

#69-F-8

W.P. 163-64-01

Q.E.W.

THOMPSON ROAD

TO LAKE ERIE

TRUNK SEWER

MEMORANDUM

To: Mr. G. K. Hunter,
Regional Road Design Engineer,
Central Region (Toronto),
Central Building.

From: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

ATTENTION:

DATE: May 26, 1969

OUR FILE REF:

IN REPLY TO

MAY 30 1969

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
Proposed Trunk Sewer Along Q.E.W.
From Thompson Road to Lake Erie
Town of Fort Erie, Ontario
District No. 4 (Hamilton)
W.J. 69-F-8 -- W.P. 163-64-01

Enclosed please find our complete foundation report
for the above mentioned project.

We believe that factual information pertaining to
subsoil conditions at the site, and recommendations regarding
the design and construction of the storm sewer, contained
within the report, should be sufficient for your purposes.

If additional information is required, or should the
report require further clarification, please contact this
Office.

AGS/MdeF
Attach.

cc: Messrs. H. A. Tregaskes

B. R. Davis

D. W. Farren

G. K. Hunter (2)

H. Greenland (2)

E. J. McCabe

T. J. Kovich

W. S. Melinyshyn

McCormick & Rankin, Consulting Engineers

B. A. Singh

Foundations Files

Gen. Files

A. G. Stermac
A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

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FOUNDATION INVESTIGATION REPORT
For
Proposed Trunk Sewer Along Q.E.W.
From Thompson Road to Lake Erie
Town of Fort Erie, Ontario
District No. 4 (Hamilton)
W.J. 69-F-8 -- W.P. 163-64-01

1. INTRODUCTION:

Following a verbal request by Mr. E. J. McCabe, Expressway Consultant Control Engineer, Central Region, in February 1969, an investigation was carried out by this Section to determine the subsoil conditions existing at the site of the above mentioned proposed trunk sewer.

This report contains the results of our field and laboratory investigation, together with our recommendations relating to dewatering problems and foundations of the proposed trunk sewer.

2. DESCRIPTION OF THE SITE AND GEOLOGY:

The site is located in the Town of Fort Erie from Thompson Road and Q.E.W. to Lake Erie near the Peace Bridge Plaza. The total length of the proposed sewer line is about 8,400 ft. From Thompson Road to just east of Central Avenue, the sewer runs parallel to, but on the north side of the Q.E.W. It then crosses the Q.E.W. and Goderich Street just in front of the Peace Bridge Plaza. From there to Garrison Road the line is parallel to and just east of Goderich Street. The sewer discharges into Lake Erie.

From Thompson Road to Central Avenue the area is flat to very gently sloping except at the C.N. Railway crossing where a cut has been made to accommodate the railway line. The average ground level in this stretch varies between elev. 625 and 635. From the point where the sewer crosses Goderich Street for a length of about 200 ft., it is located under the paved area

2. DESCRIPTION OF THE SITE AND GEOLOGY: (cont'd.) ...

adjacent to the Peace Bridge Plaza. Thereafter, it traverses the Parks Commission lawns down to Lake Erie. From Goderich Street to Lake Erie the ground is flat to very gently sloping, the ground level varying between elev. 576 and 582.

Physiographically, the site is situated in the 'Haldimand Clay Plain'. Based on available geological information, it is known that the overburden of this region consists mainly of lacustrine clay deposited in glacial Lake Warren, formed during the retreat of the last continental glacier.

3. FIELD AND LABORATORY WORK:

The field work along the proposed route of the sewer, consisted of 31 sampled boreholes and 22 dynamic cone penetration tests. In addition, three boreholes were put down by driving NX casing to bedrock, where it was shallow, in order to determine the bedrock elevation. Four boreholes - Nos. 16, 42, 43 and 44 - carried out in the past for the investigation of foundations of the proposed structures in this area, are also included in the report. At the four locations - Borehole Nos. 22, 23, 28 and 33 - Geonor piezometers were installed by the following method: At each location three holes were put down to different depths in the overburden and a split-spoon sample taken from the bottom of each hole. The Geonor brass piezometers were then hammered down to at least 3 ft. below the bottom of the borehole. At each location one piezometer was driven down to bedrock, and two others were driven down to suitable depths in the overburden.

All holes were advanced using conventional diamond drilling equipment adapted for soil sampling purposes, and continuous flight augers. A driving energy of 350 ft.-lbs. per blow was used for the dynamic cone penetration tests.

Disturbed samples were recovered using 2-inch, 2-1/2-inch and 3-inch O.D. split-spoon samplers driven into the soil under the weight of a 140-lb. hammer falling through a distance of 30 inches. The majority of the samples were obtained by means of

3. FIELD AND LABORATORY WORK: (cont'd.) ...

a 2-inch O.D. split-spoon. Bedrock was proven in three boreholes by obtaining BXL size rock cores, and in ten boreholes by obtaining AXT size rock core samples. In other boreholes the bedrock surface was assumed to be the level at which practical refusal to augering or driving the casing, or the cone, was reached.

Samples were visually examined in the field and subsequently in the laboratory. Tests were carried out on selected samples to determine the following physical properties of the various soil types:

Grain-size Distribution

Atterberg Limits

Natural Moisture Contents

The results of field and laboratory tests are summarized in the Record of Borehole sheets, which are contained in the Appendix to the report.

The locations and the elevations, together with the estimated stratigraphical profile, are given on Drawing Nos. 69-F-8A, B, and C, which are also contained in the Appendix to this report. The borehole locations and elevations were surveyed by personnel from Central Region Engineering Surveys Section.

4. SUBSOIL CONDITIONS:

4.1) General:

In general, the subsoil to the west of Goderich Street consists of 15 to 40 ft. of hard to stiff clayey silt with some sand and traces of gravel, which is underlain by a thin sandy silt layer in an area between the C.N. Railway tracks and Erie Street. Between Goderich Street and Lakeshore Boulevard the subsoil consists of 3 to 9 ft. of granular fill material. It is reported that the area between Lakeshore Boulevard and Lake Erie has been reclaimed from Lake Erie. The fill material in this area is locally obtained clayey silt to silty clay material 6 to 10 ft. thick. The overburden

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.1) General: (cont'd.) ...

at all places, is underlain by limestone bedrock.

The boundaries between the various soil types and the bedrock are shown on the attached Record of Borehole sheets. The estimated stratigraphical profiles shown on Drawing Nos. 69-F-84, B, and C, are based upon this information.

From ground level downwards, the different soil deposits are described as follows:

4.2) Clayey Silt to Silty Clay Fill:

This material was found in boreholes 1 to 5 between Lakeshore Boulevard and Lake Erie. It is reported that the land between Lakeshore Boulevard and the waterfront was reclaimed from Lake Erie, and that locally available soil was used as the fill material. The thickness of this deposit varies from about 6 to 10 ft. It is mainly clayey silt to silty clay with some sand. The 'N' values indicate a very stiff to firm consistency. The following is the range of Atterberg Limits:

Liquid Limit	:	31	-	50%
Plastic Limit	:	19	-	23%
Natural Moisture Content	:	17	-	29%

4.3) Sand and Gravel Fill:

This fill material was found in boreholes 7 to 13. The composition of the deposit varies from gravel with sand to fine sand. In borehole 7 it was mainly gravel with sand, while in boreholes 8, 9 and 10, it was essentially fine to medium sand with traces of gravel, silt and clay. Boreholes 7 and 8 were put down on the lawn, and boreholes 9 and 10 were put down on the paved area of the Peace Bridge Plaza. The thickness of the pavement is 1.0 ft. The thickness of the fill material varies from about 3 to 9 ft.

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.3) Sand and Gravel Fill: (cont'd.) ...

The 'N' values indicate a loose to compact denseness. Grain-size analyses indicate the following distribution and are plotted on Fig. 7 of the Appendix:

	<u>Gravel</u>	<u>Sand</u>	<u>Silt and Clay</u>
Borehole 7	55 %	34 %	11 %
Boreholes 8, 9 and 10	3 - 18%	70 - 93%	2 - 21%

4.4) Clayey Silt, some Sand, Traces of Gravel:

This is the predominant soil deposit at the site. The thickness of the deposit between Goderich Street and Q.E.W. varies from 5 to 22 ft. because of the undulating topography. North of the Q.E.W. the thickness of the material varies from 24 to 40 ft. It is directly underlain by limestone bedrock, except from Erie Street to about 1,500 ft. west of it, in which area it is underlain by a relatively thin layer of sandy silt which, in turn, is underlain by the bedrock.

The subsoil essentially consists of clayey silt with some sand and traces of gravel. Thin sand and/or silt seams which may be water-bearing are present, but they do not follow any regular pattern. The 'N' values show that the consistency of the stratum varies in general from hard to stiff with depth, indicating a decrease in shear strength with depth. This decrease in strength is contrary to what would normally be expected in the field and could be because of the presence of hydrostatic pressures which increase with depth. The borings done in the past in this area show that, at some places, the consistency is firm.

Based on the foregoing, it is estimated that the undrained shear strength of the stratum, in general, varies from more than 2,000 p.s.f. at the top to about 1,000 p.s.f. at the bottom. At some places, where the soil is firm, it may be as low as 500 p.s.f.

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.4) Clayey Silt, some Sand, Traces of Gravel:

The physical properties of the soil, as determined from laboratory testing, are summarized below:

Atterberg Limits:

Liquid Limit	19	-	34 %
Plastic Limit	11	-	18 %
Natural Moisture Content	9	-	27 %

Grain-Size Distribution:

Gravel	0	-	17 %
Sand	2	-	27 %
Silt	44	-	61 %
Clay	18	-	45 %

The envelope of grain-size distribution curves is shown in Fig. 5 of the Appendix.

4.5) Sandy Silt, some Clay, Traces of Gravel:

This deposit was intersected in boreholes 29, 30, 31 and 32 only, and extends for a distance of 1,500 ft. from Erie Street to the west of it. It is overlain by the clayey silt deposit and underlain by bedrock. The thickness of the layer varies from about 1 ft. to 4 ft. It is classified as compact sandy silt with some clay and traces of gravel. Grain-size analyses show the following distribution, and they are plotted on Fig. 6 of the Appendix.

Gravel	2	-	8 %
Sand	32	-	38 %
Silt	44	-	46 %
Clay	14	-	15 %

This material is highly susceptible to 'boiling' caused by unbalanced hydrostatic head.

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.6) Limestone Bedrock:

The bedrock was proven in boreholes 1, 5 and 7, by obtaining BXL size rock cores, and in boreholes 9, 17, 20, 22, 24, 26, 27, 31, 34, 37 and 42, by obtaining AXT size rock core samples. In other boreholes the bedrock surface was assumed to be the level at which practical refusal to augering, driving the casing, or the cone was reached. The rock cores obtained show the rock to be generally crystalline limestone with chertified patches. The bedrock is generally sound, as indicated by the relatively high recovery of 80% to 100%.

The rock core samples were examined by Mr. Ken Ingham, Geologist, Department of Highways, and are described as follows:

"The General area between Thompson Road and Lake Erie is underlain by the Bois Blanc foundation; a dense, fine grained, cherty limestone. A brief description of the rock-cores from holes 26, 27, 31, 34 and 42 is attached to illustrate the general lithology.

"The formation is more or less uniformly medium bedded dipping gently to the south at approximately 25 ft. per mile. The rock appears to be sound and unweathered from the surface down, with very little fracturing - the only fracture noted was an inclined fissure at the top of hole 42. The vertical joint pattern, as seen in areas exposed elsewhere, is somewhat variable but two main sets are usually present spaced from 5 to 15 ft. apart.

"The section between Thompson Road and hole 31 is apparently a coralline facies with some reef development. The coral biostrome (flat reef-like complex) encountered in the top 2.5 ft. of hole 42 is typical of such structures that are found in this facies of the Bois formation. They are generally 5 to 8 ft. thick and 100 to 200 ft. in length. The biostrome in hole 42 appears to be at the top of a slight rise in the bedrock. When these structures are encountered enclosed within the bedrock they

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.6) Limestone Bedrock: (cont'd.) ...

Description of rock core samples by Mr. Ken Ingham,
D.H.O. Geologist - (cont'd.) ...

sometimes contain small quantities of oil, and, more rarely, water and gas under pressure. The section from hole 27 to the lake appears to be more typical of the Bois Blanc formation, being a medium or dark brownish grey dense limestone with minor fossil fragments. All four holes contained appreciable chert and chertified limestone (i.e. silica and silicified limestone), constituting from 15 to 25 percent of the formation. This again is typical of the Bois Blanc limestone. The cores examined indicate that the rock would have a moderately good bridging capacity."

The bedrock, in general, slopes from west to east, its surface varying between elev. 609 and 567.

Two Packer tests were carried out to determine the pervious nature of the bedrock. The depths of the rock subjected to the Packer test were 10.0 ft. in borehole 42, and 5.0 ft. in borehole 27. The observations regarding the test, are given below:

Borehole 42:

Water under pressure was pumped into the Packer via 'A' rods inserted in a BX casing drilled 6 inches into rock. When a 3.4-ft. section - from 2.3 ft. to 5.7 ft. below top of bedrock - of AX diameter test hole was subjected to about 17 p.s.i. differential head of water, all the water (about .22 cu.ft./min.) disappeared into it. Any further increase in the differential head returned the water to the surface. When a section from 6.3 to 10.7 ft. below the rock surface was used for testing, only an insignificant amount of water could be pumped into the rock even at 60 p.s.i. pressure.

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.6) Limestone Bedrock: (cont'd.) ...

Borehole 42: (cont'd.) ...

A test was carried out by simply filling the BX casing with water. The casing, which was drilled into the bedrock, stood 4.0 ft. above ground level. It was observed that the water level in the casing fell at a fast rate. The pressure head in the bedrock corresponded to an elev. 626.7 - i.e., 6.7 ft. below the ground surface.

The tests described above indicate that the top 2.5 to 5.5 ft. of bedrock is either fissured, or has vertical joints which act as drainage paths. Below that, the rock is relatively impermeable.

Borehole 27:

No water could be pumped into the rock when the Packer was placed at 1.2 ft. below the rock surface. When the Packer was placed only 0.2 ft. below the rock surface, water could be pumped into the rock, but was returning to the surface. When an open BX casing, drilled 0.2 ft. into the rock, was filled with water, the level dropped, but at a slower rate as compared to borehole 42. This indicates that the top 1.2 ft. of the bedrock is either fissured, or has vertical joints which act as drainage paths.

5. GROUNDWATER CONDITIONS:

Groundwater level observations were carried out during the period of the field investigation. The groundwater level between Goderich Street and Lake Erie corresponds to the lake water level - i.e., elev. 572 \pm . To the west of Central Avenue the prevailing groundwater level is very close to the ground surface. Between Central Avenue and Goderich Street, the groundwater levels vary between the two extreme conditions mentioned above. The exact water levels observed during the time of the field investigation, are shown on Drawings 69-F-8A, B and C, as well as on the borehole logs.

5. GROUNDWATER CONDITIONS: (cont'd.) ...

A daily record was kept of the water levels in boreholes 18, 19, 21, 25 and 27, drilled by means of an auger machine. The water levels in boreholes 18, 19 and 21 rose about 10 ft. in one day following the end of boring. It took 3 - 4 days for the water levels to rise to a level close to the ground surface, but in the meantime, the hole had caved in. In boreholes 25 and 27 it took only 1 to 2 days for the water to rise to about the ground level.

As mentioned previously in 4.6, when boreholes penetrate the fissured zone at the bedrock surface, water levels are established very quickly because of the permeable nature of this zone.

Geonor type piezometers were installed at four locations as shown on Drawing Nos. 69-F-8A, B and C. At each location three piezometers were put down to various depths in the overburden, the lowest one in each case being just on top of the underlying bedrock. The piezometric level in almost all of the piezometers was observed to be slightly below the respective ground level. In borehole No. 17, slight artesian conditions were encountered within the bedrock (3 ft. above ground level). In borehole Nos. 37 and 42, when cased down to bedrock, the water level was established at 6.7 ft. below ground level - i.e., at elev. 626.7.

6. DISCUSSION AND RECOMMENDATIONS:

It is proposed to construct a storm trunk sewer from Thompson Road to Lake Erie, along the north side of the Q.E.W. The size of the sewer varies from 48 inches to 72 inches in diameter. According to the invert levels shown on the latest plans and profiles submitted to this office, at some places the sewer has to be constructed within the bedrock, while at other places, it is to be constructed within the overburden. It is possible that some changes may be made in the invert levels depending upon the most economical method of construction. Therefore, the various alternative methods of constructing the

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

sewer are discussed separately below under the appropriate headings.

6.1) General:

The thickness of the overburden overlying the limestone bedrock varies from 7 to 40 ft. To the west of Goderich Street, the overburden consists, in general, of 15 to 40 ft. of hard to stiff cohesive clayey silt with some sand and traces of gravel. Between approximate Sta's. 317+00 and 332+00 the bottom 1 to 4 ft. of the overburden consists of compact to dense sandy silt with some clay and traces of gravel. This material is non-cohesive in nature. To the east of Goderich Street, the overburden consists of 5 to 10 ft. of fill material. The fill material between Goderich Street and Lakeshore Boulevard consists of fine to medium sand, while from Lakeshore Boulevard to Lake Erie it is locally obtained clayey silt to silty clay. At all locations the bedrock consists of dolomitic limestone of which the upper 1 to 5 feet contains numerous fissures.

The groundwater level between Goderich Street and Lake Erie corresponds to the lake water level - i.e., elev. 572 ±. To the west of Central Avenue the prevailing groundwater level is very close to the ground surface. Between Central Avenue and Goderich Street the groundwater levels vary between the two extreme conditions mentioned above.

Packer tests, as described under Groundwater Conditions, were carried out in boreholes 42 and 27 to determine the permeability of bedrock. The Packer tests showed that in borehole 42, the top 2 to 5 ft. of the bedrock is fissured, or has interconnected vertical joints which act as drainage paths, while in borehole 27 this zone is limited to only the top 1.2 ft. of the bedrock. However, the results of the Packer tests should be viewed with caution, since they represent the conditions existing only at the specific location of the particular boreholes and elsewhere the conditions can be very much different.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.1) General: (cont'd.) ...

General conclusions to be drawn from the foregoing are that:

(1) Excavations within the overburden and rock will be subjected to the full head of the prevailing groundwater.

(2) Excavations which intersect the non-cohesive sandy silt to silt strata between approximate Sta's. 317+00 and 332+00, are likely to encounter 'boiling' conditions when the base of the trench is close to or within these soil layers, unless steps are taken to lower the prevailing hydrostatic pressure within the layers.

(3) Excavations within the cohesive overburden and at a safe distance above the rock (see (5)), should not present any major dewatering problems owing to the low permeability and cohesive nature of the soil.

(4) Excavations which intersect the fissured zones in the bedrock (and also, in some cases, the sandy silt layers overlying the rock), will be subjected to a rapid inflow of water of the relatively high permeability of these zones.

(5) Excavations close to, but above the bedrock surface, will be subjected to a head of water which can cause 'bottom heave'. The safe distance of an excavation base above bedrock for ground heave not to occur, is partly dependent upon the pressure head within the bedrock. The safe distance 'h' for various conditions of pressure head 'H' within the rock under the trench base, has been estimated and plotted on Fig. 8 of the Appendix.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.2) Sewers Completely within the Overburden Constructed by Open Cut Methods:

Since the future performance of the sewer pipes is dependent to a very great extent on the type and quality of the bedding used, it is essential that the latter be placed and compacted under dry conditions. Field investigations have shown that, over most of the area, a hydrostatic pressure equal to the full head of the prevailing groundwater level, exists within the permeable fissured zone of the bedrock. In order to construct the sewer in safety and under dry conditions, it will be necessary to lower this pressure to a safe level in order to prevent ground heave of the trench base and/or 'boiling'.

Where the sewer is completely within the cohesive clayey silt strata, the possibility of ground heave exists when the bottom of the trench is within a certain distance of the fissured zone for a particular hydrostatic pressure. Figure 8 shows a plot of 'safe distances' which have been calculated for various hydrostatic heads. To ensure safety, therefore, it will be necessary, during construction, to lower the hydrostatic head in the fissured zone to the required safe level and maintain it at this level until backfilling is completed. Seepage water within the actual trench must be completely pumped out prior to placing any bedding for the pipe.

Where the sewer is close to, or within the non-cohesive sandy silt stratum, a danger of 'boiling' of the trench base exists. In order to prevent this, and to achieve dry safe working conditions, the hydrostatic pressure within the sandy silt strata must be lowered to a level at least 2 ft. below the trench base, and must be maintained at this level until backfilling of the trench is completed.

Suggested standards for Class 'A', Class 'B', and for the Unyielding Foundation case have been prepared and are shown on Figs. 1, 2, and 3 of the Appendix. Bedding must always be

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.2) Sewers Completely within the Overburden Constructed by Open Cut Methods: (cont'd.) ...

placed in a dry trench, and particular attention should be paid to compaction and shaping of the bedding material.

The following types of bedding are recommended for the proposed sewer where it is located completely within the overburden:

- (a) Bottom of pipe 3 ft. or less above bedrock - bedding as per Fig. 3 of the Appendix.
- (b) Bottom of pipe more than 3 ft. above bedrock - bedding as per Fig. 2 of the Appendix.

6.3) Sewers Constructed by Tunnelling through the Overburden:

Where sewers are constructed by tunnelling through the overburden, because of the high groundwater level, it will be necessary to lower the water level below the tunnel base, or to construct the tunnel using air pressure greater than the prevailing hydrostatic pressure to achieve safe dry working conditions. Contractors who consider using air pressure, should be advised that they would be responsible for determining the air pressure to be used and also, that they would be responsible for preventing leakage through the boreholes that have been drilled at the site insofar as it affects their operations.

6.4) Sewers Constructed within the Bedrock by Open Cut Methods:

Where sewers are constructed within bedrock by open cut methods, east of Goderich Street, no major problems are anticipated. It is believed that the water encountered in the bedrock excavation can be handled by pumping methods. Where the bedrock is at greater depth - i.e., west of Goderich Street, a suitable dewatering scheme will be necessary to keep the excavation dry in order to place properly compacted bedding. A substantial water inflow may be encountered because of the fissured permeable nature of the upper few feet of the bedrock, as mentioned earlier.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.4) Sewers Constructed within the Bedrock by Open Cut Methods:
(cont'd.) ...

Because of the fissured nature of the bedrock, it is recommended that a granular type bedding not be used for sewers where the pipe bottom is on or within the bedrock. There is a danger that fine material might migrate through the rock fissures causing loss of compaction. It is therefore recommended that a Class 'A' type bedding be constructed as shown on Fig. 1 of the Appendix. In this case, the thickness of concrete under the pipe should be 6 inches.

6.5) Sewers Constructed by Tunnelling through the Bedrock:

The bedrock is, in general, from the surface, sound, dense, fine-grained, cherty limestone, of which the upper 1 to 5 ft. is fissured. Where sewers are constructed by tunnelling through the bedrock, a minimum of 8 ft. of bedrock cover is recommended for bridging purposes in the case of sewers larger than 54 inches in diameter. For estimating purposes, it may be assumed that about 10% overbreak would occur in sewers larger than 54 inches in diameter. In the case of sewers of diameter 54 inches or less, a minimum of 5 ft. of bedrock cover is recommended. For estimating purposes, an overbreak of 15% should be assumed.

It is recommended that tunnelling be carried out by conventional drill and blast methods rather than by tunnelling machines because of the high silica content in the rock, which would result in excessive wear and tear of drilling machines. The use of air pressure may be necessary if groundwater is encountered.

In sinking shafts through the overburden, problems may occur because of the high groundwater level. Recommendations given above for tunnelling through the overburden, are applicable in this case.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.6) Stability of Excavations:

Excavations in the cohesive overburden, with side slopes of 1:1, should remain stable during the course of the work, provided the depth of the sloping portion does not exceed about 25 ft. Vertical slopes must be sheeted and adequately braced at all times. Close sheeting will be necessary below the groundwater level to prevent soil washing out.

6.7) Dewatering Procedures:

Comments and recommendations relating to dewatering and stability of excavations mentioned in the foregoing paragraphs, are based on the assumption that the conditions as determined during the field investigations, will apply during construction. These assumptions cannot be ruled out. However, it will be the responsibility of the Contractor to determine exactly the conditions which prevail during construction, and to take such steps as are necessary to ensure dry safe working conditions. It is believed that, if the sewer is constructed continuously from the outfall end, drainage in the critical zones will occur thus alleviating the situation considerably. Permanent drainage of the sewer trenches into the various manholes should be provided, using at each manhole, a short (20 ft.) length of 6" diameter, perforated pipe surrounded with a suitable filter and discharging into the manhole.

7. MISCELLANEOUS:

The field work for this project was carried out during the period March 5 to March 28, 1969, under the supervision of Mr. A. Prakash, Project Foundation Engineer, who also prepared this report.

The equipment used was owned and operated by Canadian Longyear Ltd., Johnston Drilling Co. Ltd., and P.V.K. and Sons.

This report was reviewed by Mr. K. G. Selby, Supervising Foundation Engineer.

May 1969.

APPENDIX I

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 69-F-8

LOCATION Co-ords. 589,102 N; 156,805 E.

ORIGINATED BY AP

W.P. 163-64-01

BORING DATE March 5, 1969

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Washboring, NX Casing

CHECKED BY *AS*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — w_L		BULK DENSITY	REMARKS			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT						PLASTIC LIMIT — w_p		
							20	40	60	80			100	WATER CONTENT — w	
							SHEAR STRENGTH P.S.F.					WATER CONTENT %			
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					w_p — w — w_L			
												10 20 30			
575.1	Ground Level														
0.0	Fill		1	SS	11	570									
570.1	Clayey silt, some sand traces of gravel.		2	SS	6										
5.0	Stiff to firm		3	SS	10										
567.6	Silty clay, some sand														
	Stiff														
7.5	Bedrock														
563.6	Limestone with shale layers.		4	BXL	80%										
11.5	End of Borehole					560									

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 69-F-8

LOCATION Co-ords. 589,132 N; 156,831 E.

ORIGINATED BY AP

W.P. 163-64-01

BORING DATE March 5, 1969

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Penetration

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					PLASTIC LIMIT ——— w_p				
							20	40	60	80	100	WATER CONTENT ——— w				
							SHEAR STRENGTH P.S.F.					w_p ——— w ——— w_L				
							○ UNCONFINED + FIELD VANE					WATER CONTENT %				
							● QUICK TRIAXIAL x LAB. VANE									
575.0	Ground Level															
0.0																
566.7	Hammer Bouncing															
8.3	Probable Bedrock End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 589,167 N; 156,765 E. ORIGINATED BY AP
 W.P. 163-64-01 BORING DATE March 5, 1969 COMPILED BY AP
 DATUM Geodetic BOREHOLE TYPE NX Casing & Cone CHECKED BY AP

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L		BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLT.	NUMBER	TYPE		BLOWS / FOOT	BLOWS / FOOT					PLASTIC LIMIT — w_p			WATER CONTENT — w
						SHEAR STRENGTH P.S.F.					w_p — w — w_L		WATER CONTENT %		
						○ UNCONFINED + FIELD VANE									
						● QUICK TRIAXIAL x LAB. VANE									
574.4	Ground Level														
0.0	Fill		1	2 1/2" SS	29										
	Clayey silt, some sand		2	2 1/2" SS	16										
568.1	traces of gravel.		3	SS 1 1/4" / 10"	100/2"										
568.1	Very stiff.														
6.3	Probable Bedrock														
	End of Borehole														

Caved in dry @ 5'

hammer bouncing

FOUNDATION SECTION

ORIGINATED BY **AP**

COMPILED BY AP

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 589,340 N; 156,667 E.

ORIGINATED BY AP

W.P. 163-64-01 BORING DATE March 6, 1969

COMPILED BY AP

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing & Cone

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	WATER CONTENT % w_p — w — w_L				
579.7	Ground Level															
0.0	Fill															
	Silty clay, some sand		1	SS	14											
	Stiff to firm		2	SS	5											
570.3	Bedrock		3	SS	100/4"											
9.4	Limestone, Shale layers		4	BXL	66%											
566.3			5	BXL	100%											
13.4	End of Borehole															

100/2" bouncing
 570
 560
 572.7
 Mar. 12/69

FOUNDATION SECTION

ORIGINATED BY AP

COMPILED BY AP

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION	RESISTANCE	LIQUID LIMIT ——— w_L	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	BLows / Foot 20 40 60 80 100	PLASTIC LIMIT ——— w_p		
							SHEAR STRENGTH P.S.F.		w_p ——— w ——— w_L WATER CONTENT %		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE				
581.6	Ground Level										
0.0						580					
570.6	Hammer Bouncing										
11.0	Probable Bedrock End of Borehole					570		50/0"			

FOUNDATION SECTION

JOB	69-F-8	LOCATION	Co-ords. 589,508 N; 156,562 E.	ORIGINATED BY	AP
W.P.	163-64-01	BORING DATE	March 6, 1969	COMPILED BY	AP
DATUM	Geodetic	BOREHOLE TYPE	Washboring, NX Casing & Cone	CHECKED BY	✓

SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION BLOWS / FOOT	RESISTANCE	LIQUID LIMIT ——— W _L	PLASTIC LIMIT ——— W _P	WATER CONTENT ——— W	BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT	SHEAR STRENGTH' P.S.F.	WATER CONTENT %			P.C.F.	GR. SA. SI. CL.
						○ UNCONFINED + FIELD VANE	w _p ——— w ——— w _L				
						● QUICK TRIAXIAL x LAB. VANE					
582.1	Ground Level										
0.0	Fill										
	Gravel with sand traces of silt & clay		1	SS	100/4"						
574.3	Compact		2	SS	24						
572.9	Limestone Bedrock		3	BXL	95%						
9.2	End of Borehole										
						bouncing					

JOB	69-F-8	LOCATION	Co-ords 589,773 N; 156,598 E.	ORIGINATED BY	AP
W.P.	163-64-01	BORING DATE	March 7, 1969	COMPILED BY	AP
DATUM	Geodetic	BOREHOLE TYPE	NX Casing and Cone	CHECKED BY	<i>[Signature]</i>

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT						LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.					WATER CONTENT %				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE									
581.7	Ground Level															
0.0	Fill															
	Fine sand, some gravel, traces of silt & clay.		1	SS	7	580										7 72 (21)
573.0	Loose to compact		2	SS	26		100/1"									18 70 (12)
8.7	Probable Bedrock End of Borehole					570	bouncing									caved in dry @ 8.3'

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 9

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 590,036 N; 156,685 E. ORIGINATED BY AP
W.P. 163-64-01 BORING DATE March 7, 1969 COMPILED BY AP
DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing & Cone CHECKED BY SL

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					SHEAR STRENGTH P.S.F.					WATER CONTENT %
							20	40	60	80	100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					
580.3	Ground Level																
579.3	Pavement					580									GR. SA. SI. CL.		
1.0	Fill																
576.1	Fine sand Loose to compact		1	SS	55/9"												
4.2	Bedrock																
572.6	Limestone, Shale Layers		2	AXT	90%										3 91 (6) caved in dry @ 5.5'		
7.7	End of Borehole					570											

100/3"

bouncing

3 91 (6)
caved in dry
@ 5.5'

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 10

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 589,923 N; 156,640 E. ORIGINATED BY AP
W.P. 163-64-01 BORING DATE March 10, 1969 COMPILED BY AP
DATUM Geodetic BOREHOLE TYPE NX Casing CHECKED BY LL

SOIL PROFILE		STRAT PLOT	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w		BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE		BLOWS / FOOT	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE		WATER CONTENT % w_p — w — w_L		
580.3	Ground Level										
579.3	Pavement										
1.0	Fill										
575.5	Fine to medium sand Loose		1	SS	8						
4.8	Probable Bedrock End of Borehole										5 93 (2) Caved in dry @ 2.6'

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 11

FOUNDATION SECTION

JOB 69-F-8

LOCATION

Co-ords. 589,840 N; 156,622 E.

ORIGINATED BY AP

W.P. 163-64-01

BORING DATE

March 10, 1969

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE

NX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT			LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH PS F.			w_p — w — w_L WATER CONTENT %				
580.8	Ground Level						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE							
0.0						580								
575.3	Hammer Bouncing													Caved in dry @ 3.7'
5.5	Probable Bedrock End of Borehole					570								

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 12

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 589,817 N; 156,622 E. ORIGINATED BY AP
W.P. 163-64-01 BORING DATE March 10, 1969 COMPILED BY AP
DATUM Geodetic BOREHOLE TYPE NY Casing CHECKED BY / /

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH PS.F ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE	w_p — w — w_L WATER CONTENT %		
581.1	Ground Level								
0.0					580				
574.7	Hammer Bouncing								
6.4	Probable Bedrock End of Borehole				570				Caved in dry @ 5.5'

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 13

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 589,785 N; 156,612 E. ORIGINATED BY AP
 W.P. 163-64-01 BORING DATE March 10, 1969 COMPILED BY AP
 DATUM Geodetic BOREHOLE TYPE NX Casing CHECKED BY

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE	LIQUID LIMIT — w_L		BULK DENSITY	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	PLASTIC LIMIT — w_p	WATER CONTENT — w		
581.5	Ground Level						SHEAR STRENGTH PS F	w_p — w — w_L		P.C.F.	GR, SA, SI, CL
0.0						580	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE	WATER CONTENT %			
574.7	Hammer Bouncing										caved in
6.8	Probable Bedrock End of Borehole					570					dry @ 6.5'

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 15

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 590,360 N; 156,427 E. ORIGINATED BY AP
 W.P. 163-64-01 BORING DATE March 10, 1969 COMPILED BY AP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger and Cone CHECKED BY Y

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w		BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80			100
596.2	Ground Level											
	Very Stiff	1	SS	18								
	Stiff	2	SS	8	590							
	Clayey silt to silty clay, some sand	3	SS	12								
		4	TW	PM								
579.8		5	SS	20/11"	580							
16.4	Probable Bedrock End of Borehole											
					570							

60/4"

▼ 584.7
Mar. 20/69
Caved at
15'

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 16 (Formerly BH 2 67-F-85) FOUNDATION SECTION

JOB 69-F-8

LOCATION

Co-ords. 590,548 N; 156,103 E.

ORIGINATED BY ZO

W.P. 163-64-01

BORING DATE

Sept. 27 - Sept. 29, 1967

COMPILED BY WH

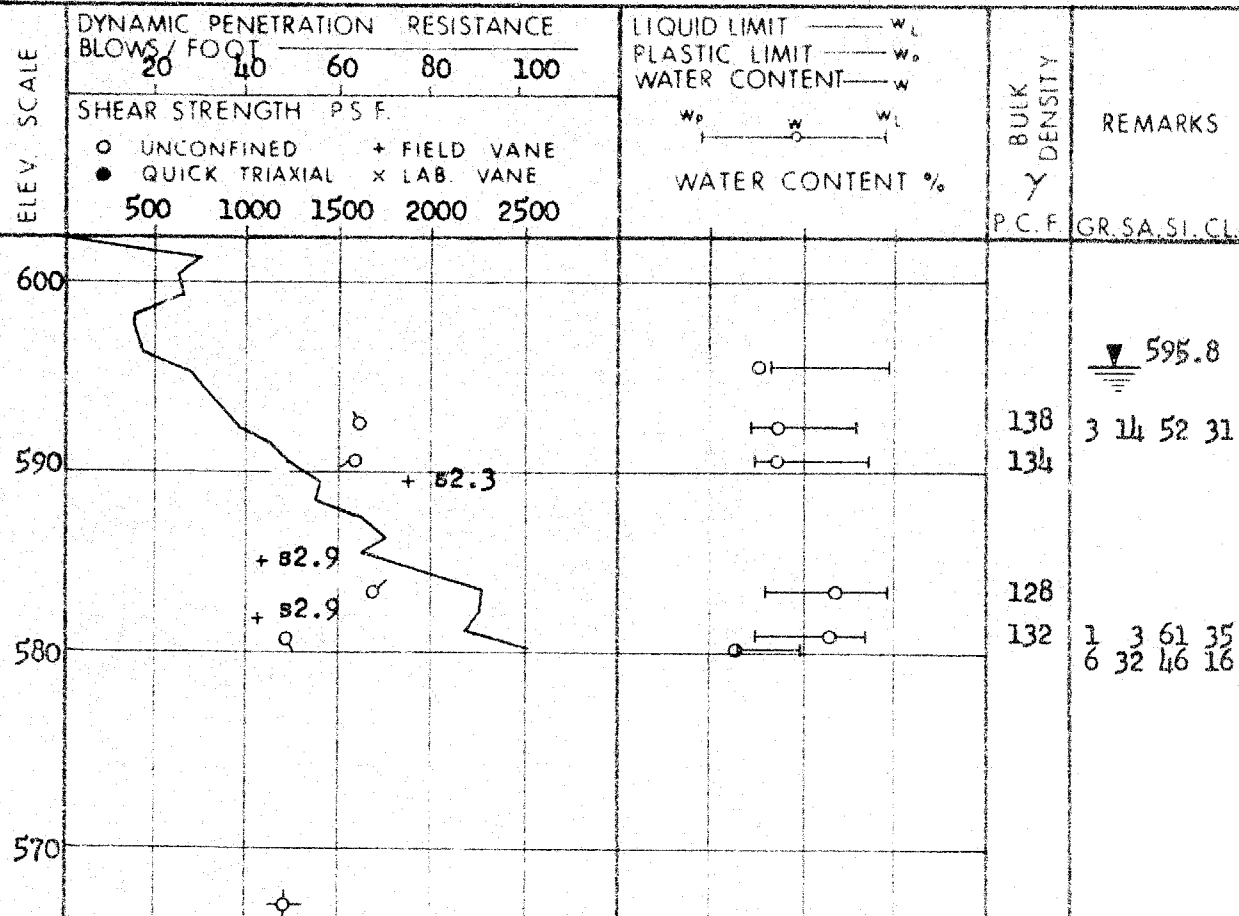
DATUM Geodeticq

BOREHOLE TYPE

Diamond Drill

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w_p ——— w ——— w_L WATER CONTENT %					
602.3	Ground Level						500	1000	1500	2000	2500						
0.0	Fill material. Silty clay with sand and gr.		1	SS	21												
598.3			2	SS	20												
4.0	Desiccated (Brown)		3	TW	PM												
595.3	Very stiff		4	SS	16												
7.0	Clayey silt with some sand & trace of gravel (occ. thin clay and silt seams)		5	TW	PM												
		6	TW	PM													
	Greyish Brown	7	TW	PM													
580.0	Stiff to very stiff	8	TW	PM 16"													
22.3	Sound Limestone Bedrock with some chetified patches	9	AXT	85%													
		10	AXT	98%													
571.8		11	AXT	98%													
30.5	End of Borehole																



FOUNDATION SECTION

JOB	69-F-8	LOCATION	Co-ords. 590,646 N; 155,843 E..	ORIGINATED BY	AP
W.P.	163-64-01	BORING DATE	March 10 - 11, 1969	COMPILED BY	AP
DATUM	Geodetic	BOREHOLE TYPE	Washboring, NX Casing & Cone	CHECKED BY	<i>[Signature]</i>

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION BLOWS / FOOT	RESISTANCE	LIQUID LIMIT ——— w_L	PLASTIC LIMIT ——— w_p	WATER CONTENT ——— w	BULK DENSITY γ	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100			w_p ——— w ——— w_L
							SHEAR STRENGTH P.S.F.							
611.4	Ground Level											P.C.F.	GR. SA. SI. CL.	
0.0	Clayey silt some sand traces of gravel (occ. thin sand seams)		1	CS		610							3 15 55 27	
			2	SS	100									
			3	SS	55									
			4	2 1/2" SS	37									
			5	2 1/2" SS	24									
			6	1 1/2" SS	18									
			7	SS	19									
			8	SS	26									
			9	SS	14									
			10	SS	8									
580.0	Limestone Bedrock		11	SS 105/11"		580								
31.4			12	AXT 100%										
575.0														
36.4	End of Borehole					570								

FOUNDATION SECTION

CHECKED BY

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — w_L		BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	RESISTANCE	PLASTIC LIMIT — w_p	WATER CONTENT — w			
					20	40	60	80	100			
					SHEAR STRENGTH P.S.F.				WATER CONTENT %			
					○ UNCONFINED + FIELD VANE				w_p — w — w_L			
					● QUICK TRIAXIAL x LAB. VANE							
623.6	Ground Level											
0.0	Clayey silt some sand traces of gravel Hard Very Stiff											
		1	SS	30	620							▼ 620.0 Mar. 21/69 caved at 22.5'
		2	SS	40								
		3	2 1/2" SS	86								
		4	SS	21	610							
		5	SS	15								
		6	SS	20	600							
		7	3" SS	70								
		8	3" SS	46	590							▼ 598.0 Mar. 12/69 caved at 35'
583.1		9	SS	18 1/6"								
40.5	Probable Bedrock End of Borehole				580							

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 19

FOUNDATION SECTION

JOB 69-F-8

LOCATION Co-ords. 590,675 N; 155,132 E.

ORIGINATED BY AP

W.P. 163-64-01

BORING DATE March 11 - 12, 1969

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Cont. Flight Auger and Cone

CHECKED BY

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.					WATER CONTENT %				
626.8	Ground Level						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					w_p ——— w ——— w_L				
0.0	Clayey silt some sand traces of gravel Hard Very stiff Stiff		1	SS	47	620										▼ 624.2 Mar. 21/69 Caved at 24.5'
			2	SS	53											
			3	SS	16	610										
			4	SS	12											
			5	SS	12	600										
			6	SS	12											
			7	SS	11											
			8	3"SS	26	590										
587.7			9	SS	18/1"											
39.1	Probable Bedrock End of Borehole					580										▼ 602.4 Mar. 13/69 Caved at 37'

▼ 624.2
Mar. 21/69
Caved at
24.5'

▼ 602.4
Mar. 13/69
Caved at
37'

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 20

FOUNDATION SECTION

JOB 69-F-8

LOCATION

Co-ords. 590,667 N; 154,757 E.

ORIGINATED BY AP

W.P. 163-64-01

BORING DATE

March 11 - 12, 1969



COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE

Washboring, NX Casing and Cone

CHECKED BY

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS		
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BLOWS / FOOT 20 40 60 80 100					SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE				WATER CONTENT % w_p ——— w ——— w_L	
629.5	Ground Level																
0.0	Clayey silt some sand traces of gravel		1	CS													
			2	SS	40												
			3	2 1/2" SS	90												
			4	2 1/2" SS	53												
			5	SS	21												
			6	SS	17												
			7	SS	19												
			8	SS	22												
			9	SS	66												
589.0			Bedrock		10	SS	100/6"	590									
40.5	Limestone, Shale Layers		11	AXT	65%												
584.0																	
45.5	End of Borehole																

couldn't be
blackened
2.0 core
dropped in
the hole

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 21

FOUNDATION SECTION

JOB 69-F-8

LOCATION

Co-ords. 590,803 N; 154,472 E.

ORIGINATED BY

AP

W.P. 163-64-01

BORING DATE

March 12, 1969

COMPILED BY

AP

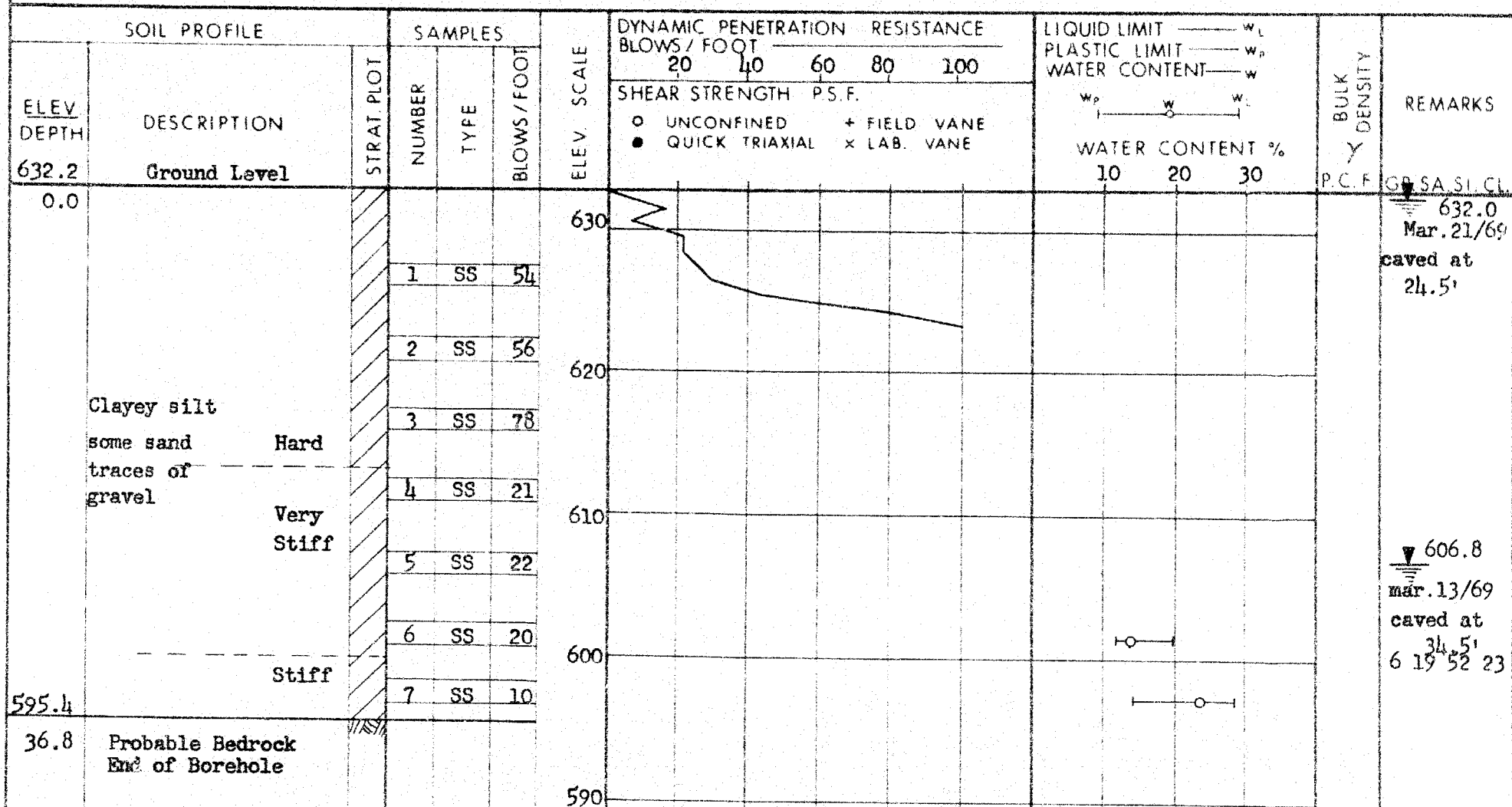
DATUM Geodetic

BOREHOLE TYPE

Cont. Flight Auger and Cone

CHECKED BY

AP



DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 22

FOUNDATION SECTION

JOB 69-F-8

LOCATION

Co-ords. 590,803 N; 154,542 E.

ORIGINATED BY

AP

W.P. 163-64-01

BORING DATE

March 12 - 14, 1969

COMPILED BY

AP

DATUM Geodetic

BOREHOLE TYPE

Cont. Flight Auger

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— w_L			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	RESISTANCE	PLASTIC LIMIT ——— w_p	WATER CONTENT ——— w			
632.0	Ground Level												
0.0													
						630							629.6
													629.5
													628.2
			1	SS	71	620							
	Clayey silt		2	SS	31								
	some sand	Hard											
	traces of	Very	3	SS	17	610							Tip el. 612.9
	gravel	Stiff											4 19 51 26
			4	SS	25								
598.5						600							Tip el. 603.2
			5	SS	14								4 20 51 25
33.5	End of Borehole					590							Tip el. 594.3
													Probable Bedrock at el. 594.3

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 23

FOUNDATION SECTION

JOB 69-F-8

LOCATION

Co-ords. 590,704 N; 155,807 E.

ORIGINATED BY

AP

W.P. 163-64-01

BORING DATE

March 13, 1969

COMPILED BY

AP

DATUM Geodetic

BOREHOLE TYPE

Cont. Flight Auger

CHECKED BY

AP

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.				w_p	w	w_L		
617.4	Ground Level						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE				WATER CONTENT % 10 20 30			P.C.F.	GR SA SI CL
0.0						610									615.2 614.6 613.4
	Clayey silt with sand		1	SS	45										
	Hard					600									
	traces of gravel		2	SS	27										7 20 48 25
	Very Stiff														
			3	SS	18	590									Tip el. 592.7
	Stiff														
584.9			4	SS	9										Tip el. 587.7
32.5	End of Borehole					580									0 2 54 44 Tip el. 580.0 Probable Bedrock at el. 580.

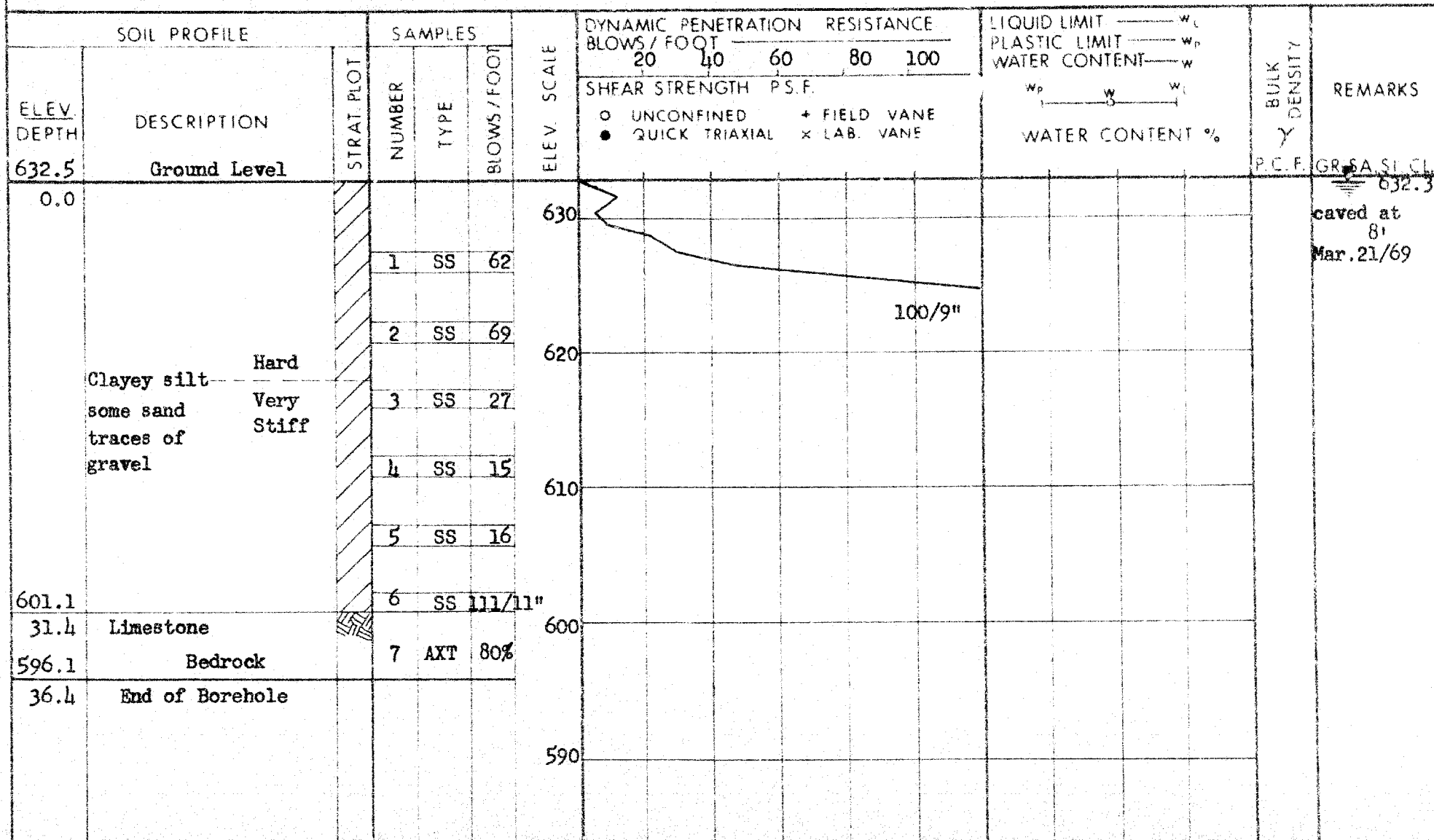
DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 24

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 590,916 N; 154,225 E.
 W.P. 163-64-01 BORING DATE March 13, 1969
 DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing and Cone

ORIGINATED BY AP
 COMPILED BY AP
 CHECKED BY *AK*



DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 25

FOUNDATION SECTION

JOB 69-F-8

LOCATION Co-ords. 591,009 N; 153,933 E.

ORIGINATED BY: AP

W.P. 163-64-01

BORING DATE **March 13, 1969**

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Cont. Flight Auger and Cone

CHECKED BY

[illegible]

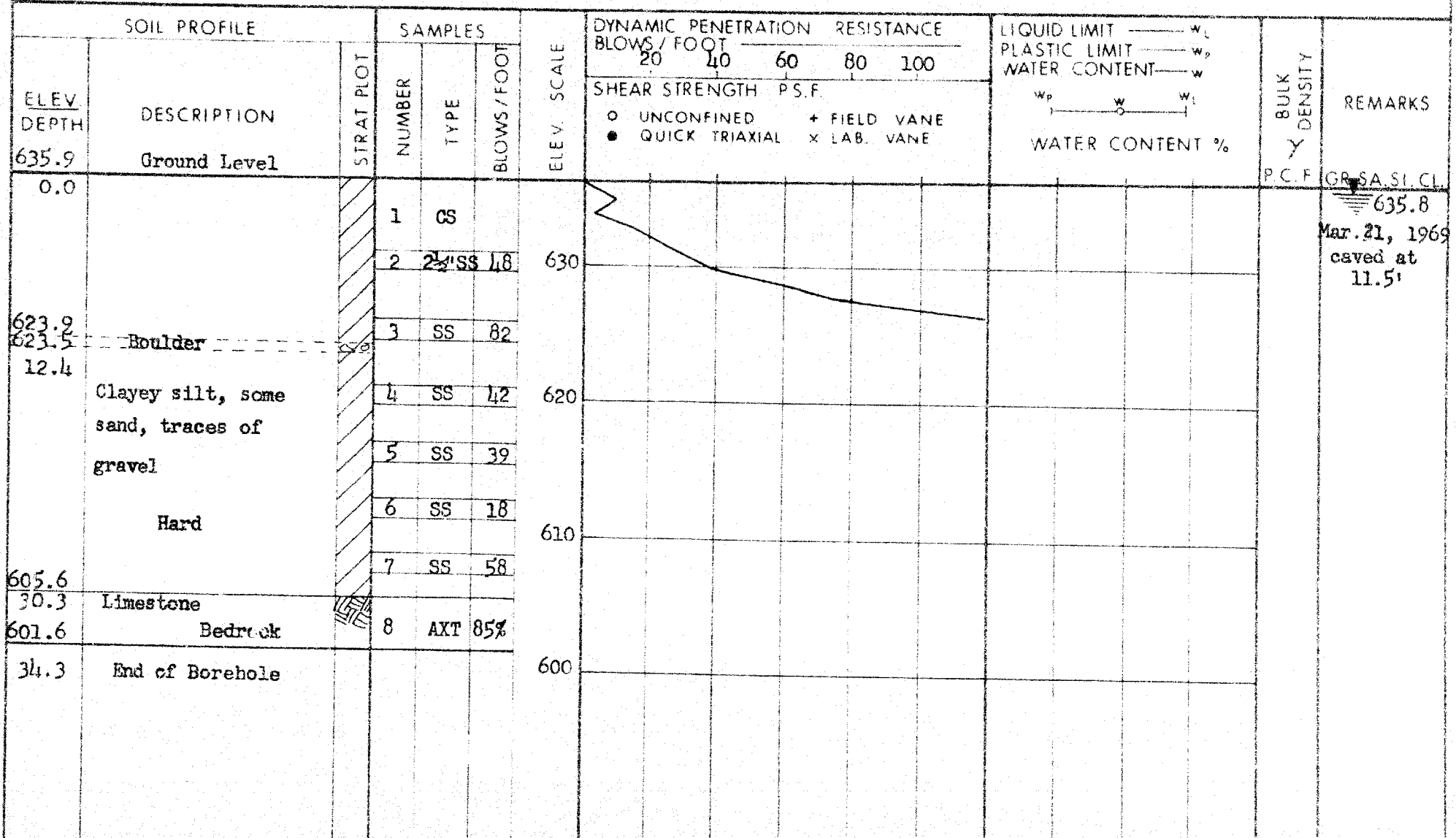
DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 26

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 591,112 N; 153,668 E.
 W.P. 163-64-01 BORING DATE March 13 - 14, 1969
 DATUM Geodetic BOREHOLE TYPE Washboring; NX Casing and Cone

ORIGINATED BY AP
 COMPILED BY AP
 CHECKED BY *AP*



635.8
 Mar. 21, 1969
 caved at
 11.5'

FOUNDATION SECTION

ORIGINATED BY AP

COMPILED BY AP

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 28

FOUNDATION SECTION

JOB 69-F-8

LOCATION Co-ords. 591,247 N; 153,407 E.

ORIGINATED BY AP

W.P. 163-64-01

BORING DATE March 17, 1969

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Cont. Flight Auger

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— w_L		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT ——— w_p	WATER CONTENT ——— w		
636.7	Ground Level							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE	w_p ——— w ——— w_L WATER CONTENT %			
0.0	Clayey silt some sand traces of gravel		1	SS	61	630						634.7
	Hard		2	SS	30	620						635.2
	Very stiff		3	3"SS	64	610						Tip el. 616.5
607.7			4	3"SS	60	600						Tip el. 611.6
29.0	End of Borehole											Tip el. 603.5
												Probable Bedrock at el. 603.5

FOUNDATION SECTION

CHECKED BY

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE	w_p	w	w_L		
636.7	Ground Level											
0.0												
	Clayey silt with sand traces of gravel	Hard	1	SS	45	630						
			2	SS	57							
		Very stiff	3	SS	32	620						
			4	SS	23							
		stiff	5	SS	14	610						
			6	SS	16							
			7	SS	12							
601.7	Sandy silt, some clay traces of gravel		8	SS	100/2"	600						
36.7	Probable Bedrock											
	End of Borehole											
						590						

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 30

FOUNDATION SECTION

JOB 69-F-8

LOCATION

Co-ords. 591,268 N; 152,832 E.

ORIGINATED BY AP

W.P. 163-64-01

BORING DATE

March 17, 1969

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE

Washboring, NX Casing and cone

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					PLASTIC LIMIT ——— w_p				
							20	40	60	80	100	WATER CONTENT ——— w				
SHEAR STRENGTH P.S.F.							+ FIELD VANE					WATER CONTENT %				
● QUICK TRIAXIAL							x LAB. VANE					w_p ——— w ——— w_L				
												10 20 30				
635.5	Ground Level															
0.0																
			1	SS	60	630										
			2	SS	50											
			3	SS	59	620										
			4	SS	16											
			5	SS	19	610										
			6	SS	18											
603.5																
32.0	Sandy silt, some clay		7	SS	16	600										
600.1	traces of gravel															
35.4	Probable Bedrock															
	End of Borehole															
						590										

634.5
Mar. 21/69
caved at
10.'

2 38 46 41

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 31

FOUNDATION SECTION

JOB	69-F-8	LOCATION	Co-ords. 591,427 N; 152,257 E.	ORIGINATED BY	AP
W.P.	163-61-01	BORING DATE	March 17, 1969	COMPILED BY	AP
DATUM	Geodetic	BOREHOLE TYPE	Cont. Flight Auger, NX Casing, Core & Cone	CHECKED BY	

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 32

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 591,455 N; 151,975 E.
W.P. 163-64-01 BORING DATE March 18, 1969
DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger and Cone

ORIGINATED BY AP
COMPILED BY AP
CHECKED BY //

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT ——— % PLASTIC LIMIT ——— % WATER CONTENT ——— %			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		20	40	60	80	100	W _p	W _L	W _U		
636.9	Ground Level														
0.0															
			1	SS	61										
			2	SS	138/10"										
	Clayey silt with sand		3	SS	30										
	traces of gravel		4	SS	24										
	Hard		5	3"SS	55										
	Very Stiff		6	SS	107/11"										
609.9	Sandy silt, some clay, traces of gravel.														
27.0															
607.5	Probable Bedrock														
29.4	End of Borehole														

636.9
Mar. 21/69
caved at
18.5'

8 32 45 15

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 33

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 591,450 N; 152,005 E ORIGINATED BY AP
 W.P. 163-64-01 BORING DATE March 18, 1969 COMPILED BY AP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger CHECKED BY 41

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT ——— w_L PLASTIC LIM T ——— w_p WATER CON. ——— w		BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE		WATER CONTENT %				
637.3	Ground Level											GR. SA. SI. CL.	
0.0	Clayey silt with sand traces of gravel Hard Very Stiff		1	SS	45	630						636.6 636.2	
			2	SS	28	620							626.7 Tip el. 622.3
612.3			3	SS	-								Tip el. 615.3
25.0	End of Borehole					610						Tip el. 608.3 Probable Bedrock at el. 608.3	

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 34

FOUNDATION SECTION

JOB 69-F-8	LOCATION Co-ords. 591,530 N; 151,627 E.	ORIGINATED BY AP
W.P. 163-64-01	BORING DATE March 19, 1969	COMPILED BY AP
DATUM Geodetic	BOREHOLE TYPE Washboring & NX Casing	CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— W _L			BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT		PLASTIC LIMIT ——— W _p		WATER CONTENT ——— W			
							SHEAR STRENGTH P.S.F.		WATER CONTENT %					
635.7	Ground Level													
0.0	Clayey silt some sand traces of gravel		1	SS	16	630								
			2	SS	36									
			3	SS	47	620								
			4	SS	13									
			5	SS	17	610								
604.3			6	SS	21									
31.4	Limestone													
599.3	Bedrock		7	AXT	100%	600								
36.4	End of Borehole													
						590								

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 35

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 591,619 N; 151,433 E. ORIGINATED BY AP
 W.P. 163-64-01 BORING DATE March 20, 1969 COMPILED BY AP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger CHECKED BY *AP*

SOIL PROFILE		STRAT. PLT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE		WATER CONTENT % 10 20 30				
635.2	Ground Level												
0.0													
			1	SS	50	630							
			2	SS	35								
	Hard												
	Clayey silt with sand traces of gravel		3	SS	31	620							
	Very Stiff		4	SS	20								
	Stiff		5	SS	14	610							
606.2													
29.0	Probable Bedrock End of Borehole					600							

617.2

Mar. 21/69

Caved at

25.5'

5 21 49 25

▼ 617.2
 Mar. 21/69
 Caved at
 25.5'
 5 21 49 25

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 36

FOUNDATION SECTION

JOB 69-F-8

LOCATION

Co-ords. 591,305 N; 152,935 E.

ORIGINATED BY: AP

W.P. 163-64-01

BORING DATE

March 20, 1969

COMPILED BY AP

DATUM Geodetic

BORE HOLE TYPE

Cont. Flight Auger

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 37

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 591,687 N; 151,198 E. ORIGINATED BY AP
 W.P. 163-64-01 BORING DATE March 20, 1969 COMPILED BY AP
 DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY LL

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT.	NUMBER	TYPE		BLOWS / FOOT	SHEAR STRENGTH P.S.F.		WATER CONTENT % w_p — w — w_L			
633.3	Ground Level						<div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL x LAB. VANE</div>					
0.0					630							
	Stiff		1	SS	10							
	Clayey silt		2	SS	43							
	some sand											
	Hard		3	SS	67							
	traces of											
	gravel		4	SS	17							
609.3					610							
24.0	Limestone		5	AXT	100%							
604.3	Bedrock											
29.0	End of Borehole				600							

626.6

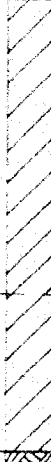

Mar. 26/69

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 38

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 591,740 N; 150,905 E. ORIGINATED BY AP
 W.P. 163-64-01 BORING DATE March 20, 1969 COMPILED BY AP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.		w_p — w — w_L WATER CONTENT % 10 20 30					
632.3	Ground Level						 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE							
0.0	Clayey silt some sand traces of gravel Hard Very Stiff		1	SS	44	630								
			2	SS	46	620								
			3	SS	30									
608.3			4	SS	17	610								
24.0	Probable Bedrock End of Borehole					600								

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 39

FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 591,833 N; 150,660 E.

ORIGINATED BY AP

W.P. 163-64-01 BORING DATE March 20, 1969

COMPILED BY AP

DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.		w_p ——— w ——— w_L WATER CONTENT %					
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB. VANE						
630.8	Ground Level													
0.0	Clayey silt some sand traces of gravel					630								
			1	SS	40									
			2	SS	41	620								
			3	SS	22									
			4	SS	10	610								
			5	SS	12									
			6	SS	14									
			7	SS	13									
602.6			8	SS	12									
28.2	Probable Bedrock End of Borehole					600								

2 13 49 36

3 16 61 20

FOUNDATION SECTION

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.		WATER CONTENT % 10 20 30				
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB. VANE					
630.7	Ground Level					630							
0.0	Clayey silt, some sand, traces of gravel. Hard		1	SS	69								
			2	SS	58	620							
			3	SS	29								
			4	3"SS	50	610							
603.7			5	3"SS	57								
27.0	Probable Bedrock End of Borehole					600							

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 41

FOUNDATION SECTION

JOB 62-F-8 LOCATION Co-ords. 591,798 N; 150,145 E. ORIGINATED BY AP
 W.P. 163-64-01 BORING DATE March 21, 1969 COMPILED BY AP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger CHECKED BY 4/

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.				w_p	w	w_L		
630.3	Ground Level						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE								
0.0						630									
			1	SS	14										
			2	SS	39	620									
	Clayey silt, some sand, traces of gravel		3	3"SS	50										
			4	3"SS	55	610									
	Hard Very stiff		5	SS	17										
604.6															
25.7	Probable Bedrock														
	End of Borehole					600									

3 8 44 45

DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 42

FOUNDATION SECTION

JOB 69-F-8

LOCATION Co-ords. 591,685 N; 151,203 E.

ORIGINATED BY AP

W.P. 163-64-01

BORING DATE March 27, 1969

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Washboring, NX & BX Casing, Core

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w		BULK DENSITY P.C.F. γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.		w_o ——— w ——— w_u WATER CONTENT %			
633.3	Ground Level						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					GR. SA. SI. CL.
0.0	Clayey silt, some sand, traces of gravel					630						▼ 626.6 Mar. 27/69
						620						
						610						
608.1	Limestone		1	AXT 95%								
25.2												
	Bedrock		2	AXT 95%		600						
598.1	End of Borehole											
35.2							590					

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 43 (Formerly BH 9 67-F-70) FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 591,240 N; 153,090 E. ORIGINATED BY JBD

W.P. 163-64-01 BORING DATE August 23, 1967 COMPILED BY MW

DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT 20 40 60 80 100							WATER CONTENT % w_p w w_L		
							SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE									
637.2	Ground Level															
0.0	Clayey silt with sand trace of gravel. Hard to stiff		1	SS	73											
			2	SS	49											
			3	SS	45											
			4	SS	28											
			5	SS	21											
			6	SS	17											
			7	SS	11											
			8	SS	12											
600.0	End of Borehole Probable Bedrock															
37.2																

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICERECORD OF BOREHOLE No. 44 (Formerly BH#10
67-F-76) FOUNDATION SECTION

JOB 69-F-8 LOCATION Co-ords. 591,807 N; 149,845 E. ORIGINATED BY JBD
 W.P. 163-64-01 BORING DATE August 19 & 22, 1966 COMPILED BY MW
 DATUM Geodetic BOREHOLE TYPE Cont.Flight Auger CHECKED BY

SOIL PROFILE		SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					SHEAR STRENGTH P S F					WATER CONTENT %		
						20	40	60	80	100	500	1000	1500			2000	2500	10
											○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
630.3	Ground Level																	
0.0	Clayey topsoil. V. Stiff	1	SS	16	630													
1.0	Clayey silt, traces of sand and gravel.	2	SS	44														
		3	TW	31	620													
		4	SS	23														
		5	TW	PH	610													
	Very stiff to hard	6	SS	16														
603.6																		
26.7	End of Borehole Probable Bedrock				600													

626.1

RECORD OF BOREHOLE No. 45 (Formerly BH 6
67-P-75) FOUNDATION SECTION

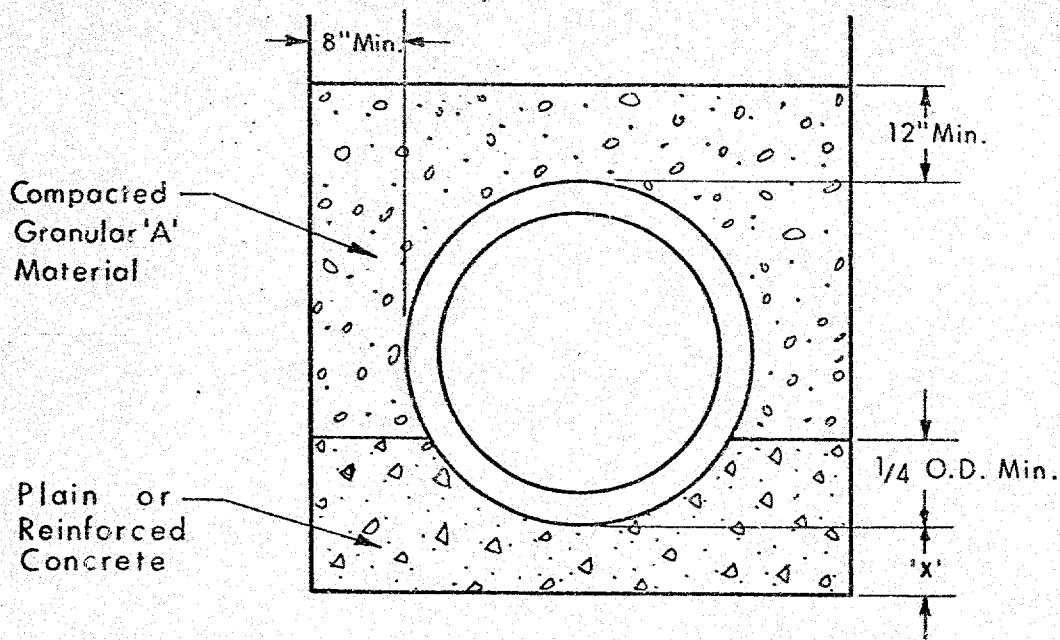
ORIGINATED BY WGH

COMPILED BY AMS

CHECKED BY

SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w		BULK DENSITY P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH PSF ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE 500 1000 1500 2000 2500	WATER CONTENT % w_p — w — w_L 10 20 30			
633.9	Ground Level										
0.0	Mottled clayey silt, silt seams, trace of organics.		1	SS	18	630				133	628.9
626.9	Very stiff.										
7.0	Clayey silt, traces of sand and gravel		2	SS	44						
			3	SS	44	620					
			4	SS	31						
	Very stiff to hard.		5/6	SS	28						
			7	SS	19						
			8	TW	PH	610					
			9	SS	22						
604.9			10	TW	PH						
29.0			11	SS	1275"						
	Dolomite		12	AXT	83%	bouncing					
			13	AXT	97%						
	Bedrock		14	AXT	92%						
595.9											
38.0	End of Borehole					590					

Class "A" Bedding



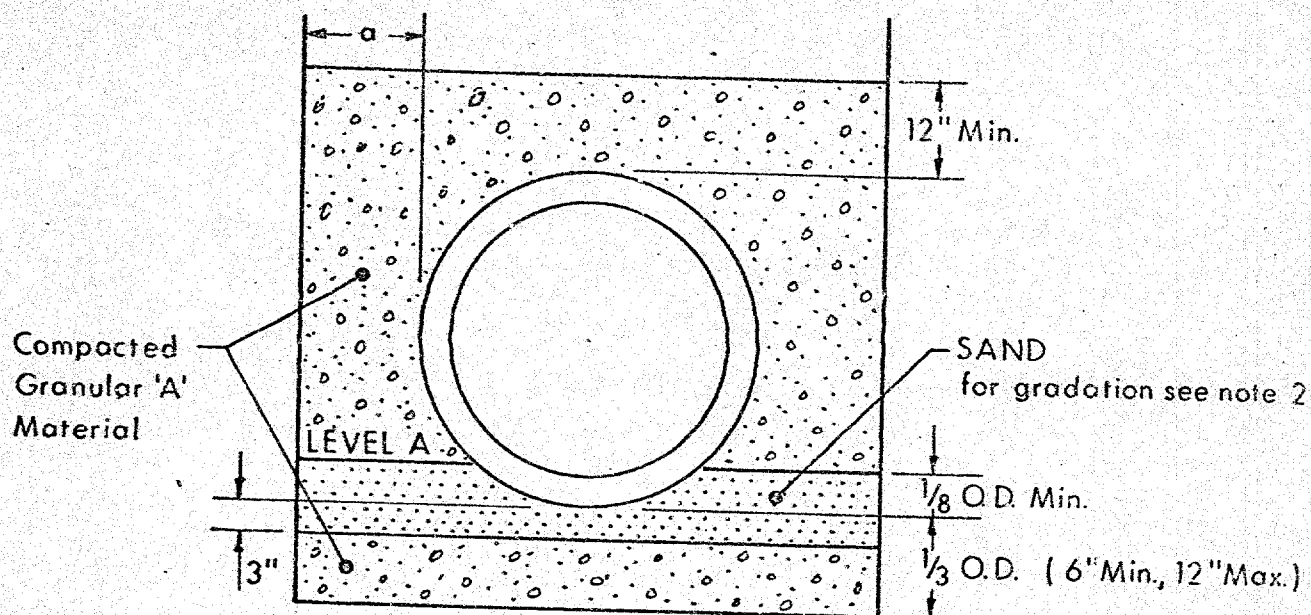
NOTES:

1. The quality of the concrete shall be as specified in D.H.O. Specifications Form 9, Section 9.04 and of minimum compressive strength of 2000 p.s.i. at 28 days. The nominal max. size of the coarse aggregate shall be $3/4$ inch unless otherwise specified.
2. Granular 'A' backfill shall be placed in 6 inch horizontal layers fully compacted to 100% Proctor Density up to a level 12 inches above the top of the pipe.
3. Dimension 'x' shall be 6" where the foundation is bedrock. Otherwise 'x' shall be $1/4$ I.D. or 6" whichever is greater.

FIG. 1

JOB 69-F-8

CLASS 'B' BEDDING



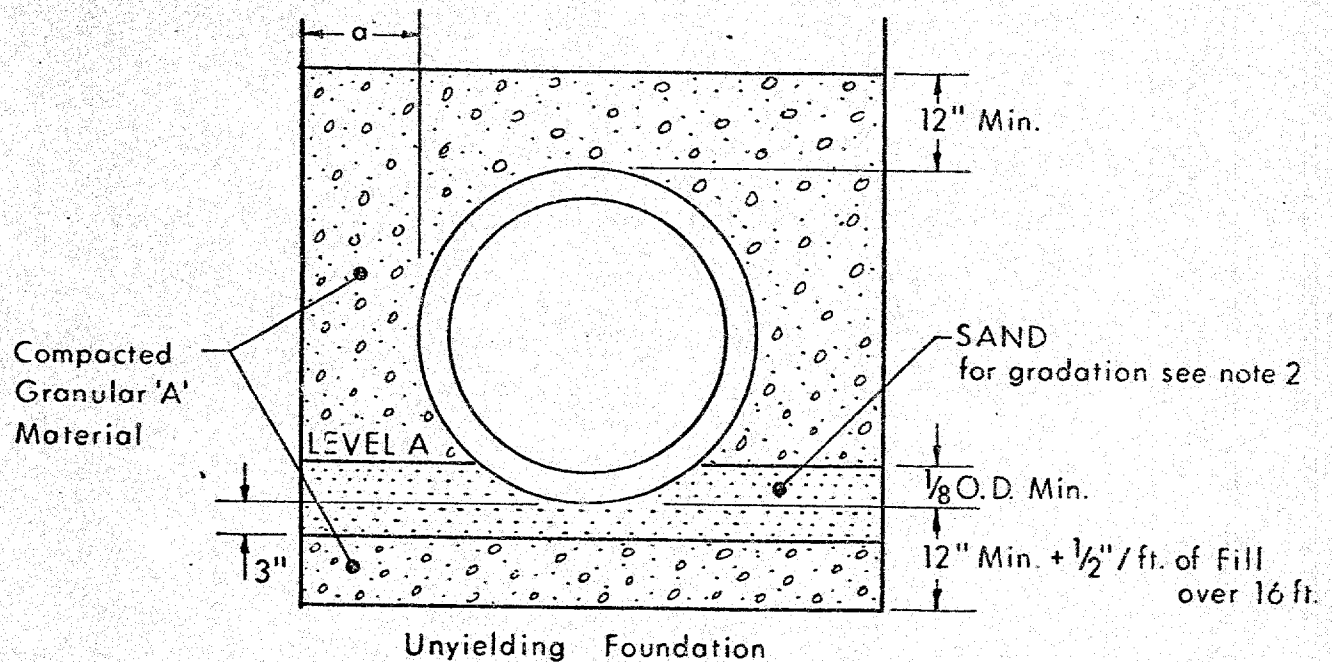
NOTES:

1. Granular material shall be placed in horizontal 6 inch layers fully compacted to 100% Proctor Density up to level A. It shall then be re-excavated to conform with the shape of the pipe bottom using a template. The remainder of the backfill shall be placed in 6 inch layers fully compacted to 12 inches above the top of the pipe.
2. Gradation for sand shall be as per D.H.O. Form 1003 for H.L. 4, 5, 6 & 8, Table 1A. A tolerance of 15% of material passing the $\frac{3}{8}$ inch Sieve and retained on the No. 4 ($\frac{3}{16}$ inch) Sieve shall be permitted.
3. Dimension 'a' for pipes 4.0 ft. I.D. or less shall be 15 inches. Dimension 'a' for pipes larger than 4.0 ft. I.D. shall be equal to $\frac{1}{3}$ I.D. or 2.0 ft. whichever is less.

FIG. 2

JOB 69-F-8

BEDDING ON UNYIELDING FOUNDATION

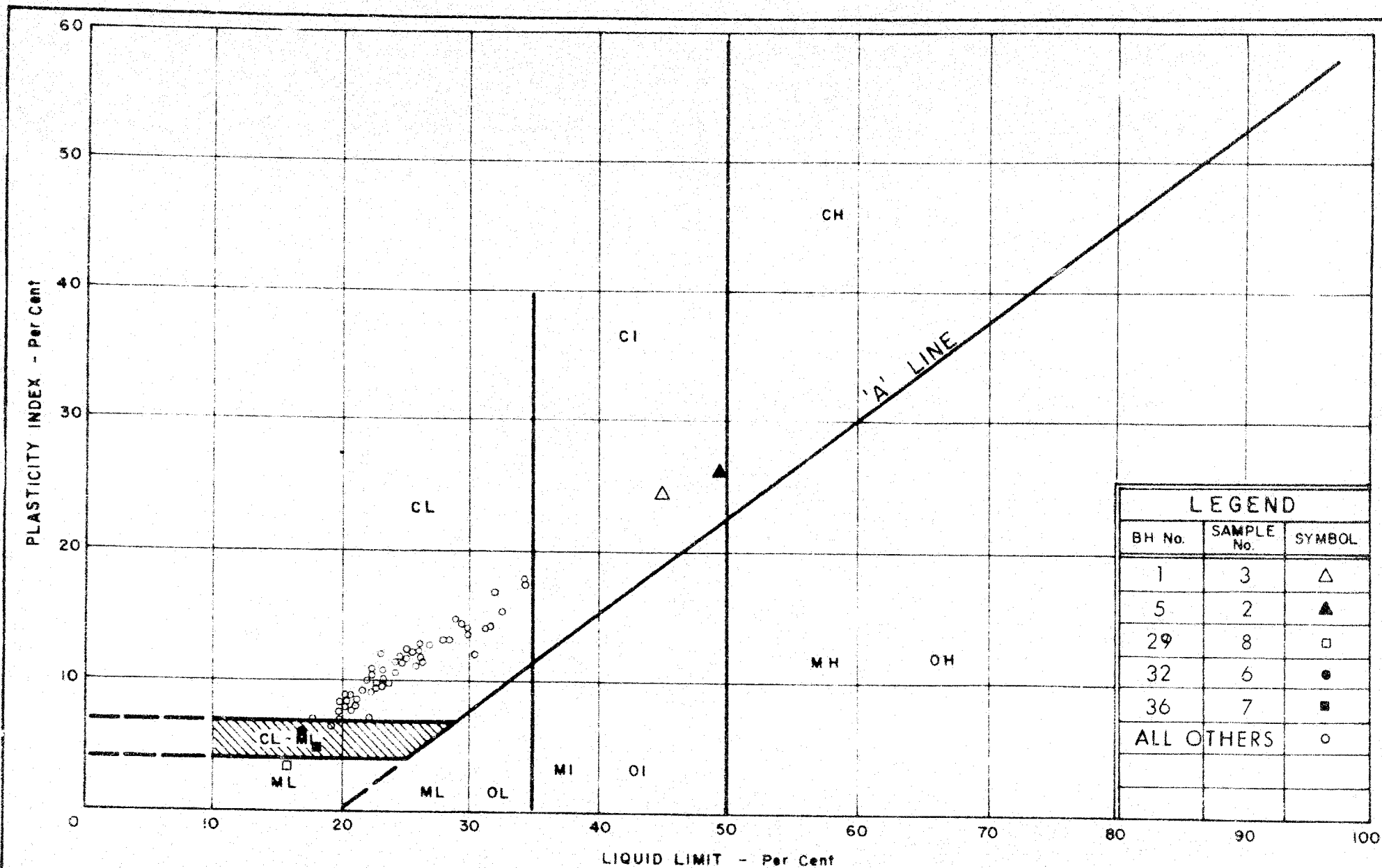


NOTES:

1. Granular material shall be placed in horizontal 6 inch layers fully compacted to 100% Proctor Density up to level A. It shall then be re-excavated to conform with the shape of the pipe bottom using a template. The remainder of the backfill shall be placed in 6 inch layers fully compacted to 12 inches above the top of the pipe.
2. Gradation for sand shall be as per D.H.O. Form 1003 for H.L. 4, 5, 6 & 8, Table 1A. A tolerance of 15% of material passing the 3/8 inch Sieve and retained on the No. 4 (3/16 inch) Sieve shall be permitted.
3. Dimension 'a' for pipes 4.0 ft. I.D. or less shall be 15 inches. Dimension 'a' for pipes larger than 4.0 ft. I.D. shall be equal to 1/3 I.D. or 2.0 ft. whichever is less.

FIG. 3

JOB 69-F-8



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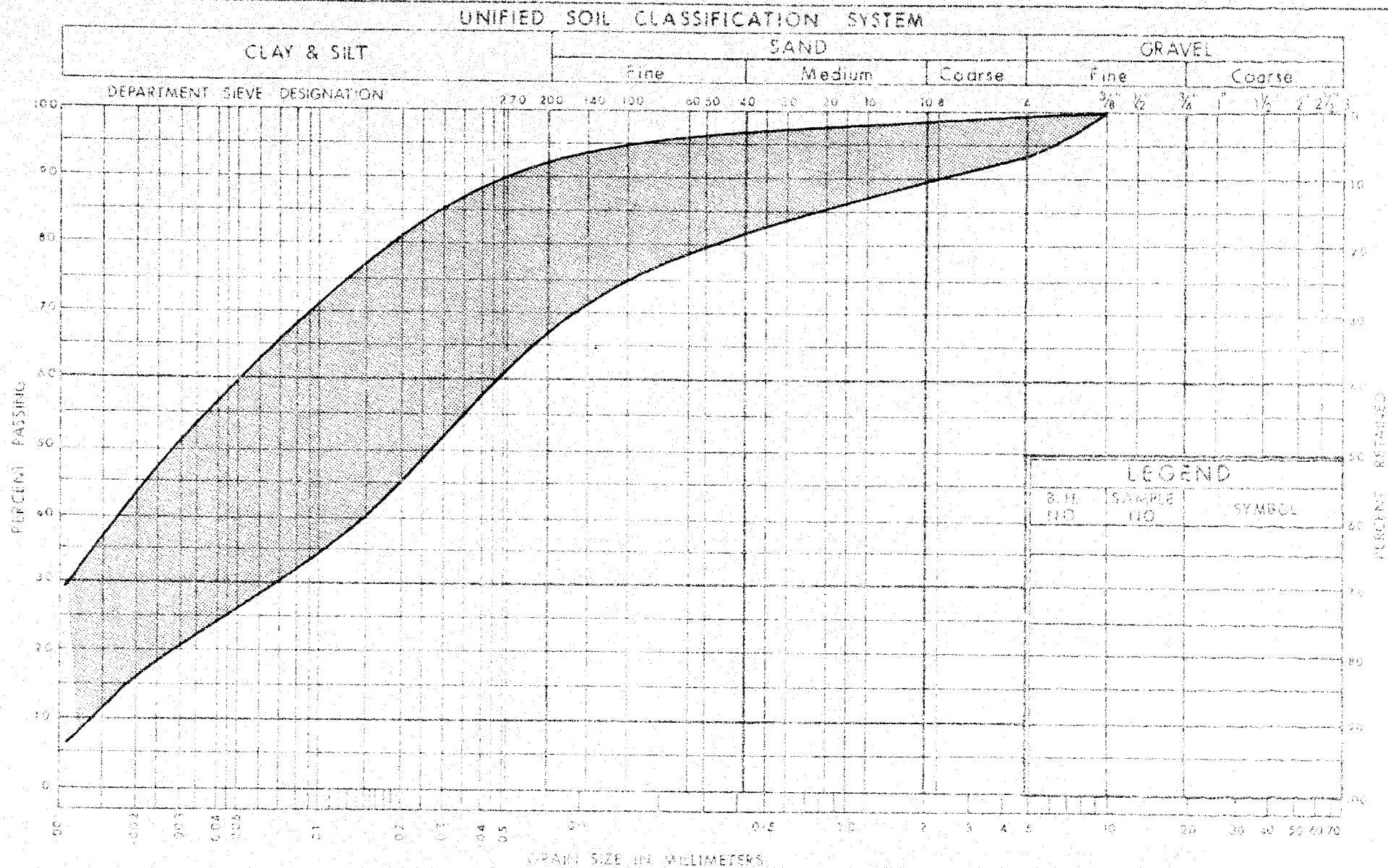
PLASTICITY CHART

W.P. No. 163-64-01

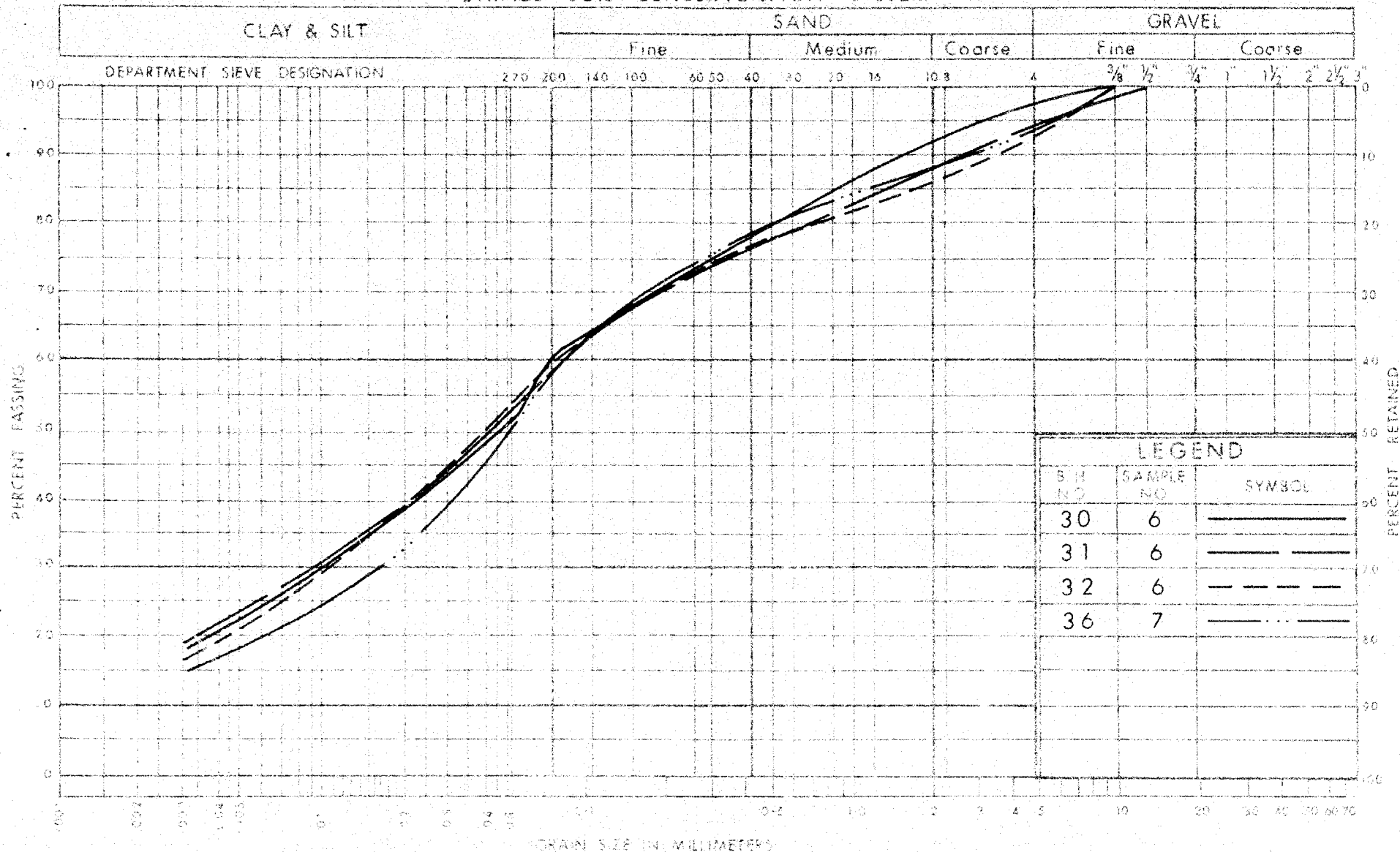
JOB No. 69-F-8

FIG. NO. 4

WF No. 163-64-01
JOB No. 69-F-8
FIG. NO. 5



UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
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TESTING
DIVISION

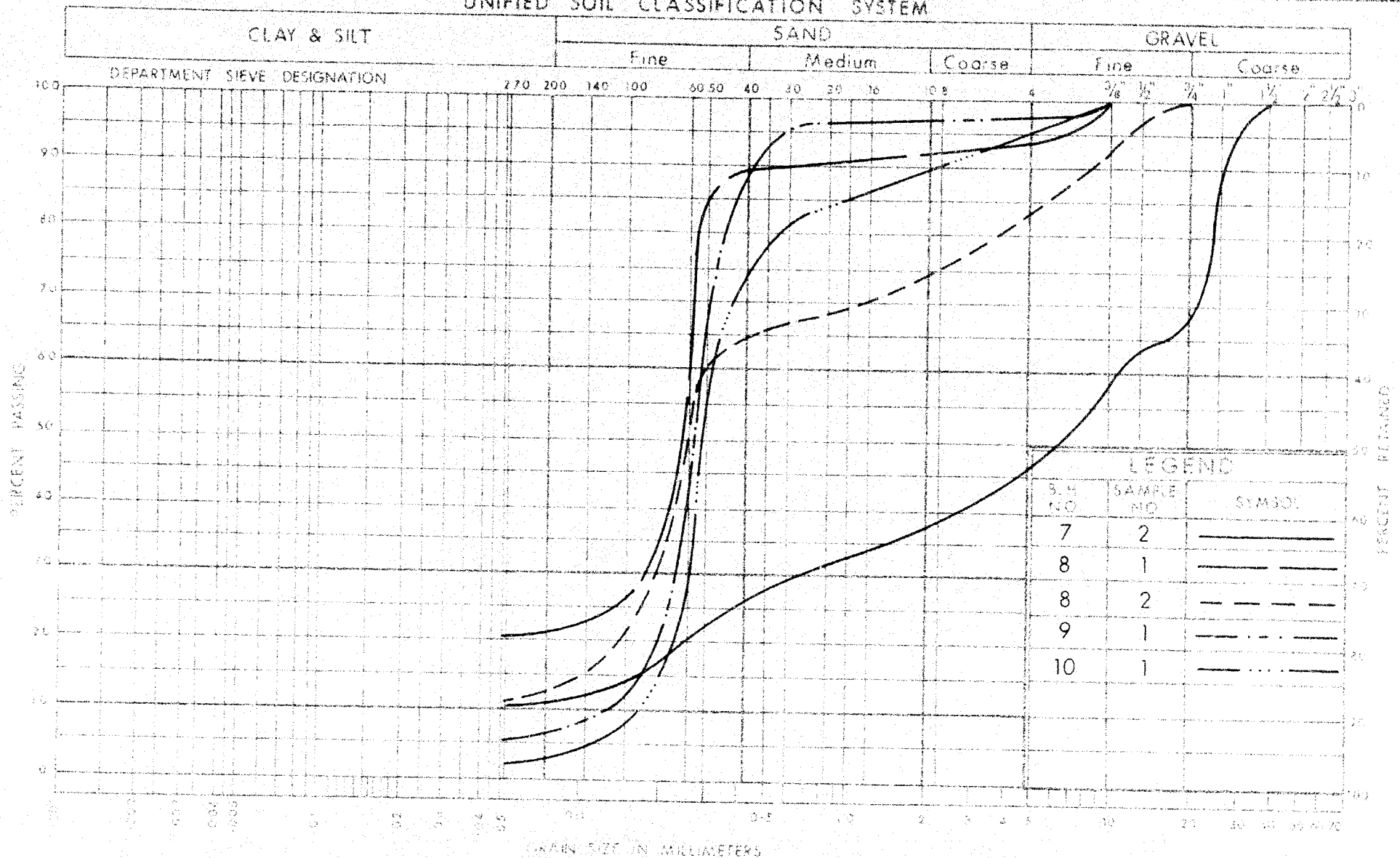
GRAIN SIZE DISTRIBUTION SANDY SILT

W.P. No. 163-64-01

JOB No. 68-F-8

FIG. NO 6

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION SAND

DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

WP No 163-64-01

JOB No 69-F-8

FIG. NO 7

GRAPH RELATING DEPTH OF EXCAVATION AND WATER LEVEL
TO PREVENT BOTTOM HEAVE IN CLAYEY SILT LAYER

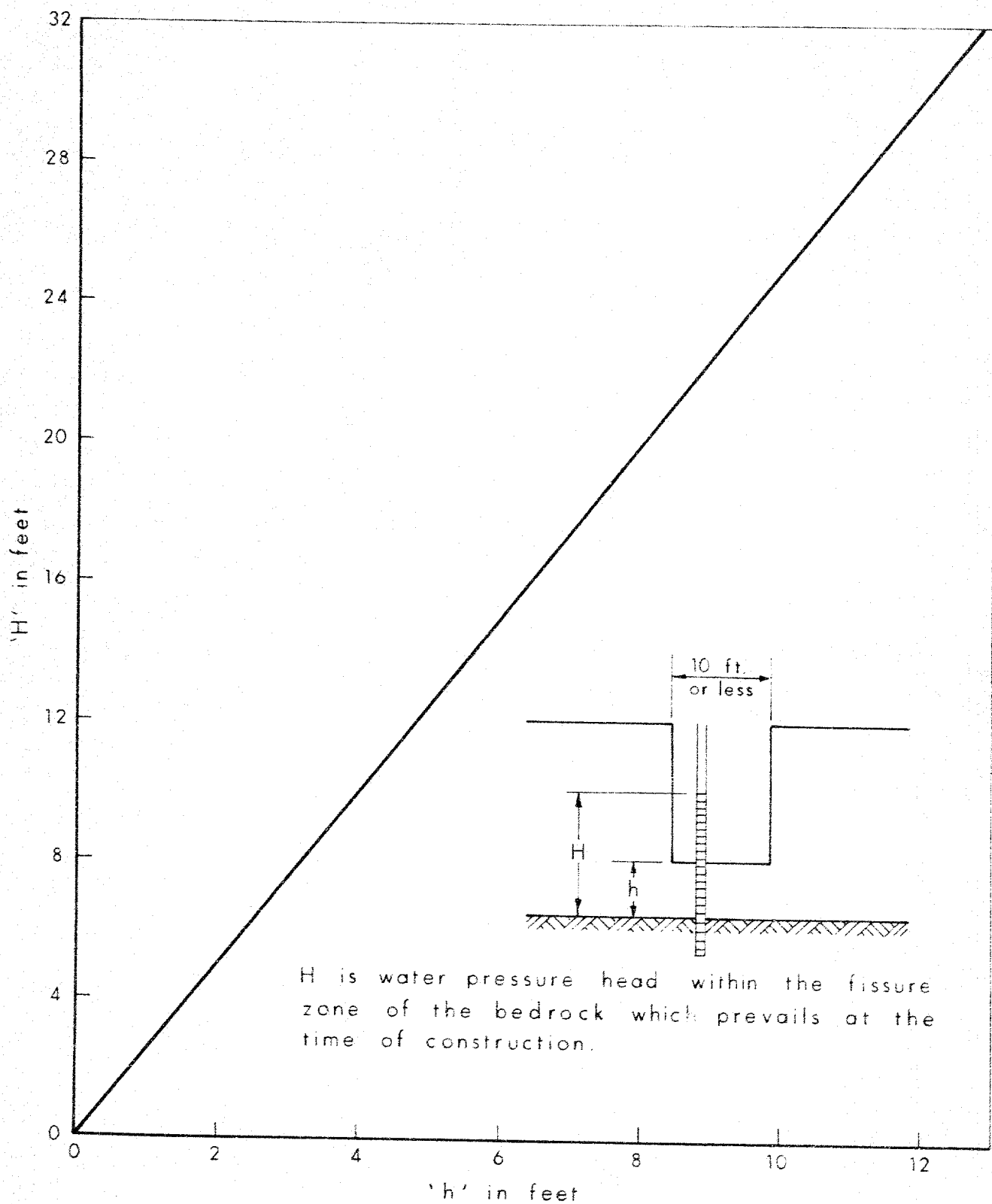


Fig. 8

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S	SPLIT SPOON	T.W	THINWALL OPEN
W.S	WASHED SAMPLE	T.P	THINWALL PISTON
S.B	SCRAPER BUCKET SAMPLE	O.S	OESTERBERG SAMPLE
A.S	AUGER SAMPLE	F.S	FOIL SAMPLE
C.S	CHUNK SAMPLE	R.C	ROCK CORE
S.T	SLOTTED TUBE SAMPLE		
	P.H		SAMPLE ADVANCED HYDRAULICALLY
	P.M		SAMPLE ADVANCED MANUALLY

SOIL TESTS

Q _u	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V	FIELD VANE
Q _{cu}	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q _d	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_r	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

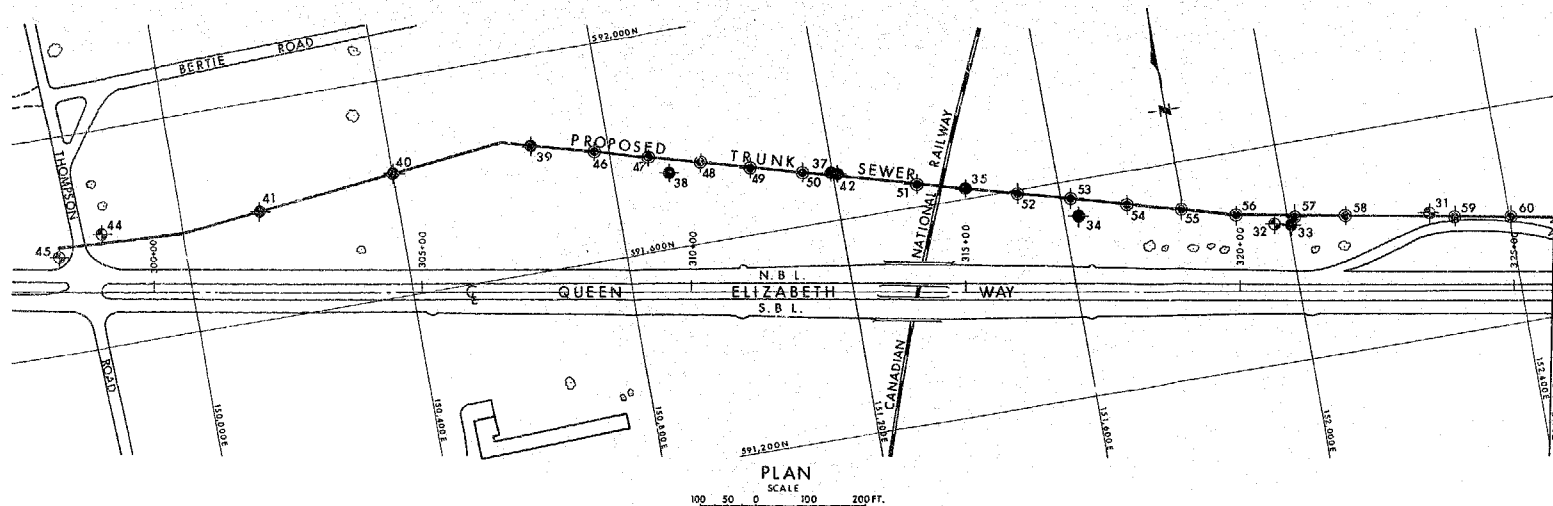
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

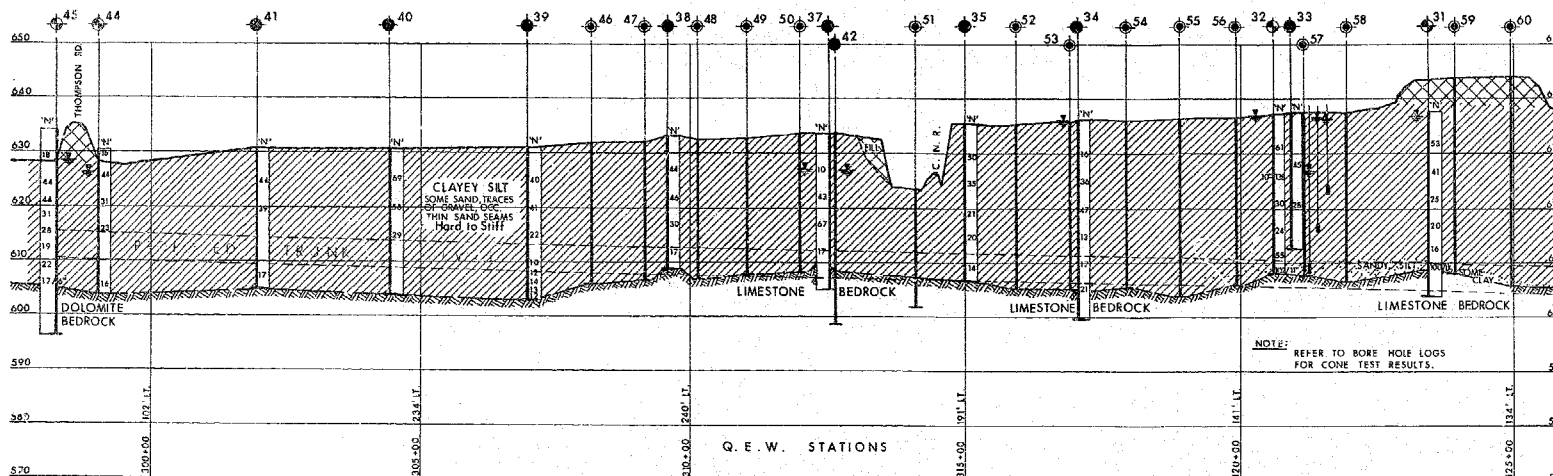
B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

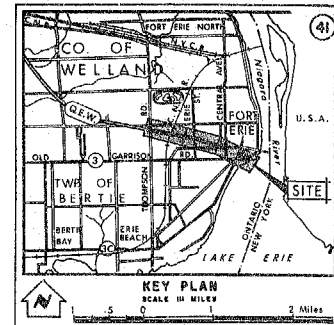
H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



PLAN
SCALE
100 50 0 100 200 FT.



Q. E. W. STATIONS
Q. E. W. STATIONS
SCALE
HORIZ. 100 50 0 100 200 FT.
VERT. 10 5 0 10 20 FT.



- LEGEND**
- Bore Hole
 - Cone Penetration Hole
 - Bore & Cone Penetration Hole
 - Water Levels established at time of field investigation, March 1969
 - Bedrock Probe Hole
 - Piezometer

NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
31	637.4	591,427	152,257
32	636.9	591,435	151,875
33	637.3	591,450	152,005
34	635.7	591,530	151,627
35	635.2	591,619	151,433
37	635.3	591,667	151,198
38	637.3	591,740	150,905
39	630.8	591,833	150,460
40	630.7	591,825	150,400
41	630.3	591,798	150,145
42	633.3	591,685	151,203
44	630.3	591,607	149,845
45	633.9	591,778	149,763
46	631.8	591,802	150,776
47	632.2	591,771	150,873
48	632.8	591,720	150,888
49	632.7	591,698	151,145
50	632.5	591,618	151,150
51	635.3	591,550	151,524
52	635.3	591,537	151,717
53	634.0	591,460	152,014
54	637.0	591,483	151,810
55	637.0	591,442	152,014
56	643.6	591,409	152,002
60	644.0	591,390	152,402

NO.	ELEVATION	CO-ORDINATES	DESCRIPTION
35	630.8	591,833	150,460
38	637.3	591,740	150,905
39	630.8	591,833	150,460
40	630.7	591,825	150,400
41	630.3	591,798	150,145
42	633.3	591,685	151,203
44	630.3	591,607	149,845
45	633.9	591,778	149,763
46	631.8	591,802	150,776
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60	644.0	591,390	152,402

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE - FOUNDATION SECTION

PROPOSED TRUNK SEWER

KING'S HIGHWAY NO. Q. E. W. DIST. NO. 4
CO. OF WELLAND TOWN OF FORT ERIE
TWP. BERTIE LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SURV. A. P. CHECKED BY: J. P. F. 64-01
DRAWN G. P. CHECKED BY: J. P. F. 64-01
DATE: April 29, 1969 SITE NO. 69-F-8A
APPROVED: J. P. F. 64-01
ENGINEERING NO. 70-11

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

SEE DRAWING NO. 69-F-8A

KEY PLAN
SCALE IN MILES

LEGEND

- Bore Hole
- ⊙ Bedrock probe hole
- ⊕ Cone Penetration Hole
- ⊗ Bore & Cone Penetration Hole
- ⊙ Water Level established at time of field investigation, March 1969
- Piezometer

NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
19	526.8	590,675	155,132
20	629.5	590,667	154,757
21	632.2	590,803	154,472
22	632.0	590,803	154,542
24	632.5	590,916	154,725
25	634.6	591,009	153,931
26	635.9	591,112	153,668
27	636.4	591,205	153,412
28	636.7	591,247	153,407
29	636.7	591,372	152,575
30	635.5	591,264	152,430
36	637.3	591,305	152,735
43	637.2	591,240	153,090
61	616.8	591,370	152,508
62	637.2	591,239	152,713
63	637.8	591,222	153,102
64	638.6	591,130	153,524
65	635.0	591,045	153,758
66	634.7	591,023	153,648
67	634.3	590,982	153,540
68	633.8	590,937	154,037
69	633.3	590,900	154,121
70	632.6	590,857	154,213
71	632.8	590,843	154,242
72	631.8	590,816	154,304
73	630.2	590,787	154,564

NO.	DATE	BY	DESCRIPTION
1	7-6	S.C.	BEDROCK PROBES ADDED

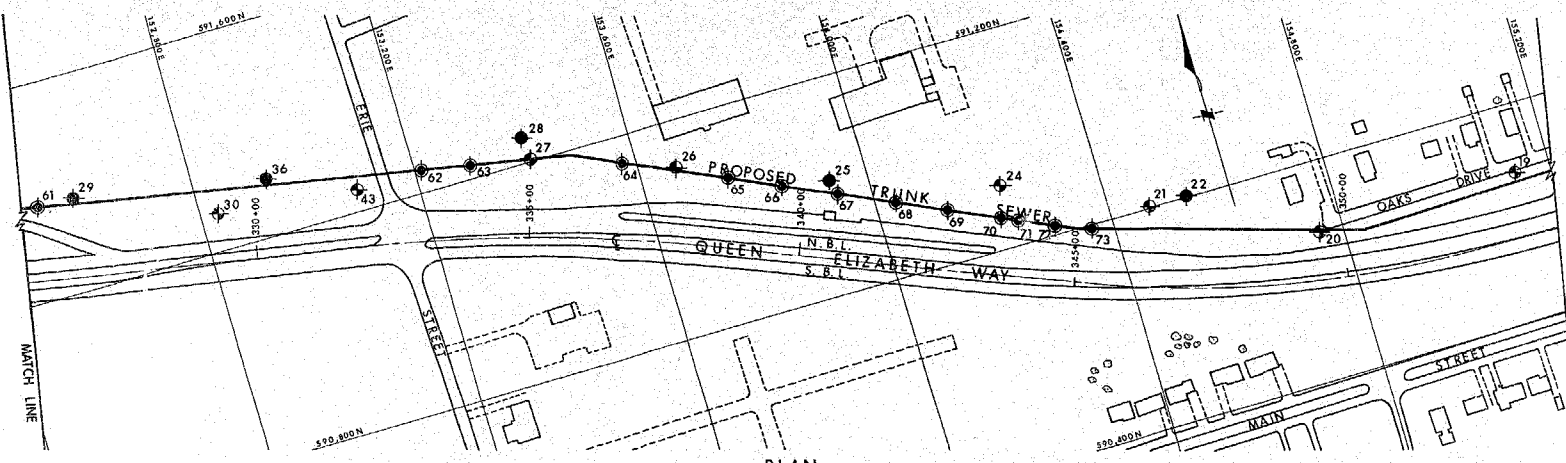
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE - FOUNDATION SECTION

PROPOSED TRUNK SEWER

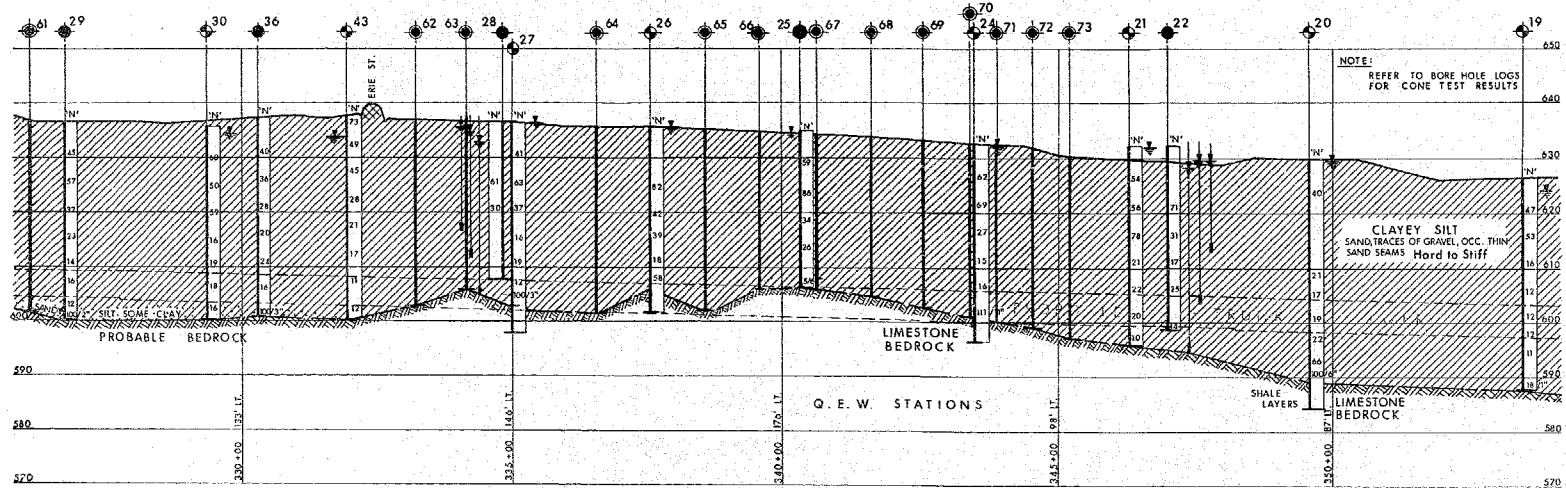
KING'S HIGHWAY NO. Q.E.W. DIST. NO. 4
CO. WELLAND TOWN OF FORT ERIE
TWP. BERTIE LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMITTED BY: CHIEF ENGINEER, M.P. NO. 163-0-6-01
CHECKED BY: CHIEF ENGINEER, JOB NO. 69-F-8
DATE: APR 30, 1969 SITE NO. 69-F-8-B
APPROVED: [Signature] ENGINEER, CONT. NO. 70-11



PLAN
SCALE
100 50 0 100 200 FT.



Q.E.W. STATIONS
Q.E.W. STATIONS

SCALE
HORIZ. 100 50 0 100 200 FT.
VERT. 10 5 0 10 20 FT.

NOTE - Water Levels in Bore Holes 36 & 29 not established at time of field investigation.

NOTE - The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

SEE DRAWING NO. 69-F-8A

KEY PLAN
SCALE IN MILES

LEGEND

- Bore Hole
- ⊙ Bedrock probe hole
- ⊕ Cone Penetration Hole
- ⊗ Bore & Cone Penetration Hole
- ☆ Water Levels established at time of field investigation, March 1969

NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	575.1	589,102	156,805
2	575.0	589,132	156,931
3	574.4	589,167	156,765
4	576.4	589,255	156,727
5	579.7	589,340	156,667
6	581.0	589,425	156,612
7	582.1	589,508	156,562
8	581.7	589,773	156,598
9	580.3	590,036	156,685
10	580.3	589,923	156,640
11	580.8	589,840	156,622
12	581.1	589,817	156,622
13	581.5	589,785	156,612
14	583.8	590,158	156,588
15	596.2	590,360	154,427
16	602.3	590,548	156,103
17	611.4	590,646	155,843
18	623.6	590,675	155,518
23	617.4	590,704	155,807
74	606.3	590,657	155,963
75	598.1	590,555	156,136
76	595.1	590,500	156,238
77	600.4	590,410	156,358
78	594.0	590,299	156,477

REVISIONS	NO.	DATE	BY	DESCRIPTION
1	1	APR 30 1969	G.P.	ADDED BORE HOLE PROFILES
2	2	APR 30 1969	G.P.	ADDED BORE HOLE PROFILES

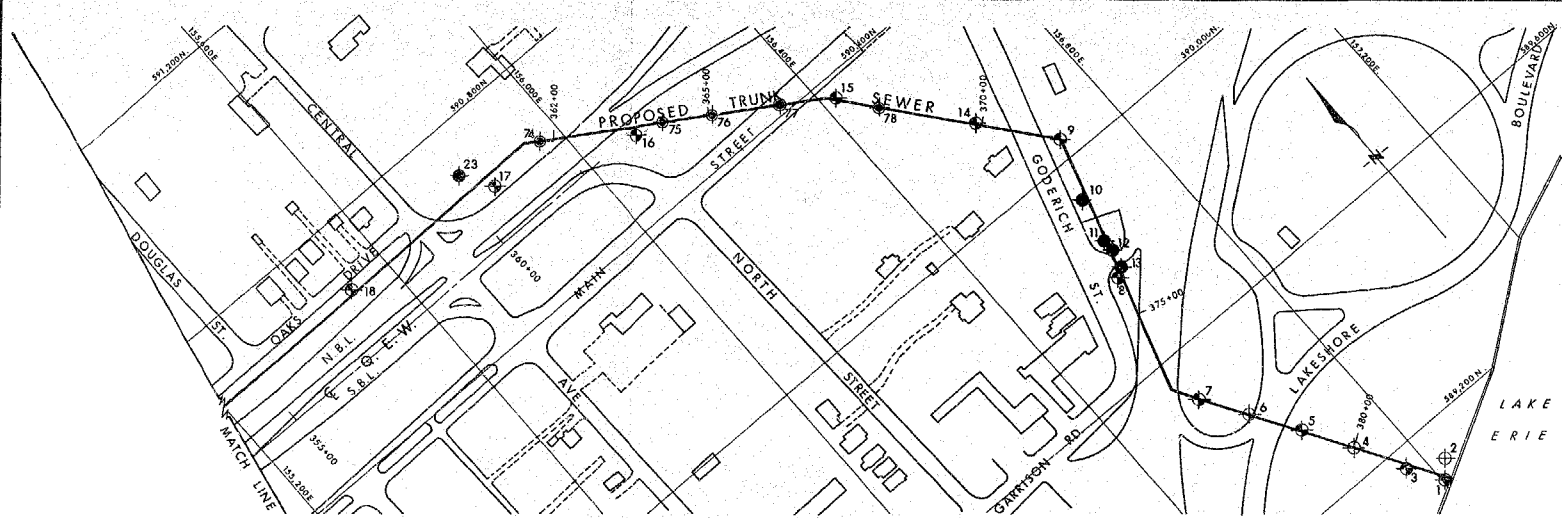
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE - FOUNDATION SECTION

PROPOSED TRUNK SEWER

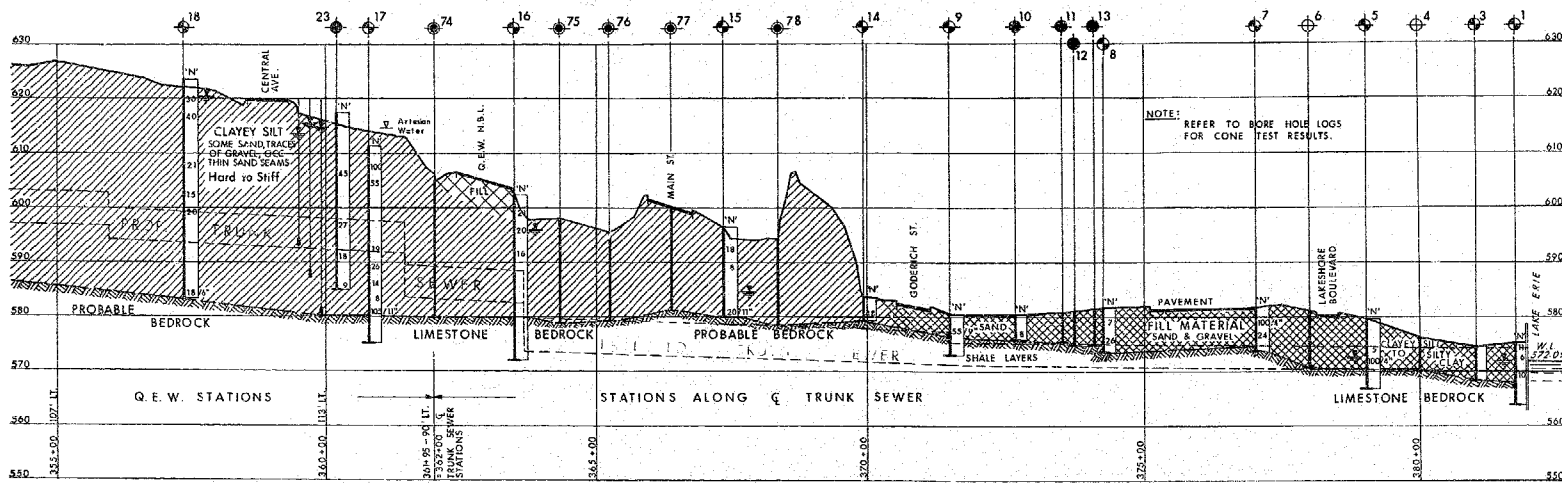
RING'S HIGHWAY NO. Q.E.W. DIST. NO. 4
CO. WELLAND TOWN OF FORT ERIE
TWP. BERTIE LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMITTAL: P. CHECKED: G.P. REP. NO. 163-64-01 B.S.T. DRAWING NO. 69-F-8C
DRAWN: G.P. CHECKED: G.P. JOB NO. 69-F-8
DATE: April 30, 1969 SITE NO. BRIDGE DRAWING NO.
APPROVED: [Signature] DATE: [Blank] CONT. NO. 70-11



PLAN
SCALE
100 50 0 100 200 FT.



Q.E.W. PROFILE ALONG SEWER

SCALE
HORIZ. 100 50 0 100 200 FT.
VERT. 10 5 0 10 20 FT.

NOTE: The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

NOTE: Water Levels in Bore Holes 3, 7, 8, 9, 10, 11, 12, 13, 14, & 18 not established at time of field investigation

PRINCIPALS
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G. A. RANKIN, P. ENG.
R. C. McCORMICK, P. ENG.
R. D. NAIRN, P. ENG.
J. F. BEATSON
ASSOCIATES
J. L. MALCOLM, P. ENG.
C. P. KORZENIOWSKI, P. ENG.
D. R. BLAY, P. ENG.

McCORMICK, RANKIN & ASSOCIATES
LIMITED

CONSULTING ENGINEERS

PORT CREDIT OTTAWA



MEMBER
ASSOCIATION OF CONSULTING
ENGINEERS OF CANADA

8 STAVESBANK ROAD
PORT CREDIT, ONTARIO

TELEPHONE 274-3477

May 22, 1969

Mr. G. K. Hunter, P. Eng.,
Regional Road Design Engineer,
Central Region, R. D. O.,
DEPARTMENT OF HIGHWAYS,
DOWNSVIEW, Ontario.

Attention: Mr. E. McCabe, P. Eng.

RE: W. P. 163-64-01 - O. E. W.
Trunk Sewer from Thompson Road to
Peace Bridge
District 4 - Hamilton
Our File W. O. 427-68

Dear Sir :

Some question has arisen recently on the apparent disparity of estimates made to compare the relative economics of tunnelling and deep trenching for trunk sewers at Fort Erie and at Niagara Falls. We have had the opportunity to review the estimates and would like to make the following comments :-

- (1) The major difference in cost between the Fort Erie sewer and the Niagara Falls sewer is in the apparent need for granular fill in the Niagara Falls sewer and the disposal of the excavated trench material. These two items alone account for over 50% of the total cost.
- (2) A rough estimate of the Niagara Falls system shows that if backfill costs and disposal costs are eliminated by using native backfill, the total cost of the mixed tunnel and open cut construction would be almost identical to the all tunnel construction.

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

Mr. G. K. Hunter, P. Eng.

- (3) Mr. K. Selby has assured us that there would appear to be no reason why native backfill could not be used on the Fort Erie project. Obviously it will be necessary to use some granular backfill under pavements, but these areas form a relatively minor portion of the deep sewer.
- (4) Applying the unit costs provided for the Niagara Falls project to our project, the cost per linear foot for a 28' trench is \$120.50. Our original estimate was \$125.00, which seems to compare favourably.
- (5) Because of outlet and slope limitations, it is not possible to lower the trunk sewer entirely into rock; however, it is possible to obtain approximately 5,000' with a minimum rock "bridge" of 10'.

From Station 348+20 to Station 364+00, a distance of 1,580', the tunnel would vary from a 10' maximum bridge to an all earth tunnel. This section would probably give the most difficulty from a construction viewpoint, but is also the most difficult section to do by open cut as it involves detours at Oakes Drive, Central Avenue and the Q.E.W.

From Station 364+00 to the outlet, the sewer would be in open cut as this section is relatively shallow.

To summarise :-

5,000' of tunnel in rock
 1,580' of tunnel in transitional rock/earth zone
1,795' in open cut

Total 8,375'

Mr. G. K. Hunter, P. Eng.

- (6) Calculations are presently being carried out to assess the cost of concrete bedding where recommended by the Foundation Section. If this cost, plus the cost of dewatering, adds substantially to the cost per linear foot of the sewer, the alternative of tunnelling may seem more acceptable.
- (7) In either event, it now appears that the original estimates for the storm sewer should now be revised upwards in view of the poor foundation conditions. A more up-to-date figure based on recent estimates would be \$1,250,000.

A more accurate comparison of costs for both systems is currently being prepared and it is hoped that we will be in a position to present these at our next progress meeting.

Yours very truly,
MCCORMICK, RANKIN & ASSOCIATES LIMITED

R. C. McCormick
R. C. McCormick, P. Eng.

RCM/MA

c.c. Mr. K. Selby, P. Eng.

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. K. G. Selby
Foundations Engineer

From: K. Ingham
Materials and Testing Office

Date: April 23, 1969

Our File Ref.

In Reply To

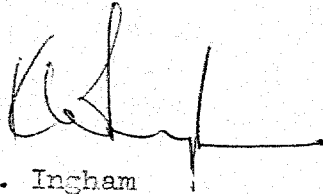
Subject: Trunk Sewer, Thompson Road and Q.E.W. to Peace Bridge Plaza

The general area between Thompson Road and Lake Erie is underlain by the Bois Blanc foundation; a dense, fine grained, cherty limestone. A brief description of the rock-cores from holes 26, 27, 31, 34 and 42 is attached to illustrate the general lithology.

The formation is more or less uniformly medium bedded dipping gently to the south at approximately 25 ft. per mile. The rock appears to be sound and unweathered from the surface down, with very little fracturing - the only fracture noted was an inclined fissure at the top of hole 42. The vertical joint pattern, as seen in areas exposed elsewhere, is somewhat variable but two main sets are usually present spaced from 5 to 15 ft. apart.

The section between Thompson Road and hole 31 is apparently a coralline facies with some reef development. The coral biostrome (flat reef-like complex) encountered in the top 2.5 ft. of hole 42 is typical of such structures that are found in this facies of the Bois Blanc formation. They are generally 5 to 8 ft. thick and 100 to 200 ft. in length. The biostrome in hole 42 appears to be at the top of a slight rise in the bedrock. When these structures are encountered enclosed within the bedrock they sometimes contain small quantities of oil, and, more rarely, water and gas under pressure. The section from hole 27 to the lake appears to be more typical of the Bois Blanc formation, being a medium or dark brownish grey dense limestone with minor fossil fragments.. All four holes contained appreciable chert and chertified limestone (i.e. silica and silicified limestone), constituting from 15 to 25 percent of the formation. This again is typical of the Bois Blanc limestone. The cores examined indicate that the rock would have a moderately good bridging capacity. If rock-tunnelling is contemplated it is recommended that tunnels of 4 ft. diameter and smaller have a minimum of 3 ft. of rock cover, and tunnels 4 ft to 6 ft. in diameter have a minimum of 5 ft. of rock cover, to ensure that the roof is self-supporting.

Tunnelling is feasible by conventional drill-and-blast methods but the high silica content in the rock would probably rule out the use of tunnelling machines.

A handwritten signature in dark ink, appearing to be 'K. Ingham', with a long horizontal stroke extending to the right.

K. Ingham
Geologist

KI:nm

<u>Hole No.</u>	<u>Description</u>	<u>Interval</u>	<u>Thickness</u>
26	Limestone: dark grey; fine grained; thin to medium bedded; thin black shale seams between beds; small irregular nodules of dark grey about 0.05-0.1 ft. in diameter constitute approximately 5% of the section; irregular patches of dark grey chertified limestone, up to 0.4 ft. in diameter constitute approximately 10% of the section. Recovery 85%	30.3-34.3	4.0
27	Limestone: dark grey to medium grey; fine grained; medium bedded; thin black shale seams between beds; some light grey fossiliferous sections; nodules of medium grey mottled chert, 0.05 - 0.2 ft. in diameter constitute approximately 15% of the section; irregular patches of chertified limestone constitute 10%; some small nodules of dark grey chert. Recovery 80%	33.5-38.5	5.0
31	Limestone, coralline: while coral and crinoid debris and small cup-corals in a matrix of dark grey limestone; fine grained, medium grained sections; medium bedded; occasional thin irregular shale seams throughout; chertified portions up to 0.3 ft. in diameter constitute 20% of the sections; minor small nodules of black and medium grey chert. Recovery 100%	25.7-37.7	12.0
34	Limestone, coralline: abundant small cup-corals and coral debris in a matrix of medium to medium brownish grey limestone, fine grained; medium bedded; irregular small spots of blue and milky-white chert constitute 10% of the section; occasional thin irregular black shale seams throughout. Recovery 100%	31.5-36.5	5.0

<u>Hole No.</u>	<u>Description</u>	<u>Interval</u>	<u>Thickness</u>
42	Limestone; light grey coral biostratigraphy; medium grained; medium to thick bedded; fine to medium porosity; (inclined fissure 26.5-27.2).	25.2-27.7	2.5
	Limestone, coralline: abundant small cup-corals and coral debris in a matrix of medium grey limestone; fine grained, medium bedded; occasional thin bands of light brownish grey aphanitic limestone; minor blue and white chert; thin shale seams between beds, rare thick greenish grey shale seams. Recovery 95%	27.7-35.2	7.5