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Bridge Division,
Materials & Research Division,
(Foundation Section)

August 1, 1962.

D.H.C. FOUNDATION INVESTIGATION
REPORT -
W.J. 61-F-118 -- W.P. (N11)

Attention: Mr. S. McCombie.

Re: Embankment Failures on Hwy.#3A,
County of Welland, District #4.

Attached, we are forwarding to you, our detailed foundation investigation report outlining the subsoil conditions at the above-mentioned site, as well as recommendations for the stability of the embankment.

We believe you will find the information contained in this report, adequate for your future design work. Should you require additional data, or clarification of the contents of this report, please do not hesitate to contact our Office.

KYL/MdeF
Attach.

cc: Messrs. A. M. Toye (2)
H. A. Tregaskes
H. D. McMillan
J. C. Thatcher
G. K. Hunter
L. Eadie
T. J. Kovich
J. Roy
J. E. Gruspier
E. H. Saint
F. Norman
Foundations Office ✓
Gen. Files.

KYH
K. Y. Lo,
SUPERVISING FOUNDATION ENGR.
For:
A. G. Stermac,
PRINCIPAL FOUNDATION ENGINEER.

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FOUNDATION INVESTIGATION

For

Embankment Failures on
Hwy. #3A, County of
Welland.
W.P. Nil -- W.J. 61-F-118
District #4.

1. INTRODUCTION:

The Foundation Section has been requested by the Hamilton District to investigate the slow and continual failure of the embankment of Highway #3A where it runs adjacent to the Welland River west of the City of Welland. This report contains the results of the field and laboratory investigation together with recommendations for remedial measures.

2. DESCRIPTION OF THE SITE AND GEOLOGY:

The site lies in the physiographic region known as the Haldimand Clay Plain. The subsoil consists of silts and clays deposited from Lake Warren on top of the glacial drift which overrides the bedrock of dolomite and shales. The Welland River meanders over this plain on its way to the Niagara River to the east.

3. FIELD AND LABORATORY INVESTIGATION:

The field work consists of 13 boreholes and one dynamic cone penetration test. The boreholes were put down

3. FIELD AND LABORATORY INVESTIGATION: (Cont'd.) ... using NX casing to depths varying from 20 feet in B.H. #5 to 77 feet in B. H. #6 using a skid-mounted machine and standard wash boring method. Continuous undisturbed sampling using 2.0 inch I.D. shelby tubes, was carried out in boreholes 2, 3 and 4 to a depth of 20 feet, in boreholes 1, 7, 8, 9 and 10 to 30 feet and in borehole 12 using 3 inch I.D. shelby tubes to a depth of 40.0 feet. In B.H. #3 in-situ vanes were carried out at 2 feet intervals to a depth of 34 feet below existing ground.

In particular five cross sections of the highway were investigated at chainages 26+53 B.H.'s 1 and 6, 28+20 B.H.'s 2 and 5, 32+56 B.H.'s 3 and 4, 32+84 B.H.'s 1, 8, 9 and 10 and 123+17 B.H.'s 11, 12 and 13.

A total of 10 piezometers were put down, 7 at the section at chainage 32+84 and three at the section at chainage 123+17. Piezometric water levels were observed during and after the investigation. A drawing showing the location and details of these piezometers are contained in this report.

To determine the location of the slip surface 5/8" I.D. black polythene tubing was installed at two sections where failure is presently in progress. The pipe was attached to a specially machined cone which was then driven 40 feet into the ground. A mandrel was designed

3. FIELD AND LABORATORY INVESTIGATION: (Cont'd.) ...

which fill to the bottom of the black pipe at the time of installation. With progressive failure the pipe closes at the failure zone preventing the passage of the mandrel thus locating the failure zone. The location of the black pipes together with the interpreted failure zone are shown on Dwg. #61-F-118A in this report.

The samples were returned to the laboratory where tests were carried out on selected representative samples to determine Atterberg limits and moisture content, density, particle size distribution and unconfined shear strength. In addition consolidated undrained triaxial tests with pore pressure measurements and standard consolidation tests were carried out. The results of these tests are contained in the appendix of this report.

A plan of the site showing the location of the boreholes and the inferred soil stratigraphy is shown in Dwg. #61-F-118A.

4. HISTORY:

No exact records of the nature and times of occurrence of the failures have been recorded. However, it is known that within two years of the construction of the highway embankments in 1930, using the local silty clay, the first failure took place. Failure takes the

cont'd. /4 ...

4. HISTORY: (Cont'd.) ...

form of a slow progressive movement, the maximum known movement being of the order of four inches. Surface signs of movement are:-

1. A tension crack in the pavement which runs parallel to the centreline of the highway and five feet to the river side of it.
2. A vertical downward displacement of the pavement within the failure zone of four inches. Four to five feet of asphalt and granular material placed to maintain the grade of the highway was found in B.H.'s 13 and 8.
3. The guard rails have been displaced in the form of a long circular arc down the embankment and towards the river.
4. The majority of the failures have taken place in the past on the Welland River side of the embankment.

5. SUBSOIL CONDITIONS:

5.1 General:

The principal soil stratum at the site is a very stiff to soft; gray to reddish brown silty clay containing occasional thin silt seams. The upper 15 feet of this stratum is desiccated. The embankment has been constructed from the local silty clay which has been replaced where failure has taken place by granular material and asphalt.

cont'd. /5 ...

5. SUBSOIL CONDITIONS: (Cont'd.) ...

At the embankment toe along by the river a layer of soft to firm grey to brown clay fill varying in thickness from 4 to 7 feet was found.

5.2 Embankment Material:

The embankment has been constructed from the silty clay. In B.H. #9 this clay fill was found to a depth of 8 feet, beneath which was found to be natural layered silty clay. In B.H. #8 a mixture of angular granular material and asphalt was found to a depth of 5 feet. Beneath this and lying on top of the natural silty clay a 2 feet layer of clay fill was obtained.

The liquid limit for this clay fill varies between 43 and 53 with an average of 50. The plastic limits varies from 22 to 25 with an average of 24. An average moisture content is 26. The limit weight varies between 122 and 125 pounds per cubic foot with an average of 123 pounds per cubic foot. It is to be noted that all these properties correspond to those of the natural clay. Two unconfined compression tests carried out on this material yielded shear strengths of 1580 and 3380 pounds per square foot.

5.3 Firm Grey to Brown Clay Fill:

This firm grey to brown clay fill was found at the surface in boreholes 4, 5, 6, 7 and 11 varying in thickness between 4 and 7 feet.

5. SUBSOIL CONDITIONS: (Cont'd.) ...

The liquid limits range between 44 and 64 with an average of 53 and the plastic limits from 23 to 28 with an average of 25. An overall average moisture content is 28. The unit weight varies between 111 and 122 pounds per cubic foot with an average 117 pounds per cubic foot. Unconfined compression tests carried out on two samples from B.H. #11 yielded shear strengths of 909 and 915 pounds per square foot indicating the material to have a consistency which is firm.

5.4 Very Stiff to Soft Silty Clay:

This material was found in all the boreholes. In borehole #6 it was found to a depth of 75 feet below ground level. The upper 20 feet of this stratum is distinctly stratified. The layers vary in thickness with a maximum thickness of 1/8" and are of similar compositions. This stratum contains occasional and randomly placed very thin, less than 1/16" thick, grey silt seams. In boreholes 11 and 12 at a depth of 22 feet a layer of red silt 2 feet in thickness was found followed by a 4 feet thick layer of clayey silt to silty clay.

Particle size distribution curves for the silty clay, the clayey silt and the red silt are shown in the Appendix of this report.

cont'd. /7 ...

5. SUBSOIL CONDITIONS: (Cont'd.) ...

For the silty clay the liquid limits range from 28 to 64 with an average value of 47. The plastic limits ranges from 17 to 28 with an average of 23. An average moisture content is 30. The unit weight for this silty clay varies between 109 and 130 pounds per cubic foot. The liquidity index increases from 0.1 to the desiccated crust to 0.5 with depth.

Typical limits for the clayey silt are liquid limit 23 and plastic limit 18 with a moisture content of 22.

A plot of the plasticity index against liquid limit for typical samples on Casagrande chart is contained in the appendix.

The shear strength of this material was determined by in-situ vane testing and unconfined compression tests. The field vane results are generally higher than those of the unconfined compression tests. Several stress strain curves obtained from the unconfined compression tests are contained in the appendix. In the desiccated portion of the stratum the shear strength varies between 750 and 5300 pounds per square foot with an average of 2000 p.s.f. In the lower portion of the stratum the shear strength varies from 320 to 1500 pounds per square foot.

cont'd. /8 ...

5. SUBSOIL CONDITIONS: (Cont'd.) ...

In order to study the long term stability of the embankment a number of consolidated undrained triaxial compression tests with pore pressure measurements were carried out on representative samples. The Mohr circles for these tests are contained in the appendix. From the envelope an effective angle of shearing resistance of 30 and an effective cohesion of zero were obtained. If the Mohr circles are drawn for large strain conditions an effective angle of 25° and an effective cohesion of zero were obtained.

A number of consolidation tests were carried out on samples from the same depth as those used to determine the effective parameters. The resulting $e \log p$ curves are contained in the appendix. From this curves a preconsolidation ratio of approximately 1.5 is obtained.

6. GROUND WATER CONDITIONS:

The water levels in the boreholes as recorded at the time of the investigation are shown on Drawing #61-F-118A. In order to determine in greater detail the ground water conditions at the site a total of ten piezometers were installed. A drawing showing the locations of the piezometers and the water levels recorded is contained in the appendix. The Welland River is subjected to flooding and recorded water levels are high, high water level 568.50,

6. GROUND WATER CONDITIONS: (Cont'd.) ...

normal high water level 566.0+ and normal low water level 559.0 - 561.0.

7. DISCUSSIONS AND RECOMMENDATIONS:

Highway #3A was constructed in the years 1928 to 1930 the following year the profile grade was raised 2.5 feet and some time later small failures occurred and have continued to the present day. As the failures did not occur during or immediately after construction the stability of the embankment has been studied in terms of effective stresses. Two sections in particular have been studied i.e. at chainages 123+17 and 32+84. Using effective stress parameters of $c' = 0$ and $\phi' = 25^\circ$ and pore pressures estimated from a steady seepage condition, a factor of safety of 1.07 was obtained along the failure surface indicated approximately by the black pipes at chainage 32+84 when analysed under a sudden draw down condition of 4 feet to normal river level a factor of .88 was obtained.

At chainage 123+17 a factor of safety of 1.12 under a draw down condition of 4 feet was obtained along the failure surface indicated by the measurements of the black pipes.

The results of the analyses therefore indicates that the slopes are unstable for condition of rapid

cont'd. /10 ...

7. DISCUSSIONS AND RECOMMENDATIONS: (Cont'd.) ...

draw down from high water level to normal water level. At certain sections, steady seepage is also a critical case. The physical causes of instability leading to slow progressive movement are erosion of the banks and the prevailing pore water pressure conditions throughout the seasons.

In order to increase the stability of one embankment, rockfill berms have been designed to give a 33% increase of factor of safety at section of chainage 32+84 and a 45% increase at section of chainage 123+17. A higher factor of safety is unwarranted since the failure takes the form of creep.

The details of the berms are shown on Drawings #61-F-118A.

8. SUMMARY:

1. Small, slow and continuous failures have taken place in the embankment of Hwy. #3A where it runs adjacent to the Welland River in the County of Welland.

2. The subsoil at the site is principally a very stiff to soft silty clay, the top 15 feet of which is desiccated and layered. The embankment has been constructed from this silty clay.

3. It is suggested that the stability of the embank-

8. SUMMARY: (Cont'd.) ...

ment be increased by the construction of rock berms at the toe of the failure slopes as recommended in this report.

9. MISCELLANEOUS:

The field work, performed during the period from April 12 to May 5, 1962, together with the preparation of this report was undertaken by Mr. T. F. Widdis. The investigation was carried out under the general supervision of Mr. M. Devata.

Equipment used was owned and operated by Johnston Drilling Co. Ltd., Ottawa.

July 1962.

APPENDIX I.

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

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

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

DESCRIPTION OF SOIL

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

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

TYPE OF SAMPLE

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

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

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

GENERAL

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

STRESS AND STRAIN

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

EARTH PRESSURE

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

FOUNDATIONS

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

SLOPES

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

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

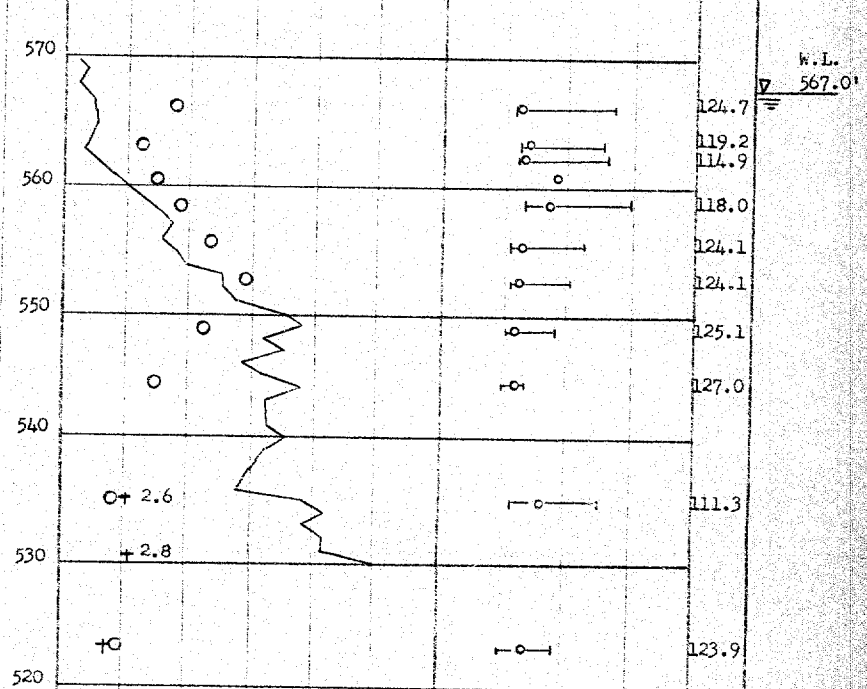
RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

JOB 61-F-118 LOCATION Sta. 26+53 (11.5' Rt.) ORIGINATED BY T.F.W.
W.P. - BORING DATE Dec. 5, 1961. COMPILED BY H.S.
DATUM 571.5 BOREHOLE TYPE WashBoring CHECKED BY T.F.W.

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT — *L PLASTIC LIMIT — *P WATER CONTENT — *W			BULK DENSITY P C F	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	20	40	60	80	100	WATER CONTENT % 20 40 60		
							SHEAR STRENGTH P.S.F. Triaxial shear strength Field Vane Test							
							1000	2000	3000	4000	5000			
571.5	Groundlevel													
0.0														
567.0	Asphalt & granular fill													
4.5			1	TW									124.7	
			2	TW										
			3	TW									119.2	
			4	SS									114.9	
			5	TW										
			6	TW									118.0	
			7	TW										
			8	TW									124.1	
			9	TW									124.1	
			10	TW										
			11	TW										
			12	TW									125.1	
			13	TW										
			14	TW									127.0	
			15	TW										
			16	TW										
			17	TW										
			18	TW									111.3	
			19	TW										
21.5													123.9	
0.0	End of borehole.													

Very stiff brown to reddish brown silty clay.



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MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO 2

FOUNDATION SECTION

JOB 61-F-118 LOCATION Sta. 28+20 (12' Rt.) ORIGINATED BY T.F.W.
W.P. - BORING DATE Dec. 7, 1961. COMPILED BY H.S.
DATUM 572.1 BOREHOLE TYPE Wash Boring. CHECKED BY T.F.W.

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER TYPE	BLOWS / FOOT	ELEV SCALE	SHEAR STRENGTH P.S.F. Triaxial shear strength Field Vane Test.						
						1000	2000	3000	4000	5000	20 40 60	
572.1 0.0	Groundlevel				572							
	Granular fill with asphalt.											
566.5 5.6												W.L. 566.6
			1 TW									
			2 TW		562							117.2
			3 SS 7for6"			O						
			4 TW									
	Medium stiff to stiff brown to reddish brown silty clay.		5 TW			O						118.9
			6 SS 16									
			7 TW									
			8 TW		552			O				124.1
			9 TW									
					542							
			10 TW			O + 3.2						111.3
			11 TW			+ 3.7						
535.6 36.5	End of borehole.				532							

N.B. "Note difference scales"

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

JOB 61-F-118

LOCATION 32756 (11' Rt.)

ORIGINATED BY T.F.W.

W.P. -

BORING DATE Dec. 8, 1961.

COMPILED BY H.S.

DATUM 574.2

BOREHOLE TYPE Wash Boring.

CHECKED BY T.F.W.

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F. Triaxial shear strength Field Vane Test		
574.2	Groundlevel					575			
0.0	Granular fill with asphalt.								W.L. 571.7
568.7			1	TW	8				122.0
5.5			2	TW	9				117.2
			3	TW	9	565			120.0
			4	TW	10				115.9
			5	TW	10				126.1
			6	TW	P				122.0
			7	TW	P				111.2
			8	TW	P	555			115.6
			9	TW	P				
	Medium stiff to stiff		10	TW	P	545			
	brown to reddish brown		11	TW	P				
	silty clay.		12	TW	P	535			
			13	TW	P				
525.7						525			
48.5	End of borehole.								

N.B. "Note difference scales" —

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

JOB 61-F-118

LOCATION 32756 (33' Rt.)

DESIGNATED BY T.F.W.

W.P. -

BORING DATE Dec. 8, 1961.

COMPILED BY B.K.

DATUM 565.8

BOREHOLE TYPE Washboring.

CHECKED BY T.F.W.

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLLOT	SAMPLES		BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — % PLASTIC LIMIT — % WATER CONTENT — %		BULK DENSITY P.C.F.	REMARKS
			NUMBER	TYPE			20	40	60	80	100	W.P.	W.L.		
							SHEAR STRENGTH P.S.F. Triaxial shear strength Field Vane Test					WATER CONTENT %			
							500	1000	1500	2000	2500	20	40	60	
565.8	Groundlevel					566									
0.0	Medium stiff grey to brown clay. (Fill)		1	Tw P											
			2	SS 5											
			3	Tw P											
			4	SS											
558.8			5	Tw 14											
7.0						556									
			6	SS 23											
			7	Tw 16											
			8	SS 16											
	Medium stiff to stiff, layered, reddish brown, silty clay.		9	Tw P											
			10	SS 5		546									
			11	Tw P											
			12	SS 4		536									
			13	Tw P											
529.3			14	Tw P											
36.5	End of borehole.					526									

N.B. "Note different scales".

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 61-F-118LOCATION 32+56, 27' Rt.ORIGINATED BY T.F.W.W.P. -BORING DATE Dec. 12, 1961.COMPILED BY B.K.DATUM 567.3BOREHOLE TYPE Washboring NX Casing.CHECKED BY T.F.W.

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT w_L		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT w_P	WATER CONTENT w		
567.3	Groundlevel										
	Medium stiff, brown clay with some gravel.	1	SS	5							
562.8		2	SS	7							
4.5	Medium stiff grey to brown silty clay.	3	SS	5	560.0						
		4	SS	7							
		5	SS	5	550.0						
545.8		6	SS	5							
21.5	End of borehole.				540.0						

N.B. "Note different scales".

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO 6

FOUNDATION SECTION

JOB 61-F-118LOCATION 26+53 25.0' RT.ORIGINATED BY T.F.W.W.P. -BORING DATE Dec. 13, 1961.COMPILED BY B.K.DATUM 566.3BOREHOLE TYPE Washboring NX Casing.CHECKED BY T.F.W.

SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — w_L PLASTIC LIMIT — w_P WATER CONTENT — w		BULK DENSITY PCF	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	SHEAR STRENGTH P.S.F. Triaxial shear strength Field Vane Test	WATER CONTENT % 20 40 60		
566.3	Groundlevel									
	Soft brown clay.		1	SS	4					
559.8			2	SS	5	560				
6.5			3	SS	10					
			4	SS	7	550				
			5	SS	3	540				
							+ 2.7			
	Medium stiff, grey to brown, to reddish brown, silty clay.		6	Tw	P	530				117.1
			7	Tw	P	520				
			8	Tw	P	510				
							+ 4.0			
			9	SS	4	500				
							+ 4.3			
489.8			10	SS	6	490				
76.5	End of borehole.									

N.B. "Note different scales".

RECORD OF BOREHOLE NO 7

FOUNDATION SECTION

JOB 61-F-118

LOCATION 32490 30' Rt.

DESIGNED BY T.F.W.

W.P. -

BORING DATE March 27, 1962.

SAMPLED BY B.K.

DATUM 565.5

BOREHOLE TYPE Washboring

CHECKED BY T.F.W.

SOIL PROFILE		SAMPLES		ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT _____ % PLASTIC LIMIT _____ % WATER CONTENT _____ %		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE		SHEAR STRENGTH P.S.F. Unconfined shear strength Field Vane		500 1000 1500 2000 2500			
65.5	Groundlevel							WATER CONTENT % 20 40 60 80		
	Firm brown clay.	1	TW P							
4.5		2	TW P						119.0	
61.0		3	TW P	560						
		4	TW P			3.8			117	
		5	TW P			2.8			120	
		6	TW P				3.2		118	
		7	TW P						124	
		8	TW P			2.4			124	
	Soft to very stiff, grey to brown, silty clay, containing occasional very thin seams of grey silt.	9	TW P				2.1		125	
		10	TW P	550		2.9			123	
		11	TW P			2.3			128.0	
		12	TW P							
		13	TW P							
		14	TW P							
		15	TW P				7.2		110.0	
		16	TW P			6.3			110.0	
		17	TW P	540		7.5			115.0	
		18	TW P			6.0			111.0	
		19	TW P			1.8			109.0	
		20	TW P			5.3			109.0	
				530						
		21	TW P			2.3 + 3.5			118.0	
				520						
2.5	End of borehole	22	TW P			2.9 + 4.3			116.0	

N.B. "Note different scales".

JOB 61-F-118

LOCATION 3278 16' Rt.

ORIGINATED BY T.F.W.

W.P. -

BORING DATE March 5, 1962.

SAMPLED BY B.K.

DATUM 574.09

BOREHOLE TYPE

CHECKED BY T.F.W.

SOIL PROFILE		SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — *L PLASTIC LIMIT — *P WATER CONTENT — *W			BULK DENSITY Y P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE		SHEAR STRENGTH P.S.F. Unconfined shear strength Field Vane					*P	*W	*L		
574.09						500	1000	1500	2000	2500	20	40	60		
569.09	Fill consisting of granular material and asphalt.														
569.09					570										
567.59	Grey-brown clay fill.		1	TW P										120	
6.5			2	TW P										117	
			3	TW P										117	
	Firm to stiff, brown, laminated silty clay.		4	TW 7										117	
			5	TW 7										120	
			6	TW 7	560									118	
			7	TW P										115	
			8	TW P										121	
			9	TW P										124	
			10	TW P										124	
	Firm to stiff, grey, silty clay, containing very thin grey silt seams.		11	TW P										124	
			12	TW P										120	
			13	TW P	550									124	
			14	TW P										130	
			15	TW P										130	
			16	TW P										125	
43.6			17	TW P										111	
30.5	End of borehole.														
					540										

N.B. "Note different scales".

DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS & RESEARCH DIVISION		RECORD OF BOREHOLE NO. 9		FOUNDATION SECTION
JOB 61-F-118	LOCATION 33450 16.0' Lt.	INITIATED BY T.F.W.		
W.P. -	BORING DATE April 12, 1962.	COMPILED BY B.K.		
DATUM 574.6	BOREHOLE TYPE Washboring NX Casing.	CHECKED BY T.F.W.		

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — *L PLASTIC LIMIT — *P WATER CONTENT — *W		BULK DENSITY P.C.F.	REMARKS							
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F. Unconfined shear strength Field Vane				WATER CONTENT %						
						1000	2000	3000	4000	5000	20	40	60	80		
572.6	Groundlevel															
2.0	Stiff to very stiff grey to brown silty clay fill.		1 TW 14		570										125	
			2 TW 39													
566.6			3 TW 36												122	
8.0			4 TW P												118	
	Firm to very stiff, brown to grey, laminated silty clay containing occasional thin grey silt layers.		5 TW P												118	
			6 TW P												120	
			7 TW P												121	
			8 TW P												116	
			9 TW P												118	
			10 TW P												118	
			11 TW P												119	
			12 TW P												121	
			13 TW P												121	
			14 TW P												124	
	Firm to stiff, brown to grey silty clay containing thin grey silt seams and some pockets of clayey silt.		15 TW P		550										125	
			16 TW P												122	
			17 TW P												124	
			18 TW P													
						540										
			19 TW P												130	
			20 TW P												116	
						530										
			21 TW P												125	
		22 TW P												130		
					520											
		23 TW P												105		
		24 TW P												106		
					510											
501.6			25 TW P												107	
7.3	End of borehole.				500											

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 10

FOUNDATION SECTION

JOB 61-R-118

LOCATION 32° 41.0' Lt.

ORIGINATED BY T.F.W.

W. P. _____

BORING DATE April 17, 1962.

COMPILED BY B.K.

DATUM 566.4

SOREHOLE TYPE Washboring IX Casing.

CHECKED BY _____ T.F.W.

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT ——— w _L PLASTIC LIMIT ——— w _p WATER CONTENT ——— w		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER TYPE BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F. Unconfined shear strength Field Vane	w _p ——— w _L	WATER CONTENT % 20 40 60		
566.4 0.0			1 TW P 2 TW P 3 TW P 4 TW P	560	500 1000 1500 2000 2500			117.0 117.0 114.0	
	Firm to stiff brown to grey silty clay, containing thin grey silt seams and some pockets of clayey silt.		8 TW P 9 TW P 10 TW P	550					
						+ 4.0 + 5.0			
					540				
						+ 3.9			
					530				
						+ 2.6			
					520				
						+ 6.1			
					510				
						+ 4.7 + 4.0 + 4.7			
73.4 73.0	End of borehole.			500					
					+ 3.5				

N.B. "Note different scales".

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 61-F-118 LOCATION 123+16 26.5' Lt. ORIGINATED BY T.F.W.
W P - BORING DATE April 25, 1962. COMPILED BY B.K.
DATUM 569.2 BOREHOLE TYPE Washboring NX Casing. CHECKED BY T.F.W.

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH P.S.F. Unconfined shear strength Field Vane					*D — W — WL			
569.2	Groundlevel					500	1000	1500	2000	2500	WATER CONTENT % 20 40 60 80			
	Firm brown silty clay fill.		1	TW 7			0					10 —	122.0	
564.7			2	TW P			0					10 —	117.0	
4.5			3	TW 9										
			4	TW 13	210									
			5	TW 16	560		0					10 — 0 —	117.0	
			6	TW 11				0				10 —	117.0	
	Firm to stiff layered, brown to grey, silty clay.		7	TW 13				0				10 —	121.0	
			8	TW 6			0					10 —	121.0	
			9	TW 19				0				10 —	121.0	
			10	TW 14	550		0					10 —	123.0	
			11	TW P			0					10 —	127.0	
47.2			12	TW P				0				10 —		
22.0	Brown silt to clayey silt with soft silty clay.		13	TW 17								0		
			14	TW P								10 —	121.0	
			15	TW P			0					10 —	128.0	
41.2			16	TW P			0					10 —	126.0	
28.0			17	TW P	540		0					10 —	124.0	
	Soft to firm grey silty clay containing occasional very thin grey silt seams.		18	TW P			0					10 — 0 —	109.0	
			19	TW P			0					10 — 0 —	113.0	
			20	TW P			0					10 — 0 —	114.0	
			21	TW P			0					10 — 0 —	115.0	
			22	TW P				0				10 — 0 —	117.0	
			23	TW P	530		0					10 — 0 —	118.0	
28.70			24	TW P			0					10 —	124.0	
40.5	End of borehole.													
					520									

N.B. "Note different scales".

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 13

FOUNDATION SECTION

JOB 61-F-118

LOCATION 123/06 15.5' LRT.

ORIGINATED BY T.F.W.

W P _____

GORING DATE May 1, 1962.

RECEIVED BY B.K.

DATUM 574.0

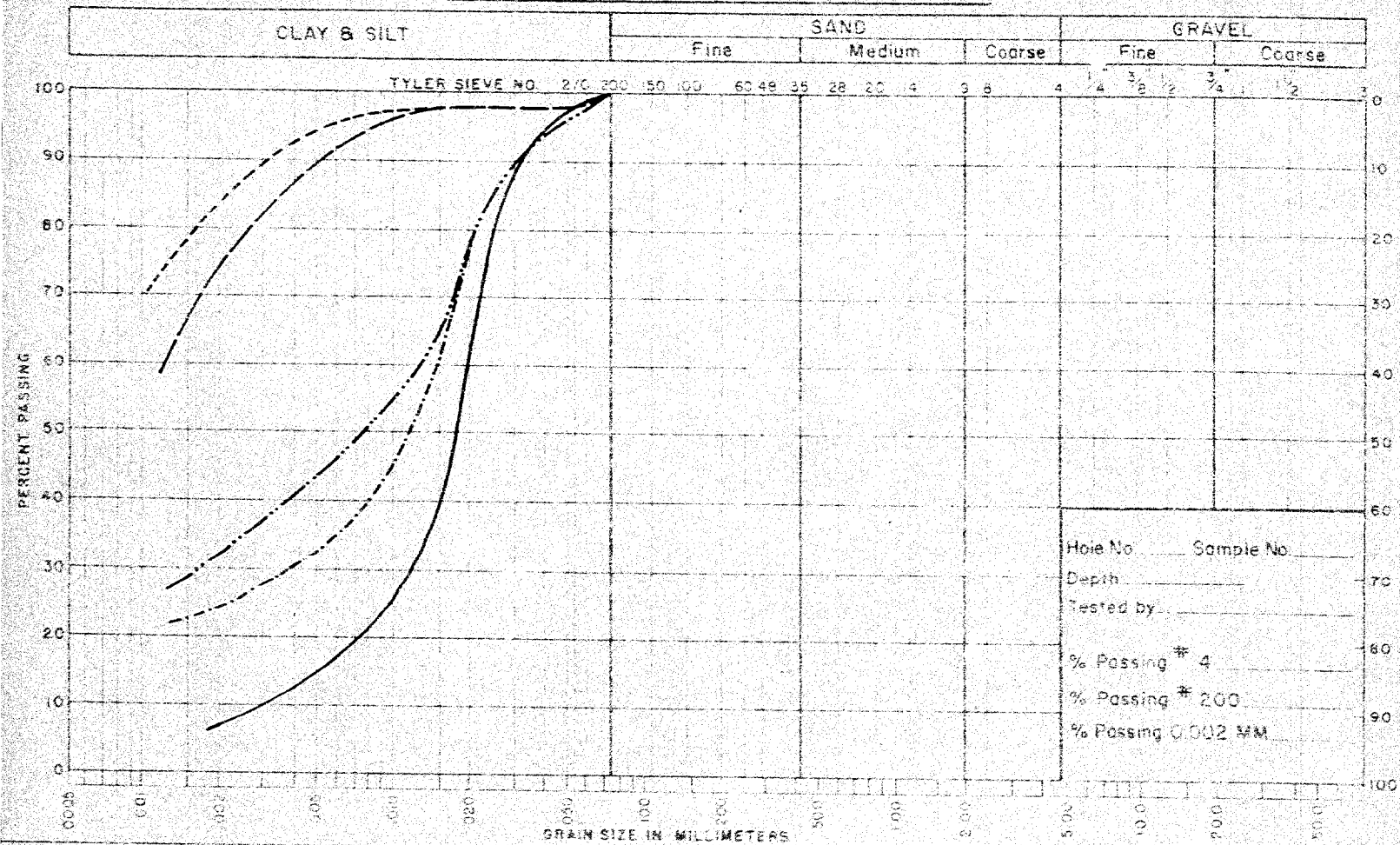
BOREHOLE TYPE Washboring

CHECKED BY T.F.W.

[illegible]

N.B. "Note different scales".

UNIFIED SOIL CLASSIFICATION SYSTEM



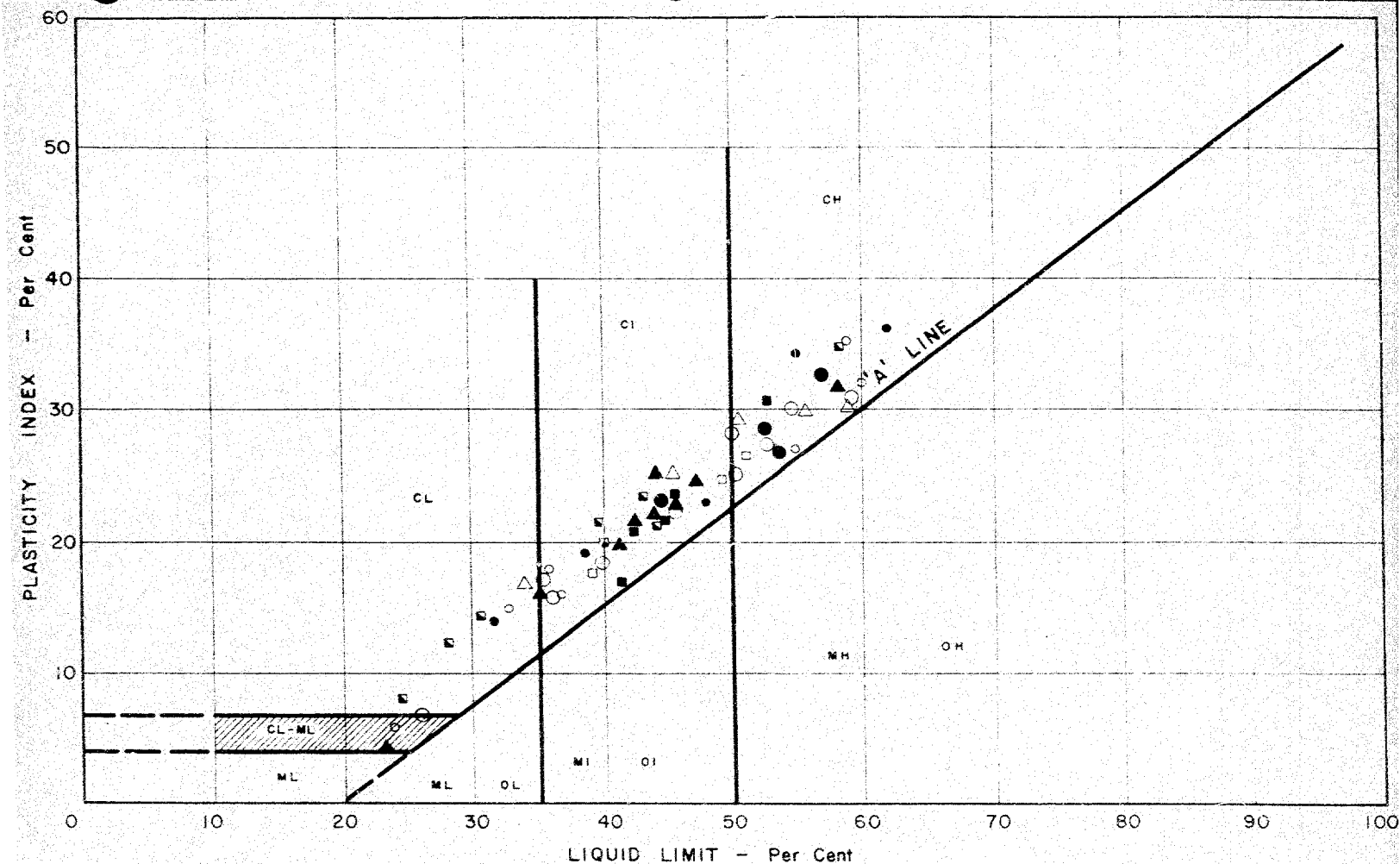
NOTES	SILTY CLAY - BOREHOLE NO. 7	SAMPLE NO'S	
		15	_____
		16	_____
CLAYEY SILT -	" " II	" "	14 _____
		16	_____
SILT -	" " II	" "	13 _____

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH SECTION
GRAIN SIZE DISTRIBUTION

Job No. 61-F-118

W F No

LOCATION HIGHWAY NO. 3A



NOTES

- | | | |
|-----------------|-----------------|-----------------|
| ○ - BOREHOLE №1 | ● - BOREHOLE №2 | △ - BOREHOLE №3 |
| ▲ - BOREHOLE №4 | □ - BOREHOLE №5 | ■ - BOREHOLE №6 |
| ◊ - BOREHOLE №7 | ◐ - BOREHOLE №8 | ◑ - BOREHOLE №9 |

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION
PLASTICITY CHART

Job No. 61-F-118 W.P. No. _____
Location HIGHWAY №3A - WELLAND

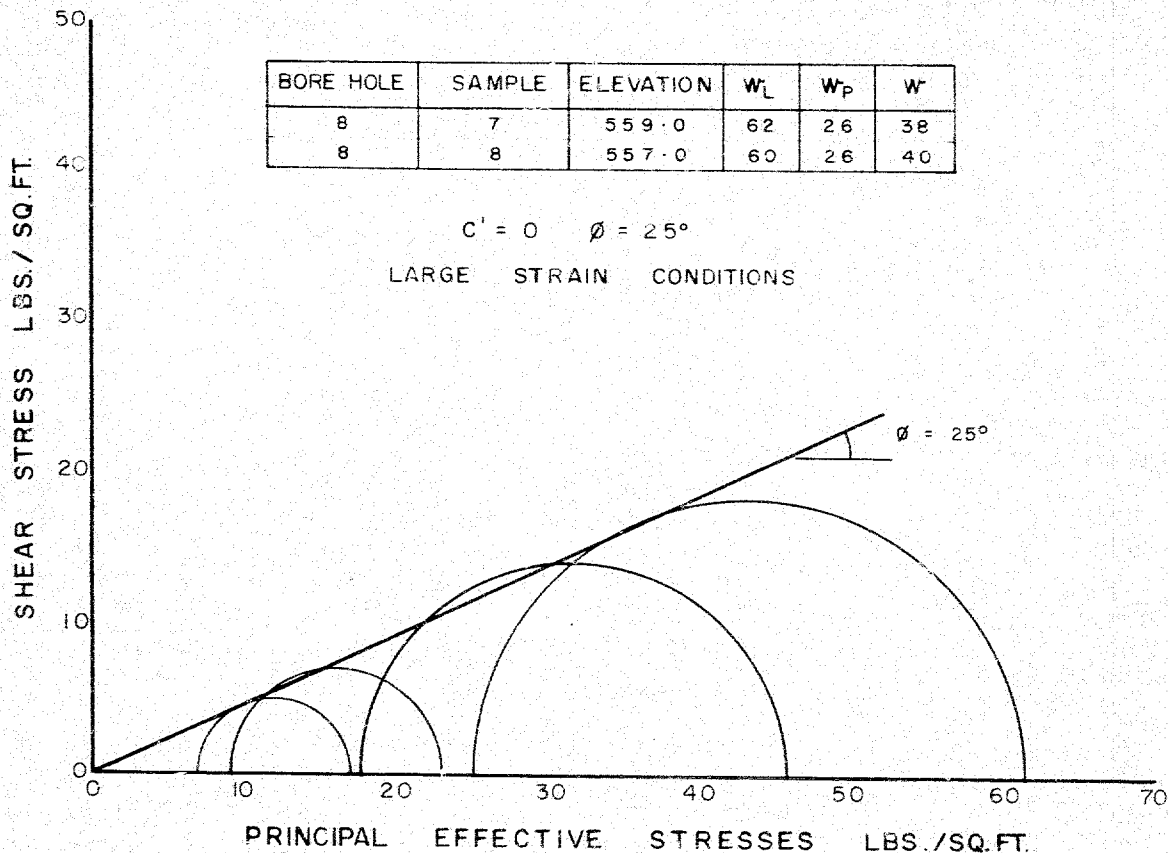
ORIGINATED T. WIDDIS
 DRAWN D. MUMFORD
 CHECKED *(initials)*
 APPROVED *(initials)*
 DATE 19 JULY 1962

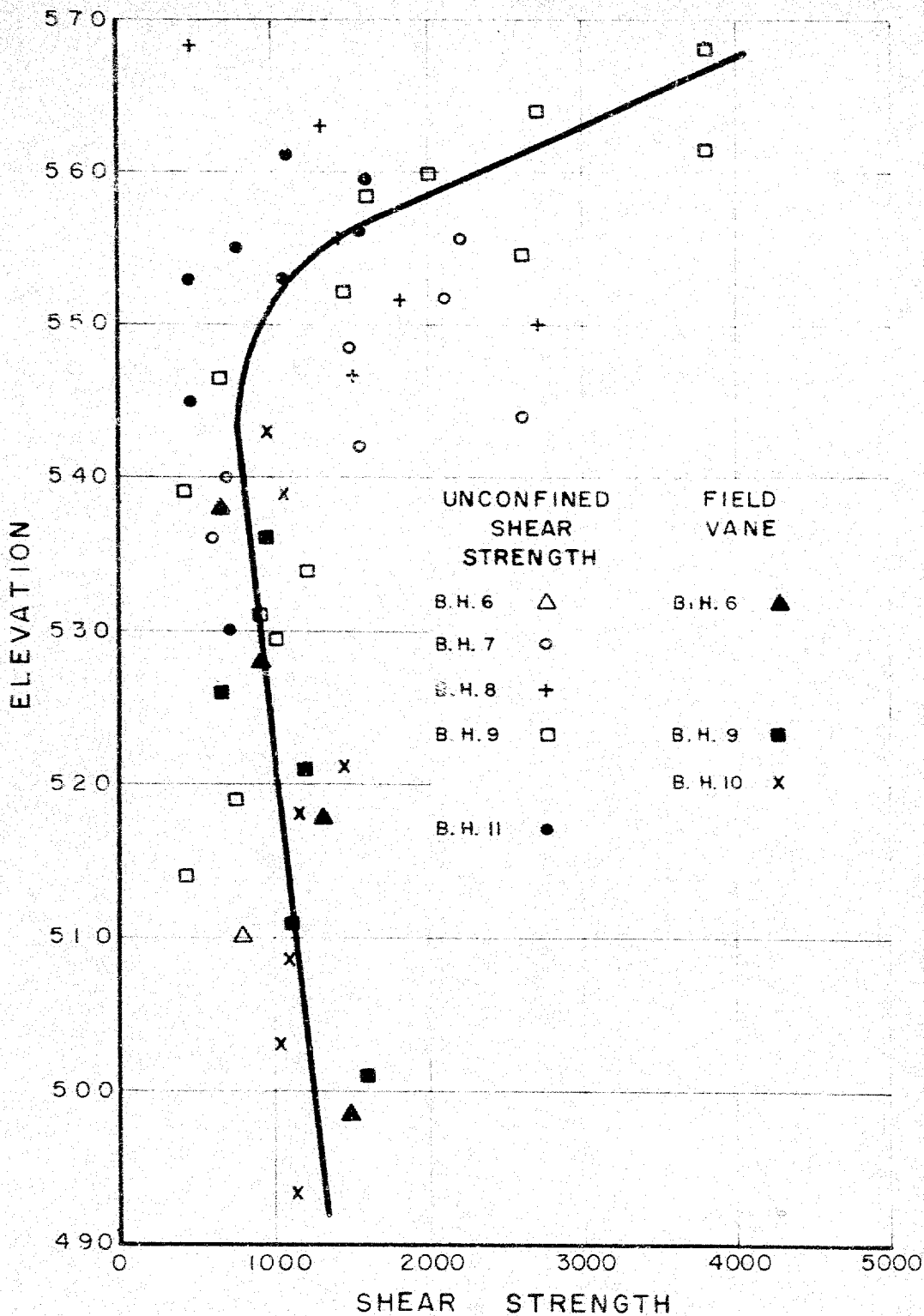
DEPARTMENT OF HIGHWAYS, ONTARIO
 MATERIALS & RESEARCH SECTION
 HIGHWAY NO. 3A
 CONSOLIDATED UNDRAINED COMPRESSION
 TESTS WITH PORE PRESSURE MEASUREMENTS
 JOB NO. 61 - F - 118
 DWG. NO. 61 - F - 118 D

BORE HOLE	SAMPLE	ELEVATION	w_L	w_p	w
8	7	559.0	62	26	38
8	8	557.0	60	26	40

$$c' = 0 \quad \phi = 25^\circ$$

LARGE STRAIN CONDITIONS





ORIGINATED T. WIDDIS

DRAWN D. MUMFORD

CHECKED *HW*

APPROVED *HW*

DATE 19 JULY 1962

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & RESEARCH SECTION

HIGHWAY NO. 3A

SHEAR STRENGTH AGAINST DEPTH

SCALE 1" = 10'

W. P. NO.

JOB NO. 61-F-118

DWG. NO. 61-F-118 E

570

560

550

540

530

520

510

APR 27/62
WL 562.2

GRANULAR FILL

CLAY FILL

SILTY CLAY

HWY. 3A
STA. 32+84PIEZOMETER READINGS MAY 29/62
STA. 32 + 84

570

560

550

540

530

520

510

ORIGINATED T. WIDDIS

DRAWN D. MUMFORD

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH SECTION

HIGHWAY NO. 3A

SCALE 1" = 10'

W.P. NO.

JOB NO. 61-F-118

PIEZOMETER LOCATIONS & READINGS MAY 29/62

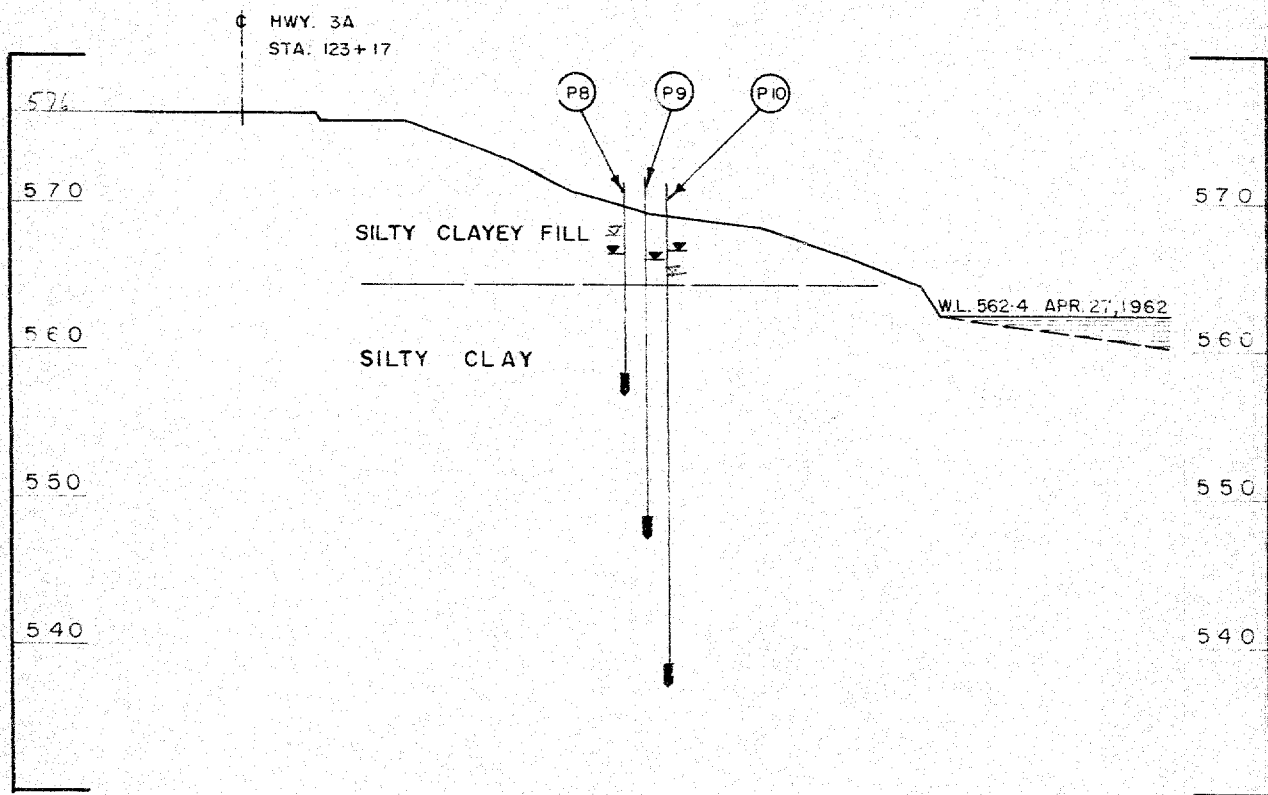
APPROVED

DATE

DWG. NO. 61-F-118 F

DATE: 17 JULY 1962
 APPROVED: *[Signature]*
 CHECKED: *[Signature]*
 DRAWN: D. MUMFORD
 ORIGINATED: T. WIDDIS

DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & RESEARCH SECTION
 HIGHWAY NO. 3A
 PIEZOMETER LOCATIONS & READINGS
 DWG. NO. 61 - F - 1186

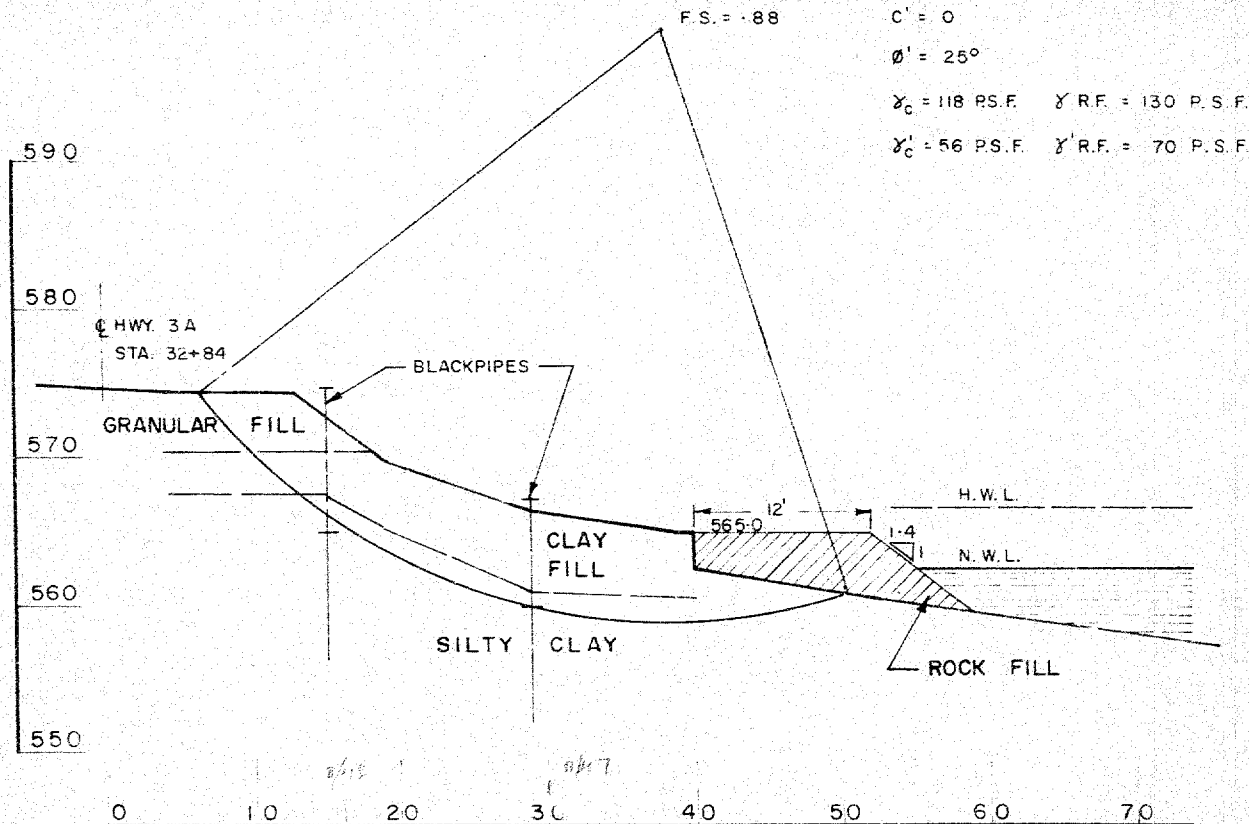


PIEZOMETER READINGS MAY 29/62
 STA. 123+17

ORIGINATED T. WIDDIS
 DRAWN D. MUMFORD
 CHECKED *HW*
 APPROVED

DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & RESEARCH SECTION
 HIGHWAY NO. 3A - STA. 32+84
 SHOWING SLIP CIRCLE
 TUBES AND BLACK PIPE CLOSURES

SCALE 1" = 10'
 W.P. NO.
 JOB NO. 61-F-118
 DWG. NO. 61-F-118 H



SECTION AT STA. 32+84 (C-C)

1. SLIP CIRCLE IS DRAWN THROUGH CLOSURES IN BLACK PIPE
2. ROCK BERM INCREASES F.S. BY 45%

ORIGINATED T. WIDDIS
 DRAWN D. MUM FORD
 CHECKED J. L. J.
 APPROVED

DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & RESEARCH SECTION
 HIGHWAY NO. 3A - STA. 123+17
 SHOWING SLIP CIRCLE
 THROUGH BLACK PIPE CLOSURES
 SCALE 1" = 10'
 W.P. NO.
 JOB NO. 61 - F - 118
 DWG. NO. 61 - F - 118

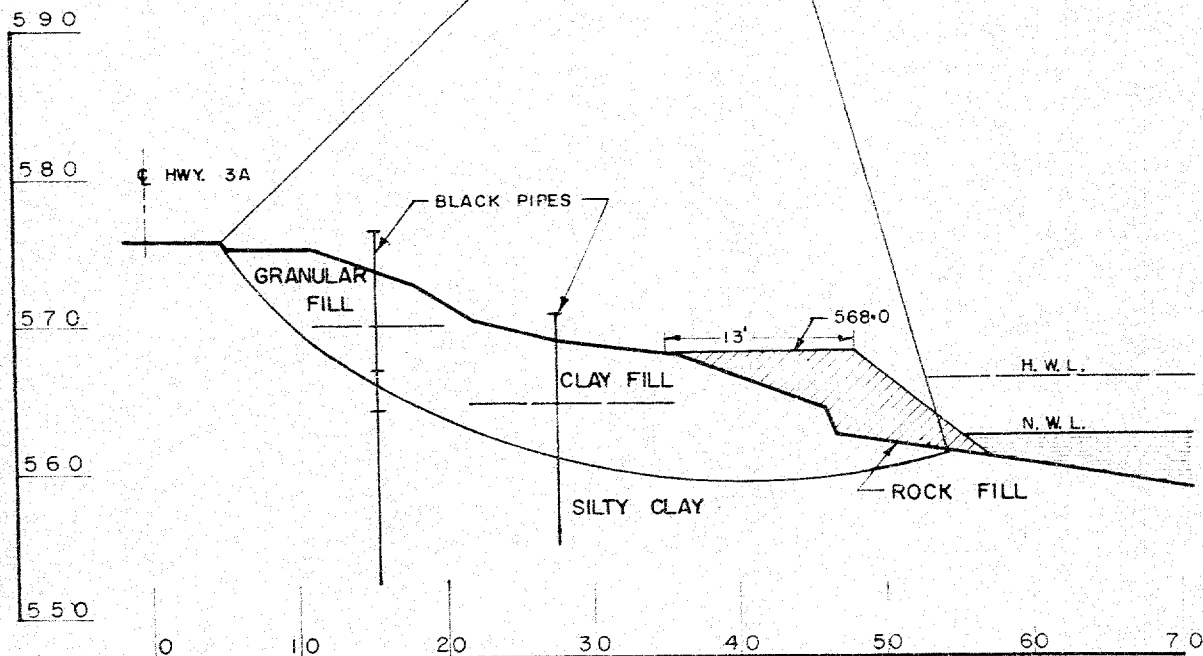
1. SLIP CIRCLE IS DRAWN THROUGH CLOSURES IN BLACK PIPE.
2. ROCK BERM INCREASES F.S. BY 33%

$$C' = 0$$

$$\phi' = 25^\circ$$

$$\gamma_c = 118 \text{ P.S.F.} \quad \gamma_{R.F.} = 130 \text{ P.S.F.}$$

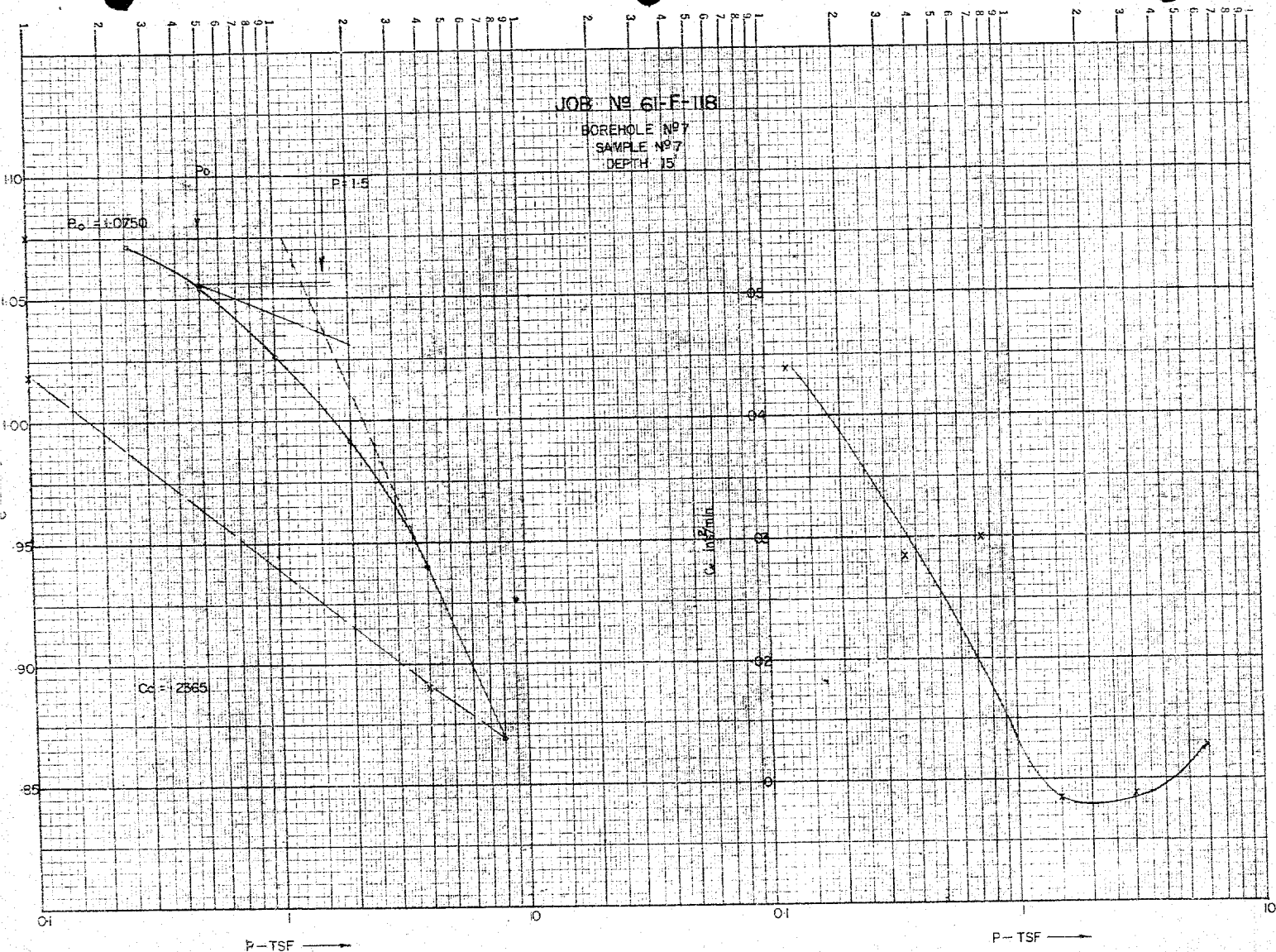
$$\gamma'_c = 56 \text{ P.S.F.} \quad \gamma'_{R.F.} = 70 \text{ P.S.F.}$$



SECTION AT STA. 123+17 (D-D)

JOB NO 61-F-118

BOREHOLE NO 7
 SAMPLE NO 7
 DEPTH 15'

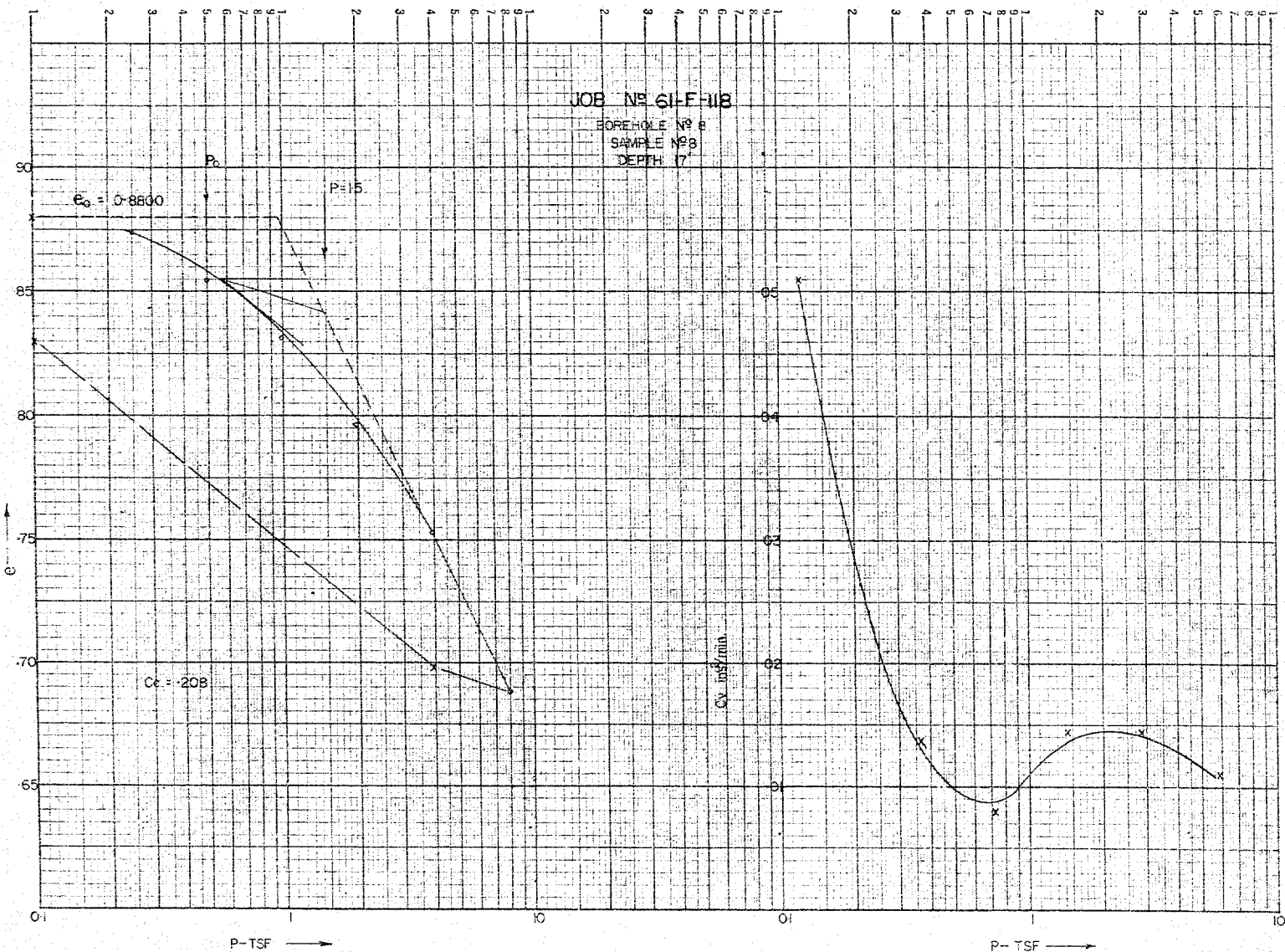


JOB NO 61-F-118

BOREHOLE NO 8

SAMPLE NO 8

DEPTH 17'



PIEZOMETER READINGS - HWY 3A

W.L

PIEZ#3 -1'9" BELOW TOP OF CSG; -0'6" BELOW G.L

NOTE: 2 TUBES IN CSG; SAME W.L IN BOTH TUBES

BOTH TUBES HAVE BEEN PULLED DOWN 1' FROM
PACKING AT TOP OF PIPE

PIEZ#4 W.L @ -10'1" BELOW TOP OF CSG; -8'11" BELOW G.L

NOTE: TOP OF TUBING AT G.L;

CSG PUSHED OVER SLIGHTLY BY FILL

PIEZ#5 W.L UNKNOWN; CAP FROZEN & CSG PUSHED OVER BY FILL

PIEZ#6 W.L @ -8'9" BELOW TOP OF CSG; W.L @ -7'0" BELOW G.L

PIEZ#7 W.L @ -1'8" BELOW TOP OF CSG; W.L @ +4" ABOVE G.L

PIEZ#8 W.L @ -4'2" BELOW TOP OF CSG; W.L @ -2'0 $\frac{1}{2}$ " BELOW
G.L

PIEZ#9 W.L UNKNOWN; CAP FROZEN

PIEZ#10 W.L @ -5'8" BELOW TOP OF CSG; W.L @ -3'9" BELOW
G.L

NOTE: CONSIDERABLE ROCK FILL PLACED IN
AREA OF PIEZOMETERS WITH CONSIDERABLE
CHANGE IN GROUND LEVEL. ORIGINAL PIEZOMETER
GROUND ELEVATIONS NO LONGER APPLY.
SEE PHOTOS IN INDEX.

MEMORANDUM

To: Mr. A. Stermac,
Foundations Engineer,

FROM: Mr. R. Britton,
Construction Engineer,
District 4 - Hamilton.

DATE: September 26, 1962.

OUR FILE REF.

IN REPLY TO

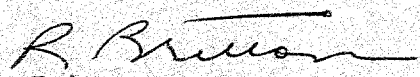
SUBJECT:

Highway 3A, Vicinity of Beckett's Bridge, easterly.

Please be advised that the District Superintendent of Operations has advised that in his opinion, the high water level attained at this section of the Welland River was in the vicinity of ^{Elev.} 570.0.

J.C. THATCHER,
District Engineer.

Per:


R. Britton,
Construction Engineer.

RB/lr

MEMORANDUM

To: Mr. A. G. Stermac,
Principal Foundation Eng.
Room 107, Lab. Bldg.

FROM: B. Wilkie

DATE: September 13, 1962.

OUR FILE REF.

IN REPLY TO

SUBJECT: Welland River Levels

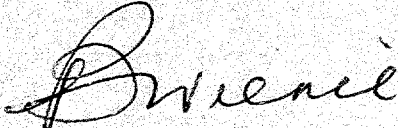
On January 19, 1962 and at your request
I ascertained the levels of this river, from the
County Engineer as follows:

Normal Water Levels	559 to 561
Normal High Water	566
High High Water	568.5

All readings are of geodetic origin.

I trust this is the information you require.

BW/et


B. Wilkie,
Bridge Hydrology Engineer.

Mr. H. Greenland,
District Engineer,
Hamilton.

Mr. A. G. Stermac,
Principal Foundation Engr.,
Foundation Section,
Materials & Research Division.

January 21, 1963

D.H.O. FOUNDATION INVESTIGATION REPORT
AND ADDENDUM TO REPORT

On
Embankment Failures on Hwy. #3A, County
of Welland, Dist. #4. W.J. 61-F-118.

It is known that the portion of Hwy. 3A, where it runs adjacent to the Welland River west of the City of Welland, has been and still is failing, and that permanent maintenance has to be carried out. Because of this and also because of the possibility of a more serious, sudden embankment failure, it was concluded that this problem deserves serious consideration.

A radical realignment of the highway to an area farther away from the river where there would be no stability problems, of course, represents a very good and safe solution. However, this may also represent quite an expensive proposition. It was therefore, decided that an investigation into the causes of the embankment instability be undertaken, and recommendations for measures necessary to secure the stability and eliminate the maintenance of the embankment be put forward.

In response to a request by the District, the Foundation Section has carried out this investigation, and attached is a report and an addendum to the report containing all the factual information, the discussion and the necessary proposals.

A number of alternative solutions are presented in order to allow greater flexibility in the subsequent planning. All of these solutions either maintain the present Centre-line or have the Centre-line only slightly shifted away from the river. The presented remedial measures refer to what is considered a typical and representative cross-section. From the knowledge of the topography of the area, it is believed that these measures would, with possible smaller alterations, apply throughout the entire section where failures have been experienced in the past, and where signs of instability are apparent. However, for detailed work, a survey comprising numerous cross-sections, would have to be carried out.

cont'd. /2 ...

Mr. H. Greenland,
Dist. Engr., Hamilton.

January 21/63

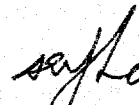
With the other information available to the District, in addition to that contained in the attached report, a more realistic study and comparison of the different alternative solutions can now be initiated and carried out.

If, at any stage, further co-operation of this Section is required, please feel free to call on us.

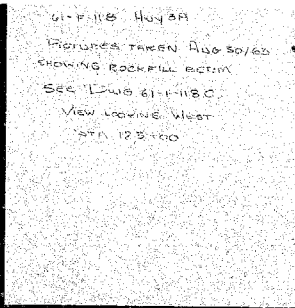
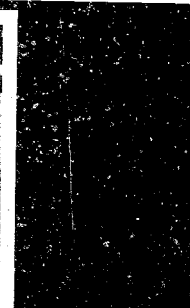
KYL/MdeF
Attach.

cc: Mr. H. Greenland (6)
Mr. T. J. Kovich

Foundations Office
Gen. Files. ✓


K. Y. Lo,
SUPERVISING FOUNDATION ENGR.
For:

A. G. Stermac,
PRINCIPAL FOUNDATION ENGR.



61-F-118 HUY 3A

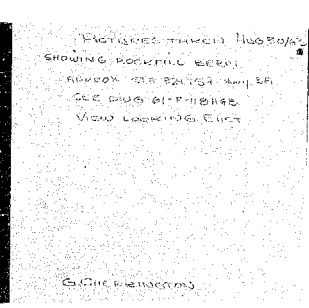
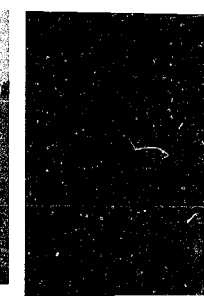
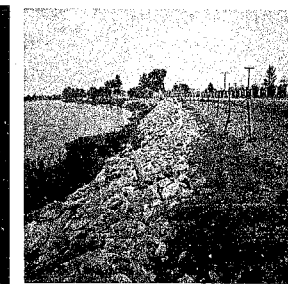
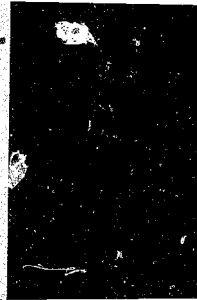
PICTURES TAKEN AUG 30/63

SHOWING ROCKFILL BEHIND

SEE LWS 61-F-118 C

VIEW LOOKING WEST

ATA 123+00



PICTURES TAKEN AUG 30/63

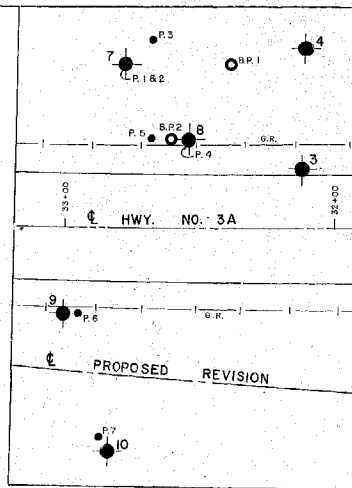
SHOWING ROCKFILL BEHIND

ARMYON STA 24+54 40+54

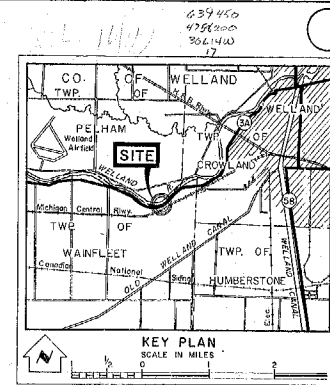
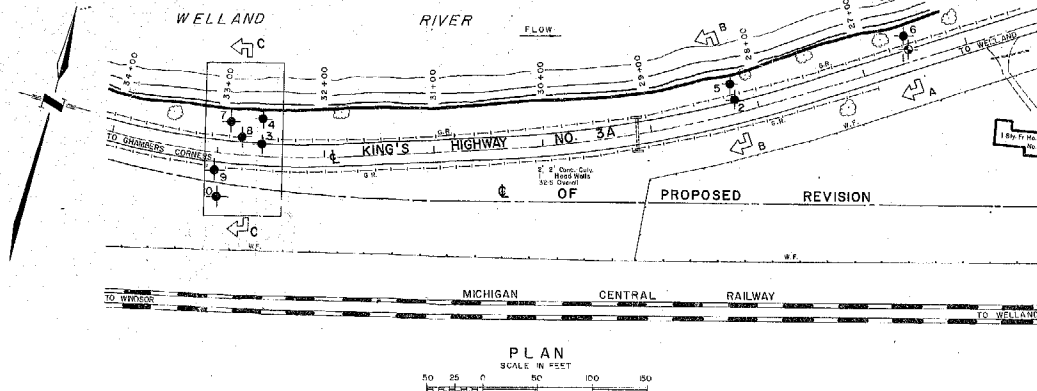
SEE DWS 61-F-118 HRS

VIEW LOOKING EAST

G. C. H. HENRYSON

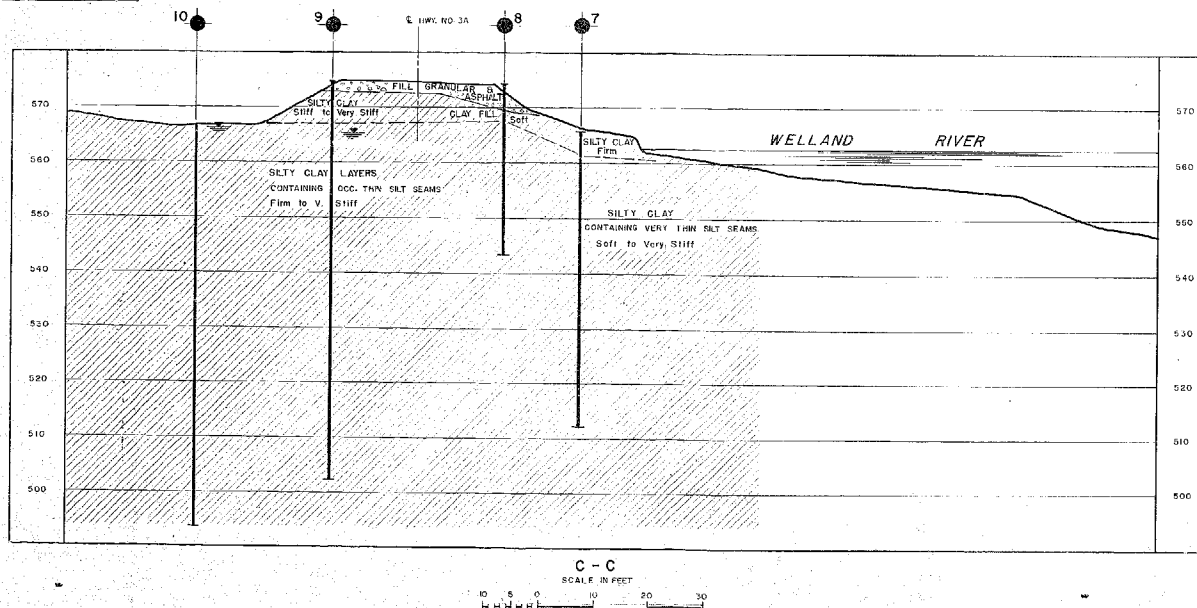


DETAILS AT STA. 32+75 ±
SCALE IN FEET
0 10 20 30

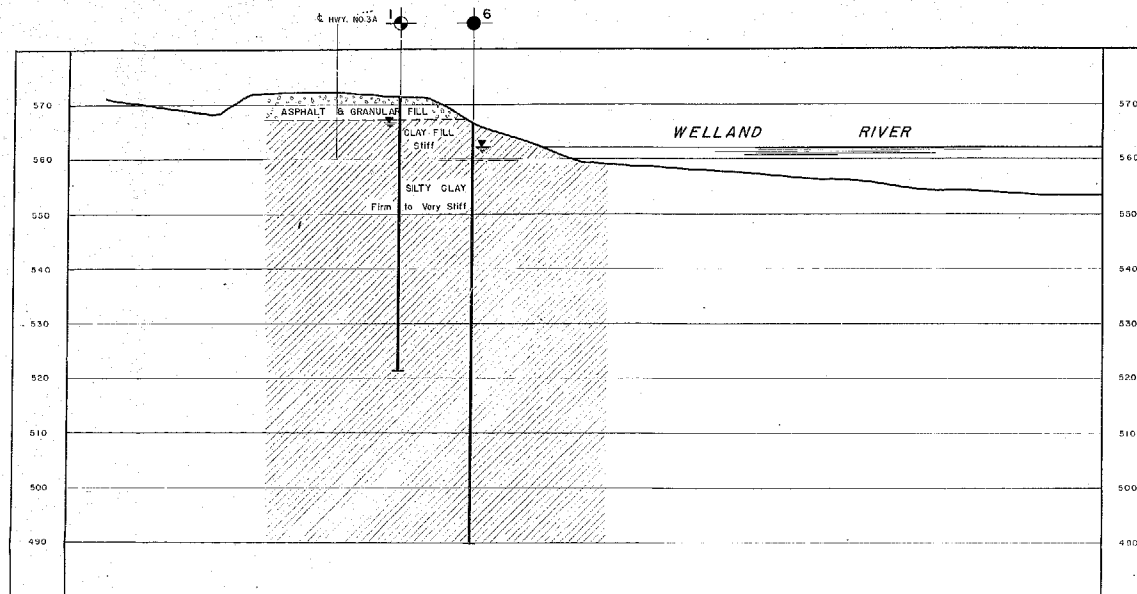


LEGEND			
	Bore Hole		
	Cone Penetration Hole		
	Bore & Cone Penetration Hole		
	Water Levels established at time of field investigation		
	Piezometer		
	Black Pipe		
NO.	ELEVATION	STATION	OFFSET
1	571.5	26+53	15' RT
2	572.1	28+30	10' RT
3	572.2	32+50	10' RT
4	574.5	32+56	34' RT
5	567.5	29+30	57' RT
6	568.3	28+43	25' RT
7	565.5	32+90	30' RT
8	574.1	32+76	15' RT
9	574.8	33+00	16' LT
10	566.4	32+92	41' LT
P.1	567.4	32+90	30' RT
P.2	567.5	32+90	30' RT
P.3	566.8	32+64	23' RT
P.4	574.7	32+78	16' RT
P.5	574.2	32+64	16' RT
P.6	570.4	32+37	15' LT
P.7	569.5	32+32	35' LT
G.P.1	509.1	52+70	39' RT
G.P.2	574.6	32+60	16' RT

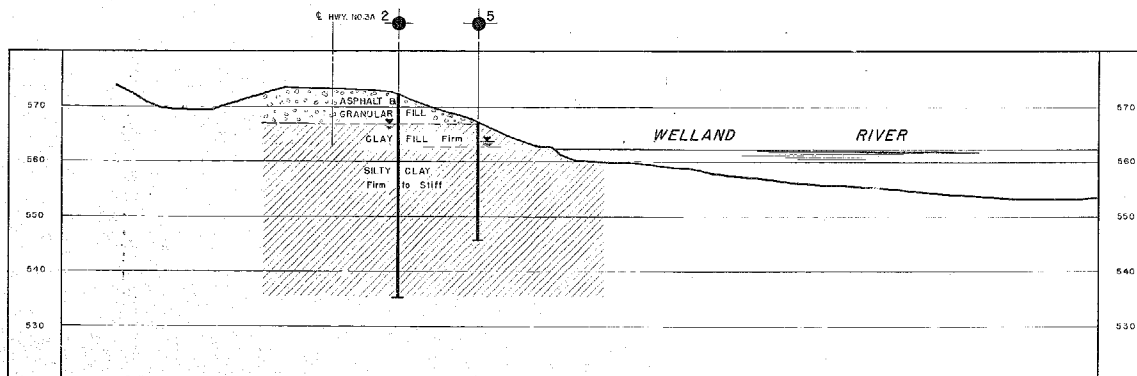
NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.



DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS & RESEARCH DIVISION - FOUNDATION SECTION		
HIGHWAY NO. 3A SLOPE FAILURE AT WELLAND		
ORIGINATED BY: W. W. W. W.	DISTRICT NO. 4	DATE: MAY 28, 1962
DRAWN BY: F. CLARK	W.R. NO. --	JOB NO. 61-F-114
CHECKED BY: J. J. J.	CONTRACT NO.	DRAWING NO.
APPROVED BY: J. J. J.		61-F-118A

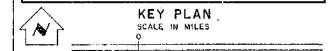


A-A
SCALE IN FEET
10 20 30



B-B
SCALE IN FEET
10 20 30

SEE DRAWING NO. 61-F-118A



LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation

NO.	ELEVATION	STATION	OFFSET
SEE DRAWING NO. 61-F-118A			

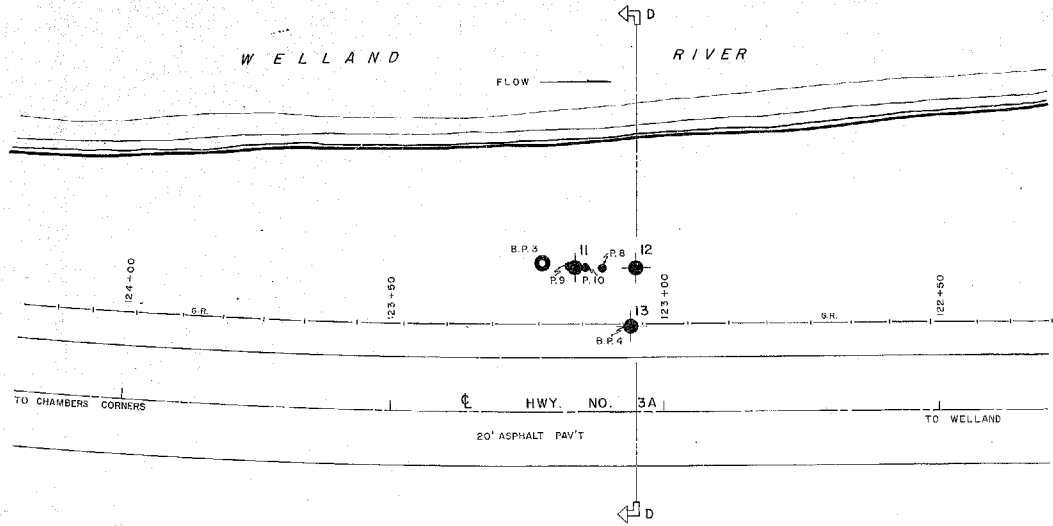
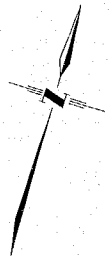
- NOTE -

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

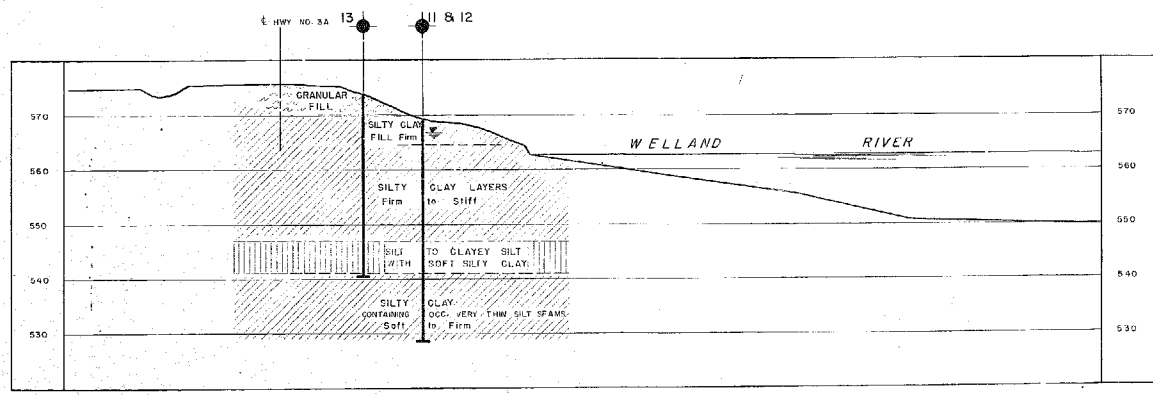
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION - FOUNDATION SECTION

HIGHWAY NO. 3A SLOPE FAILURE AT WELLAND

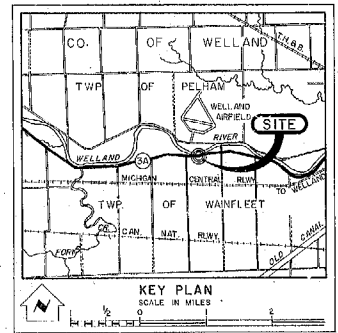
ORIGINATED T. WIDDIS	DISTRICT NO. 4	DATE MAY 28, 1962
DRAWN F. CLARK	W.P. NO. -	JOB NO. 61-F-118
CHECKED <i>W.R. M.</i>	CONTRACT NO.	DRAWING NO.
APPROVED <i>W.R. M.</i>		61-F-118B



PLAN
SCALE IN FEET
0 5 10 20 30



D - D
0 5 10 20 30



LEGEND			
	Bore Hole		
	Cone Penetration Hole		
	Bore & Cone Penetration Hole		
	Water Levels established at time of field investigation		
	Piezometer		
	Stack Pipe		
NO.	ELEVATION	STATION	OFFSET
11	569.2	123+00	26.5 FT.
12	569.7	123+05	26.2 FT.
13	574.0	123+06	15.5 FT.
P.B.	571.4	123+11	26.2 FT.
P.O.	571.8	123+17	26.7 FT.
H.10	571.4	123+14	26.4 FT.
D.P.3	571.6	123+22	27.2 FT.
B.P.4	578.5	121+05	16.5 FT.

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

DEPARTMENT OF HIGHWAYS - ONTARIO MATCHES & RESEARCH DIVISION - FOUNDATION SECTION			
HIGHWAY NO. 3A SLOPE FAILURE AT WELLAND			
COORDINATED BY: WIDEN	DISTRICT NO. 4	DATE: JUNE 1, 1968	
DRAWN BY: F. CLARK	W.P. NO. —	JOB NO. 61-F-118	
CHECKED BY: [Signature]	CONTRACT NO.	DRAWING NO.	
APPROVED BY: [Signature]		61-F-118 C	