



**DRAFT
FOUNDATION INVESTIGATION
REPORT
NORTH CURRENT RIVER
CULVERT REPLACEMENT
HIGHWAY 527
TOWNSHIP OF SHUNIAH
AGREEMENT NO.: 6011-E-0022
ASSIGNMENT NO.:**

**JUNE 2013
GS-TB-016954**

PREPARED FOR:
Ministry of Transportation
Geotechnical Section
Northwestern Region
615 South James Street
Thunder Bay, Ontario
P7E 6P6

2 Copy - Ministry of Transportation, Thunder Bay, ON
1 Copy - DST Consulting Engineers Inc., Thunder Bay, ON

DST CONSULTING ENGINEERS INC.
605 Hewitson Street, Thunder Bay, Ontario P7B 5V5
Phone: 1-807-623-2929 Fax: 1-807-623-1792

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FACTUAL INFORMATION

1. INTRODUCTION

DST Consulting Engineers Inc. (DST) has been retained by The Ministry of Transportation, Geotechnical Section Northwestern Region to conduct a geotechnical investigation for the replacement of the North Current River culvert on Highway 527. This work was carried out under Agreement No.: 6011-E-0022, Geotechnical Retainer, Thunder Bay area.

This report addresses the field investigation, laboratory test program factual report on conditions (Part 1) and recommendations for design and construction for the proposed culvert replacement (Part 2).

2. SITE DESCRIPTION

The existing structure at this location is a twin Structural Plate Corrugated Steel Pipe and each has a width of 2.1 m, height of 3.0 m and length of 20.4 m with a depth of soil cover of approximately 3.7 m. The embankment at the culvert was identified to be failing in the southbound lane causing lane closure and disruption to traffic.

The embankment slopes at the culvert inlet and outlet this location are vertical gabion walls with embankments at the North and South approach of approximately 2H:1V. Both sides of the embankment are sparsely vegetated (Figure 2.3). The photographs shown in Figures 2.1 to 2.4 were taken by DST on May 29th, 2013.

Geological information is available from published Ontario Geological Survey Map # 52ANW by the Ontario Ministry of Natural Resources for the Kaministiquia area, in the District of Thunder Bay. The map indicates that the local area dominant landform is identified as rock knobs with irregular surfaces generally this and discontinuous glacial overburden of boulder, sand-rich till. The topography in the area is mainly high local relief with dry drainage conditions.



Figure 2.1 South approach facing north - 2013-05-29



Figure 2.2 North approach facing south - 2013-05-29



Figure 2.3 Inlet facing south - 2013-05-29



Figure 2.4 Outlet facing south - 2013-05-29

3. INVESTIGATION PROCEDURES AND LABORATORY TESTING

Site work was carried out between June 3rd and 11th, 2013 utilizing a CME 750 all-terrain drill rig and hand equipment that was operated by DST personnel. A total of eight (8) boreholes were advanced for the purpose of foundation investigation at this site, four (4) using hollow stem augers and diamond drilling techniques and four (4) using hand operated equipment. Boreholes through the existing road embankment were advanced to depths between 10.4 and 11.6 m. Borehole at the proposed detour location were advanced to depths between 0.5 and 1.4 m .

Four boreholes were advanced through the embankment fill at approximately Station 10+336, 10+346, 10+360 and 10+366 at offsets of 3.2, 3.7, 1.0 and 1.3 m left respectively. Four boreholes were advanced along the proposed detour alignment at approximately Station 10+307, 10+326, 10+356 and 10+369 at an offset of 16, 14, 14 and 17 m right.

A borehole location plan and stratigraphic section are shown in Appendix C. The number and locations of all boreholes and depths of boreholes were specified by MTO in consultation with DST.

The borehole locations are referenced to the MTO Station numbering system as indicated on the base drawings provided by the MTO. Topographic site survey was completed by others prior to the geotechnical investigation. Table 3.1 summarizes the borehole locations, elevations, depths, and offsets.

All boreholes were abandoned using suitable abandonment barrier as described in Ontario Regulation 903 and its amendments. Boreholes were decommissioned by backfilling to the bottom of the road base with cuttings and bentonite chips. From the bottom of the road base, granular materials were replaced to the bottom of the asphalt.

The fieldwork was supervised on a full-time basis by DST personnel who located the borehole locations in the field, performed sampling, in-situ testing and logged the boreholes. Soil samples were obtained from the auger flights and from the split spoon sampler used for the standard penetration test (SPT). The SPT involves driving a 51 mm diameter thick-walled sampler into the soil under the energy of a 63.5 kg weight falling through 760 mm. The number of blows required to drive the sampler 305 mm is known as the standard penetration blow count (N) which provides an indication of the condition or consistency of the soil. The soil samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in Thunder Bay for further analysis.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of engineering properties. Laboratory tests included moisture contents and sieve analyses. A total of forty one (41) moisture contents and eleven (11) particle size analyses have been carried out for this assignment. Laboratory test results are presented in Appendix D, Enclosures.

Table 3.1 Detail of borehole locations

Borehole ID	Station	Elevation (m)	Depth (m)	Offset (m)
BH 1	10+360	397.1	11.6	1.0 Lt
BH 2	10+366	397.2	11.4	1.3 Lt
BH 3	10+346	369.9	11.3	3.7 Lt
BH 4	10+336	369.9	10.4	3.2 Lt
BH 5	10+369	392.8	0.5	17 Rt
BH 6	10+356	392.3	1.4	14 Rt
BH 7	10+326	392.3	1.2	14 Rt
BH 8	10+307	392.8	1.2	16 Rt

4. DESCRIPTION OF SUBSURFACE CONDITIONS

The subsurface conditions at the culvert location are presented based on the data obtained during field and laboratory testing.

4.1 Soil Stratigraphy along Roadway Alignment

The generalized stratigraphy of the existing road embankment based on the conditions encountered in Boreholes 1 through 4, consists of a pavement structure composed of asphalt overlying sand and crushed gravel, which is underlain by sand. Below the pavement structure, embankment fill consisting of a combination of rock, gravel and sand fill. Below the embankment fill, materials encountered varied between boreholes. Boreholes 1 and 4 encountered silt and sand with variable organic content underlain by predominantly sand over bedrock. Boreholes 2 and 3 encountered predominantly sand over bedrock.

Table 4.1 Summary of embankment soil strata at the culvert location

Layer	Depth (m)*	Elevation (m)**	Comments
Asphalt	0 to 0.05(0.06)	396.9(397.2) to 396.9(397.1)	
Gravel and Sand Fill	0.05(0.06) to 0.2(0.3)	396.9(397.1) to 396.6(396.9)	Granular A
Sand Fill	0.2(0.3) to 0.7(0.9)	396.6(396.9) to 396.1(396.5)	Granular B
Rock Fill, Gravel Fill and Sand Fill	0.7(0.9) to 3.8(5.3)	396.1(396.5) to 391.8(393.1)	
Silt and Sand	3.8(5.3) to 5.2(6.1)	391.8(393.1) to 391.0(391.7)	Encountered in BH 1 and BH 4, trace organics and wood debris
Sand	4.5(6.1) to 7.6(8.6)	391.0(392.4) to 388.5(389.3)	Cobbles noted throughout
Bedrock	> 7.6(8.6)	< 388.5(389.3)	Bedrock confirmed in all BHs

*Depth (m) presented as upper boundary min(max) to lower boundary min(max)

** Elevation (m) presented as upper boundary min(max) to lower boundary min(max)

Cross sectional profiles of the site at Station 10+350 and along the roadway alignment can be found in Appendix C, Drawings 2 and 3.

4.1.1 Asphalt

Asphalt was encountered in Boreholes 1, 2, 3 and 4 with thicknesses of approximately 0.06,

0.05, 0.06 and 0.05 m at depths between 0 to 0.06 m (Elev. 397.10 to 397.04 m), 0 to 0.05 m (Elev. 397.15 to 397.10 m), 0 to 0.06 m (Elev. 396.92 to 396.84 m) and 0 to 0.05 m (Elev. 396.87 to 396.82 m) respectively.

4.1.2 Sand and Crushed Gravel Fill (Base)

Base material of sand and crushed gravel fill was encountered in Boreholes 1 2, 3 and 4 with thicknesses of approximately 0.23, 0.17, .19 and 0.25 m, at depths between 0.06 to 0.29 m (Elev. 397.04 to 396.81 m), 0.05 to 0.22 m (Elev. 397.10 to 396.93 m), 0.06 to 0.25 m (Elev. 396.84 to 396.65 m) and 0.05 to 0.30 m (Elev. 396.82 to 396.57 m).

The moisture content of the samples tested ranged from 2 to 3 %. The results of the laboratory tests are summarized in Table 4.2.

Table 4.2 Summary of base material sieve analyses

Laboratory Results - Sieve Size Analyses	
Gravel %	48
Sand %	42
Fines %	10

4.1.3 Sand Fill (Subbase)

Subbase material of sand fill was encountered in Boreholes 1 2, 3 and 4 with thicknesses of approximately 0.6, 0.5, 0.4 and 0.5 m, at depths between 0.3 to 0.9 m (Elev. 396.8 to 396.2 m), 0.2 to 0.7 m (Elev. 396.9 to 396.4 m), 0.3 to 0.7 m (Elev. 396.7 to 396.3 m) and 0.3 to 0.8 m (Elev. 396.6 to 396.1 m) respectively.

The moisture content of the samples tested ranged from 2 to 3 %. The results of the laboratory tests are summarized in Table 4.3.

Table 4.3 Summary of subbase material sieve analyses

Laboratory Results - Sieve Size Analyses	
Gravel %	16 to 26
Sand %	62 to 76
Fines %	8 to 12

4.1.4 Gravel and Sand Fill

Gravel and sand fill was encountered in Boreholes 3 and 4 with thicknesses of approximately 3.0 and 2.2 m at depths between 0.7 to 3.7 m (Elev. 396.2 to 393.2 m) and 0.8 to 3.0 m (Elev.

396.1 to 393.9 m) respectively. Cobbles were noted within the gravel and sand fill.

SPT 'N' values obtained in this material range from 8 to 14 blows per 0.3 m penetration indicating a loose to compact condition. The moisture contents of samples tested ranged from 3 to 5 %. The results of the laboratory tests are summarized in Table 4.4.

Table 4.4 Summary of gravel and sand fill sieve analyses

Laboratory Results - Sieve Analyses	
Gravel %	47
Sand %	46
Fines %	7

4.1.5 Rock Fill

Rock fill with infill varying from sand with some gravel and silt to sandy gravel with some silt was encountered in Boreholes 1, 2, 3 and 4 with thicknesses of approximately 3.0, 4.4, 0.8 and 0.8 m at depths between 0.9 to 3.9 m (Elev. 396.2 to 393.2 m), 0.7 to 5.1 m (Elev. 396.5 to 392.1 m), 3.7 to 4.5 m (Elev. 393.2 to 392.4 m) and 3.0 to 3.8 m (Elev. 393.9 to 393.1 m) respectively.

SPT 'N' values obtained in this material range from 7 to 100+ blows per 0.3 m penetration indicating a loose to very dense condition. However, some SPT values obtained may be artificially high due to the presence of rock fill within the stratum. The moisture contents of infill samples tested ranged from 1 to 22 %. The results of the laboratory tests are summarized in Table 4.5.

Table 4.5 Summary of rock fill infill sieve analyses

Laboratory Results - Sieve Analyses	
Gravel %	16 to 52
Sand %	37 to 69
Fines %	11 to 15

4.1.6 Sand Fill

Sand fill was encountered in Borehole 1 with a thickness of approximately 1.4 m at depths between 3.9 to 5.3 m (Elev. 393.2 to 391.8 m). Fibrous organic material was noted within the sample collected at the interface between fill and native materials.

SPT 'N' values obtained in this material range from 5 to 16 blows per 0.3 m penetration indicating a loose to compact condition. The moisture contents of samples tested ranged from 14 to 39 %. The results of the laboratory tests are summarized in Table 4.6.

Table 4.6 Summary of sand fill sieve analyses

Laboratory Results - Sieve Analyses	
Gravel %	8
Sand %	60
Fines %	32

4.1.7 Silt and Sand

Silt and sand was encountered beneath the embankment fill in Boreholes 1 and 4 with thicknesses of approximately 0.8 and 1.4 m at depths between 5.3 to 6.1 m (Elev. 391.8 to 391.0 m) and 3.8 to 5.2 m (Elev. 393.1 to 391.7 m) respectively. Fibrous organic material and wood debris was noted within the samples collected from this stratum.

SPT 'N' values obtained in this material range from 3 to 16 blows per 0.3 m penetration indicating a very loose to compact condition. The moisture contents of samples tested ranged from 25 to 127 %. The results of the laboratory tests are summarized in Table 4.7.

Table 4.7 Summary of silt and sand sieve analyses

Laboratory Results - Sieve Analyses	
Gravel %	3
Sand %	40
Silt %	48
Clay %	9

4.1.8 Sand

Sand was encountered beneath the fill material in Boreholes 2 and 3 with thicknesses of approximately 3.0 and 3.4 m, at depths between 5.1 to 8.1 m (Elev. 392.1 to 389.1 m) and 4.5 to 7.9 m (Elev. 392.4 to 389.0 m) respectively and beneath the silt and sand in Boreholes 1 and 4 with thicknesses of approximately 2.5 m and 2.4 m, at depths between 6.1 to 8.6 m (Elev. 391.0 to 388.5 m) and 5.2 to 7.6 m (Elev. 391.7 to 389.3 m) respectively.

SPT 'N' values obtained in this material range from 9 to greater than 100 blows per 0.3 m penetration indicating a loose to very dense condition. However, some SPT values obtained may be artificially high due to the presence of cobbles within the stratum. The moisture contents of samples tested ranged from 3 to 24 %. The results of the laboratory tests are summarized in Table 4.8.

Table 4.8 Summary of sand sieve analyses

Laboratory Results - Sieve Analyses	
Gravel %	33 to 34
Sand %	51 to 53
Fines %	13 to 16

4.1.9 Bedrock

Bedrock was confirmed in Boreholes 1, 2, 3 and 4 at depths below 8.6 m (Elev. 388.5 m), 8.1 m (Elev. 389.1 m), 7.9 m (Elev. 389.0 m) and 7.6 m (Elev. 389.3 m) respectively. All cores were logged and assessed for Total Core Recovery (TCR) and Rock Quality Designation (RQD) values. Exposed bedrock knobs are present approximately 30 and 100 m east and west of the culvert location respectively. It is possible that the bedrock dips toward the culvert location and to the north.

TCR values varied between 98 and 100 %. RQD values varied between 43 and 100 %. The two lowest RQD recorded of 43 % and 50 % were RC1 sampled in Boreholes 1 and 2 at the interface between the overburden and the bedrock. All other RQD values were greater than 60 % indicating predominantly fair to excellent rock quality.

Table 4.9 RQD classification ranges

RQD %	Rock Quality
0 – 25	Very Poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

4.2 Soil Stratigraphy along Detour Alignment

The generalized stratigraphy of the along the detour alignment based on the conditions encountered in Boreholes 5 through 8, consists of topsoil over silt and sand with variable organic content, which is underlain by sand.

Table 4.10 Summary of soil strata at detour location

Layer	Depth (m)*	Elevation (m)**	Comments
Topsoil	0 to 0.1(0.3)	392.3(392.8) to 392.0(392.5)	
Silt and Sand	0.1(0.3) to 0.5(1.2)	392.0(392.7) to 391.3(392.3)	Refusal in BH 5 and 8
Sand	1.0 to 1.2(1.4)	391.3 to 390.9(391.1)	Encountered in BH 6 and 7. Refusal in BH 6 and 7

*Depth (m) presented as upper boundary min(max) to lower boundary min(max)

** Elevation (m) presented as upper boundary min(max) to lower boundary min(max)

4.2.1 Topsoil

Topsoil was encountered in Boreholes 5, 6, 7 and 8 with thicknesses of approximately 0.1, 0.3, 0.3 and 0.3 m at depths between 0 to 0.1 m (Elev. 392.8 to 392.7 m), 0 to 0.3 m (Elev. 392.5 to 392.2 m), 0 to 0.3 m (Elev. 392.5 to 392.2 m) and 0 to 0.3 m (Elev. 392.8 to 392.5 m) respectively.

4.2.2 Silt and Sand

Silt and sand was encountered beneath the topsoil in Boreholes 5, 6, 7 and 8 along the detour alignment with thicknesses of approximately 0.4, 0.7, 0.7 and 0.9 at depths between 0.1 to 0.5 m (Elev. 392.7 to 392.3 m), 0.3 to 1.0 m (Elev. 392.0 to 391.3 m), 0.3 to 1.0 m (Elev. 392.0 to 391.3 m) and 0.3 to 1.2 m (Elev. 392.7 to 391.6 m). Fibrous organic material and wood debris was noted within the samples collected from this stratum. Auger refusal was encountered in Boreholes 5 and 8 at depths of 0.5 and 1.2 m respectively and is assumed to be the bottom of this stratum at those locations.

4.2.3 Sand

Sand was also encountered along the detour alignment beneath the silt and sand in Boreholes 6 and 7 with undetermined thicknesses, at depths greater than 1.0 m (Elev. 391.3 m) and greater than 1.0 m (Elev. 391.3 m) respectively.

4.3 Groundwater

The groundwater table was identified below the ground surface during the field investigation and visual identification of soil samples. The estimated depth of groundwater level below the ground surface is given in Table 4.12. The groundwater levels and water levels at the culvert can be expected to vary with season and precipitation events.

Table 4.11 Depth of water table at boreholes

Borehole	June 3 rd to 11 th , 2013	
	Depth Measured (m)	Elevation (m)
BH 1	4.8	392.3
BH 2	5.2	392.0
BH 3	4.7	392.2
BH 4	4.6	392.3
BH 5	0.3	392.5
BH 6	0.1	392.2
BH 7	0.1	392.2
BH 8	0	392.8

5. MISCELLANEOUS

Site work was carried out between June 3rd and 11th, 2013 utilizing a CME 750 all-terrain drill rig and hand equipment operated by DST personnel. Fieldwork was supervised on a full time basis by Peter Raynak who located the boreholes in the field, performed sampling, in-situ testing and logged the boreholes. Soil samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in Thunder Bay for further analysis. Interpretation of the data and preparation of the report was completed by Wesley Saunders, P.Eng and reviewed by Prof. Myint Win Bo, P.Eng a designated principal contact for MTO projects.

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FOUNDATION DESIGN REPORT

6. PROJECT DESCRIPTION

DST Consulting Engineers Inc. (DST) has been retained by The Ministry of Transportation, Geotechnical Section Northwestern Region to conduct a geotechnical investigation for the replacement of the North Current River culvert on Highway 527. This work was carried out under Agreement No.: 6011-E-0022, Geotechnical Retainer, Thunder Bay area.

The existing structure at this location is a twin Structural Plate Corrugated Steel Pipe and each has a width of 2.1 m, height of 3.0 m and length of 20.4 m with a depth of soil cover of approximately 3.7 m. The embankment at the culvert was identified to be failing in the southbound lane causing lane closure and disruption to traffic.

The generalized stratigraphy of the existing road embankment based on the conditions encountered in Boreholes 1 through 4, consists of a pavement structure composed of asphalt overlying sand and crushed gravel, which is underlain by sand. Below the pavement structure, embankment fill consisting of a combination of rock, gravel and sand fill. Below the embankment fill, materials encountered varied between boreholes. Boreholes 1 and 4 encountered silt and sand with variable organic content underlain by predominantly sand over bedrock. Boreholes 2 and 3 encountered predominantly sand over bedrock.

The generalized stratigraphy of the along the detour alignment based on the conditions encountered in Boreholes 5 through 8, consists of topsoil over silt and sand with variable organic content, which is underlain by sand.

This section presents interpretation of the geotechnical data presented in the factual report and provides geotechnical design recommendations and construction concerns for the proposed culvert replacement.

6.1 Discussion

The proposed replacement structure for the culvert replacement is a larger open footing culvert such as a Super-Cor steel structure supported on spread footings. Open cut excavation with the

temporary detour of traffic over a modular bridge has been considered for the replacement of the structure.

The design of the culvert must be in accordance with the Canadian Highway Bridge Design Code CAN/CSA-S6-06 (CHBDC, 2006) and all relevant Ministry of Transportation specification and guidelines.

6.1.1 Earth Excavation

An open cut operation at the location of the existing culvert alignment is proposed by Genivar for the culvert replacement. This method of construction may result in traffic disturbances and may require temporary surface water ditch diversion and temporary support for traffic. This method can readily accommodate excavation of large boulders, if encountered during excavation. As a minimum, the procedures should be in accordance with OPSS 902 "Construction Specifications for Excavating and Backfilling - Structures". Where temporary protection systems are required they shall be constructed in accordance with OPSS 539 "Construction Specification for Temporary Protection Systems" and Section 6.1.6 Roadway Protection.

If organic materials are encountered during excavation, the excavations to remove these organics and wood should be completed in accordance with OPSS 209 "Construction Specification for Embankments Over Swamps and Compressible Soils". It is anticipated that the existing groundwater table will be above the invert level. Excavation below the water table can be undertaken by either dewatering of the excavation or in the wet without lowering the water table. If excavation is completed in the wet, any sub-excavated materials can be replaced with 19 mm Type I or II clear stone as defined in OPSS 1004.05.02. If fine materials are present beneath the clear stone a non-woven geotextile (OPSS 1860.07.05.01 Class II) with the filtration opening size (FOS) less than 135 µm may be required for separation. No compaction is required for placement of the clear stone.

6.1.2 Staged Construction

Staged construction has been identified by prime consultant, Genivar, as the preferred approach to maintain traffic during the construction of the culvert at this site. The proposed staged construction includes three (3) stages.

Stage 1 is construction of the temporary detour alignment with a modular bridge structure which involves the temporary detour of traffic to the existing northbound lane while the temporary retaining walls and abutments for the modular bridge are constructed for the

subsequent detour. Excavation adjacent the roadway is anticipated to be to an elevation of approximately 391 m to allow for placement of suitable bedding materials for the detour structure. Use of temporary concrete barriers will be required.

Stage 2 is excavation and removal of the existing structure, installation of the replacement structure and reinstatement of the southbound lane which involves the temporary detour of traffic using the modular bridge structure. Excavation is anticipated to be to an elevation of approximately 390 m to allow for placement of suitable bedding materials for the replacement structure.

Stage 3 is removal of the modular bridge structure and reinstatement of the northbound lane which involves the temporary detour of traffic to the reinstated southbound lane. Use of temporary concrete barriers will be required.

The final embankment foreslopes should be reinstated as presented in Section 6.1.12 Embankment Foreslopes.

6.1.3 Foundation Design

6.1.3.1 Open Footing Culvert

The culvert will be located at approximately the same vertical and horizontal alignment as the existing structure. As the proposed culvert is not expected to be heavily loaded, a shallow foundation is considered suitable for this site. As the cross sectional area of the structural arch culvert will remove the existing soil materials, the overall effect on the culvert foundation soils will be a small decrease in stress at the base of the culvert.

The geotechnical resistance was estimated for the ultimate limit state (ULS) and serviceability limit state (SLS) for a maximum settlement of 25 mm. The resistance at ULS was calculated by applying load resistance factor of 0.5 according to the Bridge Design Code (CHBDC) CAN/CSA-S6-06 section 6.6.3.6, Table 4.1. The geotechnical resistance was estimated assuming a strip footing of various widths with a length equal to 23.7 m situated at an elevation of approximately 390 m. Post construction settlement is not expected as the footing will be founded on dense native sand material over shallow bedrock. Due to the nature of founding material post construction settlement is negligible therefore SLS becomes equal to ULS.

Table 6.1 Geotechnical resistances and reactions for structural arch culvert

Footing Width L=23.7 m	Depth of Soil Cover	Ultimate bearing capacity (kPa)	Factored Resistance at ULS (kPa)	Resistance at SLS (kPa)
B = 1.0 m	0	170	85	85
	0.3	270	135	135
	0.45	320	160	160
	0.5	340	170	170
B = 1.5 m	0	250	125	125
	0.3	360	180	180
	0.45	410	205	205
	0.5	420	210	210
B = 2.0 m	0	330	165	165
	0.3	440	220	220
	0.45	490	245	245
	0.5	510	255	255
B = 2.5 m	0	410	205	205
	0.3	520	260	260
	0.45	570	285	285
	0.5	590	295	295

Culvert foundation can be constructed either with dewatering of excavation or without lowering the water in the excavation. If the construction of foundation is carried out in the wet, foundation construction can be performed by Tremie concrete placement. In this case, soil below foundation should be carefully prepared to minimize the disturbance. Alternatively, use of precast concrete footings can be considered.

6.1.3.2 Bin Wall Abutments and Retaining Walls for Temporary Modular Bridge Detour

The bin wall abutments to be constructed for the temporary detour are proposed to be 7.0 m wide by 2.4 m long and approximately 2.5 m in height with a base elevation to be set on at of approximately 392.5 m. Retaining walls to be constructed are proposed to extend north and south of the north and south abutments for the temporary bridge respectively and are required to maintain construction within the existing MTO right of way. As soft compressible soils are currently present at the proposed bin wall and retaining wall locations, it is recommended that all organic and undesirable soft materials encountered are removed to undisturbed dense native

sand and replaced with engineered fill.

Acceptable engineered fill should not contain debris, organic matter, frozen materials, or large stones, must meet SSP110S13 Granular B requirements and be compacted to 95% of standard Proctor maximum dry density in accordance with OPSS 501 "Construction Specification for Compacting". As the excavated level for footing preparation is below surface and / or groundwater level, dewatering may be required. Alternatively, if construction is performed without dewatering fill material should consist of 53 mm clear stone or 19 mm Type I or II clear stone as defined in OPSS 1004.05.02. A non-woven geotextile (OPSS 1860.07.05.01 Class II) with the filtration opening size (FOS) less than 135 µm may be required for separation. No compaction is required for the placement of the clear stone. Where required, suitable rip rap should be placed adjacent the structures to prevent failure due to undermining likely to be caused by erosion between natural soil and clear stone for this case.

The geotechnical resistance was estimated for the ultimate limit state (ULS) and serviceability limit state (SLS) for a maximum settlement of 25 mm. The resistance at ULS was calculated by applying load resistance factor of 0.5 according to the Bridge Design Code (CHBDC) CAN/CSA-S6-06 section 6.6.3.6, Table 4.2. The geotechnical resistance was estimated assuming a strip footing of 7.0 m wide by 2.4 m long situated at an elevation of approximately 392.5 m over 2 m of engineered fill. Post construction settlement is not expected as the footing will be founded on engineered fill underlain by dense native sand material over shallow bedrock.

Table 6.2 Geotechnical resistances and reactions for bin wall abutment

Footing Width L=7.0 m	Depth of Soil Cover	Ultimate bearing capacity (kPa)	Factored Resistance at ULS (kPa)	Resistance at SLS (kPa)
B = 2.4 m	0	360	180	180
	0.6	840	420	420

6.1.4 Embankment Design

As the embankment is predominantly underlain by dense sand and shallow bedrock there will not be any instability due to global slip passing through these materials provided all very loose silt and sand materials are removed during construction and replaced with engineered fill. Due to relatively consistent refusal elevations, there should not be any instability due to sliding failure

of the embankment material along the bedrock surface. Possible embankment failures are limited to shallow slip failures if the proposed embankment slope does not have suitable gradient of slope with recommended type of granular fill.

Considering soil parameters as described in Table 6.3 Typical soil parameters for earth loads, the temporary side slopes above the water table supporting traffic during the construction stages should not be steeper than 2H:1V and 1.5H:1V for granular and rock fill materials respectively. Design of temporary slopes below the water table will depend on the dewatering method. Embankment foreslopes should be reinstated as indicated in Section 6.1.11 Embankment Foreslopes.

6.1.5 Lateral and Sliding Resistances

The analysis of horizontal and vertical effects of earth and structural loads on the structure can be performed considering soil parameters given in Table 6.3 and assuming linearly variation of stress change with the depth as described in Section 7.8.5.3.2 in Canadian Highway Bridge Design Code (CHBDC). Temporary bracing and shoring may be designed using the typical soil parameters given in Table 2.2, but the designer/contractor should verify the appropriate soil parameters for the designs of specific retaining system. Interface friction angles and adhesion parameters are referenced from the Canadian Foundation Engineering Manual 2006 (CFEM), Section 24.5 Wall Friction, Table 24.4.

It is recommended that all excavations be either adequately sloped or securely shored and braced to prevent earth caving and to provide a safe and stable work area. The design should incorporate the effects of hydrostatic pressure, traffic surcharge and retained sloping earth conditions in the shoring design.

The coefficients for lateral earth pressure can be calculated using equations provided in Table 4.4. Where no significant earth movements are expected, the coefficient K_0 should be used.

Table 6.3 Typical soil parameters for earth loads

Soil Type	Unit Weight (kN/m ³)	Internal Friction Angle (Deg)	Interface Friction Angle δ (Deg)
Rock Fill	17	45	22
Granular A (compacted)	21	36	22
Granular B (compacted)	21	35	22
Silt (non-plastic)	19	30	11
Sand (dense native)	20	35	17

Table 6.4 Lateral earth pressure coefficients

Earth Pressure Coefficient	Equation*
Active Earth Pressure (K_a)	$\frac{1 - \sin\phi}{1 + \sin\phi}$
Passive Earth Pressure (K_p)	$\frac{1 + \sin\phi}{1 - \sin\phi}$
At rest (K_o)	$(1 - \sin\phi)$

* ϕ is an angle of internal friction

6.1.6 Roadway Protection

Roadway protection for this project should be constructed in accordance with the requirements of the Occupational Health and Safety Act of Ontario (OHSA), O.Reg. 213/91. According to O.Reg. 213/91, s.226, the soils in the area of interest classify as Type 3 and Type 4 if located above and below the water table respectively. Type 3 soils generally are stiff to firm and compact to loose or are previously excavated soil, exhibit signs of surface cracking, exhibit signs of seepage, if it is dry, may run easily into a conical pile and have a low degree of internal strength. Type 4 soils generally are soft to very soft and very loose in consistency, very sensitive and upon disturbance are significantly reduced in natural strength, run easily or flow unless it is completely supported before excavation procedure, have almost no internal strength, are wet or muddy and exerts substantial fluid pressure on its supporting system. In accordance with O. Reg. 213/91, s.227 (3), if an excavation contains more than one type of soil, the soil shall be classified with the highest number as described in O.Reg. 213/91, s.226. These should

be assessed and confirmed in the field as construction progresses.

If roadway protection is required during the culvert replacement, installation of a cantilever wall may be considered due to the shallow bedrock formation to ensure the stability of the bank and is a feasible option. The design of the cantilever walls may be performed using the typical soil parameters given in Table 6.3, but the designer/contractor should verify the appropriate soil parameters for the designs.

The construction methodology must be in accordance with OPSS 539 “Construction Specification for Temporary Protection Systems” as well as all Ministry of Transportation, Ministry of Environment, Ministry of Natural Resources and Department of Fisheries and Oceans guidelines, and also the Occupational Health and Safety Act of Ontario. The contractor’s method and equipment must be suitable for the site conditions and materials used.

6.1.7 Structural Backfill

The backfill for the structure should be designed in accordance the contract documents, Section 7.7.5 of the CHBDC and as specified in OPSS 902 “Construction Specification for Excavation and Backfilling - Structures”.

The bottom of the excavation on which the footing is to rest should not be disturbed. As soft compressible soils are identified to be present at the site, it is recommended that all organic and undesirable soft materials encountered are removed to undisturbed dense native sand. Where required, replacement to desired foundation elevations with engineered fill is recommended.

Acceptable engineered fill should be extended laterally to at least 0.5 m from the edge of footing, not contain debris, organic matter, frozen materials, or large stones, must meet SSP110S13 Granular A requirements and be compacted to 95% of standard Proctor maximum dry density in accordance with OPSS 501 “Construction Specification for Compacting”. As the excavated level for footing preparation is below surface and / or groundwater level, dewatering may be required. Alternatively, if construction is performed without dewatering fill material should consist of 53 mm clear stone or 19 mm Type I or II clear stone as defined in OPSS 1004.05.02. A non-woven geotextile (OPSS 1860.07.05.01 Class II) with the filtration opening size (FOS) less than 135 µm may be required for separation. No compaction is required for the placement of the clear stone.

The extent of the backfill should be selected as given specification in Figure 7.7 in the

Canadian Highway Bridge Design Code. The structural backfill should be free of stones exceeding 75 mm in any dimension, debris, organic matter, or frozen materials. Heavy equipment should not be allowed within 1 m of the culvert walls. The backfill material should be separated from the adjacent soil with a non-woven Class II geotextile specified in OPSS 1860. Overfill soils should not be compacted greater than the compaction or equivalent stiffness of soils in the foundation.

6.1.8 Channel Diversion and Dewatering

It is proposed that the existing culverts may be utilized for diverting the river during construction. This may be possible if for example, a sheet pile vertical cut off wall is installed between the culverts and the water flow is diverted through the south culvert during the removal of the north culvert and preparation of the northern portion of the channel and footings. However, this would require the footing elevation to be above the anticipated water levels such that water flow could be diverted to the northern portions of the channel for the removal of the south culvert and preparation of the southern portion of the channel and the footings. The proposed open footing culvert structure could then be installed after the removal of all temporary sheet pile walls. Alternatively, the culvert may be replaced by diverting the flow through a temporary bypass.

It is important to ensure that a flood in the river does not cause damage to the partly constructed permanent works, to the temporary works or to plant. Floods have a habit of occurring overnight or at weekends and inadequate temporary works can fail with expensive consequences.

In order to prevent water from entering the construction area, a dyke made of sand bags has sometimes been used as a hydraulic barrier. However, a sheet pile vertical cut-off wall will provide better control of both surface and groundwater. A suitable sump and pump system, supported by an efficient deep well on wellpoint system, will be required to dewater and stabilize the excavation. A well designed well system with a suitable diameter of well at an appropriate spacing will be required for working under dry condition and to prevent disturbance of the excavation base through sand boiling and hydraulic heave. The variable stratigraphy below the embankment fill including the silt and sand layer and the dense sand layer must be considered in the dewatering design. It should be noted that depending on the season, depth of excavation and amount of water flow through the river may vary. The contractor should be prepared to tackle this situation. If flow of the river is high, a cofferdam set up can be considered for the construction.

Where dewatering is performed, all dewatering operations should be completed in accordance with OPSS 517 “Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation”. If construction is to be completed in the dry a continuous dewatering operation must be provided to keep the excavation stable and free of water. The excavation must be monitored daily throughout the duration of excavation until the completion of backfilling to confirm this. The dewatering system must be maintained and the surrounding area monitored for impacts to items such as, but not limited to, settlement and groundwater usage. In addition, the control of water from the dewatering operation should be accordance with OPSS 518 “Construction Specification for Control of Water from Dewatering Operations”.

Water shall be disposed of so as not to be injurious to public health or safety, property, the environment, fisheries, or any part of the work completed or under construction. Dewatering operations shall be directed to a sediment control device or natural attenuation area prior to discharge to watercourses. If a natural attenuation area is used, a minimum 15 m setback shall be maintained from the receiving watercourse. When water is discharged to a watercourse, the water discharged shall be done in a manner that does not cause erosion or other damage to adjacent lands.

Since high volume of dewatering ($>50 \text{ m}^3/\text{day}$) is expected, Permit To Take Water (PTTW) should be obtained for this construction from Ministry of the Environment. The construction should also be performed accordance to the Ministry of Natural Resources and Department of Fisheries and Oceans guidelines.

6.1.9 Erosion Control

Erosion control is essential adjacent to the structures for the successful performance of the culvert. The rip rap reduces the flow velocity close to the channel bed and prevents failure by undermining which is likely to be caused by erosion between natural soil and clear stone for this case. All rip rap should be installed in accordance with OPSS 511 “Construction Specification for Rip Rap, Rock Protection, and Granular Sheeting”.

The temporary erosion and sedimentation measures during the construction of culvert shall be controlled as described in OPSS 805 “Construction Specification for Temporary Erosion and Sedimentation Control Measures”.

6.1.10 Frost Protection

In accordance with OPSD 3090.100 “Foundation Frost Depths for Northern Ontario”, the frost penetration at this location is approximately 2.2 m. The frost susceptible soils shall not be used adjacent to the culvert wall within the depth of frost penetration. The native soils present under the proposed footing elevations of 390 m are considered to have low susceptibility to frost heaving.

6.1.11 Embankment Foreslopes

The embankment slopes at the culvert inlet and outlet for this location are vertical gabion walls with embankments at the north and south approach of approximately 2H:1V. The foreslopes should be reinstated with a slope not steeper than 2H:1V if being constructed with granular materials. The foreslopes should be reinstated with a slope not steeper than 1.5H: 1V if being constructed with rock fill.

Where retaining structures are used to achieve embankment foreslopes steeper than mentioned in the above paragraph, embankments should be constructed in accordance with manufacturer specifications.

6.1.12 Construction Concerns

Should open cut excavation replacement be selected, the main construction issues that need for be addressed for this are removal of cover/embankment materials, staged removal of the existing culverts, possible provisions required for temporary roadway protection, diversion of the channel, excavation below the water table, erosion at the structure and undermining of structure footings, frost/heave in silt and sand soil below culvert and reinstatement of the embankment fill. Particular attention should be paid to maintain the integrity of the existing culvert during the staged method of construction as well as the ability of the chosen construction method to accommodate the presence of rock fill and cobbles within the embankment fill and native materials.

A Quality Verification Engineer shall be required to inspect the condition of the foundation and surrounding soils before installation of bedding and other backfills and ensure the width of trench and trench slope walls are suitable, and ensure compliance with materials placed and compaction methods.

7. REFERENCES

Canadian Highway Bridge Design Code (2006), CAN/CSA-S6-06, A National Standard of Canada, Canadian standards Association.

Municipal and Provincial Common, Volume 1 - General & Construction Specifications, “*Ontario Provincial Standard for Roads & Public Works*” Spec No. OPSS 501, 510, 511, 517, 518, 539, 805, 902.

Municipal and Provincial Common, Volume 3 - Drawings for Roads, Barriers, Drainage, Sanitary Sewers, Watermains and Structures, “*Ontario Provincial Standard for Roads & Public Works*” Spec No. OPSD 203.040, 3090.100.

Municipal and Provincial Common, Volume 2 - Material Specifications, “*Ontario Provincial Standard for Roads & Public Works*” Spec No. OPSS 1860.

Special Provisions, Ontario Provincial Standards, SSP110S13.

8. LIMITATIONS OF REPORT

A description of limitations which are inherent in carrying out site investigation studies is given in Appendix 'A', and this forms an integral part of this report.

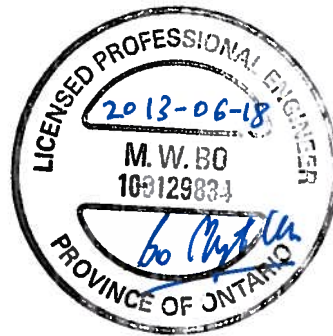
For DST CONSULTING ENGINEERS INC.

Prepared by:

Reviewed by:



Wesley Saunders, P.Eng
Project Manager (GeoServices)



Dr. M W Bo, PhD., P. Eng, P.Geo, Int PE,
C.Geol, C. Eng, Eur Geol, Eur Eng
Vice President / Senior Principal
(GeoServices)

APPENDIX 'A'

LIMITATIONS OF REPORT

LIMITATIONS OF REPORT

GEOTECHNICAL STUDIES

The data, conclusions and recommendations which are presented in this report, and the quality thereof, are based on a scope of work authorized by the Client. Note that no scope of work, no matter how exhaustive, can identify all conditions below ground. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the specific locations tested, and conditions may become apparent during construction which were not detected and could not be anticipated at the time of the site investigation. Conditions can also change with time. It is recommended practice that a Quality Verification Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavation, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Unless otherwise noted, the information contained herein in no way reflects on environmental aspects of either the site or the subsurface conditions.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs, e.g. the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

Any results from an analytical laboratory or other subcontractor reported herein have been carried out by others, and DST Consulting Engineers Inc. cannot warranty their accuracy. Similarly, DST cannot warranty the accuracy of information supplied by the client.

APPENDIX 'B'
DESCRIPTIVE TERMS
FOR SOIL CLASSIFICATION

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

TEXTURAL CLASSIFICATION OF SOILS

BOULDERS	COBBLES	GRAVEL	SAND	SILT	CLAY
GREATER THAN 200 mm	75 TO 200 mm	4.75 TO 75 mm	0.075 TO 4.75 mm	0.002 TO 0.075 mm	LESS THAN 0.002 mm

COARSE GRAIN SOIL DESCRIPTION (50% GREATER THAN 0.075 mm)

TERMINOLOGY	TRACE OR OCCASIONAL	SOME	WITH	ADJECTIVE (e.g. SILTY OR SANDY)	AND (e.g. SAND AND SILT)
	LESS THAN 10%	10 TO 20%	20 TO 30%	30 TO 40%	40 TO 60%

CONSISTENCY*: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (C_u) AND SPT 'N' VALUES AS FOLLOWS

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 - 100	100 - 200	> 200
N (BLOWS / 0.3 m)	<2	2 - 4	4 - 8	8 - 15	15 - 30	>30
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

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

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


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

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100 mm+ IN LENGTH EXPRESSED AS A PERCENTAGE OF THE LENGTH OF THE CORING RUN.

THE **ROCK QUALITY DESIGNATION (R.Q.D)** FOR MODIFIED RECOVERY IS:

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

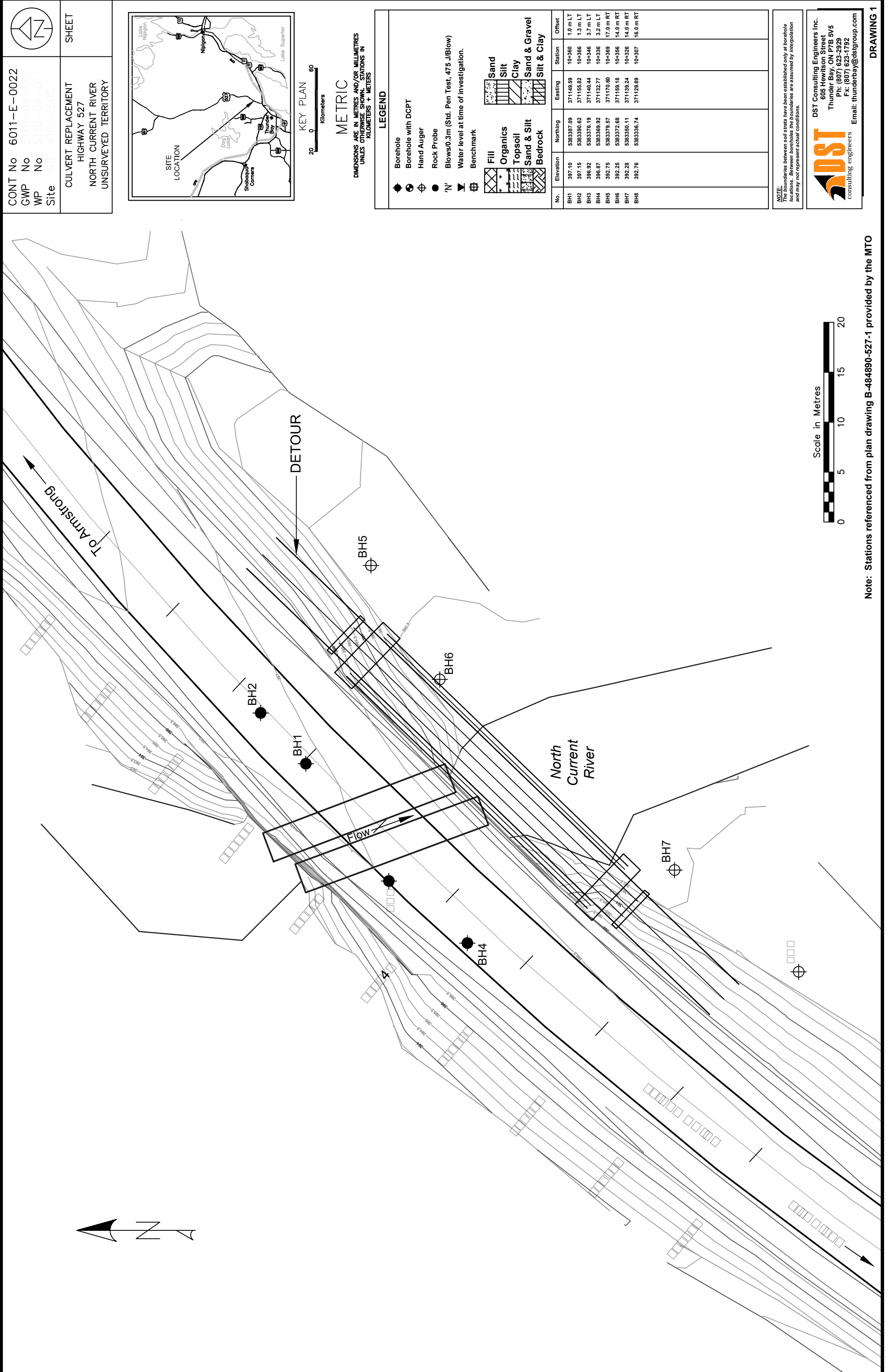
LEGEND OF RECORDS FOR BOREHOLES: SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS	SPLIT SPOON SAMPLE	WS	WASH SAMPLE
TW	THIN WALL SHELBY TUBE SAMPLE	AS	AUGER (GRAB) SAMPLE
PH	SAMPLER ADVANCED BY HYDRAULIC PRESSURE	TP	THIN WALL PISTON SAMPLE
WH	SAMPLER ADVANCED BY SELF STATIC WEIGHT	PM	SAMPLER ADVANCED BY MANUAL PRESSURE
SC	SOIL CORE	RC	ROCK CORE
	WATER LEVEL	$SENSITIVITY = \frac{UNDISTURBED\ SHEAR\ STRENGTH}{REMOLDED\ SHEAR\ STRENGTH}$	

*HIERARCHY OF SOIL STRENGTH PREDICTION: **1)** LABORATORY TRIAXIAL TESTING. **2)** FIELD INSITU VANE TESTING. **3)** LABORATORY VANE TESTING. **4)** SPT VALUES. **5)** POCKET PENETROMETER.

A P P E N D I X ‘ C ‘

D R A W I N G S



CONT No 6011-E-0022

GWP No 5110-09-00

WP No 5110-09-01

Site No 415-2500

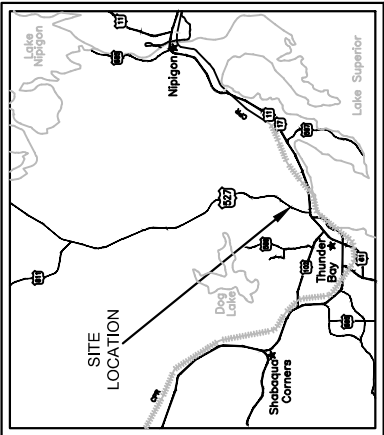
CULVERT REPLACEMENT

HIGHWAY 527

NORTH CURRENT RIVER

UNSURVEYED TERRITORY

SHEET



METRIC

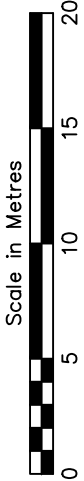
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN. STATIONS IN
KILOMETERS + METERS

LEGEND				
	Borehole		Borehole with DCPT	
	Hand Auger		Rock Probe	
	'N'		Blows/0.3m (Std. Pen Test, 47.5 J/Blow)	
	Water level at time of investigation.		Benchmark	
	Fill		Organics	
	Topsoil		Sand & Silt	
	Bedrock		Sand	
			Silt	
			Clay	
			Sand & Gravel	
			Silt & Clay	
No.	Elevation	Northing	Easting	Station
BH1	397.10	5383387.09	371149.59	10+360
BH2	397.15	5383390.62	371155.82	1.0 m LT 10+366
BH3	396.92	5383376.19	371140.44	1.3 m LT 10+346
BH4	396.87	5383369.92	371132.77	3.7 m LT 10+336
BH5	392.75	5383379.57	371170.60	3.2 m LT 10+369
BH6	392.25	5383372.68	371159.18	17.0 m RT 10+356
BH7	392.28	5383350.11	371139.24	14.0 m RT 10+326
BH8	392.76	5383336.74	371129.89	14.0 m RT 10+307

NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

DST Consulting Engineers Inc.
605 Hewitson Street
Thunder Bay, ON P7B 5V5
Ph: (807) 623-2929
Fx: (807) 623-1792
Email: thunderbay@dstgroup.com

Note: Stations referenced from plan drawing B-484890-527-1 provided by the MTO



CONT No 6011-E-0022

GWP No 5110-09-000

WP No 5110-09-001

Site No 415-25100

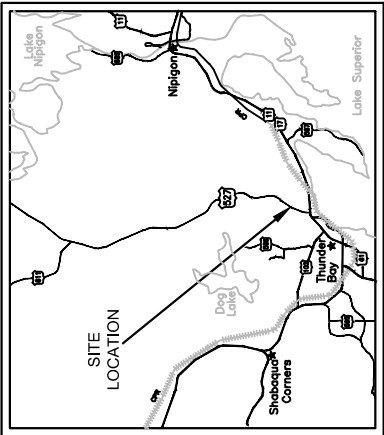
CULVERT REPLACEMENT

HIGHWAY 527

NORTH CURRENT RIVER

UNSURVEYED TERRITORY

SHEET



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN. STATIONS IN
KILOMETERS + METERS

LEGEND

Borehole

Borehole with DCPT

Dynamic Cone Penetration Test

Rock Probe

'N'

Blows/0.3m (Std. Pen Test, 47.5 J/Blow)

Water level at time of investigation.

Benchmark

Fill

Organics

Topsoil

Sand & Silt

Bedrock

Sand

Silt

Clay

Sand & Gravel

Silt & Clay

No.	Elevation	Northing	Easting	Station	Offset
BH1	397.10	5383387.09	371149.59	10+360	1.0 m LT
BH2	397.15	5383390.62	371155.82	10+366	1.3 m LT
BH3	396.92	5383376.19	371140.44	10+346	3.7 m LT
BH4	396.87	5383369.92	371132.77	10+336	3.2 m LT
BH5	392.75	5383379.57	371170.60	10+369	17.0 m RT
BH6	392.25	5383372.68	371159.18	10+356	14.0 m RT
BH7	392.28	5383350.11	371139.24	10+326	14.0 m RT
BH8	392.76	5383336.74	371129.89	10+307	16.0 m RT

NOTE:
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DST

DST Consulting Engineers Inc.
605 Hewitson Street
Thunder Bay, ON P7B 5V5
Ph: (807) 623-2929
Fx: (807) 623-1792
Email: thunderbay@dstgroup.com

DRAWING 1

CONT No 6011-E-0022

GWP No 5110-09-00

WP No 5110-09-01

Site No 415-2510

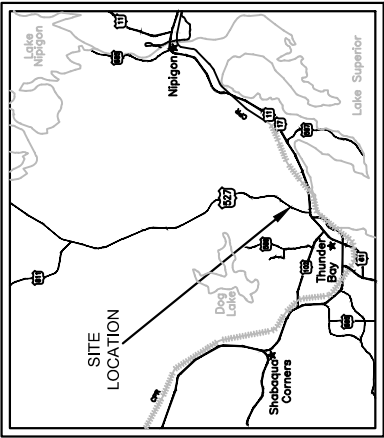
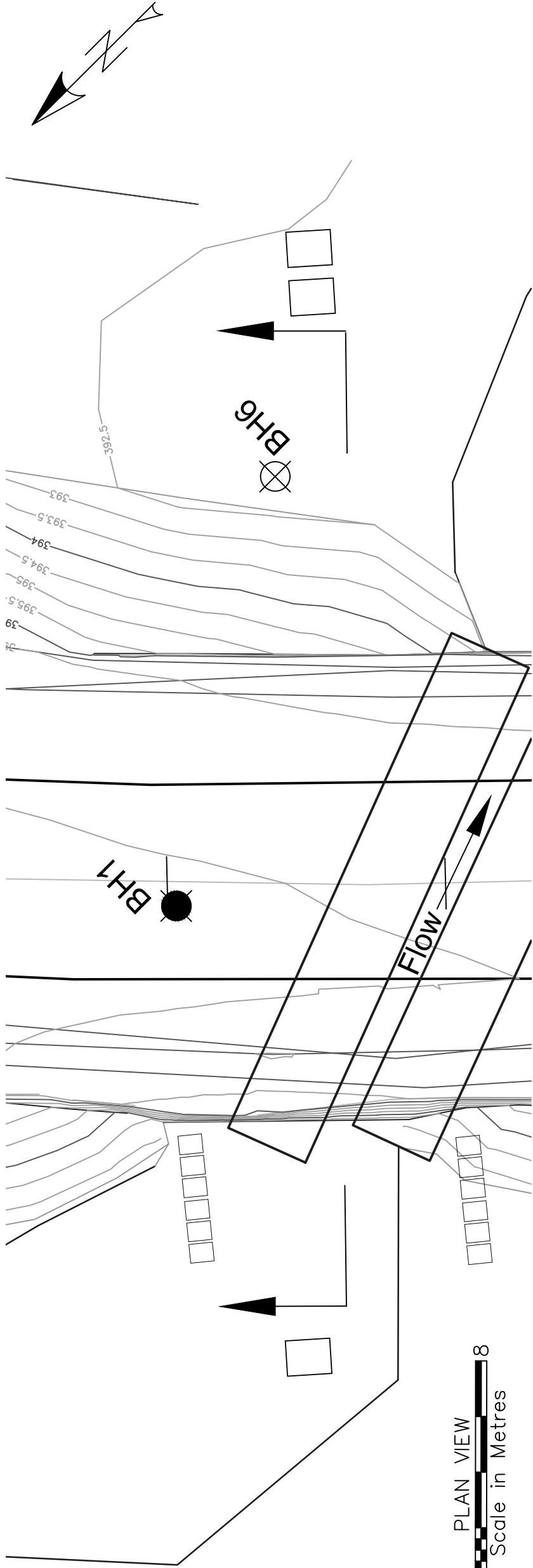
CULVERT REPLACEMENT

HIGHWAY 527

NORTH CURRENT RIVER

UNSURVEYED TERRITORY

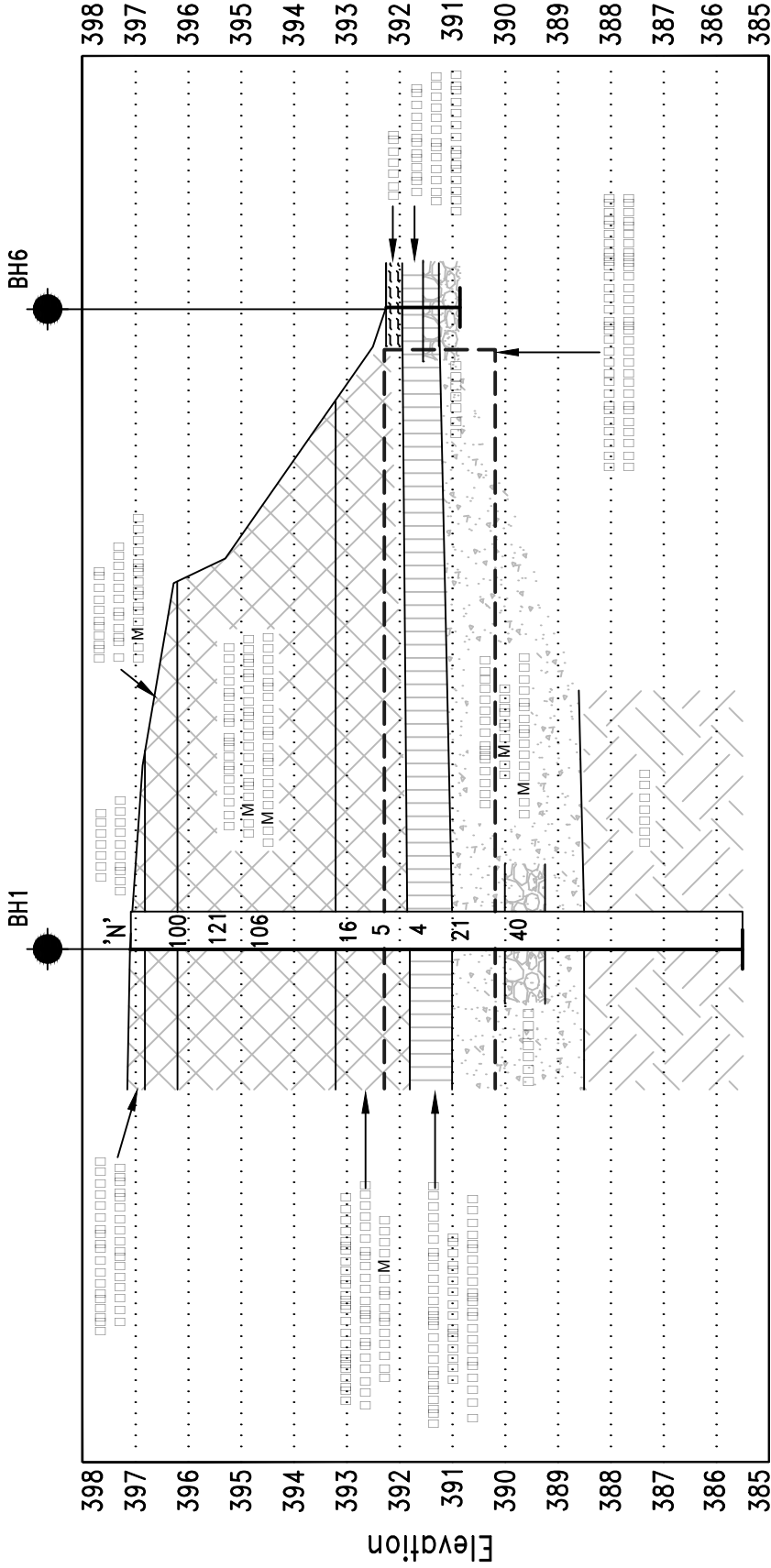
SHEET



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN. STATIONS IN
KILOMETERS + METERS

LEGEND				
	Borehole		Borehole with DCPT	
	Dynamic Cone Penetration Test		Rock Probe	
	Blows/0.3m (Std. Pen Test, 47.5 J/Blow)		Water level at time of investigation.	
	Benchmark		Fill	
	Organics		Topsoil	
	Sand & Silt		Sand	
	Bedrock		Silt	
	Clay		Sand & Gravel	
	Silt & Clay			
No.	Elevation	Northing	Easting	Station
BH1	397.10	5383387.09	371149.59	10+360
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BH5	392.75	5383379.57	371170.60	10+369
BH6	392.25	5383372.68	371159.18	10+356
BH7	392.28	5383350.11	371139.24	10+326
BH8	392.76	5383336.74	371129.89	10+307
				1.0 m LT
				1.3 m LT
				3.7 m LT
				3.2 m LT
				17.0 m RT
				14.0 m RT
				14.0 m RT
				16.0 m RT



NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.



DST Consulting Engineers Inc.
605 Hewitson Street
Thunder Bay, ON P7B 5V5
Ph: (807) 623-2929
Fx: (807) 623-1792
Email: thunderbay@dstgroup.com

CONT No 6011-E-0022

GWP No 5110-09-100

WP No 5110-09-01

Site No 415-2510C

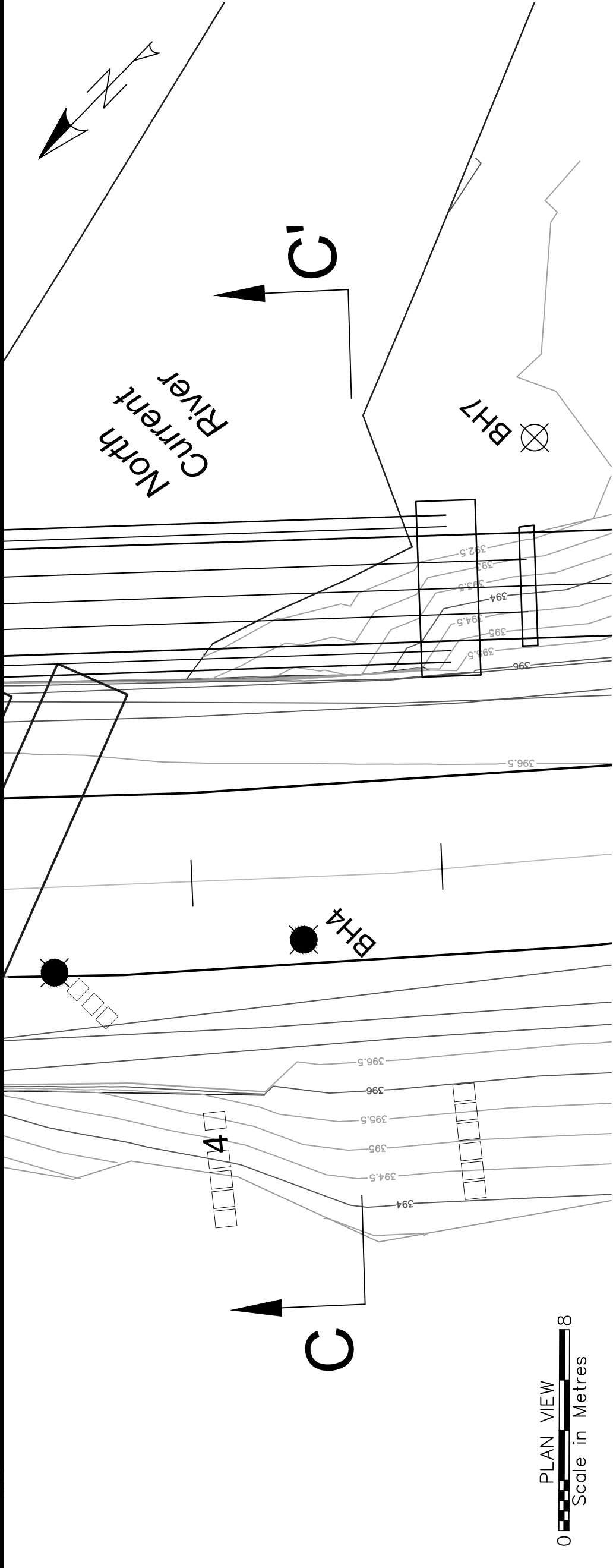
CULVERT REPLACEMENT

HIGHWAY 527

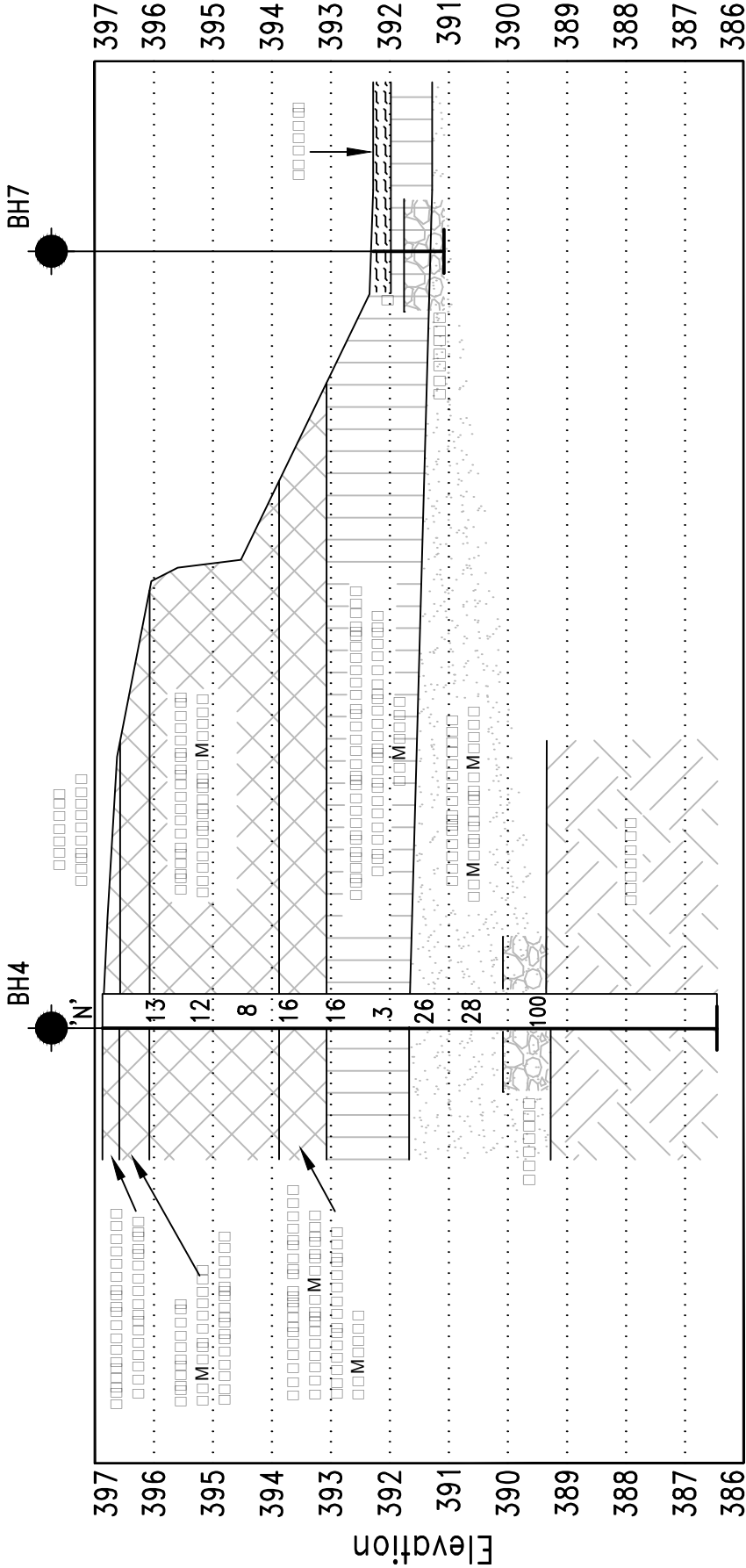
NORTH CURRENT RIVER

UNSURVEYED TERRITORY

SHEET



Note: Stations referenced from plan drawing B-484890-527-1 provided by the MTO



LEGEND				
	Borehole		Borehole with DCPT	
	Dynamic Cone Penetration Test		Rock Probe	
	'N'		Blows/0.3m (Std. Pen Test, 47.5 J/Blow)	
	Water level at time of investigation.		Benchmark	
	Fill		Organics	
	Topsoil		Sand & Silt	
	Bedrock		Sand & Gravel	
	Silt & Clay		Sand	
	Silt		Clay	

No.	Elevation	Northing	Easting	Station	Offset
BH1	397.10	5383387.09	371149.59	10+360	1.0 m LT
BH2	397.15	5383390.62	371155.82	10+366	1.3 m LT
BH3	396.92	5383376.19	371140.44	10+346	3.7 m LT
BH4	396.87	5383369.92	371132.77	10+336	3.2 m LT
BH5	392.75	5383379.57	371170.60	10+369	17.0 m RT
BH6	392.25	5383372.68	371159.18	10+356	14.0 m RT
BH7	392.28	5383350.11	371139.24	10+326	14.0 m RT
BH8	392.76	5383336.74	371129.89	10+307	16.0 m RT

NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

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APPENDIX 'D'

ENCLOSURES

RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION North Current River Culvert - 5383387.09 m N, 371149.59 m E ORIGINATED BY PR
DIST HWY 527 BOREHOLE TYPE Solid Stem Auger, Washbore COMPILED BY ML
DATUM Geodetic DATE 2013 06 03 CHECKED BY WS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
397.1	GROUND SURFACE													
397.0	ASPHALT - 55 mm		AS1	AS			397							Water level at 4.8 mbgs on completion 26 62 (12) SPT Values: 4 blows/150 mm 10 blows/0 mm SPT Values: 19 blows/150 mm 65 blows/150 mm 66 blows/150 mm SPT Values: 21 blows/150 mm 41 blows/150 mm 65 blows/150 mm 8 60 (32)
396.8	FILL - SAND & CRUSHED GRAVEL - trace silt, brown						396							
396.2	FILL - SAND - with gravel, some silt, brown, very dense		SS2	SS	100+		395							
0.9	ROCKFILL - with sand, some gravel and silt, brown, very dense		SS3	SS	100+		394							
			SS4	SS	100+		393							33 51 (16)
393.2							392							
3.9	FILL - SAND - Silty, trace organics, trace gravel, brown, loose to compact		SS5	SS	16		391							
			SS6	SS	5		390							
391.8							389							
5.3	SILT & SAND - trace gravel, clay, organics and wood debris, brown, very loose		SS7	SS	4		388							
391.0							387							
6.1	SAND - Gravelly, some silt, grey, compact to dense - COBBLES		SS8	SS	21		386							
			SS9	SS	40									
388.5														
8.6	BEDROCK		RC1	RC										
	RC1 - 0.61 m, REC - 0.58 m, RQD - 43%													
	RC2 - 1.52 m, REC - 1.42 m, RQD - 60%		RC2	RC										
	RC3 - 0.91 m, REC - 0.91 m, RQD - 80%		RC3	RC										
385.5														
11.6	End of Borehole at 11.6 m													

ON_MOT GS-TB-016954 HWY 527 SOIL WASHOUT.GPJ DST_MIN.GDT 6/17/13

NR = NO RECOVERY

+ 3, X 3: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 1

RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION North Current River Culvert - 5383390.62 m N, 371155.82 m E ORIGINATED BY PR
DIST HWY 527 BOREHOLE TYPE Solid Stem Auger, Washbore COMPILED BY ML
DATUM Geodetic DATE 2013 06 05 CHECKED BY WS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
397.2	GROUND SURFACE													
397.1	ASPHALT - 50 mm		AS1	AS			397							48 42 (10)
396.9	FILL - SAND & CRUSHED GRAVEL - some silt, brown													Water level at 5.2 mbgs on completion
396.5	FILL - SAND - with gravel, some silt, brown, dense		SS2	SS	35		396							
0.7	ROCKFILL - with sand, some gravel and silt, brown, loose to very dense													
							395							
			SS3	SS	79		394							
			SS4	SS	21		393							16 69 (15)
			SS5	SS	7		392							
392.1	- trace wood, loose						391							
5.1	SAND - Gravelly, some silt, brown, compact to very dense		SS6	SS	10		390							
			SS7	SS	34									
	- COBBLES & BOULDERS													
			SS8	SS	86		389							
389.1	BEDROCK						388							
8.1	RC1 - 0.93 m, REC - 0.91 m, RQD - 50%		RC1	RC			387							
	RC2 - 1.45 m, REC - 1.45 m, RQD - 60%		RC2	RC			386							
	RC3 - 0.91 m, REC - 0.91 m, RQD - 80%		RC3	RC										
385.8														
11.4	End of Borehole at 11.4 m													

ON_MOT GS-TB-016954 HWY 527 SOIL WASHOUT.GPJ DST_MIN.GDT 6/17/13

NR = NO RECOVERY

+ ³, X ³: Numbers refer to
Sensitivity

○ ³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH4

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION North Current River Culvert - 5383369.92 m N, 371132.77 m E ORIGINATED BY PR
DIST HWY 527 BOREHOLE TYPE Solid Stem Auger, Washbore COMPILED BY ML
DATUM Geodetic DATE 2013 06 07 CHECKED BY WS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
396.9	GROUND SURFACE													
396.8	ASPHALT - 50 mm													
396.6	FILL - SAND & CRUSHED GRAVEL - trace silt, brown													
396.1	FILL - SAND - some gravel, trace silt, brown													
0.8	FILL - GRAVEL & SAND - trace silt, brown, compact		SS1	SS	13		396							
			SS2	SS	12		395							
			SS3	SS	8		394							
393.9	ROCKFILL - with sandy gravel, some silt, trace organics, brown, compact		SS4	SS	16		393							52 37 (12)
393.1	SILT & SAND - trace gravel, clay and organics, brown, very loose to compact		SS5	SS	16		392							3 40 48 9
391.7	SAND - Gravelly, some silt, brown, compact		SS6	SS	3		391							34 53 (13)
			SS7	SS	26		390							
			SS8	SS	28		389							
	- COBBLES						388							
389.3	BEDROCK		SS9	SS	100+		387							SPT Values: 10 blows/0 mm
7.6	RC1 - 1.32 m, REC - 1.32 m, RQD - 77%		RC1	RC										
	RC2 - 1.5 m, REC - 1.5 m, RQD - 100%		RC2	RC										
386.5	End of Borehole at 10.42 m													
10.4														

ON_MOT_GS-TB-016954 HWY 527 SOIL WASHOUT.GPJ DST_MIN.GDT 6/17/13

NR = NO RECOVERY

+ 3, X 3: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 4

RECORD OF BOREHOLE No BH5

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION North Current River Culvert - 5383379.57 m N, 371170.6 m E ORIGINATED BY PR
 DIST HWY 527 BOREHOLE TYPE Hand Auger COMPILED BY ML
 DATUM Geodetic DATE 2013 06 07 CHECKED BY WS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
392.8	GROUND SURFACE																
392.7	TOPSOIL - 100 mm		AS1	AS												Water level at 0.3 mbgs on completion	
392.3	SILT & SAND - trace gravel, clay and organics, brown																
0.5	End of Borehole at 0.5 m Auger refusal on cobbles																

ON_MOT GS-TB-016954 HWY 527 SOIL WASHOUT.GPJ DST_MIN.GDT 6/17/13

NR = NO RECOVERY

+ ³, X ³: Numbers refer to Sensitivity

○ ³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH6

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION North Current River Culvert - 5383372.68 m N, 371159.18 m E ORIGINATED BY PR
DIST HWY 527 BOREHOLE TYPE Hand Auger COMPILED BY ML
DATUM Geodetic DATE 2013 06 07 CHECKED BY WS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
392.3	GROUND SURFACE																
392.0	TOPSOIL - 300 mm																
0.3	SILT & SAND - trace gravel, clay and organics, brown/black		AS1	AS													
391.3																	
1.0	SAND - Gravelly, some silt, brown		AS2	AS													
390.9	- COBBLES																
1.4	End of Borehole at 1.4 m Auger refusal on cobbles																

ON_MOT_GS-TB-016954 HWY 527 SOIL WASHOUT.GPJ DST_MIN.GDT 6/17/13

NR = NO RECOVERY

+ ³, X ³: Numbers refer to
Sensitivity

○ ³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH7

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION North Current River Culvert - 5383350.11 m N, 371139.24 m E ORIGINATED BY PR
 DIST HWY 527 BOREHOLE TYPE Hand Auger COMPILED BY ML
 DATUM Geodetic DATE 2013 06 07 CHECKED BY WS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
392.3	GROUND SURFACE																
392.0	TOPSOIL - 300 mm																
0.3	SILT & SAND - trace gravel, clay and organics, brown																
391.3			AS1	AS													
391.0	SAND - Gravelly, some silt, brown - COBBLES																
1.2	End of Borehole at 1.2 m Auger Refusal on Cobbles																

ON_MOT_GS-TB-016954 HWY 527 SOIL WASHOUT.GPJ DST_MIN.GDT 6/17/13

NR = NO RECOVERY

+ 3, X 3: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 7

RECORD OF BOREHOLE No BH8

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION North Current River Culvert - 5383336.74 m N, 371129.89 m E ORIGINATED BY PR
 DIST HWY 527 BOREHOLE TYPE Hand Auger COMPILED BY ML
 DATUM Geodetic DATE 2013 06 07 CHECKED BY WS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
392.8	GROUND SURFACE																
392.5	TOPSOIL - some rockfill, 300 mm															Water level at surface.	
0.3	SILT & SAND - trace gravel, clay and organics, brown/black																
391.6	- COBBLES																
1.2	End of Borehole at 1.2 m Auger Refusal on Cobbles																

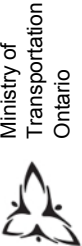
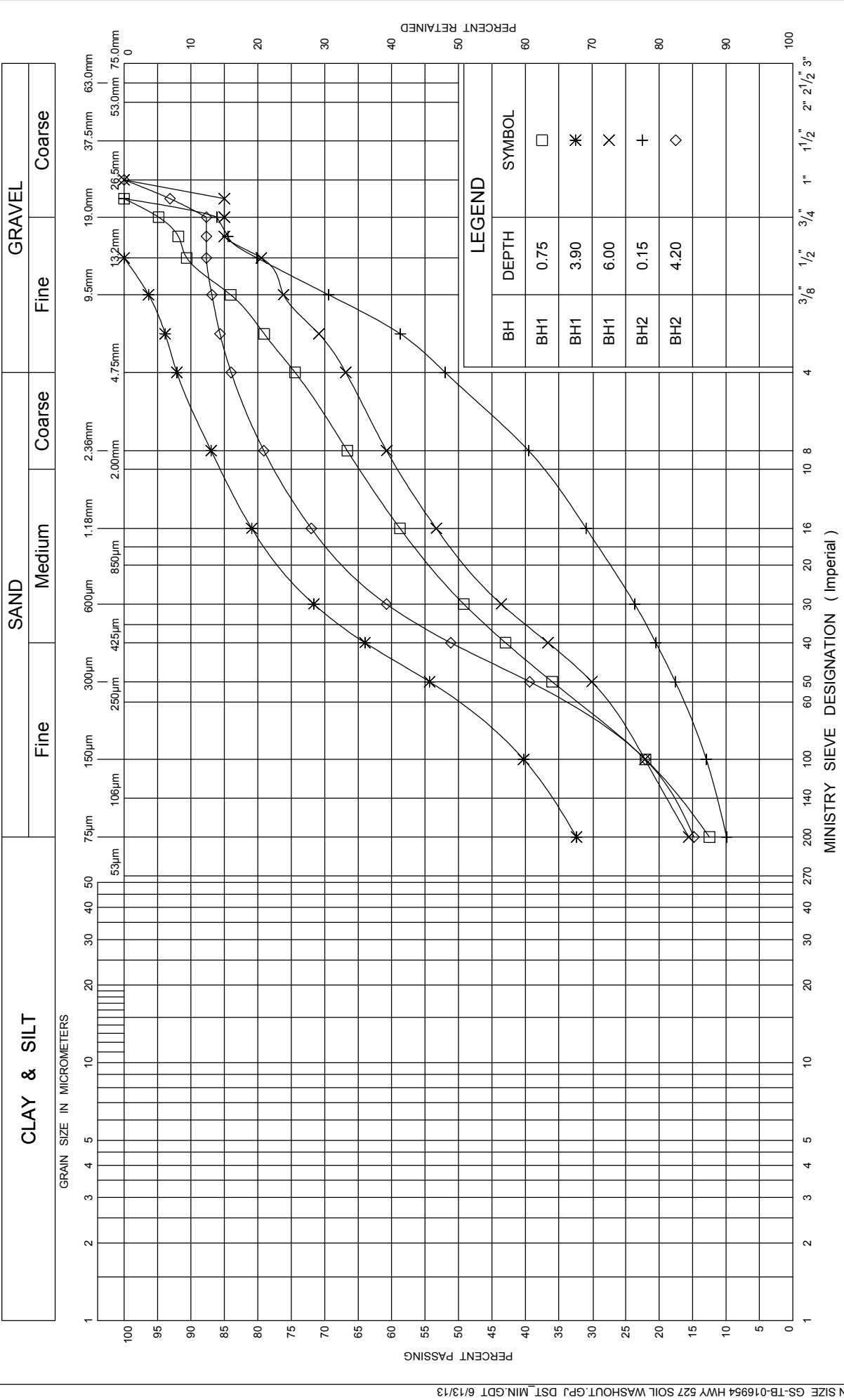
ON_MOT_GS-TB-016954 HWY 527 SOIL WASHOUT.GPJ DST_MIN.GDT 6/17/13

NR = NO RECOVERY

+ ³, X ³: Numbers refer to
Sensitivity

○ ³% STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

ENCLOSURE □

WP 6011-E-022

□ □ □ □ □ □ □ □ 527

UNIFIED SOIL CLASSIFICATION SYSTEM

