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GIFFELS ASSOCIATES LIMITED

**FOUNDATION INVESTIGATION
HIGHWAY 416 UNDERPASS
AT COUNTY ROAD 20**

**W.P. 369-89-05, SITE 16-314
HWY. 416, DISTRICT 9, EASTERN
GEOCREES # 31B-71**

APRIL 26, 1991

PROJECT NO. 10187

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TABLE OF CONTENTS

	PAGE
1.0 Introduction	1
2.0 Site Description and Geology	2
3.0 Procedure	3
3.1 Field Investigation	3
3.2 Survey	4
3.3 Laboratory Testing	4
4.0 Results of the Investigation	5
4.1 Subsurface Conditions	5
4.2 Groundwater	9
5.0 Discussion and Recommendations	10
5.1 Proposed Development	10
5.2 Geotechnical Assessment	10
5.3 Structure Foundations	11
5.4 Other Considerations	17
5.5 Abutment Backfill	17
5.6 Approach Fills	18
5.7 Construction Considerations	19
5.8 Groundwater Chemistry	20
6.0 Miscellaneous	21

Appendix 1

Explanation of Terms Used in Report

Record of Boreholes

Figure 1-5: Grain Size Distribution

Figure 6 : Plasticity Chart

Figure 7 : Abutment on Compacted Fill

Appendix 2

Drawing No. 3698905- A - Bore Hole Locations & Soil Strata



Report

to

Giffels Associates Limited

on

Foundation Investigation

Highway 416 Underpass
at County Road 20

W.P. 369-89-05
Site 16-314

Hwy. 416
District 9
Eastern

Jacques, Whitford Limited

April 26, 1991

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FOUNDATION INVESTIGATION REPORT

for

Highway 416 Underpass at County Road 20

**WP 369-89-05 Site 16-314
DISTRICT 9, EASTERN REGION**

1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out at the above noted site in the Township of Oxford, Ontario. The investigation was carried out in accordance with our proposals dated August 1 and October 15, 1990. Authorization to carry out the work was provided by Mr. R. W. Bratty, P.Eng. of Giffels Associates Limited on November 1, 1990.

This report contains factual information obtained from this investigation pertaining to the subsurface conditions.



2.0 SITE DESCRIPTION AND GEOLOGY

The site is located along existing Highway 16 some 10 kilometres southeast of Kemptville, Ontario. The topography of the site is generally flat. The existing County Road 20 is a two-lane paved road with gravel shoulders, and is in general about 1 metre above the surrounding ground. Outside of the right-of-ways of existing Highway 16 and County Road 20, the site south of County Road 20 is treed, and the site north of County Road 20 consists of open fields with mixed bush. A rock cut is present at both the east and west sides of the existing Highway 16 immediately south of County Road 20.

Drainage of the site is provided by highway ditches that are connected to culverts.

The existing geotechnical/geological information suggests that the proposed site is within a glacial till plain with sand and silt deposits in the low-lying areas. Bedrock underlying the overburden consists of Ordovician limestone bedrock of the Oxford Formation. Overburden thickness at the site is expected to range from less than 1 metre to about 6 metres.



3.0 PROCEDURE

3.1 Field Investigation

Prior to the onset of the drilling investigation, the necessary utility check clearances were obtained by our site personnel.

The field work for this investigation was carried out between December 12 and 17, 1990. A total of ten (10) boreholes, (numbered 90-1 to 90-10) were put down at the site. Boreholes 90-1 to 90-3, and 90-6 to 90-8 were put down at the structure foundation locations. Boreholes 90-4, 90-5, 90-9 and 90-10 were put down at the approach fill locations. The test locations and the proposed structure locations are indicated on Drawing No. 3698905-A provided in Appendix 2.

All boreholes were put down using a track-mounted power auger drill suitably equipped for soil and bedrock sampling. The boreholes were put down using hollow stem augers. B-size casings and rock coring techniques were employed in Borehole 90-6 to advance through the overburden. Bedrock was proven by coring at selected borehole locations. Dynamic cone penetration tests (DCPT) were conducted at selected borehole locations.

The boreholes were put down to depths ranging from 0.6 m to 9.0 m. Boreholes 90-3 to 90-5, 90-9 and 90-10 were terminated at depths ranging from 0.6 m to 5.2 m, upon hollow stem auger refusal. Boreholes 90-1, 90-2, 90-6 to 90-8 were terminated after coring in BQ-size 1.5 m to 4.6 m into bedrock.

The overburden soils encountered were sampled by means of a split tube sampler during the performance of Standard Penetration Tests (SPT) (ASTM D1586). Sampling was generally conducted on a near continuous basis (intervals of 0.76 m).

All soil samples recovered were stored in moisture-proof bags and were returned to our Ottawa laboratory together with the rock cores for detailed classification and testing.

Standpipe piezometers 19 mm in diameter were installed in Boreholes 90-1 to 90-7 between depths of 3.4 m and 9.0 m, as shown on the Record of Boreholes in Appendix 1. The standpipes in Boreholes 90-1, 90-6 and 90-7 were backfilled with sand and sealed with bentonite within the bedrock. Soil cuttings were then used to backfill these three boreholes



from the seal to the ground surface. All remaining boreholes were backfilled to ground surface with soil cuttings and mounded at the ground surface to prevent water infiltration.

3.2 Survey

The borehole locations and ground surface elevations were surveyed by Giffels Associates Limited personnel after completion of the field work. The elevations are referenced to Geodetic datum. The borehole coordinates and elevation data are summarized on Drawing 3698905-A in Appendix 2.

3.3 Laboratory Testing

To identify the properties of the soil samples collected from the field investigation, the following laboratory tests were carried out:

- Detailed visual classification,
- Natural moisture content,
- Sieve and hydrometer analyses,
- Atterberg Limits determination.

In addition to the above, point load tests were carried out on representative bedrock core samples.

Samples remaining after testing will be stored in our laboratory for a period of six months after issuance of the final report. They will then be discarded unless we are directed otherwise.



4.0 RESULTS OF THE INVESTIGATION

4.1 Subsurface Conditions

The subsurface conditions observed in the boreholes are presented in detail on the Record of Boreholes provided in Appendix 1. An Explanation of Terms Used in Report is also provided in Appendix 1. The laboratory test results are summarized on the Record of Boreholes and also on Figures 1 to 6 in Appendix 1.

The ground surface elevations at the borehole locations varied from El. 97.6 m to 99.1 m at the time of the investigation. The surficial material at the boreholes consists of topsoil or sand and gravel/silty sand fill, overlying sandy silt or sand and gravel (where present), overlying clayey silt (where present), overlying a heterogeneous mixture of silt, sand, gravel and boulders (glacial till), all underlain by limestone bedrock. The bedrock surface was encountered between El. 92.5 m and 97.6 m. The groundwater table was observed between El. 97.1 m and 98.6 m.

A brief discussion of the observed subsurface conditions is provided below. Specific details of the subsurface materials should be obtained from the Record of Boreholes.

4.1.1 Topsoil

A surficial layer of topsoil was encountered in Boreholes 90-1, 90-3 to 90-5, 90-9 and 90-10. The thickness of the topsoil ranges from 100 mm to 300 mm.

4.1.2 Sand and Gravel (Fill) / Silty Sand (Fill)

Sand and gravel, some silt (fill) was encountered from ground surface in Boreholes 90-2, 90-6 and 90-7. Silty sand (fill) was encountered from ground surface in Borehole 90-8. The thickness of the fill ranges from 1.4 m to 2.1 m. The fill is believed to have been placed during the construction of County Road 20.



The SPT conducted in the sand and gravel fill layer yielded N values ranging from 15 to 34, indicating a denseness of compact to dense. The grain size distribution obtained from laboratory sieve analysis of a representative sand and gravel fill sample is 49% gravel, 34% sand, and 17% silt and clay (Figure 1 in Appendix 1). The above grain-size distributions represent the minus 38 mm fraction of the sand and gravel fill. Larger sizes may also be present.

The SPT conducted in the silty sand fill layer yielded an N value of 5, indicating a denseness of loose. Moisture content test of a representative sample yielded 14%.

Based on visual identification and laboratory tests, both the sand and gravel fill and the silty sand fill are classified as cohesionless materials.

4.1.3 Sandy Silt

Sandy silt was encountered underlying the topsoil in Boreholes 90-1, 90-5, 90-9 and 90-10, and underlying the fill in Boreholes 90-6 to 90-8. The thickness of the sandy silt ranges from 0.1 m to 1.5 m.

The SPT conducted in the sandy silt layer yielded N values ranging from 9 to 31, indicating a denseness of loose to compact. The moisture content of this material ranges from 15% to 20% with an average of 17%. The grain size distribution of a representative sandy silt sample based on laboratory sieve analysis is 0% gravel, 27% sand, and 73% silt and clay (Figure 2 in Appendix 1). Based on visual identification the sandy silt is classified as a cohesionless material.

4.1.4 Sand

Sand, some gravel, some silt was encountered underlying the fill in Borehole 90-2 and underlying the topsoil in Borehole 90-3. The thickness of the sand ranges from 0.9 m to 1.5 m.

The SPT conducted in the sand layer yielded N values ranging from 3 to 24, indicating a denseness of loose to compact. The grain size distribution of a representative sample based on laboratory sieve analysis is 12% gravel, 70% sand, and 18% silt and clay (Figure 3 in Appendix 1). Based on visual identification and laboratory tests, the sand is classified as a cohesionless material.



4.1.5 Clayey Silt

Clayey silt, trace sand was encountered underlying the sand in Boreholes 90-2 and 90-3, and underlying the sandy silt in Boreholes 90-5 to 90-8. The thickness of the clayey silt ranges from 0.6 m to 2.7 m.

The SPT conducted in the clayey silt layer yielded N values ranging from 15 to 35, suggesting a consistency of very stiff to hard. The results of laboratory testing are provided on the Record of Boreholes, on Figures 4 and 6 in Appendix 1, and are summarized below:

Property	Range	# Tests	Average
Moisture Content (%)	19-23	10	21
Liquid Limit (%)	36	3	36
Plastic Limit (%)	17-23	3	19
Plasticity Index (%)	14-19	3	17
Grain Size			
% Gravel	0-1	3	0
% Sand	1-12	3	6
% Silt	47-65	3	54
% Clay	34-44	3	39
Unit Weight (kN/m ³)	18.3-20.9	4	19.9

Based on the above tests and visual identification, the clayey silt is classified as a cohesive material of low to intermediate plasticity.

4.1.6 Heterogeneous Mixture of Silt, Sand, Gravel and Boulders (Glacial Till)

A heterogeneous mixture of silt, sand, gravel and boulders (glacial till) was encountered underlying the topsoil in Borehole 90-4, and underlying the clayey silt in Boreholes 90-3, and 90-5 to 90-7. The glacial till can be generally described as silty sand / sandy silt with some gravel and boulders. The thickness of this deposit ranges from 0.6 m to 3.2 m.

The SPT conducted in the glacial till stratum yielded N values ranging from 23 to over 70, indicating a denseness of compact to very dense, and generally in the dense to very dense range. Penetration of this stratum required the application of rock coring techniques in Borehole 90-6 due to the presence of cobbles and boulders. The results of laboratory testing are provided on the Record of Boreholes, on Figure 5 in Appendix 1, and are summarized below:

Property	Range	# Tests	Average
Moisture Content(%)	9-20	9	12
Grain Size			
% Gravel	8-12	3	10
% Sand	31-54	3	38
% Silt and Clay	38-61	3	52

The above grain-size distributions represent the minus 38 mm fraction of the glacial till. Cobbles and boulders are also present in this material. Based on the above tests and visual identification, the glacial till is classified as a cohesionless material.

4.1.7 Bedrock

Bedrock was encountered and proven by coring in BQ-size in Boreholes 90-1, 90-2, 90-6 to 90-8. The bedrock surface at these locations was encountered between El. 93.2 m and 97.6 m (depths of 0.2 m to 5.9 m). The bedrock is a grey limestone with very close to moderately close spaced horizontal fractures. The bedrock is very poor to excellent in quality (RQD ranging from 0% to 95%). The average RQD over the 12.6 m of rock cored was 41%, indicating an overall rock mass quality of poor. Core recoveries ranged from 55% to 100%. Unconfined compressive strength, based on point load tests of the intact core samples, ranges from 60 MPa to 233 MPa with an average (based on 10 tests) of 153 MPa.

In Boreholes 90-3 to 90-5, and 90-9 and 90-10, hollow stem auger refusal was encountered between El. 92.5 m and 97.6 m (depths of 0.6 m to 5.2 m). Comparing with the proven (cored) bedrock elevations, it is considered that auger refusal was encountered on probable bedrock at these borehole locations.



4.2 Groundwater

Groundwater levels were recorded during drilling and in standpipe piezometers after drilling.

The standpipes in Boreholes 90-1, 90-6 and 90-7 were sealed in the bedrock. Groundwater levels recorded at these locations, which represent the levels within the bedrock, ranged between El. 97.8 m and 98.6 m (depths of 0 m to 1.2 m). In the remaining boreholes, groundwater levels recorded, which represent the levels within the overburden, ranged between El. 97.1 m and 98.4 m (depths of 0 m to 1.2 m). Groundwater levels are subject to seasonal fluctuations and can vary from the values given in this report.



5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Proposed Development

The site is located at the intersection of the existing Highway 16 and County Road 20 in the Township of Oxford, Ontario (refer to the Key Plan provided on Drawing No. 3698905-A in Appendix 2).

The proposed bridge structure is part of the Highway 416 development from Highway 401 to Highway 43. The County Road 20 structure is to consist of the following components:

- A two-span (40-metre spans) structure over Highway 416 southbound lane (SBL) and northbound lane (NBL). The structure is to consist of a continuous box girder.
- The structure will be supported by two (2) abutments with associated approach fills and a median pier which consists of three (3) individual columns.
- Fill heights at abutment locations are to range from approximately 7.2 m to 7.4 m.

5.2 Geotechnical Assessment

The following assessment and recommendations are presented based on comments on a draft report submitted on March 15, 1991, and on subsequent discussions with Giffels Associates Limited.

The bedrock elevation is variable at the site and generally slopes downward from west to east, and also from south to north. At the locations of the structural units, the bedrock surface elevation ranges from El. 93.2 m to El. 97.6 m Geodetic, and as much as 2.3 metres at an individual structural unit.

Based on the existing geotechnical conditions and on the type of structure proposed, it has been concluded that the preferred foundation type would consist of both abutments perched within compacted Granular 'A' fill, and the centre pier supported on spread footings placed on the bedrock.



As alternatives to the above, the following foundation types may be considered:

- | | | |
|---------------|---|--|
| West Abutment | - | spread footings on bedrock, or |
| | - | cast-in-place drilled piles socketed into bedrock. |
| Centre Pier | - | cast-in-place drilled piles socketed into bedrock. |
| East Abutment | - | driven end bearing piles on bedrock, or |
| | - | cast-in-place drilled piles socketed into bedrock. |

The approach fills of up to about 7.4 m in height may be constructed using side slopes of 2 horizontal to 1 vertical for granular borrow, or side slopes of 2.5 horizontal to 1 vertical for fine-grained borrow. No embankment stability and settlement problems are anticipated. This report contains our detailed recommendations in the following areas:

- 1) Structure Foundations
- 2) Abutment Backfill
- 3) Approach Fills
- 4) Construction Considerations

5.3 Structure Foundations

5.3.1 West Abutment

In consideration of the relatively shallow bedrock at this location, the abutment may be founded on spread footings perched within compacted Granular 'A' fill, on spread footings founded on the limestone bedrock, or on cast-in-place drilled piles socketed into bedrock. The preferred foundation type for the west abutment is to use a perched abutment founded on Granular 'A' fill.

Perched Abutment

Silty sand fill was encountered from ground surface in Borehole 90-8. To ensure uniform density under the perched abutment, and that the required degree of compaction is achieved, the existing fill should be removed and replaced with compacted Granular 'A' fill. Prior to placement of the Granular 'A' fill, the following is recommended:

- Remove all surficial organic/loosened materials and existing fill within the plan limits of the granular core.
- Proof roll the exposed surface. Soft areas revealed under proof rolling should be excavated.
- Construct granular pad using OPSS Granular 'A' material in accordance with details shown on Figure 7 in Appendix 1. The Granular 'A' should be compacted in accordance with OPSS 501.

Spread footings placed on granular pads constructed as recommended above may be designed based on the following design values:

<u>Factored Bearing Capacity at U.L.S.</u>	<u>Bearing Capacity at S.L.S. Type II</u>
900 kPa	350 kPa

The above bearing pressures have been calculated based on a footing width (B) of 4 m, and that the underside of the abutment footings will be placed at or above El. 100.5 m as indicated by Giffels Associates. The S.L.S. Type II bearing pressure has been calculated assuming that a total settlement of 25 mm is satisfactory.



Spread Footings

Alternatively, the west abutment may be supported on spread footings founded on the very poor to fair quality limestone bedrock encountered at El. 97.6 m and 95.7 m in Boreholes 90-1 and 90-8, respectively. Spread footings founded on the bedrock may be designed using the following value:

Factored Bearing Capacity at U.L.S. 1500 kPa

The limestone bedrock is considered to be an unyielding foundation base and hence a S.L.S. Type II bearing capacity would not be applicable.

Based on Boreholes 90-1 and 90-8, the bedrock is sloping downward at about 10% from south to north. The bedrock should be prepared such that the slope of the bearing surface is no steeper than 10%.

Cast-In-Place Drilled Piles

The west abutment may be perched and founded on cast-in-place drilled piles socketed into bedrock. The compressive load carrying capacity of socketed piles can be calculated from either end bearing or from bond capacity between the concrete and the rock face within the socket. Socketed piles may be designed based on the following parameters:

- The capacity based on end bearing alone using a factored bearing capacity at U.L.S. of 1500 kPa, or
- The capacity based on bond stress alone using a factored ultimate concrete/rock bond stress of 450 kPa.

For design based on end bearing or bond, a minimum socket length of 1 m is recommended. Concrete for pile sockets should have a minimum compressive strength of 30 MPa. The base of the sockets should be well cleaned before concreting regardless whether the design is based on end bearing or bond.



The uplift capacity of socketed piles may be taken as the lesser of:

- capacity calculated using a factored ultimate bond stress of 450 kPa, and
- capacity calculated from a rock mass resistance assuming a 60° failure cone and a rock mass submerged unit weight of 15.0 kN/m³. The failure cone is defined using the lower end of the pile as the apex, and the axis of the pile as the altitude.

5.3.2 Centre Pier

Foundations of the centre pier (3 columns) will be placed in the median ditch and below frost penetration depth, resulting in a foundation level of about El. 96.7 m or below.

Spread Footings

Footings placed within the overburden below frost penetration depth would yield a rather low bearing capacity (S.L.S. Type II) of about 200 kPa. The preferred foundation type is to found spread footings on the limestone bedrock. Spread footings founded on the bedrock may be designed using the following value:

Factored Bearing Capacity at U.L.S. 1500 kPa

A S.L.S. Type II bearing capacity would not be applicable on unyielding bedrock.

The bedrock surface should be prepared such that the slope of the bearing surface is no steeper than 10%.

Footings placed on mass concrete placed on bedrock can be considered at the centre pier location. This option would likely be more economical than placing the footings directly on bedrock for the following reasons:

- reduction in structural steel cost,
- reduction in dewatering effort since shorter construction time will be required within the excavation.

The factored bearing capacity at U.L.S. of 1500 kPa would also be applicable in this case.

Cast-In-Place Drilled Piles

Alternatively, the centre pier may be supported on cast-in-place drilled piles socketed into bedrock. The compressive load carrying capacity and the uplift capacity of socketed piles can be calculated as outlined in Section 5.3.1.

5.3.3 East Abutment

Footings placed within the overburden below frost penetration depth would yield a rather low bearing capacity (S.L.S. Type II) of about 200 kPa. The abutment at this location may be founded on spread footings perched within compacted Granular 'A' fill, on driven steel H-piles, or on cast-in-place drilled piles socketed into bedrock. The preferred foundation type for the east abutment is to use a perched abutment founded on Granular 'A' fill.

Perched Abutment

For abutment supported on spread footings perched within compacted Granular 'A' fill, existing fill removal, site preparation and fill placement procedures outlined in Section 5.3.1 above would also be applicable. Spread footings placed on granular pads constructed as recommended may be designed based on the following design values:

<u>Factored Bearing Capacity at U.L.S.</u>	<u>Bearing Capacity at S.L.S. Type II</u>
800 kPa	300 kPa

The relatively weaker overburden conditions (specifically the sand, sandy silt and clayey silt) present at the east abutment location are reflected in the lower bearing capacities. Considerations could be given to sub-excavating to El. 96.0 m within the plan limits of the granular core, and replacing with compacted Granular 'A' fill. Spread footings in this case may be designed based on the following bearing pressures:

<u>Factored Bearing Capacity at U.L.S.</u>	<u>Bearing Capacity at S.L.S. Type II</u>
900 kPa	350 kPa

The bearing capacities recommended above for both cases have been calculated based on a footing width (B) of 4 m, and that the underside of the abutment footings will be placed at or above El. 100.5 m as indicated by Giffels Associates. The S.L.S. Type II bearing pressure has been calculated assuming that a total settlement of 25 mm is satisfactory.

Driven Piles

Alternatively, the east abutment may be supported on end-bearing steel H-piles equipped with reinforced tips (to facilitate pile penetration through the glacial till deposit) and driven to bedrock (El. 93.2 m in both Boreholes 90-3 and 90-6). The following design parameters are recommended for vertical steel H-piles:

<u>Pile Type</u>	<u>Factored Capacity at U.L.S. (kN)</u>	<u>Capacity at S.L.S. Type II (kN)</u>	<u>Estimated Pile Tip (m)</u>
HP 310 x 79	1150	890	about 93
HP 310 x 110	1600	1150	about 93

Steel H-piles should be driven to refusal with a pile hammer delivering an energy of 3.5 J/mm² to 4.5 J/mm² of steel cross-sectional area. With this energy, refusal may be taken as:

- i) 20 blows for the last 25 mm of penetration; and
- ii) a total of 50 blows for not more than 100 mm of penetration.

In cases where piles do not penetrate the glacial till stratum, the pile capacity should be controlled in the field using current MTO pile driving standards. Additional piles may be required. Attempts should be made in all cases to drive the piles to the bedrock surface.

Pile caps may be perched within the embankment fill provided that particle sizes in the fill immediately beneath the pile locations do not exceed 75 mm. No dewatering will be required in this case. Alternatively, the pile caps may be founded within the overburden. Some dewatering may be required for the overburden excavation. Refer to Section 5.7.1 for details.

Resistance to lateral load for battered piles should be calculated in accordance with Section 6-8.3.8 of the O.H.B.D.C.



Cast-In-Place Drilled Piles

Consideration may also be given to a perched east abutment supported on cast-in-place drilled piles socketed into bedrock. The compressive load carrying capacity and the uplift capacity of socketed piles can be calculated as outlined in Section 5.3.1.

5.4 Other Considerations

5.4.1 Sliding Resistance

Sliding resistance between concrete footings and Granular 'A' should be calculated in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. using a factored friction coefficient of 0.56. This coefficient is obtained assuming an unfactored friction angle of 35 degrees. Sliding resistance between concrete footings and limestone bedrock should be calculated using a factored coefficient of 0.46, assuming an unfactored friction angle of 30 degrees.

If additional sliding resistance is required due to lateral pressure or sloping bedrock, considerations can be given to employing shear keys and rock anchors where appropriate. The uplift capacity of grouted anchors may be designed as outlined in Section 5.3.1 for the uplift capacity of rock socketed piles.

5.4.2 Frost Protection

A minimum earth cover of 1.8 m over footings should be provided for frost protection. For footings founded on clean good or excellent quality bedrock, the minimum earth cover requirement may be reduced to 0.9 m.

Pile caps should also be provided with 1.8 m of earth cover for frost protection.

5.5 Abutment Backfill

The abutments should be backfilled with free draining materials such as OPSS Granular 'A' or Granular 'B' Type I or Type II, to prevent hydrostatic pressure build-up.

Computation of earth pressures should be in accordance with Section 6-6.1.2.1 of the O.H.B.D.C. For abutments that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied structures, the at rest pressure should be used for design, unless the stem can deflect enough (approximately 0.05 percent of the wall height) to establish the active pressure. For a horizontal backfill, the following parameters are recommended for design:

	Granular <u>'A'</u>	Granular <u>'B' Type I</u>
Bulk unit weight, γ (kN/m ³)	22.0	21.2
Effective friction angle, ϕ °	35°	30°
At Ultimate Limit States		
Coefficient of active earth pressure (K_a)	0.34	0.41
Coefficient of earth pressure at rest (K_o)	0.51	0.58
At Serviceability Limit States		
Coefficient of active earth pressure (K_a)	0.27	0.33
Coefficient of earth pressure at rest (K_o)	0.43	0.50

Compaction of the granular backfill near the walls should be carried out using hand-operated equipment to prevent overstressing the abutment walls.

5.6 Approach Fills

Fill placement of up to 7.4 metres is proposed for the approach fills within the investigated area. Side slopes of 2 horizontal to 1 vertical would be appropriate for fills constructed of granular borrow or select subgrade materials. If fine-grained borrow materials are to be used, side slopes of 2.5 horizontal to 1 vertical would be appropriate.

All organic and deleterious materials should be stripped and removed prior to fill placement within the entire fill area. Based on the approach fill boreholes (Boreholes 90-4, 90-5, 90-9 and 90-10), the anticipated depth of stripping varies from 100 mm to 300 mm.

The exposed surface should be proof rolled and soft areas removed prior to fill placement. The fills should be placed and compacted in accordance with OPSS 212 and 501.

Settlements of the embankment and the underlying soil are not expected to exceed 25 mm and will be largely complete after construction. It is recommended to place the fill early in the construction stage, and to delay the paving, to allow any time dependent portions of these settlements to take place.

To protect against surficial instability, normal slope vegetation should be established in accordance with MTO standards as soon as possible after construction.

5.7 Construction Considerations

5.7.1 Dewatering

For the perched abutment system, only minor dewatering will be required, except for the west abutment where the sub-excavation option is selected. Dewatering will be required for the installation of spread footings at this site. For the driven pile options, dewatering will be required only when pile caps are to be founded within the overburden.

Dewatering may be achieved by utilizing perimeter ditches within a gravity system in conjunction with a sump pump discharge system to drain accumulated water. Alternatively, a well point system installed outside of the excavation may be used to drawdown the water table. It is recommended that well points be installed concentrically in cased holes, and surrounded by a well screen and a properly graded free draining soil filter.

Other dewatering alternatives can also be considered. The more economical and practically feasible dewatering alternative should be selected. It is the responsibility of the contractors to construct the footings and/or pile caps in the dry without disturbing the foundation soils and integrity of the structural components.

5.7.2 Temporary Excavations

In view of the high groundwater table present at the time of the investigation, and the cohesionless nature of some native deposits, temporary excavations up to 3 m in depth should be undertaken using slopes no steeper than 1 horizontal to 1 vertical. Temporary slopes greater than 3 m high should be constructed at 1.5 horizontal to 1 vertical. In cohesionless deposits where seepage is noted, flatter side slopes may be required or alternatively a shoring system may be utilized, especially in space constrained areas.



5.7.3 Cast-In-Place Drilled Piles Installation

The installation of cast-in-place drilled piles socketed into bedrock at this site will require sleeving. Advancement through the glacial till in some locations will penetrate cobbles and boulders. Groundwater will likely be encountered during pile installation. Concrete placement will therefore likely require that the tremie method be used. Rock socketed piles should be inspected to confirm that the socket is extended sufficiently into the bedrock, and that the base and the shaft face are adequately prepared. As such, dewatering equipment such as submersible pumps will likely be required to allow inspection.

5.8 Groundwater Chemistry

Three (3) groundwater samples were submitted to Areco Canada Inc. in Ottawa for pH, sulphate and chloride testing. The test results are summarized below:

Borehole	pH	Sulphate (ppm)	Chloride (ppm)
90-3	7.4	34	129
90-5	7.9	35	145
90-8	7.5	38	297

The above test results indicate that the potential degree of sulphate attack is negligible. However the chloride ion concentration of the groundwater sample from Borehole 90-8 indicates positive degree of potential attack on exposed steel.

Based on the above, we recommend that epoxy coated reinforcing steel be used.

6.0 MISCELLANEOUS

The field work for this investigation was carried out under the supervision of A. MacGarvie, CET, utilizing equipment owned and operated by George Downing Estate Drilling Limited.

The project was carried out under the general supervision of G. Kack, Project Manager. The report was written by both undersigned.

Respectfully submitted

JACQUES, WHITFORD LIMITED



A handwritten signature in black ink, appearing to read "C. C. Kwok".

Charles C.K. Kwok, M.Sc., P.Eng.
Project Engineer



A handwritten signature in black ink, appearing to read "Gordon Kack".

Gordon J. Kack, M.E.Sc., P.Eng.
Project Manager

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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kn/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kn/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kn/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kn/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m ³	SEEPAGE FORCE
γ'	kn/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 90-1

METRIC

W P 369-89-05 LOCATION Co-ords: N 4 978 939.7; E 376 918.5 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE BW Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE December 12, 1990 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
97.8	Ground Surface															
97.7	Topsoil		1	SS	50/0	Dec. 14, 1990										
97.8	Sandy Silt		2	BQ	REC	Seal										RQD = 0%
0.2	Brown			RC	100%											
	Bedrock		3	BQ	REC	97										RQD = 0%
	Limestone			RC	61%											
	Very Poor to Poor		4	BQ	REC	96										RQD = 0%
				RC	55%	Sand Backfill										
			5	BQ	REC	95										RQD = 35%
				RC	100%											
			6	BQ	REC	Piezometer										RQD = 43%
				RC	100%	94										
93.0																
4.8	End of Borehole															

RECORD OF BOREHOLE No 90-2

METRIC

W P 369-89-05 LOCATION Co-ords: N 4 978 967.7; E 376 947.4 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BW Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE December 12, 1990 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)				
99.0	Ground Surface													GR SA SI CL
0.0	Sand and Gravel, some silt (Fill) Dense		1	SS	34									
97.6														
1.4	Sand, some gravel, some silt Brown Loose to Compact		2	SS	8									
			3	SS	20									12 70 (18)
96.1														
2.9	Clayey Silt, trace sand		4	SS	31									1 12 47 40
95.5	Very Stiff Grey													
3.5	Bedrock Limestone Poor		5	BQ RC	REC 80%									RQD = 38%
94.0														
5.0	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 90-3

METRIC

W P 369-89-05 LOCATION Co-ords: N 4 978 987.4; E 376 982.1 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE December 13, 1990 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
97.6	Ground Surface												
97.4	Topsoil												
0.2	Sand, some gravel, some silt Brown Loose to Compact		1	SS	3								
96.5			2	SS	24								
1.1	Clayey Silt, trace sand Very Stiff Grey		3	SS	20								
			4	TW	PH								
93.8													
3.8	Het. Mixture of Silt Sand, Gravel and Boulders (Glacial Till) Dense Grey		5	SS	34								
93.2													
4.4	End of Borehole Auger Refusal Probable Bedrock												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 90-4

METRIC

W P 369-89-05 LOCATION Co-ords: N 4 979 009.7; E 377 016.5 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE December 17, 1990 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
98.1																	
97.9	Topsoil																
0.2	Het. Mixture of Silt, Sand, Gravel and Boulders (Glacial Till) Compact to Very Dense		1	SS	23												
			2	SS	74												
			3	SS	69												
			4	SS	58/13												
94.7																	
3.4	End of Borehole Auger Refusal Probable Bedrock																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 90-5

METRIC

W P 369-89-05 LOCATION Co-ords: N 4 979 037.4; E 376 999.5 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE December 13, 1990 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
97.7	Topsoil																
97.5	Sandy Silt Compact		1	SS	3												
	Grey brown Brown																
			2	SS	12												
96.3																	
1.4	Clayey Silt, trace sand Very Stiff to hard Grey		3	SS	31												
			4	SS	21												
94.7																	
3.0	Het. Mixture of Silt, Sand, Gravel and Boulders (Glacial Till) Dense Grey		5	SS	37												
			6	SS	35												
			7	SS	50/8cm												
92.5																	
5.2	End of Borehole Auger Refusal Probable Bedrock																

RECORD OF BOREHOLE No 90-6

METRIC

W P 369-89-05 LOCATION Co-ords: N 4 979 002.4; E 376 973.0 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BW Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE December 17, 1990 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
99.1														
0.0	Sand and Gravel, some silt (Fill) Compact		1	SS	15									49 34 (17)
97.6														
1.5	Sandy Silt Compact Grey		2	SS	13									
			3	SS	29									0 27 (73)
96.1														
3.0	Clayey Silt, trace sand Very Stiff Grey		4	SS	17									
			5	SS	16									
94.6														
4.5	Het. Mixture of Silt, Sand, Gravel and Boulders (Glacial Till) Very Dense Grey		6	SS	50/10cm									
			7	BQ RC	REC 30 cm									
			8	BQ RC	REC 52 cm									
93.2														
5.9	Bedrock Limestone Fair to Excellent			BQ RC	REC 100%									RQD = 60%
			9	BQ RC	REC 100%									RQD = 95%
91.3														
7.8	End of Borehole													

RECORD OF BOREHOLE No 90-7

METRIC

W P 369-89-05 LOCATION Co-ords: N 4 978 979.1; E 376 941.3 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BW Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE December 13, 1990 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
99.1																	GR SA SI CL
0.0	Sand and Gravel, some silt, trace cobbles (Fill) Compact		1	SS	20		99										0 27 (73)
			2	SS	60/0		98										
97.0							97										
2.1	Sandy Silt Brown Compact		3	SS	31		96										
96.4							95										
2.7	Clayey Silt, trace sand Stiff to Very Stiff		4	SS	16		94										
			5	SS	16		93										RQD = 30%
			6	SS	15		92										
93.8							91										
5.3	Het. Mixture of Silt, Sand, Gravel and Boulders (Glacial Till) Very Dense Grey		7	SS	50/0		90										
93.2							89										RQD = 52%
5.9	Bedrock Limestone Poor to Fair		8	BQ RC	REC 100%		88										
							87										RQD = 52%
			9	BQ RC	REC 100%		86										
90.1							85										RQD = 52%
9.0	End of Borehole						84										

RECORD OF BOREHOLE No 90-8

METRIC

W P 369-89-05 LOCATION Co-ords: N 4 978 952.7; E 376 910.6 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE December 14, 1990 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
98.7	Ground Surface												
0.0	Silty Sand (Fill) Brown Loose		1	SS	5	* Dry							
97.3													
1.4	Sandy Silt												
96.9	Loose Grey		2	SS	9								
1.8	Clayey Silt, trace sand Hard Brown/Grey		3	SS	35								
95.7													
3.0	Bedrock Limestone Fair		4	BQ RC	REC 100%								RQD = 50%
94.1													
4.6	End of Borehole * Borehole dry during the site investigation												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 90-9

METRIC

W P 369-89-05 LOCATION Co-ords: N 4 978 940.8; E 376 875.8 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE December 14, 1990 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
97.9	Topsoil															
97.8	Sandy Silt		1	SS	4											
0.1	Brown															
97.3																
0.6	End of Borehole															
	Auger Refusal															
	Probable Bedrock															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 90-10

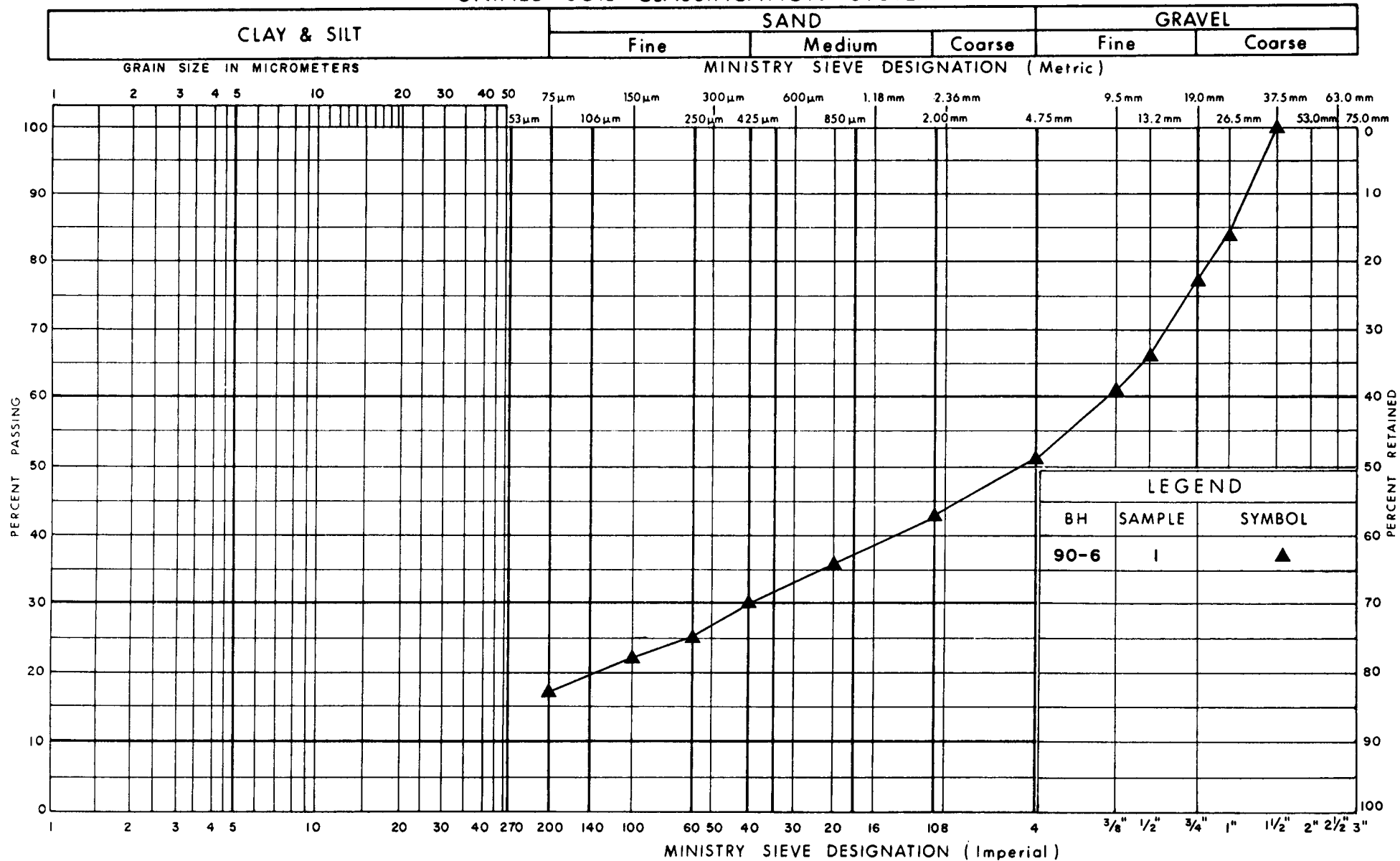
METRIC

W P 369-89-05 LOCATION Co-ords: N 4 978 910.4; E 376 894.5 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE December 13, 1990 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa								
98.4																
0.0	Topsoil		1	SS	8											
98.1																
0.3	Sandy Silt Brown															
97.6																
0.8	End of Borehole Auger Refusal Probable Bedrock															

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

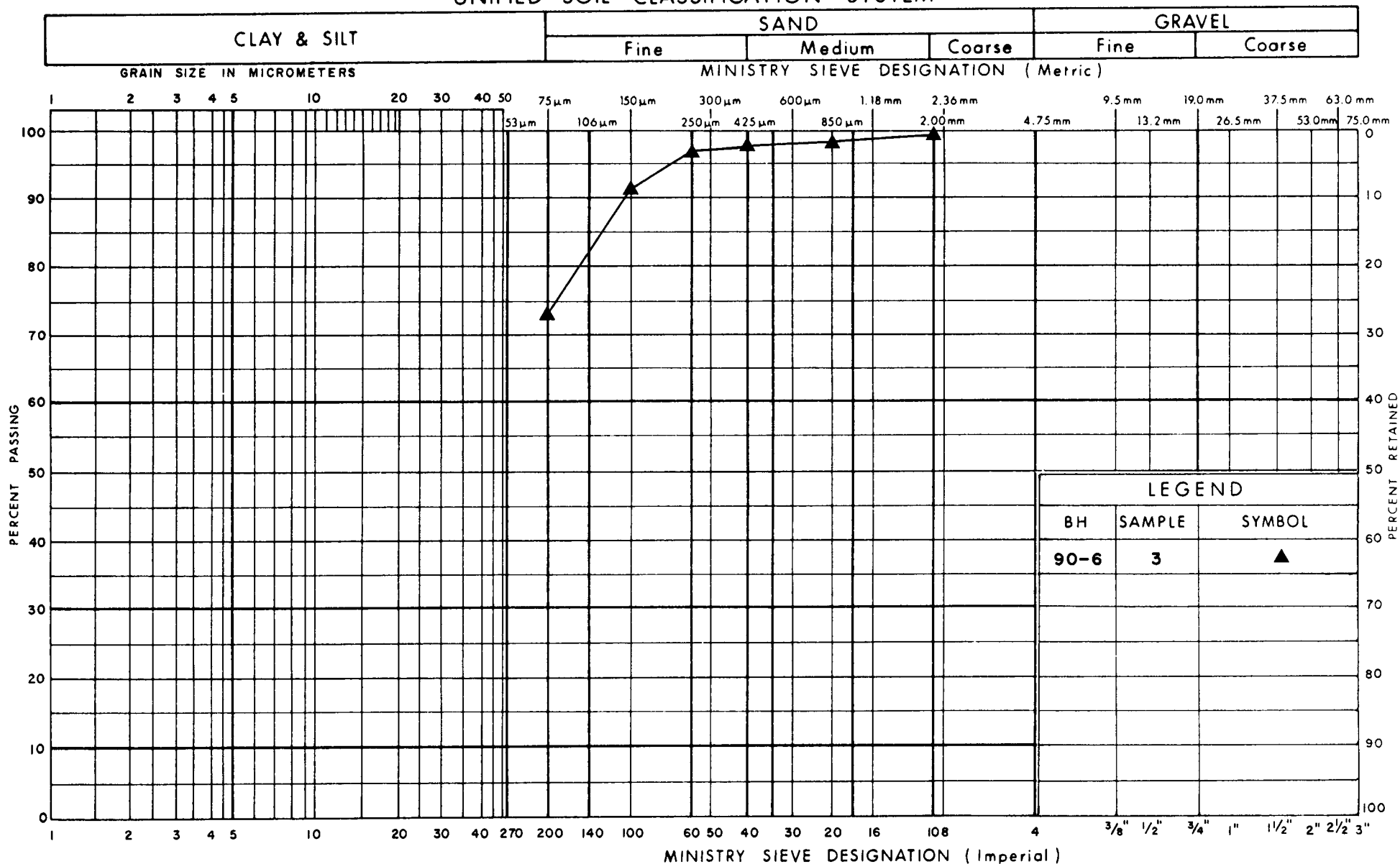
GRAIN SIZE DISTRIBUTION

SAND & GRAVEL, SOME SILT (Fill)

FIG No I

W P 369-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

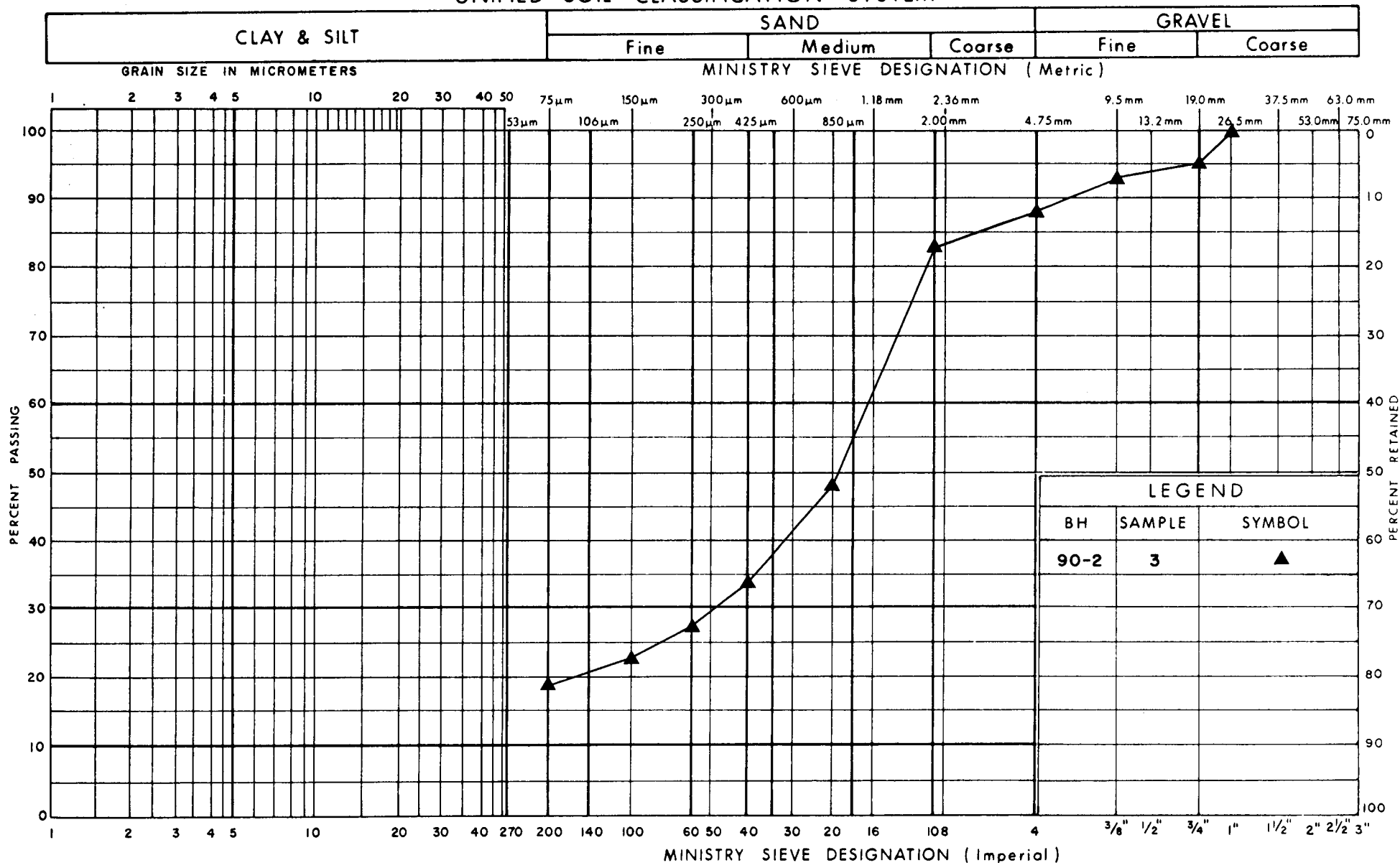
GRAIN SIZE DISTRIBUTION

SANDY SILT

FIG No 2

W P 369-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM



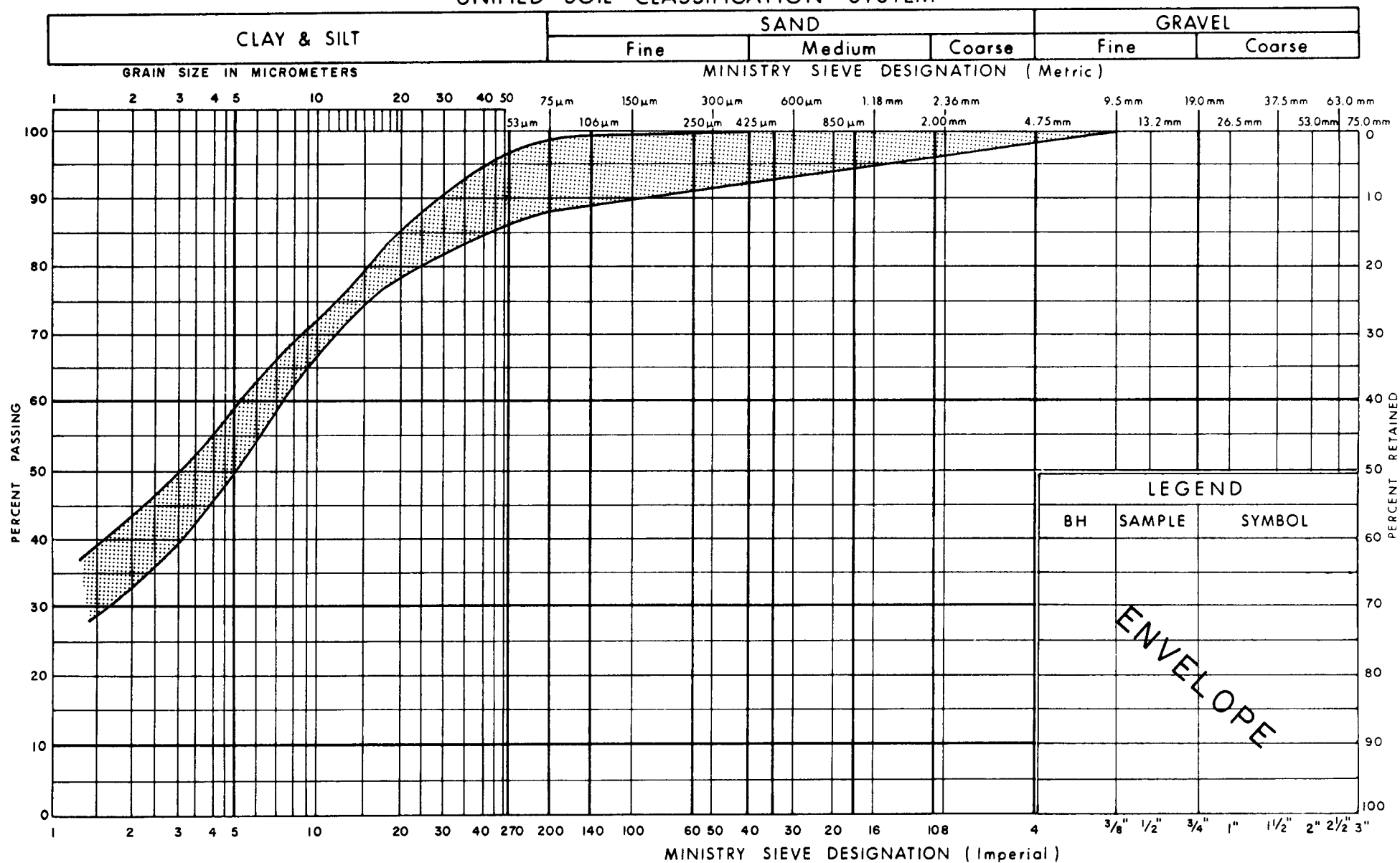
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SAND, SOME GRAVEL, SOME SILT

FIG No 3

W P 369-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
CLAYEY SILT

FIG No 4

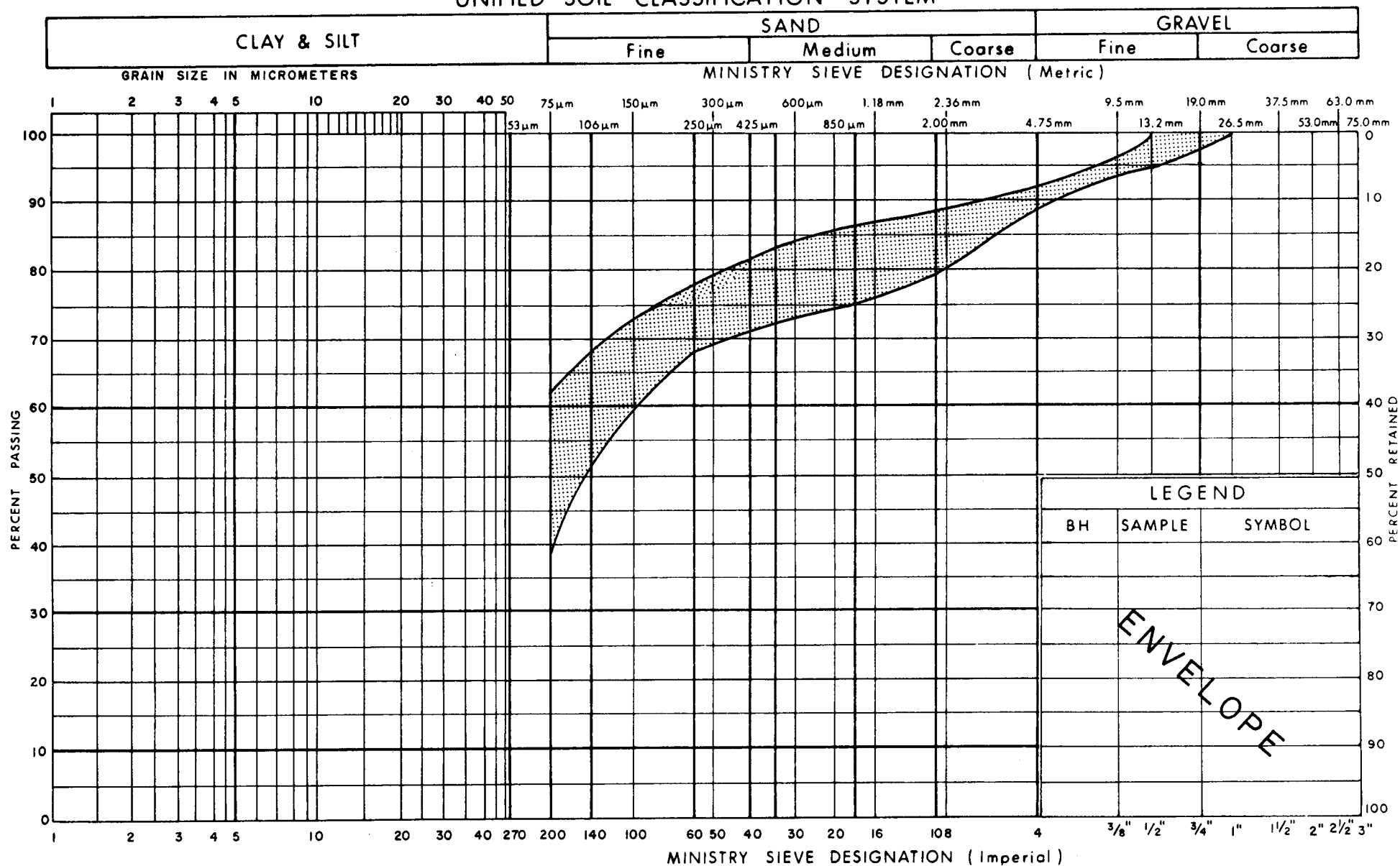
W P 369-89-05



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Transportation

UNIFIED SOIL CLASSIFICATION SYSTEM



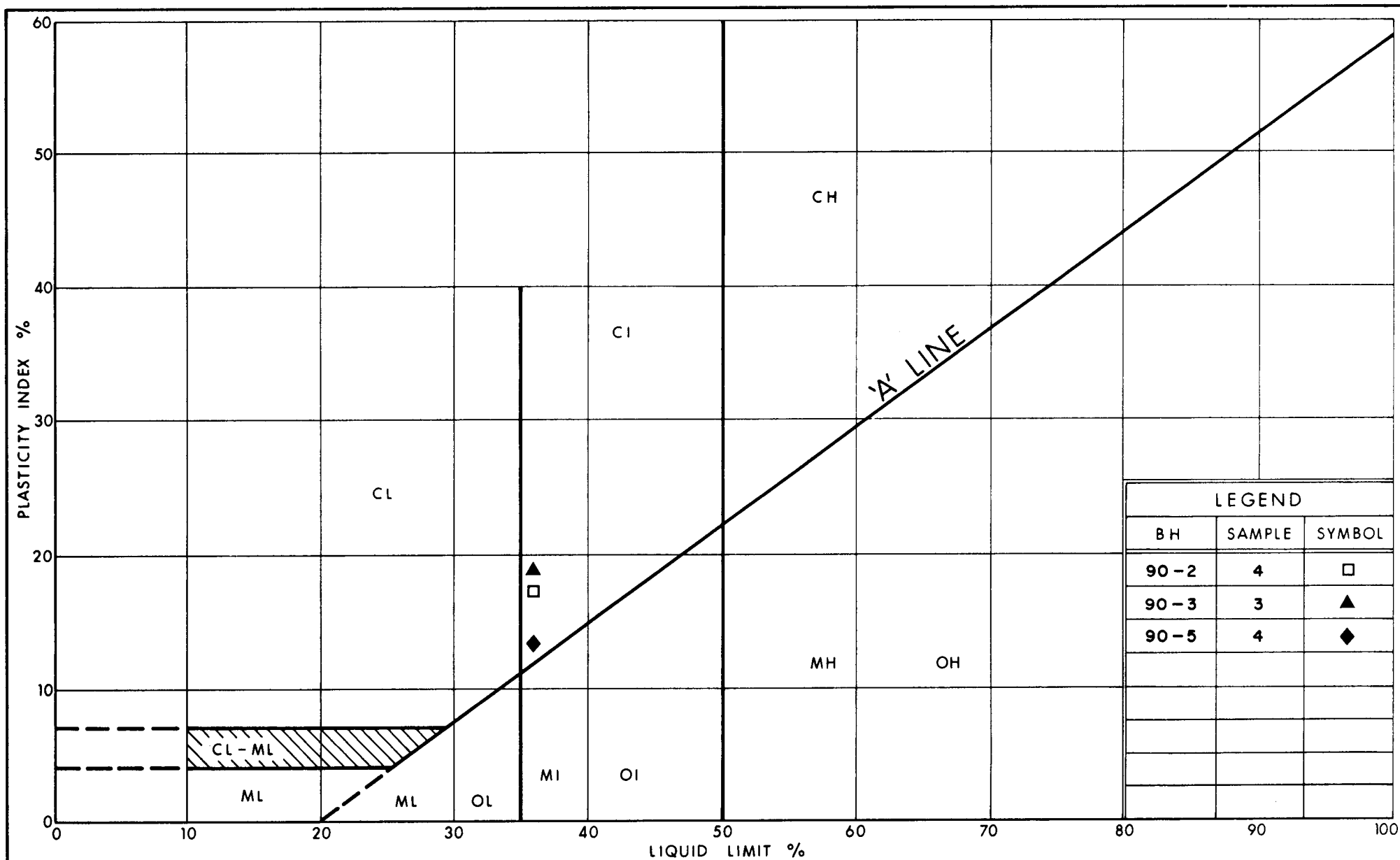
Ontario

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Transportation

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF
SILT, SAND, GRAVEL & BOULDERS (Glacial Till)

FIG No 5

W P 369-89-05



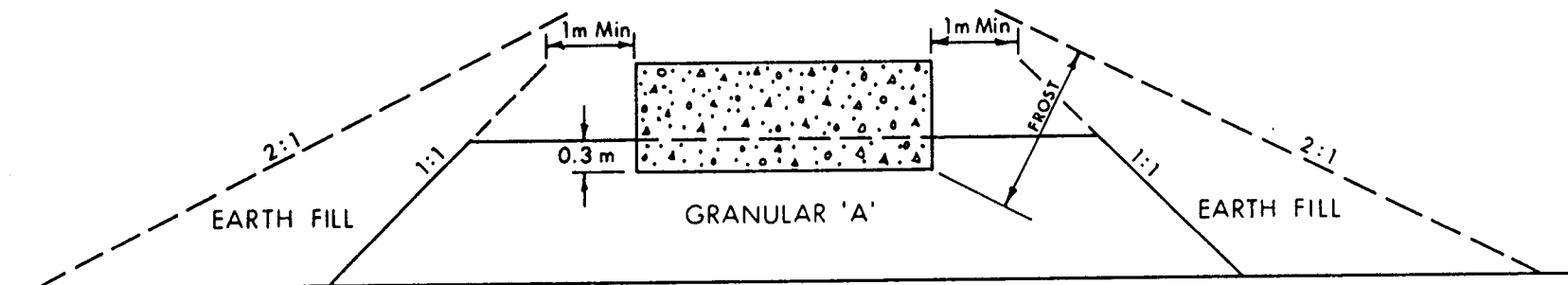
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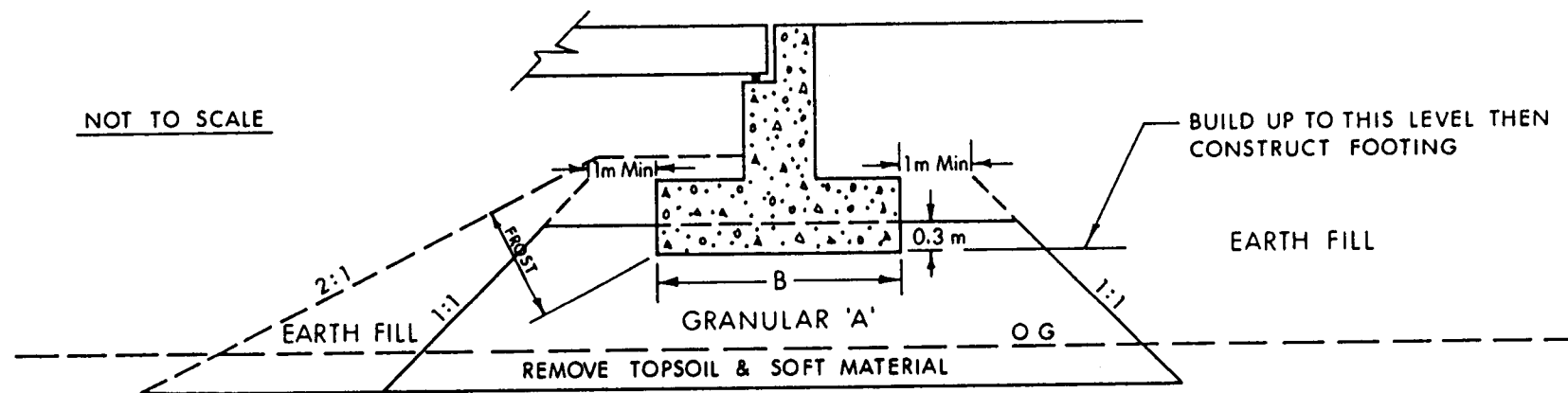
PLASTICITY CHART CLAYEY SILT

FIG No 6

W P 369-89-05



X SECTION



LONGITUDINAL SECTION

NOTES:

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING.
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.



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ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE

FIG No 7

W P 369-89-05

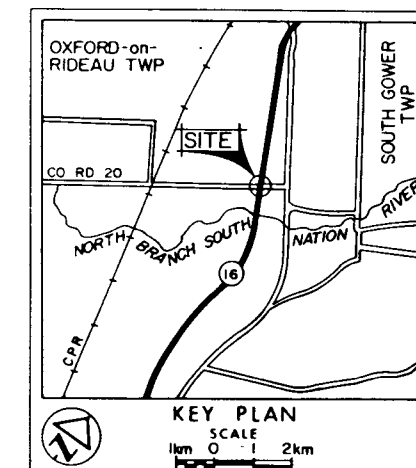
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 369-89-05
HWY 416 UNDERPASS
AT COUNTY ROAD 20
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

JACQUES, WHITFORD LIMITED



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 90 12
- W/L in Piezometer
- Piezometer

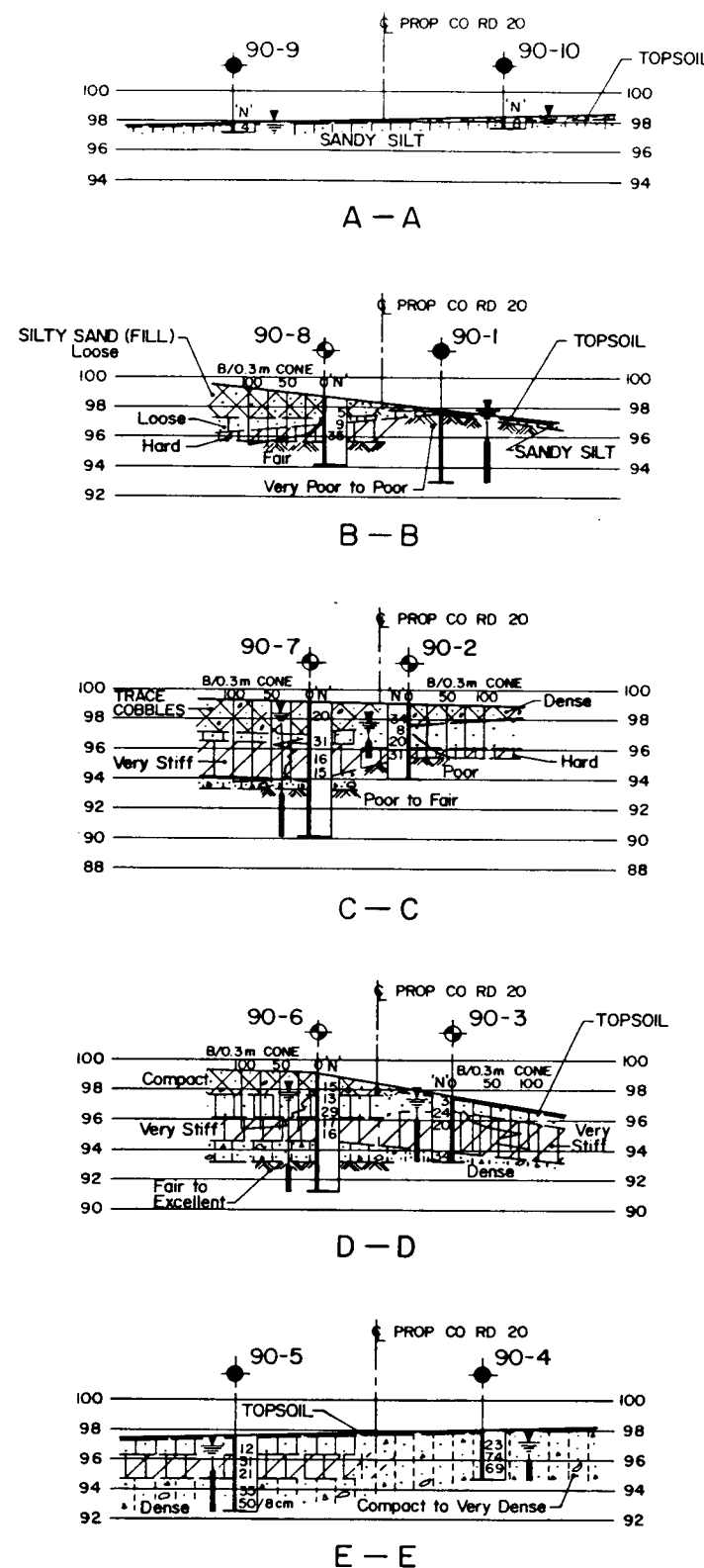
No	ELEVATION	CO-ORDINATES NORTH	EAST
90-1	97.8	4 978 939.7	376 918.5
90-2	99.0	4 978 967.7	376 947.4
90-3	97.6	4 978 987.4	376 982.1
90-4	98.1	4 979 009.7	377 016.5
90-5	97.7	4 979 037.4	376 999.5
90-6	99.1	4 979 002.4	376 973.0
90-7	99.1	4 978 979.1	376 941.3
90-8	98.7	4 978 952.7	376 910.6
90-9	97.9	4 978 940.8	376 875.8
90-10	98.4	4 978 910.4	376 894.5

NOTE

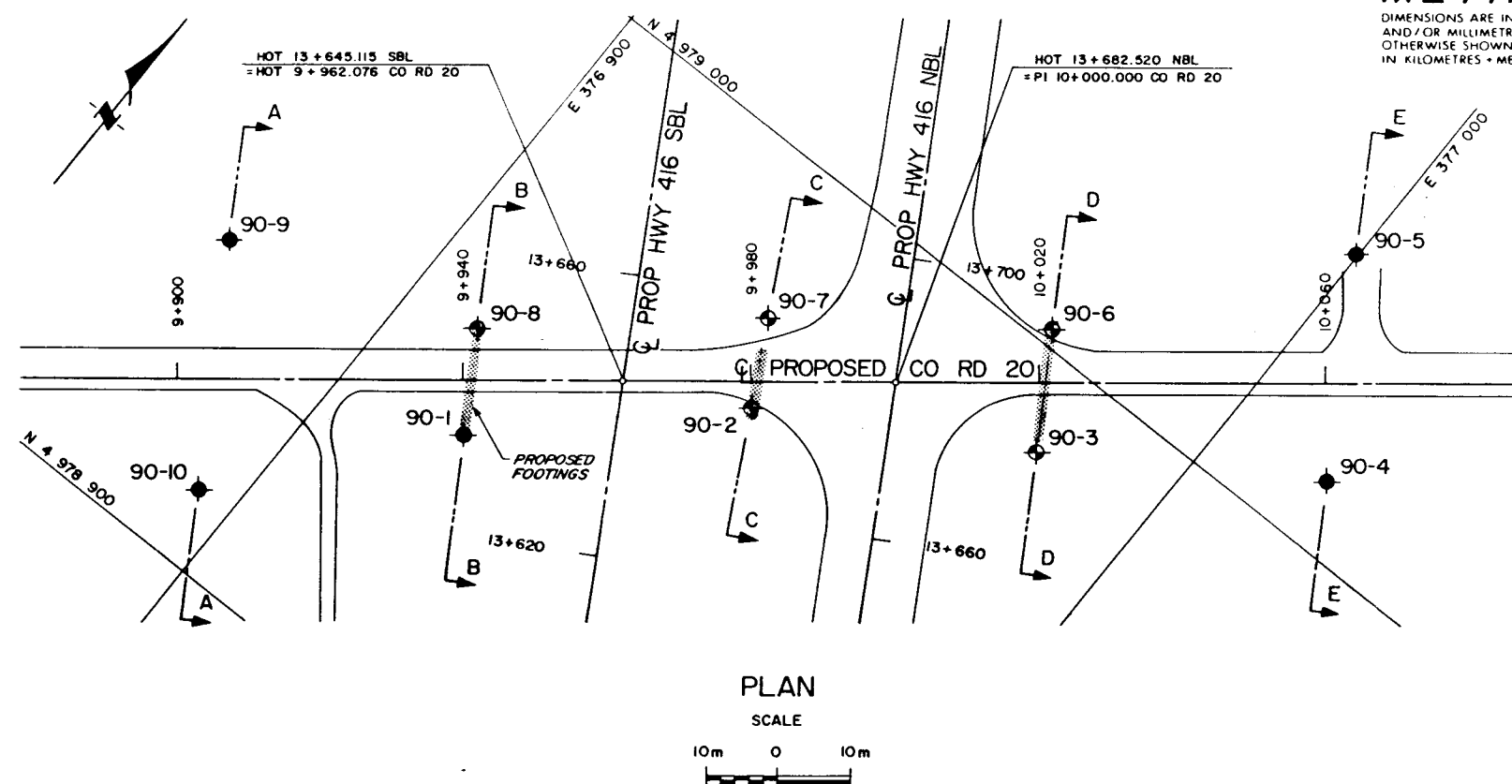
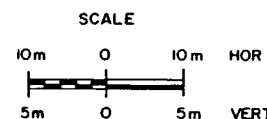
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION
1			
Geocrs No 31B-71			
HWY No 416			DIST 9
SUBM'D CKD CHECKED			DATE 1991 03 15 SITE 16-314
DRAWN GBB CHECKED			APPROVED DWG 3698905-A

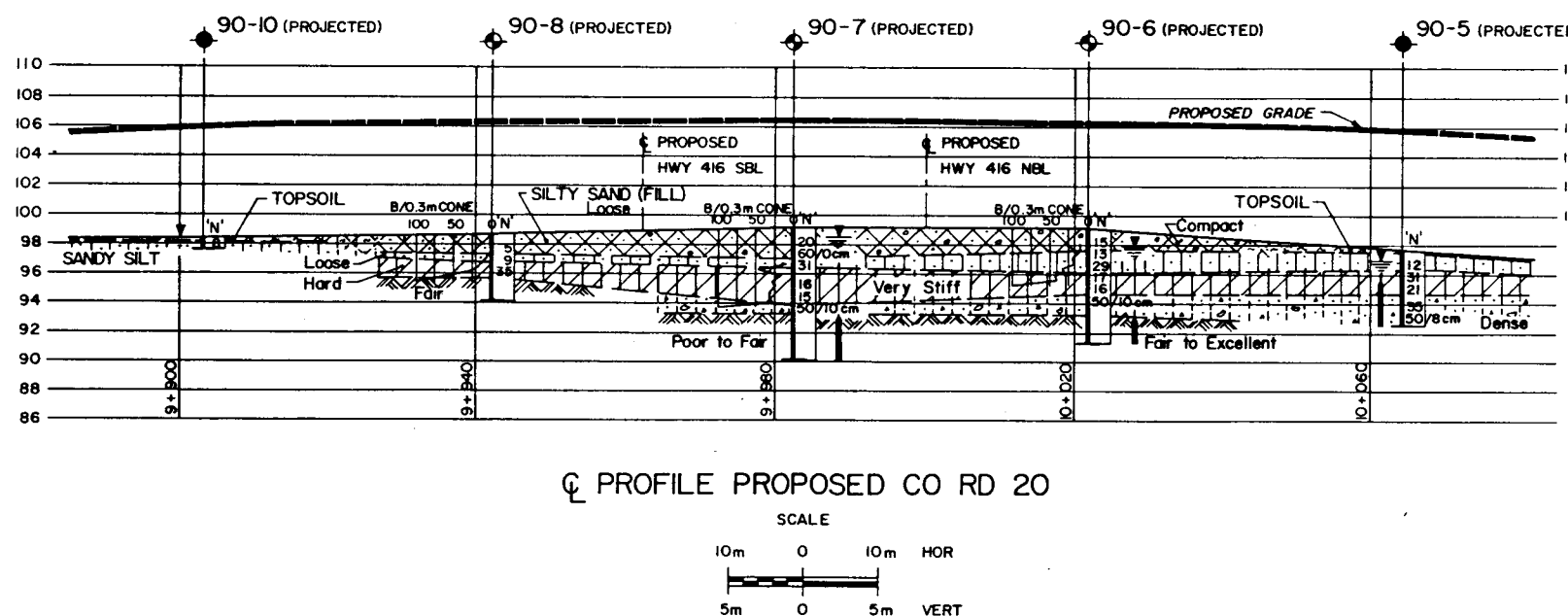
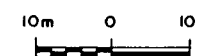


SECTIONS



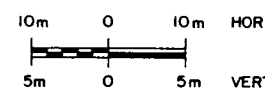
PLAN

SCALE



PROFILE PROPOSED CO RD 20

SCALE



SOIL STRATIGRAPHY LEGEND

	SANDY SILT Compact		SAND, SOME GRAVEL, SOME SILT Loose to Compact		HET MIXTURE OF SILT, SAND, GRAVEL & BOULDERS Very Dense (GLACIAL TILL)
	CLAYEY SILT TRACE SAND Very Stiff to Hard		SAND & GRAVEL, SOME SILT Compact (FILL)		LIMESTONE BEDROCK