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FOUNDATION
INVESTIGATION AND DESIGN REPORT
PLAINS ROAD OVERPASS AT CP RAIL
HIGHWAY 6 WIDENING
BETWEEN HIGHWAYS 403 AND 5
G.W.P. 19-95-00

Submitted to:

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PART A

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1.0 INTRODUCTION

Golder Associates Ltd. has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the following components associated with the widening of Highway 6 between Highways 403 and 5 near Waterdown, Ontario:

- Three bridge structures – replacement of the existing three-span Highway 6 bridge over CP Rail, a new Plains Road bridge over CP Rail, and a new underpass at York Road.

- The Bruce Trail pedestrian tunnel extending under Highway 6, in the vicinity of Old Guelph Road.

- Replacement and/or extension of five culverts.

- High embankments along Highway 6, York Road and the proposed Plains Road.

This report addresses the new Plains Road overpass at the CP Rail line. A foundation investigation has been carried out to determine the subsurface conditions at the site.

The terms of reference for the scope of work are outlined in Golder Associates' Proposal No. P01-1166, dated June 2000. The work has been carried out in accordance with Golder Associates' Quality Control Plan for Foundation Engineering Services, dated July 2000.

2.0 SITE DESCRIPTION

This 2.5 km length of Highway 6, between Highway 403 and Highway 5 (Dundas Street), is located within the City of Burlington in the Regional Municipality of Halton, and the Towns of Dundas and Flamborough in the New City of Hamilton.

Highway 6 crosses the Niagara escarpment south of Highway 5, in the vicinity of Old Guelph Road. The escarpment crest is at about Elevation 215 m; above the crest, the ground surface rises northward to about Elevation 220 m near the north limit of the project at Highway 5. The cut through the escarpment – the "Clappison Cut" – was first constructed in 1921. Above Old Guelph Road, near-vertical rock cuts up to about 15 m in height have been constructed on either side of Highway 6. Below the crest, the ground surface declines from Elevation 215 m to about Elevation 147 m in the vicinity of York Road, and about Elevation 133 m near the south limit of the project. Immediately south of Old Guelph Road, Highway 6 has been constructed on embankment fill which is up to about 15 m in height.

The Plains Road – CP Rail structure will be located immediately east of the existing Highway 6 – CP Rail structure. At the site, the natural ground surface varies from about Elevation 145 m to 143 m; the ground surface generally declines to the south and west of the proposed structure location. The CP Rail line has been constructed in a cut between 4 m and 6 m deep, with the rail grade at about Elevation 139 m to 139.6 m within the limits of the proposed Plains Road structure. The rail grade and the cut depth decline from east to west at the structure site. The Plains Road grade within the structure limits is proposed to be at about Elevation 147.5 m, requiring approach embankments between about 2 m and 4 m in height. Highway 6, to the west, has been constructed on an embankment up to about 6 m high, with the existing highway grade at about Elevation 146.5 m to 147 m.

3.0 INVESTIGATION PROCEDURES

A subsurface investigation was carried out for the Plains Road – CP Rail structure in January 2001, September 2002 and December 2002, at which time nine boreholes were advanced. The locations at which boreholes could be drilled were restricted due to the relatively steep highway embankment side slopes, the existing Highway 6 embankment side slopes, clearance distances from the CP Rail line, and the presence of a fibre optic cable along the north side of the rail line.

Seven of the boreholes (Boreholes P1 to P6 and P8) were drilled to depths of between 9 m and 22 m, to extend through the existing fill, where present, and into the underlying hard clayey silt till / residual soil some 10 m below the rail cut grade. The remaining two boreholes (Borehole P7 and P9) were advanced for the north and south approach embankments, respectively; these boreholes were extended to depths of about 3.5 m and 5.0 m, respectively.

All of the boreholes were advanced by solid stem augers using bombardier-mounted drill rigs supplied and operated by Master Soil Investigations Ltd. of Weston, Ontario and Geo-Environmental Drilling Inc. of Milton, Ontario. Samples of the overburden were obtained at 0.75 m and 1.5 m intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedure. It is noted that the split-spoon sampler was driven using a manual hammer in Boreholes P1, P3, P4, P5, P6 and P7, and using an automatic hammer for Boreholes P2, P8 and P9. The water level in the open boreholes was observed throughout the drilling operations, and a piezometer was installed in Boreholes P2 and P4 to monitor the groundwater level at the site.

The field work was supervised on a full-time basis by a member of Golder Associates' staff who located the boreholes in the field, directed the drilling, sampling, and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder Associates' laboratory in Mississauga for further examination. Index and classification tests consisting of water content determinations, Atterberg Limits testing and grain size distribution analyses were carried out on selected soil samples.

The borehole locations and ground surface elevations were measured by Callon Dietz, Ontario Land Surveyors or were determined by Golder Associates relative to points staked by Callon Dietz on the foundation elements. The borehole locations, including MTM NAD83 northing and easting coordinates, and ground surface elevations referenced to geodetic datum are shown on Drawing 1.

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

This 2.5 km section of Highway 6 traverses the Niagara Escarpment, which separates the lower Iroquois Plain to the south from the Flamborough Plain to the north, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, Third Edition, 1984). In the vicinity of the Escarpment itself, covering much of the study area for this project, the Halton Till of the Peel Plain physiographic region is present, according to the *Urban Geology of Canadian Cities* (Karrow and White, 1998).

The escarpment crest is located just north of Old Guelph Road, and well-jointed and bedded sedimentary bedrock consisting of dolostone, limestone, sandstone and shale is exposed in the existing Highway 6 cut. Typically, natural talus intermixed with rubbly glacial debris covers the lower slopes of the escarpment. Below the escarpment, the bedrock consists of shale.

The Halton Till of the Peel Plain physiographic region typically ranges in composition from a dense, reddish clayey silt to silt till to a grey, plastic clayey silt to silty clay till. This Halton Till is the lowest and oldest soil deposit encountered in excavations in the Hamilton area, and it typically rests directly on the bedrock. Commonly, there is a transition zone of residual soil and/or disturbed bedrock at the contact between the Halton Till and the shale.

4.2 Site Stratigraphy

As part of the subsurface investigation for this structure site, nine boreholes were advanced in 2001 and 2002. The borehole locations and ground surface elevations are shown on Drawing 1.

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in-situ and laboratory testing are given on the Record of Borehole sheets and Figures 1 to 4. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations. It is noted that the samplers used in the geotechnical investigation limit the maximum particle size that can be sampled to about 40 mm (for standard 50 mm diameter split-spoon samplers); larger particle sizes present within the deposits, including cobbles and boulders, are not represented on the grain size distribution test result figures.

In summary, the soils encountered at this site consist of a layer of topsoil up to 300 mm thick, overlying a deposit of hard, brown to grey-brown clayey silt till, which in turn overlies a deposit of hard, red-brown clayey silt till / residual soil. In one of the boreholes, the till / residual soil deposit was penetrated and found to be underlain by red-brown shale bedrock. The surface of the shale was encountered in this borehole at Elevation 124.9 m (about 14 m below the rail cut grade, and 22 m below the proposed Plains Road grade). A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections, and stratigraphic profiles and sections of this site are shown on Drawings 1 and 2.

4.2.1 Clayey Silt Till to Silty Clay Till

The site is underlain by a deposit of brown to grey-brown clayey silt till, which grades to a silty clay till at some of the borehole locations. This till contains trace to some sand, and trace gravel and shale fragments. This deposit is glacially-derived and, as such, should be expected to contain cobbles and boulders even though such obstructions were not specifically encountered in the boreholes advanced at the site. Grain size distribution test results obtained on three samples of this till are shown on Figure 1 following the text of this report. The base of this till deposit was encountered between about Elevation 132 m and 130 m, approximately 7 m to 9.5 m below the existing rail cut grade.

Atterberg limits testing carried out on thirteen samples of this till measured plastic limits of 15 to 18 per cent and liquid limits of 27 to 35 per cent, with corresponding plasticity indices of 12 to 17 per cent. The results of the limits testing, shown on Figure 2, indicate that the till is predominantly an inorganic clayey silt of low plasticity, although portions of the till grade to an intermediate plasticity silty clay. The measured natural moisture contents range from 8 to 18 per cent, typically at or slightly below the plastic limit for the material.

The till has a hard consistency, with measured SPT “N” values typically ranging from 32 to greater than 100 blows per 0.3 m of penetration. In Borehole P2, an SPT “N” value of 22 blows per 0.3 m of penetration was measured at about Elevation 133 m (approximately 11 m depth). It should be noted that the measured SPT “N” values in Boreholes P2, P8 and P9 are typically lower than those measured in the other six boreholes at the site. Boreholes P2, P8 and P9 were drilled using a drill rig equipped with an automatic hammer. Based on a review of the ratios of the automatic versus manual SPT “N” values, it is considered that some of the SPT “N” values measured with the manual hammer are higher than what would be anticipated; however, the SPT “N” values are still expected to be in the range of 50 to 90 blows per 0.3 m of penetration.

4.2.2 Clayey Silt Till / Residual Soil

The brown to grey-brown clayey silt to silty clay till is underlain by a red-brown deposit consisting of clayey silt till / residual soil, the top of which was encountered in the boreholes between about Elevation 132 m and 130 m (about 7 m to 9.5 m below the existing rail cut grade). The till / residual soil deposit was proved for a thickness of at least 2 m to 4 m in the boreholes. In Borehole P8, where the deposit was fully penetrated, the till / residual soil deposit is about 6 m thick.

The till / residual soil contains trace to some sand, and trace gravel and shale fragments; relatively thin layers or lenses of weathered shale and limestone were noted within this deposit in the samples recovered at this site and the adjacent Highway 6 – CP Rail structure site. Grain size distribution test results obtained for two samples of this till / residual soil are shown on Figure 3. In Boreholes P2 and P8, an interlayer of grey silty clay till / residual soil was encountered within the red-brown clayey silt till / residual soil deposit. The top of this interlayer was at about Elevation 129.3 m and 127.0 m in Boreholes P2 and P8, respectively, and the interlayer at these two locations was 1 m and 0.6 m thick.

Atterberg limits testing carried out on four samples of the red-brown till / residual soil measured plastic limits of 13 to 14 per cent, liquid limits of 22 to 27 per cent, and plasticity indices of 9 to 12 per cent. The results of the limits testing, shown on Figure 4, indicate that the till / residual soil is inorganic and of low plasticity. The measured natural moisture contents range from 8 to 13 per cent, typically at or slightly below the plastic limit for the material.

The red-brown till / residual soil has a hard consistency, with measured SPT "N" values generally well above 100 blows per 0.3 m of penetration. However, within and immediately below the grey silty clay till / residual soil interlayer encountered in Borehole P8 (where an automatic hammer was used), SPT "N" values of 71 and 80 blows per 0.3 m of penetration were measured.

4.2.3 Shale Bedrock

Red-brown shale bedrock of the Queenston Formation was encountered below the red-brown till / residual soil in one borehole (Borehole P8) at this structure site. At this location, the surface of the shale was encountered at Elevation 124.9 m, approximately 14 m to 14.5 m below the rail cut grade and 22.5 m below the proposed Plains Road grade. Shale bedrock was also encountered in one borehole at the Highway 6 – CP Rail structure site immediately west of this site; in that borehole, the surface of the shale bedrock is at Elevation 129.7 m.

4.3 Groundwater Conditions

With the exception of Borehole P8 which was advanced into the shale bedrock at the site, all of the boreholes were dry during and on completion of the drilling operations for this site. Water was encountered at Elevation 125.2 m, just above the surface of the shale bedrock, during drilling of Borehole P8.

A piezometer was installed in Boreholes P2 and P8 at this structure site, and in one borehole (Borehole H3) at the Highway 6 structure site. Each of these piezometers is screened within the till / residual soil. The water levels measured in the piezometers on November 11 and November 22, 2002 varied from about Elevation 138 m to 136 m, as summarized in the following table:

Borehole No.	***Piezometer Tip and Filter Pack Interval***	***Water Level Elevation***	
		Nov. 11, 2002	***Nov. 22, 2002***
H3	Till / residual soil below Elevation 132.1 m	138.0 m	138.0 m
P2	Till / residual soil below Elevation 127.6 m	136.0 m	136.0 m
P8	Till / residual soil below Elevation 126.1 m	137.1 m	136.9 m

It should be noted that groundwater levels are expected to fluctuate seasonally and are expected to rise during wet periods of the year.

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PART B

FOUNDATION DESIGN REPORT
PLAINS ROAD OVERPASS AT CP RAIL
HIGHWAY 6 WIDENING BETWEEN HIGHWAYS 403 AND 5
G.W.P. 19-95-00

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides foundation design recommendations for the proposed Plains Road overpass at CP Rail. The recommendations are based on interpretation of the factual data obtained from a limited number of boreholes advanced during the subsurface investigation at this site. The interpretation and recommendations provided are intended only to provide the designers with sufficient information to assess the feasible foundation alternatives for design of the proposed overpass and staging of this construction. As such, where comments are made on construction they are provided only in order to highlight those aspects which could affect the planning of the project.

The new Plains Road alignment will extend along the east side of Highway 6 from Old Plains Road (just north of Highway 403) to York Road. A new bridge will be required to carry Plains Road over the CP Rail line. It is understood that the preferred option involves construction of a single-span structure.

5.2 Bridge and Retaining Wall Foundation Options

At the structure site, the natural ground surface varies from about Elevation 145 m to 143 m, generally declining toward the south and west. The CP Rail line has been constructed in a cut between 4 m and 6 m deep, with the rail grade at about Elevation 139 m to 139.6 m within the proposed structure limits; the rail grade and the cut depth decline toward the west. In the immediate vicinity of the new structure, Plains Road will be constructed on between 2 m and 4 m of embankment fill, such that its profile grade is at about Elevation 147.5 m at the structure site.

The native soils at the site consist of hard clayey silt to silty clay till, overlying hard clayey silt till / residual soil below about Elevation 132 m to 130 m (about 7 m to 9.5 m below the existing rail cut grade), in turn overlying shale bedrock. The native till soils at relatively shallow depth below the existing rail cut are suitable for support of the proposed abutments and associated retaining walls, such as concrete cantilever retaining walls, on shallow foundations. In addition, the native soils are suitable for use of a mechanically-reinforced soil retaining wall system (retained soil system or RSS wall) adjacent to the bridge abutments at this site.

Deep foundations, such as driven steel H-piles, could also be considered for support of the proposed single-span structure and associated retaining walls. However, depending upon the pile-driving equipment that is used at the site, pre-augering for driven piles could be required due to the hard nature of the till / residual soil deposits through and into which the piles would be driven, as well as the potential presence of cobbles and boulders within these glacially-derived materials.

Recommendations for both shallow and deep foundations for the bridge abutments and associated retaining walls are presented in the following sections.

5.3 Spread Footings

The bridge abutments may be supported on spread footings placed below any topsoil and fill to be founded within the undisturbed clayey silt to silty clay till deposit. Any associated concrete cantilever wing walls / retaining walls may also be supported on spread footings founded on the undisturbed clayey silt to silty clay till deposit. As noted in Section 5.3.3, a minimum of 1.2 m of soil cover must be provided above the footing level to ensure adequate protection against frost penetration. In this regard, a founding level of Elevation 137.8 m may be taken for the design of the spread footings. Consideration could be given to stepping the footing upward toward the east end of the structure, where the rail cut grade is higher; however, this would allow raising the footing only to about Elevation 138.4 m based on the assumed highest grade within the rail cut of Elevation 139.6 m. The grades should be checked to ensure adequate frost cover is provided.

5.3.1 Geotechnical Resistance

Spread footings placed on the undisturbed clayey silt to silty clay till deposit, at or below the design elevation given above, may be designed based on a factored geotechnical resistance at Ultimate Limit States (ULS) of 850 kPa. The settlement of the footings will be dependent on the footing size, configuration, and applied loads. The geotechnical resistance at Serviceability Limit States (SLS) may be taken as 450 kPa. These geotechnical resistances assume a footing width of 4.2 m and a footing length of about 32 m. The geotechnical resistances should be reviewed if there are significant changes in the foundation geometry.

The geotechnical resistances provided herein are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Sections 6.7.2 and 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC)* and its *Commentary*.

5.3.2 Resistance to Lateral Loads

Resistance to lateral forces / sliding resistance between the concrete footings and subsoils should be calculated in accordance with Section 6.7.5 of the *CHBDC*. The coefficient of friction, tan δ, may be taken as 0.55 for cast-in-place concrete footings constructed on the undisturbed, hard clayey silt till. This represents an unfactored value; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

5.3.3 Frost Protection

The footings should be provided with a minimum of 1.2 m of soil cover for frost protection.

5.4 Driven Steel H-Pile Foundations

Steel H-piles should be driven to found at least 1 m into the clayey silt till / residual soil. The surface of this deposit was encountered in the boreholes between about Elevation 132 m and 130 m, but typically at about Elevation 131 m. It should be recognized that the hard nature of the till will likely result in heavy driving; in addition, the use of driven foundations at this site must take into account the hard nature of the till deposits and the potential presence of cobbles and boulders within the deposits. Stiffening of the pile toe and top will be required for protection during driving. Pre-augering could be required to ensure a reasonable pile length without undue heavy driving, depending on the type of pile-driving equipment used for construction. However, in general, if the H-piles meet refusal above approximately Elevation 132 m such that the pile length is inadequate for structural considerations, the pile would have to be withdrawn and augering carried out to remove or displace the obstruction, prior to re-driving.

5.4.1 Axial Geotechnical Resistance

The factored axial resistance at ULS for steel HP 310 x 110 piles driven to found within the clayey silt till / residual soil may be taken as 1,600 kN. The settlement of the individual piles and the pile group at the above pile loads is anticipated to be less than 25 mm. The geotechnical resistance at SLS for 25 mm of settlement will be greater than the factored axial resistance at ULS and, as such, the ULS conditions will govern at this site.

To achieve the above design resistance of 1,600 kN at ULS, the piles should be driven to a final set of no less than 15 blows per 25 mm of penetration using a hammer with rated energy of about 50 kJ, and not exceeding 60 kJ. Provision should be made to re-tap selected piles to confirm the set after adjacent piles have been driven, in accordance with MTO’s current Special Provision.

5.4.2 Resistance to Lateral Loads

Lateral loading could be resisted fully or partially by the use of battered piles. If vertical piles are used, the resistance to lateral loading will have to be derived from the soil in front of the piles. If integral abutments are under consideration, there may also be a requirement for the piles to move sufficiently to accommodate the bridge deck deflections.

The resistance to lateral loading in front of the pile may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction, k_h, is based on the following equation for cohesive soils:

$$k_h = \frac{k_{s1}}{5B}$$ where B is the pile diameter (m) and

k_{s1} is the coefficient of horizontal subgrade reaction, as given below.

The following ranges for the value of k_{s1} may be assumed in the structural analysis:

Soil Unit	k_{s1}
Hard clayey silt to silty clay till above about Elevation 131 m	50 to 100 MPa/m
Hard clayey silt till / residual soil below about Elevation 131 m	100 to 150 MPa/m

Group action for lateral loading should be considered when the pile spacing in the direction of the loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of lateral subgrade reaction in the direction of loading by a reduction factor as follows:

Pile Spacing in Direction of Loading d = Pile Diameter	***Reduction Factor***
8d	1.0
6d	0.7
4d	0.4
3d	0.25

5.4.3 Frost Protection

The pile caps should be provided with a minimum of 1.2 m of soil cover for frost protection.

5.5 Retained Soil System (RSS) Walls

A mechanically-reinforced soil retaining wall system (retained soil system or RSS wall) consists of granular fill placed and compacted in layers, and reinforced with metal or fabric strips or grids. A facing material, typically pre-cast concrete panels mechanically fastened to the reinforcing strips or grids, is used to form the face of the reinforced soil structure and to prevent the loss of fill material.

Use of an RSS wall is considered appropriate for the proposed wing walls / retaining walls, which will be between about 4 m and 8 m high. A typical RSS wall is founded at least 0.3 m below the existing ground surface in front of the wall. For the reinforced earth mass founded on the hard clayey silt to silty clay till below the existing rail cut grade (i.e. at or below about Elevation 139 m to 139.5 m at the west and east limits of the proposed structure, respectively), the factored geotechnical resistance at ULS will depend on the width of the reinforced soil mass and the following values may be used for design:

- 275 kPa for a 4 m high wall; and
- 500 kPa for an 8 m high wall.

These values assume that the RSS wall acts as a unit and utilizes the full width of the reinforced soil mass which is taken as two-thirds of the height of the wall. The geotechnical resistance at SLS, for 25 mm of settlement, may be taken as 400 kPa.

The resistance to lateral forces / sliding resistance between the compacted Granular "A" and the till subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. The coefficient of friction, tan δ or tan N', between the compacted Granular "A" of the RSS wall and the generally hard clayey silt to silty clay till may be taken as 0.55. This represents an unfactored value; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

The internal stability of the mechanically-reinforced soil walls should be checked by the RSS supplier / designer. The Factor of Safety related to global stability for properly designed and constructed RSS walls at this site will be greater than 1.3.

5.6 Lateral Earth Pressures for Design

The lateral earth pressures acting on the abutment stems and any associated wing walls / retaining walls will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill, on the magnitude of surcharge including construction loadings, on the freedom of lateral movement of the structure, and on the drainage conditions behind the walls.

The following recommendations are made concerning the design of the walls. It should be noted that the above design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select free-draining granular fill meeting the specifications of Ontario Provincial Standard Specifications (OPSS) Granular 'A' or Granular 'B' but with less than 5 per cent passing the 200 sieve should be used as backfill behind the walls. This fill should be compacted in loose lifts not greater than 200 mm in thickness to 95 per cent of the material's Standard Proctor maximum dry density in accordance with OPSS 501. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD 3501.00 and 3504.00.

- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the wall stem, in accordance with *CHBDC* Section 6.9.3 and Figure 6.9.3. Compaction equipment should be used in accordance with OPSS 501.06. Other surcharge loadings should be accounted for in the design, as required.

- The granular fill may be placed either in a zone with width equal to at least 1.2 m behind the back of the wall stem (Case I in Figure C6.9.1(l) of the *Commentary to the CHBDC*) or within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Case II in Figure C6.9.1(l) of the *Commentary to the CHBDC).*

- For Case I, the pressures are based on the existing and proposed embankment fill materials and the following parameters (unfactored) may be assumed:

Soil unit weight:	20 kN/m^3
Coefficients of lateral earth pressure:	
Active, K_a	0.35
At rest, K_o	0.50

- For Case II, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	Granular 'A'	**Granular 'B' Type II**
Soil unit weight:	22 kN/m^3	21 kN/m^3
Coefficients of lateral earth pressure:		
Active, K_a	0.27	0.31
At rest, K_o	0.43	0.47

- If the wall support and superstructure allow lateral yielding of the stem, active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design.

5.7 Excavations and Temporary Roadway Protection

Excavations for construction of the abutment and wing wall / retaining wall footings will extend to at least 1.2 m below the existing rail cut grade. This will require excavation into the existing permanent cut slopes along the north and south sides of the rail line, which are between 4 m and 6 m high. The excavations will extend through the existing hard clayey silt to silty clay till, and will generally remain above the water table at the site (taken as Elevation 137 m). Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities. The clayey silt to silty clay till is classified as a Type 3 soil, according to the OHSA.

Temporary excavations (i.e. those which are only open for a relatively short period) through the clayey silt to silty clay till should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V).

Where space restrictions preclude the use of temporary open-cuts, a temporary excavation support system will be required. The temporary excavation support system should be designed and constructed in accordance with MTO's Special Provision 539S01. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in SP 539S01.

5.8 Approach Embankment Design

The construction of the Plains Road approach embankments will require placement of 2 m to 4 m of fill above the existing ground surface behind the proposed abutments. Based on the borehole results, the embankment subgrade soils will consist of very stiff to hard clayey silt till. Any topsoil, organic matter and softened / loosened soils should be stripped from below the approach embankment areas and all subgrade soils proof-rolled prior to fill placement. Embankment fill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 per cent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase and base courses should be compacted to 100 per cent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified personnel during placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

With appropriate subgrade preparation and proper placement and compaction of embankment fill materials, 2 m to 4 m high approach embankments with side slopes maintained at 2 horizontal to 1 vertical (2H:1V) will have an adequate factor of safety against deep-seated slope instability. To reduce surface water erosion on the embankment side slopes, placement of topsoil and seeding or pegged sod is recommended.

5.9 Design and Construction Considerations

5.9.1 Obstructions

The native soils at the site are glacially-derived and, as such, are expected to contain cobbles and boulders, although no such obstructions were encountered in the boreholes advanced at this structure site. The presence of such obstructions could affect the installation of driven steel H-piles for deep foundations or temporary excavation support, and could also affect the installation of soil or rock anchors (tie-backs). Provision should be made in the Contract Documents to ensure that the Contractor is equipped to handle such obstructions.

5.9.2 Groundwater and Surface Water Control

Excavations will generally be maintained above the groundwater table; however, seepage into the excavation could occur from perched water within lenses or interlayers of permeable material that may be present within the till deposit. It is considered that the quantity of groundwater seepage can be handled by pumping from properly filtered sumps placed at the base of the excavation. The sumps should be maintained outside the footing limits.

The soils in which the footing or pile cap excavations will be formed are susceptible to disturbance from ponded water and construction traffic. Provision should be made in the Contract Documents for the placement of a lean concrete mat to protect the soils from such disturbance. Such a working mat should be placed within four hours after subgrade preparation and inspection.

GOLDER ASSOCIATES LTD.

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LCC/ASP/FJH/lcc
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LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to “A” size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u,s_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. General

π	3.1416
in x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\,\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
v	poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma$-u)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1+\sigma_2+\sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s/\rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_1	liquid limit
w_p	plastic limit
l_p	plasticity index $= (w_1 - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p)/I_p$
I_C	consistency index $= (w_1 - w)/I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p/\sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u,s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

Notes:

1 $\tau = c' + \sigma' \tan\phi'$

2 shear strength = (compressive strength)/2

* density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

PROJECT 001-1141F

RECORD OF BOREHOLE No P1

1 OF 2

METRIC

W.P. 19-95-00

LOCATION N 4795502.9 ;E 272225.0

ORIGINATED BY GM

DIST Central HWY 6

BOREHOLE TYPE 108mm Diameter Solid Stem Augers

COMPILED BY LCC

DATUM Geodetic

DATE Jan.08/01

CHECKED BY ASP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES
145.1	Ground Surface			
0.0	Clayey SILT, trace sand and gravel Very stiff Red-brown			
		1	SS	21
143.7 1.4	Clayey SILT, trace to some sand, trace gravel (Till) Hard Brown becoming grey-brown below 3m depth Dry to moist	2	SS	69
		3	SS	86
		4	SS	100
		5	SS	90
		6	SS	80
		7	SS	75/.15
		8	SS	50
		9	SS	66
		10	SS	75
		11	SS	70
132.0 13.1	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till/Residual Soil) Hard Red-brown Dry to moist	12	SS	72/.15

STRAT PLOT

GROUND WATER CONDITIONS

ELEVATION SCALE

DYNAMIC CONE PENETRATION RESISTANCE PLOT

20 40 60 80 100

SHEAR STRENGTH kPa

○ UNCONFINED + FIELD VANE

● QUICK TRIAXIAL × REMOULDED

20 40 60 80 100

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

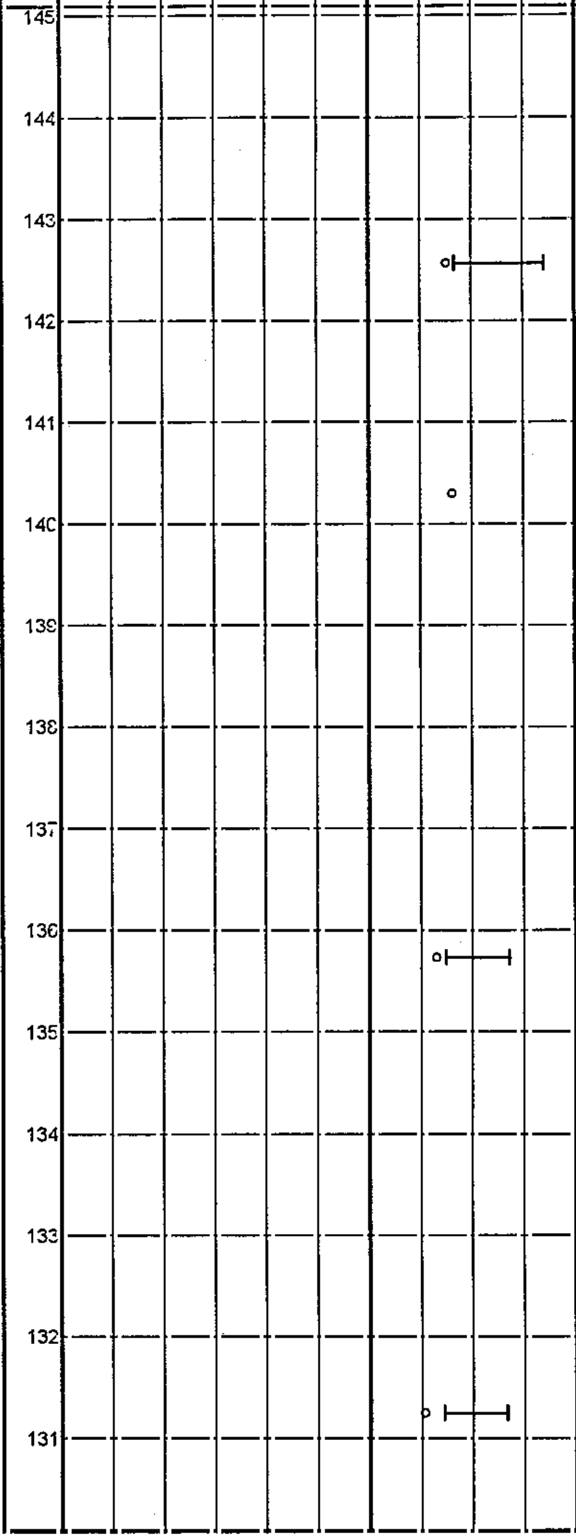
WATER CONTENT (%)

10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL



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$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT 001-1141F

RECORD OF BOREHOLE No P1 2 OF 2 **METRIC**

W.P. 19-95-00

LOCATION N 4795502.9 :E 272225.0

ORIGINATED BY GM

DIST Central HWY 6

BOREHOLE TYPE 108mm Diameter Solid Stem Augers

COMPILED BY LCC

DATUM Geodetic

DATE Jan.08/01

CHECKED BY ASP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION *— CONTINUED FROM PREVIOUS PAGE —*	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR	SA	SI	CL
	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till/Residual Soil) Hard Red-brown Dry to moist		13	SS	102/.15		130							
							129							
			14	SS	110/.23									
128.1 17.0	End of Borehole Note: Borehole dry on completion of drilling operations.													

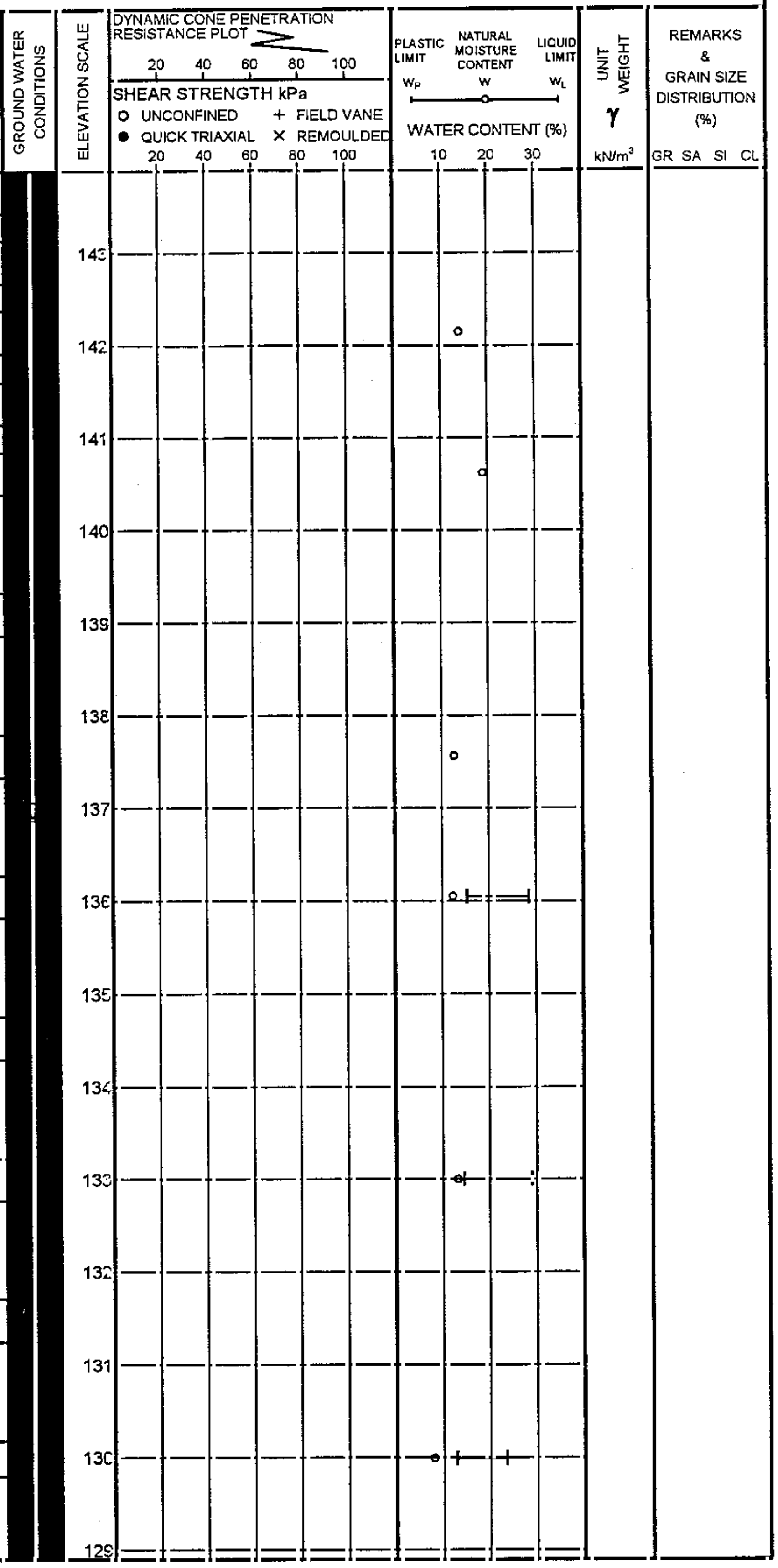
$+^3, \times^3$: Numbers refer to Sensitivity O $^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No P2

1 OF 2 **METRIC**

PROJECT 001-1141F			
W.P. 19-95-00	LOCATION N 4795520.1 ;E 272224.5	ORIGINATED BY GM	
DIST Central HWY 6	BOREHOLE TYPE 108mm Diameter Solid Stem Augers	COMPILED BY LCC	
DATUM Geodetic	DATE Sept.23/02	CHECKED BY LCC	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES
143.9	Ground Surface			
0.0 143.6	Topsoil	1	SS	10
0.3	Clayey SILT, trace sand, gravel and shale fragments (Till) Hard Brown to grey-brown Moist	2	SS	37
		3	SS	49
		4	SS	43
		5	SS	34
		6	SS	36
		7	SS	42
		8	SS	32
		9	SS	35
	Becoming very stiff between 10m and 12m depth.	10	SS	22
		11	SS	58
130.9 13.0	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till/Residual Soil) Hard Red-brown Moist	12	SS	110
129.3 14.6				



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+³,X³: Numbers refer to Sensitivity

O³% STRAIN AT FAILURE

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PROJECT 001-1141F

RECORD OF BOREHOLE No P2

2 OF 2

METRIC

W.P. 19-95-00

LOCATION N 4795520.1 ;E 272224.5

ORIGINATED BY GM

DIST Central HWY 6

BOREHOLE TYPE 108mm Diameter Solid Stem Augers

COMPILED BY LCC

DATUM Geodetic

DATE Sept.23/02

CHECKED BY LCC

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —										
	Silty CLAY, trace sand (Till/Residual Soil) Hard Grey Moist	▨	13	SS	115				○		
128.3 15.6	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till/Residual Soil) Hard Red-brown Dry to moist						128				
			14	SS	125		127				
126.7 17.2	End of Borehole										

Notes:

1. Borehole dry on completion of drilling operations.

2. Water level in piezometer measured on November 11, 2002 at 7.9m depth (Elev.136.0m) .

3. Water level in piezometer measured on November 22, 2002 at 7.9m depth (Elev.136.0m) .

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No P3

1 OF 2 **METRIC**

PROJECT 001-1141F

W.P. 19-95-00

DIST Central HWY 6

DATUM Geodetic

LOCATION N 4795533.2 ;E 272223.0

BOREHOLE TYPE 108mm Diameter Solid Stem Augers

DATE Jan.15-16/01

ORIGINATED BY GM

COMPILED BY LCC

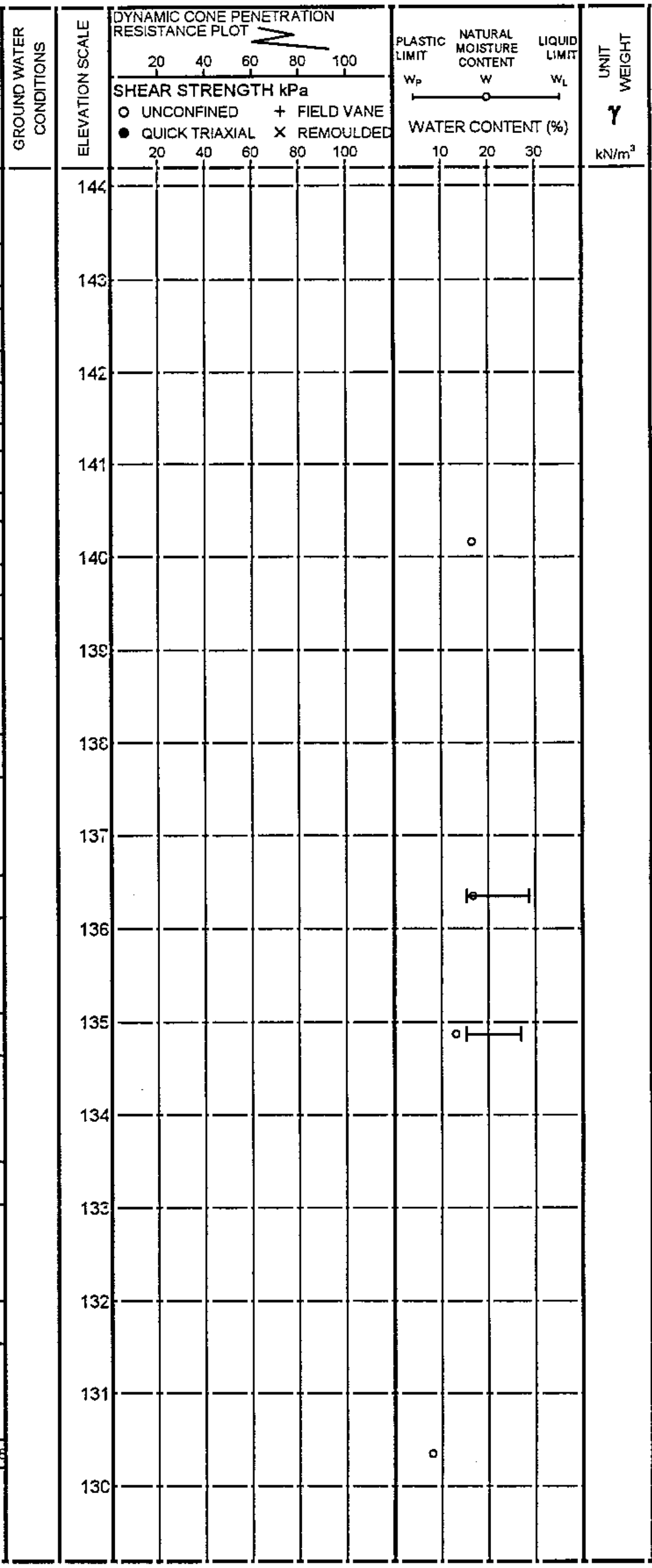
CHECKED BY ASP

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
144.2	Ground Surface
0.0	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till) Hard Brown to grey-brown Dry to moist
131.1 13.1	Clayey SILT, trace to some sand, trace gravel and shale fragments (till/residual soil) Hard Red-brown Dry to moist

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	51	
2	SS	78	
3	SS	45	
4	SS	72	
5	SS	57	
6	SS	59	
7	SS	57	
8	SS	83	3 15 56 26
9	SS	53	
10	SS	65	
11	SS	85	
12	SS	100/.08	



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$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

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PROJECT 001-1141F　　**RECORD OF BOREHOLE No P3**　　2 OF 2　　**METRIC**

W.P. 19-95-00　　LOCATION N 4795533.2 ;E 272223.0　　ORIGINATED BY GM

DIST Central　HWY 6　　BOREHOLE TYPE 108mm Diameter Solid Stem Augers　　COMPILED BY LCC

DATUM Geodetic　　DATE Jan.15-16/01　　CHECKED BY ASP

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION — CONTINUED FROM PREVIOUS PAGE —	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Clayey SILT, trace to some sand, trace gravel and shale fragments (till/residual soil) Hard Red-brown Dry to moist		13	SS	105/.15		129				
							128				
			14	SS	110						
127.2 17.0	End of Borehole Note: Borehole dry on completion of drilling operations.										

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$+^3, \times^3$: Numbers refer to Sensitivity　　$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No P4

1 OF 1 **METRIC**

PROJECT 001-1141F
W.P. 19-95-00
DIST Central HWY 6
DATUM Geodetic

LOCATION N 4795470.0 ;E 272252.4
BOREHOLE TYPE 108mm Diameter Solid Stem Augers
DATE Jan.24/01

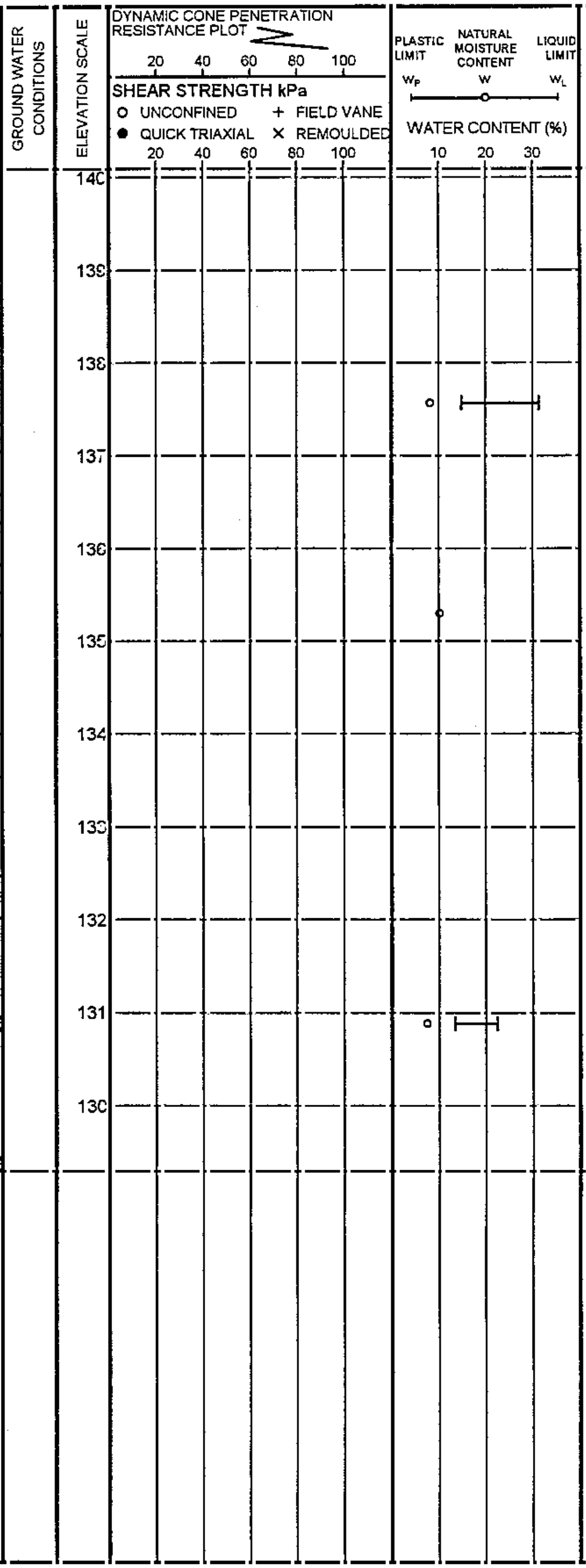
ORIGINATED BY GM
COMPILED BY LCC
CHECKED BY ASP

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
140.1	Ground Surface
0.0	Clayey SILT, some sand, trace gravel and rootlets Stiff Brown
138.7 1.4	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till) Hard Brown to grey-brown Dry to moist
132.2 7.9	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till/Residual Soil) Hard Red-brown Dry to moist
129.3 10.8	End of Borehole Note: Borehole dry on completion of drilling operations.

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	11
2	SS	110
3	SS	70
4	SS	90
5	SS	90
6	SS	80
7	SS	91
8	SS	100/.28
9	SS	105/.15
10	SS	100/.1



UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	4	18	60	18

$+^3, \times^3$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

PROJECT 001-1141F

RECORD OF BOREHOLE No P5 1 OF 1 **METRIC**

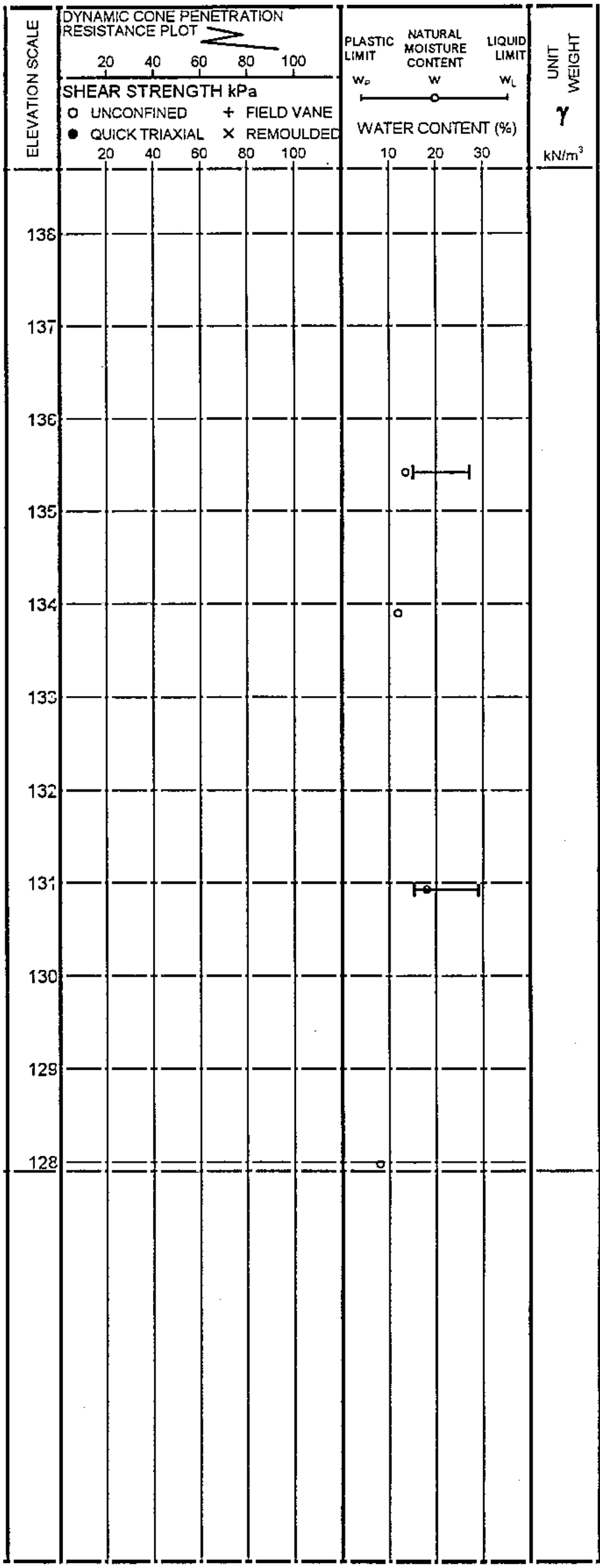
W.P. 19-95-00 LOCATION N 4795491.6 ;E 272248.5 ORIGINATED BY GM

DIST Central HWY 6 BOREHOLE TYPE 108mm Diameter Solid Stem Augers COMPILED BY LCC

DATUM Geodetic DATE Jan.22/01 CHECKED BY ASP

ELEV DEPTH	SOIL PROFILE DESCRIPTION
138.7	Ground Surface
0.0	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till) Hard Brown to grey-brown Dry to moist
130.2 8.5	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till/Residual Soil) Hard Red-brown Dry to moist
127.9 10.8	End of Borehole Note: Borehole dry on completion of drilling operations.

SAMPLES NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	69				
2	SS	87				
3	SS	72				
4	SS	86				
5	SS	75				
6	SS	90				
7	SS	88				
8	SS	100/.15	5	13	56	26
9	SS	100/.08				
10	SS	102/.15				



REMARKS & GRAIN SIZE DISTRIBUTION (%)

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No P6

1 OF 1 **METRIC**

PROJECT 001-1141F
W.P. 19-95-00
DIST Central HWY 6
DATUM Geodetic

LOCATION N 4795517.3 ;E 272244.8
BOREHOLE TYPE 108mm Diameter Solid Stem Augers
DATE Jan.22/01

ORIGINATED BY GM
COMPILED BY LCC
CHECKED BY ASP

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
139.3	Ground Surface
0.0	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till) Hard Brown to grey-brown Moist
130.8 8.5	Clayey SILT, trace to some sand, trace gravel and shale fragments (Till/Residual Soil) Hard Red-brown Moist
130.0 9.3	End of Borehole Note: Borehole dry on completion of drilling operations.

SAMPLES

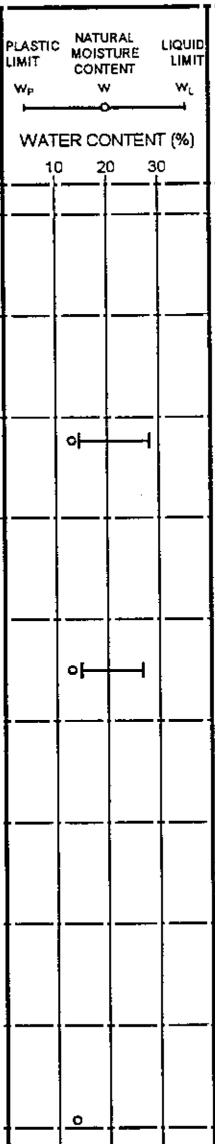
NUMBER	TYPE	"N" VALUES
1	SS	62
2	SS	51
3	SS	65
4	SS	68
5	SS	69
6	SS	74
7	SS	101
8	SS	110/.15
9	SS	200/.15

GROUND WATER CONDITIONS

ELEVATION SCALE: 139, 138, 137, 136, 135, 134, 133, 132, 131, 130

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100



UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

Golder Associates

PROJECT 001-1141F

RECORD OF BOREHOLE No P7

1 OF 1

METRIC

W.P. 19-95-00

LOCATION N 4795522.2 ;E 272216.9

ORIGINATED BY GM

DIST Central HWY 6

BOREHOLE TYPE 108mm Diameter Solid Stem Augers

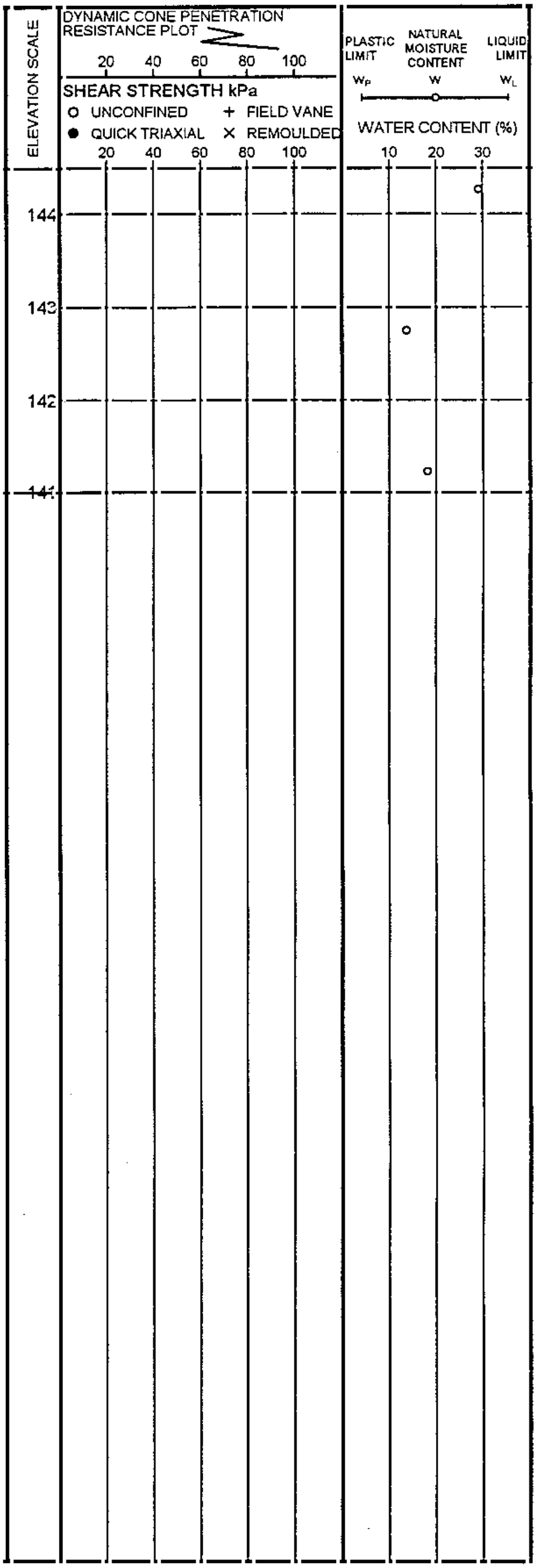
COMPILED BY LCC

DATUM Geodetic

DATE Jan.09/01

CHECKED BY ASP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			
144.5	Ground Surface							
0.0	Topsoil							
0.2	Clayey SILT, trace sand and gravel Firm Mottled brown		1	SS	7			
143.7 0.8	Clayey SILT, trace sand and gravel (Till) Very stiff to hard Brown to grey-brown Moist		2	SS	24			
			3	SS	90			
			4	SS	60			
			5	SS	49			
141.0 3.5	End of Borehole Note: Borehole dry on completion of drilling operations.							



+3, X3: Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE

MISS_MTO 0011141F.GPJ ON_MOT.GDT 16/4/04

Golder Associates

RECORD OF BOREHOLE No P8

1 OF 2 **METRIC**

PROJECT 001-1141F
W.P. 19-95-00
DIST Central HWY 6
DATUM Geodetic

LOCATION N 4795533.0 ;E 272218.2
BOREHOLE TYPE 108mm Diameter Solid Stem Augers
DATE Sept.24/02

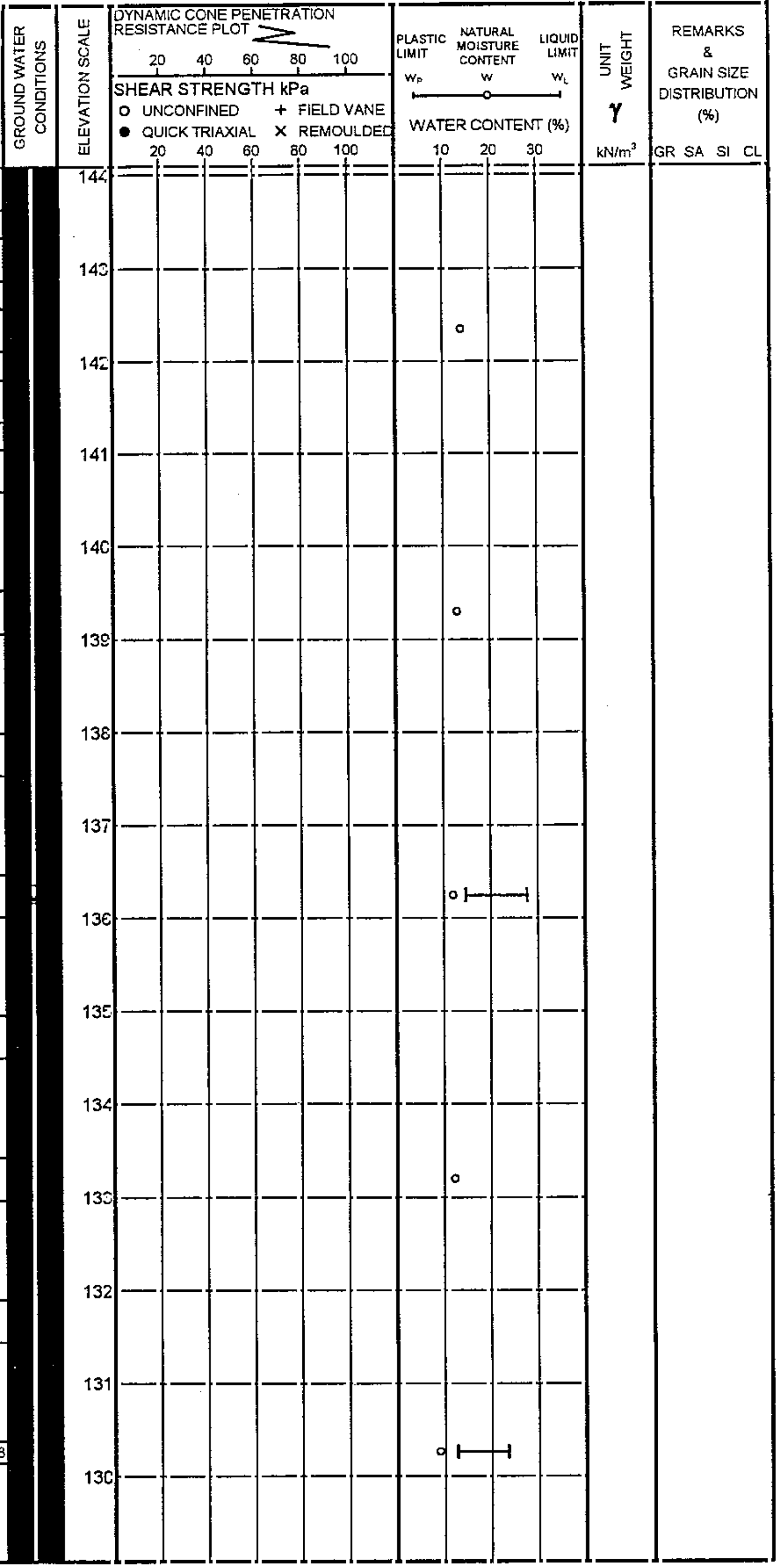
ORIGINATED BY GM
COMPILED BY LCC
CHECKED BY ASP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
144.1	Ground Surface
0.0 / 143.8	Topsoil
143.5 / 0.6	Clayey SILT, trace sand and rootlets Stiff Brown Dry to moist
	Clayey SILT, trace sand, gravel and shale fragments (Till) Hard Brown to grey-brown Moist
131.0 / 13.1	Clayey SILT, trace to some sand, trace gravel, shale and limestone fragments (Till/Residual Soil) Hard Red-brown Dry to moist

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	9
2	SS	29
3	SS	47
4	SS	36
5	SS	35
6	SS	48
7	SS	32
8	SS	31
9	SS	39
10	SS	32
11	SS	49
12	SS	52/.08



Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No P8

2 OF 2

METRIC

PROJECT 001-1141F

W.P. 19-95-00

LOCATION N 4795533.0 ;E 272218.2

ORIGINATED BY GM

DIST Central HWY 6

BOREHOLE TYPE 108mm Diameter Solid Stem Augers

COMPILED BY LCC

DATUM Geodetic

DATE Sept.24/02

CHECKED BY ASP

— CONTINUED FROM PREVIOUS PAGE —

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES
	Clayey SILT, trace to some sand, trace gravel, shale and limestone fragments (Till/Residual Soil) Hard Red-brown Dry to moist	13	SS	55/.08
		14	SS	71
127.0 17.1	Silty CLAY, trace sand, containing calcareous shale layers (Residual Soil) Hard Grey Moist			
126.4 17.7	Clayey SILT, trace to some sand, trace gravel, shale and limestone fragments (Residual Soil) Hard Red Dry to moist	15	SS	80
124.9 19.2	SHALE (Bedrock) Red	16	SS	105/.02
		17	SS	[illegible]
121.2 22.9	End of Borehole			

ELEVATION SCALE: 129, 128, 127, 126, 125, 124, 123, 122

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100
- O UNCONFINED
- \+ FIELD VANE
- ● QUICK TRIAXIAL
- X REMOULDED

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Notes:

1. Water level in open borehole at 18.9m depth (Elev.125.2m) on completion of drilling.

2. Water level in piezometer measured on November 11, 2002 at 7.0m depth (Elev.137.1m) .

3. Water level in piezometer measured on November 22, 2002 at 7.2m depth (Elev.136.9m) .

$+^3, \times^3$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No P9

1 OF 1 **METRIC**

PROJECT 001-1141F
W.P. 19-95-00
DIST Central HWY 6
DATUM Geodetic
LOCATION N 4795497.2 ;E 272257.2
BOREHOLE TYPE 108mm Diameter Solid Stem Augers
DATE Dec. 19/02
ORIGINATED BY PKS
COMPILED BY LCC
CHECKED BY ASP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
145.0	Ground Surface						
0.0	Clayey silt some sand, trace gravel, trace organics (Fill) Firm to very stiff Brown/black Moist	▩	1	SS	7		
			2	SS	15		144
143.5 1.5	Clayey SILT, some sand and gravel (Till) Hard Brown to grey-brown Moist	▨	3	SS	47		143
			4	SS	52		
			5	SS	52		142
							141
			6	SS	48		140
140.0 5.0	End of Borehole Note: Borehole dry on completion of drilling operations.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

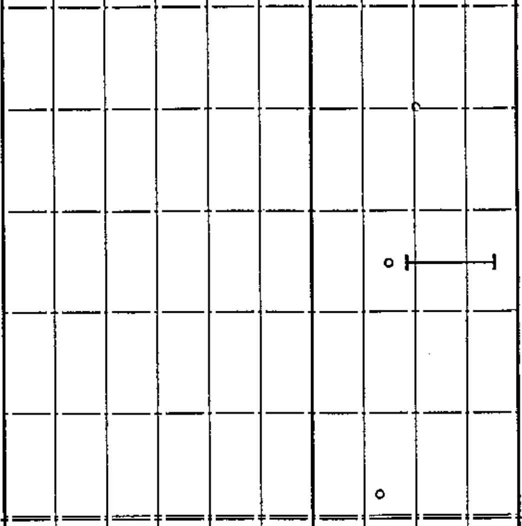
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL



+³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

MISS MTO 0011141F.GPJ ON MOT.GDT 16/4/04

DIST. HWY. 6
CONT No. 2004-2004
WP No. 19-95-00

SHEET

PLAINS ROAD OVERPASS
AT CP RAIL

BOREHOLE LOCATIONS AND SOIL STRATA

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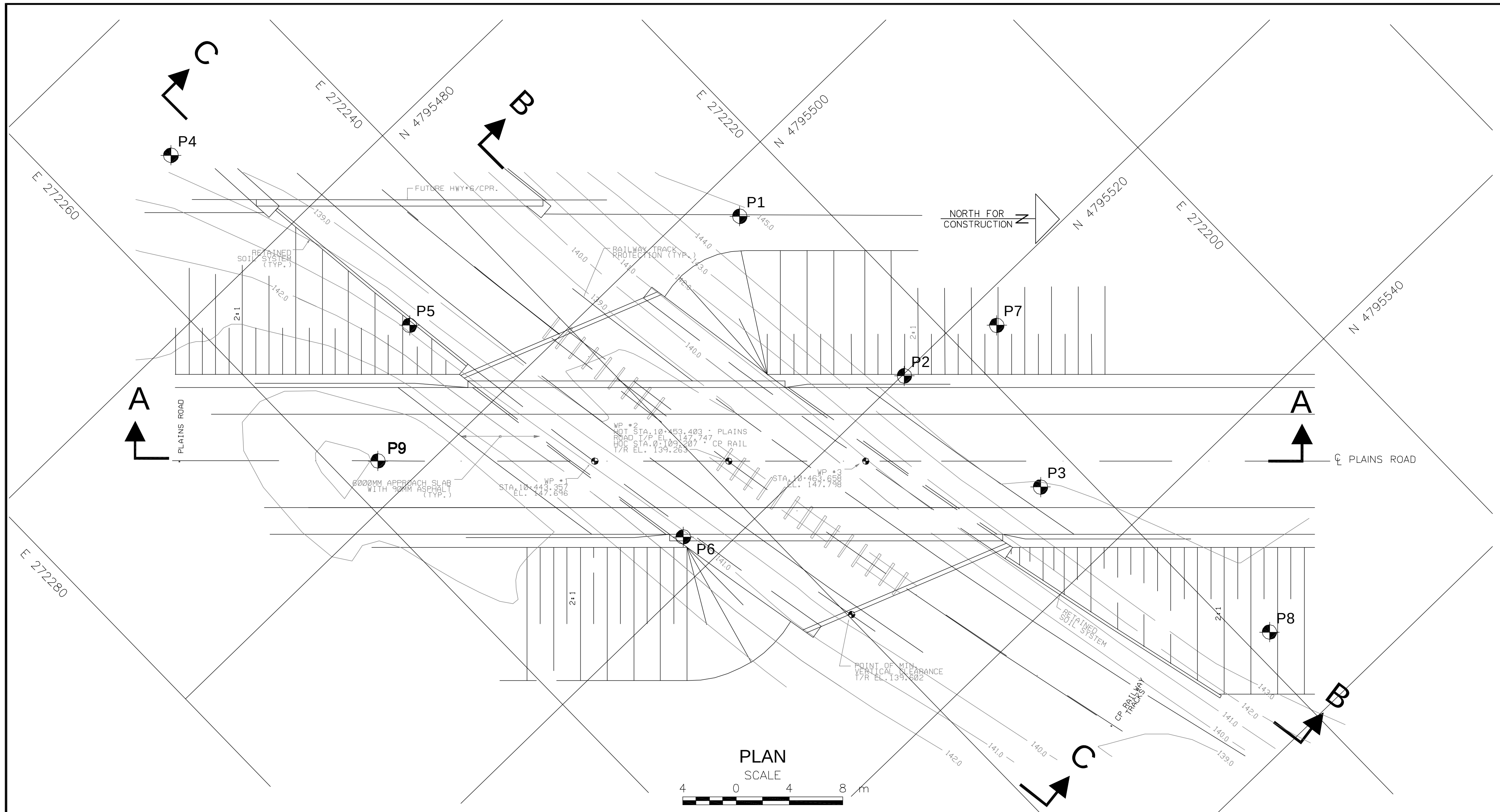
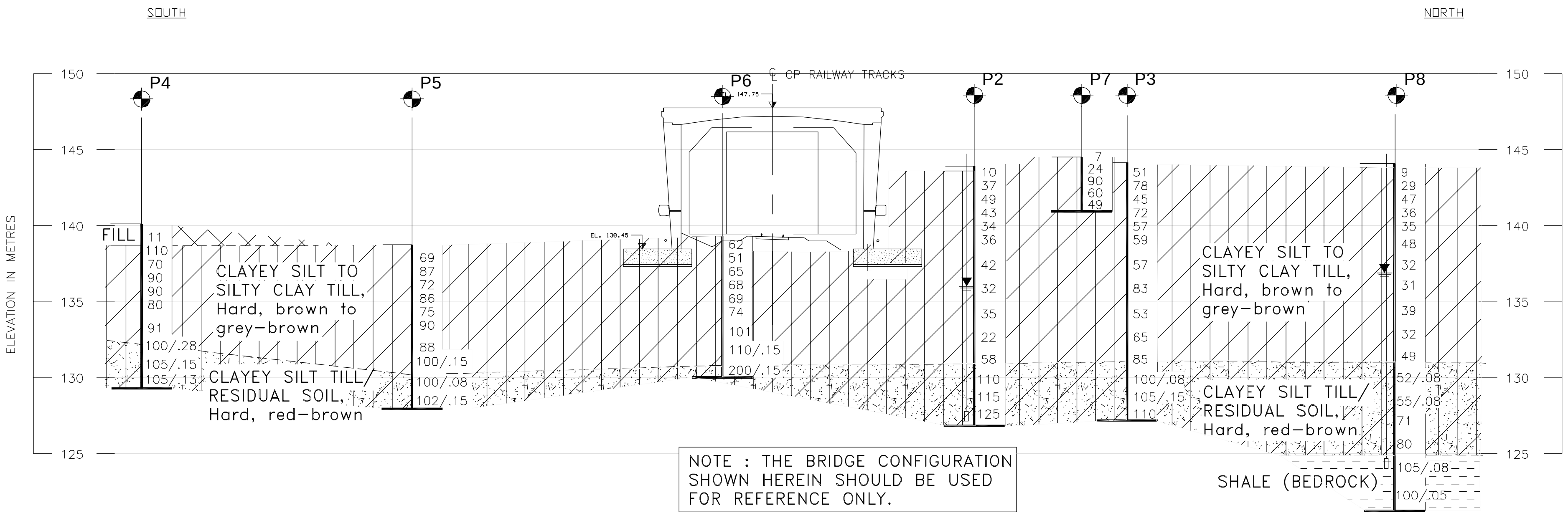
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



PLAN

SCALE

4 0 4 8 m

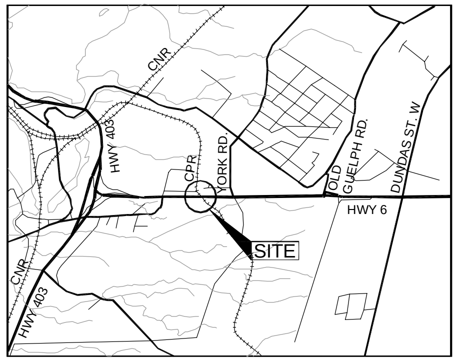


NOTE : THE BRIDGE CONFIGURATION SHOWN HEREIN SHOULD BE USED FOR REFERENCE ONLY.

SECTION A : PROFILE ALONG CENTRELINE OF PLAINS ROAD

SCALE

4 0 4 8 m



KEY PLAN

LEGEND

●	Borehole
⊕	Probehole
▪	Seal
▯	Piezometer
N	Standard Penetration Test value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▼	WL in piezometer, November 2002
▽	WL upon completion of drilling

No.	ELEVATION	LOCATION	
		NORTHING	EASTING
P1	145.1	4795502.9	272225.0
P2	143.9	4795520.1	272224.5
P3	144.2	4795533.2	272223.0
P4	140.1	4795470.0	272252.4
P5	138.7	4795491.6	272248.5
P6	139.3	4795517.3	272244.8
P7	144.5	4795522.2	272216.9
P8	144.1	4795553.0	272218.2
P9	145.0	4795497.2	272257.2

NOTES

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

REFERENCE

The base plan was provided in digital form (PlaGa.DGN) by URS Canada Inc. on April 8, 2004.

DATE	BY	REVISION

Geocres No.

HWY. 6		PROJECT NO. 001-1141F	DIST.
SUBM'D. LCC	CHKD. LCC	DATE: APRIL, 2004	SITE:
DRAWN: MHW	CHKD. LCC	APPD. ASP	DWG. 1

PLOT DATE: April 16, 2004
FILENAME: T:\Projects\2000\001-1141F\NOV-DEC.2002\P1141F02.dwg

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

DIST. HWY. 6
CONT No. 2004-2004
WP No. 19-95-00

PLAINS ROAD OVERPASS AT CP RAIL

SOIL STRATA

SHEET

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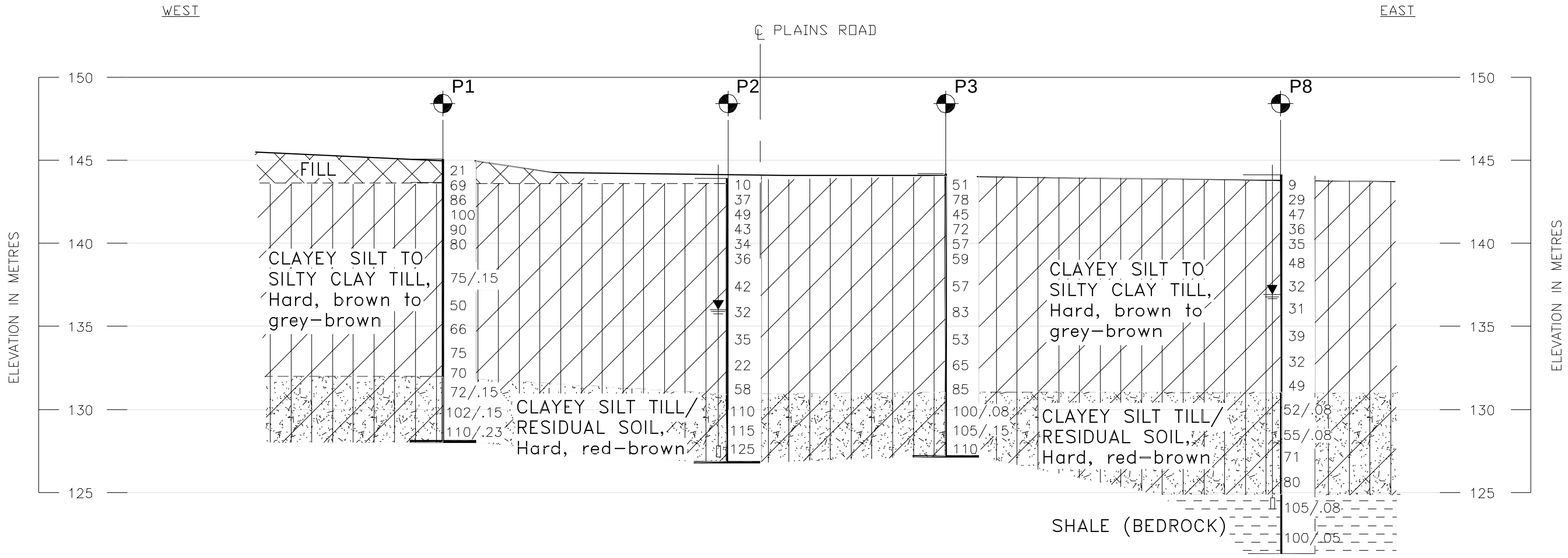
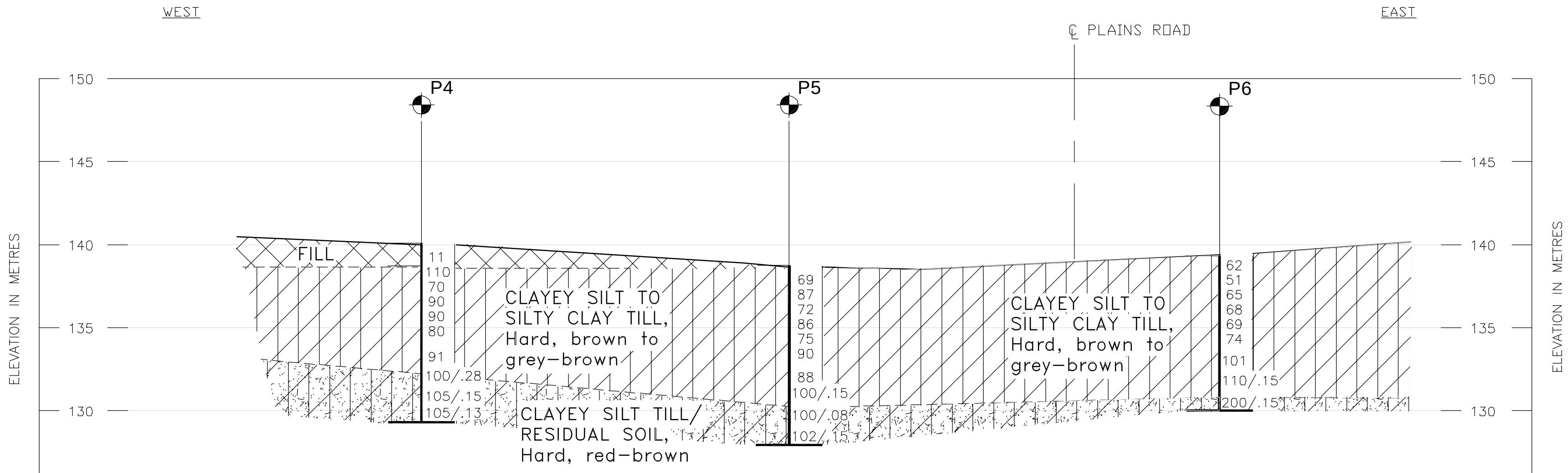


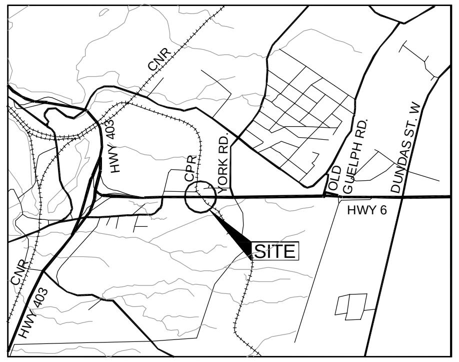
SECTION B : PROFILE ALONG NORTH ABUTMENT

SCALE
4 0 4 8 m



SECTION C : PROFILE ALONG SOUTH ABUTMENT

SCALE
4 0 4 8 m



KEY PLAN

LEGEND

⊕	Borehole
⊕	Probehole
▮	Seal
▯	Piezometer
N	Standard Penetration Test value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▼	WL in piezometer, November 2002
▽	WL upon completion of drilling

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P2	143.9	4795520.1	272224.5
P3	144.2	4795533.2	272223.0
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P5	138.7	4795491.6	272248.5
P6	139.3	4795517.3	272244.8
P7	144.5	4795522.2	272216.9
P8	144.1	4795553.0	272218.2
P9	145.0	4795497.2	272257.2

NOTES

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

REFERENCE

The base plan was provided in digital form (PlaGa.DGN) by URS Canada Inc. on April 8, 2004.

F.J. HEFFERNAN

A.S. POSCHMANN

NO.	DATE	BY	REVISION

Geocres No.

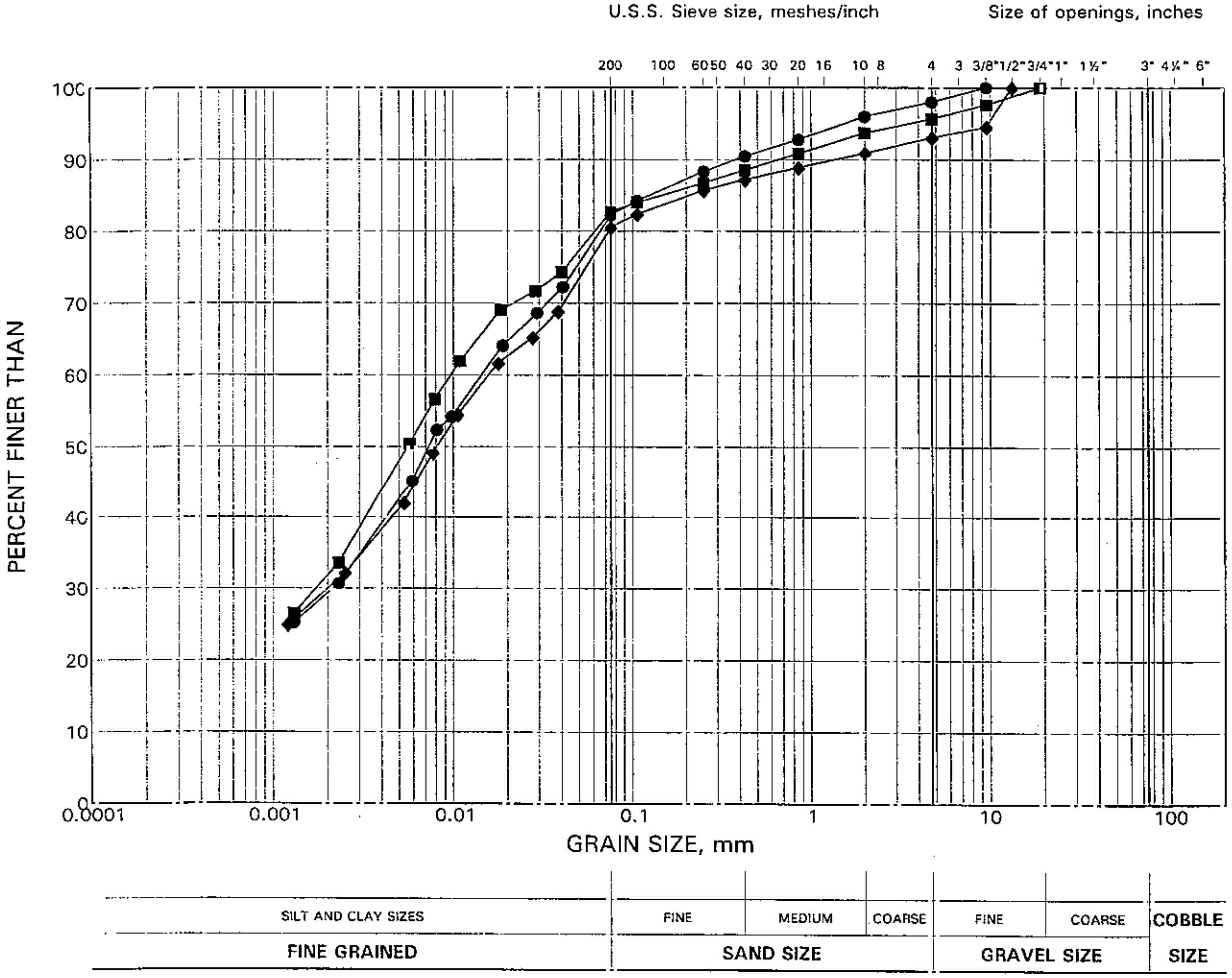
HWY. 6		PROJECT NO. 001-1141F	DIST.
SUBM'D. LCC	CHKD. LCC	DATE: APRIL, 2004	SITE:
DRAWN: MHW	CHKD. LCC	APPD. ASP	DWG. 2

PLOT DATE: April 16, 2004
FILENAME: T:\Projects\2000\001-1141F\NOV-DEC,2002\P1141F02.dwg

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt to Silty Clay Till

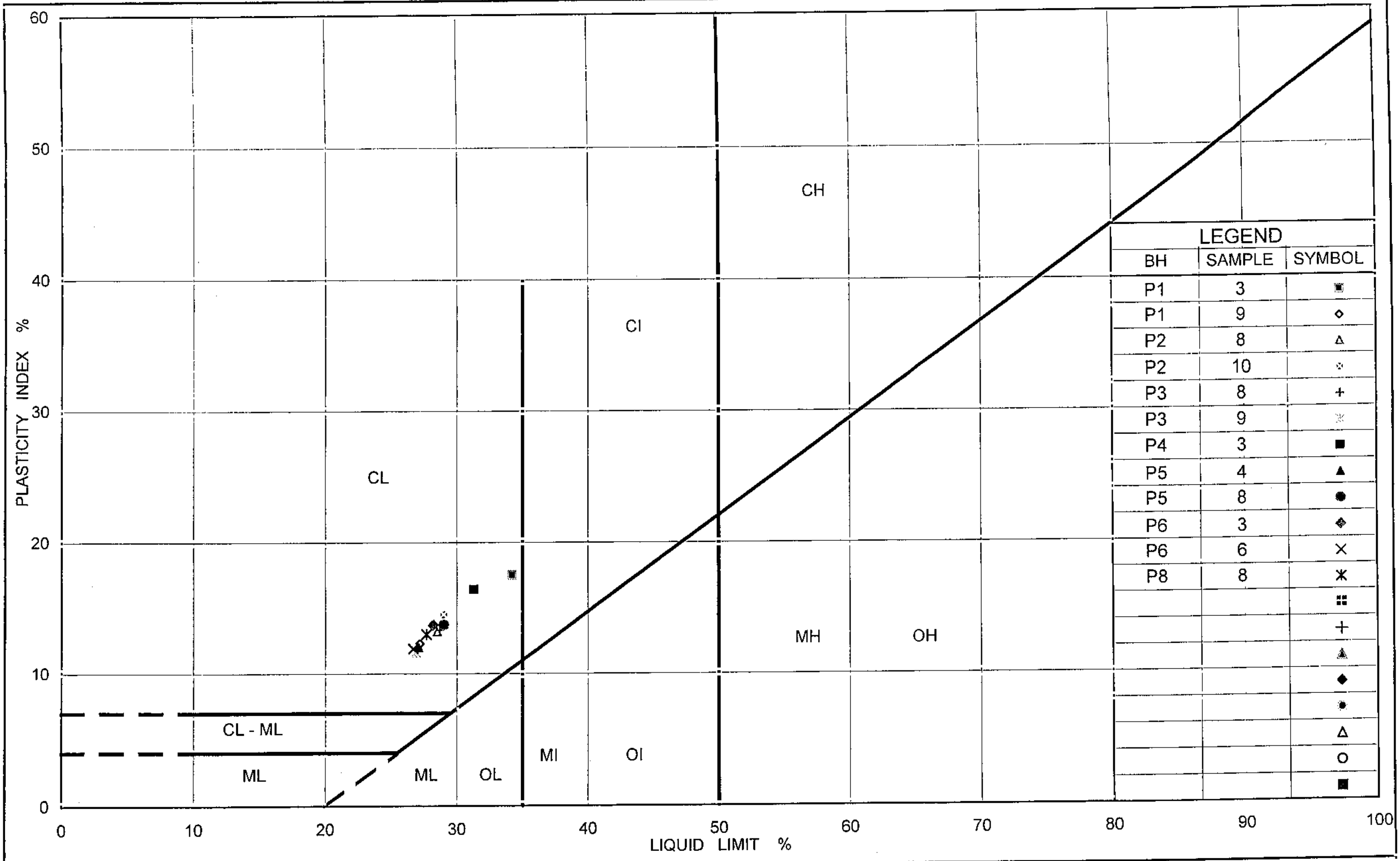
FIGURE 1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	P3	8	136.4
■	P5	8	130.8
◆	P8	8	136.3

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt to Silty Clay Till

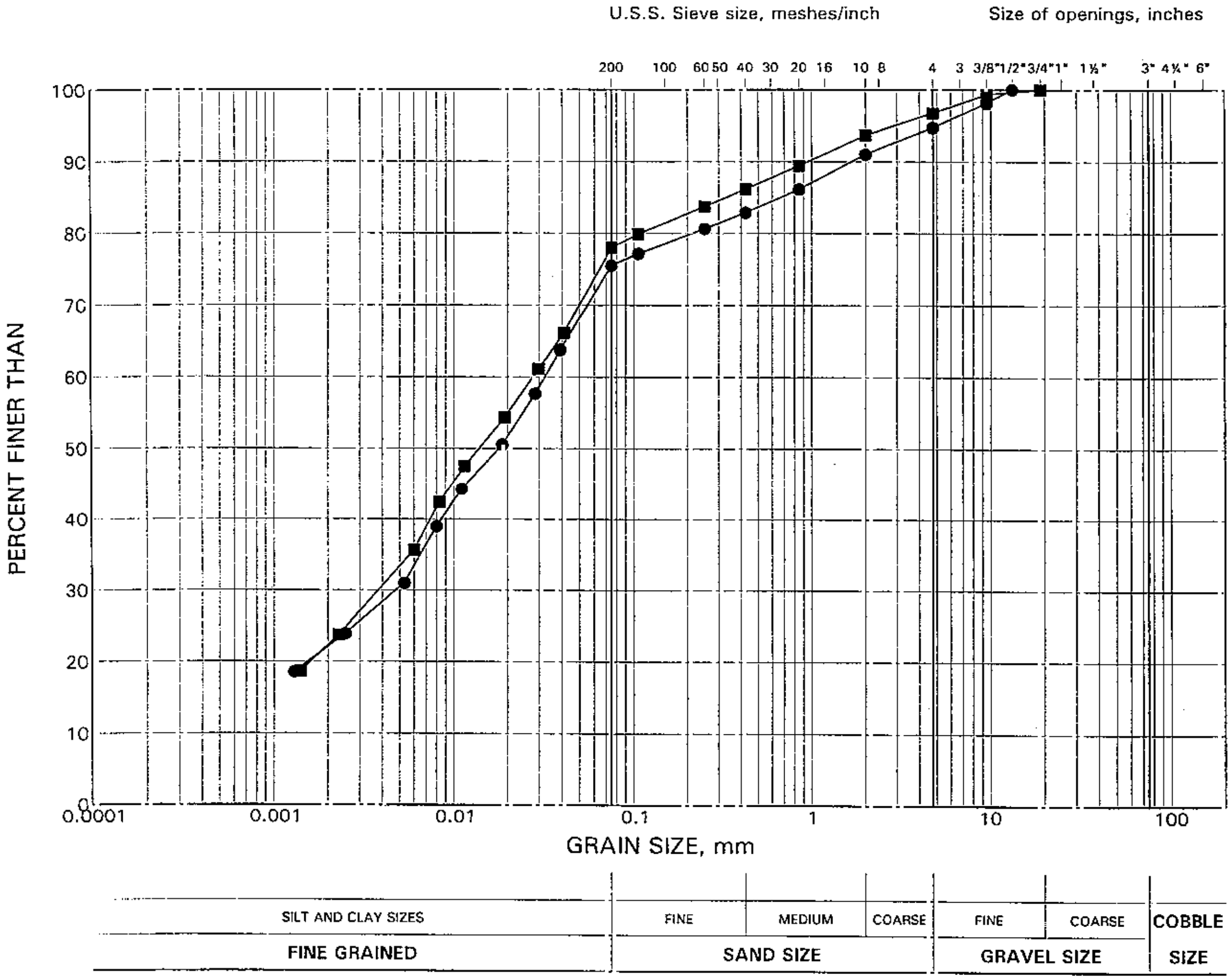
FIG No. 2

Project No. 001-1141F

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till / Residual Soil

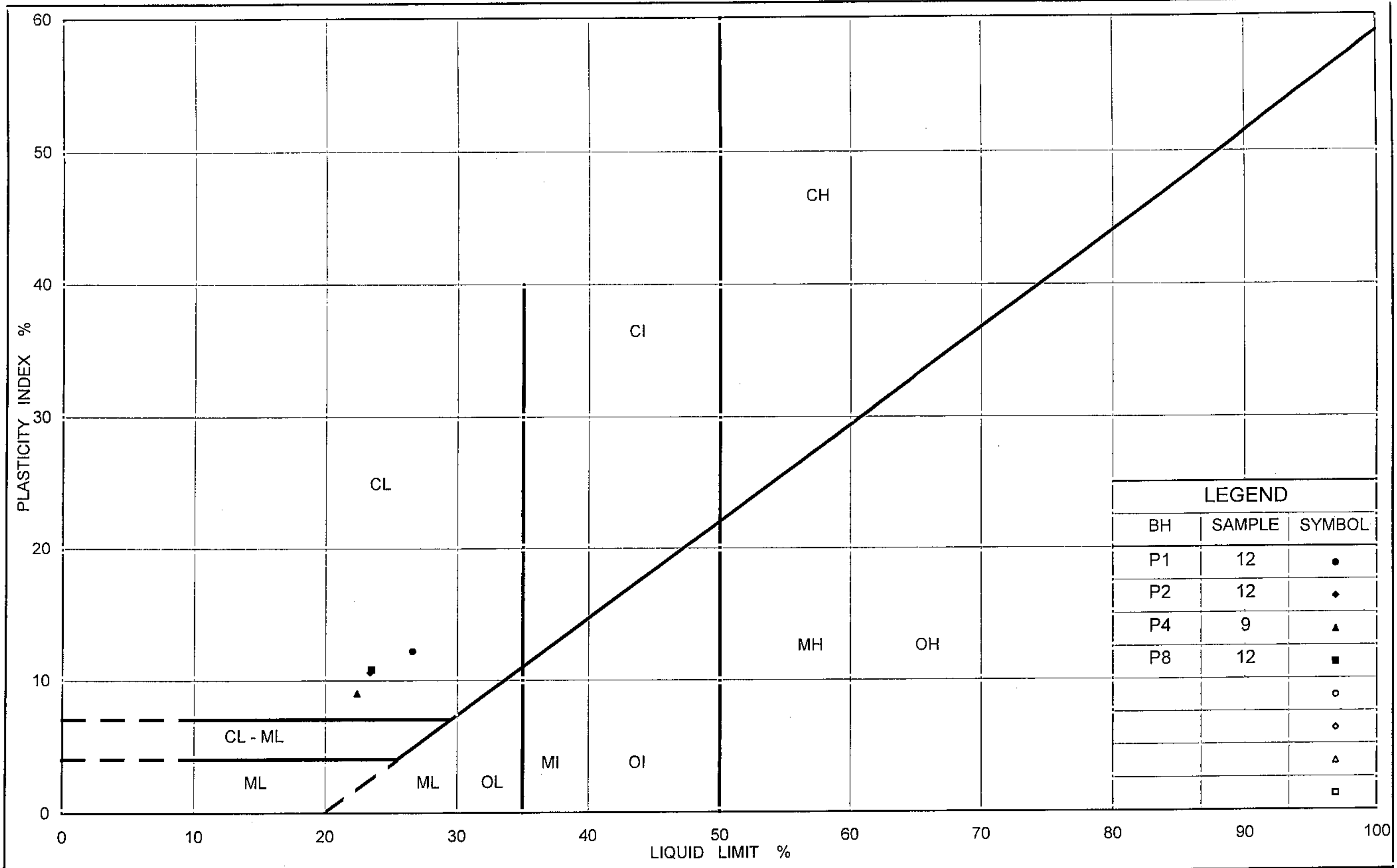
FIGURE 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	P2	12	130.0
■	P4	9	130.8

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt Till / Residual Soil

FIG No. 4

Project No. 001-1141F