



THURBER ENGINEERING LTD.

**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
CPR OVERHEAD AT TERRACE BAY STRUCTURE REPLACEMENT
HIGHWAY 17, DISTRICT OF THUNDER BAY,
TOWNSHIP OF STREY, ONTARIO
LATITUDE: 48.788510°, LONGITUDE: -87.092973°
G.W.P. 6113-17-00 SITE No. 48E-0018/B0**

GEOCRES Number: 42D-61

Report

to

McIntosh Perry

Date: September 30, 2021
File: 29475



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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a preliminary foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed structure replacement of the CPR (Canadian Pacific Railway) Overhead bridge. The CPR Overhead bridge is located on Highway 17, on the easterly limits of the Town of Terrace Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the existing CPR Overhead bridge site and based on the data obtained, to provide a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by McIntosh Perry to carry out this foundation investigation under the Ministry of Transportation (MTO) Northwest Region Agreement Number 6020-E-0001.

2. SITE DESCRIPTION

The site is located on Highway 17, on the easterly limit of the Town of Terrace Bay, in Strey Township, Thunder Bay District, Ontario. The existing overhead allows the CPR line to operate under Highway 17 in an east-west direction. Highway 17 runs in a general northeast-southwest direction at the bridge site. For the purposes of this report and drawings, Highway 17 is considered to run approximately east-west, and the existing bridge foundations are referred to as the west abutment, west pier, east pier, and east abutment.

The Ontario Structure Inspection Manual (OSIM) report prepared by MTO on October 24, 2019 indicates that the existing structure is a three-span, steel beam/girder bridge with a cast-in-place



concrete deck, built in 1948 with a major rehabilitation in 2000. The inspection report indicates that the bridge deck is approximately 52.4 m long and 14.5 m wide. Based on existing survey data for the site, the ground surface elevation of Highway 17 at the existing bridge is approximately Elevation 280.2 m. The existing bridge is supported on cast-in-place concrete footings at the abutments and piers.

The grade of Highway 17 at the CPR overhead is generally raised from the surrounding lands. The lands surrounding the overhead bridge include access roads, dense treed areas and CPR switches to the north side of the bridge. Photographs of the bridge and surrounding area are presented in Appendix C. No obvious indications of road settlement were observed, and the existing Highway 17 embankment slopes appeared to be performing satisfactorily.

Based on published geological information, the bridge lies within an area consisting of glaciomarine deposits of sand and gravelly sand. Based on local geological maps, the bedrock in the area is identified as massive to foliated granodiorite to granite.

An existing General Plan Drawing from 1947, DWG No. D2942 that pertains to the original bridge, indicates that the subsurface stratigraphy consists of coarse to fine sand, underlain by sandy silt to sand and silt. The stratigraphy is reproduced and presented on the soil strata drawings included in Appendix D.

3. INVESTIGATION PROCEDURES

The field investigation for the replacement overhead bridge was carried out between December 7 and 19, 2020 and consisted of drilling and sampling four (4) foundation boreholes, labeled 20-01 to 20-04, and two (2) dynamic cone penetration tests (DCPTs), labeled 20-01A DCPT and 20-04A DCPT. Boreholes 20-02 and 20-03 were drilled adjacent to the existing east pier to depths ranging from approximately 27.4 to 32.3 m (Elevation 249.2 to 238.8 m). Part of these depths were DCPTs driven below the sampled depth. Access to the west pier was not allowed by CPR with the track-mounted drill rig due to sloping terrain and close proximity to the active CPR track. Boreholes 20-01 and 20-04, as well as DCPTs 20-01A DCPT and 20-04A DCPT, were advanced near the locations of the existing bridge abutments, and extended to depths ranging from approximately 20.3 to 29.2 m (Elevation 259.8 to 250.9 m).

The borehole logs from the foundation investigation are included in Appendix A. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata drawing included in Appendix D. The boreholes from the archival drawing from 1947, DWG No. D2942, are also shown on the stratigraphic profile, and labeled as BH 47-1 to BH 47-3. The archival drawing is



included in Appendix E. The boreholes are not identified on the drawing, and therefore the assigned labels of BH 47-1 to BH 47-3 have been added to the drawing.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from field measurements and the topographic drawings provided to Thurber by McIntosh Perry. The coordinate system MTM NAD 83, Zone 14 was used for the boreholes. CPR flagging protection was arranged for drilling Boreholes 20-02 and 20-03.

A rubber tracked CME 55 drill rig was used to advance all of the boreholes using hollow stem augers and NW casing. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A Dynamic Cone Penetration Test (DCPT) was also conducted at the base of Boreholes 20-02 and 20-03 as well as from the existing ground surface at DCPTs 20-01A DCPT and 20-04A DCPT to provide additional information for the investigation.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

A standpipe piezometer was installed in Borehole 20-02 to permit measurement of the groundwater level. The piezometer was decommissioned at the end of the field investigation in general accordance with Ontario Regulation 903 as amended.

Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
20-01	29.2 / 250.9	-	Backfilled with grout from 29.2 to 3.0 m, bentonite from 3.0 to 0.3 m, sand to 0.2 m, then asphalt to surface.
20-01A DCPT	20.3 / 259.8	-	Backfilled with grout from 20.3 to 0.2 m, then asphalt to surface
20-02	32.3 / 238.8	30.5 / 240.5	Filter sand from 30.5 to 27.1 m, then bentonite to surface.
20-03	27.4 / 243.8	-	Backfilled with bentonite from 27.4 m to surface.



Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
20-04	27.7 / 252.5	-	Backfilled with grout from 27.7 to 3.0 m, bentonite from 3.0 to 0.3 m, sand to 0.2 m, then asphalt to surface.
20-04A DCPT	20.8 / 259.3	-	Backfilled with bentonite from 20.5 to 0.2 m, then asphalt to surface

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer), where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, samples of the fill and native soil from the boreholes near the existing abutments and piers were collected. The samples were submitted to SGS, a CALA accredited analytical laboratory in Mississauga, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

5. SUBSURFACE CONDITIONS

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

In general, the subsurface conditions encountered at the boreholes consisted of asphalt and granular fill, underlain by native deposits of sand and silt. Descriptions of the individual strata are presented below.



5.1 Asphalt

A 140 to 150 mm thick layer of asphalt was encountered at the ground surface in Boreholes 20-01 and 20-04, which were located on the shoulders of Highway 17.

5.2 Sand Fill

Sand fill was encountered below the asphalt or at the ground surface in all boreholes. The fill typically consisted of fine to coarse sand with traces of gravel and silt.

The sand fill extended to depths ranging from 9.7 to 10.2 m (Elev. 270.4 to 270.0 m) for the bridge abutment Boreholes 20-01 and 20-04. In Boreholes 20-02 and 20-03 near the track level, the sand fill extended to depths ranging from 0.8 to 1.2 m (Elev. 270.3 to 269.9 m). The upper 1.3 m of the fill in Borehole 20-04 consisted of silty sand with trace gravel. Trace organics were also encountered within the sand fill in Borehole 20-03.

The relative density of the sand fill generally ranged between loose and compact, with SPT 'N' values ranging from 4 to 27 blows for 0.3 m of penetration. The measured moisture content in the granular fill ranged from 4 to 18%, with a moisture content of 34% in Borehole 20-03, where trace organics were present. However, most samples had moisture contents between 4 and 6%.

The results of grain size analyses conducted on selected samples of the sand fill are illustrated on Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	1 to 3
Sand	90 to 95
Silt and Clay	4 to 8

5.3 Sand

A deposit of native sand containing trace to some gravel and trace to some silt was encountered below the granular fill in all boreholes. The thickness of the sand deposit ranged from 9.5 to 10.7 m and extended to depths of 10.7 to 20.9 m (Elev. 260.7 to 259.4). The 20-04A DCPT encountered refusal of 100 blows per 0.3 m of penetration at a depth of 20.8 m (Elev. 259.3 m), near the base of the native sand deposit.



A 1.5 m thick layer of very dense sandy silt was encountered within the sand deposit at a depth of 14.8 m (Elev. 265.3 m) in Borehole 20-01. An SPT 'N' value of 86 blows per 0.3 m of penetration was recorded in this layer.

SPT 'N' values measured in the native sand deposit ranged from 9 to 33 blows per 0.3 m of penetration, indicating that the deposit ranges from loose to dense. The measured moisture contents in the sand ranged from 4 to 28%.

The results of grain size analyses conducted on samples of the sand are illustrated on Figure B2 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 4
Sand	70 to 90
Silt and Clay	6
Silt	10 to 28
Clay	1 to 2

5.4 Silt

A native deposit of silt, containing trace to some sand and trace clay was encountered below the native sand in all boreholes. In the archival boreholes 47-1 to 47-3, the silt deposit is described as sandy silt to sand and silt. Boreholes 20-01, 20-02 and 20-04 were terminated within the silty sand at depths from 27.7 to 31.1 m (Elev. 252.5 to 240.0 m). Where fully penetrated in Borehole 20-03, the thickness of the native silt deposit was 10.1 m, with a base depth of 20.8 m (Elev. 250.4 m). The 20-01A DCPT encountered refusal of 100 blows per 0.3 m of penetration at a depth of 20.3 m (Elev. 259.8 m), within the native silt deposit.

A 1.6 m thick layer of dense sand with some silt was encountered within the silt deposit at a depth of 21.6 m (Elev. 258.5 m) in Borehole 20-01. A 1.5 m thick zone of intermittent layers of very dense sand and silt was encountered within the silt deposit at a depth of 16.3 m (Elev. 254.7 m) in Borehole 20-02.

SPT 'N' values measured in the silt deposit ranged from 23 to greater than 100 blows for 0.3 m of penetration, indicating that the deposit is compact to very dense. The measured moisture contents in the silt ranged from 10 to 21%.



The results of grain size analyses conducted on samples of the silt are illustrated on Figure B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	3 to 18
Silt	79 to 93
Clay	2 to 4

5.5 Silty Sand

Borehole 20-03 was terminated within a deposit of silty sand with trace clay below the native silt deposit. The borehole was sampled until a depth of 21.9 m (Elev. 249.2 m) and extended by DCPT until refusal was encountered at a depth of 27.4 m (Elev. 243.8 m).

The silty sand was compact, with an SPT 'N' value of 28 blows per 0.3 m of penetration. The measured moisture content of the silty sand was 18%.

The results of a grain size analysis conducted on a sample of the silty sand are illustrated on Figure B4 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	67
Silt	32
Clay	1

5.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes and the piezometer installed in Boreholes 20-02. A summary of the water level measurements is provided in Table 5.1 below:

Table 5.1 - Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
20-01	December 15, 2020	11.1	269.0	Open borehole
	December 19, 2020	11.1		

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
20-02	December 8, 2020	1.2	269.8	Piezometer
	December 9, 2020	2.1	268.9	
	December 10, 2020	2.1	268.9	
20-04	December 14, 2020	7.3	272.9	Open borehole
	December 15, 2020	11.3	268.9	
	December 19, 2020	11.3	268.9	

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

6. CORROSIVITY AND SULPHATE TEST RESULTS

Two (2) samples of the fill and native soil were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 - Analytical Test Results

Parameter	Units (soil)	Test Results	
		BH20-02 SS3, 2.3 to 2.9 m	BH20-04 SS4, 3.0 to 3.7 m
		Native Sand	Fill Sand
Sulphide	%	<0.04	<0.04
Chloride	µg/g	26	660
Sulphate	µg/g	4.1	21
pH	no unit	8.92	9.06
Conductivity	uS/cm	131	1350
Resistivity (calculated)	ohms.cm	7,630	740
Redox Potential	mV	280	310

7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting



coordinates and ground surface elevations were estimated based on field measurements relative to the topographic plans provided by MTO.

RPM Drilling of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. CPR provided railway flagging protection. The field investigation was supervised on a full-time basis by Ms. Madisan Chiarotto, EIT of Thurber. The overall supervision of the field program was conducted by Mr. Joshua Alexander, EIT. and Mr. Mark Farrant, P.Eng. of Thurber. Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory.

Interpretation of the field data and preparation of this report was carried out by Mr. Joshua Alexander, EIT and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report, and presents preliminary foundation design recommendations for the proposed replacement of the CPR (Canadian Pacific Railway) Overhead bridge in Terrace Bay, Ontario.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of McIntosh Perry and the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. Contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The site is located on Highway 17, on the easterly limit of the Town of Terrace Bay, in Strey Township, Thunder Bay District, Ontario. The existing overhead allows the CPR line to operate under Highway 17 in an east-west direction. Highway 17 runs in a general northeast-southwest direction at the bridge site. For the purposes of this report and drawings, Highway 17 is considered to run approximately east-west, and the existing bridge foundations are referred to as the west abutment, west pier, east pier, and east abutment.

The Ontario Structure Inspection Manual (OSIM) report prepared by MTO on October 24, 2019 indicates that the existing structure is a three-span, steel beam/girder bridge with a cast-in-place concrete deck, built in 1948 with a major rehabilitation in 2000. The inspection report indicates that the bridge deck is approximately 52.4 m long and 14.5 m wide. Based on existing survey data



for the site, the ground surface elevation of Highway 17 at the existing bridge is approximately Elevation 280.2 m. The existing bridge is supported on cast-in-place concrete footings at the abutments and piers.

Based on preliminary structural drawings and discussions with McIntosh Perry, it is understood that the existing bridge on Highway 17 may be replaced with either a single-span or a three-span bridge, with several shallow and deep foundation options being considered. The single-span option would include backfilling in front of the existing abutments within Retained Soil System (RSS) walls utilized to retain the fill. The backfill and RSS walls of up to approximately 8 m high are expected to induce short-term settlement of the foundation soils, which will be experienced at the existing foundations and the CP tracks. The Highway 17 embankment is anticipated to be widened by approximately 1 m on the south side of the highway to accommodate a 700 mm alignment shift to the south. An approximately 500 mm grade raise is also anticipated. A structural memo by McIntosh Perry including a Life-Cycle Cost Analysis indicates that the single-span option is more economical and is the preferred option. A preliminary draft General Arrangement (GA) drawing of the 32.5 m long single-span option is included in Appendix F for reference. As an offline detour route is not feasible for Highway 17, it is anticipated that staged construction incorporating temporary roadway protection systems will be utilized during replacement of the bridge.

9. STRUCTURE FOUNDATIONS

This section presents discussions on the proposed foundation alternatives for the replacement CP Overhead bridge.

In general, the foundation soil stratigraphy at the location of the bridge consists of typically loose to compact granular fill (sand) overlying native deposits of compact to dense sand and dense to very dense silt. The short-term water level elevation in the boreholes and piezometer was measured at approximate Elevation 269 m.

Based on the subsurface conditions at this site, consideration was given to supporting the replacement bridge on the following foundation types:

- Spread footings placed on native sand;
- Steel H-Piles or Pipe Piles driven to very dense silt; and
- Drilled in Steel Pipe Piles founded on very dense silt.



Recommendations for design of the feasible foundation options are provided in the following sections. A comparison of the technical advantages and disadvantages of the alternative foundation options is presented in Appendix G.

9.1 Spread Footings on Native Sand

From a geotechnical perspective, the replacement CP Overhead bridge could be supported on spread footings founded on the native compact to dense sand if used at the abutments for the single-span option, or the piers for the three-span option. Spread footings are not recommended at the abutments for the three-span option, as they would be founded either on the loose to compact sand fill, or would require approximately 10 to 12 m deep excavations through the cohesionless sand fill to construct the footings on the native compact to dense sand.

In order to avoid extensive dewatering in the native cohesionless sand, spread footings on the compact to dense native sand should be founded at approximate Elev. 269 m. Some dewatering will however be required in order to maintain dry excavations for footing construction. As the frost penetration depth at this site is approximately 2.2 m, some additional fill may also be required above the grade level to provide sufficient cover against frost action, where the grade level above the concrete footings is below Elev. 271.2 m.

9.1.1 Axial Geotechnical Resistance and Geotechnical Reaction

The following values of factored Geotechnical Resistance at ULS and Geotechnical Reaction at SLS may be used for design of concrete spread footings placed at Elev. 269 m on properly prepared compact to dense native undisturbed sand:

Table 9.1 – Geotechnical Resistances

Footing Width (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS (kPa) (for up to 25 mm settlement)
2	270	150
3	310	125
4	350	110

A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.



The factored ultimate resistance and settlement are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the footing width or founding elevation differs significantly from that given above.

The geotechnical resistances quoted above are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistances should be calculated as indicated in the CHBDC 2019 Clause 6.10.5.3.

Spread footings are not recommended due to the relatively low geotechnical resistance, risk of future footing settlement, and the need to dewater the foundation soils.

9.1.2 Lateral Resistance

The lateral resistance of the concrete footings founded on sand may be computed using an unfactored friction coefficient of 0.5. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance. The resistance factor that should be applied to the unfactored friction coefficient is 0.8.

9.2 Steel H-Piles or Pipe Piles Driven to Silt

The use of driven steel H-piles or pipe piles to support the abutments or piers for the single-span or three-span options is not recommended at this site. Vibrations from the pile driving process will induce settlement of the foundation soils and impact the foundations of the existing bridge, which must stay in operation during staged construction of the replacement bridge.

The vibration associated with pile driving at the abutments or piers is expected to cause approximately 10 to 20 mm of settlement at the existing railway tracks. Pile driving will also take place within 1 to 2 m of the existing bridge pier footings. Given the small clearance, pile driving will cause significant vibration to the existing pier footings and columns. The vibration levels will likely exceed the tolerable limit of the existing structure. The footing settlements in response to the repeated ground vibrations during pile driving are estimated to be in the order of 25 to 50 mm or more. The potential for damage of the existing structure is therefore expected to be high. Vibration monitoring of the existing foundations will be required throughout the pile driving process.

In light of the above, driven piles are not recommended at this site, and drilled-in pipe piles (described in Section 9.3) are recommended.



Further consideration may be given to driven piles during the detailed design phase, provided that considerations could be made in the design to mitigate the effects of the vibration. The potential for settlement due to vibration should also be discussed with CPR to confirm whether the railway tracks can accommodate the settlement. As the boreholes for this investigation did not reach the bedrock elevation, it is also recommended that additional deeper boreholes be drilled during the detailed design phase in order to establish a confirmed refusal layer or the bedrock elevation at the foundation locations.

9.3 Drilled in Pipe Piles Founded on Silt

The replacement CP Overhead bridge may also be supported on drilled-in steel pipe piles founded on the very dense silt and filled with concrete. This option offers an advantage over driven piles as the potential for damage to the existing structure due to vibration is low.

Since the boreholes for this investigation did not reach the bedrock elevation or a confirmed refusal layer, the pipe piles will be largely frictional in nature. It is recommended that additional deeper boreholes be drilled during the detailed design phase in order to establish the refusal elevation or bedrock elevation at the foundation locations, to allow for higher geotechnical resistances based on end bearing to be used for drilled in pipe piles.

9.3.1 Drilled in Pipe Pile Axial Resistance

Tables 9.4 and 9.5 provide geotechnical resistances and estimated tip elevations for drilled in concrete filled open-ended pipe pile (PP) options for the single-span and three-span bridge alternatives. The pile tip elevations provided are based on drilling to Elev. 253 or 245 m, with pile lengths ranging from 16 to 33 m. The underside of pile caps, if utilized, are assumed to be at approximate Elev. 278 m for each abutment foundation element. Therefore, the top of the pile will be located at approximate Elev. 278 m. For the three-span option, the pier piles would be drilled in from approximate Elev. 269 m. It is understood that for the single-span alternative, a double row of piles would first be drilled at the abutments, with the RSS walls built around them afterwards. As the depth to bedrock has not been established, it is recommended that the deeper pile option (driven to Elev. 245 m) be selected for the single-span abutments or three-span piers to achieve a higher pile capacity.

**Table 9.4 – Recommended Axial Geotechnical Resistances
for Drilled in Pipe Piles (Single-Span Bridge)**

Foundation Element	Pile Type	Approximate Pile Length / Tip Elevation (m)	Factored ULS Geotechnical Resistance Per Pile (kN)	SLS Resistance Per Pile (for up to 25 mm settlement) (kN)
East and West Abutments	PP 356x12.7	25 / 253	625	500
		33 / 245	900	750
	PP 406x12.7	25 / 253	750	600
		33 / 245	1100	900

**Table 9.5 – Recommended Axial Geotechnical Resistances
for Drilled in Pipe Piles (Three-Span Bridge)**

Foundation Element	Pile Type	Approximate Pile Length / Tip Elevation (m)	Factored ULS Geotechnical Resistance Per Pile (kN)	SLS Resistance Per Pile (for up to 25 mm settlement) (kN)
East and West Piers	PP 356x12.7	16 / 253	625	500
		24 / 245	900	750
	PP 406x12.7	16 / 253	750	600
		24 / 245	1100	900
East and West Abutments	PP 356x12.7	25 / 253	900	750
	PP 406x12.7	25 / 253	1100	900

The pipe pile resistance values presented above assume a concrete compressive strength of 35 MPa. Consideration may be given to selecting a larger pipe pile wall thickness to account for potential future corrosion concerns.

9.3.2 Drilled-In Pipe Pile Installation

Installation of pipe piles must be in accordance with OPSS.PROV 903.

The method of installation of the pipe piles is the responsibility of the Contractor. A suitable method to prevent the loss of ground during installation must be selected.

During and subsequent to installation, the pipe pile will be partially filled with water and it may not be practical to dewater the pipe prior to concreting. Tremie concrete will be required for concreting the pipe piles.

9.4 Pile Lateral Resistance

The geotechnical lateral resistance acting on a pile in cohesionless soil may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \gamma' z K_p \quad (\text{kPa})$$

Where	z	=	depth of embedment of pile (m)
	D	=	pile width or diameter (m)
	n_h	=	coefficient related to soil relative density (kN/m^3)
	γ'	=	effective unit weight (kN/m^3)
	K_p	=	passive earth pressure coefficient

For analysis of the interaction between a pile and the surrounding soil, the above equations and parameters recommended in Table 9.6 below, may be used. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

Table 9.6 – Soil Parameters for Lateral Pile Resistance

Approximate Elevation (m)	n_h (kN/m^3)	K_p	Unit Weight* (kN/m^3)	Soil Conditions
280 to 270	3,000	3.0	20	Compact to loose sand fill
270 to 269	4,000	3.1	21	Compact to dense sand
269 to 260	3,500	3.1	11*	Compact to dense sand
260 to 240	5,000	3.3	10*	Compact to very dense silt

*Bouyant unit weight below groundwater level

The spring constant, K_s , for analysis may be obtained by the expression, $K_s = k_s L D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), D is the pile width (m) and L is



the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance, P_{ult} , may be obtained from the expression, $P_{ult} = p_{ult} L D$. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

The modulus of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Section C.6.11.3.4 of CHBDC 2019.

Horizontal loads may be resisted by means of battered piles (i.e. for H-pile case) if load requirements exceed the available lateral pile resistances.

9.5 Downdrag

The single-span bridge replacement option would include placement of up to 8 m of backfill in front of the existing bridge abutments. The new fill will result in the development of downdrag forces along the length of the single-span abutment piles associated with settlement of the foundation sand and silts under the weight of the new fill. Discussion of settlement due to the new fill is provided in Section 14 below. All settlement in the cohesionless soils is elastic, and should be complete within approximately 1 month after completion of fill placement. If the new fill can be placed as a preload prior to driving the piles however, then downdrag will not be a concern. For the three-span replacement bridge option, downdrag should not be a concern.

For design purposes, an unfactored downdrag load of 400 kN per pile is recommended to evaluate the impact of downdrag on the abutment piles.

This downdrag load should be multiplied by a load factor of 1.25 as per CHBDC Commentary Clause C6.11.4.10 to obtain a factored downdrag load. In accordance with Section 6.11.4.10 of the CHBDC and Clause C6.11.4.10 of the Commentary, in the structural design of a pile, the factored downdrag load should be added to the factored permanent loads to assess the effects of downdrag. The factored dead and downdrag load should not exceed the factored structural resistance of a pile at the neutral plane.

9.6 Frost Cover

The depth of frost penetration at this site is approximately 2.2 m, as per OPSD 3090.100. Typically, the base of all footings, concrete pile caps and concrete abutment stems, if employed, must be provided with a minimum of 2.2 m of earth cover as protection against frost action.



9.7 Recommended Foundation

It is recommended that either the single-span or three-span replacement bridge options be supported on drilled in pipe piles founded on very dense silt. Drilled in pipe piles offer higher geotechnical resistances than spread footings, minimal requirement for excavation or dewatering, and low risk of damaging the existing structure or foundations from vibrations due to pile driving.

9.8 Abutment Type

The preliminary draft GA drawing (see Appendix F) for the single-span replacement bridge option indicates that the design is based on a non-integral abutment with two rows of piles. During the detailed design stage, if deeper boreholes are drilled to establish the bedrock elevation, then a higher geotechnical capacity would be available, and an integral abutment design may be achieved by drilling in and socketing a single row of H-piles into bedrock at the abutments. This may require a temporary liner within which the H-piles would be lowered and grouted into the rock sockets.

10. EXCAVATION AND GROUNDWATER CONTROL

All excavations must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the existing fill and native soils may be classified as Type 3 soil above the water level and Type 4 soil below the water level.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902. Excavations for placement of footings or pile caps, if utilized, will be carried out through the existing granular fill, and into the native sand deposit. Any excavations below the groundwater level will require dewatering to lower the groundwater level below the base of the excavation and permit construction in the dry and facilitate compaction of the backfill materials. A Permit to Take Water (PTTW) would likely be required for this dewatering. Therefore it is recommended that all excavations be kept above the groundwater level (approximate Elev. 269 m) to avoid the need for extensive dewatering, a PTTW, base boiling and sloughing of the excavations.

Selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor's experience, equipment and interpretation of the site conditions.

The design of the dewatering system, if utilized, is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 which amends OPSS 902. SP FOUN0003 has been included in Appendix H.



In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517. Due to the proximity of the railway track and the presence of existing structures within 100 m of the site, a preconstruction survey is required at this site, thus Designer Fill-In ** in SP FOUN0003 should be “250 m”.

Dewatering must remain operational and effective until the foundations are constructed. Suggesting wording for an NSSP in this regard is included in Appendix H.

11. RETAINED SOIL SYSTEM (RSS) ABUTMENT WALLS

The single-span bridge alternative is expected to utilize RSS walls to retain the abutment backfill. The RSS walls and the backfill in front of the existing abutments is up to approximately 8 m high, with the base of the RSS walls located at approximately Elev. 270 m.

The contract drawings should include information on the longitudinal alignment of the RSS walls in plan, the top and base elevations of the walls in profile, cross-sectional space constraints and an NSSP for the RSS walls.

The performance of an RSS is dependent on, among other factors, the characteristics of its foundation. Failure to provide an adequate foundation may lead to excessive settlements and distortion of the RSS and, in severe cases, to possible failure of the system. The foundation of the entire RSS mass should be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

The borehole information indicates that the soil conditions at and below the proposed wall base levels generally consist of compact to dense sand, just above the groundwater level of Elev. 269 m. To provide a uniformly competent subgrade, the RSS mass should be founded on a 500 mm thick engineered granular fill pad. The top of the engineered fill pad should be embedded a minimum of 1 m below the final ground surface at the wall location, and the base of the fill pads should be kept above Elev. 269.5 m to avoid the need for dewatering excavations that extend below the water table, and avoid potential wash out of fine materials within the fill pad. Any topsoil, organics, loose fill, and any soft/wet material should be stripped from the footprint of the RSS. The subgrade under the RSS foundation should be inspected and any loose or soft areas sub-excavated and replaced with well compacted granular materials prior to placing the wall.

The engineered fill pad material placed under the RSS mass should consist of OPSS Granular A or Granular B Type II and should be placed and compacted in accordance with OPSS.PROV 501. The bedding should extend at least 500 mm beyond the limits of the entire RSS mass. A minimum



strip length of 80% of the height difference between the design grade and the base of the RSS wall is recommended.

RSS walls founded on this material may be designed using a factored geotechnical resistance at ULS of 400 kPa and a geotechnical reaction at SLS of 250 kPa.

Accounting for the up to 8 m high embankment fill behind the RSS walls, the geotechnical resistances at SLS correspond to settlement up to 65 to 90 mm at the base of the RSS walls at the front slopes. Discussions must be held with the RSS supplier to check whether this amount of settlement can be accommodated in the RSS wall design and construction. Alternatively, in order to reduce the magnitude of settlement under the RSS wall, consideration may be given to preloading the embankment fill, which could be challenging due to the limited clearance from the existing railway tracks, or partially filling the lower part of the RSS wall with light-weight fill such as cellular concrete. Further discussion on settlement is provided in Section 14. The geotechnical resistance is for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design should be reduced in accordance with the CHBDC 2019, Clause 6.10.5.3.

The entire block of reinforced earth should be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall may be estimated using an ultimate friction coefficient of 0.5 for an engineered granular fill subgrade.

The proprietary RSS system should meet the Ministry's specifications for performance and appearance. The RSS supplier/designer may specify more stringent criteria or other requirements related to the particular design and construction. The internal stability of the RSS wall should be analysed by the supplier/designer of the proprietary product selected for this site. Global stability of the RSS walls is described in Section 15.

12. LATERAL EARTH PRESSURES

Backfill placed behind the bridge abutments should be placed in accordance with OPSS 902. All backfill should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II or Type III conforming to the requirements of OPSS.PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 3101.150, as appropriate. Compaction equipment to be used adjacent to the walls should be restricted in accordance with OPSS.PROV 501.

Earth pressures acting on the structures may be assumed to be distributed triangularly and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the



pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K (\gamma h + q)$$

Where:

- p_h = horizontal pressure on the wall at depth h (kPa)
- K = coefficient of lateral earth pressure (see Table 12.1)
- γ = unit weight of retained soil (see Table 12.1)
- h = depth below top of fill where pressure is computed (m)
- q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment walls are dependent on the material used as backfill. Typical values are given in Table 12.1.

Table 12.1 – Coefficients of Lateral Earth Pressure (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active K_A (Unrestrained Wall)	0.27	0.38*	0.31	0.46*
At-rest K_0 (Restrained Wall)	0.43	-	0.47	-
Passive K_P	3.7	-	3.3	-

* For abutment walls, if required

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill which linearly decreases to 0 kPa at a depth of 1.7 m (for Granular B Type I) or at a depth of 2.0 m (for Granular A or B Type II).

13. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site class is based on the soil conditions encountered in the upper 30 m of the stratigraphy. In view of the presence of loose to

very dense fill and native subsurface soils, the site is considered to be classified as Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2,475-year return period seismic event at this site is 0.033 g as per the National Building Code of Canada (NBCC).

In accordance with Section 6.14.7 of the CHBDC 2019, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 13.1 may be used:

Table 13.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)		
	OPSS Granular A or Granular B Type II $\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$	Existing Sand Fill $\phi = 31^\circ$; $\gamma = 21 \text{ kN/m}^3$
Active (K_{AE})*	0.29	0.32	0.34
At Rest (K_{OE})**	0.48	0.53	0.54
Passive (K_{PE})	3.6	3.2	3.1

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

In view of the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

14. SETTLEMENT

An approximately 500 mm grade raise and 1 m embankment widening are anticipated for both the single-span and three-span replacement bridge alternatives at this site. For the three-span bridge arrangement, the short-term settlement induced by the grade raise and widening is estimated to be approximately 15 to 20 mm.

The single-span option also includes backfill and RSS walls of up to approximately 8 m high in front of the existing bridge abutments, which will also induce short-term settlement of the foundation soils. Table 14.1 provides a summary of the preliminary estimated foundation settlement at various locations:

Table 14.1 – Summary of Preliminary Settlement Estimates

Location	Estimated Settlement (mm)
Highway 17 Side Slopes	25-35
Replacement Abutment Front Slopes	65-90
Existing Abutments	15-20
Existing Piers	20-25
Nearest Railway Track	5-10

Due to the cohesionless nature of the foundation soils, the foundation settlements noted above will take place fairly rapidly and are expected to be completed within approximately 1 month after completion of fill placement. Following the selection of the bridge alternative, foundation settlements of the detailed design configuration should be assessed. As the existing bridge is expected to be utilized during construction for staging purposes, settlement monitoring of the bridge should be conducted. The existing bridge may need to be jacked up and shimmed to compensate for the settlement and maintain the desired grade level. Settlement monitoring of the CPR tracks should also be conducted. The structural designers should also check if the existing bridge can withstand the settlement that would be imposed by the additional load from this fill.

15. APPROACH EMBANKMENTS AND FORWARD SLOPES

The existing Highway 17 embankment fill is approximately 10 m in height at the east and west approaches. The embankment side slopes are inclined at approximately 2H:1V near the bridge and appear to be in stable condition, as shown on Figure 1 in Appendix I, in which a stability analysis of 2H:1V sides slopes indicated a Factor of Safety against slope failure of 1.4.

As discussed in Section 11 above, the single-span replacement bridge will likely utilize RSS walls to retain the abutment backfill, and will include up to 8 m of embankment fill in front of the existing abutments behind the new RSS walls. A preliminary stability analysis conducted for the forward slopes in front of the replacement bridge abutment RSS walls was conducted. Figure 2 in Appendix I shows a preliminary analysis of the forward slopes, with a Factor of Safety of 1.6, indicating that the proposed forward slopes are expected to be stable.

The slope stability analyses conducted are based on preliminary subsurface information only. The stability of the final embankment side slopes and forward slopes and global stability of the RSS walls should be reassessed during detailed design when a final bridge configuration is available.



In general, all surficial organic material and loose/wet subgrade soils must be removed prior to placement of the new embankment fill. New embankment fill should be constructed in accordance with OPSS.PROV 206 using granular material conforming to OPSS.PROV 1010 and compacted in accordance with OPSS.PROV 501. The embankment material should consist of imported Granular A, Granular B Type I, Type II material.

16. EROSION PROTECTION

The existing approach embankment side slopes appear to be well vegetated, however a lack of vegetation, signs of erosion and the presence of some voids under the abutments are noted under the forward slopes. Appropriate erosion protection must be provided on the forward slopes.

Measures should be taken to control surficial drainage to prevent runoff from the highway down the embankment slopes.

A vegetation cover should be established on all exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

17. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the samples of the fill and native soils indicate the following conditions at the locations tested:

- The potential for corrosion on concrete or metal foundations from the surrounding existing fill is considered to be high as indicated by the high chloride concentration and low resistivity value of the sample tested.
- The potential for soil corrosion on concrete or metal from the native soils is considered to be low.
- The potential for sulphate attack on concrete foundations from the surrounding fill or native soils is considered to be negligible due to the low concentrations of sulphate in the samples tested.
- The effect of road de-icing salt should be considered when selecting corrosion protection measures and the class of concrete.

18. CONSTRUCTION CONCERNS

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



- Pile driving activities if utilized are anticipated to cause vibration of the existing bridge structure foundations and CPR railway tracks, which will lead to settlement and potential damage to these existing facilities. Driven piles are therefore not recommended.
- The RSS walls will be subjected to 65 to 90 mm of settlement. If the RSS wall design cannot accommodate this magnitude of settlement, use of light-weight fill such as cellular concrete should be considered in the lower part of the RSS backfill.
- Settlement monitoring of the existing bridge during foundation construction should be carried out. Provisions should be made for jacking up and shimming the bridge if excessive settlements are noted.
- Settlement monitoring of the CPR tracks during foundation construction and placement of new fill should be carried out.
- Seasonal fluctuations of the groundwater level are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall, which may impact the construction.

19. FURTHER INVESTIGATION

During detailed design of the replacement bridge, additional subsurface information should be collected to supplement the information provided in this report. It is anticipated that a minimum of four additional boreholes are required, however sufficient boreholes should be advanced to meet the latest Guideline for MTO Foundation Engineering Services. This includes providing two boreholes at each foundation element and may also require boreholes at the approach embankments and for temporary roadway protection systems if proposed. In particular, two foundation boreholes are recommended at the location of the west abutment for the single-span arrangement or the west pier for the three-span arrangement as no boreholes could be advanced at this location during the current foundation investigation. Site access to this location should be carefully assessed, and may require temporary closures of the closest railway track to allow a drill rig to safely access and work near the existing west pier. Consideration should also be given to allowing for deeper boreholes to explore the depth to bedrock at the site, if higher geotechnical capacities are preferred for the pile foundations. If the bedrock elevation can be established by deeper boreholes, then an integral abutment design may be considered at this site, using a single row of H-piles socketed into bedrock.

20. CLOSURE

Engineering analysis and preparation of this report was carried out by Mr. Mark Farrant, P.Eng. and Mr. Keli Shi, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION


MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No BH20-01

1 OF 4

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 601.5 E 297 983.7 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring COMPILED BY BH
DATUM Geodetic DATE 2020.12.15 - 2020.12.19 LATITUDE 48.788777 LONGITUDE -87.092772 CHECKED BY JA

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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Continued Next Page

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

RECORD OF BOREHOLE No BH20-01

2 OF 4

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 601.5 E 297 983.7 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring COMPILED BY BH
DATUM Geodetic DATE 2020.12.15 - 2020.12.19 LATITUDE 48.788777 LONGITUDE -87.092772 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				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						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L			
	Continued From Previous Page							20	40	60	80	100	20	40	60		
	SAND , trace silt to silty, trace clay Compact Grey to Brown Wet <																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S2 MTO-29475.GPJ 2017TEMPLATE(MTO).GDT 9/29/21

RECORD OF BOREHOLE No BH20-01

3 OF 4

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 601.5 E 297 983.7 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring COMPILED BY BH
DATUM Geodetic DATE 2020.12.15 - 2020.12.19 LATITUDE 48.788777 LONGITUDE -87.092772 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE										
	Continued From Previous Page		15	SS	32											0	15	82	3
258.5																			
21.6	SAND, some silt Dense Grey Wet																		
256.9			16	SS	75														
23.2	SILT, some sand, trace clay Very Dense Grey Wet																		

Continued Next Page

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

ONTMT4S2 MTO-29475.GPJ 2017TEMPLATE(MTO).GDT 9/29/21

RECORD OF BOREHOLE No BH20-01

4 OF 4

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 601.5 E 297 983.7 ORIGINATED BY MC
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring COMPILED BY BH
 DATUM Geodetic DATE 2020.12.15 - 2020.12.19 LATITUDE 48.788777 LONGITUDE -87.092772 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
Continued From Previous Page																	
WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2020.12.15 11.1 269.0 2020.12.19 11.1 269.0																	

RECORD OF BOREHOLE No BH20-01A DCPT 1 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 602.4 E 297 984.3 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.19 - 2020.12.19 LATITUDE 48.788784 LONGITUDE -87.092764 CHECKED BY JA

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
280.1 0.0	GROUND SURFACE DCPT Begins						280				
							279				
							278				
							277				
							276				
							275				
							274				
							273				
							272				
							271				

Continued Next Page

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

RECORD OF BOREHOLE No BH20-01A DCPT 2 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 602.4 E 297 984.3 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.19 - 2020.12.19 LATITUDE 48.788784 LONGITUDE -87.092764 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
	Continued From Previous Page						270			
							269			
							268			
							267			
							266			
							265			
							264			
							263			
							262			
							261			

Continued Next Page

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

RECORD OF BOREHOLE No BH20-01A DCPT 3 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 602.4 E 297 984.3 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.19 - 2020.12.19 LATITUDE 48.788784 LONGITUDE -87.092764 CHECKED BY JA

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			20	40	60	80					
	Continued From Previous Page						260									
259.8																
20.3	END OF DCPT UPON REFUSAL. BACKFILLED WITH GROUT FROM 20.3 TO 0.2 m, THEN ASPHALT TO SURFACE.															



ONTMT4S2 MTO-29475.GPJ 2017TEMPLATE(MTO).GDT 9/29/21

RECORD OF BOREHOLE No BH20-02

1 OF 4

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 579.1 E 297 987.5 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring/DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.07 - 2020.12.08 LATITUDE 48.788575 LONGITUDE -87.092720 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						PLASTIC LIMIT w _p NATURAL MOISTURE CONTENT w LIQUID LIMIT w _L				
271.0	GROUND SURFACE							20	40	60	80	100						
0.0	SAND , trace silt, trace gravel Brown Moist (FILL)		1	GS			271							○				
270.3																		
0.8	SAND , trace silt to silty, trace gravel, trace clay Compact Light Brown to Brown Moist to Wet		1	SS	16		270							○				4 90 6 (SI+CL)
			2	SS	13		269							○				
			3	SS	12		268							○				
			4	SS	13		267							○				0 76 22 2
							266											
			5	SS	26		265							○				
							264											
			6	SS	15		263							○				
							262							○				
			7	SS	18													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH20-02

2 OF 4

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 579.1 E 297 987.5 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring/DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.07 - 2020.12.08 LATITUDE 48.788575 LONGITUDE -87.092720 CHECKED BY JA

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 (%)	
	Continued From Previous Page							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>				<div><div>204060</div><div>○</div></div>						
260.1	SILT, some to trace sand, trace clay Dense to Very Dense Grey Wet		8	SS	30		261									0 11 87 2		
11.0							260											
							259											
					9	SS	57		258									
								257										
					10	SS	30		256									
								255										
					11	SS	60		254									
254.7			Intermittent layers of sand and silt					253										0 91 9 (SI+CL)
16.3								252										
					12	SS	56											
253.2																		
17.8																		
					13	SS	100/ 0.250											

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

ONTMT4S2 MTO-29475.GPJ 2017TEMPLATE(MTO).GDT 9/29/21

RECORD OF BOREHOLE No BH20-02

3 OF 4

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 579.1 E 297 987.5 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring/DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.07 - 2020.12.08 LATITUDE 48.788575 LONGITUDE -87.092720 CHECKED BY JA

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			20	40	60	80					
Continued From Previous Page																
			14	SS	68		251									
							250									
							249									
			15	SS	49		248								0 3 93 4	
							247									
							246									
			16	SS	54		245									
							244									
							243									
			17	SS	57		242								0 6 90 4	

Continued Next Page

+ 3, X 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH20-02

4 OF 4

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 579.1 E 297 987.5 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring/DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.07 - 2020.12.08 LATITUDE 48.788575 LONGITUDE -87.092720 CHECKED BY JA

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			20	40	60						80	100	20	40	60					
	Continued From Previous Page																								
240.0	Compact		18	SS	23																				
31.1	End of sampling and start DCPT.																								
238.8																									
32.3	<p>END OF BOREHOLE AT 32.3m UPON DCPT REFUSAL. Monitoring Well installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. BACKFILLED WITH GROUT FROM 32.3 TO 10.7 m, BENTONITE TO SURFACE.</p> <p>WATER LEVEL READINGS</p> <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH(m)</th> <th>ELEV.(m)</th> </tr> </thead> <tbody> <tr> <td>2020.12.08</td> <td>1.2</td> <td>269.8</td> </tr> <tr> <td>2020.12.09</td> <td>2.1</td> <td>268.9</td> </tr> <tr> <td>2020.12.10</td> <td>2.1</td> <td>268.9</td> </tr> </tbody> </table>	DATE	DEPTH(m)	ELEV.(m)	2020.12.08	1.2	269.8	2020.12.09	2.1	268.9	2020.12.10	2.1	268.9												
DATE	DEPTH(m)	ELEV.(m)																							
2020.12.08	1.2	269.8																							
2020.12.09	2.1	268.9																							
2020.12.10	2.1	268.9																							

RECORD OF BOREHOLE No BH20-03

1 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 581.9 E 297 969.3 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring/DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.09 - 2020.12.10 LATITUDE 48.788600 LONGITUDE -87.092968 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				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					
								20 40 60 80 100					
271.2	GROUND SURFACE							20 40 60 80 100					
0.8	TOPSOIL (25mm)							20 40 60 80 100					
	SAND, some gravel, trace organics Compact Brown Moist to Wet (FILL)		1	SS	11		271						
269.9			2	SS	14		270						
1.2	SAND, trace silt to silty, trace clay Compact Brown Wet												
			3	SS	18		269						0 71 28 1
			4	SS	15		268						
			5	SS	16		267						
			6	SS	19		266						0 89 10 1
			7	SS	17		265						
			8	SS	20		264						
							263						
			9	SS	16		262						

Continued Next Page

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

RECORD OF BOREHOLE No BH20-03

2 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 581.9 E 297 969.3 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring/DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.09 - 2020.12.10 LATITUDE 48.788600 LONGITUDE -87.092968 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
	Continued From Previous Page						20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _P w w _L					
							20 40 60 80 100	WATER CONTENT (%)					
260.5													
10.7	SILT, some sand, trace clay Compact to Very Dense Grey Wet		10	SS	26								0 18 79 3
				11	SS	56							
				12	SS	37							
				13	SS	93							
				14	SS	65							0 12 86 2
			15	SS	103								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH20-03

3 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 581.9 E 297 969.3 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Augers/Washboring/DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.09 - 2020.12.10 LATITUDE 48.788600 LONGITUDE -87.092968 CHECKED BY JA

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)						
	Continued From Previous Page		16	SS	113/ 0.250		251								
250.4 20.8	Silty SAND , trace clay Compact Brown Wet						250								
249.2 21.9	Compact		17	SS	28									0 67 32 1	
	End of sampling and start DCPT.						249								
							248								
							247								
							246								
							245								
							244								
243.8 27.4	END OF BOREHOLE AT 27.4m UPON DCPT REFUSAL. BACKFILLED WITH BENTONITE FROM 27.4 m TO SURFACE.														

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH20-04

1 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 542.1 E 297 961.5 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/Washboring COMPILED BY BH
DATUM Geodetic DATE 2020.12.12 - 2020.12.18 LATITUDE 48.788242 LONGITUDE -87.093073 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						WATER CONTENT (%) W _P W W _L																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
280.2	GROUND SURFACE							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								</

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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH20-04

2 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 542.1 E 297 961.5 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/Washboring COMPILED BY BH
DATUM Geodetic DATE 2020.12.12 - 2020.12.18 LATITUDE 48.788242 LONGITUDE -87.093073 CHECKED BY JA

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
270.0	Continued From Previous Page	⊗					270									
10.2	SAND, trace silt to silty, trace clay Compact to Dense Brown Wet		9	SS	32		269									
							268									
			10	SS	29		267									
							266									
			11	SS	27		265									
							264									
			12	SS	24		263									
							262									
			13	SS	31		261									
			14	SS	30											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH20-04

3 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 542.1 E 297 961.5 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/Washboring COMPILED BY BH
DATUM Geodetic DATE 2020.12.12 - 2020.12.18 LATITUDE 48.788242 LONGITUDE -87.093073 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
259.4			15	SS	27		260							0 72 26 2
20.9	SILT, some sand, trace clay Dense to Very Dense Grey Wet						259							
			16	SS	32		258							
							257							
							256							
			17	SS	100/ 0.225		255							
							254							0 22 75 3
			18	SS	102/ 0.200		253							
252.5			19	SS	100/ 0.275									
27.7	END OF BOREHOLE AT 28.0m. BOREHOLE OPEN TO 14.3m AND WATER LEVEL AT 7.3m UPON COMPLETION. BACKFILLED WITH GROUT FROM 27.7 TO 3.0 m, BENTONITE FROM 3.0 TO 0.3 m, SAND TO 0.2 m, THEN ASPHALT TO SURFACE. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2020.12.15 11.4 268.9 2020.12.15 11.3 268.9													

ONTMT4S2 MTO-29475.GPJ 2017TEMPLATE(MTO).GDT 9/29/21

RECORD OF BOREHOLE No BH20-04A DCPT 1 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 540.6 E 297 960.7 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.18 - 2020.12.18 LATITUDE 48.788229 LONGITUDE -87.093084 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
280.1 0.0	GROUND SURFACE DCPT Begins						280			
							279			
							278			
							277			
							276			
							275			
							274			
							273			
							272			
							271			

Continued Next Page

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

RECORD OF BOREHOLE No BH20-04A DCPT 2 OF 3

METRIC

W.P. 6113-17-01 LOCATION CPR Overhead, Terrace Bay N 5 405 540.6 E 297 960.7 ORIGINATED BY MC
DIST Thunder Bay HWY 17 BOREHOLE TYPE DCPT COMPILED BY BH
DATUM Geodetic DATE 2020.12.18 - 2020.12.18 LATITUDE 48.788229 LONGITUDE -87.093084 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
	Continued From Previous Page						270			
							269			
							268			
							267			
							266			
							265			
							264			
							263			
							262			
							261			

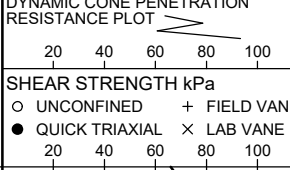
Continued Next Page

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

RECORD OF BOREHOLE No BH20-04A DCPT 3 OF 3

METRIC

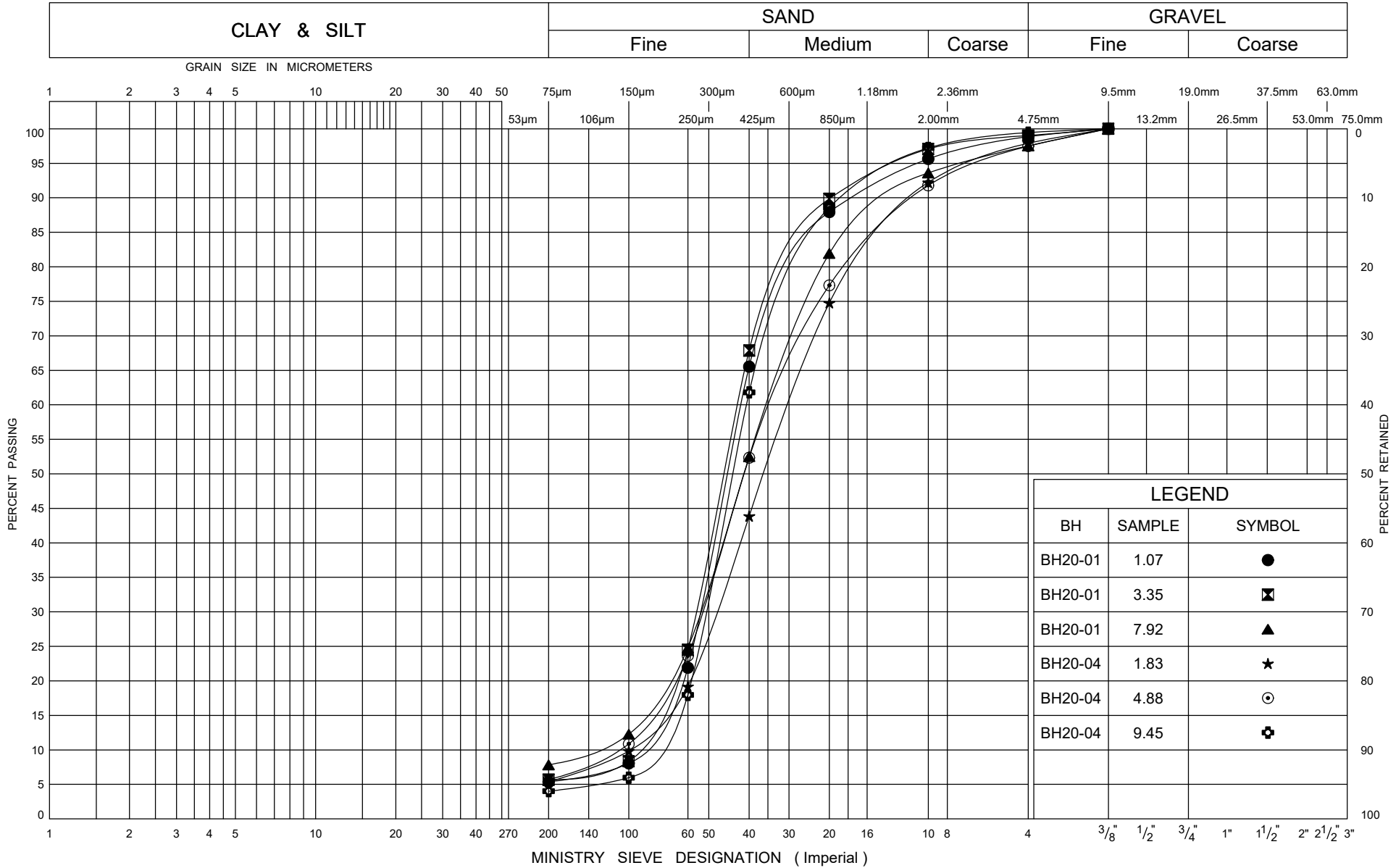
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 DIST Thunder Bay HWY 17 BOREHOLE TYPE DCPT COMPILED BY BH
 DATUM Geodetic DATE 2020.12.18 - 2020.12.18 LATITUDE 48.788229 LONGITUDE -87.093084 CHECKED BY JA

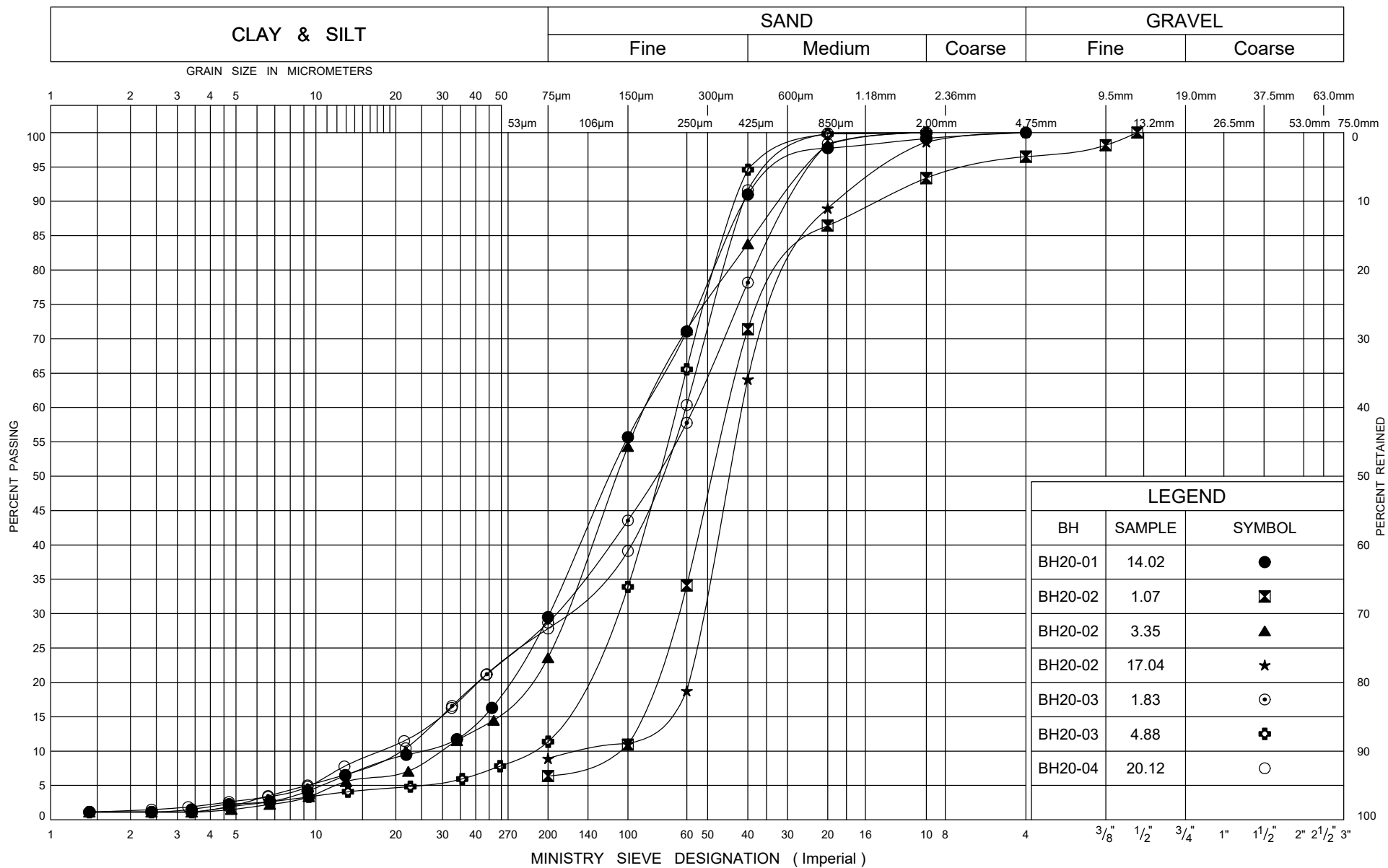
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — W _L WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page						260				
259.3											
20.8	END OF DCPT UPON REFUSAL.										

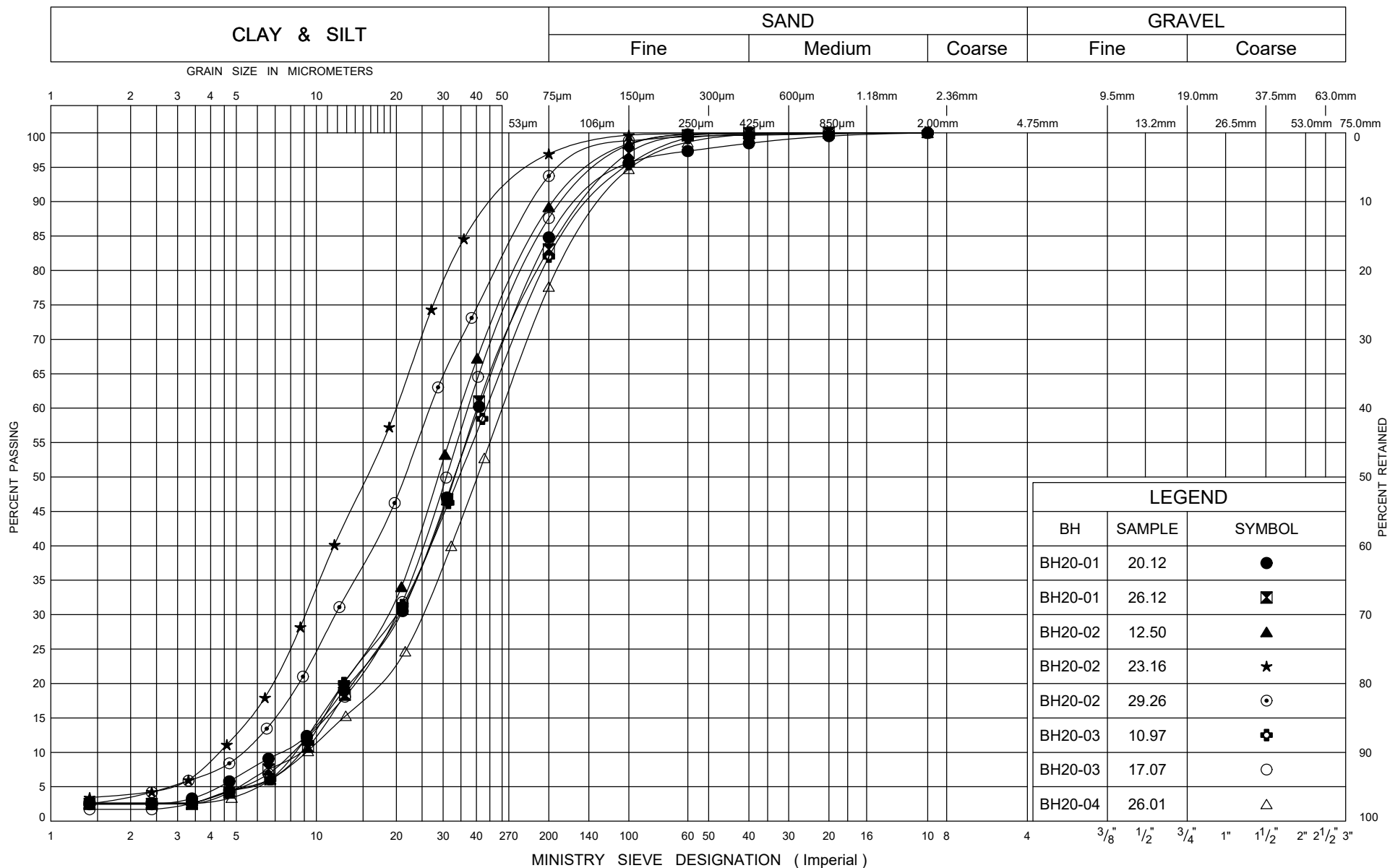


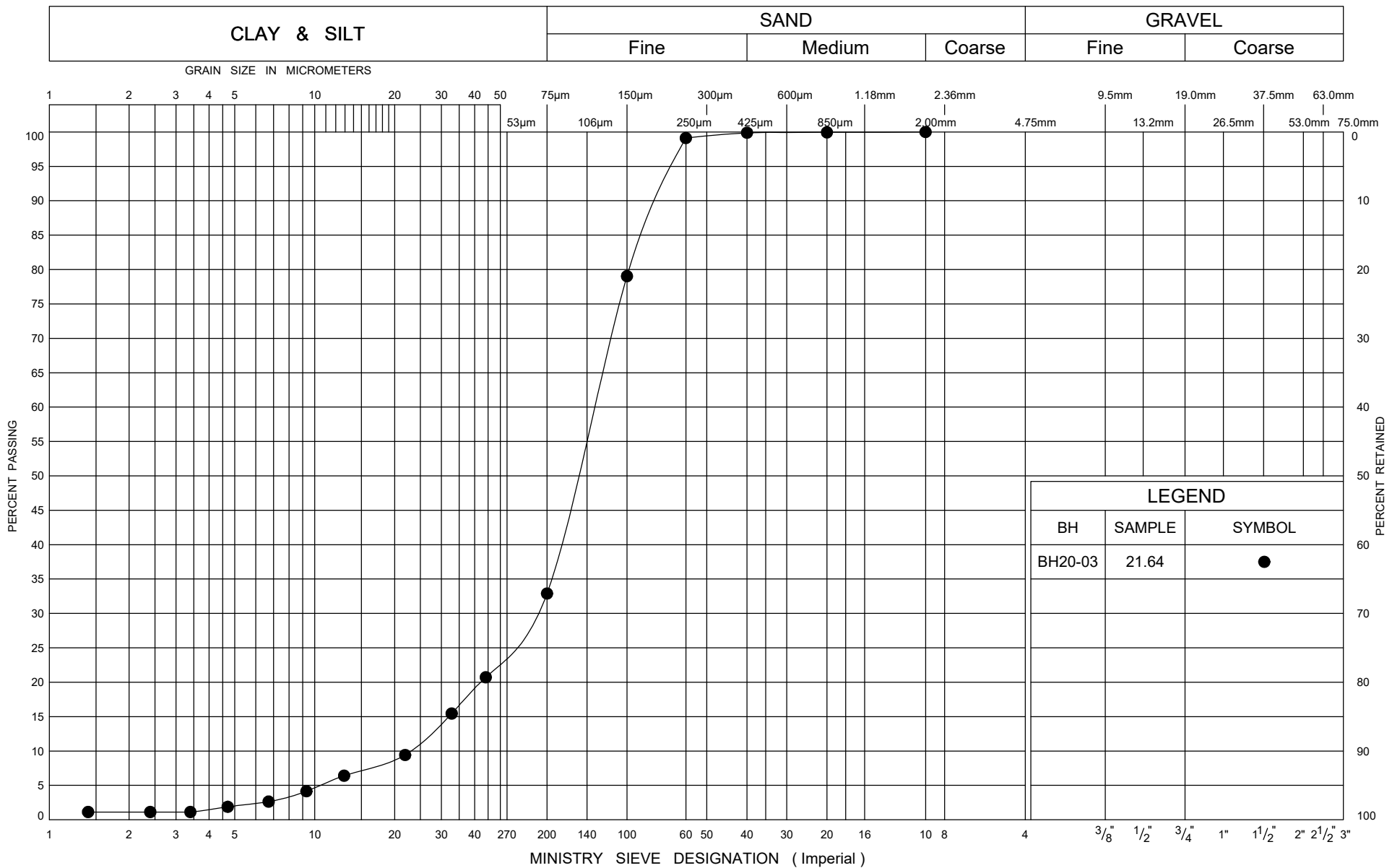
Appendix B

Geotechnical Laboratory Test Results











FINAL REPORT

CA14102-JAN21 R1

29475, Hwy 17, CPR Bridge Terrace Bay

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7, Canada

Contact Joshua Alexander

Telephone 613-606-7303

Facsimile

Email jalexander@thurber.ca

Project 29475, Hwy 17, CPR Bridge Terrace Bay

Order Number

Samples Soil (2)

LABORATORY DETAILS

Project Specialist Brad Moore Hon. B.Sc

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2143

Facsimile 705-652-6365

Email brad.moore@sgs.com

SGS Reference CA14102-JAN21

Received 01/07/2021

Approved 01/14/2021

Report Number CA14102-JAN21 R1

Date Reported 01/14/2021

COMMENTS

Temperature of Sample upon Receipt: 6 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of Custody Number: 013627

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Brad Moore Hon. B.Sc

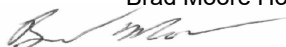




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Legend..... 7

Annexes..... 8



FINAL REPORT

CA14102-JAN21 R1

Client: Thurber Engineering Ltd.

Project: 29475, Hwy 17, CPR Bridge Terrace Bay

Project Manager: Joshua Alexander

Samplers: Madison Chiarotto

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6
Sample Name	BH20-04 SS4	BH20-02 SS3
Sample Matrix	Soil	Soil
Sample Date	12/12/2020	07/12/2020

Parameter	Units	RL		Result	Result
Corrosivity Index					
Corrosivity Index	none	1		13	4
Soil Redox Potential	mV	-		310	280
Sulphide (Na ₂ CO ₃)	%	0.04		< 0.04	< 0.04
pH	pH Units	0.05		9.06	8.92
Resistivity (calculated)	ohms.cm	-9999		740	7630

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6
Sample Name	BH20-04 SS4	BH20-02 SS3
Sample Matrix	Soil	Soil
Sample Date	12/12/2020	07/12/2020

Parameter	Units	RL		Result	Result
General Chemistry					
Conductivity	uS/cm	2		1350	131

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6
Sample Name	BH20-04 SS4	BH20-02 SS3
Sample Matrix	Soil	Soil
Sample Date	12/12/2020	07/12/2020

Parameter	Units	RL		Result	Result
Metals and Inorganics					
Moisture Content	%	0.1		4.5	17.8
Sulphate	µg/g	0.4		21	4.1



FINAL REPORT

CA14102-JAN21 R1

Client: Thurber Engineering Ltd.

Project: 29475, Hwy 17, CPR Bridge Terrace Bay

Project Manager: Joshua Alexander

Samplers: Madison Chiarotto

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6
Sample Name	BH20-04 SS4	BH20-02 SS3
Sample Matrix	Soil	Soil
Sample Date	12/12/2020	07/12/2020

Parameter	Units	RL		Result	Result
Other (ORP)					
Chloride	µg/g	0.4		660	26



FINAL REPORT

CA14102-JAN21 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0098-JAN21	µg/g	0.4	<0.4	0	20	95	80	120	105	75	125
Sulphate	DIO0098-JAN21	µg/g	0.4	<0.4	4	20	95	80	120	87	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0012-JAN21	%	0.04	< 0.04	13	20	80	80	120			

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0079-JAN21	uS/cm	2	< 2	0	20	98	90	110	NA		



QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0079-JAN21	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates 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.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --



Appendix C

Site Photographs



Photo C1: North approach to existing bridge looking South along Highway 17.
(Date taken: December 7, 2020)



Photo C2: East side of bridge looking west. (Date taken: December 7, 2020)



Photo C3: West side of bridge looking east. (Date taken: December 7, 2020)



Photo C4: North pier looking south. (Date taken: December 7, 2020)



Photo C5: Underside of bridge deck looking south from north pier. (Date taken: December 7, 2020)



Photo C6: North abutment looking north. (Date taken: December 7, 2020)



Photo C7: South abutment looking south. (Date taken: December 7, 2020)



Photo C8: CPR tracks looking east from south pier. (Date taken: December 11, 2020)

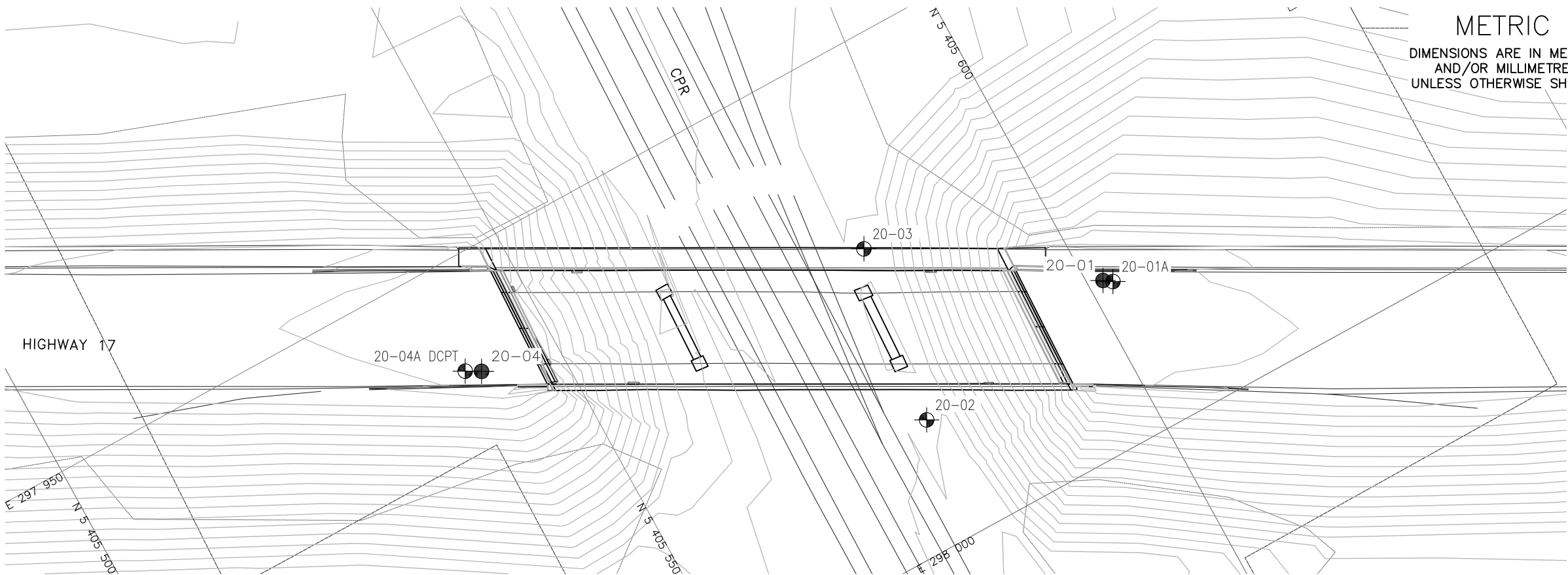


Photo C9: CPR tracks looking west from south pier. (Date taken: December 11, 2020)



Appendix D

Borehole Locations and Soil Strata Drawings



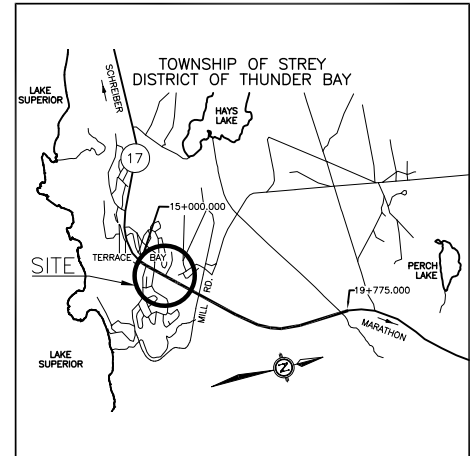
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 6113-17-01

HIGHWAY 17
REPLACEMENT OF CPR
OVERHEAD AT TERRACE BAY
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

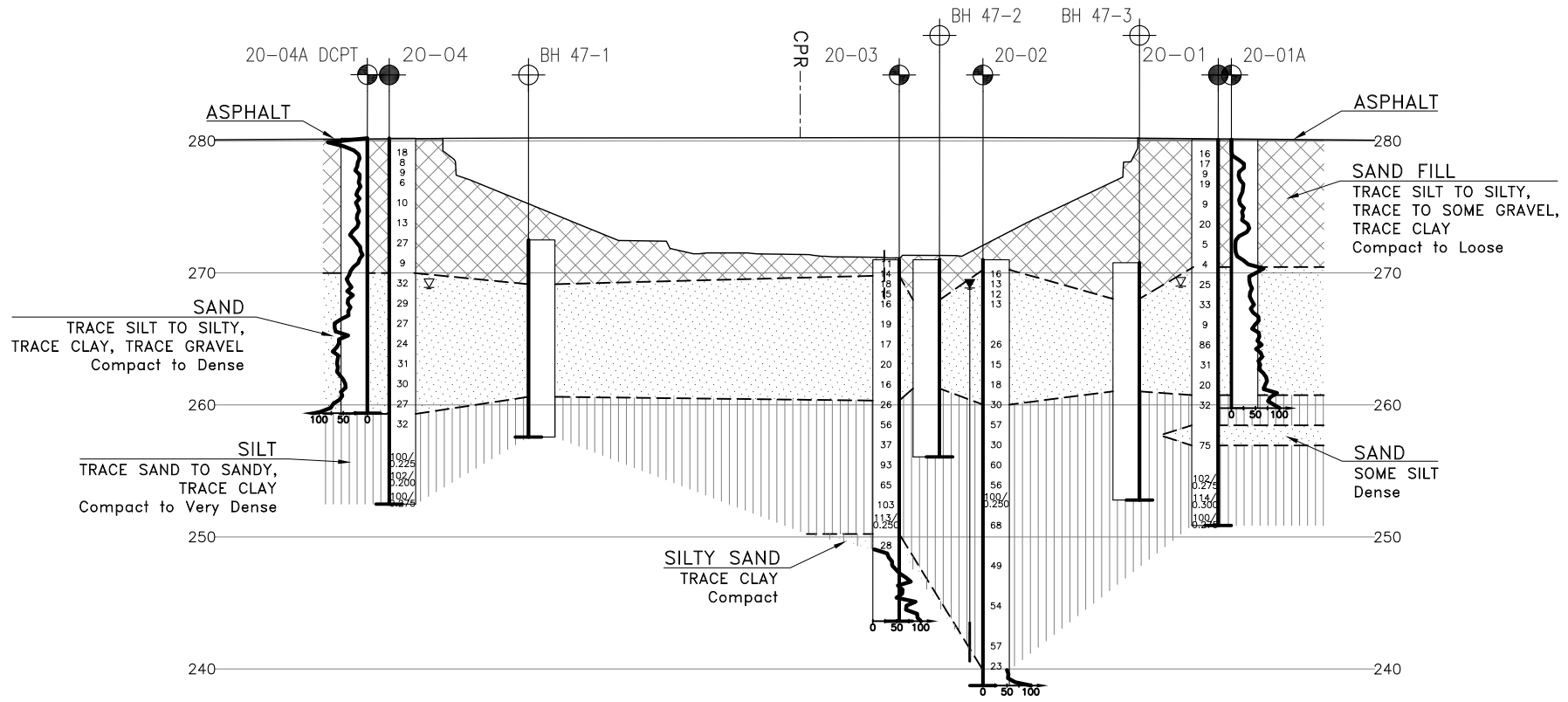
- Borehole
- Borehole and Cone
- Archival Borehole - circa 1947
- N
- Blows /0.3m (Std Pen Test, 475J/blow)
- CONE
- Blows /0.3m (60' Cone, 475J/blow)
- PH
- Pressure, Hydraulic
- Water Level During Drilling
- Water Level In Piezometer
- 90%
- Rock Quality Designation (RQD)
- A/R
- Auger Refusal

NO	ELEVATION	NORTHING	EASTING
20-01	280.1	5 405 601.5	297 983.7
20-01A	280.1	5 405 602.4	297 984.3
20-02	271.0	5 405 579.1	297 987.5
20-03	271.2	5 405 581.9	297 969.3
20-04	280.2	5 405 542.1	297 961.6
20-04A DCPT	280.1	5 405 540.6	297 960.7

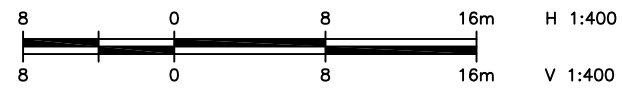
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No. 42D-61



PROFILE ALONG HWY 17

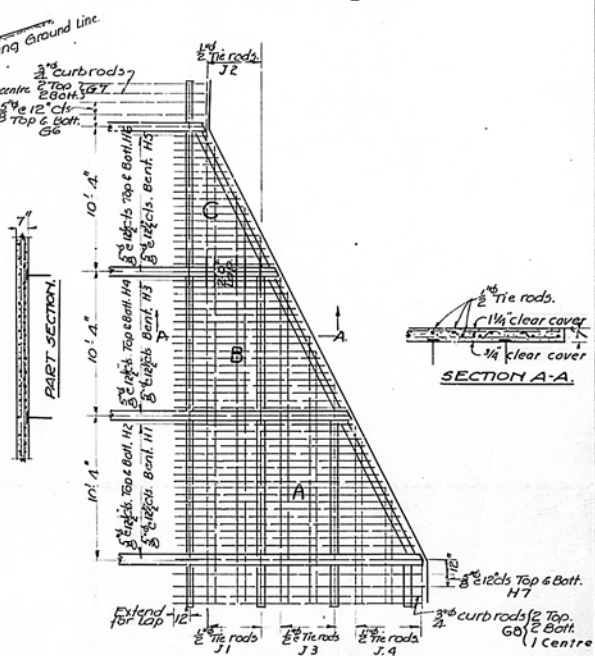
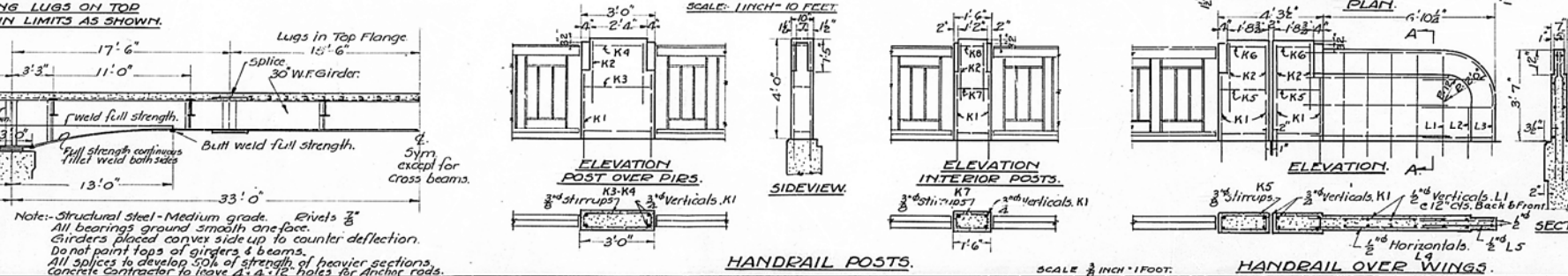
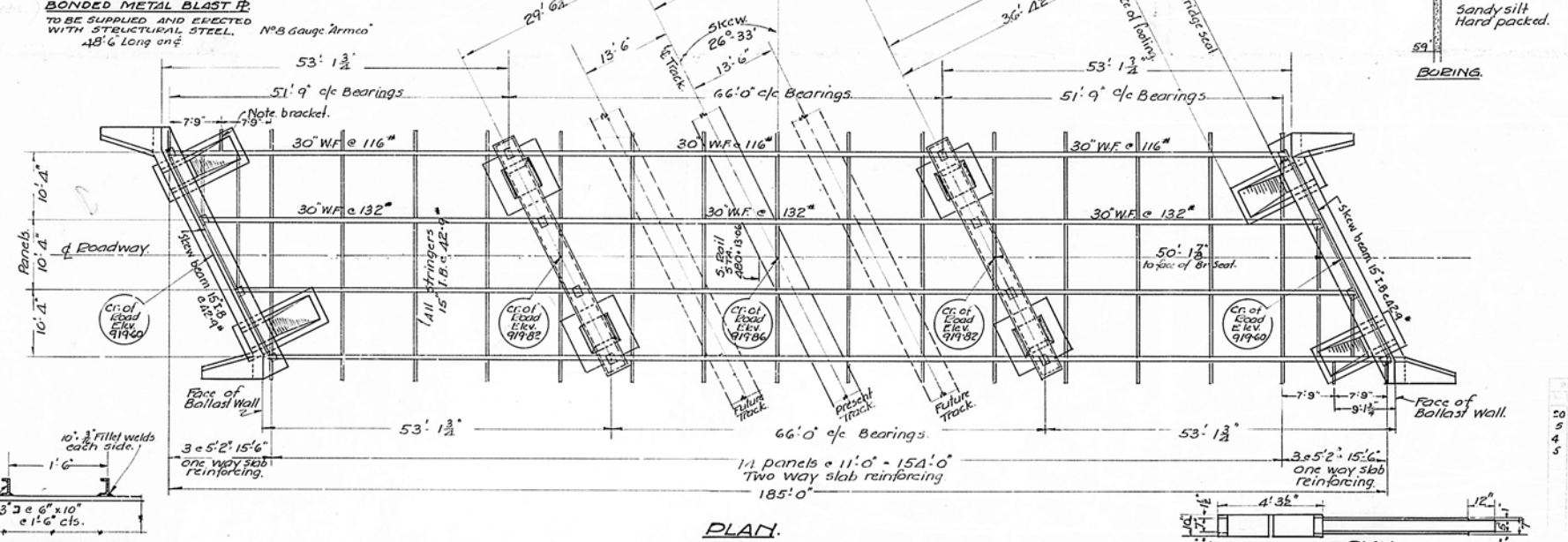
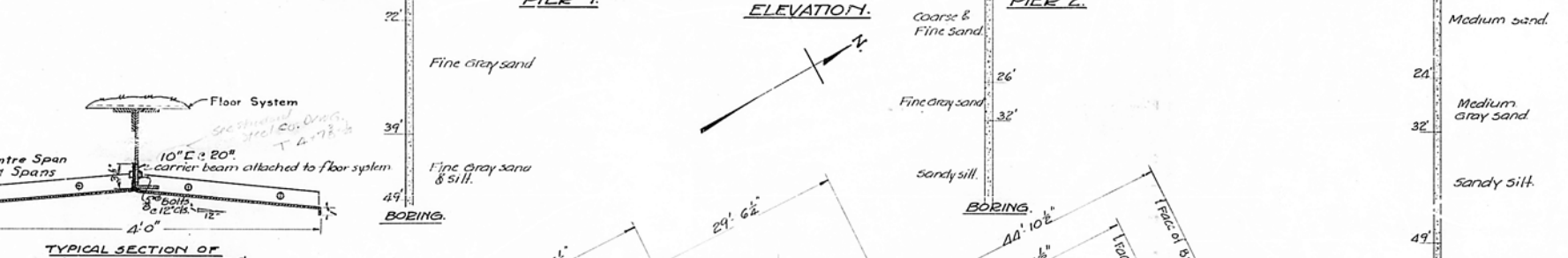
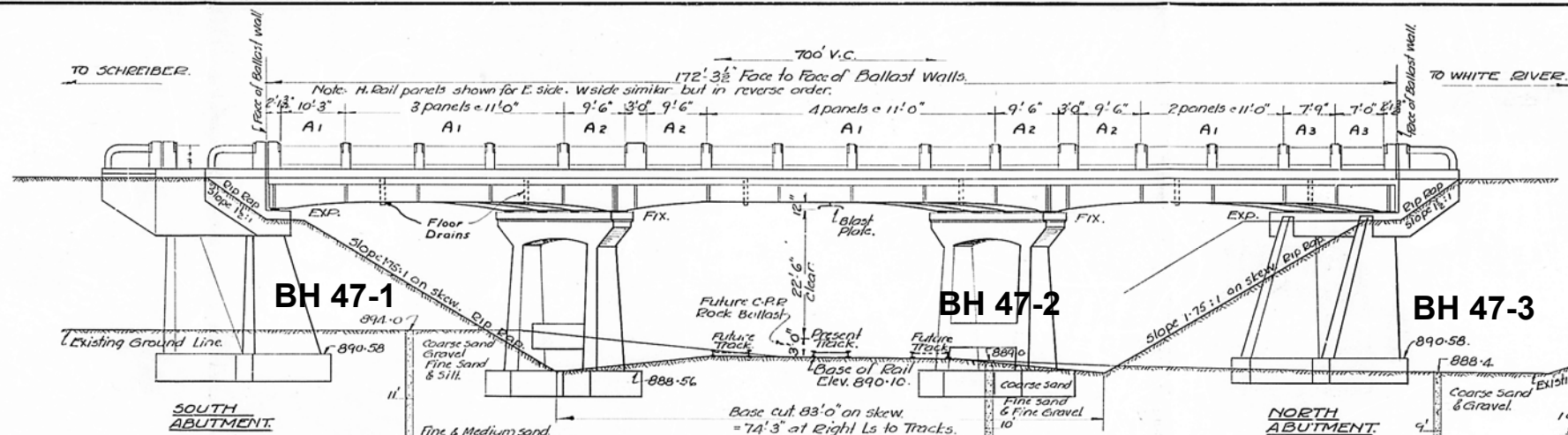


REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JA	CHK MF	CODE
DRAWN	BH	CHK PKC	SITE 48E-0018/B0
LOAD	DATE	SEP 2021	DWG 1



Appendix E

1947 Archival Drawing No. D2942



NOTE FOR DIVISION ENGINEER.
Work on this structure must not be commenced until monuments to fix control points have been erected and checked by the engineer.

NOTE FOR CONTRACTOR.
Structure to be built in accordance with D.H.O. General Specifications for Highway Bridges 1935 Form N99, and the "Special Specifications" as given in the "Information to Bidders" sheet, additional copies of which may be obtained from the Division engineer.

CONCRETE MIX. Footings. 1: 2: 4.
All other concrete 1: 1 1/2: 3 1/2.
with 1 lb of Pozzolith per bag of cement.

NOV.17/27	WV	1/4 EXTRA COVER UNDERSIDE OF DECK, CENTRE SPAN
NOV.17/27	WV	COLLISION STRUT ON PIPE
DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS, ONTARIO.
BRIDGE OFFICE.

OVERHEAD GRADE SEPARATION
BETWEEN THE
CANADIAN PACIFIC RAILWAY
AND
REVISION OF THE KING'S HIGHWAY #17.
AT TERRACE BAY TOWNSITE
SCHREIBER TO WHITE RIVER DIV. NO 19.
TWP. NO 83. DISTRICT OF THUNDER BAY.

GENERAL PLAN.

APPROVED. *John J. G. G. G.*
Chief Bridge Engineer. Chief Engineer.

Design	PL	check	Loading	H20	CONTRACTS	47-95
					CNCR. WORK	STREET
					STEEL	47-102
					TORONTO. DWG NO	
					DATE: 21.1.1947	D2942
						SHEET
						1-



Appendix F

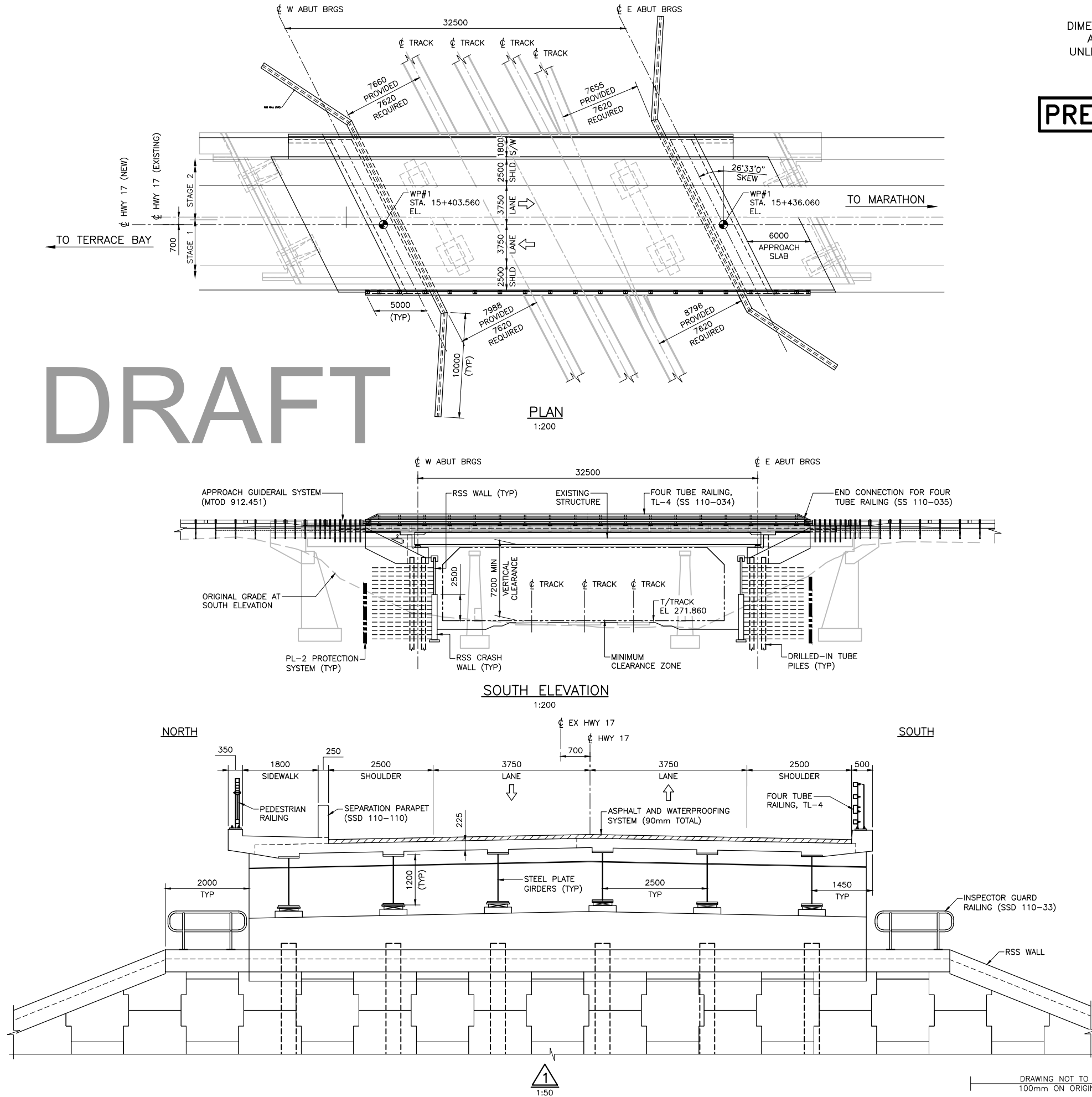
Preliminary General Arrangement Drawing

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MODIFIED: 3/25/2021 4:08:26 PM BY: D.SIMMS
DATE PLOTTED: 3/26/2021 11:20:50 AM BY: DEREK SIMMS

MINISTRY OF TRANSPORTATION, ONTARIO

PR-D-707 BR-05

CONSTRUCTION
NORTH



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

PRELIMINARY

HIGHWAY 17 CONT. No. GWP No. 6113-17-00		SHEET 1
CPR OH AT TERRACE BAY REPLACEMENT		
PRELIMINARY DESIGN GENERAL ARRANGEMENT		
McINTOSH PERRY		

GENERAL NOTES:

- CLASS OF CONCRETE
DECK 30 MPa
REMAINDER 30 MPa
UNLESS OTHERWISE NOTED.
- CLEAR COVER TO REINFORCING STEEL
DECK TOP, CURB & SIDEWALK 70 ± 10
DECK SOFFIT 40 ± 10
REMAINDER 70 ± 20
- REINFORCING STEEL
REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
BAR MARKS WITH PREFIX 'GIII' DENOTE GLASS FIBRE REINFORCED POLYMER BARS.
STAINLESS REINFORCING STEEL SHALL BE TYPE 316 LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPa, UNLESS OTHERWISE SPECIFIED.
GLASS FIBRE REINFORCED POLYMER REINFORCING BARS SHALL BE GRADE III. THE NOMINAL DIAMETER, TENSILE MODULUS OF ELASTICITY AND GUARANTEED MINIMUM TENSILE STRENGTH SHALL BE AS SPECIFIED IN THE CONTRACT DOCUMENTS.
UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES SHALL BE CLASS B.
BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS. WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1 UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES:

- THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESSES FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.
- PROVIDE 20mmx20mm CHAMFER AT ALL EXPOSED EDGES OF NEW CONCRETE.

LIST OF ABBREVIATIONS:

ABUT	ABUTMENT	NB	NORTHBOUND
APPROX	APPROXIMATE	NBL	NORTHBOUND LANES
BRGS	BEARINGS	NTS	NOT TO SCALE
BVC	BEGINNING OF VERTICAL CURVE	SB	SOUTHBOUND
DIA	DIAMETER	SBL	SOUTHBOUND LANES
EL	ELEVATION	SHLD	SHOULDER
EVC	END OF VERTICAL CURVE	STA	STATION
EXIST	EXISTING	T/P	TOP OF PAVEMENT
EXP	EXPANSION	VERT	VERTICAL
FIN	FINISH	VPI	VERTICAL POINT OF INTERSECTION
FIX	FIXED	TYP	TYPICAL
MIN	MINIMUM	WP	WORKING POINT

APPLICABLE STANDARD DRAWINGS:

OPSD 3101.150	WALLS, ABUTMENT, BACKFILL MINIMUM GRANULAR REQUIREMENT
OPSD 3370.100	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD
OPSD 3370.101	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS
MTOD 0912.451	BARRIERS AND RAILINGS STEEL BEAM GUIDE RAIL AND CHANNEL ANCHORAGE
MTOD 3941.210	FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	D.S.	CHK G.Z.	CODE CHBDC - 19/LOAD CL-625-ONT
DRAWN	K.M.	CHK D.S.	SITE 48E-0018/BO/STRUCT
			SCHEME
			DWG
			01



Appendix G

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES

Concrete Spread Footings on Native Sand	Driven H-Piles or Pipe Piles to Native Silt	Drilled in Pipe Piles To Native Silt
<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally lower cost than H-pile or pipe pile foundations. ii. Very low risk of structural damage from vibrations compared to driven piles. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Lower geotechnical resistance than H-piles or pipe piles. ii. Not an option for abutments for three-span bridge option due to deep excavations through cohesionless fill to construct footings on native sand. iii. If single-span bridge option selected, the footings will be susceptible to settlement due to backfill placed in front of existing abutments. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Higher geotechnical resistance than spread footings. ii. Minimal excavation or dewatering required. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost than footings. ii. Vibration due to pile driving may cause settlement of existing bridge foundations and damage to existing structure. iii. If single-span bridge option selected, the piles will be susceptible to downdrag due to settlement from backfill placed in front of existing abutments. iv. Driven pipe piles cause relatively larger displacements around the piles compared to H-piles. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Higher geotechnical resistance than spread footings. ii. Minimal excavation or dewatering required. iii. Very low risk of structural damage from vibrations compared to driven piles. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Specialized installation with potential higher unit cost than driven piles. ii. If single-span bridge option selected, the piles will be susceptible to downdrag due to settlement from backfill placed in front of existing abutments.
NOT RECOMMENDED	NOT RECOMMENDED	RECOMMENDED



Appendix H

List of OPSSs and OPSDs and Suggested Wording for NSSP



1. List of OPSS and OPSD Documents Relevant to this Project

- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS PROV 517 (Construction Specification for Dewatering)
- Special Provision No. FOUN0003 to OPSS 902 (Dewatering Structure Excavations)
- OPSS PROV 804 (Construction Specification for Seed and Cover)
- OPSS 902 (Construction Specification for Excavating and Backfilling – Structures)
- OPSS PROV 903 (Construction Specification for Deep Foundations)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- OPSD 3090.100 (Foundation Frost Depths for Northern Ontario)
- OPSD 3101.150 (Walls Abutment, Backfill Minimum Granular Requirements)

2. Suggested Wording for NSSPs

- **“Dewatering”**

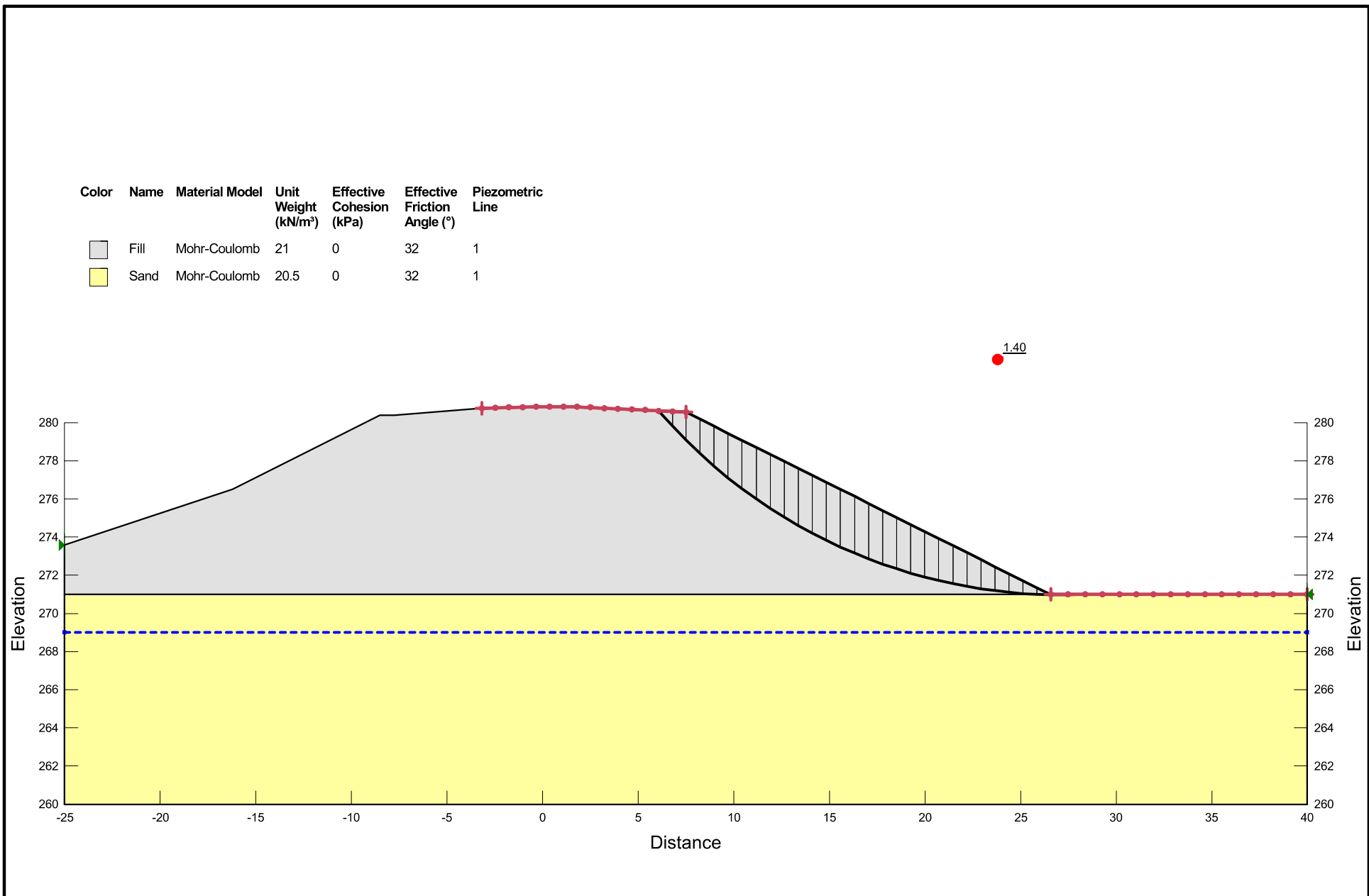
Effective dewatering shall be designed and provided by the Contractor during structure excavation, footing or pile cap placement and backfilling to allow the work to proceed in the dry. Excavation below the groundwater level will lead to subgrade softening. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final subgrade level throughout construction.

The dewatering system is to be designed in accordance with SP FOUN0003 and OPSS.PROV.517. A preconstruction survey is required, thus Designer Fill-In ** in SP FOUN0003 should be “250 m”. Special Provision FOUN0003 is included below.



Appendix I

Stability Analysis Figures




	Project			Additional Details	
	Terrace Bay			Name: Sta. 15+448	
	Analysis			Comments:	
	Proposed Widened Slope (2H:1V)			Method: Morgenstern-Price, Half-Sine	
Seismic Coefficient	Last Run		Scale	Entry: (6.0760067, 280.6212) m, Exit: (28.379726, 271) m	
H: 0g, V: 0g	2021-03-29, 05:42:13 PM		1:281	Center: (27.123115, 298.74961) m, Radius: 27.778052 m	

Figure 1

