

# Memorandum



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2010 11 02

To: Lindsay Dancavitch, EIT  
Northeastern Region

From: Pavements and Foundations Section  
Room 232, Building C  
Downsview, Ontario

Re: Comments on the Draft Foundation Investigation and Design Report  
Sloan Culvert Replacement, Hwy 101 approximately 8.5km of Hwy 7072  
Township of Ivanhoe – Site 46-542  
GWP No.: 5464-08-01

We have evaluated the Draft Foundation Investigation and Design Report for the above noted project produced by DST Consulting Engineers Inc dated October 20 2010. The report was received by our office on October 21, 2010 under Genivar Transmittal email.

Our evaluation is based on verifying that the Foundation Investigation and Design Report satisfy the specific requirements for this assignment and for MTO to determine the consultant's performance in providing the deliverables as would be required by MTO for similar consultant assignments. The accuracy of the subsurface information and the adequacy and technical aspects of the recommendations remain the responsibility and liability of the consultant. Any deficiency identified in this memorandum is intended to alert the Consultant but shall not relieve the Consultant of any responsibility for their work. The Ministry assumes no responsibility or liability for these aspects of the report. Following are our comments:

## PART 1 – FACTUAL INFORMATION

1. MTO GEOCRES No. **42B-7** has been assigned to the Final Report and Foundation Drawing (BH Locations and Soil Strata).

**Corrections have been made. Please refer Cover page, Page 1 and Page 10.**

2. The Final Foundation Investigation and Design Report and Foundation Drawings must be signed and stamped by two Professional Engineers licensed by PEO, one of which shall be DST's Designated Principal Contact identified for MTO Foundation Engineering Projects.

**Final report documents signed.**

3. Section 2 Site Description (page 2) – Conditions of existing culvert should be described. Please consider a review.

Existing culvert conditions added to Section 2 paragraph 2.

Culverts dimensions are not in agreement with dimensions provided in the drawings. Review is required.

Corrections have been made. Please refer Page 2.

4. Section 3 Investigation Procedures and Laboratory testing (page 4) – Stations for Boreholes 2 and 3 should be reviewed.

Stationing at the culvert has been identified as Station 10+000. The Stations at boreholes 1, 2 and 3 are 10+000, 10+000 and 9+995 respectively.

5. Record of Boreholes – Grain size distribution presented in % should not be less than 100% or more than 100%. Please review results of samples tested.

Corrections have been made. Please refer Enclosures 1 to 3.

6. Drawings – All drawings should be reviewed with respect of existing culvert dimensions. Also the North indication on Drawing 4 should be reviewed.

Corrections have been made. Please refer Drawing 4.

Since cobbles and boulders were identified in the boreholes, drawings 2 to 4 should noted the presence of them on the subsurface profiles.

Corrections have been made. Please refer Drawings 2 to 4.

## PART 2 – ENGINEERING RECOMMENDATIONS

7. General - Cross sections and plan view of staged construction should be presented and described along the report. All stages shall be analyzed and verified regarding stability and construction issues. A detailed explanation including elevations is required.

Staging drawings added as Drawings 5 and 6. The slope stability conditions were evaluated for all stages and are presented in Section 5.1.4 Embankment Design.

8. Section 5.1.1 – Earth Excavation (page 10) – On the first paragraph it is stated that the “*It can more readily accommodate excavation of large boulders and bedrock, if encountered during excavation*”. Since cobbles and boulders were identified during Foundation Investigation, please clarify this sentence. Bedrock should be noted in separate. Clarification is required.

Reference to excavation of bedrock has been removed.

9. Section 5.1.4 Embankment Design (page 11) – Slope stability sections analyzed should be presented, parameters and approach should be described and results concluded.

Embankment design for new staged construction with widening has been added to the

evaluated conditions. A table summarizing the conclusions has also been presented. Parameters used are shown in Table 5.3.

10. Section 5.1.6 Roadway Protection (page 12) – It is mentioned that cantilevered sheet piles system may be considered at the site. According BH-3 the first 1.3m of the embankment identified presence of cobbles and boulders. The option presented should address this presence and propose an alternative solution in case the sheet piles can't penetrate the fill layer. Also, in staged construction approach the sequence of construction shall identify when the roadway protection shall be installed.

Comment regarding the selection of adequate equipment and pile thickness has been added. Please refer Section 5.1.6.

11. Section 5.1.7 Bedding (page 13) – The recommendations presented assumed that the bedding will be placed with dewatering system in place. According Section 5.1.1 Earth Excavation on page 10, it is mentioned that the excavation can be undertaken without dewatering in place. In that case, please clarify how the bedding will be placed and which material will be considered below the water table.

Dewatering is required as all work is to be completed in the dry. Reference to placement of bedding without dewatering has been removed.

12. Section 5.1.9 Channel Diversion and Dewatering (page 14) – Should a NSSP be included in the Contract Documents alerting the Contractor of the subsurface and groundwater conditions and the requirements for dewatering to facilitate excavations? Wording for the NSSP should be included in the Appendix to the report.

NSP 30005 has been added to the Appendix of the Foundation Report.

13. Section 5.1.12 Embankment Foreslopes (page 16) – Please make clear if the existing slopes should be reconstructed. The Prime Consultant should be able to clarify the geometry of the existing slopes. Clarification is required.

This has been clarified in the report. Existing embankment foreslopes indicated as approximately 1.5H:1V on both the west and east embankments. The permanent foreslopes should be reinstated with a slope not steeper than 2H: 1V if being constructed with granular materials. The permanent foreslopes should be reinstated with a slope not steeper than 1.5H: 1V if being constructed with rock fill.

14. Section 5.1.13 Constructions Concerns (page 16) – It is pointed out on that cobbles and boulders were encountered during geotechnical investigation. Should a NSSP be included in the contract documents to alert the Contractor of the possible presence of cobbles and boulders that may affect the installation of roadway protection system?

NSP has been added to the Appendix of the Foundation Report

The Final Foundation Report should be accompanied by a cover letter from DST Consulting Engineers Inc explaining changes made in the Final Report in response to these comments on the Draft Report. Where changes are not made, explanation is required. If you have any questions or

need any clarification then please contact us.

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For  
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**FOUNDATION INVESTIGATION  
AND DESIGN REPORT  
HIGHWAY 101  
TOWNSHIP OF IVANHOE  
AGREEMENT No.: 5010-E-0006  
WP No.: 5464-08-01  
GWP: 5464-08-00  
GEOCRES NO.: 42B-7**

**April 2011**

**Prepared for:**

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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
SLOAN CREEK CULVERT REPLACEMENT  
HIGHWAY 101  
TOWNSHIP OF IVANHOE  
AGREEMENT NO.: 5010-E-0006  
WP: 5464-08-01  
GWP: 5464-08-00  
GEOCRES NO. 42B-7**

**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

DST Consulting Engineers Inc. has been subcontracted by Genivar which was retained by the Ministry of Transportation (MTO), Northeastern Region, to conduct a geotechnical investigation for the replacement of a culvert on Highway 101. This work was carried out under Agreement No.: 5010-E-0006, Detailed Design for the Replacement/Rehabilitation of Various Culverts.

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 site is located on Highway 101, approximately 8.5 km west of Highway 7072, Township of Ivanhoe, New Liskeard Area. The structural site number is 46-542.

Existing culvert at this location is a two-span timber box culvert with the dimensions of 4.5 m width, 1.7 m height and 27 m length (Figure 2.1) and consists of about 4 m thick cover. The culvert was identified to be in poor condition and the timber element of this structure appeared to be with significant rotting, with extensive wood shoring in place, especially at the west end (Figures 2.2 and 2.3). In addition, east head wall was identified to be completely separated. The entrance and exit extremities of the culvert have rotated upward inhibiting flow. It is understood that the existing culvert will be replaced by a pre-cast box structure.

The embankment slopes at this location are approximately 2H:1V except the slopes, closer to the existing culvert, where they were identified to be approximately 1H:1V. Both sides of the embankment are heavily vegetated (Figures 2.4 and 2.5). The photographs shown in Figures 2.1 to 2.4 were taken by MTO and photograph shown in Figure 2.3 was captured during DST's drilling activities.



Figure 2.1 Culvert outlet (looking south)



Figure 2.2 Culvert outlet (looking west)



Figure 2.3 Culvert in poor condition (looking north)





Figure 2.4 Vegetation (looking north)



Figure 2.5 Vegetation (looking southwest)

### **3. INVESTIGATION PROCEDURES AND LABORATORY TESTING**

Site work was carried out in a period between September 19, 2010 and September 28, 2010 utilizing a CME 750 drill rig that was operated by DST personnel. A total of three (3) hydraulically drilled boreholes using hollow stem augers were put down for the purpose of foundation design at this site.

Two boreholes were advanced at either end of the existing culvert (inlet and outlet). The remaining one that was close to the existing culvert was advanced at right side of the roadway centreline at a distance of 1.3 m. The minimum number of boreholes, and depths and locations of boreholes were chosen according to the given specification in Request for Quotation (RFQ) by MTO. Borehole locations and stratigraphic sections are shown on the Borehole Location Plans, (Drawings 1 to 4). All boreholes were abandoned using suitable abandonment barrier as described in O. Reg. 903 and its amendments.

The borehole locations are referenced to the MTO Station numbering system as indicated in the RFQ. The ground surface elevations at the borehole locations were surveyed by DST personnel. A station selected on top of a rock knob was assigned as temporary benchmark with elevation of 352.2 m (Drawing 1). Station 10+000 was assigned to the center of the culvert as shown in Drawing 1. Table 3.1 summarizes the detail of borehole locations and depths.

Table 3.1 Detail of borehole locations

Borehole ID	Station	Elevation (m)	Depth (m)	Offset (m)
BH1	10+000	343.6	10.0	15.0 Rt
BH2	10+000	343.2	4.3	12.0 Lt
BH3	9+995	347.8	11.5	1.3 Rt

The fieldwork was supervised on a full-time basis by DST personnel who located the boreholes in the field, performed sampling and in-situ testing and logged the boreholes. Standard Penetration Testing (SPT) was performed in each borehole. 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, particle size analyses and Atterberg limits including plastic limit and liquid limit. A total of thirty one (31) moisture contents, two (2) sieve analyses, fifteen (15) particle size analyses and one (1) Atterberg limit test has been carried out for this assignment. Laboratory test results are presented in the Boreholes Logs (Enclosures 1 to 3), and Plots (Enclosures 4 to 9).

#### **4. DESCRIPTION OF SUBSURFACE CONDITIONS**

The subsurface conditions are presented based on the information obtained during field and laboratory testing.

The generalized stratigraphy of the existing embankment, based on the conditions encountered in boreholes, consists of surfacing (hot mix asphalt) overlying a fill that is underlain by a silt material. The fill consists of sand overlying silt that is underlain by sand. Auger refusals were encountered at different elevations in each borehole (Table 4.1).

Table 4.1 Depths and elevations of auger refusals

Borehole ID	Depth of auger refusal (m)	Elevation of auger refusal (m)
BH1	10.0	333.6
BH2	4.3	338.9
BH3	11.5	336.3

##### **4.1 Asphalt**

Asphalt was encountered in Borehole 3 that was drilled on the embankment. The thickness of the asphalt is approximately 150 mm.

##### **4.2 Embankment Fill**

Thickness of the fill is about 5.0 m at this location. Within the fill, boulders and cobbles were noted during the drilling process. Grain size distributions of the fill material are reported in borehole logs (Enclosures 1 to 3) and plots (Enclosures 6 and 7).

The upper fill material was identified below the asphalt as “Sand and Gravel”, based on the main fractions of the material. The thickness of the sand and gravel layer is about 1.1 m and this material consists of occasional cobbles and boulders. The sand material consists of gravel varying from 37 to 41%, sand varying from 51 to 53% and fines varying from 5 to 12%. According to the granular gradations, the material identified in the embankment fill can be classified as “Granular B Type 1” (SP110S13, Table 2). SPT value is about 21 and indicates the compactness condition as compact. The moisture contents vary from 2 to 12%.



A silt fill material was identified below the “Sand and Gravel” and has a thickness of about 0.8 m. The silt material, having a trace of rootlets, consists of about 22% sand, 72% silt and 6% clay. The SPT value is about 17 and indicates the compactness condition as compact. The moisture content of the silt material is about 21%.

A sand fill material was identified below the silt material and has a thickness of about 3.1 m. Occasional cobbles were identified within the sand layer that consists of gravel varying from 2 to 19%, sand varying from 40 to 46%, silt varying from 32 to 53% and clay varying from 2 to 6%. SPT values vary from 4 to 23 and indicate a compactness varying from very loose to compact. The moisture contents of the sand material vary from 9 to 16%.

#### **4.3     Silt**

A silt material was identified below the fill material in Borehole 3 and below topsoil in Boreholes 1 and 2 (Enclosures 1 to 3). The silt material extends down to the auger refusal in Boreholes 1 and 3, and to sand material in Borehole 2. Thickness of the silt material varies from 3.5 to 9.9 m. Within the silt material, occasional cobbles and boulders were identified.

One Atterberg limit test (Enclosure 9) indicates that the silt has a liquid limit of about 23% and plasticity index of about 5%, indicating clay with low plasticity to silt with low plasticity. The moisture contents of the silt vary from 8 to 28%. SPT values vary from 23 to 100+ and indicate the consistency from very stiff to hard.

#### **4.4     Sand**

A sand material was identified below 3.7 m depth in Borehole 2 (Enclosure 2). The thickness of the sand layer is about 0.6 m. Within the sand material, occasional cobbles and boulders were identified.

According to the particle analysis results, the sand material consists of 7% gravel, 62% sand, 22% silt and 9% clay. The moisture content of the sand is about 10%. SPT value is more than 100 and indicates the compactness condition of very dense.

#### **4.5     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 elevation is given in Table 4.2. The water level at the culvert was at an elevation of 342.5 m during the field investigation. The groundwater levels and water level at the culvert can be expected to vary with season and precipitation events.

Table 4.2 Probable depth of water table at boreholes

Borehole ID	Borehole elevation (m)	Water table elevation (m)	Depth of water table below the ground surface (m)
BH1	343.6	342.6	1.0
BH2	343.2	342.9	0.3
BH3	347.8	342.4	5.3

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GWP: 5464-08-00  
GEOCRES NO. 42B-7**

**PART 2: ENGINEERING DISCUSSIONS AND RECOMMENDATIONS**

**5. PROJECT DESCRIPTION**

DST Consulting Engineers Inc. (DST) has been subcontracted by Genivar which was retained by Ministry of Transportation (MTO), Northeastern Region, to conduct a geotechnical investigation for the replacement of a culvert on a Highway 101. This proposed culvert is to be replaced by a pre-cast box structure (3600 x 2500 mm and 26.94 m in length). The proposed culvert invert elevation varies from 342.3 to 341.9 m. A staged method involving widening the embankment on the south side of the culvert with reduction of the existing embankment to a minimum of 1 m above the culvert is the preferred replacement approach. Roadway protection may be required to facilitate the staged construction.

The generalized stratigraphy of the existing embankment, based on the conditions encountered in boreholes, consists of hot mix asphalt overlying a fill that is underlain by silt indicating consistency from very stiff to hard. The fill consists of sand, indicating compactness condition as compact, overlying compact silt that is underlain by sand material indicating compactness condition from very loose to compact. Cobbles and boulders were encountered in the boreholes during the geotechnical investigation. Auger refusals were at different elevation in each borehole. In addition, water table was indentified at an elevation of about 342.7 m.

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

**5.1 Precast Concrete Box Culvert**

For this culvert replacement, a four sided precast concrete culvert is to be used. Open cut excavation will be used to replace the structure.

The design of the culvert must be in accordance with the Canadian Highway Bridge Design

Code CAN/CSA-S6-06 and all relevant Ministry of Transportation specification and guidelines.

#### 5.1.1 Earth Excavation

An open cut operation along the proposed culvert alignment is proposed by MTO 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. It can more readily accommodate excavation of large boulders with this method, if encountered during excavation. As a minimum, the procedures should be in accordance with OPSS 902 "Construction Specifications for Excavating and Backfilling-Structures".

If organic materials are encountered during excavation, the excavations to remove these organics and wood should be completed in accordance with OPSD 203.040. It is anticipated that the existing groundwater table will be above the invert level and dewatering will be required as all work is to be completed in the dry.

#### 5.1.2 Staged Construction

Staged construction has been identified by prime consultant (Genivar) as preferred approach to maintain traffic during the construction of the culvert at this site. The proposed stage construction includes two (2) stages as given in Drawing 5 and 6. Slope stability analyses for the proposed slope geometries have been conducted for all stages and are presented in Section 5.1.4 Embankment Design.

Stage 1 is a temporary lane diversion which involves widening of the northbound lane to 6.76 m with temporary side slopes of 3H:1V and 1.25H:1V in the granular and rock fill materials respectively as well as the installation of level II roadway protection. Excavation adjacent to the roadway protection is anticipated to an elevation of approximately 341.3 m to allow for placement of bedding materials. Use of temporary concrete barriers will be required.

Stage 2 is a temporary land diversion which involves widening of the southbound lane to 6.76 m with temporary side slopes of 3H:1V and 1.25H:1V in the granular and rock fill materials respectively as well as the installation of level II roadway protection. Excavation adjacent the roadway protection is anticipated to an elevation of approximately 341.3 m to allow for placement of bedding materials. Use of temporary concrete barriers will be required.

Embankment foreslopes should be reinstated as recommended in Section 5.1.12 Embankment

Foreslopes.

### 5.1.3 Foundation Design

The culvert will be located approximately at the same elevation and location as the existing culvert. As the proposed culvert is not expected to be heavily loaded, a shallow foundation is considered suitable for this site. 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 6.1. The geotechnical resistance was estimated assuming a strip footing consisting of a width equal to the width of the culvert (3.6 m), a minimum depth of 4.0 m below top of pavement and bedding material placed on undisturbed soil below an elevation of 343.8 m.

Table 5.1 Geotechnical resistances and reactions

Footing Size	Ultimate bearing capacity (kPa)	Resistance at ULS (kPa)	Resistance at SLS (kPa)
B = 3.6 m	500	250	115

Where unsuitable or unstable soils are encountered, the foundation soils must be removed to a firm or hard soils and replaced to the foundation grade with Granular "A" material meeting OPSS 1010 specifications and compacted to a minimum of 95 % of standard Proctor maximum dry density.

### 5.1.4 Embankment Design

Slope stability analyses were carried out with limit equilibrium methods using Geoslope version 2004 software applying Morgenstern and Price methods, and applying a pseudo-static analysis. As only drained materials are present on site, only drained analyses were performed. Slope stability analyses were performed under the following slope conditions with an embankment height of up to 5.4 m:

- Reinstated embankment with minimum 2H:1V granular fill foreslopes,
- Reinstated embankment with 1.5H:1V rock fill foreslopes,
- Widened embankment with temporary 1.25H:1V rock fill foreslopes.

Results indicate that stability will meet or exceed suitable design factors of safety under a drained condition for the evaluated slope configurations and are presented in Table 5.2.

Table 5.2 Summary of stability analyses

Slope Condition	Depth of Water Table below Top of Pavement (m)	Foreslope Gradient	Factor of Safety
Reinstated Embankment with Granular Fill	3.5	2H : 1V	1.3
Reinstated Embankment with Rock Fill	3.5	1.5H : 1V	1.2
Temporary Embankment with Rock Fill	4.5	1.25H : 1V	1.2

This analyses considered the soil parameters as defined in Table 5.3 and a water table at 3.5 m and 4.5 m below the top of pavement in reinstated and temporary embankment conditions respectively. The existing embankment slope must not be steeper than 1.5H:1V prior to the placement of rock fill and the minimum thickness of the rock fill must be greater than 2 m to achieve an adequate FOS for the temporary rock fill embankment. The minimum thickness of rock fill must be greater than 2 m to achieve an adequate FOS for the reinstated rock fill embankment.

Excavation of temporary side slopes above the water table that do not support traffic should not be steeper than 1.0H:1.0V, although, flatter slopes may be required depending on construction methods. Temporary rock fill slopes above the water table supporting traffic during the construction stages should not be steeper than 1.25H:1V. Temporary granular slopes above the water table supporting traffic during the construction stages should not be steeper than 2H:1V. Design of temporary slopes below the water table will depend on the dewatering method. Embankment foreslopes should be reinstated as indicated in Section 5.1.12 Embankment Foreslopes.

The trench width must be sufficient to permit proper use of compaction equipment suited for the material to be compacted, to reach the degree of compaction required, and to accommodate within the space available as per SP105S10, "Construction Specification for Compaction".

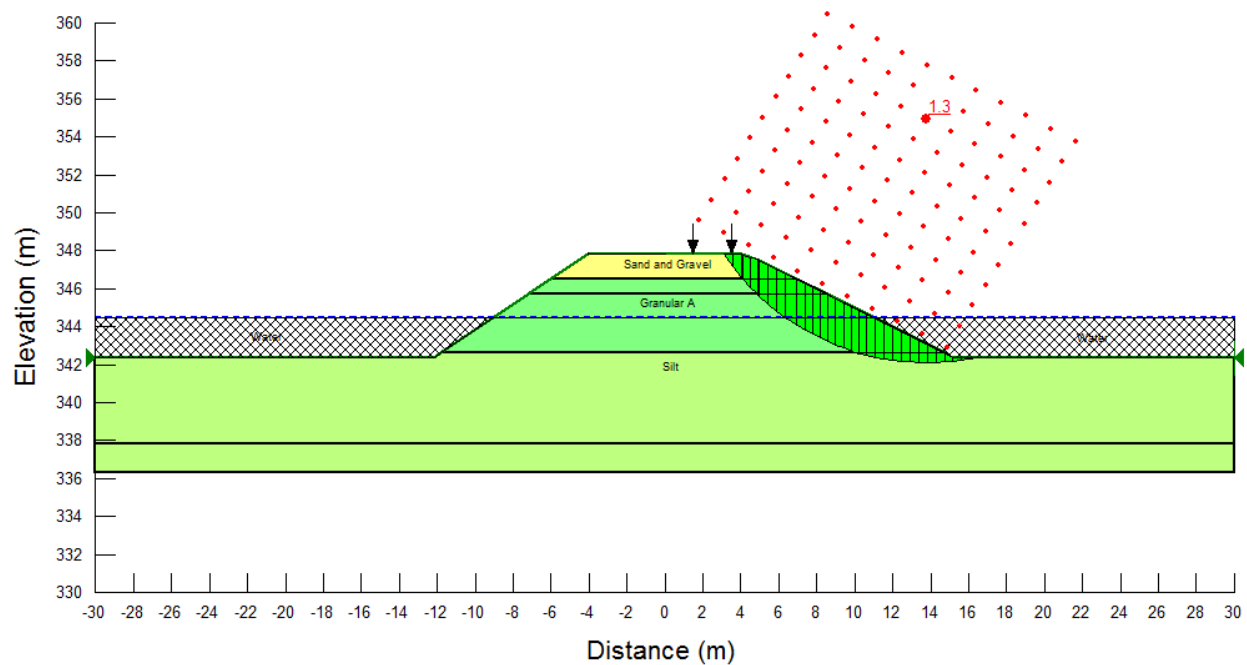


Figure 5.1 Slope stability analysis of reinstated embankment with 2H:1V granular fill foreslopes under drained condition

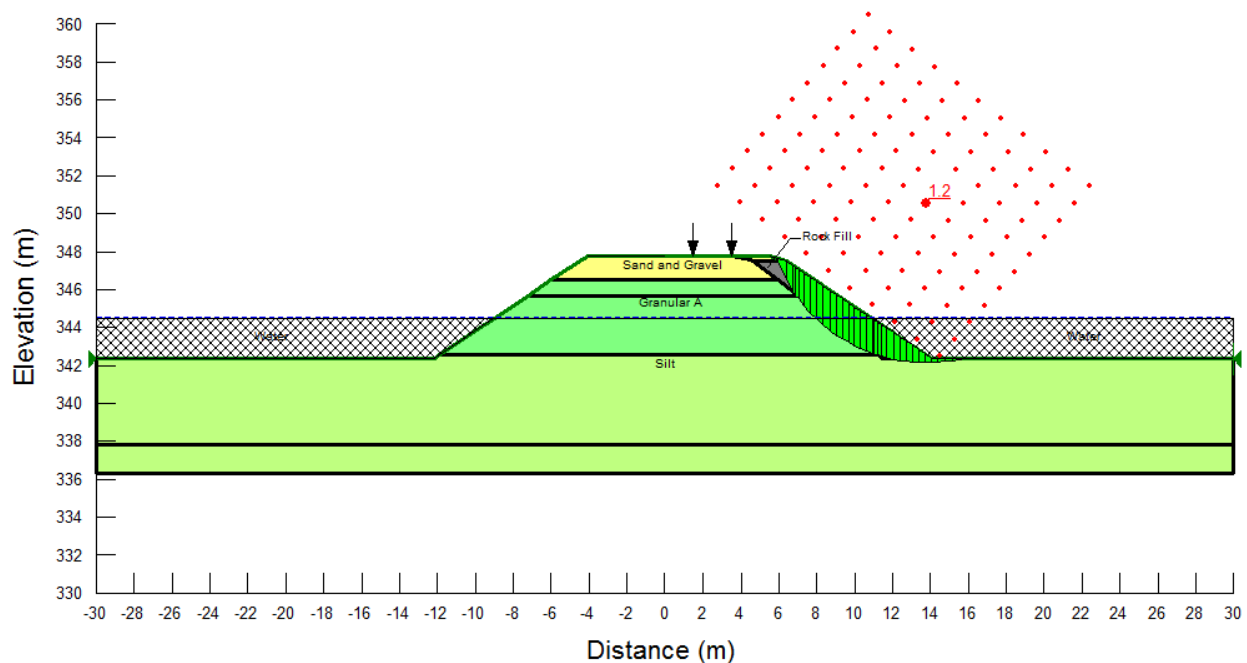


Figure 5.2 Slope stability analysis of reinstated embankment with 1.5H:1V rock fill foreslopes under drained condition

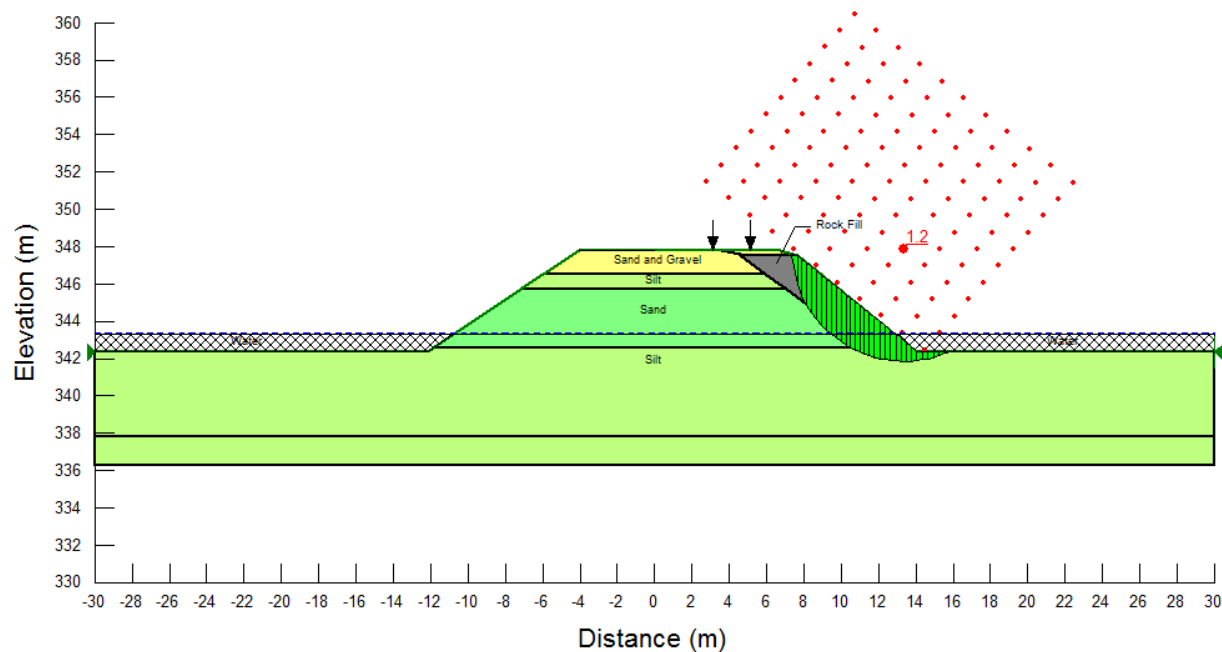


Figure 5.3 Slope stability analysis of temporary embankment with 1.25H:1V rock fill foreslopes under drained condition

### 5.1.5 Lateral and Sliding Resistances

The analysis of horizontal and vertical effects of earth loads on the culvert can be performed considering soil parameters given in Table 5.2 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. Temporary bracing and shoring may be designed using the typical soil parameters given in Table 5.2, but the designer/contractor should verify the appropriate soil parameters for the designs of specific bracing and shoring system.

Retaining walls are proposed by the prime consultant to be constructed at the inlet and outlet of the culvert. Dimensions of the retaining walls have not been provided during the foundation investigation. Retaining walls may be designed using the typical soil parameters given in Table 5.2, but the designer/contractor should verify the appropriate wall parameters for the designs of retaining walls.

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 bracing design.



Table 5.3 Typical soil parameters for earth loads

Soil type	Unit weight (kN/m <sup>3</sup> )	Internal friction angle (Deg)	Interface friction angle, $\delta$ (Deg)
Rock Fill	22	45	-
Granular A	21	35	17
Granular B	21	35	17
Sand & Gravel	21	33	16
Sand	20	32	15
Silt	19	32	15

#### 5.1.6 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 section 226. These should be assessed and confirmed in the field as construction progresses.

Since roadway protection is required during the culvert replacement, installation of a cantilevered sheet pile system may be considered to ensure the stability of the bank and is a feasible option. The design of sheet piles may be performed using the typical soil parameters given in Table 5.3, but the designer/contractor should verify the appropriate soil parameters for the designs. Since the embankment is not to be reduced in height, the potential of encountering cobbles and boulders is likely. The contractor should be prepared to handle the presence of occasional cobbles and boulders with the selection of adequate driving or vibratory equipment as well as steel

thickness.

The construction methodology must be in accordance with 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.

#### 5.1.7 Bedding

For the conditions at this site the proposed construction will be undertaken with dewatering. The foundation soils, silts in particular, will be very susceptible to disturbance and weakening as a result of traffic, standing water and frost. Any foundation soils that could be disturbed shall be protected. The bottom of the excavation on which the culvert or granular pad is to rest shall not be disturbed. The bedding placement should commence immediately after the final removal of material to the foundation level has been completed.

The bedding shall be a minimum of 0.5 m thick and extend to a minimum width (half of the width of culvert) beyond all sides of the culvert. The bedding material should consist of "Granular A" as per Soil Group I in accordance with Table 7.4 of the Canadian Highway Bridge Design Code. The "Granular A" shall be in accordance to OPSS 1010 and SP110S13. The "Granular A" should be placed in layers not exceeding 200 mm in thickness, loose measurement, and each layer compacted to a minimum of 95 % of standard Proctor maximum dry density. The middle one-third of the culvert width of the top bedding layer, having minimum thickness of 50 mm, shall be loosely placed and uncompacted.

#### 5.1.8 Sidefill and Overfill

The material used for culvert sidefill should not contain debris, organic matter, frozen materials, or large stones of a diameter greater than one-half the thickness of the compacted layers being placed or 100 mm, whichever is smaller. Soils shall be deposited uniformly on each side of the structure in order to prevent lateral displacement. The minimum width of the sidefill should be at least half of the culvert width in each side. The sidefill should consist of Granular A" and compacted to 95% of standard Proctor maximum dry density.

Overfill should consist of "Granular A" and should be compacted to not greater than the compaction or equivalent stiffness of soils in the sidefill zone and bedding. The backfill materials should be separated from the adjacent soil with a non-woven Class II geotextile, with a filtration

opening size of between 50 to 100  $\mu\text{m}$ , specified in OPSS 1860.

When the concrete culvert is installed on the undisturbed original ground and fill material is placed around and over the culvert, relative settlements between the fill adjacent to the sides of the culvert and the fill directly over the culvert generates downward frictional forces on the culvert, also effecting a load transfer. This increased load on the culvert can be represented by a column of fill of width  $K \times B$ , where  $K$  is a load transfer coefficient and  $B$  is the width of the culvert. For the design purpose,  $K$  can be assumed as 1.35.

#### 5.1.9 Channel Diversion and Dewatering

The culvert shall be replaced by diverting the creek channel temporarily adjacent to the existing culvert. It is important to ensure that a flood in the channel 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.

If the creek has comparatively a small amount of flow that may depend on the season, it may be feasible for the creek flow to be directed by staging construction. In order to prevent back up of water from upstream and downstream, 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, possibly supported by an efficient wellpoint system, will be required to dewater and stabilize the excavation. A well designed well-point system with a suitable diameter of well point at an appropriate spacing will perform better for working under dry condition and to prevent disturbance of the excavation base through sand boiling and hydraulic heave. It should be noted that depending on the season, depth of excavation and amount of water flow through the creek may vary. The contractor should be prepared to tackle this situation. The contractor should be alerted of the high water table and surface water, for example through a non standard special provision (NSSP).

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. The control of water from the dewatering operation should be accordance with OPSS 518 "Construction Specification for Control of Water from Dewatering Operations".

#### 5.1.10 Erosion Control

Erosion control is essential at inlet and outlet for the successful performance of a culvert. Generally, rip-rap is used to avoid the erosion at inlet and outlet of the culvert. The rip-rap slows down the flow close to the channel bed and prevents culvert failure by the undermining.

To prevent erosion of the surrounding soils at the inlet, rip-rap Treatment shall be applied accordance with OPSD 810.020 “Rip-Rap Treatment for Ditch Inlets” and OPSS 511 and SP511S01 “Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting”.

The outlet shall be rip-rapped to prevent erosion of the surrounding soils accordance with OPSD 810.010 “Rip-Rap treatment for Sewer and Culvert Outlets” and OPSS 511 and SP511S01 “Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting”.

To prevent undermining of the bedding, cutoff walls shall be installed along the entrance and exit end bottom sides of culvert. Cutoff wall should be designed based on velocity of the water flow and the type of soil underneath.

The temporary erosion and sedimentation measures during the construction of culvert shall be controlled as described in OPSS 577 “Construction Specification for Temporary Erosion and Sedimentation Control Measures”.

#### 5.1.11 Frost Protection

In accordance with OPSD 3090.100 “Foundation Frost Depths for Northern Ontario”, the frost penetration at this location is about 2.4 m. The frost susceptible soils shall not be used adjacent to the culvert wall within the depth of frost penetration from the road surface. The soils under the culvert are highly frost susceptible (capable of forming thick ice lenses with the associated pressures and heave).

During winter season, ice may form inside the culvert and a low flow rate may assist the ice formation. It is expected that ice may extend to the culvert invert and frost could therefore extend into the soils below the culverts, possibly as deep as 2.4 m. The frost heave may generate additional stresses on the culvert foundation and walls.

Three design approaches are commonly applied; designing the culvert with enough strength and rigidity to tolerate these pressures (recognizing that the maximum differential pressures and

movements as a result of frost lensing cannot be accurately quantified); removing the frost susceptible soils within the frost zone; or providing adequate insulation to reduce frost penetration. As the frost penetration is extended below the invert level of the culvert, the frost protection should be in accordance with OPSD 803.010 "Backfill and Cover for Concrete Culverts, Frost Penetration Line below Top of Culvert".

If sub-excavation for frost effects is carried out in the dry (with adequate dewatering controls), the material can be replaced with Granular B Type 1 material compacted to 95% of standard proctor maximum dry density. If the excavation is in the wet (water is maintained at or above adjacent groundwater table) then the material should be rockfill or clear stone surrounded by geotextile, without the need for compaction. Depending on the structural design of the culvert, partial sub-excavation (less than 2.4 m) may also be considered to reduce differential stresses associated with frost; however the exact pressures and movements cannot be accurately quantified.

Acceptable insulation to prevent frost penetration would be 150 mm Dow Styrofoam Highload 40 Insulation or an equivalent material with a compressive strength of approximately 275 kPa or greater. For a region that has a freezing index greater than 3000 Fahrenheit Degree-Days it is recommended that the insulation be placed beneath the structure and extend 2.44 m from the concrete face of the buried structure.

#### 5.1.12 Embankment Foreslopes

Existing culvert foreslopes are approximately 1.5H:1V on both the west and east embankments. 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. The minimum thickness of rock fill must be greater than 2 m to achieve an adequate FOS for the reinstated rock fill embankment.

#### 5.1.13 Construction Concerns

The main construction issues that need to be addressed for this site are removal of cover/embankment materials, staged removal of the existing culvert, provisions required for temporary roadway protection, diversion of the channel, excavation below the water table and reinstatement of the embankment fill. These items are important for the successful installation of the new culvert. Particular attention should be paid to maintain the integrity of the existing culvert during the staged method of construction.

An on-site 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.

## 6. 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 510, 511, 518, 577, 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, 803.010, 810.010, 810.020, 3090.100.

Municipal and Provincial Common, Volume 2 - Material Specifications, "*Ontario Provincial Standard for Roads & Public Works*" Spec No. OPSS 1010, 1860.

Special Provisions, Ontario Provincial Standards, SP110S13, SP105S10, SP511S01.

## 7. 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:



for

Loges Paramaguru, PhD  
Geotechnical Specialist

Reviewed by:



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

Reviewed by:



Mike Fabius, P. Eng.  
Senior Principal



## **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 DST Consulting Engineers 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'**

**NONSTANDARD PROVISIONS**

## **DEWATERING STRUCTURE EXCAVATION - Item No.**

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### **Non-Standard Special Provision**

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#### **902.01 SCOPE**

Section OPSS 902.01 of OPSS 902 is amended by the addition of the following:

As part of the work under this item, the Contractor shall:

- Carry out any additional field investigation the Contractor deems necessary in order to engineer the unwatering systems;
- Design and install dewatering systems to construct the work in the dry;
- Carry out works necessary for the dewatering system that may include sheet piling, tremie concrete seal, sand bagging, etc.;

The Contractor is advised that the use of a suitable sump and pump system is required for working under dry conditions and to prevent disturbance of the excavation base through hydraulic heave. It should be noted that depending on the season, depth of excavation and amount of water flow through the creek may vary.

The Contractor shall provide a continuous dewatering operation 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.

Section OPSS 902.01 of OPSS 902 is amended by the following subsection:

#### **902.01.01 Flow Rates**

The Contractor must satisfy himself with the local conditions and anticipated water flows, levels and flow velocity to be met with during construction. He shall make his own estimate of the facilities required and difficulties to be encountered including the nature of subsurface materials and conditions. For the protection scheme water flows, the water elevation is shown on the Contract Documents.

#### **902.03 DEFINITIONS**

Section OPSS 902.03 of OPSS 902 is amended by the addition of the following:

<b>Stamped:</b>	Refers to drawings or details that have been reviewed and stamped "Conforms With Contract Documents". The stamp shall
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include the date and signature of the Quality Verification Engineer (QVE).

**Quality Verification Engineer (QVE):** An Engineer licensed to practice in the Province of Ontario who has a minimum of five (5) years of experience in the field of design and/or construction of dewatering systems. The Contractor shall retain the QVE to ensure conformance with the contract document.

**Dewatering System Design Engineer:** An Engineer licensed to practice in the Province of Ontario who has a minimum of five (5) years of experience in the field of design and/or construction of bridges. In addition, the Dewatering System Design Engineer shall have had responsible experience in the design of at least 5 other dewatering systems. The Contractor shall retain the Dewatering System Design Engineer to ensure conformance with the contract documents and issue certificate(s) of conformance for the design.

## **902.04 SUBMISSION AND DESIGN REQUIREMENTS**

Section OPSS 902.04 of OPSS 902 is amended by the addition of the following:

Design of components of the dewatering systems shall be in accordance with CAN/CSA-S6-00 and standard referenced therein.

### **Submission of Shop Drawings**

All shop drawings submissions shall bear the seal and signature of the Dewatering System Design Engineer.

The Contractor shall submit to the Quality Verification Engineer shop drawings for review and stamping.

At least two weeks prior to the commencement of dewatering system construction, the Contractor shall submit to the Contract Administrator, for information purposes only, four (4) sets of stamped drawings/calculations of the dewatering system.

The Contractor shall, at least three (3) weeks prior to the commencement of the dewatering system installation, submit to the QVE for review, four sets of drawings and calculations indicating:

- the dewatering system design, including design criteria and loading;
- the location, type and dimensions of each dewatering system to be used;
- a schematic showing the configuration of all dewatering systems;
- the material and dimensions of dewatering system components to ensure stability of the design excavation and the dewatering system, and the construction sequence and schedule of each

component for which the dewatering system is designed.

The QVE shall review all calculations, construction details, shop drawings and procedures.

All submissions shall bear the seal and signature of the Dewatering System Design Engineer and QVE.

### **Certificates of Conformance**

The Dewatering System Design Engineer shall inspect the installation of each component prior to the executing of the next stage in that dewatering system. After the installation/construction of each component, the Contractor shall submit a Certificate of Conformance to the Contract Administrator, sealed and signed by the Dewatering System Design Engineer. The Certificates of Conformance shall state that the dewatering system is in place, and has been installed in conformance with the stamped shop drawings and the Contract Drawings.

The Contractor will note that several Certificates of Conformance may be required, each to coincide with each dewatering system installation.

### **902.07 CONSTRUCTION**

Section OPSS 902.07 of OPSS 902 is amended by the addition of the following:

All concrete work must be carried out in the dry.

Minimum dimensions for the inside face of the dewatering system shall be sufficient for installation of the new culvert.

### **902.10 BASIS OF PAYMENT**

Section OPSS 902.10 of OPSS 902 is amended by the addition of the following:

Payment at the contract price for the dewatering systems shall be full compensation for all labour, equipment and materials to carry out the work.

## **EARTH EXCAVATION FOR STRUCTURE - Item No.**

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### **Special Provision**

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OPSS 902 shall apply except as amended and extended herein:

#### **902.01 SCOPE**

OPSS 902.01 shall be amended by the addition of the following:

Work under this tender item includes the excavation to construct the new culvert including its footings, retaining wall and bedding below the roadway subgrade.

#### **902.07 CONSTRUCTION**

##### **902.07.05 Excavation**

##### **902.07.05.02 Excavation for Foundation**

Subsection OPSS 902.07.05.02 shall be amended by the addition of the following:

If organic materials are encountered during excavation, the sub-excavations to remove any organics and wood shall be completed in accordance with OPSD 203.040.

Any disturbed and unsuitable soils shall be replaced by compacted “Granular A” material.

## **NOTICE TO CONTRACTOR**

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Special Provision

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### **FOUNDATION CONDITIONS**

The Contractor is advised of the following foundation conditions:

Occasional cobbles and boulders were identified within the fill and native materials within the advanced borehole locations.

The foundation soils, sensitive soil in particular, will be very susceptible to disturbance and weakening as a result of traffic, standing water and frost. Any foundation soils that could be disturbed should be protected. The bottom of the excavation on which the culvert or granular pad is to rest shall not be disturbed. The bedding placement shall commence immediately after the final removal of material to the foundation level has been completed.



**RIVER STONE - Item No.**

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**Special Provision**

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The river stone to be provided under this Tender Item shall meet the following specifications:

- Round washed river stone with a diameter between 10 – 25mm.
- Thickness of river stone to be 300mm.

River stone shall be placed in all areas of disturbed streambed, both at the inlet and the outlet.

**MEASUREMENT FOR PAYMENT**

Measurement is by the area in metres squared of the stream bottom.

**BASIS OF PAYMENT**

Payment at the contract price for the tender items shall be full compensation for all labour, Equipment and Materials to do the work.

# **DRAWINGS**

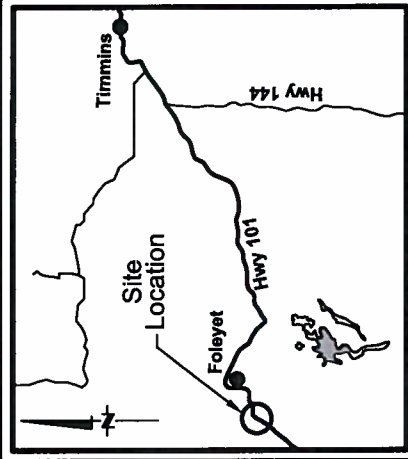
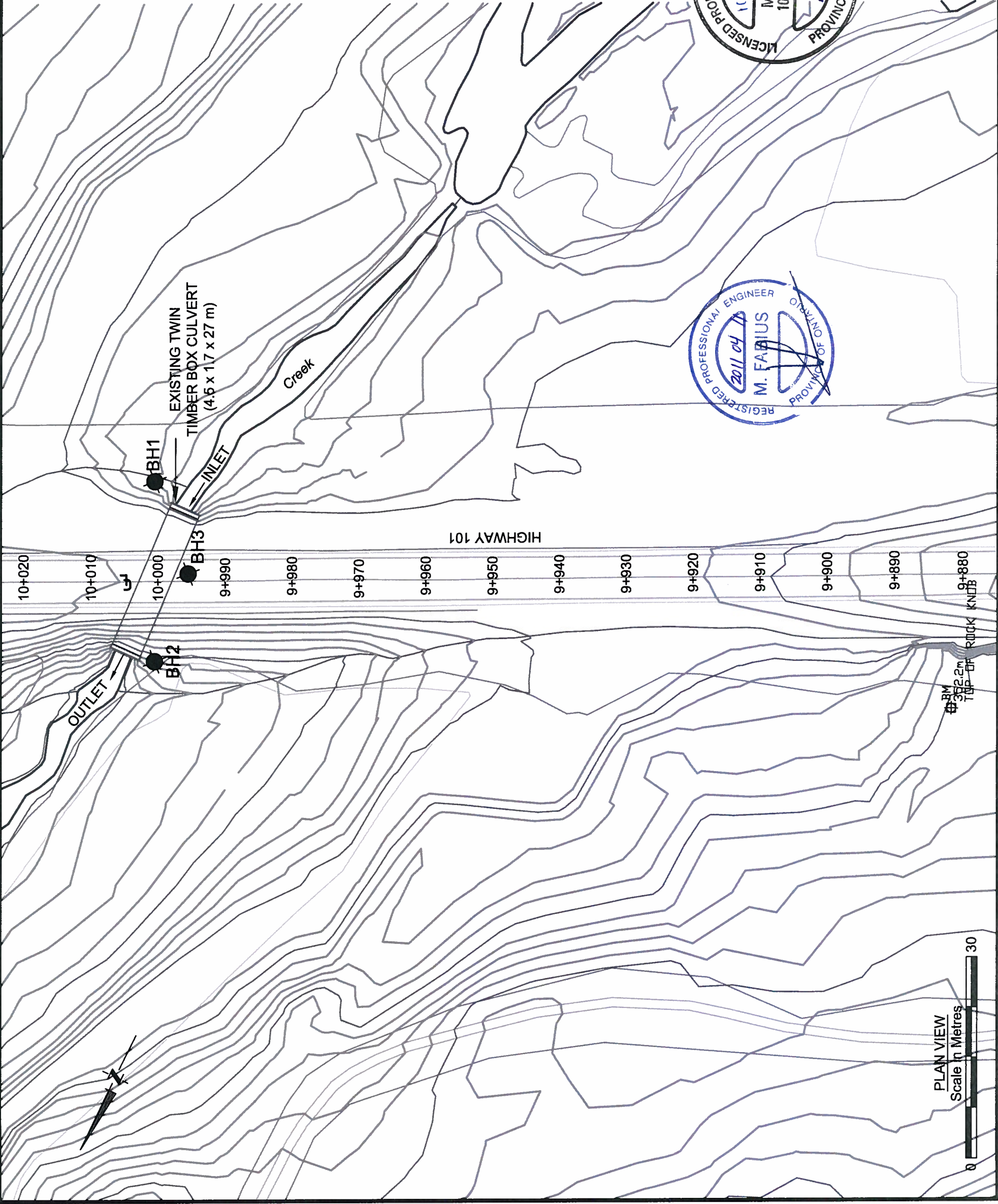
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CONT No 2011-5116  
GWP No 5464-08-00  
WP No 5464-08-01  
Site No 46-542  
Geocres No 42B-7

⚡

SHEET  
13

CULVERT REPLACEMENT  
AT SLOAN CREEK  
Highway 101 – Foleyet Twp.  
Geotechnical Investigation

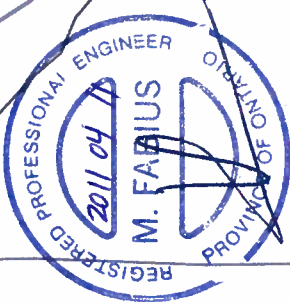
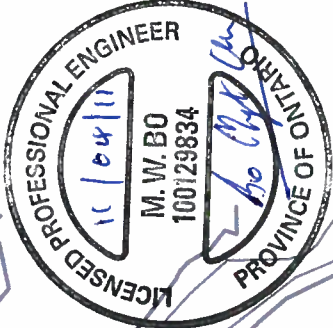
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AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN NUMBERS + METERS



KEY PLAN  
SCALE IN KILOMETRES  
0 70

LEGEND				
◆	Borehole/Hand Auger			
⊕	Borehole with DCPT			
⊕	Dynamic Cone Penetration Test (DCPT)			
●	Rock Probe			
⋈	'N'			
≡	Blows/0.3m (Std. Pen Test, 475 J/Blow)			
≡	Water level at time of investigation.			
⊕	Benchmark			
⊗	Fill	⊗	Sand	
⊗	Organics	⊗	Silt	
⊗	Topsoil	⊗	Clay	
⊗	Till	⊗	Sand & Gravel	
⊗	Bedrock	⊗	Boulders	
No.	Elevation	Nothing	Station	Offset
BH1	343.392	5341489	413584	10+000 15.0 m RT
BH2	343.222	5341484	413572	10+000 12.0 m LT
BH3	347.762	5341489	413573	9+895 1.3 m RT

NOTE: Coordinates based on MTM Zone 13



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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PLAN VIEW  
Scale in Metres  
0 30

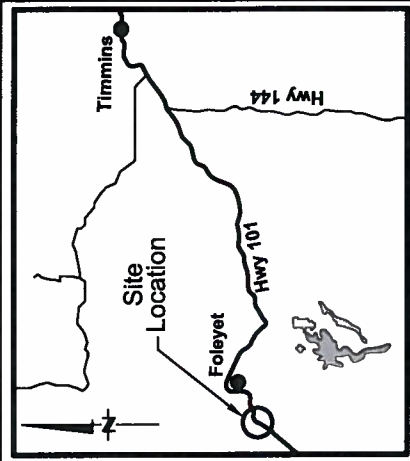


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IN KILOMETRES + METERS

AGREEMENT No 5010-E-0006  
CONT No 2011-5116  
GWP No 5464-08-00  
WP No 5464-08-01  
Site No 46-542  
Geocres No 428-7

CULVERT REPLACEMENT  
AT SLOAN CREEK  
Highway 101 - Foleyet Twp.  
Borehole Locations and Stratigraphy

SHEET  
14



LEGEND

- Borehole
- Borehole with DCPT
- Dynamic Cone Penetration Test (DCPT)
- Rock Probe
- Blows/0.3m (Std. Pen Test, 475 J/Blow)
- Water level at time of investigation.
- Benchmark

- Fill
- Organics
- Topsoil
- Till
- Bedrock
- Sand
- Silt
- Clay
- Sand & Gravel
- Boulders

No.	Elevation	Northing	Easting	Station	Offset
BH1	342.962	5341469	413584	10+000	15.0 m RT
BH2	343.222	5341484	413572	10+000	12.0 m LT
BH3	347.762	5341469	413573	9+985	1.3 m RT

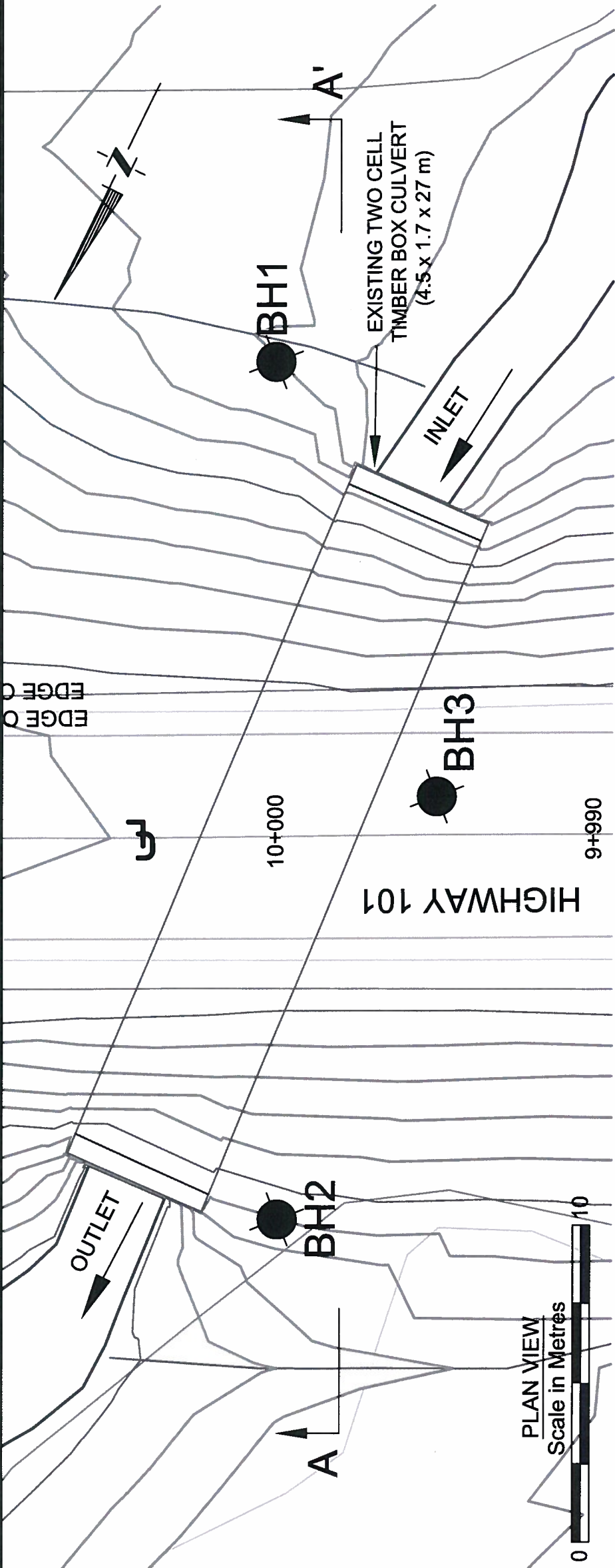
NOTE: Coordinates based on MTM Zone 13

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.

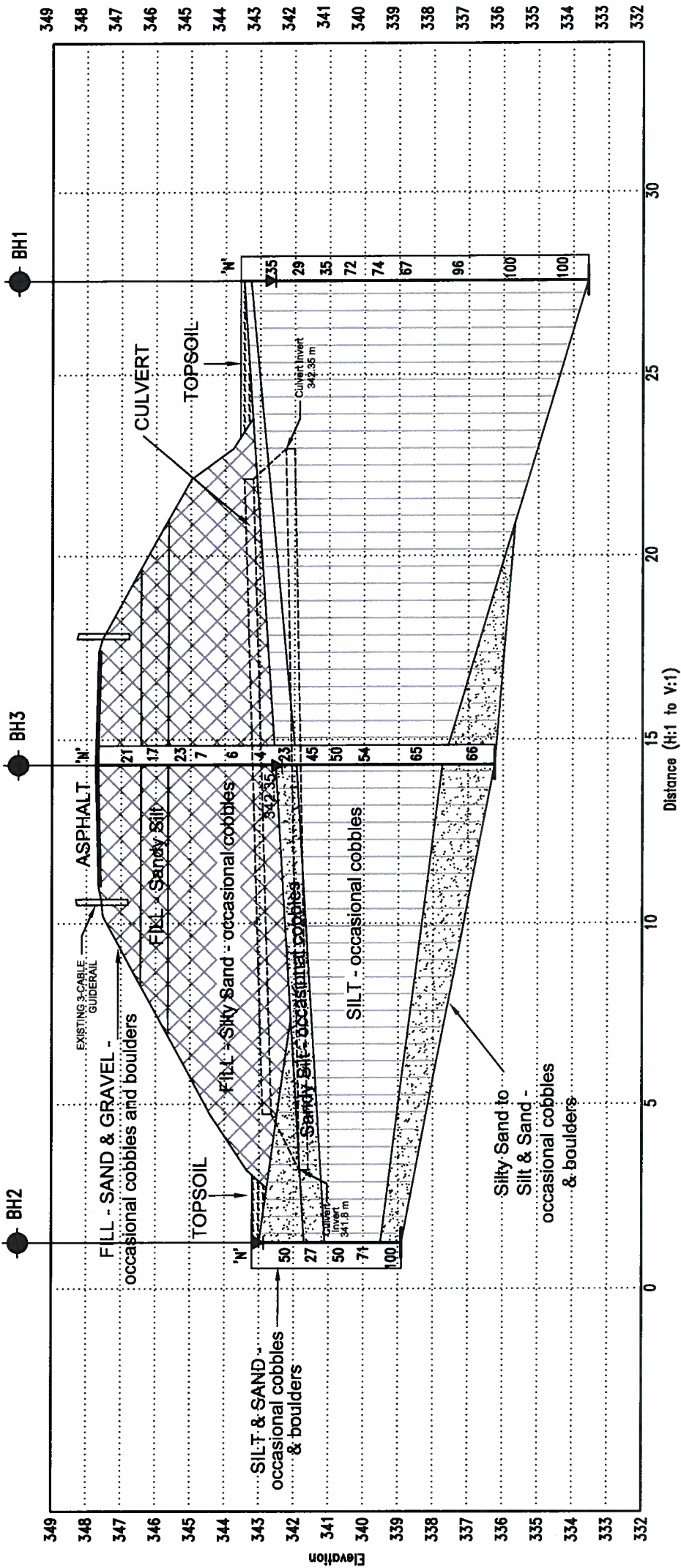


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DRAWING 2










PROFILE ALONG SECTION A-A'







 Borehole/Hand Auger  
 Borehole with DCPT  
 Dynamic Cone Penetration Test (DCPT)  
 Rock Probe  
 Blows/0.3m (Std. Pen Test, 475 J/Blow)  
 Water level at time of investigation.  
 Benchmark

**NOTE: Coordinates based on MTM Zone 13**

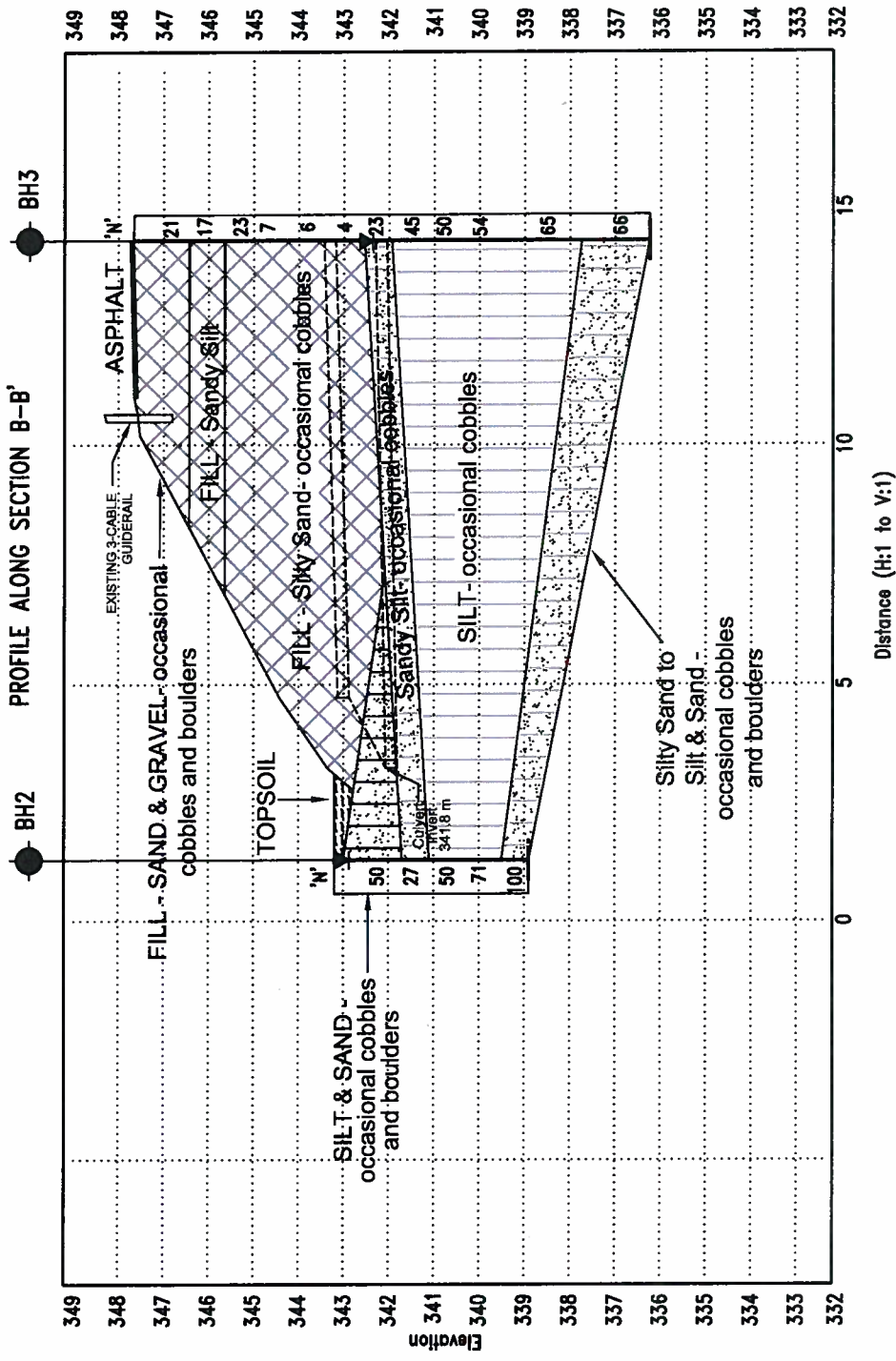
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETERS + METERS

**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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### DRAWING 3

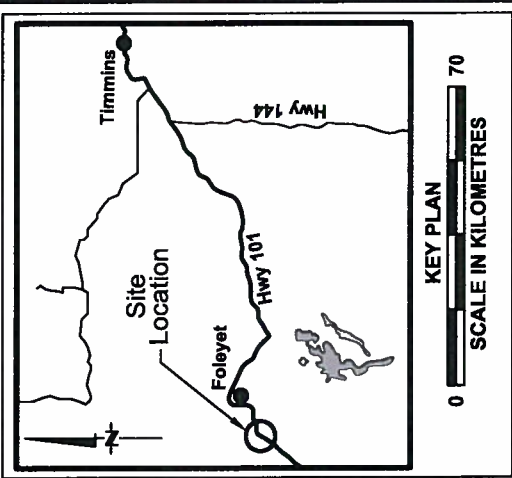


METRIC  
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AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METERS

AGREEMENT No 5010-E-0008  
CONT No 2011-5116  
GWP No 5464-08-00  
WP No 5464-08-01  
Site No 46-542  
Geocres No 42B-7

CULVERT REPLACEMENT  
AT SLOAN CREEK  
Highway 101 - Foleyet Twp.  
Borehole Locations and Stratigraphy

SHEET  
16



Borehole

Borehole with DCPT

Dynamic Cone Penetration Test (DCPT)

Hand Auger

Blows/0.3m (Std. Pen Test, 475 J/Blow)

Water level at time of investigation.

Benchmark

Fill

Organics

Topsoil

Till

Bedrock

Sand

Silt

Clay

Sand & Gravel

Boulders

No.	Elevation	Northing	Easting	Station	Offset
BH1	343.592	5341459	413584	10+000	15.0 m RT
BH2	343.232	5341484	413572	10+000	12.0 m LT
BH3	347.762	5341468	413573	9+995	1.3 m RT

NOTE: Coordinates based on NAD 83 Zone 18

NOTE:  
Interpolated elevations between soil depths 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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DRAWING 4

PLAN VIEW  
Scale in Metres

Profile Along Section C-C'



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

AGREEMENT No 5010-E-0006  
CONT No 2011-5116  
GWP No 5464-08-00  
WP No 5464-08-01  
Site No 46-542  
Geocres No 42B-7

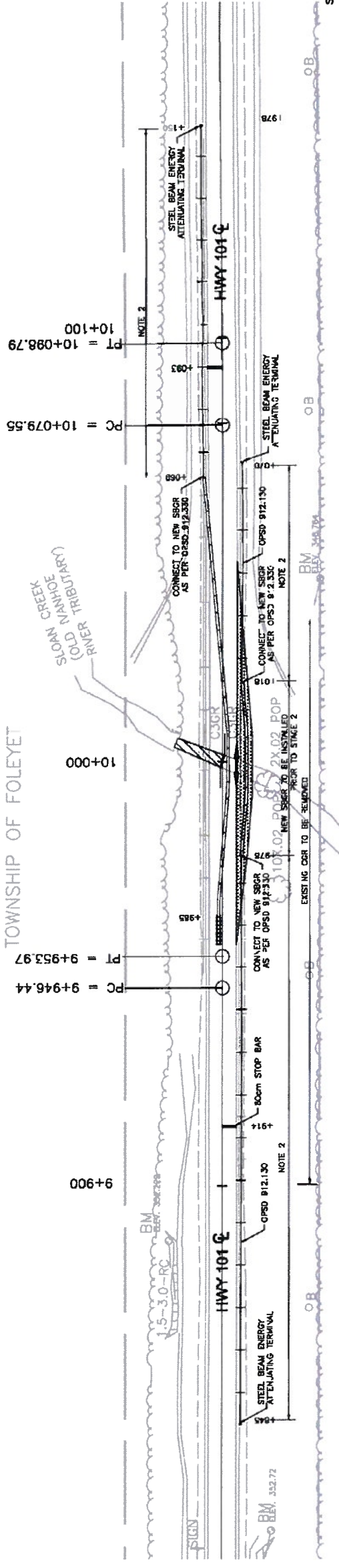
CULVERT REPLACEMENT  
AT SLOAN CREEK  
Highway 101 - Foleyet Twp.  
STAGE 1

SHEET

- LEGEND
- EXISTING SHOULDER TO BE PAVED
  - UNDER CONSTRUCTION
  - COMPLETED CONSTRUCTION
  - TEMPORARY CONCRETE BARRIER
  - END TREATMENT

- NOTES:
- STAGING DRAWING TO BE READ IN CONJUNCTION WITH CHAIRMAN'S REPORT (TOTAL) AND CHAIRMAN'S REPORT (TEMPORARY CONSTRUCTION) AND CHAIRMAN'S REPORT (PERMANENT AND ELEVATION WARNINGS) AND OPSD 911.222.
  - NEW SBR AS PER OPSD 912.130 TO BE INSTALLED ON 10+012 TO 10+070 MRL AND STA 10+089 TO 10+150 SBR FOR TO IMPLEMENTATION OF STAGE 1, INCLUDING ENERGY ATTENUATING TERMINAL.
  - WORKING FOR STAGING REQUIRES EXISTING SLOPES TO BE BENCH-ED AS PER OPSD 208.010

DISTRICT OF SUDBURY  
TOWNSHIP OF FOLEYET

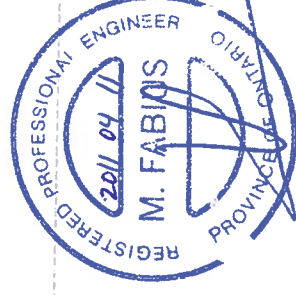
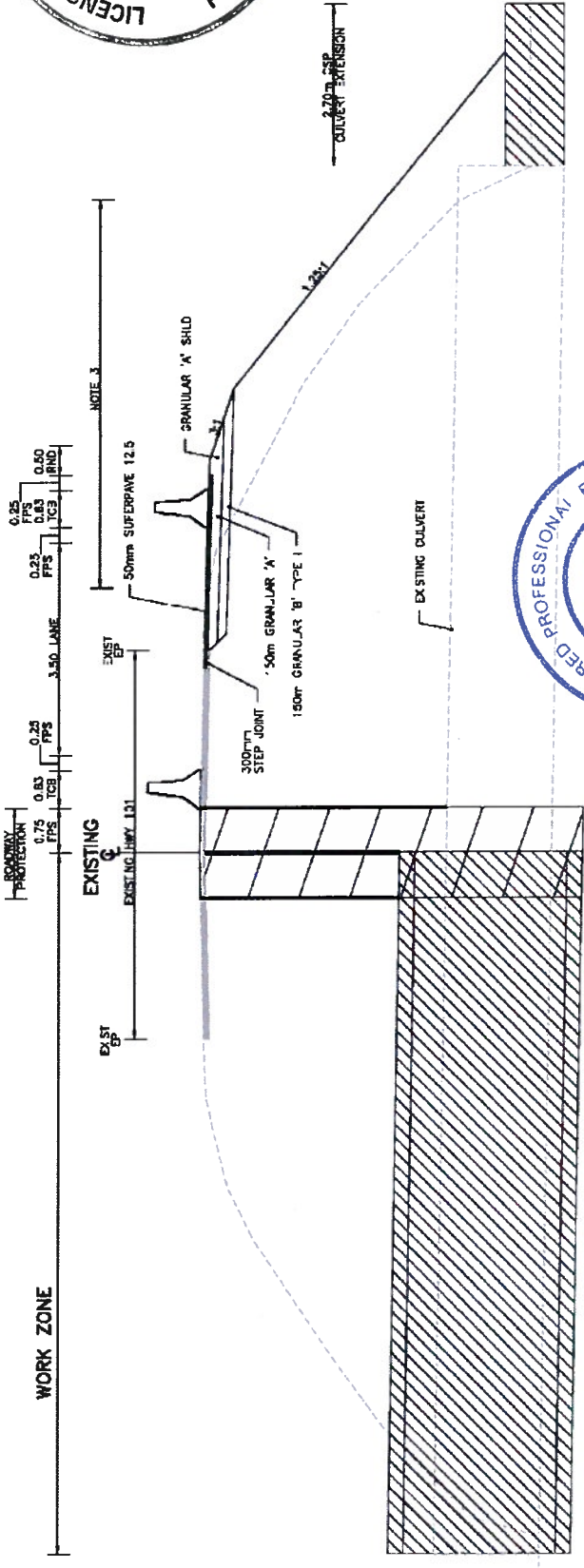
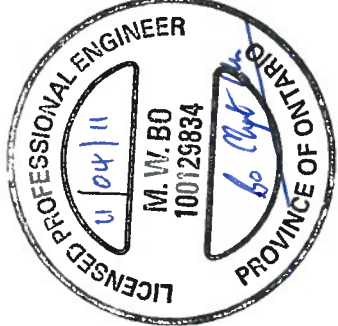


LEGEND

Borehole	Dynamic Cone Penetration Test (DCPT)	Hand Auger	Blows/0.3m (Std. Pen Test, 475 J/Blow)	Water level at time of investigation.	Benchmark
Fill	Organics	Topsoil	Till	Bedrock	
Sand	Silt	Clay	Sand & Gravel	Boulders	

No.	Elevation	Northing	Eastng	Station	Offset
BH1	343.592	5341459	413584	10+000	15.0 m RT
BH2	343.222	5341484	413572	10+000	12.0 m LT
BH3	347.762	5341469	413573	9+995	1.3 m RT

NOTE: Coordinates based on NAD 83 Zone 13



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

AGREEMENT No 5010-E-0006  
CONT No 2011-5116  
GWP No 5464-08-00  
WP No 5464-08-01  
Site No 46-542  
Geocres No 42B-7

CULVERT REPLACEMENT  
AT SLOAN CREEK  
Highway 101 - Foleyet Twp.  
STAGE 2

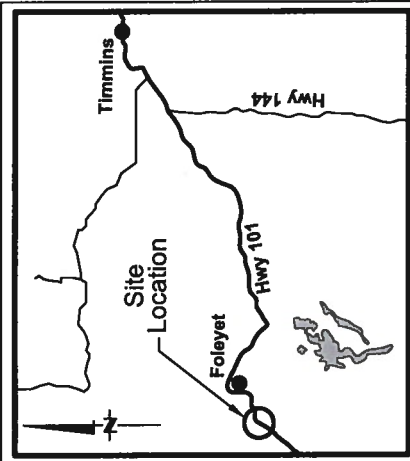
SHEET

LEGEND

- EXISTING SHOULDER TO BE PAVED
- UNDER CONSTRUCTION
- COMPLETED CONSTRUCTION
- TEMPORARY CONCRETE BARRIER
- E.V.O TREATMENT

NOTES:

- STAGING DRAWING TO BE READ IN CONJUNCTION WITH ONTARIO TRAFFIC MANUAL (OTM), BOOK 7 (TEMPORARY CONDITION AND BOOK 1 (PAVEMENT HAZARD AND DELINEATION MARKINGS) AND OPSD 811.232
- NEW SSGR AS PER OPSD 812.130 TO BE INSTALLED ON EXISTING SSGR. NEW SSGR TO BE PAVED AND STA. CLOSURE TO BE IN ACCORDANCE WITH OPSD 811.232 OF STAGE 2, INCLUDING ENERGY ATTENUATING TERMINAL.
- WIDENING FOR STAGING REQUIRES EXISTING SLOPES BE BENCHES AS PER OPSD 208.010



KEY PLAN  
SCALE IN KILOMETRES  
0 70

LEGEND

- Borehole
- Borehole with DCPT
- Dynamic Cone Penetration Test (DCPT)
- Hand Auger
- Blows/0.3m (Std. Pen Test, 475 J/Blow)
- Water level at time of investigation.
- Benchmark

- Fill
- Organics
- Topsoil
- Till
- Bedrock
- Sand
- Silt
- Clay
- Sand & Gravel
- Boulders

No.	Elevation	North	East	Station	Offset
BH1	343.992	5341459	413584	10+000	15.0 m RT
BH2	343.322	5341464	413572	10+000	12.0 m LT
BH3	347.762	5341469	413573	9+985	1.3 m RT

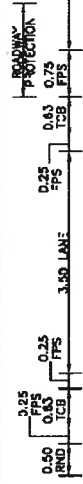
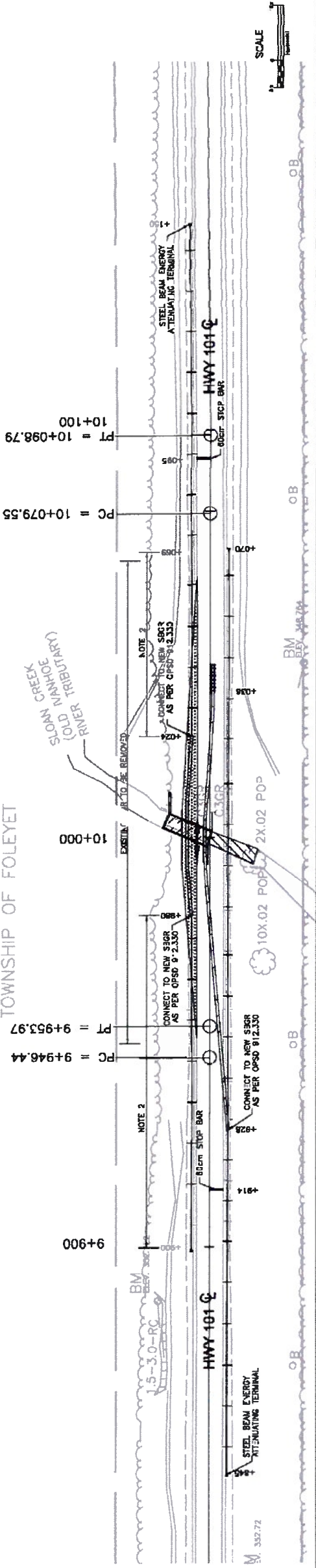
NOTE: Coordinates based on NTM Zone 13

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

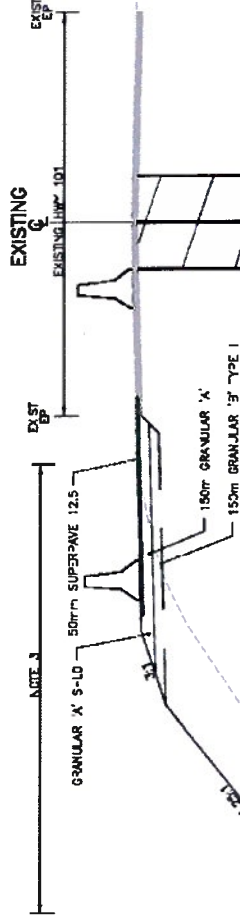
DST Consulting Engineers Inc.  
605 Hewitson Street  
Thunder Bay, ON P7B 5V5  
Ph: (807) 623-2929  
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Email: thunderbay@dsteigroup.com

DRAWING 6

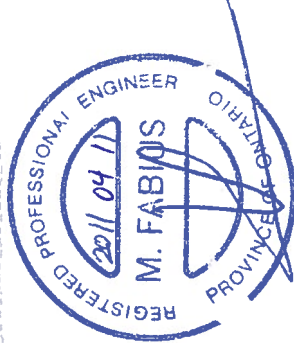
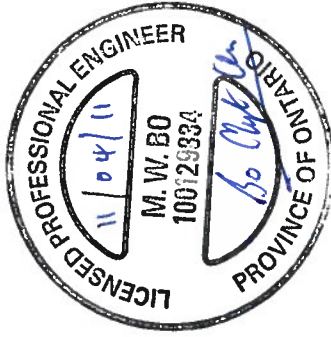
DISTRICT OF SUDBURY  
TOWNSHIP OF FOLEYET



WORK ZONE



STAGE 2  
N.T.S





# **ENCLOSURES**

# RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W.P. 5464-08-01 (Geocres No. 42B-7) LOCATION STA. 10+000 15.0 m RT (MTM Zone 13 5341459 m N, 413584 m E) ORIGINATED BY PR  
DIST HWY 101 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML  
DATUM Local DATE 2010 09 25 CHECKED BY MWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20	40	60	80	100						20	40	60
343.6	GROUND SURFACE																			
343.5	TOPSOIL - 100 mm		AS1	AS																
343.3	SILT - Sandy, some gravel, occasional cobbles and boulders, brown																			
343.3	SILT - trace clay, occasional cobbles and boulders, brown, very stiff to hard		SS1	SS	35															
	----- - some sand																			
			SS2	SS	29															
			SS3	SS	35															
			SS4	SS	72															
			SS5	SS	74															
			SS6	SS	67															
338.3																				
5.3	SILT - trace clay, grey, hard																			
			SS7	SS	96															
			SS8	SS	100+															
	----- - Clayey, occasional cobbles		SS9	SS	100+															
333.6																				
10.0	End of Borehole at 10.0 m Auger Refusal																			

✕<sup>3</sup>, ★<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 1

# RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. 5464-08-01 (Geocres No. 42B-7) LOCATION STA. 10+000 12.0 m LT (MTM Zone 13 5341484 m N, 413572 m E) ORIGINATED BY PR  
DIST HWY 101 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML  
DATUM Local DATE 2010 09 26 CHECKED BY MWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
343.2	GROUND SURFACE													
343.0	TOPSOIL - 200 mm		AS1	AS			343							2 47 48 3 Water level at 0.3 m on completion. Cave at 3.0 m.
0.2	SILT & SAND - trace clay and gravel, occasional cobbles and boulders, brown, hard		SS1	SS	50		342							
341.7														
1.5	SILT - Sandy, some gravel, trace clay, occasional cobbles, grey, very stiff		SS2	SS	27		341							
341.1														
2.1	SILT - trace clay, occasional cobbles, grey, hard		SS3	SS	50		340							7 62 22 9 SPT 50 blows/76 mm
339.5			SS4	SS	71									
3.7	SAND - Silty, trace clay and gravel, occasional cobbles & boulders, grey, very dense		SS5	SS	100+		339							
338.9														
4.3	End of Borehole at 4.3 m Auger Refusal													

✕<sup>3</sup>, ★<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 2

ON MOT CS-TB-012144 - GENIVAR - IVANHOE CREEK (SLOAN) - HWY 101.GPJ DST\_MIN.GDT 10/2/11

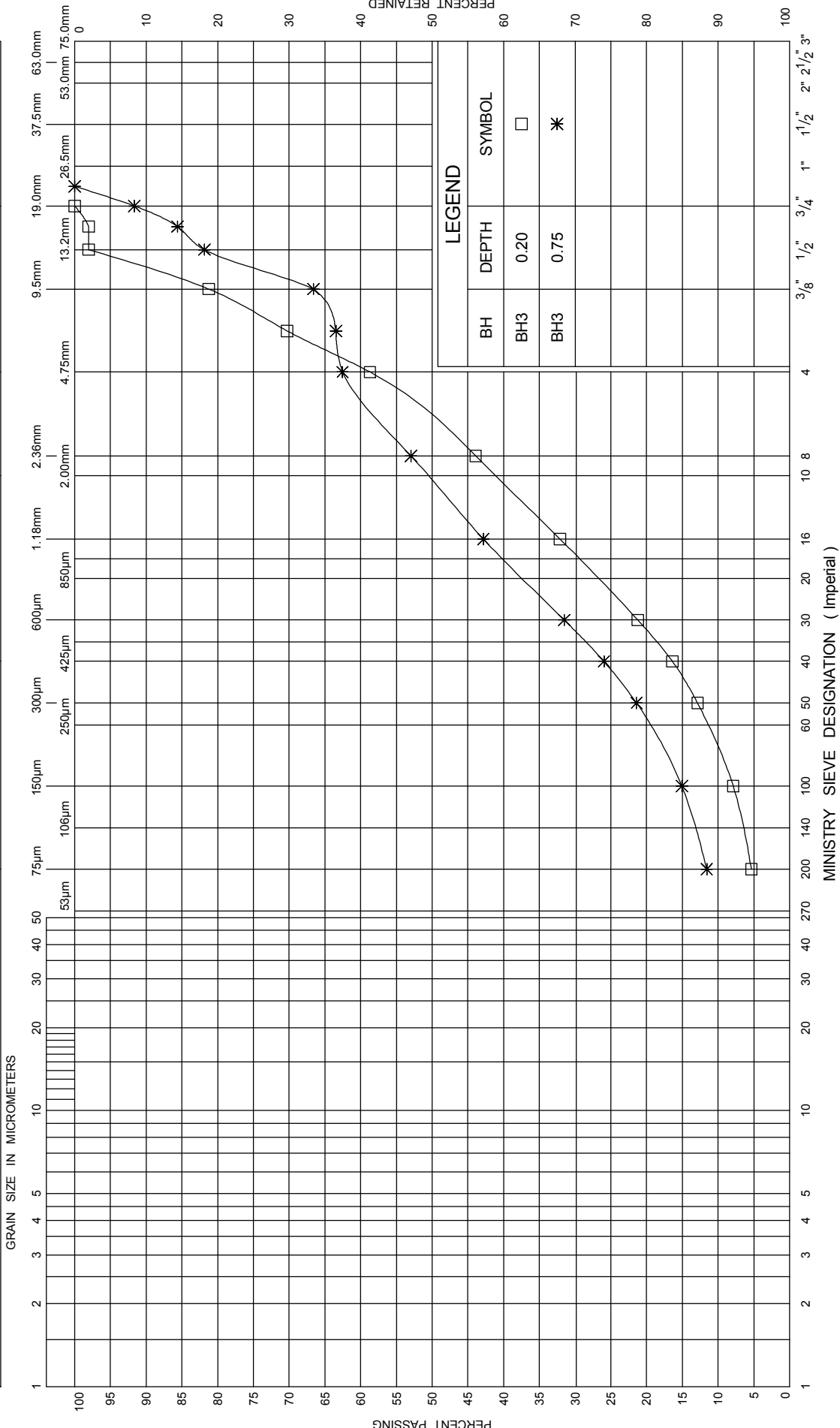
## METRIC

✕<sup>3</sup>, ★<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

ON MOT GS-TB-012144 - GENIVAR - IVANHOE CREEK (SLOAN) - HWY 101.GPJ DST MIN.GDT 10/2/11

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine		Medium	Coarse	Fine	Coarse



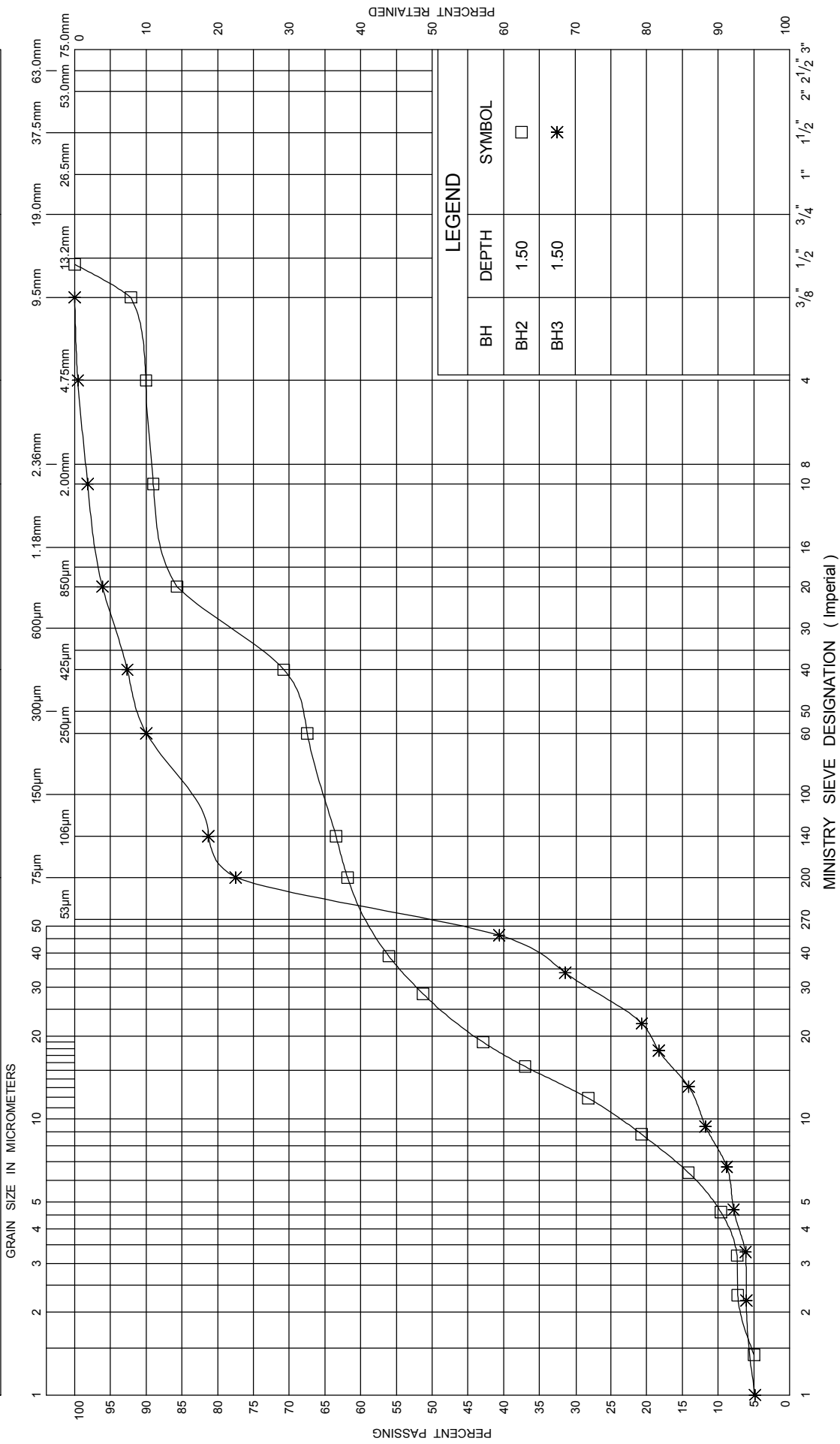
GRAIN SIZE DISTRIBUTION  
SAND & GRAVEL

ENCLOSURE 4  
W P 5464-08-01  
HIGHWAY 101



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine		Medium	Fine	Coarse



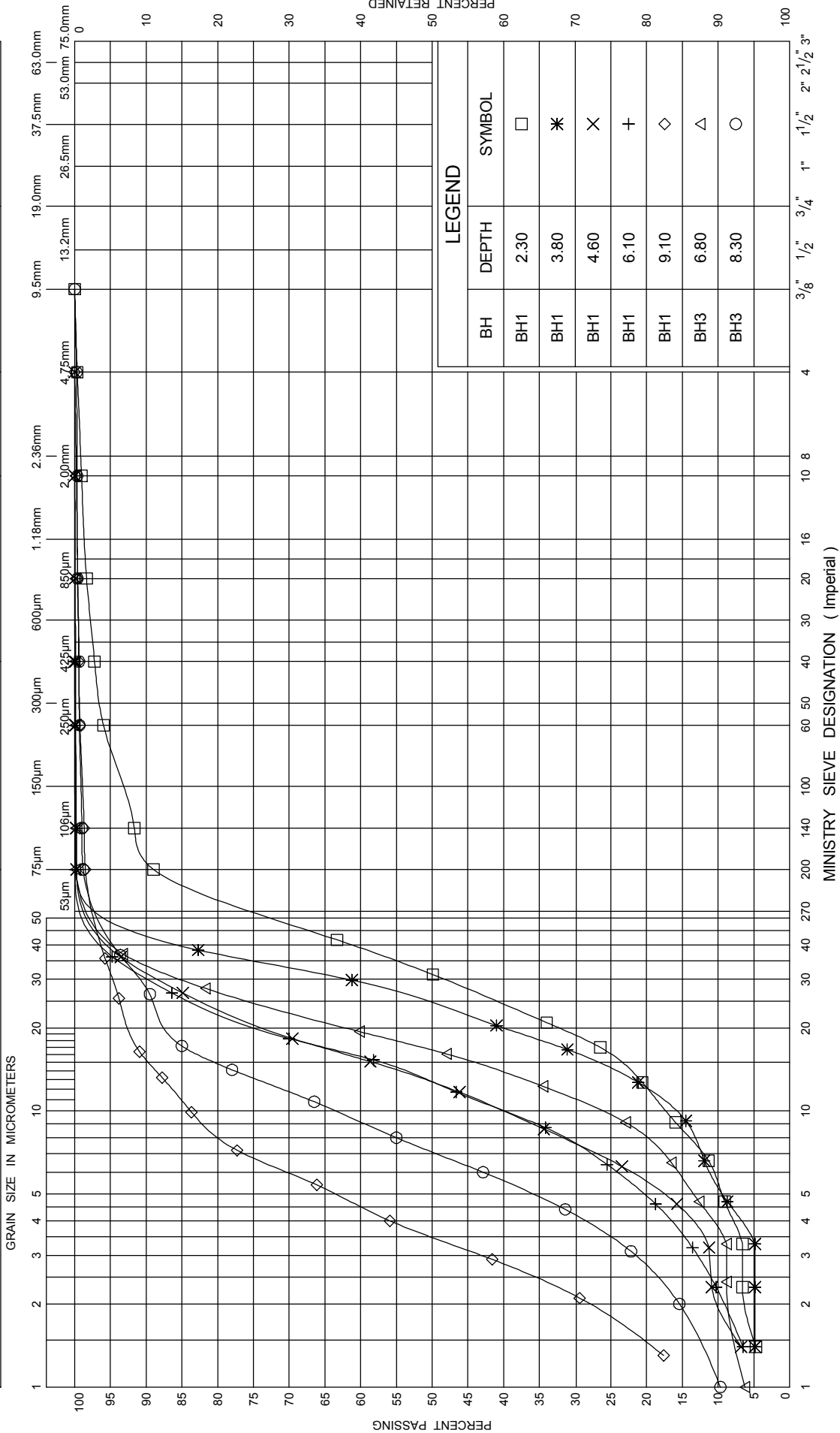
GRAIN SIZE DISTRIBUTION  
SANDY SILT

ENCLOSURE 5  
W P 5464-08-01  
HIGHWAY 101



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse



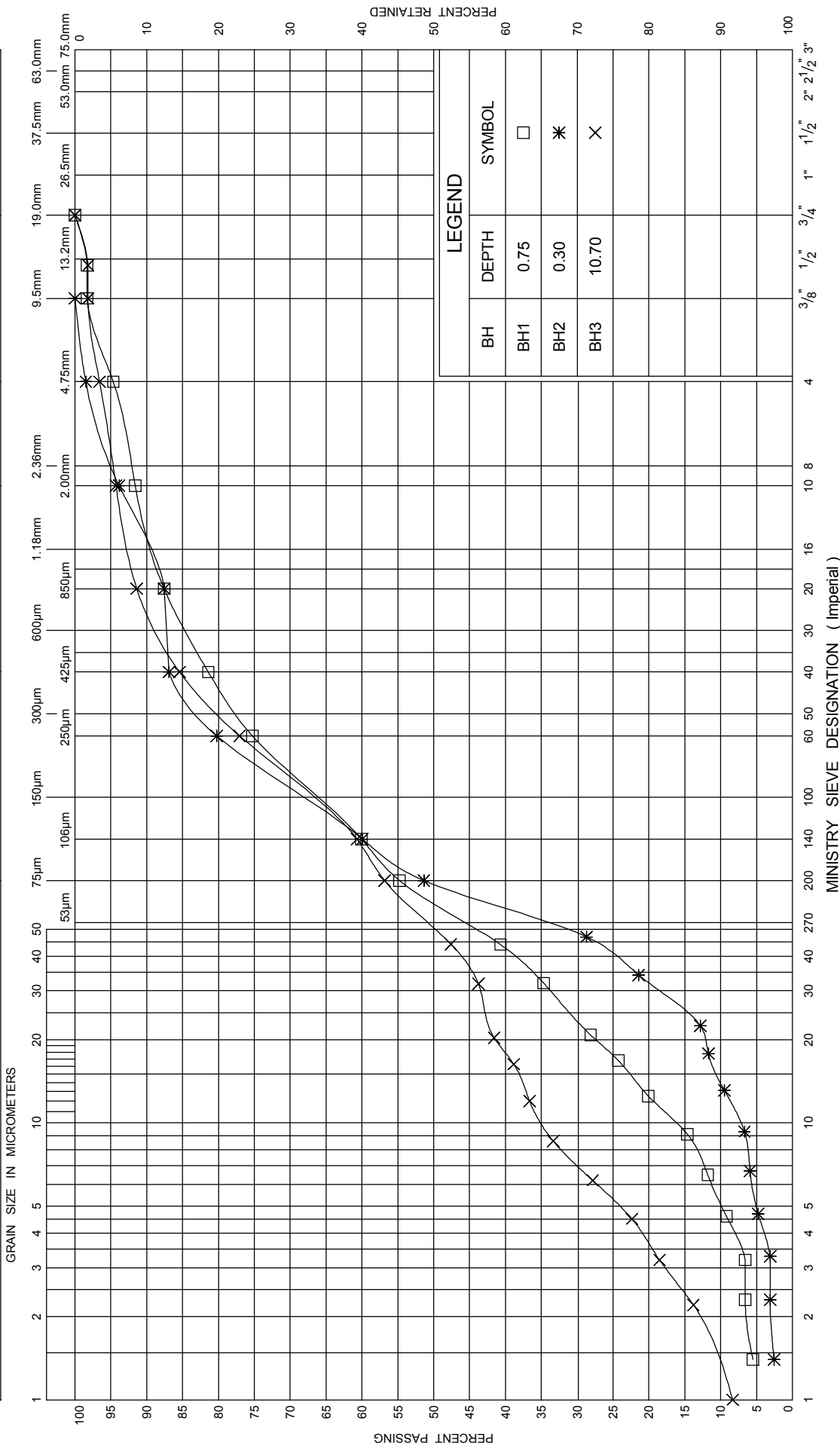
GRAIN SIZE DISTRIBUTION  
SILT

ENCLOSURE 6  
W P 5464-08-01  
HIGHWAY 101



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine		Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION  
SILT & SAND

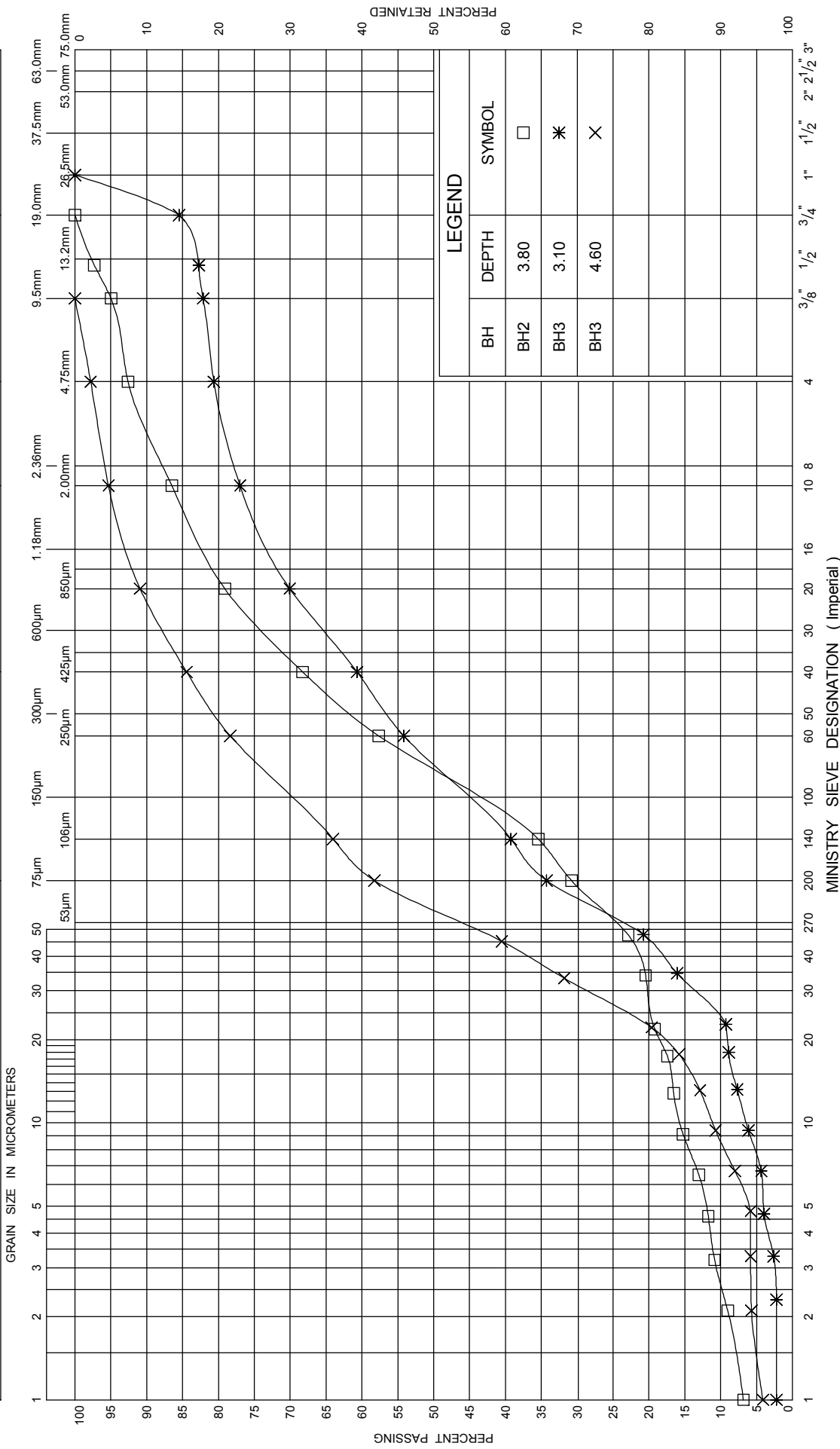
ENCLOSURE 7  
W P 5464-08-01  
HIGHWAY 101





UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine		Medium	Fine	Coarse



GRAIN SIZE DISTRIBUTION  
SILTY SAND

ENCLOSURE 8  
W P 5464-08-01  
HIGHWAY 101



