PML Ref.: 02TF059A

TABLE I

Gradation Specification for Sand Fill in

Pre-Augered Holes at Integral Abutments

MTO Sieve Designation		Percentage Passing by Mass
2 mm	#10	100
600 μm	#30	80 – 100
425 μm	#40	40 – 80
250 μm	#60	5 – 25
150 μm	#100	0 – 6

From MTO Report S0-96-01, Revision 1 – July, 1996.

DETAILED FOUNDATION DESIGN REPORT
FOR
REPLACEMENT OF BIRCH CREEK BRIDGE
W.P. 176-98-00, SITE 46-159
AND
CULVERT EXTENSION
W.P. 176-98-00, SITE 46-159
HIGHWAY 17, DISTRICT 54
SUDBURY, ONTARIO

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Highway 17, District 54
Sudbury, Ontario

INTRODUCTION

This report provides geotechnical comments and recommendations regarding design and construction of the foundations, abutments and approach embankments for the proposed replacement of the existing bridge over Birch Creek located on Highway 17 west of Sudbury, Ontario. Comments concerning design of the extension to the culvert located some 180 m west of the bridge are also provided. The investigation was conducted for Stantec Consulting Ltd. on behalf of the Ontario Ministry of Transportation.

The site is located on Highway 17 at the Birch Creek crossing about 15 km west of Espanola within the Regional Municipality of Sudbury. Highway 17 passes over Birch Creek at approximate Station 13+106, Highway 17 chainage (ref. Birch Creek Bridge, Preliminary General Arrangement Plan (PGA), Drawing P-1 dated September 2003 prepared by Stantec Consulting Ltd.).

The existing bridge is a 72 m long, 14 m wide, 5 span reinforced concrete structure.

The replacement bridge will be a 90 m long, 14.6 m wide, three span structure (middle span of 34 m and end spans of 28 m each) constructed about 16.5 (west abutment) to 18.5 m (east abutment) south of the existing bridge (centre to centre spacing). The proposed road grade at the bridge is near elevation 190.0. The approach embankments at the west and east ends of the bridge will be about 1.5 and 3.5 m above existing grade respectively. During the construction period, the existing bridge will be maintained to transport traffic over the creek.

The culvert is located near Station 12+927. It is a concrete box rigid frame structure (3 by 5 m) and crosses the highway at an approximate 45° skew to the northwest. Extension of the existing culvert to the south by some 20 to 25 m to accommodate the embankment fill to be placed along the proposed alignment is planned.

Birch Creek flows to the south and the channel is essentially perpendicular to the road alignment. The creek channel varies in width from about 5 m on the north side to 30 m on the south side of the proposed structure. The overall width of the creek valley at this location is at least 50 m. To the east and west of Birch Creek, the road was cut into the sides of the creek valley.

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised a surficial topsoil and/or fill underlain by deposits of silt and/or sand overlying a massive clay deposit consisting of layered clayey silt, silty clay and clay. The clayey soils are underlain by silt/sandy silt and sand. Bedrock/probable bedrock was identified at 45.1 m (elevation 142.9) and 60.0 m (elevation 122.4) in boreholes drilled at the east abutment and east pier respectively. Bedrock was not contacted at the termination of drilling at the west pier and west abutment at depths of 60.2 and 64.6 m, elevation 121.3 and 125.2, respectively.

The water level in the creek at the time of the preliminary investigation (January 2003) was at elevation 180.7. The creek level noted on the PGA drawing was at elevation 177.9 in August 2001.

A foundation report as well as a pile driving and load test report were prepared for the existing bridge in 1955 (MTO project No. F-55-21, W.P. 82-56). Information contained in the reports was used to assist in preparation of this report.

FOUNDATIONS

General

The upper silty/clayey soils are typically loose to compact/firm to stiff and extend to substantial depth (35 to 47 m). These deposits are underlain by pervious sandy soils. Consequently, use of caissons or spread footings to support the foundation loads are not suitable for this structure. Driven piles are considered to be the preferred system to support the foundation loads at this site from a geotechnical perspective.

End-bearing piles driven to bedrock is considered to be feasible at the east abutment and east pier. Friction piles appear to be the most cost effective foundation system at the west pier and west abutment.

Comments concerning specific items that should be considered during design/construction of the bridge are provided in subsequent sections of the report:

- The stability of the west slope of the creek valley;
- Impacts of construction on the existing structure;
- Erosion and/or scour of the toe of the creek valley slope.

The seismic coefficient for the conditions at this site is 2.0 (Type IV soil profile as per clause 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC), CAN/CSA-S6-00).

Piles

Displacement piles (timber, pipe) could have an adverse impact on the stability of the slope and the adjacent structure. It is recommended therefore that steel H-piles are used to support the foundation loads of the proposed structure. Construction of integral abutments supported on end-bearing piles founded on bedrock on the east side of Birch Creek and friction piles extending to depths of 40 to 55 m on the west side of the creek is considered to be feasible at this site.

It is noteworthy that back-analysis of the results of a “proof load test” conducted on two 0.3 m diameter, 15 m long timber piles performed at the site in 1955 (project No. F-55-21) yielded a mobilized shaft friction value of about 25 kPa. Since the test was conducted to confirm the design working load, the SLS and ULS resistances could not be assessed.

The PGA drawing indicates the underside of the pile caps at the west and east abutments will be at elevation 185.0, 175.0 at the west pier and 176.3 at the east pier.

End bearing piles at the east pier and east abutment should be driven to refusal on bedrock anticipated at the following depth/elevations:

	Depth to Rock (m)	Bedrock Elevation
East Abutment	45.1	142.9
East Pier	60.0	122.4

The recommended factored axial resistance at ultimate limit states (ULS) for an HP 310 x 110 pile is 2000 kN. (Notes 5 and 6 in Section 3.3.3 of the Pile Driving notes in the Structural Manual, June 2002) (Structural Manual).

The recommended factored axial resistance at ULS of HP 310 x 110 piles driven to various depths at the west pier and west abutment is provided in the following table: (Note 2 in Section 3.3.3 of the Structural Manual).

Factored Axial Geotechnical Resistance at ULS, kN					
West Abutment			**West Pier**		
Length of Pile (m)	**Tip Elevation**	**HP 310x110**	**Length of Pile (m)**	**Tip Elevation**	**HP 310x110**
50	135	1500	40	135	1500
55	130	2000	45	130	2000

The geotechnical resistance at serviceability limit states (SLS) normally allows for 25 mm of compression of the founding medium. Considering the bedrock to be a non-yielding material, and the movement required to mobilze shaft resistance on the piles is less than 25 mm, the geotechnical resistance is not expected to be governed by settlement criteria since the loading required is anticipated to be larger than the factored resistance at ULS.

The pile resistance should be confirmed during installation by dynamic analysis or the Hiley Formula based on a resistance of 3,000 kN (factored ULS resistance of 1,500 kN) for piles driven to the anticipated elevation of 135 and 4,000 kN (factored ULS resistance of 2,000 kN) for piles driven to the anticpated elevation of 130.

It should be noted that the resistance of piles driven to support the west pier and west abutment will primarily be mobilized by shaft friction and a substantial length of the piles will be driven through wet silty/clayey silt soils. Consequently, the soils will be disturbed during driving and the restance indicated by the Hiley Formula may not be indicative of the pile resistance <u>after</u> driving when soil "setup" occurs to mobilze the full frictional resistance.

Provision should be made to re-strike the piles to compensate for potential soil relaxation in the saturated non-cohesive silts and sands after initial driving. Re-striking may be discontinued if the pile resistance is found to be unaffected (no decrease with time) by soil relaxation.

The approach embankment within the limits of the pile foundation should comprise Granular “B” Type II to enable driving and minimize the potential for damage during pile installation.

To accommodate movement of the integral abutment system, two concentric CSPs that extend at least 3 m below the bottom of the abutment should be placed around the pile to create an annular space. The inner CSP should be filled with granular material. Alternatively, a single CSP filled with loose uniform sand meeting the grading requirements shown in Table I may be used. Refer to MTO Report SO-96-01 for further details.

The piles will be 40 to 55 m long and driven through deposits that generally comprise silt and/or sand overlying layered clayey silt, silty clay and clay; no evidence of cobbles/boulders was detected during drilling. Therefore, it is considered, based on our extensive experience with pile driving under similar conditions, that a hammer that **transfers** at least 40 kJ of energy to the pile should be employed to drive the piles. The **rated energy** of the hammer should therefore be 50 to 55 kJ, depending on the type of equipment employed.

The bedrock surface between boreholes 203 and 209 slopes down to the south at an inclination of about 39° to the horizontal. Consequently, piles driven to refusal on bedrock to support the east pier and east abutment should be equipped with rock points (OPSD 3304.00 or Special Provision 902S01 dated February 2001). It is important that the pile driving contractor is aware of the sloping bedrock condition at this site in order to ensure adequate seating of the pile into bedrock.

It is considered that tip reinforcement is not required for the friction piles driven to support the west pier and west abutment.

The piles should be installed and monitored in accordance with the requirements of Special Provision 903S01 (April 2000). This should involve confirmation of the founding elevation, alignment, plumbness, uniformity of set and quality of splices, and should be performed on a full-time basis by experienced geotechnical personnel.

Pile caps should be provided with at least 1.9 m of earth cover or equivalent thermal insulation as protection against frost action. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

Resistance to lateral loads will be provided in part by mobilization of passive resistance along the pile. The recommended lateral resistance is as follows:

	HP 310 x 110
Factored Lateral Resistance at ULS =	130 kN
Lateral Resistance at SLS =	40 kN

If greater resistance is required, batter piles should be used.

The coefficient of horizontal subgrade reaction, k_s, should be computed using the following equation to evaluate the point of contraflexture:

$$k_s = n_h\, z/b$$

where n_h = coefficient related to soil density (kN/m^3)
z = depth (m)
b = pile width (m)

Recommended values for n_h are as follows:

Granular backfill	14,000 kN/m^3
Native silt	1,300 kN/m^3

RETAINING AND ABUTMENT WALLS

The retaining and abutment walls should be designed to resist the unbalanced horizontal earth pressure imposed by the backfill adjacent to the wall and the compaction pressure developed during placement of the backfill. The lateral earth pressure, p (kPa), may be computed using the equivalent fluid pressure diagrams presented in Section 6.9 of CHBDC for a wall height of less than 6 m or employing the following equation, assuming a triangular pressure distribution:

$$P = K(\gamma h + q) + Cp$$

where K = coefficient of lateral earth pressure (dimensionless)

γ = unit weight of backfill (kN/m^3)

h = depth below final grade (m)

q = surcharge load (kPa) if present.

Cp = compaction pressure (refer to clause 6.9.3 of CHBDC)

Free-draining granular material should be used as backfill behind the wall. The following parameters are recommended for design:

	Granular "A"	Granular "B" Type II
Angle of Internal Friction, degrees	35	32
Unit weight, kN/m^3	22.8	21.2
Coefficient of Active Earth Pressure K_a	0.27	0.31
Coefficient of Earth Pressure At Rest K_o	0.43	0.47
Coefficient of Passive Earth Pressure K_p	3.69	3.25

Refer to MTO Report SO-96-01 for procedures to determine the earth pressure coefficient to be employed in design of integral abutments. The coefficient of earth pressure at rest should be used for design of rigid and unyielding walls, the active earth pressure coefficient for unrestrained structures.

A weeping tile system and/or weep holes should be installed to minimize the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

A retained soil system (RSS) could also be considered. The founding material is expected to comprise the native sandy/silty soils below the surficial fill that extended to a depth of 1.5 m (elevation 188.3) at the west abutment and 1.7 m (elevation 186.3) at the east abutment. Some settlement of the embankment due to consolidation of the subgrade soils is anticipated. Further comments in this regard are provided in the next section of the report.

The recommended bearing resistance for a RSS wall constructed on the native soil at the depth/elevation noted in the previous paragraph is:

Factored Bearing Resistance at ULS	240 kPa
Bearing Resistance at SLS	75 kPa

The parameters to be employed for design of the RSS will be dependent upon the type of backfill employed to construct the RSS:

	Granular "A"	Granular "B"	Native Soil
Friction Angle, degrees	35	33	28
Cohesion, kPa	0	0	0
Unit weight, kN/m^3	22.8	22.0	18.5

The RSS supplier should be responsible for specifying the type of backfill material employed taking into consideration the engineering properties of the proprietary product, the design life of the structure, the pullout resistance required, drainage requirements and the predicted settlements noted in the section titled "Approach Embankments". The supplier of the RSS should also be responsible for design of the structure (backfill, reinforcement, internal and external stability) and provide drawings to show pertinent information such as location, length, height, elevations, performance level, appearance etc.

APPROACH EMBANKMENTS

It is anticipated that the approach embankments will be constructed with earth borrow and/or granular material. The design calls for the embankment to be about 1.5 m high at the west abutment and 3.5 m high at the east abutment. The subgrade soil revealed in testholes drilled along the embankment consists of loose sandy (west approach) and silty soils (east approach). Construction of the embankment on the native soil is considered to be feasible.

The fill identified at the abutment locations (1.5 m at the west abutment, 1.7 m at the east abutment) should be stripped prior to placement of the embankment fill.

Backfilling adjacent to the structure should be carried out in conformance with Ontario Provincial Standard Specifications for Granular Backfill (OPSS 501, Method A, OPSD 3501).

The approach embankments should be constructed in accordance with OPSD 200.010, 202.010, 208.010 and OPSS 206 dated December 1993, amended by Special Provision (Draft dated June 20, 2001).

The embankment slopes should be inclined no steeper than 2 horizontal to 1 vertical. Since the fill height is expected to be less than 6 m, a mid-height berm will not be required.

Where slope flattening is proposed, a drainage gap should be provided in accordance with OPSD 202.020. Where slopes are flattened to eliminate the need for a guide rail, a granular infilled drainage gap should be provided in accordance with Northeastern Region Pavement Design Practices and Guidelines. OPSS Granular “B” Type II should be used for the drainage gaps.

It is considered that the approach embankment constructed in accordance with these recommendations will be stable. Some settlement of the road surface should be expected however that will result from two mechanisms – consolidation of the soil below the recently placed fill and "consolidation" of the new fill.

- Settlement of the embankment surface due to consolidation of the subgrade soil is computed to be less than 10 mm.
- The backfill placed adjacent to the abutment will be about 5 m thick. The magnitude of "consolidation" of this fill will be dependent on the workmanship employed by the contractor and, if placed in 200 to 300 mm thick lifts compacted to 98% of standard Proctor maximum dry density in accordance with the requirements of SP902S01 amended December 2001 and OPSS 501 (Method A) dated February 1996, should be in the order of 10 mm.

Consequently, the total settlement of the approach fill surface near the abutments should be less than 20 mm. The settlements should be essentially complete within 2 to 4 months after placement of the fill.

Since construction of earth fill embankments is planned and total settlement of the road surface is computed to be less than 20 mm, widening of the embankment platform called for in the Northeastern Region Engineering Directive (NRE 98-200) dated October 28, 1998 should not be necessary unless there are widening restrictions.

Fill slopes should be protected against surface erosion by sodding and suitable vegetation. Refer to OPSS 571 or 572 for time constraints and the type of seed and mulch required.

EXCAVATION AND GROUNDWATER CONTROL

The PGA drawing indicates excavation for construction of pile caps at the west and east abutments will extend to elevation 185.0 (3 m below grade) and 185.3 (less than 500 mm below grade) respectively. Excavation at the piers will extend to elevation 175.0 at the west pier (about 2 m below existing grade) and 176.3 at the east pier (about 2.5 m below existing grade).

The borehole information indicates the excavated material at the abutments will comprise sandy fill and primarily silty soils at the piers. The fill and native soils are classified as a Type 3 soil according to Occupational Health and Safety Act (Ontario Regulation 213/91) criteria.

The groundwater level in borehole 202 (west side of creek channel) was about 1.6 m below grade, elevation 183.8, and at 6.4 m, elevation 181.6, in borehole 203 drilled on the east side of the creek valley. The groundwater level at the pier location will be near the water level in the creek – elevation 177.9 in August 2001 (noted on the PGA drawing) and elevation 180.7 on January 14, 2003.

Considering the composition of the soil revealed in the boreholes drilled at the abutment locations, the anticipated depth of excavation and the groundwater level, it is considered that temporary cut slopes inclined at 45° to the horizontal should be suitable. Flatter side slopes may be required if excessively soft/wet materials or concentrated seepage zones are encountered locally. Groundwater seepage or surface water that enters the excavation for construction of the abutment foundations should be readily handled by conventional sump pumping techniques.

Excavation for construction of the piers will extend through silty soils about 5 m below the groundwater level. It is considered that open cut with inclined slopes will not be feasible for the piers. We believe it will be necessary to install steel sheet piling to support the walls of the excavation and control groundwater during construction of the pier foundations. In order to minimize potential disturbance to the slope and enhance scour protection, the sheet piling around the west pier should not be removed following construction of the pier. Further, a mud slab should be placed on the exposed subgrade to minimize distrubance to the exposed soil and provide a working surface for the workers.

The contractor should be responsible for design of the shoring system. The specifications should call for the contractor to employ a specialist consultant to design the sheeting to control groundwater ingress, prevent basal heave and support the west slope of the creek valley.

Construction should be scheduled during the drier time of the year (typically June to September) to minimize the potential for “flood” conditions during construction.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

SLOPE STABILITY

A note on a design drawing for the existing bridge (ref. D3629-1A superseded by 639-159-1A-B) indicates that a slope failure occurred on the west side of the creek during construction of the existing bridge in the 1950s. It is unknown whether the failure resulted from a “natural” instability, disturbance by the pile driving and construction operations or an oversteepened cut slope to enable construction of the adjacent pier. It is understood that the bridge was lengthened by two spans as a result of this failure.

The overall average inclination of the slope on the west side of the creek along the alignment of the proposed bridge varies from about 16° to the horizontal (3.5H:1V, north side) to 33° (1.5H:1V, centreline and south side). The inclination of the slope increases to about 39° south of the new bridge alignment.

The base of the 39° slope is subject to active erosion by the creek. It is considered that the slope is marginally stable at present and the performance of the slope is primarily governed by undercutting of the toe by creek erosion.

The mobilized geotechnical properties of the soil were deduced from information revealed in the testholes drilled at the site and back analyses of the 39° slope for a factor of safety of 1.0 using a computer application of the simplified Bishop Method of analysis. Based on this information, the factor of safety against a general shear failure of the existing slope along the south edge of the proposed bridge alignment (inclination 33°) was computed to be about 1.3, which is generally consistent with the observed performance of the slope at this location.

It is noted from the PGA drawing that the design calls for this slope to be regraded to an inclination of 2H:1V and the ground surface to be lowered by about 2 m. The factor of safety of the regraded slope against a general shear failure is computed to be 1.6 as illustrated in Figure 1.

Since a computed factor of safety of 1.5 is normally accepted as the minimum value for this type of assessment and failure does not normally occur on slopes with a computed factor of safety as low as 1.25 using the simplified Bishop technique, we consider the computed value for this project to be appropriate.

It is strongly recommended that:

i) A NSSP is prepared that will provide specific direction to the contractor to prohibit operation of construction machinery on the slope and prevent undermining of the toe of slope by excavations for construction of the piers.

   The only exception would be to allow the excavation required to flatten the slope on the west side of the creek and lower the grade between the west abutment and the crest of slope.

ii) Non-displacement “H” piles are employed to support the foundation loads.

In addition, the silty soils along the creek channel are considered to be highly erodable. Therefore, measures must be implemented to prevent erosion at the toe of slope (both sides of creek) that could initiate movement of the slope and/or undermine the piers. The design requirements (length, width, thickness, rock size and height of erosion protection on the creek valley slopes as well as below water level) will be dictated by the creek hydraulics, stream configuration and water level in the creek and should be established by a hydraulic engineer.

IMPACTS TO EXISTING STRUCTURE

It is noted that the existing bridge will be maintained to transport traffic over the Birch Creek until construction of the new bridge is completed. The existing bridge is supported on timber piles and the clearance between the existing and proposed structure ranges from about 2 m (west abutment) to 3 m (east abutment).

It is also noted from the PGA and the email provided by Stantec Consulting Ltd. on December 2, 2003 that:

i) The design calls for the west pier to be located approximately at the toe of slope on the west side of the creek and the east pier about 3.5 m east of the toe of slope on the east side of the creek.

ii) The west pier will be located about 2 m west and 2 m south of Pier A of the existing structure.

iii) The site grading work calls for the slope on each side of Birch Creek along the alignment of the new bridge to be regraded to a maximum inclination of 2H:1V and the ground surface to the west of the existing crest of slope to be lowered about 2 m.

iv) The west abutment will be located about 10.5 m west of the proposed crest of slope (11.8 m west of the existing crest of slope), at least 6 m west of a line inclined upward at 2.5H:1V from the toe of slope.

v) The centre to centre pile spacing at the abutments and piers will be about 2.5 and 1.1 m respectively.

The primary impact on the existing structure from construction of the new bridge would result from excavation for the construction of the new foundations and the pile driving operations.

We believe the excavation associated with lowering the grade between the west abutment and the crest of slope, flattening the slopes to 2H:1V, installation of low displacement "H" piles and construction of foundations to support the piers and abutments is unlikely to have significant impact on the existing structure.

Since the west pier of the proposed structure is reasonably close to pier A of the existing structure, design of the excavation shoring for construction of the west pier must consider the presence of pier A of the existing structure. Similarly, the timber piles that support pier A must be considered if design of the west pier foundation calls for installation of batter piles.

There is no need from a geotechnical perspective to remove the pile "stubs" that exist near the edge of the creek on the south side of the existing bridge unless they interfere with installation of piles to support the replacement structure.

DETOUR CONSIDERATIONS

The design calls for the existing structure to be maintained while the replacement bridge is constructed. Consequently, construction of a detour structure will not be necessary.

CULVERT

The existing culvert is an approximate 79 m long, 3 by 5 m concrete box structure. The invert level at the north end (inlet) is near elevation 182.0, based on the topographic survey drawing dated February 2003. Extension of the existing culvert to the south by some 20 to 25 m to accommodate the embankment fill to be placed along the proposed alignment is planned. The grade above the culvert will be raised by up to 6 m. Based on the subsurface conditions revealed in boreholes 205, 211 and 212, it appears that the existing culvert is founded on loose to compact silt. The subgrade material revealed in borehole 211 drilled near the outlet of the existing culvert comprised loose silt/sand overlying compact sand. Borehole 212 drilled near the end of the proposed extension encountered very loose silt/sand deposits overlying loose silt.

Consolidation of the subgrade soil below the culvert will be dictated by the stress imposed by the embankment fill. The embankment height will vary along the alignment of the culvert extension from about 6 m to less than 1 m. Consolidation of the sand/silt units below the embankment are computed to be 10 to 20 mm and should be essentially complete within one month following placement of the fill.

To minimize the magnitude of consolidation settlement of the culvert foundation, it is recommended that the loose to very loose silt/sand deposits along the alignment of the culvert be excavated and replaced with a pad of engineered fill. The width of the engineered fill pad should be 4 m wider than the culvert (2 m each side) and comprise granular material (Granular B Type II) compacted to 98% of standard Proctor maximum dry density in conformance to OPSS 501 (Method A).

The base of the engineered fill pad should be at elevation 178.5 near the outlet of the existing culvert (borehole 211), decreasing to elevation 177.5 at the outlet of the proposed extension (borehole 212). It is visualized that the pad of engineered fill will range in thickness from at least 1.5 to 2.5 m (north to south) along the alignment of the proposed extension.

Use of spread footings constructed on the engineered fill pad to support the foundation loads is considered to be feasible. Foundations constructed on the engineered fill pad to support the culvert extension should be designed using the following geotechnical resistance values:

Factored Bearing Resistance at ULS	= 450 kPa
Bearing Resistance at SLS	= 150 kPa

The resistance at SLS allows for 25 mm of settlement of the founding medium due to the stress imposed by the culvert foundation.

The seismic coefficient for the conditions at this site is 2.0 (Type IV soil profile as per clause 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC), CAN/CSA-S6-00).

All excessively loose, soft, organic or otherwise deleterious materials along the alignment of the culvert extension must be removed prior to construction of the extension.

Preparation of the subgrade should be performed and monitored in accordance with SP 902S01 (December 2001). This should include site review by geotechnical personnel during placement and compaction of the engineered fill if required.

Backfill adjacent to the culvert should be placed in general accordance with the OPSD 800 series of drawings. Backfill should be brought up simultaneously on each side of the culvert and operation of heavy equipment within 0.5 times the height of the culvert (each side) restricted to minimize the potential for movement and/or damage of the culvert due to the lateral earth pressure induced by compaction. Refer to OPSD 808.010 for additional requirements for operation of heavy equipment near the culverts.

Subgrade preparation, cover, backfill and frost treatment for the proposed culvert extension should be carried out in accordance with the Ontario Provincial Standards – OPSD 803. The bedding material should be at least 300 mm thick. A frost penetration depth of at least 1.9 m should be employed.

Excavation for construction of the culvert is expected to extend through the loose to compact silt. The silt is classified as Type 3 soil according to Occupational Health and Safety Act (Ontario Regulation 213/91) criteria. Consequently, temporary cut slopes inclined at 45° to the horizontal will be required. It may be necessary to flatten the sideslopes if excessively loose/soft conditions or concentrated seepage zones are encountered locally.

The culvert must be designed to support the stress imposed by the overlying fill as well as to resist the unbalanced lateral earth pressure and compaction pressure imposed by the backfill adjacent to the culvert walls.

The lateral earth and water pressure, p, should be computed using the equivalent fluid pressures presented in Section 6.9 of the Canadian Highway Bridge Design Code (CHBDC), CAN/CSA-S6-00, March 2001, or employing the following equation assuming a triangular pressure distribution:

$$P = K(\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + Cp$$

where K = lateral earth pressure coefficient

γ = unit weight of backfill above the design water level (kN/m^3)

γ' = unit weight of backfill below the design water level (kN/m^3)

h_1 = depth below final grade (m), above design water level

h_2 = depth below design water level (m)

q = any surcharge load (kN/m^2)

γ_w = unit weight of water = 9.8 kN/m^3

Cp = compaction pressure (refer to clause 6.9.3 of CHBDC)

The following parameters are recommended for design:

PARAMETER	GRANULAR A	GRANULAR B TYPE II
Angle of Internal Friction (degrees)	35	32
Unit Weight (kN/m^3)	22.8	21.2
Active Earth Pressure Coefficient (K_a)	0.27	0.31
At Rest Earth Pressure Coefficient (K_o)	0.43	0.47
Passive Earth Pressure Coefficient (K_p)	3.69	3.25

The design water level will be dictated by the flow of water in the watercourse and should be defined by the project hydraulic engineer.

The coefficient of earth pressure at rest should be employed to design rigid and unyielding walls and the active earth pressure coefficient for unrestrained structures.

The horizontal force imposed on the foundations of "open footing" culverts will be resisted in part by the friction force developed between the underside of the footing and the engineered fill. An unfactored friction factor of 0.55 is recommended for footings constructed on granular fill, 0.4 if constructed on the loose silt.

A weeping tile system and/or weep holes should be installed to minimize the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

The protective measures noted in the OPSD 800 series (in particular OPSD 803.030 and 803.020 for open and box culverts) to deal with erosion (outlet treatment, headwalls, cut-off walls, etc.) are considered to be appropriate. The backfill should comprise OPSS Granular A or Granular B Type II. The cut-off walls should extend to a depth at least equal to the fluctuation of the water level at the culvert location to prevent flow below the culvert that could erode the bedding material and extend laterally to protect the granular material.

The outlet protection must be sufficient to prevent erosion adjacent to the culvert as well as scour that could undermine the culvert and/or embankment foundation. The actual design requirements (length and width of the "apron" at the outlet of the culvert as well as the rock size, apron thickness and height of erosion protection on the embankment slope) will be dictated by stream hydraulics, stream configuration as well as the water level in the creek and should be established by a hydraulic engineer.

Subject to the season/precipitation patterns, it is expected that conventional sump pumping, will handle groundwater seepage or surface water entering the excavation for culvert installations. It may be necessary to implement more elaborate measures to control water flow in the event of a major storm and/or flooding at the culvert. The contract documents should have a specific item to clearly state that dewatering of excavations is the contractors responsibility.

Observed groundwater levels are subject to seasonal fluctuations and rainfall patterns.

It is recommended that the work be carried out during the dry months of June to September to minimize the potential for sloughing of the silt/sand, the amount of groundwater inflow to be handled and the volume of surface water, if any, to be diverted from the construction area.

CLOSURE

The report was prepared by Mr. G.O. Degil, Ph.D., P.Eng., Senior Foundation Engineer, and reviewed by Mr. Dennis W. Kerr, M. Eng., P.Eng., Chief Foundation Engineer. Mr. Brian R. Gray, M.Eng., P.Eng., carried out an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

Dennis W. Kerr, M.Eng., P.Eng
Chief Foundation Engineer

GD:mi:lad

Brian R. Gray, M.Eng., P.Eng.
MTO Designated Contact

RECORD OF BOREHOLE No 201

 METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 358 N; 234 693 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY G.D.

DATUM Geodetic DATE January 03, 2003 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	NATURAL MOISTURE CONTENT (%)
184.6	Ground Surface						
0.0	Sandy silt, with inclusions of topsoil. Very Loose, Brown (Fill)	1	SS	3		184	
183.9 / 0.7	Silt, with inclusions of topsoil, sand and gravel. Loose, Grey (Fill)	2	SS	10	Water level observed during drilling		
183.2 / 1.4	Silt, trace clay. Loose, Grey, Wet	3	SS	7	Water level measured after drilling	183	
		4	SS	5		182	~60
	trace clay and sand. Compact, Moist	5	SS	9		181	~22
		6	SS	13		180	
						179	
177.9 / 6.7		7	SS	16		178	
	End of Borehole						

Column headings also printed: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

* Jan. 03/03

▽ Water level observed during drilling

▼ Water level measured after drilling

+7, ×5 : Numbers refer to Sensitivity

20 / 15 —O— 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Peto MacCallum Ltd.
Foundation Design

RECORD OF BOREHOLE No 202

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 372 N; 234 724 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY G.D.

DATUM Geodetic DATE January 7 to 9, 2003 CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.4	Ground Surface								
0.0	Sand and gravel Brown (Fill)				185				
		1	SS	25	184				
	Wet	2	SS	36					
183.0 / 2.4	Silt, trace clay and sand Compact Grey Moist				183				
		3	SS	11	182				
		4	SS	10					0 2 92 6
		5	SS	9	181				
					180				
		6	SS	27	179				0 2 89 9
		7	SS	32	178				
					177				
176.4 / 9.0	Layered clayey silt, silty clay and clay Stiff to hard Grey	8	SS	29	176				
		9	SS	30	175				
					174				
		10	SS	32	173				
		11	TW	PH				20.7	0 0 71 29
		12	SS	24	172				
					171	>100			
	Cont'd								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

$+^7, \times^5$: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 202

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 372 N; 234 724 E. ORIGINATED BY F.P.
DIST 54 HWY 17 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE January 7 to 9, 2003 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DCPT / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR SA SI CL
170.4 / 15.0	Layered clayey silt, silty clay and clay; Stiff to hard; Grey *(Cont'd)*	13	TW	PH	170				
		14	SS	39					
		15	SS	34	169				0 0 81 19
		16	TW	PH	167		o		
		17	SS	28		■	o		0 0 77 23
		18	SS	30	166	■	o		
		19	TW	PH	164				
	with seams of silt	20	SS	25			H-o		0 2 78 20
	with lenses and partings of sand and silt; Stiff to Very stiff				162				
		21	SS	9	161		o		
					160	+ >100			
		22	TW	PH	158	o	I---o	18.8	0 0 53 47
		23	SS	6		■	o		
					157	+ >100			
155.4	Cont'd				156				

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L
REMARKS & GRAIN SIZE DISTRIBUTION (%)

+[7], ×[5]: Numbers refer to Sensitivity; 20 / 15 –○– 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 202

METRIC

G.W.P. 176-98-00	LOCATION	Co-ords. 5 124 372 N; 234 724 E.	ORIGINATED BY F.P.
DIST 54 HWY 17	BOREHOLE TYPE	Continuous Flight Hollow Stem Augers	COMPILED BY G.D.
DATUM Geodetic	DATE	January 7 to 9, 2003	CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
155.4 / 30.0	Layered clayey silt, silty clay and clay Stiff to Very stiff Grey	24	SS	4	155	+2			
					154				
					153				
					152				
					151				
					150				
		25	TW	PH	149			18.1	0 0 20 80
		26	SS	WH	148	>100			
					147				
					146				
					145				
		27	TW	PH	144				
		28	TW	PH	143				
141.9 / 43.5		29	SS	28	142				0 2 72 26
	End of Sampled Borehole				141				
	Cont'd								

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60.

+7, ×5: Numbers refer to Sensitivity

20 / 15 — ○ — 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Peto MacCallum Ltd.
Foundation Design

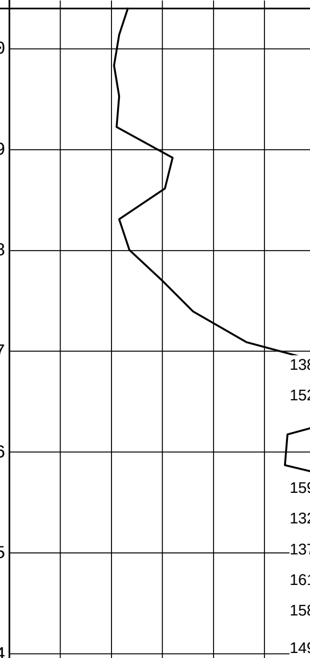
RECORD OF BOREHOLE No 202

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 372 N; 234 724 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY G.D.

DATUM Geodetic DATE January 7 to 9, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
140.4 45.0							140 139 138 137 136 135 134				
133.9 51.5	End of Dynamic Cone Penetration Test										

■ Penetrometer Test

∇ Water level observed during drilling

WH refers to penetration due to weight of rods and hammer

Date	Depth to Water (m)
Shallow Piezometer	
Jan.14/03	2.8
Jan.21/03	2.5
Oct.28/03	1.6
Deep Piezometer	
Jan.14/03	3.6
Jan.21/03	3.7
Oct.28/03	1.8

Piezometer Legend

- Auger Cuttings
- Bentonite Seal
- Filter Sand
- Screen
- Grout

$+^7, \times^5$: Numbers refer to Sensitivity

20 / 15 – 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 203

METRIC

G.W.P. 176-98-00 | LOCATION Co-ords. 5 124 388 N; 234 806 E. | ORIGINATED BY F.P.

DIST 54 HWY 17 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary | COMPILED BY G.D.

DATUM Geodetic | DATE January 13 to 16, 2003 | CHECKED BY C.N.

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
188.0	Ground Surface
188.0 / 0.0	Gravel (Fill)
187.4 / 0.6	Sand, with inclusions of gravel. Compact Brown (Fill)
186.3 / 1.7	Silt and fine sand, trace clay and gravel. Compact Brown Damp; ---- Grey
179.8 / 8.2	Layered clayey silt, silty clay and clay, trace sand. Firm to Stiff Grey
173.0	Cont'd

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	10	
2	SS	14	
3	SS	18	0 38 57 5
4	SS	26	
5	SS	21	1 42 53 4
6	SS	13	
7	SS	6	0 1 74 25
8	SS	3	
9	SS	2	
10	TW	PH	
11	SS	3	0 1 34 65

ELEVATION SCALE: 187, 186, 185, 184, 183, 182, 181, 180, 179, 178, 177, 176, 175, 174

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

Field vane sensitivities plotted: 2, 2, 1, 2

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

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 203

METRIC

G.W.P. 176-98-00 | LOCATION Co-ords. 5 124 388 N; 234 806 E. | ORIGINATED BY F.P.

DIST 54 HWY 17 | BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary | COMPILED BY G.D.

DATUM Geodetic | DATE January 13 to 16, 2003 | CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
173.0 / 15.0	Layered clayey silt, silty clay to clay, trace sand. Stiff to Very Stiff, Grey	12	SS	3				
					172	+ 2		
		13	TW	PH				
	with seams of silt				171	+ 1		
		14	SS	1	170			0 1 82 17
					169	+ >100		
		15	SS	6	168			
						+ >100		
		16	TW	PH	167			
					166	+ >100		
165.0 / 23.0	Silt, trace sand and clay. Compact, Grey, Wet				165			
		17	SS	16	164			
					163			
					162			
		18	TW	PH	161			
		19	SS	23	160			0 8 90 2
159.0 / 29.0	Fine sandy silt, trace clay. Compact, Grey, Wet				159			
158.0	Cont'd							

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20, 40, 60; UNIT WEIGHT γ kN/m³.

$+^7, \times^5$: Numbers refer to Sensitivity

20 / 15—○—5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 203

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 388 N; 234 806 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary COMPILED BY G.D.

DATUM Geodetic DATE January 13 to 16, 2003 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
158.0										
30.0	Fine sandy silt, trace clay Compact Grey Wet	20	SS	23		~20	0	21	76	3
					157					
					156					
					155					
					154					
153.5 / 34.5	Fine to medium sand, silty to some silt, trace clay, with inclusions of fine gravel Very dense Grey Wet									
					153					
					152					
		21	SS	57			0	76	22	2
					151					
					150					
					149					
					148					
					147					
					146					
		22	SS	75			0	82	17	1
					145					
					144					
	Cont'd									

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

$+^7, \times^5$: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Peto MacCallum Ltd.
Foundation Design

RECORD OF BOREHOLE No 203

 METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 388 N; 234 806 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE Continuous Flight Hollow Stem Augers and Mud Rotary COMPILED BY G.D.

DATUM Geodetic DATE January 13 to 16, 2003 CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
143.0 / 45.0						
142.9 / 45.1	Metasedimentary Bedrock Fractured					
		23	RC NQ	REC 100%		RQD 0 %
					142	
		24	RC NQ	REC 83%		RQD 0 %
					141	
		25	RC NQ	REC 85%		RQD 0 %
					140	
		26	RC NQ	REC 71%		RQD 16 %
139.1 / 48.9	End of Borehole					

Column headings: SOIL PROFILE; ELEV DEPTH; DESCRIPTION; STRAT PLOT; SAMPLES: NUMBER, TYPE, "N" VALUES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

▼ Water level measured after drilling

Date	Depth to Water (m)
Piezometer	
Jan.21/03	6.7
Oct.28/03	6.4

Piezometer Legend

- Auger Cuttings
- Bentonite Seal
- Filter Sand
- Screen
- Grout

$+^7, \times^5$: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Peto MacCallum Ltd.
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RECORD OF BOREHOLE No 204

 METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 393 N; 234 820 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY G.D.

DATUM Geodetic DATE January 17, 2003 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)
188.3	Ground Surface						
0.0	Gravel, some sand Grey (Fill)					188	
187.4 / 0.9	Sand and gravel (Fill)				∇	187	
186.9 / 1.4	Clayey silt, trace sand, Firm to stiff, Grey, with lenses and partings of sandy silt	1	SS	5			
		2	SS	8		186	
185.3 / 3.0	Silty sand, with seams of clayey silt, Compact Grey Wet	3	SS	11		185	o
184.2 / 4.1	Silt, trace sand, Compact Grey Wet					184	
		4	SS	19	▼	183	o
	with seams of clayey silt, Loose	5	SS	8		182	o
181.6 / 6.7	End of Borehole						

* Jan. 17/03

∇ Water level observed during drilling

▼ Water level measured after drilling

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^{7}, \times^{5}$: Numbers refer to Sensitivity 20 / 15 —O— 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Peto MacCallum Ltd.
Foundation Design

RECORD OF BOREHOLE No 205

 METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 325 N; 234 605 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY G.D.

DATUM Geodetic DATE January 10, 2003 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.8	Ground Surface						
0.0	Clayey silt, with inclusions of sand and gravel, Brown (Fill)				188		
		1	AS	-		~18	
187.5 / 1.3	Silt, trace to some clay, trace sand. Compact Grey. Wet to moist	2	SS	11	187	~21	0 3 90 7
					186		
		3	SS	10	185	~22	
		4	SS	14	184	~21	
					183		
		5	SS	11	182	~22	0 1 93 6
		6	SS	12	181	~21	
					180		
		7	SS	13	179	~20	
		8	SS	13	178	~23	0 1 83 16
177.5 / 11.3	End of Borehole. Borehole dry on completion of drilling						

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3

$+^7, \times^5$: Numbers refer to Sensitivity   20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Peto MacCallum Ltd.
Foundation Design

RECORD OF BOREHOLE No 206

METRIC

G.W.P. 176-98-00 | LOCATION Co-ords. 5 124 338 N; 234 715 E. | ORIGINATED BY M.R.

DIST 54 HWY 17 | BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS | COMPILED BY G.D.

DATUM Geodetic | DATE October 18, 2003 | CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
188.5	Ground Surface				*
187.9 / 0.0–0.6	Gravelly sand some silt. Brown				
187.4 / 0.6–1.1	Fine sandy silt, faintly stratified. Compact, Light brown, Damp	1	SS	13	
186.8 / 1.1–1.7	Sand, fine grained some silt. Compact, Rusty brown, Dry to damp	2	SS	5	
1.7	Silt, dilatent with occ. thin layers of clay. Loose, Grey, Wet	3	SS	5	
		4	SS	6	
		5	SS	7	
		6	SS	6	
		7	SS	8	
180.3 / 8.2		8	SS	9	
	End of borehole				

Elevation scale: 188, 187, 186, 185, 184, 183, 182, 181

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m^3

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

* Borehole dry on completion of drilling

ON_MOT VER3 02TF059.GPJ ON_MOT.GDT 12/1/03 2:58:24 PM

$+^7$, $\times^5$: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 207

METRIC

G.W.P. 176-98-00	LOCATION Co-ords. 5 124 347 N; 234 732 E.	ORIGINATED BY F.P./M.R.
DIST 54 HWY 17	BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS	COMPILED BY G.D.
DATUM Geodetic	DATE October 14 and 16, 2003	CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) w	GR SA SI CL
189.8	Ground Surface						
0.0	Topsoil						
189.5 / 0.4	Sandy silt, topsoil inclusions; Dark brown; Very loose; Brown (FILL)	1	SS	3	189	o	
188.3 / 1.5	Sandy silt, trace clay with silty sand lenses; Very loose; Brown; Moist	2	SS	2	188	o	0 35 55 10
187.5 / 2.3	Silty sand with sandy silt lenses; Loose; Brown; Moist	3	SS	6	187	o	
186.8 / 3.0	Silt, trace to some clay trace sand; Loose; Grey; Wet	4	SS	6	186	o	
		5	SS	7		o	0 1 89 10
	laminated with fine sandy silt lenses	6	SS	9	185	o	
					184		
		7	SS	9	183	o	
		8	SS	10	182	o	
					181		
		9	SS	10	180	o	0 0 87 13
		10	SS	8		o	
		11	SS	8	179	o	
		12	SS	11	178	o	
		13	SS	8	177	o	
	Compact				176		
		14	SS	15		o	
174.8	Cont'd				175		

SOIL PROFILE | SAMPLES | STRAT PLOT | GROUND WATER CONDITIONS * | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m^3 | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^7$, $\times^5$: Numbers refer to Sensitivity   20 / 15—○—5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Peto MacCallum Ltd.
Foundation Design

RECORD OF BOREHOLE No 207

METRIC

G.W.P. 176-98-00 | LOCATION Co-ords. 5 124 347 N; 234 732 E. | ORIGINATED BY F.P./M.R.

DIST 54 HWY 17 | BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS | COMPILED BY G.D.

DATUM Geodetic | DATE October 14 and 16, 2003 | CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.8 / 15.0	Silt, trace sand. Compact Grey Wet	15	SS	14	174			
	with clayey silt seams	16	SS	13	173			
		17	SS	11	172, 171			
		18	SS	12	170, 169, 168			
166.6 / 23.2	Layered clayey silt and silty clay trace sand, laminated with silt trace clay trace sand. Stiff Grey WTPL	19	SS	6	167, 166, 165			0 1 68 31
			FV			+2		
		20	TW		164, 163			
		21	SS	2	162			0 9 59 32
			FV			+5		
159.8	Cont'd				161, 160			

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS *; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+7, ×5 : Numbers refer to Sensitivity

20 / 15—○—5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 207

METRIC

G.W.P. 176-98-00 | LOCATION Co-ords. 5 124 347 N; 234 732 E. | ORIGINATED BY F.P./M.R.

DIST 54 HWY 17 | BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS | COMPILED BY G.D.

DATUM Geodetic | DATE October 14 and 16, 2003 | CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)
159.8 / 30.0	Layered clayey silt and silty clay trace sand, laminated with silt trace clay trace sand. Stiff Grey WTPL (Cont'd)						
		22	TW		159		
			FV			Field vane, sensitivity 4	
					158		
					157		
					156		
	varved, grey and reddish brown						
					155		
					154		
		23	SS	1	153		
			FV			Field vane	
					152		
					151		
					150		
					149		
					148		
		24	TW		147		
					146		
144.8	Cont'd				145		

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20, 40, 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^7$, $\times^5$: Numbers refer to Sensitivity

20, 15, 5, 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 207

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 347 N; 234 732 E. ORIGINATED BY F.P./M.R.

DIST 54 HWY 17 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS COMPILED BY G.D.

DATUM Geodetic DATE October 14 and 16, 2003 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT w (%)
144.8 / 45.0	Layered clayey silt and silty clay trace sand, laminated with silt trace clay trace sand. Stiff Grey WTPL (Cont'd)				
143.2 / 46.6	Sand, fine grained with silt. Compact Grey Saturated	25	SS	14	≈23
137.6 / 52.2	Silt, with fine sand. Very dense Grey Saturated	26	SS	69	≈21
129.8	Cont'd				

Elevation scale: 144, 143, 142, 141, 140, 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 × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

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

$+^7$, $\times^5$: Numbers refer to Sensitivity — 20, 15, 5, 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 207

METRIC

G.W.P. 176-98-00 | LOCATION Co-ords. 5 124 347 N; 234 732 E. | ORIGINATED BY F.P./M.R.

DIST 54 HWY 17 | BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS | COMPILED BY G.D.

DATUM Geodetic | DATE October 14 and 16, 2003 | CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: 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, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
129.8 / 60.0	Sand, fine grained with silt Very dense Grey Saturated						129 128 127 126				
			27	SS	66				○ (approx. 19)		
125.2 / 64.6	End of borehole										

* Borehole dry on completion of drilling

■ Penetrometer test

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

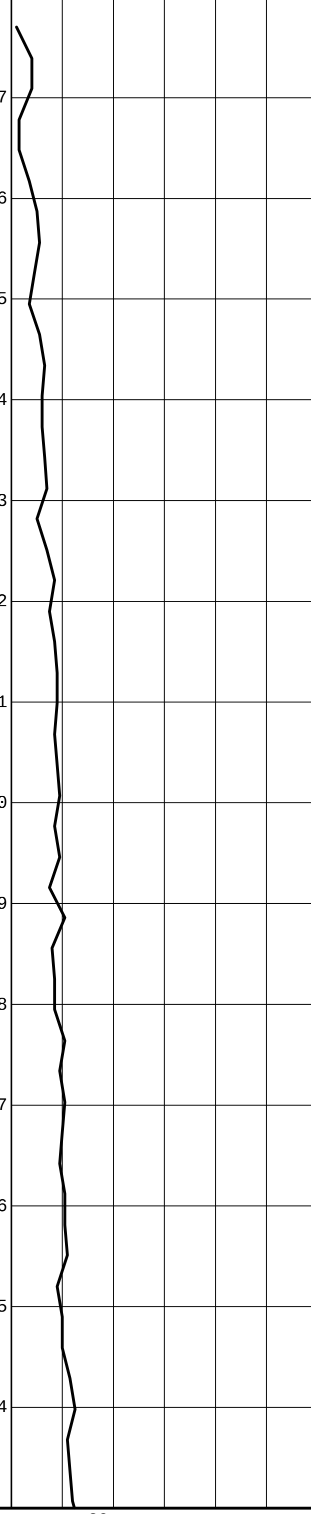
20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

RECORD OF PENETRATION TEST No 207A

 METRIC

G.W.P. 176-98-00	LOCATION Co-ords. 5 124 341 N; 234 724 E.		ORIGINATED BY M.R.
DIST 54 HWY 17	BOREHOLE TYPE DYNAMIC CONE PENETRATION TEST		COMPILED BY G.D.
DATUM Geodetic	DATE October 18, 2003		CHECKED BY C.N.

SOIL PROFILE		SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
188.0 / 0.0	Ground Surface										
							187				
							186				
							185				
							184				
							183				
							182				
							181				
							180				
							179				
							178				
							177				
							176				
							175				
							174				
	Cont'd										



$+^7$, $\times^5$: Numbers refer to Sensitivity

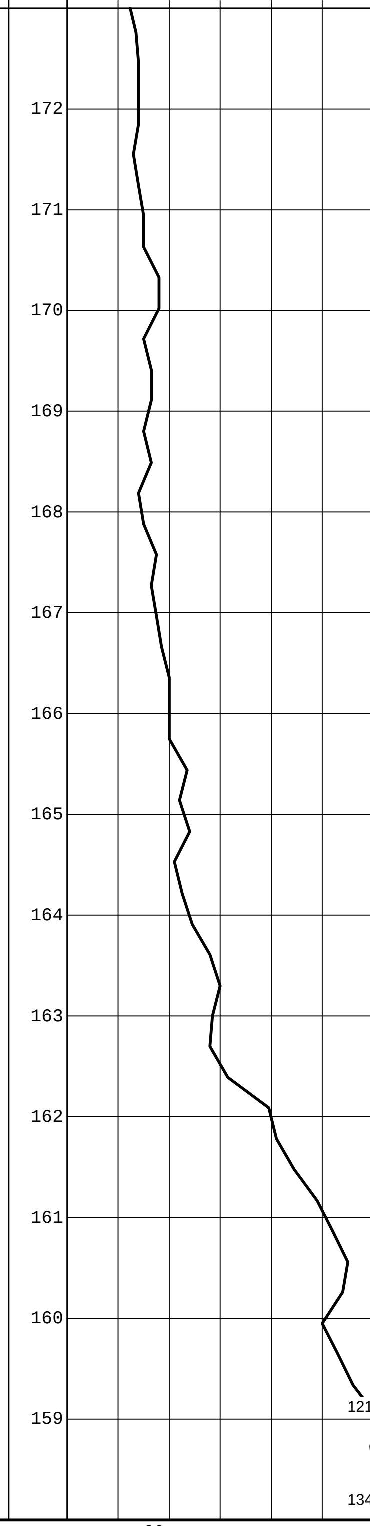
20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

RECORD OF PENETRATION TEST No 207A

METRIC

G.W.P. 176-98-00	LOCATION Co-ords. 5 124 341 N; 234 724 E.		ORIGINATED BY M.R.
DIST 54	HWY 17	BOREHOLE TYPE DYNAMIC CONE PENETRATION TEST	COMPILED BY G.D.
DATUM Geodetic	DATE October 18, 2003		CHECKED BY C.N.

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: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
173.0 / 15.0	Cont'd										



$+^7$, $\times^5$: Numbers refer to Sensitivity

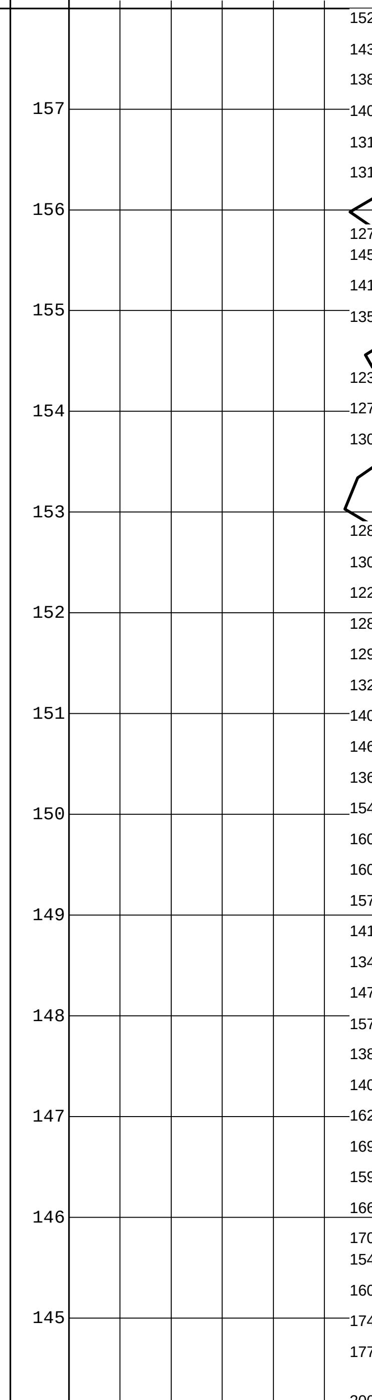
20 / 15 –O– 5 / 10 (%) STRAIN AT FAILURE

RECORD OF PENETRATION TEST No 207A

 METRIC

G.W.P. 176-98-00	LOCATION Co-ords. 5 124 341 N; 234 724 E.		ORIGINATED BY M.R.
DIST 54 HWY 17	BOREHOLE TYPE DYNAMIC CONE PENETRATION TEST		COMPILED BY G.D.
DATUM Geodetic	DATE October 18, 2003		CHECKED BY C.N.

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
158.0 30.0											
144.1 43.9	End of dynamic cone penetration test										



$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 208

METRIC

G.W.P. 176-98-00	LOCATION	Co-ords. 5 124 361 N; 234 756 E.	ORIGINATED BY F.P.
DIST 54 HWY 17	BOREHOLE TYPE	C.F.H.S.S. AND WASH BORINGS	COMPILED BY G.D.
DATUM Geodetic	DATE	October 7 to 9, 2003	CHECKED BY C.N.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.5	Ground Surface						
0.0 0.1	Topsoil						
	Silt, some clay trace sand Loose Grey Moist to wet				181		
		1	SS	7			
					180		
		2	SS	6			
		3	SS	7	179		0 1 88 11
		4	SS	6	178		
		5	SS	7	177		
		6	SS	5	176		
		7	SS	7			
	with clayey silt seams						
		8	SS	7	175		0 1 78 21
		9	SS	7	174		
		10	SS	7			
		11	SS	8	173		
		12	SS	9	172		2 0 81 17
					171		
		13	SS	8	170		
	Compact						
		14	SS	11	169		
					168		
		15	SS	11	167		
	Cont'd						

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS *; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

$+^7, \times^5$: Numbers refer to Sensitivity   20 / 15 —O— 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Peto MacCallum Ltd.
Foundation Design

RECORD OF BOREHOLE No 208

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 361 N; 234 756 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE C.F.H.S.S. AND WASH BORINGS COMPILED BY G.D.

DATUM Geodetic DATE October 7 to 9, 2003 CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
166.5 / 15.0	Cont'd. Silt, with clay trace sand with clayey silt seams. Compact Grey Wet	16	SS	10	166	0 1 74 25
	―― ―― ―― ―― with sandy silt seams	17	SS	12	165	
		18	SS	13	163	
160.8 / 20.7	Layered clayey silt and silty clay, trace sand with sandy silt seams. Stiff Grey WTPL	19	SS	6	160	
		20	TW		159	0 1 65 34
			FV			
		21	SS	WH**	157	
			FV			
		22	SS	1	154	0 0 58 42
			FV			
		23	TW		153	
	Cont'd				152	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

Field vane sensitivity values: 4, 4, 3

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L — WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

$+^7$, $\times^5$: Numbers refer to Sensitivity

20 / 15 –○– 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 208

METRIC

G.W.P. 176-98-00 | LOCATION Co-ords. 5 124 361 N; 234 756 E. | ORIGINATED BY F.P.

DIST 54 HWY 17 | BOREHOLE TYPE C.F.H.S.S. AND WASH BORINGS | COMPILED BY G.D.

DATUM Geodetic | DATE October 7 to 9, 2003 | CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)
151.5 / 30.0	Cont'd. Layered clayey silt and silty clay, trace sand. Very stiff, Grey	24	SS	2	151		o (~38)
			FV			>+ (field vane >100)	
		25	TW		150		o (~34)
147.2 / 34.3	Silt, trace sand trace clay. Very loose, Grey, Wet	26	SS	4	145–144		o (~34)
141.5 / 40.0	Sandy silt. Compact, Grey, Moist	27	SS	22	139–138		o (~20)
	Cont'd				137		

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS *; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Elevation scale: 151, 150, 149, 148, 147, 146, 145, 144, 143, 142, 141, 140, 139, 138, 137

$+^7$, $\times^5$: Numbers refer to Sensitivity

20, 15, 5, 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Peto MacCallum Ltd.
Foundation Design

RECORD OF BOREHOLE No 208

METRIC

G.W.P. 176-98-00 | LOCATION Co-ords. 5 124 361 N; 234 756 E. | ORIGINATED BY F.P.
DIST 54 HWY 17 | BOREHOLE TYPE C.F.H.S.S. AND WASH BORINGS | COMPILED BY G.D.
DATUM Geodetic | DATE October 7 to 9, 2003 | CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.4 / 45.0	Cont'd. Sandy silt. Very stiff, Grey, Moist				136, 135		
134.9 / 46.6	Sand, trace silt. Dense to very dense, Grey, Moist				134, 133		
		28	SS	52	132	~20	0 91 (9)
					131, 130, 129, 128, 127		
		29	SS	48	126	~21	
					125, 124		
		30	SS	54	123		
123.0 / 58.5	End of borehole				122		
	Cont'd						

Dynamic cone penetration values at right edge of plot: 202, 284, 273, 274, 329

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

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$+^{7}, \times^{5}$: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 208

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 361 N; 234 756 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE C.F.H.S.S. AND WASH BORINGS COMPILED BY G.D.

DATUM Geodetic DATE October 7 to 9, 2003 CHECKED BY C.N.

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 (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
121.5 / 60.0						*		291			
121.3 / 60.2	End of dynamic cone penetration test										

* Borehole dry on completion of drilling

WH** Refers to penetration due to weight of rods and hammer

Date	Depth to Water (m)
Piezometer	
Oct.28/03	3.5

Piezometer Legend

- Auger Cuttings
- Bentonite Seal
- Filter Sand
- Screen
- Grout

$+^7$, $\times^5$: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 209

METRIC

G.W.P. 176-98-00	LOCATION Co-ords. 5 124 365 N; 234 789 E.	ORIGINATED BY F.P.	
DIST 54 HWY 17	BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS	COMPILED BY G.D.	
DATUM Geodetic	DATE October 20 and 21, 2003	CHECKED BY C.N.	

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
182.4	Ground Surface
0.0	Topsoil
0.3	Dark brown Silty fine sand, with sandy silt lenses Very loose Brown Moist
181.0 / 1.4	Sand, fine to medium trace to some silt Very loose Brown Moist to wet
179.9 / 2.5	Layered clayey silt and silty clay, trace to some sand Firm Grey WTPL Stiff
168.1 / 14.3	Silt, some clay trace sand with clayey silt seams
167.4	Cont'd

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	3	
2	SS	5	0 89 (11)
3	SS	2	
4	SS	WH**	
5	SS	WH	
	FV		
6	SS	WH	
	FV		
7	SS	WH	
	FV		
8	TW		0 11 61 28
9	SS	WH	
	FV		
10	SS	WH	
	FV		
11	SS	WH	
	FV		
12	TW		
13	SS	4	

Column headings: STRAT PLOT; GROUND WATER CONDITIONS *; ELEVATION SCALE (182, 181, 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

Field vane sensitivity labels (top to bottom): 5, 10, 7, 4, 3, 2

+7, ×5: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Peto MacCallum Ltd.
Foundation Design

RECORD OF BOREHOLE No 209

METRIC

G.W.P. 176-98-00	LOCATION Co-ords. 5 124 365 N; 234 789 E.	ORIGINATED BY F.P.
DIST 54 HWY 17	BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS	COMPILED BY G.D.
DATUM Geodetic	DATE October 20 and 21, 2003	CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DYNAMIC CONE / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
167.4 / 15.0	Cont'd. Silt, some clay trace sand with clayey silt seams. Very loose to loose, Grey, Wet		FV			> + (>100, field vane)			
					167				
		14	SS	2			o		0 1 84 15
					166				
		15	SS	6			o		
					165				
		16	SS	8	164		o		
					163				
					162				
		17	SS	3	161		o		
					160				
159.2 / 23.2	Sandy silt, trace clay. Compact, Grey, Wet				159				
		18	SS	10	158		o		0 38 58 4
					157				
156.2 / 26.2	Sand, with silt trace clay. Loose, Grey, Wet				156				
		19	SS	5	155		o		
					154				
					153				
152.4	Cont'd								

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+7, ×5: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

Legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L.

RECORD OF BOREHOLE No 209

METRIC

G.W.P. 176-98-00	LOCATION Co-ords. 5 124 365 N; 234 789 E.		ORIGINATED BY F.P.
DIST 54	HWY 17	BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS	COMPILED BY G.D.
DATUM Geodetic		DATE October 20 and 21, 2003	CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) w	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
152.4 / 30.0	Sand, with silt trace clay Compact				152		
		20	SS	15		o (~20)	0 66 29 5
					151		
					150		
					149		
					148		
					147		
					146		
		21	SS	13		o	
					145		
					144		
					143		
					142		
					141		
					140		
	Dense	22	SS	30			
					139		
					138		
137.4	Cont'd						

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS *; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 209

METRIC

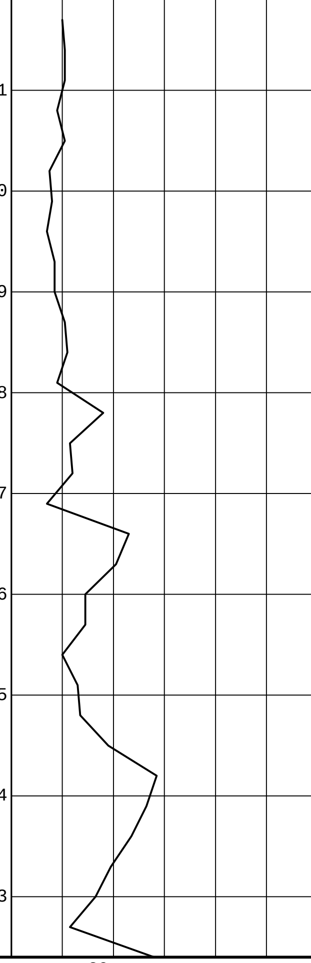
G.W.P. 176-98-00 | LOCATION Co-ords. 5 124 365 N; 234 789 E. | ORIGINATED BY F.P.

DIST 54 HWY 17 | BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS | COMPILED BY G.D.

DATUM Geodetic | DATE October 20 and 21, 2003 | CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.4 / 45.0	Sand, with silt trace clay Dense Grey Wet					
136.7 / 45.7	Sandy gravel Dense Grey Wet	23	SS	48		
132.1 / 50.3	End of borehole					
122.4	Cont'd					

Column headings: STRAT PLOT; ELEVATION SCALE (137 to 123); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³



+7, ×5 : Numbers refer to Sensitivity

20 / 15 –○– 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 209

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 365 N; 234 789 E. ORIGINATED BY F.P.

DIST 54 HWY 17 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS COMPILED BY G.D.

DATUM Geodetic DATE October 20 and 21, 2003 CHECKED BY C.N.

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
122.4 / 60.0	End of dynamic cone penetration test Refusal on probable bedrock * Borehole dry on completion of drilling WH** Refers to penetration due to weight of rods and hammer										

$+^7$, $\times^5$: Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 210

METRIC

G.W.P. 176-98-00	LOCATION Co-ords. 5 124 391 N; 234 833 E.		ORIGINATED BY F.P.
DIST 54	HWY 17	BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS	COMPILED BY G.D.
DATUM Geodetic		DATE October 22, 2003	CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa	REMARKS & GRAIN SIZE DISTRIBUTION (%)
186.1	Ground Surface					186		
0.0	Silt trace sand trace clay; Loose Grey Moist							
		1	SS	6		185		
		2	SS	8		184		
		3	SS	8		183		
		4	SS	8				
	sandy silt lenses	5	SS	8		182		
		6	SS	9		181		
	clayey silt lenses	7	SS	5		180		
179.1 / 7.0	Layered clayey silt and silty clay, trace to some sand; Firm Grey Wet				▼*	179		
		8	SS	2		178		
			FV				+ 3 (field vane, ~30)	
177.6 / 8.5	End of borehole							On completion of augering, cave-in at 7.3 m

* 2003 10 22

▼ Water level measured after drilling

+7, ×5 : Numbers refer to Sensitivity

20, 15, 5, 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No 211

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 293 N; 234 644 E. ORIGINATED BY M.R.

DIST 54 HWY 17 BOREHOLE TYPE BW WASH BORING AND HAND SAMPLING COMPILED BY G.D.

DATUM Geodetic DATE October 19, 2003 CHECKED BY C.N.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
180.5	Ground Surface				*	
0.0	Topsoil					
0.2	Dark brown Layered silts, trace sand trace clay, and fine sandy silts. Compact Brown Saturated	1	SS	2		180
		2	SS	3		
179.1 / 1.4	Sand, fine to coarse some silt some gravel. Loose Brown Saturated	3	SS	6		179
178.1 / 2.4	Silt, some sand trace clay. Compact Brown to dark brown	4	SS	23		178
177.5 / 3.0	Sand, fine to coarse trace silt. Compact Brown Saturated	5	SS	12		177
						176
		6	SS	14		175
174.7 / 5.8	Silt, trace fine sand trace clay. Loose Grey Saturated to compact	7	SS	10		
174.1 / 6.4	End of borehole					

* Borehole dry on completion of drilling

Column headings also include: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

$+^7$, $\times^5$: Numbers refer to Sensitivity

20 / 15 — 5 / 10 (%) STRAIN AT FAILURE

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Ontario

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RECORD OF BOREHOLE No 212

METRIC

G.W.P. 176-98-00 LOCATION Co-ords. 5 124 270 N; 234 659 E. ORIGINATED BY M.R.

DIST 54 HWY 17 BOREHOLE TYPE BW WASH BORING AND HAND SAMPLING COMPILED BY G.D.

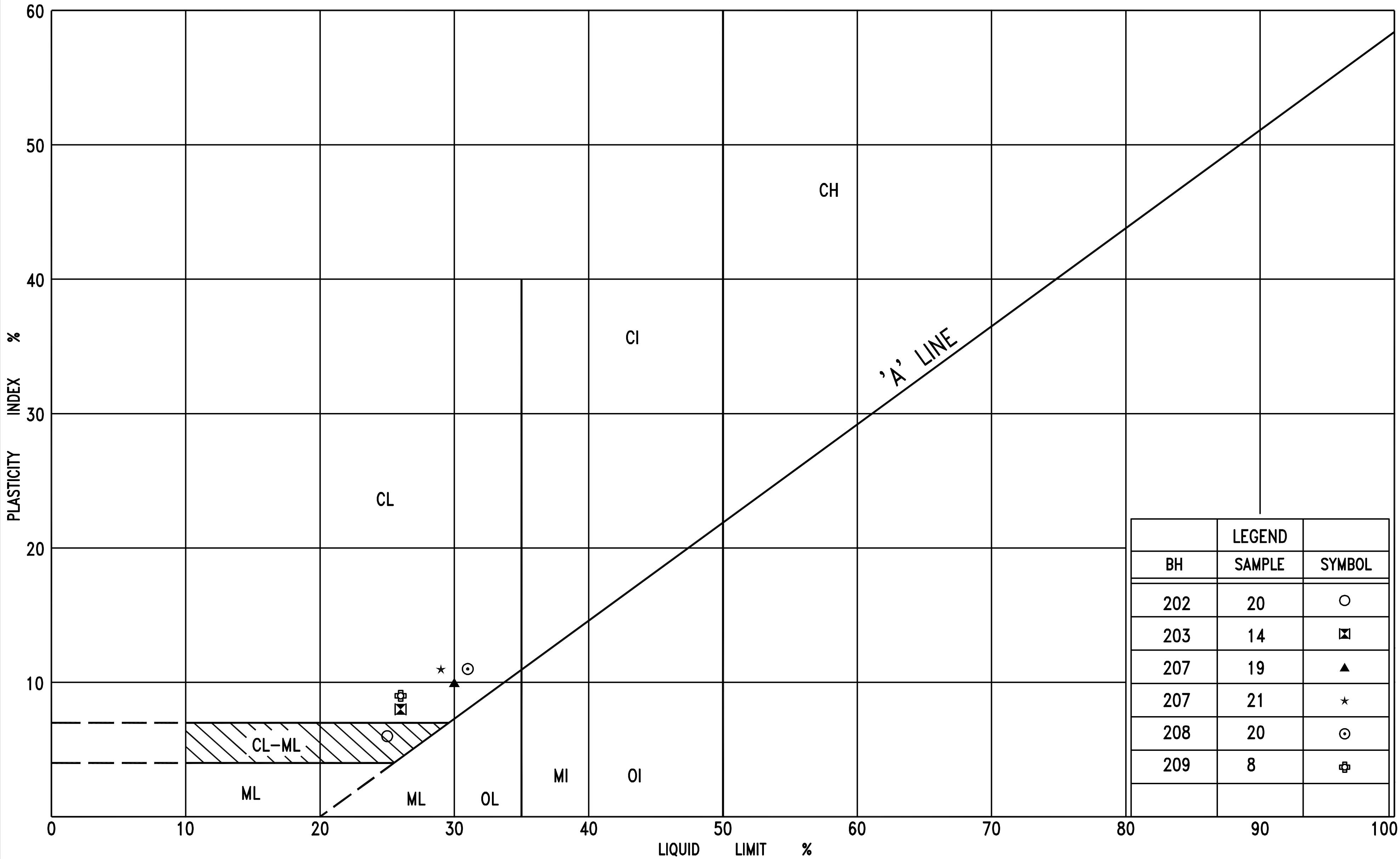
DATUM Geodetic DATE October 19, 2003 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	WATER CONTENT (%)
180.3	Ground Surface							
180.2 / 0.1	Topsoil, medium organic							
	Sand, fine grained trace silt, Very loose, Dark brown		1	SS	2		180	~19
179.6 / 0.8	Silt, trace clay, Very loose, Brown, Moist		2	SS	2			~24
	Very loose, Grey, Wet; trace sand						179	
178.2	Brown, Saturated		3	SS	2			~22
178.2 / 2.1	Sand, fine grained trace to some silt, Very loose, Dark grey, Saturated							
177.9 / 2.4	Silt, Very loose, Grey, Saturated, with occ. thin clay layers		4	SS	3		178	~21
			5	SS	5		177	~26
	Loose		6	SS	6			~22
							176	
			7	SS	7			~25
			8	SS	4		175	~23
174.5 / 5.8								

* Borehole dry on completion of drilling

Column headings also include: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20, 40, 60; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

$+^7$, $\times^5$: Numbers refer to Sensitivity   20 / 15–O–5 / 10 (%) STRAIN AT FAILURE



	LEGEND	
BH	SAMPLE	SYMBOL
202	20	○
203	14	⧗
207	19	▲
207	21	★
208	20	⊙
209	8	⌖

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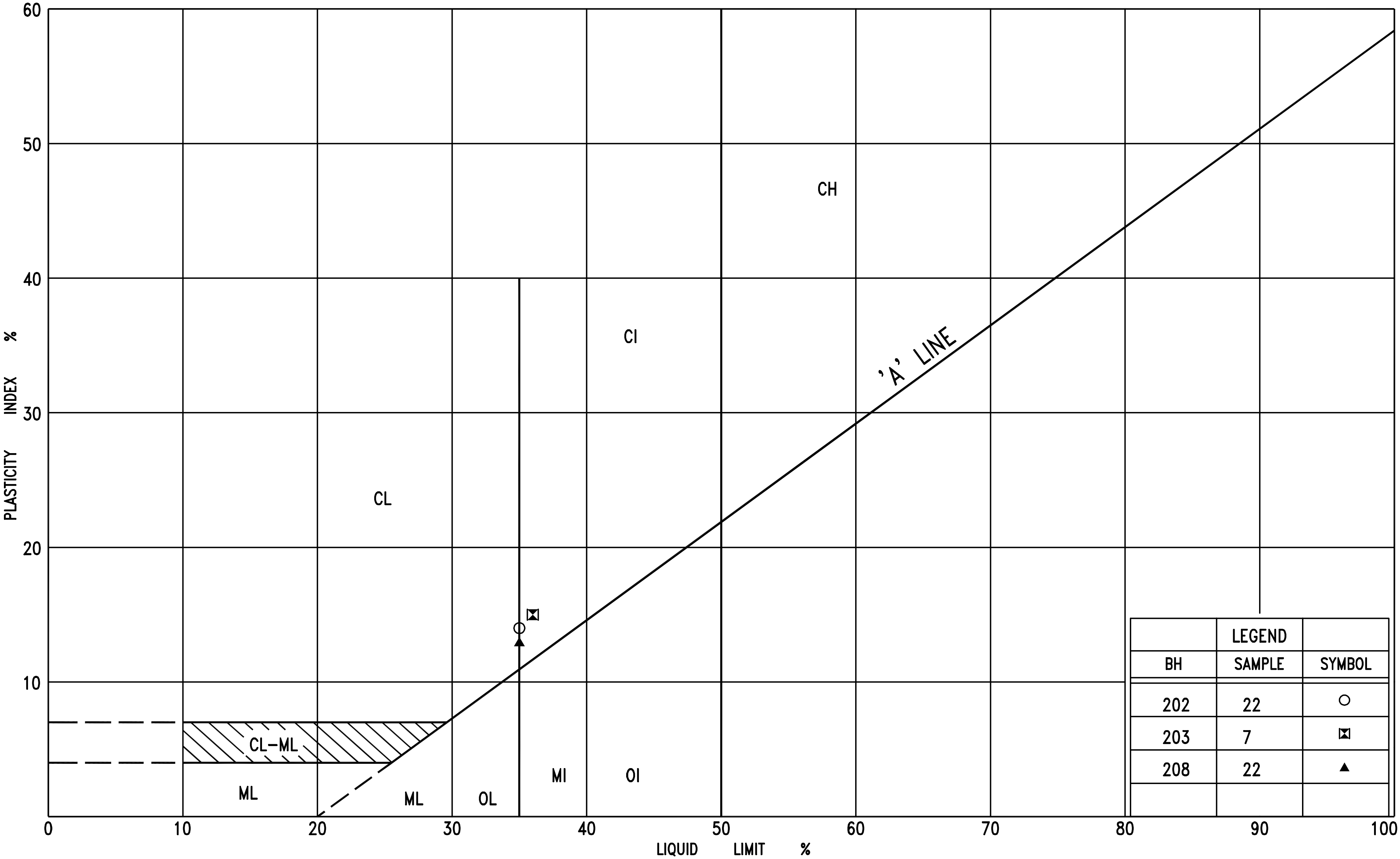
PLASTICITY CHART
CLAYEY SILT

FIG No. PC–1
HWY 17, Site 46–159
W.P. No. 176–98–00



	LEGEND	
BH	SAMPLE	SYMBOL
202	22	○
203	7	⊠
208	22	▲

PLASTICITY CHART
SILTY CLAY

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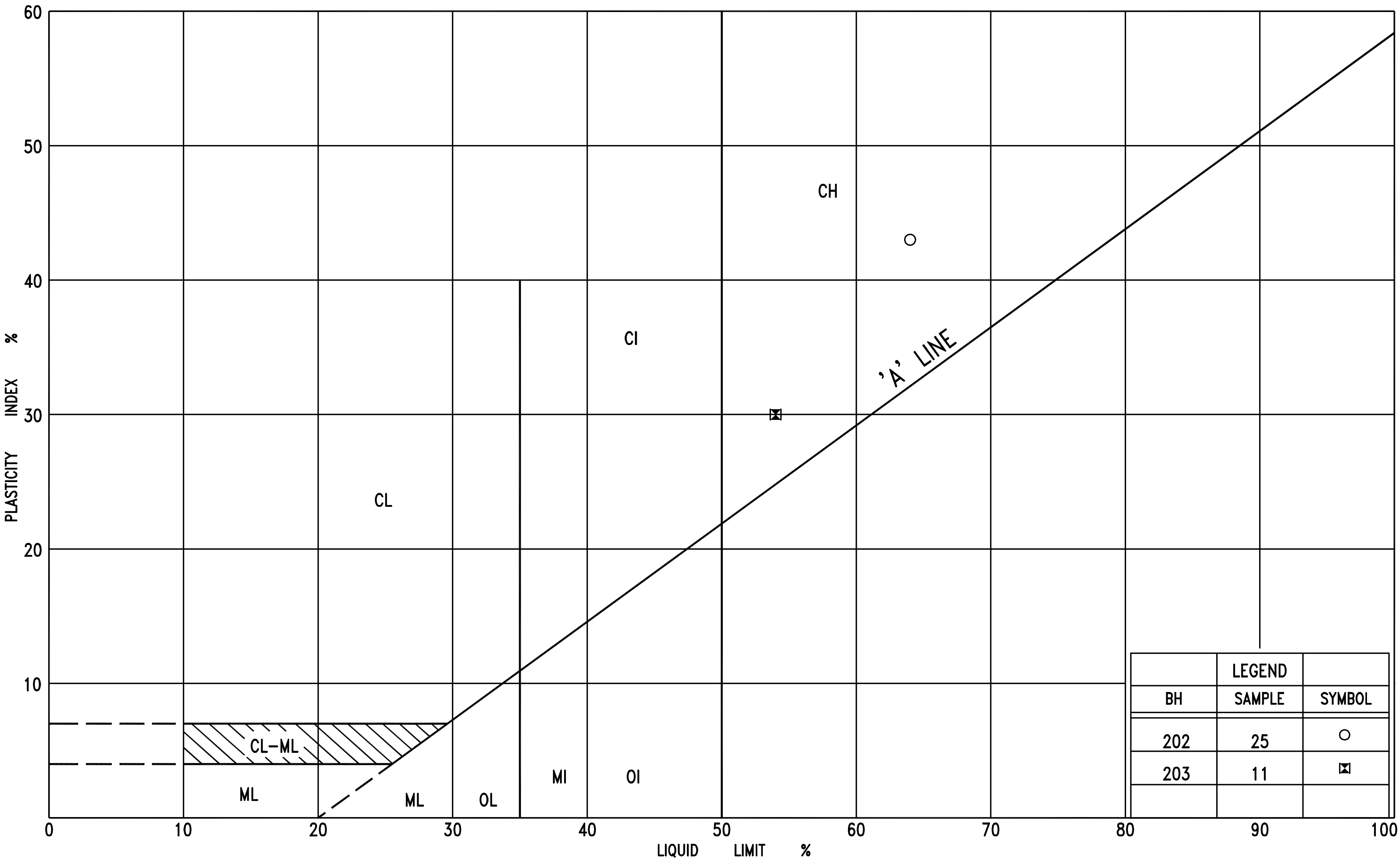
FIG No. PC-2
HWY 17, Site 46-159
W.P. No. 176-98-00



BH	SAMPLE	SYMBOL
202	25	○
203	11	⊠

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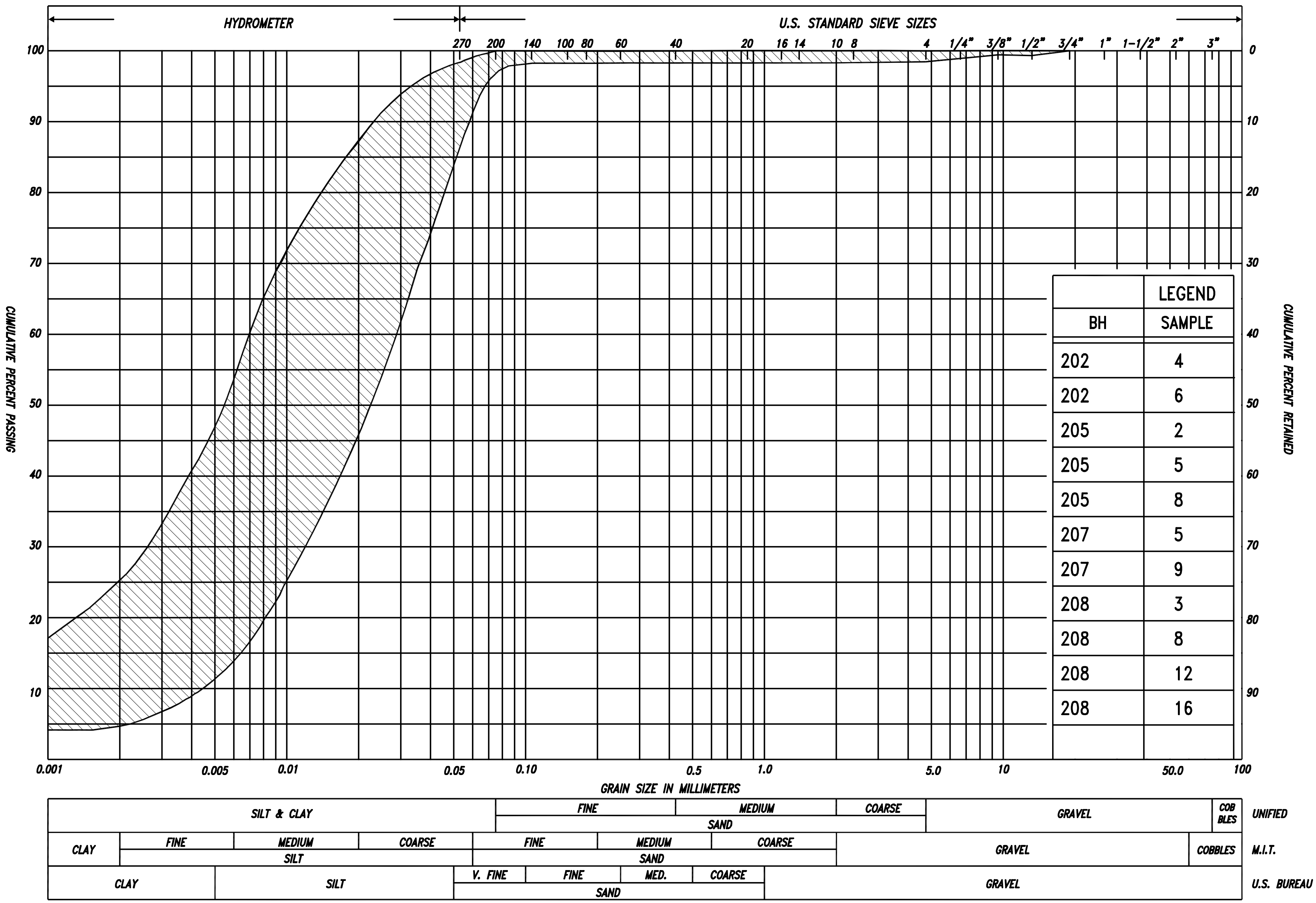
PLASTICITY CHART
CLAY

FIG No.	PC-3
HWY	17, Site 46-159
W.P. No.	176-98-00



	LEGEND
BH	SAMPLE
202	4
202	6
205	2
205	5
205	8
207	5
207	9
208	3
208	8
208	12
208	16

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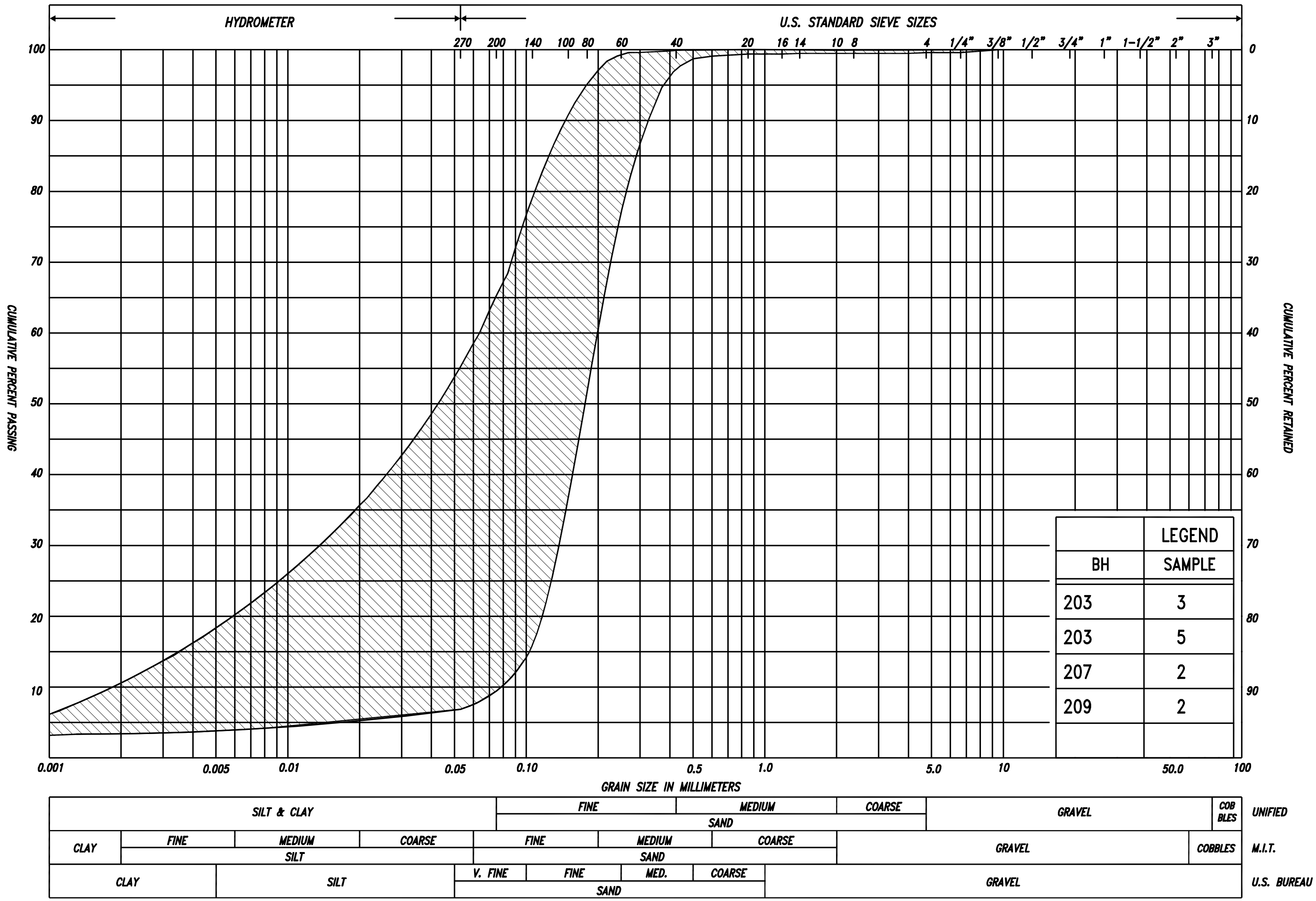
GRAIN SIZE DISTRIBUTION

SILT

FIG No.	1
HWY 17	
W.P. No.	176-98-00



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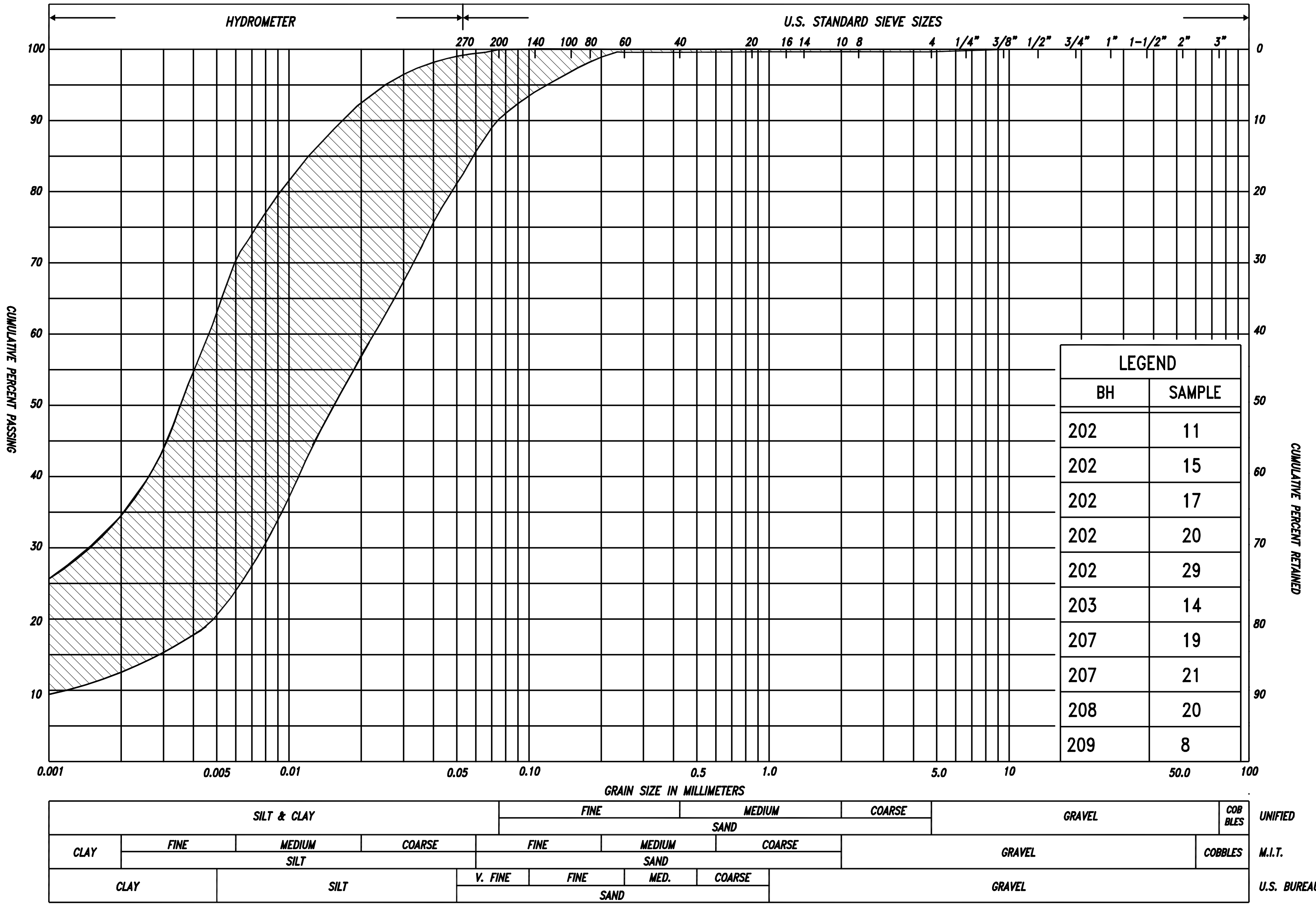
GRAIN SIZE DISTRIBUTION

SANDY SILT to SAND

FIG No.	2
HWY	17
W.P. No.	176-98-00



LEGEND	
BH	SAMPLE
202	11
202	15
202	17
202	20
202	29
203	14
207	19
207	21
208	20
209	8

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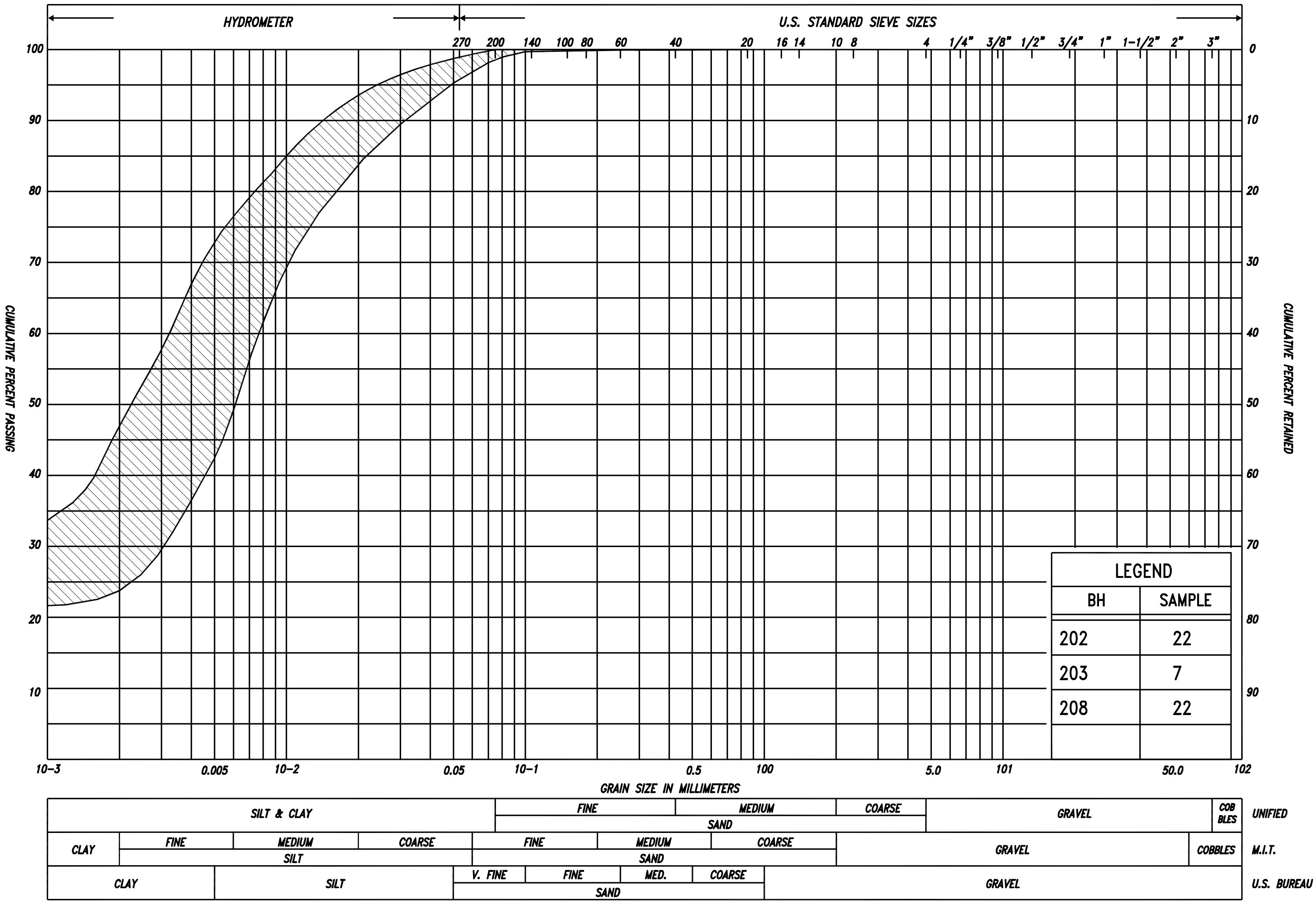
GRAIN SIZE DISTRIBUTION

CLAYEY SILT

FIG No. 3

HWY 17

W.P. No. 176-98-00



LEGEND

BH	SAMPLE
202	22
203	7
208	22

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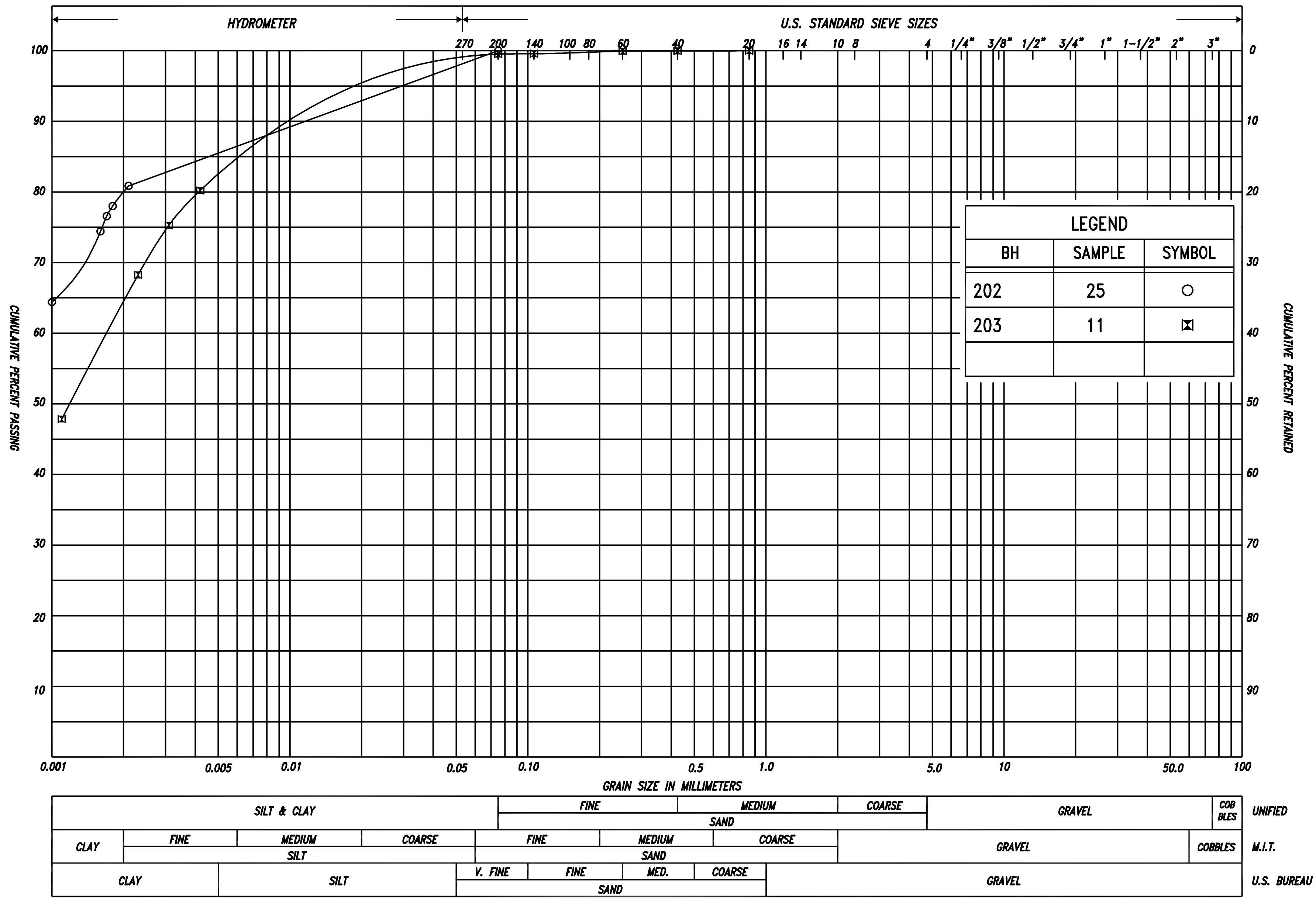
GRAIN SIZE DISTRIBUTION

SILTY CLAY

FIG No. 4

HWY 17

W.P. No. 176-98-00



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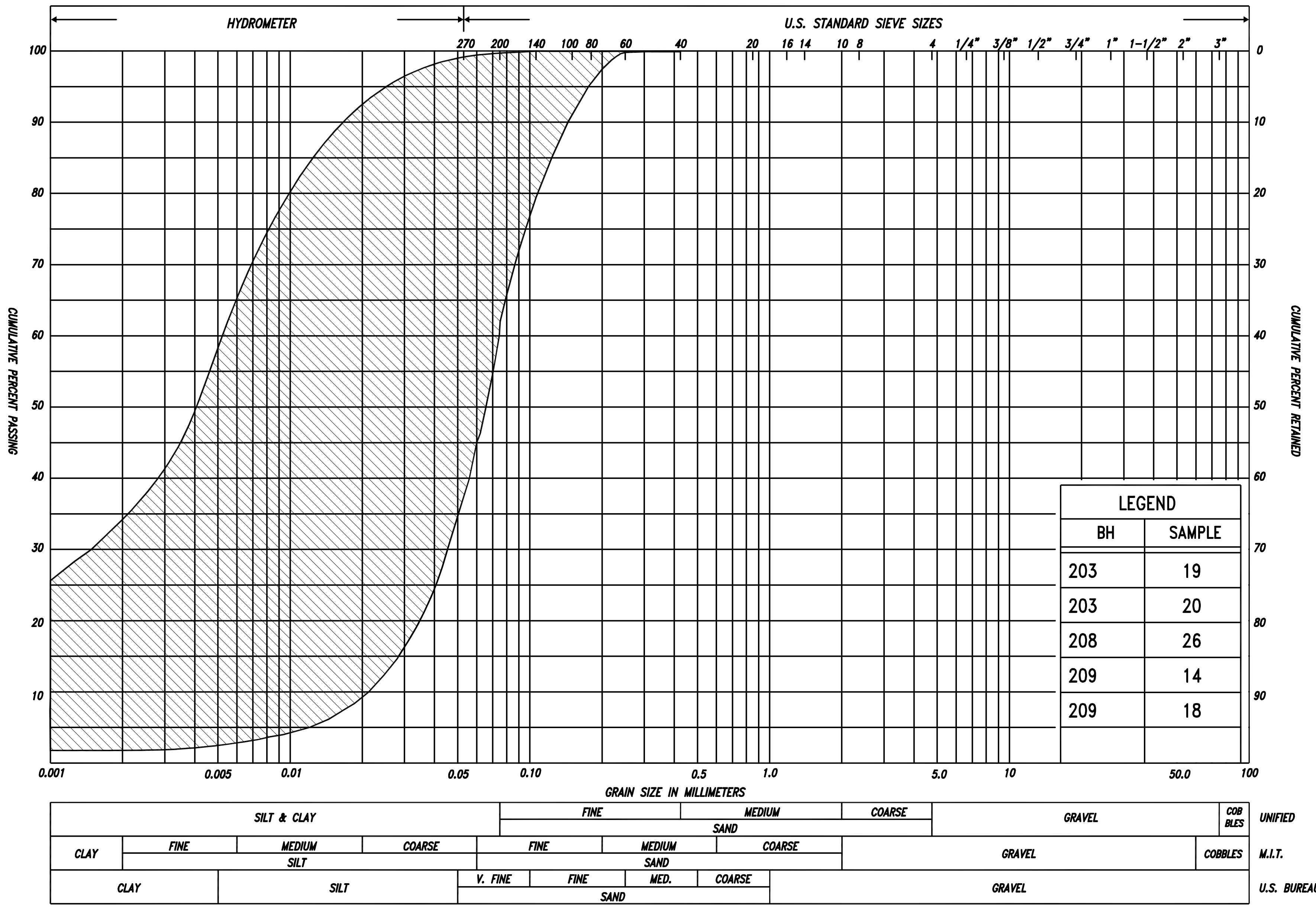
GRAIN SIZE DISTRIBUTION

CLAY

FIG No. 5

HWY 17

G.W.P. No. 176-98-00



LEGEND	
BH	SAMPLE
203	19
203	20
208	26
209	14
209	18

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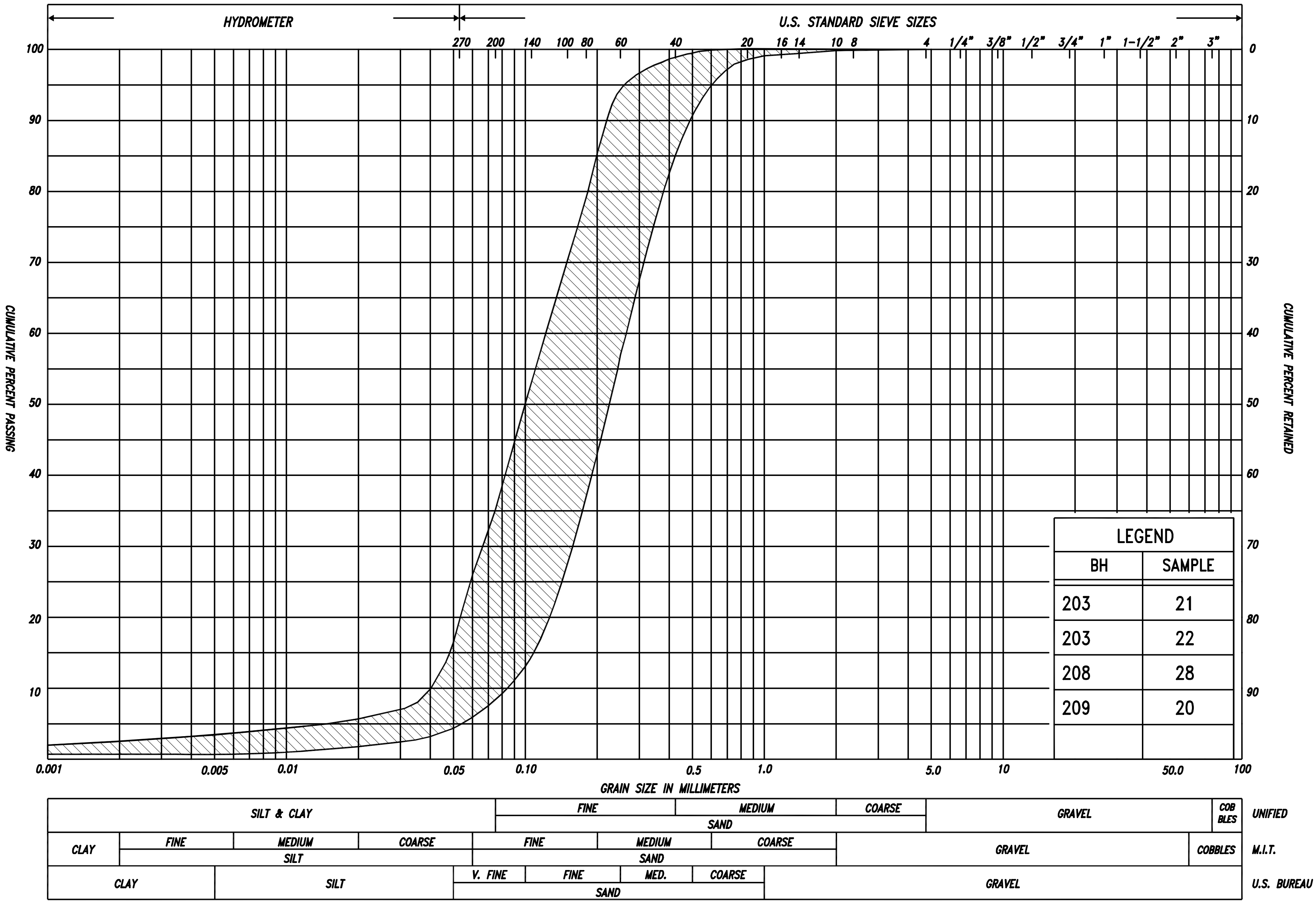
GRAIN SIZE DISTRIBUTION

SILT to SANDY SILT

FIG No. 6

HWY 17

W.P. No. 176-98-00



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GRAIN SIZE DISTRIBUTION

SILTY SAND to SAND

FIG No. 7
HWY 17
W.P. No. 176-98-00

(Legend continued)

BH No	ELEVATION	CO-ORDINATES NORTH	EAST
209	182.4	5 124 365	234 789
210	186.1	5 124 391	234 833
211	180.5	5 124 293	234 644
212	180.3	5 124 270	234 659

METRIC

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

CONT No
WP No 176-98-00

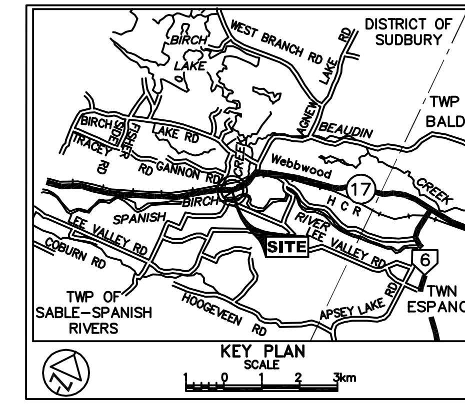
SHEET

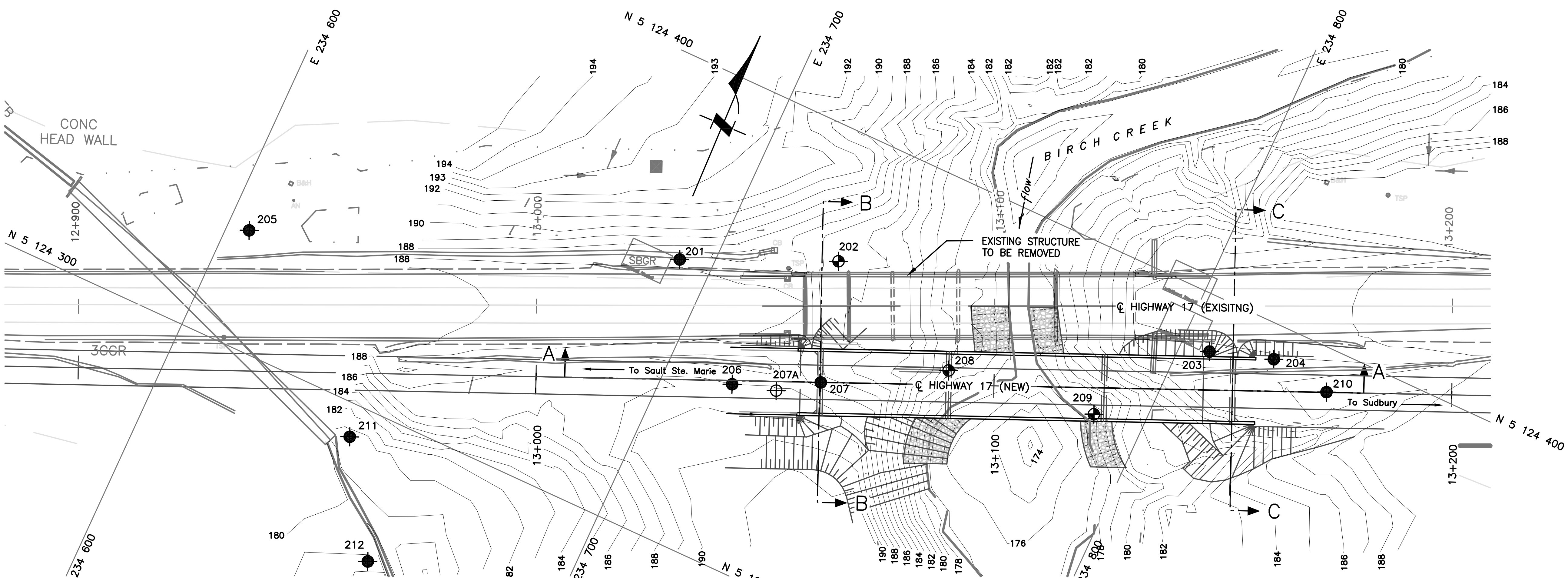
BIRCH CREEK

(Hwy 17, 15 km West of Espanola)

BOREHOLE LOCATIONS & SOIL STRATA

Peto MacCallum Ltd.
CONSULTING ENGINEERS





PLAN

SCALE

10 5 0 10 20m

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & 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 January and October 2003
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	CO-ORDINATES NORTH	EAST
201	184.6	5 124 358	234 693
202	185.4	5 124 372	234 724
203	188.0	5 124 388	234 806
204	188.3	5 124 393	234 820
205	188.8	5 124 325	234 605
206	188.5	5 124 338	234 715
207	189.8	5 124 347	234 732
207A	188.0	5 124 341	234 724
208	181.5	5 124 361	234 756

(Legend continues)

– NOTE –

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

NOTES:

1. REFER TO DRAWING NOS. 2 AND 3 FOR SECTIONS A–A, B–B AND C–C.
2. SECTIONS ARE PROVIDED SOLELY FOR ILLUSTRATIVE PURPOSES REFER TO RECORD OF BOREHOLE AND RECORD OF PENETRATION TEST FOR DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS, IN-SITU TEST DATA AND LABORATORY TEST RESULTS.

REF No E–BirchRevised.dwg; August 2003
65000458B–GA.dwg; October 2003

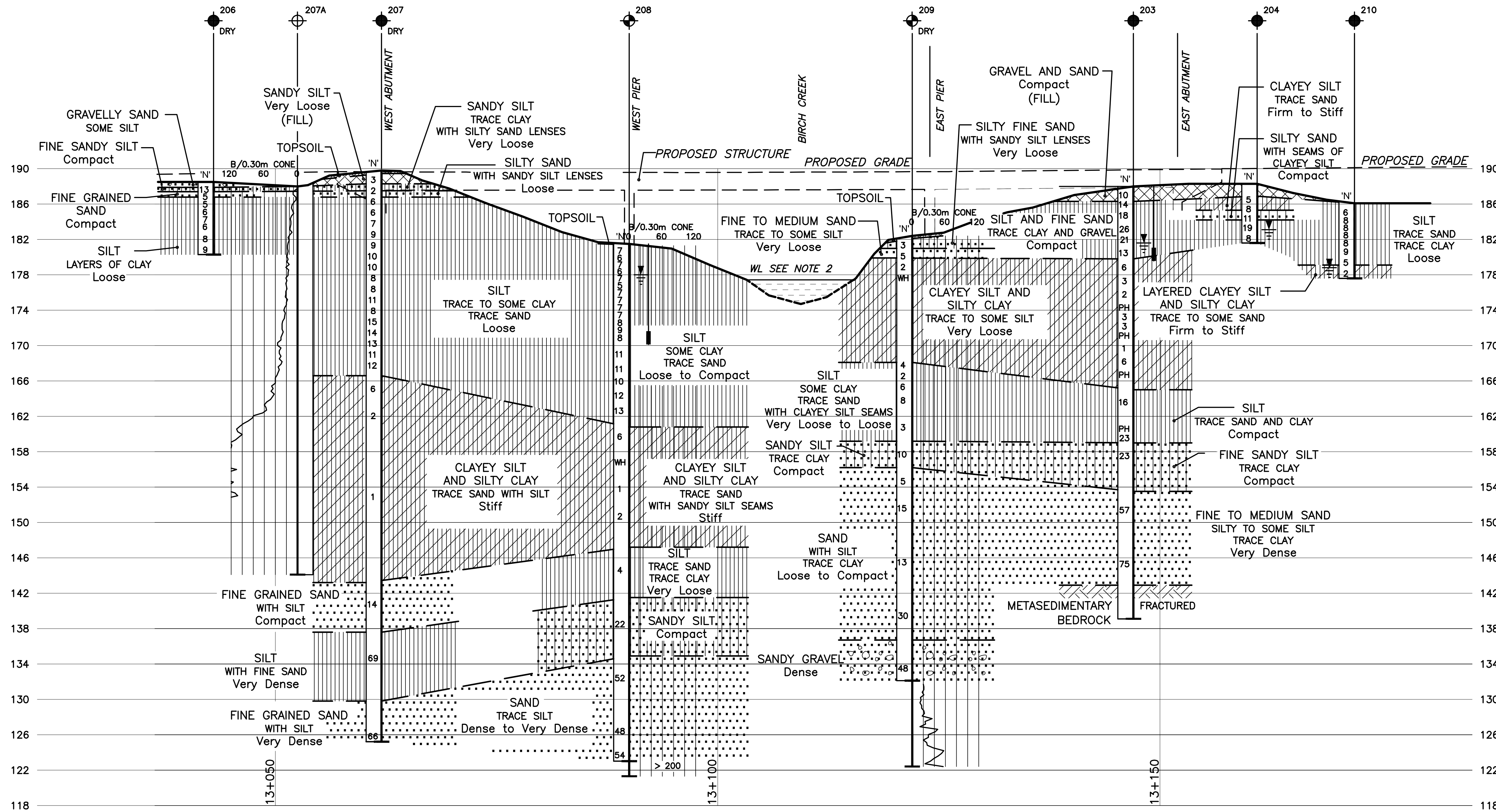
REVISIONS DATE	BY	DESCRIPTION

Geocres No. 41I–159

HWY No 17			DIST	54
SUBM'D GD	CHECKED GD	DATE DEC 02, 2003	SITE	46–159
DRAWN MM	CHECKED DWK	APPROVED	DWG	1

METRIC

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



A–A

SECTION

SCALE 5 0 5 10m

NOTES:

1. REFER TO DRAWING NO.1 FOR PLAN AND DRAWING NO.3 FOR SECTIONS B–B AND C–C.
2. WATER LEVEL 177.93 IN AUGUST 2001, 180.7 IN JANUARY 2003.
3. SECTIONS ARE PROVIDED SOLELY FOR ILLUSTRATIVE PURPOSES REFER TO RECORD OF BOREHOLE AND RECORD OF PENETRATION TEST FOR DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS, IN-SITU TEST DATA AND LABORATORY TEST RESULTS.

REF No E–BirchRevised.dwg; August 2003
65000458B–GA.dwg; October 2003

CONT No
WP No 176–98–00

BIRCH CREEK
(Hwy 17, 15 km West of Espanola)
SOIL STRATA

SHEET

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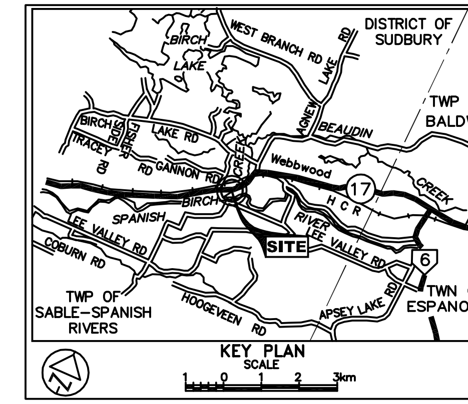


LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & 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 January and October 2003
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	CO–ORDINATES NORTH	EAST
(Refer to drawing no.1 for co–ordinates)			

(Legend continues)

– NOTE –

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 46I–159

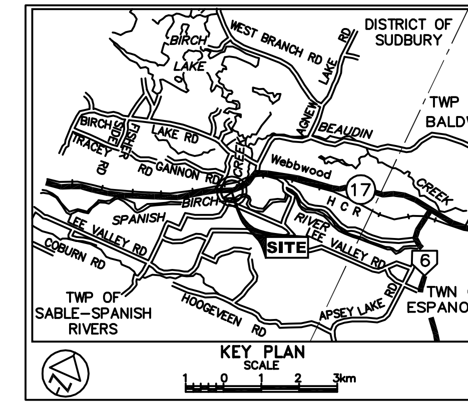
HWY No 17				DIST	54
SUBM'D GD	CHECKED GD	DATE DEC 02, 2003		SITE	46–159
DRAWN MM	CHECKED DWK	APPROVED		DWG	2

METRIC

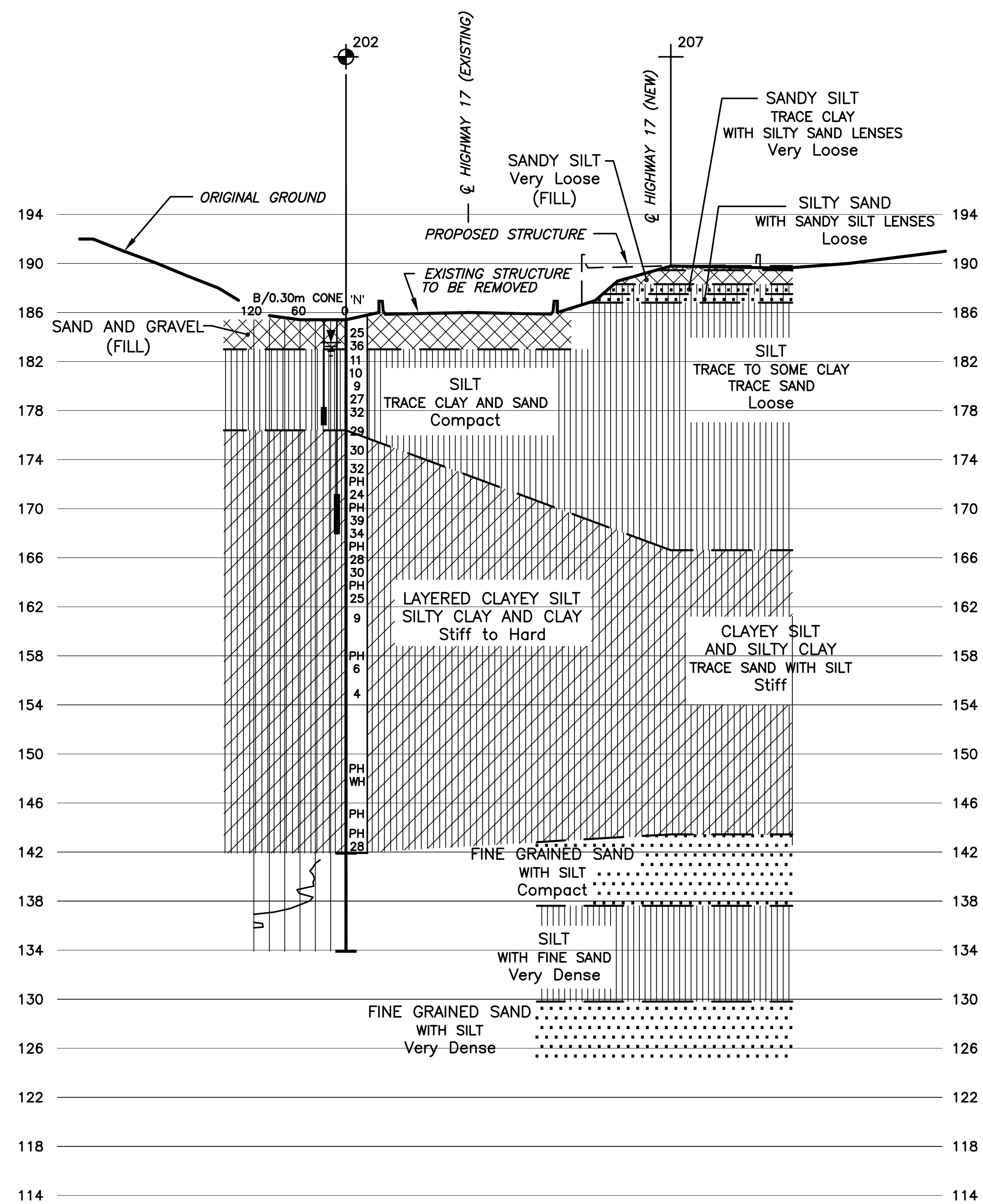
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

CONT No WP No 176-98-00	
BIRCH CREEK (Hwy 17, 15 km West of Espanola) SOIL STRATA	SHEET

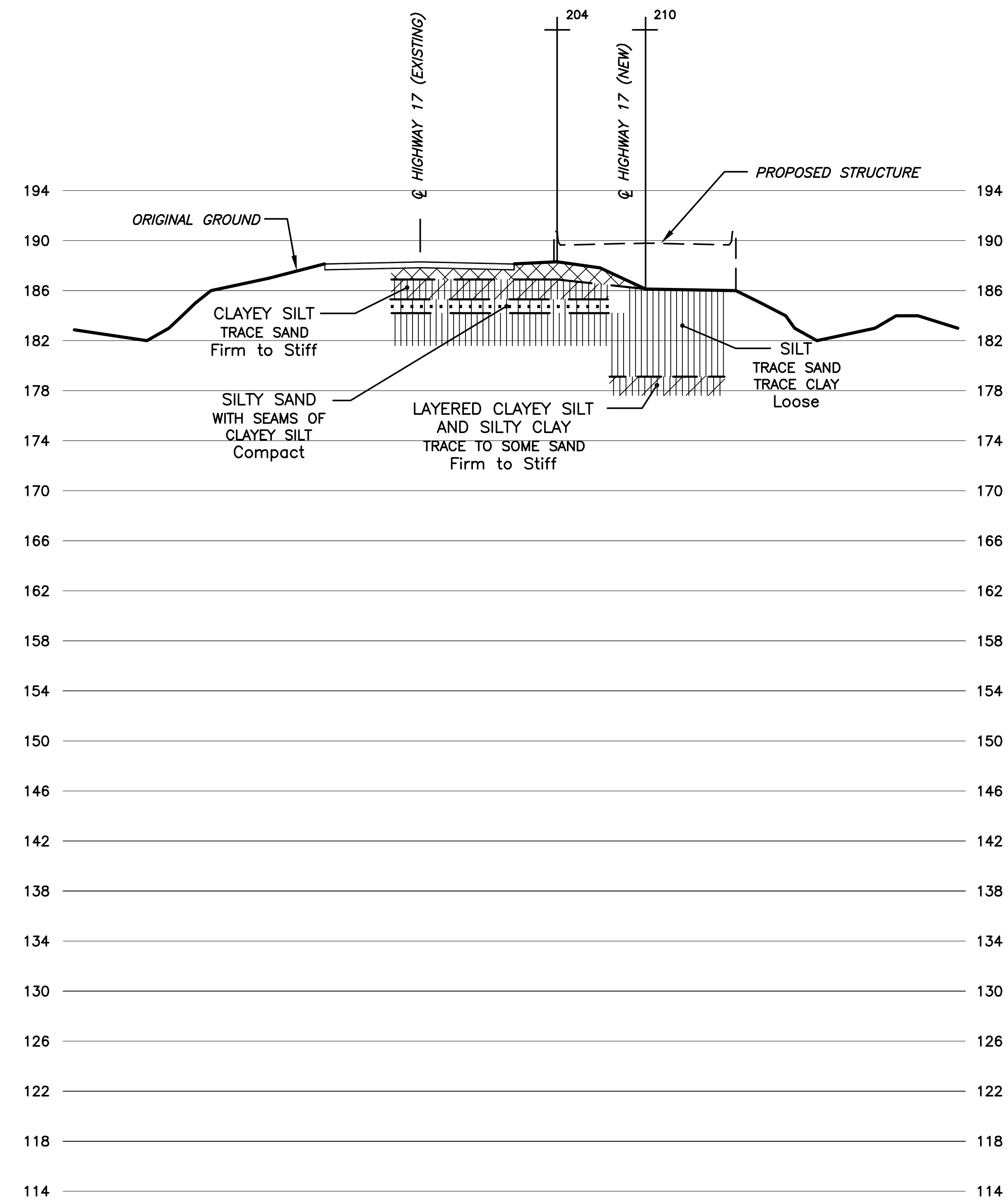
Peto MacCallum Ltd. CONSULTING ENGINEERS



KEY PLAN
SCALE
1 0 1 2 3km



B–B



C–C

NOTES:

1. REFER TO DRAWING NO.1 FOR PLAN AND DRAWING NO.2 FOR SECTION A–A.
2. SECTIONS ARE PROVIDED SOLELY FOR ILLUSTRATIVE PURPOSES REFER TO RECORD OF BOREHOLE AND RECORD OF PENETRATION TEST FOR DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS, IN-SITU TEST DATA AND LABORATORY TEST RESULTS.

SECTIONS
SCALE
5 0 5 10m

REF No E–BirchRevised.dwg; August 2003
65000458B–GA.dwg; October 2003

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & 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 January and October 2003
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	CO-ORDINATES NORTH	EAST
(Refer to drawing no.1 for co-ordinates)			

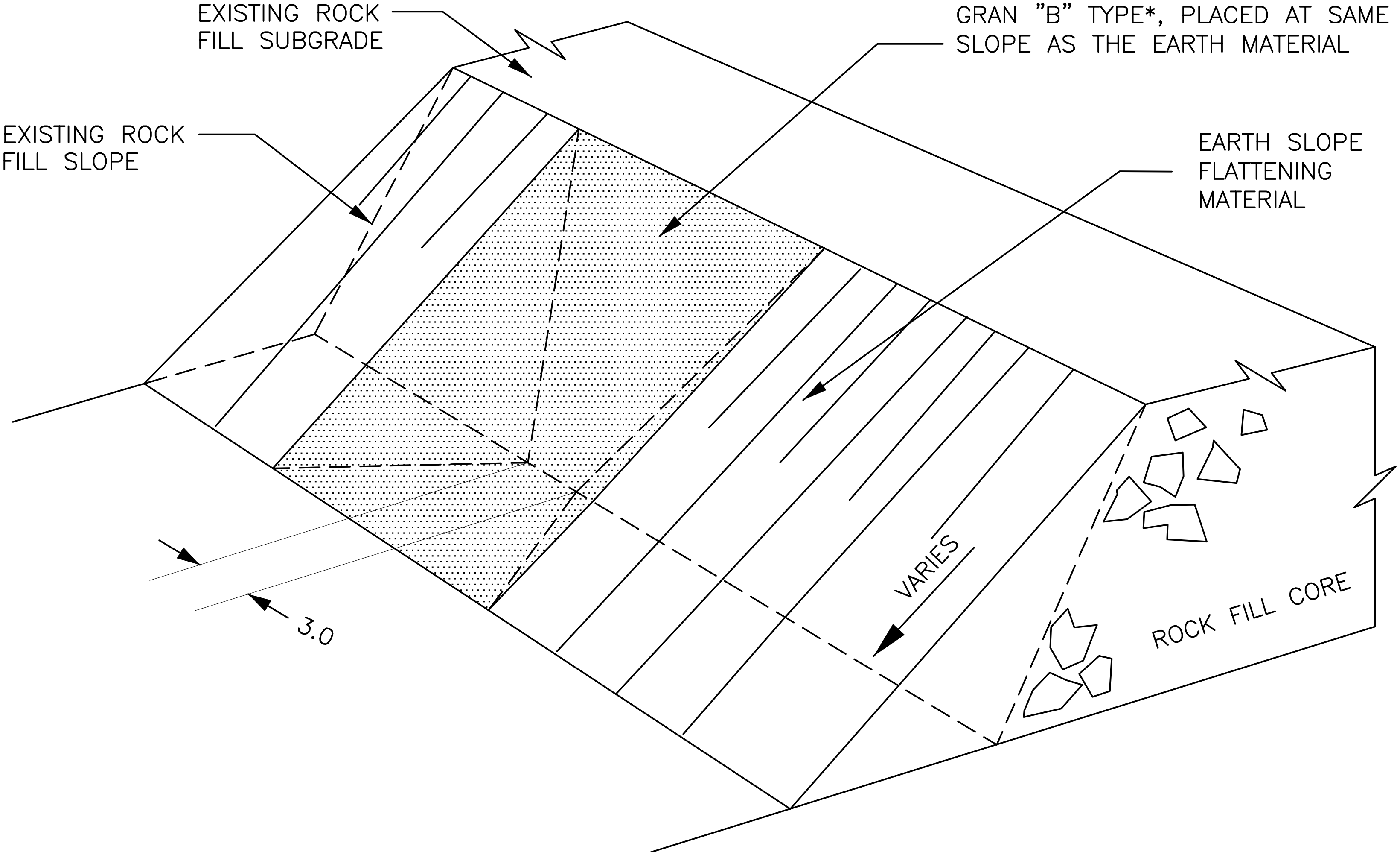
(Legend continues)

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

REVISIONS DATE	BY	DESCRIPTION

Geocres No. 46I–159

HWY No	17			DIST	54
SUBM'D	GD	CHECKED GD	DATE DEC 03, 2003	SITE	46–159
DRAWN	MM	CHECKED DWK	APPROVED	DWG	3



* GRAN 'B' TYPE I OR TYPE II AS RECOMMENDED FOR PROJECT.

ROCK FILL DRAINAGE IN SLOPE FLATTENED AREAS

NOT TO SCALE