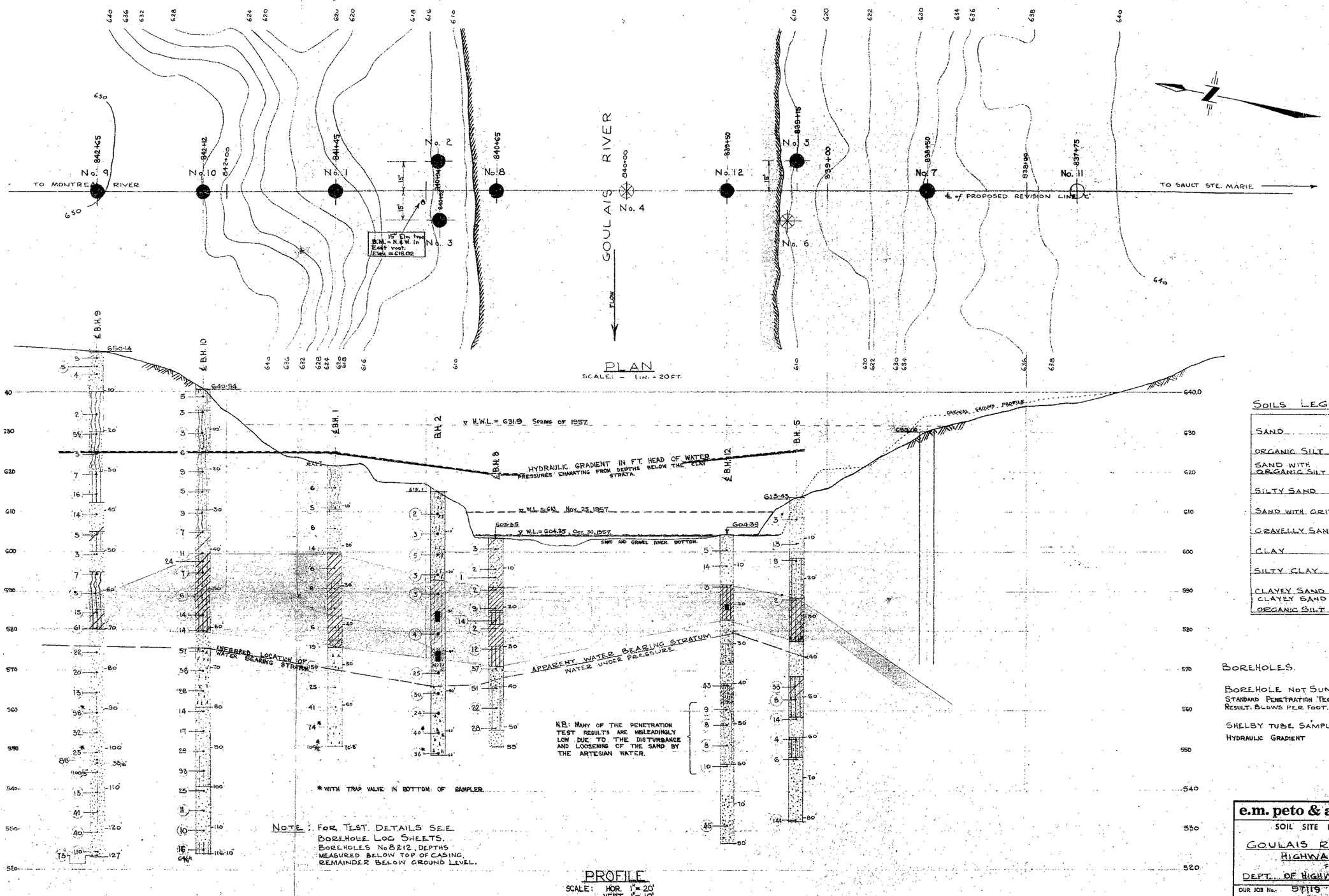
57-F-240C

W.P. 908-57

Hwy. #17

Goulais River

DISTRICT of ALGOMA
TOWNSHIP of VANKOUGHNET
S.W.¼ OF SECT. 30



NOTE: FOR TEST DETAILS SEE BOREHOLE LOG SHEETS. BOREHOLES No 8 & 12, DEPTHS MEASURED BELOW TOP OF CASING, REMAINDER BELOW GROUND LEVEL.

SOILS LEGEND

- SAND
- ORGANIC SILT
- SAND WITH ORGANIC SILT
- SILTY SAND
- SAND WITH GRITS
- GRAVELLY SAND
- CLAY
- SILTY CLAY
- CLAYEY SAND
- CLAYEY SAND WITH ORGANIC SILT

BOREHOLES.

BOREHOLE NOT SUNK

STANDARD PENETRATION TEST RESULT. BLOWS PER FOOT. (10)

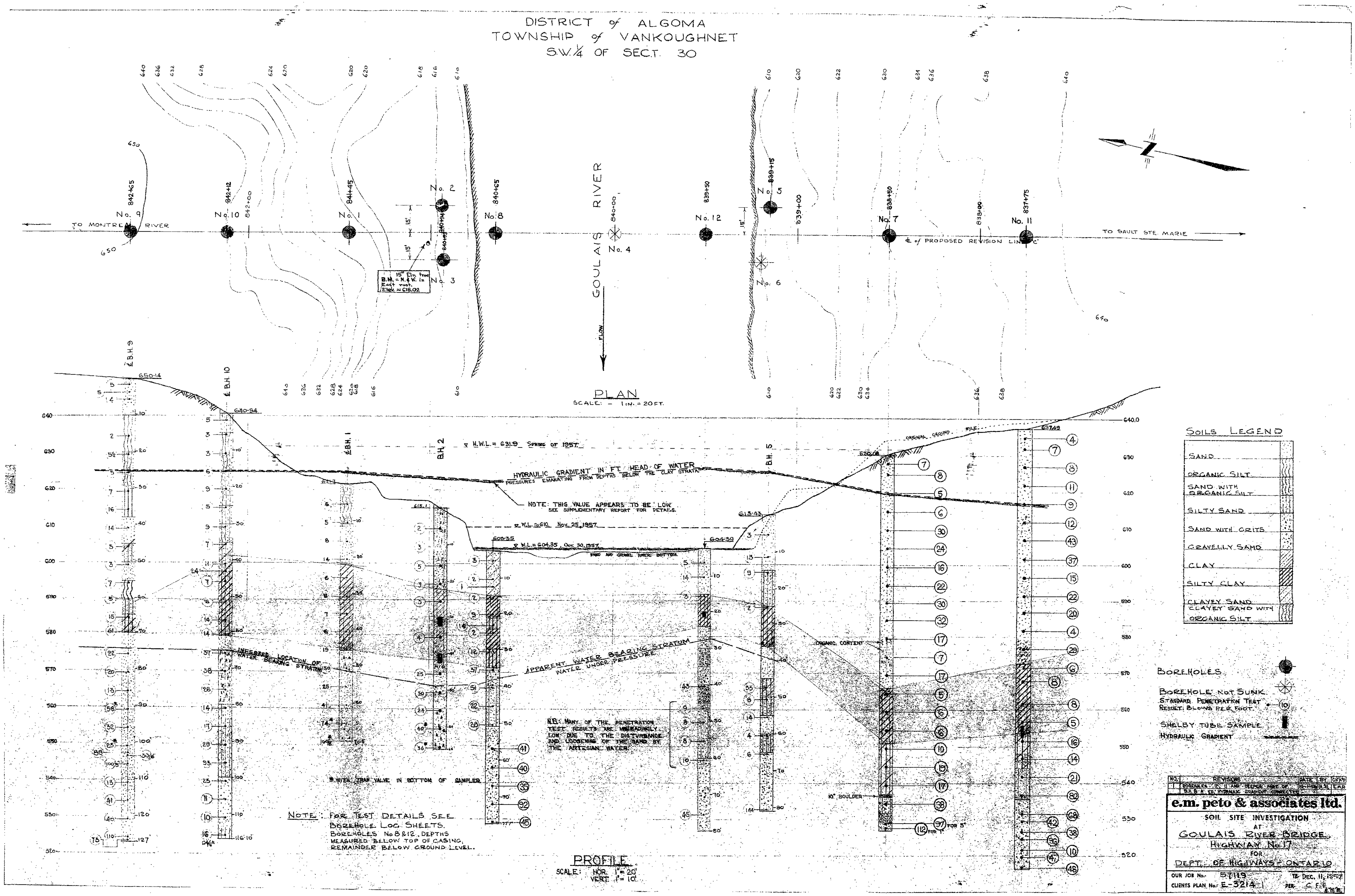
SHELBY TUBE SAMPLE

HYDRAULIC GRADIENT

e.m. peto & associates ltd.

SOIL SITE INVESTIGATION
AT
GOULAIS RIVER BRIDGE.
HIGHWAY No. 17
FOR
DEPT. OF HIGHWAYS - ONTARIO

OUR JOB No. 57119 DATE DEC. 11, 1957
CLIENTS PLAN No. E-3214-1 PER. C.F.E.



DISTRICT of ALGOMA
TOWNSHIP of VANKOUGHNET
S.W.¼ OF SECT. 30
TO MONTREAL RIVER
TO SAULT STE MARIE
GOULAIS RIVER
FLOW
No. 9
No. 10
No. 1
No. 2
No. 3
No. 8
No. 4
No. 12
No. 5
No. 6
No. 7
No. 11
℄ of PROPOSED REVISION LINE
PLAN
SCALE: - 1 IN. = 20 FT.
H.W.L. = 631.9 SPRING OF 1957
HYDRAULIC GRADIENT IN FT. HEAD OF WATER
PRESSURES EMANATING FROM DEPTHS BELOW THE CLAY STRATA
NOTE: THIS VALUE APPEARS TO BE LOW
SEE SUPPLEMENTARY REPORT FOR DETAILS.
W.L. = 610 Nov. 25, 1957
W.L. = 604.35 Oct. 30, 1957
SAND AND GRAVEL RIVER BOTTOM
INFERRED LOCATION OF WATER BEARING STRATUM
APPARENT WATER BEARING STRATUM
WATER UNDER PRESSURE
ORGANIC CONTENT
ORIGINAL GROUND LINE
BOULDER
N.B. MANY OF THE PENETRATION TEST RESULTS ARE MISLEADINGLY LOW DUE TO THE DISTURBANCE AND LOOSENING OF THE SAND BY THE ARTESIAN WATER.
* WITH TRAP VALVE IN BOTTOM OF SAMPLER.
NOTE: FOR TEST DETAILS SEE BOREHOLE LOG SHEETS.
BOREHOLES No 8 & 12, DEPTHS MEASURED BELOW TOP OF CASING, REMAINDER BELOW GROUND LEVEL.
PROFILE
SCALE: HOR. 1" = 20'
VERT. 1" = 10'
SOILS LEGEND
SAND
ORGANIC SILT
SAND WITH ORGANIC SILT
SILTY SAND
SAND WITH GRITS
GRAVELLY SAND
CLAY
SILTY CLAY
CLAYEY SAND
CLAYEY SAND WITH ORGANIC SILT
BOREHOLES
BOREHOLE NOT SUNK
STANDARD PENETRATION TEST RESULT: BLOWS PER FOOT
SHELBY TUBE SAMPLE
HYDRAULIC GRADIENT
NO. REVISIONS DATE BY CH'K'D
e.m. peto & associates ltd.
SOIL SITE INVESTIGATION
AT
GOULAIS RIVER BRIDGE
HIGHWAY No. 17
FOR
DEPT. OF HIGHWAYS - ONTARIO
OUR JOB No. 57119
CLIENTS PLAN No. E-3214-1
DEC. 11, 1957
PER C.F.F.

BA688

57-F-240C

DEPARTMENT OF HIGHWAYS OF ONTARIO

PROPOSED CROSSING

GOULAIS RIVER - HIGHWAY NO. 17

SOILS REPORT

by

B. M. PETO ASSOCIATES LTD.

TORONTO, ONTARIO

December, 1957.

e. m. peto associates ltd.

YOUR REFERENCE:-

OUR REFERENCE:- 57119

850 roselawn avenue,
TORONTO, ONTARIO.
RUssell 1 - 4955.

December 17th, 1957.

Office of the Bridge Engineer,
The Department of Highways of Ontario,
260 Davenport Road,
Toronto, Ontario.

Attention: Mr. J. G. MacAllister

Re: Coulais River Bridge,
Soil Investigation.

Dear Sirs:

1. We refer to your letter dated August 28th, 1957, in which you requested us to carry out a soils investigation at the proposed bridge site at the Coulais River crossing on Highway 17.

2. Our terms of reference required that we should carry out a complete soils investigation at the site and make a report on our findings together with such conclusions and recommendations as we considered pertinent.

3. At the time of receipt of the foregoing instructions we were already engaged on other work for the Department of Highways of Ontario, considerably further North, accordingly it was agreed we should complete this work before moving a machine onto the new site.

4. On October 4th, 1957, we were advised that Sir Alexander Gibb and Partners had been appointed as Consultants responsible for the design of the proposed bridge, and we were requested to collaborate with them to the fullest extent; to this end we have kept the Consultants fully advised regarding the progress of our investigations and have submitted to them two copies of our report for their information.

5. Unfortunately, owing to adverse weather and river conditions the completion of the site work has been delayed. Therefore we have arranged with the Consultants to submit a report covering our findings and conclusions on the Northern approach, river bed, and immediate Southern bank to date. A further report covering the work outstanding on the Southern bank and approach will be submitted as soon as possible hereafter.

6. The soil conditions and factors leading to our conclusions are considered in detail in the report attached hereto together with supporting test results given as Appendices. Here for your convenience we set out a summary of the conclusions we have reached as a result of these studies:-

a) The soils exposed in the boreholes may be broadly classified into three main types, these are:
i) Silt and silty fine sand in the upper stratum.
ii) Reddish-brown clay and silty clay underlying (i), and
iii) Coarse to medium sand forming the third and deepest stratum.

b) The two upper strata are unsuitable materials on which to place heavy load bearing foundations, on account of their inherent characteristics, as well as their susceptibility to settlement.

c) The deepest stratum, consisting of coarse sand, is the best medium available on which to place heavy structural foundations of the type envisaged.

d) The most suitable method of transferring these loads to this stratum is some form of pile foundation.

e) The question of the most suitable type of pile to be used has not been discussed in the report since it is felt that this aspect of the problem may be considered as outside our terms of reference, but it may not be regarded as remiss here to state that we incline to either the Franki or the Monotube type of pile, the final decision resting on the relative economies of the two types.

f) The sub-soil water conditions on the site have presented a special problem, particularly the Artesian water effect observed below the impermeable reddish-brown clay stratum. In this connection it is felt that this condition will present a problem during construction, rather than a permanent problem effecting the supporting power of the piles.

6. g) The question of scour around any piers placed in the river bed has been reviewed and it is considered that this is not a serious problem, having in mind the clay stratum underlying the upper fine material susceptible to scour and provided the pile foundation is designed to allow for the possibility of periodic removal of this upper material during periods of flood.

h) The action of scour is more likely to have adverse effects on the river banks and to this end it is recommended that normal revetment at the bridge crossing should be extended both upstream and downstream of the site to provide for this eventuality.

7. In the meantime, and in accordance with your instructions, we are proceeding with the completion of the supplementary report as the field results become available so that there may be no undue delay in the preparation of the design.

Yours very truly,

E. M. PETO ASSOCIATES LTD.,

E. M. Peto, P. Eng.

e. m. peto associates ltd., 850 roselawn avenue, Toronto 10, Ontario

Job No. 57119 Client's Ref. No. Date December 16th/57

Report on

SOIL SITE INVESTIGATION

at

GOULAIS RIVER BRIDGE - HIGHWAY 17

W. P. 908 - 57

for

DEPARTMENT OF HIGHWAYS OF ONTARIO

TERMS OF REFERENCE:

We were requested by letter dated August 28th, 1957, from the Department of Highways of Ontario, to carry out a soils investigation on the site of the proposed bridge on Highway 17, across the Goulais River in the Township of Tenkoughnet.

The proposal submitted to us on drawing E-3214-1 dated August 1956, suggested the need for seven test holes, covering the abutment and pier locations. Furthermore, it was left to our discretion to vary the positions of the boreholes consequent upon results obtained from the first holes driven, with the object of obtaining the most complete information of the subsoil conditions.

On October 4th, 1957, we were advised that Sir Alexander Gibb and Partners, Consulting Engineers, had been appointed as the Consultants responsible for this project.

METHOD OF OPERATION:

You will be aware that on the date we received your instructions we were already engaged on soil investigation work for a series of bridges on Highway 17 - Trans Canada Highway route - North of Agawa Bay; accordingly on completion of this work, we proposed moving this equipment to the new site at the Goulais River. This was done and investigation work commenced on October 10th, 1957, although trail clearing had commenced earlier.

METHOD OF OPERATION:

Initially the investigation program required seven holes to be put down. These covered the information required from both banks, and provided for one hole to be driven in the centre of the river.

As the result of a meeting on the site with the Consulting Engineers on October 14th, 1957, certain amendments were made regarding the siting of the boreholes, in order to comply with new design proposals envisaged

The site presented a number of problems which had to be overcome before access could be gained. The solution of these involved a considerable amount of preliminary work in connection with the strengthening of an existing bridge, and local earthwork on the site to allow the machine to be suitably located on either approach.

In view of these difficulties and the swampy nature of the approach to the South bank, coupled with additional boreholes called for by the Consultants, additional equipment was moved up from Toronto on October 24th, 1957 and work on this side commenced October 26th, 1957.

As the result of a subsequent telephone conversation with the Consultants the programme was further amended to provide for two extra boreholes situated in the river bed 25 feet from each bank. Accordingly, arrangements were made to work on these two last holes simultaneously.

The units employed were Sullivan "12" diamond drill rigs mounted on skids. The test holes were sunk by driving and cleaning BX drill casing, sampling ahead of the casing with either 2" O.D. split tube sampler of a 2" O.D. split tube sampler with liners, fitted with a special cutting nose to obtain undisturbed samples. In several of the test holes, 4" pipe was driven initially in an attempt to obtain larger diameter specimens, the hole being then continued to greater depth with the BX (2-1/2" diameter) casing. Standard penetration test results were recorded throughout when sampling (See Appendix II).

Unfortunately, work on the two holes in the river bed, was interrupted by an unseasonal rise in the river level, consequent upon heavy rainfall. At this time borehole number 12, on the South side, was cased to 80 feet and only required final sampling followed by the withdrawal of the casing. The situation at borehole number 8 on the North side of the river bed was even worse, and work had to be temporarily abandoned with 55 feet of casing in the ground. It is our intention to complete this hole to a greater depth as soon as the river level recedes, or the river freezes over sufficiently so that the work can be performed on the ice.

METHOD OF OPERATION: (Cont'd)

Sampling at depth was exceedingly difficult due to the Artesian water conditions existing below the clay stratum. In many cases, the casing was driven with the wash rods suspended inside the casing, and the wash water left on in order to restrict the tendency of the sand to "back up" inside the casing. At the test holes driven adjacent to, or inside the river banks, the action of the sampling tube on penetration beyond the end of the casing was to release water under pressure into the casing. This caused considerable difficulty, particularly in the gravel beds, where the small gravel tended to bind the split tube sampler inside the bottom of the casing.

In addition to the regular sampling, a piezometric installation, which permits direct gauge readings of the excess hydrostatic pressure at surface, was used in four of the test holes. All samples obtained to date have been carefully checked in our laboratory in Toronto, where all testing has been performed. The test results are contained in Appendix II, the basic results being given in the detailed borehole logs at the rear of this report. All soil samples from this site will be retained for a period of at least 60 days from date of our final report.

A site plan is also attached as Appendix III. On this plan are shown the final locations of all test holes, the soil stratigraphy, and the hydraulic gradient obtained from piezometer readings.

All elevations mentioned are referred to Geodetic datum, and have been obtained by using a D.M.O. bench mark at the site, which is a nail and washer in the East root of a 15" elm tree six feet West of station 641 + 02. The elevation of this bench mark is 618.02.

SITE AND GEOLOGY:

The Goulais River rises in the Wissisagi District and flows generally in a South-Westerly direction to the village of Goulais. Shortly after Goulais Village it turns and flows in a Westerly direction to Goulais Bay on Lake Superior.

The river passes over a number of rapids, before crossing the new alignment of Highway 17 at the proposed bridge site. The lower reaches are tortuous and there is a medium rate of flow except during times of heavy rainfall. The watershed is long and relatively narrow in shape, with numerous small tributaries.

SITE AND GEOLOGY: (Cont'd)

The proposed bridge site is located at a point approximately 6 miles, in a direct line, due East of the river mouth in Goulais Bay.

The mean water level of Lake Superior is 602.29 feet, while low water level at the site at the end of October was 604.35, giving a fall of a little over 2 feet.

The topography at the site is rolling to very hilly, and the vicinity of the crossing is heavily wooded, although there is some farm land up on the flats adjacent to the river. The river at the proposed crossing flows along one of the very few straight sections, which in this instance is some 600 yards long.

The river is approximately 200 feet wide at the crossing, and during October and early November 1957, was only from two to four feet deep. It has a very high flood stage and rises rapidly. On every occasion after two days of steady rain in the area, the river rose about 3 feet.

The river banks in most places are quite steep, but do not indicate any sliding caused by slope shear failure. There are, however, many examples of slope failures caused by erosion and undercutting of the river banks. Major bank failures have developed at many of the curves in the river, and even on this particular straight section of the river channel, there are numerous instances of "slumped" banks.

Generally the site conditions indicate that scour and undercutting are the main problems requiring solution.

The site has been glaciated in the past, which has resulted in deep glacial deposits. No bedrock is visible in the area.

The river valley itself is quite wide and well-incised. However the present river meanders considerably, and has a number of characteristics of a fairly young stream. Such conditions suggest that a major river flowed here at the time of the retreat of the last glaciers, and the river has now been rejuvenated. There is some geological evidence to support this.

A number of small levees parallel to the river and close to its edge, may be seen at some points, including the highway river crossing. These are the results of fairly recent floods. The levee deposits consist of stratified fine sand and silty sand with considerable organic content. The presence of an identical soil type to a major extent in most of the test holes on the banks (to depths from surface as great as 50 feet) would seem to indicate that the old river, which we believe flowed in the Goulais Valley, left exactly the same kind of levee deposits in its latter stages as the present Goulais River is depositing now.

SOIL CONDITIONS:

Three main soil types were encountered, these are:

a) Stratified Silt and Fine Sand with Organic Content.

b) Reddish Brown Stratified Silty Clay and Clayey Silt.

c) Medium to Coarse Sand with Rock Fragments.

a) Stratified Silt and Fine Sand with Organic Content.

With the exception of the present river-bed itself, the upper soil stratum basically consists of a very loose to compact, greyish-brown fine sand and sandy silt. This material tends to be stratified, and at some locations has considerable organic content. It covers the site to a depth of 12 feet at borehole 3, and to a depth of over 50 feet at borehole 9. It is quite moist to wet above the water table, and saturated beneath. This soil will become "soupy" when disturbed, and may even become quick if any fairly deep excavation is made without first taking some measures (such as well-pointing) to prevent piping. It is a most undesirable foundation material.

The unit weight of this material for design purposes may be taken to be 110 lbs. per cubic foot. The submerged unit weight is 48 lbs. per cubic foot.

The pH factor is 4.9, indicating weak to moderate acidity.

b) Reddish-Brown Stratified Silty Clay and Clayey Silt.

Underlying the upper silt and fine sand deposits is a very distinctly varved stratum of reddish-brown silty clay, with occasional layers of light grey silt, and very fine sand. This stratum varies in thickness from 24 feet at borehole 1, to only 6 ft. at borehole 9. The elevation of the upper boundary, ranges from 600 at holes 1 and 10 on the North bank, to approximately 566 at hole 7 on the South bank; whilst the lower boundary of this stratum ranges, from elevation 582 at borehole 12, to approximately 550 at borehole 7.

SOIL CONDITIONS:

b) Reddish-Brown Stratified Silty Clay and Clayey Silt (Cont'd)

This easily recognizable stratum has been encountered to a varying degree at all the boreholes driven to date. However, the stratum is thickest under the immediate Northern approach, thinning off under the present river bed. With consideration of the results from holes 7 and 11 it appears to become much thinner, and possibly even to disappear, beyond chainage 843 + 00 on the North bank, and chainage 837 + 50 on the South bank. We believe that the reasons for this pattern of occurrence are as follows:

The valley occupied by the present Goulais River was probably cut by a major pre-glacial river. At the time of the retreat of the last glaciation in North America, a river flowed in the Goulais Valley carrying glacial meltwaters into Glacial Lake Algonquin, forerunner of the present Lake Superior. At some stage in the retreat of the ice, which was not uniform, but was marked by a series of retreats, short re-advances, etc., the mouth of this river became blocked, or the lake level rose, with the result that the flow of the river was temporarily interrupted. It was during the period of such circumstances, that the silt and clay sediments were deposited in a series of thin horizontal strata across the valley floor, but not appearing elsewhere. Eventually the river resumed flowing, and the sedimentation ceased.

The varved silty clay stratum is generally of soft to firm consistency. The number of blows in the standard penetration test ranged from 2 to 15, with some higher values being obtained where the material changed to a predominately clayey silt. A considerable number of unconfined compression tests were performed, in which this material did not indicate plastic failure, due to its nuggety texture. The unconfined compressive strengths ranged from a low of only 123 lbs. per sq. ft. to a high of 1725 lbs. per sq. ft.; the higher strengths occurring at depth where the varved clay material has been subjected to somewhat higher overburden pressures. A good average value of the unconfined compressive strength is 550 lbs.per sq. ft., but the average cohesion is less than half this value since this material does have some minor internal friction. Triaxial tests are currently being done to ascertain the value of the angle of internal friction.

One remoulded shear test was also performed, and the sensitivity of the varved silty clay was found to be approximately 2.6. A further test was carried out but the result was variable due to difficulty in remoulding.

SOIL CONDITIONS:

B) Reddish-Brown Stratified Silty Clay and Clayey Silt (Cont'd)

Natural moisture contents of this stratum depended on whether the sample tested was predominately a silt or a clay. The values determined ranged from 29.3% to 77.4%. The results of the Liquid Limit and Plastic Limit tests, together with the Atterberg classifications are given in Appendix II. Generally, however, the natural moisture contents were much in excess of the Plastic Limit.

A number of hydrometer grain size tests on samples from this stratum have also been performed, and these show the relative percentages of silt and clay size particles. The grain size distribution curves are included in Appendix II.

No consolidation tests on large diameter samples were conducted, because, as the work progressed it became evident that these tests would be unnecessary, since no major loadings could be placed on the varved silty clay stratum. The compressive index has been estimated to be from .158 to .544, the lower value being for a silt, and the latter for a clay sample. This stratum can be held to be of medium to high compressibility, which is understandable, since at no time in its past history was it subject to very high overburden pressures. It is normally consolidated.

The colour of the reddish-brown clays is associated with, and probably derived from the iron-bearing red rocks of the Keweenawan series.

The pH factor is 4.8 indicating weak to moderate acidity.

c) Medium to Coarse Sand with Rock Fragments

Underlying the impermeable stratum of reddish-brown varved silty clay, and extending at least as far down as the bottom of the deepest hole, was a stratum of multi-coloured, angular shaped, igneous rock fragments. Six out of seven sieve analyses on various samples of this material gave very comparable results, and the seventh indicated a minor stratum, or pocket, of silty sand. The grain size distribution diagrams are included in Appendix II.

SOIL CONDITIONS:

c) Medium to Coarse Sand with Rock Fragments (Cont'd)

Standard penetration test results in this stratum which was encountered in every borehole, were quite variable. Although this sand is only compact in some localised areas, it is generally dense to extremely dense. The standard penetration tests do not always indicate this because of the disturbance of the sand by the Artesian water encountered below the reddish-brown silty clay stratum. It was a common occurrence for the sand to be forced back up the casing by the water pressure, this being disturbed and loosened.

The pH factor is 5.2, indicating weak acidity, which is a characteristic of materials of igneous origin.

Stream Riverbed Deposits

A group of soils of minor importance is found in the present riverbed, and overlying the reddish-brown silty clay stratum. The riverbed soils consist of saturated, grey-brown coarse sands, at some points containing fine gravel and at others containing pockets of red-brown clay secured from the stratum beneath. The riverbed soils are very loose to compact.

WATER CONDITIONS:

The Artesian water condition on this site results from the impermeable silty clay layer, which confines some of the water which flows towards the river through the soil from the crests of both banks. No water under pressure was encountered until the silty clay stratum had been penetrated.

An interesting feet observed during the sinking and sampling of the holes on both the North and South banks was that the Artesian water flow out of the holes was definitely inter-related. For example, borehole 1 was driven first, and after the silty clay was penetrated a considerable flow of water from this hole commenced. However, when borehole 2, lower down the bank, had also penetrated the silty clay stratum, water started to flow, and the pressure at borehole 1 was considerably relieved. When borehole 2 was temporarily plugged again, during the sampling operations, the flow of water from borehole 1 again increased.

WATER CONDITIONS: (Cont'd)

As a further example, at the South bank test hole 5 on completion was making a considerable flow of water. During the driving of test hole 12 at depth, the water suddenly commenced flowing around the outside of the casing from the 30 ft. depth. The water immediately cut off at hole 5. As the casing at hole 12 was driven further, the perimetral flow ceased, but the flow reappeared at hole 5.

As far as could be observed in the field, the hydrostatic pressures, or the water levels in the boreholes were not affected by rises in the stage of the river of up to 7 feet.

The individual borehole water levels and/or piezometer readings are given on the borehole logs, and the hydraulic gradient converted from the equivalent piezometric readings, is indicated on the profile.

ENGINEERING CONSIDERATIONS:

The Stratified Silt and Fine Sand Stratum.

It is apparent that this material has few properties recommending its use as a foundation material. The water content increases with depth and in the event of excavation being necessary some form of continuous sheet piling or cofferdam will be required with provision for pumping. Furthermore, in view of the tendency for piping to occur, the protective sheeting should be kept well ahead of the excavation with the object of reducing, if not eliminating, this eventuality; to this end the sheet piling should be driven into the clay stratum, but not through it. In view of its fine particle size, the material forming this stratum will respond to scour and turbulence.

Reddish-Brown Stratified Silty Clay and Clayey Silt Stratum

Both the penetration and unconfined compression tests indicate that this material has poor load carrying properties. It is also apparent from the compressive index that settlement could be anticipated in the event of a superimposed load exceeding the present overburden pressure. Any load placed on the stratum overlying this material would also induce settlement to take place.

ENGINEERING CONSIDERATIONS: (Cont'd)

Medium to Coarse Sand with Rock Fragments

This material is by far the most suitable for load bearing purposes.

The principal feature regarding this material is the Artesian water pressure which has been developed in this stratum. Observations on the site indicated that this is released as soon as the upper impermeable clay stratum is penetrated, causing scour at depth.

Furthermore in one instance, at borehole 13, water was seen to be seeping up the outside of the casing. This would appear to suggest that the clay stratum will not immediately seal off the upward flow of water, and since the flow between these holes is interconnected; it may well be that the upward flow at the holes at the lower elevations would become more marked if the seepage higher up on the banks were cut off. The design therefore should anticipate and be able to tolerate an upward flow of Artesian water, although there is a possibility that this flow of water will eventually cease. There are on record occasions where such has actually occurred.

Some "boiling" has already been observed on this site, particularly in the area surrounding borehole 1, and unless effective measures are taken to prevent this condition arising, difficulty with any excavation in the loose sand can be expected.

The Artesian water may present a problem in the construction of the supports on the North side, since the cofferdam though providing protection from static ground water, will not prevent the upward flow of water, under hydrostatic pressure, along the piles when these have penetrated the impermeable stratum. The vibration caused by driving may well release this water in sufficient quantity to cause flooding to the cofferdam area.

RECOMMENDATIONS AND CONCLUSIONS:

1. The reddish-brown stratified silty clay and clayey silt stratum, and the overlying stratified silt and fine sand stratum, are both unsuitable materials on which to place heavy load-bearing foundations.

   Accordingly it will be necessary to found the bridge on the coarse sand stratum underlying these two upper strata.

RECOMMENDATIONS AND CONCLUSIONS: (Cont'd)

2. The strata constituting the river bed deposits particularly near the surface are very loose, of small particle size, and without natural binder; accordingly we have concluded that they will be subject to scour.

3. In the provisions made for scour protection for the supports in the river bed it appears immaterial whether any interlocking steel sheet piling sunk for construction purposes is left in position or removed after the completion of construction, provided the pier support is designed accordingly.

   In this connection we strongly recommend that any cofferdam or sheet piling sunk for construction work should be driven into the clay stratum, but not through it.

4. Since it will be necessary to found on the coarse sand stratum, which is located at some depth, the most economical method will be the use of piles. These should be designed as totally end-bearing, and any assistance that may accrue from friction in the upper strata should be ignored.

5. It is doubtful whether any piles save steel "H" piles of fairly heavy section will penetrate deeper than 50 feet at the locations of boreholes 8 and 12.

6. We are of the opinion that the Artesian water observed on this site will not have any permanent adverse effect on the load carrying capacity of the piles. However, it is possible that the cofferdam area will be flooded during pile driving operations once the water bearing stratum is penetrated. Accordingly, we believe that some advantage may accrue in providing for this, such as a skin of a working concrete overlying the bottom of the cofferdam. Such a precaution will also serve to prevent against the bottom of the cofferdam area becoming live or quick as a result of driving operations.

7. Subject to erosion and undercutting of the river banks being overcome by extensive rip-rapping, there should be no problem with slope stability on this site.

RECOMMENDATIONS AND CONCLUSIONS: (Cont'd)

8. The conditions already described for the piers will apply to the North abutment.

E. M. PETO ASSOCIATES LTD.,

E. M. Peto, P. Eng.

REGISTERED PROFESSIONAL ENGINEER
E. M. PETO
PROVINCE OF ONTARIO

APPENDIX I

BOREHOLE LOGS

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE TORONTO, ONTARIO

BOREHOLE LOG

Job Name: Goulais River Bridge — Job No.: 5'219 — Borehole No.: 1

Client: Dept. of Highways of Ontario — Casing: BX (4" diam.) — Boring Date: Oct 14 - 14, 1957

Datum: Geodetic — Compiled By: M. Mindess — Checked By: E. M. Peto

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION	COLOUR	CONSISTENCY	DEPTH / ELEVATION	SAMPLE	SAMPLE TYPE	BLOWS PER FOOT	WATER CONDITION AND MOISTURE & REMARKS
			0'0" G 21.7				
FINE TO COARSE SAND AND SILT, SOME ORGANIC CONTENT	MIXED GREY AND BROWN.	LOOSE	5'0"	1	S.S.	6	QUITE MOIST. STRATIFIED.
ORGANIC SILT, SOME SEAMS OF VERY FINE SAND.	BROWNISH-GREY.	LOOSE	11'0" G 10.7	2	S.S.	5	SATURATED.
FINE SAND.	GREY	LOOSE	15'0"	3	S.S.	8	"
" "	BROWNISH-GREY	COMPACT		4	S.S.	14	"
CLAY	LIGHT REDDISH-BROWN.	FIRM	22'0" 593.7 25'0"	5	S.S.	6	SATURATED, AND MUCH WETTER THAN PLASTIC LIMIT.
CLAY, MINOR SILT CONTENT.	"	FIRM	30'0" 591.7	6	S.S.	8	AS ABOVE. LIQUID LIMIT = 59.0 % PLASTIC LIMIT = 21.9 % NATURAL M.C.= 34.2 %
SLIGHTLY SILTY CLAY	LIGHT REDDISH-BROWN	FIRM	35'0"	7	S.S.	7	AS ABOVE.
VARVED SILTY CLAY THIN SEAMS OF SILT, GREY AND WEAK RED IN COLOUR.	LIGHT REDDISH-BROWN.	FIRM	40'0"	8	S.S.	6	AS ABOVE
CLAYEY SAND WITH GREY SILT POCKETS	LT. REDDISH-BROWN & GREY.	COMPACT	44'0" 577.7 46'0" 575.7	9	S.S.	19	SATURATED.
COARSE SAND AND ROCK FRAGMENTS.	MIXED COLOURS.	VERY DENSE	50'0"	10	S.S.	150	"
COARSE SAND.	"	COMPACT	55'0"	11	S.S.	25	"
MEDIUM TO COARSE SAND		DENSE	60'0" 561.5	12	S.S.	41	" STRUCK STRONG SUPPLY OF ARTESIAN WATER AT 62
COARSE SAND.	MIXED COLOURS.	VERY DENSE	65'0"	13	S.S.	74*	" * WITH TRAP VALVE IN BOTTOM OF SAMPLER
COARSE SAND AND ROCK FRAGMENTS	"	EXTREMELY DENSE	70'8" 551.0	14	S.S.	100/8"	"
			HOLE TERMINATED				

Note: Upon completion of this test hole and the removal of the casing, a slow flow of Artesian water was noted which has continued ever since, although at a reduced rate.

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE TORONTO, ONTARIO

BOREHOLE LOG

Job Name Scarlett River Bridge Job No. 5719 Borehole No. 4

Client Dept. of Highways of Ontario Casing BX 2½" dia. Boring Date Oct. 29, 30, 31, '57

Datum Geodetic Compiled By M. Mirgess Checked By L. D. Peto

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q_u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

STRATA DESCRIPTION	COLOUR	CONSISTENCY	DEPTH / ELEV.	SAMPLE No.	SAMPLE TYPE	BLOWS / FT.	WATER LEVEL, SOIL MOISTURE & REMARKS
			0' 0" 615.1				
STRATIFIED SILT AND FINE SAND, SOME ORGANIC CONTENT	GREY-BROWN	VERY LOOSE	5' 0"	1	S.S.	2	SATURATED
AS ABOVE, BUT FINE SAND PREDOMINATES.	"	"	10' 0" 605.1	2	S.S.	3	"
SILTY FINE SAND, ORGANIC CONTENT	GREYISH-BROWN	LOOSE	15' 0"	3	S.S.	5	SATURATED. THE ORGANIC CONTENT IS IN THE FORM OF PIECES OF DECAYED WOOD.
AS ABOVE.	"	VERY LOOSE	20' 0"	4	S.S.	3	"
			22' 0" 593.1				
STRATIFIED CLAY.	LIGHT REDDISH-BROWN.	SOFT		5	S.S.	3	SATURATED. MUCH WETTER THAN PLASTIC LIMIT
SILTY CLAY, OCCASIONAL VERY THIN ($\frac{1}{32}$"-$\frac{1}{16}$") GREY SILT SEAMS.	MIXED LIGHT REDDISH BROWN AND GREY	SOFT	29' 0" 585.1	6	2" S.T.	PUSHED	SLICKENSIDED, NUGGETTY TEXTURE. Q_u FROM 32' TO 32½' = 302 P.S.F. NATURAL M.C. = 77.4% SHEAR FAILURE ALONG MANY PLANES
STRATIFIED CLAY	LIGHT REDDISH-BROWN	SOFT	35' 0"	7	S.S.	4	SATURATED. MUCH WETTER THAN PLASTIC LIMIT
VERY DISTINCTLY VARVED CLAY AND SILTY VERY FINE SAND.	LIGHT REDDISH-BROWN AND GREY.	"	41' 0" 574.1	8	2" S.T.	—	Q_u FROM 40½' TO 41' = 331 P.S.F. NATURAL M.C. = 37.0% GRADING FROM 40' TO 41': % PASSING #200 = 98 ½
SILTY VERY FINE SAND, ODD ½" STRATUM OF CLAY. HORIZONTALLY STRATIFIED	LIGHT GREY		45' 0" 570.1	9	S.S.	25	SATURATED.
MEDIUM TO COARSE SAND	MIXED COLOURS	COMPACT	50' 0"	10	S.S.	30	STRUCK FLOW OF WATER UNDER PRESSURE AT 51'.
AS ABOVE, WITH IGNEOUS ROCK FRAGMENTS.	"	"	55' 0" 560.1	11	S.S.	24	WATER CUT OFF BY SILT SEAM AT 57' DEPTH.
FINE TO VERY COARSE SAND, ROCK FRAGMENTS.			60' 0"	12	S.S.	40*	SATURATED.
AS ABOVE	"		66' 0" 549.1	13	S.S.	36*	" HIT VERY STRONG FLOW OF WATER AGAIN AT 66', ESTIMATED AT 10-15 GAL./MIN.
			HOLES TERMINATED.				* WITH TRAP VALVE IN BOTTOM OF SAMPLER.

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SOIL ENGINEERING SERVICE TORONTO ONTARIO

BOREHOLE LOG

Job Name Goulais river bridge Job No. 57-[illegible] Borehole No. 2

Client Dept of Highways of Ontario Casing BA 4½" diam. Boring Date Oct. 25-[illegible], 1957

Datum Geodetic Compiled By M. Middle Checked By A. Peto

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q_u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. SPECIFIC WATER TABLE IN SOIL

SOIL DESCRIPTION	COLOUR	CONSISTENCY	DEPTH (ELEV.)			SAMPLE TYPE	BLOWS PER FT.	REMARKS
			0' 0" (614.8)					
VERY FINE TO FINE SAND	LIGHT BROWN	VERY LOOSE	5' 0"		1	S.S.	4	QUITE MOIST
STRATIFIED SILT AND COARSE SAND, ORGANIC CONTENT	GREY	VERY LOOSE	10' 0"		2	S.S.	3	SATURATED
			12' 0" (602.8)					
STRATIFIED SILTY CLAY, SOME ORGANIC CONTENT	LIGHT BROWN AND GREY	SOFT	15' 0"		3	S.S.	3	WETTER THAN PLASTIC LIMIT
			18' 0" (596.8)					
CLAY	LIGHT REDDISH-BROWN	SOFT	20' 0"		4	S.S.	5	SATURATED, MUCH WETTER THAN PLASTIC LIMIT
STRATIFIED CLAY	AS ABOVE	"						
COARSE SAND, ½" SEAMS OF CLAY	MIXED COLOURS	LOOSE	25' 0" (589.8)		5	2" S.T.	(5) (7)	SATURATED
CLAY WITH COARSE SAND CONTENT, SOME SILT LAYERS	LIGHT REDDISH-BROWN	FIRM	31' 0" (583.8)		6	S.S.	6	
			35' 0"					Q_u from 35½'-36' = 445 P.S.F. MC=[illegible]
CLAY, WITH GREY SILT VARVES.	"	SOFT			7	2" S.T.	(6) (8)	Q_u from 36'-36½' = 317 P.S.F. Q_u from 36½'-37' = 235 P.S.F. MC=[illegible] Q_u from 37'-37½' = 389 P.S.F. ALL THESE SAMPLES SHOWED VERY DEFINITE SHEAR FAILURES.
STRATIFIED SILTY CLAY WITH GREY SILT VARVES.	LT. REDDISH-BROWN AND GREY	STIFF	40' 0"		8	S.S.	9	SATURATED
			44' 0" (570.8)					
SILTY MEDIUM TO COARSE SAND AND ROCK FRAGMENTS.	GREY	COMPACT			9	S.S.	24	STRUCK A STRONGLY WATER-BEARING STRATUM AT 46'.
			50' 0"					
SILTY VERY FINE SAND, GRITS AND ROCK FRAGMENTS.	"	"			10	S.S.	16	SATURATED
			55' 0" (559.8)					
COARSE SAND AND ROCK FRAGMENTS.	MIXED COLOURS	COMPACT			11	S.S.	19	HIT VERY STRONG FLOW OF WATER AT 56' DEPTH.
			60' 0"					
AS ABOVE		VERY DENSE			12	S.S.	71	SATURATED
COARSE SAND	"	COMPACT	66' 0" (548.8)		13	S.S.	30	MATERIAL [illegible] L.L. = 70 % P.L. = 25 % P.I. = 45 %
			HOLE TERMINATED.					

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SOIL ENGINEERING SERVICE - TORONTO, ONTARIO

BOREHOLE LOG

Job Name [illegible]   Job No. [illegible]   Borehole No. 5

Client [illegible]   Casing [illegible]   Boring Date [illegible] 1957

Datum [illegible]   Compiled By [illegible]   Checked By M. M.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q_u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth Elevation	Legend	Sample No. and Condition	Sample Type	No. of Blows per Ft.	WATER LEVELS, SOIL MOISTURE & REMARKS
			[illegible]					
[illegible]	LIGHT BROWN		[illegible]					
FINE [illegible] SOME GRITS	LIGHT BROWN	LOOSE			1	S.S.	3*	[illegible]
FINE TO VERY FINE SAND	LIGHT GREY TO LIGHT BROWN	COMPACT	[illegible]		2	S.S.	13	[illegible] MATERIAL STRATIFIED WITH NUMEROUS COLOUR VARIATIONS, SATURATED
FINE TO VERY FINE SAND, SILTY	GREY BROWN	LOOSE	598.43		3	S.S.	9	CONSIDERABLE ORGANIC CONTENT SATURATED SOME TRACES OF GRAVEL AT [illegible]
			21.0		4	S.S.	1	
					4A	S.S.	1	
			25.0					
CLAY [illegible] FINE SAND	GREY	VERY SOFT	588.43		5	S.S.	2*	*[illegible] VALVE IN BOTTOM OF SAMPLER. GOOD RESPONSE TO SHAKE TEST SATURATED. NAT M/C 27.5%
			30.0					
SILTY CLAY	REDDISH BROWN				6A, 6B	2" S.L.		THIN LAMS (1/8"-1/4") OF GREY SILT SATURATED NAT M/C 43.0%, MUCH HIGHER THAN P.L. Q_u = 494 PSF AT M/C = 46.3%
FINE TO COARSE SILTY SAND WITH GRITS	BROWNISH GREY	577.43	35.0 / 36.0		7A	2" S.L.		SATURATED.
MEDIUM TO COARSE SAND	VARIOUS		37.0		7B			SATURATED 1/4" MAX SIZE SAND PARTICLES. WATER FLOWING FROM 40' DEPTH WITH 2 1/2 lb/in² PRESSURE AT G.L.
					8A	W.S.		
MEDIUM TO COARSE SAND	VARIOUS				8B	W.S.		3/8" MAX SIZE SAND PARTICLES. SATURATED.
			45.0					
SILTY FINE TO COARSE SAND WITH MINOR CLAY CONTENT	GREY	DENSE	568.43 / 46.6		9A	S.S.	33 / 20/6"	
					9B	W.S.		SATURATED
			50.0					
VERY FINE SAND & SILT	LIGHT GREY	LOOSE			10	S.S.	8	SATURATED
			55.0					
FINE TO MEDIUM & VERY COARSE SAND	VARIOUS	COMPACT	558.43		11	S.S.	14	SATURATED
			60.0					
FINE SAND WITH SOME SILT, GRITS & SMALL PEBBLES	GREY	VERY LOOSE	553.43		12	W.S.	4*	*SATURATED. SAND WASHED UP CASING TO 40.0' DEPTH
			65.0					
VERY COARSE SAND & PEA GRAVEL	VARIOUS	LOOSE	548.43		13	W.S.	6*	SATURATED. STRONG FLOW OF WATER UP CASING
			70.0					
COARSE SAND & PEA GRAVEL	VARIOUS				14	W.S.		SATURATED. STRONG FLOW OF WATER
			[illegible]					
COARSE & SOME MEDIUM SAND	BROWN-GREY				15	W.S.		SATURATED. FLOW OF WATER CUT OFF AT 80.0'
			80.0					
COARSE & MEDIUM SAND	BROWN-GREY	VERY DENSE	81.0 / 532.43		16	W.S.	144	SATURATED. STRONG FLOW OF WATER FROM DEPTH OF 81.0', GIVING STEADY PRESSURE OF 5.7 lbs/in² A[illegible]
			HOLE TERMINATED					

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE – TORONTO, ONTARIO

BOREHOLE LOG

Job Name GRAND RIVER BR. Job No. 5711-2 Borehole No. 2

Client DEPT. OF HIGHWAYS - ONT. Casing 4 1/2" I.D. Boring Date Nov. 13, 1957

Datum Geodetic Compiled By E.T. Checked By M.M.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q/u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth, elevation	Legend	Sample No. and Condition	Sample Type	No. of Blows per ft.	WATER LEVELS, SOIL MOISTURE & REMARKS
			0-0					
			606.35		▽ APPROX. RIVER W.L. = 605.3			
			5'0					
FINE TO COARSE LAYERS OF SAND WITH ODD RED-BROWN CLAY POCKET	GREY-BROWN		601.35		1	S.S.	5	SATURATED
			10'0					
COARSE SAND WITH POCKETS OF RED-BROWN CLAY	DO.	VERY SOFT			2	S.S.	2	SATURATED
		DO.				S.S.	1	
			15'0					
VARVED CLAY	REDDISH-BROWN	DO.	591.35		3A	S.S.	2	M/C - 43.9%
					3B	3" S.L.	PUSHED	Qu = 0.3 T.S.F.
			20'0					
CLAY VARVED WITH GREY STREAKS	RED-BROWN		21'-6" 586.85		4A	3" S.L.	(9)	
					4B	S.S.	14 5/6"	21-21.5 M/C-64.5 (CLAY)
SILT WITH MINOR CLAY CONTENT	LIGHT GREY	COMPACT	24'-6" 583.35					21.6-24.6' M/C-26.3% (CLAYEY SILT)
CLAY WITH LAYERS OF GREY SILT	RED-BROWN	VERY SOFT			5	S.S.	2	M/C = 47.6%
			30'0					
SILT WITH MINOR CLAY CONTENT	LIGHT GREY	COMPACT	576.35		6	S.S.	12	M/C = 27.2%
			35'0					
COARSE SAND & FINE, MULTI-COLOURED GRAVEL	GREY-BROWN	DENSE	571.35		7	S.S.	37	SATURATED 2" LAYER OF SANDY SILT. STRUCK WATER AT 35' WITH 7' HEAD PRESSURE SAND CAME UP 13' IN CASING
			40'0					
MEDIUM & FINE SAND WITH SILT LAYERS	GREY	VERY DENSE	566.35		8	S.S.	51	VERY MOIST
			45'0					
MEDIUM & SOME FINE SAND WITH LAYERS OF SILT	DO.	COMPACT			9	S.S.	22	VERY MOIST
			50'0					
DO DO DO VERY COARSE SAND	DO GREY-BROWN	COMPACT			10	S.S.	28	
					11	W.S.		
			55'0					
			551.35					
		HOLE TERMINATED						

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE TORONTO, ONTARIO

BOREHOLE LOG

Job Name [illegible] Job No. [illegible] Borehole No. 9

Client [illegible] Casing [illegible] Boring Date [illegible]

Datum [illegible] Compiled By [illegible] Checked By M.M.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Qu UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth Elevation	Legend	Sample No. and condition	Sample Type	Blows per ft	WATER LEVELS, SOIL MOISTURE & REMARKS
			0'-0"					
VERY [illegible] MEDIUM SAND	YELLOWISH BROWN	LOOSE	0.14	SS SS	1	S.S	5	[illegible] MOIST
" " " WITH [illegible]	" "	LOOSE	5'-0"	SS	2	S.S.	5	MOIST
SILTY VERY FINE TO COARSE SAND	LIGHT GREYISH-BROWN	VERY LOOSE	10'-0"		3	S.S.	4	SATURATED
SILT WITH CONSIDERABLE ORGANIC CONTENT	DARK GREY-BROWN	"	0.14		4	S.S	3	WET, MOIST
" " " "	" "	VERY LOOSE	15'-0"		5	S.S.	2	WET
DITTO WITH SOME VERY FINE SAND	" " "	"	0.14		6	S.S.	3½	"
DITTO DITTO	" " "	LOOSE	25'-0"		7	S.S.	5	▽ W.L. OCT 31, 1957 WET
VERY FINE SANDY SILT WITH SEAMS OF CLAY & FINE SAND	LIGHT GREYISH-BROWN	LOOSE	30'-0" 0.14		8	S.S.	7	WET STRATIFIED
VERY FINE TO FINE SAND WITH ORGANIC CONTENT	GREYISH-BROWN	COMPACT	35'-0" 0.14	SS SS	9	S.S.	16	SATURATED, 3 SEAMS 1" THICK OF MEDIUM TO COARSE SAND OF VARIOUS COLOURS
" " " "	LIGHT GREY-BROWN	COMPACT	40'-0"	SS SS	10	S.S.	14	SATURATED
SILTY VERY FINE SAND	DARK GREY-BROWN	LOOSE	0.14	SS	11	S.S.	5	SEAMS OF VERY FINE SAND CLAY, VERY INTIMATELY STRATIFIED, M/C 25.7%
VERY FINE TO FINE SAND, SOME ORGANIC CONTENT	LIGHT GREY-BROWN	VERY LOOSE	50'-0" 0.14		12A 12B	S.S W.S	3	SATURATED
ORGANIC SILT VERY FINE	VERY DARK GREY, DARK BROWN	LOOSE	55'-0" 545.14		13	S.S	7	MOIST, 1/16 SEAMS OF SAND AND SILT
VERY FINE SANDY SILT	REDDISH BROWN	LOOSE	60'-0" 0.14		14	S.S	5	SATURATED ORGANIC TRACES
VERY FINE SANDY SILT & COARSE SAND			65'-0"		15	W.S.		
SILT WITH SOME CLAY	LIGHT GREY	COMPACT	582.14 68'-0" 582.14		16	S.S	15	SATURATED, INSTANTANEOUS RESPONSE TO SHAKE TEST
MEDIUM TO VERY COARSE SAND ABOVE 70' FINE TO MEDIUM SAND TRACES OF ORGANIC MATERIAL	GREY & MIXED COLOURS, LIGHT GREY-BROWN	VERY DENSE	70'-0" 75'-0"		17A 17B	S.S.	61	SATURATED, FRAGMENTS OF IGNEOUS ROCK
VERY COARSE SAND AND ANGULAR GRAVEL, 2" MAX SIZE IGNEOUS.	VARIOUS	COMPACT			18	S.S	22	SATURATED
COARSE TO VERY COARSE SAND	VARIOUS	COMPACT	80'-0" 570.14		19	S.S	20	SATURATED, PARTICLES UP TO 3/16" SIZE
DITTO DITTO	DITTO	DITTO	85'-0"		20	S.S	13	PARTICLES UP TO ¼" SIZE
DITTO DITTO PIECE OF GRANITE.	DITTO	DITTO	90'-0" 560.14		21	S.S.	58*	*WITH TRAP VALVE IN SAMPLER
COARSE SAND	DITTO	DENSE	95'-0"		22	S.S	32	
MEDIUM TO COARSE SAND	DITTO	DENSE	100'-0" 550.14		23	S.S	*25	*WITH TRAP VALVE IN SAMPLER, SATURATED
FINE TO COARSE SAND	DITTO	VERY DENSE			24	S.S. W.S.	28 33/6"	
COARSE TO VERY COARSE SAND	DITTO	DITTO	105'-0"		25	S.S	100/5"	SATURATED
DITTO DITTO	DITTO	COMPACT	110'-0"		26	S.S	18	
FINE TO COARSE SAND	DITTO	DENSE	115'-0"		27	S.S	41*	SATURATED
FINE TO COARSE SAND	DITTO	DENSE	120'-0"		28	S.S	40*	SATURATED
DITTO DITTO WITH SOME ROCK FRAGMENTS	DITTO DITTO	VERY DENSE DITTO	125'-0" 127'-0" 523.14		29 30	S.S S.S	110* 73	
			HOLE TERMINATED					

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE — TORONTO, ONTARIO

BOREHOLE LOG

Job Name ... Job No. ... Borehole No. ...

Client ... Casing ... Boring Date ...

Datum ... Compiled By ... Checked By ...

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
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ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q/u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth / Elevation	Legend	Sample No. and Condition	Sample Type	No. of Blows per ft	WATER LEVELS, SOIL MOISTURE & REMARKS
VERY FINE SANDY SILT, SOME FINE SAND	LIGHT BROWN TO GREY	LOOSE	6'-9"		1	S.S.	5	QUITE MOIST
BITTY TRACES OF ORGANIC MATTER & STONE DUST	DO.	VERY LOOSE	6'-9" TO 10'-0"		2	S.S.	3	SILT
VERY FINE SANDY SILT WITH ORGANIC CONTENT	DARK GREY TO GREY	VERY LOOSE	10'-0" TO 15'-0"		3	S.S.	3	Q MOIST. M/C = 35.4% WETTER THAN PLASTIC LIMIT. SOME COHESION. ▽ W.L. Nov. 6, 1957
VERY FINE SANDY SILT, CONSIDERABLE ORGANIC CONTENT	DO	LOOSE	15'-0" TO 20'-0"		4	S.S.	6	QUITE MOIST
FINE SAND, SILTY, CONSIDERABLE ORGANIC CONTENT	DO	LOOSE	20'-0" TO 25'-0"		5	S.S.	3	WET
FINE SAND, SILTY	GREY	LOOSE	615-94 TO 30'-0"		6	S.S.	5	SATURATED STRATIFIED
DO DO DO WITH ORGANIC CONTENT	LIGHT GREY	LOOSE	610-94 TO 35'-0"		7	S.S.	9	WET STRATIFIED. MINOR CLAY CONTENT
FINE SAND, SILTY WITH CLAYEY SILT AND FINE TO COARSE SAND	DO AND SOME REDDISH GREY	LOOSE	605-94 TO 40'-0"		8	S.S.	7	STRATIFIED QUITE MOIST
CLAYEY & SILTY MED. TO COARSE SAND, GRADING TO CLAYEY SILT AND SILTY CLAY (NUGGETY TEXTURE)	LT. REDDISH-BROWN TO GREY	COMPACT			9	S.S.	11	WET LAYERS OF VARVED TO LAMINATED SILT & FINE SAND
	REDDISH-BROWN	VERY STIFF			10	S.S.	24	M/C = 25.7% SEAMS OF FINE SILTY STRATIFIED SATURATED
	"	FIRM	45'-0"		11	2" S.L.	PUSHED	Q/u = 937 & 658 P.S.F. M/C = 63+56
	"				12	S.S.	7	SATURATED MUCH WETTER THAN PLASTIC LIMIT
								Q/u FROM 50'-50½' = 346 P.S.F. M/C = 44.0
			50'-0"					Q/u FROM 50½'-51' = 658 P.S.F. M/C = 53.9
SILTY CLAY (NUGGETY TEXTURE)	REDDISH-BROWN	FIRM			13	2" S.L.	PUSHED	STRATIFIED WETTER THAN P.L.
					14	S.S.	6	Q/u FROM 51'-51½' = 888 P.S.F.
SILT	LT. GREY	COMPACT	55'-0"		15	2" S.L.	PUSHED	SATURATED
DO. MINOR CLAY CONTENT, VARVED					16	S.S.	14	NOT PLASTIC. VY MOIST TO WET Q/u AT 55-10 & 56'-2" = 135 P.S.F. M/C = 31.7% Q/u AT 56'-2" & 56'-6" = 1785 P.S.F. Q/u FOR REMOULDED SAMPLE = 1785 P.S.F. M/C = 29.3%
SILT MINOR CLAY CONTENT, THIN LAYERS OF FINE SAND	DO	COMPACT	60'-0" TO 63'-0"		17	S.S.	14	VY MOIST TO WET M/C = 27.5%
MEDIUM TO COARSE SAND, SOME FINE SAND WITH RED GRITS	BROWN-GREY	DENSE	63'-0" TO 70'-0"		18	S.S.	37	SATURATED
MEDIUM TO COARSE SAND WITH RED GRITS	DO	DENSE	70'-0" TO 75'-0"		19	S.S.	38	"
FINE TO MEDIUM SAND & MULTI-COLOURED GRITS	GREY	COMPACT	75'-0" TO 80'-0"		20	S.S.	28	WET. WATER BEING LOST DURING DRIVING CASING.
FINE & SOME MEDIUM SAND, RED PARTICLES, SOME MINOR SILT CONTENT	GREY	COMPACT	560-24 TO 85'-0"		21	S.S.	14	SATURATED
FINE SAND, SOME MEDIUM SAND, SLIGHTLY SILTY	GREY	COMPACT	90'-0"		23	S.S.	17	" LOSING WATER WHEN DRIVING CASING. SAND BACKING UP 2'-0"
DO DO DO	DO	COMPACT	95'-0"		23	S.S.	29	SATURATED
MEDIUM SAND, SOME FINE SAND IN LAYERS, SOME SILT CONTENT	GREY BROWN	VERY DENSE	100'-0"		24	S.S.	93	" " LOSING WATER DURING DRIVING CASING.
FINE SAND, LAYERS OF VERY FINE SAND	DO.	COMPACT	540-24 TO 105'-0"		25	S.S.	23	SATURATED LOSING WATER
MEDIUM SAND, LAYERS OF FINE SAND	DO	COMPACT	110'-0"		26	S.S. W.S.	11	AS ABOVE 6½" S.S. SAMPLE LOST, W.S. RETAINED. DENSER HERE
FINE TO MEDIUM SAND, LAYER OF FINE SAND	GREY	COMPACT	115'-0"		27A	S.S.	10	6"
					27B	S.S.	16	10"
FINE SAND, LAYERED VERY FINE SAND, SOME SILT CONTENT	DO	DENSE TO EXTREMELY DENSE	116-10 TO 524-10		28	W.S.	17	SATURATED 6½" EXTREMELY DENSE GRAVEL AT 116'-8" CASING VIRTUALLY DRIVEN TO REFUSAL. NO WATER RETURNING
			HOLE TERMINATED					

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SOIL ENGINEERING SERVICE TORONTO, ONTARIO

BOREHOLE LOG

Job Name [illegible] Job No. 5718 [illegible]

Borehole No. 12

Client DEPT. OF HIGHWAYS [illegible]

Casing [illegible]

Boring Date [illegible] 1957

Datum [illegible]

Compiled By [illegible]

Checked By M.M.

SAMPLE CONDITION	SAMPLE TYPE	ABBREVIATIONS
UNDISTURBED	S.S. 2" STANDARD SPLIT TUBE SAMPLE	V.T. IN SITU VANE SHEAR TEST
FAIR	S.L. SPLIT BARREL WITH LINERS	Qu UNCONFINED COMPRESSIVE STRENGTH
DISTURBED	S.T. THIN-WALLED SHELBY TUBE SAMPLE	W.L. WATER LEVEL IN CASING
LOST	W.S. WASH SAMPLE	W.T. GROUND WATER TABLE IN SOIL
	R.C. ROCK CORE	

SOIL DESCRIPTION	COLOUR	DENSITY OR CONSISTENCY	DEPTH ELEVATION	LEGEND	SAMPLE NO. AND CONDITION	SAMPLE TYPE	NO. OF BLOWS PER FT.	WATER LEVELS, SOIL MOISTURE & REMARKS
			[illegible]					TOP OF CASING LEVEL [illegible]
COARSE SAND, SILT, FINE GRAVEL			604.35					RIVER BED LEVEL 604.35
COARSE & SOME MEDIUM SAND WITH VERY FINE GRAVEL	GREY-BROWN	LOOSE	601.89 / 10'0"		1A / 1B	S.S. / W.S.	5	
MEDIUM & SOME COARSE SAND WITH PEBBLES 3/4" DIAM.	BROWN-GREY	COMPACT	15'0"		2	S.S.	14	SATURATED
SILTY CLAY WITH SOME VERY FINE SAND & ODD PEBBLES	GREY	SOFT	591.89		3	S.S.	3	SATURATED. 86.9 % PASSING #200, 83.6 % PASSING #270
SILTY CLAY	DARK GREY	VERY SOFT	20.0					NAT M/C NEAR L.L.
DITTO WITH FINE SAND	DITTO	TO			4A B C	2" S.L.	PUSHED	VARVED CLAY SEAMS.
SILTY CLAY	RED-BROWN	SOFT						LT GREY SILT VARVES.
SILTY CLAY & FINE SAND			582.89					Qu FOR 4A=123 PSF M/C=51.5%; 4B=246 PSF M/C=40.6%; M/C=37.4% 4C=591 PSF REMOULDED=[illegible] 82 PSF
FINE TO VERY COARSE SAND	BROWN-GREY		25.0		5	W.S.	—	
COARSE SAND & PEA GRAVEL			30.0					LARGE FLOW OF WATER BETWEEN 25 & 29 [illegible] GIVING READING OF 4.3 [illegible] AT G.L.
COARSE SAND & MULTI-COLOURED GRAVEL TO 2" diam.	GREY-BROWN	COMPACT	576.89 / 35.0		6A / 6B	S.S / W.S	34	SOME FINE SAND & SILT CONTENT. STRONG FLOW OF WATER FROM 31' PRESSURE GAUGE READING 4.5 [illegible]
GRAVELLY COARSE SAND WITH TRACES OF SILT	VARIOUS		571.89 / 40.0		7	W.S.	—	GRADING: GRAVEL = 40%, SAND = 59%, SILT = 1%
SILT WITH LAYERS OF CLAYEY SILT, GRITS & PEBBLES	GREY	DENSE	566.89 / 45.0		8	S.S.	43	ODD SEAM OF RED-BROWN CLAY. M/C=24.3%, L.L.=27.5% P.L.=25.4%, P.I.=2.1, % PASSING #200=98.2%
VERY FINE SILTY SAND WITH PEBBLES	DO	LOOSE	561.89 / 50.0		9	2" S.L.	PUSHED 9	GRADING: GRAVEL = 1.6%, SAND = 3.3%, PASSING #200 = 95.1%
SILTY FINE SAND, ODD PEBBLE	DO	LOOSE	55.0		10	S.S.	8	GRADING: GRAVEL = 2.1%, SAND = 76.4%, PASSING #200 = 21.5%, SAND UP CASING 9.0
FINE TO MEDIUM SAND, SILTY	GREY-BROWN	LOOSE	60.0		11	S.S / W.S	8	FROM RODS GRADING: GRAVEL = —, SAND = 99.10, PASSING #200 = 0.90, SAND UP CASING 30.0"
MEDIUM TO COARSE SAND	DO	LOOSE	546.89		12A / 12B	S.S. / W.S	10	GRADING [illegible]: GRAVEL [illegible]; SAND 97.4% 99.6% 88.3%; PASSING #200 1.5% 0.4% 20[illegible]
MED. TO COARSE SAND	DO				13	W.S		
COARSE SAND	DO		65.0		14	W.S		STRONG FLOW AT 65. STRONG FLOW OF WATER AT 70' GAUGE READING 8.5 lbs/□" AT G.L.
COARSE SAND & PEBBLE GRAVEL 3/4" DIAM	DO / DO	PROBABLY DENSE	70.0		15 / 16	W.S / W.S		
COARSE SAND WITH 1 1/2" diam STONES	DO	DENSE	75.0 / 80.0		17	S.S.	45	CASING REQUIRING 400-500 BLOWS/FOOT
HOLE TERMINATED			526.89					*4B L.L.=39.5% P.L.=27.8% P.I.=11.7; *4C L.L.=42.7% P.L.=18.9% P.I.=22.8

APPENDIX II

LABORATORY TEST RESULTS

APPENDIX II

Standard Penetration Test

The standard penetration test is a dynamic penetration test which is widely used in the United States and Canada. It is conducted by dropping a hammer weighing 140 lbs. onto the drill rods from a height of 30 inches. The number of blows 'N' necessary to produce a penetration of one foot with the 2" standard split spoon sampler is regarded as the penetration resistance.

The results of the standard penetration test have been correlated in a general way with the pertinent physical properties of the soil.

For more detailed information concerning this test we refer you to:

pp. 265, 266, 294, 295, 300 Soil Mechanics in Engineering Practice - Terzaghi and Peck.

Chapman and Hall Ltd. London 1948.

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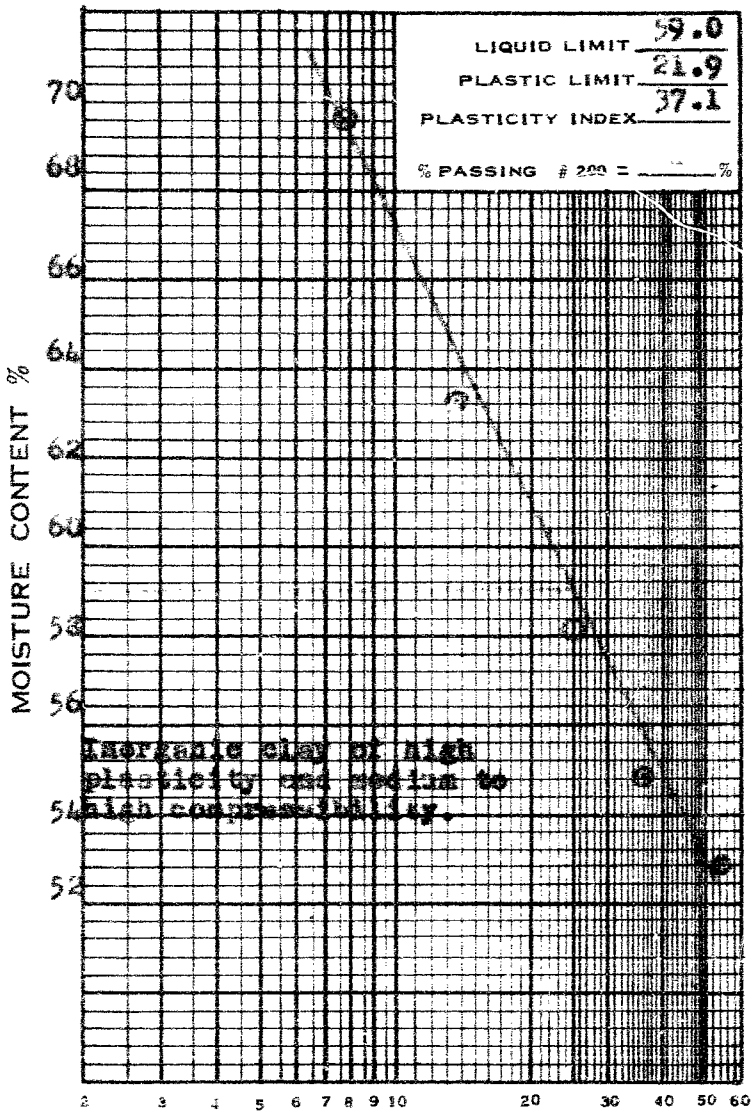
SOIL TESTING LABORATORY

LIQUID LIMIT TEST — FLOW LINE CHARTS

Job No. 57119 Project Goulais River Bridge

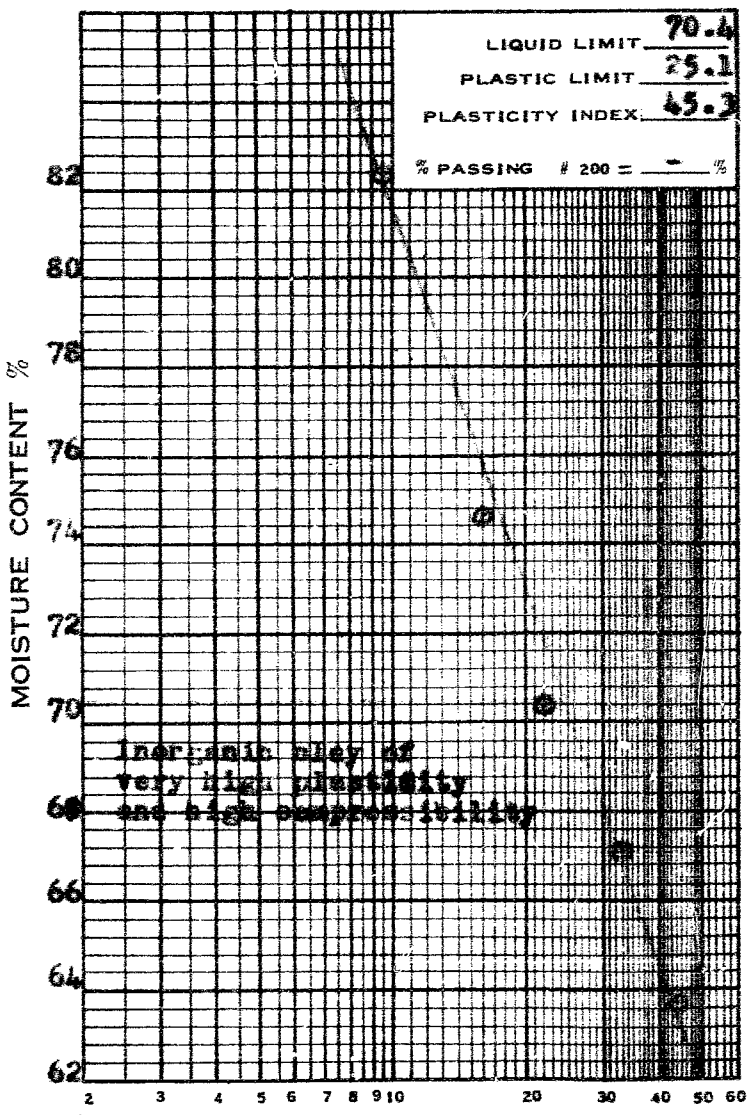
Sample From B.H. 1, Sample 5 & 6

Depth 25' - 31'



Sample From B.H. 3, Sample 7.

Depth 35' - 36'



NO. OF BLOWS (Log Scale)

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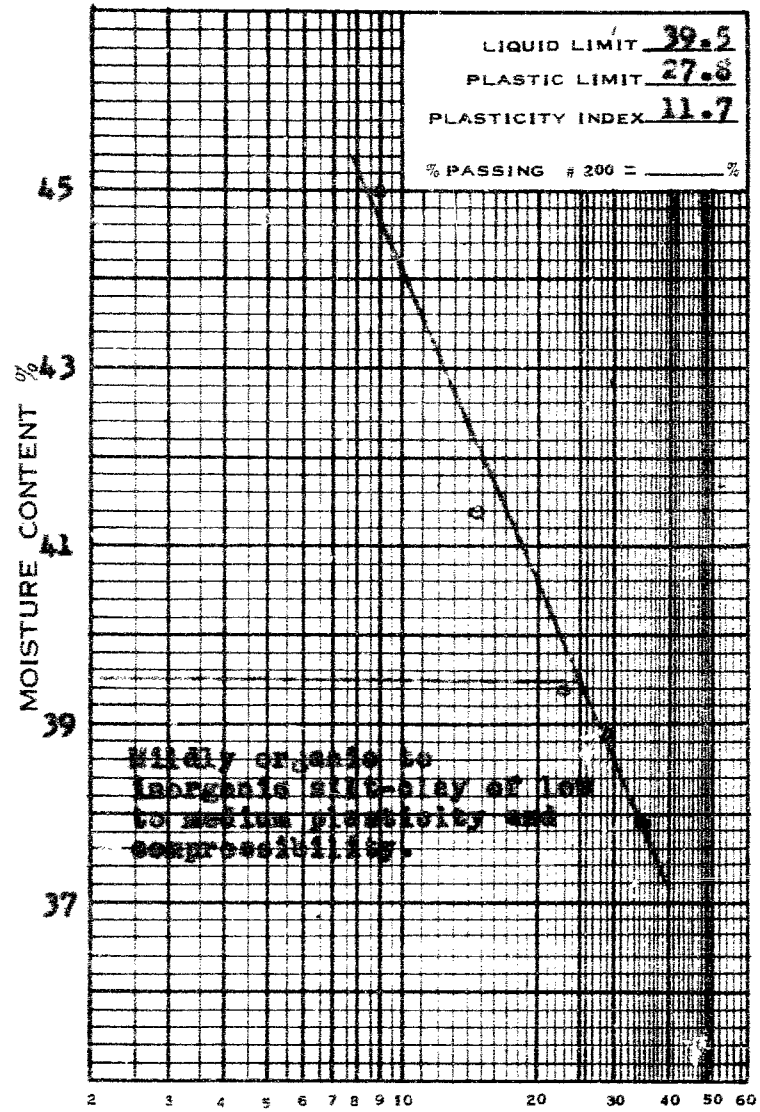
SOIL TESTING LABORATORY

LIQUID LIMIT TEST — FLOW LINE CHARTS

JOB NO. 57119 PROJECT Coulais River Bridge

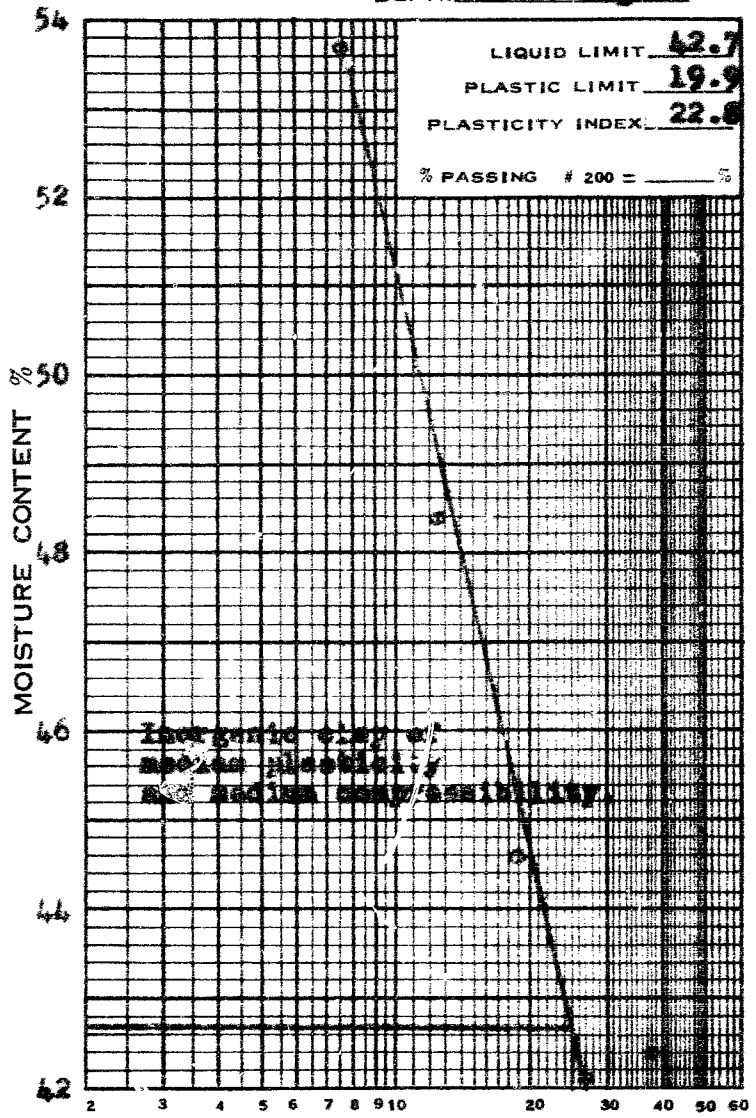
SAMPLE FROM Borehole 12, Sa. 4B

DEPTH 20½' - 21'



SAMPLE FROM Borehole 12, Sa. 4C

DEPTH 21' - 21½'



NO. OF BLOWS (LOG SCALE)

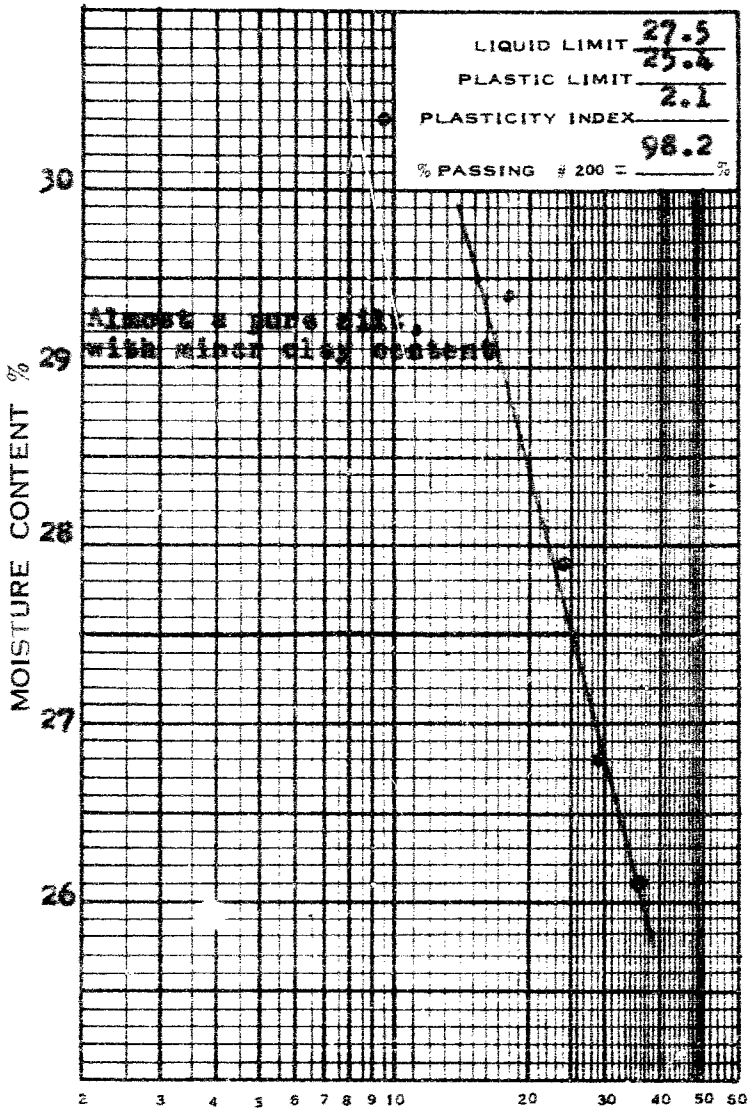
e. m. peto associates ltd.

SOIL TESTING LABORATORY

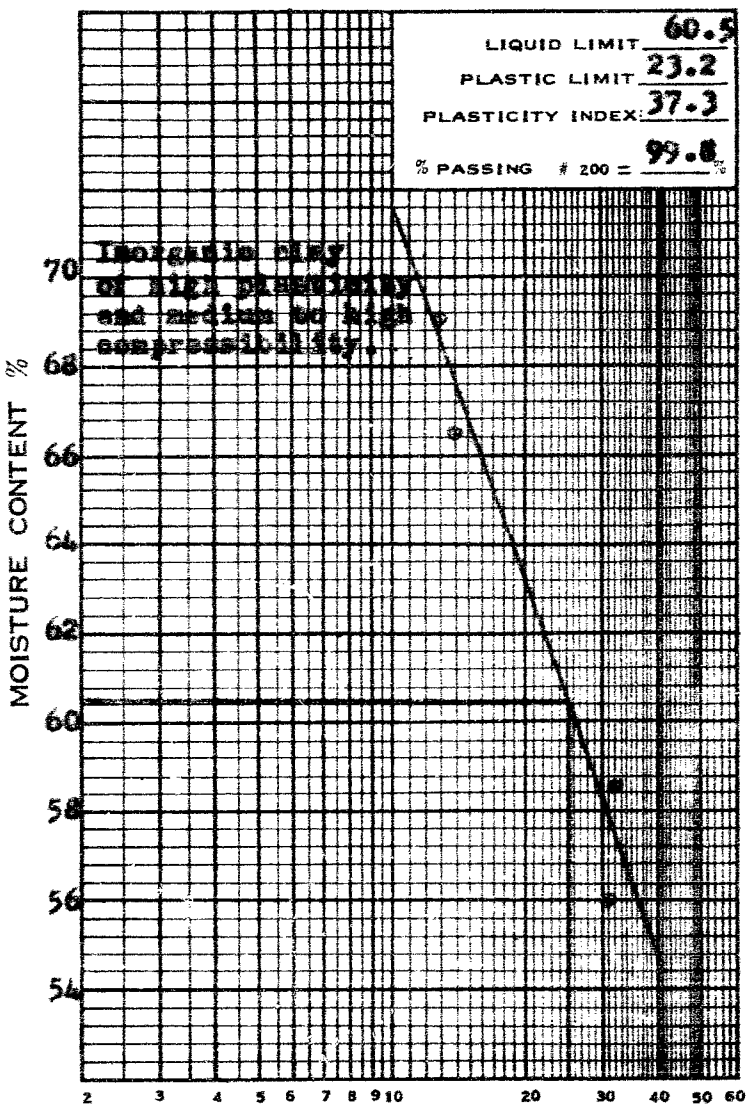
LIQUID LIMIT TEST — FLOW LINE CHARTS

Job No. 57119 Project Goulais River Bridge

Sample From B.H. 12 Sample 8
Depth 40'-41'



Sample From B.H. 8 Sample 3
Depth 15' - 16'



NO. OF BLOWS (Log Scale)

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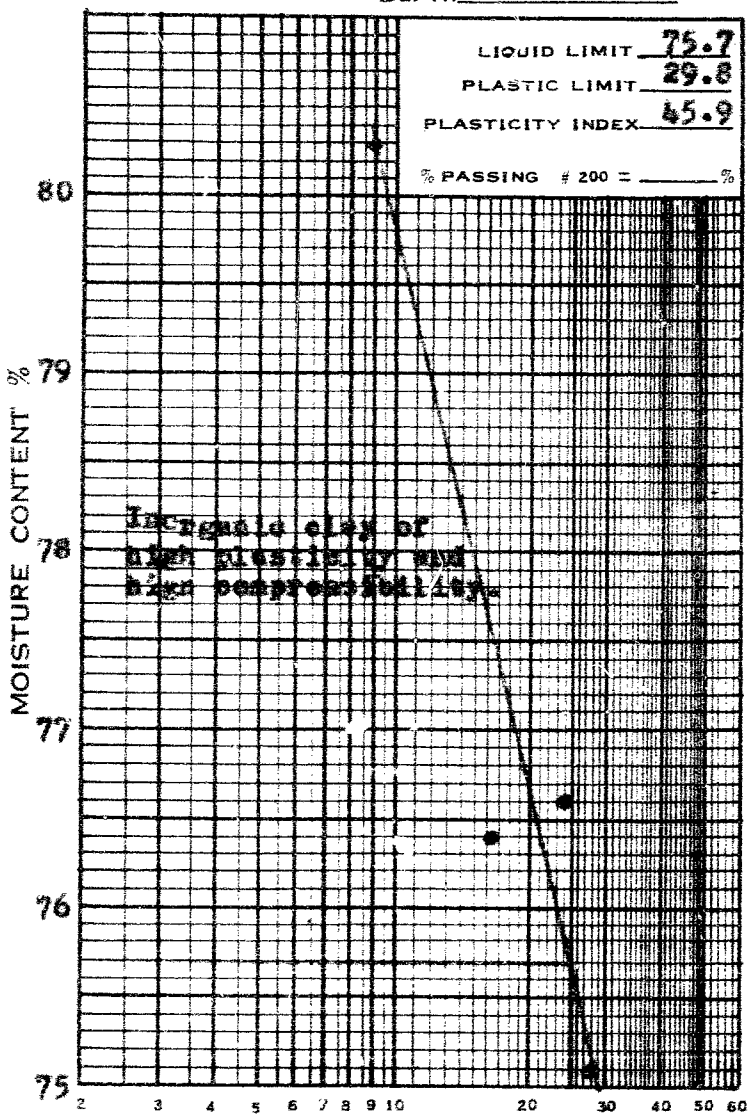
SOIL TESTING LABORATORY

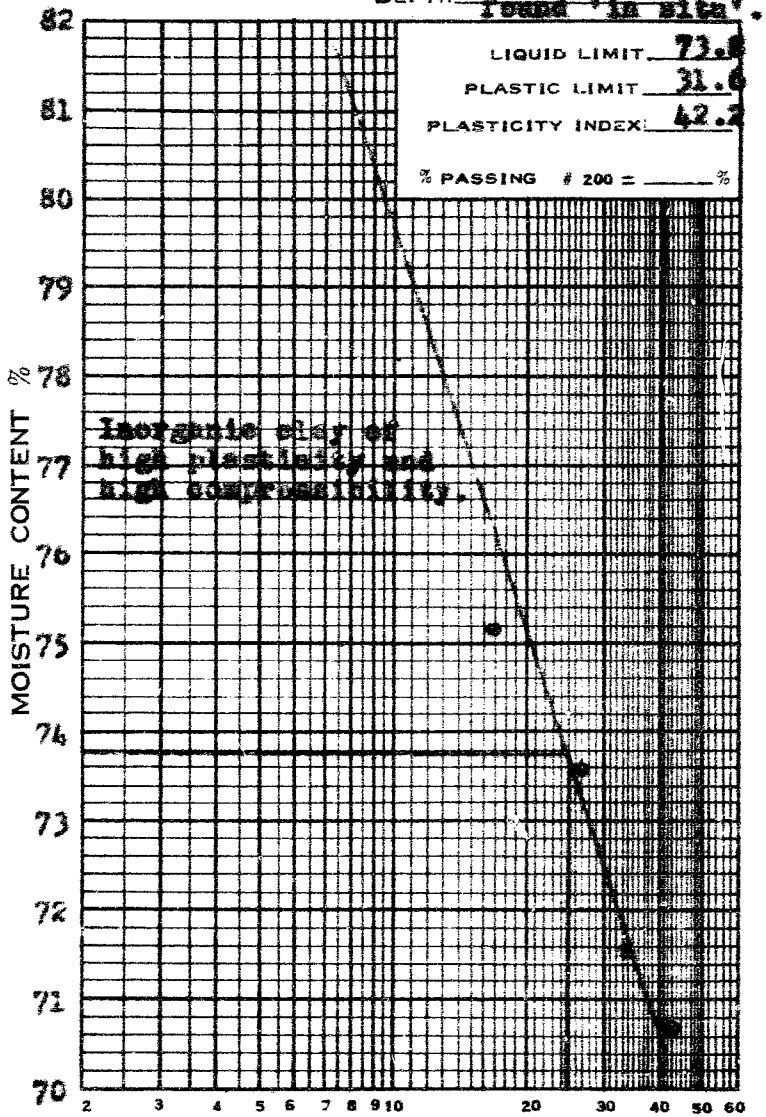
LIQUID LIMIT TEST — FLOW LINE CHARTS

Job No. 57119 Project Coulais River Bridge

Sample From riverbank: exposed varved clay.
Depth Red clay material only.



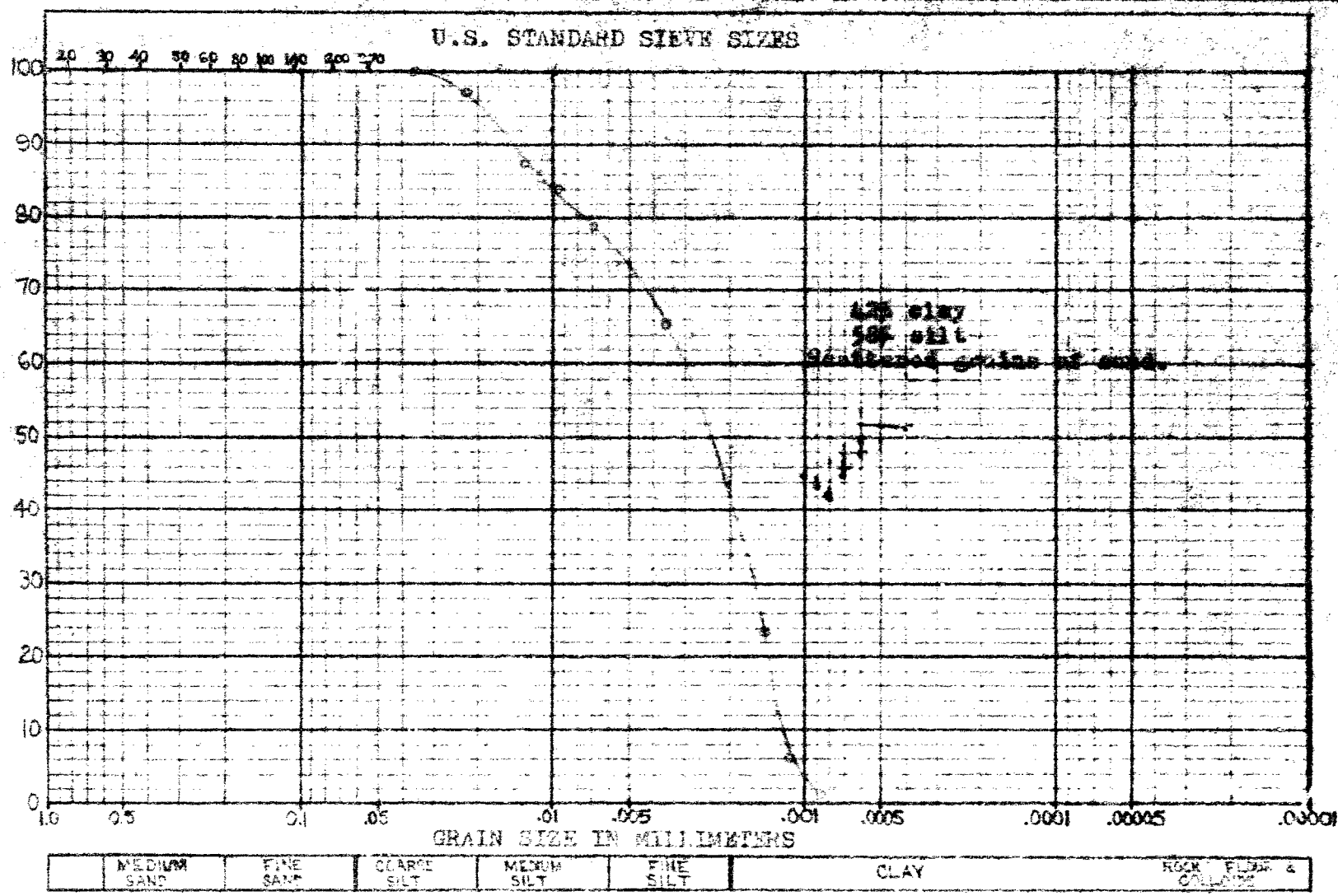
Sample From riverbank: exposed varved clay.
Depth Red and grey sample as found 'in situ'.



NO. OF BLOWS (Log Scale)

E. M. PETO ASSOCIATES LTD.

HYDROMETER GRAIN SIZE DISTRIBUTION DIAGRAM



M.I.T. CLASSIFICATION

Job Name Scalois River Bridge ... Job. No. .. 57119 ..... Borehole No. .19.. Sample No 13A-13B

Depth .50' - 51'... Elevation 549.4 .. Remarks .SPECIFIC. GRAVITY. OF. THIS. SAMPLE. =.2.70...

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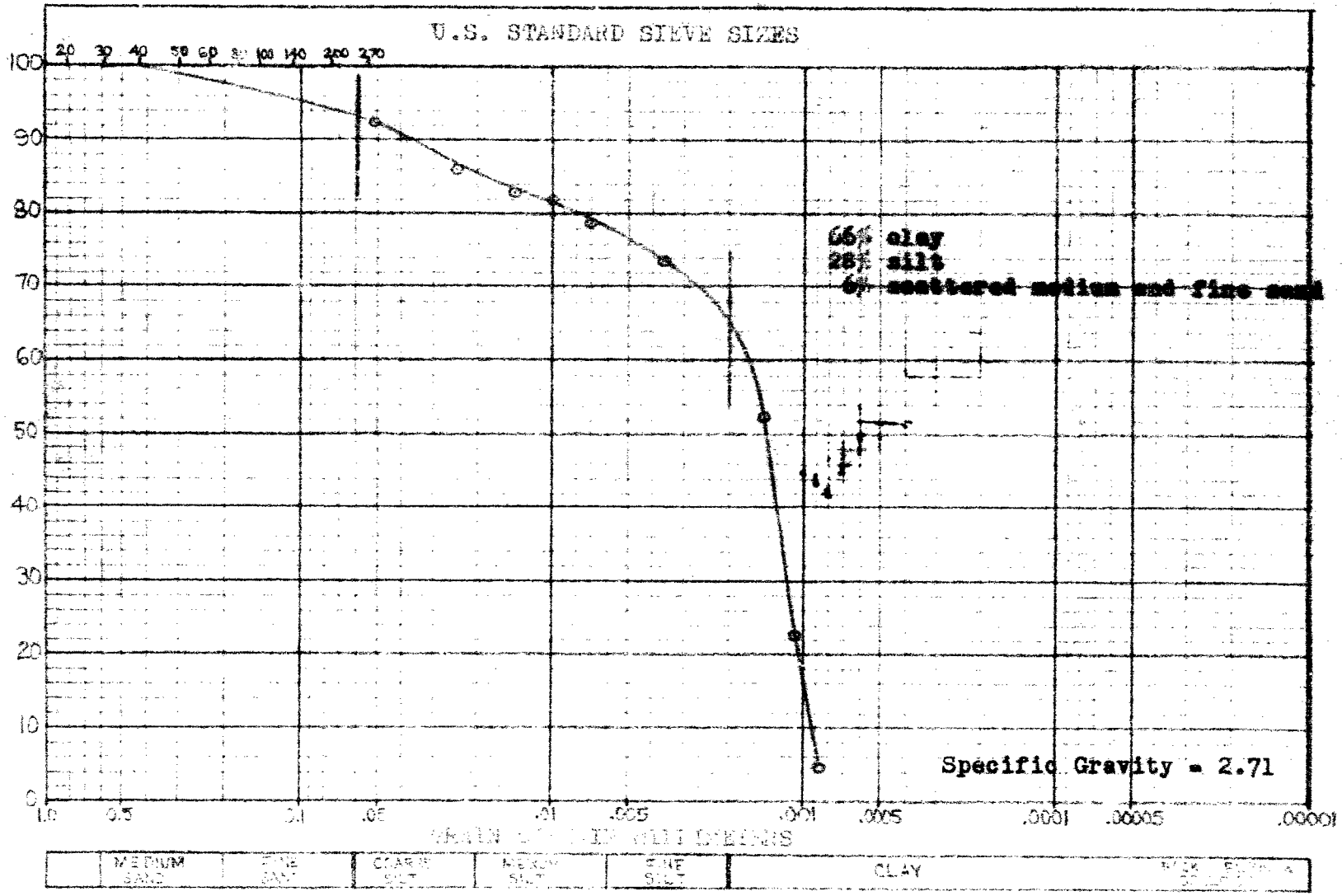
HYDROMETER GRAIN SIZE DISTRIBUTION DIAGRAM

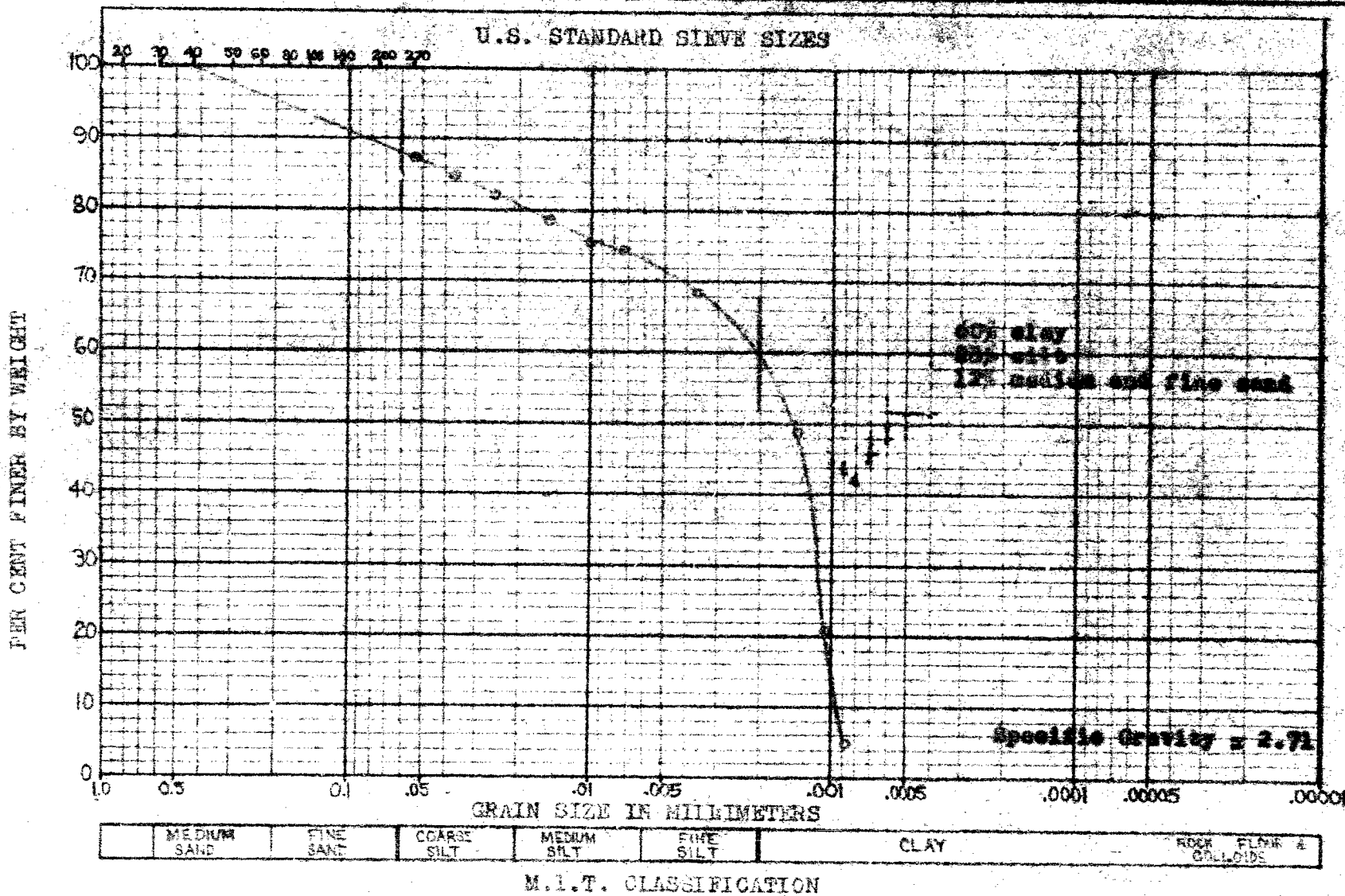


Job Name Goulais River Bridge ... Job No. 57119 ..... Borehole No. 7 ... Sample No. 9

Depth ... - ..... Elevation ... - ... Remarks Red clay sample which has been seperated out from the varved tan and gray clay dug out of the riverbank.

E. M. PETO ASSOCIATES LTD.

HYDROMETER GRAIN SIZE DISTRIBUTION DIAGRAM



M.I.T. CLASSIFICATION

Job Name Goulais River Bridge ... Job. No. ..57119..... Borehole No. ..... Sample No. .....

Depth ..... Elevation ..... Remarks Red and grey varved silty clay dug from ... exposure along riverbank. As found 'in situ'.

57119

SUMMARY OF UNCONFINED COMPRESSION STRENGTH TESTS

Sample From B.H.	Sample Number	Depth	Type of Failure	q/2 p.s.f.	Nat. M.C.	Remarks
2	6	32'- 32-1/2'	Shear failure along numerous planes.	302	77.4%	Slickensided, nuggety texture.
2	8	40-1/2' - 41'	Shear	331	37.0%	More silt than above sample
3	7	35-1/2' - 36'	Shear	445	53.4%	Some nuggety texture.
3	7	36' - 36-1/2'	Very definite shear failure	317	-	
3	7	36-1/2' - 37'	Shear	295	69.2%	Nat. M.C. almost at Liquid Limit (70.4%)
3	7	37' - 37-1/2'	Definite Shear	389	-	Failed at Plane of 60° From horizontal
5	6C	31' - 31/1/2'	Sudden shear failure	494	46.3%	Nat. M.C. much wetter than Plastic Limit.
10	11A	44' - 44-1/2'	Sudden shear failure	937	63.2%	
10	11B	44-1/2' - 45'	Very sudden shear failure	658	56.0%	
10	11C	45' - 45-1/2'	Failure by bulging of silt seam	Greater than 493	-	
10	13A	50' - 50-1/2'	Plastic and Shear failure	346	48.0%	
10	13B	50-1/2' - 51'	Sudden shear failure	658	53.8%	Nuggety texture. Seams of pure grey silt.
10	13C	51' - 51-1/2'	Very sudden, almost brittle Shear failure	886	-	Nuggety texture.
10	15B	55'10" - 56'2"	Sudden shear failure	1315	30.7%	Very distinctly varved.

Sample From B.H.	Sample No.	Depth	Type of Failure	q_u p.s.f.	Nat. M.C.	Remarks
10	15C	56'2" - 56'6"	Sudden cone-shaped shear failure	1725	-	Principally a stratified clayey silt.
10	15C	56'2" - 56'6"	Plastic Failure with Ultimate shear	658	29.3%	Remolded sample, sensitivity = 2.62
12	4A	20' - 20-1/2'	Plastic Failure with Ultimate Shear	123	51.5%	Nat. M.C. near Liquid Limit
12	4B	20-1/2' - 21'	Plastic Failure	246	40.6%	Nat. M.C. wetter than Liquid Limit (39.5%)
12	4C	21' - 21'-1/2"	Plastic Failure followed by Shear	591	37.5%	Nat. M.C. Almost at Liquid Limit (42.7%)
12	4C	21' - 21-1/2'	Plastic Failure with some indistinct shear planes.	82	36.5%	Remolded sample, sensitivity = 7.2

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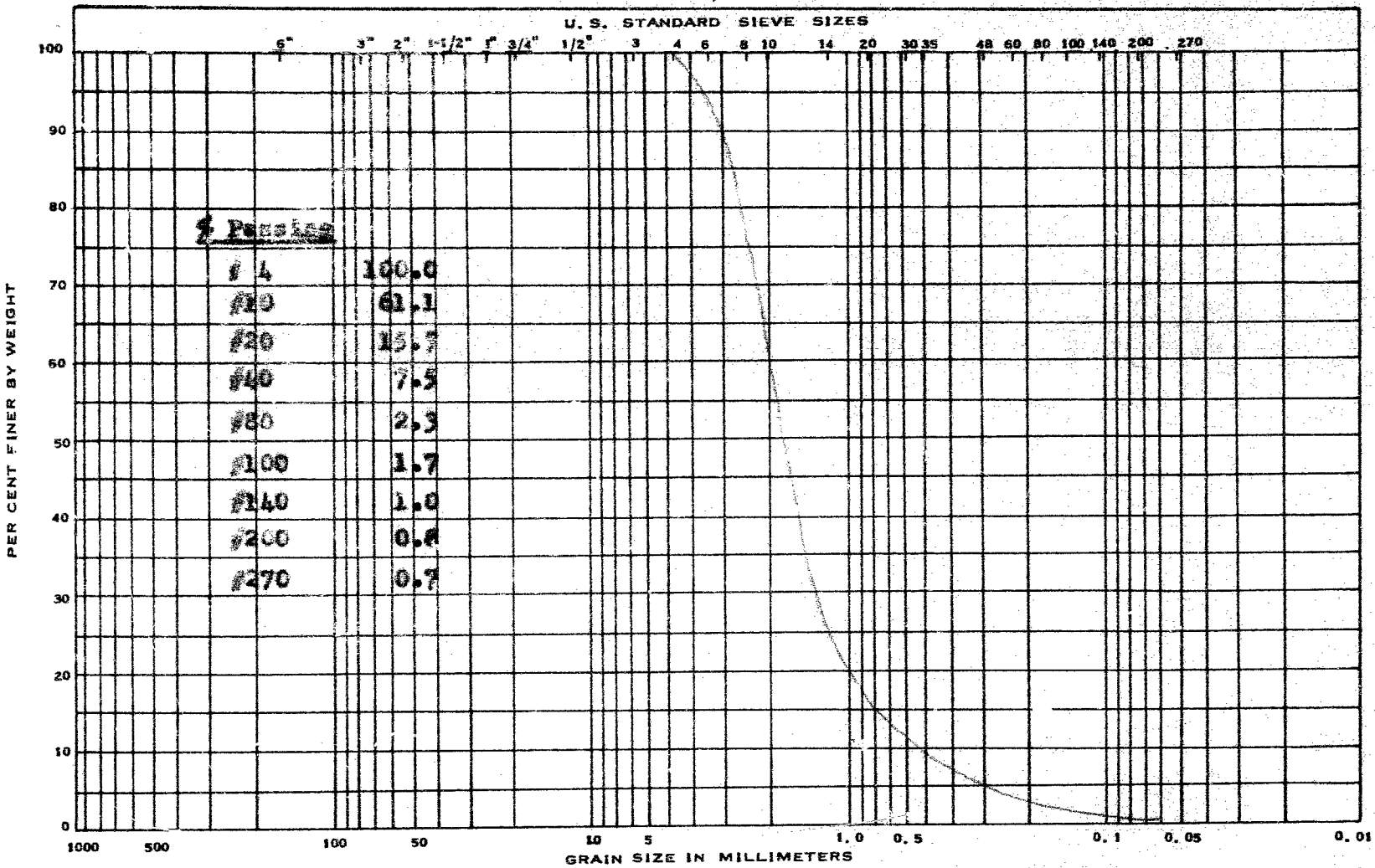

% Passing	
#4	100.0
#10	61.1
#20	15.3
#40	7.5
#80	2.3
#100	1.7
#140	1.0
#200	0.8
#270	0.7

BOULDERS	STONES	GRAVEL	COARSE SAND	MED. SAND	FINE SAND	COARSE SILT	MED. SILT

MASS. INST. OF TECH. CLASSIFICATION

JOB NAME Goulais River Bridge JOB NO. 57119 HOLE NO. 12 SAMPLE NO. 7

DEPTH 35'-36' ELEVATION 571.89 REMARKS Fine Gravel and Coarse sand.

GRAIN SIZE DISTRIBUTION DIAGRAM

COARSE MATERIALS

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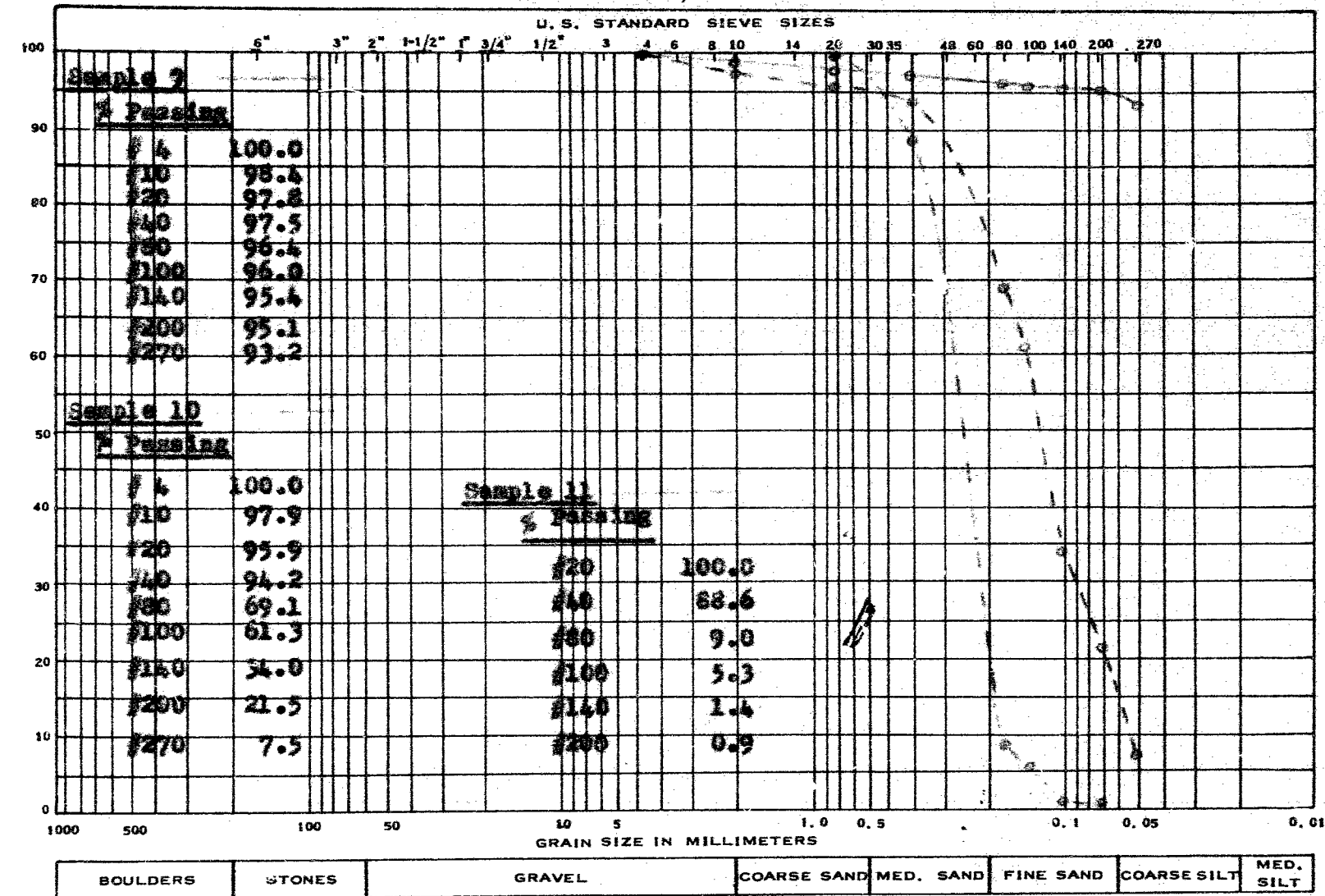

Sample 9

% Passing

#4	100.0
#10	98.4
#20	97.8
#40	97.5
#80	96.4
#100	96.0
#140	95.4
#200	95.1
#270	93.2

Sample 10

% Passing

#4	100.0
#10	97.9
#20	95.9
#40	94.2
#80	69.1
#100	61.3
#140	34.0
#200	21.5
#270	7.5

Sample 11

% Passing

#20	100.0
#40	88.6
#80	9.0
#100	5.3
#140	1.4
#200	0.9

BOULDERS	STONES	GRAVEL	COARSE SAND	MED. SAND	FINE SAND	COARSE SILT	MED. SILT

MASS. INST. OF TECH. CLASSIFICATION

JOB NAME Goulais River JOB NO. 57119 HOLE NO. 12 SAMPLE NO. 9, 10 and 11

DEPTH	ELEVATION	REMARKS
S/9 45'-46'	561.89	S/9 Sandy silt, S/10 Fine medium silty sand, S/11 medium sand.
S/10 50'-51'	556.89	
S/11 55'-56'	551.89	

GRAIN SIZE DISTRIBUTION DIAGRAM

COARSE MATERIALS

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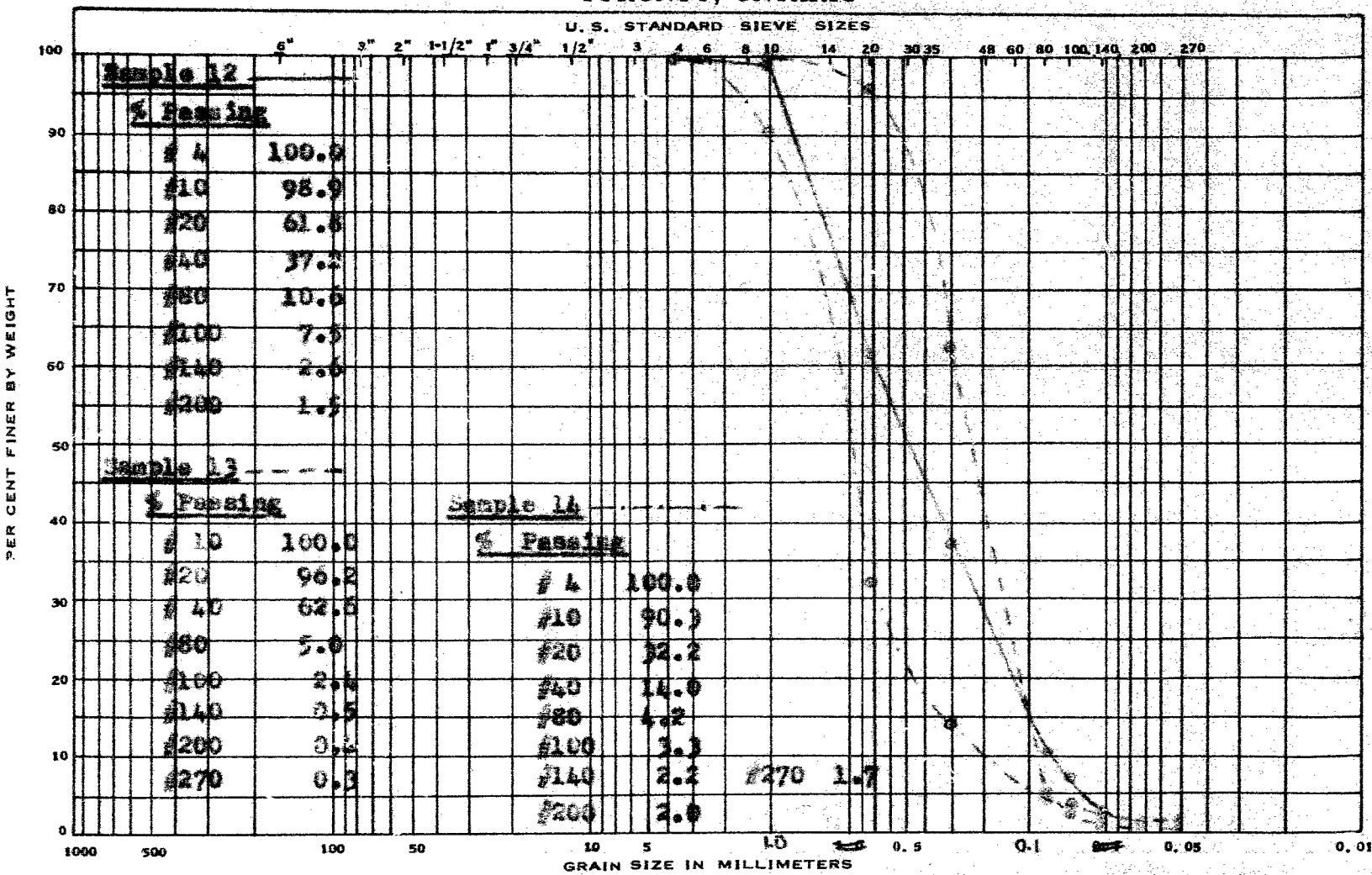
TORONTO, ONTARIO



JOB NAME Goulais River JOB NO. 57119 HOLE NO. 12 SAMPLE NO. 12, 13 and 14

DEPTH ELEVATION REMARKS

S/12 60'-61' 546.89 S/12 coarse to medium sand, S/13 medium sand.

S/13 61'-63' 545.89 S/14 coarse to medium sand.

S/14 63'-64' 543.89

GRAIN SIZE DISTRIBUTION DIAGRAM

COARSE MATERIALS

APPENDIX II

report for Dept. of Highways of Ontario. Sheet No.

pH Factors

These factors are shown in order to give some indication of the chemical effect that the soil and groundwater may have on various members of the proposed structure, particularly steel piling.

Method of Testing:

Samples of uncontaminated groundwater were not available, and therefore the following procedure was followed:

Roughly 40 grams of soil sample were used for each test. Samples were taken directly out of sample jars, thoroughly mixed with approximately 160 c.c. of distilled water, and then the resulting slurry was filtered at least twice until a fairly clear solution was obtained. These were tested using a colorimetric method.

Test No. 1 - B.H. 1, Sample 6, Depth 30'-31'. Reddish silty clay.

pH = 4.7
4.8 Weak to moderate acidity.

Test No. 2 - B.H. 2, Sample 2, Depth 10'-11'. Grey clayey and silty sand.

pH = 4.9
4.9 Weak to moderate acidity.

Test No. 3 - B.H. 5, Sample 8, Depth 40'-41'. Fine to coarse sand.

pH = 5.1
5.3 Weakly acidic.

BA 688-A

AN INDEPENDENT ORGANIZATION PROVIDING A COMPLETE SOIL ENGINEERING & INVESTIGATION SERVICE

e. m. peto associates ltd.

YOUR REFERENCE:-

OUR REFERENCE:- 57119

850 roselawn avenue,
TORONTO, ONTARIO.
RUssell 1 - 4955.

January 14th, 1958.

Department of Highways of Ontario,
280 Davenport Road,
Toronto, Ontario.

Attention: Mr. J. C. McAllister

Dear Sir:

1. Attached hereto is our report covering the work on the Southern bank, and the deepening of the hole in the river.

2. The soil conditions, factors leading to our conclusions, and supporting soil shear strength test results are given in detail in the attached report. The conclusions in this supplementary report have been influenced by information obtained verbally from the Consultant that a single 300-foot span is now contemplated.

3. Should piers in the river or adjacent to the banks be necessary, then we feel that they would best be carried on Franki compressed concrete piles driven through the silty clay stratum. This type of pile would minimize the effects of the Artesian water.

4. At chainage 841 ± 50 on the North bank either the Franki type pile or the cast-in-place, reinforced concrete pile (such as the Raymond monotube pile) would be most suitable. However, this does not preclude the use of steel "H" piles on the North bank, though they would achieve greater penetration.

5. On the South bank at chainage 838 ± 50 the most suitable type of pile, because of the length to be driven, would be either a monotube pile or a steel "H" pile.

6. The final selection of pile type becomes a matter of economy, and other engineering considerations beyond the scope of this report.

Yours very truly,

E. M. PETO ASSOCIATES LTD.,

MM:sb

E. M. Peto, P. Eng.

e. m. peto associates ltd., 850 roselawn avenue, Toronto 10, Ontario

Job No. 57119 Client's Ref. No. Date January 13th/58

SUPPLEMENTARY
Report on

SOIL SITE INVESTIGATION

GOULAIS RIVER BRIDGE

HWY. 17 - TRANS-CANADA HIGHWAY

for

DEPARTMENT OF HIGHWAYS OF ONTARIO

INTRODUCTION:

The Terms of Reference and Method of Operations were as stated in our first report for this project. However, because the Consulting Engineers were required to meet an early deadline our report was divided into two parts, to enable them to progress with a preliminary design. The first part of this report gave a general picture of site conditions together with detailed information on the North bank and soil conditions under the river. The supplement is primarily a report on the results obtained from the South bank, although some additional information is given for boreholes 8 and 12 located in the river, which was not available when the original report was issued.

At borehole 12, the untimely rise of the river, sanded over the hole, and the 80 feet of casing was left in the river bed. Every effort to locate the top of this casing by driving probe rods through a hole chopped in the ice failed, and the casing was not recovered.

It should be noted that throughout December and the early part of January 1958, the river in the vicinity of borehole 8 did not freeze over. In order to deepen this borehole to prove the existence of another soft clay stratum at depth, it was necessary to work from a rather complicated timber structure partly floating, and partly supported on surrounding ice. It was found to be impractical to measure the ground water pressure with a piezometric installation, because the air temperature remained well below freezing point. The large volume of Artesian flow from depth at this hole precluded the driving of casing or sampling deeper than 80 feet.

INTRODUCTION: (Cont'd)

Work on the site was finally completed on January 6th, 1958, immediately after which the equipment was loaded, and moved back to Toronto, arriving at noon on January 8th, 1958.

The detailed borehole logs for the three holes, together with shear strength test results are attached, followed by the amended site plan, showing boreholes 7 and 11, the deeper section of borehole 8, and the corrected hydraulic gradient.

SOIL CONDITIONS:

The deepening of borehole 8 in the river, near the North bank, confirmed a dense fine to very coarse sand deposit, as we had anticipated. This stratum is water-bearing. We believe that the excess hydrostatic pressure measured during the initial driving of this test hole is on the low side, and that the pressure from the 70 to 80 foot depth should have been considerably greater, since the flow of water from below the 70 foot depth was extremely high.

South Bank

At the proposed abutment location on the South bank, the soil conditions are rather disturbing. Instead of the soft silty clay stratum thinning out and eventually disappearing at the edge of the river valley, it dips downward at an undiminished thickness, with indications of an actual increase.

The stratification at holes 7 and 11 was found to be inclined indicating that the varved silty clay stratum has been folded downward by the weight of the material above it.

In the light of these findings, the hypothesis, submitted in the first report, regarding the formation of the clay stratum is no longer strictly correct. It now appears much more likely that this material exists for a considerable distance back along the South approach to the bridge.

Overlying the clay stratum at holes 7 and 11 is a sand deposit some 64 feet deep.

SOIL CONDITIONS: (Cont'd)

The colour of the sand grades from light brown to grey, and the density is loose to compact. At borehole 7, closer to the river, some organic material was encountered at 50 foot depth.

The natural moisture contents of the sand samples are of the order of 22.8%; whilst those of the underlying varved silty clay range from 27.8% to 70.9%. They are generally very much wetter than the plastic limit, and in some cases are near or at the liquid limit.

The unconfined compressive strength of the varved silty clay is variable, but the average is 910 lbs. per sq. ft. Three triaxial compression tests also gave variable shear strength results, but bore close agreement on the angle of internal friction, which is in the order of 1° to 2°. Angles of internal friction of such a low order are usual for a saturated clay and normal design practice errs on the side of safety in ignoring them.

The sensitivity of the silty clay from holes 7 and 11 is approximately 3.70, indicating that this material would only have 27% of its original strength after disturbance (such as pile-driving).

Consolidation tests were not made on the clay material, because of its depth of occurrence, under both the North and South approaches and abutments; furthermore the consolidation characteristics of this material have been fairly well approximated from the Atterberg limits, given in the first report, and its natural moisture contents.

Directly underlying the reddish-brown varved silty clay at holes 7 and 11 is a stratum of light grey, stratified silt with minor clay content. The silt is generally compact, but saturated, with natural moisture contents of 26%.

The total thickness of the sedimentary deposits of clay and silt is 29 feet at borehole 7 and 29-1/2 feet at borehole 11.

Beneath the clay and silt stratum, is a fine to coarse sand containing rock fragments, which was encountered at every test hole on the site. Standard penetration test results in this material are unreliable, due both to the disturbance of the sand by the Artesian water, and interference with the sampler by rock fragments. Nevertheless we believe this material to be in a dense or very dense state, due to the high resistance experienced on the site in driving both the sampler and the casing.

CONCLUSIONS:

1. The loose condition of the upper deposit of some 64 feet of sand will result in some settlement occurring in the event of fairly high loadings being applied to this material. It is an undesirable foundation medium, and its use for this purpose should be avoided.

2. The test results show that the strata of sedimentary material comprised of the varved silty clay and silt strata have very low shear strength, and are subject to considerable consolidation under load. These objectionable characteristics preclude the use of these strata for heavy load-bearing foundations.

3. For these reasons we consider that end-bearing piles will be required. However, in the location of borehole 7, which is approximately at the South abutment location, such piles would need to be at least 100 feet long.

4. There is a likelihood that consolidation of the varved silty clay and silt strata will occur under the surface loadings of the approach embankments and other surface works, with a subsequent negative frictional drag being exerted on the piles. Provision should be made for this effect in the design of the piles.

5. Having in mind that a single 300 ft. span structure is now contemplated, we feel that either monotube or steel "H" piles would be suitable for the existing site conditions. The steel "H" piles will undoubtedly obtain greater penetration in the coarse sand stratum and will transfer the load through a combination of friction and end-bearing. The monotube pile, however, is unlikely to have the penetrating power of the "H" piles under these conditions and would probably be driven to refusal shortly after entering the coarse sand stratum. Thus it appears that a final decision as to type of pile used will rest on the relative economics of either type.

6. Subject to normal engineering precautions being taken during the driving operations, settlement of the pile clusters will be within tolerable limits.

E. M. PETO ASSOCIATES LTD.,

E. M. Peto, P. Eng.

REGISTERED PROFESSIONAL ENGINEER
E. M. PETO
PROVINCE OF ONTARIO

MM:sb

Job Number 57119

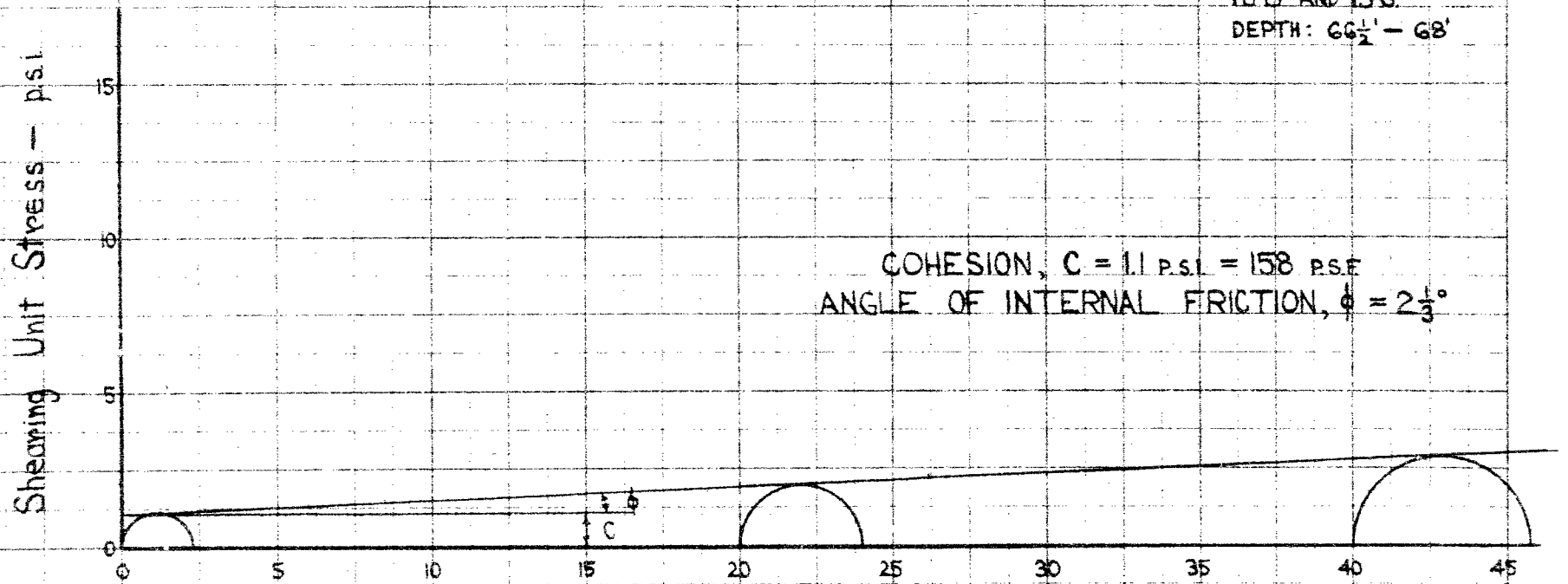
SUMMARY OF UNCONFINED COMPRESSION STRENGTH TESTS

Sample from B.H.	Sample Number	Depth	Type of Failure	q_u p.s.f	Nat. M.C.	Remarks
7	17A	71-1/2' - 72'	Very sudden, brittle	1168	-	Stratification not horizontal.
7	17A	71-1/2' - 72'	Plastic	245	53.0%	Remoulded sample. Quite plastic when remoulded. Sensitivity = 4.76
7	17B	72' - 72-1/2'	Very sudden	1069	-	1/8" - 3/16" grey seams @ 1/2" spacing, not horizontal.
7	17B	72' - 72-1/2'	Very Plastic	328	-	Remoulded sample. Sensitivity = 3.25
7	17C	72-1/2' - 73'	Sudden failure along plane @ 56° from horizontal	559	55.8%	Natural moisture content near Liquid Limit.
7	17C	72-1/2' - 73'	Very Plastic	181	-	Remoulded sample. Sensitivity = 3.08
11	18	73' - 73-1/2'	Shear along plane @ 59°	740	70.9%	Natural moisture content right at Liquid Limit.

MOHR'S CIRCLE DIAGRAM

FOR REDDISH-BROWN VARVED SILTY CLAY SAMPLES IN TRIAXIAL COMPRESSION TEST

JOB NO. 5711G
B.H. 7 SAMPLES 15A, 15B AND 15C.
DEPTH: 66½' – 68'



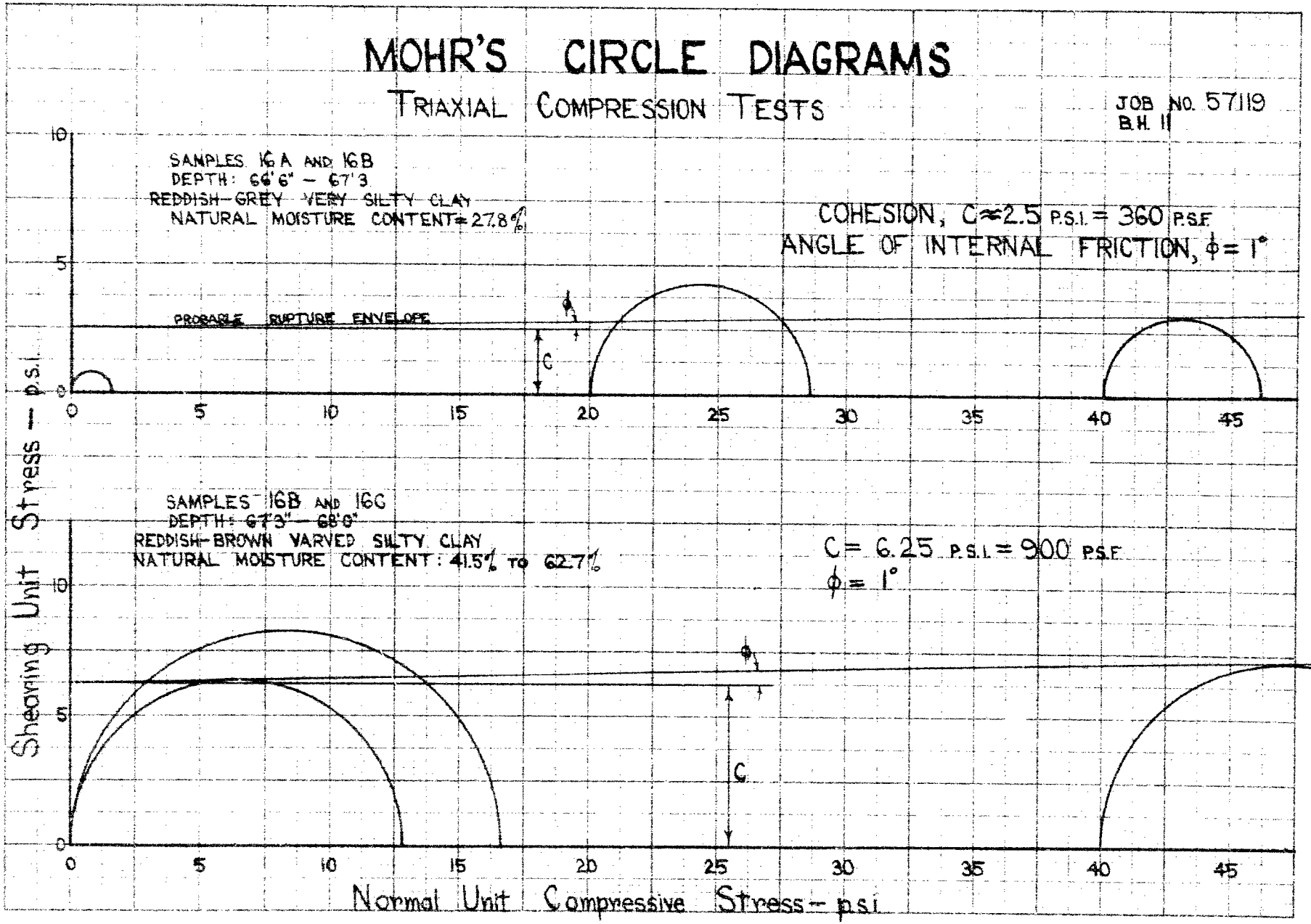
COHESION, C = 1.1 P.S.I. = 158 P.S.F.
ANGLE OF INTERNAL FRICTION, $\phi = 2\frac{1}{3}°$

10-1-58

MOHR'S CIRCLE DIAGRAMS

TRIAXIAL COMPRESSION TESTS

JOB NO. 57119
B.H. 11



e. m. peto associates ltd.

Soil Engineering Service — Toronto, Ontario

BOREHOLE LOG

Job Name: [illegible] St. — Job No.: 5716 [illegible] — Borehole No.: [illegible]

Client: Dept. of [illegible] — Casing: 4" [illegible] — Boring Date: [illegible]

Datum: [illegible] — Compiled By: [illegible] — Checked By: M.M. [illegible]

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q.U. UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

Soil Description	Colour	Density or Consistency	Depth Elevation	Legend	Sample No. and Condition	Sample Type	Blows per ft.	Water Levels, Soil Moisture & Remarks
								RIVER W.L. 607.8, JAN. 4, 1958
			606.5					APPROX. [illegible] W.L. 605.3, NOV. 11, 1957
		RIVER BED	603.4					[illegible]
FINE TO COARSE [illegible] LAYERS OF [illegible] WITH ODD RED-BROWN CLAY POCKET	GREY-BROWN		[illegible]		1	[illegible]		[illegible]
COARSE SAND WITH POCKETS OF RED-BROWN CLAY	DO.	VERY SOFT	10.0		2	S.S.	2	[illegible]
		DO			[illegible] (lost)	S.S.		
VARVED CLAY	REDDISH-BROWN	DO	15.0 / 593.[illegible]		3 / 3A	S.S. / S.L.	2	W.C. 18.0% [illegible]
CLAY VARVED WITH GREY [illegible] SILT WITH [illegible] CLAY [illegible]	RED-BROWN LIGHT GREY	COMPACT	20.0 / 21'-6" 584.65 / 24'-6" 581.35		4A / 4B	S.S.	14/6"	[illegible] 6-24 [illegible] 26 [illegible]
CLAY WITH LAYERS OF GREY SILT	RED-BROWN	VERY SOFT			5	S.S.	2	W.C. 41[illegible]
SILT WITH [illegible] CLAY [illegible]	LIGHT GREY	DENSE	30.0 / 576.[illegible]		6	S.S.	12	W.C. 21[illegible]
COARSE SAND & [illegible]	GREY-BROWN	DENSE	35.0		7	S.S.	[illegible]	SAMPLE [illegible] WATER AT 35' WITH [illegible] 12 FT IN 4 [illegible]
MEDIUM [illegible] FINE SAND WITH SILT LAYERS	GREY	VERY DENSE	40.0		8	S.S.	51	VERY MOIST
MEDIUM & [illegible] FINE SAND WITH LAYERS OF SILT	"	COMPACT	45.0		9	S.S.	22	VERY MOIST
AS ABOVE	"	COMPACT	51'-0" 555.35		10	S.S.	28	
MEDIUM TO VERY COARSE SAND (ANGULAR IGNEOUS PARTICLES)	MIXED COLOURS		55-0"		11 / 12	W.S.		N.B. DEEPENED HOLE ON JAN. 3rd-5th 1958, WORKING FROM A PLATFORM ON THE ICE. RIVER WATER LEVEL AT THIS TIME WAS 607.8.
FINE TO MEDIUM SAND.	"	DENSE			13	W.S.	41	SAND BACKED UP IN CASING 3 FT. IN ALL CASES
MEDIUM TO COARSE SAND AND GRAVEL.	MIXED COLOURS	"	61'-7"		14	W.S.	40	BELOW 55' THE SPLIT SPOON SAMPLES WERE LOST AND WASH SAMPLES WERE RETAINED.
MEDIUM TO VERY COARSE SAND	"	"	65'0" 541.4		15	W.S.	35	
ODD LAYERS OF FINE BROWN SAND.			70'0"					
FINE TO VERY COARSE SAND AND PEBBLE GRAVEL.	MIXED COLOURS	DENSE TO VERY DENSE	75'0"		16	W.S.	92	
AS ABOVE.	"	DENSE	77'-7" 528.6		17	W.S.	45	WATER FLOWING OVER TOP OF CASING (ELEV. 609.2) AT APPROX. 30 GAL. PER MIN. FROM 77' DEPTH.

HOLE TERMINATED.

e. m. peto associates ltd.

[illegible] ENGINEERING SERVICE — TORONTO, ONTARIO

BOREHOLE LOG

Job Name: [illegible] River Bridge	Job No.: 57117	Borehole No.: 7
Client: Dept. of Highways of Ontario	[illegible]: BX [illegible]	Boring Date: [illegible]
Datum: Geodetic	Compiled By: M. Kinlean	Checked By: [illegible]

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. STANDARD SPLIT TUBE SAMPLE
- S.B. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- [illegible] VANE SHEAR TEST
- Q_u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL [illegible]
- G.W.T. GROUND WATER TABLE IN [illegible]

Description	Colour	Consistency	Depth / Elevation	Sample No.	Sample Type	Blows	Remarks
			0'0" / 630.1				
VERY FINE TO FINE SAND.	LIGHT BROWN	LOOSE		1	S.S.	7	MOIST
AS ABOVE.	"		5'0"	2	S.S.	8	MOIST
FINE SAND.	GREY-BROWN	LOOSE	10'6" / 619.4	3A	S.S.	5	WET — W.L. = 10'6" DEC. 12, 1957
MEDIUM TO COARSE SAND	YELLOWISH-BROWN			3B			MOIST
" " " "	"	"	15'0"	4	S.S.	6	MOIST
MEDIUM TO COARSE SAND AND PEBBLE GRAVEL.	YELLOWISH-BROWN	COMPACT	20'0"; 21'6" / 608.6	5	S.S.	30	MOIST
FINE TO COARSE SAND.	BROWN	COMPACT	25'0"	6	S.S.	24	WET.
" " " "	LIGHT BROWN	"	30'0" / 600.1	7	S.S.	16	WET.
AS ABOVE.	"	"	35'0"	8	S.S.	22	WET.
FINE TO MEDIUM SAND.	"	"	40'0" / 590.1	9	S.S.	30	"
FINE TO COARSE SAND.	GREY	COMPACT TO DENSE.	45'0"	10	S.S.	32	WET.
" " " ", 2" STRATUM OF SILT AND DECAYED ORGANIC MATTER.	"	COMPACT	50'0" / 580.1	11	S.S.	17	"
FINE TO MEDIUM SAND, SOME ORGANIC MATTER.	GREY	LOOSE	55'0"	12	S.S.	7	SATURATED.
FINE TO MEDIUM SAND	LIGHT GREY-BROWN	COMPACT	60'0"	13	S.S.	17	WET
			64'0" / 566.1				MUCH WETTER THAN PLASTIC LIMIT. NATURAL M.C. = 69.3%. ALMOST AT LIQUID LIMIT.
STRATIFIED SILTY CLAY, SOME PEBBLES.	REDDISH-BROWN	SOFT TO FIRM.		14A, 14B	S.S.	5/4/6"	
AS ABOVE, BUT NUGGETTY TEXTURE. 1/16" SEAMS OF GREY CLAYEY SILT.				15	2" S.L.	PUSHED	COHESION, C = 158 P.S.F. [illegible]. NAT. M.C. 66'6" TO 67'0" = 61.4%. NAT. M.C. 67'6" TO 68'0" = 55.5%
VARVED SILTY CLAY, NUGGETTY TEXTURE.	REDDISH-BROWN.	FIRM	70'0"	16A, 16B	S.S.	6/3/6"	STRATIFICATION NOT HORIZONTAL. 3 U.C. TESTS AND REMOULDS:
				17	2" S.L.	PUSHED.	AVG. Q_u = 932 P.S.F. AVG. SENSITIVITY = 3.70. M.C. FROM 53.0% TO 55[illegible]
AS ABOVE, 3/16" SEAMS OF GREY CLAYEY SILT AT 1" INTERVALS.	"	"	75'0"	18A, 18B	S.S.	6/3/6"	NAT. M.C. = 45.9%. STRATIFICATION NOT HORIZONTAL
SILT, MINOR CLAY CONTENT.	LIGHT GREY, POCKETS OF RED	LOOSE TO COMPACT.	79'0" / 551.1	19	S.S.	10	SATURATED
SILT, OCCASIONAL SEAMS OF GREY SILTY CLAY.	LIGHT GREY	COMPACT	85'0"	20	S.S.	19	"
AS ABOVE.	"	"	90'0"	21	S.S.	17	" NAT. M.C. = 26.1%
10" BOULDER 93'-93'10"			93'0" / 537.1				
SILTY FINE TO COARSE SAND AND ROCK FRAGMENTS.	REDDISH-GREY	DENSE		22	S.S.	[illegible]	SATURATED.
BOULDERS AND SAND.			98'0"				
FINE TO MEDIUM SAND.	REDDISH-GREY	EXTREMELY DENSE.	100'7"	23	S.S.	57/5"	SAND BACKING UP INSIDE CASING BELOW THE 100' DEPTH.
VERY FINE TO MED. SAND.	DARK REDDISH-GREY		103'0" / 527.1	24	W.S.	112/1"	

REFUSAL. LARGE BOULDER OR BEDROCK.

e. m. peto associates ltd.

BOREHOLE LOG

Job No. 5719

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

ABBREVIATIONS

			0' 0" 637.5				
VERY FINE TO FINE SAND	LIGHT BROWN	VERY LOOSE		1	S.S.	4	MOIST
			5' 0"				
AS ABOVE.	" "	LOOSE		2	S.S.	7	"
FINE TO COARSE SAND	"	LOOSE	10' 6" 626.8	3A 3B	S.S.	8	WET
MEDIUM TO COARSE SAND.	DARK RUSTY RED		13' 0" 624.5				
FINE TO MEDIUM SAND.	LIGHT BROWN	LOOSE.		4	S.S.	11	WET
			20' 0" 617.5				
AS ABOVE.	" "	"		5	S.S.	9	MOIST — WL = 20'4" (I.E.C. 18, 1957)
		LOOSE TO	25' 0"				
MEDIUM TO COARSE SAND AND PEBBLE GRAVEL UP TO 5/8" SIZE.	BROWN	COMPACT		6	S.S.	12	MOIST
		COMPACT TO	30' 0" 607.5				
FINE TO COARSE SAND.	BROWN	DENSE		7	S.S.	43	QUITE MOIST
	LIGHT	" "	35' 0"				
AS ABOVE.	BROWN	"		8	S.S.	37	WET
			40' 0" 597.5				
" "	BROWNISH-GREY	COMPACT		9	S.S.	15	WET
			45' 0"				
" " "	GREY	"		10	S.S.	22	SATURATED.
			50' 0" 587.5				
" "	"	"		11	S.S.	20	NAT. M.C. = 22.8% SATURATED
			55' 0"				
FINE TO MED. SAND.	GREY	LOOSE		12	S.S.	4	"
			59' 0" 578.5				
FINE SAND AND PEBBLE GRAVEL INTERBEDDED WITH STRATIFIED SILTY CLAY.	GREY AND REDDISH-BROWN	COMPACT AND SOFT		13A 13B	S.S.	29 19/6"	"
FINE TO COARSE SAND AND GRAVEL UP TO 3/4" SIZE.							
AS ABOVE, SOME CLAY STRATA	BROWNISH-GREY			14	W.S.		
			64' 6" 573.0				
STRATIFIED SILTY CLAY	GREY, WITH REDDISH-BROWN TRACES,	FIRM.		15A 15B	S.S.	6 4/6"	Q_u = APPROX. 0.35 T.S.F. NAT. M.C = 43.5%
AS ABOVE, NUGGETTY TEXTURE.	GRADING TO REDDISH-BROWN			16	2" S.L.	PUSHED	MUCH WETTER THAN PLASTIC LIMIT WHEN REMOULDED.
			70' 0"	17A 17B	S.S.	8 4/6"	←NAT. M.C. = 63.5%.
STRATIFIED SILTY CLAY		FIRM.		18	2" S.T.	PUSHED (16) (15)	Q_u = 740 P.S.F. NAT. M.C. = 70.9%
	REDDISH-		75' 0" 562.5				BECOMES VERY PLASTIC
STRATIFIED SILTY CLAY, NUGGETTY TEXTURE.	BROWN, 1/8" GREY STRATA.	FIRM.		19A 19B	S.S.	8 4/6"	WHEN REMOULDED. MUCH WETTER THAN PLASTIC LIMIT
	REDDISH-		80' 0"				
AS ABOVE.	BROWN, 1/4" THICK GREY STRATA.	FIRM.		20A 20B 20C	S.S.	5 3/6"	AS ABOVE. Q_u = APPROX. 0.3 TSF NAT. M.C. = 47.2 %.
GRADING TO			83' 6" 554.0	21	2" S.T.	PUSHED	SATURATED.
SILT, MINOR CLAY CONTENT. OCCASIONAL SEAMS OF VERY FINE SAND.	GREY	COMPACT		22	S.S.	16 8/6"	SATURATED.
			90' 0"				
AS ABOVE	"	"		23	S.S.	14 8/6"	" NAT. M.C. = 26.0
			95' 0"				
SILTY VERY FINE SAND	BROWNISH-GREY	COMPACT		24	S.S.	21 13/6"	SATURATED.
SILTY VERY FINE TO COARSE SAND.	" "			25	W.S.		
			100' 0"				
VERY FINE SANDY SILT.	GREY.	COMPACT		26A 26B	S.S.	82 12/6"	"
SILTY VERY FINE SAND AND PEBBLE GRAVEL.	BROWNISH-GREY.	TO DENSE.	101' 6" 536.0				6'9" OF SAND BACKED UP IN CASING OVERNIGHT FROM 100-FT. DEPTH.
	REDDISH-	VERY	105' 0"				
FINE TO MEDIUM SAND.	GREY.	DENSE		27	S.S.	68 30/6"	SAND CONTINUALLY BACKED UP IN CASING
FINE SAND	" "	DENSE		28	W.S.	42	BELOW 100', AND ALL PENETRATION TESTS
			110' 0" 527.5				BELOW THIS DEPTH ARE
" "	REDDISH-GREY.	" "		29	W.S.	38	UNRELIABLE.
FINE TO COARSE SAND				30	W.S.	36	
			115' 0"				
FINE TO MEDIUM SAND	" "	"		31	W.S.	10	
MEDIUM TO COARSE SAND	DARK GREY	"		32	W.S.	47	TRIAXIAL COMPRESSION TEST ON SAMPLES 16A & B: COHESION, C = 360 P.S.F., ϕ = 1°, NAT. M.C. = 27.8%
" " " "	" "	"	121' 0" 516.5	33	W.S.	48	SAMPLES 16B & C: COHESION, C = 900 P.S.F., ϕ = 1°, NAT. M.C. = 41.5%-62.7%
			HOLE TERMINATED				