

Mr. A. M. Toya,

September 30, 1960.

Bridge Engineer.

FOUNDATION INVESTIGATION REPORT

Materials & Research Section.

by: H. G. Acres & Company, Limited.

Attention: Mr. S. McCosbie.

Re: Proposed Crossing Hwy. 401, Service Road and
Wood Creek, Township of Lancaster, District 9
W.P. 188-60.

Attached we are forwarding to you the report for the
above mentioned foundation investigation submitted by H. G.
Acres & Co., Ltd.

We have reviewed the report, and on the basis of the
presented factual data and information, we agree with the
conclusions and recommendations contained therein.

We believe that the given recommendations will prove
to be adequate for your future design work. However, should
there be any other questions in connection with the above
project that you would like to discuss, please feel free to
call on our Office.

L. G. Soderman,
PRINCIPAL FOUNDATIONS ENGR.
Per:

Attorney

(A. Stermac,
FOUNDATIONS OFFICE ENGR.)

AM/MSF
Attach.

cc: Messrs. A. M. Toya (2)
R. A. Tregaskes
D. G. Ramsay
J. Ford
L. E. Walker
J. S. Grunpion
A. Watt
Foundations Office
Gen. Files.

ONTARIO DEPARTMENT OF HIGHWAYS
Toronto, Ontario

REPORT
on
FOUNDATION CONDITIONS

PROPOSED CROSSING
HIGHWAY 401 SERVICE ROAD AND WOOD CREEK
TOWNSHIP OF LANCASTER, DISTRICT NO. 9
WP 188-60

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ONTARIO DEPARTMENT OF HIGHWAYS
Toronto, Ontario

REPORT
on
FOUNDATION CONDITIONS

PROPOSED CROSSING
HIGHWAY 401 SERVICE ROAD AND WOOD CREEK
TOWNSHIP OF LANCASTER, DISTRICT NO. 9
WP 188-60

Introduction

This is a report on the foundation conditions at the proposed Highway 401 service road bridge crossing of Wood Creek in Lancaster Township.

Soil explorations were carried out by H.G. Acres & Company Limited to determine the foundation conditions for the bridge and its approach embankment. A plan of the site is shown on Plate I.

The F.E. Johnston Drilling Company Limited performed the drilling and soil sampling operations, and Mr. R.J. Conlon of H.G. Acres & Company Limited supervised the work. The field work commenced on July 8, 1960, and was completed on July 19, 1960. Laboratory testing of the soil samples was completed in August 1960.

The results of the field and laboratory work are presented in this report, together with our interpretations and recommendations.

Geology of the Site

The site of the proposed crossing is in a very flat lowland plain which extends about eight miles back from the St. Lawrence River. The area is underlain by limestone bedrock at an underermined depth. During glacial times the bedrock surface was covered with a variable thickness of till. This till is composed mainly of sand and gravel with many large boulders. After the glaciers retreated, the area was inundated by the Champlain Sea and, in this marine environment, the till was buried beneath deposits of fine sand, silt and clay. Subsequent uplift has resulted in the present non-marine environment. Weathering and desiccation have developed a stiff crust about ten feet thick on the marine deposit.

Wood Creek, a meandering stream only about four feet deep, has cut its channel in the crust of the marine deposit. The stream is bounded by intermittent marshy areas. It is doubtful if the stream ever was much larger because there are no indications that any characteristic stream deposits exist.

Exploratory Work

Two diamond drills were used in the exploration work. Borings were made on both sides of Wood Creek and in the stream bed. For the borings in the stream bed, one of the drills was mounted on a raft.

In the marine deposit, the wash boring method was employed and BX casing was used to advance the hole. Two-inch diameter Shelby tube samples were taken at 6-foot intervals after the general soil profile had been established by sampling at 4-foot intervals in the initial hole (No. 893-1) of the adjacent work project (WP 117-59). Where possible, in situ vane tests were performed 18 inches below the lower elevation of the Shelby tube samples, immediately after the samples were removed.

When the till was encountered, standard penetration tests were performed and the split-spoon samples were retained. When boulders were encountered, the BX casing could not be advanced; under these circumstances, hole (No. 893-1) of the adjacent work project (WP 117-59) was advanced by diamond drilling with AX casing nine feet through a succession of boulders but bedrock was not encountered. All holes on this work

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project were stopped when they reached boulders or when the casing could not be advanced in the dense till without causing damage to it.

A total of five holes were drilled and sampled, and in each of these, vane tests and ground water observations were made.

The program of work is given in Appendix A.

Site Conditions and Soil Properties

The site investigated is in a very flat lowland plain. The general ground surface elevation is approximately 156 feet. The land is used mostly for pasture or is brush covered. It is poorly drained with only a 1 open ditches to carry surface water to Wood Creek. The creek surface elevation is approximately 152.2 feet.

The materials which were encountered in the exploratory holes are described in the attached drilling reports, Plates II to VI, inclusive. The soil conditions are quite uniform in horizontal extent except for the variable elevation of the surface of the till.

(a) - Clay Crust - This is the stiff, weathered and desiccated layer of the marine clay deposit. The crust has a variable thickness as shown on Plate I. However, the transition to the underlying deposit is at

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a uniform elevation of approximately 147 feet. Therefore, the crust does not exist in the stream bed.

Within this layer, the soil has the following average properties:

Liquid limit	=	69 per cent
Plastic limit	=	32 per cent
Water content	=	42 per cent

Vane tests were not performed because this soil was too stiff to fail by this means. The natural undrained shear strength, determined from laboratory compression tests, decreases from approximately 2,500 psf at an elevation of 149 feet to approximately 850 psf at an elevation of 146 feet. The sensitivities at these two elevations are 3.7 and 20, respectively.

(b) - Clay - This deposit is known as the Leda Clay, and generally appears homogeneous although some samples do show stratification when dried. The depth of this deposit varies because of the irregular surface of the underlying glacial till shown on Plate I.

From the samples obtained, this clay was found to have the following average properties:

Liquid limit	=	78 per cent
Plastic limit	=	27 per cent
Water content	=	77 per cent

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The natural undrained shear strength was measured by means of field vane tests and laboratory compression tests. It was found that the compression test results generally combined low strengths and high values of failure strain as shown on Plate IX, whereas it is known that this type of clay, if undisturbed, should fail at very low values of strain. Therefore, it is considered that results which display high failure strains are indicative of sample disturbance. The tests in which failure occurred at strains of 2 to 3 per cent indicate relatively undisturbed samples, and in these cases the shear strengths obtained agree closely with the vane test results. The average natural undrained shear strength obtained from the vane tests is approximately 850 psf.

The results of the laboratory tests are summarized in Appendix B and shown graphically on Plates IX and X. The results of the field vane tests are summarized in Appendix C and shown graphically on Plate X.

The maximum sensitivity of this clay indicated by the field vane tests is 6.7, but experience has shown that sensitivities measured by this method are generally lower than those measured in the laboratory. Unfortunately, when remoulded in the laboratory, the soil was too soft to test with the conventional equipment available and,

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for this reason, the sensitivity could not be determined. It has been suggested, however, that the sensitivity of this material exceeds 100⁽¹⁾.

Consolidation tests were run on this clay on samples taken from the adjacent work project (WP 117-59), and the "p-e" curves are presented on Plates VII and VIII. From these data, it may be deduced that the clay has experienced overconsolidation even below the crust. The curves for the clay have the shape characteristic of sensitive soil and once the preconsolidation pressure is exceeded, this clay is very compressible. The apparent preconsolidation pressures have been estimated and the results are summarized on Plate X. Sample disturbance reduces the value of apparent preconsolidation pressure, and because the laboratory compression tests have indicated that many of the samples were disturbed, the estimates of preconsolidation pressure are probably low.

(c) - Silt - A layer of silt from 0.5 to 4.0 feet thick was encountered beneath the clay in holes Nos. 894-1, 894-3, and 894-5. Since it was not observed in

(1) Eden, W.J. and Crawford, C.B. 1957. "Geotechnical Properties of Leda Clay in the Ottawa Area" Proc. 4th International Conference on Soil Mechanics, Vol. I. pp. 22 to 27.

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the other borings, it probably is not continuous. Vane tests in this material indicate a lower value of natural undrained shear strength than in the clay. It is believed, however, that these low strength values are a result of high water pressures transmitted from the underlying till rather than the natural consistency of the silt layer. This hydrostatic pressure condition is more fully discussed in a subsequent section dealing with ground water conditions.

(d) - Sand and Gravel Till - This till is a heterogeneous deposit of sand and gravel with some silt and clay. In general, it is of medium density as indicated by the N-values obtained from the standard penetration tests. It contains many large boulders. An outcrop of the till about one mile from the site was examined; here the boulders were as much as 6 feet in diameter. Hole No. 393-1 of the adjacent work project (WP 117-59) was advanced through the sand and gravel till 5 feet until a boulder was encountered, the hole was then continued 9 feet by drilling through a succession of boulders, but bedrock was not encountered. Because the drilling proved the existence of large boulders, it was considered impractical to support the foundation of the proposed structure on

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bedrock, and all other exploratory holes were discontinued when boulders were encountered. The cores from the drilling of the boulders in hole No. 893-1 indicated the boulders to be limestone.

(e) - Ground Water Conditions - The elevation of the free ground water surface in the clay and clay crust is probably about the elevation of the surface of Wood Creek. There are indications, however, of an excess hydrostatic pressure in the underlying sand and gravel till, and the observations supporting this conclusion are presented on the boring reports. The most significant evidence was obtained from hole No. 893-1 of the adjacent work project (WP 117-59). After this hole was completed and before the casing was removed, the water level rose to an elevation of 155.6 feet, which is 3.4 feet above the surface of Wood Creek. After water had been pumped from this hole continuously for one-half hour, the level returned immediately to an elevation of 155.6 feet. This indicates a permeable aquifer as well as the excess hydrostatic pressure.

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Design Considerations(a) - Bearing Capacity

Road Embankment - The maximum height of the road embankment is approximately 5 feet, and the load due to this embankment is 650 psf. If the shear strength of the subsoil is taken as 850 psf, the bearing capacity beneath the embankment is at least 4,400 psf, without considering an increase due to the surface crust. Therefore, the factor of safety against a bearing capacity failure beneath the embankment is greater than 6.5.

Bridge Piers - One method of supporting the bridge would be with spread footings. The net bearing pressure for a shallow footing on clay is given by the following expression:

$$q_{net} = 5 \left(1 + 0.2 \frac{D}{B} \right) \left(1 + 0.2 \frac{B}{L} \right) S_u$$

where: q_{net} denotes the net bearing capacity of the foundation soil.

D denotes the depth of the base of the footing below the surface of the overburden.

B denotes the footing width.

L denotes the footing length.

S_u denotes the natural undrained shear strength of the foundation soil.

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The base of the footings would be located where the crust is thin or non-existent and, therefore, an average value of shear strength of 850 psf would be applicable. In addition, to make allowance for the possibility of scour by the stream, the value of D has been assumed to be zero. Applying a factor of safety of 3 and a one-third reduction for eccentric loading, the allowable uniformly distributed bearing pressure can be calculated. A chart giving the allowable bearing pressures for all shapes of footings is presented on Plate XI.

The bridge will be approximately 110 feet long and 30 feet wide. Even if a centre pier were used, the total load on it would be approximately 750 kips, and would require a footing having the impractical dimensions of 30 feet by 23 feet. The allowable bearing pressure would be 1,090 psf as shown on Plate XI.

The alternative to spread footings for the support of the bridge piers is bearing piles driven to refusal in the coarse till underlying the marine clay. However, due to the high sensitivity of the clay, a non-displacement type pile such as cast-in-place concrete piles or steel piles should be used.

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The cast-in-place piles and the steel pipe piles would require the use of a steel casing. In one type, a casing is advanced and the soil cleaned out of the casing simultaneously. In the other type, the casing is driven open ended and cleaned out subsequent to completion of driving. If the latter type were used at this site, it would be necessary to clean out the casing when it had been advanced through the crust in order to prevent the crust from plugging the casing, thereby converting it into a full displacement type pile. Such a pile might best be placed by drilling an uncased hole through the crust prior to driving the casing. The existence of hydrostatic pressure in the continuous aquifer of sand and gravel till might result in a blowout in the bottom of the hole if either of these preceding types were used. In order to prevent such a blowout, the holes would have to be kept full of water and the concrete placed by displacement of the water. Such a method always leaves some doubt concerning the condition of the bottom of the pile.

Steel H-piles have very small displacements, and their installation and performance would not be affected adversely by the existing ground water conditions.

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It might be difficult, however, to develop the full capacity of such a pile in the sand and gravel till. Some piles might come to rest on large boulders, whereas others would be driven to refusal in the sand and gravel till. Therefore, the capacities of adjacent piles would probably vary markedl. It is impossible to predict accurately the capacities of these piles and it would be uneconomical to load test each of them. However, H-piles driven to a refusal of one-quarter inch per blow with a 15,000-foot pound hammer could develop a working capacity of approximately 50 tons.

(b) - Settlement

Road Embankment - The maximum height of the road embankment is approximately 5 feet. On the basis of the laboratory consolidation tests, the apparent preconsolidation pressure of the marine clay has been estimated. Due to sample disturbance, these estimated values are probably low. However, the total applied pressure at any depth including the embankment and the existing overburden will not exceed these estimated values of preconsolidation. Therefore, only small elastic and consolidation settlements will occur, and these will take place primarily during placement of the embankment.

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Bridge Footings - Throughout the depth of the clay layer, the overburden pressure plus the pressure due to the 30-foot by 23-foot spread footing does not exceed the apparent preconsolidation pressure of the marine clay. This would suggest that spread footings, if constructed, would be subject only to small elastic and consolidation settlements of the soil. However, this conclusion is dependent on the soil being undisturbed. The disturbance to the soil directly beneath the footing by construction operations might cause significant but incalculable settlements.

Conclusions

(a) - From the drilling work done at the site, the general soil profile consists of a surface deposit of marine clay varying in depth from 22 to 42 feet. The clay has a horizontal surface crust approximately 10 feet thick. Wood Creek has cut its channel through the surface crust. Beneath the marine clay is a coarse, granular till containing many large boulders. It is the irregular surface of this deposit that causes the variation in the thickness of the clay layer.

(b) - The properties of the foundation soils are summarized on Plates IX and X.

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(c) - The 5-foot high embankment approaching the bridge can be supported safely by the foundation soils. The settlement of the embankment foundation will be negligible.

(d) - Calculations using the undisturbed properties of the sensitive clay indicate that spread footings 30 feet by 23 feet could support the bridge structure. However, the size of these footings and the uncertainties about their performance on the sensitive clay make the use of spread footings inadvisable.

(e) - The bridge can best be supported by bearing piles of a non-displacement type. The use of H-piles would eliminate any ground water problems that might be encountered with open-ended piles, and would produce only very small displacement of the sensitive marine clay.

Recommendations

It is recommended that the bridge be supported on H-piles and that these be driven into the till to develop a capacity of approximately 50 tons per pile.

APPENDIX AProgram of Work

- July 6, 1960 - Diamond drills No. 1 and No. 2 arrived at the site and commenced work on the adjacent Highway 401 (WP 117-59).
- July 8, 1960 - Hole No. 894-1 was commenced.
- July 12, 1960 - Hole No. 894-1 was completed. Hole No. 894-2 was commenced.
- July 13, 1960 - Hole No. 894-2 was completed. Hole No. 894-3 was commenced.
- July 14, 1960 - Hole No. 894-3 was completed.
- July 15, 1960 - Hole No. 894-4 was commenced.
- July 18, 1960 - Hole No. 894-4 was completed. Hole No. 894-5 was commenced.
- July 19, 1960 - Hole No. 894-5 was completed.

Summary of Time

Work Type	No. of Holes	Total Length Feet	Total Time Hours
Modified wash boring ...	5	202.5	47-3/4

APPENDIX BSummary of Laboratory
Test Results

Hole No.	Sample No.	Elevation Feet	Water Content %	Liquid Limit %	Plastic Limit %	S _u _n Psf	e _f %	S _u _r Ksf	St
894-2	1	149	42.2	-	-	2670	6.0	861	3.1
	2	145	70.1	73.6	25.4	771	2.0	39	19.8
	4	139	75.5	81.7	30.2	886	3.0	B48*	-
894-3	1	144	86.4	77.7	25.9	349	7.5	B17	-
	2	138	79.8	74.9	25.4	514	6.0	-	-
	3	132	78.6	80.0	28.0	528	7.0	-	-
	5	147	37.5	-	-	509	7.5	-	-
894-5	1	149	48.3	-	-	2325	5.0	535	4.4
	2	145	76.0	-	-	575	6.0	-	-
	3	139	72.9	-	-	810	3.5	-	-

e_f - Failure strain.S_u_r - Remoulded undrained shear strength.S_u_n - Natural undrained shear strength.

St - Sensitivity.

B48 - Number of shocks in liquid limit device.

* When a remoulded sample was too soft for a compression test, the number of shocks in the liquid limit device at natural water content is given.

APPENDIX CSummary of Field Vane
Test Results

<u>Hole No.</u>	<u>Elevation Feet</u>	<u>Undrained Shear Strength Psf</u>		<u>Sensitivity</u>
		<u>Natural</u>	<u>Remoulded</u>	
894-1	145.1	870	130	6.7
	138.4	953	240	4.0
894-2	142.0	1140	305	3.7
	136.0	777	185	4.2
	130.0	833	185	4.8
	124.0	907	206	5.1
	117.5	567	130	4.4
894-3	142.2	555	314	1.8
	134.7	907	277	3.3
	128.7	878	148	5.9
	119.7	462	111	4.2
894-4	144.4	842	185	4.5
	138.4	796	139	5.7
894-5	142.9	943	240	3.9
	136.9	713	194	3.7
	126.9	962	259	3.7

APPENDIX D

List of Plates

- Plate I - Exploratory Holes, Plan and Section.
- Plate II - Drilling Report, Hole No. 894-1.
- Plate III - Drilling Report, Hole No. 894-2.
- Plate IV - Drilling Report, Hole No. 894-3.
- Plate V - Drilling Report, Hole No. 894-4.
- Plate VI - Drilling Report, Hole No. 894-5.
- Plate VII - Consolidation Test, Hole No. 893-1
Sample Elevation 142.0 Feet.
- Plate VIII - Consolidation Test, Hole No. 893-1
Sample Elevation 130.0 Feet.
- Plate IX - Summary of Drilling and Testing Results -
Laboratory Tests.
- Plate X - Summary of Drilling and Testing Results -
Comparison of All Tests.
- Plate XI - Footing Design Chart.

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 894

PROJECT WP 188-60

HOLE No. 894-1

SITE Highway 401 and Wood Creek Service Road, Lancaster Twp.

SHEET No. 1 OF 2

CONTRACTOR F.E. Johnston Drilling
Company Limited

STARTED 10.00 AM

July 8, 1960

FINISHED 9.30 AM

July 12, 1960

METHOD OF SOIL Modified Wash Boring

CASING DIAM. BX

ROCK Diamond Drill

CORE DIAM.

LOCATION: ~~Chainage~~ Chainage 41-10

ELEVATIONS: DATUM GSC

DEPARTURE On Centreline

DRILL PLATFORM

BEARING

GROUND SURFACE 157.1

INITIAL DIP 90 degrees

ROCK SURFACE

OTHER DIPS

BOTTOM OF HOLE 111.6

WATER TABLE 154.6**

DEPTH	SOIL TYPE	DESCRIPTION, COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	S A M P L E					PENETRATION TEST
			NO.	TYPE	SIZE	DEPTH	RETD	
Feet					In.	Ft	In.	Blows
0	Silty Clay	Mottled, grey brown, stiff	1	BC	2	5.0		
						6.5	18	Driven
9.5	Clay	Blue grey, homogeneous, soft to medium	2	BC	2	9.0		
						10.5	18	Bar Pushed
					Vane Test	12.0		
		blending to pinkish grey and then blue grey again between 15 and 16 feet	3	BC	2	15.2		
						16.7	18	Bar Pushed
					Vane Test	18.7		
			4	BC	2	21.5		
						23.0	18	Pushed
					Vane Test	25.5		
			5	BC	2	27.5		
						29.0	18	Pushed
					Vane Test	31.0		

SAMPLING METHOD

- A - SPLIT TUBE
- B - THIN WALL TUBE
- C - PISTON SAMPLER
- D - CORE BARREL

- E - AUGER
- F - WASH

SHIPPING CONTAINER

- N - INSERT
- O - TUBE
- P - WATER CONTENT TIN
- Q - GLASS JAR

- R - CLOTH BAG
- S - PLIOPILM BAG
- Z - DISCARDED

INSPECTOR J. Bateson

APPROVED

B. H. MacDonald

LOGGED BY R.J. Gordon

DATE

July, 1960

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 894

PROJECT WF 188-60

HOLE No. 894-1

SITE Highway 401 and Wood Creek Service Road, Lancaster Twp.

SHEET No. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION COLOUR CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTION, WATER LOSS OF CLAY, ETC.	SAMPLE					PENETRATION TEST
			NO.	TYPE	SIZE	DEPTH	DEPTH	
Feet					In.	Ft.	In.	Blows
33.5	Sandy Silt	Grey, medium consistency containing some clay	6	AQ	2	33.5		7
						34.0		9
34.0	Sand and Gravel	Grey, heterogeneous, medium density with some silt and clay				35.0	6	28
			7	AQ	2	43.5		10
						44.0		11
						44.5		18
45.5	Boulder	End of hole				45.0	6	
<p>* <u>Penetration Test</u> The value given is the number of blows of a 140-lb weight falling freely 30 inches required to advance the standard split-spoon sampler 6 inches to the depth indicated.</p>								
<p>** <u>Water Table</u> The elevation given was the equilibrium elevation of the ground water in the test hole after the hole was complete and the casing removed.</p>								

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 894

PROJECT WF 188-60

HOLE No. 894-1

SITE Highway 401 and Wood Creek Service Road, Lancaster Twp.

SHEET No. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION COLOUR CONSISTENCY, LIQUID LIMIT, WATER CONTENT, PLASTICITY, COMPACTION, WATER LOSS, ETC.	SAMPLE					PENETRATION TEST
			NO.	TYPE	SIZE	DEPTH	DEPTH	
Feet					In.	Ft.	In.	Blows *
33.5	Sandy Silt	Grey, medium consistency containing some clay	6	A2	2	33.5		
						34.0		7
						34.5		9
34.0	Sand and Gravel	Grey, heterogeneous, medium density with some silt and clay				35.0	6	28
			7	AQ	2	43.5		
						44.0		10
						44.5		11
						45.0	6	18
45.5	Boulder	End of hole						
<p><u>Penetration Test</u> The value given is the number of blows of a 140-lb weight falling freely 30 inches required to advance the standard split-spoon sampler 6 inches to the depth indicated.</p>								
<p><u>** Water Table</u> The elevation given was the equilibrium elevation of the ground water in the test hole after the hole was complete and the casing removed.</p>								

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT **Ontario Department of Highways**

JOB No. **894**

PROJECT **MI 188-40**

HOLE No. **894-2**

SITE **Highway 401 and Wood Creek Service Road, Lancaster Twp.**

SHEET No. **1** OF **2**

CONTRACTOR: **F.E. Johnston Drilling
Company Limited**

STARTED **1.00 P.M. July 12, 1960**

FINISHED **2.45 P.M. July 13, 1960**

METHOD OF DRILLING: SOIL **Modified wash boring**
ROCK **Diamond Drill**

CASING DIAM. **8 1/2"**

CORE DIAM.

LOCATION: ~~188-40~~ **Chainage 32-30**
DEPARTURE On Centreline
BEARING
INITIAL DIP 90 Degrees
OTHER DIPS

ELEVATIONS: DATUM **OSC**
DRILL PLATFORM
GROUND SURFACE **155.0**
ROCK SURFACE
BOTTOM OF HOLE **108.0**
WATER TABLE **153.0 ****

DEPTH Feet	SOIL TYPE	DESCRIPTION COLOUR CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	S A M P L E					PENETRATION TEST Blows *
			NO.	TYPE *	SIZE In.	DEPTH Ft.	RETD In.	
0	Silty Clay	knitted, grey brown, medium to stiff	1	BC	2	4.0 5.5	12	Driven
7	Clay	Blue grey, homogeneous, soft to medium	2	BC	2	8.0 9.5	18	Pushed
					Vane Test	11.0		
		Bleeding to pinkish grey and then to blue grey again from 12 to 13 feet	3	BC	2	14.0 15.5	17	Pushed
					Vane Test	17.0		
			4	BC	2	20.0 21.5	18	Pushed
					Vane Test	23.0		
			5	BC	2	26.0 27.5	18	Pushed
					Vane Test	29.0		

SAMPLING METHOD

* A - SPLIT TUBE
B - THIN WALL TUBE
C - PISTON SAMPLER
D - CORE BARREL

E - AUGER
F - WASH

SHIPPING CONTAINER

N - INSERT
O - TUBE
P - WATER CONTENT TIN
Q - GLASS JAR

R - CLOTH BAG
S - PLIOFILM BAG
Z - DISCARDED

INSPECTOR **R.J. Condon**

APPROVED

D. H. MacDonald

LOGGED BY **R.J. Condon**

DATE

July, 1960

H. G. ACRES & COMPANY LIMITED - CONSULTING ENGINEERS
 NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 894

PROJECT WF 185-60

HOLE No. 894-2

SITE Highway 401 and Wood Creek Service Road, Lancaster Twp.

SHEET No. 2 OF 2

DEPTH Feet	NO. 1221	DESCRIPTION COLOUR COMPOSITION TEMPERATURE WATER CONTENT GRAIN SIZE S.W. FACTOR WATER LOSS GRAIN SIZE	SAMPLE					PENETRATION TEST Blows *
			NO.	TYPE	SIZE In.	DEPTH Ft.	BLD In.	
			6	BO	2	32.0 33.5	18	Pushed
				Vare	Test	35.0		
32.0	Silty Sand	Grey with some clay and dark limestone gravel, medium density	7	AQ	2	37.0 37.5 38.0 38.5	6	7 5
42.0	Sand and Gravel	Grey heterogeneous with some silt and clay dense	8	AQ	2	42.0 42.5 43.0 43.5	3	16 20 20
45.0	Boulder	End of hole						
		<p><u>* Penetration Test</u> The value given is the number of blows of a 140-lb weight falling freely 30 inches required to advance the standard split-spoon sampler 6 inches to the depth indicated.</p>						
		<p><u>** Water Table</u> After the hole was complete and the casing removed the water seeped out on the ground surface.</p>						

H. G. ACRES & COMPANY LIMITED - CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Ontario Department of Highways
 PROJECT: HP 100-60
 SITE: Highway 401 and Wood Creek Service Road, Lancaster Twp.
 CONTRACTOR: F.F. Johnston Drilling Company Limited
 METHOD OF DRILLING: SOIL Modified Wash Boring
 ROCK Diamond Drill
 LOCATION: ~~Station~~ Chainage 38+55
 DEPARTURE: On Centreline
 BEARING:
 INITIAL DIP: 90 degrees
 OTHER DIPS:
 JOB No. 894
 HOLE No. 894-3
 SHEET No. 1 OF 2
 STARTED: 9.00 A.M. July 13, 1960
 FINISHED: 8.30 A.M. July 14, 1960
 CASING DIAM. BX
 CORE DIAM.
 ELEVATIONS: DATUM GSC
 DRILL PLATFORM 153.2
 GROUND SURFACE 148.2
 ROCK SURFACE
 BOTTOM OF HOLE 116.2
 WATER TABLE 152.2**

DEPTH	SOIL TYPE	DESCRIPTION COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST
			NO.	TYPE *	SIZE	DEPTH	RET'D	
Feet					In.	Ft.	In.	Slows *
0		Water						
4	Clay	Blue grey, homogeneous, soft to medium	1	BC	2	7.0 8.5	15	Pushed
				Vane Test		10.0		
			2	BC	2	14.0 15.5	18	Pushed
				Vane Test		17.5		
			3	BC	2	20.0 21.6	18	Pushed
				Vane Test		23.5		
			4	BC	2	26.0 27.5	18	Pushed
30.0	Clayey Silt	Grey, homogeneous, soft to very soft		Vane Test		33.5		
34.0	Sand and Gravel	Grey, heterogeneous of medium density with some silt and clay						

SAMPLING METHOD

A - SPLIT TUBE
 B - THIN WALL TUBE
 C - PISTON SAMPLER
 D - CORE BARREL

E - AUGER
 F - WASH

SHIPPING CONTAINER

N - INSERT
 O - TUBE
 P - WATER CONTENT TIN
 Q - GLASS JAR

R - CLOTH BAG
 S - PLIOFILM BAG
 Z - DISCARDED

INSPECTOR: J. Bateson

LOGGED BY: R. Conlon

APPROVED

N. H. MacDonald

DATE

July, 1960

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
 NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 894

PROJECT WF 188-60

HOLE No. 894-3

SITE Highway 401 and Wood Creek Service Road, Lancaster Twp.

SHEET No. 2 OF 2

DEPTH Feet	SOIL TYPE	DESCRIPTION COLOUR CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTION, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST Blows *
			NO	TYPE	SIZE In.	DEPTH Ft	RED In.	
			5	AQ	2	35.5		
						36.0		53
						36.5		31
37.0	Boulder	End of hole				37.0	M1	6
<p>* <u>Penetration Test</u> The value given is the number of blows of a 140-lb weight falling freely 30 inches required to advance the standard split-spoon sampler 6 inches to the depth indicated.</p>								
<p>** <u>Water Table</u> The elevation given is the surface of Wood Creek.</p>								

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
 NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 894

PROJECT WF 188-60

HOLE No. 894-4

SITE Highway 401 and Wood Creek Service Road, Lancaster Twp.

SHEET No. 1 OF 2

CONTRACTOR: F.E. Johnston Drilling
 Company Limited

STARTED 4.00 P.M.

July 15, 1960

FINISHED 3.30 P.M.

July 18, 1960

METHOD SOIL Modified Wash Boring

CASING DIAM.

BX

OF DRILLING: ROCK Diamond Drill

CORE DIAM.

LOCATION: ~~136+05~~ Chainage 36+05

ELEVATIONS: DATUM OSC

DEPARTURE On Centreline

DRILL PLATFORM

BEARING

GROUND SURFACE 157.4

INITIAL DIP 90 Degrees

ROCK SURFACE

OTHER DIPS

BOTTOM OF HOLE 125.9

WATER TABLE

DEPTH	SOIL TYPE	DESCRIPTION COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST
			NO	TYPE *	SIZE	DEPTH	RET'D	
Feet					In.	Ft	In.	Blows *
0	Silty Clay	Mottled, grey brown, stiff to very stiff	1	BC	2	6.0		Bar
						7.5	13	Pushed
			2	X	2	10.0		
						11.5	14	Pushed
10.5	Clay	Blue grey, homogeneous, medium to soft			Vane Test	13.0		
		Blending to pinkish grey and then blue grey again 13 to 14 feet	3	BC	2	16.0		
						17.5	18	Pushed
					Vane Test	19.0		
22.0	Sand and Gravel	Grey, heterogeneous with some silt and clay, medium density	4	AQ		22.0		
						22.5		7
						23.0		3
						23.5	5	3
			5	AQ	2	26.0		
						26.5		10
						27.0		6
						27.5	6	6

SAMPLING METHOD

A — SPLIT TUBE
 B — THIN WALL TUBE
 C — PISTON SAMPLER
 D — CORE BARREL

E — AUGER
 F — WASH

SHIPPING CONTAINER

N — INSERT
 O — TUBE
 P — WATER CONTENT TIN
 Q — GLASS JAR

R — CLOTH BAG
 S — PLIOFILM BAG
 Z — DISCARDED

INSPECTOR R.J. Conlon

APPROVED

D. H. McDonald

LOGGED BY R.J. Conlon

DATE

July, 1960

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
 NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 894

PROJECT WP 188-60

HOLE No. 894-4

SITE Highway 401 and Wood Creek Service Road, Lancaster Twp.

SHEET No. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION COLOUR CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	S A M P L E					PENETRATION TEST
			NO.	TYPE	SIZE	DEPTH	SET D	BLOWS
Feet					In.	Ft	In.	
			6	AQ	2	30.0		
						30.5		28
						31.0		26
31.5		End of hole				31.5	5	16
<p>* Penetration Test</p> <p>The value given is the number of blows of a 140-lb weight falling freely 30 inches required to advance the standard split-spoon sampler 6 inches to the depth indicated.</p>								

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 894

PROJECT WP 188-60

HOLE No. 894-5

SITE Highway 401 and Wood Creek Service Road, Lancaster Twp.

SHEET No. 1 OF 2

CONTRACTOR: F.E. Johnston Drilling Company Limited

STARTED 3.30 P.M. July 18, 1960

FINISHED 3.00 P.M. July 19, 1960

METHOD OF DRILLING: SOIL Modified Wash Boring

CASING DIAM. BX

ROCK Diamond Drill

CORE DIAM.

LOCATION: LATITUDE Chainage 37+85

ELEVATIONS: DATUM GSC

DEPARTURE On Centreline

DRILL PLATFORM

BEARING

GROUND SURFACE 155.9

INITIAL DIP 90 Degrees

ROCK SURFACE

OTHER DIPS

BOTTOM OF HOLE 112.4

WATER TABLE

DEPTH Feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	S A M P L E					PENETRATION TEST Blows *
			NO	TYPE *	SIZE In.	DEPTH Ft	RET'D In.	
0	Silty Clay	Mottled, grey brown, stiff to very stiff	1	BC	2	6.0		Bar
						7.5	12	Pushed
10.0	Clay	Blue grey, homogeneous, soft to medium	2	BC	2	10.0		
						11.5	14	Pushed
		Blending to pinkish grey and then blue grey again 13 to 14 feet		Vane Test		13.0		
			3	BC	2	16.0		
						17.5	18	Pushed
				Vane Test		19.0		
			4	BC	2	26.0		
						27.5	18	Pushed
				Vane Test		29.0		
			5	BC	2	32.0		
						33.0	12	
33.0	Silt	Grey, medium density, with some sand, gravel and clay	6	AC	2	33.0		
						33.5		1
						34.0		8
						34.5	16	14

SAMPLING METHOD

* A — SPLIT TUBE
 B — THIN WALL TUBE
 C — PISTON SAMPLER
 D — CORE BARREL

E — AUGER
 F — WASH

SHIPPING CONTAINER

N — INSERT
 O — TUBE
 P — WATER CONTENT TIN
 Q — GLASS JAR

R — CLOTH BAG
 S — PLIOFILM BAG
 Z — DISCARDED

INSPECTOR R.J. Conlon

APPROVED

D. H. MacDonald

LOGGED BY R.J. Conlon

DATE

July, 1960

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
 NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 894

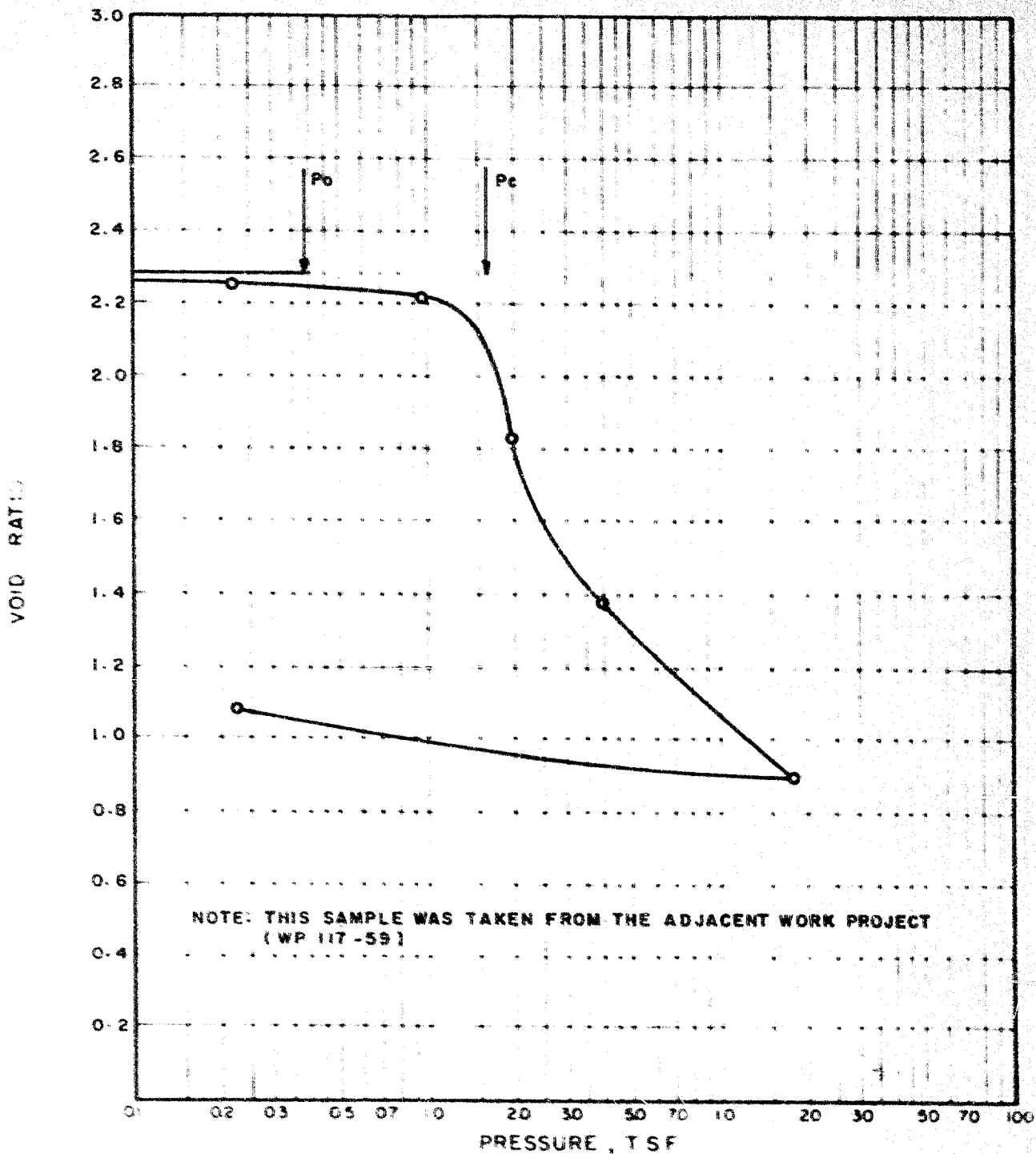
PROJECT WF 188-60

HOLE No. 894-5

SITE Highway 401 and Wood Creek Service Road, Lancaster Twp.

SHEET No. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	S A M P L E					PENETRATION TEST
			NO	TYPE	SIZE In.	DEPTH Ft	RET'D In.	Blows *
Feet								
34.5	Sand and Gravel	Grey, heterogeneous, medium density with some silt and clay	7	AZ	2	36.0 36.5 37.0 37.5		10 7 11
			8	AZ	2	42.0 42.5 43.0 43.5		16 31 13
43.5		End of hole					6	
* Penetration Test The value given is the number of blows of a 140-lb weight falling freely 30 inches required to advance the standard split-spoon sampler 6 inches to the depth indicated.								



OVERBURDEN PRESSURE - $P_0 = 0.39$ TSF
 CONSOLIDATION PRESSURE - $P_c = 1.62$ TSF

NATURAL WATER CONTENT 82.2%
 LOADING INTERVAL 100% PRIMARY CONSOLIDATION

SAMPLE No 893-80-3
 TEST No 893-9-1

TEST DATE AUGUST 17, 1960
 TESTED BY R.L.

H G ACRES & COMPANY LIMITED
 CONSULTING ENGINEERS
 NIAGARA FALLS CANADA

CONSOLIDATION TEST

ONTARIO DEPARTMENT OF HIGHWAYS

HOLE No 893-1 SAMPLE ELEV 142.0'

APPROVED

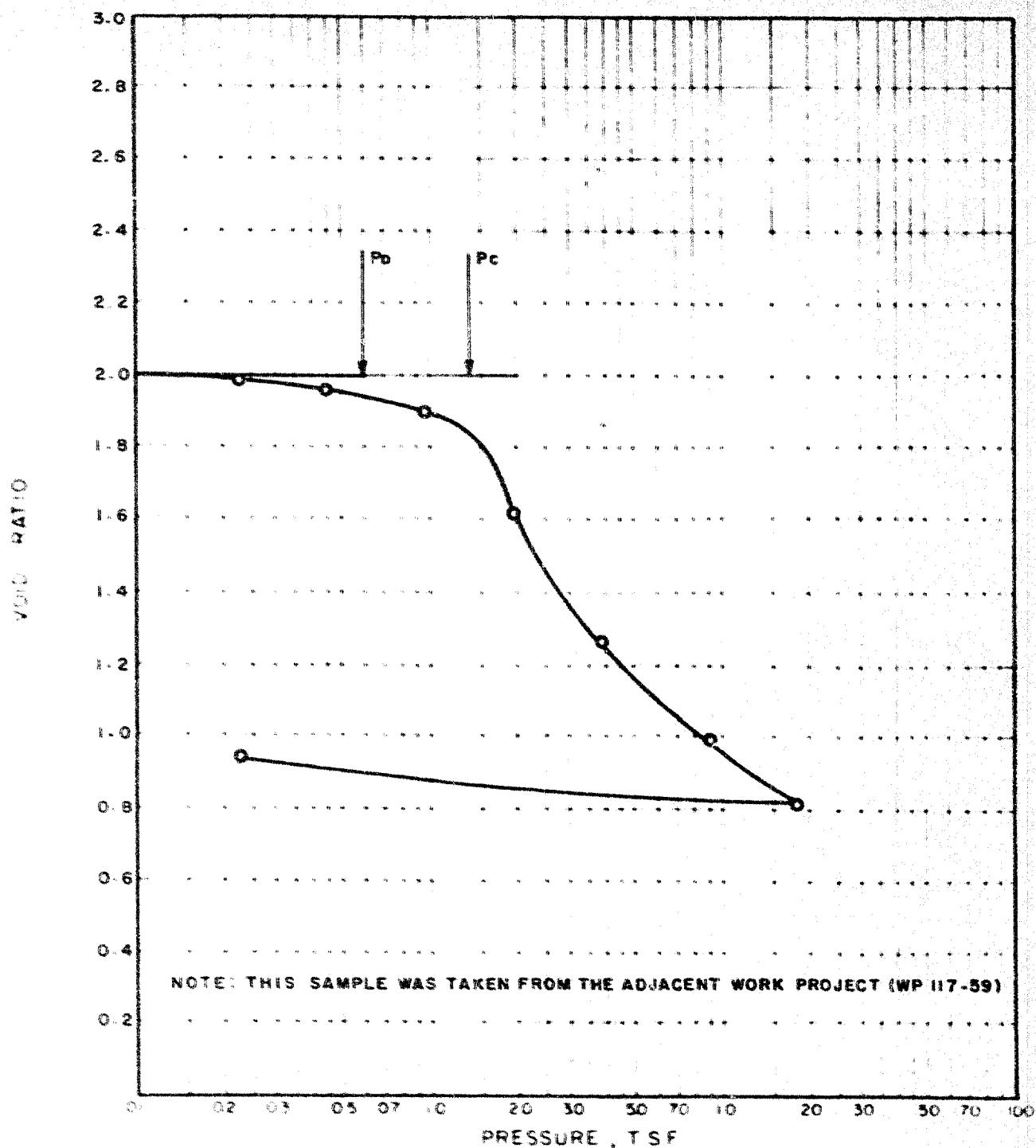
DATE AUGUST, 1960

A. H. MacDonald
 H G ACRES & COMPANY LTD

JOB No 894

PLATE - VII

WP - 188 - 60



OVERBURDEN PRESSURE - $P_0 = 0.60$ TSF

NATURAL WATER CONTENT 72.6 %

CONSOLIDATION PRESSURE - $P_c = 1.39$ TSF

LOADING INTERVAL 100% PRIMARY CONSOLIDATION

SAMPLE No 893-80-6

TEST DATE AUGUST 18, 1960

TEST No 893-9-2

TESTED BY R.L.

H. G. ACRES & COMPANY LIMITED
CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

CONSOLIDATION TEST

ONTARIO DEPARTMENT OF HIGHWAYS

HOLE No 893-1

SAMPLE ELEV 130.0'

APPROVED

DATE AUGUST, 1960

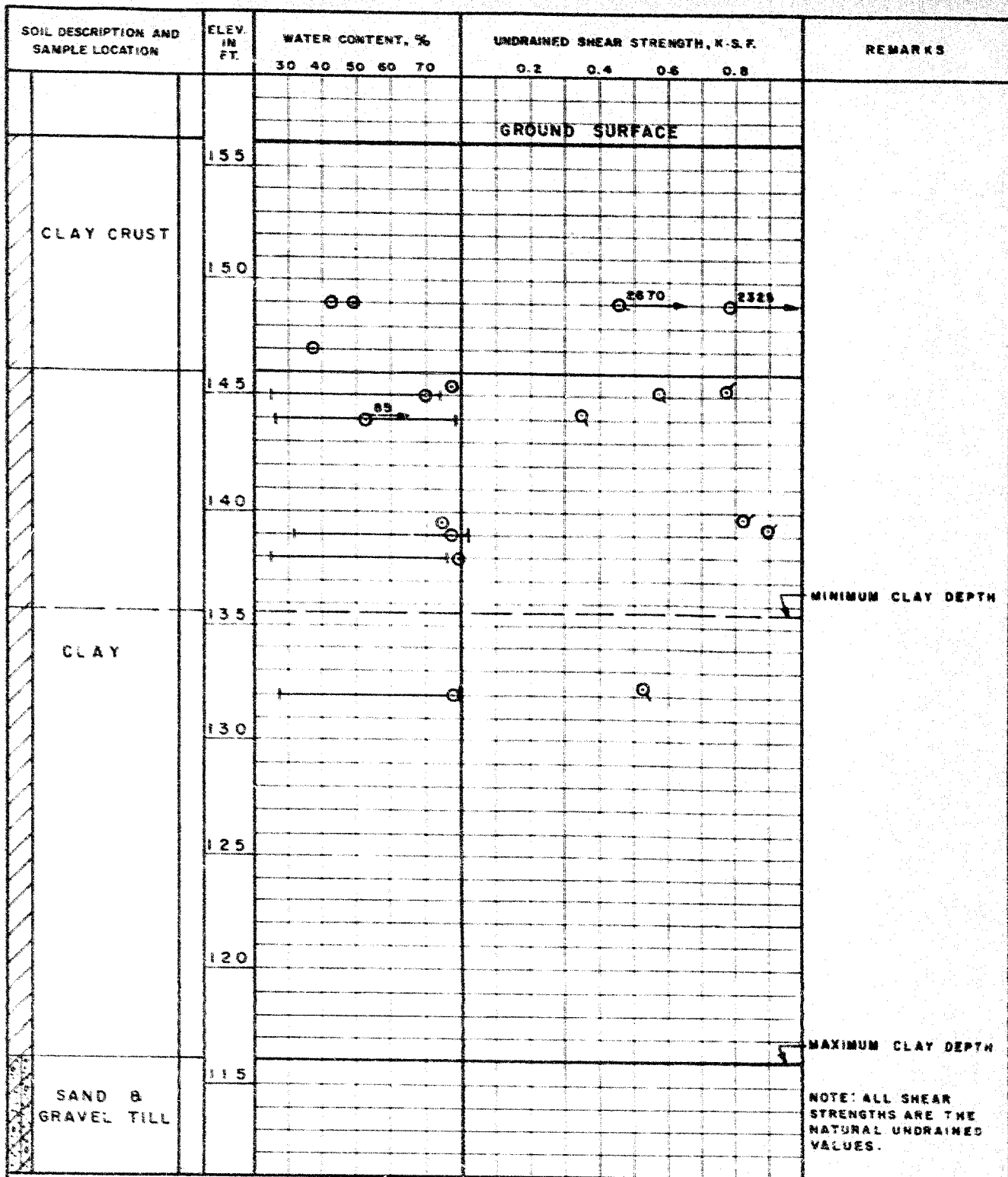
A. H. Macdonald
H. G. ACRES & COMPANY LTD

JOB No 894

PLATE - VIII

WP - 188 - 60

SK-894-L5-8



SOIL SAMPLE
 NATURAL WATER CONTENT
 LIQUID LIMIT
 PLASTIC LIMIT

UNDRAINED COMPRESSION TEST
 FIELD VANE TEST
 NATURAL STRENGTH
 REMOULDED STRENGTH

FAILURE STRAIN

H. G. ACRES & COMPANY LIMITED
CONSULTING ENGINEERS
NIAGARA FALLS CANADA

ONTARIO DEPARTMENT OF HIGHWAYS

W. P. 188-30

SUMMARY OF DRILLING AND TEST
RESULTS
LABORATORY TESTS

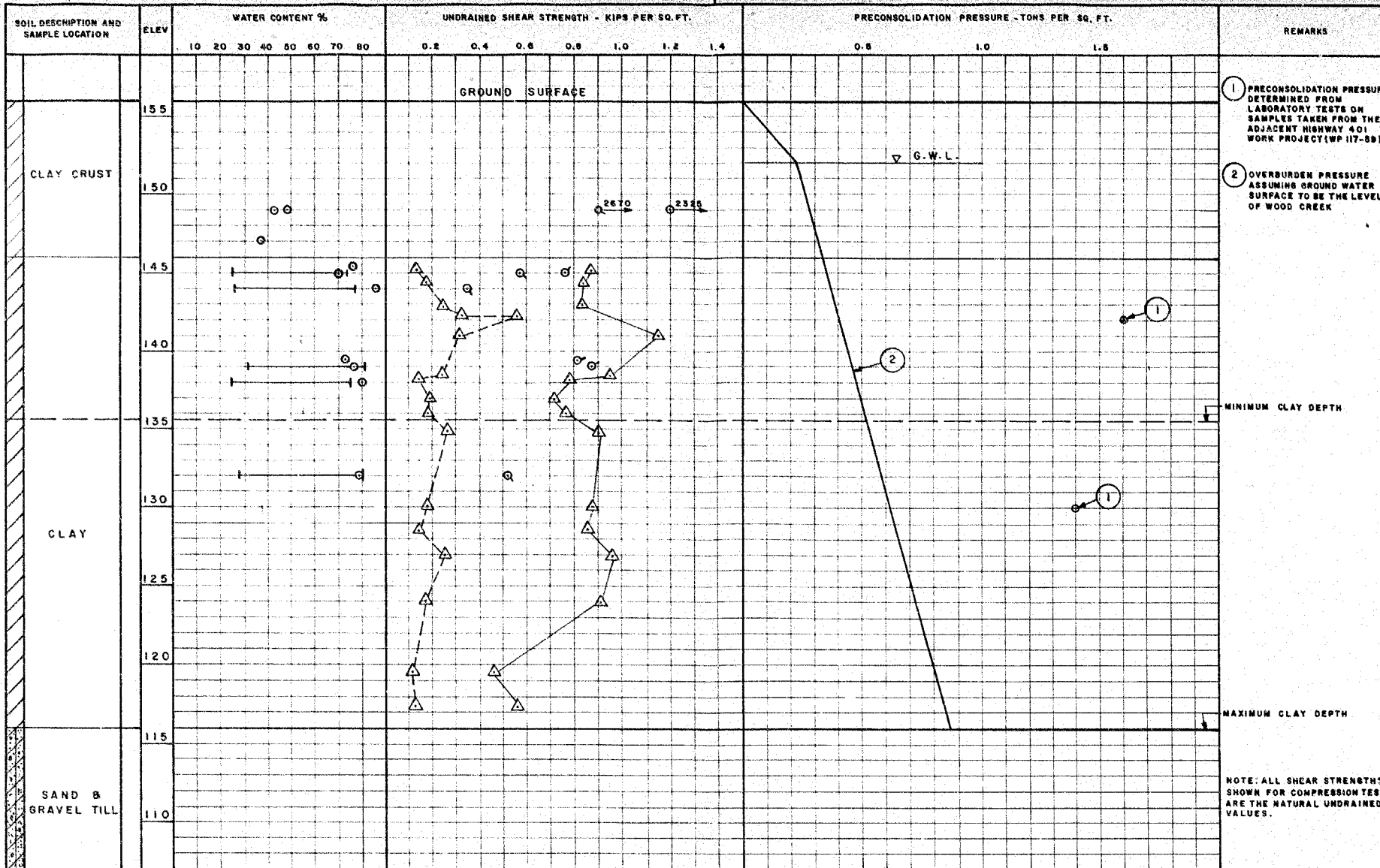
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H.G. ACRES & COMPANY LTD.

DATE: AUGUST, 1960

JOB No. 894

PLATE - IX



3 SOIL SAMPLE

○ NATURAL WATER CONTENT

— LIQUID LIMIT

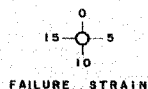
— PLASTIC LIMIT

○ UNDRAINED COMPRESSION TEST

△ FIELD VANE TEST

— NATURAL STRENGTH

--- REMOULDED STRENGTH



H. G. ACRES & COMPANY LIMITED
CONSULTING ENGINEERS
NIAGARA FALLS CANADA

ONTARIO DEPARTMENT OF HIGHWAYS

W.P. 188 - 60

SUMMARY OF DRILLING AND TEST RESULTS

COMPARISON OF ALL TESTS

APPROVED

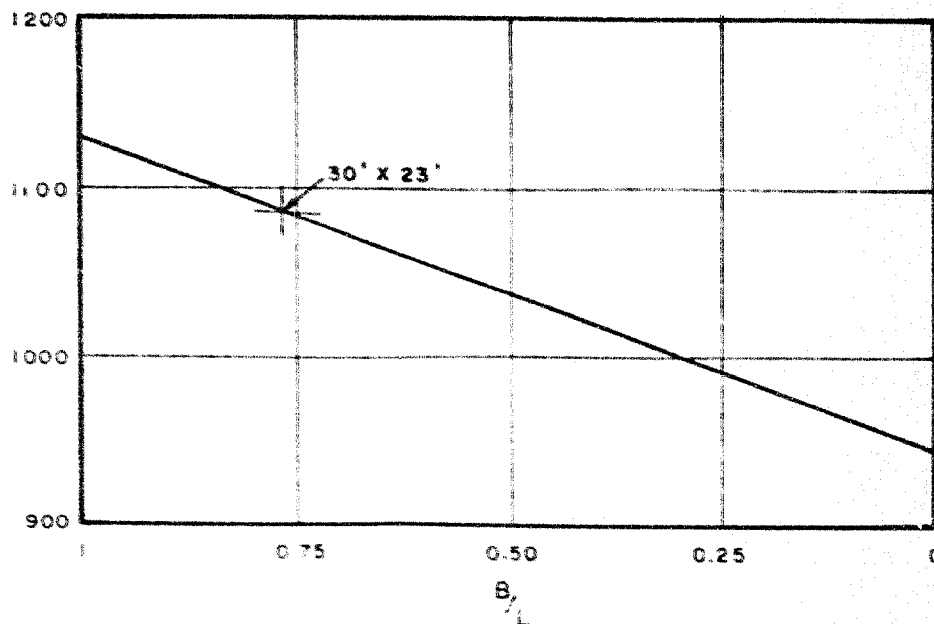
DATE: AUGUST, 1960

JOB No. 8 9 4

PLATE - X

A. H. MacDonald
H. G. ACRES & COMPANY LIMITED

ALLOWABLE UNIFORMLY DISTRIBUTED
BEARING PRESSURE, P.S.F.



NOTE:

B DENOTES FOOTING WIDTH

L DENOTES FOOTING LENGTH

H. G. ACRES & COMPANY LIMITED
CONSULTING ENGINEERS
NIAGARA FALLS CANADA

ONTARIO DEPARTMENT OF HIGHWAYS

WP 188 - 60

FOOTING DESIGN CHART

APPROVED

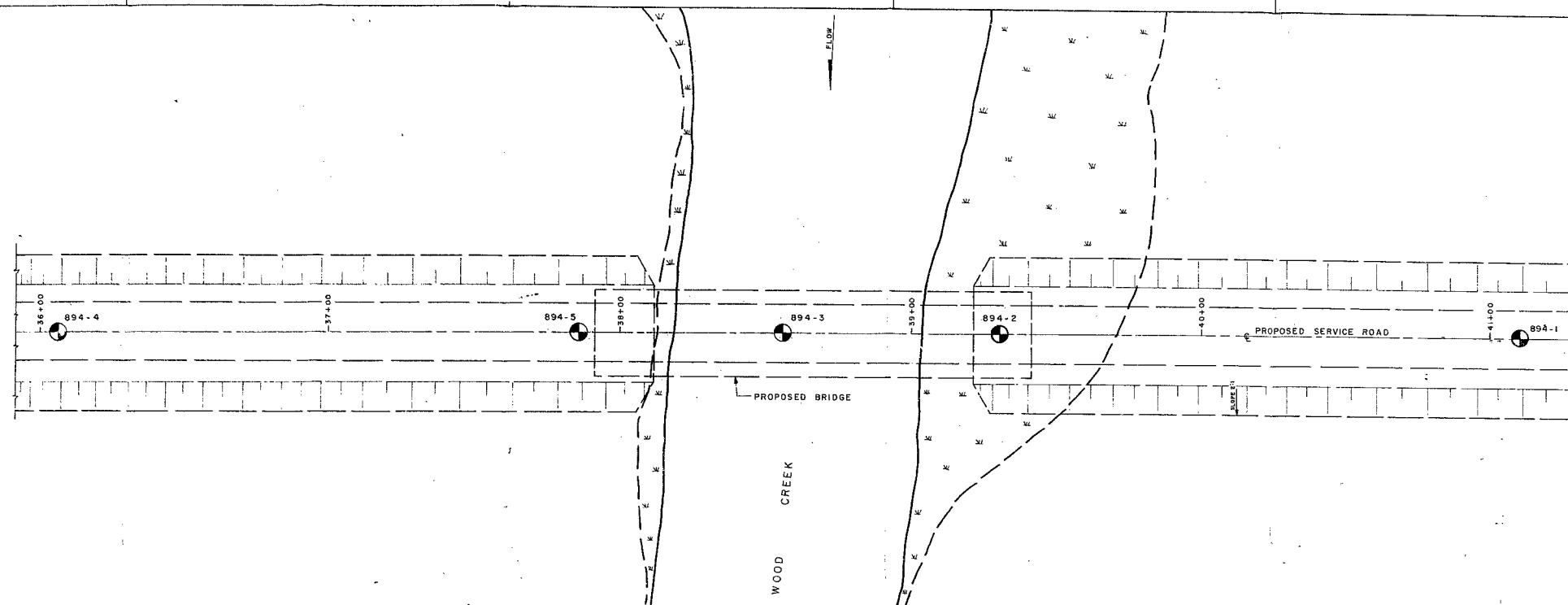
DATE: AUGUST, 1960

D. H. Lachance
H. G. ACRES & COMPANY LIMITED

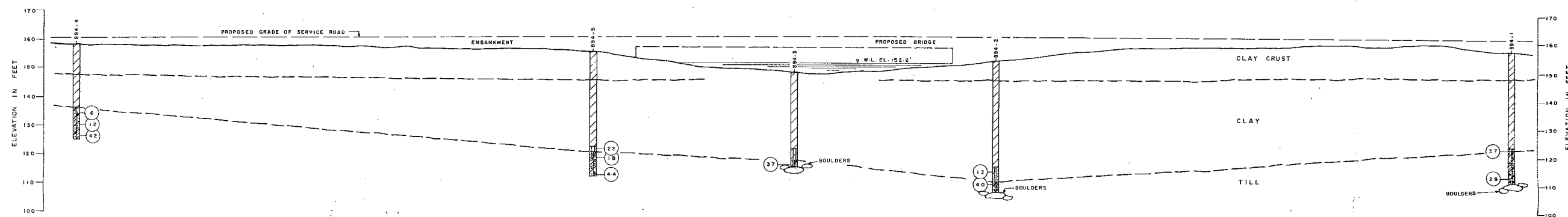
894

PLATE - XI

#60-F-212
W.P.#188-60
Hwy.#401
PROP. CROSSING
SERVICE RD.
E' WOOD CREEK
LANCASTER



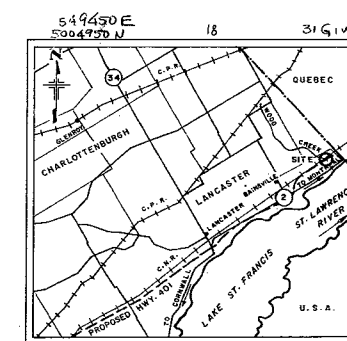
PLAN
SCALE: 1" = 20'-0"



SECTION ALONG C PROPOSED SERVICE ROAD
SCALE: 1" = 15'-0"

LEGEND

- | | | | |
|--|--------------|--|--|
| | ORGANIC SOIL | | WATER TABLE |
| | CLAY | | EXPLORATORY DRILL HOLE |
| | SILT | | SWAMP |
| | SAND | | BLOWS PER FOOT FOR STANDARD PENETRATION TEST |
| | GRAVEL | | |
| | BEDROCK | | |



KEY PLAN
SCALE: 1" = 4 MI.

H. G. ACRES & COMPANY LIMITED CONSULTING ENGINEERS NIAGARA FALLS, CANADA	
ONTARIO DEPARTMENT OF HIGHWAYS	
WP-188-60	
EXPLORATORY HOLES PLAN AND SECTION	
APPROVED <i>D. H. Macdonald</i>	DATE: AUGUST, 1963 SCALE: AS NOTED JOB NO. 894
PLATE - I	