FOUNDATION REPORT
CULVERT REPLACEMENTS, HIGHWAY 11
CHAMBERLAIN TOWNSHIP
ENGLEHART, ONTARIO

PREPARED FOR:

Ministry of Transportation of Ontario
P.O. Box 1390, 500 Rockley Road
NEW LISKEARD, Ontario
P0J 1P0

TROW CONSULTING ENGINEERS LTD.
Brampton, Cambridge, Hamilton, London, Markham,
North Bay, Ottawa, Sudbury, Thunder Bay, Winnipeg

Project: SO7015G
Date: July 29, 1996

1074 Webbwood Drive
Sudbury, Ontario P3C 3B7
Phone: (705) 674-9681
Fax: (705) 674-8271

Trow

RECORD OF TELEPHONE CALL

Date: ____________________ Time: ____________________ Job No: ____________________

Place called/calling: ____________________

Party called/calling: ____________________

Company Affiliation: ____________________

Message Received/Transmitted: ____________________

Answer Given/Received: ____________________

Signed: ____________________

TABLE OF CONTENTS

DRAWINGS

Trow Sudbury Branch

Trow Consulting Engineers Ltd.
1074 Webbwood Drive
Sudbury, Ontario P3C 3B7
Telephone: (705) 674-9681
Facsimile: (705) 674-8271

S07015G **July 29, 1996**

Ministry of Transportation of Ontario
P.O. Box 1390, 500 Rockley Road
NEW LISKEARD, Ontario
P0J 1P0

ATTENTION: Mr. Russell Proctor
District Engineering Supervisor

Dear Sir:

FOUNDATION REPORT
CULVERT REPLACEMENTS, HIGHWAY 11
CHAMBERLAIN TOWNSHIP
ENGLEHART, ONTARIO

Further to your authorization, we have completed the field work and our geotechnical analyses in connection with the above noted project. Our comments and recommendations, based on the findings at the borehole locations, are summarized in the following paragraphs.

1.0 BACKGROUND

It is understood that the Ministry of Transportation of Ontario is proposing to replace two existing box culverts located under Highway 11 in Chamberlain Township. Culvert #1 is located 3.4 kilometres north of the junction of Highway 11 and Highway 560 (near Englehart), while Culvert #2 is located 4.7 kilometres north of this junction. These culverts are broken in the centre and the fill settlement over the culverts has resulted in a sag in the centreline profile of Highway 11 over each site.

The purpose of this foundation report is to determine the soil conditions at each site and the suitability of replacing these culverts by jack and bore, tunnelling or other methods.

2.0 FIELD WORK

The field work comprised a total of four sampled boreholes (BH 1 to 4 inclusive), with two boreholes advanced at each culvert location. The boreholes were advanced using a track mounted power auger rig on July 11, 1996. The location of the boreholes are shown on enclosed Drawing 1. Details of the soil strata encountered in the boreholes are included in the attached logs, Drawings 3 to 6. Drawing 2 provides additional data on soil descriptions.

3.0 SOIL CONDITIONS

3.1 Culvert #1 (BH's 1 & 2)

The results of the boreholes indicate two types of fill over the culvert. From road level to approximately 2.4 meters of depth, the fill is a heterogeneous mixture of gravel and sand. Occasional cobbles and silt inclusions were found within these layers. The granulars are brown in colour and are generally moist. Beneath the upper granulars, a silt fill was intercepted, which is grey with brown stains and is moist to wet. Samples removed from the boreholes indicate the silt has been disturbed and traces of granulars and organics may be found within the silt, along with odd pockets of clay.

Under the existing culvert, a native, grey, silty layered clay was encountered. The unit is stratified with layers of clay and silt and is continuous to the end of the borehole, at 12.5 meters depth.

Based on field observations and recovered soil samples the water level within boreholes 1 & 2 was estimated to be 6.8 and 5.9 meters below surface level respectively. This level approximately corresponds to the mid-height level of the culvert and is expected to be closely related to the water level in the creek which experiences seasonal fluctuations.

3.2 Culvert #2 (BH's 3 & 4)

Similar to culvert #1, two types of fill exist over this culvert. A heterogenous mixture of moist, brown gravel and fine sand was found within boreholes 3 & 4 to a depth of 5 m to 6 m below grade. In BH-3, a layer of grey silt was then encountered. This silt layer was moist to wet and contained traces of organics and sand, especially at the elevation corresponding to the culvert level and slightly below. The silt was loose above and beside the culvert, but marginally increased in strength below the culvert level. In BH-4, the granular fill extended to the corresponding elevation of the top of the culvert and the silt fill exists only beside and directly under the culvert.

Extending from one metre underneath the culvert for approximately two and half meters is a loose, wet silty sand with organics and wood particles which is assumed to be the original creek bed.

Both boreholes terminated in a layer of grey, saturated wet clay, containing stratified wet silt layers. The clay commenced at approximately 10.5 metres below the surface and continued uninterrupted to the end of the borehole at 12.5 metres below the surface.

Based on recovered soil samples the water level is estimated to be six metres below surface, i.e. close to the top of the culvert. Seasonal variations in the water table may be expected, with higher levels occurring during wetter periods of the year, such as spring thaw and late fall, and lower levels during drier periods in the summer and winter.

4.0 OBSERVATIONS

A cursory examination of the two culverts was undertaken by our staff and the following observations were noted:

4.1 Culvert #1 (BH's 1 & 2)

The structure appears to be in reasonably good condition with little deterioration of the concrete. Furthermore, the culvert does not show signs of deformation, except for a centre crack, and the side walls of the culvert are perpendicular to the roof and base. Water was flowing uniformly within the culvert, at the time of the investigation, at a depth of some 50 mm.

4.2 Culvert #2 (BH's 3 & 4)

In contrast, culvert #2 shows serious signs of deterioration and structural distress. The concrete has deteriorated exposing the steel reinforcing bars at both entrances, with somewhat reduced levels of deterioration also noted in the interior of the culvert.

The culvert walls appear to have deformed slightly at the entrances, with the base of the walls spreading out past perpendicular. Furthermore, at the inlet, the base of the culvert has been "pushed up" creating extensive deformations. A triangular section of the concrete base of the culvert is "humped" and this deformed section, commencing at the entrance, extends about 1/4 of the length into the structure. The "hump" has risen approximately 600 mm at its highest point, coinciding with the centre line of the culvert. As such, the water which was approximately 75 mm deep, was forced to flow along the two exterior walls until past the "hump" at which point is resumed flowing uniformly within the culvert.

This "hump" could be the result of two different problems. The culvert may be resting on footings which have settled into the weak native soils under the embankment loads, thus trapping soil between the footings. As the culvert settles, this entrapped material will tend to push up on the bottom of the culvert. An alternative explanation has water continuing to follow the original creek bed, i.e. flowing through the permeable alluvial sand immediately under the culvert. During cold weather resulting ice repeatedly pushes up on the base of the culvert through freeze/thaw cycles. The void created would then likely be filled with soil melt in the spring. As such, the exposed end of the culvert would be "jacked" seasonally by frost action.

5.0 RECOMMENDATIONS

A hydrology study to determine the appropriate size of the replacement culverts was not part of our geotechnical study. Without this information, it is assumed, for the purpose of this report, that the cross sectional area of the culverts would remain about the same. Culvert #1 currently measures 3.7 m (12 feet) by 1.8 m (6 feet), giving a cross sectional area of 6.7 m^2. This translates into a diameter of 2.9 m (9.5 feet) for a single circular pipe. In comparison Culvert #2 measures 6.1 m (20 feet) by 1.5 m (5 feet) giving a cross sectional area of 9.3 m^2 or a diameter of 3.4 m (11 feet) for a single circular pipe.

Due to traffic volumes, height of the embankment and the lack of a detour route, open cutting of Highway 11 was not deemed to be a viable option by the Ministry of Transportation. As such, three alternative methods are discussed below.

5.1 Jack & Bore Methods

For culvert #1 the silt fill and native clay around the existing culvert would theoretically allow the use of "jack and bore techniques" to install a replacement culvert. Soil conditions at culvert #2 are similar, except for the alluvial wet sands of the original creek bed close to the invert. These sands have the potential to create additional "water" and other related problems.

A serious problem, however, exists due to the size of a single replacement culvert. The Ministry of Transportation has stipulated the use of a single opening culvert at both locations and, as developed above, this results in culverts with assumed diameters of about 3 m. Jack and bore techniques are normally limited to a maximum diameter size of about 1.5 m (5 feet). By stipulating a single opening culvert at both locations, each culvert will be at least double the maximum diameter for normal jack and bore techniques. An alternative would include the installation of two or more smaller diameter culverts, which would then make jack and bore techniques more feasible.

5.2 Tunnelling

The use of tunnelling to insert the two new large diameter culverts is feasible, however consideration must be given to the effect of the water levels at the time of installation. When the surrounding silt and sand become wet to saturated, as they were during our investigation at Culvert #2, they become "fluid like" and hence will tend to flow into the tunnel during installation. To prevent this occurrence, two alternatives are suggested. The tunnel could be pressurized (probably with air) to prevent wet soils from "sloughing" at the tunnel face before the walls can be erected. A second alternative includes dewatering the wet sandy soils below the invert level, prior to construction, or possibly using sheeting to cut off the groundwater flow.

5.3 Interior Replacement

It may be feasible, after further assessment of the condition of the existing culverts, to insert circular or arch corrugated steel culverts inside the existing box culvert and grout the remaining area around the new culvert.

This method would, however, reduce the cross sectional area available in the existing culvert opening. However, a hydrology study may indicate that a smaller cross section is acceptable. On the other hand, if a cross sectional opening, equivalent to or larger than the existing culvert is required, is may still be feasible to incorporate a new culvert(s) inside the present structure and then to install a second culvert through the adjacent embankment, at a higher elevation, to accommodate peak storm flows. This smaller culvert could then be installed with jack and bore methods. Culvert #1, due to its apparent good condition, appears to be better suited to this option than culvert #2, since culvert #2 may experience continued problems due to the seasonal frost heaving of the base.

6.0 LIMITATIONS

The comments given in this geotechnical report for the proposed culvert replacements in Englehart are intended for the initial guidance of the design team only.

The number and depth of test holes and the field and laboratory work required to determine the local underground conditions, affecting construction costs, techniques, sequencing, equipment and scheduling, etc., would in fact be much greater than has been carried out for these design purposes. In this regard, any contractors bidding on, or undertaking the works, must decide on their own investigation, as well as their own interpretation of the factual results, to draw their own conclusions as to how the subsurface conditions may affect them.

Since the evaluation and comments are necessarily on-going as new information of underground conditions becomes available, more specific information may be available with respect to conditions between test locations when construction is underway. The interpretation of the soil conditions, as well as the recommendations of this report, must therefore, be checked through field review provided by Trow to validate the information for use during construction.

The terms of reference for the geotechnical evaluation for this project were presented previously. If there are any changes, i.e. in final grades or location of the culvert, this office must be retained to review the design and provide additional comments, which could include additional investigations, analysis and reporting.

Whereas this evaluation has estimated the groundwater level at the time of the field work, and commented on general construction problems, the presence of conditions which would be difficult to establish from small diameter boreholes may affect the type and nature of dewatering procedures which should be used in practice. These conditions include local and seasonal fluctuations in the groundwater table, erratic changes in the soil profile between the tests, and thin layers of soil with large or small permeabilities compared with the general soil mass and possibly sources of relatively large recharge.

Discussions and recommendations related to any environmental impact of construction at these sites were beyond our terms of reference and consequently have not been addressed.

We trust these comments provide you with sufficient information. This report was prepared by Mr. E.A. Gonneau, B.Sc. (Eng) E.I.T. and reviewed by Mr. I.W. Gore, P.Eng. Should you have any questions, please do not hesitate to contact this office.

Yours truly,

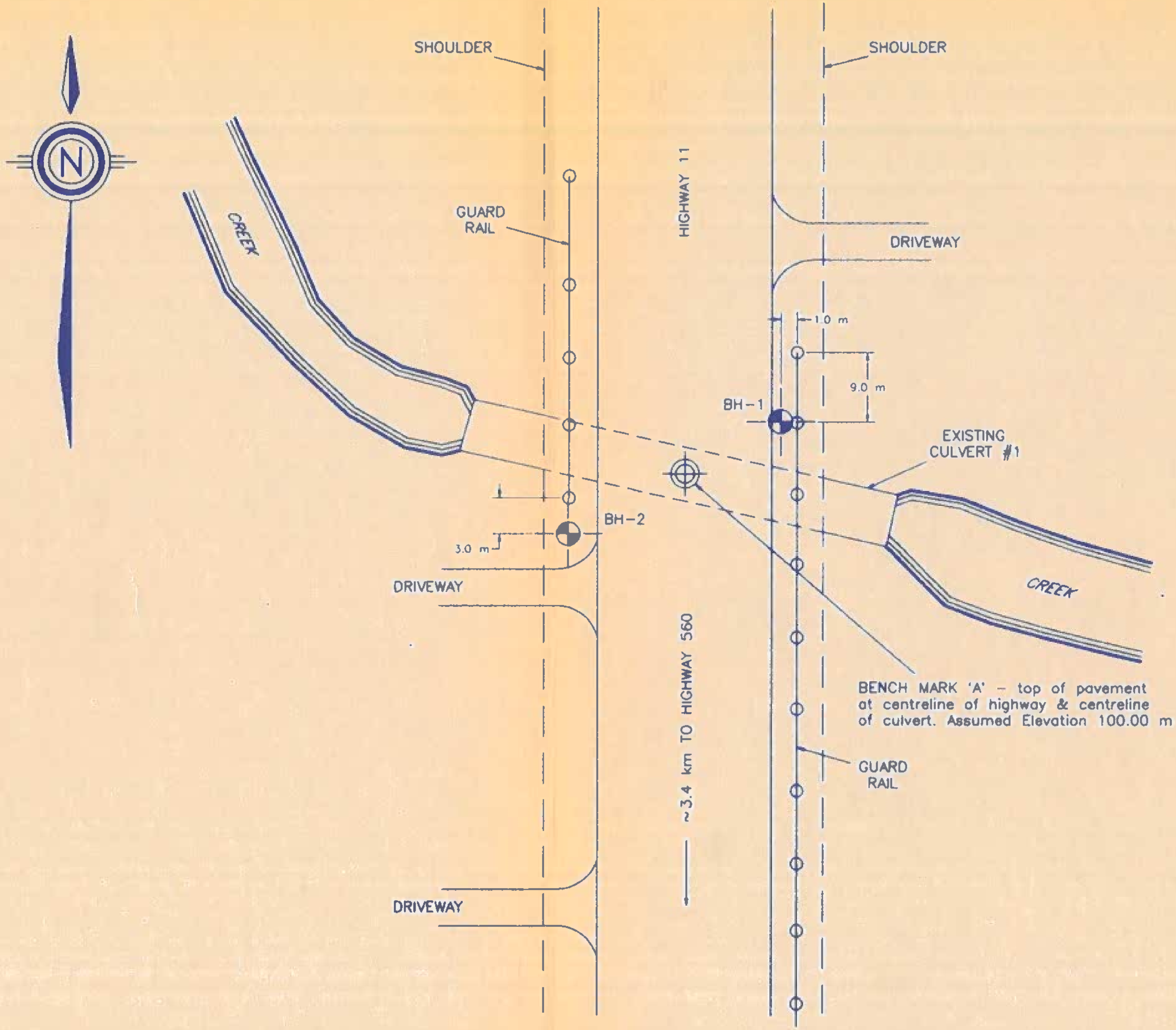
TROW CONSULTING ENGINEERS LTD.

REGISTERED PROFESSIONAL ENGINEER
I. W. GORE
PROVINCE OF ONTARIO

I.W. Gore, M.Sc., P.Eng.
Principal Engineer

Andy Schell, M.Sc., P.Eng.
Manager, Geotechnical Services

EAG:jt71
Encl.
Dist: Ministry of Transportation of Ontario (3)
Mr. Russell Proctor
District Engineering Supervisor



PLAN 'A'

NOT TO SCALE

- NOTES -

1) The boundaries and soil types have been establis
Test Hole locations. Between Test Holes they are
may be subject to considerable error.

2) Do not use Test Hole elevations for design purpo

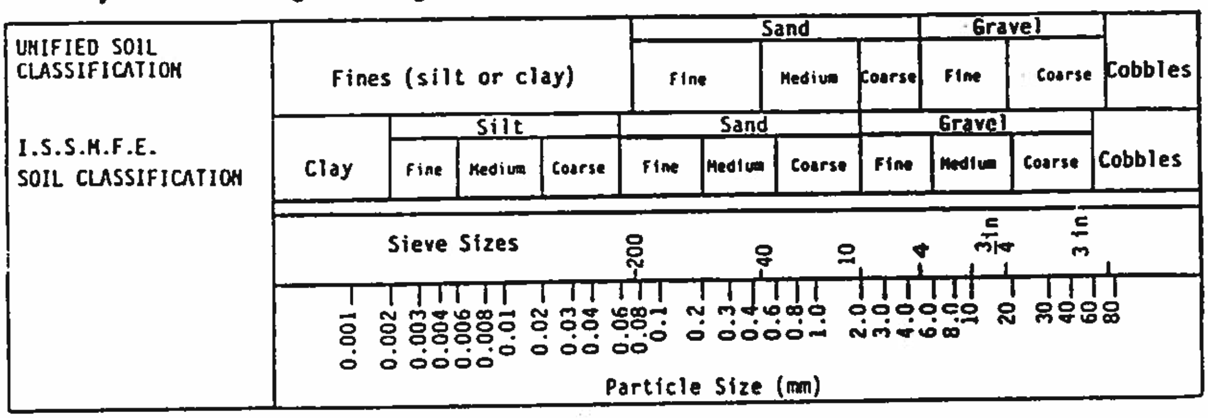
3) Soil samples will be retained in storage for 3 mo
destroyed unless client advises that an extended
required.

4) Quantities should not be established from the Info
vided at the Test Hole locations.

5) This drawing forms part of the report, project nu
enced, and should be used only in conjunction wi

NOTES ON SAMPLE DESCRIPTIONS

1. All descriptions included in this report follow the I.S.S.M.F.E. as suggested in the Canadian Foundation Manual. The laboratory grain-size analysis also follows this classification system. Others may designate the unified classification system as their source; a comparison of the two is shown for your information. Please note that, with the exception of those samples where the grain-size analysis has been carried out, all samples are classified visually and the accuracy of visual examination is not sufficient to differentiate between the classification systems or exact grain sizing.



2. **FILL:** Where fill is designated on the borehole log, it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of the site fill material. All fills should be expected to contain obstructions such as large concrete pieces of subsurface basements, floors, tanks, etc.; none of these may have been encountered in the borehole. Since boreholes cannot accurately define the contents of fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact and correct composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant on-going and future settlements. Some fill material may be contaminated by toxic waste that renders it unacceptable for deposition in any but designated land fill sites. Unless specifically stated, the fill on this site has not been tested for contaminants that may be considered hazardous. This testing and a potential hazard study can be carried out if you so request. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common but are not detectable using conventional geotechnical procedures.

3. **TILL:** The term till on the borehole logs indicate that the material originates from a geological process associated with glaciation. As a result of this geological process, the till must be considered heterogeneous in composition and, as such, may contain pockets and/or seams of material such as sand, gravel silt or clay. As till often contains cobbles (60 to 200 mm) or boulders (over 200 mm), contractors may encounter them during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size, or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited areas; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till material.

Log of BH-1

Trow

Auger Sample	⊠
SPT (N) Value	○○ ▨
Dynamic Cone Test	—
Shelby Tube	●● ■
Rock Core	⊠
Field Vane Test	+ S
Natural Moisture	×
Plastic & Liquid Limit	⊢—⊖
Undrained Triaxial at Overburden Pressure % Strain at Failure	0 / 15⊕5 / 10
Penetrometer	▲

Water Level: Est.: ▽ Measured: ▼ Perched: ▽

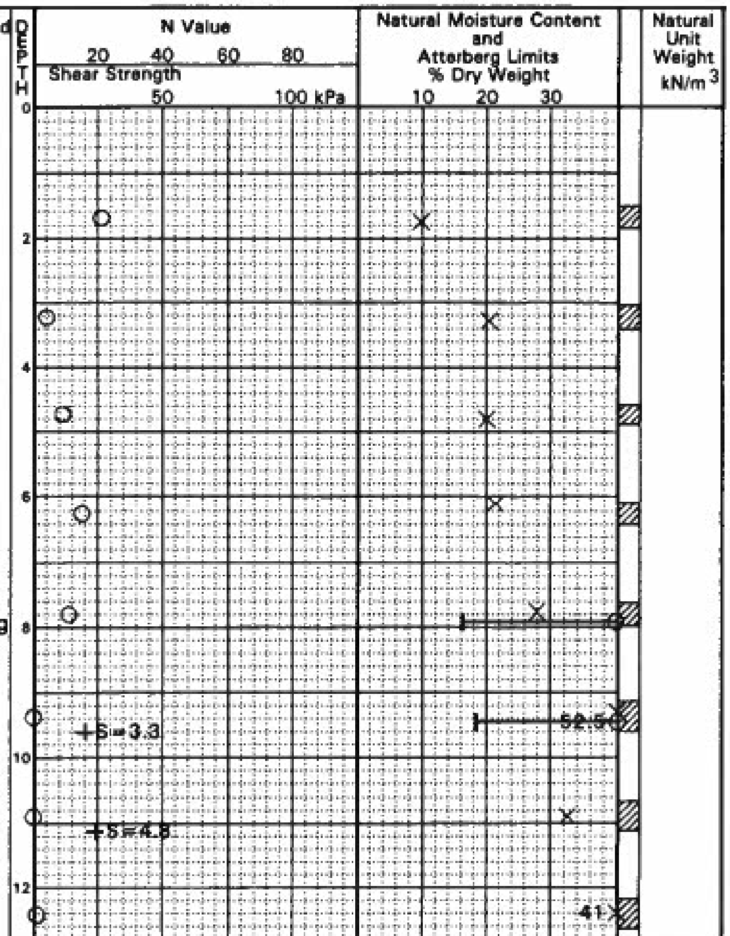
Project Geo. Investigation - Culvert Replacement Dwg. No. 3

Hwy 11, Chamberlain Twp

Englehart, Ontario Project No. S07015G

Hole location and datum see Drawing No. 1

GWL	Symbol	Soil Description	Assumed Elev. m
			99.8
	F	**FILL**, mostly sand & gravel, moist, brown, occasional cobbles and small silt inclusions. (compact)	
	F		97.3
	F	**SILT FILL**, grey with brown stains, moist to wet, trace of granulars & organics, odd pockets of clay. (loose to compact)	
▽			93.2
		SILTY CLAY, stratified with silt seams, grey, saturated. (firm/stiff becoming soft with depth)	93.0 (est) 92.3 Existing Invert
			87.0
		END OF BOREHOLE	



NOTES:
1. Borehole data requires interpretation assistance from Trow before use by others
2. Borehole advanced using continuous flight hollow stem auger equipment on July 11/96
3. Borehole backfilled on completion
4. See Drawing 2 for Notes on Sample Descriptions
5. This Drawing to be read with Trow Consulting Engineers Ltd. report S07015G

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
on compl.	6.8	10.3

Log of BH-2

Trow

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic & Liquid Limit	⊢—⊖
Dynamic Cone Test	——	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15⊕5 10
Shelby Tube	● ● ■	Penetrometer	▲
Rock Core	⊠		
Field Vane Test	+ S		

Water Level: Est.: ∇ Measured: ▼ Perched: ▽

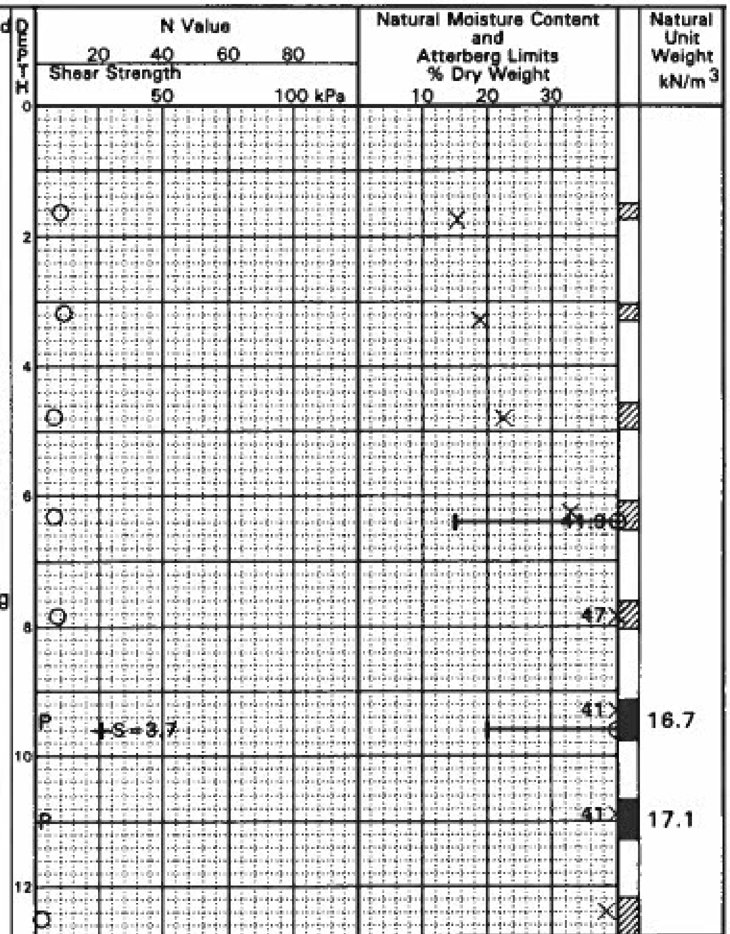
Project Geo. Investigation - Culvert Replacement Dwg. No. 4

Hwy 11, Chamberlain Twp

Englehart, Ontario Project No. S07015G

Hole location and datum see Drawing No. 1

Soil Description	Assumed Elev. m
	99.8
FILL, mostly sand & gravel, moist, brown, occasional cobbles & small silt inclusions. (loose/compact)	
	97.4
SILT FILL, grey with brown stains, moist to wet, odd pockets of clay. (loose)	
	93.8 (est)
	93.7
PEATY TOPSOIL, ~75 mm thick over **SILTY CLAY**, stratified with wet silt layers, grey/brown, saturated. (firm/stiff becoming soft with depth)	92.6 Existing Invert
	87.0
END OF BOREHOLE	



NOTES:
1. Borehole data requires interpretation assistance from Trow before use by others
2. Borehole advanced using continuous flight hollow stem auger equipment on July 11/96
3. Borehole backfilled on completion
4. See Drawing 2 for Notes on Sample Descriptions
5. This Drawing to be read with Trow Consulting Engineers Ltd. report S07015G

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
on compl.	5.9	8.6

Log of BH-3

Trow

Auger Sample	⊠		
SPT (N) Value	○ ○ ▨	Natural Moisture	×
Dynamic Cone Test	——	Plastic & Liquid Limit	├──⊖
Shelby Tube	● ● ■	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15⊕5 10
Rock Core	⊠		
Field Vane Test	+ S	Penetrometer	▲

Water Level: Est.: ∇ Measured: ▼ Perched: ▼

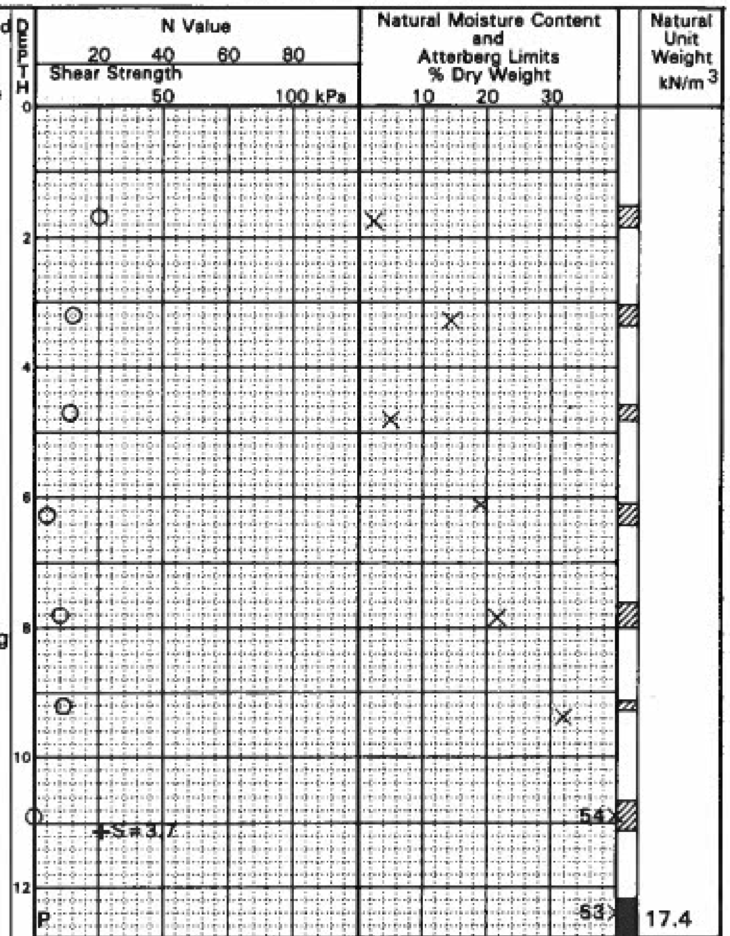
Project Geo. Investigation - Culvert Replacement Dwg. No. 5

Hwy 11, Chamberlain Twp

Englehart, Ontario Project No. S07015G

Hole location and datum see Drawing No. 1

GWL	Symbol	Soil Description	Assumed Elev. m
			100.0
	F	**FILL,** mostly sand & gravel with some cobbles, brown, moist. (compact)	94.7
∇	F	**SILT FILL,** brown & grey, trace of organics, moist to wet. (loose)	94.0 (est) 93.9 92.5
		ALLUVIAL SAND, with organics & wood particles, wet. (loose)	92.4 Existing Invert 90.6
		SILTY CLAY, stratified with wet silt seams, grey/brown, saturated. (firm becoming soft with depth)	87.2
		END OF BOREHOLE	



NOTES:
1. Borehole data requires interpretation assistance from Trow before use by others
2. Borehole advanced using continuous flight hollow stem auger equipment on July 11/96
3. Borehole backfilled on completion
4. See Drawing 2 for Notes on Sample Descriptions
5. This Drawing to be read with Trow Consulting Engineers Ltd. report S07015G

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
on compl.	8.9	11.1

Log of BH-4

Trow

Auger Sample	⊠				
SPT (N) Value	○ ○ ▨	Natural Moisture	×		
Dynamic Cone Test	—	Plastic & Liquid Limit	├──○		
Shelby Tube	● ● ■	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15⊕5 10		
Rock Core					
Field Vane Test	+ S	Penetrometer	▲		

Water Level: Est.: ▽ Measured: ▼ Perched: ▼

Project Geo. Investigation - Culvert Replacement Dwg. No. 6

Hwy 11, Chamberlain Twp

Englehart, Ontario Project No. S07015G

Hole location and datum see Drawing No. 1

Depth (m)	Soil Description	Assumed Elev. m	N Value	Natural Moisture Content (% Dry Weight)	Natural Unit Weight kN/m³
0		99.8			
0–6.1	**FILL**, mostly sand & gravel, brown, moist. (compact with loose section at base of unit)				
6.1	**SILT**, light brown then grey below ~7.5 m depth, wet. Probable FILL?. (loose)	93.7 (est)			
		92.4 Existing Invert			
8.8	**ALLUVIAL SILTY SAND**, with organics & wood particles, wet. (loose)	91.0		41	
10.6	**SILTY CLAY**, grey, stratified with wet silt seams, saturated. (soft/firm)	89.2		42	16.6
			S=4.0	46	
12.8	END OF BOREHOLE	87.0			

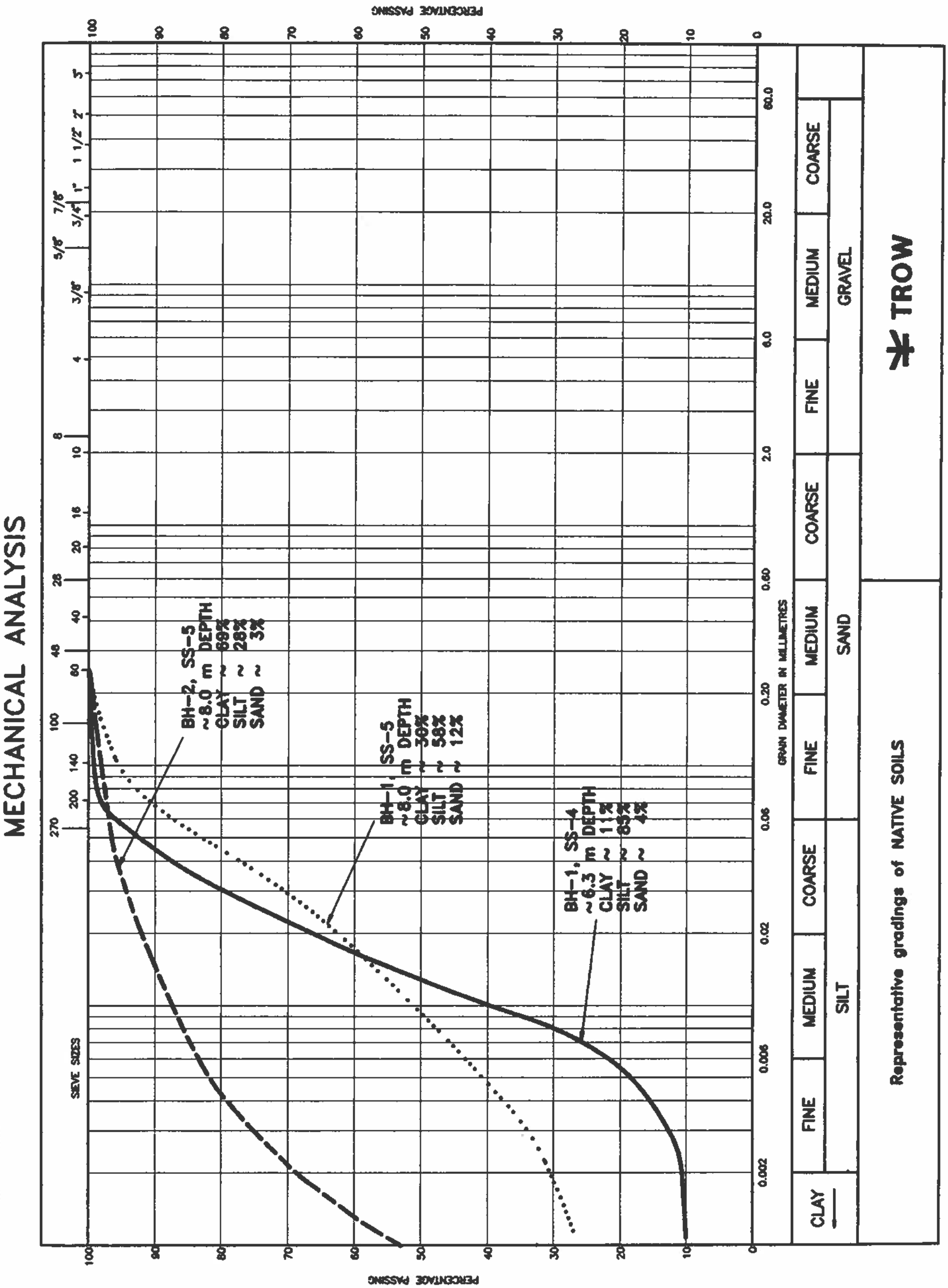
NOTES:
1. Borehole data requires interpretation assistance from Trow before use by others
2. Borehole advanced using continuous flight hollow stem auger equipment on July 11/96
3. Borehole backfilled on completion
4. See Drawing 2 for Notes on Sample Descriptions
5. This Drawing to be read with Trow Consulting Engineers Ltd. report S07015G

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
on compl.	8.7	10.7

PROJ. No. S07015G

DRAWING No. 7



PROJ. No. S07015G

DRAWING No. 8