



**PREDRAFT
FOUNDATION INVESTIGATION REPORT
GRAND RIVER BRIDGE REPLACEMENT
HIGHWAY 3, CAYUGA
SITE NO. 9-43
G.W.P. 3501-01-00
for
MCCORMICK RANKIN CORPORATION**

PREDRAFT FOR REVIEW AND COMMENT BY MRC, NOT FOR DISTRIBUTION TO MTO

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**PREDRAFT
FOUNDATION INVESTIGATION REPORT**

Grand River Bridge Replacement
G.W.P. 3501-01-00, Site No. 9-43
Highway 3, District 31
Cayuga

1. INTRODUCTION

This report summarises the results of the foundation investigation carried out for the proposed replacement of the existing bridge on Highway 3 that crosses the Grand River near the west limit of Cayuga, Ontario. The study was conducted for McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation of Ontario (MTO).

The existing structure is a five span steel through truss bridge of approximate 188 m overall length, each span being some 37 m long. The roadway is 7 m wide and accommodates two lanes of traffic. A concrete sidewalk is located on the north side of the structure. Situated in the Grand River, the piers rest on 3 by 11 m spread footings founded at elevation 172.8 to 173.9, about 2 to 3 m below the water level in the river.

The centre of the bridge is at Station 10+000, Highway 3 chainage, in the Township of North Cayuga. The bridge was constructed in 1923 and rehabilitated in 1976. Additional rehabilitation was undertaken in 2001 to repair corroded truss members and the exposed concrete deck. Some repair work was also performed in 2004 and 2005.

The report provides subsurface information pertaining to the proposed structure and approach embankments within about 20 m of the abutments.

A preliminary foundation investigation for the rehabilitation or replacement of the Grand River bridge was conducted in September 2005. Information from that feasibility study is documented in GEOCREs No. 30L13-18 (PML Ref.: 04HF058A dated July 9, 2009).



2. SITE DESCRIPTION

The Grand River bridge on Highway 3 is located just west of Cayuga. The proposed structure will carry Highway 3 traffic over the river. The alignment of the bridge extends in the west-east direction. The surrounding lands to the east within the boundaries of Cayuga are developed for light industrial, commercial and residential purposes. Residential and agricultural development exists to the west of the bridge.

The Grand River is about 180 m wide and flows to the south at the site. Although subject to seasonal variations and weather dependent precipitation, the water level is normally near elevation 176.0, corresponding to a water depth of 2 to 3 m. The top of the bridge deck is at approximate elevation 182.8, some 7 m above the river level.

The valley walls of the Grand River at the bridge site are up to 5 m high and relatively steep, near vertical at some locations. Vegetation along the banks of the river mainly consists of grass and small shrubs, with occasional areas of thick vegetation and trees. No evidence of rock outcrops or rock remnants was noted during site visits.

Selected photographs of the existing bridge are provided in Appendix A.

3. GEOLOGY

Cayuga is located within the Haldimand Clay Plain physiographic region. The area is typically characterised by relatively flat lying stratified clay deposits; however, the unit is relatively thin and locally does not cover elevated portions of the older till deposits and/or bedrock surface. The bedrock comprises a succession of Paleozoic formations that dip slightly to the south under Lake Erie. The bedrock was identified at elevation 171.1 to 174.8 at the bridge site. It is noted that the Onondaga Escarpment is visible about 2 km west of the site, with a number of stream courses located along the west and south sides of the Grand River valley south of the site. It is understood that the course and very low gradient of the river at this location are somewhat controlled by the presence of the escarpment.



Based on Ontario Division of Mines (ODM) Map 988, Paleozoic Geology of the Dunville Area, bedrock at the site comprises dolostone of the Bertie Formation (to the south and west) and interbedded dolostone, shale and evaporites of the Salina Formation (to the north and east), both deposited during Silurian geologic time. The map shows the interpolated geological boundary between the two formations passing through the river at the bridge site. Taking account of the conditions at the boreholes, it appears that the actual contact occurs slightly east and north of the bridge.

The Bertie Formation is described as a dark brown, bituminous dolostone; grey argillaceous dolostone; brown and cream mottled dolostone; light brown finely laminated dolostone. The underlying Salina Formation is described as argillaceous dolostone, shale and evaporites (gypsum).

Based on ODM Map P.981, Quaternary Geology of the Dunville Area, in late Wisconsinan geologic time the area was covered by the Ontario-Erie glacial lobe which deposited a gravelly silt till known as the Wentworth Till. Ice movement was towards the southwest as evidenced by the alignment of a number of drumlins (elongated hills) in the Cayuga area. After the glacier melted, the area was flooded by glacial Lake Warren. Deep water deposits of clay and silt accumulated to form the relatively flat lying clay plains which exist around and between the drumlins.

The Grand River subsequently cut a valley into the overburden. Recent stream deposits, predominantly silt and clay, locally sand and gravel, have accumulated in the bottom of the valley.

4. INVESTIGATION PROCEDURES

The field work for this study was carried out during the period of June 21 to September 17, 2010 and comprised 20 boreholes drilled to depths of 5.8 to 17.5 m at the locations shown on Drawing GR-1, attached.



Further details are summarised in the following table:

LOCATION	BOREHOLE No.	DEPTH (m)		
		AUGER	ROCK CORE *	TOTAL
West Abutment and Approach	R3	6.7	–	6.7
	W1A	8.0	–	8.0
	W2	10.1	6.7	16.8
Pier 1	P1	3.8	9.0	12.8
	P1A	4.3	13.2	17.5
	DP1	4.3	3.0	7.3
Pier 2	P2	4.3	8.8	13.1
	P2A	4.0	13.5	17.5
	DP2	4.3	3.3	7.6
Pier 3	P3	4.9	8.0	12.9
	P3A	4.3	13.1	17.4
	DP3	4.6	3.6	8.2
Pier 4	P4	4.6	9.7	14.3
	P4A	4.6	12.8	17.4
	DP4	4.4	2.9	7.3
East Abutment and Approach	E1	8.7	5.2	13.9
	E2	6.7	6.7	13.4
	DE2	4.1	7.7	11.8
	E1A	6.7	–	6.7
	DE1A	5.8	–	5.8

* NQ diamond rock coring equipment

The locations of the boreholes were programmed and established in the field by Peto MacCallum Ltd. The ground surface elevations at the boreholes were provided by MRC.

The test holes at the bridge piers were advanced employing a D-25 drill rig mounted on a barge and those at the abutments and approaches using continuous flight hollow and solid stem augers, powered by a truck-mounted CME-75 drill rig, supplied and operated by specialist drilling contractors, working under the full-time supervision of a member of our engineering staff. Sixteen boreholes were extended 2.9 to 13.5 m into bedrock using NQ diamond rock coring equipment supplemented by NW wash boring techniques.

Representative soil samples were recovered at frequent depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. In situ vane shear and



penetrometer testing was also performed to further assess the shear strength of the cohesive soils encountered. The results of the field tests and observations are reported on the Record of Borehole sheets.

The programme of field testing included measurement of the hydraulic conductivity of bedrock at the site. Twenty-eight packer tests were carried out at various depths in the boreholes to evaluate the permeability of the surrounding rock mass. The packer test results are given in Table A.

Except for the boreholes advanced over water, the groundwater conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, when appropriate, by measurement of the water level in the open borehole. Upon completion of drilling, the boreholes were backfilled with a bentonite-cement mixture in accordance with the MTO guidelines and Ontario Regulation 903 for borehole abandonment procedures.

Soils were identified in the field in accordance with the MTO Soil Classification procedures. All of the recovered samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determination. In addition, 12 Atterberg limits tests and 24 grain size distribution analyses were carried out on selected soil samples, with the results presented in Figures PC-1 to PC-7 and Figures GS-1 to GS-13 respectively as well as on the corresponding Record of Borehole sheets. Organic content was determined on one sample.

5. SUMMARISED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, boundary elevations, standard penetration test data, in situ vane and penetrometer undrained shear strength values and groundwater observations. The results of laboratory Atterberg limits testing, grain size distribution analyses, moisture content determination are also shown on the Record of Borehole sheets.



The borehole locations, stratigraphic profile and cross-sections prepared from the borehole data are shown on Drawings GR-1 to GR-3, appended **(NOTE: Soil strata drawings will be completed after receiving the GA drawing from MRC)**. The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary.

The subsurface stratigraphy revealed in the boreholes drilled on land generally comprised surficial fill over topsoil or organic clayey deposits underlain by clayey silt and/or sandy/gravelly soils mantling bedrock. Cobbles and boulders were encountered in one borehole. The bedrock surface was contacted / inferred at depths of 4.1 to 10.1 m (elevation 172.7 to 174.8). Groundwater was at depths of 5.1 to 7.6 m (elevation 175.2 to 176.5) upon completion of drilling.

At the bridge pier locations, the depth of water in the Grand River ranged from 0.9 to 2.2 m. The soil stratigraphy under the water comprised sandy/gravelly soils extending to bedrock. Boulders were encountered in 5 boreholes. The bedrock surface was contacted at elevation 171.1 to 172.7. The water level in the river was at elevation 176.0 in November 2004 and during this investigation.

The strata encountered are summarised below.

5.1 Fill

Pavement fill was present surficially in most boreholes advanced on land. Covered with 150 to 300 mm of asphalt and composed of sand and gravel / gravelly sand, the pavement fill was loose to very dense (SPT-'N' values of 5 to 78) and typically 5 to 12% in moisture content. The pavement fill was 0.7 to 2.1 m thick and extended to elevation 179.2 to 182.0.

Present at surface in borehole DE2 and overlain by the pavement fill at depths of 0.7 to 2.1 m (elevation 179.2 to 182.0) in the remaining boreholes was sandy clayey silt fill / silty clay fill / clay fill. Another layer of the sandy clayey silt fill was encountered below sand fill at 4.4 m depth (elevation 178.4) in borehole E1. The cohesive fill layers were firm to very stiff in consistency and had a moisture content of 6 to 32%, typically 16 to 32%. Penetrometer tests on 2 samples of the



clay fill from borehole W2 indicated a shear strength varying between 50 and 150 kPa. The cohesive fill layers were 0.6 to 4.5 m in thickness and penetrated at depths of 1.4 to 7.5 m (elevation 175.3 to 181.4).

Sand fill with boulders or brick pieces was revealed within or below the cohesive fill layers at depths of 1.4 and 3.0 m (elevation 181.4 and 179.3) in boreholes E1 and R3 respectively. This unit was loose in relative density (SPT-'N' values of 4 to 8) and 3 to 9% in moisture content. The sand fill had a thickness of 3.0 m in the former borehole and 1.0 m in the latter and was penetrated at respective depths of 4.4 and 4.0 m (elevation 178.4 and 178.3).

The fill material was penetrated at depths of 0.7 to 7.5 m (elevation 175.3 to 179.2).

The results of Atterberg limits testing and grain size distribution analyses performed on 7 samples of the fill units are presented in respective Figures PC-1 to PC-3 and GS-1 to GS-4. The clay fill had a liquid limit of 54 and 57, plastic limit of 25 and 26, its plasticity index being 29 and 31 respectively. The liquid and plastic limits of the silty clay fill were 41 and 19 respectively, thus giving the plasticity index of 22. The sandy clayey silt fill had a liquid limit of 28 and 34, plastic limit of 16 and 19, with the plasticity index of 12 and 15 respectively.

5.2 Topsoil

Surficial topsoil was present below the fill at depths of 4.0 and 5.6 m (elevation 178.3 and 177.0) in boreholes R3 and W1A respectively. With a moisture content of 24 to 27%, the silty topsoil was 1.2 and 0.7 m thick and penetrated at respective depths of 5.2 and 6.3 m (elevation 177.1 and 176.3).

5.3 Organic Silty Clay / Clayey Silt

Directly beneath the fill at depths of 2.1 to 7.5 m (elevation 175.3 to 178.5) in boreholes W2, E1 and DE1A was organic silty clay / organic clayey silt. This deposit was firm to hard in consistency and had an organic content of 1.7% in one determination. The results of in situ vane testing carried out within the organic clayey silt in borehole W2 yielded an undisturbed shear strength of



29 kPa (soil sensitivity of 2). The deposit was 1.2 to 2.5 m in thickness and penetrated at depths of 4.2 to 8.7 m (elevation 174.1 to 176.4). It is noted that the organic silty clay contained cobbles in borehole E1.

The results of Atterberg limits testing and grain size distribution analyses conducted on 2 samples of the deposit are presented in Figures PC-4, GS-5 and GS-6. The liquid and plastic limits of the organic silty clay were 39 and 21 respectively, thus giving the plasticity index of 18. The moisture content of the deposit varied between 11 and 50%.

5.4 Clayey Silt / Sandy Clayey Silt

Underlying the fill, topsoil or organic silty clay at depths of 0.7 to 6.3 m (elevation 176.3 to 178.2) in boreholes R3, W1A, DE1A and DE2 was a cohesive deposit of clayey silt / sandy clayey silt. Firm to very stiff in consistency, this deposit was 0.7 to 1.9 m thick and penetrated at depths of 2.6 to 7.5 m (elevation 175.0 to 176.4).

The results of Atterberg limits testing and grain size distribution analyses performed on 5 cohesive samples are presented in respective Figures PC-5, PC-6 and GS-7, GS-8. The liquid and plastic limits of the clayey silt ranged from 23 to 34 and from 15 to 23 respectively, with the plasticity index of 8 to 11. The sandy clayey silt had a liquid limit of 25, plastic limit of 16, its plasticity index being 9. The moisture content of the deposit varied between 9 and 30%, locally reaching 56% due to the presence of organics.

5.5 Sandy/Gravelly Soils

Except for borehole E1, sandy/gravelly soils (sand till, gravel till, sand and gravel, dolostone fragments) were revealed below the fill or (organic) clayey deposits at depths of 2.2 to 8.4 m (elevation 174.4 to 179.2) in all the boreholes drilled on land. These strata were loose to dense (SPT-'N' values of 8 to 47) and had a moisture content of 7 to 15%. The sandy/gravelly soils were 0.5 to 4.5 m in thickness and penetrated at depths of 4.1 to 10.1 m (elevation 172.7 to 174.8) in boreholes W1A, W2, E2 and DE2. The remaining boreholes were terminated in the strata at depths of 5.8 to 6.7 m (elevation 174.8 to 175.8).



The results of Atterberg limits testing and grain size distribution analyses conducted on 3 samples of the till units are presented in Figures PC-7, GS-9 and GS-10. The sand till had a liquid limit of 18 and 19, plastic limit of 13, thus giving the plasticity index of 5 and 6.

In the Grand River, except for organic silt followed by silt in borehole P4, cohesionless soils of sandy/gravelly gradation were revealed under the water at depths of 0.9 to 2.2 m (elevation 173.8 to 175.1) in boreholes P1 to P3, P1A to P4A, DP1 to DP4. Very loose to very dense, typically compact to dense (SPT-'N' values of 2 to 113, with higher N-values reflecting the cobble/boulder content), these strata were 2.1 to 3.5 m thick and extended to bedrock contacted at depths of 3.8 to 4.9 m (elevation 171.1 to 172.2). In addition, the dense to very dense sand and gravel was identified at elevation 172.8 to 173.9 in boreholes 1 to 4 drilled through the bridge piers. The sand and gravel under the piers had a thickness of 0.2 to 2.2 m and was penetrated on encountering bedrock at elevation 171.2 to 172.7. It is worth noting that boulders were contained within the strata in boreholes P2 to P4, P1A and P3A.

The results of grain size distribution analyses performed on 7 samples of the sand and gravel / gravelly sand / sand are presented in Figures GS-11 to GS-13.

5.6 Bedrock

Bedrock was contacted or inferred by refusal at depths of 8.0 and 10.1 m (elevation 174.6 and 172.7) in boreholes W1A and W2 put down on the west side of the Grand River and 4.1 to 8.7 m (elevation 173.7 to 174.8) in boreholes E1, E2 and DE2 on the east side. The bedrock surface was at elevation 171.1 to 172.7 at the bridge pier locations, including boreholes 1 to 4 drilled through the piers. The bedrock generally comprises a buff dolostone of the Bertie Formation underlain 4.6 to 6.6 m deeper (elevation 164.8 to 168.3) by a dark grey to buff dolostone of the Salina Formation.

The hydraulic conductivity of bedrock at the site was evaluated in a number of packer tests carried out at various depths in boreholes P1 to P4, P1A to P4A. The permeability of the rock mass surrounding the boreholes was $(9-19) \cdot 10^{-4}$ cm/s in the Bertie Formation and $(6-970) \cdot 10^{-6}$ cm/s in the Salina Formation. It is noteworthy that the permeability was relatively low despite all the



fracturing, poor core recovery and voiding reported within the Bertie Formation; this confirms various observations that the fractures / voids appear to be infilled with sand. Within the underlying Salina Formation, the permeability was more variable, with no take in three instances, which is consistent with the appearance of the rock; the numerous seams were generally tight or infilled with evaporites that tend to somewhat reduce the overall hydraulic conductivity. Refer to Table A for the packer test results.

The measured core recovery varied between 0 and 100% (typically over 85% in the Salina Formation). The Rock Quality Designation (RQD) determined from the rock cores was in a range of 0 to 52%, thus indicating a very poor to poor, locally fair quality rock in the Bertie Formation. The rock quality in the Salina Formation was very poor to excellent (RQD values of 0 to 93%).

A detailed description of the rock cores retrieved from boreholes P1 to P4, P1A to P4A, DP1 to DP4, E1, E2, DE2 and W2 is given in Table B, appended. Photographs of the rock cores are provided in Appendix B.

5.6.1 West Abutment

The bedrock surface was contacted at 10.1 m depth (elevation 172.7) in borehole W2.

The bedrock comprises a buff moderately to highly (locally completely) weathered medium strength dolostone of the Bertie Formation.

The measured core recovery varied between 0 and 67%. The RQD determined from the rock cores was in a range of 0 to 22%, thus indicating a very poor quality rock.



5.6.2 Pier 1

The bedrock surface was contacted at depths of 3.8 to 10.1 m (elevation 171.7 to 172.7) in boreholes 1 (advanced from the bridge deck during the preliminary investigation), P1, P1A and DP1. The depth to and surface elevation of the bedrock identified in the boreholes drilled at Pier 1 are summarised in the following table:

Location	Borehole No.	Depth to Rock (m)	Bedrock Elevation
Pier 1	1	10.1*	172.7*
	P1	3.8*	172.2*
	P1A	4.3*	171.7*
	DP1	4.3*	171.7*

* confirmed by rock coring

The bedrock surface has a maximum relief of 1.0 m and dips to the south at an angle of up to 5°. The bedrock typically comprises a buff slightly to highly weathered low to high strength dolostone of the Bertie Formation underlain at elevation 165.6 to 166.0 by a dark grey to buff slightly weathered medium strength dolostone of the Salina Formation.

The measured core recovery varied between 20 and 100%. The RQD values ranged from 0 to 21% (a very poor quality rock) in the Bertie Formation and from 0 to 83% (a very poor to good quality rock) in the Salina Formation.



5.6.3 Pier 2

The bedrock surface was contacted at depths of 4.0 to 10.7 m (elevation 171.7 to 172.1) in boreholes 2 (advanced from the bridge deck during the preliminary investigation), P2, P2A and DP2. The depth to and surface elevation of the bedrock identified in the boreholes drilled at Pier 2 are summarised in the following table:

Location	Borehole No.	Depth to Rock (m)	Bedrock Elevation
Pier 2	2	10.7*	172.1*
	P2	4.3*	171.7*
	P2A	4.0*	172.0*
	DP2	4.3*	171.7*

* confirmed by rock coring

The bedrock surface has a maximum relief of 0.4 m and dips to the south at an angle of about 2°. The bedrock typically comprises a buff slightly to highly weathered low to high strength dolostone of the Bertie Formation underlain at elevation 166.7 to 167.1 by a dark grey to buff slightly weathered medium strength dolostone of the Salina Formation.

The measured core recovery varied between 46 and 100%. The RQD values ranged from 0 to 52% (a very poor to fair quality rock) in the Bertie Formation and from 0 to 93% (a very poor to excellent quality rock) in the Salina Formation.



5.6.4 Pier 3

The bedrock surface was contacted at depths of 4.3 to 11.1 m (elevation 171.1 to 171.7) in boreholes 3 (advanced from the bridge deck during the preliminary investigation), P3, P3A and DP3. The depth to and surface elevation of the bedrock identified in the boreholes drilled at Pier 3 are summarised in the following table:

Location	Borehole No.	Depth to Rock (m)	Bedrock Elevation
Pier 3	3	11.1*	171.7*
	P3	4.9*	171.1*
	P3A	4.3*	171.7*
	DP3	4.6*	171.4*

* confirmed by rock coring

The bedrock surface has a maximum relief of 0.6 m, convexing between the locations of boreholes 3 and P3A. The bedrock typically comprises a buff slightly to moderately weathered low to high strength dolostone of the Bertie Formation underlain at elevation 166.0 to 166.1 by a dark grey to buff slightly weathered medium strength dolostone of the Salina Formation.

The measured core recovery varied between 33 and 100%. The RQD values ranged from 0 to 33% (a very poor to poor quality rock) in the Bertie Formation and from 0 to 91% (a very poor to excellent quality rock) in the Salina Formation.



5.6.5 Pier 4

The bedrock surface was contacted at depths of 4.4 to 11.6 m (elevation 171.2 to 171.6) in boreholes 4 (advanced from the bridge deck during the preliminary investigation), P4, P4A and DP4. The depth to and surface elevation of the bedrock identified in the boreholes drilled at Pier 4 are summarised in the following table:

Location	Borehole No.	Depth to Rock (m)	Bedrock Elevation
Pier 4	4	11.6*	171.2*
	P4	4.6*	171.4*
	P4A	4.6*	171.4*
	DP4	4.4*	171.6*

* confirmed by rock coring

The bedrock surface has a maximum relief of 0.4 m and is generally flat lying, slightly concaving near the location of borehole 4. The bedrock typically comprises a buff slightly to moderately weathered low to high strength dolostone of the Bertie Formation underlain at elevation 164.8 to 165.2 by a dark grey slightly weathered medium to high strength dolostone of the Salina Formation.

The measured core recovery varied between 37 and 100%. The RQD values ranged from 0 to 47% (a very poor to poor quality rock) in the Bertie Formation and from 21 to 82% (a very poor to good quality rock) in the Salina Formation.

5.6.6 East Abutment

The bedrock surface was contacted at depths of 8.7 and 6.7 m (elevation 174.1 and 173.7) in boreholes E1 and E2 respectively.

The bedrock comprises a buff slightly to highly (locally completely) weathered medium to high strength dolostone of the Bertie Formation underlain at elevation 168.3 in borehole E2 by a dark grey slightly weathered dolostone of the Salina Formation.



The measured core recovery varied between 5 and 100%. The RQD determined from the rock cores was in a range of 0 to 23%, thus indicating a very poor quality rock in the Bertie Formation. The rock quality in the Salina Formation was fair (RQD of 51%) based on one rock core sample.

5.6.7 Approaches

The bedrock surface was contacted at 4.1 m depth (elevation 174.8) in borehole DE2 and inferred by refusal at a depth of 8.0 m (elevation 174.6) in borehole W1A.

The bedrock comprises a buff slightly to moderately (locally completely) weathered medium to high strength dolostone of the Bertie Formation.

The measured core recovery varied between 18 and 95%. The RQD determined from the rock cores was in a range of 0 to 29%, thus indicating a very poor to poor quality rock.

5.7 Groundwater

In the course of the field work, groundwater was observed in 6 out of the 8 boreholes drilled on land. In the process of augering, water was detected at depths of 1.5 to 7.5 m (elevation 175.1 to 181.3) in boreholes W1A, W2 and E2. Upon completion of drilling, groundwater was measured in boreholes R3, W1A, W2, E1A and DE1A to be at depths of 5.1 to 7.6 m (elevation 175.2 to 176.5). Observation of groundwater conditions was not possible in the boreholes advanced over water at the pier locations. The groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

The water level in the Grand River was at elevation 176.0 in November 2004 and during the field work for this study (June to September 2010).



6. CLOSURE

The field work was carried out under the supervision of Messrs. M. Rapsey and F. Portela, Senior Technicians, and direction of Mr. M. Narduzzi, BEng, and Mr. C.M.P. Nascimento, P.Eng., Senior Project Engineer. The equipment was supplied by Walker Drilling Ltd. and Geo-Environmental Drilling Inc. The laboratory testing of soil samples was carried out in the Toronto laboratory of Peto MacCallum Ltd.

This report was prepared by Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer, and reviewed by Mr. B.R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C.M.P. Nascimento, P.Eng., Senior Project Engineer, conducted an independent review of the report.

Sincerely

Peto MacCallum Ltd.

PREDRAFT

Grigory O. Degil, PhD, P.Eng.
Senior Foundation Engineer

NOTE: The Final Report will be signed and stamped by two Professional Engineers licensed by PEO, one of which is the Designated Principal Contact for MTO foundation projects

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GD/CN/BRG:gd-mi



TABLE A
Packer Test Results

Rock Formation	Borehole No.	Depth (m)	Elevation (m)	Recovery (%)	RQD (%)	Permeability (cm/s)
Bertie	P3	4.7 – 6.4	169.6 – 171.3	80 – 100	0 – 7	$9.0 \cdot 10^{-4}$
	P4	5.0 – 6.1	169.9 – 171.0	84	21	$1.3 \cdot 10^{-3}$
	P3A	5.0 – 6.2	169.8 – 171.0	95	17	$1.4 \cdot 10^{-3}$
	P2A	5.5 – 6.9	169.1 – 170.5	78	45	$1.1 \cdot 10^{-3}$
	P1A	5.8 – 6.9	169.1 – 170.2	20 – 92	0 – 12	$1.4 \cdot 10^{-3}$
	P4	6.3 – 7.5	168.5 – 169.7	97	47	$1.2 \cdot 10^{-3}$
	P4A	6.5 – 7.8	168.2 – 169.5	80 – 83	0 – 12	$1.0 \cdot 10^{-3}$
	P2A	7.0 – 7.9	168.1 – 169.0	95	0	$1.9 \cdot 10^{-3}$
	P1	7.0 – 8.2	167.8 – 169.0	80	8	$1.1 \cdot 10^{-3}$
	P3A	8.3 – 8.9	167.1 – 167.7	94	23	$1.7 \cdot 10^{-3}$
	P4A	8.4 – 9.5	166.5 – 167.6	68	23	$1.0 \cdot 10^{-3}$
Bertie / Salina	P1A	9.8 – 11.4	164.6 – 166.2	45 – 93	7 – 62	$7.6 \cdot 10^{-4}$
Salina	P3A	10.0 – 11.4	164.6 – 166.0	88	36	$9.7 \cdot 10^{-4}$
	P2A	10.1 – 11.4	164.6 – 165.9	90	55	$9.1 \cdot 10^{-4}$
	P2	10.9 – 11.9	164.1 – 165.1	93 – 100	78 – 93	$< 9.1 \cdot 10^{-6}$
	P1	11.6 – 12.8	163.2 – 164.4	100	75	$1.8 \cdot 10^{-4}$
	P4A	11.6 – 12.8	163.2 – 164.4	100	74	$< 8.2 \cdot 10^{-6}$
	P2	11.7 – 13.1	162.9 – 164.3	100	93	$< 7.2 \cdot 10^{-6}$
	P3	11.8 – 12.9	163.1 – 164.2	100	0 – 82	$< 1.4 \cdot 10^{-5}$
	P4	12.2 – 13.4	162.6 – 163.8	98	45 – 82	$7.4 \cdot 10^{-6}$
	P1A	12.8 – 14.5	161.5 – 163.2	93 – 100	57 – 83	No Take
	P3A	13.1 – 14.4	161.6 – 162.9	97	57	No Take
	P4	13.2 – 14.3	161.7 – 162.8	98	82	$1.1 \cdot 10^{-5}$
	P4A	13.2 – 14.6	161.4 – 162.8	96 – 97	53 – 60	$< 6.3 \cdot 10^{-6}$
	P3A	14.7 – 15.9	160.1 – 161.3	100	47	No Take
	P3A	16.1 – 17.4	158.6 – 159.9	100	45	$4.5 \cdot 10^{-5}$
	P4A	16.2 – 17.4	158.6 – 159.8	100	43	$1.2 \cdot 10^{-4}$
	P1A	16.2 – 17.5	158.5 – 159.8	97	58	$8.9 \cdot 10^{-6}$



TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
P1	4	3.8 – 4.7	69	0	3.8 – 10.0	DOLOSTONE: Buff coloured, aphanitic, locally laminated, pitted, medium to high strength, with shale seams and occasional friable layers below 6.7 m depth, low to medium strength, slightly to highly (locally completely) weathered, with occasional voids (600 mm at 6.1 m depth, 300 mm at 9.3 m depth)*, very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, locally infilled with sand, very poor quality. (Bertie Formation)
	5	4.7 – 5.2	100	0		
	6	5.2 – 6.7	50	21		
	7	6.7 – 8.2	80	8		
	8	8.2 – 9.8	65	16		
	9	9.8 – 11.3	20	0	10.0 – 12.8	DOLOSTONE/SHALE/EVAPORITES: Dark grey argillaceous dolostone with numerous inclusions and occasional layers of white gypsum, low strength, interbedded with layers of buff coloured dolostone, fine grained to aphanitic, with numerous seams infilled with gypsum and/or selenite, medium strength, very close to close spaced, flat bedding layers, smooth to rough planar, tight to slightly altered, very poor becoming good quality. (Salina Formation) *: Void depth/thickness based on drilling observations
	10	11.3 – 12.8	100	75		

Originated: JFW
Compiled: FP
Checked: GD/ CN



TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
P1A	5	4.3 – 5.5	69	21	4.3 – 10.4	DOLOSTONE: Buff coloured, aphanitic, pitted, locally laminated, medium to high strength, with occasional layers (280 to 840 mm thick) of grey to dark grey shale to shaley dolostone, medium strength, slightly to moderately (locally highly) weathered, very close to close spaced flat lying bedding layers, rough planar, tight to slightly altered with oxidation stains and/or silt on partings, very poor quality. (Bertie Formation)
	6	5.5 – 6.5	92	12		
	7	6.5 – 6.9	20	0		
	8	6.9 – 8.4	100	19		
	9	8.4 – 9.9	45	7		
	10	9.9 – 11.4	93	62	10.4 – 17.5	DOLOSTONE/SHALE/EVAPORITES: Dark grey argillaceous dolostone with numerous inclusions and occasional layers (up to 250 mm thick) of white gypsum, low strength, with occasional layers (up to 640 mm thick) of brown, fine grained dolostone, with occasional gypsum inclusions, selenite on partings, medium strength. Below 15.2 m depth, grey to buff coloured dolostone, fine grained to aphanitic, locally pitted, medium strength, with occasional layers (up to 250 mm thick) of dark grey shale or shaley dolostone, low strength, with occasional seams (up to 1 mm thick) infilled with white and/or clear gypsum and/or selenite throughout, slightly weathered, very close to close (locally moderate) spaced flat bedding layers, rough (locally smooth) planar, tight to slightly altered, fair to good quality. (Salina Formation)
	11	11.4 – 13.0	100	83		
	12	13.0 – 14.5	93	57		
	13	14.5 – 16.0	93	62		
	14	16.0 – 17.5	97	58		
DP1	4	4.3 – 5.8	93	18	4.3 – 7.3	DOLOSTONE: Buff coloured, fine grained to aphanitic, laminated, pitted, with occasional dark shale seams, medium strength, slightly to moderately weathered, very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, very poor quality. (Bertie Formation)
	5	5.8 – 7.3	72	18		

Originated: JFW
Compiled: FP
Checked: GD/ CN



TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
P2	6	4.3 – 5.3	100	0	4.3 – 8.9	DOLOSTONE: Buff coloured, aphanitic, laminated, pitted, medium to high strength, with occasional dark shale and/or friable layers, low strength, slightly to highly (locally completely) weathered, with occasional voids (300 mm at 8.6 m depth)*, very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, locally infilled with sand, very poor to fair quality. (Bertie Formation)
	7	5.3 – 5.6	50	0		
	8	5.6 – 6.2	100	0		
	9	6.2 – 6.9	57	0		
	10	6.9 – 7.2	50	0		
	11	7.2 – 8.3	93	52	8.9 – 13.1	DOLOSTONE/ SHALE/EVAPORITES: Dark grey argillaceous dolostone with numerous (25 to 50%) inclusions (typically 1 to 10 mm, locally up to 75 mm diameter) and occasional layers (up to 300 mm thick) of white gypsum, low strength, interbedded with layers (up to 500 mm thick) of buff coloured dolostone, fine grained to aphanitic, with numerous seams (1 mm thick) infilled with gypsum and/or selenite, medium strength, slightly weathered, close to moderate (locally very close) becoming close to wide spaced, flat bedding layers, smooth to rough planar, tight to slightly altered, very poor becoming good to excellent quality. (Salina Formation)
	12	8.3 – 9.8	46	8		
	13	9.8 – 11.6	93	78		
	14	11.6 – 13.1	100	93		
						*: Void depth/thickness based on drilling observations

Originated: JFW
Compiled: FP
Checked: GD/ CN



TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
P2A	3	4.0 – 5.3	75	42	4.0 – 9.3	DOLOSTONE: Buff coloured, aphanitic, pitted, locally laminated, with occasional black shaley seams, medium to high strength, with 300 mm thick shale layer at 7.9 m depth, dark grey to black, fissile, low strength, slightly to moderately weathered, very close to close spaced flat bedding layers, rough planar, tight to slightly altered, poor to very poor quality. (Bertie Formation)
	4	5.3 – 6.9	78	45		
	5	6.9 – 7.9	95	0		
	6	7.9 – 8.4	100	0		
	7	8.4 – 9.9	57	0		
	8	9.9 – 11.4	90	55	9.3 – 17.5	DOLOSTONE/SHALE/EVAPORITES: Dark grey argillaceous dolostone or shale with numerous inclusions and occasional layers (up to 300 mm thick) of white gypsum, low strength, with occasional layers (up to 330 mm thick) of light grey, fine grained dolostone, with occasional gypsum inclusions, selenite on partings, medium strength. Below 14.5 m depth, predominantly dolostone, light brown to buff or grey, fine grained to aphanitic, locally with distorted laminations, medium strength, with occasional seams (up to 1 mm thick) infilled with white and/or clear gypsum and/or selenite throughout, slightly weathered, very close to close (locally moderate) spaced flat bedding layers, rough (locally smooth) planar, tight to slightly altered, fair (locally poor) quality. (Salina Formation)
	9	11.4 – 13.0	97	63		
	10	13.0 – 14.5	100	62		
	11	14.5 – 16.0	100	73		
	12	16.0 – 17.5	100	29		
DP2	3	4.3 – 5.5	79	0	4.3 – 7.6	DOLOSTONE: Buff coloured, aphanitic, laminated, pitted, with occasional dark shale and/or bituminous seams/layers, low to medium strength, slightly to moderately weathered, very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, very poor to poor quality. (Bertie Formation)
	4	5.5 – 6.7	100	40		
	5	6.7 – 7.6	81	24		

Originated: JFW
Compiled: FP
Checked: GD/ CN



TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
P3	5	4.9 – 5.7	100	0	4.9 – 10.0	DOLOSTONE: Buff coloured, aphanitic, locally laminated, pitted, medium to high strength, slightly weathered, with occasional brown to dark brown layers (75 to 180 mm thick), low strength, highly weathered, very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, locally infilled with sand, very poor quality. (Bertie Formation)
	6	5.7 – 7.2	80	7		
	7	7.2 – 8.8	88	25		
	8	8.8 – 9.1	87	0		
	9	9.1 – 9.9	43	0	10.0 – 12.9	DOLOSTONE/SHALE/EVAPORITES: Dark grey argillaceous dolostone with numerous (25 to 50%) inclusions (1 to 10 mm diameter) and occasional layers (up to 150 mm thick) of white gypsum, low strength, interbedded with layers (380 mm and 630 mm thick) of grey to dark grey shale with numerous seams (1mm thick) infilled with gypsum and/or selenite, medium strength, also with layer (250 mm thick) of buff coloured dolostone, aphanitic, pitted with numerous seams (1 mm thick) infilled with gypsum and/or selenite, high strength; slightly weathered, very close to close spaced, flat bedding layers, smooth to rough planar, tight to slightly altered, fair to good (locally very poor) quality. (Salina Formation)
	10	9.9 – 11.4	98	55		
	11	11.4 – 11.8	97	53		
	12	11.8 – 12.4	100	0		
	13	12.4 – 12.9	100	82		

Originated: JFW
Compiled: FP
Checked: GD/ CN



TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
P3A	5	4.3 – 4.6	50	0	4.3 – 9.9	DOLOSTONE: Buff coloured, aphanitic, pitted, locally laminated, medium to high strength, with 600 mm thick shale layer at 8.3 m depth, dark grey to black, fissile, low strength, slightly to moderately weathered, very close to close spaced flat lying bedding layers, rough planar, tight to slightly altered, very poor quality. (Bertie Formation)
	6	4.6 – 6.2	95	17		
	7	6.2 – 6.9	77	0		
	8	6.9 – 7.7	43	14		
	9	7.7 – 8.3	100	0	9.9 – 17.4	DOLOSTONE/SHALE/EVAPORITES: Dark grey argillaceous dolostone or shale with numerous inclusions and occasional layers of white gypsum, low strength, with occasional layers (up to 480 mm thick) of light grey or buff dolostone to shaley dolostone, fine grained dolostone, with occasional gypsum inclusions, selenite on partings, medium strength. Below 15.2 m depth, predominantly dolostone, buff coloured, fine grained to aphanitic, locally pitted, medium strength, with occasional seams (up to 1 mm thick) infilled with white and/or clear gypsum and/or selenite throughout, slightly weathered, very close to close spaced flat bedding layers, rough (locally smooth) planar, tight to slightly altered, poor to fair (locally excellent) quality. (Salina Formation)
	10	8.3 – 8.9	94	23		
	11	8.9 – 9.9	33	11		
	12	9.9 – 11.4	88	36		
	13	11.4 – 12.9	100	91		
	14	12.9 – 14.4	97	57		
	15	14.4 – 16.9	100	47		
	16	16.9 – 17.4	100	45		
DP3	4	4.6 – 4.9	100	0	4.6 – 8.2	DOLOSTONE: Buff coloured, fine grained to aphanitic, laminated, pitted, medium strength, interbedded with dark grey shaley layers, low strength, slightly to moderately (locally completely) weathered, with occasional voids (300 mm thick at 7.1 m depth), very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, locally infilled with sand, very poor to poor quality. (Bertie Formation)
	5	4.9 – 6.1	83	0		
	6	6.1 – 7.3	74	33		
	7	7.3 – 8.2	74	0		

Originated: JFW
Compiled: FP
Checked: GD/ CN



TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
P4	6	4.6 – 6.3	84	21	4.6 – 10.8	DOLOSTONE: Buff coloured, aphanitic, pitted, locally laminated, medium to high strength, interbedded with grey to dark grey shale to shaley dolostone, locally banded, medium strength, slightly (locally highly) weathered, with occasional voids (750 mm at 10.1 m depth), very close to close spaced flat lying bedding layers, rough planar, tight to slightly altered, very poor to poor quality. (Bertie Formation)
	7	6.3 – 7.6	97	47		
	8	7.6 – 9.3	58	0		
	9	9.3 – 9.8	50	0		
	10	9.8 – 11.3	43	21		
	11	11.3 – 12.8	98	45	10.8 – 14.3	DOLOSTONE/SHALE/EVAPORITES: Dark grey argillaceous dolostone with numerous inclusions and occasional layers of white gypsum, low strength, interbedded with layers of buff coloured dolostone, fine grained to aphanitic, medium to high strength, slightly (locally highly) weathered, very close to close spaced flat bedding layers, rough planar, tight to slightly altered with occasional friable layer, very poor to poor becoming good quality. (Salina Formation) * Void depth/thickness based on drilling observations
	12	12.8 – 14.3	98	82		

Originated: JFW
Compiled: FP
Checked: GD/ CN



TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
P4A	4	4.6 – 5.8	75	9	4.6 – 11.2	DOLOSTONE: Buff coloured, aphanitic, pitted, locally laminated, with occasional grey, fine grained layers, medium to high strength, interbedded with grey to dark grey shale to shaley dolostone, locally banded, medium strength, slightly (locally highly) weathered, with occasional voids, very close to close spaced flat lying bedding layers, rough planar, tight to slightly altered, very poor quality. (Bertie Formation)
	5	5.8 – 6.7	83	0	11.2 – 17.4	
	6	6.7 – 8.2	80	12		
	7	8.2 – 9.8	68	23		
	8	9.8 – 11.3	52	7		
	9	11.3 – 12.8	100	74	DOLOSTONE/SHALE/EVAPORITES: Dark grey argillaceous dolostone (70%) with numerous inclusions and occasional layers of white gypsum (30%), low strength, interbedded with layers of grey or buff coloured dolostone (up to 600 mm thick), fine grained to aphanitic, locally pitted, with occasional seams (up to 3 mm thick) infilled with white and/or clear gypsum and/or selenite, medium to high strength, slightly weathered, very close to close spaced flat bedding layers, rough (locally smooth) planar, tight to slightly altered, poor to fair quality. (Salina Formation)	
	10	12.8 – 14.3	96	53		
	11	14.3 – 15.8	97	60		
	12	15.8 – 17.4	100	43		
DP4	4	4.4 – 5.8	81	0	4.4 – 7.3	DOLOSTONE: Buff coloured, fine grained to aphanitic, laminated, pitted, medium strength, becoming grey with occasional brown layers, slightly to moderately (locally completely) weathered, with occasional voids (300 mm thick at 7.0 m depth), very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, locally infilled with sand, very poor quality. (Bertie Formation)
	5	5.8 – 7.3	70	8		

Originated: JFW
Compiled: FP
Checked: GD/ CN



TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
E1	10	8.7 – 9.1	78	0	8.7 – 13.9	DOLOSTONE: Buff coloured, aphanitic, laminated, pitted, medium to high strength, interbedded with dark grey shale to shaley and/or petroliferous dolostone (75 to 650 mm thick layers) very low to low strength, slightly to moderately (locally highly) weathered, with occasional voids (300 mm thick at 11.3 m depth), very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, locally infilled with clayey silt or sand, very poor quality. (Bertie Formation) Note: After RC 14, 1.5 m of sand sized cuttings in core barrel.
	11	9.1 – 10.7	5	0		
	12	10.7 – 11.3	33	15		
	13	11.3 – 12.4	73	10		
	14	12.4 – 13.9	87	23		
E2	9	6.7 – 7.6	100	0	6.7 – 12.1	DOLOSTONE: Buff coloured, aphanitic, laminated, pitted, medium to high strength, interbedded with dark grey shale to shaley and/or petroliferous dolostone (100 mm thick layers), low to medium strength, slightly to highly (locally completely) weathered, very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, locally sandy filling, very poor quality. (Bertie Formation)
	10	7.6 – 9.1	13	0		
	11	9.1 – 10.6	76	0		
	12	10.6 – 12.1	88	7		
	13	12.1 – 13.4	85	51		
					12.1 – 13.4	DOLOSTONE/SHALE/EVAPORITES: Dark grey shale to shaley dolostone, with occasional seams/layers of white gypsum and/or selenite, low strength, slightly weathered, very close to close spaced, flat bedding layers, rough to smooth planar, tight to slightly altered with minor scale and/or selenite on partings, fair quality. (Salina Formation)

Originated: JFW
Compiled: FP
Checked: GD/ CN

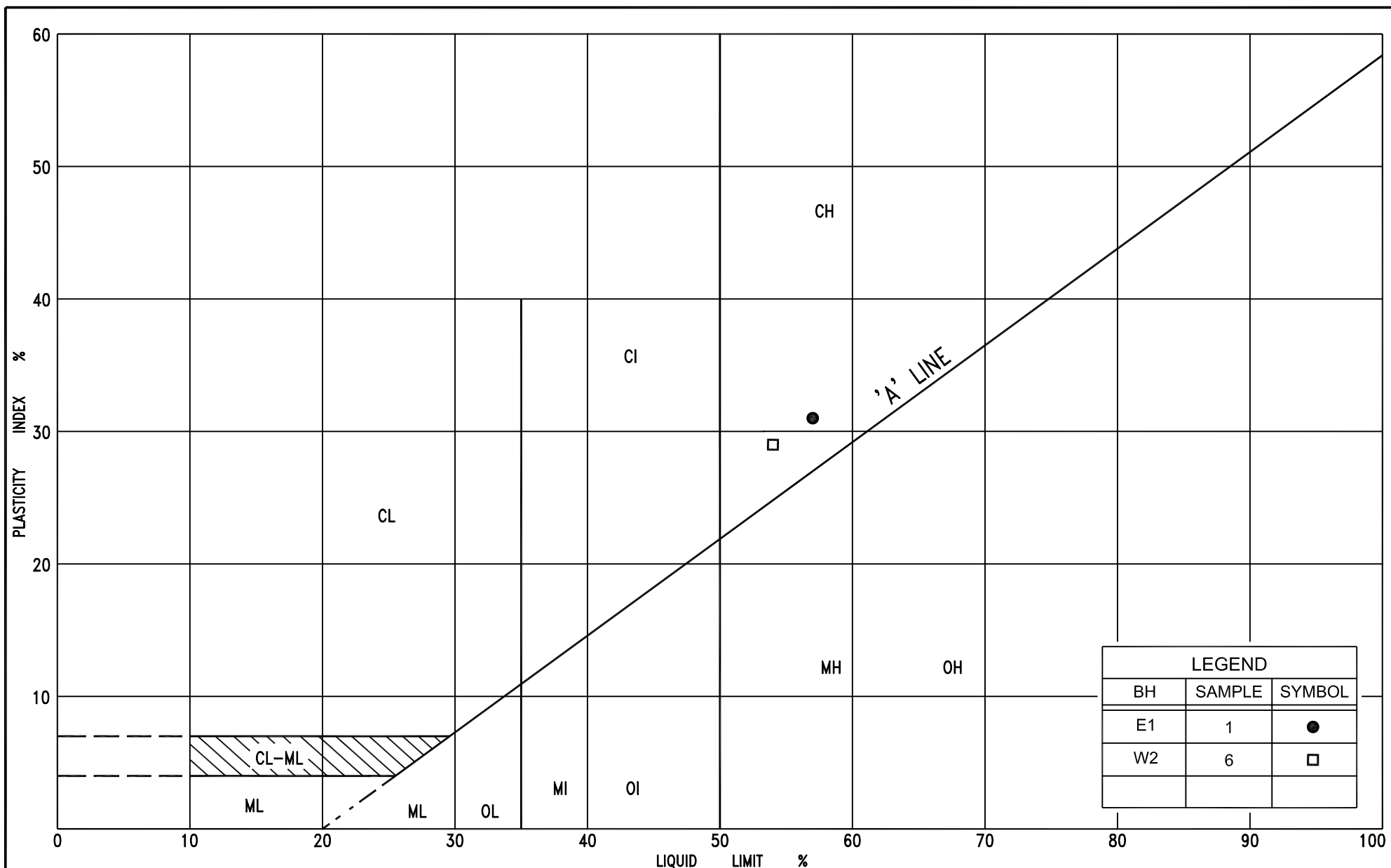


TABLE B
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
DE2	6	4.1 – 4.8	50	0	4.1 – 11.8	DOLOSTONE: Buff coloured, aphanitic, pitted, occasional laminations, medium to high strength, interbedded with dark grey shale to shaley dolostone (50 to 300 mm thick layers), very low to low strength, slightly to moderately (locally completely) weathered, with occasional voids (100 mm thick at 10.0 m, 10.3 m and 10.8 m depth)*, very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, locally infilled with sand, isolated seam at 11.8 m depth infilled with gypsum, very poor to poor quality. (Bertie Formation) * Void depth/thickness based on drilling observations.
	7	4.8 – 5.7	50	0		
	8	5.7 – 7.3	18	0		
	9	7.3 – 8.8	92	0		
	10	8.8 – 10.3	47	7		
	11	10.3 – 11.8	95	29		
W2	12	10.1 – 10.5	0	0	10.1 – 16.8	DOLOSTONE: Buff coloured, aphanitic, pitted, occasional laminations, medium strength, interbedded with grey to dark grey shale or shaley dolostone, low to medium strength, moderately to highly (locally completely) weathered, very close to close spaced, flat bedding layers, rough planar, tight to slightly altered, very poor quality. (Bertie Formation) NOTE: Much of the core was highly fractured or shattered.
	13	10.5 – 12.0	31	0		
	14	12.0 – 13.5	52	0		
	15	13.5 – 15.3	62	22		
	16	15.3 – 16.8	67	17		

NOTE: RQD = Rock Quality Designation

Originated: JFW
Compiled: FP
Checked: GD/ CN

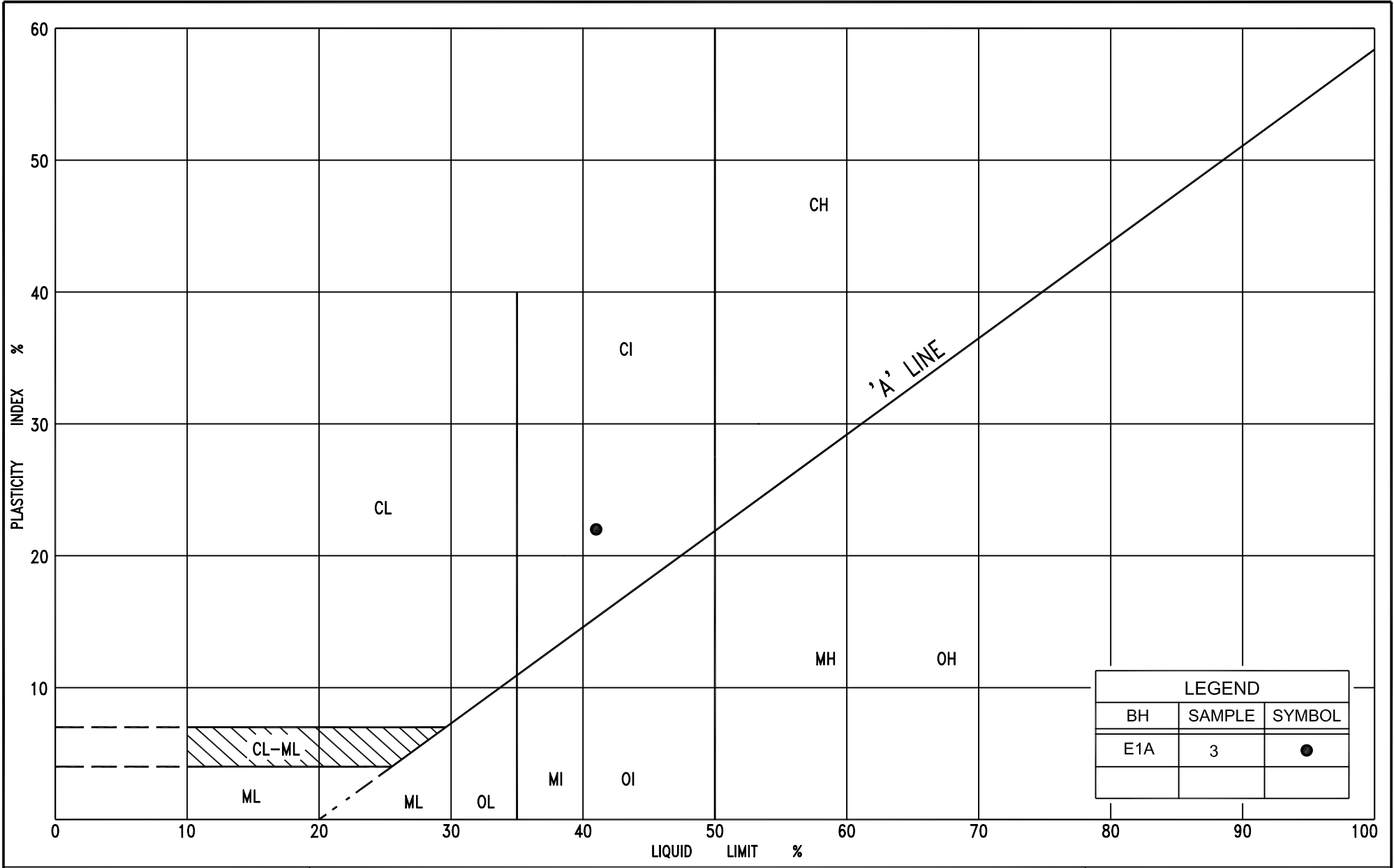


PLASTICITY CHART
 CLAY, with silt, trace to some sand, trace gravel
 (FILL)

FIG No. PC-1

HWY: 3

G.W.P. No. 3501-01-00



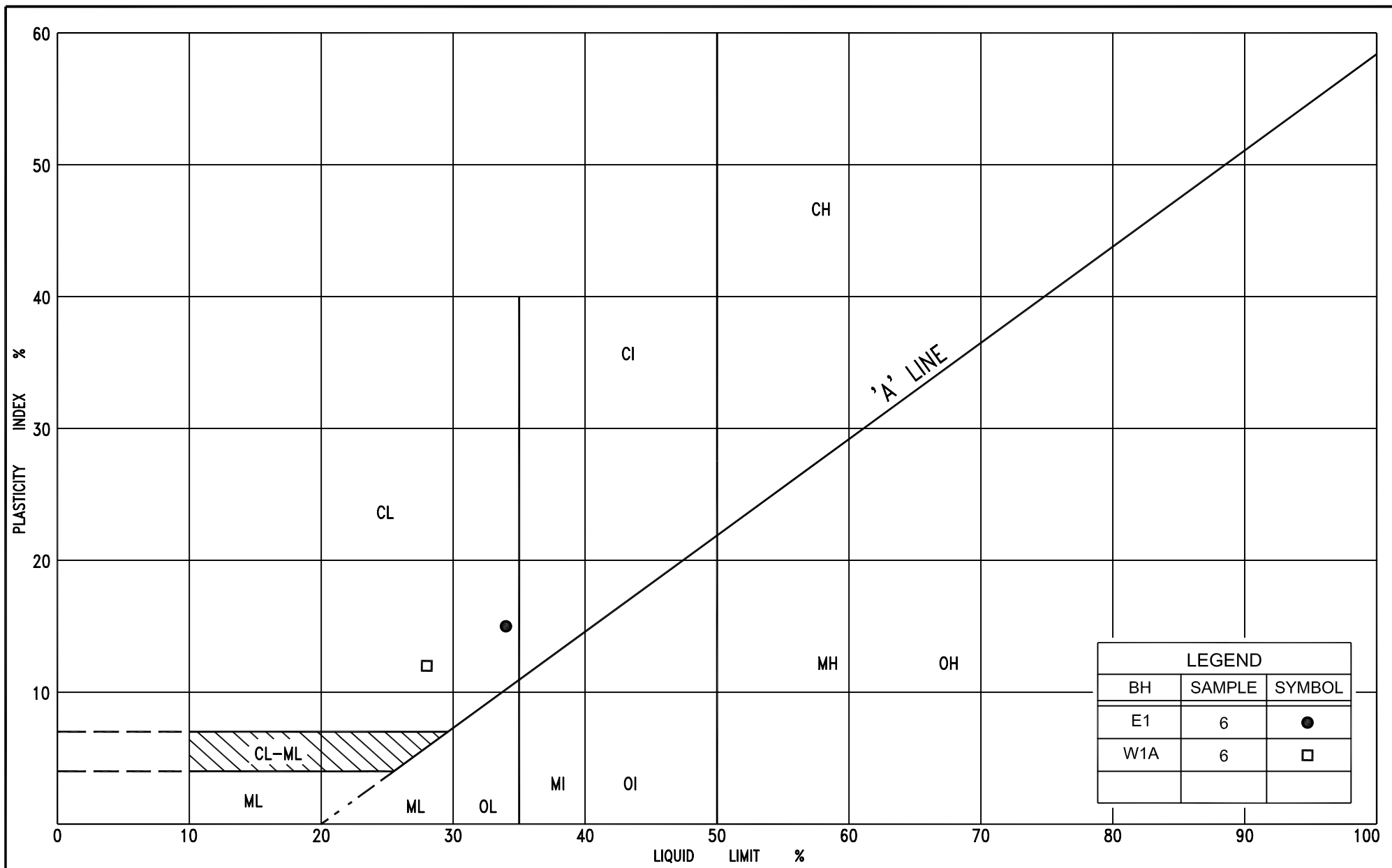
PLASTICITY CHART

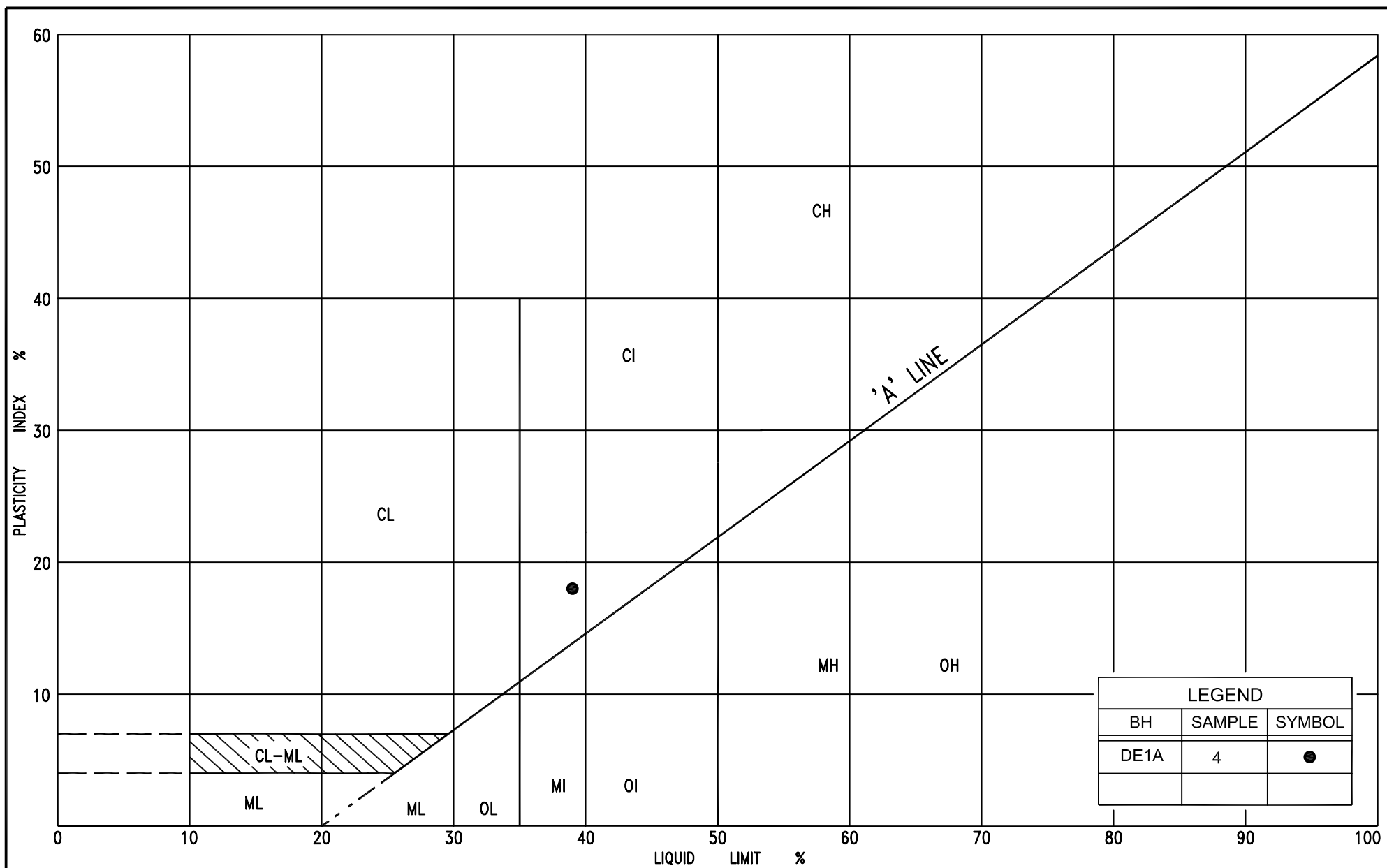
SILTY CLAY, trace sand
(FILL)

FIG No. PC-2

HWY: 3

G.W.P. No. 3501-01-00



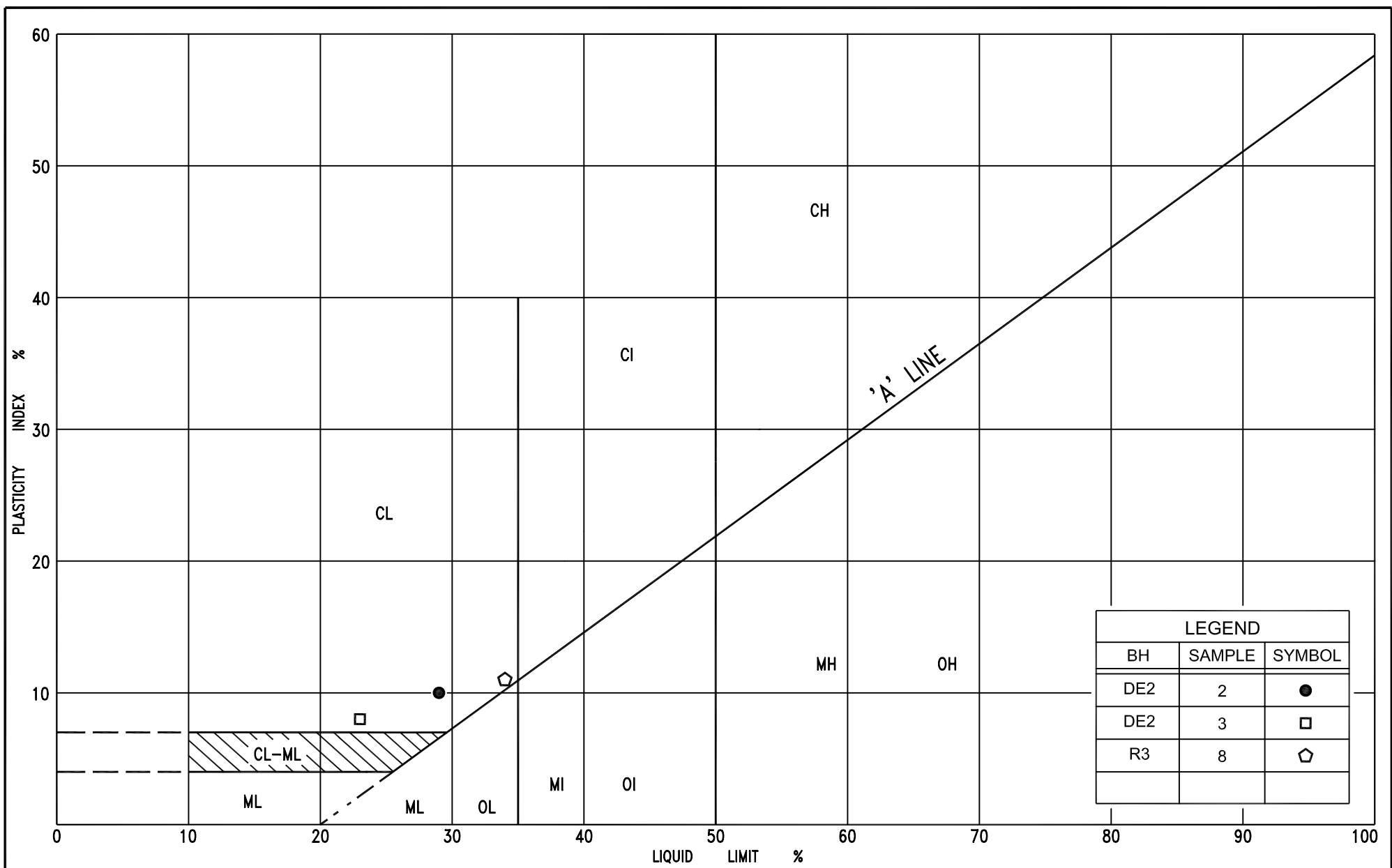


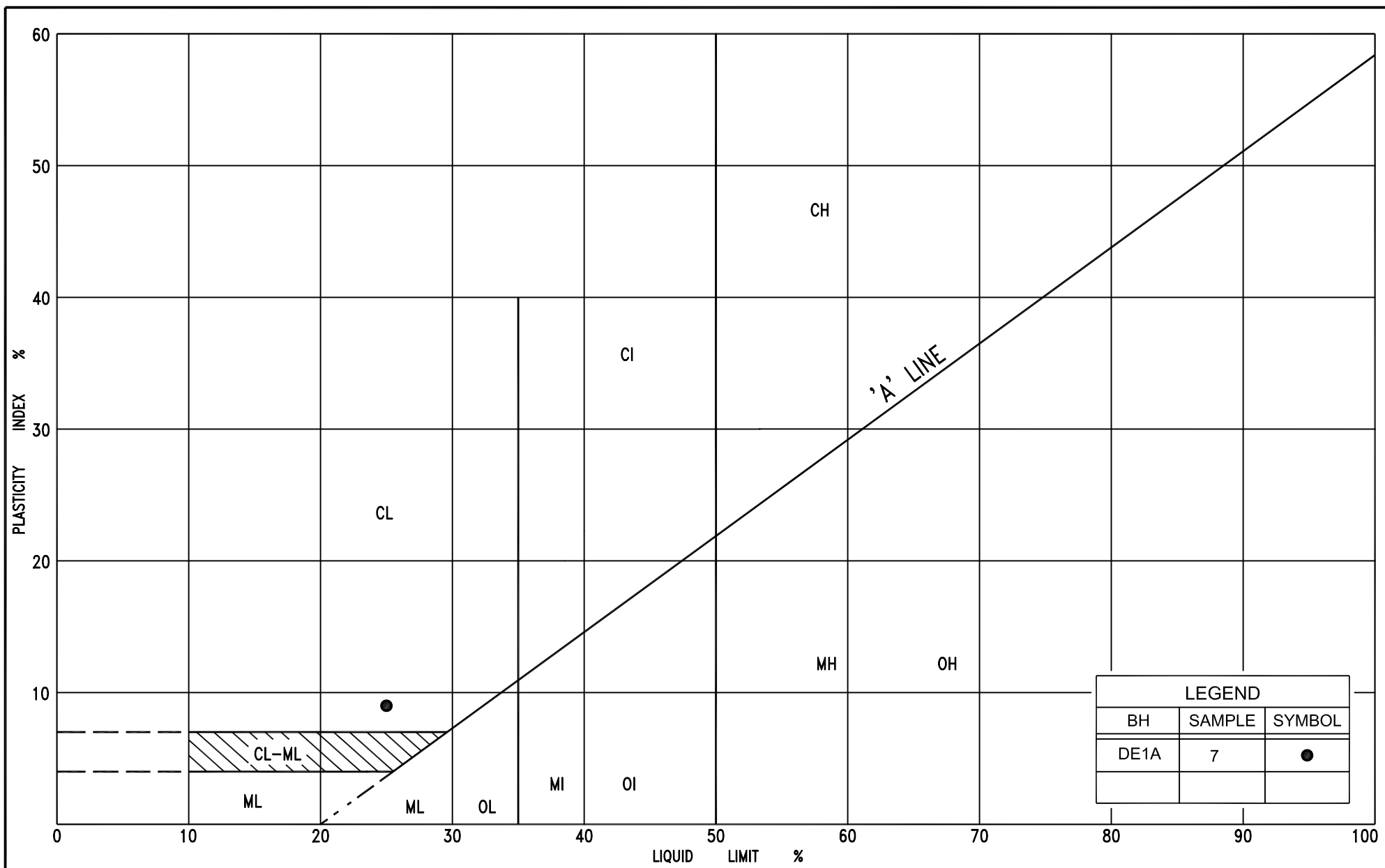
PLASTICITY CHART
ORGANIC SILTY CLAY, some sand, trace gravel

FIG No. PC-4

HWY: 3

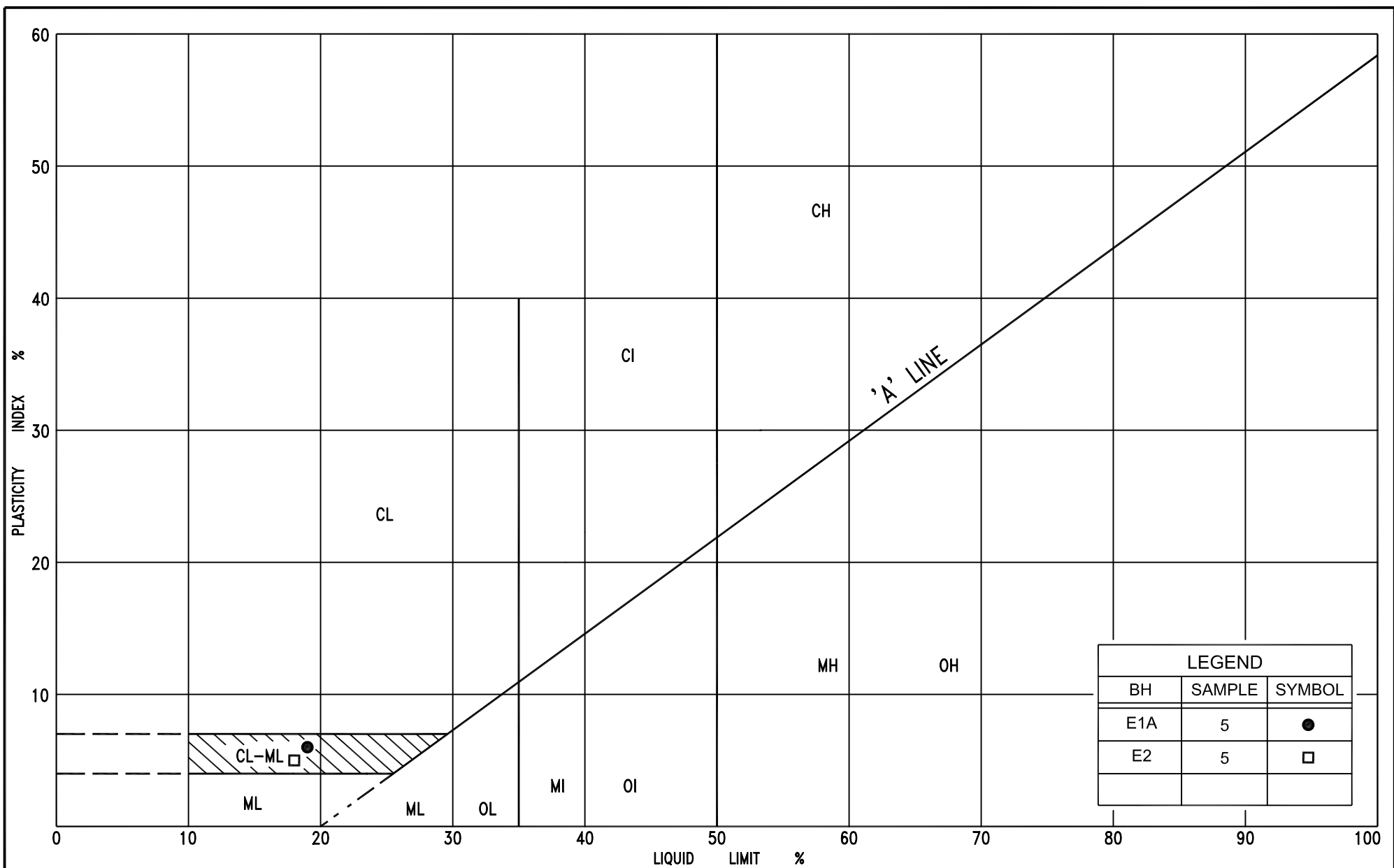
G.W.P. No. 3501-01-00





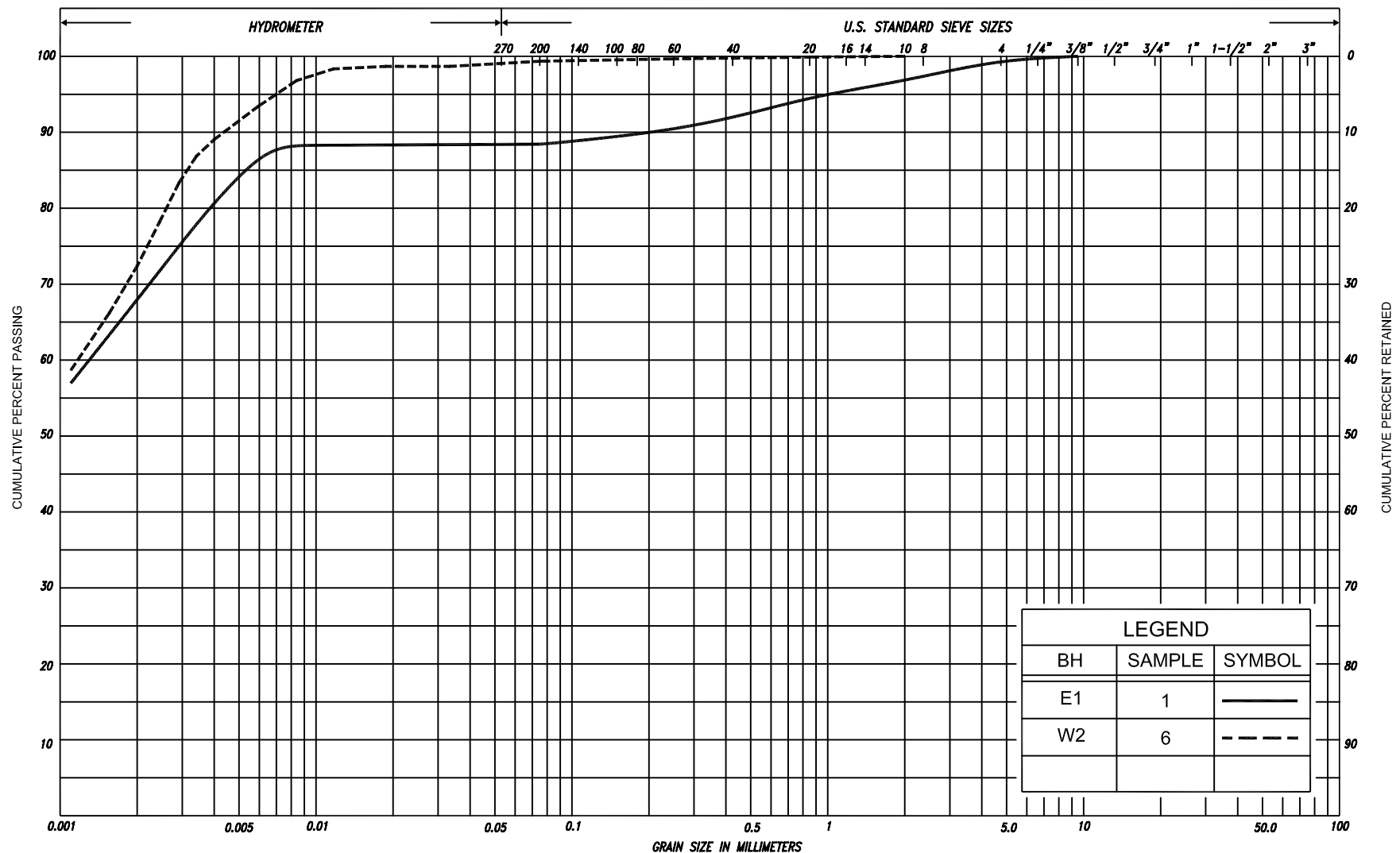
PLASTICITY CHART
SANDY CLAYEY SILT, trace to some gravel

FIG No. PC-6
HWY: 3
G.W.P. No. 3501-01-00



PLASTICITY CHART
 SAND, with silt, some to with gravel, trace clay
 clayey silt layers
 (TILL)

FIG No. PC-7
 HWY: 3
 G.W.P. No. 3501-01-00



SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED	
CLAY	FINE		MEDIUM	COARSE	FINE		MEDIUM		COARSE	GRAVEL			COBBLES	M.I.T.
	SILT				SAND									
CLAY		SILT			V. FINE	FINE	MED.	COARSE	GRAVEL					U.S. BUREAU
				SAND										

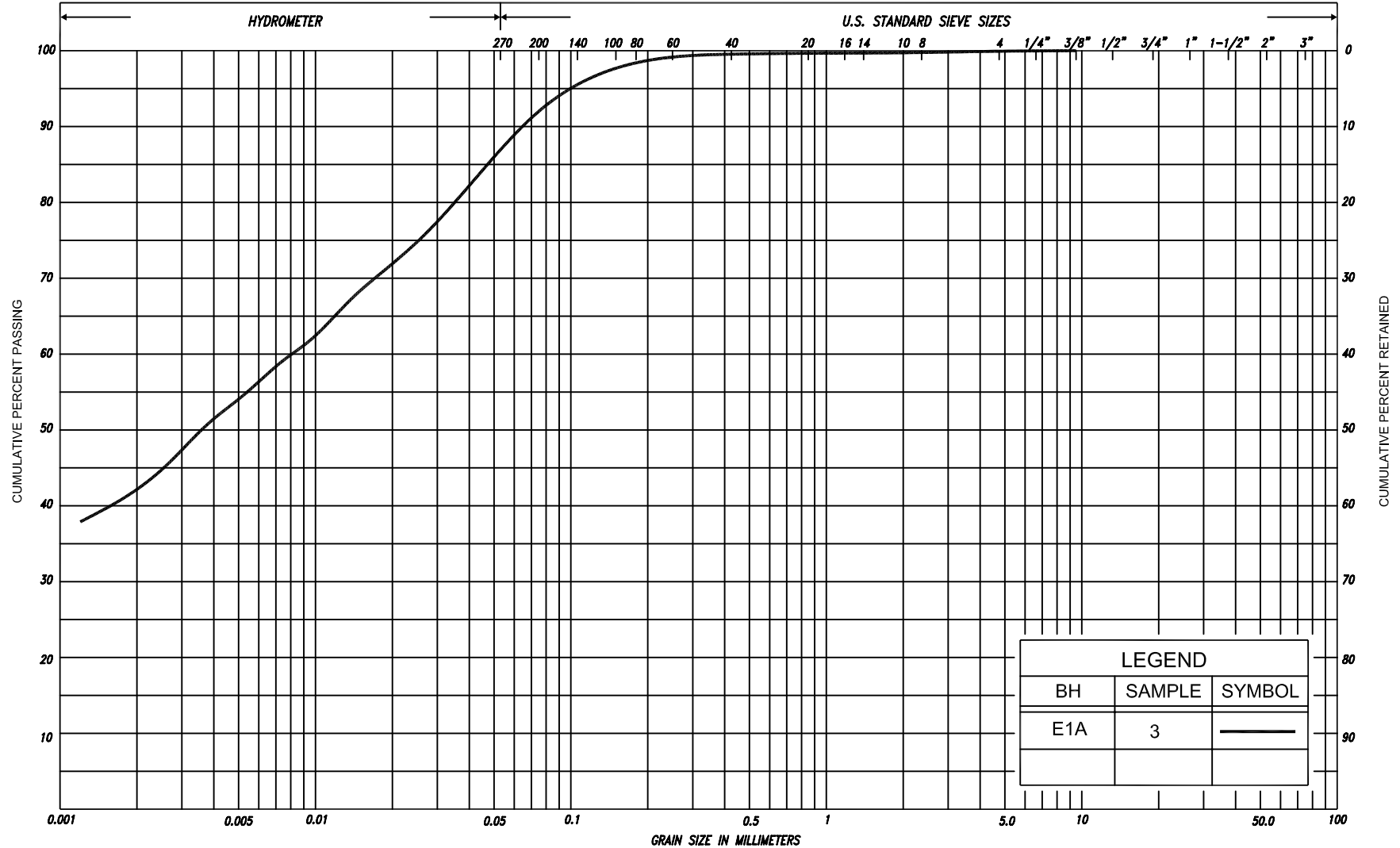


GRAIN SIZE DISTRIBUTION CLAY, with silt, trace to some sand, trace gravel (FILL)

FIG No. GS-1

HWY: 3

G.W.P. No. 3501-01-00

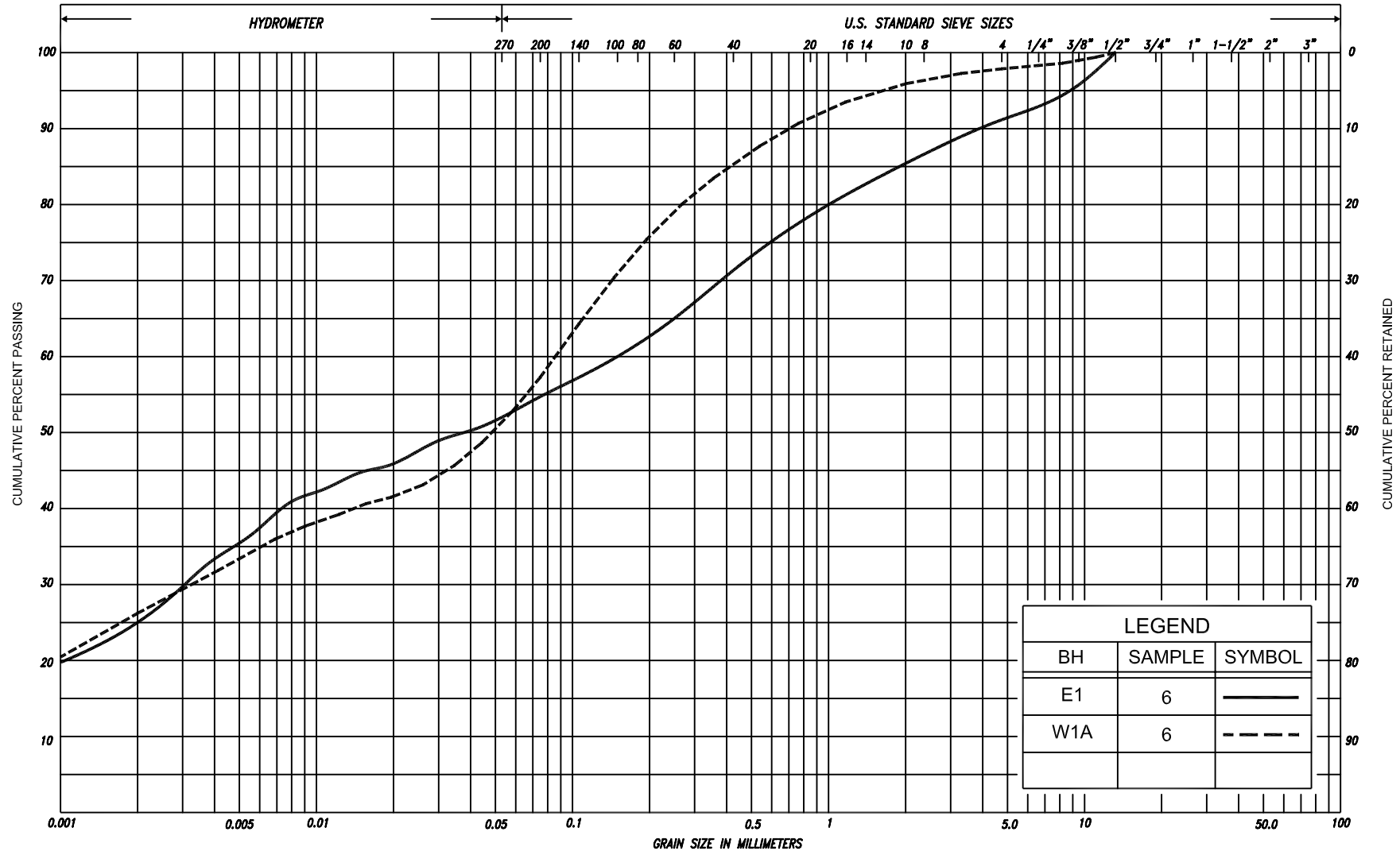


SILT & CLAY				GRAIN SIZE IN MILLIMETERS			GRAVEL		COBBLES	UNIFIED
				FINE	MEDIUM	COARSE				
				SAND						
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL		COBBLES	M.I.T.
				SILT						
				V. FINE	FINE	MED.	COARSE	GRAVEL		U.S. BUREAU
				SAND						



GRAIN SIZE DISTRIBUTION SILTY CLAY, trace sand (FILL)

FIG No.	GS-2
HWY:	3
G.W.P. No.	3501-01-00

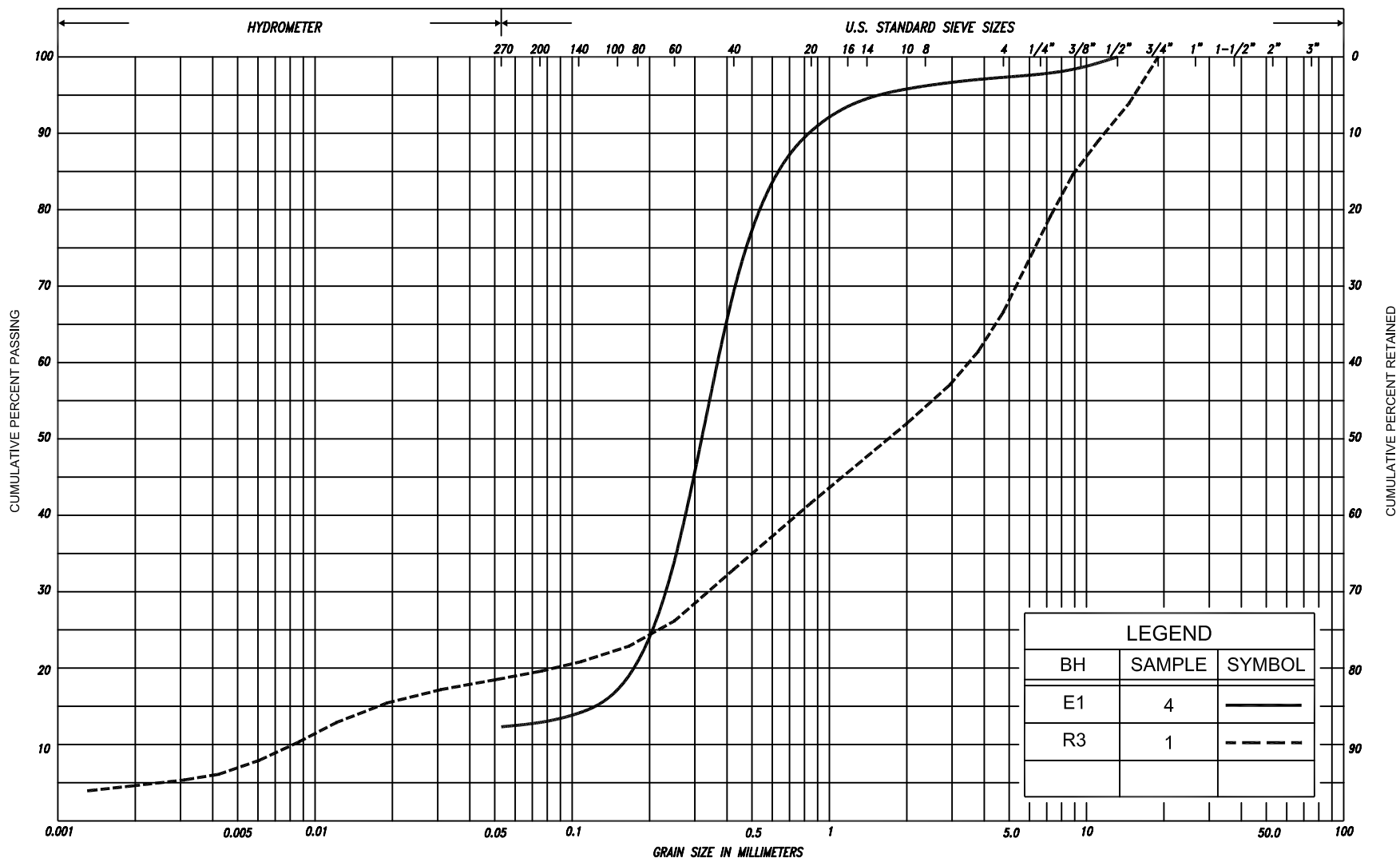


SILT & CLAY				FINE		MEDIUM		COARSE		GRAVEL				COBBLES	UNIFIED		
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT				SAND				GRAVEL				COBBLES	U.S. BUREAU			
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL						U.S. BUREAU	



GRAIN SIZE DISTRIBUTION SANDY CLAYEY SILT, trace gravel (FILL)

FIG No. GS-3
HWY: 3
G.W.P. No. 3501-01-00

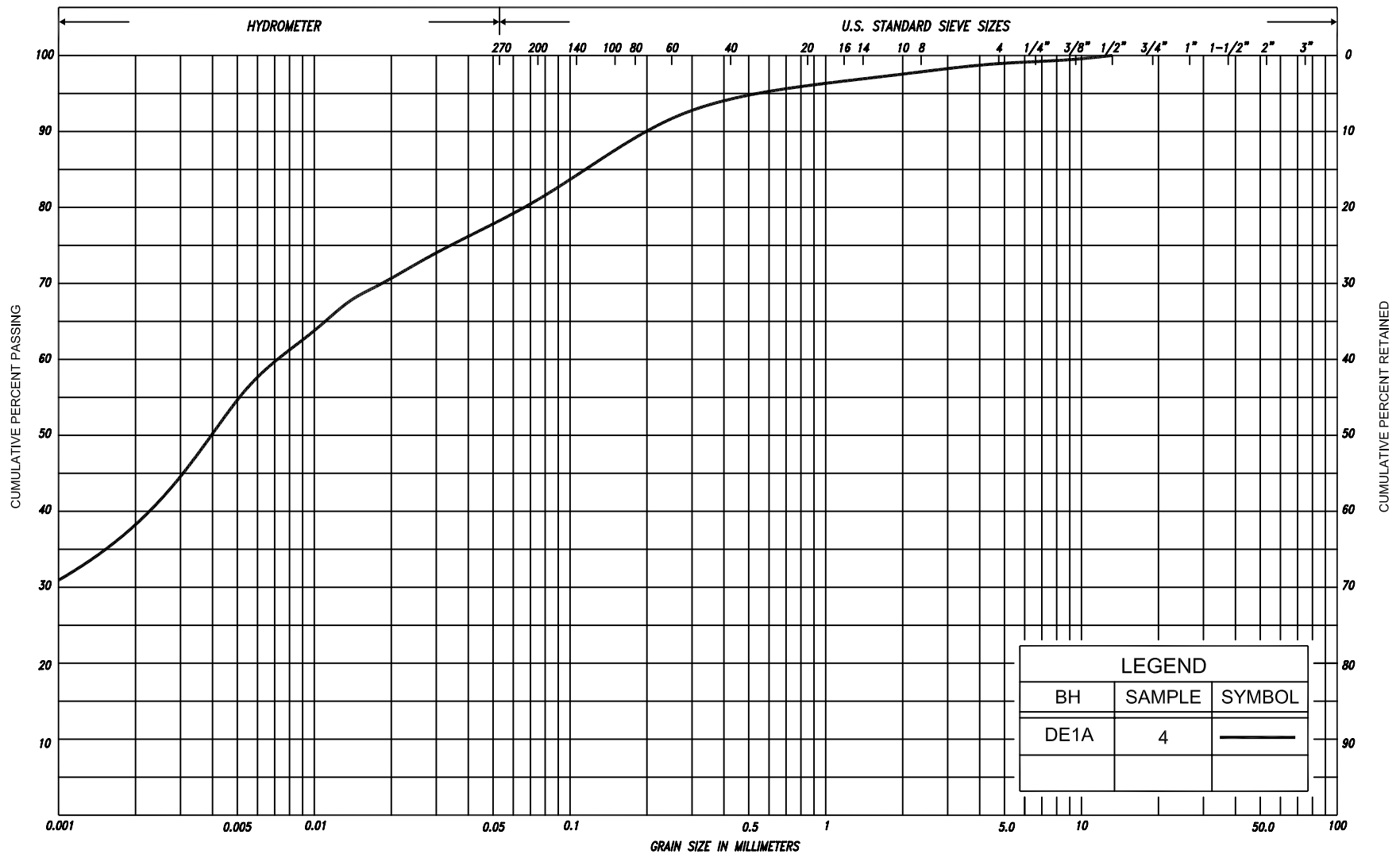


SILT & CLAY				FINE		MEDIUM		COARSE		GRAVEL			COBBLES	UNIFIED		
				SAND												
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL		COBBLES	M.I.T.
	SILT						SAND									
CLAY		SILT			V. FINE		FINE		MED.		COARSE		GRAVEL			U.S. BUREAU
					SAND											



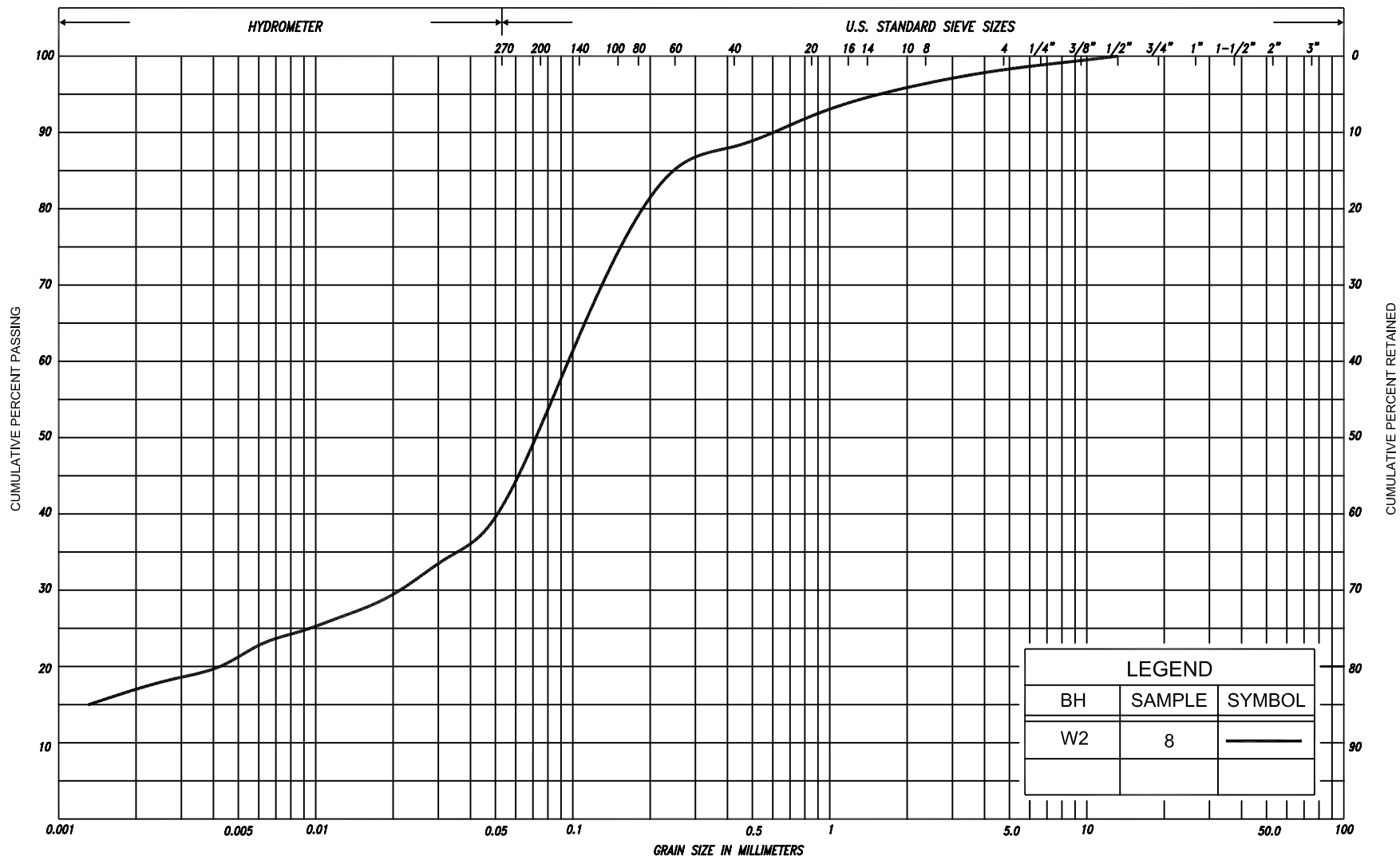
GRAIN SIZE DISTRIBUTION
 SAND, some silt, trace gravel
 GRAVELLY SAND, some silt, trace clay
 (FILL)

FIG No. GS-4
 HWY: 3
 G.W.P. No. 3501-01-00



LEGEND		
BH	SAMPLE	SYMBOL
DE1A	4	—

SILT & CLAY				FINE		MEDIUM		COARSE		GRAVEL				COBBLES	UNIFIED	
				SAND												
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL		COBBLES	M.I.T.
	SILT															
CLAY			SILT			V. FINE	FINE	MED.	COARSE		GRAVEL				U.S. BUREAU	
						SAND										



SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COBBLES	UNIFIED	
CLAY	FINE		MEDIUM		COARSE	FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT							SAND								U.S. BUREAU
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL						
					SAND											

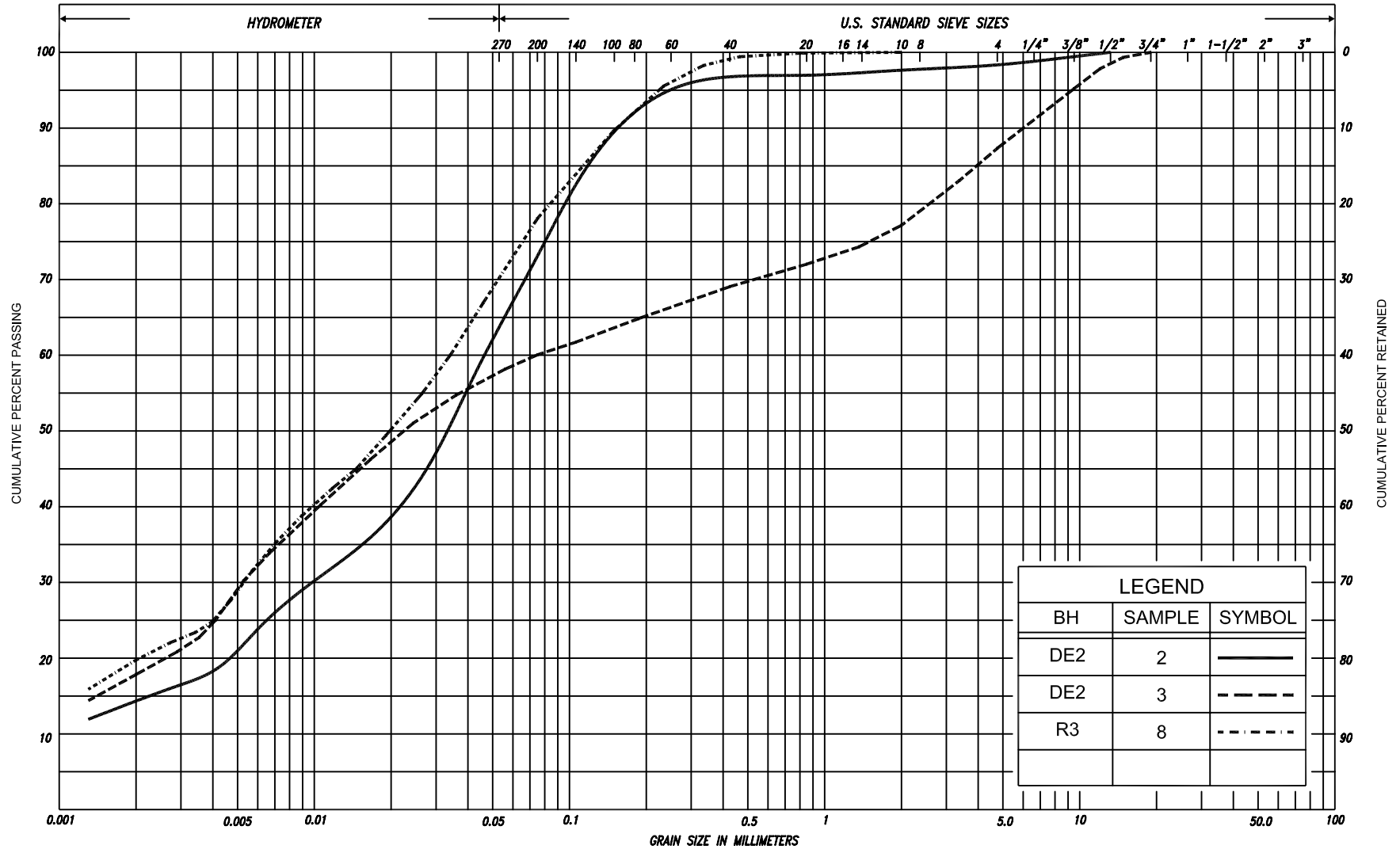


GRAIN SIZE DISTRIBUTION ORGANIC CLAYEY SILT, trace sand, trace gravel sand layers

FIG No. GS-6

HWY: 3

G.W.P. No. 3501-01-00



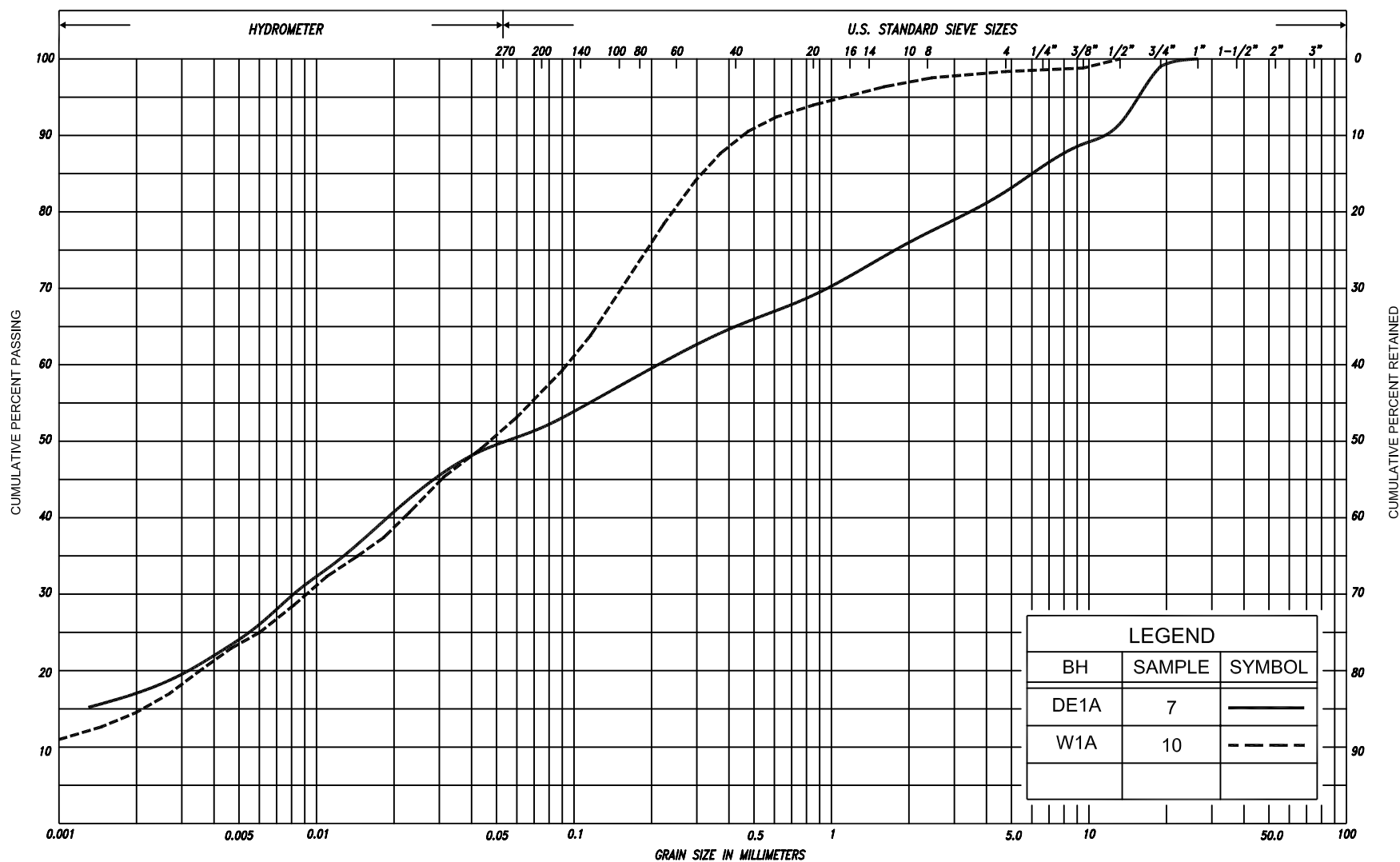
SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL		COR BLES	UNIFIED
CLAY	FINE		MEDIUM		COARSE		SAND		GRAVEL		COBBLES	M.I.T.
	SILT				FINE		MEDIUM		COARSE			
CLAY		SILT			V. FINE	FINE	MED.	COARSE	GRAVEL			U.S. BUREAU



GRAIN SIZE DISTRIBUTION

CLAYEY SILT, with sand, trace to some gravel

FIG No. GS-7
 HWY: 3
 G.W.P. No. 3501-01-00



SILT & CLAY				FINE SAND			MEDIUM SAND		COARSE SAND	GRAVEL		COBBLES	UNIFIED
CLAY	SILT			SAND			SAND		COARSE SAND	GRAVEL		COBBLES	M.I.T.
	SILT			SAND			SAND		COARSE SAND	GRAVEL		COBBLES	U.S. BUREAU



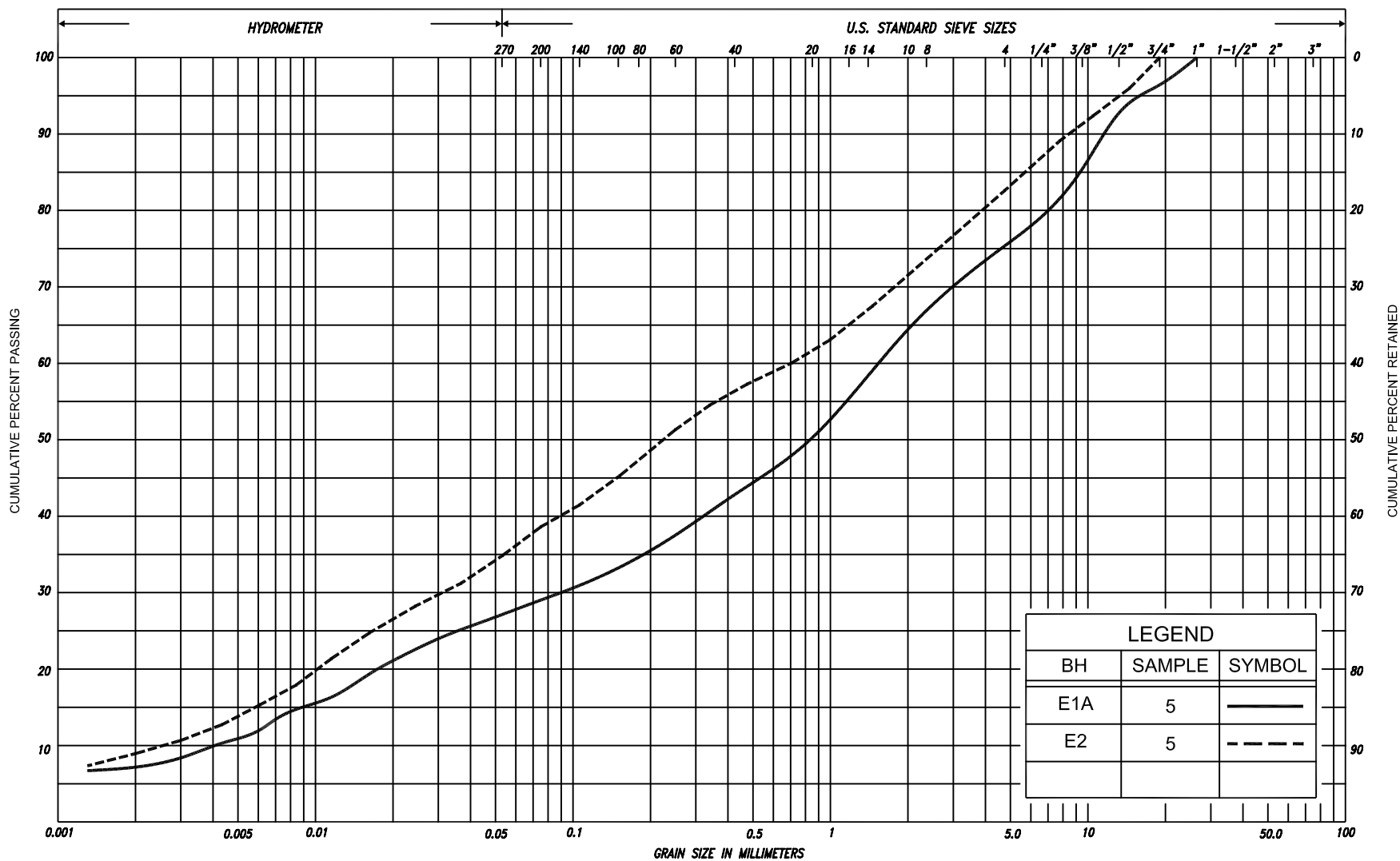
GRAIN SIZE DISTRIBUTION

SANDY CLAYEY SILT, trace to some gravel

FIG No. GS-8

HWY: 3

G.W.P. No. 3501-01-00

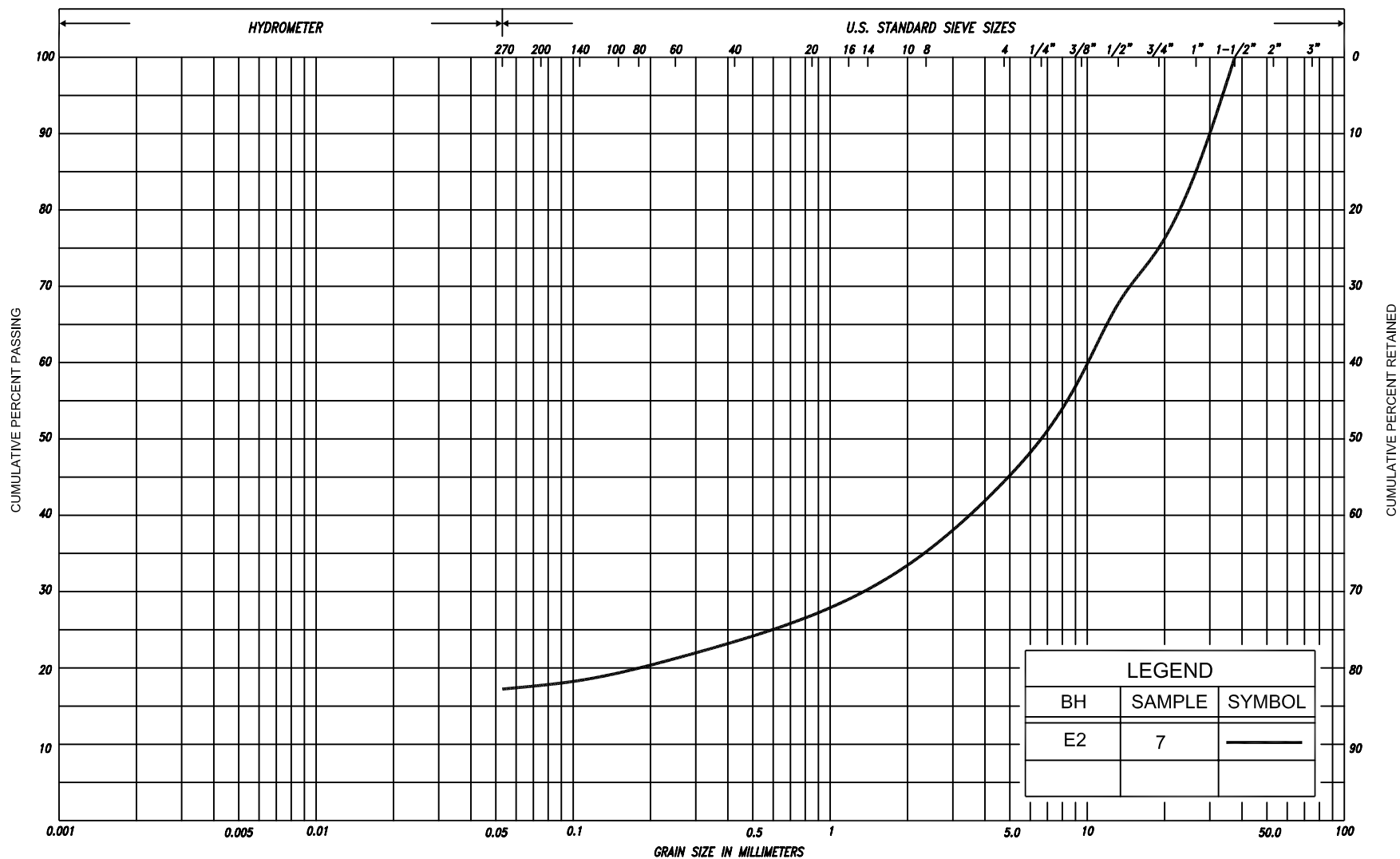


SILT & CLAY				FINE		MEDIUM		COARSE		GRAVEL			COBBLES	UNIFIED		
				SAND												
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL		COBBLES	M.I.T.
	SILT						SAND									
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL						U.S. BUREAU
					SAND											



GRAIN SIZE DISTRIBUTION
 SAND, with silt, some to with gravel, trace clay
 clayey silt layers
 (TILL)

FIG No. GS-9
 HWY: 3
 G.W.P. No. 3501-01-00

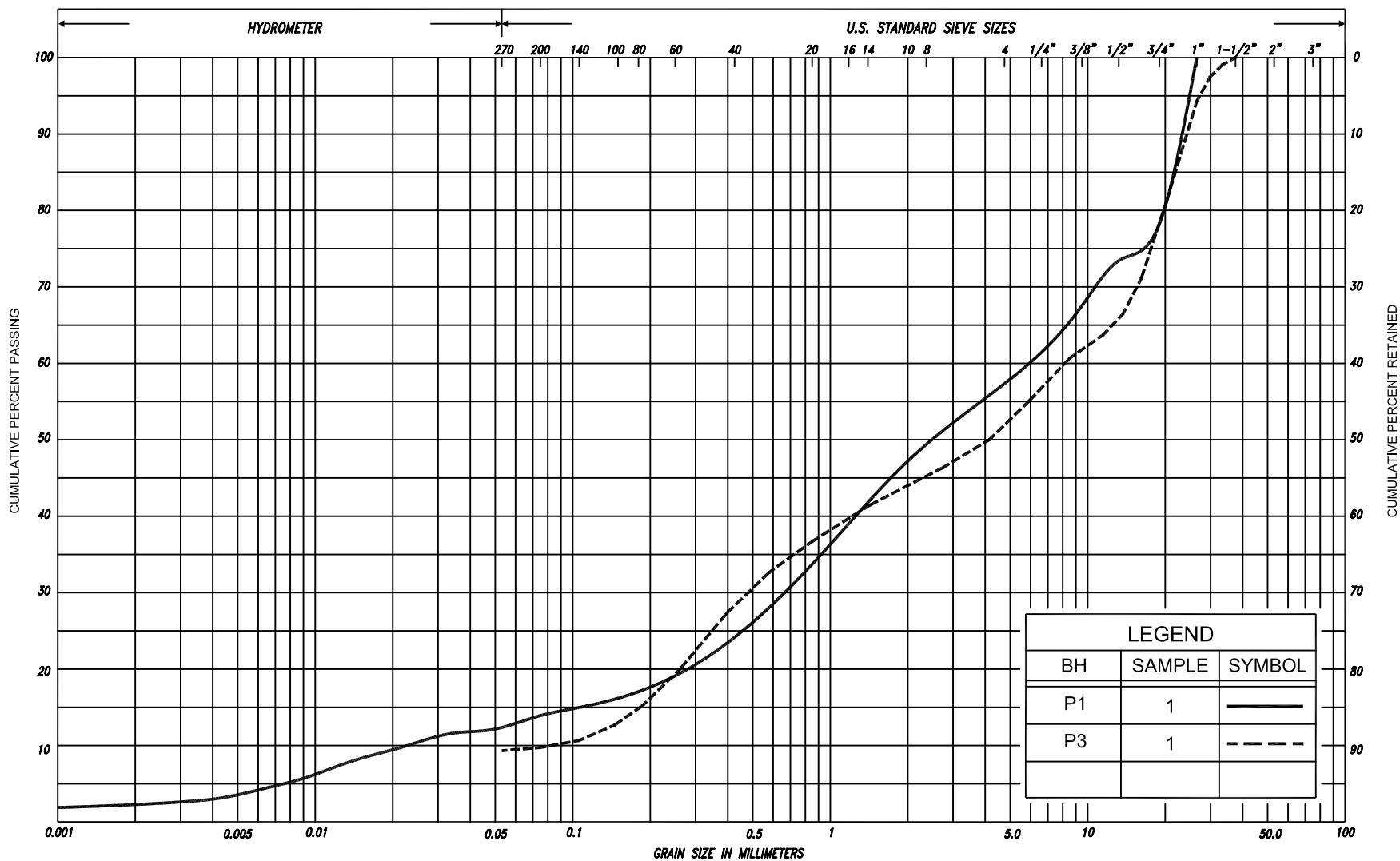


SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL		COB BLES	UNIFIED		
				SAND										
CLAY	FINE	MEDIUM	COARSE	FINE		MEDIUM		COARSE		GRAVEL		COBBLES	M.I.T.	
	SILT													
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL						U.S. BUREAU
				SAND										



GRAIN SIZE DISTRIBUTION GRAVEL, with sand, some silt, trace clay (TILL)

FIG No. GS-10
HWY: 3
G.W.P. No. 3501-01-00



SILT & CLAY				FINE SAND			MEDIUM SAND		COARSE SAND		GRAVEL		COBBLES	UNIFIED
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL		GRAVEL		GRAVEL		COBBLES	M.I.T.
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL		GRAVEL		GRAVEL		U.S. BUREAU



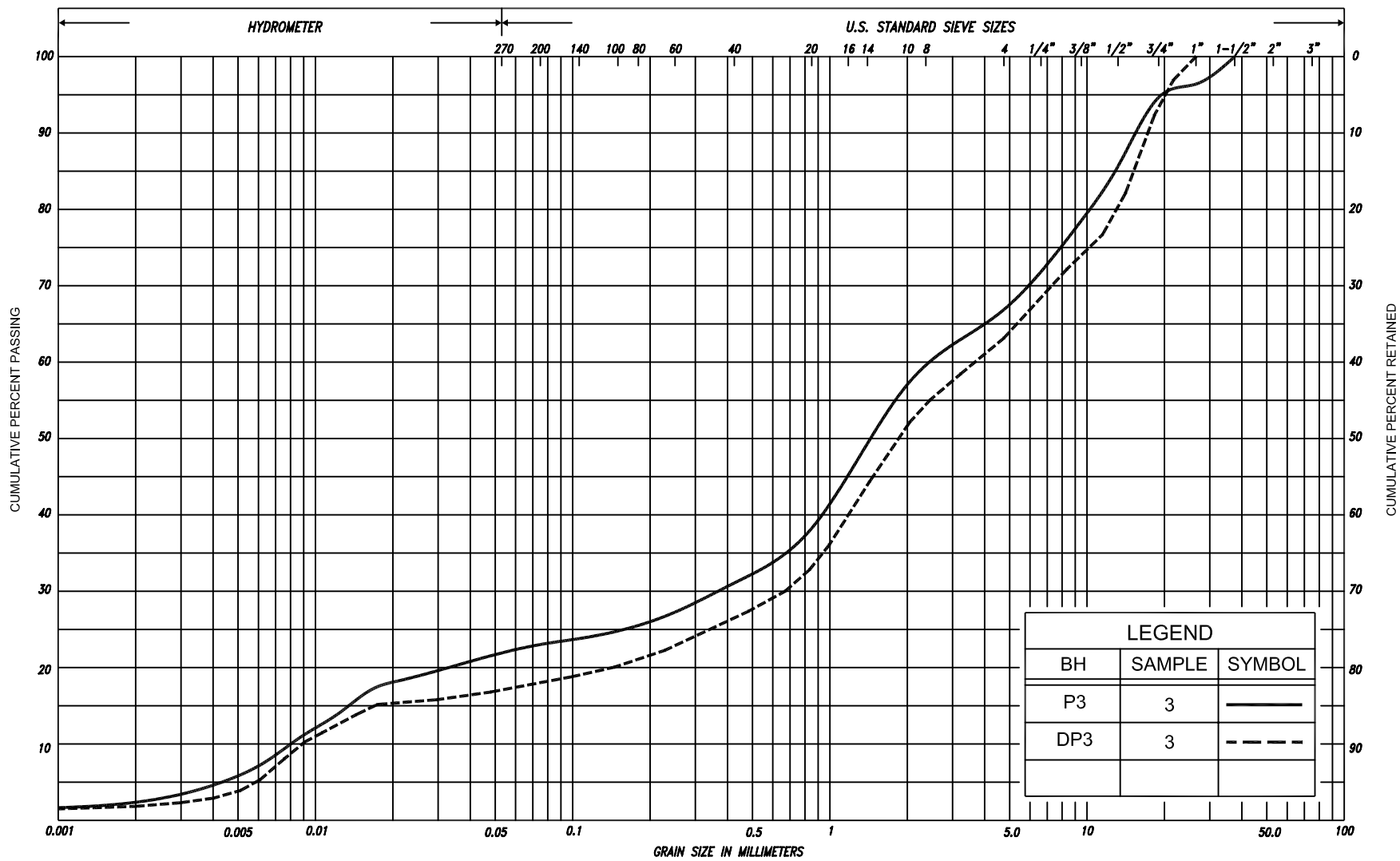
GRAIN SIZE DISTRIBUTION

SAND and GRAVEL, trace to some silt, trace clay

FIG No. GS-11

HWY: 3

G.W.P. No. 3501-01-00



SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COB BLES	UNIFIED	
					SAND											
CLAY	FINE		MEDIUM		COARSE	FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT															
CLAY		SILT			V. FINE	FINE	MED.	COARSE	GRAVEL							U.S. BUREAU
					SAND											



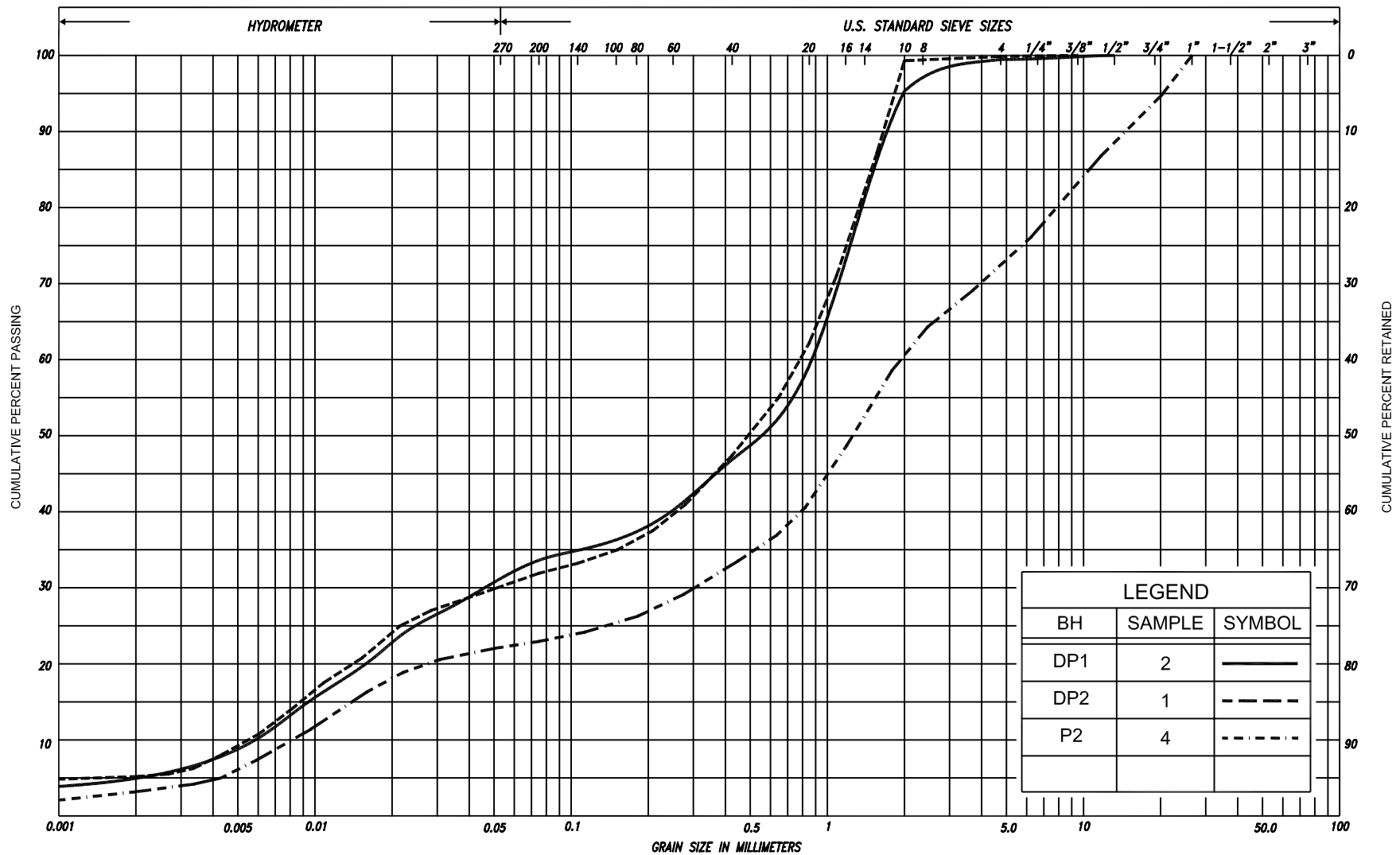
GRAIN SIZE DISTRIBUTION

GRAVELLY SAND, some to with silt, trace clay

FIG No. GS-12

HWY: 3

G.W.P. No. 3501-01-00



SILT & CLAY				FINE SAND			MEDIUM SAND		COARSE SAND		GRAVEL		COB BLES	UNIFIED
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL		GRAVEL		GRAVEL		COBBLES	M.I.T.
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL		GRAVEL		GRAVEL		U.S. BUREAU



GRAIN SIZE DISTRIBUTION
SAND, with silt, trace to with gravel, trace clay

FIG No. GS-13
HWY: 3
G.W.P. No. 3501-01-00

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No E1

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 667.8 N; 275 405.4 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY N.R.

DATUM Geodetic DATE June 23, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
					WATER CONTENT (%)												
182.8	Ground Surface						20	40	60	80	100						
0.0	200mm asphalt over sand and gravel, some silt (PAVEMENT FILL)																
182.0	Clay some sand, trace gravel		1	SS	9		182						○			1 11 20 68	
0.8	Stiff Brown Moist																
	Sand with gravel, some silt		2	SS	8		181										
	Loose Brown Moist																
	boulders		3	SS	7		180						○				
	trace gravel		4	SS	4		179						○			3 84 (13)	
178.4	Sandy clayey silt trace gravel																
4.4	Firm Brown Moist		5	SS	3		178						○				
	(FILL)		6	SS	5		177						○			9 36 30 25	
			7	SS	4		176						○				
	decayed wood		8	SS	5		175										
175.3	Organic silty clay cobbles		9	SS	43		174										
7.5	Stiff to Black Moist hard to wet												○				
174.1	Dolostone bedrock		10	RC NQ	REC 78%		173									RQD 0%	
8.7	Slightly to moderately (locally highly) weathered		11	RC NQ	REC 5%		172									RQD 0%	
	Medium to high strength		12	RC NQ	REC 33%		171									RQD 15%	
	Very poor quality (Bertie Formation)		13	RC NQ	REC 73%		170									RQD 10%	
			14	RC NQ	REC 87%		169									RQD 23%	
168.9	End of borehole																
13.9	* Borehole charged with drilling water															C.F.H.S.A. denotes Continuous Flight Hollow Stem Augers	

RECORD OF BOREHOLE No E2

1 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 666.0 N; 275 412.3 E ORIGINATED BY M.R.
DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY N.R.
DATUM Geodetic DATE June 22, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa									
							20 40 60 80 100									
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
WATER CONTENT (%)					20 40 60											
180.4	Ground Surface															
0.0	Gravelly sand with silt, trace clay		1	SS	9							○				
	Loose Brown Moist to wet															
	(PAVEMENT FILL)		2	SS	6							○				
179.2	Silty clay, trace sand inclusions of sandy silt and topsoil															
1.2	Firm Brown Moist		3	SS	5							○				
	(FILL)															
178.2	Sand, with silt some gravel, trace clay clayey silt layers		4	SS	15							○				
2.2	Compact Brown Moist															
	(TILL)		5	SS	20							○				17 44 30 9
			6	SS	23							○				
176.0	Gravel, with sand some silt, trace clay															
4.4	Loose to Brown Wet compact		7	SS	8							○				55 27 (18)
	(TILL)		8	SS	50/13cm											
174.8	Dolostone fragments some sand, trace silt															
5.6	Dense Buff Wet															
173.7	Dolostone bedrock		9	RC NQ	REC 100%											RQD 0%
6.7	Slightly to highly (locally completely) weathered															
	Medium to high strength		10	RC NQ	REC 13%											RQD 0%
	Very poor quality (Bertie Formation)															
			11	RC NQ	REC 76%											RQD 0%
			12	RC NQ	REC 88%											RQD 7%
	Dolostone/Shale/Evaporites bedrock Slightly weathered Low strength Fair quality (Salina Formation)		13	RC NQ	REC 85%											RQD 51%
167.0	End of borehole															
13.4	Sample 8: Sampler bouncing															
	Cont'd															

Cont'd

RECORD OF BOREHOLE No E2

2 of 2

METRIC

G.W.P.	3501-01-00	LOCATION	Grand River Bridge, Cayuga Co-ords: 4 756 666.0 N; 275 412.3 E	ORIGINATED BY	M.R.
DIST	London HWY 3	BOREHOLE TYPE	C.F.H.S.A. and Rotary Diamond Coring	COMPILED BY	N.R.
DATUM	Geodetic	DATE	June 22, 2010	CHECKED BY	G.D.

[illegible]

RECORD OF BOREHOLE No E1A

1 of 1

METRIC

G.W.P. 3501-01-00

LOCATION

Grand River Bridge, Cayuga

Co-ords: 4 756 677.1 N; 275 430.3 E

ORIGINATED BY M.R.

DIST London HWY 3

BOREHOLE

Continuous Flight Solid Stem Augers

COMPILED BY N.R.

DATUM Geodetic

DATE _____

June 24, 2010

CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa									WATER CONTENT (%)	
							20 40 60 80 100										
182.5 0.0	Ground Surface 150mm asphalt over sand and gravel, some silt Compact Brown Moist to loose (FILL)					182									0 8 50 42		
			1	SS	12												
			2	SS	6		181										
	Silty clay, trace sand Stiff Brown Moist		3	SS	10		180										
179.2 3.3	Sand, with gravel with silt, trace clay clayey silt layers Compact Brown Moist		4	SS	14		179										
			5	SS	21												
	Dense Mottled grey (TILL)		6	SS	40	178											
177.0 5.5	Dolostone fragments with sand, some silt Dense Buff Moist to wet					177											
175.8 6.7	End of borehole		7	SS	47	176											
* 2010 06 24 Water level measured after drilling																	

RECORD OF BOREHOLE No DE1A

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 646.7 N; 275 420.4 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.

DATUM Geodetic DATE June 24, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa										WATER CONTENT (%)		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
180.6	Ground Surface						20	40	60	80	100								
0.0	Sand and gravel, some silt		1	SS	8														
	Loose Brown Moist																		
	Silty clay some sand, trace gravel topsoil inclusions		2	SS	8														
	Firm Brown Moist (FILL)		3	SS	6														
178.5	Organic silty clay some sand, trace gravel		4	SS	5														
2.1	Firm Black/ brown Moist		5	SS	7														
			6	SS	7														
176.4	Sandy clayey silt some gravel		7	SS	8														
4.2	Stiff Brown Moist organics		8	SS	37														
175.0	Black Wet																		
5.6	Dolostone fragments some sand, some silt																		
174.8	Dense Buff Wet																		
5.8	End of borehole																		
	Sample 8: Sampler bouncing																		
	* 2010 06 24																		
	Water level measured after drilling																		

RECORD OF BOREHOLE No DE2

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 619.7 N; 275 398.7 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY N.R.

DATUM Geodetic DATE June 24 and 25, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE								○		
							20	40	60	80	100									
178.9	Ground Surface																			
0.0	Sandy clayey silt some gravel, asphalt pieces		1	SS	5															
178.2	Firm Brown Moist 																			

RECORD OF BOREHOLE No R3

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 596.4 N; 275 180.2 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.

DATUM Geodetic DATE June 24, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE												
182.3	Ground Surface						20	40	60	80	100									
0.0	Gravelly sand some silt, trace clay		1	SS	25	*	182											34 47 15 4		
	Compact Dark brown/ grey																			
	Sandy clayey silt trace gravel		2	SS	15		181													
	Very stiff Dark brown to stiff brown		3	SS	7		180													
	Silty clay, trace sand topsoil inclusions		4	SS	7															
Firm Brown Moist (FILL)	5	SS	8	179																
Sand some gravel, trace silt																				
Loose Light brown Moist																				
178.3	brick pieces		6	SS	8															
4.0	Topsoil																			
			7	SS	7	178														
177.1	Clayey silt, with sand																			
5.2	Firm Brown Moist to wet		8	SS	5	177											0 22 58 20			
176.4	Sand and gravel, some silt					*														
5.9	Compact Brown Wet		9	SS	30		176													
175.8	Dolostone fragments some sand, trace silt																			
6.5	Dense Buff Wet																			
175.6	End of borehole																			
6.7																				
<div>* 2010 06 24</div> <div> Water level measured after drilling</div>																				

* 2010 06 24

Water level measured after drilling

RECORD OF BOREHOLE No W1A

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 600.0 N; 275 194.1 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.

DATUM Geodetic DATE June 24, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa										WATER CONTENT (%)		
							20 40 60 80 100										20 40 60		
182.6	Ground Surface																		
0.0	200mm asphalt over sand and gravel, some silt asphalt layers																		
	Very dense Grey Moist to compact		1	SS	78														
	(PAVEMENT FILL)		2	SS	33														
181.2	Sandy clayey silt some gravel		3	SS	7														
1.4	Firm Dark brown Moist to wet trace sand, trace gravel																		
	Mottled grey/brown		4	SS	6														
			5	SS	7														
	silty sand layers																		
	(FILL)		6	SS	6														
			7	SS	5														
177.0	Topsoil		8	SS	6														
5.6																			
176.3	Clayey silt, trace sand		9	SS	5														
6.3	Firm Brown Moist sandy, trace gravel																		
			10	SS	2														
175.1	Sand and gravel, some silt																		
7.5	Dense Brown Wet		11	SS	65/28cm														
174.6																			
8.0	End of borehole																		
	Refusal on probable bedrock																		
	Sample 11: Sampler bouncing																		
	* 2010 06 24																		
	▽ Water level observed during drilling																		
	▼ Water level measured after drilling																		

RECORD OF BOREHOLE No W2

1 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 607.2 N; 275 219.9 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY N.R.

DATUM Geodetic DATE June 21, 2010 CHECKED BY G.D.





SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										○		
								● QUICK TRIAXIAL × LAB VANE												
182.8	Ground Surface						20	40	60	80	100	20	40	60						
0.0	300mm asphalt over sand and gravel, some silt																			
	Compact Brown Moist to dark brown																			
	(PAVEMENT FILL)		1	SS	12															
181.4	Clay with silt, trace sand																			
1.4	Very stiff Brown Moist to firm		2	SS	4					150										
	(FILL)		3	SS	5															
			4	SS	7															
			5	SS	6															
			6	SS	7															
			7	SS	3															
176.9	Organic clayey silt trace sand, trace gravel sand layers to 6.7m depth		8	SS	3															
5.9	Firm Brown/grey Moist to wet		9	SS	1															
				FV																
	decayed wood and peat		10	SS	4															
174.4	Dolostone fragments some sand, trace silt		11	SS	50/5cm															
8.4	Dense Buff Wet																			
172.7	Dolostone bedrock		12	RC NQ	REC 0%															
10.1	Moderately to highly (locally completely) weathered																			
	Medium strength		13	RC NQ	REC 31%															
	Very poor quality (Bertie Formation)		14	RC NQ	REC 52%															
			15	RC NQ	REC 62%															
167.8																				

RECORD OF BOREHOLE No W2

2 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga
 Co-ords: 4 756 607.2 N; 275 219.9 E ORIGINATED BY M.R.
 DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY N.R.
 DATUM Geodetic DATE June 21, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL						× LAB VANE		○
167.8							20	40	60	80	100	20	40	60						
15.0	Dolostone bedrock					167														
	Moderately to highly (locally completely) weathered																			
	Medium strength Very poor quality (Bertie Formation)		16	RC NQ	REC 67%													RQD 17%		
166.0	Cont'd.					166														
16.8	End of borehole																			
	Sample 11: Sampler bouncing																			
	 * 2010 06 21																			
	 Water level observed during drilling																			
	 Water level measured after drilling																			
	 Penetrometer test																			
	C.F.H.S.A.denotes Continuous Flight Hollow Stem Augers																			

RECORD OF BOREHOLE No P1

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga
 Co-ords: 4 756 627.7 N; 275 256.7 E ORIGINATED BY M.R.
 DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY M.N.
 DATUM Geodetic DATE August 24 & 25, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
176.0 0.0	Top of water Water																			
174.4 1.6	Sand and gravel some silt, trace clay Compact Brown Wet to loose dolostone fragments		1	SS	29												42 44 12 2			
			2	SS	7															
172.2 3.8	Dolostone bedrock Slightly to highly (locally completely) weathered Medium to high strength Very poor quality (Bertie Formation)		3	SS	50/15cm															
			4	RC NQ	REC 69%												RQD 0%			
			5	RC NQ	REC 100%												RQD 0%			
			6	RC NQ	REC 50%												RQD 21%			
			7	RC NQ	REC 80%												RQD 8%			
			8	RC NQ	REC 65%												RQD 16%			
			9	RC NQ	REC 20%												RQD 0%			
			10	RC NQ	REC 100%												RQD 75%			
163.2 12.8	End of borehole Sample 3: Sampler bouncing * 2010 08 24 & 25 ▽ Water level observed during drilling ▽ Water level measured after drilling																			

RECORD OF BOREHOLE No P2

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 618.8 N; 275 299.3 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY M.N.

DATUM Geodetic DATE August 19, 2010 CHECKED BY G.D.



SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPa					W _p	W	W _L		
176.0	Top of water						20	40	60	80	100					
0.0	Water						20	40	60	80	100					
174.8																
1.2	Sand and gravel, some silt boulders		1	SS	26/15cm											
	Compact Dark Wet brown		2	RC	-											
173.0			3	SS	15											
3.0	Sand, with gravel with silt, trace clay dolostone fragments		4	SS	10											
	Compact Brown Wet		5	SS	26											
171.7																
4.3	Dolostone bedrock		6	RC	REC 100%											
	Slightly to highly (locally completely) weathered		7	RC	REC 50%											
	Medium to high strength		8	RC	REC 100%											
	Very poor to fair quality (Bertie Formation)		9	RC	REC 57%											
			10	RC	REC 50%											
			11	RC	REC 93%											
	Dolostone/Shale/Evaporites bedrock		12	RC	REC 46%											
	Slightly weathered															
	Medium strength															
	Very poor becoming good to excellent quality		13	RC	REC 93%											
	(Salina Formation)															
			14	RC	REC 100%											
162.9																
13.1	End of borehole															
	Samples 1 and 5: Sampler bouncing															
	* 2010 08 19															
	Water level observed during drilling															
	Water level measured after drilling															

RECORD OF BOREHOLE No P3

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga
 Co-ords: 4 756 651.6 N; 275 328.2 E ORIGINATED BY M.R.
 DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY M.N.
 DATUM Geodetic DATE August 16, 17 and 18, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p W W _L				
								○ UNCONFINED + FIELD VANE					○				
								● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)				
176.0	Top of water						20	40	60	80	100						
0.0	Water																
174.6																	
1.4	Sand and gravel trace to some silt		1	SS	22											48 42 (10)	
	Compact Brown Wet boulders																
			2	RC	-												
172.6																	
3.4	Gravelly sand with silt, trace clay		3	SS	32											33 44 21 2	
	Dense Brown Wet																
171.6			4	SS	100/0cm												
4.4	dolostone fragments																
171.1																	
4.9	Dolostone bedrock		5	RC NQ	REC 100%											RQD 0%	
	Slightly weathered																
	Medium to high strength																
	Very poor quality			6	RC NQ	REC 80%											RQD 7%
	(Bertie Formation)																
				7	RC NQ	REC 88%											RQD 25%
				8	RC NQ	REC 87%											RQD 0%
			9	RC NQ	REC 43%											RQD 0%	

RECORD OF BOREHOLE No P4

1 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga
 Co-ords: 4 756 642.0 N; 275 371.0 E ORIGINATED BY F.P.
 DIST London HWY 3 BOREHOLE TYPE Casing and Rotary Diamond Coring COMPILED BY M.N.
 DATUM Geodetic DATE August 11, 12 and 13, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										○		
								● QUICK TRIAXIAL × LAB VANE												
176.0 0.0	Top of water Water						20	40	60	80	100	20	40	60						
174.8 1.2	Organic silt some sand, some gravel Very loose Dark Wet grey		1	SS	WH**															
173.4 2.6	boulders		2	RC	-															
	Silt some sand, some gravel Loose to Brown Wet very loose		3	SS	7															
	dolostone fragments		4	SS	2															
			5	SS	43															
171.4 4.6	Dolostone bedrock Slightly (locally highly) weathered Medium to high strength Very poor to poor quality (Bertie Formation)		6	RC NQ	REC 84%											RQD 21%				
			7	RC NQ	REC 97%											RQD 47%				
			8	RC NQ	REC 58%											RQD 0%				
			9	RC NQ	REC 50%											RQD 0%				
			10	RC NQ	REC 43%											RQD 21%				
	Dolostone/Shale/Evaporites bedrock Slightly (locally highly) weathered Medium to high strength Very poor to poor becoming good quality (Salina Formation)		11	RC NQ	REC 98%											RQD 45%				
			12	RC NQ	REC 98%											RQD 82%				
161.7 14.3	End of borehole																			
Cont'd																				

Cont'd

RECORD OF BOREHOLE No P4

2 of 2

METRIC

G.W.P.	3501-01-00	LOCATION	Grand River Bridge, Cayuga Co-ords: 4 756 642.0 N; 275 371.0 E	ORIGINATED BY	F.P.
DIST	London HWY 3	BOREHOLE TYPE	Casing and Rotary Diamond Coring	COMPILED BY	M.N.
DATUM	Geodetic	DATE	August 11, 12 and 13, 2010	CHECKED BY	G.D.

[illegible]

RECORD OF BOREHOLE No P1A

1 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 606.7 N; 275 263.8 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY N.R.

DATUM Geodetic DATE September 15 to 17, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										○		
								● QUICK TRIAXIAL × LAB VANE												
176.0	Top of water						20	40	60	80	100						GR SA SI CL			
0.0	Water						20	40	60	80	100									
175.0	Sand and silt		1	SS	1/15cm															
174.8	Very loose Black Wet																			
174.8	Sandy gravel and boulders																			
173.9	Brown Wet																			
2.1	Dolostone fragments in a silty sand matrix		2	SS	16															
	Compact Buff Wet		3	SS	6															
	to loose																			
			4	SS	14/15cm															
171.7	Dolostone bedrock																			
4.3	Slightly to moderately (locally highly) weathered		5	RC NQ	REC 69%												RQD 21%			
	Medium to high strength		6	RC NQ	REC 92%												RQD 12%			
	Very poor quality (Bertie Formation)		7	RC NQ	REC 20%												RQD 0%			
			8	RC NQ	REC 100%												RQD 19%			
			9	RC NQ	REC 45%												RQD 7%			
			10	RC NQ	REC 93%												RQD 62%			
	Dolostone/Shale/Evaporites bedrock																			
	Slightly weathered		11	RC NQ	REC 100%												RQD 83%			
	Medium strength																			
	Fair to good quality (Salina Formation)		12	RC NQ	REC 93%												RQD 57%			

Cont'd

RECORD OF BOREHOLE No P1A

2 of 2

METRIC

G.W.P.	3501-01-00	LOCATION	Grand River Bridge, Cayuga Co-ords: 4 756 606.7 N; 275 263.8 E	ORIGINATED BY	M.R.
DIST	London HWY 3	BOREHOLE TYPE	C.F.H.S.A. and Rotary Diamond Coring	COMPILED BY	N.R.
DATUM	Geodetic	DATE	September 15 to 17, 2010	CHECKED BY	G.D.

[illegible]

RECORD OF BOREHOLE No P2A

1 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 638.6 N; 275 292.8 E ORIGINATED BY M.R.
DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY N.R.
DATUM Geodetic DATE September 12 to 14, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
WATER CONTENT (%)					20 40 60												
176.0 0.0	Top of water Water																
175.1 0.9	Sand and gravel Loose Brown Wet		1	SS	9												
174.4 1.6	Dolostone fragments in a sily sand matrix Very dense Buff Wet		2	SS	113												
172.0 4.0	Dolostone bedrock Slightly to moderately weathered Medium to high strength Poor to very poor quality (Bertie Formation)		3	RC NQ	REC 75%											RQD 42%	
			4	RC NQ	REC 78%											RQD 45%	
			5	RC NQ	REC 95%											RQD 0%	
			6	RC NQ	REC 100%											RQD 0%	
			7	RC NQ	REC 57%											RQD 0%	
			8	RC NQ	REC 90%											RQD 55%	
			9	RC NQ	REC 97%											RQD 63%	
			10	RC NQ	REC 100%											RQD 62%	

Cont'd

RECORD OF BOREHOLE No P2A

2 of 2

METRIC

G.W.P.	3501-01-00	LOCATION	Grand River Bridge, Cayuga Co-ords: 4 756 638.6 N; 275 292.8 E	ORIGINATED BY	M.R.
DIST	London HWY 3	BOREHOLE TYPE	C.F.H.S.A. and Rotary Diamond Coring	COMPILED BY	N.R.
DATUM	Geodetic	DATE	September 12 to 14, 2010	CHECKED BY	G.D.

[illegible]

RECORD OF BOREHOLE No P3A

1 of 2

METRIC

G.W.P. 3501-01-00

LOCATION

Grand River Bridge, Cayuga

Co-ords: 4 756 630.1 N; 275 335.2 E

ORIGINATED BY M.R.

DIST London HWY 3

BOREHOLE TYPE

C.F.H.S.A. and Rotary Diamond Coring

COMPILED BY N.R.

DATUM Geodetic

DATE

September 3, 7 and 8, 2010

CHECKED BY G.D.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)				
								○ UNCONFINED	+	FIELD VANE												
								● QUICK TRIAXIAL	×	LAB VANE												
176.0	Top of water						20	40	60	80	100											
0.0	Water						20	40	60	80	100											
174.6																						
1.4	Silty sand and gravel organics to 1.5m		1	SS	30																	
	Compact to dense Brown Wet		2	RC	-																	
173.7	boulders																					
2.3	Dolostone fragments in a silty sand matrix																					
	Compact to Buff Wet very dense		3	SS	20																	
			4	SS	88																	
171.7			5	RC NQ	REC 50%																	
4.3	Dolostone bedrock															RQD 0%						
	Slightly to moderately weathered																					
	Medium to high strength		6	RC NQ	REC 95%											RQD 17%						
	Very poor quality (Bertie Formation)		7	RC NQ	REC 77%											RQD 0%						
			8	RC NQ	REC 43%											RQD 14%						
			9	RC NQ	REC 100%											RQD 0%						
			10	RC NQ	REC 94%											RQD 23%						
			11	RC NQ	REC 33%											RQD 11%						
	Dolostone/Shale/Evaporites bedrock		12	RC NQ	REC 88%											RQD 36%						
	Slightly weathered																					
	Medium strength																					
	Poor to fair (locally excellent) quality		13	RC NQ	REC 100%											RQD 91%						
	(Salina Formation)																					
			14	RC NQ	REC 97%											RQD 57%						

Cont'd

RECORD OF BOREHOLE No P3A

2 of 2

METRIC

G.W.P.	3501-01-00	LOCATION	Grand River Bridge, Cayuga Co-ords: 4 756 630.1 N; 275 335.2 E	ORIGINATED BY	M.R.
DIST	London HWY 3	BOREHOLE TYPE	C.F.H.S.A. and Rotary Diamond Coring	COMPILED BY	N.R.
DATUM	Geodetic	DATE	September 3, 7 and 8, 2010	CHECKED BY	G.D.

[illegible]

RECORD OF BOREHOLE No P4A

1 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 663.2 N; 275 364.0 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY M.N.

DATUM Geodetic DATE August 31, September 01 and 02, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										○		
								● QUICK TRIAXIAL × LAB VANE												
176.0 0.0	Top of water Water						20	40	60	80	100	20	40	60	kn/m³	GR SA SI CL				
174.5 1.5	Sand and gravel, trace silt wood pieces Compact Brown Wet		1	SS	14															
173.6 2.4	Dolostone fragments in a silty sand matrix Compact Buff Wet to dense		2	SS	18															
171.4 4.6	Dolostone bedrock Slightly (locally highly) weathered Medium to high strength Very poor quality (Bertie Formation)		3	SS	36															
			4	RC NQ	REC 75%											RQD 9%				
			5	RC NQ	REC 83%											RQD 0%				
			6	RC NQ	REC 80%											RQD 12%				
			7	RC NQ	REC 68%											RQD 23%				
			8	RC NQ	REC 52%											RQD 7%				
			9	RC NQ	REC 100%											RQD 74%				
			10	RC NQ	REC 96%											RQD 53%				

Cont'd

RECORD OF BOREHOLE No P4A

2 of 2

METRIC

G.W.P. 3501-01-00

LOCATION

Grand River Bridge, Cayuga

Co-ords: 4 756 663.2 N; 275 364.0 E

ORIGINATED BY M.R.

DIST London HWY 3

BOREHOLE

C.F.H.S.A. and Rotary Diamond Coring

COMPILED BY M.N.

DATUM Geodetic

DATE _____

August 31, September 01 and 02, 2010

CHECKED BY G.D.

[illegible]

RECORD OF BOREHOLE No DP1

1 of 1

METRIC

G.W.P. 3501-01-00

LOCATION

Grand River Bridge, Cayuga

Co-ords: 4 756 596.3 N; 275 267.0 E

ORIGINATED BY M.R.

DIST London HWY 3

BOREHOLE

C.F.H.S.A. and Rotary Diamond Coring

COMPILED BY M.N.

DATUM Geodetic

DATE _____

August 26, 2010

CHECKED BY G.D.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W _p	W	W _L		
176.0 0.0	Top of water Water																
174.1 1.9	Dolostone fragments in a silty sand matrix Dense to Buff Wet compact		1	SS	43												
			2	SS	18												1 65 29 5
			3	SS	18												
171.7 4.3	Dolostone bedrock Slightly to moderately weathered Medium strength Very poor quality (Bertie Formation)		4	RC NQ	REC 93%												RQD 18%
			5	RC NQ	REC 72%												RQD 18%
168.7 7.3	End of borehole																
<p>* 2010 08 26</p> <p> Water level observed during drilling</p> <p> Water level measured after drilling</p>																	

RECORD OF BOREHOLE No DP2

1 of 1

METRIC

G.W.P. 3501-01-00

LOCATION

Grand River Bridge, Cayuga

Co-ords: 4 756 608.1 N; 275 302.8 E

ORIGINATED BY M.R.

DIST London HWY 3

BOREHOLE

C.F.H.S.A. and Rotary Diamond Coring

COMPILED BY M.N.

DATUM Geodetic

DATE _____

August 26, 2010

CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	w _p	w	w _L		
SHEAR STRENGTH kPa								WATER CONTENT (%)									

RECORD OF BOREHOLE No DP3

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Grand River Bridge, Cayuga Co-ords: 4 756 619.8 N; 275 338.6 E ORIGINATED BY M.R.

DIST London HWY 3 BOREHOLE TYPE C.F.H.S.A. and Rotary Diamond Coring COMPILED BY M.N.

DATUM Geodetic DATE August 27, 2010 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE									
176.0	Top of water						20	40	60	80	100						GR SA SI CL			
0.0	Water						20	40	60	80	100									
174.2	Dolostone fragments in a silty sand matrix		1	SS	96															
1.8	Very dense Buff Wet		2	RC	-															
			3	SS	62												37 45 16 2			
171.4	Dolostone bedrock		4	RC NQ	REC 100%												RQD 0%			
4.6	Slightly to moderately (locally completely) weathered		5	RC NQ	REC 83%												RQD 0%			
	Medium strength		6	RC NQ	REC 74%												RQD 33%			
	Very poor to poor quality (Bertie Formation)		7	RC NQ	REC 74%												RQD 0%			
	void																			
167.8	End of borehole																			
8.2																				
	* 2010 08 27																			
	▽ Water level observed during drilling																			
	▼ Water level measured after drilling																			

RECORD OF BOREHOLE No DP4

1 of 1

METRIC

G.W.P. 3501-01-00

LOCATION

Grand River Bridge, Cayuga

Co-ords: 4 756 631.6 N; 275 374.4 E

ORIGINATED BY M.R.

DIST London HWY 3

BOREHOLE

C.F.H.S.A. and Rotary Diamond Coring





COMPILED BY M.N.

DATUM Geodetic

DATE _____

August 31, 2010

CHECKED BY G.D.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p w w _L				GR	SA	SI	CL
													○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
176.0 0.0	Top of water Water							20	40	60	80	100								
174.0 2.0	Dolostone fragments in a silty sand matrix Compact Buff/ Wet to dense brown		1	SS	40															
			2	SS	14															
			3	SS	72															
171.6 4.4	Dolostone bedrock Slightly to moderately (locally completely) weathered Medium strength Very poor quality (Bertie Formation)		4	RC NQ	REC 81%														RQD 0%	
			5	RC NQ	REC 70%															RQD 8%
168.7 7.3	End of borehole																			
<div>* 2010 08 31</div> <div> Water level observed during drilling</div> <div> Water level measured after drilling</div>																				

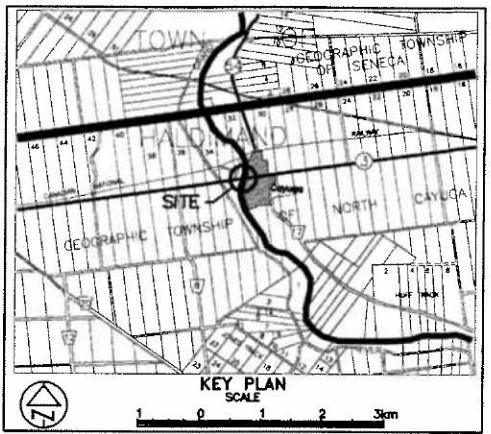
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES

CONT No
GWP No 3501-01-00

GRAND RIVER BRIDGE
HIGHWAY 3, AT CAYUGA
BOREHOLE LOCATIONS

SHEET

PMI Peto MacCallum Ltd
CONSULTING ENGINEERS

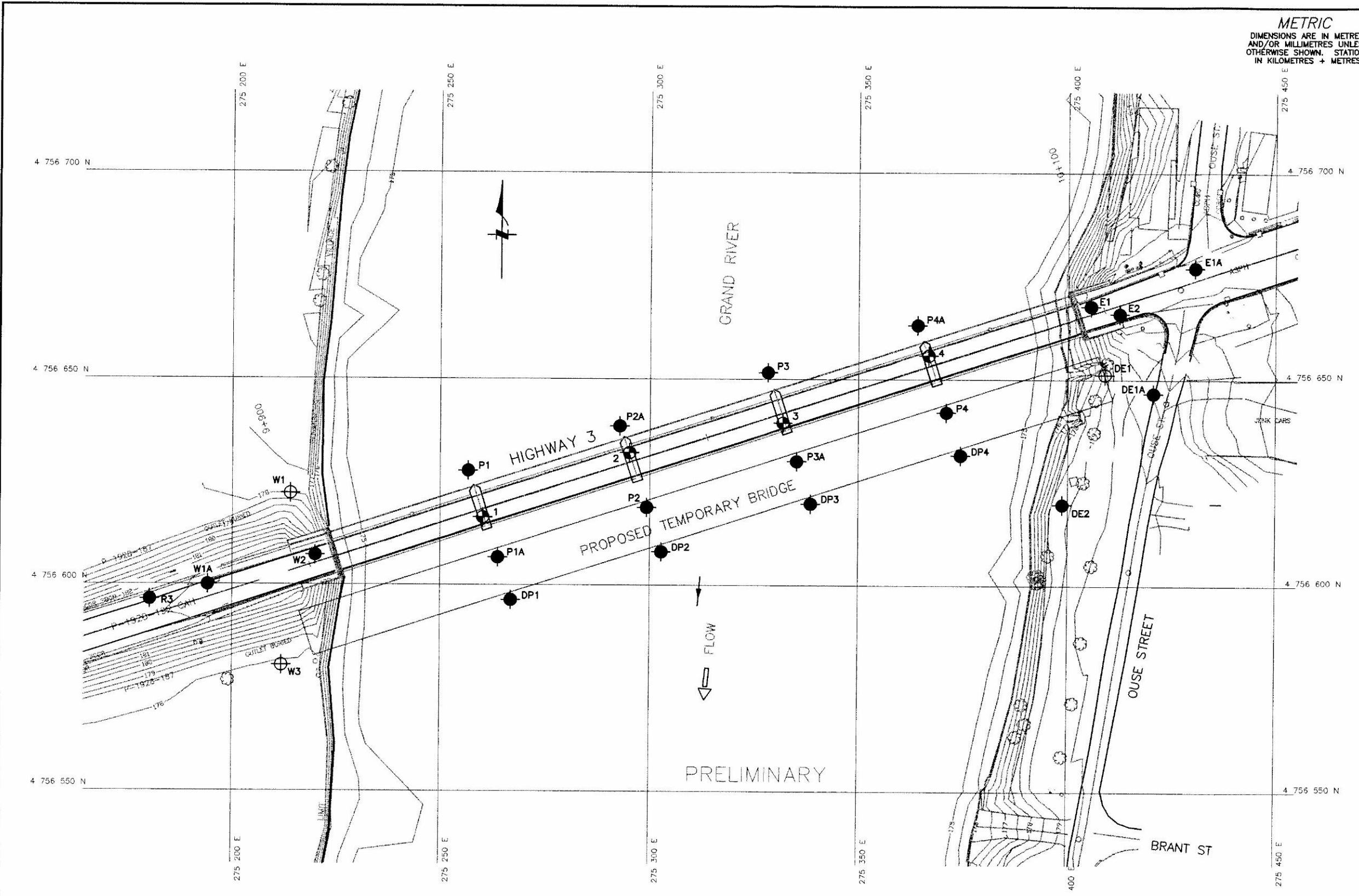


LEGEND				
	Boreholes for current investigation			
	Boreholes to be drilled			
	Boreholes from preliminary investigation			
N	Blows/0.3m (Std. Pen Test, 475 J/blow)			
CONE	Blows/0.3m (60° Cone, 475 J/blow)			
W L	W L at time of investigation June to September 2010			
	Head			
	ARTESIAN WATER Encountered			
	PIEZOMETER			
BH No	ELEVATION	COORDINATES		
		NORTHINGS	EASTINGS	
E1	182.8	4 756 667.8	275 405.4	
E2	180.4	4 756 666.0	275 412.3	
E1A	182.5	4 756 677.1	275 430.3	
DE1	TO BE DRILLED LATER			
DE1A	180.6	4 756 646.7	275 420.4	
DE2	178.9	4 756 619.7	275 398.7	
W1	TO BE DRILLED LATER			
W1A	182.6	4 756 600.0	275 194.1	
W2	182.8	4 756 607.2	275 219.9	
W3	TO BE DRILLED LATER			
R3	182.3	4 756 596.4	275 180.2	
P1	176.0	4 756 627.7	275 256.7	
P2	176.0	4 756 618.8	275 299.3	
P3	176.0	4 756 651.6	275 328.2	
P4	176.0	4 756 642.0	275 371.0	

(Legend Continues)
- NOTE -
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

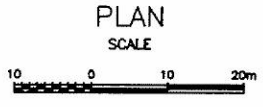
DATE	BY	DESCRIPTION

Geocres No. XXX-XXX
HWY No 3
SUBMITT GD CHECKED GD DATE DEC. 07, 2010 SITE 9-43
DRAWN NA CHECKED CN APPROVED BRG DWG GR-1



(Legend Continued)

BH No	ELEVATION	COORDINATES	
		NORTHINGS	EASTINGS
1	182.8	4 756 616	275 260
2	182.8	4 756 632	275 295
3	182.8	4 756 639	275 332
4	182.8	4 756 656	275 367



(Legend Continued)

BH No	ELEVATION	COORDINATES	
		NORTHINGS	EASTINGS
P1A	176.0	4 756 606.7	275 263.8
P2A	176.0	4 756 638.6	275 292.8
P3A	176.0	4 756 630.1	275 335.2
P4A	176.0	4 756 663.2	275 364.0
DP1	176.0	4 756 596.3	275 267.0
DP2	176.0	4 756 608.1	275 302.8
DP3	176.0	4 756 619.8	275 338.6
DP4	176.0	4 756 631.6	275 374.4

(Legend Continues)

- NOTES:
- REFER TO DRAWINGS GR-2 AND GR-3 FOR CENTRELINE PROFILE AND SECTIONS A-A, B-B, C-C AND D-D.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

REF No. MRC Drawing:
ACAD-7730-Archaeological Plan-Ground Penetration
(DETOUR TEMP RET. WALL) August 26, 2010.



Appendix A

Site Photographs



Photograph 1: Locations of boreholes R3 and W1A on the west approach to the bridge. (June 2010)



Photograph 2: Looking southeast from the location of borehole W1. (June 2010)



Photograph 3: Looking northeast from the archeological site situated south of the west approach. (June 2010)



Photograph 4: Looking west from the west abutment. (June 2010)



Photograph 5: Looking northwest from the boat launch ramp on the left (east) bank of the Grand River. (June 2010)



Photograph 6: Looking east from the sidewalk near the east abutment. (June 2010)



Photograph 7: Looking northeast from the south side of the east abutment. (June 2010)



Photograph 8: Looking at the bridge from the location of borehole DE1A. (June 2010)



Appendix B

Rock Core Photographs



Photograph 1: Cores retrieved from borehole DP1. Cores 4 and 5 from 4.3 to 7.3 m depth. RQD value was 18% for both cores, indicating very poor rock quality.



Photograph 2: Cores retrieved from borehole DP2. Cores 3 to 5 from 4.3 to 7.6 m depth. RQD values ranged from 0 to 40%, indicating very poor to poor rock quality.



Photograph 3: Cores retrieved from borehole DP3. Cores 4 to 7 from 4.6 to 8.2 m depth. RQD values ranged from 0 to 33%, indicating very poor to poor rock quality.



Photograph 4: Cores retrieved from borehole DP4. Cores 4 and 5 from 4.4 to 7.3 m depth. RQD values were 0 and 8% respectively, indicating very poor rock quality.



Photograph 5: Cores retrieved from borehole P1. Cores 4 to 10 from 3.8 to 12.8 m depth. RQD values ranged from 0 to 75%, indicating very poor becoming good rock quality.



Photograph 6: Cores retrieved from borehole P1A. Cores 5 to 14 from 4.3 to 17.5 m depth. RQD values ranged from 0 to 83%, indicating very poor becoming fair to good rock quality.



Photograph 7: Cores retrieved from borehole P2. Cores 6 to 14 from 4.3 to 13.1 m depth. RQD values ranged from 0 to 93%, indicating very poor to fair becoming good to excellent rock quality.



Photograph 8: Cores retrieved from borehole P2A. Cores 3 to 12 from 4.0 to 17.5 m depth. RQD values ranged from 0 to 73%, indicating very poor to poor becoming fair (locally poor) rock quality.



Photograph 9: Cores retrieved from borehole P3. Cores 5 to 13 from 4.9 to 12.9 m depth. RQD values ranged from 0 to 82%, indicating very poor becoming fair to good (locally very poor) rock quality.



Photograph 10: Cores retrieved from borehole P3A. Cores 5 to 16 from 4.3 to 17.4 m depth. RQD values ranged from 0 to 91%, indicating very poor becoming poor to fair (locally excellent) rock quality.



Photograph 11: Cores retrieved from borehole P4. Cores 6 to 12 from 4.6 to 14.3 m depth. RQD values ranged from 0 to 82%, indicating very poor to poor becoming good rock quality.



Photograph 12: Cores retrieved from borehole P4A. Cores 4 to 12 from 4.6 to 17.4 m depth. RQD values ranged from 0 to 74%, indicating very poor becoming poor to fair rock quality.



Photograph 13: Cores retrieved from borehole W2. Cores 12 to 16 from 10.1 to 16.8 m depth. RQD values ranged from 0 to 22%, indicating very poor rock quality.



Photograph 14: Cores retrieved from borehole E1. Cores 10 to 14 from 8.7 to 13.9 m depth. RQD values ranged from 0 to 23%, indicating very poor rock quality.



Photograph 15: Cores retrieved from borehole E2. Cores 9 to 13 from 6.7 to 13.4 m depth. RQD values ranged from 0 to 51%, indicating very poor becoming fair rock quality.



Photograph 16: Cores retrieved from borehole DE2. Cores 6 to 11 from 4.1 to 11.8 m depth. RQD values ranged from 0 to 29%, indicating very poor to poor rock quality.