

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30M5-193

DIST. 4 REGION

W.P. No. 406-85-01/02

CONT. No.

W. O. No.

STR. SITE No. 10-490

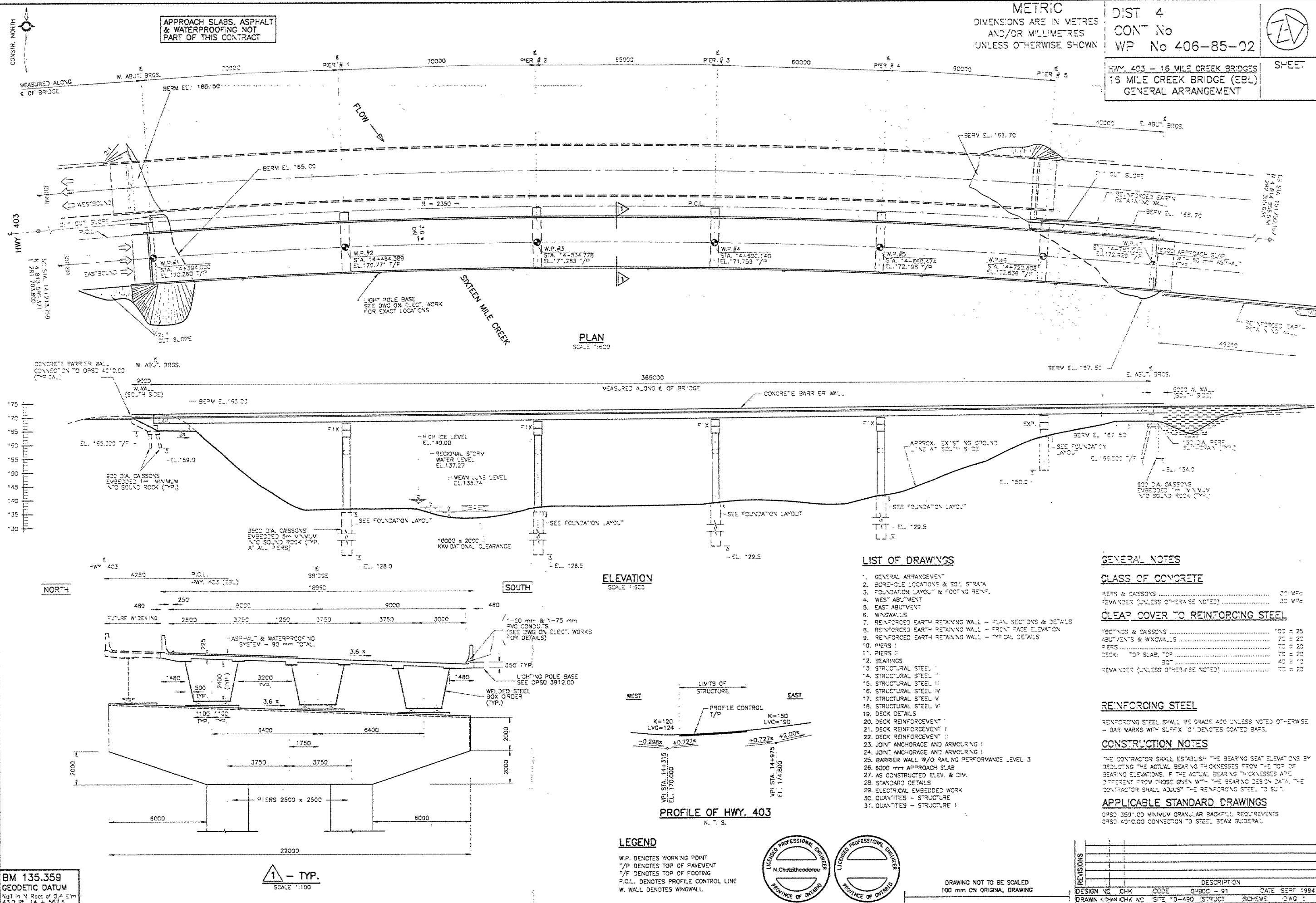
HWY. No. 403

LOCATION HWY 403 & 16 MILE CREEK

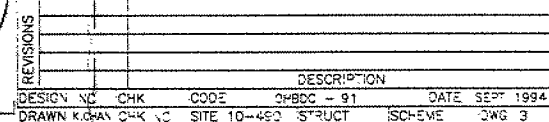
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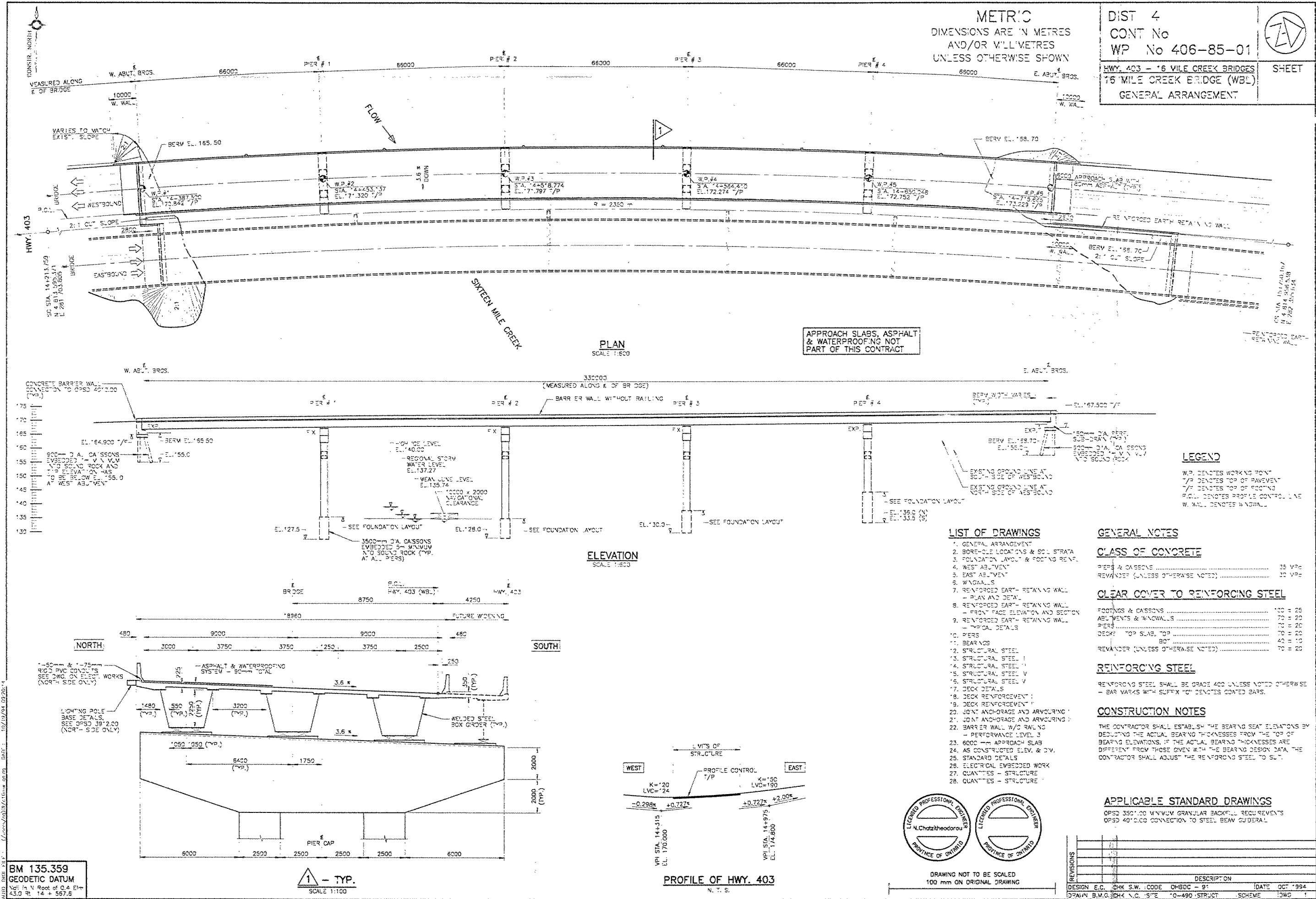
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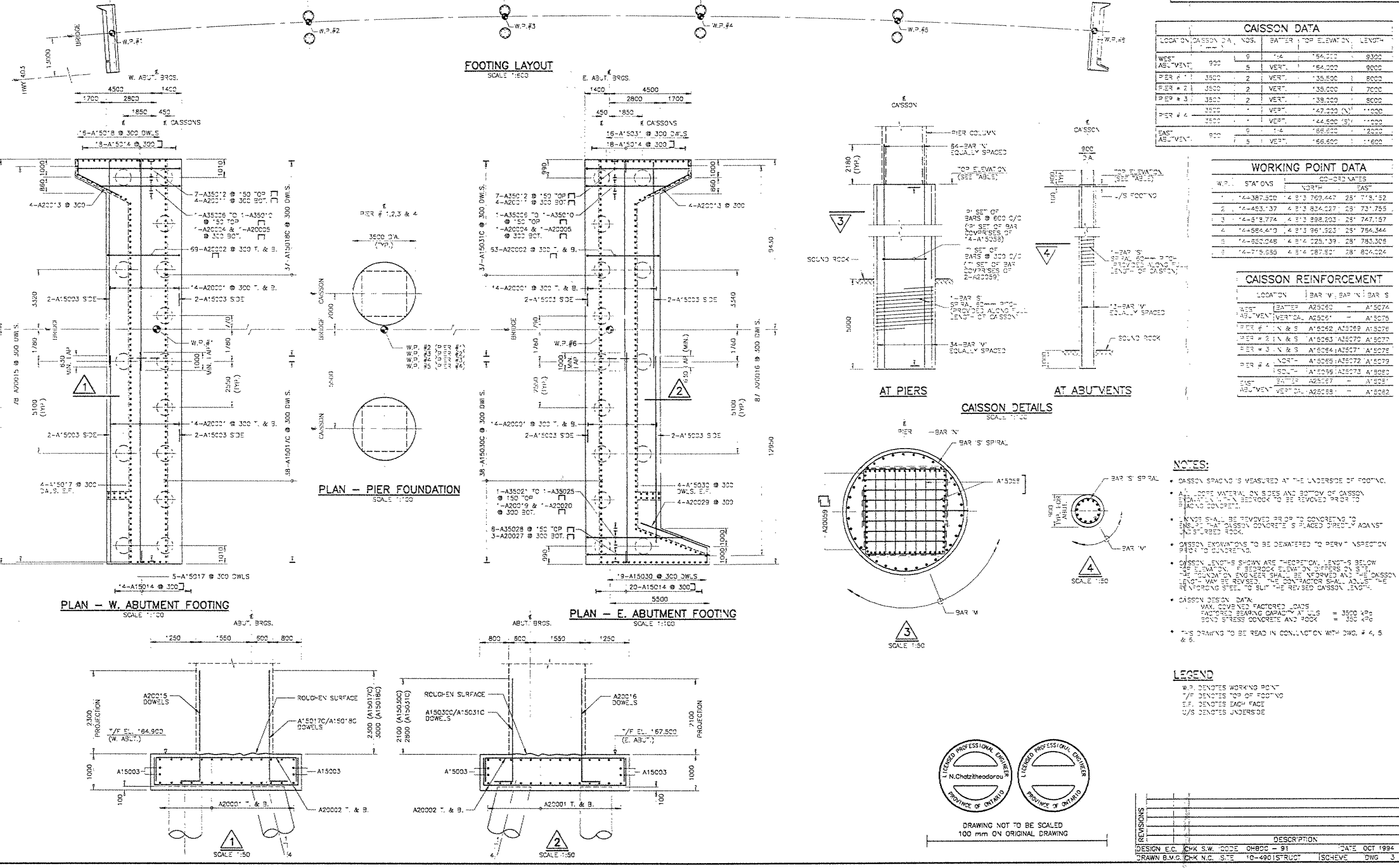
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ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

406-85-01 (WBL)
WP 406-85-02 (EBL) DIST 4
HWY 403 STR SITE 10-490
Hwy. 403 - 16 Mile Creek Bridges

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FOUNDATION INVESTIGATION REPORT

FOR

HWY. 403 - 16 MILE CREEK BRIDGES

W.P. 406-85-01, (WBL)

W.P. 406-85-02, (EBL)

SITE 10-490

District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted in conjunction with the proposed Hwy. 403 - 16 Mile Creek Bridges. The proposed five span WBL structure and six span EBL structure will span the existing 16 Mile Creek Valley which is approximately 350 metres wide and 37 metres deep.

SITE DESCRIPTION AND GEOLOGY

The site is located at the proposed Hwy. 403 - 16 Mile Creek crossing situated along the 16 Mile Creek valley approximately 0.5 km north of Burnhamthorpe Rd. in the Town of Oakville, Regional Municipality of Halton. The site, as shown on the key plan on drawing 4068501/02-A in the Appendix, is located approximately 3 kilometres north of Hwy. 5 and 2 kilometres east of Hwy. 25. Burnhamthorpe Rd. which provides access to the site on either side of the 16 Mile Creek Valley actually dead ends on either side of the 16 Mile Creek.

The 16 Mile Creek Valley is approximately 350m in width and up to 37m in depth and houses the meandering 16 Mile Creek which has a width and depth of approximately 50 metres and 3 metres respectively. The water level in the creek at the time of the investigation was approximately one (1) metre.

The floodplain beyond the 16 Mile Creek is relatively flat and is confined by existing slopes present at the site. West of the 16 Mile Creek, slopes vary from 1H:1V to vertical, the latter comprised of exposed rock faces. On the east side, slopes are approximately at 1.5H:1V. The flatter slopes are covered with medium dense deciduous trees including oak, elm, and maple trees. The trees are relatively tall ranging up to 20 metres in height. The trees located on the existing natural slopes are near vertical within the upper portion of the slope, which is indicative of stable slopes. However, some movement within the lower slope, both at the western and eastern valley slopes, is indicated by displaced trees that are not vertical. Sparse tall trees and smaller bush are present within the floodplain.

The surface topography at the crests of the valley are irregular and gently undulating. Numerous drainage gullies are present within the slope providing natural surface runoff drainage channels to the floodplain. Excavated pathways approximately 3 metres in width are also present both on the east and west side of the 16 Mile Creek extending from the top of the slope to the floodplain. These pathways, which were benched into existing slopes, were previously used as access routes to the floodplain.

Physiographically, the site is located within the geological domain known as the "South Slope". The South Slope is the southern slope of the Oak Ridges Moraine and also includes a strip south of the Peel Plain. The South Slope is predominantly a moraine till plain known as the Trafalgar Moraine in the site area, having been formed following the retreat of the Wisconsin ice sheet which covered the area during the Pleistocene epoch (over 12,000 years ago). Overburden, therefore, consists of unsorted, unstratified heterogeneous mixtures of clayey silts, sands and gravels of glacial till origin. At the site, the overburden has a thickness of up to approximately 13 metres.

The overburden is underlain by shale bedrock of the Queenston Shale Formation of the Upper Ordovician Period.

After deglaciation and draining of glacial lakes Lake Warren and the short lived Lake Peel north of the Trafalgar Moraine, stream erosion began. As a result, the overburden and bedrock were eroded producing the valley that presently exists at the 16 Mile Creek.

INVESTIGATION PROCEDURE

General

Physical and mechanical soil properties were obtained by in situ and laboratory testing. The site preparatory work, field and laboratory investigation and testing programs are summarized below.

Site Preparation

Environmental constraints and existing site conditions dictated the need for appropriate environmental consideration and site preparatory work. On March 5, 1992, a site meeting was conducted with external environmental agencies including the Ministry of Natural Resources and Halton Regional Conservation Authority and the internal Ministry of Transportation Environmental Unit. At that time, the various environmental concerns were raised and strategies developed to address these concerns and to mitigate damages to the environment during the field investigation. The fieldwork commenced once written authorization to proceed was given by the environmental authorities.

In order to access some boreholes located at the proposed two most easterly pier locations and a proposed retaining wall located in conjunction with the eastbound structure at the east abutment location, temporary access pathways were constructed employing a D3C dozer owned and operated by H & S Excavating. Temporary ramps were excavated into the existing slope at Boreholes B-14, B-15, B-16, B-21, B-23 and B-24 and a Caterpillar 416 Combination Backhoe was used to restore the slope. The temporary ramps were constructed transverse to the existing slope and temporary cut slopes at 0.5H:1V were protected using polyethylene polytarps. Drilling water discharge was controlled by placing a custom made cylindrical container with a spout connected to a hose concentric to the borehole. Bentonite was then placed around the perimeter of the container or reservoir at the ground surface. Straw bales were used as silt fences to retain the fines in the drilling fluid.

Any tree clearing was conducted by chainsaw cutting without root removal. Any disturbance to the baseflow channel was avoided throughout the investigation.

Field Investigation

The fieldwork for the investigation was carried out between 92 05 27 and 92 06 11 and consisted of a total of twenty two (22) sampled boreholes advanced to depths ranging from 4.1 metres to 18 metres and one test pit excavated to 1.6 metres. Two (2) track mounted drilling units, equivalent to CME 55 units, were used to advance the boreholes. Solid stem augering techniques were used to penetrate the overburden and the surficial weathered bedrock. Rock coring techniques employing BW casing and a BQ core barrel and NW casing and NQ core barrels were used to retrieve up to 7.6 metres of rock core.

The one test pit was advanced using a tire mounted Combination Backhoe to a depth of 1.6 metres.

Two boreholes were advanced within a ramp located within the existing slope excavated with the D3C dozer approximately 20 metres downslope of the proposed WBL abutment and most easterly EBL pier location. The purpose of retrieving this additional information was to determine the horizontal extent of the bedrock surface at this pier location and investigate any possible rock surface ridging. Bedrock was exposed within the excavated ramp and elevations of the bedrock surface were obtained.

At the locations where overburden overlies the bedrock, disturbed subsoil samples were retrieved employing a standard split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). Subsoil samples were generally retrieved at 0.7 m intervals for the surficial 6 metres or until bedrock was encountered and at 1.5m intervals beyond 6 metres within the overburden. Split spoon samples were also retrieved within the surficial metre or so of weathered shale.

All subsoil samples were identified in the field and then placed in sealed plastic jars to ensure the preservation of the natural moisture contents. Samples were subsequently transported to the laboratory and then classified employing both visual and laboratory methods as described below. Rock core were also identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD'S) and core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory for detailed rock core logging also discussed below.

Groundwater levels were determined by monitoring the levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevation of the individual boreholes and the bedrock surface elevations was provided by Central Region Surveys and Plans.

Laboratory Analyses

Subsoil samples were visually examined in the laboratory using procedures described in the MTO Soil Classification Manual. These procedures consist of estimating the particle size distribution of the material and conducting manual physical index property tests.

The visual examinations of the samples were combined with some laboratory testing on selected representative samples. Laboratory tests were carried out to define the behaviour, gradation and other physical properties of the soil and included:

- 1) Atterberg Limits
- 2) Grain Size Distributions
- 3) Natural Moisture Contents
- 4) Bulk Unit Weights

Laboratory tests were conducted in accordance with the respective procedures outlined in the MTO Laboratory Testing Manual and as described in Chapter 3 of the MTO Soil Classification Manual.

As mentioned earlier, detailed rock core logs were produced by an in-house resident geologist and "Rock Core Descriptions" for all rock core retrieved are contained in the Appendix to this report. The descriptions include rock colour, strength, jointing, bedding and composition.

Laboratory test results on subsoil samples have been summarized below in the subsequent section of this report entitled "Subsurface Conditions", and are illustrated on the corresponding boreholes and figures included in the Appendix of this report. Rock core recoveries and rock quality designations are summarized both in the Rock Core Descriptions and on individual borehole logs.

SUBSURFACE CONDITIONS

General

As the site geology and site conditions suggest, subsurface conditions consist of overburden comprised of a cohesive heterogeneous mixture of clayey silt, sand and gravel overlying shale bedrock. The thickness of the heterogeneous mixture of clayey silt, sand and gravel which is a moraine till of glacial origin varies from approximately 6.9m to 7.3m at the crest of the western ridge of the valley, and from approximately 1.6m to 13m along the slope and at the crest of the eastern ridge of the valley.

Within the floodplain, the overburden has either been completely eroded and hence exposed bedrock exists or only shallow thicknesses of the overburden ranging up to 4.6m is present. The thickness of the overburden is greater within proximity of the toe of the eastern slope (pier #4 location). A ridge approximately 1.5 metres high between piers #3 and #4 (see Dwg. 4068501/02-A) appears to represent the delineation between exposed bedrock and overburden overlying bedrock east of 16 Mile Creek.

The bedrock at the site is red shale with interbedded grey siltstone. The bedrock has been severely weathered for the surficial 2 to 3 metres at most locations across the site.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation, are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are provided on Dwg. 4068501/02-A also included in the Appendix. A detailed description of the subsurface conditions encountered is given below.

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

Overburden present at the site consists of a cohesive heterogeneous mixture of clayey silt, sand and gravel. This deposit of glacial till origin also contains boulders and cobbles as inferred by auger grinding during sample retrieval.

The thickness of this deposit varies across the site. Within the floodplain adjacent to the 16 Mile Creek, this material has been completely eroded (see BH's 4, 5 and 6) or is present in shallow thicknesses of 1.5 to 1.7 metres (see BH's 7 and 9). At boreholes 10, 11 and 12 located between proposed piers #3 and #4 (within proximity of the toe of the eastern valley slope), the deposit is thicker and is approximately 3.8m to 4.6m in thickness.

At the crests of the valley slopes, the deposit increases even further in thickness. At the top of the slope on the west side (proposed west abutment location, see BH's 1 and 3), the thickness of the deposit is approximately 6.9m to 7.3m. At the crest of the eastern slope, the thickness of the deposit varies between approximately 9.1 to 13 metres.

The thickness of the deposit decreased down the slope on the east side of the valley at the proposed pier structure location. Approximately 20 metres beyond the WBL abutment and proposed most easterly pier, the thickness is only approximately 1 to 1.5 metres.

The deposit has three (3) distinct colours at the crest of the valley slopes. The surficial 4.6m to 7.6m of the deposit has been oxidized and hence is brown in colour. Beneath the oxidized depth, the material is unoxidized and grey for a further thickness ranging from 1.5m to 6.8m. The grey material is then underlain by a reddish material which directly overlies the bedrock and in fact contains fragments of the red parent shale bedrock. The thickness of this lower red material is approximately 1.5 to 3 metres.

Within the floodplain, the heterogeneous mixture of clayey silt, sand and gravel has a reddish brown to red hue.

The main component of this unsorted, unstratified deposit is the clayey silt material. This material matrix essentially binds the coarser sands and gravels within the deposit. A grain size distribution envelope for the deposit as determined by mechanical sieve and

hydrometer analyses is given in Figure 1 in the Appendix. The envelope includes particle sizes up to 75mm (coarse gravel) and hence excludes the boulder and cobble sizes. The envelope reveals that the fine grained portions (less than 75 micrometres) contribute approximately 26% to 70% of this deposit.

Atterberg Limit Tests were carried out to define the behaviour and plasticity of the fine grained portion of the soil (less than 425 micrometres) and the results are plotted on Figure 2. A summary of the indices is provided in Table 1 below. Bulk unit weights and natural moisture contents are also included in the table.

Table 1 - Heterogeneous Mixture of Clayey Silt.
Sand and Gravel (Glacial Till)

	Range (%)	# of Tests
Natural Moisture Content ($w\%$)	6.5 - 18	19
Liquid Limit ($w_L\%$)	22 - 35	19
Plastic Limit ($w_p\%$)	13 - 20	19
Plasticity Index ($I_p\%$)	8 - 15	19
Bulk Unit Weight (kN/m^3), γ	18.9 - 23.3	12

The test results reveal that the fine grained portion of the deposit is of low plasticity and hence is classified as clayey silt. Natural moisture contents are generally close to the plastic limit of the soil indicating that the soil is in a plastic to semi-solid state.

Standard Penetration Tests (SPT) carried out in this deposit revealed 'N' values ranging from 21 blows/ 0.3m to 100 blows/ 0.1m. In general, 'N' values exceeded 30 blows/ 0.3m and hence the material can be categorized as having a hard consistency. The occasional 'N' value that was less than 30 blows/ 0.3m was encountered within the grey material and the 100 blow material was encountered within the red material overlying bedrock.

Bedrock

Bedrock across the site consists of shale with interbedded siltstone of the Queenston Shale Formation and exists at varying elevations. At the western and eastern crests of the valley , the bedrock exists at elevations 164.0m to 164.2m and 158.5 m to 160.9m respectively. Within the floodplain, the bedrock surface elevation varies from 133.7m to 136.0m. Within the investigated area of the upper eastern slope, the bedrock surface slopes or steps from an elevation of 162.1m to 152.0m. Bedrock surface profiles at the eastern slope are shown in the Appendix. Bedrock is exposed at many locations within the floodplain and vertical rock ridges are also present. The vertical rock ridges exposed along the western valley slope have shown signs of significant deterioration.

The upper surface of the bedrock surface has been severely weathered and degraded to the condition of existing as shale fragments within a hard clayey silt matrix. The boundary between this material and the overlying till is difficult to discern due to their similarity in composition and consistency. Both rock coring and solid stem augering techniques were used to penetrate the surficial weathered zone. Split spoon samples

were also retrieved albeit with considerable penetration resistance (typically greater than 100 blows/ 0.3m).

The thickness of the weathered zone ranges from 0.6m to 3.0m, but is underlain by more competent, sound and unweathered rock. This competent rock was explored for thicknesses of 1.5 to 3 metres.

The competence and integrity of the rock was assessed by physical observation and by core recovery and rock quality designation (RQD) measurement in situ. Full rock core recoveries were difficult to achieve within the weathered zone and recoveries as low as 47% were retrieved at some borehole locations. Rock Quality Designations within this weathered rock ranged from 0% to 10%, but were generally 0%.

Within the more competent rock, rock recoveries were generally between 90 and 100% and RQD's ranged from 19% to 100%. The lower RQD's within the unweathered rock may be a reflection of the drilling procedure rather than the actual quality of the rock. It was concluded during the field investigation that the water pump rate and core size significantly influence the RQD. Core recoveries and RQD's improved when the water pump rate was reduced and the core size increased from BQ to NQ. Hence, once these modifications were made, more representative rock core samples were retrieved and RQD's generally exceeded 50% indicating a fair to excellent rock quality. Rock quality generally improved with depth.

The shale bedrock is generally greyish red and has randomly interbedded greenish grey siltstone layers ranging from approximately 25mm to 200mm in thickness. The rock is horizontally bedded and is an extremely friable material with a very low slaking durability. The rock contains close to extremely close spaced fractures that are generally flat, planar to undulating and smooth.

Rock strength as determined by index property examination in the laboratory is generally weak to very weak.

A detailed description of the characteristics and properties of the rock as determined by the logging of the rock core in the laboratory is attached in the Appendix under the heading "Rock Core Descriptions".

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water level in the open boreholes throughout the duration of the field investigation. Particular attention was given to avoiding non representative water levels produced by the drilling water.

Within the floodplain area, water levels were generally at elevations corresponding to the water level present within the 16 Mile Creek. At the time of the investigation, water levels were approximately 1.5m to 3m below the ground surface, equivalent to elevations ranging from 137.5m to 133.3m. The higher water level elevation correspond to the

higher ground surface elevations at BH's 10, 11 and 12 located at proposed pier #4 closer to the toe of the existing slope.

Boreholes advanced at the top of the existing slopes revealed water levels at or below the bedrock surface. Within the ramps excavated in the eastern slope, water was not evident in the overburden, confirming a depressed water table.

At the west abutment, the water table was measured at 7.3m below the ground surface (Elevation 164.2m), an elevation corresponding to the bedrock surface.

At the east abutment location, the water table elevation was found to exist at a depth ranging from approximately 10.6 to 11.1 metres (approximate elevation 161 to 162 metres).

Groundwater levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a five (5) span beam type WBL structure and a six (6) span beam type EBL structure that will carry the Hwy 403 over the existing broad and deep 16 Mile Creek Valley. The westbound structure is approximately 319 metres in total length comprised of spans from west to east equivalent to 67m - 67m - 65m - 60m - 60m. The eastbound structure has a total length of approximately 364 metres comprised of spans from west to east equivalent to 67m - 67m - 65m - 60m - 60m - 45m. Sixteen Mile Creek will flow beneath the second span from the west. It is proposed that the west abutment of the WBL and EBL commence at Sta. 14+383.5 and Sta. 14+400.0 respectively.

Three pier foundation location (Pier's #1 to #3) exist within the floodplain of the 16 Mile Creek Valley. These piers will be approximately 30 metres in height. The fourth pier foundation location (Pier #4) is located within the toe of eastern slope. The EBL structure has a fifth pier within the eastern valley slope. Piers #4 and #5 will vary in height from approximately ten (10) to twenty (20) metres depending on the location of the pier on the existing slope. Abutment foundation locations are proposed at the crests of either valley slope.

The proposed grades of the structures are approximately 171m for the westbound and 170m for the eastbound structure. The existing ground surface is approximately 171 to 171.5m at the west abutment and varies from approximately 163m to 173.5m at the east abutment. Therefore, the proposed and existing grades are similar at the west abutment

whereas at the east abutment a combination of excavation cuts up to 3.5 metres and fills up to 7 metres will be required. The bridge decks have longitudinal gradients of 1.2% sloping downward in a westerly direction and also have transverse gradients sloping southwardly at 3.6%.

The proposed cross section for each structure is of an initial width of 14 metres with plans of a future 3.75 metre widening. An 11 metre distance between inside and outside edge of pavement with 1.5 metre shoulders have been planned for both structures. The structures are to be 13 metres apart. The substructure and piers are to be designed to accommodate the ultimate width of the structure.

A plan illustrating the proposed twin structures including the proposed structure foundation locations is shown on Dwg. 4068501/02-A in the Appendix. Proposed profile grades superimposed on the existing surface topography is also illustrated on the drawing. Stratigraphical sections at structure foundations are also included on Dwgs. 4068501/02-A&B.

Recommendations pertaining to the following foundation and geotechnical considerations are included in the purview of this report:

- 1) Structure Foundation
- 2) Approaches
- 3) Construction Considerations

STRUCTURE FOUNDATIONS

General

Recommendations for the design of the structure foundations are given below. Shallow foundations and/or deep foundations have been given depending on the subsurface conditions and the surface topography at each structure foundation location. In all cases, the foundation that produces the most economical and technically feasible design shall be selected.

It will be noticed that some borehole locations do not coincide with proposed footing locations. This is for the reason that foundation locations were revised subsequent to the initial investigation. Recommendations for the revised footing locations were derived from extrapolation/ interpolation of the nearest borehole information. Therefore it is strongly recommended that the subsoil/ rock conditions at the revised footing locations be inspected during construction to confirm the conditions at these locations.

PIERS

a) Piers on Spread Footings on Bedrock (Piers #1 and #2)

General

Piers #1 and #2 are situated immediately adjacent to the existing Sixteen Mile Creek within the floodplain where bedrock is either exposed or underlain by shallow thicknesses

of overburden. It is therefore recommended that piers #1 and #2 be supported by either shallow foundations or alternatively concrete caissons founded on sound, competent and unweathered bedrock. Founding elevations given in Table 2 and Table 3 below take into consideration the varying ground surface elevations at the proposed structure foundation locations and the extent of the weathered bedrock. The recommendations are applicable for both westbound and eastbound structures.

Shallow Foundations

Piers #1 and #2 can be supported by conventional spread footings founded directly on sound, unweathered bedrock as summarized in Table 2 below.

Table 2 - Spread Footings on Bedrock - Piers #1 and #2

Structure	Founding Elevation (m)	Factored Capacity at U.L.S (kPa)	Bearing Capacity at S.L.S Type II (kPa)
Pier #1	≤ 133	1500	N/A
Pier #2	≤ 133	1500	N/A

As indicated in Table 2, the bearing capacity at Serviceability Limit States is not applicable because the magnitude of pressure required to produce 25mm of total or differential settlement will exceed the factored capacity at Ultimate Limit States.

The capacities provided in Table 2 apply to normal vertical loads only. These capacities must be reduced to account for any load inclination. This reduction shall be carried out in accordance with Section 6-7.3.3.5 of the O.H.B.D.C.

All footings shall be located a minimum three (3) metres from the Sixteen Mile Creek bank and shall be protected from scour caused by any moving water attributable to any flood. Rip rap or rock protection as specified in OPSS 1004.05.06 can be used.

The computation of the sliding resistance of the foundation shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. An unfactored friction angle of 26° can be used between the concrete and the sound bedrock. Additional sliding resistance can be obtained by employing rock dowels or anchors beneath the footing into the sound bedrock. Dowels or anchors consisting of dwydag bars installed and grouted in holes drilled beneath the founding elevation. An unconfined compressive strength of 10,000 kPa and a unit weight of 22 kN/m^3 can be used to compute the lateral capacity provided by the dowels or anchors. Dowels or anchors shall be designed as permanent members and hence adequately protected against long term corrosion.

Shale bedrock is inherently friable and has a low slaking durability. Shale is particularly susceptible to degradation caused by wet-dry cycles and any significant construction traffic. To preserve the integrity of the sound rock, it is therefore recommended that a minimum 100mm thick layer of lean concrete working slab be placed on the shale

bedrock within 4 hours of exposure. The foundation base shall be free of any softened or disturbed zones prior to the placement of the working slab. Any weak and weathered layers of rock exposed at the founding elevation shall be removed.

The shale bedrock should be regarded as frost susceptible and hence adequate cover shall be provided. The frost penetration depth at the site is 1.2m and hence a minimum soil cover of 1.2 metres or equivalent frost protection shall be provided. Special care and adequate protection during winter construction shall be provided to ensure that the founding bedrock is not subjected to freezing.

Deep Foundations

Alternatively, piers #1 and #2 can be supported on concrete caissons installed in drilled shafts using the end bearing capacities tabulated in Table 3 below. The capacities provided are applicable to caisson diameters of 0.76m but capacities for other caisson diameters can be obtained in proportion to the respective end bearing areas. The capacity is based on an ultimate capacity of 3500 kPa. In order to satisfy the definition of deep foundation unit, the caisson must have a minimum embedment such that the D/B ratio exceeds 2, where D is the embedment depth taken from the frost penetration depth and B is the caisson diameter.

Table 3 - Axial Capacities - Concrete Caissons

Structure	Caisson Diameter (m)	Factored Axial Capacity at U.L.S. (kN)	Axial Capacity at S.L.S. Type II (kN)	Caisson Bottom Elevation (m)
Piers #1 & #2 (WB & EB)	0.76	1600	N/A*	≤133

* The axial capacity at S.L.S. Type II will not govern the foundation design because the bedrock is considered as an unyielding material and consequently the load required to produce 25mm of settlement will exceed the factored axial capacity at the U.L.S.

The proposed method of caisson installation shall be in accordance with OPSS 903.07.03 and subject to review by this office.

Axial capacities provided in Table 3 are for vertical piles only. Reductions of axial capacities for inclined loadings shall conform to factors provided in Section 6-8.3.4.3 of the O.H.B.D.C. Pile spacing shall conform with Section 6-8.3.10 of the O.H.B.D.C. For centrally loaded piles, equal load sharing on the deep foundation units can be assumed. The design of eccentric loaded deep foundation units shall comply with Section 6-8.3.4.2 of the O.H.B.D.C.

The lateral resistance for both vertical and battered piles shall be computed in accordance with Section 6-8.3.8 of the O.H.B.D.C. Pertinent unfactored soil/ rock parameters to facilitate the design of the lateral pile capacity of vertical piles have been provided in

Table 4. Concrete caissons can be installed in inclined holes, but construction limitations restrict the batter to 1H:4V.

Table 4 - Horizontal Capacity Design Parameters - Piers #1 & #2

Rock	Elevation (m)	Unconfined Compressive Strength (kPa)	Unit Weight (kN/m ³) (γ)
Weathered Shale	> 133	1,000	20
Unweathered Shale	\leq 133	10,000	22

b) Piers #3 and #4

General

The ground surface elevation at the proposed piers #3 and #4 located approximately 30 metres beyond the toe of the eastern valley slope varies from approximately 139m to 140m, some 4 metres higher than the elevation at piers #1 and #2 located adjacent to the Sixteen Mile Creek. At pier #4 encroachment into the toe of the slope is required. Ground surface elevations range from approximately 140m to 145m. Structure

foundations can be founded on either spread footings or deep foundations as described below.

Shallow Foundations

Foundations for piers #3 and #4 can be supported on conventional shallow foundations founded within the competent heterogeneous mixture of clayey silt, sand and gravel deposit as summarized in Table 5 below.

Table 5 - Spread Footings on Native Soil - Piers #3 & #4

Structure	Founding Elevation (m)	Factored Capacity at U.L.S (kPa)	Bearing Capacity at S.L.S Type II (kPa)
Westbound	≤ 138.3	675	450
Eastbound	≤ 138.3	525	350

Settlements induced as a result of the applied pressures tabulated in Table 5 will be due to the recompression of the founding soil and elastic in nature. These settlements will occur during or immediately following construction and are anticipated to be within 25mm total or differential.

Similar to spread footings on bedrock, the capacities provided in Table 5 apply to vertical loads only. These capacities must be reduced to account for any load inclination. This reduction shall be carried out in accordance with Section 6-7.3.3.5 of the O.H.B.D.C.

The computation of the sliding resistance of the foundation shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. An unfactored friction angle of 30° can be used between the concrete and the native heterogeneous mixture of clayey silt, sand and gravel. If additional sliding resistance is required, consideration can be given to employing shear keys into the native soil or dowels into the rock. Parameters to facilitate the calculation of the horizontal capacity of these additional sliding resistance methods are given in Table 6 below.

Table 6 - Horizontal Capacity Design Parameters- Piers #3 & #4

Soil/ Rock	Elevation (m)	Angle of Internal Friction (ϕ)	Unconfined Compressive Strength (kPa)	Unit Weight (kN/m^3) (γ)
Clayey Silt (Till)	138.3 - 135	30°	350	21
Weathered Shale	135 - 134	N/A	1,000	20
Unweathered Shale	< 134	N/A	10,000	22

Dowels or rock anchors shall be designed as permanent members as discussed previously in conjunction with spread footings on bedrock.

The founding soil shall be protected against deterioration caused by weathering and construction related activities. A 100mm thick layer of lean concrete working slab should be placed on the native soil at the founding elevation within 4 hours of exposure. The

foundation base shall be free of any softened or disturbed material prior to the placement of the working slab.

The founding soil shall be protected against frost penetration. Consequently, all footings must have a minimum 1.2m of earth cover or equivalent frost protection.

A temporary shoring scheme shall be designed to facilitate the construction of spread footings at the toe of the slope to safeguard against any slope instability. A timber lagging-soldier pile shoring wall is recommended. Soldier piles can be installed in preaugered holes. The wall can be designed assuming it is supporting the heterogeneous mixture of clayey silt, sand and gravel with an angle of internal friction (ϕ) equal to 30° and a bulk unit weight of 21 kN/m^3 . If required, rock anchors or rakers can be used to support the wall. The rock anchors shall be found in competent, unweathered rock (approximately Elevation 135 m) and can be designed using a rock-grout bond stress of 100 kPa. Rakers can be founded on spread footings within the clayey silt till deposit using the parameters tabulated in Table 5.

b) Deep Foundation

Alternatively, piers #3 and #4 can be founded on deep foundation units end bearing on sound, competent bedrock at elevation 134m. Deep foundation units can consist of either concrete caissons or steel H-piles driven into preaugered holes. Driven steel H-piles through the overburden and the weathered shale are not considered feasible at the

proposed pier location because of the difficulty anticipated penetrating layers of the hard glacial till deposit and the fact that the weathered shale contains random layers of unweathered rock. The resistance provided by hard layers of glacial till will in addition restrict the embedment length of the pile such that minimum pile lengths of 3 metres are not satisfied. The minimum pile length is needed to achieve any lateral rigidity.

Concrete caissons can be installed in drilled shafts and designed using the end bearing capacities tabulated in Table 7 below. The capacities provided are applicable to caisson diameters of 0.76m but capacities for other caisson diameters can be obtained in proportion to the respective end bearing areas.

Table 7 - Axial Capacities - Concrete Caissons

Structure	Caisson Diameter (m)	Factored Axial Capacity at U.L.S. (kN)	Axial Capacity at S.L.S. Type II (kN)	Caisson Bottom Elevation (m)
Pier #3 (WB & EB)	0.76	1600	N/A*	134

* The axial capacity at S.L.S. Type II will not govern the foundation design because the bedrock is considered an unyielding material and consequently the load required to produce 25 mm of settlement will exceed the factored axial capacity at the U.L.S.

The proposed method of caisson installation shall be in accordance with OPSS 903.07.03 and subject to review by this office.

Consideration can also be given to driving piles into preaugered holes. The advantage of this type of foundation is that a smaller diameter hole can be augered to facilitate the installation (i.e. 0.35m versus 0.76m). For purposes of the O.H.B.D.C., the design axial capacities for vertical piles driven in preaugered holes to the sound competent bedrock surface at Elevation 134m is given in Table 8 below.

Table 8 - Axial Capacities - Driven Steel H-Piles in Preaugered Holes

Pile Type	Factored Capacity at U.L.S. (kN)	Axial Capacity at S.L.S. Type II (kN)
HP 310x110	1600	1150

It is recommended that a layer of fresh concrete, a minimum of 1m thick, be placed in the bottom of the hole prior to driving the pile. The concrete should seal the bedrock surface and prevent the deterioration of the bedrock. Obviously, the piles must be driven before the concrete hardens.

Axial capacities provided in Tables 7 and 8 are for vertical piles only. Reductions of axial capacities for inclined loadings shall conform to factors provided in Section 6.8.3.4.3 of the O.H.B.D.C.

Pile spacing shall conform with Section 6.8.3.10 of the O.H.B.D.C. For centrally loaded piles equal load sharing on the deep foundation units can be assumed. The design of eccentric loaded deep foundation units shall comply with section 6.8.3.4.2 of the O.H.B.D.C.

The lateral resistance for both vertical and battered piles shall be computed in accordance with Section 6-8.3.8 of the O.H.B.D.C. Pertinent unfactored soil/ rock parameters to facilitate the design of the lateral pile capacity of vertical piles have been provided in Table 6. Horizontal capacities are applicable only to installations where the annulus of the preaugered hole has been filled with concrete.

Concrete caissons can be installed in inclined holes, but construction limitations restrict the batter to 1H:4V.

Pier #5 - EBL Structure

General

Pier #5 for the eastbound structure is located amidst the existing natural slope at the site. The foundation investigation revealed that the bedrock surface within the slope decreases in elevation both parallel and perpendicular to the proposed foundation. The foundation design must therefore consider the sloping surface.

Foundation

Deep foundation units consisting of either concrete caissons installed into drilled shafts or steel H-piles driven into preaugered holes are recommended. It is absolutely prudent that the piles be socketed sufficiently into the bedrock and hence driven steel H-piles are not considered suitable foundations. Table 9 below provides the recommended tip elevation for either foundation type. The axial capacities and design and construction criteria previously specified for the deep foundation units for piers #3 and #4 (eg. inclined loadings, pile spacing) are equally applicable for pier #5. The axial capacities are given in Tables 7 and 9 for concrete caissons and steel H piles driven into preaugered holes respectively.

Table 9 - Caisson/ Steel H-pile (Augered Hole) Tip Elevations

Structure	Tip Elevation (m)
Eastbound	150.5

Horizontal capacities shall be computed in accordance with Section 6-8.3.8 of the O.H.B.D.C. Parameters to facilitate the computation of the horizontal capacity of the deep foundation units are given in Table 10 below.

Table 10 - Horizontal Capacity Design Parameters - Pier #5

Structure	Rock	Elevation (m)	Unconfined Compressive Strength (kPa)	Unit Weight (kN/ m ³) (γ)
EASTBOUND	Weathered Shale	N/A	N/A	N/A
	Unweathered Shale	< 152	10,000	22

ABUTMENTS

General

Both the west and east abutments are situated at the crest of existing native slopes comprised of a cohesive heterogeneous mixture of clayey silt, sand, and gravel for thicknesses of approximately 7 metres at the west abutment and 12 to 13 metres at the east abutment overlying shale bedrock with interbedded siltstone. The ground surface elevations at the west abutment varies from approximately 170.9m to 171.5m and at the east abutment from 170.7m to 173.5m.

Foundation design, therefore, must be carried out considering this existing slope. Shallow and deep foundation (driven steel H-piles, concrete caissons, steel H-piles in augered holes) alternatives have been given and are discussed below. In the case of spread footings and driven steel H-piles it is recommended that the edge of the foundation be positioned a minimum three (3) metres from the crest of the slope with 2H:1V forward

earth slopes as discussed below. The practicality of satisfying this criteria must be assessed. Furthermore, forward slopes shall be provided with a surface erosion scheme also described later in the report. Concrete caissons shall be socketed a minimum one metre into sound bedrock.

Shallow Foundations

Abutment foundations can be supported on conventional shallow foundations founded within the competent heterogeneous mixture of clayey silt, sand and gravel deposit as summarized in Table 11 below. The bearing capacities tabulated in Table 11 are applicable to those foundations that satisfy the three (3) metre edge distance and 2H : 1V geometry mentioned above and as illustrated in Figure 3 in the Appendix.

Table 11 - Spread Footings on Native Soil - Abutments

Structure	Founding Elevation (m)	Factored Capacity at U.L.S (kPa)	Bearing Capacity at S.L.S Type II (kPa)
West Abutment	≤ 167.6	750	500
East Abutment			
- Westbound Structure	> 170	600	400
	$< 170-167$	450	300
- Eastbound Structure	169-167	750	500

Table 11 provides a range of founding elevations that includes a minimum to account for the frost penetration depth of 1.2 metres and also a maximum depth which is considered

feasible and economical. The bearing capacities also account for weaker material present between elevations 167m and 162m at the Westbound east abutment structure. Foundation capacities are hence applicable only within the range of elevations tabulated.

Settlements induced as a result of the applied pressures tabulated in Table 11 will be due to the recompression of the founding soil and elastic in nature. These settlements will occur during or immediately following construction and are anticipated to be within 25mm total or differential.

The capacities provided in Table 11 apply to vertical loads only. These capacities must be reduced to account for any load inclination. This reduction shall be carried out in accordance with Section 6-7.3.3.5 of the O.H.B.D.C.

The computation of the sliding resistance of the foundation shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. An unfactored friction angle of 30° can be used between the concrete and the native heterogeneous mixture of clayey silt, sand and gravel. Additional sliding resistance can be provided by constructing shear keys into the native soil using an unfactored friction angle of 30° and a unit weight of 21 kN/m^3 to compute the passive resistance of the shear key.

The founding soil shall be protected against deterioration caused by weathering and construction related activities by constructing a 100mm thick lean concrete working slab at the founding elevation within 4 hours of exposure. The foundation base shall be free of any softened or disturbed material prior to the placement of the working slab.

Deep Foundations

Alternatively, abutment foundations can be founded on deep foundation units end bearing on bedrock. Deep foundation units can consist of:

- (a) drilled caissons
- (b) steel H-piles driven in
preaugered holes

(a) Concrete Caissons

Concrete caissons can be installed in preaugered holes drilled to sound, competent bedrock at elevations give in Table 12 below. Axial capacities of the concrete caissons are also given below in Table 12 for caisson diameters of 0.76m, but as described earlier in this report, other caisson diameters can be used with proportional end bearing capacities. Reductions of the axial capacities for inclined loadings shall conform to factors provided in Section 6.8.3.4.3 of the O.H.B.D.C.

Table 12 - Axial Capacities - Concrete Caissons

Structure	Caisson Diameter (m)	Factored Axial Capacity at U.L.S. (kN)	Axial Capacity at S.L.S. Type II (kN)	Caisson Bottom Elevation (m)
West Abutment	0.76	1600	N/A*	161
East Abutment				
- Westbound	0.76	1600	N/A*	158
- Eastbound	0.76	1600	N/A*	155.5

* The axial capacity at S.L.S. Type II will not govern the foundation design because the bedrock is considered as an unyielding material and consequently the load required to produce 25mm of settlement will exceed the factored axial capacity at the U.L.S.

The lateral resistance for both vertical and battered caissons shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C. Pertinent unfactored soil/ rock parameters to facilitate the design of the lateral pile capacity are given in Table 13 below. It is recommended that in order to achieve any horizontal resistance, the deep foundation be embedded into the bedrock such that the foundation is positioned a minimum three (3) metres from an imaginary 45° line projected from the crest of the slope as illustrated in figure 4 in the Appendix.

Table 13 - Horizontal Capacity Design Parameters (Abutments)

Soil/ Rock	Elevation (m)	Unconfined Compressive Strength (kPa)	Unit Weight (kN/m ³) (γ)
i) West			
Clayey Silt Till	> 164.5*	500	21
Weathered Shale	164.5-162	1,000	20
Unweathered Shale	< 162	10,000	22
ii) East			
<u>Westbound</u>			
Clayey Silt Till	> 160.5*	400	21
Weathered Shale	160.5-159	1,000	20
Unweathered Shale	< 159	10,000	22
<u>Eastbound</u>			
Clayey Silt Till	> 159*	500	21
Weathered Shale	159-156.5	1,000	20
Unweathered Shale	< 156.5	10,000	22

* exclude frost penetration depth.

Concrete caissons can be installed in inclined holes, but as discussed previously are restricted to a 1H:4V batter.

(b) Steel H-piles Driven into Preaugered Holes

As recommended for piers #4 and #5, the abutments can be founded on steel H-piles driven into preaugered holes. Should this design be adopted, axial capacities given for the steel H-piles (see Table 8) and the end bearing elevations given for the caisson option in Table 12 (i.e. sound bedrock) can be employed.

Horizontal capacities can be computed in accordance with section 6.8.3.8 of the O.H.B.D.C. using the parameters given in Table 13.

Reinforced Earth Abutment Walls

Consideration can be given to employing reinforced earth abutment walls, should this option prove to be an economical alternative. The levelling pads can be founded on the native surficial heterogeneous mixture of clayey silt, sand, and gravel using the bearing capacities previously recommended for the shallow foundations on the native soil (see Table 11) or alternatively deep foundation units, also previously discussed. Reinforced earth abutment walls shall also be positioned a minimum 3 metres distance from the slope.

Some subexcavation may be required to facilitate the installation of the reinforcement strips. This must be considered in evaluating the cost effectiveness of the reinforced earth wall.

One of the main technical advantages of the reinforced earth wall module is its ability to resist horizontal forces. This advantage is particularly valuable when constructing walls adjacent to slopes where horizontal resistance offered by conventional foundations may be limited.

A Non-Standard Special Provision (NSSP) shall be included in the contract documents that addresses the supply and installation of the reinforced earth module.

RETAINING WALL

A retaining wall has been proposed perpendicular to the east abutment of the eastbound structure. A drainage gully and a sloping topography at this location has dictated the need for this retaining wall. In view of the sloping terrain at and adjacent to the proposed retaining wall, it is recommended that deep foundations consisting of augered concrete caissons or steel H-piles driven into preaugered holes be used to support the retaining wall. The axial capacities and design and construction criteria previously specified in this report are equally applicable for the retaining wall. The axial capacities are given in Tables 7 and 8 for concrete caissons and steel H piles driven into preaugered holes respectively. The recommended end bearing tip elevation is 153.0m

In the computation of the deep foundation units at the proposed retaining wall location, consideration must be given to the sloping surfaces present. It is recommended that in order to achieve any horizontal resistance, the deep foundation be embedded into the

bedrock such that the foundation is positioned a minimum three(3) metres from an imaginary 45° line projected from the crest of the slope as illustrated in Figure 4 in the Appendix.

The horizontal capacity shall be computed in accordance with Section 6-8.3.8 of the O.H.B.D.C. Parameters to facilitate the computation of the horizontal capacity of the deep foundation units are given in Table 14 below. The parameters provided in Table 14 apply ONLY to deep foundation units that satisfy the three (3) metre edge distance criteria.

Table 14 - Horizontal Capacity Design Parameters
Retaining Wall @ East Abutment
(Eastbound Structure)

Soil/ Rock	Elevation (m)	Unconfined Compressive Strength (kPa)	Unit Weight (kN/ m ³) (γ)
Clayey Silt (Till)	165-160	400	21
	160-156.5	1000	21
Weathered Shale	156.5-154	1000	20
Unweathered Shale	< 154	10,000	22

carried out using an in-house MTO slope application software package which is based on Sarma's method of limiting equilibrium. The formulation of Sarma's method is described in a paper entitled "Stability Analysis of Embankments and Slopes", Sarma, S.K. (1973), Geotechnique 23, No. 3, pp. 423-433.

The process of stability analyses involves the selection of pertinent shear strength parameters and physical soil properties such as unit weight, inputting the subsurface and groundwater conditions and then designing a surface geometry that produces an acceptable factor of safety of 1.3 using the MTO slope program.

Figure 5 in the Appendix illustrates the subsurface conditions and relevant subsoil parameters used in the stability analyses. In all cases, circular slip surfaces were evaluated and a critical slip surface was searched. Based on the results of the analyses, it is recommended that the river banks be cut to 2H:1V within the earth overburden (Elevation 164 and above at the west abutment; Elevation 160 and above at the east abutment). Below these elevations, it is recommended that the slopes remain unchanged and left at the existing natural slopes. It is further recommended that the existing tree cover be preserved to ensure the stability of the existing slopes.

Surface erosion protection shall be established on the slopes as soon as possible as per conventional MTO standards. Should conventional concrete pavers not be considered feasible at the site, a natural material such as rock protection or alternatively a synthetic

revetment material can be considered. Various proprietary surface erosion products are available in the market. Additional information regarding these products can be obtained from this office. Surface runoff water shall be appropriately controlled at the toe of the slope.

Approach Fills

i) Backfill to Structures

It is recommended that to prevent hydrostatic pressure build-up on the abutment and retaining walls, backfill material against the retaining wall consist of Granular "A" or Granular "B". Design parameters of the soil are given in Table 15 below. Weep holes should also be designed in the walls to facilitate drainage.

Table 15 - Backfill Properties

	Granular "A"	Granular "B"
Unfactored Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m ³), γ	22.8	21.2
Coefficient of Earth Pressure at Rest (K_0)* - S.L.S. Type II - U.L.S.	0.43 0.51	0.50 0.58
Coefficient of Active Earth Pressure (K_a)* - S.L.S. Type II - U.L.S.	0.27 0.35	0.33 0.41

* Horizontal surface backfill only.

Granular backfill geometries are illustrated on OPSD 800 series. The backfill beyond the granular wedge as illustrated on the OPSD drawings can consist of acceptable borrow material as defined in OPSS 212.05.

The earth pressure coefficient at rest is to be used in design if the abutment/ retaining walls are rigid and unyielding.

ii) Transverse Slopes

As discussed previously, embankment fills up to approximately 8 metres will be required at the south side of the east abutment of the eastbound structure. A retaining wall has presently been proposed to retain this soil. Alternatively, transverse slopes may be considered. In view of the competent nature of the subsoil, no deep seated stability problems are anticipated and any settlement will be the result of movement within the fill itself. This settlement is expected to be within 25mm and should be realized during or immediately following construction. The fill material shall be benched into the existing native slope in accordance with OPSD 208.01.

It is cautioned, however, that the slopes must be protected in addition to the conventional surface erosion vegetation cover with rip rap or equivalent if any gulleying activity is expected. A gulley already exists in this area.

CONSTRUCTION CONSIDERATIONS

1. Dewatering

No major dewatering difficulties are anticipated during the excavation and construction of the structure foundations within the native heterogeneous mixture of clayey silt, sand and

gravel and/ or the shale bedrock. Any localized seepage or surface runoff can be readily discharged from spread footing excavations or preaugered holes employing conventional sump pump techniques. Discharge of water within the floodplain must satisfy applicable environmental regulation.

2. Founding Material Inspection

The foundation base material shall be inspected in accordance with OPSS 902.07.020.01 (Excavation for foundations) and OPSS 903.08.02 (Caissons) to ensure its quality. Any weathered or softened material must be removed and replaced with mass concrete.

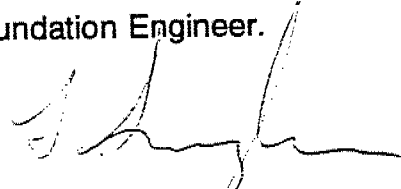
3. Temporary Excavation

Any temporary excavation within the native heterogeneous mixture of clayey silt, sand and gravel shall be carried out at 1.5H:1V slopes. Within the weathered bedrock, temporary excavations shall be carried out no steeper than 1H:1V.

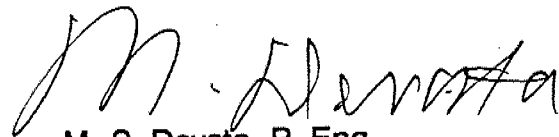
MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer and L. Dametto Engineering Student, utilizing equipment owned and operated by Master Soils Investigation.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by Mr. M. S. Devata, Chief Foundation Engineer.



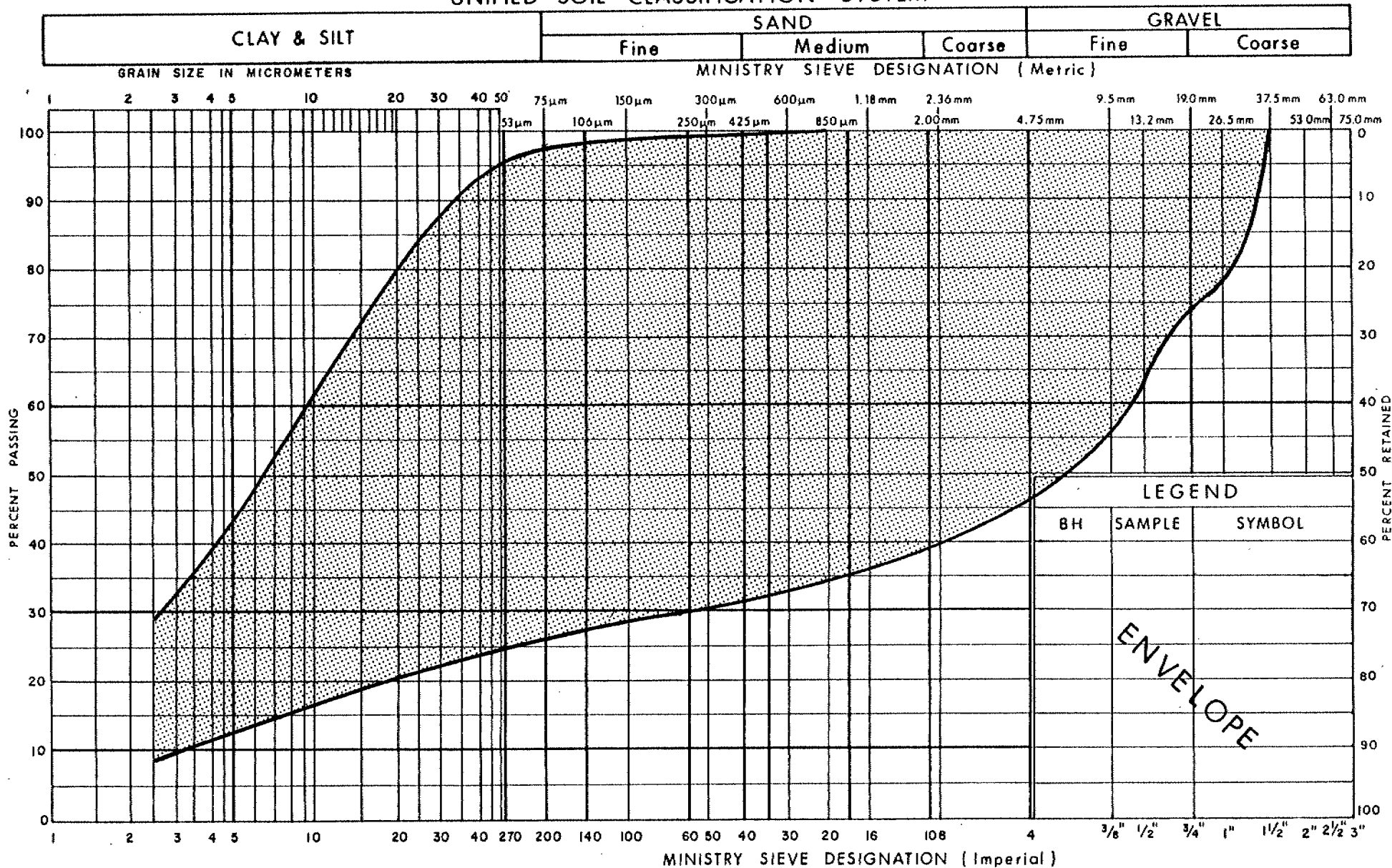
T. Sangiuliano, P. Eng.
Foundation Engineer



M. S. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

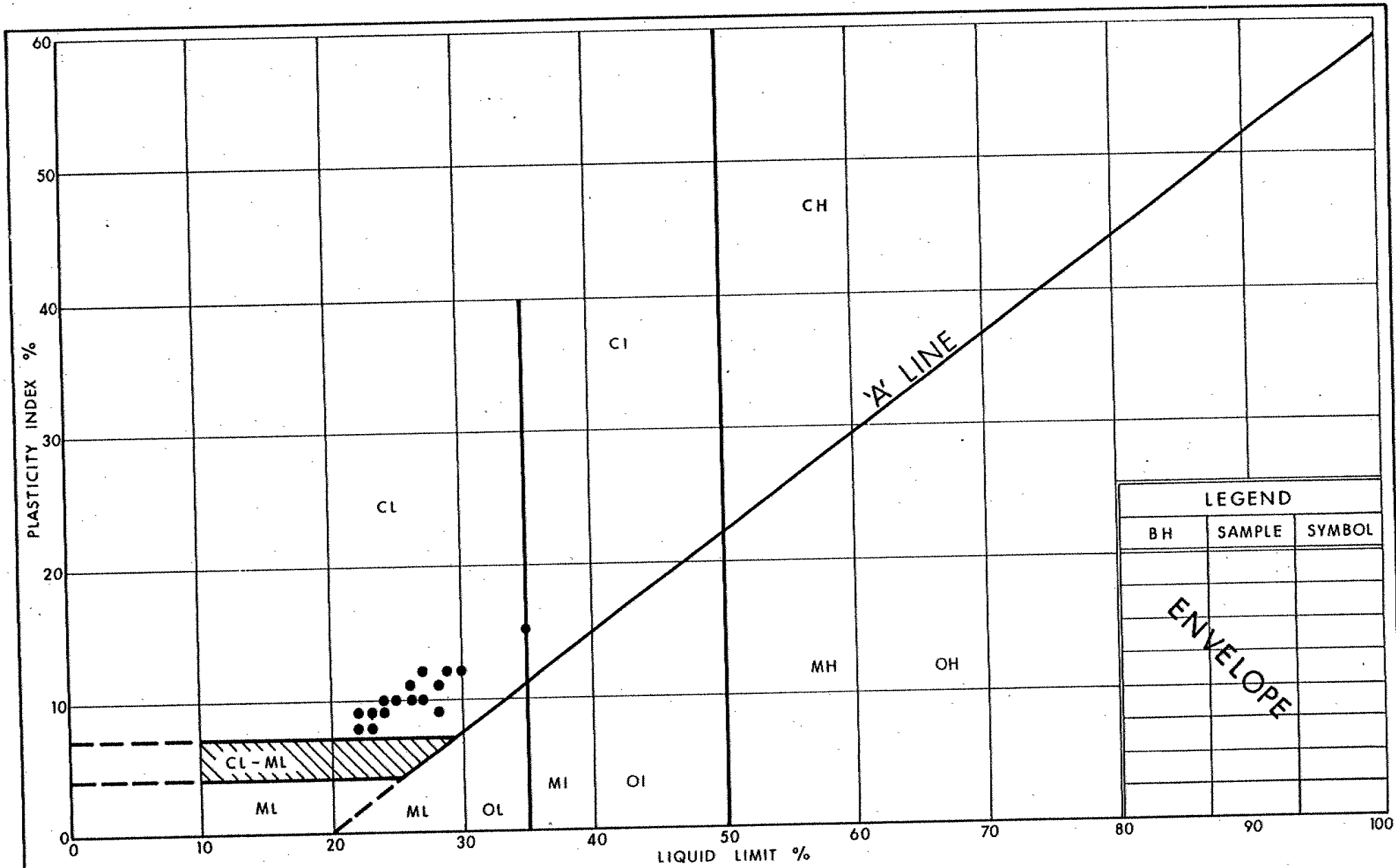


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GRAIN SIZE DISTRIBUTION
HET MIXTURE OF CLAYEY SILT,
SAND & GRAVEL (Glacial Till)

FIG No 1

W P 406 - 85 - 01 / 02

Ministry of
Transportation

PLASTICITY CHART
HET MIXTURE OF CLAYEY SILT,
SAND & GRAVEL (Glacial Till)

FIG No 2

W P 406-85-01/02

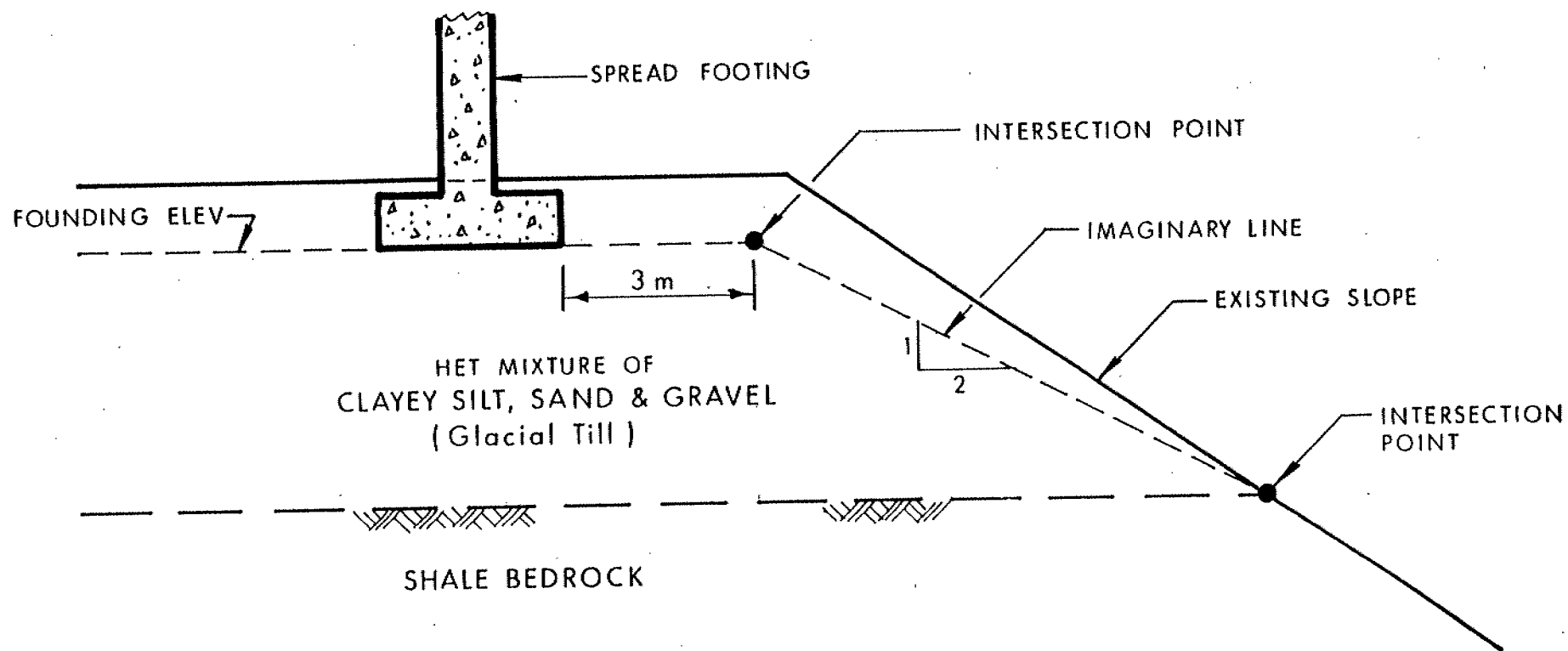


Figure 3 - SPREAD FOOTINGS ADJACENT TO SLOPES

NOT TO SCALE

Hwy 403 Dist 4

WP 406-85-01/02

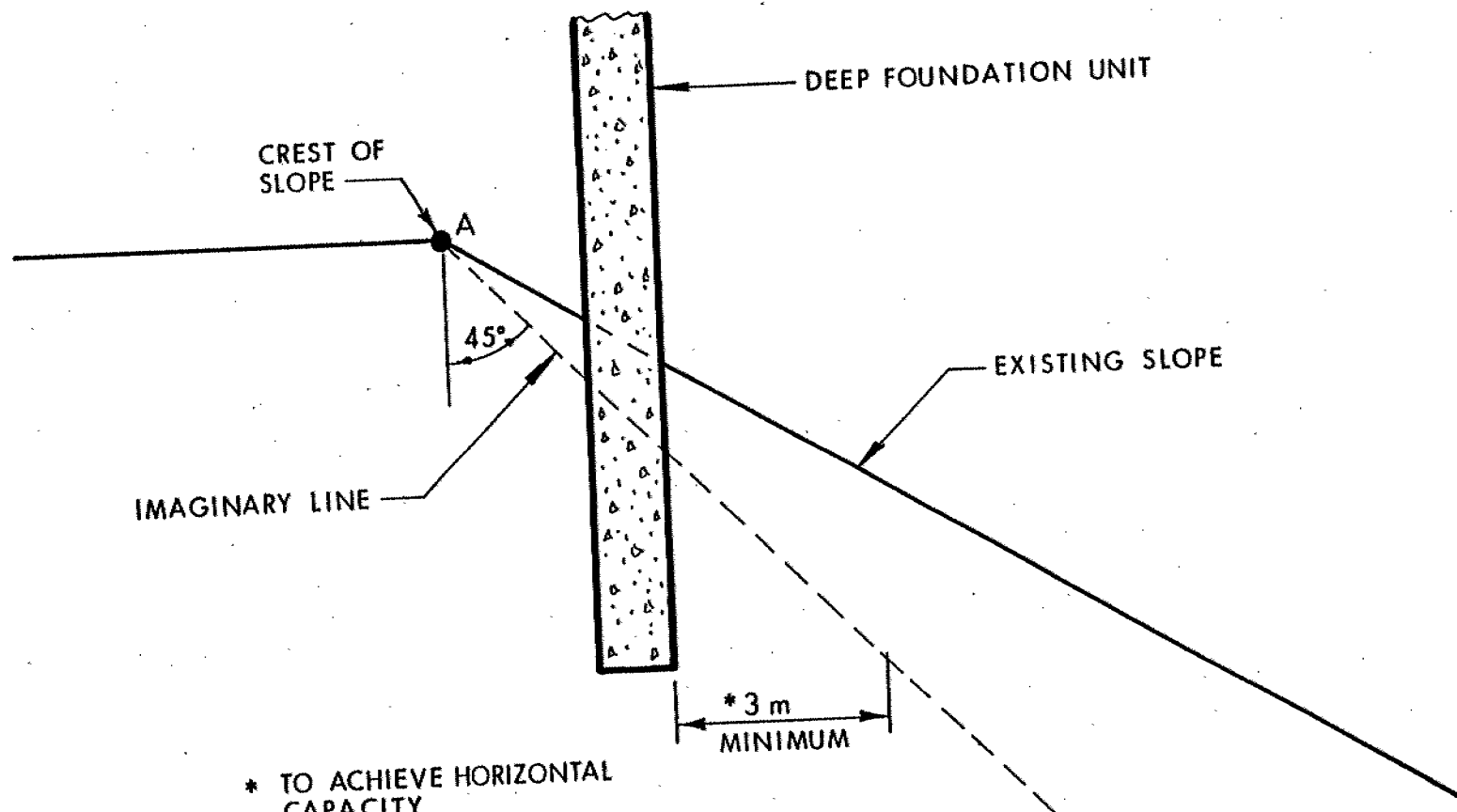


Figure 4 - HORIZONTAL CAPACITY OF
DEEP FOUNDATION UNITS LOCATED ON SLOPES

NOT TO SCALE

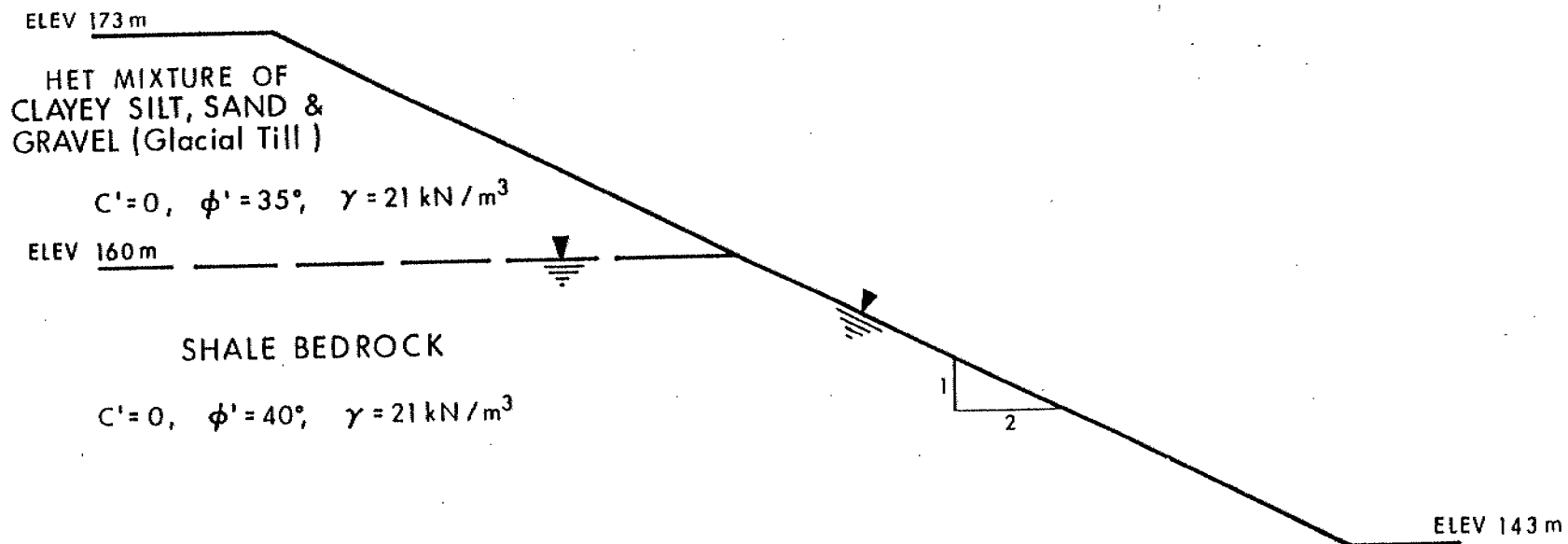


Figure 5 - SLOPE STABILITY ANALYSES

NOT TO SCALE

Hwy 403 Dist 4
WP 406-85-01/02

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No B-1

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 763.5 E 281 709.3 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, BW Casing, BQ Rock Core COMPILED BY TS
DATUM Geodetic DATE 92 05 27 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W _P	W	W _L		
170.9	Ground Surface															
0.0																
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	43											
	Hard		2	SS	60											
			3	SS	68											
			4	SS	70											
			5	SS	62											
			6	SS	57											
	Brown		7	SS	50											
	Grey		8	SS	100	/10cm										
	Red		9	SS	100	/10cm										
164.0			10	SS	100	/10cm										
6.9	Weathered		11	RC	REC 90%											RQD = 22%
	Unweathered		12	RC	REC 94%											RQD = 43%
	Shale Bedrock with interbedded Siltstone		13	RC	REC 97%											RQD = 68%
	Red with interbedded Grey. Weak to Very Weak															
158.7																
12.2	End of Borehole * GWL not established															

RECORD OF BOREHOLE No B-3

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 765.4 E 281 751.5 ORIGINATED BY LD
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Rock Core COMPILED BY TS
DATUM Geodetic DATE 92 05 27 CHECKED BY PP

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
171.5	Ground Surface																
0.0																	
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	36												
	Hard		2	SS	45												
			3	SS	52												
			4	SS	61												
			5	SS	47												
	Brown		6	SS	56												
	Grey		7	SS	30												
			8	SS	103												
	Red		9	SS	100												
164.2			10	SS	100												
7.3																	
	Weathered		11	RC	REC 98%												
	Unweathered		12	RC	REC 100%												
	Shale Bedrock with interbedded Siltstone		13	RC	REC 100%												
	Red with interbedded Grey, Weak to Very Weak																
157.6																	
13.9	End of Borehole • 92 06 08																

RECORD OF BOREHOLE No B-4

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 832.6 E 281 723.7 ORIGINATED BY LD
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, BW Casing, BQ Rock Core COMPILED BY TS
DATUM Geodetic DATE 92 05 27-28 CHECKED BY PP



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			20	40	60	80	100					
136.0	Ground Surface																
0.0	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak Weathered ----- Unweathered		1	SS	21												
			2	SS	100												
			3	RC	REC 47%												RQD = 0%
			4	RC	REC 85%												RQD = 0%
			5	RC	REC 100%												RQD = 63%
			6	RC	REC 85%												RQD = 35%
128.4	End of Borehole * 92 05 28																

RECORD OF BOREHOLE No B-5

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 828.1 E 281 743.8 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Rock Core COMPILED BY TS
 DATUM Geodetic DATE 92 05 28 CHECKED BY PP

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			20 40 60 80 100					W _p W W _L						
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100					WATER CONTENT (%) 10 20 30						
135.9	Ground Surface																		
0.0	Weathered ----- Unweathered Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		1	SS	18		134												
2			RC	REC 93%														RQD = 48%	
3			RC	REC 95%															RQD = 65%
4			RC	REC 98%															RQD = 90%
130.6																			
5.3	End of Borehole • 92 05 29																		

RECORD OF BOREHOLE No B-6

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 833.3 E 281 765.9 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Rock Core COMPILED BY TS
 DATUM Geodetic DATE 92 05 27-28 CHECKED BY PP

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					10 20 30				
134.8	Ground Surface																
0.0																	
			1	SS	100	/10cm	134										
			2	SS	90	/15cm											
	Weathered ----- Unweathered																
	Shale Bedrock with interbedded Siltstone		3	RC	REC 95%		132								RQD = 93%		
	Red with interbedded Grey, Weak to Very Weak		4	RC	REC 100%										RQD = 73%		
			5	RC	REC 99%		130								RQD = 99%		
128.9																	
5.9	End of Borehole																
	• 92 05 29																

RECORD OF BOREHOLE No B-7

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 911.0 E 281 742.7 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Rock Core COMPILED BY TS
 DATUM Geodetic DATE 92 05 29 CHECKED BY PP

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			20	40	60	80	100					
135.4	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Red, Hard						134										
133.7			1	SS	38												
1.7	Weathered Unweathered		2	SS	100	/15cm											
			3	RC	REC 94%		132										RQD = 63%
	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		4	RC	REC 76%												RQD = 19%
			5	RC	REC 77%		130										RQD = 50%
129.0																	
6.4	End of Borehole • 92 06 01																

RECORD OF BOREHOLE No B-9

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 910.3 E 281 784.9 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Rock Core COMPILED BY TS
DATUM Geodetic DATE 92 05 29 CHECKED BY PP

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			20	40	60	80	100					
136.0	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	14												
134.5	Red, Stiff		2	SS	100												
1.5	Weathered Unweathered		3	RC	REC 74%		134										RQD = 0%
	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		4	RC	REC 98%		132										RQD = 65%
			5	RC	REC 100%		130										RQD = 90%
129.8	End of Borehole * 92 06 01																

RECORD OF BOREHOLE No B-10

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 988.8 E 281 764.3 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Rock Core COMPILED BY TS
 DATUM Geodetic DATE 92 05 28 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
140.5	Ground Surface													
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	10		140							
	Red		2	SS	14									
	Stiff Hard		3	SS	49		138							54 20 18 8
			4	SS	81									
			5	SS	70									
135.9			6	SS	100	/25cm	136							
4.6	Weathered Unweathered		7	SS	**									RQD = 8%
	Shale Bedrock with interbedded Siltstone		8	RC	REC 58%		134							RQD = 32%
	Red with interbedded Grey, Weak to Very Weak		9	RC	REC 52%									
			10	RC	REC 97%		132							RQD = 48%
130.9														
9.6	End of Borehole • 92 05 29 • Sampler Bouncing													

RECORD OF BOREHOLE No B-11

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 982.9 E 281 784 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 01 CHECKED BY PP

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			20 40 60 80 100					W _P W W _L				
								SHEAR STRENGTH kPa					WATER CONTENT (%)				
139.8	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Reddish Brown to Red, Hard		1	SS	35											0 2 72 26	
			2	SS	43												
			3	SS	46												
			4	SS	100	/18cm											
136.0			5	SS	100	/18cm											
3.8	Weathered Unweathered Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		6	RC	REC 80%											RQD = 38%	
			7	RC	REC 86%											RQD = 30%	
			8	RC	REC 83%											RQD = 60%	
130.8																	
9.0	End of Borehole • GWL not established																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No B-12

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 813 986.6 E 281 806.5 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Rock Core COMPILED BY TS
 DATUM Geodetic DATE 92 05 28 CHECKED BY PP

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 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
139.5	Ground Surface													
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Reddish Brown to Red Very Stiff to Hard		1	SS	17									
			2	SS	30									
			3	SS	32									
			4	SS	26									
			5	SS	29									
134.9			6	SS	120									
4.6	Weathered ----- Unweathered Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		7	RC	REC 89%									ROD = 58%
			8	RC	REC 100%									ROD = 64%
			9	RC	REC 100%									ROD = 97%
130.0														
9.5	End of Borehole • 92 06 01													

RECORD OF BOREHOLE No B-13 1 OF 1 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 065.7 E 281 788.6 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 01 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
168.2	Ground Surface																
0.0	Heterogenous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	55		168										
	Hard		2	SS	60											22.0	5 22 46 27
	Brown		3	SS	88		166										
	Grey		4	SS	90											19.5	5 28 42 25
	Red		5	SS	72		164										
			6	SS	100	/10cm										19.5	28 27 25 17
162.0			7	SS	100	/5cm	162										
6.2			8	SS	**												
	Weathered		9	RC	REC 88%		160										RQD = 11%
	Unweathered		10	RC	REC 100%												RQD = 40%
	Shale Bedrock with interbedded Siltstone																
	Red with interbedded Grey, Weak to Very Weak		11	RC	REC 95%		158										RQD = 51%
158.8																	
11.4	End of Borehole * GWL not established ** Sampler Bouncing																

RECORD OF BOREHOLE No B-14

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 064.5 E 281 801.8 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 01 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
166.5	Ground Surface																
0.0						*											
				EXCAVATION			166										
				AUGER													
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	38		164										
	Hard		2	SS	44												
			3	SS	48												
			4	SS	65		162										
	Brown		5	SS	100	/23cm											
	Red		6	SS	100	/10cm											
160.4																	
6.1			7	SS	→		160										
	Weathered																
	Unweathered																
	Shale Bedrock with interbedded Siltstone		8	RC	REC 99%		158										ROD = 88%
	Red with interbedded Grey, Weak to Very Weak		9	RC	REC 100%												ROD = 57%
156.1																	
10.4	End of Borehole																
	* GWL not established																
	→ Sampler Bouncing																

RECORD OF BOREHOLE No B-15 1 OF 1 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 066.0 E 281 815.9 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 03 CHECKED BY PP

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			20	40	60	80	100					
161.5	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	24	* /8cm	160										
	Red, Very Stiff to Hard		2	SS	41												
159.2			3	SS	100												
2.3	Weathered ----- Unweathered						158										
	Shale Bedrock with interbedded Siltstone		4	RC	REC 92%												RQD = 38%
	Red with interbedded Gray, Weak to Very Weak		5	RC	REC 100%												RQD = 61%
155.4							156										
6.1	End of Borehole * GWL not established																

RECORD OF BOREHOLE No B-16 1 OF 1 METRIC

W.P. 405-85-01/02 LOCATION Co-ords: N 4 814 065.5 E 281 825.6 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 03 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
158.8	Ground Surface														
0.0					*										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)			EXCAVATION		158									
	Red, Very Stiff to Hard			ALGER											
155.7			1	SS	28						6				1 3 70 26
			2	SS	60	156									
3.1	Weathered Unweathered				/8cm										
	Shale Bedrock with interbedded Siltstone		3	RC	REC 95%										RQD = 75%
	Red with interbedded Grey, Weak to Very Weak		4	RC	REC 100%	154									RQD = 100%
152.8															
6.2	End of Borehole														
	• GWL not established														

RECORD OF BOREHOLE No B-17 1 OF 2 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 103.9 E 281 801.7 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 01 CHECKED BY PP

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			20	40	60
173.5	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard Brown Grey Very Stiff Red		1	SS	36	*											
			2	SS	53												
			3	SS	57												
			4	SS	50												
			5	SS	48												
			6	SS	45												
			7	SS	30												
			8	SS	24												
			9	SS	26												
			10	SS	27												
			11	SS	21												
			12	SS	100				/23cm								
160.5	Shale Bedrock with interbedded Siltstone Weathered Unweathered Red with interbedded Grey, Weak to Very Weak		13	RC	REC 65%												
13.0			14	RC	REC 92%												
158.3																	

15.2 Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No B-17 2 OF 2 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 103.9 E 281 801.7 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 01 CHECKED BY PP

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		20	40	60	80	100					
158.3	Continued															
15.2	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		14	RC	REC 92%	158										ROD = 50%
			15	RC	REC 100%											ROD = 53%
156.1																
17.4	End of Borehole * GWL not established															

RECORD OF BOREHOLE No B-18 1 OF 2 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 099.2 E 281 814.9 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 02 CHECKED BY PP

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							10 20 30		
173.1	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown, Hard Gray, Very Stiff		1	SS	12		172										
			2	SS	51												
			3	SS	49												
			4	SS	50		170										
			5	SS	40												
			6	SS	42												
			7	SS	29		168										
			8	SS	25												
			9	SS	18		166										
			10	SS	21		164										
			11	SS	18		162										
160.9	Shale Bedrock with interbedded Siltstone Red with interbedded Gray, Weak to Very Weak		12	SS	100	/25cm	160										
12.2			13	SS	100	/18cm											
			14	RC	REC 92%		158										
157.9	Weathered Unweathered													RQD = 13%			

15.2 Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No B-18 2 OF 2 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 099.2 E 281 814.9 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 02 CHECKED BY PP

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		20	40	60	80	100					
157.9	Continued															
15.2	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		14	RC	REC 92%											RQD = 13%
			15	RC	REC 100%											RQD = 78%
155.8						156										
17.3	End of Borehole • 92 06 05															

RECORD OF BOREHOLE No B-19

1 OF 2

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 118.4 E 281 835.6 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Core COMPILED BY TS
DATUM Geodetic DATE 92.06.02 CHECKED BY PP

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 (%)		
								• UNCONFINED + FIELD VANE • QUICK TRIAXIAL * LAB VANE									
							20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W _P	W	W _L					
171.8	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		1	SS	34												
			2	SS	62												
			3	SS	72												
			4	SS	92												
			5	SS	56												
			6	SS	56												
			7	SS	37												
			8	SS	37												
			9	SS	37												
			10	SS	59												
159.3	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		11	SS	100	/8cm											
12.3			12	SS	100	/8cm											
			13	RC	REC 60%												
			14	RC	REC 93%												
156.4	Weathered Unweathered																

15.2

Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No B-19 2 OF 2 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 118.4 E 281 835.6 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 02 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
156.4	Continued															
15.2	Shale Bedrock with interbedded Siltstone Red with interbedded Grey. Weak to Very Weak		14	RC	REC 93%											ROD - 81%
			15	RC	REC 93%											ROD - 91%
154.0																
17.6	End of Borehole * 92 06 05															

RECORD OF BOREHOLE No B-20

1 OF 2

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 113.6 E 281 848.7 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 03 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							w _p w w _L		
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100							WATER CONTENT (%) 10 20 30		
170.7	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		1	SS	25		170							5 27 47 21			
			2	SS	38												
			3	SS	67		168										
			4	SS	84												
			5	SS	60												
			6	SS	78		166										
			7	SS	77												
							164										
	Brown Grey		8	SS	67									6 30 44 20			
			9	SS	49		162										
	Red		10	SS	100	/15cm	160										
158.5			11	SS	100	/8cm											
12.2	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak						158										
			12	SS	100	/8cm											
155.5	Weathered						156										

15.2 Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No B-20 2 OF 2 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 113.6 E 281 848.7 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 03 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N° VALUES		20	40	60	80	100					
155.5	Continued		13	SS	**											
15.2	Unweathered		14	RC	REC 100%											RQD = 83%
	Shale Bedrock with interbedded Siltstone															
	Red with interbedded Grey, Weak to Very Weak		15	RC	REC 100%	154										RQD = 88%
152.7																
18.0	End of Borehole															
	* GWL not established ** Sampler Bouncing															

RECORD OF BOREHOLE No B-21 1 OF 1 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 133.0; E 281 850.9 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 04 CHECKED BY PP

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 (%)									
165.6	Ground Surface						20	40	60	80	100	10	20	30			
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	51												
			2	SS	93												
			3	SS	47												
	Brown, Hard Grey, Very Stiff		4	SS	20												
			5	SS	29												
			6	SS	22												
	Red, Hard		7	SS	105												
			8	SS	100	/15cm											
156.5			9	SS	100	/10cm											
9.1																	
	Weathered Unweathered		10	SS	100	/3cm											
	Shale Bedrock with interbedded Siltstone		11	RC	REC 83%											RQD = 41%	
	Red with interbedded Grey. Weak to Very Weak		12	RC	REC 98%											RQD = 94%	
152.2																	
13.4	End of Borehole * GWL not established																

RECORD OF BOREHOLE No B-22 1 OF 2 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 146.1 E 281 860.9 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 04 CHECKED BY PP

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			20	40	60	80	100					
169.7	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	83												
			2	SS	73		168									20.7	4 25 49 22
			3	SS	104												
			4	SS	98												
	Brown Grey		5	SS	51		166										
			6	SS	40												
	Hard Very Stiff		7	SS	29		164										3 30 45 22
			8	SS	21		162										
			9	SS	27		160										
	Red, Hard		10	SS	100	/23cm	158										
157.5			11	SS	100	/6cm											
12.2	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		12	SS	—		156										
	Weathered Unweathered		13	RC	REC 87%												RQD = 58%
154.5			14	RC	REC 100%												RQD = 100%

15.2 Continued

+3, x5, Numbers refer to
Sensitivity

20
15-0.5 (X) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No B-22 2 OF 2 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 146.1 E 281 860.9 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 04 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W _p	W	W _L		
154.5	Continued															
15.2	Shale Bedrock with interbedded Siltstone		14	RC	REC 100%	154										RQD = 100%
153.2	Red with interbedded Grey, Weak to Very Weak															
16.5	End of Borehole • GWL not established • Sampler Bouncing															

RECORD OF BOREHOLE No B-23

1 OF 1

METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 057.3 E 281 814.0 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NO Rock Core COMPILED BY LD
DATUM Geodetic DATE 92 06 08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
158.5	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Red, Hard		EXCAVATION			DRY *	158										
			AUGER														
156.2			1	SS	41												
2.3	Shale Bedrock with interbedded Siltstone Weathered Unweathered		2	SS	72		156										
			3	SS	100	/23cm											
	Red with interbedded Grey, Weak to Very Weak		4	RC	REC 100%		154										RQD = 35%
			5	RC	REC 100%												RQD = 75%
151.8							152										
6.7	End of Borehole • 92 06 08 (within overburden)																

RECORD OF BOREHOLE No B-24 1 OF 1 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 054.1; E 281 786.1 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Rock Core COMPILED BY LD
 DATUM Geodetic DATE 92 06 08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
153.6	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) ----- Brown Hard Red		1	SS	42	DRY *											
162.1																	
1.5	Shale Bedrock with interbedded Siltstone		2	SS	87		162										
	Weathered		3	SS	100	/15cm											
	Unweathered																
	Red with interbedded Grey, Weak to Very Weak		4	RC	REC 100%		160										RQD = 46%
159.5																	
4.1	End of Borehole * 92 06 08 (within overburden)																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No TP 1 1 OF 1 METRIC

W.P. 406-85-01/02 LOCATION Co-ords: N 4 814 059.0 E 281 830.0 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE Backhoe, SS Auger, NW Casing, NO Rock Core COMPILED BY TS
 DATUM Geodetic DATE 92 06 10 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
153.6	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)					DRY *											
152.0	Red, Hard		EXCAVATION				153										
1.6	End of Borehole (Shale Bedrock Surface) * 92 06 10																

ROCK CORE DESCRIPTION

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CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
B-1	11	7.72-9.14	90	22	7.72-12.19	SHALE , greyish red, with interbedded greenish grey SILTSTONE (15%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 7.72-7.81 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	12	9.14-10.67	94	43		
	13	10.67-12.19	97	68		
B-3	11	9.30-10.82	98	36	9.30-13.87	SHALE , greyish red, with interbedded greenish grey SILTSTONE (22%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	12	10.82-12.34	100	76		
	13	12.34-13.87	100	71		
B-4	3	1.80-3.33	47	0	1.80-7.60	SHALE , greyish red, with interbedded greenish grey SILTSTONE (16%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 1.80-3.33 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	4	3.33-4.85	85	0		
	5	4.85-6.38	100	63		
	6	6.38-7.60	95	35		
B-5	2	1.52-2.54	93	48	1.52-5.59	SHALE , greyish red, with interbedded greenish grey SILTSTONE (21%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	3	2.54-4.06	95	65		
	4	4.06-5.59	98	90		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION **WP 406-85-01/02**

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CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
B-6	3	1.68-2.90	95	93	1.68-5.94	SHALE, greyish red, with interbedded greenish grey SILTSTONE (21%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures wide to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	4	2.90-4.42	100	73		
	5	4.42-5.94	99	99		
B-7	3	2.44-3.66	94	63	2.44-6.40	SHALE, greyish red, with interbedded greenish grey SILTSTONE (15%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to dipping, planar to undulating, smooth.
	4	3.66-5.18	76	19		
	5	5.18-6.40	77	50		
B-9	3	1.75-3.12	74	0	1.75-6.17	SHALE, greyish red, with interbedded greenish grey SILTSTONE (20%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 1.75-2.41 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	4	3.12-4.65	98	65		
	5	4.65-6.17	100	90		
B-10	8	5.33-6.55	58	8	5.33-9.60	SHALE, greyish red, with interbedded greenish grey SILTSTONE (14%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	9	6.55-8.08	52	32		
	10	8.08-9.60	97	48		
B-11	6	4.57-5.94	80	38	4.57-8.99	SHALE, greyish red, with interbedded greenish grey SILTSTONE (12%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	7	5.94-7.47	86	30		
	8	7.47-8.99	83	60		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION **WP 406-85-01/02**

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CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
B-12	7	5.03-6.43	89	58	5.03-9.47	SHALE, greyish red, with interbedded greenish grey SILTSTONE (19%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	8	6.43-7.95	100	64		
	9	7.95-9.47	100	97		
B-13	9	6.86-8.38	88	11	6.86-11.43	SHALE, greyish red, with interbedded greenish grey SILTSTONE (18%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	10	8.38-9.91	100	40		
	11	9.91-11.43	95	51		
B-14	8	5.94-7.39	99	68	5.94-8.86	SHALE, greyish red, with interbedded greenish grey SILTSTONE (13%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	9	7.39-8.86	100	57		
B-15	4	3.05-4.57	92	38	3.05-5.49	SHALE, greyish red, with interbedded greenish grey SILTSTONE (12%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	5	4.57-5.49	100	61		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION

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CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
B-16	3	1.78-3.18	95	75	1.78-4.70	SHALE, greyish red, with interbedded greenish grey SILTSTONE (9%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, planar to undulating, smooth.
	4	3.18-4.70	100	100		
B-17	13	12.80-14.33	65	0	12.80-17.37	SHALE, greyish red, with interbedded greenish grey SILTSTONE (11%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 12.80-14.40 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	14	14.33-15.85	92	50		
	15	15.85-17.37	100	53		
B-18	14	14.25-15.77	92	13	14.25-17.30	SHALE, greyish red, with interbedded greenish grey SILTSTONE (7%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 14.25-14.86 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	15	15.77-17.30	100	78		
B-19	13	13.01-14.53	60	0	13.01-17.58	SHALE, greyish red, with interbedded greenish grey SILTSTONE (13%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 13.01-14.64 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	14	14.53-16.05	93	81		
	15	16.05-17.58	93	91		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION

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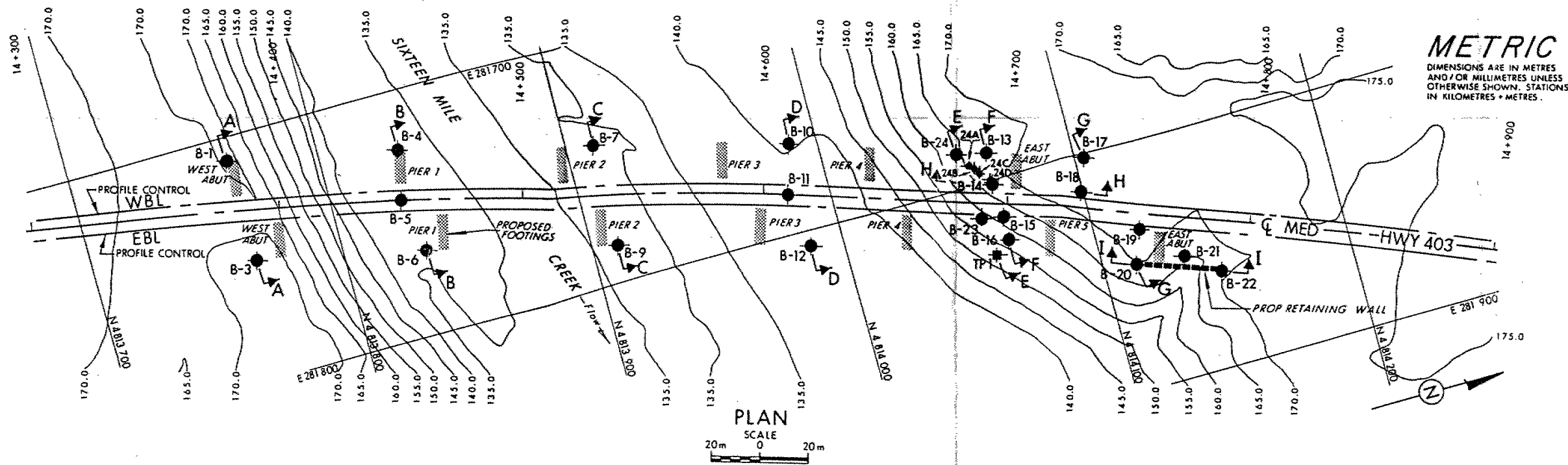
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
B-20	14	15.24-16.76	100	83	15.24-17.98	SHALE, greyish red, with interbedded greenish grey SILTSTONE (13%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat, planar to undulating, smooth.
	15	16.76-17.98	100	88		
B-21	11	10.67-11.89	83	41	10.67-13.41	SHALE, greyish red, with interbedded greenish grey SILTSTONE (20%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 10.67-11.07 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	12	11.89-13.41	98	94		
B-22	13	13.41-14.94	87	58	13.41-16.46	SHALE, greyish red, with interbedded greenish grey SILTSTONE (12%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 13.41-13.97 m); fractures wide to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	14	14.94-16.46	100	100		
B-23	4	3.66-5.18	100	35	3.66-6.71	SHALE, greyish red, with interbedded greenish grey SILTSTONE (23%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	5	5.18-6.71	100	75		
B-24	4	2.74-4.06	100	46	2.74-4.06	SHALE, greyish red, with interbedded greenish grey SILTSTONE (23%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

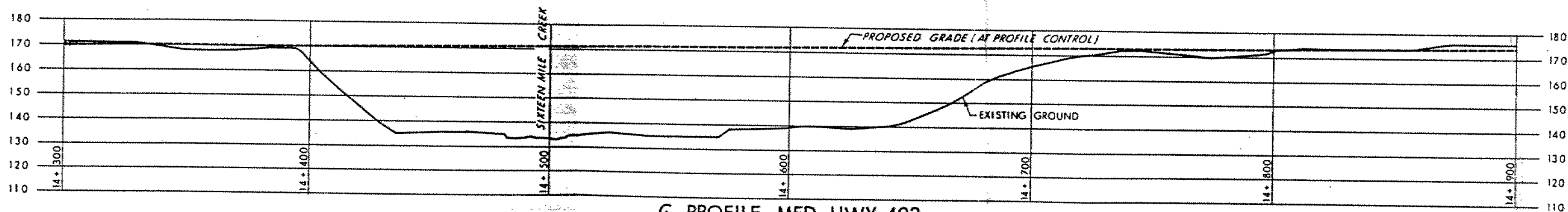
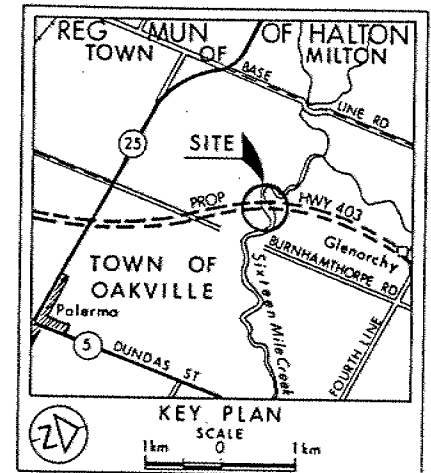
(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section



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

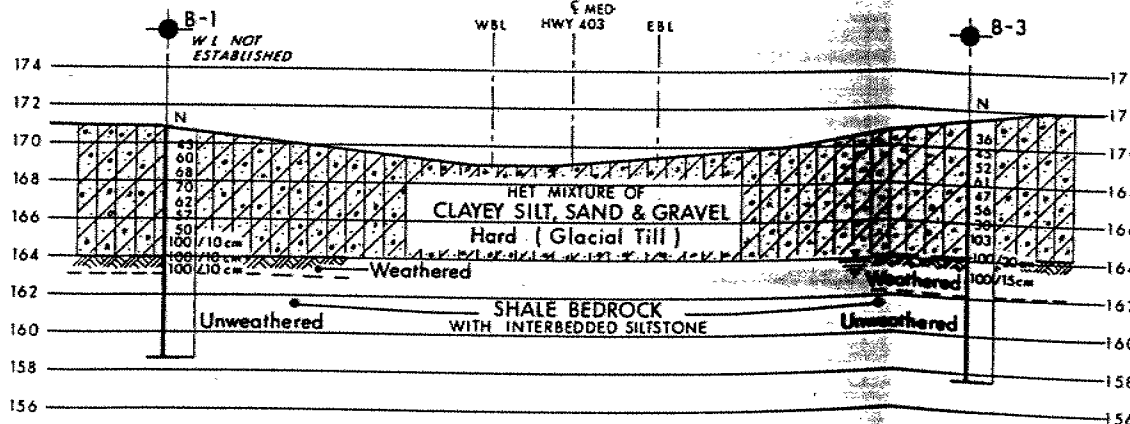
CONT No
WP No 406-85-01/02
SIXTEEN MILE CREEK
BORE HOLE LOCATIONS & SOIL STRATA



PROFILE MED HWY 403

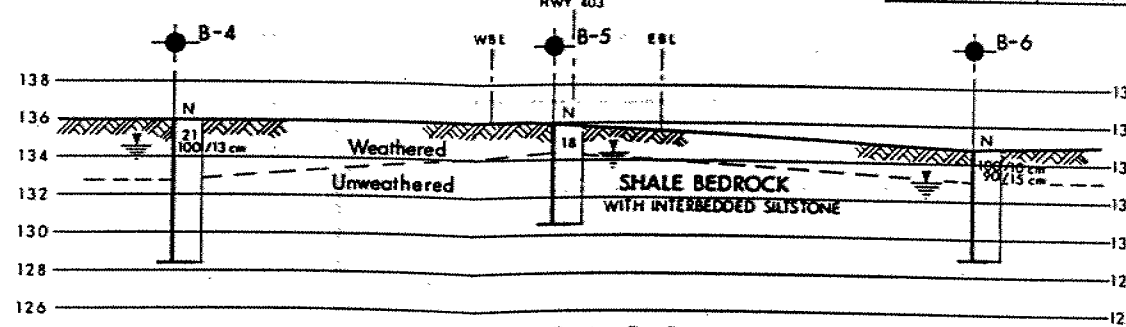
SCALE 0 20m

BEDROCK SURFACE POINTS			
No	ELEVATION	CO-ORDINATES NORTH	EAST
24A	161.9	4 814 058.4	281 791.3
24B	161.2	4 814 060.1	281 794.0
24C	160.5	4 814 061.8	281 796.1
24D	159.2	4 814 064.6	281 799.1



SECTION A-A ADJACENT TO W ABUTMENT (WBL & EBL)

SCALE 0 4m



SECTION B-B ADJACENT TO PIER 1 (WBL & EBL)

NOTE
For Subsoil Stratigraphical Sections C-C To I-I
Refer To DWG 4068501/02-B

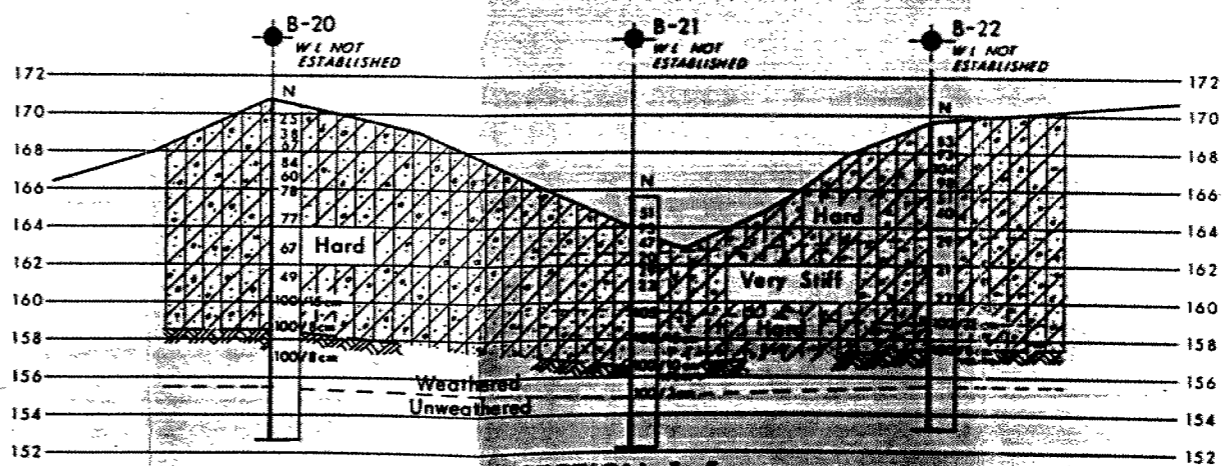
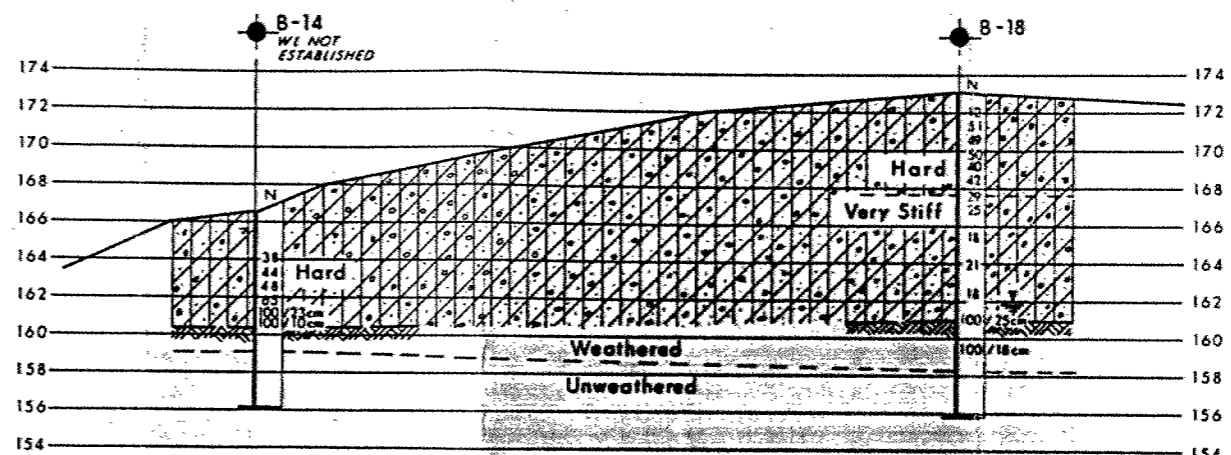
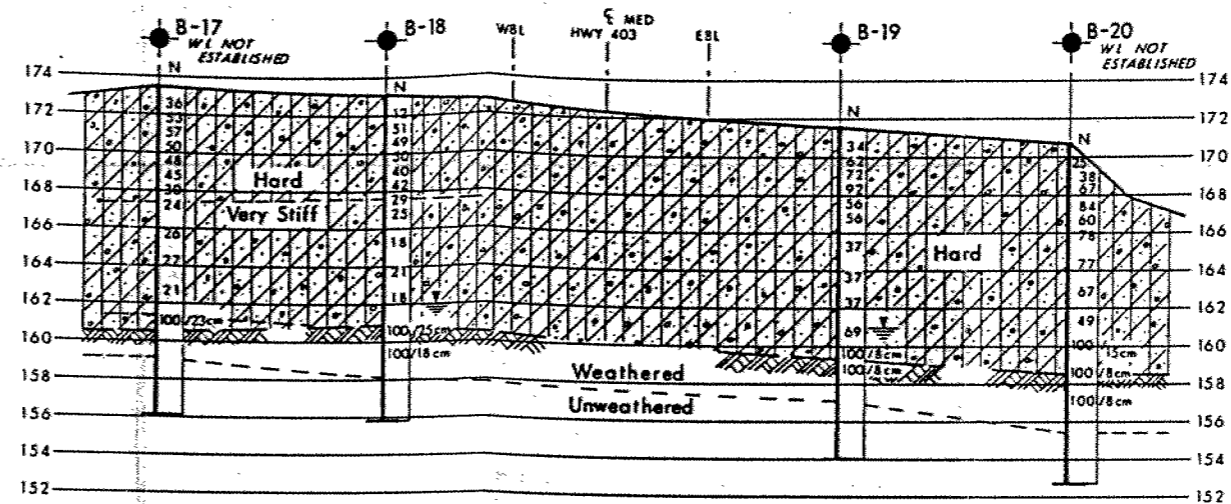
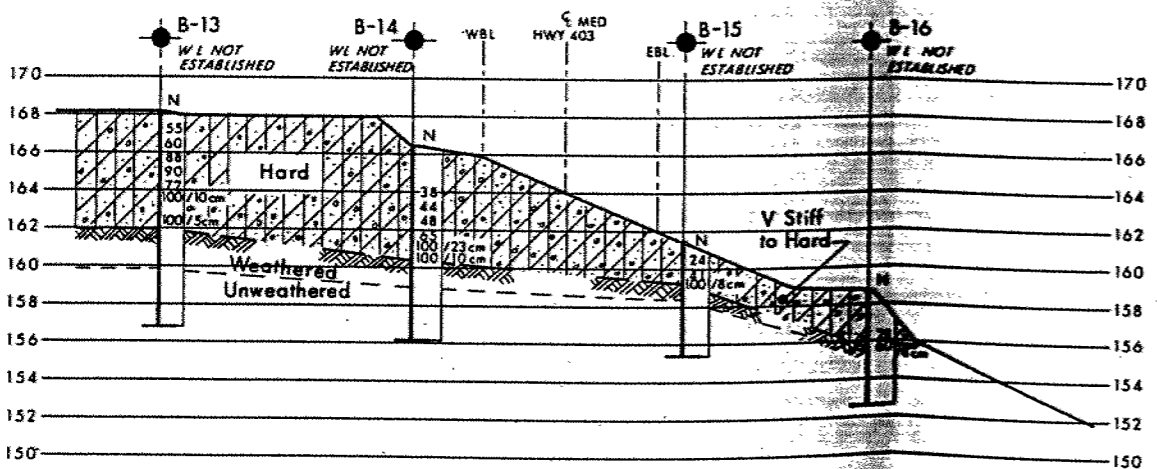
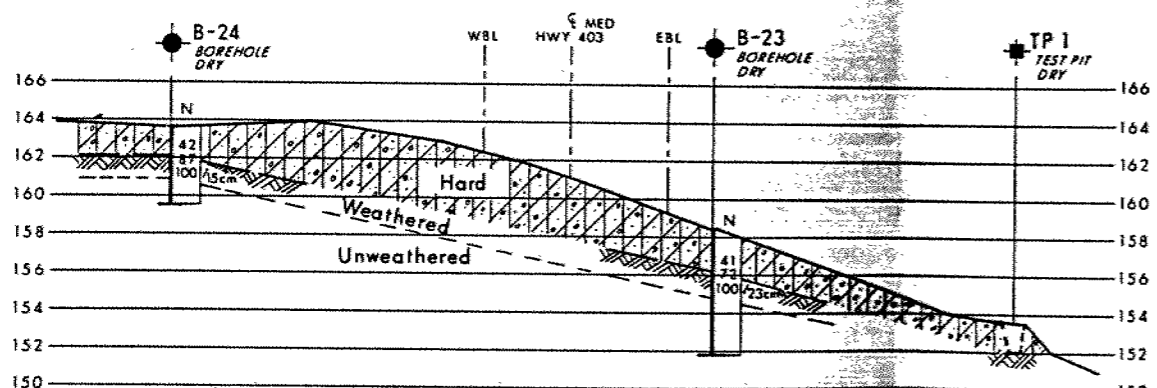
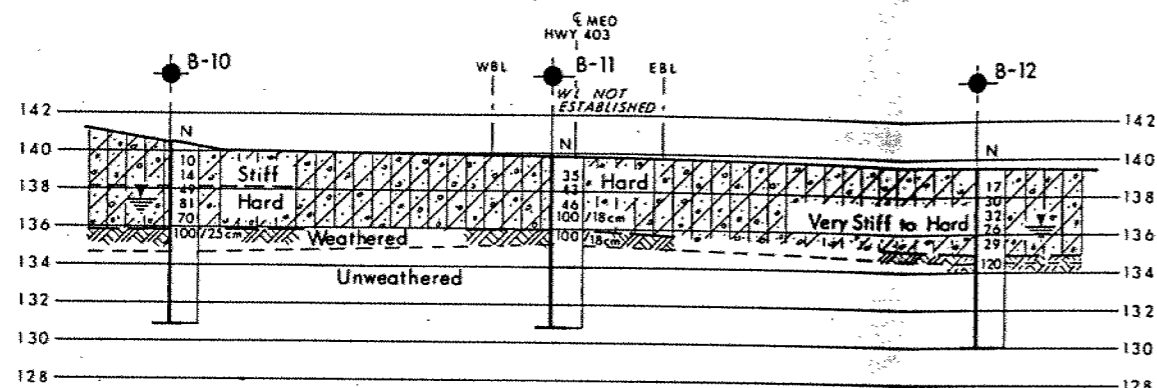
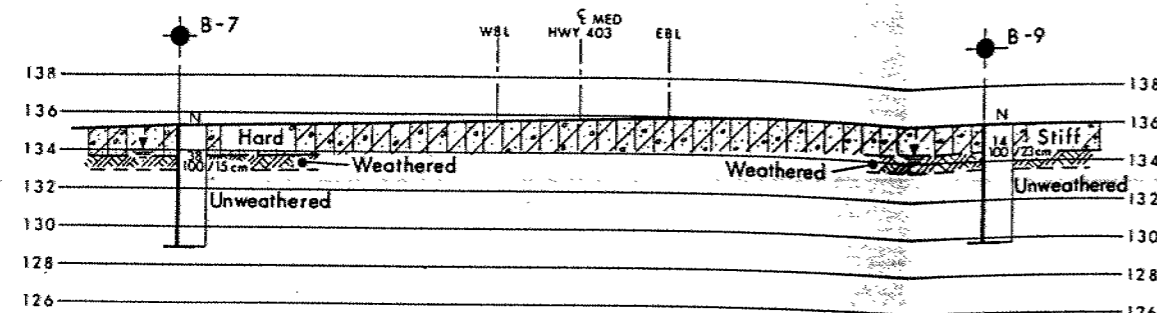
LEGEND			
●	Bore Hole		
⊕	Dynamic Cone Penetration Test (Cone)		
⊗	Bore Hole & Cone		
N	Blows/0.3m (Std Pen Test, 475 J/blow)		
CONE	Blows/0.3m (60° Cone, 475 J/blow)		
W.L.	W.L. at time of investigation 1992 05 and 06		
⊕	Test Pit		
⬤	Bedrock Surface Points		
No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
B-1	170.9	4 813 763.5	281 709.3
B-3	171.5	4 813 765.4	281 751.5
B-4	136.0	4 813 832.6	281 723.7
B-5	135.9	4 813 828.1	281 743.8
B-6	134.8	4 813 833.3	281 765.9
B-7	135.4	4 813 911.0	281 742.7
B-9	136.0	4 813 910.3	281 784.9
B-10	140.5	4 813 988.8	281 764.3
B-11	139.8	4 813 982.9	281 784.0
B-12	139.5	4 813 986.6	281 806.5
B-13	168.2	4 814 065.7	281 788.6
B-14	166.5	4 814 064.5	281 801.8
B-15	161.5	4 814 066.0	281 815.9
B-16	158.8	4 814 065.5	281 825.6
B-17	173.5	4 814 103.9	281 801.7
B-18	173.1	4 814 099.2	281 814.9
B-19	171.6	4 814 118.4	281 835.6
B-20	170.7	4 814 113.6	281 848.7
B-21	165.6	4 814 133.0	281 850.9
B-22	169.7	4 814 146.1	281 860.9
B-23	158.5	4 814 057.3	281 814.0
B-24	163.6	4 814 054.1	281 786.1
TP1	153.6	4 814 059.0	281 830.0

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.



REV.	DATE	BY	DESCRIPTION
1			
Geocres No 30M5-193			
HWY No 403		DIST 4	
SUBMITTS CHECKED 11		DATE 1993 11 04	
DRAWN R5 CHECKED 01		SITE 10 - 490	
		DWG 4068501/02-A	



SOIL STRATIGRAPHY LEGEND

HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL (Glacial Till)

SHALE BEDROCK WITH INTERBEDDED SILTSTONE

NOTE

For Plan, Profile, Subsoil Stratigraphical Sections A-A & B-B Refer To DWG 4068501/02-A

CONT No
WP No 406-85-01/02

SIXTEEN MILE CREEK

BORE HOLE LOCATIONS & SOIL STRATA

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

See DWG 4068501/02-A

KEY PLAN
SCALE

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1992 05 and 06
- ★ Test Pit

No	ELEVATION
B-7	135.4
B-9	136.0
B-10	140.5
B-11	139.8
B-12	139.5
B-13	168.2
B-14	166.5
B-15	161.5
B-16	158.8
B-17	173.5
B-18	173.1
B-19	171.6
B-20	170.7
B-21	165.6
B-22	169.7
B-23	158.5
B-24	163.6
TP 1	153.6

NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

REV.	DATE	BY	DESCRIPTION
1			

Geocres No 30M5-193

HWY No 403	SUBMITTALS	CHECKED	DATE 1993 11 04	DIST 4
DRAWNERS	CHECKED	APPROVED		SITE 10-490
				DWG 4068501/02-B



memorandum



To: V. Boehnke
Head, Structural Section
Central Region

Attn: K. Wong
Structural Engineer

From: Foundation Design Section
Room 315, Central Building

Re: Advanced Foundation Investigation Report
HWY 403 - 16 Mile Creek Overpass
WP 406-85-01/02, Site 10-490
District 4, Burlington

Date: 92 07 14

Attached please find the text component of the Foundation Investigation Report produced in conjunction with the proposed beam type twin structures that will carry the proposed Hwy 403 over the Sixteen Mile Creek. The report does not include the Appendix but does contain sufficient information to allow for the foundation and geotechnical design of the structure and related earthworks. It is anticipated that the final report which will include the Appendix containing pertinent plans, borehole logs, stratigraphical sections and figures will be completed by September 30, 1992.

If you have questions regarding the advanced foundation report or require additional information, please do not hesitate to contact this office.

A handwritten signature in black ink, appearing to read "T. Sangiuliano".

T. Sangiuliano, P. Eng.
Foundation Engineer

for

P. Payer, P. Eng.
Senior Foundation Engineer

memorandum



To: H.A. McNeely, Supervisor
Environmental Unit
5th Floor, Atrium Tower

Date: 92 03 15

Attn: C. Southey

From: Foundation Design Section
Room 315, Central Building

Re: Foundation Investigation Site Preparation
Hwy 403 & 16 Mile Creek
WP 406-85-01/02, Site 10-490

The comments given by the various authorities at the site visit conducted at the above mentioned project on March 5, 1992 proved to be very informative and of immense assistance in the planning of our foundation investigation. Our investigation plan proposal is summarized below and illustrated on the attached plan of the site. The plan recognizes the prudence of minimizing environmental damage.

GENERAL

All boreholes will be advanced with a conventional track mounted drilling unit. All activities associated with the site preparation and actual borehole advancement will be carried out in an environmentally conscientious manner under the supervision of the undersigned. Silt fences will be provided at areas across the site where it is deemed necessary to prevent any soil migration during the investigation and any trees that require clearing will be chainsaw cut without any root removal.

As discussed at the site meeting, the foundation investigation will proceed from west to east to allow the Virginia Bluebell on the east side to surface and hence be recognized. Areas 3 and 4 as described below will be investigated only after all other areas have been investigated.

The site will be restored as close to its original state as practically possible.

BOREHOLE LOCATIONS AND FOOTPRINT AREAS

The attached plan identifies the proposed borehole locations and designated footprint areas that envelope series of boreholes based on access and mobilization. It has been decided to mitigate disturbance by conducting the investigation strictly for the beam type structure ONLY at this time. Should the arch-type option be declared as a viable alternative at a later time, an

investigation will be coordinated and conducted accordingly.

A total of twenty-two(22) boreholes have been planned and six(6) footprint areas established. Access and site preparation work required at each area is given below.

1) WEST OF 16 MILE CREEK

Area 1

Area 1 is accessible easily from Ingill's property west of the borehole locations. Only minor clearing of low lying shrubs is required and hence no construction equipment is needed.

Area 2

Area 2 will be accessed from an existing ramp as shown on the attached plan. Some minor clearing will be required which can be achieved by the travel of the track mounted bombardier. The Virginia Bluebell located adjacent to this area will be protected from any damage by restricting activity from the existing toe of slope. It is asked that an accurate location of the Virginia Bluebell be forwarded to ensure this protection.

2) EAST OF 16 MILE CREEK

Area 3

Area 3 is located east of 16 Mile Creek and is accessible partially from an existing ramp (from the crest of the valley slope to the toe of the valley slope) and across the floodplain area to the specific borehole locations. The travel within the floodplain area will require the construction of an additional ramp. As requested by the H.R.C.A., the proposed ramp construction is illustrated on the attached Figure 1. A dozer will be required to blade the soil to construct the ramp and a backhoe will be required to restore the original slope. Some minor clearing of bush will be required beyond the constructed slope towards the boreholes.

The *Mertensia Virginica* located in Area 3 will be delineated by snow fence prior to investigation in this area. It is again asked that an accurate location of the Virginia Bluebell be forwarded to ensure this protection.

Area 4

Area 4 is accessible from the existing ramp mentioned in conjunction with Area 3 and travel across basically flat terrain beyond the ramp. Some minor clearing of shrubs and trees only will be required. This will be achieved by chainsaw cutting and bombardier travel.

Area 5

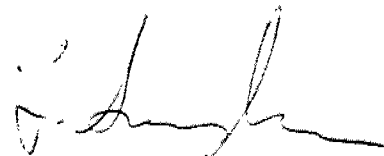
Area 5 requires the most extensive preparation because the proposed boreholes in this area are located on the existing slope. As illustrated on the attached plan, two(2) transverse pathways to access boreholes B-13 and A-14 and boreholes A-15 and B-16 respectively are proposed. The pathways will be "benched" into the slope as shown on Section 1-1' for a distance up to approximately 50 metres. The width of the bench required is 3 metres and the excavated slope is approximately 1/2H:1V. The excavated material will be temporarily stockpiled on the flat terrain beyond the slope and protected from the climatic conditions with polyethylene.

To facilitate the restoration of the slope, a 0.3 m bench into the slope is also recommended. This bench which is a measure commonly employed to ensure a stable slope provides a "shear key" for the fill material that will be placed in the excavated areas. It is proposed to place the excavated material in 200 mm lift thicknesses and compacted using a hand compactor.

Area 6

All boreholes in Area 6 are easily accessible and are located on flat terrain except borehole B-21. To gain access to borehole B-21, a temporary ramp is to be constructed ranging in height up to 5 metres. A proposed section of the embankment is shown in Section 2-2' attached. As shown on the section, a temporary corrugated circular steel pipe will be placed to allow water transmission beneath the embankment. A silt fence will be constructed at a standard distance beyond the pipe culvert. This proposal is temporary and will be removed upon completion of the borehole.

We trust the above proposal satisfies the environmentally related concerns expressed by the various authorities. If any clarification is required or additional concerns need to be addressed, please do not hesitate to contact this office. In order to satisfy scheduling requirements, an expedient review of our proposal would be greatly appreciated such that we can procure approval to commence the field investigation.

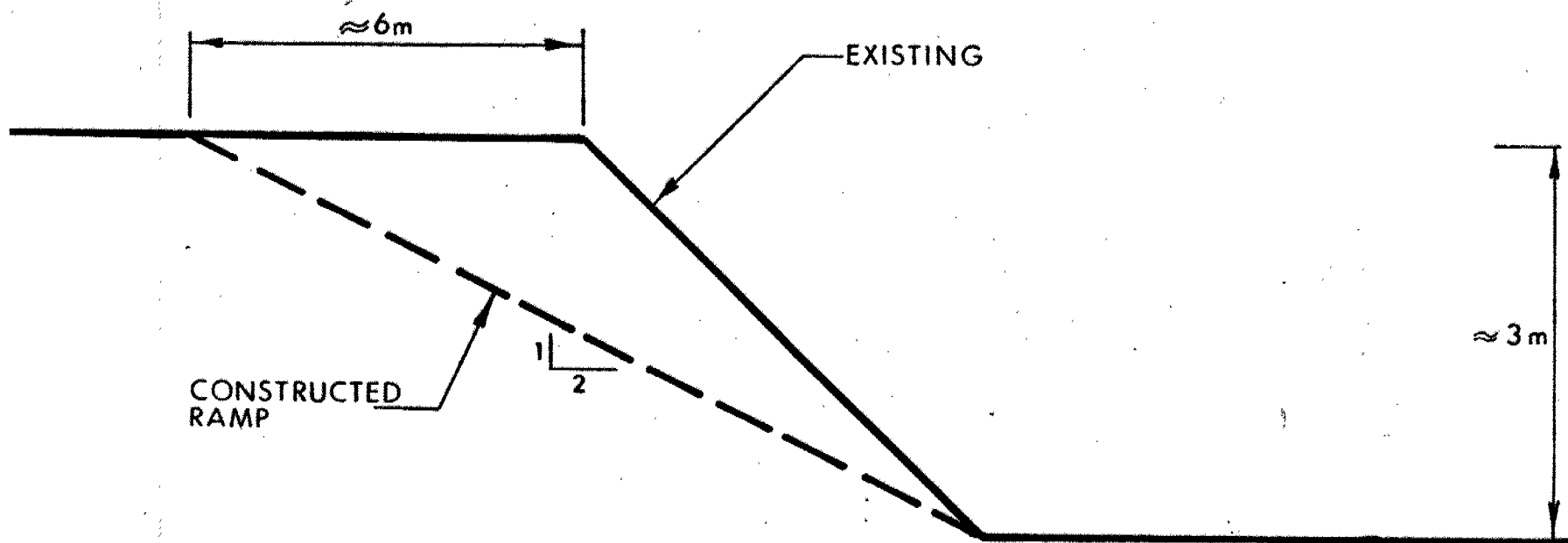


T. Sangiuliano, P.Eng.
Foundation Engineer

for

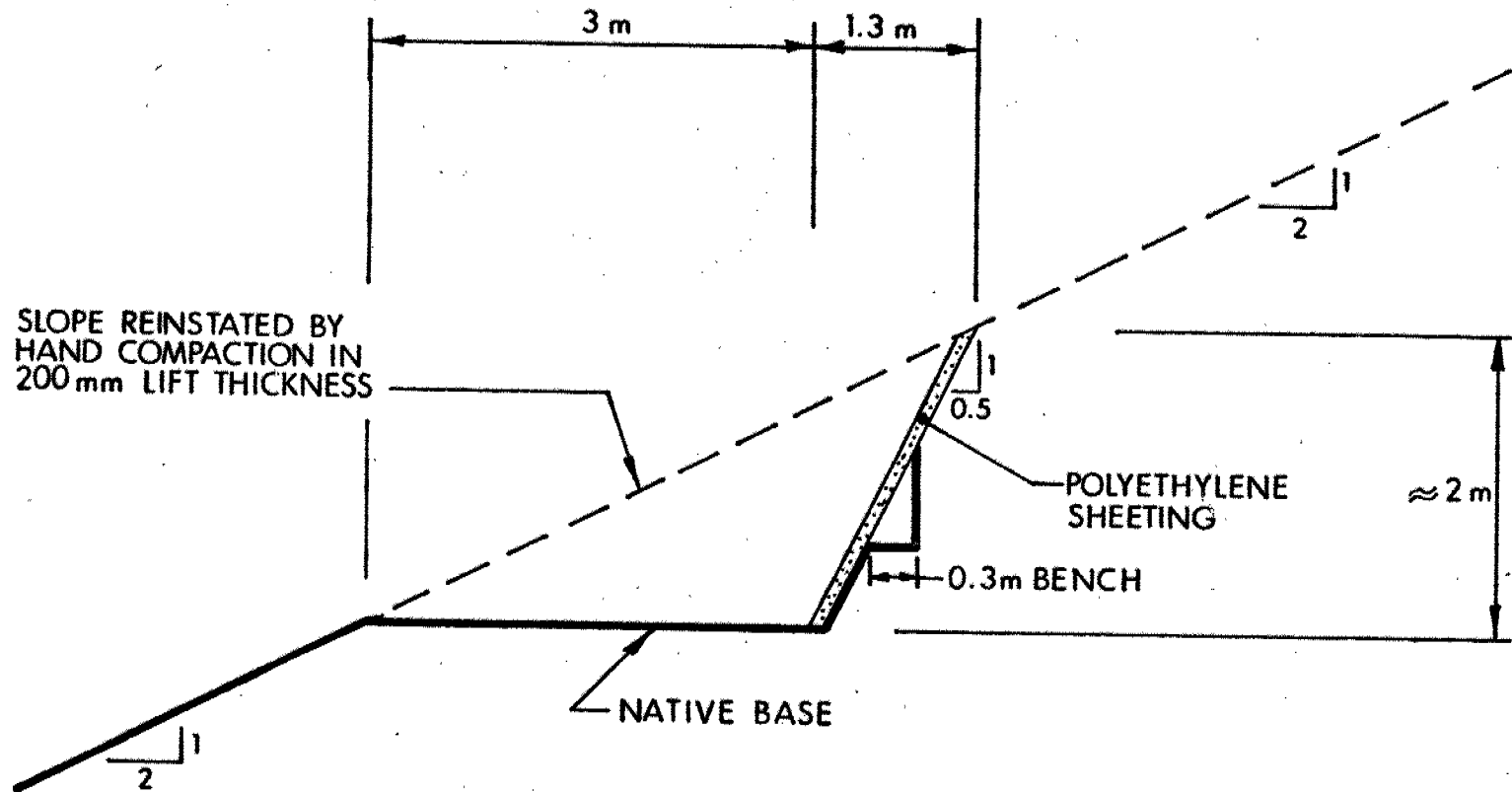
T. Kim, P. Eng.
Senior Foundation Engineer

Figure 1. RAMP CONSTRUCTION - AREA 3



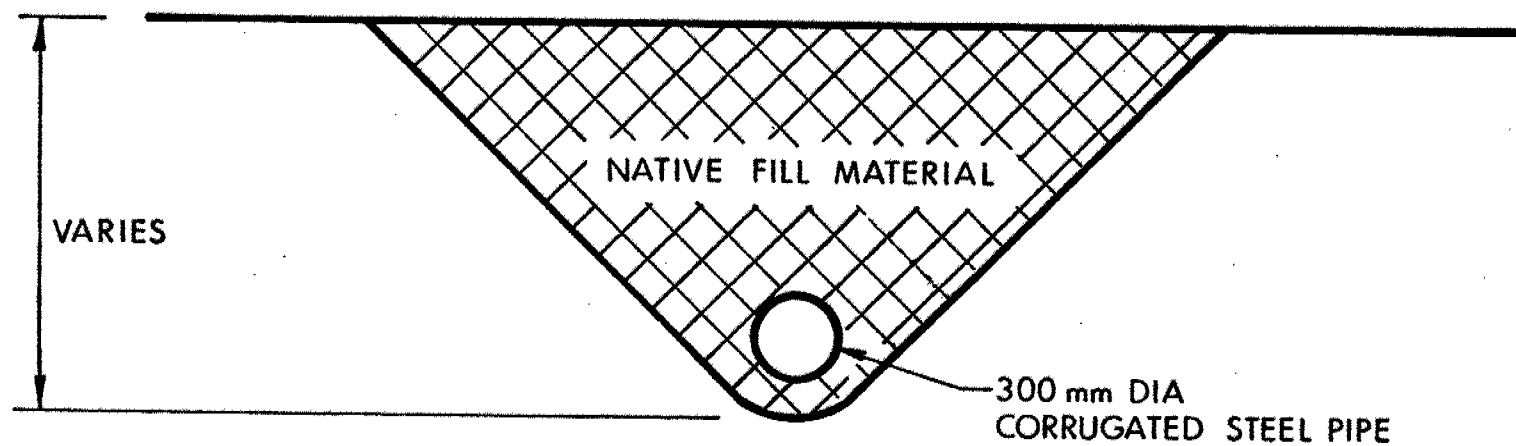
NOT TO SCALE

SECTION 1-1'



NOT TO SCALE

SECTION 2-2'



NOT TO SCALE