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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
REHABILITATION OF RETAINING WALL  
BAYFIELD RIVER BRIDGE, HIGHWAY 21  
SITE NO. 12-188  
W.P. 348-98-00, AGREEMENT NO. 3005-A-000012**

**Submitted to:**

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**Distribution:**

**15 Copies - Morrison Hershfield Limited**  
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### Explanation of Terms Used in Report

Drawing No. 1	Borehole Locations and Soil Data
Drawing No. 2	Conceptual Rock Fill Configuration
Appendix "A"	Record of Borehole Sheets
Appendix "B"	Laboratory Test Results
Appendix "C"	Statement of Limitations

## 1. INTRODUCTION

This report presents the results of a foundation investigation carried out by AGRA Earth & Environmental Limited (AGRA) on behalf of Morrison Hershfield Limited at the existing Bayfield River Bridge (Site No. 12-188).

A section of the gabion retaining wall at the northeast corner of the existing bridge has been distorted and settled. The damage to the retaining wall has caused the embankment to become unstable and subject to erosion.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes. Based on this information, possible methods of rehabilitating the retaining wall and protecting the embankment from further erosion will be provided.

The work presented herein was undertaken under MTO W.P. 348-98-00, Agreement No. 3005-A-000012, and confirmed by Morrison Hershfield Limited, in a letter dated October 12, 1999.

Golder Associates undertook underwater investigation work at this site in 1986 under Agreement No. 4213-3086-043. This information was reviewed to supplement the present investigation.

## 2. SITE DESCRIPTION

### 2.1 Site Location and Condition

Highway 21 crosses the Bayfield River in Bayfield, Ontario. The existing  $\pm 12$  m wide by  $\pm 62$  m long Bayfield River Bridge was constructed in 1950 and consists of two spans supported on abutments and a central pier. The abutments and pier are supported on footing foundations founded at elevation 173.7 m (570.0 ft). The deck of the bridge is at elevation 185.6 m and the water level at the time of the fieldwork was at elevation 176.4 m.

Golder's 1986 report did not find any undermining of the abutments and central pier. However, an item of concern is the "void beneath gabion baskets on north abutment".

A gabion retaining wall exists along the east side of the north bridge abutment. The gabion wall wraps around the northeast side and is about 50 m long. The gabion baskets were typically 900 mm wide. The northwest side is supported by steel sheet piling.

At the time of field investigation, the gabion wall was exposed some 3 to 3.5 m above the water level at the bridge abutment. The height of the wall drops gradually towards the north. A portion of the gabion wall (approximately 8 m long) near the north end (on the east side) has settled some 1 to 1.5 m, presumably due to erosion/scouring and undermining by the river current. Minor movement of the embankment slope was also

observed at this failed retaining wall section. Major erosion/scouring has taken place immediately upstream of the site.

Adjacent to the bridge abutment, the gabion retaining wall appears to have bulged out. A 3 m wide gabion mat was noted lying on the streambed in front of the gabion wall.

The main river channel runs along the north abutment and the depth of the channel is approximately 3 to 4 meters. The north embankment is approximately 6 to 8 m higher than the retaining wall and standing at an average inclination of 1.6H to 1V. The slope surface is vegetated with mature trees and undergrowth.

The river is very shallow south of the main (north) channel. Islands of sand and gravel deposits were formed immediately upstream of the bridge. The south river channel is about 1.0 to 1.5 m deep in front of the south abutment. The embankment of the south abutment experiences some minor erosion.

## **2.2 Physiography and Topography**

The site is located within the Physiographic Region known as the Huron Slope. It occupies a narrow strip of land along the eastern side of Lake Huron in the Bruce and Huron Counties. It is essentially a clay plain modified by a narrow strip of sand, and by the beaches of glacial Lake Warren. The site, being located in the Bayfield River, is further modified by the Bayfield River. The lower Bayfield Valley is about 30 m deep and up to 0.8 km wide. High-level terraces and old oxbows are found in the valley.

The area is generally underlain by the clay till of the Port Huron Moraine System. The bedrock is limestone of the Detroit River Group, Onondaga Formation of the Middle Devonian age.

## **3. INVESTIGATION PROCEDURES**

### **3.1 Field Investigation**

Between September 16 and 28, 1999, a CME 55 track mounted drill rig was used on site for drilling and Standard Penetration Testing (SPT) following the procedures of ASTM D 1586.

Prior to field drilling, permissions to drill in Bayfield River were obtained from the Ministry of Natural Resources, Ministry of Environment and Ausable Bayfield Conservation Authority. A detailed sampling procedure was submitted to and approved by these authorities.

The initial drilling involved three (3) boreholes drilled in the river, one (1) borehole along the gabion wall and one (1) borehole at the top of the embankment slope adjacent to Highway 21. In order to drill the boreholes in the river, the drillrig was placed on a barge (with spud legs). Drilling and sampling were carried out using hollow stem augers, which



were performed inside a 300 mm diameter steel pipe (temporary liner) in order to prevent the auger cuttings from entering freely into the water.

One (1) borehole on top of the existing retaining wall was located in an area inaccessible to the drillrig. This borehole was advanced with a vibratory probe and continuous SPT sampling.

The boreholes were numbered 1 through 6 and the depths of the boreholes are as follows:

Borehole No.	Depth of Borehole (m)
1	9.2
2	8.3
3	7.5
4	10.0
5	15.7
6	10.7

Soil samples were retrieved at selected intervals of depths throughout the boreholes in conjunction with Standard Penetration Tests (SPT). Samples were generally taken at intervals of 0.75 m to 1.5 m intervals. Dynamic cone penetration testing was also carried out.

Seepage and water levels were noted in each borehole during and at the completion of drilling and sampling. A standpipe piezometer was installed in Borehole 5 for future monitoring of the groundwater level. All boreholes were grouted with bentonite mix at completion of sampling.

The fieldwork was supervised by a member of our field engineering staff under the direction of the project engineer. Our field staff cleared the location of buried utilities and logged the boreholes. The soil samples obtained were placed in labeled containers and transported to our Waterloo Office for further examination and laboratory testing.

The location and surface elevations at the as drilled borehole locations were surveyed by AGRA field staff. The borehole locations were referenced to the existing features such as the gabion retaining wall, abutment and catchbasins and plotted on a site plan supplied by MTO. The elevations of the boreholes were surveyed with reference to a Bench Mark set on the bridge abutment.

AGRA field staff also surveyed two cross-sections of the northeast embankment for the purpose of slope stability analysis.

The location of the boreholes, soil data and the slope profiles are presented on Drawing No.1.

The results of the drilling, sampling, in-situ testing and water level measurements are summarized on the Record of Borehole sheets and are enclosed in Appendix "A".

### 3.2 Laboratory Analysis

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all retrieved soil samples. In addition, grain size analyses, unit weights, Atterberg Limits and laboratory shear vane tests were performed on selected samples.

The results of the laboratory testing are presented on the borehole logs enclosed in Appendix "A", and in Figures 1 to 5 in Appendix "B".

## 4. SUBSURFACE CONDITIONS

### 4.1 General Subsurface Conditions

In general, the subsurface deposits at the site consist of mixed embankment fill to approximately the stream bed level (near elevation 174.5 m), typically  $\pm 11$  m thick from the existing Highway 21 road grade. The native soil deposits encountered below the stream bed level consists of sand and gravel over clayey silt which is in turn underlain by a gravelly sandy silt till interbedded with sand and gravel deposits.

In the streambed, a 0.4 to 1.0 m thick sediment was contacted. The sediment consists of clayey silt or sand and gravel mixed with wood and organic inclusions.

#### 4.1.1 Fill

Boreholes 4 and 6 were drilled behind the existing gabion wall and Borehole 5 were drilled at the top of the embankment adjacent to Highway 21. These boreholes contacted fill materials, which consist of loose/firm mixed gravel, silt, sand and clay. The lower portion of the fill also contains frequent organic inclusions. Two (2) typical grain size distributions of the fill are shown in Figure 2 of Appendix "B".

Standard penetration testing provided "N" values from 38 to 4 blows per 0.3 m. The upper portion of the fill was in compact to dense condition, and the fill became loose or firm to stiff below the upper compact layer. The unit weight of the fill material was measured to be between 18.5 and 22.8 kN/m<sup>3</sup>.

The fill materials were generally in moist to wet condition with natural moisture contents measured between 5 and 25 %.

#### 4.1.2 Sediment

Boreholes 1, 2 and 3 were located in the river. The water level was surveyed to be near elevation 176.4 m at the time of the fieldwork. There was some 1.7 to 2.1 m of water at the borehole locations. However, the streambed was noted to be 3 to 4 m deep at the north river channel.

Boreholes 1 to 3 contacted 0.4 to 1.0 m of sediment. The sediment consists of clayey silt or sand and gravel mixed with wood and organic inclusions.

#### 4.1.3 Sand and Gravel

Immediately underlying the fill and sediment, a sand and gravel deposit was encountered in five (5) of the six (6) boreholes (with the exception of Borehole 2). The thickness of this granular deposit ranged from 0.4 to 2.1 m. In Boreholes 1 to 4, sand and gravel also underlay the clayey silt.

The sand and gravel deposit contains some silt and cobbles/boulders. Three (3) typical grain size distributions of the sand and gravel are shown in Figure 3 of Appendix "B".

Standard penetration tests yielded typical "N" values from 16 to over 50 blows per 0.3 m, indicating a compact to very dense condition. One "N" value was measured at over 100 blows per 0.3 m in Borehole 2, indicating very dense condition.

The sand and gravel deposit was saturated with moisture contents measured between 5 and 20 %.

#### 4.1.4 Clayey Silt

A major stratum of brown to grey clayey silt was contacted below the sand and gravel deposit in all six (6) boreholes. This deposit was encountered at elevation  $\pm 174.2$  to 173.0 m and extended to elevation  $\pm 171.1$  to 171.5 m, and was approximately 1.7 to 2.9 m thick.

This deposit consists of silt lenses and was gravelly at various depths and locations. Eight (8) typical grain size distributions of the clayey silt are shown in Figures 4 and 5 of Appendix "B".

Standard penetration tests yielded "N" values from 5 to 33 blows per 0.3 m. Laboratory shear vane tests yielded undrained shear strength between 25 and 115 kPa. Based on these test results and tactile examination, the clayey silt is considered to have a firm to hard consistency. The unit weight of the clayey silt was measured to be between 20.2 and 21.0 kN/m<sup>3</sup>.

The Liquid Limit and Plastic Limit were determined on seven (7) samples (see Figure 1 of Appendix "B") and the results are summarized below:

Liquid Limit	18 to 25 %, average at 22%
Plastic Limit	11 to 15 %, average at 13%
Plasticity Index	7 to 10 %, average at 9%

These results are indicative of clayey soils of generally low plasticity. The measured natural moisture contents obtained from the deposit range from 10 to 21 % (with an average of 17 %).

#### 4.1.5 Silt Till

A major stratum of silt till underlay the clayey silt or sand and gravel layers. The silt till consists of embedded sand and gravel and frequent layers of sand and gravel deposit. The silt till extended to borehole termination depths of 7.5 to 9.2 m below the river level, near elevations 167.2 to 168.9 m. Refusal to augering was met at these levels which inferred the contact of bedrock.

The grain size distribution of a sample from Borehole 1 is shown on Figure 6 of Appendix "B". The deposit can be described as sandy silt till with some gravel.

Standard penetration tests yielded "N" values from 49 to over 100 blows per 0.3 m. The silt till is classified as dense to very dense. Natural moisture contents were between 9 and 15 %.

Boulders and/or cobbles are frequently embedded within glacial till deposits. The very high blow counts and augering resistance within the silt till may infer the presence of cobbles and boulders.

#### 4.2 Groundwater Conditions

On completion of drilling, the following observations of groundwater levels were made:

Borehole No.	Depth of Borehole (m)	Observation
1	9.2	Water level same as the river level at elevation 176.4 m
2	8.3	Water level same as the river level at elevation 176.4 m
3	7.5	Water level same as the river level at elevation 176.4 m
4	10.0	Water level at elevation 176.4 m 3 hours after completion
5	15.7	Water at 10.0 m, Elevation 175.5 m on 10/13/99, in standpipe
6	10.7	Water level at elevation 176.4 m 1 hour after completion

The water table in the boreholes was observed to be close to the water level in the river at elevation 176.4 m. It is noted that the groundwater table will fluctuate in response to the river condition.

Locally at Borehole 2, artesian condition was observed during sampling in the sand and gravel deposit, which was contacted below the clayey silt. After the clayey silt layer was penetrated, water level rose to 0.8 m above the river level for about 10 minutes.

## **5. DISCUSSION AND RECOMMENDATIONS**

### **5.1 General**

Based on our interpretation of the factual information obtained during this investigation, this section of the report provides our recommendations on the possible methods of rehabilitating the retaining wall and protecting the embankment from further erosion. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction, they are provided only to highlight those aspects, which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

The location and soil data of the boreholes and two cross-sections of the embankment slope are schematically shown on Drawing No. 1.

Details of the gabion wall construction were not available for review.

### **5.2 Stability of Existing Slope**

The main river channel runs along the north abutment and the depth of the channel is approximately 3 to 4 m. The north embankment is approximately 6 to 8 m higher than the retaining wall and standing at an average inclination of 1.6H to 1V, approximately 32 degrees to the horizontal. The slope surface is vegetated with mature trees and undergrowth. Near the north end of the study area, the existing gabion wall has been distorted and settled some 1 to 1.5 m. Minor slumping of the slope immediately behind the gabion retaining wall also took place. This instability has been caused by erosion/scouring and undermining by the river current. The upper portion of the fill embankment slope appeared to be stable but minor surficial creeping in the past was evident as observed during our field work in September 1999.

The embankment fill consists of loose/firm mixed gravel, silt, sand and clay. The lower portion of the fill also contains frequent organic inclusions.

Slope stability analyses were performed on the most critical section of the embankment (Cross-section B-B as indicated on Drawing No. 1). The results of the analyses indicate that the fill embankment slope has a factor of safety in the order of 1.1 to 1.2 against surficial translational type failure depending on the geotechnical parameters chosen for the existing fill materials. The results correspond with our field observations as the surficial sliding taken place is shallow and is limited to the toe portion of the slope. The slope has re-stabilized and surficial sliding has stopped unless further triggered by scouring. The trees and surficial vegetation have aided to minimize the extent of the failure.

### 5.3 Possible Methods of Embankment Protection

The existing condition of the gabion retaining wall can be summarized as follow:

1. Golder's 1986 report did not find any undermining of the abutments and central pier. However, an item of concern is the "void beneath gabion baskets on north abutment".
2. Adjacent to the bridge abutment, the gabion retaining wall appears to have bulged out.
3. With reference to Cross-section B-B, a portion of the gabion wall near the north end (on the east side) has settled some 1 to 1.5 m, presumably due to scouring and undermining by the river current. Minor movement of the embankment slope was also observed at this distorted retaining wall section.
4. Major erosion/scouring has taken place immediately upstream of the site.

The main river channel runs towards the distorted retaining wall and then along the north abutment. It is possible that the gabion wall was not founded deep enough below the scour depth, thus undermining has resulted. The gabion baskets were also broken, that may be caused by debris flow in the river or simply deterioration/rusting of the wires.

Based on our observations, the entire wall has failed, although to a different degree of severity. Two possible methods of protecting the toe from being further eroded are discussed below.

#### 5.3.1 Rock Fill

Filling the area in front of the existing gabion wall with rip rap or armour stones will provide an erosion resistance barrier against the river current and stabilize the embankment slope. Various configuration of rock fill can be designed, such as rip rap blankets, cut off trench fill or berms. The sizes of the stones must be designed to resist hydraulic forces. Prior to placement of any stones, the sediments at the streambed must be excavated to the inorganic soil (sand and gravel or clayey silt) to prevent settlement. The stones should be placed on a geotextile filter cloth.

In light of the fact that the river channel runs along the existing gabion retaining wall, any form of rock fill placement will encroach into the river channel. This will affect the dynamics of the river flow pattern and will likely not be environmentally acceptable to the various authorities having jurisdiction on the Bayfield River.

For preliminary design purposes and considerations, the following configuration of rock fill can be adopted:

- Limit the maximum slope of the rock fill to 1.5 H to 1 V for both above and below the river level
- Found the rock fill below the anticipated scour level

A conceptual design summarizing the above recommendations is provided on Drawing No. 2.

### 5.3.2 Retaining Wall Replacement

In order not to encroach into the river channel, the existing gabion retaining wall will have to be replaced at the existing location. Although, a gravity type retaining structure could be re-constructed, it is deemed impractical and may not be environmentally acceptable, as most of the construction will be carried out under water. It is feasible that the main channel can be temporarily diverted and the construction area "coffer-dammed" in order to allow construction to proceed. However, it is believed that various authorities will not approve such a proposal.

An interlocking steel sheet pile wall could be the acceptable wall type as it will be less disruptive during construction and it is consistent with the type of retaining wall construction throughout the Bayfield Harbour area.

The existing gabion wall will have to be demolished and removed from the present location prior to driving the sheet pile wall. Alternatively, the sheet piles can be driven behind the existing gabion wall. After the sheet piles are installed, the portion of the gabion wall (above the river water level) can be removed to acquire a consistent appearance as that of the northwest corner of the bridge.

The sheet pile wall will have to be tied back by soil anchors in order to support the high lateral earth pressure.

### 5.4 Sheet Pile Wall Design

Based on the soil information, the maximum penetration of the steel sheet piles will be near elevation 170.5 m as high "N" values and augering resistance were encountered below this level. This represents approximately 4 m below the streambed at the time of fieldwork. It is noted that the existing footing for the north abutment was placed near elevation 173.7 m and scouring has not undermined the existing footing.

The top of the retaining wall will be near elevation 179.2 m, which is the top elevation of the existing gabion wall near the north abutment.

The lateral earth pressure,  $P_h$ , acting on the sheet pile wall may be computed employing the following geotechnical parameters:

Unfactored active earth pressure coefficient for retained soil,  $\phi = 28^\circ$  :

$$K_a = 0.9$$

Unfactored passive earth pressure coefficient for soil in front of the retaining wall, (available only in the soil below the anticipated scour depth)

$$K_p = 2.8$$

Unit weight of soil :    above river level =  $20 \text{ kN/m}^3$   
                             below river level =  $10 \text{ kN/m}^3$

Traffic surcharge due to Highway 21:            12 kPa

The above active earth pressure coefficient is based on a  $32^\circ$  sloped (1.6H to 1V) embankment.

Soil anchor tie back is required to support the sheet pile retaining wall. The anchors will have to be founded within the native soil deposits, which were contacted below elevation 175.3 m in Borehole 5. For preliminary design of soil anchors, a tentative bond strength of 60 kPa (unfactored) along the shaft of the soil anchor can be used. The bond strength should be confirmed by loading test of at least two anchors. In addition, all soil anchors should be proof-loaded to 133% of the design load during their installation, and then locked off at 110 % of the design load.

Appropriate factor of safety must be applied for the sheet pile wall design. The global stability of the overall retained embankment should be checked. The structural capacity of the sheet pile wall should also be checked against the potential ice load.

## 5.5 Demolition

It is anticipated that the removal of the existing gabion wall (if desired) will have to be carried out within a controlled environment such that any soil/silt will not enter the river freely. Possible methods that can be considered are silt fence and temporary "cofferdam" constructed of gravel and rock fill.

Based on the configuration of the embankment slope and the construction of the existing wing wall/abutment, we do not anticipate any significant slope instability problems during construction of the new retaining wall. The near vertical earth slope created after the gabion wall is removed can be trimmed back temporarily to a slightly shallower angle. Disturbance and removal of any existing vegetation should be kept to minimal.

Any underground utilities within the construction area should be identified and potential conflict with the proposed construction considered.



## 5.6 Protection of South Abutment

Presently, the embankment of the south abutment is not protected by any revetment and has experienced minor erosion. To prevent further erosion and scour, a rip rap blanket can be placed upstream (at the southeast corner of the bridge) of the south abutment. The design of the rip rap blanket should be carried out cognizant of the river hydraulics.

## 6. STATEMENT OF LIMITATION

We recommend that once the details of the proposed structure are finalized, our recommendations should be reviewed for their specific applicability.

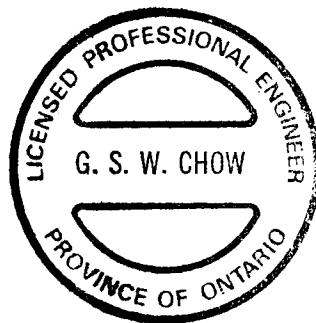
The Limitation of Report, as quoted in Appendix "C", is an integral part of this report.

Yours truly,  
AGRA Earth & Environmental Limited

  
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## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
$E$	kPa	MODULUS OF LINEAR DEFORMATION
$G$	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{VO}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_f$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$e$	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$n$	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$w$	1, %	WATER CONTENT	$D$	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$v$	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$i$	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$k$	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	$j$	kN/m <sup>3</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

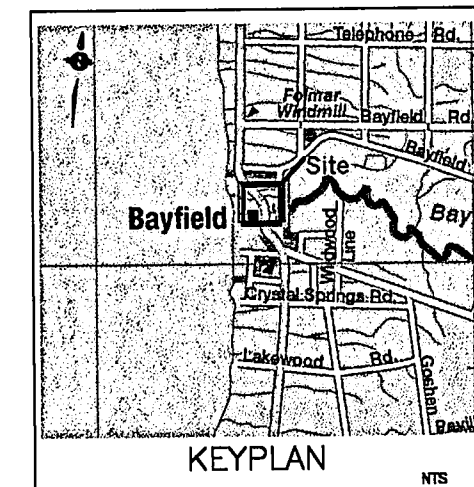
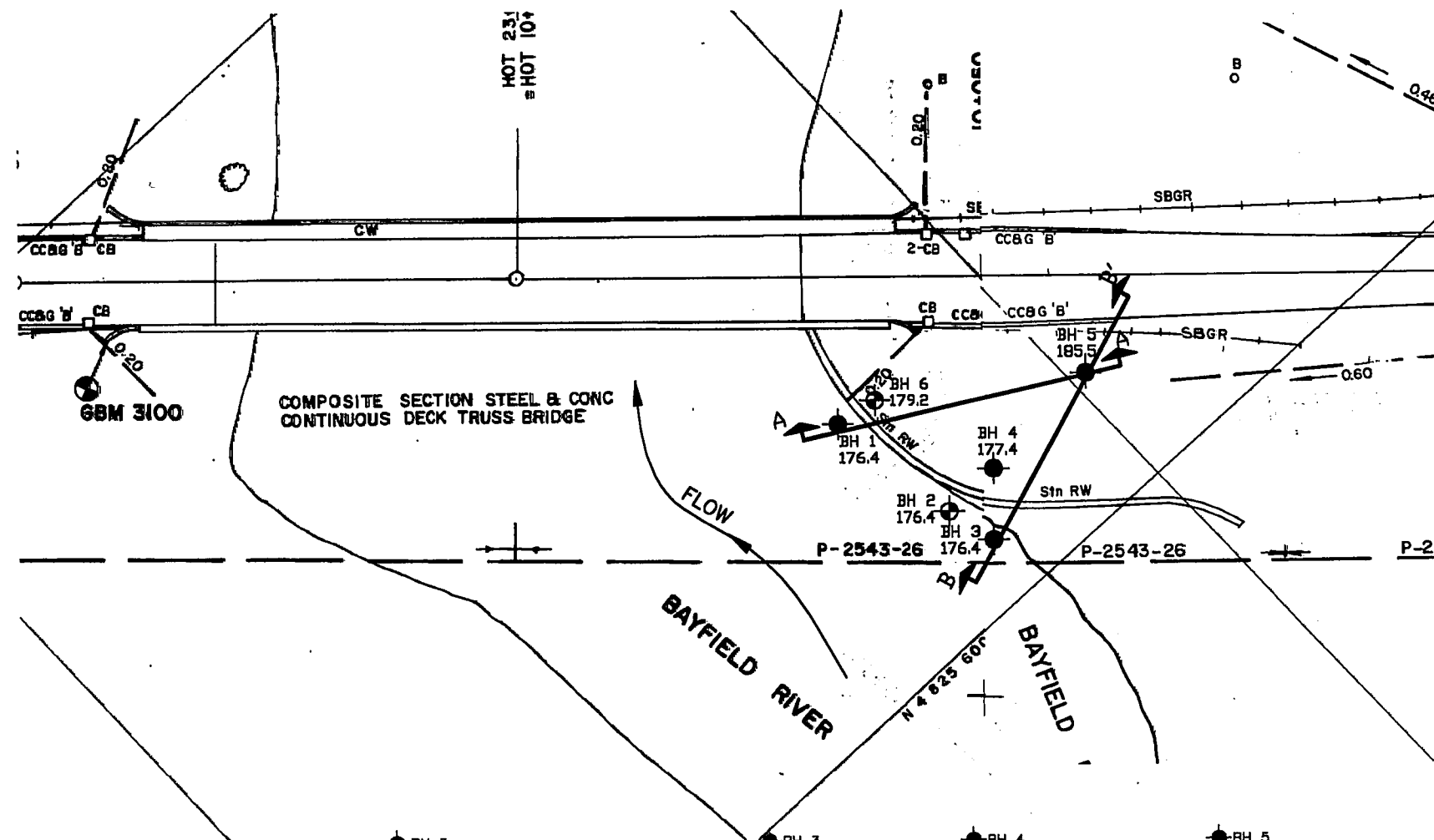
CONT No 000  
WP No 348-98-00



Bayfield River Bridge  
Highway 21  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

**AGRA** Earth & Environmental  
ENGINEERING GLOBAL SOLUTIONS

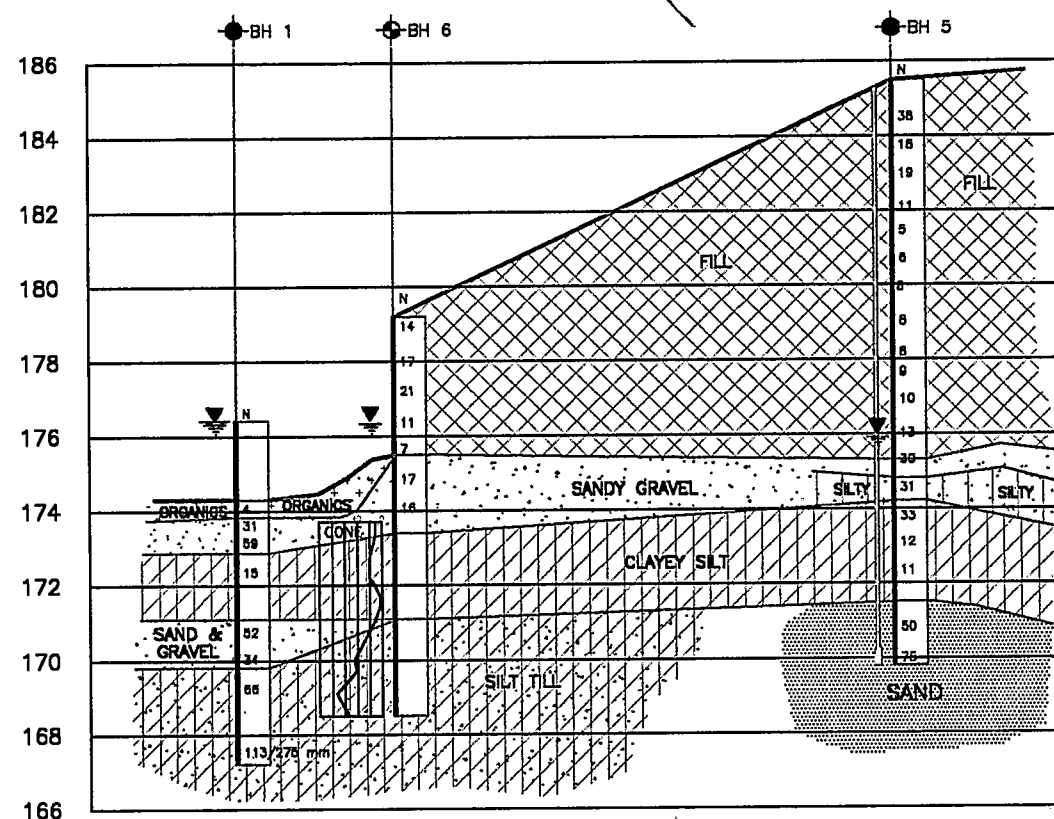


# LEGEND

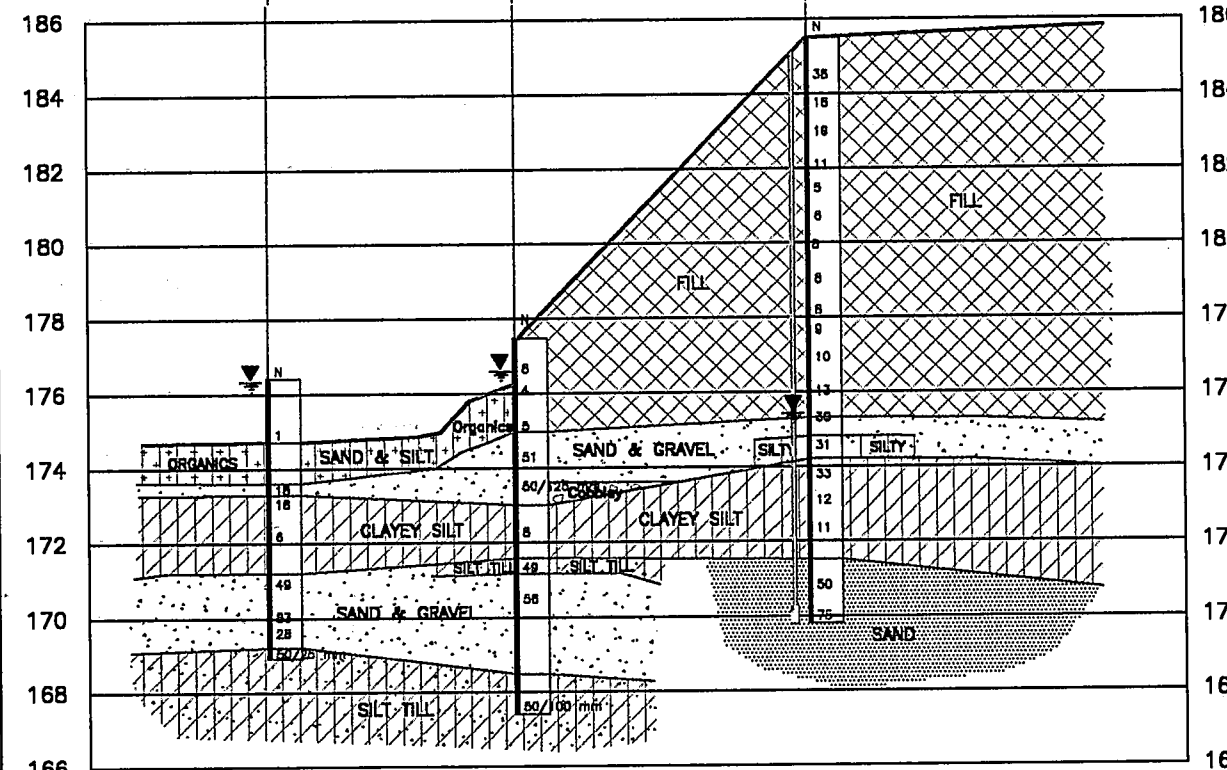
- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation
- Standpipe

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	178.4		
2	178.4		
3	178.4		
4	177.4		
5	185.5		
6	179.2		

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



SECTION A-A'



SECTION B-B'

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 02.01 of OPS Gen. Cond.

REVISIONS				
	12/13/98	SSY		
	12/08/98	SSY		
	DATE	BY	DISCRPTION	

Geocres : 40P12-9

HWY No.		HWY NO 21		DIST 31	
SUBM'D SSY	CHECKED EYC	DATE 10/18/98		SITE 12-188	
DRAWN SSY	CHECKED EYC	APPROVED		DWG 1.	

SECTION B-B'

CONCEPTUAL ROCK FILL CONFIGURATION

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

CONT No 000  
WP No 348-98-00

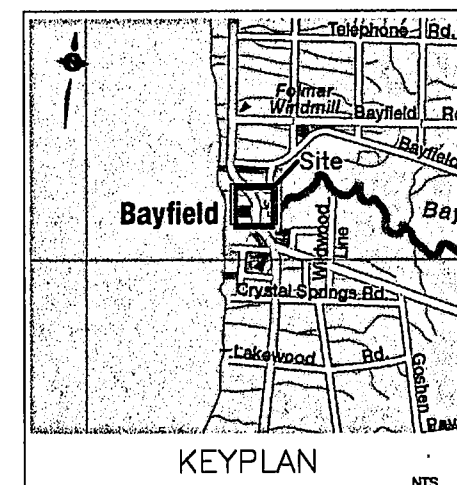
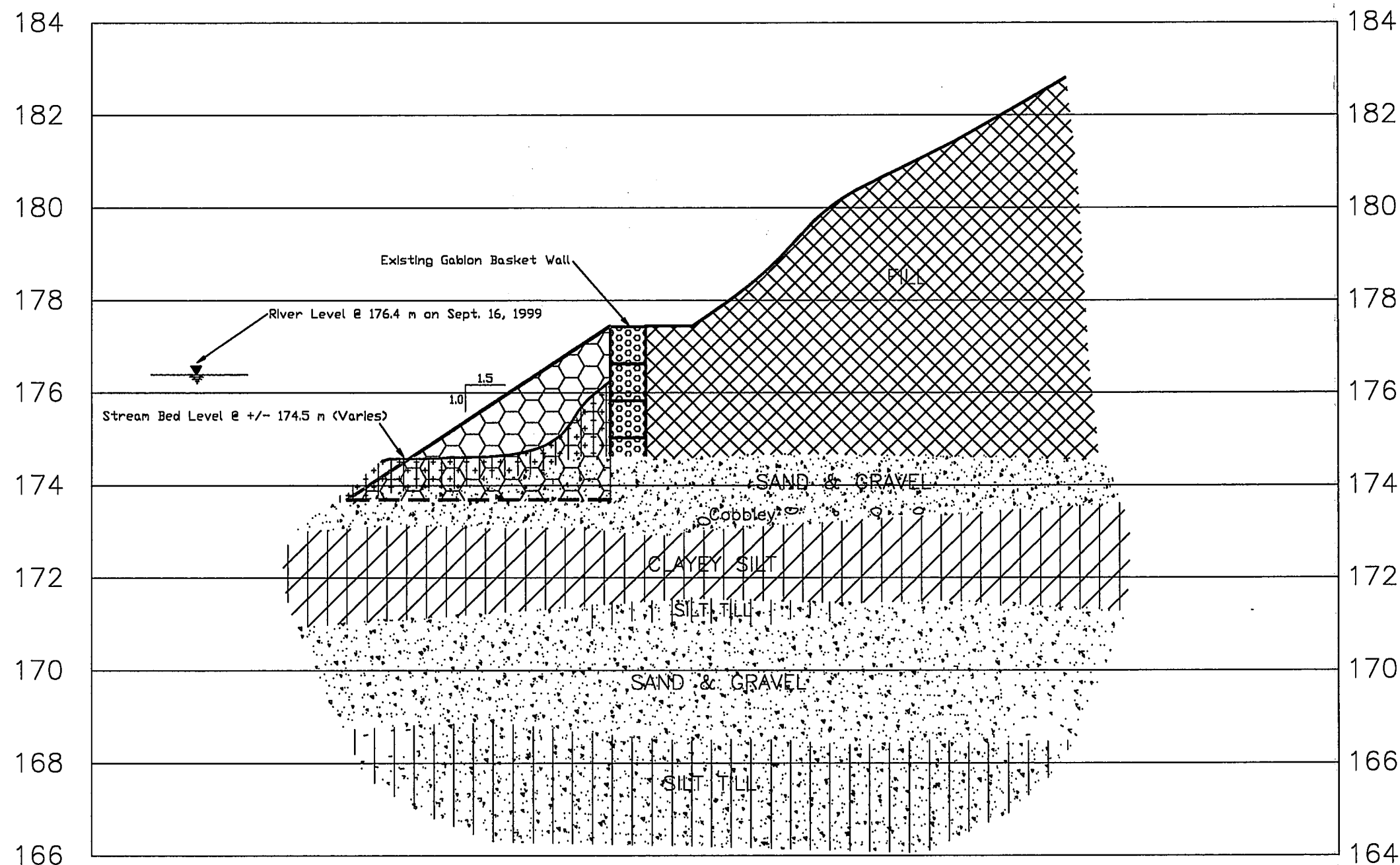


**Bayfield River Bridge**  
Highway 21  
**BORE HOLE LOCATIONS & SOIL STRATA**






SHEET



**AGRA** Earth & Environmental  
ENGINEERING GLOBAL SOLUTIONS



### LEGEND

- |   |                                      |
|---|--------------------------------------|
|  | Bore Hole                            |
|  | Dynamic Cone Penetration Test (Cone) |
|  | Bore Hole & Cone                     |
| N   | Blows/0.3m (Std Pen Test, 475 J/blow |
| CONE  | Blows/0.3m (60° Cone, 475 J/blow     |
|  | W L at time of Investigation         |
|  | Standpipe                            |

Note:

1. Rock fill to be founded below anticipated scour level and at least below Elevation 173.7 m (base of existing bridge abutment footing).
2. Place rock fill on geotextile filter cloth.
3. Rock fill slope no steeper than 1.5 H to 1.0 V.
4. Size of rock fill to be designed by others.
5. Base of existing gabion wall not known.

**NOTE:** The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

REVISIONS			
	DATE	BY	DISCRIPTION
Geocres : 40P12-9			

HWY No.		HWY NO 21		DIST 31	
SUBM'D SSS	CHECKED EYC	DATE 01/26/00		SITE 12-188	
DRAWN SSS	CHECKED EYC	APPROVED		DWG 2.	

# APPENDIX “A”






## Record of Borehole Sheets

# RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
 DIST 31 HWY 21 BOREHOLE TYPE H/S Auger with casing COMPILED BY SEW  
 DATUM Geodetic DATE 16.09.99 - 17.09.99 CHECKED BY EYC

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED	● QUICK TRIAXIAL							◆ FIELD VANE	✕ LAB VANE	
176.4	Water						20	40	60	80	100	10	20	30	GR SA SI CL			
0.0																		
174.3	CHANNEL BED at 2.05m BELOW WATER LEVEL on 9/16/99																	
2.1	Loose, grey SANDY GRAVEL SEDIMENT saturated		1	SS	4													
173.7																		
2.7	Dense to very dense, grey SANDY GRAVEL saturated		2	SS	31										67 27 (6)			
			3	SS	59													
172.9																		
3.5	Stiff, light brown CLAYEY SILT, trace sand, trace to some gravel very moist		4	SS	15								20.5	0 7 63 30				
			5	ST											12 21 45 22 35 kPa			
			6	ST														
171.1																		
5.3	Very dense to dense, grey SAND and GRAVEL saturated		7	SS	52													
			8	SS	34													
169.8																		
6.8	Very dense, grey/brown SILT TILL, some clay, gravel and sand layers moist																	
			9	SS	66								23.0	14 24 46 16				
								</										

EXPRESS: 12-188.GPJ EXPRESS.GDT 13/12/99

# RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
 DIST 31 HWY 21 BOREHOLE TYPE H/S Auger with casing COMPILED BY SEW  
 DATUM Geodetic DATE 16.09.99 - 16.09.99 CHECKED BY EYC

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	◆ FIELD VANE ✕ LAB VANE						
176.4	Water							20 40 60 80 100							
0.0															
174.5	CHANNEL BED at 1.85m BELOW WATER LEVEL on 9/16/99														
1.9	Firm, grey CLAYEY SILT SEDIMENT, some sand, trace gravel, some wood fragments saturated		1	SS	6										
174.1															
2.3	Firm, grey CLAYEY SILT, trace to some gravel moist to very moist														
			2	SS	5										
			3	SS	7										
171.5			4	SS	57										
4.9	Compact to dense, grey SAND and GRAVEL saturated		5	CT	0										
			6	CT	14										
			7	CT	33										
			8	CT	30										
			9	CT	25										
169.5			10	CT	50										
6.9	Very dense, grey SILT TILL, some clay, sand and gravel very moist														
168.8			11	SS 5#/170mm											
7.6	Very dense, grey SAND and GRAVEL saturated														
168.1															
8.3	AUGER REFUSAL at 8.3 m NOTE* Artesian condition rose to 0.8 m above water level of river for approximately 10 minutes after sample 4														

EXPRESS, 12-188.GPJ EXPRESS.GDT 13/12/99

## 1 OF 1

**METRIC**

W.P.	348-98-00	LOCATION	SITE No. 12-188, Bayfield River Bridge, Hwy. 21	ORIGINATED BY	SEW
DIST	31	HWY	21	BOREHOLE TYPE	H/S Auger with casing
DATUM	Geodetic	DATE	17.09.99 - 17.09.99	CHECKED BY	EYC

[illegible]

+3, X3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE



# RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
 DIST 31 HWY 21 BOREHOLE TYPE H/S Auger COMPILED BY SEW  
 DATUM Geodetic DATE 20.09.99 - 20.09.99 CHECKED BY EYC

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED	● QUICK TRIAXIAL							◆ FIELD VANE	✕ LAB VANE	
177.4	Ground						20	40	60	80	100	10	20	30	kN/m <sup>3</sup>	GR SA SI CL		
0.0	Compact to loose, dark brown silt and gravel FILL, some fine sand and cobbles																	
	moist		1	SS	8													
			2	SS	4													
175.0	wood inclusions																	
2.5	saturated		3	SS	5													
174.7	Very dense, dark grey coarse SAND and GRAVEL saturated		4	SS	51													
2.7																		
173.6	Silty, some cobbles																	
3.8			5	SS 50/125mm														
173.0	Soft to firm, brown CLAYEY SILT, trace to some gravelly silt layers very moist																	
4.4																		
			6	SS	8													
171.3	Dense, brown SILT TILL damp		7	ST														
6.1																		
170.9	Very dense, grey coarse SAND and GRAVEL saturated																	
6.6			8	SS	49													
			9	SS	56													
168.2	Very dense, greyish brown SILT TILL, trace to some sand damp																	
9.3																		
167.4	AUGER REFUSAL at 10.0 m NOTE* Water level encountered at 176.4 m 3 hrs after completion		10	SS 50/100mm														
10.0																		

EXPRESS 12-188.GPJ EXPRESS.GDT 13/12/99

# RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
 DIST 31 HWY 21 BOREHOLE TYPE H/S Auger COMPILED BY SEW  
 DATUM Geodetic DATE 21.09.99 - 21.09.99 CHECKED BY EYC

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
185.5	Ground																
0.0	Dense to compact, dark brown silty sand and gravel FILL, large asphalt pieces damp		1	SS	38		185										55 40 (5)
			2	SS	18		184									19.5	
183.2	Compact, dark brown silt and sand FILL, some gravel, glass fragments damp		3	SS	19		183									22.8	28 56 (18)
2.3			4	SS	11		182										
181.7	Firm to stiff, greyish brown clay and silt FILL, occasional gravel, some dark grey staining moist		5	SS	5		181									18.5	
3.8			6	SS	6		180									19.5	
			7	SS	8		179										
			8	SS	8		178										
			9	SS	8		177									21.5	
			10	SS	9		176									20.5	
			11	SS	10		175									18.5	
			12	SS	13		174										
175.3	Compact, dark grey SAND and GRAVEL		13	SS	30		173									21.0	10 18 47 25
10.2	Silty Saturated		14	SS	31		172									20.2	0 2 66 42
174.8			15	SS	33		171										
10.7	Hard to stiff, brown CLAYEY SILT, trace sand and gravel moist		16	SS	12		170										
174.2			17	SS	11												
11.3			18	ST													
171.5	Dense to very dense, brown fine SAND saturated		19	SS	50												
14.0			20	SS	75												
169.8	END OF BOREHOLE at 15.7 m NOTE* Water level recorded in piezometer at 10.0m on 10/13/99																
15.7																	

EXPRESS 12-188.GPJ EXPRESS.GDT 13/12/99

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
 DIST 31 HWY 21 BOREHOLE TYPE Continuous SPT COMPILED BY SEW  
 DATUM Geodetic DATE 28.09.99 - 28.09.99 CHECKED BY EYC

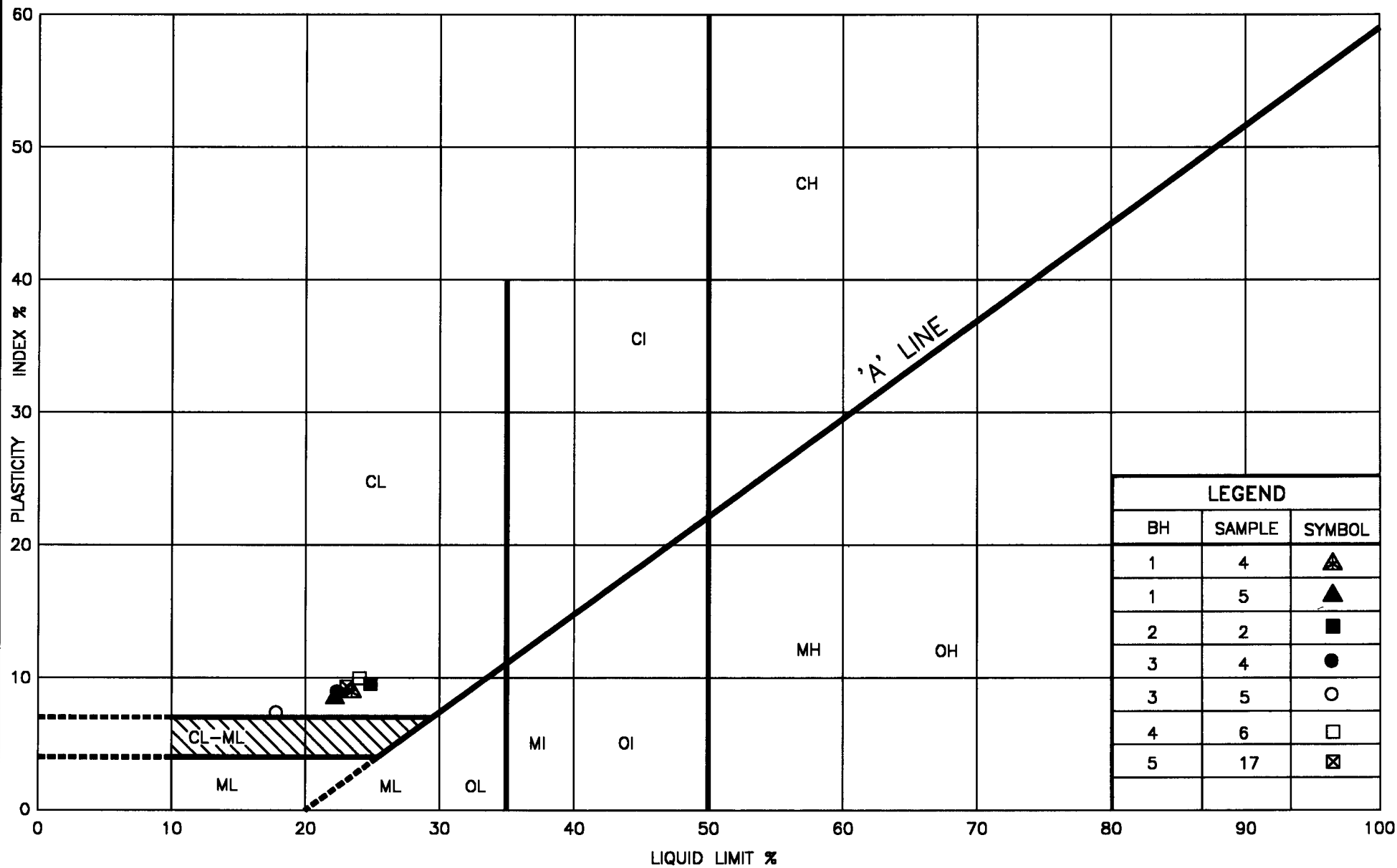
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
179.2	Ground							20 40 60 80 100						
0.0	Loose to compact, dark brown to black sandy silt FILL, some crushed gravel moist		1	SS	14		179							
177.9			2	SS	17		178							
1.2	Compact, brown clayey silt FILL, trace gravel moist to very moist													
177.5			3	SS	21		177							
1.7	Compact, dark grey silt and fine sand FILL moist													
176.9			4	SS	11		176							
2.3	Loose, olive organic silt FILL, some wood inclusions wet													
176.5			5	SS	7		175							
2.7	Loose, dark grey fine sand and silt FILL, frequent shell fragments, frequent woody inclusions saturated													
175.5			6	SS	17		174							
3.7	Compact, grey coarse to medium SAND, some gravel, frequent fine to medium sand layers saturated		7	SS	16		173							
173.4			8	CT	12		172							
5.8	Soft to firm, grey CLAYEY SILT wet		9	CT	10		171							
			10	CT	16		170							
			11	CT	21		169							
			12	CT	21									
			13	CT	11									
			14	CT	1									
			15	CT	2									
171.1			16	CT	9									
8.1	Compact to very dense, grey SILT TILL, some clay, gravel and sand moist to damp		17	CT	15									
			18	CT	23									
			19	CT	44									
			20	CT	48									
			21	CT	40									
			22	CT	55									
			23	CT	74									
			24	CT	55									
168.5														
10.7	END OF BOREHOLE at 10.7 m NOTE* Water level at 176.4 m, 1hr after completion													

Dynamic cone penetration tests carried out

EXPRESS 12-188.GPJ EXPRESS GDT 13/12/99

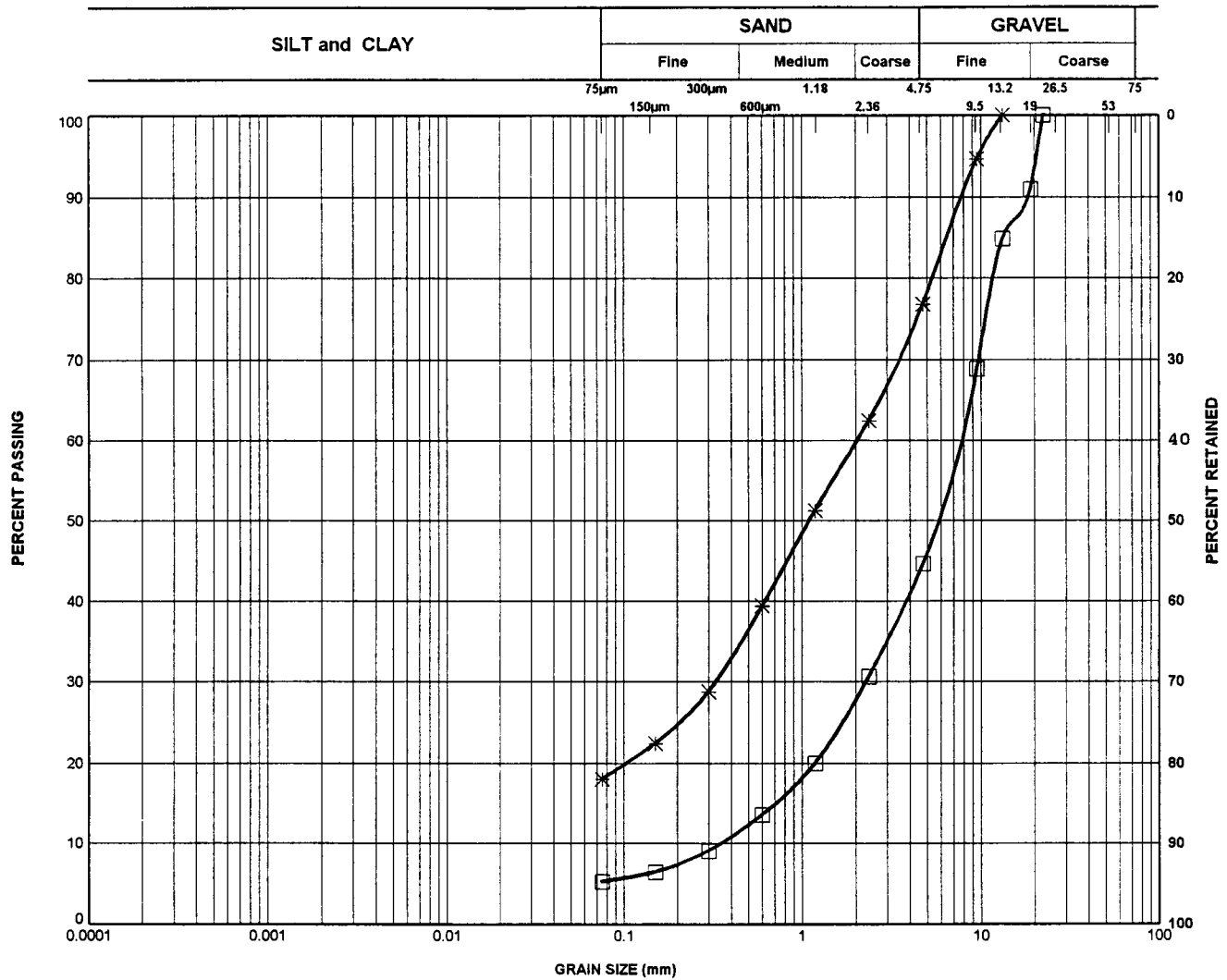
# APPENDIX “B”

## Laboratory Test Results



# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM

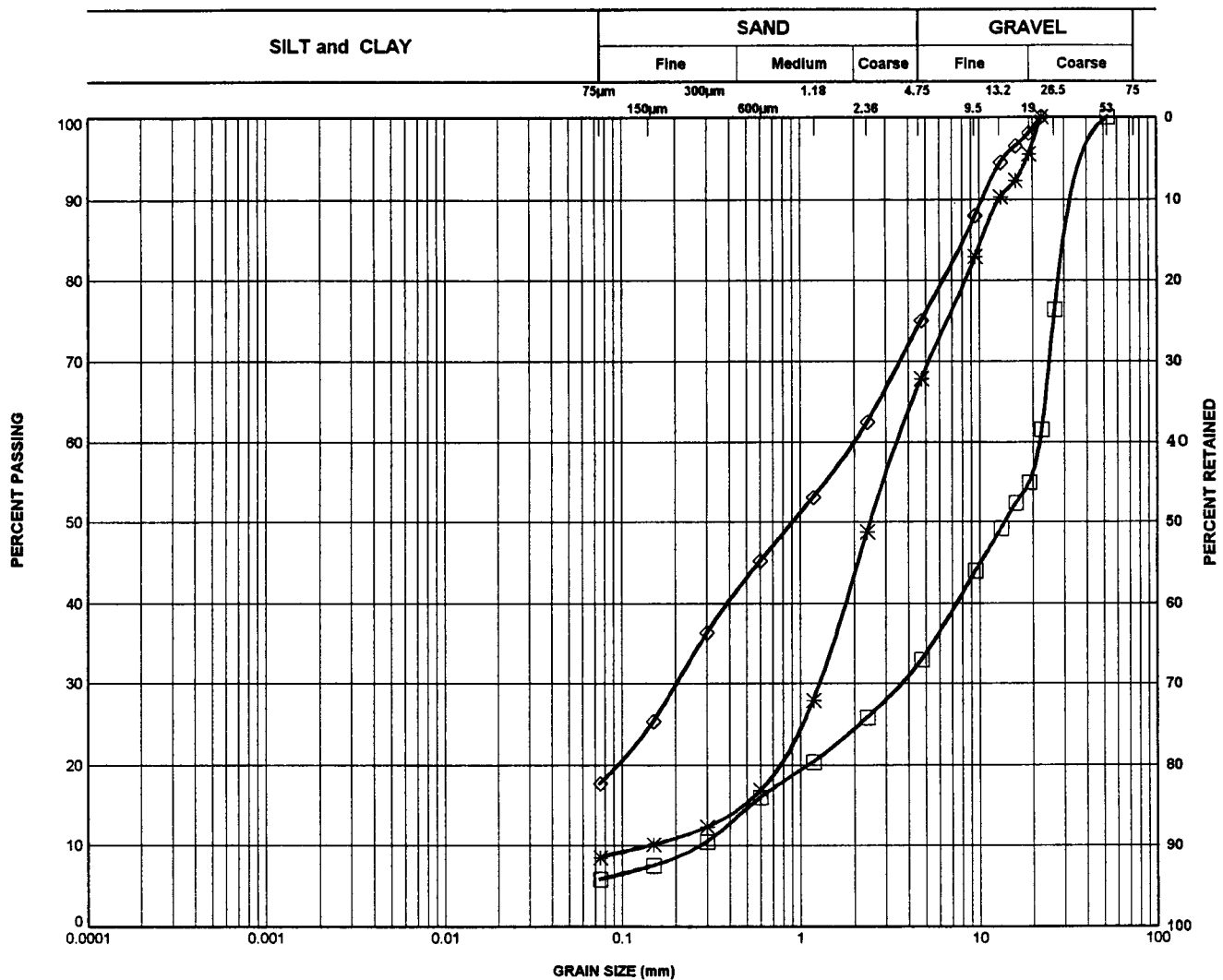


LEGEND		
SYMBOL	BOREHOLE	DEPTH (m)
□	5	0.8
✱	5	2.4

**SAND and GRAVEL FILL**

# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM



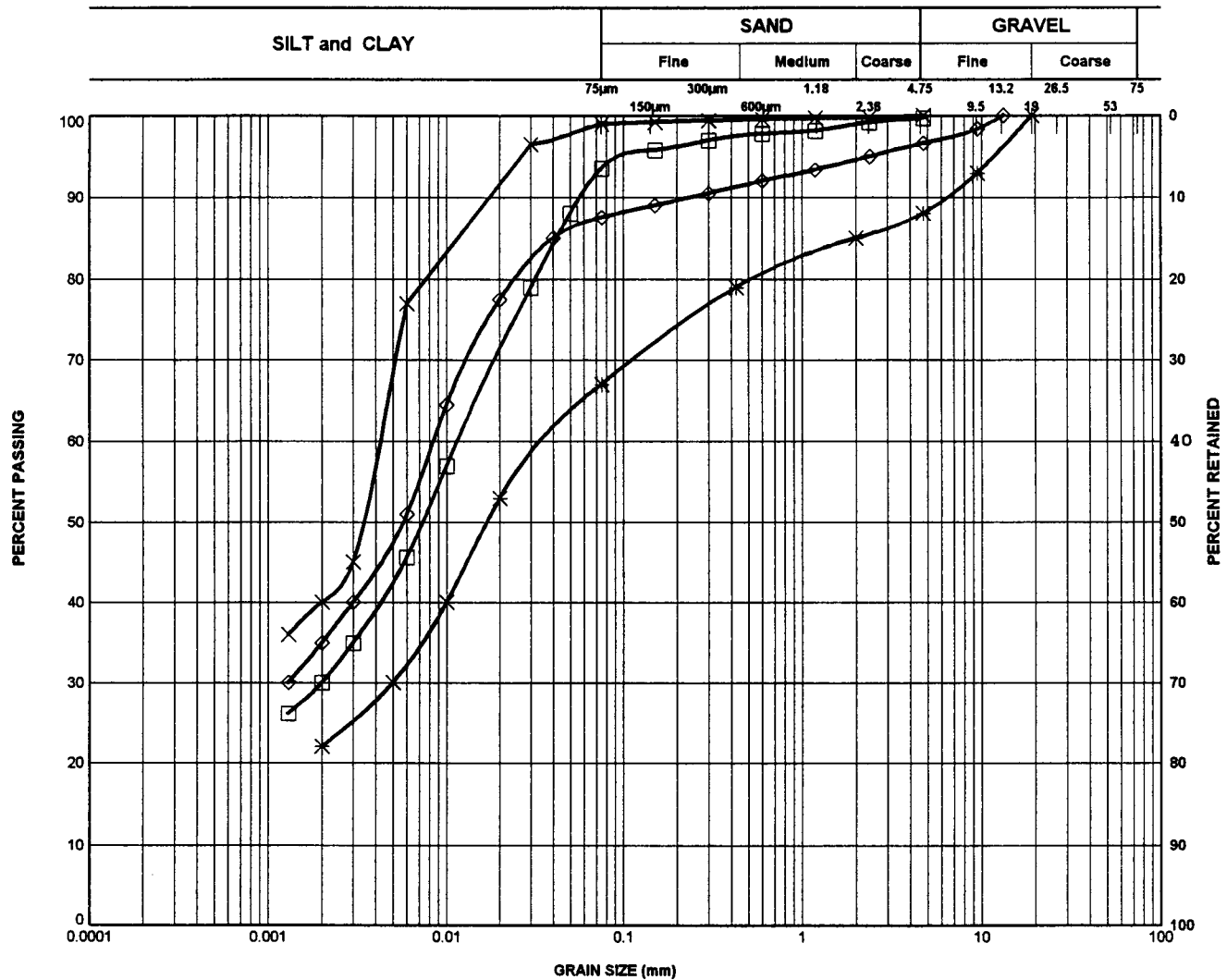
### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)
□	1	2.6
*	3	5.4
◇	3	6.1

**SAND and GRAVEL**

# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM



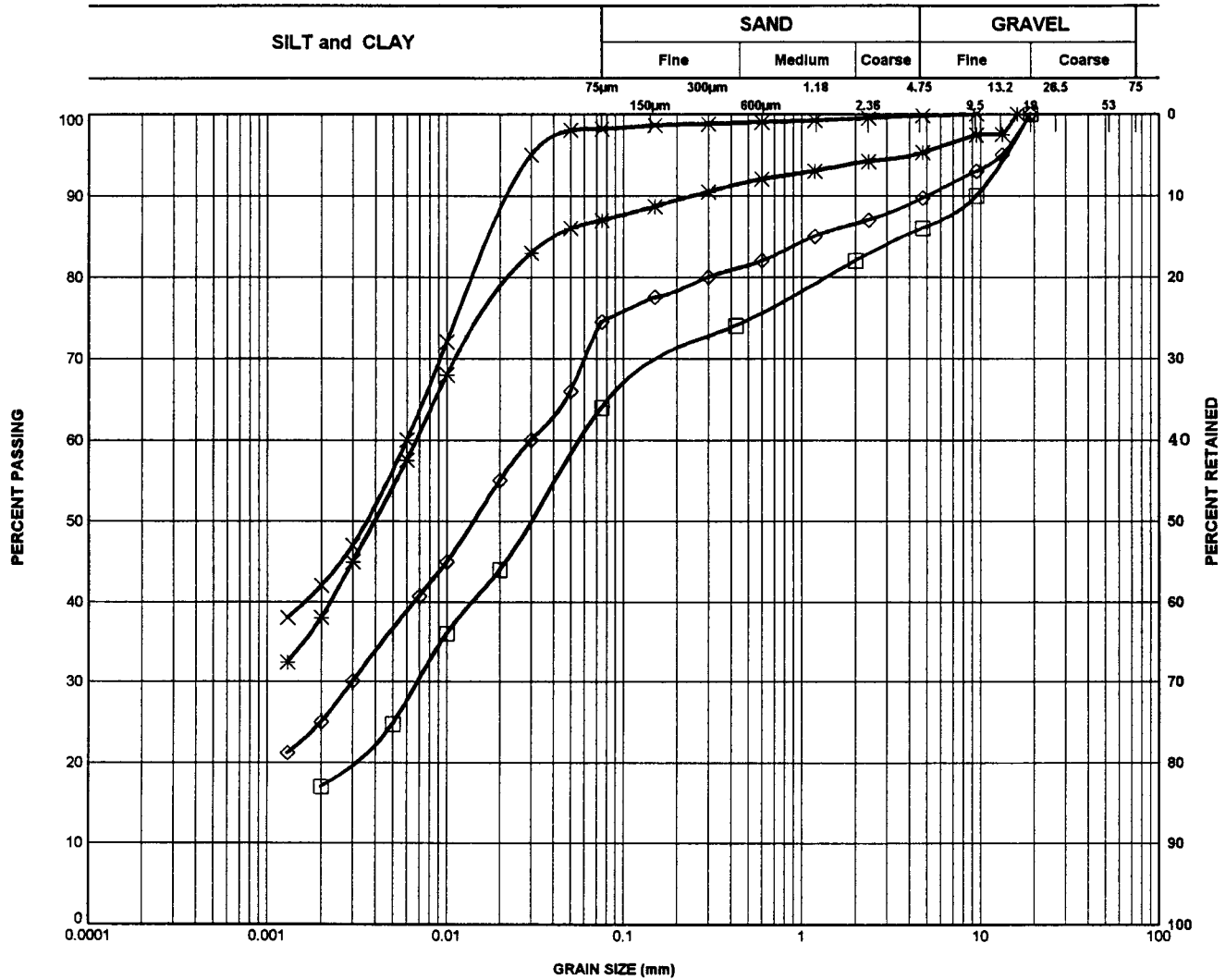
LEGEND		
SYMBOL	BOREHOLE	DEPTH (m)
□	1	3.9
*	1	4.6
◇	2	3.4
×	3	3.8

**CLAYEY SILT**



# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM



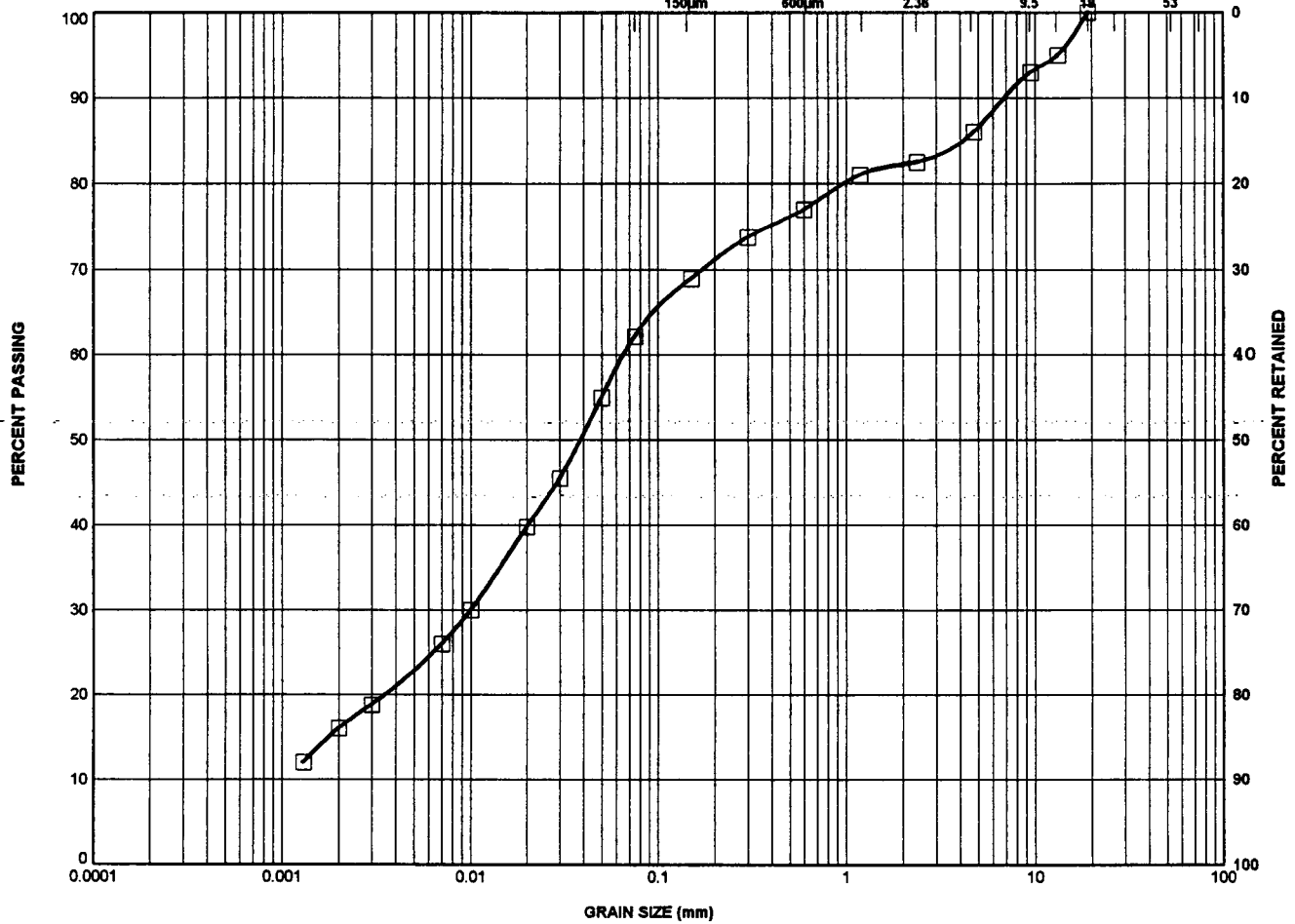
LEGEND		
SYMBOL	BOREHOLE	DEPTH (m)
□	3	4.6
*	4	5.3
◇	5	11.5
×	5	13.0

**CLAYEY SILT**

# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM

SILT and CLAY	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse
	75µm	300µm	600µm	2.36	4.75



LEGEND		
SYMBOL	BOREHOLE	DEPTH (m)
□	1	6.9

**SILT TILL**

# APPENDIX “C”

## Statement of Limitations

## LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Soils 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 comments made 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. For example, 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.

The benchmark and elevations mentioned in this report were obtained strictly for use in the geotechnical design of the project and by this office only, and should not be used by any other parties for any other purposes.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. AGRA Earth & Environmental Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report does not reflect the environmental issues or concerns unless otherwise stated in the report. 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 the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.



GEOCRES No

40P12-9

FEB. 5. 2001

# **FOUNDATION INVESTIGATION REPORT**

## **CONTRACT NO. 2000-0098**

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### Explanation of Terms Used in Report

Drawing No. 1	Borehole Locations and Soil Data
Appendix "A"	Record of Borehole Sheets
Appendix "B"	Laboratory Test Results

## 1. INTRODUCTION

This report presents the results of a foundation investigation carried out by AGRA Earth & Environmental Limited (AGRA) on behalf of Morrison Hershfield Limited at the existing Bayfield River Bridge (Site No. 12-188).

A section of the gabion retaining wall at the northeast corner of the existing bridge has been distorted and settled. The damage to the retaining wall has caused the embankment to become unstable and subject to erosion.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes. Based on this information, possible methods of rehabilitating the retaining wall and protecting the embankment from further erosion will be provided.

The work presented herein was undertaken under MTO W.P. 348-98-00, Agreement No. 3005-A-000012, and confirmed by Morrison Hershfield Limited, in a letter dated October 12, 1999.

Golder Associates undertook underwater investigation work at this site in 1986 under Agreement No. 4213-3086-043. This information was reviewed to supplement the present investigation.

## 2. SITE DESCRIPTION

### 2.1 Site Location and Condition

Highway 21 crosses the Bayfield River in Bayfield, Ontario. The existing  $\pm 12$  m wide by  $\pm 62$  m long Bayfield River Bridge was constructed in 1950 and consists of two spans supported on abutments and a central pier. The abutments and pier are supported on footing foundations founded at elevation 173.7 m (570.0 ft). The deck of the bridge is at elevation 185.6 m and the water level at the time of the fieldwork was at elevation 176.4 m.

Golder's 1986 report did not find any undermining of the abutments and central pier. However, an item of concern is the "void beneath gabion baskets on north abutment".

A gabion retaining wall exists along the east side of the north bridge abutment. The gabion wall wraps around the northeast side and is about 50 m long. The gabion baskets were typically 900 mm wide. The northwest side is supported by steel sheet piling.

At the time of field investigation, the gabion wall was exposed some 3 to 3.5 m above the water level at the bridge abutment. The height of the wall drops gradually towards the north. A portion of the gabion wall (approximately 8 m long) near the north end (on the east side) has settled some 1 to 1.5 m, presumably due to erosion/scouring and undermining by the river current. Minor movement of the embankment slope was also



observed at this failed retaining wall section. Major erosion/scouring has taken place immediately upstream of the site.

Adjacent to the bridge abutment, the gabion retaining wall appears to have bulged out. A 3 m wide gabion mat was noted lying on the streambed in front of the gabion wall.

The main river channel runs along the north abutment and the depth of the channel is approximately 3 to 4 meters. The north embankment is approximately 6 to 8 m higher than the retaining wall and standing at an average inclination of 1.6H to 1V. The slope surface is vegetated with mature trees and undergrowth.

The river is very shallow south of the main (north) channel. Islands of sand and gravel deposits were formed immediately upstream of the bridge. The south river channel is about 1.0 to 1.5 m deep in front of the south abutment. The embankment of the south abutment experiences some minor erosion.

## **2.2 Physiography and Topography**

The site is located within the Physiographic Region known as the Huron Slope. It occupies a narrow strip of land along the eastern side of Lake Huron in the Bruce and Huron Counties. It is essentially a clay plain modified by a narrow strip of sand, and by the beaches of glacial Lake Warren. The site, being located in the Bayfield River, is further modified by the Bayfield River. The lower Bayfield Valley is about 30 m deep and up to 0.8 km wide. High-level terraces and old oxbows are found in the valley.

The area is generally underlain by the clay till of the Port Huron Moraine System. The bedrock is limestone of the Detroit River Group, Onondaga Formation of the Middle Devonian age.

## **3. INVESTIGATION PROCEDURES**

### **3.1 Field Investigation**

Between September 16 and 28, 1999, a CME 55 track mounted drill rig was used on site for drilling and Standard Penetration Testing (SPT) following the procedures of ASTM D 1586.

Prior to field drilling, permissions to drill in Bayfield River were obtained from the Ministry of Natural Resources, Ministry of Environment and Ausable Bayfield Conservation Authority. A detailed sampling procedure was submitted to and approved by these authorities.

The initial drilling involved three (3) boreholes drilled in the river, one (1) borehole along the gabion wall and one (1) borehole at the top of the embankment slope adjacent to Highway 21. In order to drill the boreholes in the river, the drillrig was placed on a barge (with spud legs). Drilling and sampling were carried out using hollow stem augers, which

were performed inside a 300 mm diameter steel pipe (temporary liner) in order to prevent the auger cuttings from entering freely into the water.

One (1) borehole on top of the existing retaining wall was located in an area inaccessible to the drillrig. This borehole was advanced with a vibratory probe and continuous SPT sampling.

The boreholes were numbered 1 through 6 and the depths of the boreholes are as follows:

Borehole No.	Depth of Borehole (m)
1	9.2
2	8.3
3	7.5
4	10.0
5	15.7
6	10.7

Soil samples were retrieved at selected intervals of depths throughout the boreholes in conjunction with Standard Penetration Tests (SPT). Samples were generally taken at intervals of 0.75 m to 1.5 m intervals. Dynamic cone penetration testing was also carried out.

Seepage and water levels were noted in each borehole during and at the completion of drilling and sampling. A standpipe piezometer was installed in Borehole 5 for future monitoring of the groundwater level. All boreholes were grouted with bentonite mix at completion of sampling.

The fieldwork was supervised by a member of our field engineering staff under the direction of the project engineer. Our field staff cleared the location of buried utilities and logged the boreholes. The soil samples obtained were placed in labeled containers and transported to our Waterloo Office for further examination and laboratory testing.

The location and surface elevations at the as drilled borehole locations were surveyed by AGRA field staff. The borehole locations were referenced to the existing features such as the gabion retaining wall, abutment and catchbasins and plotted on a site plan supplied by MTO. The elevations of the boreholes were surveyed with reference to a Bench Mark set on the bridge abutment.

AGRA field staff also surveyed two cross-sections of the northeast embankment for the purpose of slope stability analysis.

The location of the boreholes, soil data and the slope profiles are presented on Drawing No.1.

The results of the drilling, sampling, in-situ testing and water level measurements are summarized on the Record of Borehole sheets and are enclosed in Appendix "A".

### 3.2 Laboratory Analysis

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all retrieved soil samples. In addition, grain size analyses, unit weights, Atterberg Limits and laboratory shear vane tests were performed on selected samples.

The results of the laboratory testing are presented on the borehole logs enclosed in Appendix "A", and in Figures 1 to 5 in Appendix "B".

## 4. SUBSURFACE CONDITIONS

### 4.1 General Subsurface Conditions

In general, the subsurface deposits at the site consist of mixed embankment fill to approximately the stream bed level (near elevation 174.5 m), typically  $\pm 11$  m thick from the existing Highway 21 road grade. The native soil deposits encountered below the stream bed level consists of sand and gravel over clayey silt which is in turn underlain by a gravelly sandy silt till interbedded with sand and gravel deposits.

In the streambed, a 0.4 to 1.0 m thick sediment was contacted. The sediment consists of clayey silt or sand and gravel mixed with wood and organic inclusions.

#### 4.1.1 Fill

Boreholes 4 and 6 were drilled behind the existing gabion wall and Borehole 5 were drilled at the top of the embankment adjacent to Highway 21. These boreholes contacted fill materials, which consist of loose/firm mixed gravel, silt, sand and clay. The lower portion of the fill also contains frequent organic inclusions. Two (2) typical grain size distributions of the fill are shown in Figure 2 of Appendix "B".

Standard penetration testing provided "N" values from 38 to 4 blows per 0.3 m. The upper portion of the fill was in compact to dense condition, and the fill became loose or firm to stiff below the upper compact layer. The unit weight of the fill material was measured to be between 18.5 and 22.8 kN/m<sup>3</sup>.

The fill materials were generally in moist to wet condition with natural moisture contents measured between 5 and 25 %.

#### 4.1.2 Sediment

Boreholes 1, 2 and 3 were located in the river. The water level was surveyed to be near elevation 176.4 m at the time of the fieldwork. There was some 1.7 to 2.1 m of water at the borehole locations. However, the streambed was noted to be 3 to 4 m deep at the north river channel.

Boreholes 1 to 3 contacted 0.4 to 1.0 m of sediment. The sediment consists of clayey silt or sand and gravel mixed with wood and organic inclusions.

#### 4.1.3 Sand and Gravel

Immediately underlying the fill and sediment, a sand and gravel deposit was encountered in five (5) of the six (6) boreholes (with the exception of Borehole 2). The thickness of this granular deposit ranged from 0.4 to 2.1 m. In Boreholes 1 to 4, sand and gravel also underlay the clayey silt.

The sand and gravel deposit contains some silt and cobbles/boulders. Three (3) typical grain size distributions of the sand and gravel are shown in Figure 3 of Appendix "B".

Standard penetration tests yielded typical "N" values from 16 to over 50 blows per 0.3 m, indicating a compact to very dense condition. One "N" value was measured at over 100 blows per 0.3 m in Borehole 2, indicating very dense condition.

The sand and gravel deposit was saturated with moisture contents measured between 5 and 20 %.

#### 4.1.4 Clayey Silt

A major stratum of brown to grey clayey silt was contacted below the sand and gravel deposit in all six (6) boreholes. This deposit was encountered at elevation  $\pm 174.2$  to 173.0 m and extended to elevation  $\pm 171.1$  to 171.5 m, and was approximately 1.7 to 2.9 m thick.

This deposit consists of silt lenses and was gravelly at various depths and locations. Eight (8) typical grain size distributions of the clayey silt are shown in Figures 4 and 5 of Appendix "B".

Standard penetration tests yielded "N" values from 5 to 33 blows per 0.3 m. Laboratory shear vane tests yielded undrained shear strength between 25 and 115 kPa. Based on these test results and tactile examination, the clayey silt is considered to have a firm to hard consistency. The unit weight of the clayey silt was measured to be between 20.2 and 21.0 kN/m<sup>3</sup>.

The Liquid Limit and Plastic Limit were determined on seven (7) samples (see Figure 1 of Appendix "B") and the results are summarized below:

Liquid Limit	18 to 25 %, average at 22%
Plastic Limit	11 to 15 %, average at 13%
Plasticity Index	7 to 10 %, average at 9%

These results are indicative of clayey soils of generally low plasticity. The measured natural moisture contents obtained from the deposit range from 10 to 21 % (with an average of 17 %).

#### 4.1.5 Silt Till

A major stratum of silt till underlay the clayey silt or sand and gravel layers. The silt till consists of embedded sand and gravel and frequent layers of sand and gravel deposit. The silt till extended to borehole termination depths of 7.5 to 9.2 m below the river level, near elevations 167.2 to 168.9 m. Refusal to augering was met at these levels which inferred the contact of bedrock.

The grain size distribution of a sample from Borehole 1 is shown on Figure 6 of Appendix "B". The deposit can be described as sandy silt till with some gravel.

Standard penetration tests yielded "N" values from 49 to over 100 blows per 0.3 m. The silt till is classified as dense to very dense. Natural moisture contents were between 9 and 15 %.

Boulders and/or cobbles are frequently embedded within glacial till deposits. The very high blow counts and augering resistance within the silt till may infer the presence of cobbles and boulders.

#### 4.2 Groundwater Conditions

On completion of drilling, the following observations of groundwater levels were made:

Borehole No.	Depth of Borehole (m)	Observation
1	9.2	Water level same as the river level at elevation 176.4 m
2	8.3	Water level same as the river level at elevation 176.4 m
3	7.5	Water level same as the river level at elevation 176.4 m
4	10.0	Water level at elevation 176.4 m 3 hours after completion
5	15.7	Water at 10.0 m, Elevation 175.5 m on 10/13/99, in standpipe
6	10.7	Water level at elevation 176.4 m 1 hour after completion

The water table in the boreholes was observed to be close to the water level in the river at elevation 176.4 m. It is noted that the groundwater table will fluctuate in response to the river condition.

Locally at Borehole 2, artesian condition was observed during sampling in the sand and gravel deposit, which was contacted below the clayey silt. After the clayey silt layer was penetrated, water level rose to 0.8 m above the river level for about 10 minutes.

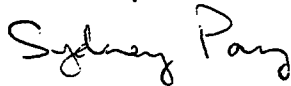
## 5. MISCELLANEOUS

The field work for this investigation was carried out between September 16 and 28, 1999 under the supervision of Scott Watling, Senior Technologist of AGRA Earth & Environmental Limited under the direction of Eric Y. Chung, P.Eng. This report was prepared by Eric Y. Chung and reviewed by Sydney Pan, P.Eng.

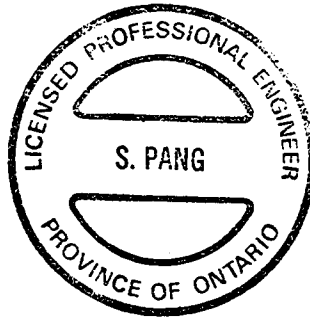
Yours truly,  
AGRA Earth & Environmental Limited



Eric Y. Chung, M.Eng., P.Eng.  
Kitchener-Waterloo Branch Manager



Sydney Pang, Ph.D., P.Eng.  
Senior Geotechnical Engineer



## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### MECHANICAL PROPERTIES OF SOIL

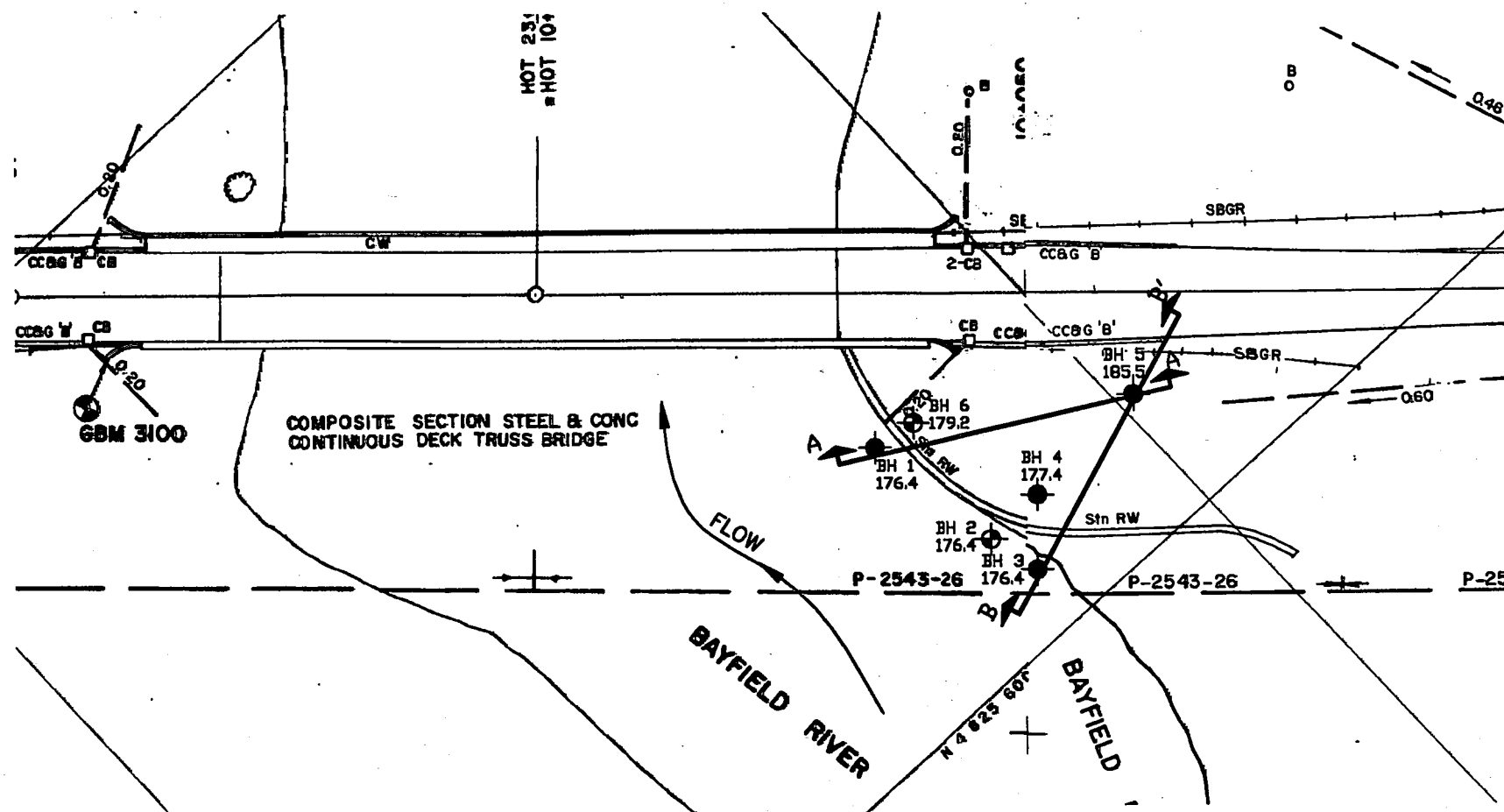
$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^3$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						



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

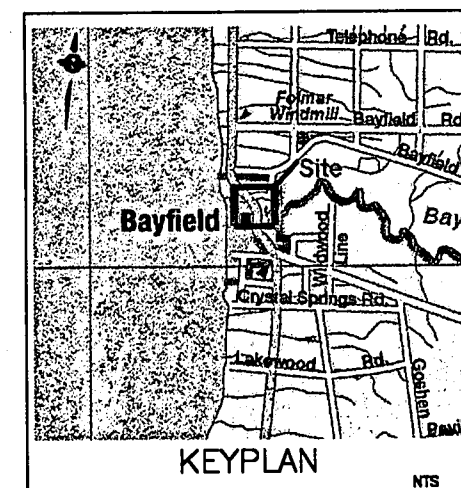
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WP No 348-98-00



Bayfield River Bridge  
Highway 21  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

**AGRA Earth & Environmental**  
ENGINEERING GLOBAL SOLUTIONS



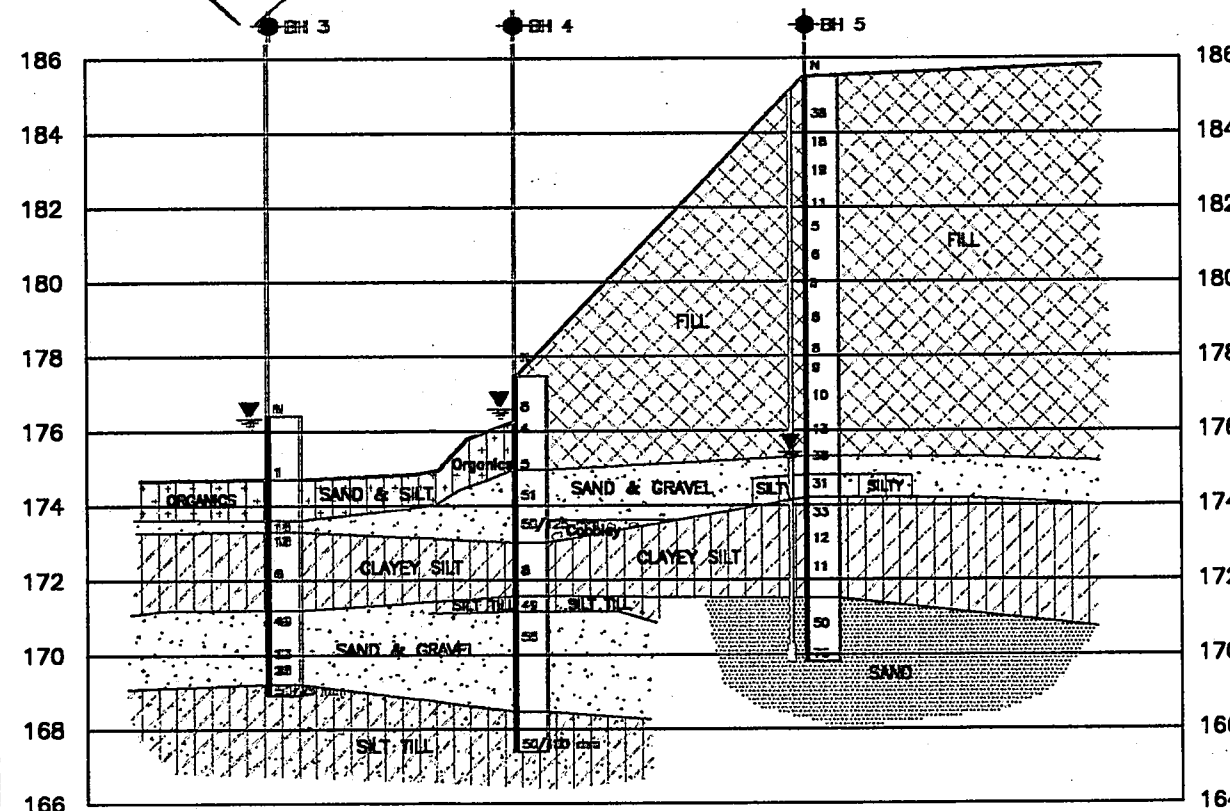
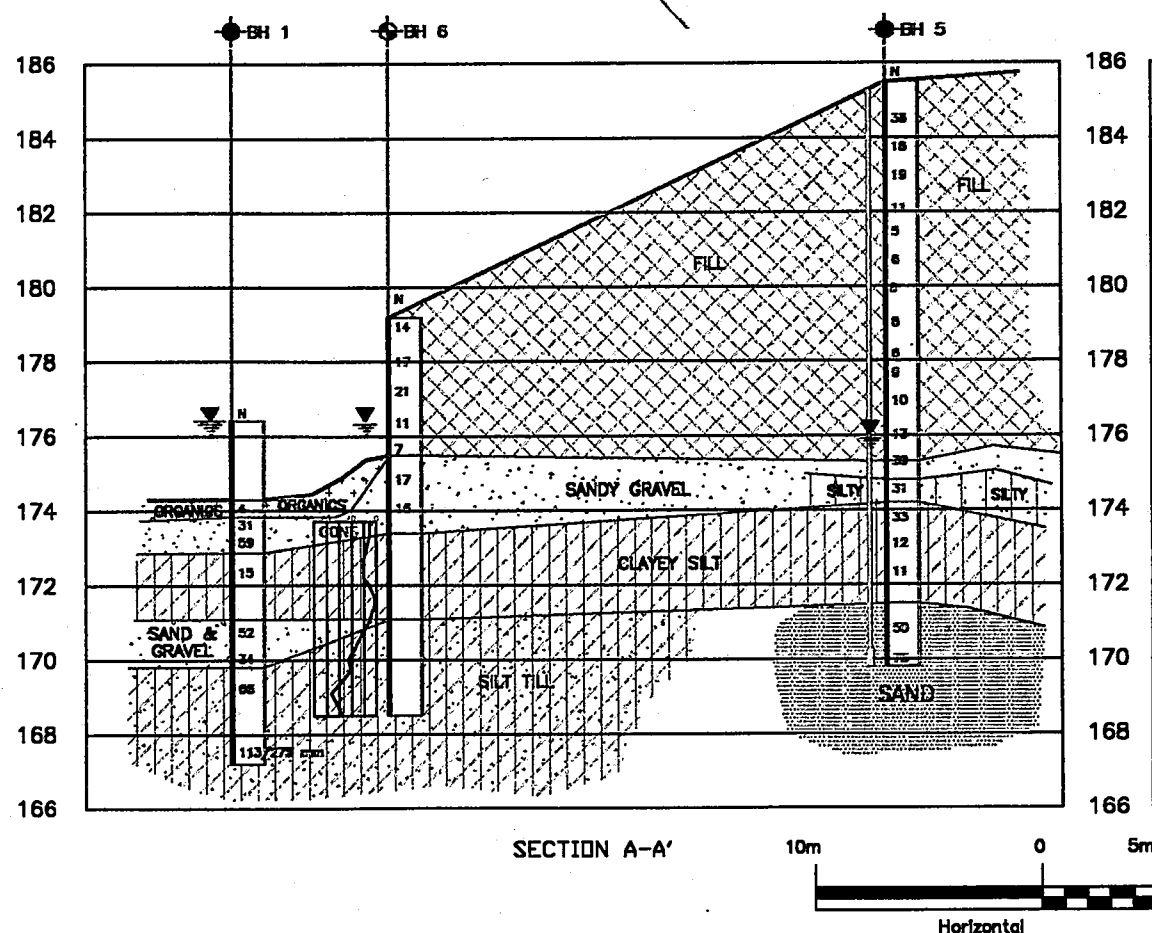
### LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation
- Standpipe

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	176.4		
2	176.4		
3	176.4		
4	177.4		
5	185.5		
6	179.2		

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

REVISIONS	DATE	BY	DESCRIPTION
12/13/99	SSY		
12/08/99	SSY		
Geocres : 40P12-8			
HWY No.	HWY NO 21	DIST	31
SUBM'D SSY	CHECKED EYC	DATE 10/18/99	SITE 12-188
DRAWN SSY	CHECKED EYC	DATE	DWG 1.



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downs Ave. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 022.01 of OPS Gen. Cond.



# APPENDIX “A”

## Record of Borehole Sheets

# RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
DIST 31 HWY 21 BOREHOLE TYPE H/S Auger with casing COMPILED BY SEW  
DATUM Geodetic DATE 18.09.99 - 17.09.99 CHECKED BY EYC

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)				
176.4 0.0	Water						20	40	60	80	100								
174.3	CHANNEL BED at 2.05m BELOW WATER LEVEL on 9/16/99																		
2.1	Loose, grey SANDY GRAVEL SEDIMENT saturated		1	SS	4														
173.7	Dense to very dense, grey SANDY GRAVEL saturated		2	SS	31														
			3	SS	59														
172.9	Stiff, light brown CLAYEY SILT, trace sand, trace to some gravel very moist		4	SS	15														
3.5			5	ST															
			6	ST															
171.1	Very dense to dense, grey SAND and GRAVEL saturated		7	SS	52														
5.3			8	SS	34														
169.8	Very dense, grey/brown SILT TILL, some clay, gravel and sand layers moist		9	SS	66														
6.6																			

EXPRESS 12-188 GPJ EXPRESS.GDT 13/12/99

# RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
DIST 31 HWY 21 BOREHOLE TYPE H/S Auger with casing COMPILED BY SEW  
DATUM Geodetic DATE 16.09.99 - 16.09.99 CHECKED BY EYC

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80
178.4	Water															
0.0																
174.5	CHANNEL BED at 1.65m BELOW WATER LEVEL on 9/16/99															
1.9	Firm, grey CLAYEY SILT SEDIMENT, some sand, trace gravel, some wood fragments saturated		1	SS	6											
174.1																
2.3	Firm, grey CLAYEY SILT, trace to some gravel moist to very moist															
171.5																
4.9	Compact to dense, grey SAND and GRAVEL saturated		2	SS	5											
			3	SS	7											
			4	SS	57											
			5	CT	0											
			6	CT	14											
			7	CT	33											
			8	CT	30											
			9	CT	25											
169.5			10	CT	50											
6.9	Very dense, grey SILT TILL, some clay, sand and gravel very moist															
168.8																
7.8	Very dense, grey SAND and GRAVEL saturated		11	SS 59/170mm												
168.1																
8.3	AUGER REFUSAL at 8.3 m NOTE* Artesian condition rose to 0.8 m above water level of river for approximately 10 minutes after sample 4															

EXPRESS 12-188 GPJ EXPRESS GDT 13/12/99

# RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
 DIST 31 HWY 21 BOREHOLE TYPE H/S Auger with casing COMPILED BY SEW  
 DATUM Geodetic DATE 17.09.99 - 17.09.99 CHECKED BY EYC

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	◆ FIELD VANE ✕ LAB VANE						
176.4	Water							20 40 60 80 100							
0.0															
	CHANNEL BED at 1.70m BELOW WATER LEVEL on 9/16/99														
174.7															
1.7	Very loose, black SAND and SILT SEDIMENT, wood inclusions, occasional cobble saturated		1	SS	1										
174.3															
2.1	Compact														
173.6															
2.7	Compact, dark grey SAND and GRAVEL saturated		2	SS	18										
173.3															
3.1	Very stiff, greyish brown CLAYEY SILT moist		3	SS	18										
172.7															
3.7	Soft to firm, grey CLAYEY SILT, trace to some gravel very moist		4	SS	6										

EXPRESS. 12-188.GPJ EXPRESS.GDT 13/12/99

# RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
 DIST 31 HWY 21 BOREHOLE TYPE H/S Auger COMPILED BY SEW  
 DATUM Geodetic DATE 20.09.99 - 20.09.99 CHECKED BY EYC

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
177.4	Ground													
0.0	Compact to loose, dark brown silt and gravel FILL, some fine sand and cobbles													
	moist		1	SS	8									
			2	SS	4									
175.0	wood inclusions saturated		3	SS	5									
174.7	Very dense, dark grey coarse SAND and GRAVEL saturated		4	SS	51									
173.6	Silty, some cobbles		5	SS 50/125mm										
173.0	Soft to firm, brown CLAYEY SILT, trace to some gravelly silt layers very moist		6	SS	8									
171.3	Dense, brown SILT TILL damp		7	ST										
170.9	Very dense, grey coarse SAND and GRAVEL saturated		8	SS	49									
168.2	Very dense, greyish brown SILT TILL, trace to some sand damp		9	SS	56									
167.4	AUGER REFUSAL at 10.0 m NOTE* Water level encountered at 176.4 m 3 hrs after completion		10	SS 50/100mm										

EXPRESS: 12-188 GPJ EXPRESS.GDT 13/12/99

# RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
 DIST 31 HWY 21 BOREHOLE TYPE H/S Auger COMPILED BY SEW  
 DATUM Geodetic DATE 21.09.99 - 21.09.99 CHECKED BY EYC

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	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 80 100										
							○ UNCONFINED	✱ FIELD VANE										
							● QUICK TRIAXIAL	✱ LAB VANE										
							20 40 60 80 100					10 20 30						
185.5	Ground																	
0.0	Dense to compact, dark brown silty sand and gravel FILL, large asphalt pieces damp		1	SS	38		185							55 40 (5)				
			2	SS	18		184						19.5					
183.2	Compact, dark brown silt and sand FILL, some gravel, glass fragments damp		3	SS	19		183						22.8	28 56 (18)				
2.3			4	SS	11		182											
181.7	Firm to stiff, greyish brown clay and silt FILL, occasional gravel, some dark grey staining moist		5	SS	5		181						18.5					
3.8			6	SS	6		180						19.5					
			7	SS	8		179											
			8	SS	8		178											
			9	SS	8		177						21.5					
			10	SS	9		176						20.5					
			11	SS	10		175						18.5					
			12	SS	13		174											
175.3	Compact, dark grey SAND and GRAVEL		13	SS	30		173											
10.2			14	SS	31		172											
174.8	Silty Saturated		15	SS	33		171											
10.7			16	SS	12		170											
174.2	Hard to stiff, brown CLAYEY SILT, trace sand and gravel moist		17	SS	11													
11.3			18	ST														
171.5	Dense to very dense, brown fine SAND saturated		19	SS	50													
14.0			20	SS	75													
169.8	END OF BOREHOLE at 15.7 m NOTE* Water level recorded in piezometer at 10.0m on 10/13/99																	
15.7																		

EXPRESS. 12-188 GPJ EXPRESS GDT 13/12/99

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 348-98-00 LOCATION SITE No. 12-188, Bayfield River Bridge, Hwy. 21 ORIGINATED BY SEW  
 DIST 31 HWY 21 BOREHOLE TYPE Continuous SPT COMPILED BY SEW  
 DATUM Geodetic DATE 28.09.99 - 28.09.99 CHECKED BY EYC

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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	● FIELD VANE						
								● QUICK TRIAXIAL	✕ LAB VANE						
179.2	Ground					20 40 60 80 100	20 40 60 80 100	10 20 30							
0.0	Loose to compact, dark brown to black sandy silt FILL, some crushed gravel moist		1	SS	14		179								
177.9			2	SS	17		178								
1.2	Compact, brown clayey silt FILL, trace gravel moist to very moist														
177.5			3	SS	21		177								
1.7	Compact, dark grey silt and fine sand FILL moist														
176.9			4	SS	11		176								
2.3	Loose, olive organic silt FILL, some wood inclusions wet		5	SS	7		175								
176.5			6	SS	17		174								
2.7	Loose, dark grey fine sand and silt FILL, frequent shell fragments, frequent woody inclusions saturated		7	SS	16		173								
175.5			8	CT	12		172								
3.7	Compact, grey coarse to medium SAND, some gravel, frequent fine to medium sand layers saturated		9	CT	10		171								
			10	CT	16		170								
173.4			11	CT	21		169								
5.8	Soft to firm, grey CLAYEY SILT wet		12	CT	21										
			13	CT	11										
			14	CT	1										
			15	CT	2										
171.1			16	CT	9										
8.1	Compact to very dense, grey SILT TILL, some clay, gravel and sand moist to damp		17	CT	15										
			18	CT	23										
			19	CT	44										
			20	CT	48										
			21	CT	40										
			22	CT	55										
			23	CT	74										
			24	CT	55										
168.5															
10.7	END OF BOREHOLE at 10.7 m NOTE* Water level at 176.4 m, 1hr after completion														

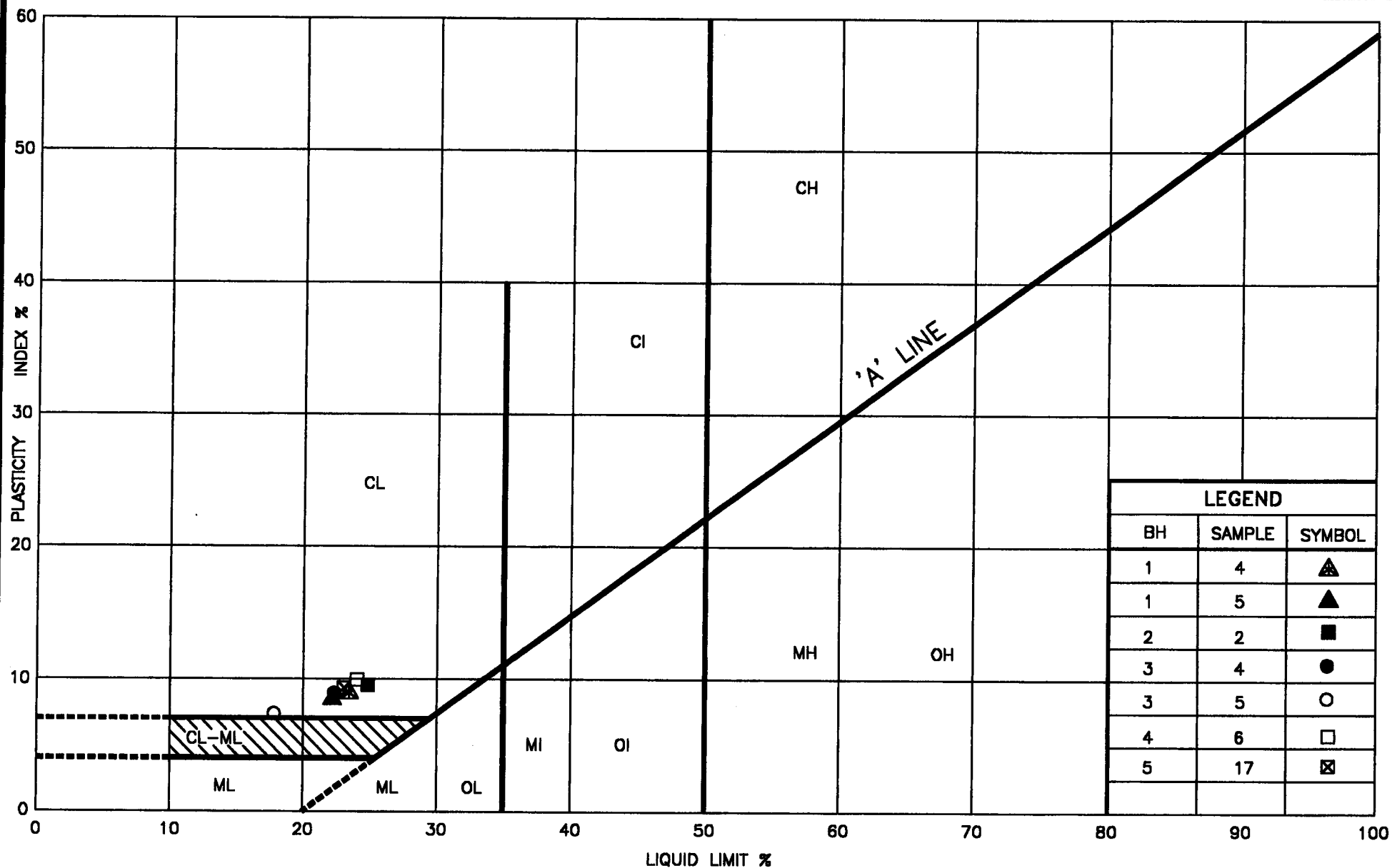
+3, X3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

EXPRESS: 12-188.GPJ EXPRESS.GDT 13/12/99

# APPENDIX “B”

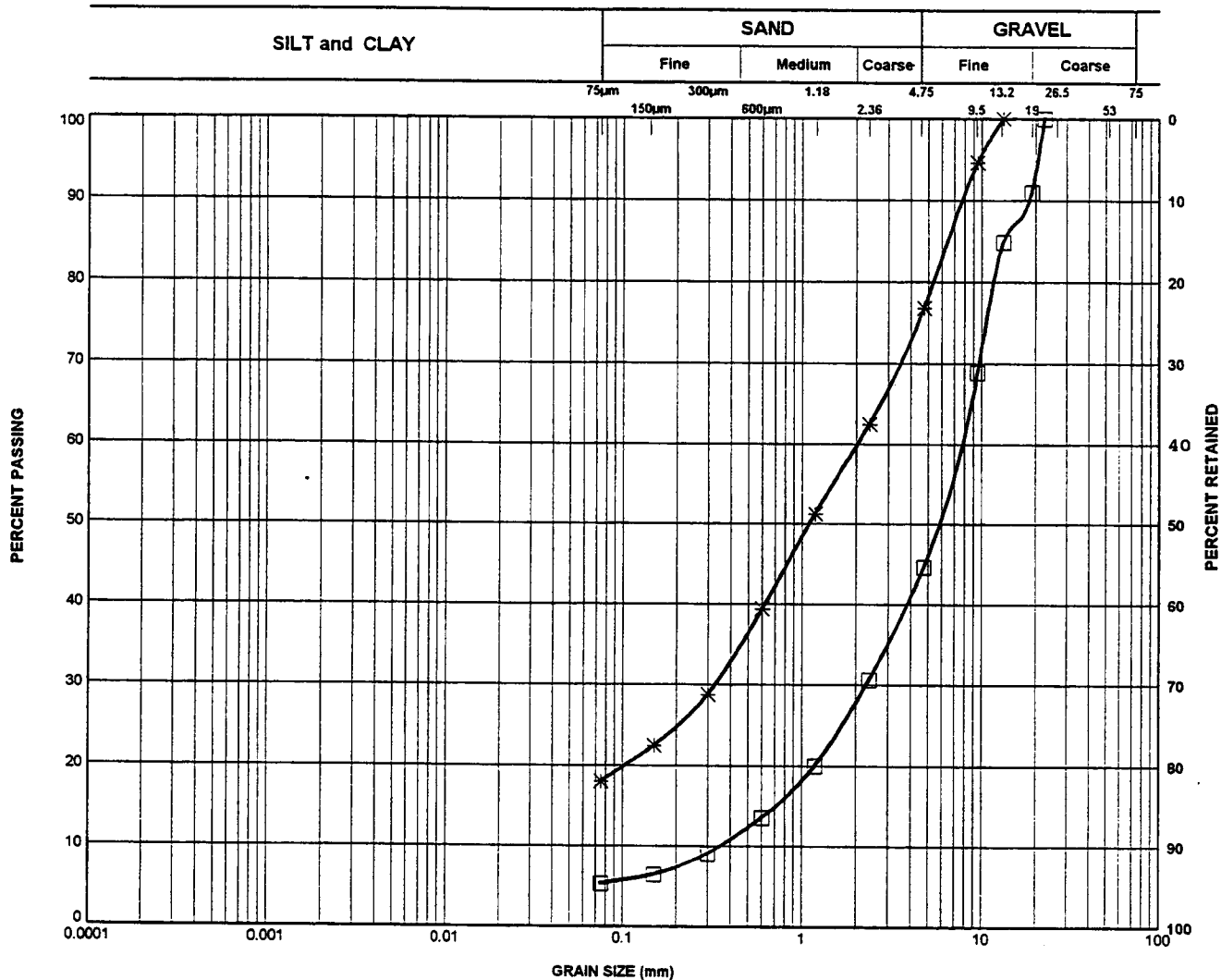
## Laboratory Test Results





# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM

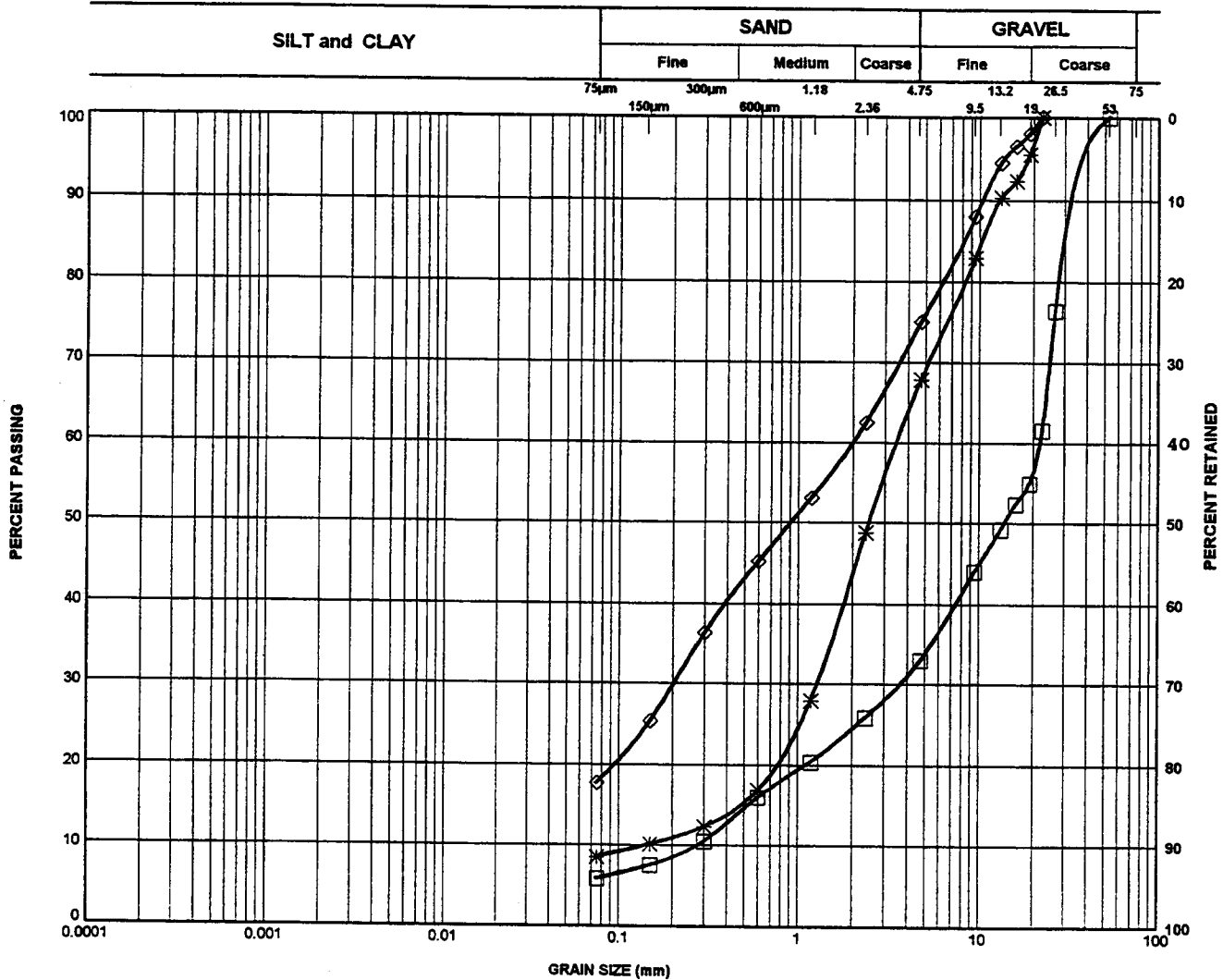


LEGEND		
SYMBOL	BOREHOLE	DEPTH (m)
□	5	0.8
*	5	2.4

**SAND and GRAVEL FILL**

# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM



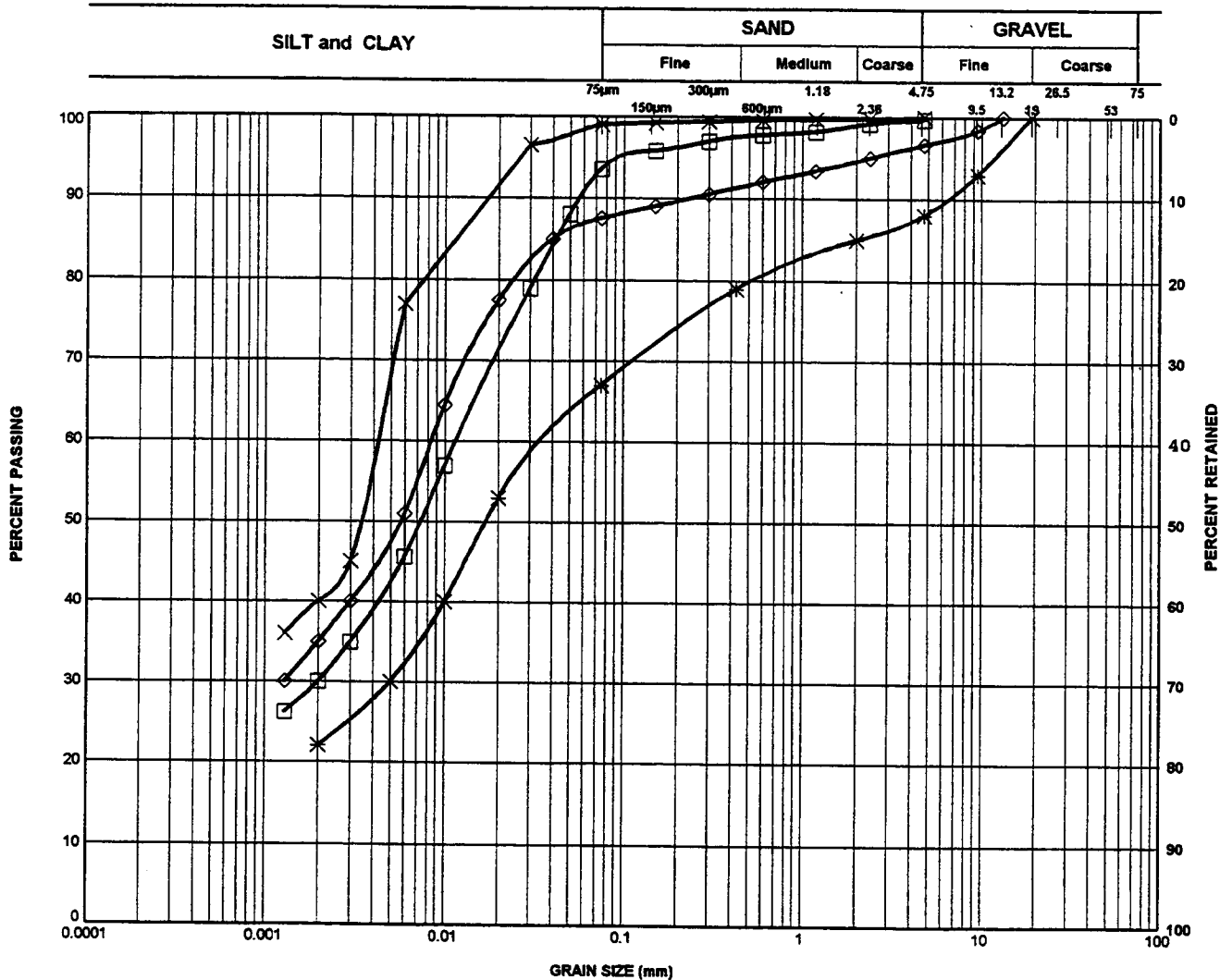
### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)
□	1	2.6
*	3	5.4
◇	3	6.1

**SAND and GRAVEL**

# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM

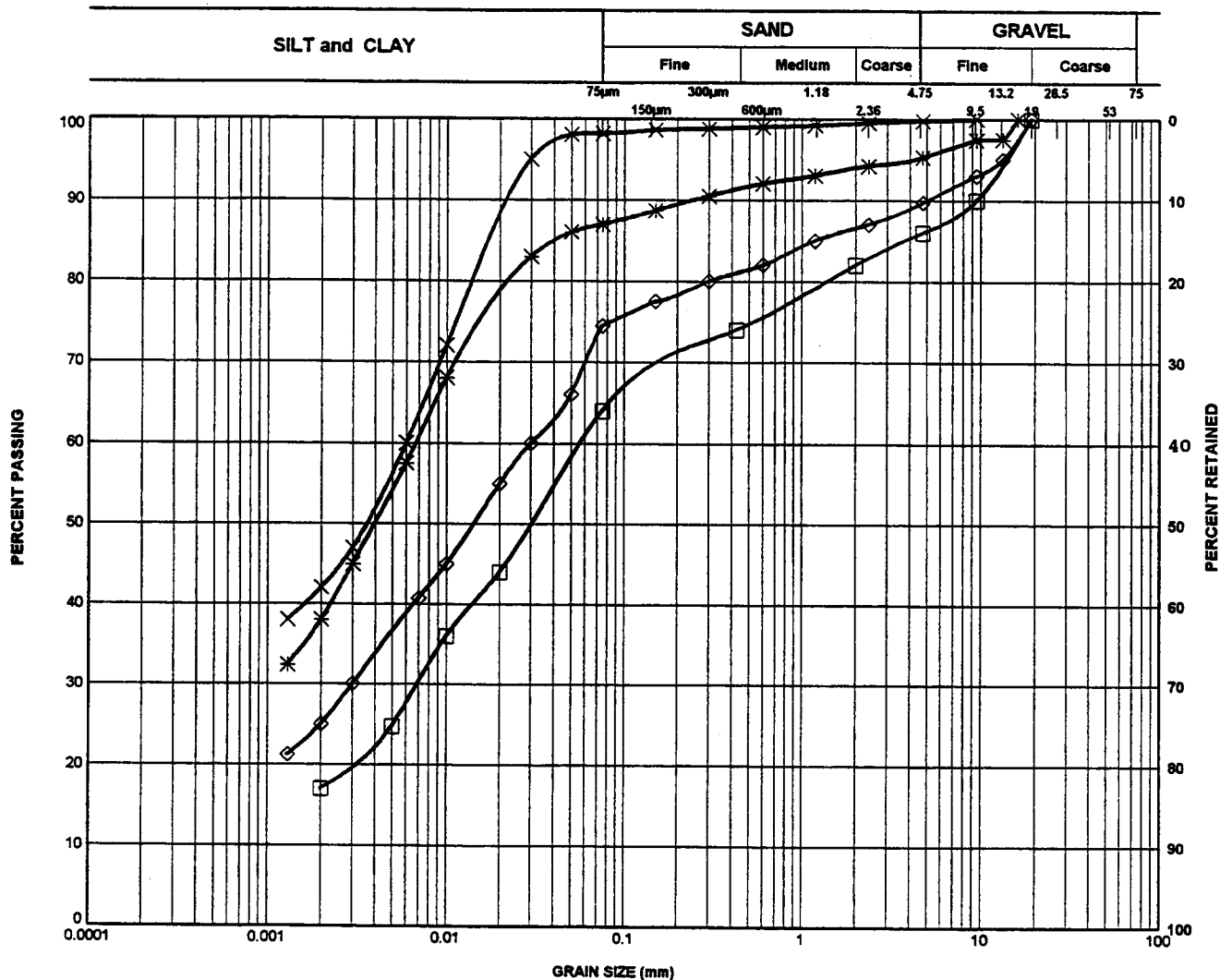


LEGEND		
SYMBOL	BOREHOLE	DEPTH (m)
□	1	3.9
*	1	4.6
◇	2	3.4
×	3	3.8

**CLAYEY SILT**

# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM

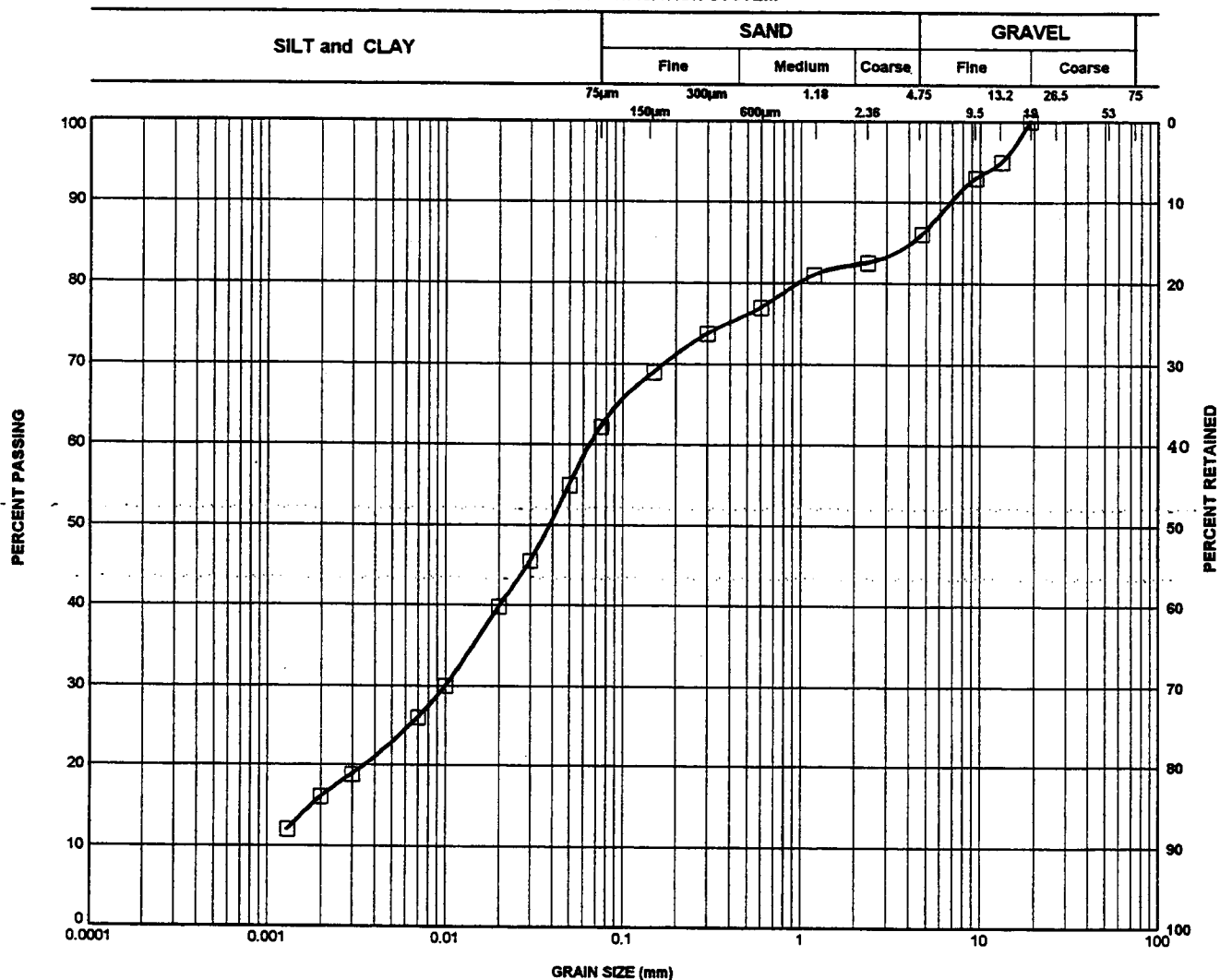


LEGEND		
SYMBOL	BOREHOLE	DEPTH (m)
□	3	4.6
*	4	5.3
◇	5	11.5
×	5	13.0

**CLAYEY SILT**

# GRAIN SIZE DISTRIBUTION

## UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND		
SYMBOL	BOREHOLE	DEPTH (m)
□	1	6.9

**SILT TILL**



## **Golder Associates**

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

REPORT TO  
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

UNDERWATER INSPECTIONS  
BRIDGE PIERS AND ABUTMENTS  
DISTRICTS 3 (STRATFORD)  
AND 5 (OWEN SOUND)  
AGREEMENT NO. 4213-3086-043

Distribution:

3 copies - Ministry of Transportation and Communications  
London, Ontario  
2 copies - Golder Associates  
London, Ontario

November 1986

861-3255



## Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

November 24, 1986

Our ref: 861-3255

Ministry of Transportation and  
Communications  
659 Exeter Road  
LONDON, Ontario  
N6A 5H2

ATTENTION: Mr. V.F. Boehnke, P. Eng.  
Head, Structural Section

RE: UNDERWATER INSPECTIONS  
BRIDGE PIERS AND ABUTMENTS  
DISTRICTS 3 (STRATFORD)  
AND 5 (OWEN SOUND)  
AGREEMENT NO. 4213-3086-043

Dear Sirs:

This letter and the attached documents present the results of an underwater bridge inspection programme carried out in the above noted districts. The purpose of this letter is to outline inspection methods, describe the Field Bridge Inspection Report forms and related terminology and, finally, to summarize any major elements of concern disclosed throughout the course of the programme.

1. TERMS OF REFERENCE

It is understood that the primary objective of the programme was to determine the underwater condition of bridge piers and abutments, particularly as related to concrete deterioration, steel corrosion and bottom scour. The programme was to consist of the inspection of nine single bridges and one double bridge. Adverse water conditions prohibited the inspection of one bridge, as later identified.



The investigation programme was carried out in accordance with our proposal dated September 18, 1986 and Consultant's Agreement No. 4213-3086-043. A list of the bridges inspected together with their respective inspection dates, is presented in Table I, attached.

## 2. FIELD WORK

### 2.1 General

All field work was carried out by a two man inspection team consisting of one diver/technician and one geotechnical engineer. Inspection procedures typically consisted of underwater inspection of relevant bridge component materials and channel bottom characteristics. This was followed by water depth soundings and a brief above-water inspection. Field data and pertinent observations were recorded on Field Bridge Inspection Report Forms, as attached.

### 2.2 Underwater Inspection

Underwater inspections were carried out by the diver/technician with observations being relayed to, and recorded by the engineer.

Visual inspections of both concrete and steel were carried out to the extent possible consistent with water clarity. The visual inspections were supplemented with hammer testing for material soundness. River bottom materials were also examined and identified visually and then probed to evaluate approximate densities. Probing entailed the underwater insertion, by hand, of a 12.5 millimetre diameter metal rod with a blunt tapered end. Probe insertion was also conducted at material interfaces to gauge the integrity of contacts. Bridge material conditions, channel bottom material types, and probe

penetration depths are presented in the appropriate sections on the attached Field Bridge Inspection Reports. Where small diameter (less than 2 metres), localized depressions in channel materials were observed in close proximity to bridge components, they were identified as visible scour and their locations and approximate depths were recorded on the inspection forms.

Where visibility permitted, underwater photographs were taken of any features of particular relevance to the inspection programme.

### 2.3 Depth Soundings

Water depth soundings were conducted from the surface (by small boat) by lowering a graduated survey rod to the river bottom. Soundings were taken in a series of lines moving outward from the bridge component being inspected. Each line typically consisted of three soundings at intervals of 1.5 metres with the first being taken directly against the bridge component at the channel bottom. For each bridge, water levels were referred to a structural datum which can be utilized to correlate measured channel bottom depths with structural drawings.

Large scale bottom geometry features which could not be observed visually may be inferred from sounding depths. Sounding locations and depths are provided in the appropriate section on the Field Bridge Inspection Report forms.

### 2.4 Above-Water Inspection

We understand that each bridge included in the underwater inspection programme was previously inspected above water by representatives of the Ministry of Transportation

and Communications. In addition, a brief above-water inspection was carried out at each site as part of the current programme. The purpose of this inspection was to provide a ready comparison between above-water and below-water material conditions as well as to provide a means of correlating descriptive terminology used in the underwater inspections with that used previously by the Ministry. Photographs were generally taken of any particularly relevant above-water features.

### 2.5 Bridge 12-102

Bridge 12-102 is the Maitland River Bridge at Goderich. Heavy rainfall had caused swollen river conditions and rapid flow and consequently, the inspection was not carried out in the interest of diver safety.

## 3. FIELD BRIDGE INSPECTION REPORT FORMS

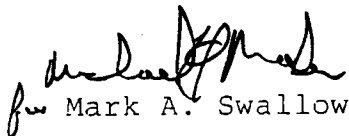
The report forms, following the text of this report, contain the observations and data recorded in the field and are generally self-explanatory. Where blank spaces have been left on the forms, the information concerned was either not applicable or not determined.

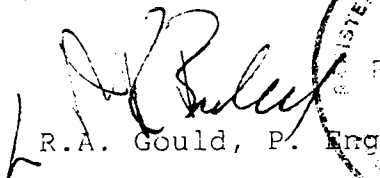
## 4. SUMMARY OF ITEMS OF CONCERN

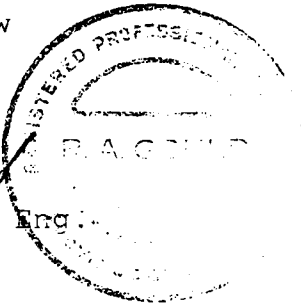
Table II contains a brief summary of the items of primary concern disclosed at each site. Those bridges for which no items are noted may possess other problems which are described on the Field Bridge Inspection Report forms.

We trust that this letter, the attached tables, and the attached field reports provide sufficient information to fulfill your current requirements. Should any point require additional clarification, or if we can be of further service in this or other similar projects, please do not hesitate to contact this office.

Yours truly  
GOLDER ASSOCIATES

  
for Mark A. Swallow

  
R.A. Gould, P. Eng.



MAS/RAG/bb

TABLE 1

861-3255

BRIDGE SUMMARY FOR UNDERWATER INSPECTIONS

<u>SITE NO.</u>	<u>BRIDGE NAME</u>	<u>HIGHWAY</u>	<u>DATE INSPECTED</u>
25-264 ✓	Perth Middlesex Boundary Bridge	7	October 6/86
12-102 ✓	Maitland River Bridge*	21	October 6/86
12-188 ✓	Bayfield River Bridge	21	October 7/86
2-274 ✓	Saugeen River Bridge	4	October 8/86
30-116	Nottawasaga River Bridge	26	October 9/86
30-334	North Canal Twin Bridges East Bridge West Bridge	400	October 10/86 October 14/86
30-46 ✓	Trent Valley Canal Bridge	11	October 15/86
30-10	Severn River Bridge	11	October 15/86
30-02	Matchedash Bay Bridge	69	October 16/86
33-58	Grand River Covered Bridge	86	October 17/86

\*Not inspected due to swift current

SUMMARY OF ITEMS OF PRIMARY CONCERN

<u>BRIDGE NAME</u>	<u>ITEMS OF CONCERN</u>
Perth Middlesex Boundary Bridge	<ul style="list-style-type: none"><li>- concrete delaminations behind steel nosing above and below water</li><li>- steel nosing peeling on west pier</li></ul>
Bayfield River Bridge	<ul style="list-style-type: none"><li>- void beneath gabion baskets on north abutment</li></ul>
Saugeen River Bridge	<ul style="list-style-type: none"><li>- bottom scour approximately 0.4 to 0.5 metres deep at north tips of both piers</li></ul>
Nottawasaga River Bridge	<ul style="list-style-type: none"><li>- moderate delaminations above water on south face of east pier</li><li>- bottom scour approximately 0.5 metres deep at northwest end of east pier</li></ul>
North Canal Twin Bridges	
East Bridge	<ul style="list-style-type: none"><li>- cracking and surface erosion at base of 4th column from east on central pier</li><li>- central pier footing undermined by up to 0.8 metres</li><li>- gulley eroded in north abutment</li></ul>
West Bridge	<ul style="list-style-type: none"><li>- central pier footing undermined by up to 0.3 metres</li></ul>
Trent Valley Canal Bridge	<ul style="list-style-type: none"><li>- moderate cracking and efflorescence above water on south abutment</li><li>- poor concrete-bedrock contact at south abutment</li><li>- fractured foundation rock at south abutment</li><li>- rubble zone in retaining wall at north abutment</li></ul>

SUMMARY OF ITEMS OF PRIMARY CONCERN

<u>BRIDGE NAME</u>	<u>ITEMS OF CONCERN</u>
v Severn River Bridge	- severe cracking on underside of bridge deck and on west face of south abutment
v Grand River Covered Bridge	- severe cracking and surface erosion at base of north abutment - erosion of mortar from joints central pier

# FIELD BRIDGE INSPECTION REPORT - UNDERWATER FEATURES

## PART A - GENERAL DESCRIPTION

PROJECT NO. 861-3255

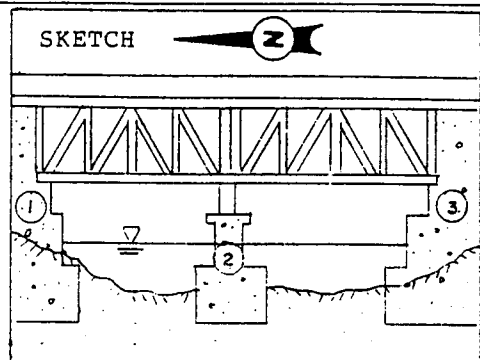
### INSPECTION

DATE: October 7, 1986  
 CREW: Mark Swallow (Engineer), Greg Prichard (Diver/Technician)  
 WEATHER: Sunny  
 TEMPERATURE: 13°C  
 TO BE INSPECTED: Central Pier 2 Abutments

### IDENTIFICATION

BRIDGE NAME: Bayfield River Bridge  
 SITE NO: 12-188, District 3  
 LOCATION: Hwy. 21 & Bayfield River  
 NO. OF SPANS: 2  
 APPROXIMATE AGE: 40 years  
 ELEVATION DATUM: Top of Central Pier

### SKETCH



### WATER INFORMATION

DEPTH OF WATER FROM DATUM: 2.15 m  
 DIRECTION OF FLOW: West  
 VELOCITY OF FLOW: Negligible  
 WATER TEMPERATURE: 13°C  
 WATER CLARITY:

VISIBILITY: ☒ <0.5m ☐ 0.5-2m ☐ >2m

### PHOTOGRAPHS

NO.	DESCRIPTION	ATTACHED
1-4	General above water bridge and diver	2



# FIELD BRIDGE INSPECTION REPORT - UNDERWATER FEATURES

## PART B - COMPONENT DESCRIPTION

SITE NO. 12-188, District 3

### PIER/ABUTMENT DESCRIPTION

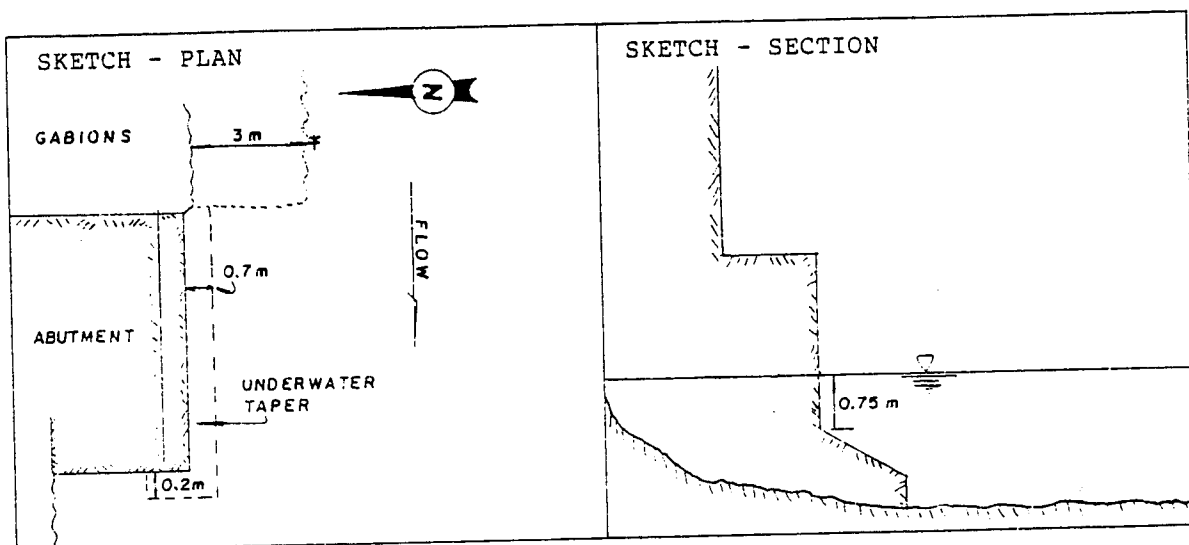
☐ PIER ☒ ABUTMENT

PIER/ABUTMENT NO. 1

DEPTH FROM DATUM TO TOP OF FOOTING: 2.90 m

### FOUNDATION TYPE

Footing on Piles ☐  
 Spread Footing ☒  
 Unknown ☐



### CONDITION OF MATERIALS

#### CONCRETE

Surface Erosion  
 Delaminations  
 Cracking  
 Efflorescence  
 Exposed Reinforcing

ABOVE WATER				BELOW WATER			
NONE	MINOR	MOD.	SEVERE	NONE	MINOR	MOD.	SEVERE

x				x			
x					x*		
	x				x		
	x				x		
x				x			

\*probe inserted  
 0.3m horizontally  
 beneath gabion mats

\*-2m from east end  
 0.2m below water  
 delam. to depth 35 mm

#### STEEL

SHEETING ☐ NOSING ☐ COMPLETE

Corrosion  
 Buckling


#### REINFORCING

Corrosion

--	--	--	--	--	--	--	--

# FIELD BRIDGE INSPECTION REPORT - UNDERWATER FEATURES

PART B - COMPONENT DESCRIPTION (Cont.) SITE NO. 12-188, District 3

PIER/ABUTMENT NO. 1

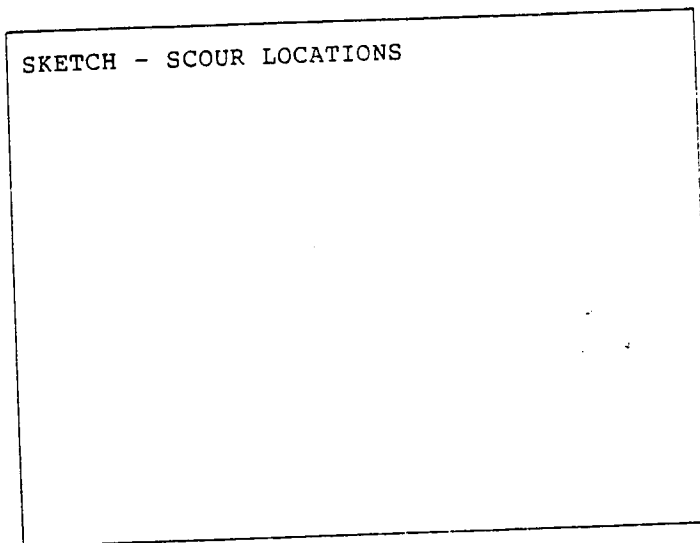
## CHANNEL BOTTOM

MATERIAL TYPE Sand and gravel, 100 mm silt at east, occasional concrete rubble  
PROBE PENETRATION 75 mm

VISIBLE SCOUR ☐ Yes  
☒ No

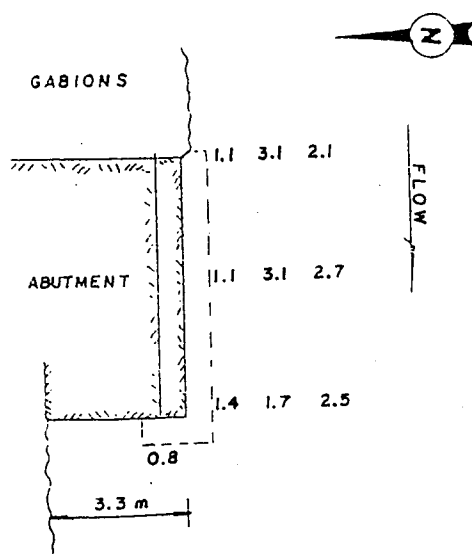
APPROXIMATE SCOUR DEPTH: n/a

SKETCH - SCOUR LOCATIONS



## SOUNDINGS

SKETCH - SOUNDING LOCATIONS PLAN



### NOTE:

- Depths given in metres below water level
- 1.5m spacing between successive soundings
- first sounding immediately against component at channel bottom

# FIELD BRIDGE INSPECTION REPORT - UNDERWATER FEATURES

## PART B - COMPONENT DESCRIPTION

SITE NO. 12-188, District 3

### PIER/ABUTMENT DESCRIPTION

☒ PIER ☐ ABUTMENT

PIER/ABUTMENT NO. 2

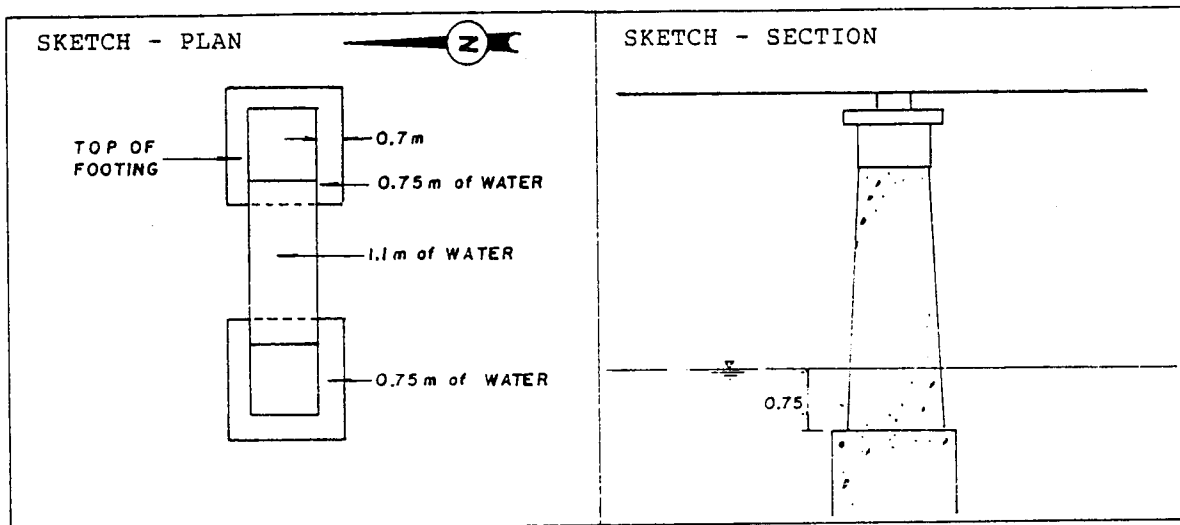
DEPTH FROM DATUM TO TOP OF FOOTING: 2.90 m

### FOUNDATION TYPE

Footing on Piles ☐

Spread Footing ☒

Unknown ☐



### CONDITION OF MATERIALS

#### CONCRETE

Surface Erosion

Delaminations

Cracking

Efflorescence

Exposed Reinforcing

ABOVE WATER				BELOW WATER			
NONE	MINOR	MOD.	SEVERE	NONE	MINOR	MOD.	SEVERE

x				x			
x				x			
	x				x		
	x				x		
x				x			

#### STEEL

SHEETING ☐ NOSING ☐ COMPLETE

Corrosion

Buckling


#### REINFORCING

Corrosion

--	--	--	--	--	--	--	--

# FIELD BRIDGE INSPECTION REPORT - UNDERWATER FEATURES

## PART B - COMPONENT DESCRIPTION (Cont.)

SITE NO. 12-188, District 3

PIER/ABUTMENT NO. 2

### CHANNEL BOTTOM

MATERIAL TYPE Sand and gravel, cobbles and boulders; silt in depressions

PROBE PENETRATION 0.1 m

VISIBLE SCOUR ☐ Yes

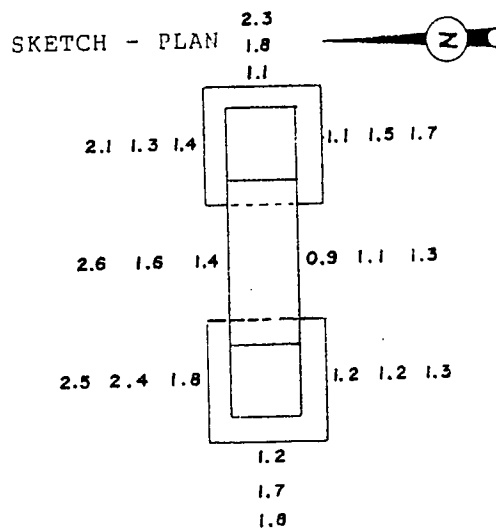
☒ No

APPROXIMATE SCOUR DEPTH: n/a

### SKETCH - SCOUR LOCATIONS

### SOUNDINGS

#### SKETCH - SOUNDING LOCATIONS PLAN



#### NOTE:

- Depths given in metres below water level
- 1.5m spacing between successive soundings
- first sounding immediately against component at channel bottom

# FIELD BRIDGE INSPECTION REPORT - UNDER PIER FEATURES

## PART B - COMPONENT DESCRIPTION

SITE NO. 12-188, District 3

### PIER/ABUTMENT DESCRIPTION

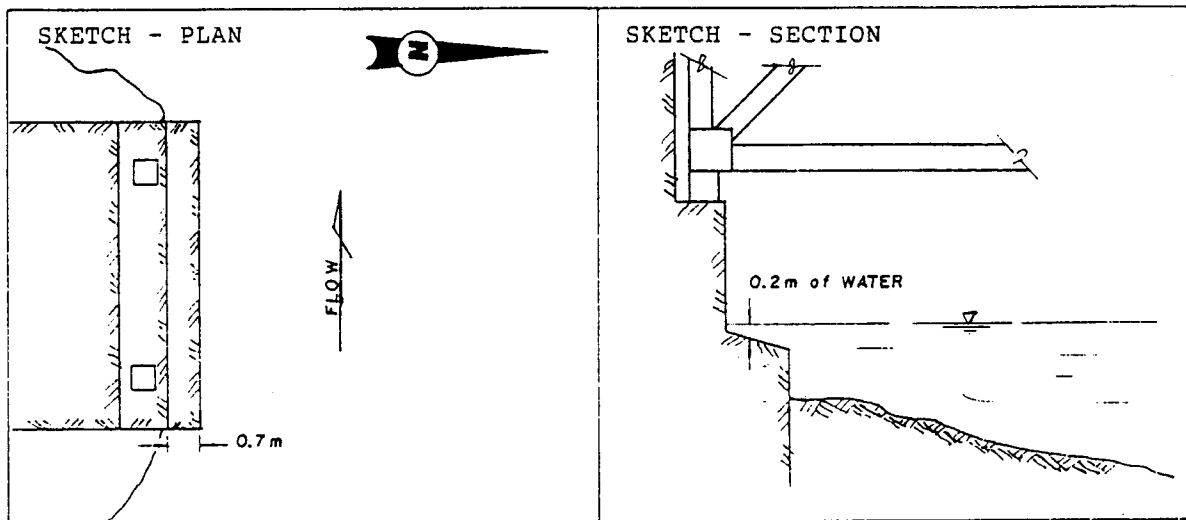
☐ PIER ☒ ABUTMENT

PIER/ABUTMENT NO. 3

DEPTH FROM DATUM TO TOP OF FOOTING: 2.35 m

### FOUNDATION TYPE

Footing on Piles ☐  
 Spread Footing ☒  
 Unknown ☐



### CONDITION OF MATERIALS

#### CONCRETE

Surface Erosion  
 Delaminations  
 Cracking  
 Efflorescence  
 Exposed Reinforcing

ABOVE WATER				BELOW WATER			
NONE	MINOR	MOD.	SEVERE	NONE	MINOR	MOD.	SEVERE

x				x			
x				x			
	x				x		
	x				x		
x				x			

#### STEEL

SHEETING ☐ NOSING ☐ COMPLETE

Corrosion  
 Buckling


#### REINFORCING

Corrosion

--	--	--	--	--	--	--	--

FIELD BRIDGE INSPECTION REPORT - UNDERWATER FEATURES

PART B - COMPONENT DESCRIPTION (Cont.) SITE NO. 12-188, District 3

PIER/ABUTMENT NO. 3

CHANNEL BOTTOM

MATERIAL TYPE 0.13m silt over sand and gravel, cobbles and concrete rubble

PROBE PENETRATION 0.2 m

VISIBLE SCOUR ☐ Yes

☒ No

APPROXIMATE SCOUR DEPTH: n/a

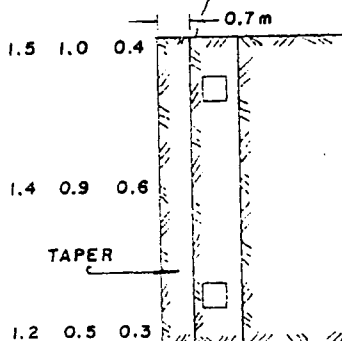
SKETCH - SCOUR LOCATIONS

SOUNDINGS

SKETCH - SOUNDING LOCATIONS PLAN



FLOW

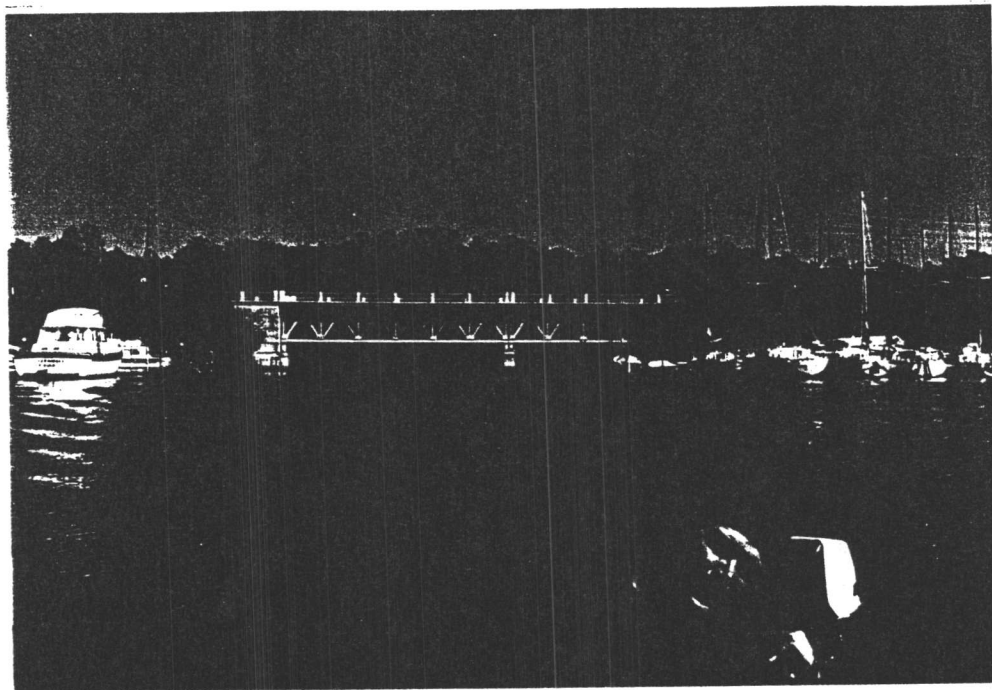


NOTE:

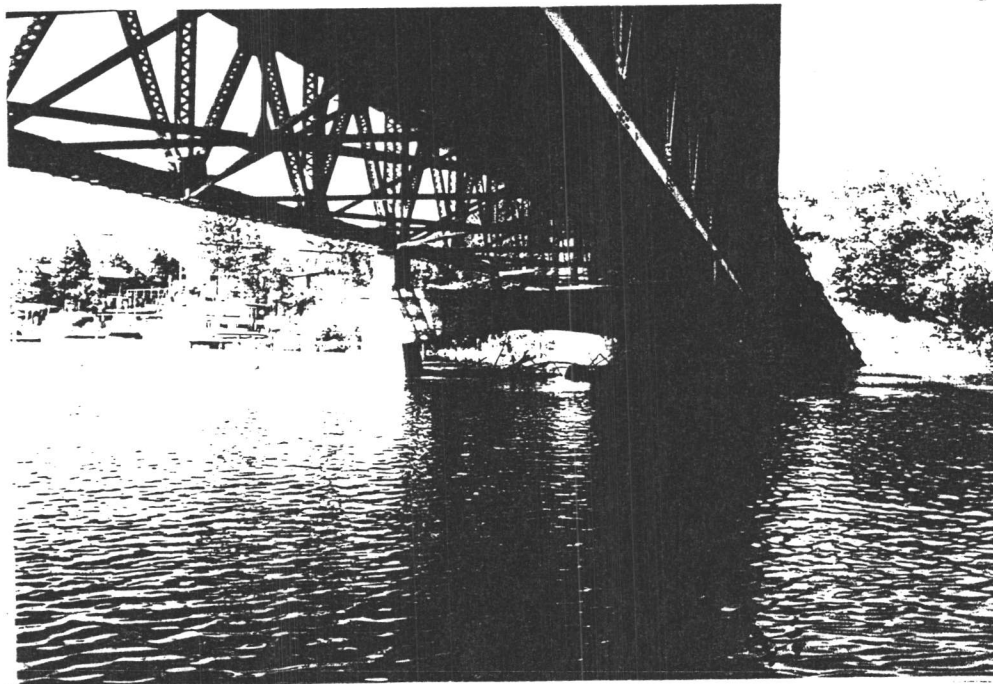
- Depths given in metres below water level
- 1.5m spacing between successive soundings
- first sounding immediately against component at channel bottom

# SITE PHOTOGRAPHS

BAYFIELD RIVER BRIDGE



GENERAL , LOOKING EAST



CENTRAL PIER , LOOKING NORTH









