainy River bridge replacement. It shall not be used or relied upon for any other purposes, or by any other parties including construction or design-build contractors. Where comments are made in this report on construction, they are provided only to highlight aspects, which could affect the design of the project. Contractors must make their own interpretation of the subsurface information based on the data provided in the Preliminary Foundation Investigation Report as it may affect equipment selection, proposed construction methods and scheduling.



11. PROJECT DESCRIPTION

11.1. General

The discussions and recommendations presented in this report are based on the preliminary alignment of the proposed replacement bridge provided by Stantec, and the findings of the preliminary foundation investigation carried out by PML.

We understand that the existing two-lane Baudette – Rainy River bridge was built in 1959 and is nearing the end of its service life. MnDOT and MTO have jointly retained Stantec to undertake the preliminary design of the proposed replacement bridge and to prepare a class environmental assessment (Class EA) study of the site. The PML assignment included providing a Preliminary Foundation Investigation and Design Report to evaluate the foundation options for the replacement bridge. Currently, Stantec has proposed to locate the replacement bridge on the south side of the existing bridge. Refer to Drawing RR-1 (Appendix A) and the elevation views and copies of drawings of the existing structure provided in Appendix G for details of the Baudette – Rainy River Bridge. Drawing RR-1 illustrates the alignment of the proposed replacement bridge relative to the location of the existing bridge, and a railway bridge located about 85 m (280 ft.) further to the north.

11.2. Existing Bridge and Approach Embankment

Refer to Appendix G for copies of existing drawings (SH # 15S, 16S, 17S, 18S and 19AS) that show the details of the piers of the existing Baudette – Rainy River bridge.

The following description is provided for illustrative purposes for this preliminary foundation design report. Refer to the appropriate documents for other purposes.

The existing bridge is about 390.6 m (1,281.5 ft.) long and consists of six (6) main spans and two (2) approach spans on the Canadian side and four (4) approach spans on the US side. The existing drawings and documents number the piers from Pier 1 at the US side to Pier 7, at the Canadian side. The bridge consists of simply supported steel truss spans between Piers 1 and 7. The length of each of these spans is about 59 m (193.6 ft.). On the Canadian side, the structure also consists of two (2) simply supported steel girder approach spans between the abutment and Pier 7. On the US side, the bridge has four (4) simply supported steel girder approach spans between the

Part B – Preliminary Foundation Design Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 040FDR

PML Ref.: 14TF020, December 21, 2016, Page 15



abutment and Pier 1. The length of each approach span is about 6.1 m (20 ft.). The main spans are supported on concrete columns on deep foundations, while the end spans are on steel pile bents. The riding surface of the existing structure is made of a steel grating deck.

The bridge accommodates two lanes of vehicular traffic. The width of each lane excluding the sidewalk is approximately 3.66 m (12 ft.). The bridge also consists of a 1.96 m (6.4 ft.) wide sidewalk cantilevered from the steel beam on the south side of the bridge.

The RFP indicates that Pier 1 and Pier 7 of the existing bridge were founded on piles. The piles used appear to be timber piles and were designed to carry a load of 196 kN (20 Tons). Based on the existing drawings of the bridge provided in Appendix G, each of Piers 1 and 7 are founded on two columns supported by a pile group. Each pile group consists of twelve (12) piles. The piles are connected to a pile cap at El. 319.8 m (1049.24 ft.). The spacing between the two pile groups is approximately 4.9 m (16 ft.). The thickness of the pile cap is approximately 0.9 m (3 ft.).

The pile groups at Piers 2, 3, 4, 5 and 6 were encased in large diameter circular steel tubes. Based on the existing drawings provided in Appendix G, the encasing circular steel tubes were installed to depths ranging from 6.4 m (21ft.) to 8.5 m (28 ft.).

Each of Piers 3, 4 and 5 are supported on two (2) pile groups of twenty seven (27) piles, and are encased in a 3.96 m (13 ft.) diameter steel tube installed to depths ranging from 1.4 m (4.5 ft.) to 2.4 m (7.75 ft.) below the riverbed to the sandy layer at about El. 314.6 m (1032.22 ft.).

Pier 6 is supported on two (2) pile groups of nineteen (19) piles, and is enclosed in 3.35 m (11 ft.) diameter steel tube to a depth of 2.1 m (7 ft.) below the riverbed. The steel tube for Pier 6 was installed to the sandy layer at approximately El. 315.1 m (1033.71 ft.). Pier 2 is also placed on a foundation similar to Pier 6, but the liner was installed to El. 316.8 m (1039.21 ft.).

The tops of all piles were cut off 305 mm (1 ft.) below the top of the steel tubes. The cavities between the top of the steel tubes and the ground level were subsequently filled with 20 MPa (2000 psi) concrete. The bridge columns were constructed with 25 MPa (2500 psi) concrete.

According to the Bridge Rehabilitation Study report prepared by MnDOT, dated May 14, 2013, the substructure elements of the bridge are in fair condition. However, an underground inspection report



prepared by WSP Canada (WSP), with inspection date of October 21, 2014, concluded that the underground components of the bridge are in poor condition. Based on the WSP report, Piers 5 and 6 on the Canadian side showed heavy pitting and rust on the steel tubes of the caissons. The MnDOT report indicated the presence of scour depressions at all piers with the most severe scour at Pier 6. It is also understood that riprap was placed in the past at Piers 2 to 6 to control scour.

The top of the approach embankment on the Canadian side is at El. 328.3 m (1077.1 ft.) and the toe is at El. 324.4 m (1064.3 ft.). This indicates an embankment height of about 4 m (13.1 ft.). During fieldwork, it was observed that the existing approach embankment and the riverbank on the Canadian side exhibited no signs of distress, slope failure or settlement. Both the south and north sides of the approach embankment were moderately vegetated with grass, shrubs and few trees. No large-scale erosion was observed on slopes or along the riverbank and abutment area.

11.3. Proposed Replacement Bridge

Based on the conceptual plan (drawing) provided by Stantec and shown on Drawing RR-1 in Appendix A, it is assumed that the existing structure will be replaced by a bridge consisting of five (5) spans, including a configuration of four (4) piers and two (2) abutments. The lengths of the main spans in this replacement bridge are approximately 90 m (295.3 ft.). As shown on Drawing RR-1 in Appendix A, the alignment of the replacement bridge will be parallel to the existing bridge with modifications to the end span configuration. The piers for the proposed replacement bridge will be offset at least 10 m (33 ft.) away from the existing piers. The abutments are expected to have similar offset as the piers and the approach embankments will be widened on the south side with identical grade as the existing structure to accommodate the new alignment.

11.4. Foundation Conditions

In summary, the subsurface conditions on the Canadian side of the existing bridge approach and the abutment area consists of a thin layer of topsoil followed by 1.9 m (6.2 ft.) to 4.5 m (14.8 ft.) thick fill. The fill is underlain by 800 mm (2.6 ft.) buried topsoil and organic deposits, which are underlain by firm to very stiff silty clay to the full depth of investigation of 12.8 m (42 ft.).



The upper part of the stratigraphy on the Canadian side of the river consists of approximately 1 m (3.3 ft.) to 6 m (19.7 ft.) thick sand layer below about 0.9 m (3 ft.) to 1.0 m (3.3 ft.) of alluvium. In Borehole 16-1, located near Pier 5 of the existing bridge, the sand layer is underlain by a dense to very dense sand to silty sand deposit with occasional cobbles, to the maximum depth of investigation of 31.1 m (102 ft.). In Borehole 16-2 and 16-3, located near Piers 6 and 7 of the existing bridge, the sand layer is underlain by a 12.4 m (40.7 ft.) thick, firm to very stiff silty clay deposit. The silty clay is underlain by the very dense sand to silty sand deposit.

For the US side of the bridge, the borehole logs provided in the Technical Memorandum prepared by HNTB Corporation (HNTB), dated April 13, 2016, should be consulted to maintain consistency in the design. Drawing RR-1 (Appendix A) presents the location of boreholes drilled on the US side. The logs for these boreholes are provided in Appendix F.

The groundwater level was at El. 322.9 m (1059.4 ft.), and was observed to be the same as the water level in the river. Artesian condition were not noted at the time of drilling.

12. EVALUATION OF FOUNDATION ALTERNATIVES

The evaluation of the foundation alternatives for preliminary design and planning are based on the subsoil conditions encountered along the proposed alignment, the foundations of the existing bridge and its performance, and the conceptual plan (drawing) provided by Stantec for the proposed replacement bridge. The comparison of various alternatives considered in terms of advantages, disadvantages, relative costs and risks/consequences are provided in Table 3. The alternatives considered for supporting the proposed bridge are as follows:

- Driven steel H-piles;
- Closed-end pipe piles;
- Drilled shaft or large diameter caissons;
- Shallow foundations.

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Table 3 – Evaluation of Foundation Alternatives

FOUNDATION TYPE	ADVANTAGES	DISADVANTAGES	RISKS / CONSEQUENCES	RELATIVE COST	FEASIBILITY
Driven Steel H-piles	<ul style="list-style-type: none">• Ability to penetrate through cobbles or dense gravel layers• Low displacement pile results in less soil densification and heave and hence less potential disturbance to existing bridge foundations• Easy to splice and increase the length• Pile resistance can be assessed during driving• Conventional construction equipment• Robust foundation to withstand stresses and corrosion	<ul style="list-style-type: none">• Driving shoes required to pass through obstructions• Nuisance to public resulting from noise and vibration• Susceptible to corrosion in zones exposed to fluctuations in water levels• Requires permanent scour protection liner	<ul style="list-style-type: none">• Possible pile tip damage if piles are not adequately protected while driving through very dense soils• Possible variation in pile set elevations may have to be considered in design of pile group• Vibration-induced settlement damage to foundations of existing bridge	Moderate cost relative to other alternatives although water work will be expensive	Feasible and recommended

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Table 3 – Evaluation of Foundation Alternatives

FOUNDATION TYPE	ADVANTAGES	DISADVANTAGES	RISKS / CONSEQUENCES	RELATIVE COST	FEASIBILITY
Closed-end driven steel pipe piles	<ul style="list-style-type: none">• Ease of inspection for damage after driving• Easy to splice in the field	<ul style="list-style-type: none">• Pile may hang up at higher elevation• May require pre-augering to install through obstruction to achieve adequate pile length• Difficulty to drive the pipe through obstructions• Nuisance to public resulting from noise and vibration• Require permanent scour protection liner• Are displacement piles and may cause more displacement of the ground.	<ul style="list-style-type: none">• Possible pile tip damage if piles are not adequately protected while driving through very dense soils• Possible variation in pile set elevations may have to be considered in design of pile group• Vibration-induced settlement damage to foundations of existing bridge	Relatively higher cost than H-piles especially if pipes are filled with concrete	Feasible but not recommended

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Table 3 – Evaluation of Foundation Alternatives

FOUNDATION TYPE	ADVANTAGES	DISADVANTAGES	RISKS / CONSEQUENCES	RELATIVE COST	FEASIBILITY
Caissons/Drilled Shafts	<ul style="list-style-type: none">• Reduced nuisance to public for noise and vibration compared to pile driving• Ability to achieve high axial and lateral capacity• Facilitates elimination of pile cap if pile bent configuration adopted• Ability to install through cobbles and boulders• Can be installed with limited vertical clearance	<ul style="list-style-type: none">• Challenging construction procedures required to maintain stability of caisson excavation in underwater construction complicated by potentially unstable noncohesive ground• Environmental concerns for potential use of slurry to stabilise the base during caisson installation• Probably will require permanent liner• Construction procedures may influence the integrity and performance of the caisson• Requirement for caisson integrity testing to test for potential necking of concrete	<ul style="list-style-type: none">• Loss of ground into caisson excavation could lead to undermining the existing bridge during construction• Potential for necking of concrete in caisson could reduce the reliability of caisson to support axial or lateral loads• High potential for construction difficulties and cost overrun	High cost	Feasible but not recommended

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Table 3 – Evaluation of Foundation Alternatives

FOUNDATION TYPE	ADVANTAGES	DISADVANTAGES	RISKS / CONSEQUENCES	RELATIVE COST	FEASIBILITY
Shallow Foundations	<ul style="list-style-type: none">• Reduced nuisance to public for noise and vibration compared to pile driving• Can be constructed with limited vertical clearance	<ul style="list-style-type: none">• Construction would have to be carried out under a 14 m (50 ft.) high water, leading to very difficult condition• Would require extensive scour protection• Subsoil conditions are not favourable to support shallow foundations	<ul style="list-style-type: none">• Associated with high potential for construction difficulties causing construction delays	High cost due to the need to construct under a high level of water and dewatering requirement	Not feasible



The following sections provide evaluations of the foundation alternatives presented in Table 3 and the discussion for the preferred alternatives:

12.1. Driven Steel H-Piles

Considering the subsoil conditions at the pier locations and abutment, the foundations for the piers and abutment may be supported on steel H-piles driven to the dense to very dense sand to silty sand materials. Pile bents or large diameter liner may be required at the pier locations to protect the foundations from scour and to overcome construction of piers under water. However, the abutments may be supported on pile cap build below the frost depth.

Generally, H-piles are low displacement piles, and the dense cohesionless soils encountered at the recommended founding levels may not be significantly affected by pile driving.

The piles at pier locations may be driven to about El. 304.6 m (999 ft.) in a group and designed assuming the geotechnical resistances provided in Section 13.1.1. As stated in Section 13.7, the scour elevation for the 100 year event for the 5-Span bridge piers is reported to be at El. 307.6 m (1009.36 ft.). Piles may be driven to pre-determined elevation and ultimate geotechnical resistance achieved may be checked by employing the Hiley Formula or Pile Driving Analyser (PDA).

The pile group will probably have to be enclosed in a large diameter permanent liner for scour protection and to provide a cofferdam to permit construction under water. The liner should be installed to the maximum depth of scour, probably by vibration, and the piles should only be driven after the liner reaches the required depth. Upon the completion of pile driving, the liner may be cleaned to an appropriate depth and filled with concrete either by tremie methods, or by installing a tremie plug to permit dewatering to place structural concrete in the dry.

Considering occasional cobbles encountered below about E. 310.0 m (1017 ft.), the pile tips may have to be reinforced to drive the piles through cobbles. Oversized driving shoes similar to Ontario Provincial Standard Design (OPSD) 3000.100 (Foundation Piles Steel H-Pile Driving Shoe) or Titus H bearing pile point may reduce the shaft friction and may lead to overrun of pile lengths.



The structural details of the abutment (supported on piles or perched) were not available at the time of preparing this report. The abutment may be supported on a pile cap constructed below the frost depth. It is anticipated that the piles for the abutment may be driven to about El. 307 m (1007 ft.) to achieve the geotechnical resistances provided in Section 13.1.1.

To construct the pile cap in the dry at the abutment, a cofferdam and dewatering scheme would be required. The silty clay layer found at the bottom of the pile cap will be susceptible to disturbance from construction traffic, and any ponded water or river flow. In order to limit the degradation of the soil and provide a working platform, a concrete working slab (lean concrete) may be placed on the subgrade. The recommendation provided for pier foundations may be used for the pile tip reinforcement and the termination of pile driving at the abutment.

12.2. Driven Closed End Pipe Piles

Medium size steel pipe piles, ranging in diameter from 400 mm (16 in.) to 550 mm (22 in.) with concrete plug or steel plate at the bottom, could be driven to refusal or to a pre-determined elevation. These closed end pipe piles derive their geotechnical resistance from a combination of shaft friction and end bearing, and they may be considered for use at the site.

However, closed end pipe piles are displacement piles. Driveability of these piles in soils containing cobbles and boulders may require pre-augering to install the piles to adequate depth below the scour depth. If pre-augering is used for installation, the shaft resistance would have to be neglected. Further, the pre-augered holes may not stay open in sandy material below the water table.

Considering the subsoil conditions and the installation difficulties because of cobbles and hard layers, this option may not be cost effective and practical to use at the project site.

In addition, the potential of uplift of the existing structure induced by driving closed end pipe piles should be considered in the detail design stage.

12.3. Drilled Shaft or Large Diameter Caisson

The caissons at this site would have to be installed in sandy material with occasional cobbles and boulders, and at least with 7.0 m (23 ft.) high water level with strong currents. The drilled shaft will



probably require a permanent liner to support the caisson walls and bentonite slurry to stabilize the sandy material during installation. Removal of cobbles and boulders may be difficult with conventional equipment and may require special equipment or divers. In addition, there may be environmental restrictions to use bentonite slurry within the river.

A wet construction method would have to be employed for the installation of drilled shafts, and visual inspection of the unexposed portion of the shaft would not be possible. Cleaning and inspection of the base would be at best very difficult. Special integrity testing methods would be required to ensure the continuity and carrying capacity of the shaft. Therefore, the use of large diameter caisson or drilled shafts at the site is not recommended.

12.4. Shallow Foundations

The soil conditions at pier locations to a depth of about 7.0 m (23 ft.) are not favourable for shallow foundations. The sandy material at the site requires protection of foundation from potential scour, which would require sheet piles to well below the maximum depth of anticipated scour. Construction of shallow foundation under 14.0 m (46 ft.) of water is not feasible or not economical.

The soil conditions at the abutment consist of about 4 m (13 ft.) of fill followed by 800 mm (2.6 ft.) of organics, and stiff to very stiff silty clay at a depth of 5.3 m (17.4 ft.), El. 323.0 m (1059.7 ft.). The construction of shallow foundation would require at least a 7.5 m (24.6 ft.) deep excavation and a properly designed dewatering scheme to construct the footings in the dry.

Therefore, the option of using shallow foundations for piers or abutment is not practical and feasible.

12.5. Recommended Option

Based on the evaluation given above, it has been concluded that driven H-piles are geotechnically the recommended alternatives. However, collaboration with the US design team will be required to deliver the preferred consistent foundation design for the entire bridge.



13. PRELIMINARY RECOMMENDATIONS

13.1. Axial Geotechnical Resistance

The axial geotechnical resistances provided in Table 4 may be used for preliminary foundation design of driven steel H-piles and for planning purposes. Steel H-piles heavier than HP 310 x 110 may be considered to permit sacrificial materials to allow for corrosion.

The geotechnical resistances in Table 4 are for reference and planning purposes only. Consideration was given to the influence that the depth of scour, and consequently, the depth of the steel tube liner has on the side friction component of pile resistance. The resistance values must be re-assessed at the detail design when the structural arrangements are available. Full-scale static load tests could be considered to verify and optimize pile resistances used for detail design.

Table 4 – Recommended Axial Geotechnical Resistance Values

PILE SECTION	PILE LOCATION	PROPOSED PILE TIP ELEVATION (m)	FACTORED GEOTECHNICAL RESISTANCE AT ULS	FACTORED GEOTECHNICAL RESISTANCE AT SLS
HP 310 x 110	Bridge Piers	304.6 m (999 ft.)	1000 kN (100 tons)	800 kN (80 tons)
	Abutment	307 m (1007 ft.)	1000 kN (100 tons)	800 kN (80 tons)

Geotechnical resistances shall be reduced in accordance with the spacing between piles suggested in Clause 6.11.4.7 of the Canadian Highway Bridge Design Code (CHBDC), 2014, if minimum spacing required for mobilising the full shaft resistance cannot be met.

13.2. Lateral Geotechnical Resistance

The design value used for lateral pile resistance should not exceed 110 kN (24.7 kips) for Factored Resistance at ULS and 80 kN (18 kips) for resistance at SLS. If greater lateral resistance is required, the option of using battered piles may be considered.



The lateral resistance within the frost penetration depth shall be ignored. If pre-drilled holes are used, the lateral resistance within the depth of pre-drilling shall not be used.

When piles that are installed in groups are subjected to lateral loads, additional design issues must be considered. Piles in a group carry unequal lateral loads, depending on their location within the group, the configuration, the spacing between piles and their diameter.

For a group of piles, the coefficient of subgrade reaction and ultimate lateral resistance may have to be reduced, based on pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Table 5.

Table 5 – Lateral Pile Resistance Reduction Factors

PILE GROUP CONFIGURATION	PILE SPACING (CENTRE TO CENTRE)	REDUCTION FACTOR
Pile group oriented perpendicular to the direction of loading	1 D	0.5
	4 D	1.0
Pile group oriented parallel to direction of loading	3 D	0.25
	4 D	0.4
	6 D	0.7
	8 D	1.0

D = Pile Diameter

13.3. Retaining Walls

Retaining walls should be designed to resist the horizontal earth pressure imposed by the backfill and any surcharge load. The earth pressure for concrete structures should be computed as per Clause 6.12.2 of Canadian Highway Bridge Design Code (CHBDC, 2014). The earth pressure calculation should include maximum water level expected behind the wall. The lateral earth pressure, p (kPa), may be computed using the diagrams for equivalent fluid pressure given in CHBDC, 2014, or by employing the following equation, assuming a triangular pressure distribution:

$$p = K (\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + C_p + C_s$$

where K = Coefficient of lateral earth pressure (dimensionless)

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- γ = Unit weight of backfill material above design water level (kN/m³)
 γ' = Unit weight of submerged backfill ($\gamma - \gamma_w$) material below design water level (kN/m³)
 γ_w = Unit weight of water (9.8 kN/m³, 62.4 lb/ft³)
 h_1 = Depth below final grade above design water level (m)
 h_2 = Depth below design water level (m)
 q = Surcharge load (kPa)
 C_p = Compaction pressure (kPa) (Clause 6.12.3 of CHBDC, 2014)
 C_s = Earth pressure from seismic events, (kPa) (Clause 4.6.5 of CHBDC, 2014)

Ontario Provincial Standard Specifications (OPSS) Granular 'A' or 'B Type II' should be used as backfill material behind the wall and carried out based on the requirements specified in the OPSS 902 (Excavation and Backfilling of Structures). The backfill material should be placed in layers not exceeding 200 mm (8 in.) in thickness before compaction. The list of all OPSSs and Ontario Provincial Standard Drawings (OPSDs) used in this report is provided in Appendix H.

Heavy vibratory compaction equipment adjacent to retaining structures should be restricted to limit the compaction pressure described in Clause 6.12.3 of the CHBDC, 2014. The type of compaction equipment and the compaction procedure that can be used for this purpose should be in accordance with OPSS 501 (Construction Specification for Compacting).

Table 6 provides the recommended preliminary earth pressure coefficients for granular backfill.

Table 6 – Preliminary Earth Pressure Coefficients

PARAMETERS	OPSS GRANULAR A	OPSS GRANULAR B TYPE II
Internal Friction Angle, (degrees)	35	30
Unit weight, γ (kN/m ³)	22.5± 0.3	21.5 ± 0.3
Coefficient of Active Earth Pressure, K_a	0.27	0.33
Coefficient of Earth Pressure At Rest, K_o	0.43	0.5
Coefficient of Passive Earth Pressure, K_p	3.69	3



The coefficient of earth pressure “at rest” should be used for design of rigid and unyielding walls where sufficient movement of the structure wall will not be permitted. For unrestrained structures, the active earth pressure coefficient should be employed.

Adequate drainage should be provided behind retaining walls to prevent the build-up of hydrostatic pressure. A weeping tile system (OPSS 405, Construction Specification for Pipe Sub-drains, and OPSD 3190.100, Walls Retaining and Abutment Wall Drain) should be installed to minimise the build-up of hydrostatic pressure. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

Both reinforced concrete gravity (or cantilever) and reinforced soil system (RSS) walls are geotechnically feasible alternatives for retaining walls at the project site. The cantilever walls could be cast-in-place (CIP) or made up of precast elements. Cast-in-place concrete gravity and cantilever walls will require longer construction time and deeper excavations compared to RSS walls. However, at locations affected by the waterway, RSS walls may not be practical and could suffer damages due to wave action or constant flow of water. For these reasons, RSS walls should not be considered near the river below the known or estimated high water level.

13.4. Approach Embankment

It is assumed that the profile grade of the new bridge and the approach embankment will be maintained at the same level as the existing. However, the proposed alignment of the bridge indicates that there will be a requirement for widening of the existing embankment on the south side. The height of the approach embankment is expected to remain at about 4 m (13 ft.). Any spongy or soft area observed under the plan limits of the embankment should be sub-excavated and the excavated surface should be proof rolled and backfilled with acceptable fill material.

Embankment widening should be designed and constructed in conformance with OPSD 203.020 (Embankments over swamp). Benching should be in conformance with OPSD 208.010 (Benching of Earth Slopes). The widened portion of the embankment, outside the existing edge of shoulders, should be preloaded for as long as possible prior to paving but at least for a period of 1 month.



Riprap should be provided in accordance with OPSD 810.010 (General Riprap Layout), to protect the toe of the embankment and prevent erosion. Riprap shall be provided to a minimum height of 1.0 m (3.3 ft.) above the high flood level expected in the river. A General Arrangement drawing for the Canadian side of the existing bridge prepared by Hatch Mott MacDonald, dated Feb. 2004, that shows the high and low water levels in the river is provided in Appendix G.

13.4.1. Slope Stability

The height of the existing approach fill is approximately 7 m (23 ft.) above the riverbed at the shoreline and the embankment itself is about 4 m (13 ft.) high. Information on the embankment of the existing bridge is not available, but the side slopes appeared to be at an approximate gradient of 2H:1V. No major instability problems are anticipated for an embankment widening constructed with a 2H:1V side slope, based on the observed good performance of the existing slope. A detailed analysis should be carried out for detail design.

13.4.2. Settlement

The height of approach embankment in the proposed widening area is not expected to exceed 4.0 m (13 ft.). Therefore, the load imposed by the new fill may be limited to about 80 kPa (11.6 psi), assuming a compacted density value of 20 kN/m³ (127.3 lb/ft³). The results of the consolidation test conducted on silty clay sample are given in Appendix D. These results indicate a pre-consolidation pressure of 146 kPa (21.2 psi) compared to an effective overburden pressure of 70 kPa (10.2 psi). Based on these results, the silty clay layer may be categorised as slightly over consolidated soil. Hence, no major post construction settlements are expected under a fill height of 4.0 m. However, the settlement problems associated with the proposed widening should be assessed at the final design stage when the details of the proposed widening become available.

13.5. Frost Protection

In accordance with OPSD 3090.100 (Foundation Frost Penetration Depths for Northern Ontario), a minimum of 2.2 m (7.2 ft.) earth cover is required to protect against the frost penetration in the area where the bridge is located. Frost tapers within the granular backfill should be constructed in accordance with OPSD 3101.150 (Walls Abutment, Backfill, Minimum Granular Requirement).



Equivalent thermal insulation can be provided by appropriate thickness of rigid polystyrene. Polystyrene insulation should meet requirements of National Standards of Canada, CAN/ULC-S701-05 (Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering). Appropriate thickness can be determined from manufacturer's literature.

13.6. Seismic Considerations

The Spectral and Peak Ground Accelerations ($S_a(0.2)$ and PGA) for the project site, based on the Town of Rainy River, and for the 2% in 50 year probability of exceedance, is 0.059 and 0.035, respectively (National Building Code of Canada, 2015). The Reference Peak Ground Acceleration (PGA_{ref}) based on these $S_a(0.2)$ and PGA values is 0.028. The soil at the site for seismic design purposes is classified as Type D in accordance with Clause 4.4.3.2 of CHBDC, 2014. This indicates that the risk of seismic activity affecting the bridge is low.

For the design of retaining walls, seismic loading must be taken into account in accordance with Clause 4.6.4 of CHBDC, 2014, as it can result in increased lateral earth pressure. The walls should be designed to withstand the combined lateral loading for the appropriate static pressure conditions plus the applicable seismic induced dynamic earth pressure.

13.7. Scour and Erosion Protection

As discussed in the technical memorandum prepared by HNTB for the US side of the proposed bridge, the depth of total scour for the 100 and 500 year events were estimated by another consultant (HZ United). For a 5-Span bridge, the scour depth at the bridge piers for a 100 year event was estimated to be as high as 9.6 m (31.3 ft.), and the corresponding 100 year scour elevation is 307.6 m (1009.4 ft.). Steel liners will provide scour protection for piles supporting the piers. Generally, scour protection shall be provided in accordance with Clause 1.9.5 of CHBDC, 2014.

The prediction of scour depth and the required mitigation measures will be a critical aspect of the detail design, as it will affect the foundation layout, the depth of piles, the depth of caisson liner and the construction sequence. Scour design is a multi-disciplinary exercise that involves the structural and hydrology designer as well as the foundation/geotechnical designer working as a team. The



scour design should consider ground conditions and provide relevant characterization related to scour design such as erodibility. Reference may be made to the following guidelines:

- US Federal Highway Administration (FHWA) Hydraulic Engineering Circular 18 (HEC-18), Evaluating Scour at Bridges, April 2012.
- US FHWA HEC-23, Bridge Scour and Stream Instability Countermeasures, Experience, Selection, and Design Guidance, Volume 1 and Volume II, September 2009.

In addition to scour, work around the abutment area of the new bridge and embankment widening may expose slopes for erosion. Therefore, erosion protection measures should be provided.

The erosion protection should be constructed in accordance with OPSS 511 (Rock Protection). Erosion protection along the riverbank should extend from the anticipated high water level to the toe of the slope and a minimum distance equivalent to the riverbank across the river bottom.

If the approach embankments are composed of earth fill, they should be covered with topsoil or suitable excess earth material from swamps or muskeg areas and seeded in accordance with OPSS 802 (Construction Specification for Topsoil) and OPSS 804 (Construction Specification for Topsoil) as soon as grading is completed to prevent erosion and material degradation.

In addition to scour and erosion control, the effect of piers and abutments of the new replacement bridge on the risk of undermining the existing bridge as well as the railway bridge further north should be investigated during the detail design phase.

13.8. Soil Corrosion

Samples of the sand to silty sand deposit as well as the overlying silty clay layer were tested for soil corrosivity and potential exposure of concrete to sulphate attack. A summary of the chemical corrosivity test results are provided in Table 2 of Part A of this report.

In the sand to silty sand deposit, the sulphate content for the sample taken from Borehole 16-1 was 24 µg/g or 0.0024%. According to Clause 4.1.1.6 of the Canadian Standards Association (CSA) standard A23.1-14, soluble sulphate concentrations less than 1000 µg/g or 0.1% indicate a low degree of sulphate attack when concrete is in contact with soil or groundwater.



In the silty clay, the sample from Borehole 16-4 had a sulphate content of 365 $\mu\text{g/g}$ (0.0365%). However, the concentration for the sample from Borehole 6-2 was 1160 $\mu\text{g/g}$ (0.116%). Based on CSA standard A23.1-14, this value indicated a moderate attack if concrete is exposed to the soil. Hence, for a concrete work within the silty clay, sulphate resistance cement may be required.

Further, high resistivity value was obtained for the sample taken from Borehole 16-1, indicating a non-corrosive environment for steel piles embedded in the sand to silty sand deposit.

For the silty clay sample from Borehole 16-4 with a value of 2110 ohm-cm, a moderately corrosive environment may be expected, as the resistivity is a little higher than 2000 ohm-cm. However, the resistivity value for the sample from Borehole 16-2 is 909 ohm-cm, and this suggests that the soil can be classified as highly corrosive for buried unprotected steel elements.

The chloride contents provided in Table 2 for all soil samples (4 ppm to 9 ppm) suggest a non-corrosive environment for buried metal or a steel pile. For a corrosive environment, it is generally recognised that chloride concentrations should be higher than 250 ppm. In addition, a pH level of 7.82 to 9.12 was measured for all samples and this indicates a neutral soil pH environment.

Generally, no sulphate attack is expected from selected backfill materials. However, it may be advisable to test backfill material for corrosion potential if it is imported from unknown sources.

14. CONSTRUCTION CONSIDERATIONS

14.1. Staging of Construction

PML understands that there is no local detour available nearby and the closest border crossing to the US is in Fort Frances. The planning and design of the new replacement bridge should consider the sequence and staging of construction to divert the traffic. Construction staging may not be required if the existing bridge remains open for traffic during construction.

A monitoring plan will have to be developed and implemented during the construction of the replacement bridge to maintain the structural integrity of the existing bridge and safety of the public. A monitoring plan should also include the safety and integrity of the railway bridge located further north and other facilities that can be affected by vibration and ground movement. Non-Standard



Special Provision (NSSP) should be developed and included in the contract document for implementation by the contractor during construction.

14.2. Excavation, Pile Installation and Obstructions

Excavation for construction of foundations at abutment location is expected to extend to a depth of about 3 m (10 ft.) below the existing grade. Embankment widening at the approach may involve partial removal of the existing 4 m (13 ft.) thick fill on the south side.

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and MTO Regulations for Construction Projects. The protection system for excavations should follow OPSS 539 (Construction Specification for Temporary Protection Systems), and OPSS 902 (Construction Specifications for Excavating and Backfilling – Structures).

Excavation of the soils at the project site may be carried out using conventional excavation equipment. All excavated surfaces should be kept free of frost and water during the period of construction. Runoff shall be directed away from open excavations and should not be allowed to flow into the excavation. Excavated material shall not be stockpiled on top of the excavation.

Based on borehole logs, the excavations for the construction of the pile cap at the abutment will be advanced through embankment fill material and silty clay layer. For OHSA classification purposes, the fill materials should be classified as Type 3 soils. For excavations through multiple soil layers, the side slope geometry is governed by the soil with the highest number designation.

At the approach embankment where the fill contains clayey silt materials, open excavation with a side slope of 1H:1V may not be stable. Hence, roadway protection will be required at this location.

The design and installation of shoring for roadway protection, if required should be the responsibility of the contractor. Shoring system may consist of soldier piles and timber lagging or sheet pile walls with struts. Shoring should be designed and installed in accordance with OPSS 539 (Construction Specification for Temporary Protection Systems) Level 2 performance.



14.3. Pile Installation and Obstructions

In view of the presence of occasional cobbles and boulders below about El. 302 m (990.8 ft.), an appropriate NSSP need to be included in the contract document at the detail design phase to alert the contractor. The contractor may select and use the appropriate methods and equipment to account for obstructions from cobbles or boulders during the installation of piles or liners.

14.4. Dewatering

The groundwater should be lowered a minimum of 0.5 m (1.6 ft.) below the base of excavations for construction in the dry, and the contractor should be responsible for selection, performance and detailed design of the dewatering system including the cofferdam. The dewatering system should be designed to conform to the requirement of OPSS 517 (Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation) and OPSS 518 (Construction Specification for Control of Water from Dewatering Operations). In addition to these standard specifications, the inclusion of applicable NSSPs into contract documents should be considered.

14.5. Permission to Take Water (PTTW)

In accordance with the Ontario Water Resources Act, the Water Taking and Transfer Regulation 387/04, a Permit to Take Water (PTTW) from the Ministry of Environment is required if the discharge from dewatering is greater than 50,000 L/day (13,208 gal/day). Although the requirement for this permit depends on the water tightness of the contractor's selected dewatering system, it is recommended that a PTTW be obtained due to the proximity to the river.

In addition, construction site dewatering involving between 50,000 L/day (13,208 gal/day) and 400,000 L/day (105,668 gal/day) will require registration in the Environmental Activity and Sector Registry (EASR) under water taking EASR Regulation 63/16.

15. SCOPE OF ADDITIONAL INVESTIGATION AND DESIGN SERVICES

Detailed foundation engineering services will be required during the design phase of the project.

The following recommendations for scope of foundations engineering services at the detail design phase of the project refer to the Canadian side of the proposed bridge replacement.

Part B – Preliminary Foundation Design Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 040FDR

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The extent of additional investigations at this site during detail design should include at least one (1) borehole at each pier location as well as the abutment, and one (1) borehole about 20 m from the abutment on the approach embankment. The boreholes at pier locations should be strategically located to represent the subsurface conditions under the footprint of the proposed foundation elements. The borehole at the abutment should be drilled on land, near the limits of the existing bridge. The boreholes should extend to competent soil to carry deep foundations estimated to be at least 35 m (115 ft.) deep. The borehole at the approach should be completed at the crest of the south side of the embankment and may be about 15 m (50 ft.) deep. If boreholes encounter bedrock, they should be extended at least 3.0 m (10 ft.) into the bedrock.

As noted above, engineering services should include preparation of NSSP's for contract documents.

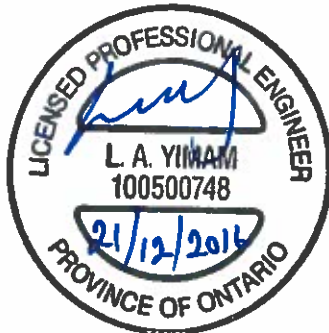


16. CLOSURE

This report was prepared by Lulseged Yimam, PhD, P.Eng., and reviewed by M. Vasavithasan, M.Sc. Eng., P. Eng., Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Principal Consultant, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.



Lulseged Yimam, PhD, P.Eng.
Senior Engineer, Geotechnical Services



Mark Vasavithasan, M.Sc., Eng. P. Eng.
Senior Engineer, Geotechnical Services



Carlos M.P. Nascimento, P.Eng.
Project Manager and
MTO Designated Principal Contact

LY/MV/CN:nk

Part B – Preliminary Foundation Design Report

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MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 040FDR

PML Ref.: 14TF020, December 21, 2016



APPENDIX F

Records of Previous Boreholes Drilled on the US Side of the Bridge

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION
LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION



This boring was taken by EPC under a consultant contract for Mn/DOT

UNIQUE NUMBER 77676

U.S. Customary Units



State Project 3905-09		Bridge No. or Job Desc. 9412		Trunk Highway/Location MN Trunk Highway 72			Boring No. B100		Ground Elevation 1063.9 (survey)		
Location Lake of the Woods/South Zone Co. Coordinate: X=570333 (ft)=229620							Machine CME 750 ATV			SHEET 1 of 1	
Latitude (North)=48°43'05.77" Longitude (West)=94°35'31.24"							Hammer CME Automatic			Drilling Completed 9/17/13	
No Station-Offset Information Available											
DEPTH	Depth	Lithology	Classification	Drilling Operation	SPT	MC	COH	γ	Soil	Other Tests Or Remarks	
	Elev.				N60	(%)	(psf)	(pcf)			Rock
					REC	RQD	ACL	Core Breaks		Formation or Member	
			Top of Driling Platform (0.0 feet ; Elevation 1063.9)							SPT hammer calibrated to 67% efficiency on 9/6/13	
5	5.0 1058.9									Drill Rig Platform including barge deck spudded approximateley 50' Northeast of 1st pier. Rainy River	
10			Water								
15	16.0 1047.9		Clay (C), gray, wet to waterbearing, trace sand, trace gravel, stiff consistency.		10	68					
20	19.5 1044.4		Sandy Loam (SL) gray, wet to waterbearing, trace gravel, slightly plastic, loose relative density.		8	75					
25	21.0 1042.9		Clay (C), gray to grayish brown, wet, stiff consistency.		10	20					
30	23.5 1040.4		Sand (S), gray to grayish brown, waterbearing, fine to coarse grained, medium dense to loose relative density.		16	20				Boulder encountered	
35	29.5 1034.4				10	17					
40			Clay (C), gray, wet, trace gravel, little sand, stiff consistency.		9	19		101		Hand Pen. = 1.7 tsf	
45	46.0 1017.9					23	1690	106		Hydrometer gradation performed on shelby tube from 31 - feet.	
50					11	23		106		Hand Pen. = 1.7 tsf	
55						23	1250	106		Hand Pen. = 1.7 tsf	
60					13	19		128		Shelby tube pushed a rock. Hard	
65						12		134		Hand Pen. = 5.9 tsf	
70					85	14				Drillers note: w/gravel, hard drilling	
75	77.1 986.8				121	9				Hand Pen. = 4.8 tsf	
					50/5"	10				Drillers note: drilled through a boulder at 47.5'	
					50/.5"						
					50/3"	9					
					50/3"	15					
			Sandy Loam (SL), gray, moist to wet, trace to little gravel, slightly plastic, very dense relative density.		336	9		133			
					50/1"	7					
					134	11		134			
					50/4"	11					
					50/3"	9					
					50/3"	9					
					50/5"	8		127			
					50/4"	14					
					75/0"					Auger refusal at 77.1' probable boulder.	

Index Sheet Code 3.0

Soil Class:GEH Rock Class: Edit: Date: 10/16/13
G:\GINT\PROJECTS-ACTIVE\3905-09 BAUDETTE INTL BRIDGE.GPJ

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION
LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION



This boring was taken by EPC under a consultant contract for Mn/DOT

UNIQUE NUMBER 77677

U.S. Customary Units



State Project 3905-09		Bridge No. or Job Desc. 9412		Trunk Highway/Location MN Trunk Highway 72		Boring No. B101		Ground Elevation 1064.4(survey)		
Location Lake of the Woods/South Zone Co. Coordinate: X=570495 (ft) Y=228725						Machine CME 750 ATV		SHEET 1 of 2		
Latitude (North)=48°43'06.8" Longitude (West)=94°35'28.82"						Hammer CME Automatic		Drilling Completed 9/18/13		
No Station-Offset Information Available										
DEPTH	Depth Elev.	Lithology	Classification	Drilling Operation	SPT	MC	COH	γ	Soil/ Rock	Other Tests Or Remarks
					N ₆₀	(%)	(psf)	(pcf)		REC
			Top of Driling Platform (0.0 feet ; Elevation 1064.4)							SPT hammer calibrated to 67% efficiency on 9/6/13
5	5.5 1058.9									Drill Rig Platform including barge deck spudded approximately 50' Northeast of 2nd pier.
10										
15			Water							Rainy River
20										
25	23.5 1040.9		Sand (S), gray to grayish brown, waterbearing, trace to little gravel, fine to coarse grained, loose relative density.		6	20				
30	28.5 1035.9				6	19			104	Hand Pen. = 1.0 tsf
35			Clay(C), gray, wet, trace gravel, stiff to very stiff consistency.		20	25			103	Hand Pen. = 1.8 tsf
40							2000		105	Hand Pen. = 1.4 tsf
45	43.5 1020.9				12	23				
50					28	25				Boulder at 38', attempted shelby tube. Crushed tube.
55					19	15				
60			Sandy Loam (SL), gray, moist to wet to waterbearing, trace to little gravel, trace clay, very dense relative density.		224	13			136	
65					50/4"	7				Hydrometer gradation performed on samples from 48.5' to 56.2'.
					50/4"	8				
					50/4"	8				
					50/4"	10				
					50/2"	10				
					50/4"	8				Hydrometer gradation performed on samples from 58.5' to 66.3'.
					50/5"	17				
					50/3"	15				
					50/3"	10				
					50/1"	10				Cobbles and Boulders encountered
	68.6 995.8		Probable boulder, auger refusal at 69.2'.							Drillers note: drilled for 1 hour on boulder/bedrock to get from 67' to 69'. Spent
	69.2									
	995.2									

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION
LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION



This boring was taken by EPC under a consultant contract for Mn/DOT

UNIQUE NUMBER 77677

U.S. Customary Units



Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

SHEET 2 of 2

State Project 3905-09		Bridge No. or Job Desc. 9412	Trunk Highway/Location MN Trunk Highway 72				Boring No. B101	Ground Elevation 1064.4 _(survey)		
DEPTH	Depth	Lithology	Classification	Drilling Operation	SPT	MC	COH	γ	Soil	Other Tests Or Remarks
	Elev.				N ₆₀	(%)	(psf)	(pcf)		
					REC	RQD	ACL	Core Breaks	Rock	Formation or Member
					(%)	(%)	(ft)			

1/2 hour drilling from 69' to 69.2'.

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION
LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION



This boring was taken by EPC under a consultant contract for Mn/DOT

UNIQUE NUMBER 77678

U.S. Customary Units



State Project 3905-09		Bridge No. or Job Desc. 9412		Trunk Highway/Location MN Trunk Highway 72		Boring No. B102		Ground Elevation 1063.9 (survey)	
Location Lake of the Woods/South Zone Co. Coordinate: X=570647 (ft)=228821 Latitude (North)=48°43'07.77" Longitude (West)=94°35'26.55" No Station-Offset Information Available						Machine CME 750 ATV		SHEET 1 of 2	
						Hammer CME Automatic		Drilling Completed 9/24/13	
DEPTH	Depth Elev.	Lithology	Classification	Drilling Operation	SPT N₆₀	MC (%)	COH (psf)	γ (pcf)	Soil
					REC (%)	RQD (%)	ACL (ft)	Core Breaks	Other Tests Or Remarks
									Formation or Member
5.0	1058.9		Top of Drilling Platform (0.0 feet ; Elevation 1063.9)						SPT hammer calibrated to 67% efficiency on 9/6/13
10									
15			Water						
20									
23.0	1040.9								
25					0	10			
30			Sand (S), brown to gray, wet to waterbearing, coarse to fine grained, very loose relative density.		3	40			Drill Rig Platform including barge deck spudded approximately 50' Northeast of 3rd pier.
33.0	1030.9				2	18			
35					4	18			
38.0					8	21		109	Hand Pen. = 1.5 tsf
40			Clay (C), gray, wet, trace gravel, little to some sand, medium to soft consistency.		7	23	1400	101	Hand Pen. = 1.6 tsf
45					10	11		100	Hand Pen. = 1.3 tsf
48.0	1015.9				32	560		95	Hand Pen. = 1.8 tsf
50					16	12			Hydrometer gradation performed on shelly tube from 41'.
55			Sandy Loam (SL), gray, moist to wet, trace to little gravel, trace clay, slightly plastic, very dense relative density.		73	9			
58.0					50/5"	10		128	
60					50/5"	9			
					50/5"	13			
					50/2"	9			

Index Sheet Code 3.0

(Continued Next Page)

Soil Class: GEH Rock Class: Edit: Date: 10/16/13
G:\GINT\PROJECTS-ACTIVE\3905-09 BAUDETTE INTL BRIDGE.GPJ

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION
LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION



This boring was taken by EPC under a consultant contract for Mn/DOT

UNIQUE NUMBER 77678

U.S. Customary Units



Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

SHEET 2 of 2

State Project 3905-09		Bridge No. or Job Desc. 9412		Trunk Highway/Location MN Trunk Highway 72			Boring No. B102		Ground Elevation 1063.9(survey)	
DEPTH	Depth	Lithology	Classification	Drilling Operation	SPT N ₆₀	MC (%)	COH (psf)	γ (pcf)	Soil	Other Tests Or Remarks
	Elev.				REC (%)	RQD (%)	ACL (ft)	Core Breaks		Formation or Member
	60.5 1003.4				50/0.5"					
65					24	10	0.58			Substantial auger refusal at 60.6' - boulder, set up for rock coring.
70				WS		18				Samples 17- 26 were either boulders that were in the core barrel or cuttings from return water.
75					0		0.00			
80				WS	8					Drillers Note: Sand recovered in wash cuttings.
85					6	5	0.33			
90			Boulders and Cobbles (4" - 12") mixed with apparent Sandy Loam, gray.	WS	5	20				Drillers Note: Sand recovered in wash cuttings.
95										
100					7		0.00			
105										
110				WS	7	19				Drillers Note: Sand recovered in wash cuttings.
115	116.0 947.9		End of boring at 116'		5		0.00			Formation started caving in around drill rod. Unable to spin drill rod.

Part B – Preliminary Foundation Design Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

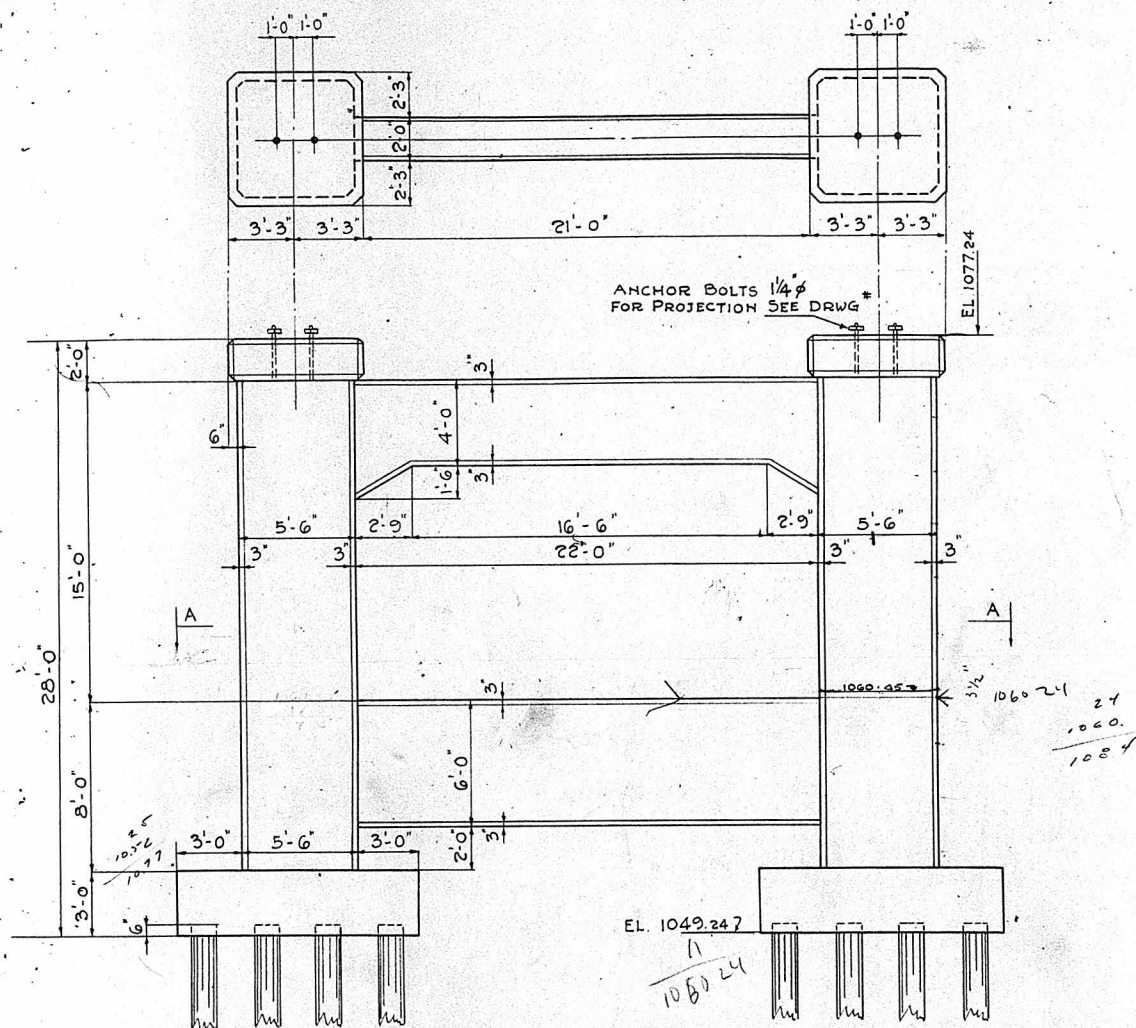
MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 040FDR

PML Ref.: 14TF020, December 21, 2016

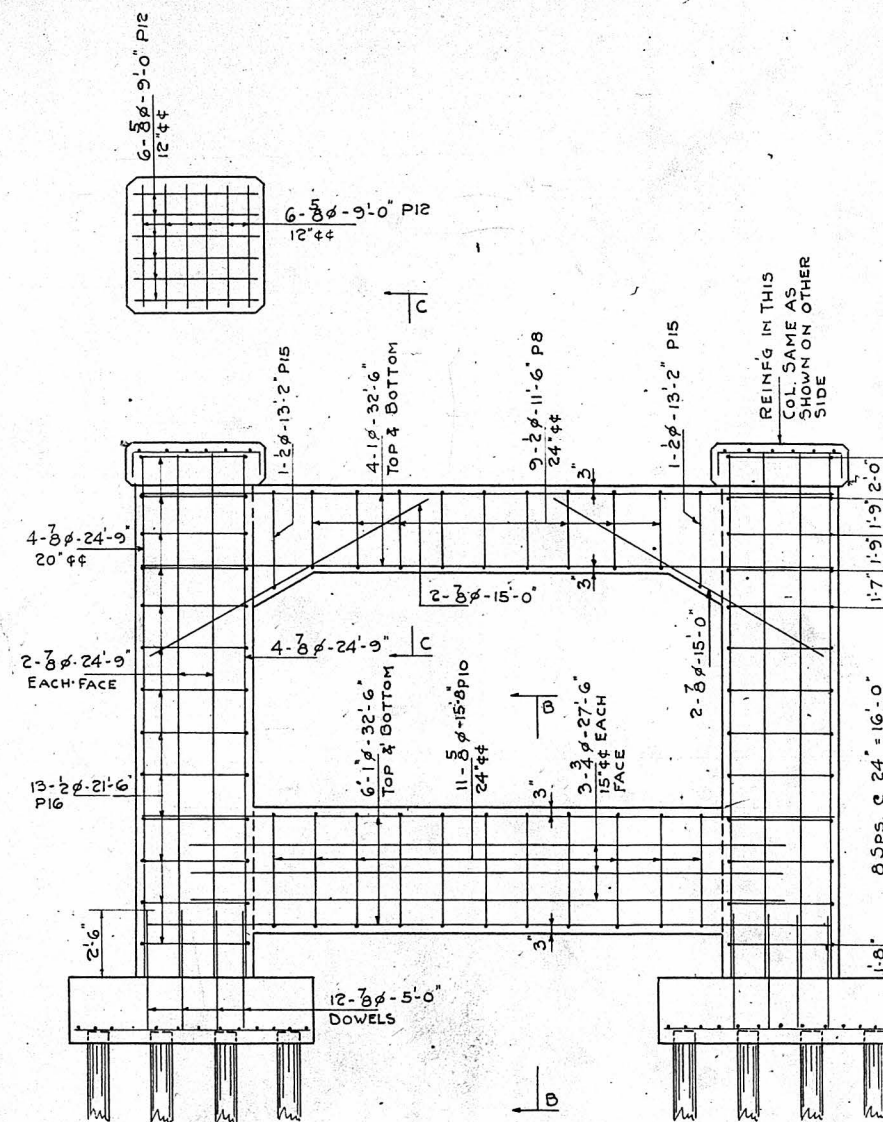
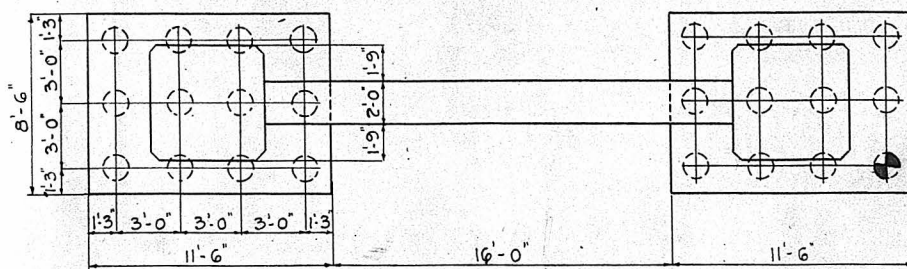


APPENDIX G

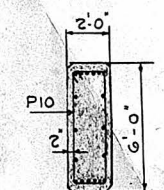
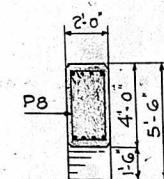
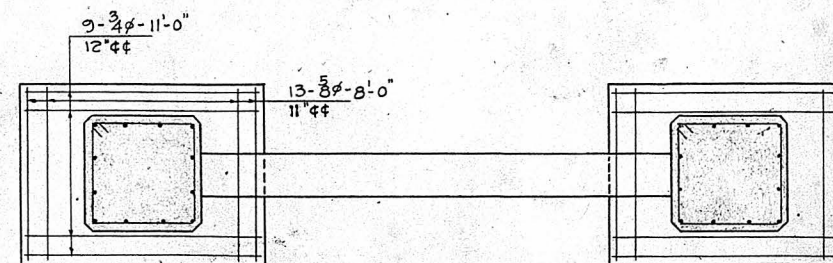
Existing Baudette – Rainy River Bridge Drawings



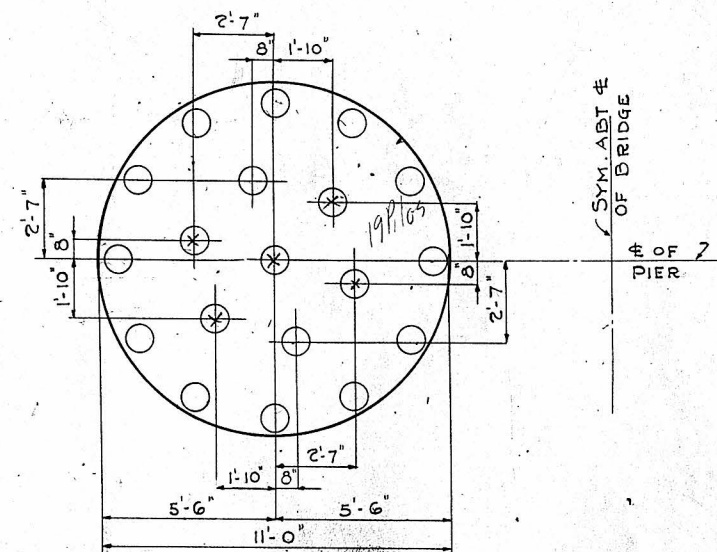
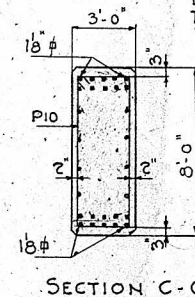
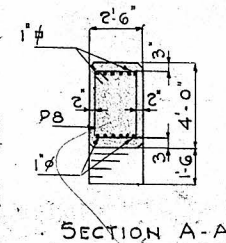
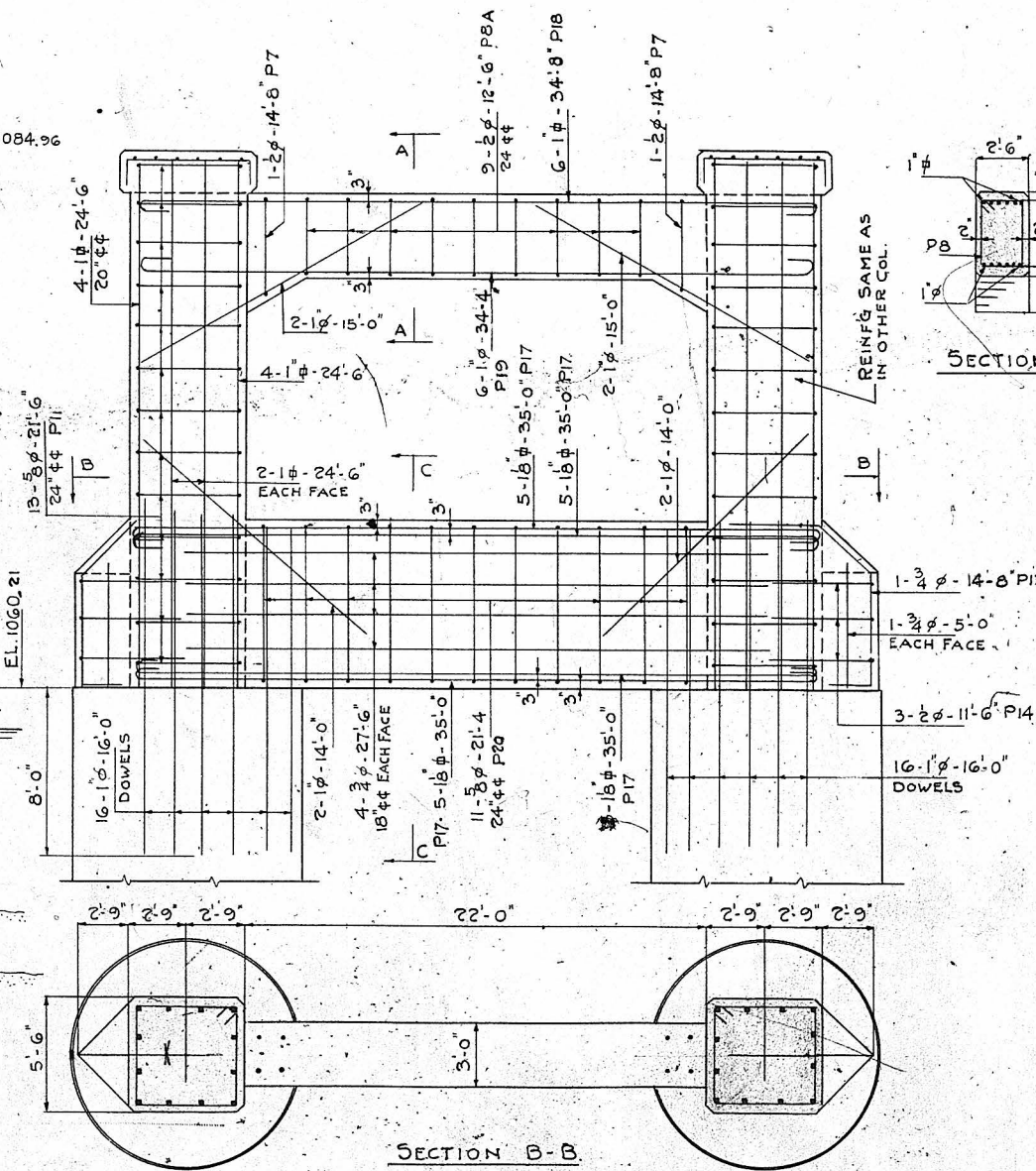
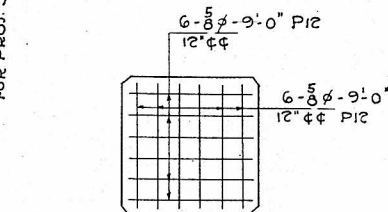
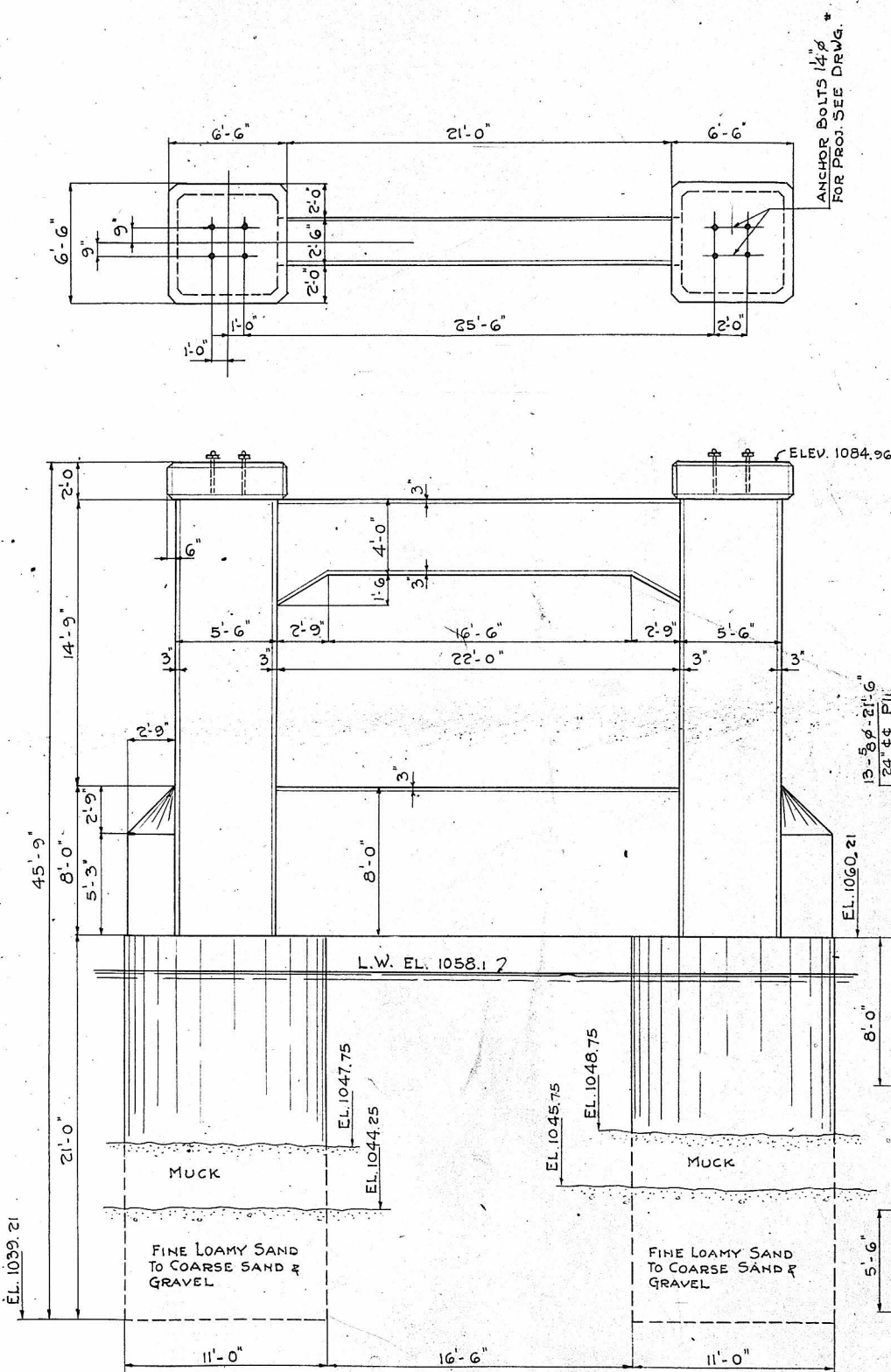
ELEVATION OF PIERS #1 & #7



REINFORCING DETAIL OF PIERS #1 & #7



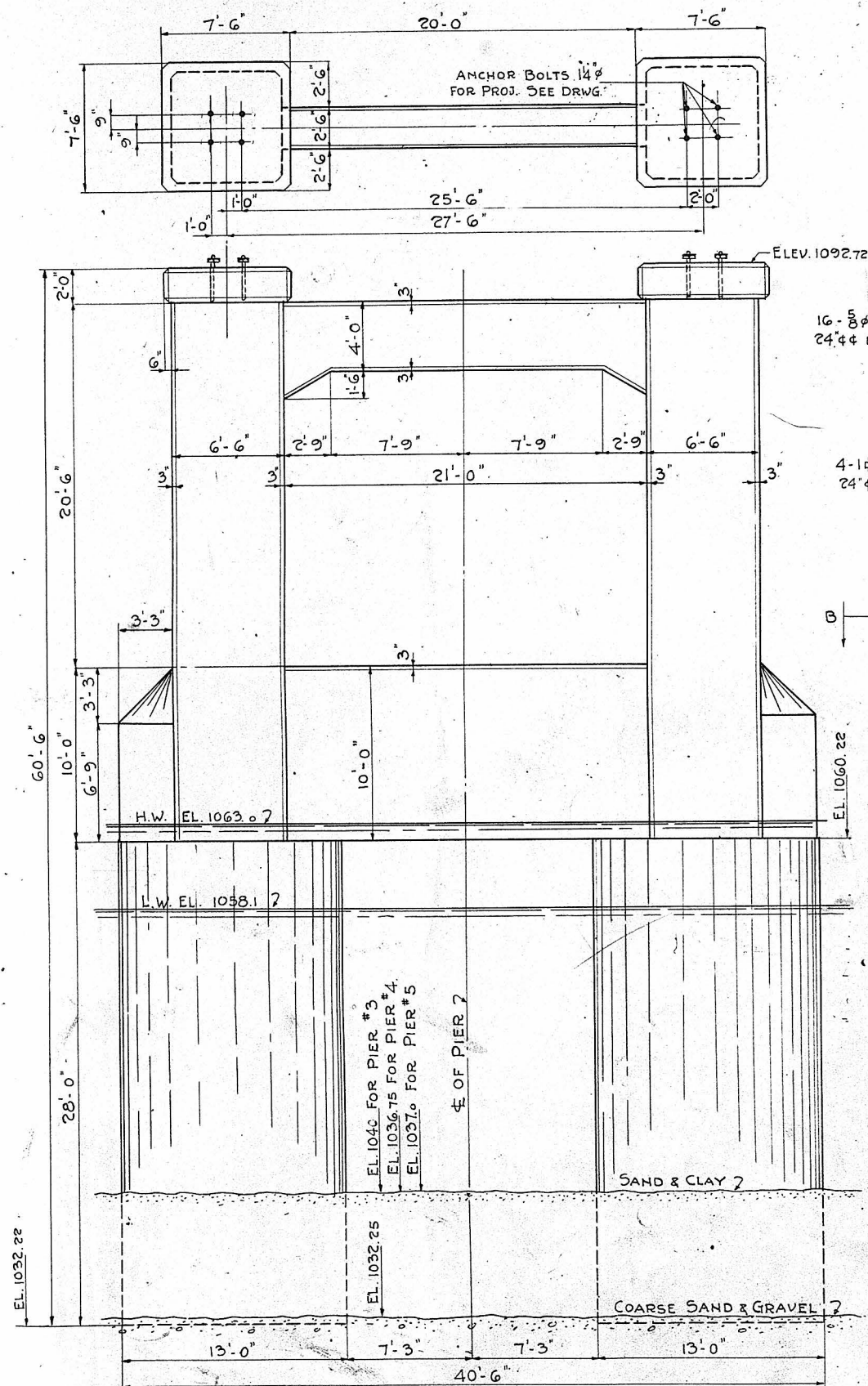
GEN. NOTE:
FOR LOCATION OF PIERS SEE DRWG. #1.
EACH PILE TO BE DRIVEN TO 20 TONS
BEARING.
CONCRETE MIX - 2500* CONCRETE.
FOR STEEL LIST SEE SHEET #R1.
FOR BENDING DETAILS SEE SHEET #R1.



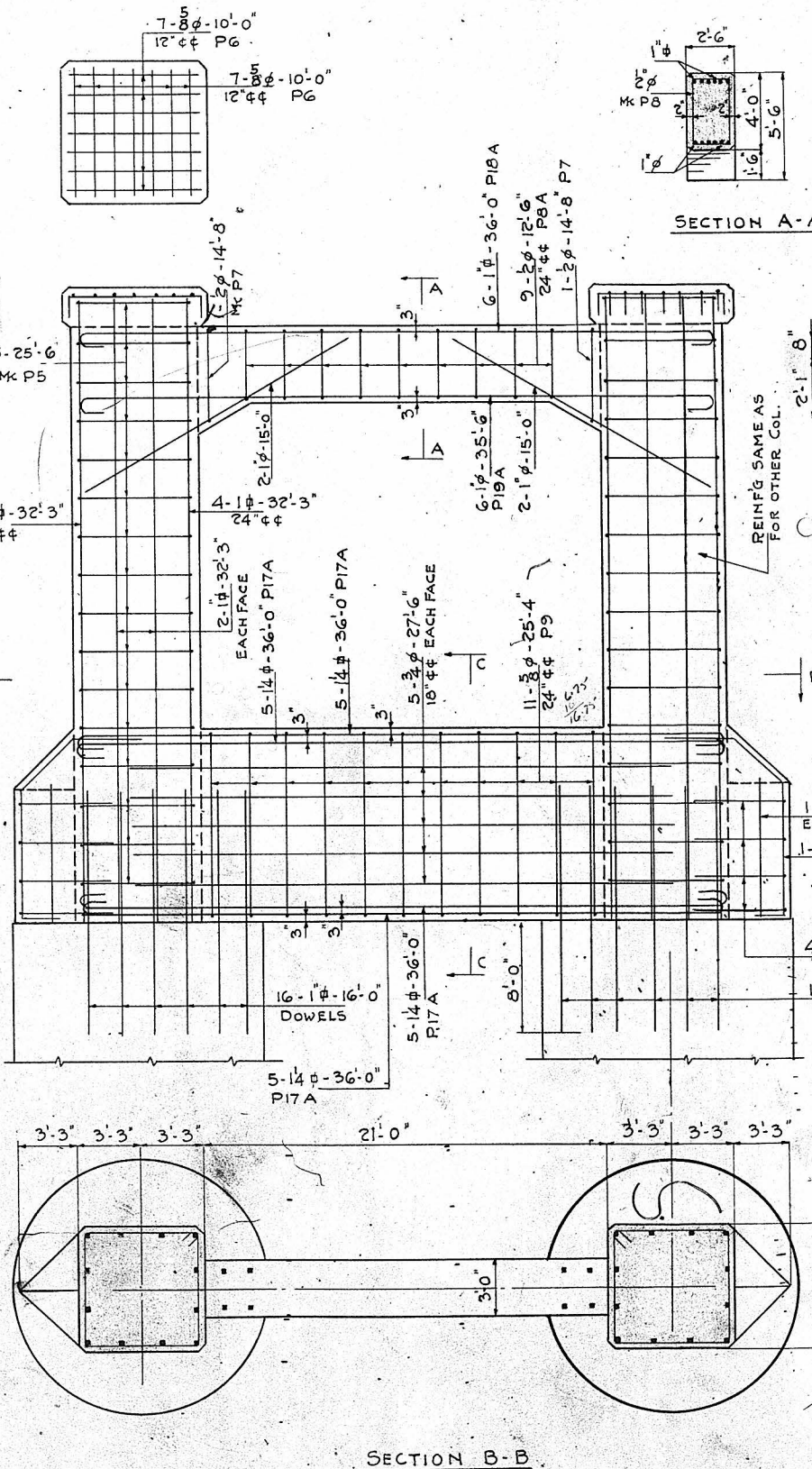
OUTER LINE OF PILES TO BE DRIVEN CLOSE
TO STEEL TUBE 2'-7" ± AS SHOWN.
INNER PILES TO BE SPACED AS SHOWN.
ALL PILES TO BE DRIVEN TO 20 TONS BEARING
TOP OF PILES TO BE AT LEAST 1'-0" BELOW
TOP OF STEEL TUBE.

GEN. NOTE:

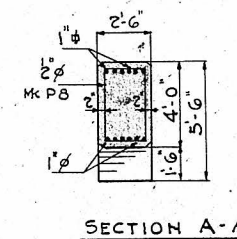
FOR LOCATION OF PIER SEE DRWG. #1
CONCRETE MIX - 2500* CONCRETE IN BENT; 2000* IN CAISSONS.
AFTER STEEL CAISSONS ARE DOWN TO ELEV.
SHOWN AND PILING IS DRIVEN CAISSONS HAVE
TO BE FILLED WITH CONCRETE UNDER WATER BY
MEANS OF A TREMIE.
FOR STEEL LIST SEE SHEET *R2.
FOR BENDING DETAILS SEE SHEET *R2.



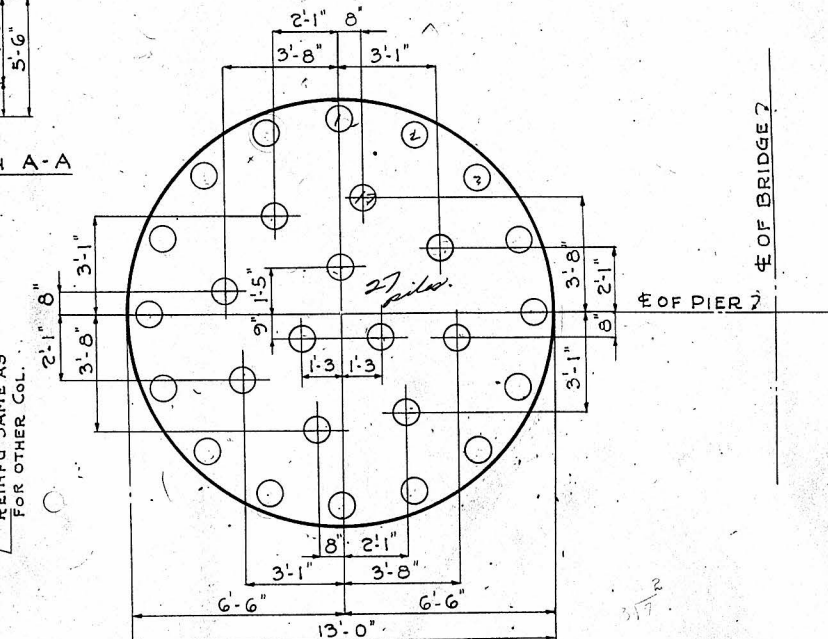
DETAIL OF PIERS *3, *4 & *5



REINFORCING DETAIL OF PIERS *3, *4 & *5

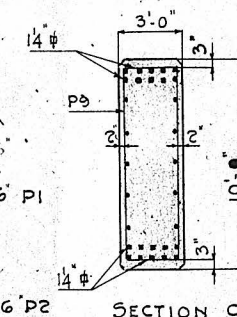


SECTION A-A



PILING PLAN.

OUTER LINE OF PILES TO BE DRIVEN CLOSE TO STEEL TUBE 2'-4" DIA. AS SHOWN. INNER PILES TO BE SPACED AS SHOWN. ALL PILES TO BE DRIVEN TO 20 TONS BEARING. TOP OF PILES TO BE AT LEAST 1'-0" BELOW TOP OF STEEL TUBE.



SECTION C-C

GEN. NOTE:

FOR LOCATION OF PIERS SEE DRWG. 1. * CONCRETE MIX - 2500# CONCRETE IN BENT, 2000 IN CAISSONS. AFTER STEEL CAISSONS ARE DOWN TO ELEV. SHOWN BY OPEN EXCAVATION AND PILING IS DRIVEN, CAISSONS HAVE TO BE FILLED WITH CONCRETE UNDER WATER BY MEANS OF A TRIMIE. FOR STEEL LIST SEE SHEET *R3. FOR BENDING DETAILS SEE SHEET *R3.

DETAIL OF PIERS *3, *4 AND *5.

BAUDETTE- RAINY RIVER INTERNATIONAL BRIDGE.

Part B – Preliminary Foundation Design Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 040FDR

PML Ref.: 14TF020, December 21, 2016



APPENDIX H

List of Ontario Provincial Standard Specifications (OPSS) and
List of Ontario Provincial Standard Drawings (OPSD) Mentioned in the Report

Part B – Preliminary Foundation Design Report

Baudette - Rainy River International Bridge Replacement,

MnDOT Bridge No. 39016 / MTO Site No. 45-110, MN TH 72 / Highway 11,

MnDOT Project No. SP 3905-09, MnDOT Contract No. 02047, GWP 6046-08-00, Index No.: 040FDR

PML Ref.: 14TF020, December 21, 2016

**LIST OF STANDARD SPECIFICATIONS MENTIONED IN THE REPORT**

DOCUMENT	TITLE
OPSD 3000.100	Foundation Piles Steel H-Pile Driving Shoe
OPSS 902	Excavation and Backfilling of Structures
OPSS 501	Construction Specification for Compacting
OPSS 405	Construction Specification for Pipe Sub-Drains
OPSD 3190.100	Walls Retaining and Abutment Wall Drains
OPSD 203.020	Embankments over Swamp
OPSD 208.010	Benching of Earth Slopes
OPSD 810.010	General Rip-Rap Layout Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Penetration Depth for Northern Ontario
OPSD 3101.150	Walls Abutment Backfilling Minimum Granular Requirement
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 802	Construction Specification for Topsoil
OPSS 804	Construction Specification for Seed and Cover
OPSS 539	Construction Specification For Temporary Protection Systems
OPSS 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 518	Construction Specification for Control of Water from Dewatering Operations