

GEOCRES No. 42E-4DIST. 19 REGION W.P. No. 381-90-01CONT. No. W. O. No. STR. SITE No. 48E-6HWY. No. 11LOCATION Hwy 11 @ CNR overhead
at Longlac, KenogamisisNo of PAGES - River

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

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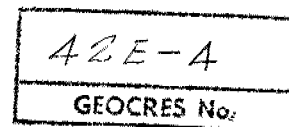
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**FOUNDATION INVESTIGATION
HIGHWAY 11 AND KENOGAMI RIVER/CNR OVERHEAD
AT LONGLAC
W.P. 381-90-01 SITE 48E-6
DISTRICT 19 THUNDER BAY ONTARIO
Consultant Agreement No.: 4540-9193-091**



Prepared For:

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DECEMBER, 1994.

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1. INTRODUCTION

AGRA Earth & Environmental Limited, Consulting Engineers, was retained by the Pavements & Foundations Section of the Ontario Ministry of Transportation, Engineering Materials Office, to conduct a geotechnical investigation at the site of the proposed Highway 11 and Kenogami River/C.N.R. Overhead at Longlac, W.P. 381-90-01, Site 48E-6, in the Town of Longlac, Ontario. The project is located in District 19, Thunder Bay.

Dominion Soil Investigation Inc. (A Division of AGRA Earth & Environmental Limited), submitted Proposal P-94065 on April 7, 1994 in response to a Request for Proposal dated April 5, 1994, from the Ministry. As per the proposal, the geotechnical investigation was to consist of fourteen boreholes at agreed locations. The scope of the fieldwork was subsequently increased by three sampled borings and eight auger probes.

The purpose of the investigation was to obtain information about the subsurface conditions at the site of the proposed bridge and approach embankments and, based on the findings, to provide recommendations for the geotechnical design of the foundations of the proposed structure and approach fills.

The fieldwork was carried out during the period of April 12 and 28, 1994, and consisted of fifteen boreholes drilled from land or ice, and from water using a raft. In a number of boreholes bedrock was cored by diamond drilling. Subsequently, on July 4 and 5, 1994, two sampled boreholes and eight auger probes were put down from the approach fills to determine the nature of the material making up the existing approach fills. A detailed description of field procedures is given in Appendix 'A'.

The plan locations of the boreholes along with stratigraphic sections are shown on Drawings No. 3819001-A and 3819001-B. Details of subsurface conditions encountered at each borehole location, including results of in-situ testing, are presented on the Record of Borehole Sheets, Enclosure Nos. 1 to 20, inclusive.

2. THE SITE

The site is located in Daley Township, close to the westerly boundary with Oakes Township and close to the Long Lake Indian Reserve. It can be found on Sheet 42E/15, "Longlac", of the 1:50000 National Topographic Series Maps. Enroute from the west on Highway 11, the bridge serves as gateway to the Town of Longlac which has about 2000 inhabitants. The nearest towns are Geraldton and Hearst, located about 35 km west and 212 km to the east of the site, respectively.

Highway 11 runs along the north shore of Long Lake. At the northeast "corner" of the lake, Kenogami River flows into the lake, and the river is presently bridged by the existing structure which will be replaced by the new bridge. At this point, the CN Railway also crosses the river therefore, the highway bridge is sufficiently elevated above the railway bridge to allow trains to pass by.

.../...

The existing highway bridge, which will be replaced, was built in the 1940's, as a multi-span, concrete slab-type structure. It appears that the end-spans of the bridge are cantilevers and there is no reaction-carrying abutment at either end of the bridge, probably in anticipation of settlement of the approach embankments. At the west "abutment" there are indications (a second asphalt pavement layer below the present one) that settlement did indeed occur in the past.

The surrounding terrain is flat where Kenogami River is meandering as a result of the small gradient of the land. In the vicinity of the bridge the ground is swampy over a length of approximately one kilometre. The west approach embankment leading to the bridge site was built on a causeway, close to the northerly shore of the lake and near the southerly edge of the swamp. The east approach embankment is built on the east shore of the river and lake, mostly on land, although the toe of the existing approach fill extends slightly into the bed of the lake/river.

3. SUBSURFACE CONDITIONS

The major part of the fieldwork was carried out in April, 1994, after a very severe and long winter. Nine of the fifteen boreholes were located over ice: four (1, 10, 11 and 12) around the east end of the west approach embankment, the remaining five (3, 4, 5, 7 and 8) around the west end of the east approach embankment. Three boreholes (2, 9 and 15) were drilled from a raft in the river, while the remaining three (6, 13 and 14) were on land, on the east shore of the lake.

The second and minor part of the fieldwork was carried out in July, 1994, and consisted of sampled borings and probes in the approach embankments in order to assess the materials making up the existing approach fills. The findings in these embankment borings/probes will be discussed at the end of this section.

The average top of ice elevation at the nine boreholes (Boreholes 1, 3, 4, 5, 7, 8, 10, 11 and 12), drilled in the frozen lake, was 312.5 m (range: 312.3 m to 313.0 m). At the time of fieldwork the ice was, on the average, 0.5 m thick (range: 0.3 to 0.8 m) and the lake was completely frozen to the bottom, which was found to be at an average Elevation 312.0 m (range: 311.7 to 312.4 m) at the borehole locations. The elevation of the bottom of the lake at the unfrozen rivermouth was lower; the average lake-bottom elevation was found to be 310.1 m (range: 310.0 m to 310.2 m), based on the findings in the three borings (Nos. 2, 9 and 15) which were drilled from a raft. The three remaining boreholes (Nos. 6, 13 and 14), were drilled along the east approach embankment, on land, at Elevations 314.2, 315.6 and 316.5 m, respectively. In Borehole 6, the ground was found to be frozen as deep as 1.8 m below grade.

The stratigraphy encountered in the borings and the engineering properties of the encountered soil strata will be described in the following paragraphs. All elevations and thicknesses are based on the findings in the boreholes; between or beyond the borings there could be variations. In subsections 3.1 through 3.6 the subsurface conditions encountered in the lakebed will be discussed. The soil stratigraphy encountered on land will be described in subsection 3.7.

.../...

3.1 Mud

This is a recent, "underconsolidated", and highly unstable lakebed deposit, which consists of layers of silts, fine sands, or a mixture of the two, and of finely dispersed organic matter and layers of peat. Wood barks, wood cuttings and roots were also encountered, and the material is in a saturated, very loose or very soft state. The 'N'-values were as low as 2, and moisture contents as high as 50% were obtained on some samples, due to the high organic content. The organic content of one sample (Borehole 3, Sample 3), was found to be 19%, as determined by the ignition method. The occasional cobble and boulder was also encountered (see Borehole 1).

The mud is highly compressible but quick-consolidating, and has very low shear strength. It would be mostly displaced by any load placed over it.

Based on the field and laboratory examination and test results, the following engineering properties were assigned to the mud in the stability analyses.

Natural unit weight (saturated):	γ	17.3 kN/m ³
Undrained cohesion (shear strength):	c	0 kPa
Undrained angle of internal friction:	ϕ	25 degrees
Drained cohesion:	c'	0 kPa
Drained angle of internal friction:	ϕ'	25 degrees

At the borehole locations the average top and bottom elevations of the mud were found to be 311.5 m (range: 312.4 m to 310.0 m) and 309.3 m (range: 310.5 m to 307.9 m), respectively. The average thickness of the stratum is 2.2 m, ranging from 3.8 m (in Borehole 10) to 1.2 m (in Borehole 11).

3.2 Upper Silt

The mud is underlain by a silt deposit with interbedded silty fine sand layers. The stratum was encountered between average elevations of 309.3 m (range: 310.8 to 307.9 m) and 306.3 m (range: 308.1 to 305.1 m), with an average thickness of 3.1 m (range: 4.0 m to 1.7 m). In Boreholes 9 and 15 the silt deposit extended to Elevation 296.9 m and 303.0 m, respectively, without a silty clay layer in between. In these two holes the silt deposit was 11.1 m and 5.7 m thick, respectively.

Typically, the recorded 'N'-values were between 10 and 20, occasionally as high as 31 and as low as 5 blows/0.3 m, indicating a generally compact condition with some loose zones. Due to the low in-situ effective overburden pressure, these 'N'-values are estimated to indicate relative densities between 50 and 67%.

.../...

The natural water content of the upper silt was found to be generally between 21 and 30%. Occasionally, lower values (16.5%) were obtained in the sandy layers, and higher values (36.7%) in zones interbedded with clay laminations. Finely dispersed organic impurities were also encountered but the organic content was found to be low (0.4%).

Typical grain size distribution curves are shown on Figure 1. They indicate that the upper silt deposit consists of almost pure, non-plastic silt (95% of the particles passing the MTO No. 200 sieve size), and the layers consist of silty very fine sand.

Based on the gradation characteristics and 'N'-values, the following engineering properties were used for the upper silt in the stability analyses:

Natural unit weight (saturated):	γ_s	17.6 kN/m ³
Undrained cohesion (shear strength):	c	0 kPa
Undrained angle of internal friction:	ϕ	31 degrees
Drained cohesion:	c'	0 kPa
Drained angle of internal friction:	ϕ'	31 degrees

The silt consolidates rapidly due to the presence of fine sand layers.

3.3 Silty Clay

This deposit was encountered in the westerly boreholes (1, 2, 10, 11 and 12), which were drilled in the lakebed. In these five boreholes, the silty clay deposit was found between the average elevations of 305.9 m (range: 306.7 to 305.1 m) and 302.3 m (range: 304.7 to 300.0 m), with an average thickness of 3.6 m (range: 6.1 to 1.8 m).

The silty clay has the following plasticity characteristics:

Liquid Limit:	59 to 23%
Plastic Limit:	27 to 13%
Plasticity Index:	32 to 4%

The higher values represent highly plastic clay (CH), the lower ones silty clay or clay (CL or CI), and a pair of results, with a plasticity index of 4%, indicates silt. The wide range of plasticity indices is due to the heterogeneity of the deposit: it also contains fine sand and silt layers.

The measured natural water content of the silty clay was mostly between 25 and 35%; values as high as 49% were obtained in highly plastic clay layers.

.../...

Four typical grain size distribution curves on Figure 2, indicate that the silty clay has maximum 6% very fine sand content, and 18 to 32% of the particles are of "clay size", i.e. 2 microns or less in "diameter".

Six consolidation tests were also performed and the results are shown on Figure Nos. 6, 7 and 8. Two of the six tests were run on silty layers, the other four on silty clay. The consolidation tests show that the silty clay is somewhat overconsolidated (the overconsolidation ratio is generally between 1.5 and 2), and the compression indices were found to range between 0.12 and 0.47, the lower values representing the silty material.

Field vane shear tests, and undrained triaxial compression tests gave shear strength values generally between 20 and 30 kPa, with some results as high as 40 to 60 kPa, or even higher, caused by a silt or fine sand layer. The recorded 'N'-values in the deposit range from 1 to 13 blows/0.3 m. Based on these values, together with a visual and tactile excavation of the soil samples, the consistency of the deposit is described as generally firm.

For the stability analysis the following engineering properties were assumed:

Natural unit weight (saturated):	γ	19.5 kN/m ³
Undrained cohesion (shear strength):	c	25 kPa
Undrained angle of internal friction:	ϕ	0 degrees
Drained cohesion:	c'	0 kPa
Drained angle of internal friction:	ϕ'	19 degrees

3.4 Lower Silt

A second (lower) silt deposit was encountered in Boreholes 1, 2, 10, 11 and 12, underlying the silty clay deposit, between the average elevations of 302.3 m (range: 304.7 m to 300.00 m) and 287.6 m (possibly lower) (range: 291.6 m to below 282 m), i.e. its average thickness is 14.7 m, possibly more. Since the silty clay layer was not encountered in Borehole Nos. 7, 9 and 15, in these boreholes, the upper and lower silt deposits constitute one continuous stratum of 3.7, 11.1 m and 5.7 m thickness, respectively.

The lower silt deposit is similar in composition to the upper silt deposit, however, there are more numerous fine sand layers in the material and its relative density is also higher, as indicated by the 'N'-values (generally over 15 or 20 blows for 0.3 m penetration).

The grain size distribution curves are plotted on Figure Nos. 3 and 4. It can be seen that the gradation of samples is similar to those taken from the upper silt deposit: the samples ranged from almost pure silt with minimal very fine sand content, to very fine sandy silt. Silty clay laminations were also observed in some samples. The water content of the lower silt deposit is generally around 20%, with occasional higher values of about 40% in the clayey laminae.

.../...

For the stability analysis, the following soil properties were assigned to this material:

Natural unit weight (saturated):	γ	18.0 kN/m ³
Undrained cohesion (shear strength):	c	0 kPa
Undrained angle of internal friction:	ϕ	33 degrees
Drained cohesion:	c'	0 kPa
Drained angle of internal friction:	ϕ'	33 degrees

3.5 Silty Sand

In Borehole 1, an almost 3 m thick silty fine sand deposit was encountered below the lower silt. This material is believed to be compact, in spite of the low 'N'-values (4 and 6), namely, the upward directed seepage forces may have disturbed the fine, cohesionless and uniformly graded material thereby reducing the Standard Penetration Resistances.

3.6 Heterogeneous Mixture of Silt, Sand and Gravel, Occasional Cobbles and Boulders (Glacial Till)

In Boreholes 1 through 5, 7, 8 and 9, the lower silt deposit is underlain by a silty sand (glacial till) stratum which ranges in thickness from 0.1 m to possibly more than 6.2 m. The top elevation of the till deposit ranges from 308 m to 282.8 m, and its density ranges from very dense (over 100 blows/0.3 m penetration) in Boreholes 1 2, 3, 5 and 9, to compact in Boreholes 4, 7 and 8. The extremely high 'N'-values were mainly caused by the boulders and cobbles embedded in the till.

The wide gradation of the till is shown on Figure 5. Its moisture content is low, around 10 to 12%. Generally, the deposit lies too deep below the surface to have any influence on the stability conditions of the approach embankments; it only plays a role that driven piles will either reach a satisfactory set in it, or will have to be driven through it to refusal at the bedrock.

3.7 Subsurface Stratigraphy on Land (east approach embankment area)

Boreholes 6, 13 and 14 were drilled on land and these penetrated more competent deposits than those drilled in the water. In Borehole 6 mixed earth and rubble fill of 2 m thickness was placed over the lacustrine silt to create dry land: this silt deposit is 2 m thick and is compact due to the consolidating weight of the mixed fill. Finally a 1.5 m thick glacial till deposit was found to overlie the bedrock which was cored. In Borehole 13 the soil consisted of some surficial fill with (frozen) silty clay below, and at 1.6 m depth auger refusal, probably caused by bedrock, was encountered.

.../...

In Borehole 14, a silty sand deposit was encountered below the ground surface level, to a depth of 3.1 m, where refusal was encountered, probably on bedrock. From the recorded 'N'-values which range from 16 to 41 blows/0.3 m this deposit is described as compact to dense.

3.8 Bedrock

The bedrock was cored in six of the fifteen boreholes and was found to consist mainly of granodiorite, an acid-intrusive Archean rock type of the Pre-Cambrian period. In Borehole 2, quartz syenite veins and andesite were encountered within the main granodiorite rock. The rock is of good quality as indicated by the high recovery rates (generally 100%, with occasional values of 92 to 98%), and high RQD values (generally between 90 and 100%, in some cases 60 to 75%). In Borehole 6 a boulder and probably the upper broken zone of the bedrock was penetrated where the RQD values were 0 and 24% in the first two runs.

The bedrock surface is quite variable and, in the geological past, Kenogami River may have had a predecessor because in Borehole 1 the overburden was found to extend below Elevation 276.6 m while the surface of the bedrock was encountered at El. 291.5 in Borehole 2, and refusal, probably indicating bedrock, was encountered at El. 291.3 m and 287.7 m, in Boreholes 10 and 11, respectively. In Borehole 12, the bedrock lies even deeper, as shown by the dynamic cone penetration test, which could be driven as deep as El. 276.5 m. These borings were made close to, or in the present river channel.

The bedrock surface is rising towards the east, and it was encountered or inferred at Elevation 305.4 m in Boreholes 3 and 8. In Borehole 5, it was cored beginning at El. 307.6 m, and was inferred at Elevation 308.7 m in Borehole 6. The average slope of the bedrock surface between the borehole locations appears to be of the order of 3 horizontal to 1 vertical between Boreholes 9 and 15 and possibly steeper than this between Boreholes 1 and 2. Attention is called to the drilling experience in Borehole 3 where the sloping bedrock surface deflected the auger and the borehole had to be relocated. Further easterly, in Boreholes 13 and 14, refusal was encountered at El. 314.0 and 313.4 m, respectively. Not far from the site, towards the east, rock outcrops indicate the rising bedrock surface.

3.9 Approach Embankment Materials

In July, 1994, auger probes and sampled boreholes were put down in the west and east approach embankments to investigate the types of material from which the embankments were constructed.

West Approach Embankment: Eight probes (P1 to P8) were made in the roadway between Stations 10+416.3 and 10+434.5. The probes encountered rockfill at depths ranging between 0.7 m and 1.1 m depth which caused auger refusal, after penetrating a maximum of about 4.7 m into it. In Probe Hole P8 the rockfill was cored from 1.1 m to 2.7 m depth. Detailed logs of the probes are shown below.

.../...

East Approach Embankment: Two sampled boreholes (P9 and P10) were put down at Stations 10+609.2, 3.5 m Right, and 10+622.6, 3.0 m Right. Split Spoon samples were taken and Standard Penetration tests were performed. The embankment material was found to consist of silty fine sand.

3.10 Groundwater

In April, 1994, when the three boreholes were drilled from a raft, the Kenogami River level was at Elevation 311.4 m.

The four boreholes at the west abutment were drilled through 0.3 to 0.6 m of ice, whose top elevation was 312.3 to 312.7 m (average: 312.4 m). The groundwater level ranged from Elevation 312.2 m in Borehole 1 to Elevation 311.4 m in Borehole 10 (average Elevation 311.9 m).

At the east abutment, Boreholes 3, 4, 5, 7 and 8 were drilled in shallow water, near the shore of the lake. The top elevation of the ice was between 312.4 m and 313.0 m (average: 312.6 m). The ice was 0.2 m to 0.8 m thick and groundwater was encountered between Elevation 311.5 m and 312.1 m (average: Elevation 311.8 m).

Boreholes 13 and 14 were drilled further away from the shore, from higher ground (Elevation 315.6 m and Elevation 316.5 m, respectively). Groundwater was not encountered in these borings within the explored depth (maximum 3.1 m).

4. DISCUSSION AND RECOMMENDATIONS

4.1 Summary of Subsurface Conditions

The stations along Highway 11 are increasing from west to east therefore the subsurface conditions will also be summarized proceeding from the west towards the east.

West from the bridge site, the highway is carried by a high approach embankment which was built as a causeway across the shallow waters of Long Lake, close to its swampy north shore. Probe hole findings and visual observations indicate that **rockfill** was used to build the embankment; the rocks were most likely dumped onto the lakebed which was found to consist of **soft/very loose mud** (layered fine sands, silts, wood fragments and peat). This material is generally 1.2 to 3.5 m thick and is underlain by **two compact silt deposits** which are separated by a **firm silty clay layer**. Due to their lacustrine origin, all deposits are layered. The upper silt is generally 3 to 5 m thick, the silty clay is 2 to 6 m thick, and the lower silt extends to a **heterogeneous mixture of silt, sand and gravel (glacial till)** deposit overlying the mainly granodiorite **bedrock**. Similar conditions were encountered at the site of the bridge itself, in the Kenogami River. In general, the surface of the bedrock rises from west to east.

.../...

The boreholes show that the east approach embankment was built of **silty sand** which was placed on land deposits consisting of **loose to compact fine sand and silt**, with the bedrock lying maximum 7 m below existing ground level, at the borehole locations. The westerly toe of the east approach embankment extends into the river/lakebed, and rock outcrops, a couple of hundred metres east from the site, also indicate that the bedrock surface is rising towards the east.

At the time of the fieldwork the water level in the river was at El. 311.5 m. The water level, would, however, fluctuate with the seasons of the year, wind direction, etc.

4.2 Alternative Conceptual Arrangements

Two main alternatives are being considered:

Alternative I consists of replacing the existing bridge with a new, four-span structure along the centreline of the existing highway and bridge. The approach embankment will be raised slightly; the table below shows the existing and proposed highest new road levels:

	<u>West Abutment</u>	<u>East Abutment</u>
Existing Road Level:	El. 321.5 \pm m	El. 324.8 \pm m
New Road Level:	El. 323.0 \pm m	El. 325.5 \pm m

During demolition and re-construction of the existing bridge, traffic from Highway 11 will be re-directed over a detour to be built 23 m c/c south from the existing bridge. For the detour, new but low approach embankments will have to be built with the top of road level at El. 316 \pm m, for a level crossing with the CNR tracks. Kenogami River will be bridged by a temporary three-spanned structure.

Alternative II consists of building a new bridge at 16 or 18 m c/c distance south from the existing structure which will remain in use during construction of the new structure. To provide sufficient clearance for the CN railway line below, new and high approach embankments will have to be built at both ends of the new bridge which may consist of four to six spans. The top of west and east embankments could be as high as El. 323.0 m, and El. 325.5 m, respectively; the same as for Alternative I.

.../...

4.3 Foundations

4.3.1 General

The proposed new bridge - including the temporary detour structure, if Alternative I is chosen - will have to be supported by some type of deep foundation for lack of suitable bearing stratum within economical depth for spread footings. Augered cast-in-place concrete caissons and driven steel H-bearing piles were considered; the relative advantage/disadvantages of the two will be discussed below.

Augered cast-in-place concrete caissons are not considered suitable at this site because creating a water-tight seal at the base of the caissons to permit rock excavation (if necessary), and cleaning and inspection of the bearing surface, could be very expensive.

4.3.2 Steel H-Bearing Piles

Steel H-bearing piles, driven by a suitable hammer, are recommended for supporting the proposed structure. These piles would generally develop the required capacity when reaching bedrock, with the exception of Borehole 1, where the piles could encounter practical refusal at El. 281 \pm m, in the very dense glacial till. Hard driving is anticipated and therefore the piles should have reinforced tips as per MTO Drawing No. OPSD 3301. "Oslo-points" may also have to be provided on a unit-price basis in the event that they are needed to seat the piles on bedrock. (Note: in Borehole 3 the auger was deflected by the sloping bedrock surface at 7 m depth).

The Factored Pile Capacity at the Ultimate Limit States (Q_u), and the Pile Capacity at the Serviceability Limit States, (Q_s), for two pile sizes are given below:

PILE SIZE	Q_u kN	Q_s kN
HP 310 x 110	1,600	1,150
HP 310 x 79	1,150	900

Unbalanced horizontal forces, including ice forces, should be resisted by battered piles, depending on the magnitude of the forces. Due to the large moment-arm and the weak soils encountered in the riverbed, the lateral resistance of steel H-bearing piles will likely be very small.

The **driving of piles** in the field should be controlled by the Hiley formula, using a safety factor of at least 3. The piles should be driven with a hammer, capable of delivering a minimum energy of about 50 kJ per blow, to practical refusal on the surface of bedrock, or to a final set of about 20 blows/25 mm penetration in the very dense glacial till.

.../...

The table below shows the anticipated pile tip elevations:

LOCATION	BOREHOLE NUMBER	APPROXIMATE PILE TIP ELEVATIONS
West Abutment	1, 10	El. 280 to 291
West Pier	2, 9	El. 292 to 296
Centre Pier	3, 15	El. 303 to 305
East Pier	4, 7, 8	El. 305
East Abutment	5, 6	El. 308

It can be seen that the pile lengths will vary considerably and therefore, we recommend that unit prices be provided in the contract documents for adjustments.

The installation details of piles at the two abutment locations and at the piers will differ, as discussed later.

4.3.3 Negative Skin Friction

Below the approach embankments negative skin friction (down-drag) could decrease the useful load carrying capacity of the piles. This down-drag would develop as a result of settlement of the subsurface soils, especially the settlement occurring in the upper silt and in the silty clay deposits. The magnitude of this down-drag load will, to a large extent, depend on the construction schedule. Assuming that the piles would be driven before the embankment is raised, or immediately thereafter, the down-drag values for **Alternative I**, should be taken into account as shown below:

New Bridge, West Abutment

Existing embankment raised by 1.5 m,
from El. 321.5 m to El. 323.0 m

	<u>without down-drag</u>	<u>with down-drag</u>
Ultimate Limit States:	Q_f (kN)	Q'_f (kN)
HP 310 x 110	1600	1350
HP 310 x 79	1150	900

.../...

Serviceability Limit States:	Q_s (kN)	Q'_s (kN)
HP 310 x 110	1150	980
HP 310 x 79	900	730

These values are based on the assumption that the piles will be protected from rock fill and that there will be no direct contact between the pile and the rock fill, as discussed in Section 4.3.4 of the report.

If the embankment is built to its maximum height minimum four months prior to driving the piles, the down-drag forces can be neglected.

Existing embankment raised by maximum 0.5 m, from Elevation 321.5 m to Elevation 322.0 m	down-drag need not be considered
--	--

New Bridge, East Abutment

We recommend that the embankment should be raised at least six weeks prior to driving the piles in which case the negative skin friction can be neglected.

Detour Bridge, West Abutment

Detour embankment (= berm)
top of berm at El. 316.0 m

	<u>without down-drag</u>	<u>with down-drag</u>
Ultimate Limit States:	Q_f (kN)	Q'_f (kN)
HP 310 x 110	1600	1475
HP 310 x 79	1150	1025
Serviceability Limit States:	Q_s (kN)	Q'_s (kN)
HP 310 x 110	1150	1065
HP 310 x 79	900	815

As mentioned before, the down-drag values are based on the assumption that the piles will be protected from rock fill, and that the piles will not be in direct contact with the rockfill.

.../...

We recommend that the embankment should be built to its maximum height minimum four months prior to driving the piles in which case the down-drag forces can be neglected.

Detour Bridge, East Abutment

As a result of constructing the detour embankment to Elevation 316.0 m, negative skin friction could develop on the piles due to compression of the underlying soil. We recommend that the approach embankment should be built at least six weeks prior to driving the piles in which case the down-drag can be neglected.

4.3.4 Piles for the West Abutment

The piles for the west abutment will have to be installed through rockfill embankment which can be very difficult and expensive. One approach would consist of excavating the rockfill before driving the piles, and replacing it after the piles were installed. The excavated rockfill can be utilized in the berm along the north side of the approach embankment which will be discussed later in this report. After the piles were installed, a sleeve (e.g. corrugated pipe or similar) should be placed over them to protect the piles while replacing the rockfill. The maximum size of rockfill should be limited to 150 mm around the piles and the rockfill should be deposited evenly to avoid generating unbalanced lateral forces. To minimize transfer of down-drag forces from the rockfill, the space between the piles and sleeves should be left open and filled with concrete just prior to building the abutment.

Alternatively, suitable drilling methods, (e.g. churn-drilling), can be employed to drill through the rockfill. Casing, possibly more than one size, should be installed, to prevent caving of the bore, and the casing should be filled with concrete up to the abutment level as late as possible, just prior to building the superstructure.

For the temporary bridge abutments, placing material suitable for pile driving may be considered in the section through which piles will be driven. In this case, however, a suitable filter should be provided between the finer material and the rock fill to avoid infiltration of the fines into the rock fill.

If the underside of the abutment is one metre or more above the High Water Level, and the rockfill is free-draining, frost protection would not be necessary.

4.3.5 Piles for the East Abutment

The east approach embankment was found to consist of silty sand materials, therefore, major driving difficulties caused by underground obstructions due to rock fill are not anticipated here.

Full frost protection of 2.6 m should be provided for the abutment.

.../...

4.3.6 Piles for the Piers

If the piles are at a sufficient distance from the toe of the approach embankments, no major driving difficulties are foreseen, although the occasional boulder-size rock fragment could obstruct the penetration of some of the piles. In such instances the pile may have to be withdrawn or abandoned, and replaced by additional pile(s).

For piles driven in the river, a pile cap may not be required but in such instances, a pre-fabricated steel sleeve should be installed around the piles, in accordance with Standard MTO details. The sleeve should extend from the depth of scour up to the bent supporting the bridge girders.

Alternatively, a pile-cap can be constructed under protection of a cofferdam which has to be properly engineered to resist hydrostatic and ice forces, and upward directed seepage effects.

For the temporary detour structure, concrete encasement of the piles is not considered necessary. If required, ice forces could be resisted by timber log booms.

4.3.7 Abutment on Spread Footings

For the sake of completeness, the feasibility of building a "perched abutment", resting on spread footings placed in the approach fill, was also investigated. This foundation method was ruled out, however, because the composition, method of placement, degree of compaction, etc., of the embankment material are not known. Therefore, the behaviour and settlement of abutment foundations cannot be predicted with reasonable degree of accuracy, especially since evidence of settlement of the road (i.e. the embankment fill) was noted (i.e. double layer of asphalt). In our opinion, there definitely is a risk of differential settlements of unpredictable magnitude occurring between the nearest pier and abutment. Although the risk of structural damage to the bridge could be mitigated by making the exterior spans of the bridges statically determinate, disruption of traffic and potentially very expensive repair work may be necessary if movements do occur.

4.4 Lateral Earth Pressures Acting on Structures

Free-draining material, such as Granular 'A' or 'B' aggregates (OPSS 1010), should be used within a wedge behind the abutments and retaining walls bounded by a plane rising at 45° to the horizontal as shown in Figure 6-7.4.4 of the O.H.B.D.C., 3rd Edition. The free-draining backfill material and the provision of weep holes in the abutment walls should prevent hydrostatic pressure build-up. Design parameters for the free-draining backfill are given in the table below:

.../...

Backfill Properties

	<u>Rockfill</u>	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (ϕ , unfactored)	44°	35°	30°
Unit Weight (kN/m ³)	18.0	22.8	21.2
Coefficient of Active Earth Pressure (K_a)			
- S.L.S.	0.27	0.27	0.33
- U.L.S.	0.33	0.33	0.40
Coefficient of Earth Pressure at Rest (K_o)			
- S.L.S.	0.43	0.43	0.50
- U.L.S.	0.50	0.50	0.58

If rockfill is placed behind the abutment, the maximum particle size should be limited to 150 mm within a 0.5 m zone along the abutment to minimize damage to the concrete.

Over-compaction of the backfill could lead to the development of large horizontal pressures behind the abutments and retaining walls. Vibratory equipment for use behind the retaining structures should therefore be restricted in size as per current Ontario Ministry of Transportation Specifications.

4.5 Approach Embankments

4.5.1 General

The geotechnical conditions at the west and east embankments are different, as shown below.

	<u>West Embankment</u>	<u>East Embankment</u>
Embankment Foundation (overburden):	relatively deep deposits of very loose/soft mud, and slightly over- consolidated silts and silty clays	shallow deposits of loose mud or silty clay or mixed fill, and compact silt, or fine sand, underlain by glacial till

.../...

Embankment Material:	rockfill	silty and sandy fill
Embankment Geometry:	generally 1 1/2 (H) to 1(V), with at least one section (Station 10+422) where the side slope is 1.15(H) to 1(V)	about 2(H) to 1(V)

Because of these differences, the two approach embankments will be discussed separately.

4.5.2 West Approach Embankment

As mentioned before, the west approach embankment has been built as a causeway close to the north shore of Long Lake, in shallow and probably partly marshy waters. The embankment was found to consist of rockfill, with a thin blanket of silty clay fill cover and, at some locations, two levels of asphalt pavement structure above it. The top of the embankment (between the exterior edges of shoulders) is about 18 m wide and the side slopes are about 1 1/2(H) to 1(V). The MTO surveyors who were on the site in July, 1994, determined that at Station 10+422 the north embankment slope was as steep as 1.15(H) to 1(V), between El. 315.5 m and 320 m, but below El. 315.5 m the embankment slope was (or has) flattened to 2(H) to 1(V).

Due to the presence of deep silt and silty clay deposits below the west approach embankment, extensive stability analyses were carried out, both for the short and the long term. A rockfill embankment was analyzed, with 1 1/2(H) to 1(V) side slopes. Janbu's simplified method and the 'PC-Slope' program were used in the analyses, along with the undrained and drained soil properties listed in Chapter 3 of this report. In the analyses the lake bottom near the toe of the approach embankment/berm was assumed to be level.

The results of the analyses are discussed in the following paragraphs:

CASE I: Existing Conditions

Top of Embankment: El. 321.5 m (highest point)

	Factor of Safety
end of construction	1.14
long term (present)	1.17

.../...

For the short-term stability, the critical slip circle cuts through the full height of the embankment and extends deep into the firm silty clay layer. For the long-term stability, the critical circle is shallow, cuts through the sloping side of the embankment and only extends into the "mud".

These results indicate that, although the existing embankment appears to be stable, the calculated factor of safety with respect to general foundation failure is less than 1.3.

CASE II: Embankment Raised to El. 323.0 m

In Alternative I the existing approach embankment would be raised to El. 323.0 m which would further decrease the safety factor, as shown by the results of the short-term stability analysis.

	Factor of Safety
end of construction	1.06

The critical circle cuts through the full height of the embankment and extends into the firm silty clay deposit.

CASE III: Embankment Raised to E. 323.0 m - with Berm

The low safety factors indicate that a berm is required. We recommend that the berm consist of rockfill with 1 1/2(H) to 1(V) side slopes. Assuming that the top of the raised embankment is at El. 323.0 m, and that the top of the berm is at El. 316.0 m, the stability of the berm-supported embankment is a function of the width of the berm across the top. Two berm widths were analyzed: 12 m and 15 m.

	Factor of Safety with Rockfill Berm	
	12 m wide	15 m wide
	rockfill berm at El. 316.0 m	
Rockfill approach embankment:		
end of construction	1.34	1.45
long term	1.58	satisfactory

In all cases, the critical slip circle cuts through the full height of the approach embankment, and extends deep into the silty clay layer.

.../...

The recommended details of the stabilizing berm are as follows:

On the **south side** of the westerly embankment the berm should be minimum 12 m wide. This berm - which will serve as a detour embankment during construction of the bridge in Alternative I - will run westward at El. 316.0 to about Station 10+380, then rise gradually to El. 316.8 at Station 10+270 meet the existing grade of Highway 11. At this point, however, the proposed new grade of the highway will be raised to El. 317.2 m. The stability of the south berm, with its top at El. 316.8 m, was also checked:

Factor of Safety

Rockfill berm for detour

end of construction

1.21

The critical slip circle cuts through the side slope of the berm, is shallow and extends into the mud, indicating that local sloughing may occur during construction and some rockfill material will be lost. The "mud", would however, consolidate quickly and, as a result, the factor of safety is also expected to increase with time.

Westerly from Station 10+270 the berm would decrease in height and gradually blend into the existing alignment of Highway 11.

At the **east end** of the approach embankment, the berm should be 12 m wide, with its crest at El. 316.0 m, and this berm width should be maintained for a full 180 degrees around the embankment. The construction of this berm will decrease the cross-sectional volume of the river channel, and if this considered objectionable then the existing embankment should be excavated to Elevation 316.0 m for a length of 12 m, thereby creating a berm. Although this would increase the length of the new bridge, it appears to be a geotechnically equivalent (or even superior) solution to building a new berm.

On the **north side** of the west approach embankment the 12 m wide berm should continue to Station 10+400, maintaining its top elevation at El. 316 m. Westward from Station 10+400, the berm can be narrower and lower, linearly decreasing to 5 m width and to El. 314.5 m at Station 10+290, where the top of approach embankment is at El. 318 m. At this point the following calculated safety factors were obtained for a rockfill embankment, with 1 1/2(H) to 1(V) side slopes.

.../...

Top of Approach Embankment at El. 318.0 m
5 m wide berm at El. 314.5 m

Factor of Safety

end of construction	1.45
long term	1.58

For both the short-term and long-term cases, the critical slip circle cuts through the full height of the embankment but, while for the short-term analysis the circle extends deep, into the silty clay layer, for the long-term the circle it is shallow and extends into the mud only.

From Station 10+290 westward the berm along the north side can gradually blend into the existing approach embankment, and disappear, say, over a length of 90 m, i.e. berm would not be required west from Station 10+200.

CASE IV: Existing Conditions, Berm Added

In this case, the approach embankment would remain at the present elevation of 321.5 m, but a 12 m wide rockfill berm with top elevation at 316.0 m would be added.

Rockfill approach embankment:	Factor of Safety
end of construction	1.43

The critical slip circle cuts through the full height of the embankment and extends into the silty clay deposit.

CASE V: Embankment Raised to El. 322.0 m, with Berm

In this event the embankment would be raised by 0.5 m, to Elevation 322.0 m, with a 12 m or 15 m wide rockfill berm, top elevation at 316.0 m.

Rockfill approach embankment was analyzed:	Factor of Safety	
	12 m wide berm	15 m wide berm
end of construction	1.40	1.49
long term	satisfactory	satisfactory

.../...

In all cases, the critical slip circle cuts into the full height of the embankment and extends into the silty clay layer.

It can be seen that a berm is necessary even if the embankment is maintained at its present height. Since on the south side of the embankment a detour will be needed, this detour itself will serve as the stabilizing berm.

Settlement of the Embankment

Based on the borehole results and the consolidation test results which were performed on the relatively undisturbed soil samples, the following settlements and rate of settlement values were obtained.

The calculated total settlement for a berm with top Elevation at 316 m is about 0.4 m. If the embankment is raised by 1.5 m to El. 323.0 m, the expected settlement is about 0.1 to 0.2 m. Ninety percent of the total consolidation should be completed within four months.

The settlement due to subsidence of the rockfill itself is not included in the above values and it was assumed that the "mud" will consolidate or will be displaced almost instantly, upon application of the load.

4.5.3 East Approach Embankment

At the east approach embankment the grade may be raised by as much as 0.7 m if the four-span arrangement is adopted. If the bridge will have six spans, the present grade will remain unchanged.

The conditions were explored with six boreholes (Boreholes 4 to 7, & 13 and 14). The borings indicate that the bedrock lies 5 to 7.5 m below surface level and the overburden consists mainly of a 2 to 4.6 m thick layer of compact silt layer overlying silty sand till and bedrock. In the boreholes drilled in water, maximum 2 m thick mud was encountered just below the ice.

Additional two boreholes (P9 and P10) were subsequently drilled from the top of the embankment and these indicate that the approach embankment was built from silty sand and fine sand fill, using 2(H) to 1(V) side slopes. Refusal, probably on bedrock, was encountered a short distance below the fill, at Elevation 313.2 m in Borehole P9. At Station 10+612, the north slope of the embankment is flatter (3H to 1V) below El. 317 m which indicates that local sloughing has occurred in the past due to displacement of the mud in the lake/river. As a result, the embankment fill material came to rest at a flatter slope than the fill above. Along the southern half of the end of the east approach embankment the CN railway embankment and the highway embankment join each other and the mud has either been displaced or fully consolidated.

.../...

If the embankment is not raised, the existing conditions may be considered as stable and no special precautions are needed. If the embankment is raised by 0.7 m, around the west end of the embankment, the mud may be displaced by the fill. On the south side, the detour will act as a stabilizing berm.

During any work along the CN-tracks, caution should be exercised not to endanger the stability of the CN-embankment. As well, the top-of-rail elevations should be continuously monitored during construction to make sure that the rail elevations be adjusted should settlement occur.

4.6 Recommended Alternative

From the geotechnical point of view it is our opinion that Alternative I is the recommended choice. Even if the existing approach embankment is not raised, its stability should be increased by adding berms along both of its sides, and around its end. Since in Alternative I a low detour embankment will have to be built, it will immediately serve as a permanent berm for the main embankment, along the south side.

If Alternative II were chosen, a berm would still be required along the south side of the embankment, although the berm could be omitted along the north side because the existing embankment could be excavated to a lower elevation after the new bridge is completed and serve as a berm, whose dimensions and extent should be as recommended in this report. Also in Alternative II the negative skin friction (down-drag) acting on the piles would be very high and the piles could not be driven before the soil strata are fully consolidated below the new high approach embankments. It is estimated that about six months would be necessary for sufficient consolidation.

Alternative I also appears to be the more economical choice because it requires less rockfill.

5. CLOSURE

The Limitations of Report, as quoted in the Appendix, are an integral part of this report.

AGRA Earth & Environmental Limited



Leslie S. Rolko, P. Eng.



Z.S. Ozden, P. Eng.

.../...

APPENDICES

APPENDIX 'A'
METHOD OF INVESTIGATION

The fieldwork for this project was carried out during the periods of April 12 and 18, 1994, and July 4 and 5, 1994. In April, fifteen boreholes were drilled while in July, six auger probes and four sampled boreholes were put down. The borehole locations (stations and offsets) and elevations were determined by the surveyors of MTO.

In April, the fifteen boreholes (Nos. 1 through 15) ranged in depth from 1.6 m to 36.1 m, and the total drilling amounted to 211.0 m. This length does not include the 5.5 m Dynamic Cone Penetration Test which was driven from 30.5 to 36.0 m depth to obtain subsurface information below the sampled depth of Borehole 12. Three borings (Nos. 2, 9 and 15) were drilled from a raft in the river, the remainder on ice, or on land. The bedrock was cored in six boreholes to lengths ranging from 1.5 to 2.3 m; BXL-size (40 mm diameter) core was recovered.

The July program consisted of six auger probes (P1 through P6), one sampled borehole (P7), and one corehole (P8), on the west approach embankment. Two sampled boreholes (P9 and P10) were put down on the east approach embankment.

.../...

The locations of boreholes and auger probes are shown on the Location Plan, Drawing Nos. 3819001-A & B.

The April program was carried out using two tire-mounted drill rigs (a BOA 8M and CME 750) for the land and ice borings, while a CME 45 type, trailer-mounted rig was used to work from the raft. In July the CME 45 drill rig was used for the probes and boreholes. All equipment is owned and operated by Dominion Soil Thunder Bay Limited, but the field sampling was directed, supervised and records were kept by an experienced Geotechnical Engineer from AGRA Earth & Environmental Limited, Scarborough, Ontario.

Representative samples were taken with a 51 mm o.d. split spoon (SS-samples), in accordance with the Standard Penetration Test method. The test results, referred to as the Standard Penetration Resistances or 'N'-values, provide a measure of the degree of compactness of granular soils, or consistency of cohesive soils. Relatively undisturbed soil samples were taken with 51 mm diameter thin-walled tubes (TW-samples) and in-situ shear tests were performed with a four-winged vane. Both the undisturbed and remoulded shear strengths of the soil were measured. The groundwater conditions were observed during drilling and after completion of the boreholes; standpipes or piezometers were not installed in any of the boreholes.

.../...

The samples were taken to our laboratory in Scarborough where the TW samples were extruded, identified and tested. The water content of over 60 samples (both SS and TW samples) was measured, together with the natural unit weight of the TW samples. For proper classification of the encountered soil samples, grain size distribution analyses and Atterberg Limits tests were performed. To measure the undrained shear strength of the soil for the stability analyses, unconsolidated/undrained triaxial compression tests were performed on three samples and the consolidation characteristics of six samples were determined on six samples. The organic content of two samples was determined using the H_2O_2 digestion method.

The soil profiles, sampling and coring details and field and most laboratory test results are shown on the Record of Borehole sheets. The grain size distribution curves and consolidation test results are shown one Figure Nos. 1 through 5, and 6 through 8, respectively.

.../...

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LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Geotechnical Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in testholes. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

RECORD OF BOREHOLE No 1

METRIC

W P 381-90-01 LOCATION Station 10+435, 24.0 m Lt ORIGINATED BY CR
 DIST Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CR
 DATUM Geodetic DATE April 18 - 20, 1994. CHECKED BY 300

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					
312.7	ICE SURFACE																
0.0	ICE																
312.4	COBBLES & BOULDERS		1	AS	---	ON COMPLETION OF BORING	312										Borehole was relocated 3x to bypass cobbles and boulders
	"MUD"		2	SS	2												
	(dark brown SANDY SILT with layers of SILTY FINE SAND, and wood fragments, peat traces)		3	SS	7												
			4	SS	2		310										
308.9	very loose saturated		5	SS	3												
3.8	grey SILT with layers of SILTY FINE SAND compact saturated		6	SS	15		308										0 7 86 7
			7	SS	13												
			8	SS	12		306										
305.2	grey SILTY CLAY with layers of SILT firm wet		9	TW	PH		304										19.5 17.4 17.0 0 0 69 31
7.5			10	SS	2												
302.8			11	SS	9		302										
9.9	grey SILT with layers of FINE SAND compact saturated silty clay lamination		12	SS	40		300										0 0 88 12
			13	SS	13												
			14	SS	21		298										
			15	SS	23		296										0 1 74 25
			16	SS	24		294										
			17	SS	33		292										
290.1			18	SS	8												
22.6																	

Continued

+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

Continued

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 1 Continued										METRIC		
W P 381-90-01		LOCATION Station 10+435, 24.0 m Lt				ORIGINATED BY <u>WLR</u>						
DIST <u>Thunder Bay 19 HWY 11</u>		BOREHOLE TYPE <u>Hollow Stem Augering and Washboring</u>				COMPILED BY <u>WLR</u>						
DATUM <u>Geodetic</u>		DATE <u>April 18 - 20, 1994.</u>				CHECKED BY <u>ESD</u>						
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
290.1	Continued											
22.6	silty clay laminations	19	SS	24								
	grey SILT with layers of FINE SAND compact saturated	20	SS	22								
		21	SS	31								
285.6					286							
27.1	SILTY FINE SAND trace gravel (probably compact) saturated	22	SS	4								
		23	SS	6								
282.8												
29.9	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)	24	SS	80/15cm								
		25	RC	REC 50%								
		26	SS	100/8cm								
		27	SS	92/15cm								
	damp to moist											
276.6	very dense	28	SS	100/15cm								
36.1	END OF BOREHOLE											

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 381-90-01 LOCATION Station 10+474, 6.0 m Lt ORIGINATED BY CLL
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CLL
 DATUM Geodetic DATE April 23-24, 1994. CHECKED BY ase

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20 40 60 80 100										
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE											
311.4	WATER SURFACE													GR SA SI CL				
0.0	KENOAGAMI RIVER													Drive N-casing and clean. Wash to 4.6 m. Advance bore with BW casing.				
310.2	"MUD" (dark brown SANDY SILT with layers of SILTY FINE SAND, wood fragments, peat traces very loose saturated)		1	SS	PH		310											
1.2			2	SS	3													
308.2			3	SS	3													
3.2	grey SILT with clay laminations compact saturated		4	SS	25		308											
306.5			5	SS	10													
4.9	grey SILTY CLAY with layers of SILT firm wet		6	TW	PH		306	+3.2						0 0 68 32				
304.7																		
6.7			7	SS	17		304	+3.2						Ap.23				
	silty clay laminations		8	SS	10		302							Ap.24				
	grey SILT		9	SS	11		300							0 18~79 ~3				
	with layers of FINE SAND		10	SS	10													
	silty clay laminations		11	SS	24		298							0 5 87 8				
	compact dense		12	SS	15		296											
	saturated Heterogeneous Mixture of SILT, SAND AND GRAVEL, occasional Cobbles and Boulders (Glacial Till)		13	SS	40		294											
291.6	grey, very dense		15	SS	50/3 cm		292							REC RQD				
19.9	BEDROCK (GRANODIORITE, QUARTZ SYENITE, ANDESITE)		16	BXL RC	---									96% 93%				
289.8			17	BXL RC	---		290							100% 88%				
21.6	END OF BOREHOLE																	

+3, x5 : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4										METRIC				
W P 381-90-01		LOCATION Station 10+565, 11.0 m Lt						ORIGINATED BY <u>con</u>						
DIST Bay 19 HWY 11		BOREHOLE TYPE Hollow Stem Augering						COMPILED BY <u>con</u>						
DATUM Geodetic		DATE April 21, 1994						CHECKED BY <u>aso</u>						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						
312.6	ICE SURFACE													
0.0	ICE													
311.8														
0.8	"MUD" brown grey SILT with traces of org. matter loose saturated		1	SS	5	ON COMPLE- TION OF BORING								
			2	SS	4									
310.0			3	SS	8									
2.6			4	SS	17									
	SILT with some Sand saturated		5	SS	10									
			6	SS	16									
	silty clay compact laminations		7	SS	11									
306.2														
6.4	grey compact wet		8	SS	17									
305.0			9	SS	30/0	PEN								
7.6	END OF BOREHOLE AUGER & SS REFUSAL PROBABLE BEDROCK													
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6										METRIC			
W P 381-90-01		LOCATION Station 10+610, 29.0 m Rt				ORIGINATED BY <u>CM</u>							
DIST Bay 19 HWY 11		BOREHOLE TYPE Hollow Stem Augering and Washboring				COMPILED BY <u>CM</u>							
DATUM Geodetic		DATE April 22 - 23, 1994.				CHECKED BY <u>ZSO</u>							
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					
314.2	GROUND SURFACE												
0.0	brown/dark brown MIXED FILL		1	AS	---								Frozen to 1.8m depth
312.2	silt, clay, sand cobble, concrete frag- ments		2	SS	4								
2.0	traces of grey organic SILT matter		3	SS	10								
	with silty clay laminations		4	SS	8								
310.2	compact saturated		5	SS	31								
4.0	grey		6	SS	17								
308.7	compact moist to wet BOULDER		7	RC	---								
5.5	BEDROCK (GRANODIORITE)		8	RC	---								
			9	BXL	---								
306.9	END OF BOREHOLE												
7.3	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7										METRIC			
W P 381-90-01		LOCATION Station 10+581, 4.5 m Rt				ORIGINATED BY <u>un</u>							
DIST Bay 19 HWY 11		BOREHOLE TYPE Hollow Stem Augering				COMPILED BY <u>un</u>							
DATUM Geodetic		DATE April 20 and 21, 1994.				CHECKED BY <u>290</u>							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
312.6	ICE SURFACE												
0.0	23 cm ICE												
0.2	"MUD" (dark grey and brown, layers of SILTY SAND and PEAT very loose saturated)		1	AS	---								
310.8			2	SS	3								
1.8	grey SILT		3	SS	6								
			4	SS	19								
			5	SS	10								
	compact saturated		6	SS	16								
			7	SS	17								
307.1													
5.5	grey		8	SS	24								
	compact wet		9	SS	50/3	cm							
305.0													
7.6	BEDROCK (GRANODIORITE)		10	BXL RC	---								
303.4													
9.2	END OF BOREHOLE												
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 381-90-01 LOCATION Station 10+539, 27.0 m Rt ORIGINATED BY CR
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CR
 DATUM Geodetic DATE April 15, 1994. CHECKED BY ZSO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
312.4	ICE SURFACE																
0.0	ICE						312										
311.7																	
0.7	"MUD" (dark brown and grey SILTY FINE SAND with layers of ORGANIC SILT and PEAT very loose saturated		1	SS	7												
			2	SS	2												
309.8			3	SS	11		310										
2.6	grey traces of SILT organics with silty clay laminations compact saturated		4	SS	12												
			5	SS	13												
			6	SS	12		308										
306.9																	
5.5	grey		7	SS	14		306										
305.4	compact saturated		8	SS	60/5	cm											18 40 36 6
7.0	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK																
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9										METRIC				
W P 381-90-01		LOCATION Station 10+480, 24.0 m Rt				ORIGINATED BY <u>CR</u>								
DIST Bay 19 HWY 11		BOREHOLE TYPE Washboring				COMPILED BY <u>CR</u>								
DATUM Geodetic		DATE April 25, 1994.				CHECKED BY <u>Z90</u>								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa						
311.4	WATER SURFACE													
0.0	KENOGAMI RIVER													
310.0														
1.4	"MUD" (greyish and dark brown SILTY FINE SAND with layers of SILT & PEAT very loose saturated)		1	SS	1									
308.0			2	SS	3									
3.4			3	SS	15									
			4	SS	9									
			5	SS	5									
			6	SS	6									
	grey shell fragments		7	SS	12									
	SILT		8	SS	11									
	layers of Fine Sand		9	SS	11									
			10	SS	24									
	clay laminations		11	SS	24									
			12	SS	7									
	shell fragments compact		13	SS	50/5	cm								
296.9	grey very dense		14	BXL RC										
296.4			15	BXL RC										
15.0	BEDROCK (GRANODIORITE)													
294.1														
17.3	END OF BOREHOLE													
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)													

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 10

METRIC

W P 381-90-01 LOCATION Station 10+430, 23.0 m Rt ORIGINATED BY LM
DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY LM
DATUM Geodetic DATE April 12, 1994. CHECKED BY Zao

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
312.3	ICE SURFACE																
0.0	ICE						312										
311.7																	
0.6	"MUD" (dark brown and grey SANDY SILT with layers of SILTY FINE SAND, wood fragments and traces of peat) very loose saturated		1	SS	3												
			2	SS	3												
			3	SS	1		310										
			4	SS	2												
307.9																	
4.4	grey SILT with silty clay laminations compact saturated		5	SS	9		308			2.7							
			6	SS	7												
305.1																	
7.2	grey SILTY CLAY with silt layers firm wet		7	SS	4		306										
			8	TW	PH												
302.1																	
10.2			9	SS	10		304										
			10	SS	26		302										
			11	SS	16												
			12	SS	19		300										
			13	SS	30												
			14	SS	23		298										
			15	SS	22												
291.3			16	AS	---		296										
21.0	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK		17	SS	30/0	PEN	294										
							292										

RECORD OF BOREHOLE No 11

METRIC

W P 381-90-01 LOCATION Station 10+400, 22.0 m Rt ORIGINATED BY CR
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CR
 DATUM Geodetic DATE April 13, 1994. CHECKED BY ZW

OFFICE REPORT ON SOIL EXPLORATION

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							WATER CONTENT (%)	GR SA SI CL			
								SHEAR STRENGTH kPa											
								○ UNCONFINED	+ FIELD VANE										
								● QUICK TRIAXIAL	x LAB VANE										
								25 50 75 100 125											
312.3	ICE SURFACE																		
0.0	ICE						312												
311.7																			
0.6	"MUD" (brown Silty Sand with organics) very loose saturated		1	SS	3														
310.5			2	SS	6														
1.8			3	SS	11		310							0 36 62 2					
	grey SILT with Fine Sand layers traces of		4	SS	12														
	organic matter compact saturated		5	SS	15		308							0 71 28 1 SS6: organic content 0.4%					
306.7			6	SS	31														
5.6			7	SS	13		306							0 1 81 18					
	grey SILTY CLAY with silt layers firm wet		8	TW	PH			+4.4											
			9	TW	PH		304	+3.2						TW8 & TW9: no recovery TW8: sample recovered in SS					
301.9			10	SS	2			+3.3											
10.4	traces of organics		11	SS	12		302												
			12	SS	28		300							0 16 78 6					
	silty clay laminations		13	SS	16		298							SS14: 0 5 84 11					
	SILT silty clay laminations		14	SS	4		296							SS14 & SS17 'N'-values probably reduced by upward see- page forces					
			15	SS	10		294							0 16 81 3					
	with layers of FINE SAND		16	SS	29		292												
			17	SS	3														
			18	SS	14		290												
289.7	compact saturated																		

22.6

Continued

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 11 Continued METRIC

W P 381-90-01 LOCATION Station 10+400, 22.0 m Rt. ORIGINATED BY CR
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CR
 DATUM Geodetic DATE April 13, 1994. CHECKED BY Zao

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
289.7	Continued															
22.6	silty clay															
	SILT with laminations		19	SS	10											
	layers of Fine Sand compact saturated															
287.7			20	SS	50/8	cm	288									
24.6	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK															

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 12

METRIC

W P 381-90-01 LOCATION Station 10+361, 19.0 m Rt ORIGINATED BY cm
DIST Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY cm
DATUM Geodetic DATE April 13 - 14, 1994. CHECKED BY zro

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	SHEAR STRENGTH kPa					
312.5	ICE SURFACE													GR SA SI CL
0.0	ICE						312							
311.9														
0.6	"MUD" (dark brown SILTY FINE SAND traces of wood bark,peat) very loose saturated		1	SS	3									
			2	SS	1									
310.1							310							
2.4	grey		3	SS	11									
			4	SS	11									
	SILT with layers of Silty Fine Sand compact saturated		5	SS	30		308							
			6	SS	24									
306.1							306							
6.4			7	SS	8			7.6						
	grey		8	TW	PH							19.3		
	SILTY CLAY						304	4.9				21.3		
	with		9	SS	1									0 5 72 23
	layers of SILT		10	TW	PH									
	firm wet		11	SS	4		302	4.1				Ap.13		
												Ap.14		
300.0			12	SS	27		300	2.9						
12.5														
	grey						298							
	silty clay laminations		13	SS	17									
			14	SS	10									
	SILT						296							
			15	SS	12									
	with						294							
	layers of Fine Sand		16	SS	7									
	compact saturated													
			17	SS	28									
							292							
			18	SS	21									
289.9							290							SS16: 'N'-value probably reduced by upward see- page forces

Continued

+³, x⁵: Numbers refer to
Sensitivity

20
15 → 5 (%) STRAIN AT FAILURE
10

Continued

SS16:
'N'-value
probably
reduced by
upward see-
page forces

RECORD OF BOREHOLE No 12 Continued METRIC

W P 381-90-01 LOCATION Station 10+361, 19.0 m Rt ORIGINATED BY CR
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CR
 DATUM Geodetic DATE April 13 - 14, 1994. CHECKED BY ZSO

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
289.9	<p>Continued</p> <p>grey SILT with layers of Fine Sand compact saturated</p>		19	SS	18								
22.6													
			20	SS	18	288							
			21	SS	21	286							
			22	SS	11	284							
282.0	END OF SAMPLED BOREHOLE					282							<p>Augered to E1. 282.0m (easy auger- ing) then drove dyna- mic cone penetration test</p>
30.5						280							
						278							
276.5	END OF DCPT												
36.0													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 13

METRIC

W P 381-90-01 LOCATION Station 10+670, 28.0 m Rt ORIGINATED BY UK
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY UK
 DATUM Geodetic DATE April 23, 1994. CHECKED BY JKO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
315.6	GROUND SURFACE												
0.0	Sandy Silt Fill Topsoil		1	AS	---	BH DRY							
	brown SILTY CLAY (frozen)		2	SS	22								
314.0	cobble		3	SS	30/8								
1.6	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 14										METRIC					
W P 381-90-01		LOCATION Station 10+707, 25.0 m Rt				ORIGINATED BY <u>CR</u>									
DIST Bay 19 HWY 11		BOREHOLE TYPE Hollow Stem Augering				COMPILED BY <u>CR</u>									
DATUM Geodetic		DATE April 23, 1994.				CHECKED BY <u>Zso</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT <u>2</u>			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
316.5	GROUND SURFACE														
0.0	frozen to 0.8 m depth		1	AS	---		316								Borehole was relocated once because of boulder @ 1.2m depth
	brown SILTY SAND moist wet		2	SS	41										
			3	SS	16										
			4	SS	28										
313.4	compact to dense		5	SS	30/0	CAVE PEN	314								
3.1	END OF BOREHOLE REFUSAL TO SS PROBABLE BEDROCK														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 15

METRIC

W P 381-90-01 LOCATION Station 10+500, 24.0 m Rt ORIGINATED BY LA
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Washboring COMPILED BY CR
 DATUM Geodetic DATE April 25 - 26, 1994. CHECKED BY 280

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				
311.4	WATER SURFACE															
0.0	KENOGAMI RIVER															
310.2	"MUD" (dark brown, SILTY FINE SAND with peat, wood, etc.)		1	SS	1		310									
308.7	very loose saturated															
2.7	traces of organics		2	SS	18		308									
			3	SS	17											
	SILT with thin Silty Clay laminations		4	SS	15											
	compact saturated		5	SS	9		306									0 8 85 7
			6	SS	11											
			7	SS	15		304									
303.0	END OF BOREHOLE REFUSAL PROBABLE BEDROCK															
8.4																

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No P9

METRIC

W P 381-90-01 LOCATION Station 10+609.2, 3.5 m Rt
Thunder
DIST Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering
DATUM Geodetic DATE July 5, 1994. ORIGINATED BY HL
COMPILED BY HL
CHECKED BY 300

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
								SHEAR STRENGTH kPa						
						○ UNCONFINED	+ FIELD VANE			WATER CONTENT (%)				
						● QUICK TRIAXIAL	x LAB VANE							
324.6	TOP OF PAVEMENT													
0.0	170 mm ASPHALT													
	FILL - gravelly sand with occasional cobbles		1	SS	38									
323.0														
1.6			2	SS	37									
	FILL - silty sand some gravel, occasional sandy zones		3	SS	14									
			4	SS	15									
			5	SS	5									
316.8	damp to moist		6	SS	11									
7.8	POSSIBLE FILL - fine sand to silt with occasional silty clay and silt sand seams		7	SS	16									
314.6														
10.0	SILTY SAND traces rock fragments		8	SS	11									
313.2	compact wet													
11.4	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK													

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No P10

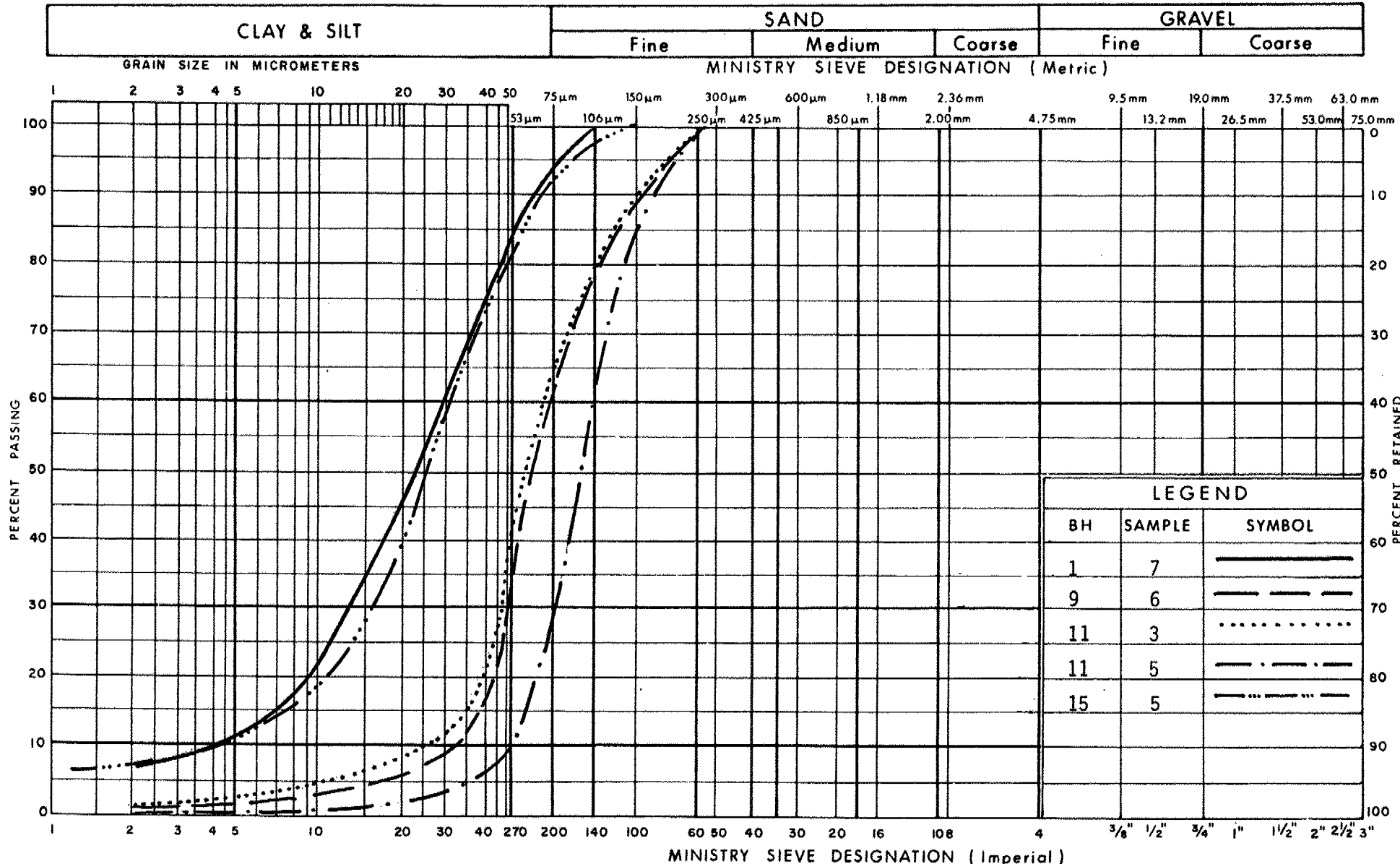
METRIC

W P 381-90-01 LOCATION Station 10+622.6, 3.0 m Rt ORIGINATED BY CH
DIST Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY CH
DATUM Geodetic DATE July 5, 1995. CHECKED BY CH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)				
324.6	TOP OF PAVEMENT													
0.0	190 mm ASPHALT													
	FILL - gravelly sand with silt layer													
323.2														
1.4			1	SS	10									
	FILL - silty sand													
			2	SS	4									
			3	SS	6									
318.8														
5.8	POSSIBLE FILL - fine sand		4	SS	8									
316.5			5	SS	10									
8.1	END OF SAMPLED BOREHOLE													
314.2														
10.4	END OF DCPT													

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

Ontario

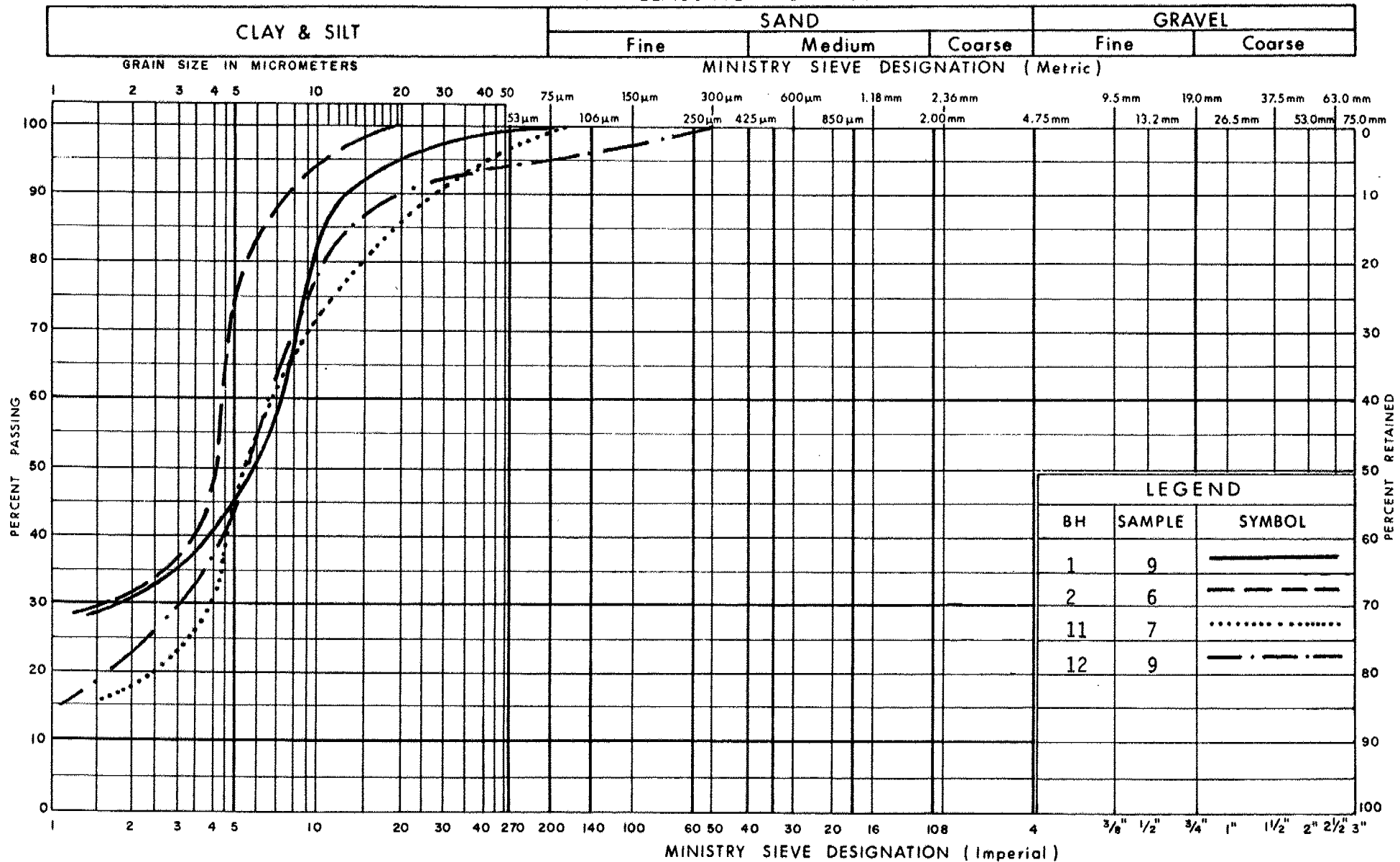
GRAIN SIZE DISTRIBUTION

(UPPER) SILT with silty fine sand layers

FIG No 1

W P 381-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

SILTY CLAY

FIG No 2

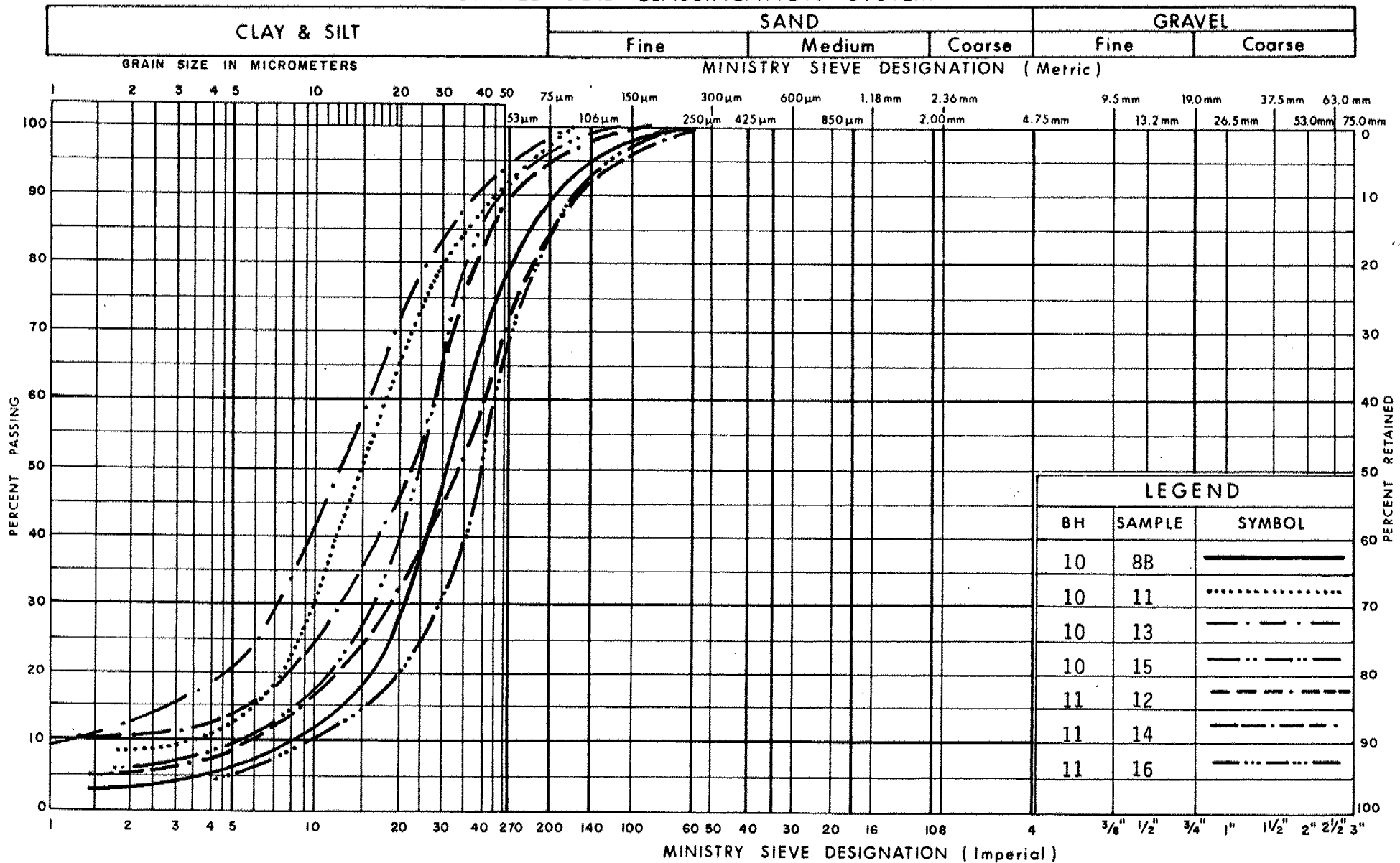
W P 381-90-01

Coarse

(LOWER) SILT I

Ministry of
Transportation

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

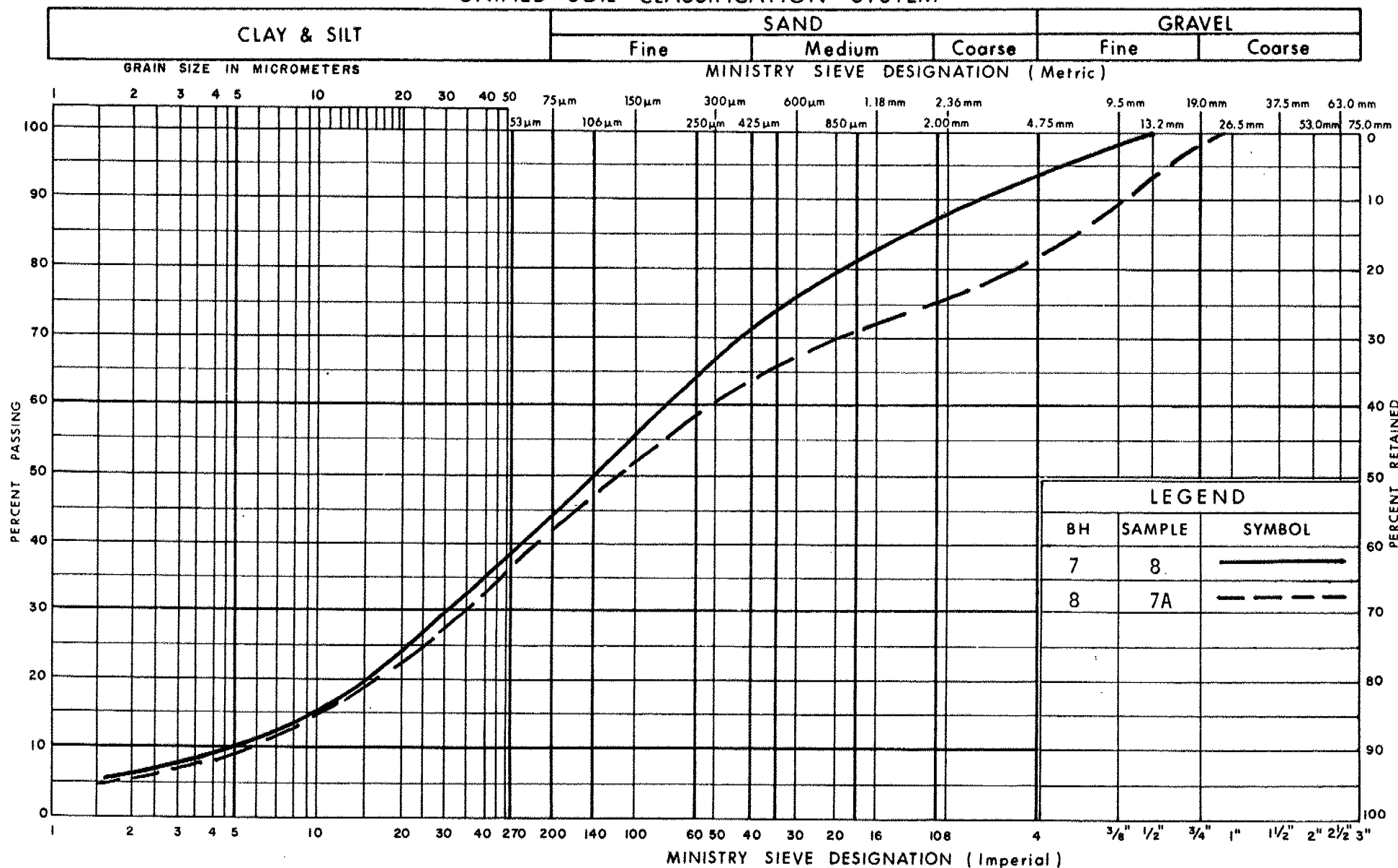
GRAIN SIZE DISTRIBUTION

(LOWER) SILT II

FIG No 4

W P 381-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

Heterogeneous mixture of SILT,
SAND and GRAVEL, occasional
Cobbles and Boulders (Glacial Till)

FIG No 5

W P 381-90-01

VOID RATIO - PRESSURE CURVES

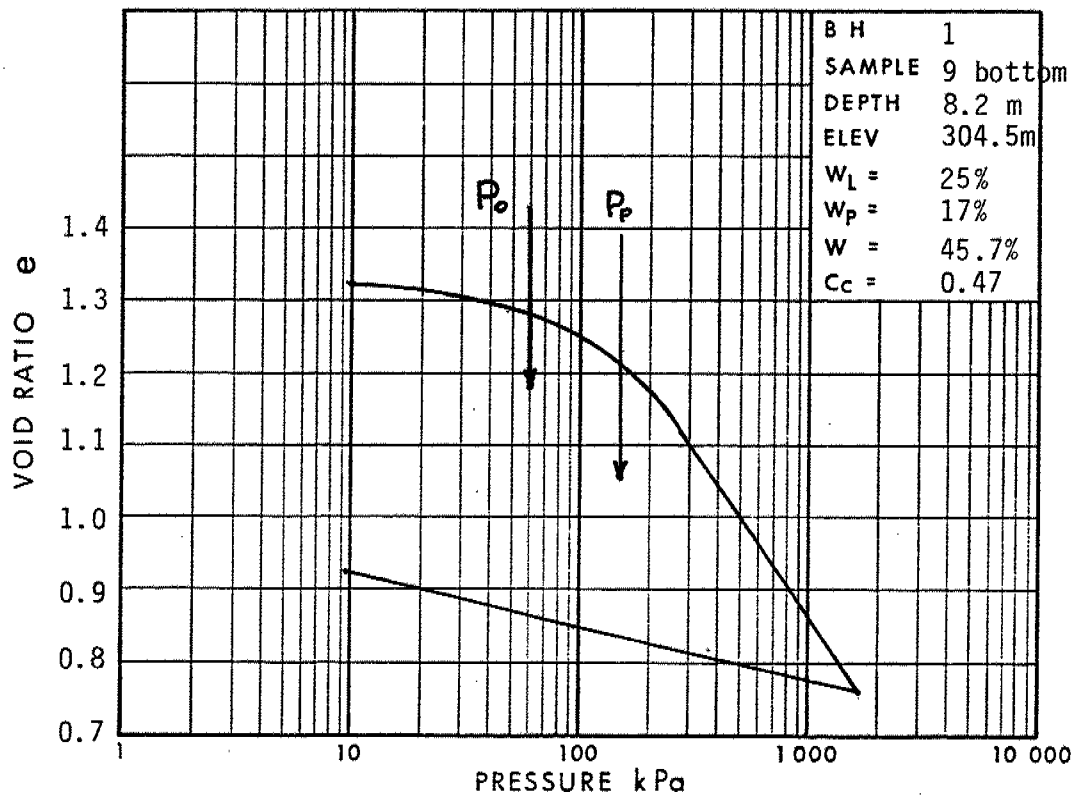
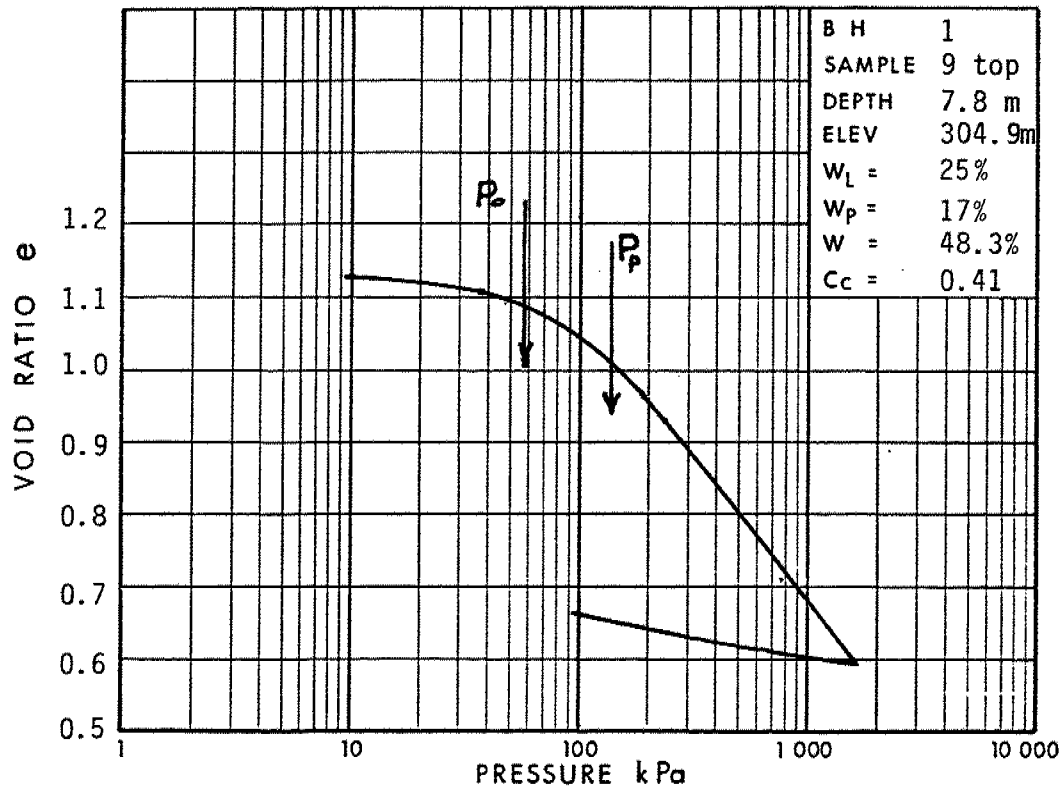


Fig 6

VOID RATIO - PRESSURE CURVES

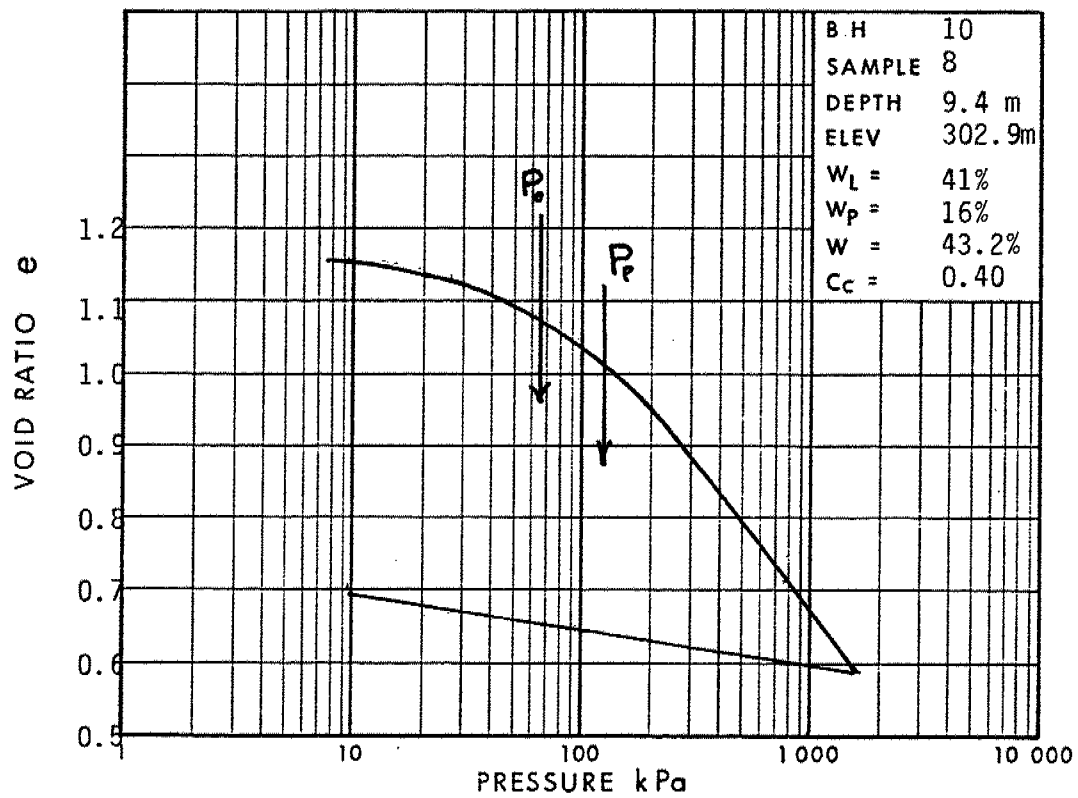
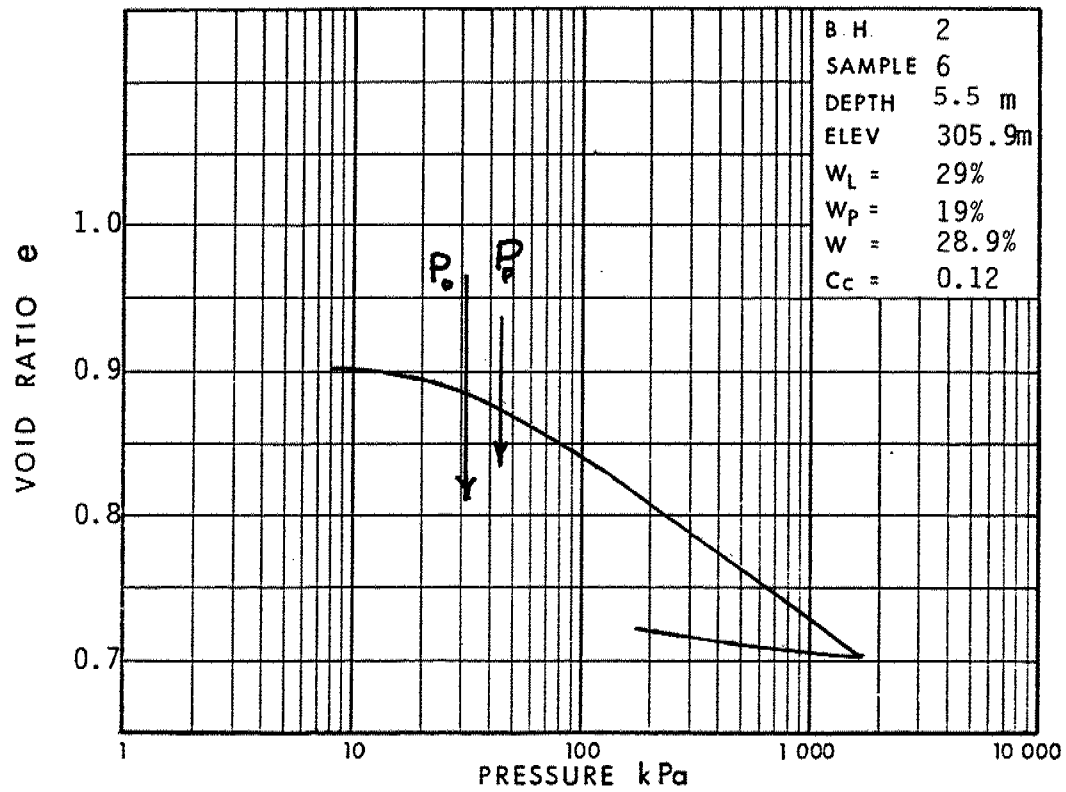


Fig 7

VOID RATIO - PRESSURE CURVES

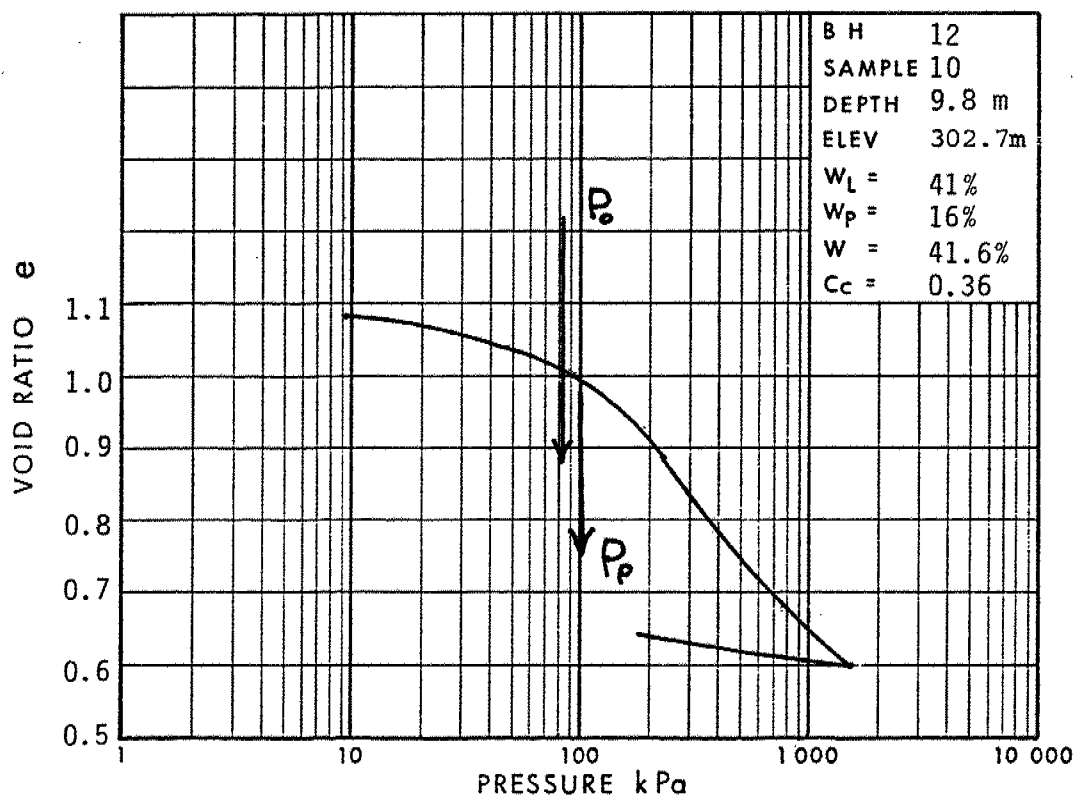
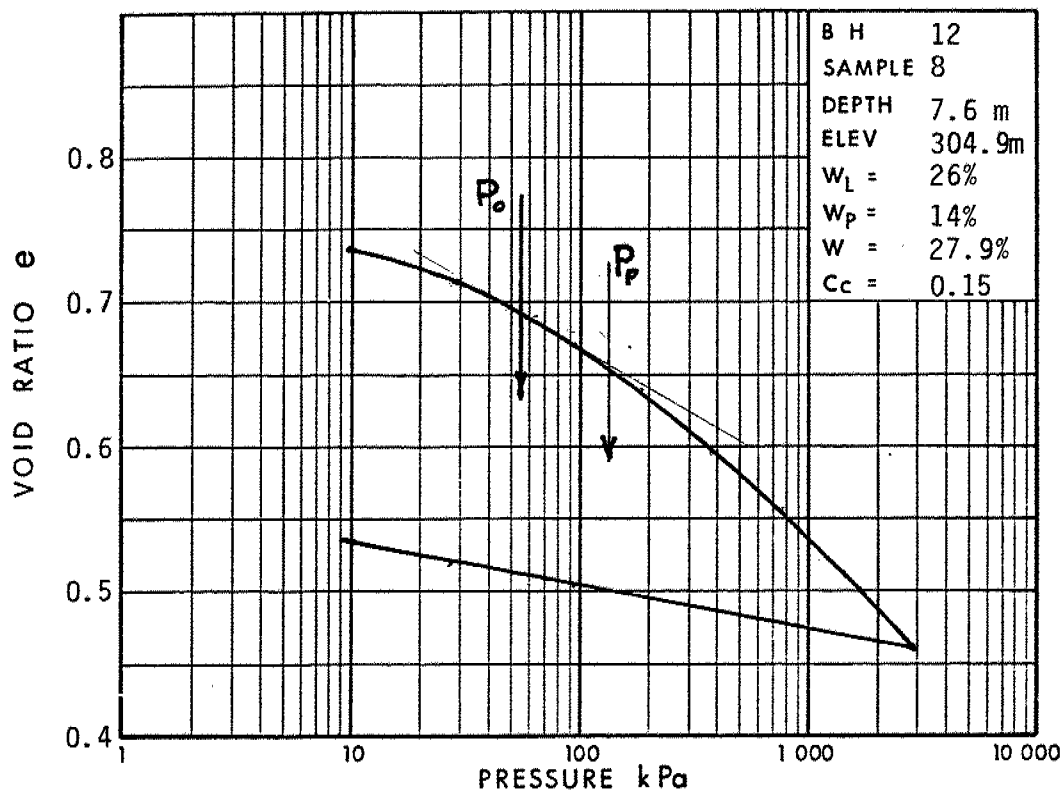


Fig 8

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

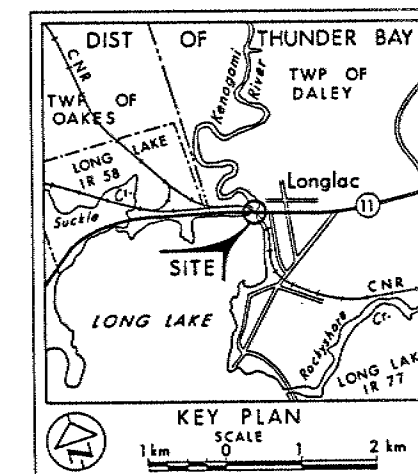
CONT No
WP No 381-90-01

KENOGAMI RIVER/CNR O'HEAD
(AT LONGLAC)
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

AGRA Earth & Environmental Limited



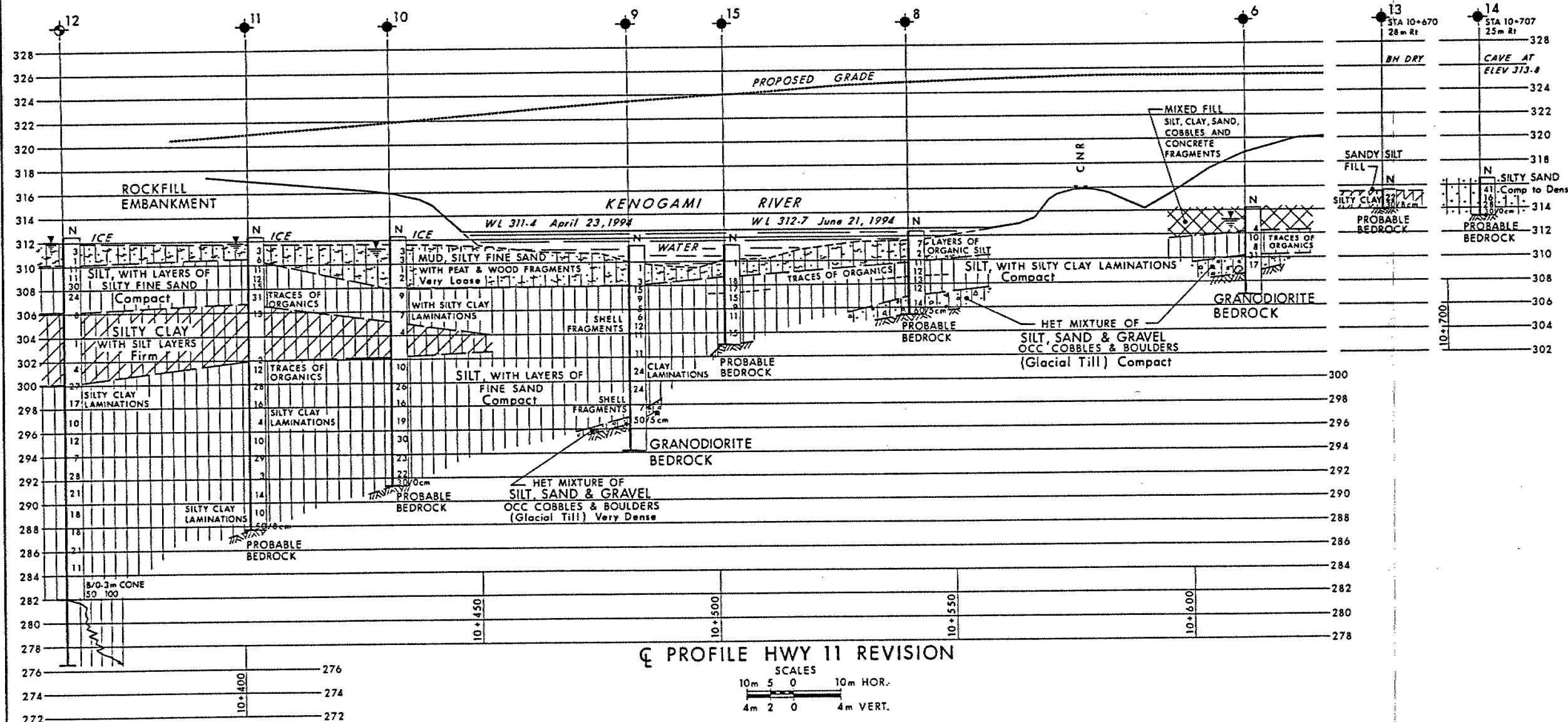
NOTE:

For subsurface information
of Probe Holes (P1 to P8)
refer to section 3.9 of the Text.

PLAN
SCALE
10m 5 0 10m

NOTE:

For subsurface information and
Profile along Q of existing Hwy 11
refer to Dwg No 3819001-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 in Boreholes
- W at time of investigation 1994 04
- ⊕ Probe Hole

No	ELEVATION	STATION	OFFSET Q EXIST HWY 11
1	312.7	10+435	24.0m Lt
2	311.4	10+474	6.0m Lt
3	312.4	10+522	6.0m Rt
4	312.6	10+565	11.0m Lt
5	313.0	10+591	27.0m Lt
6	314.2	10+610	29.0m Rt
7	312.6	10+581	4.5m Rt
8	312.4	10+539	27.0m Rt
9	311.4	10+480	24.0m Rt
10	312.3	10+430	23.0m Rt
11	312.3	10+400	22.0m Rt
12	312.5	10+361	19.0m Rt
13	315.6	10+670	28.0m Rt
14	316.5	10+707	25.0m Rt
15	311.4	10+500	24.0m Rt
P1	321.5	10+434.5	3.5m Rt
P2	321.4	10+432.0	3.5m Rt
P3	321.3	10+429.9	3.2m Rt
P4	320.8	10+416.3	3.5m Rt
P5	321.5	10+434.5	3.2m Lt
P6	321.3	10+432.0	3.2m Lt
P7	321.3	10+430.0	2.8m Lt
P8	320.9	10+421.1	2.8m Lt
P9	324.6	10+609.2	3.5m Rt
P10	324.6	10+622.6	3.0m Rt

NOTE:

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

NOTE: The complete foundation investigation and design report for
this project and other related documents may be examined at the
Engineering Materials Office, Downsview. Information contained in
this report and related documents is specifically excluded in
accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION

Geacres No 42E-4

HWY No 11	DIST 19
SUBMIT SR [CHECKED]	DATE 1994 12 12
DRAWN RM [CHECKED]	APPROVED
SITE 48E-6	DWG 3819001-A

METRIC

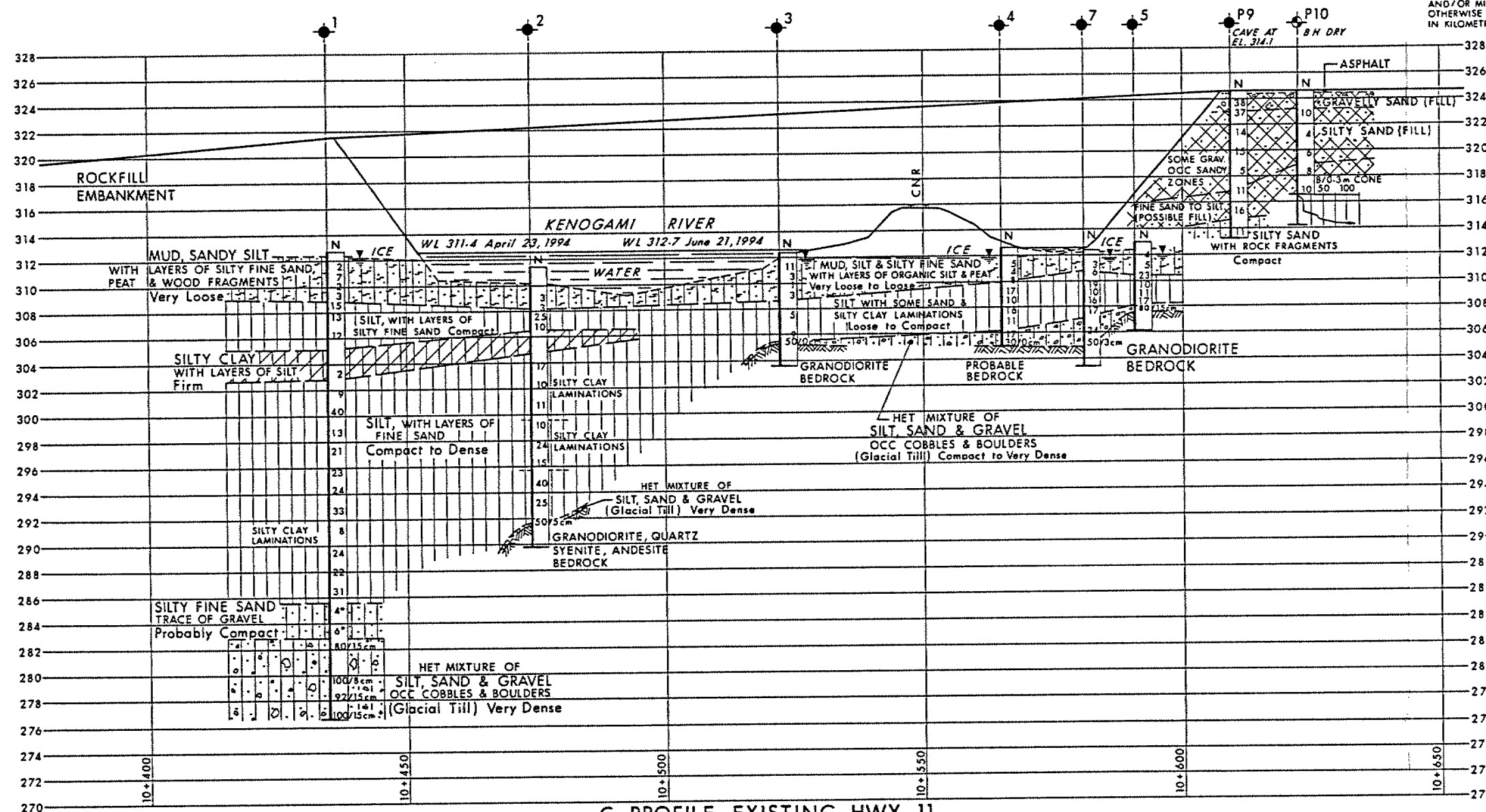
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 381-90-01

KENOAGAMI RIVER/CNR O'HEAD
(AT LONGLAC)
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

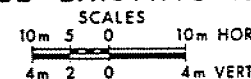
AGRA Earth & Environmental Limited



NOTE:

*N'-Values probably
reduced by upward
seepage forces.

PROFILE EXISTING HWY 11



NOTE:

For Plan refer to
Dwg No 3819001-A.

SEE DWG 3819001-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)
- in Boreholes
- WL at time of investigation 1994 04

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REV.	DATE	BY	DESCRIPTION
1			
Geocres No 42E-4			
HWY No 11			DIST 19
SUBMITTAL CHECKED			DATE 1994 12 14
DRAWN RM CHECKED			SITE 48E-6
			DWG 3819001-B