EA 1446

67-F-3??

R E P O R T

to

OTTER CREEK CONSERVATION AUTHORITY

on

SOIL CONDITIONS

PROPOSED DAM

NORWICH ONTARIO

Distribution:

4 copies : Crysler, Davis & Jorgensen, Limited
Consulting Engineers

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Our Reference
FC 1079
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[illegible] January [illegible]

STRUCTURE SITE No. 24-284

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

I N D E X

SOILS REPORT

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BORING RECORDS

APPENDIX I

Figure 1 : Laboratory Testing - Results.

DRAWING PC 1078-1 : Borehole Location and Inferred Soil Stratigraphy

INTRODUCTION

Franki of Canada Limited has been retained by Gryzler, Davis and Fergusen, Limited, Consulting Engineers for the Otter Creek Conservation Authority, to carry out a soil investigation at the site of a proposed dam on Otter Creek at Norwich, Ontario.

The object of the investigation was to determine and interpret the soil conditions at the site as they affect the design of the dam and the spill-way.

PROCEDURE

The field work was carried out on January 3rd, 4th, 5th, and 10th, 1962 and consisted of 3 detailed boreholes with adjacent dynamic penetration tests and one additional dynamic penetration test. The necessity of the additional test was decided after the main field work had been completed and this test was carried out on January 16th 1962.

Frequent samples were taken in each borehole and in-situ falling head permeability tests were carried out to enable estimation of possible seepage from the proposed reservoir. The location of the borings are given on Drawing FC 1078-1 which also shows a section of the inferred soil stratigraphy. A detailed log for each boring is given on the Boring Records.

Soil testing on samples obtained was carried out in our laboratory and the results are given on Figure 1 of Appendix I and on the Boring Records. Samples remaining after testing will be stored until 1st August 1962 and then discarded unless other instructions are received.

Elevations referred to in this report are Geodetic and were obtained from a benchmark shown on the Drawing.

SOIL CONDITIONS

The main soil strata encountered by the borings are as follows :

Fill

All boreholes were put down through the embankment and encountered fill to a depth of 3 to 4 feet. This fill consists mainly of brown to dark brown organic silty fine sand occasionally mixed with clay and containing dispersed gravel. Occasionally pockets of organic material were encountered.

Due to its nature, variations in composition of the fill may be expected but on the basis of this investigation the fill generally appeared to be fairly clean. On the slopes of the embankment foreign material such as broken concrete, bricks, etc, were locally observed. It could not be determined whether these were part of the fill or served as protection of the fill in periods of high water.

Because of the frozen condition of the upper 2 feet of the fill, it was difficult to establish its density, but based on the penetration values of the lower part of the fill, it appears that little effort has been made to compact the fill during placing.

Permeability tests carried out in the fill gave a coefficient of average permeability smaller than 10^{-7} centimeters per second. These values should be regarded with reservation however, since they cannot be representative for the fill in general.

Very Loose to Loose Brown Silty Fine Sand to Sandy Silt

Beneath the fill in boreholes 1 and 3 and inferred in penetration test 4 is a stratum of silty fine sand to sandy silt. The material is stratified and generally cross bedded and frequently contains dark brown organic seams.

The material is generally fine grained, varying between a silty fine sand and sandy silt. Grainsize analyses were carried out on representative samples in this range and the resulting grainsize distribution curves are shown on Figure 1 of Appendix I. They show the material to be fairly uniform in the sand sizes, suggesting it to be pervious. The maximum coefficient of average permeability obtained in the field was of the order of 1.5×10^{-3} centimeters per second. The upper part of the stratum contains in addition to sand and silt some clay sizes, and in this part the permeability was found to be much less, of the order of 10^{-4} centimeters per second. It should be emphasized however that due to the stratified nature of the stratum, the permeability in a horizontal direction will be greater than that in a vertical direction. The above results of the in-situ falling head permeability tests therefore are of necessity conservative and it is recommended that the coefficient of horizontal permeability be taken as at least 10^{-3} centimeters per second.

Natural moisture content determination carried out on samples from the stratum gave a moisture content ranging from 22 to 28 percent.

Standard penetration or 'N' values obtained ranged from 2 to 6 blows per foot, indicating the very loose to loose relative density of the stratum. This is confirmed by the results of the dynamic penetration tests.

Very Loose to Loose Grey Stratified Sand

The brown fine grained sand and silt in boreholes 1 and 3 are underlain by a stratum of stratified grey sand. The grey sand is of fine to coarse grainsize and moderately silty. It is further distinctly stratified and cross-bedded and contains organic seams as well as pieces of wood and dispersed gravel.

Although the overall grainsize is coarser than that of the overlying brown sand, the material is also better graded, as indicated by a typical grainsize curve on Figure 1 and it may therefore be expected that the coefficient of vertical permeability of the grey sand would be similar to that of the brown sand. This was borne out in in-situ permeability tests. The coefficient of horizontal permeability however should be greater and is estimated to be of the order of 5×10^{-3} centimeters per second. A natural moisture content of 47 percent was obtained on a sample from the stratum.

The 'N' values obtained ranged from 2 to 6 blows per foot, indicating the very loose to loose relative density of the stratum, which is confirmed by the results of the dynamic penetration tests.

Very Dense Grey-brown Silt to Silt Till

Beneath the grey sand in boreholes 1 and 3 and beneath the fill in borehole 2 is a stratum of silt changing to silt till to the depth explored.

The upper part of the stratum consists of cross-bedded silt with occasional sandy pockets and seams about 1/8-inch in thickness. With depth the silt contains isolated gravel and resembles a till material. The gravel pieces are generally very sharp angular and up to 1/4-inch in size. Some typical grainsize curves obtained for the silt are shown on Figure 1.

The colour of the stratum in boreholes 1 and 3 is grey-brown grading to grey. In borehole 2 the upper 5 feet of the stratum are brown in colour becoming grey-brown below this depth. The brown colour is a result of oxidation.

Standard penetration or 'N' values obtained were greater than 50 blows per foot and frequently greater than 100 blows per foot indicating the very dense nature of the ...ial. In borehole 3 however very low 'N' values were ...untered at a depth of about 20 feet. There is no geological explanation for decrease in density at this depth and it is believed that the low values obtained are due to hydrostatic pressure in locally coarser material in the borehole after removal of the overburden.

Falling head permeability tests carried out in the silt stratum all showed the material to be practically impervious.

The natural moisture content of the silt ranged from 12 to 17 percent. A unit weight determination gave a value of 142 pounds per cubic foot.

WATER CONDITIONS

The ground water level in the boreholes was observed throughout the period of the investigation and was found to be close to river level which at that time was at elevation 846. In boreholes 1 and 3 the ground water level establishes itself almost immediately; in borehole 2 it took about 3 days for the water level to come to equilibrium, due to the very low permeability of the silt stratum.

DISCUSSION

The proposed dam will be about 300 feet long. The regulated high water level in the reservoir will be at elevation 856. The top of the dam will be at elevation 859 and its width at the top will be about 20 feet. The spillway will be a reinforced concrete structure, about 45 feet wide and having three gates with removable stop logs. In the present design, the structure has a raft type foundation exerting a dead weight, evenly distributed, loading of about 1000 pounds per square foot. Due to unbalanced water pressure and ice the theoretical maximum foundation pressure at the downstream side could increase to about 1500 pounds per square foot.

The present elevation of the top of the roadway is at about elevation 854. This roadway will be incorporated in the proposed dam and must be raised to elevation 859. The present fill, based on the results of this investigation, consists generally of fine silty sand and appears to be fairly clean. The fill is in a loose condition and due to its nature may, locally, be very unsatisfactory material. Since the present fill is only about 4 feet high, it is recommended that rather than using it as a core for the proposed dam, it be spread over the base width of the proposed dam. It should then be compacted to its maximum density before additional fill is placed. The new fill will probably be locally obtained and it may be advisable, depending on its nature, to subject this fill to testing before specifying its use. In a doubtful case, grainsize analyses and compaction tests would indicate the competence of the material for use as fill and placing procedures could be established.

The stability of the dam under full hydrostatic pressure was examined and found to be adequate. Based on the sub-soil conditions it is considered that settlement of the dam will not occur, provided that the dam fill itself be well compacted during placing to avoid internal settlement. It is further recommended that placing and compaction of the fill be carried out in layers not exceeding 6 to 9 inches in thickness.

The expected water supply of the drainage basin above the dam is not known, nor are data for the required flow downstream available. Seepage considerations depend on the above factors. The subsoil overlying the silt stratum is moderately pervious. Using the high water level behind the dam and an average permeability of 10^{-3} centimeters per second a seepage analysis shows that the seepage would not exceed 0.1 cubic feet per second. This value is considered to be insignificant. However, the upstream face of the dam should be protected against wave action, preferably by rip-rap. In order to make the rip-rap protection stable, it is recommended that a graded filter be provided beneath the rip-rap or alternatively an impervious layer such as a clay blanket. In this regard it is understood that a clay pit exists in the vicinity of the damsite.

At the location of the structure, the computed foundation pressures of 1000 to 1500 pounds per square foot could be allowed at or below elevation 84.3. In the very dense silt stratum. The actual safe bearing capacity is of the order of 5000 pounds per square foot and the factor of safety in the present design is adequate. Settlement under the proposed foundation pressures should be negligible.

In the present design the foundation level is at elevation 840 with cut-off walls at the heel and toe to elevation 837. This latter elevation is close to that at which a notable decrease in density was noticed in borehole 2. The same trend although much less distinct is indicated in the other borings. It is not clear which significance should be attached to this phenomenon but it would be advisable to keep the cut-off walls as high as possible above elevation 837.

The stability of the structure under full hydrostatic pressure was further investigated. A sliding wedge type of failure was analysed with the sliding surface at elevation 840. The factor of safety against this type of failure was found to be adequate.

Based on the grainsize distribution and permeability of the silt it is considered that no special safeguards against piping need be provided.

Excavation to foundation level has to go below the ground water level. The most practical way to carry out the excavation would probably be to dam off the present river course and detour the river away from the present structure. The excavation should be kept larger than the footing size and provision should be made for perimeter drains which may consist of ditches extending below the main excavation level. These drains should be graded towards sumps, from which water may be removed if required. The grey sand above the silt may have to be temporarily sheeted during excavation.

CONCLUSIONS AND RECOMMENDATIONS

1. The site is part of an extensive silt to silt till stratum of high relative density, covered by very loose to loose stratified granular deposits.
2. The ground water level at the time of the investigation was at elevation 846.
3. It is recommended that the present roadway fill be spread and compacted prior to placing the new fill.
4. Depending on the nature of the new fill it may be advisable to carry out some routine testing on bulk samples from this fill to determine its suitability and the placing procedures.
5. The stability of the proposed dam is adequate and no settlement should occur.
6. Seepage will be small and probably insignificant.
7. Erosion protection should be provided at the upstream face of the dam.
8. The foundation design of the proposed structure is adequate but it is recommended that it be kept as high as possible.

FRANKI OF CANADA LIMITED

AP/DMB

A. Prior, P. Eng.
Divisional Soils Engineer

FRANKI OF CANADA LTD.

BORING RECORD

DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT -

CONTRACT FC 1072 BORING 4 BORING DATE 16 .. 62

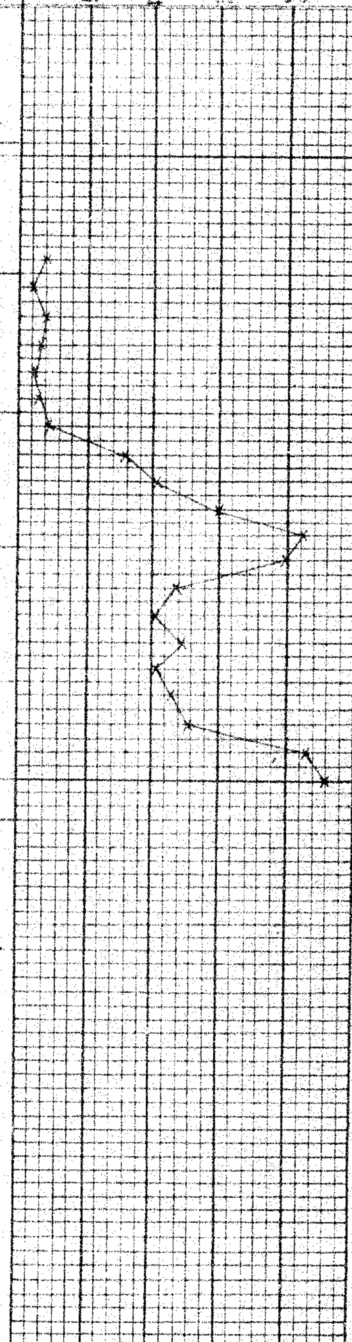
DATUM GEODETIC DIAM. ______ HAMMER 140 LBS. DROP 30 IN.

SOIL PROFILE – DESCRIPTION	STRAT. PLOT	ELEV DEPTH	ELEV SCALE
GROUND LEVEL		854.5 / 0.0	855
PROBABLY SANDY FILL		850.5 / 4.0	850
PROBABLY LOOSE SILTY SAND TO SANDY SILT		846.5 / 8.0	845
PROBABLY LOOSE STRATIFIED SAND		844.5 / 10.0	
PROBABLY VERY DENSE SILT		831.5 / 23.0	840, 835
END OF PENETRATION TEST			830, 825

STANDARD PENETRATION RESISTANCE

DYNAMIC PENETRATION RESISTANCE ×—×

BLOWS PER FOOT



SAMPLES – DEPTH	TYPE	NUMBER	% RECOVERY

SAMPLE TYPES

AS AUGER SAMPLE
DO DRIVE OPEN
DF DRIVE FOOT VALVE
SO SLEEVE OPEN
SF SLEEVE FOOT VALVE
TO THIN WALLED OPEN
TP THIN WALLED PISTON
WS WASHED SAMPLE

RC ROCK CORE
K_P FIELD PERMEABILITY TEST
GROUND WATER LEVEL AT TIME OF BORING

REMARKS ______

FRANKI OF CANADA

SOIL INVESTIGATIONS

MECHANICAL ANALYSIS

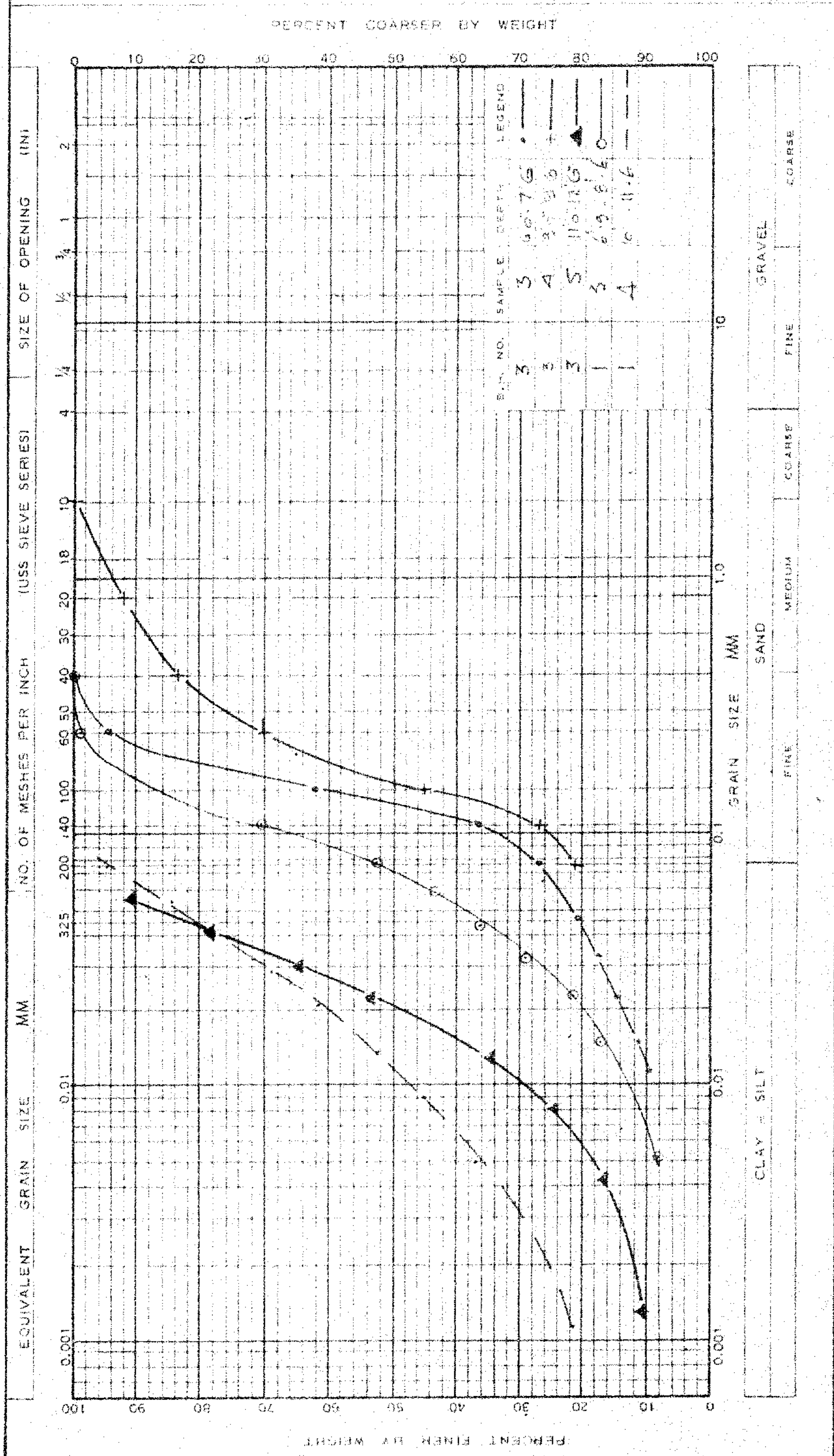
P.C. NO. [illegible] LAB. NO. 1

PROJECT Norwich Dam Out

BOREHOLE NO. 5 SAMPLE NO. [illegible]

TESTED BY [illegible] DATE [illegible]

CHECKED BY ______ DATE ______

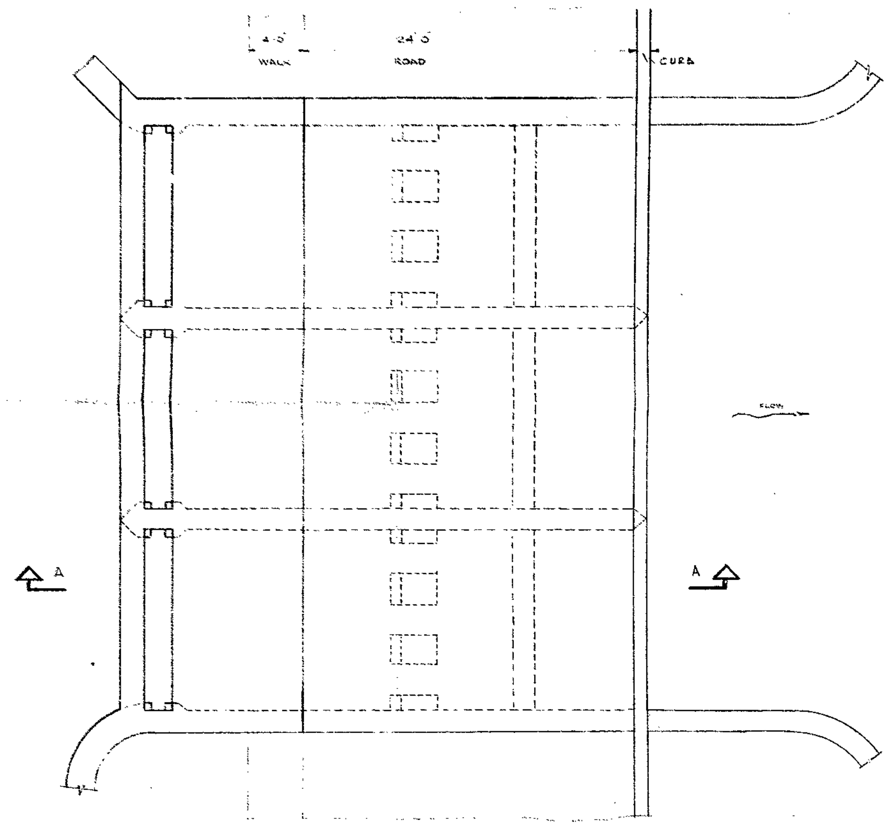


#62-F-312 M

DAM AT

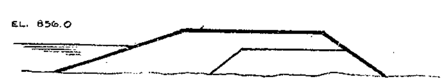
OTTER CREEK

NORWICH TWP.



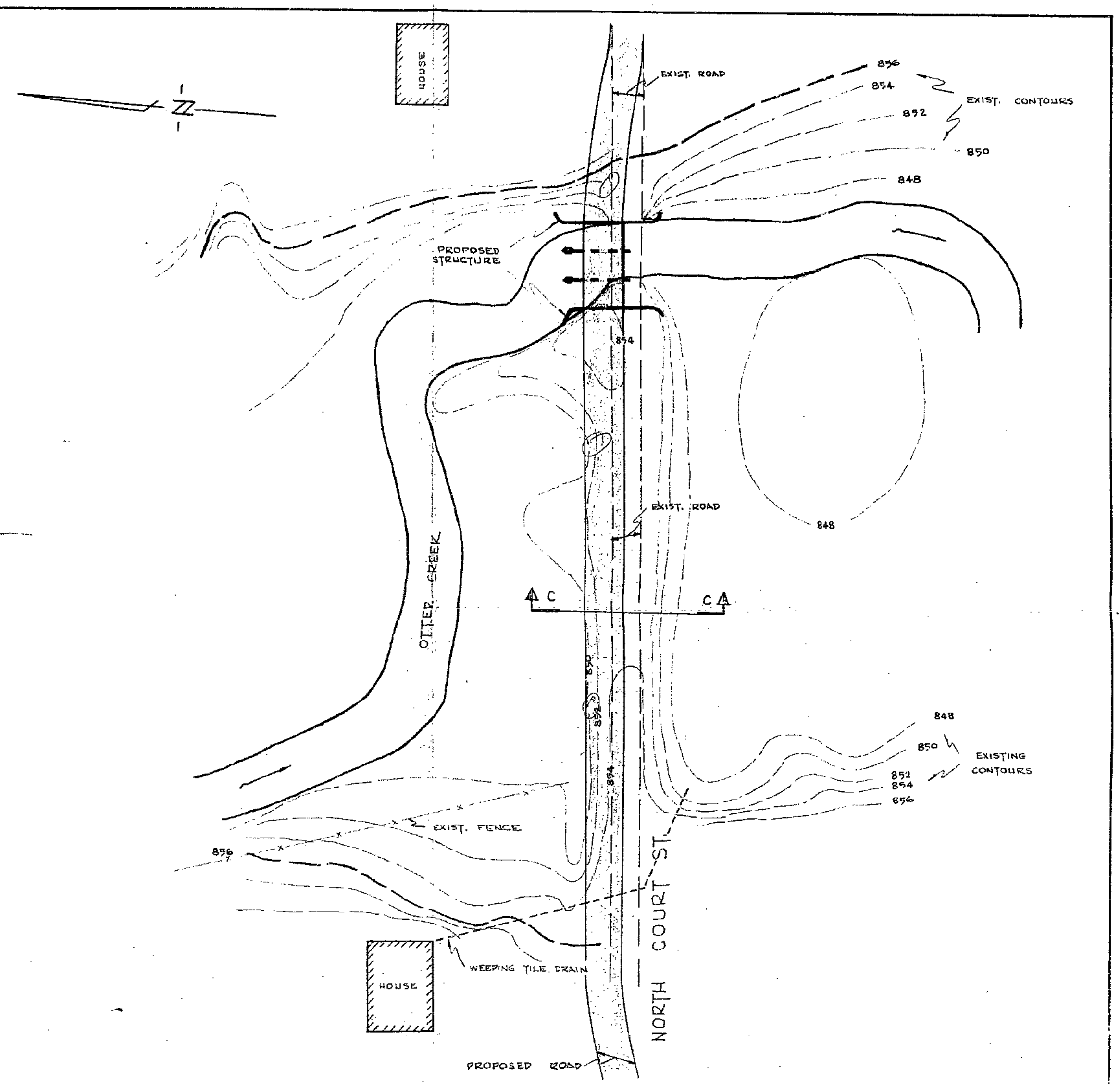
PLAN OF PROPOSED SPILLWAY

SCALE 1 IN. = 6 FT.



SECTION C-C

1 IN. = 20 FT.

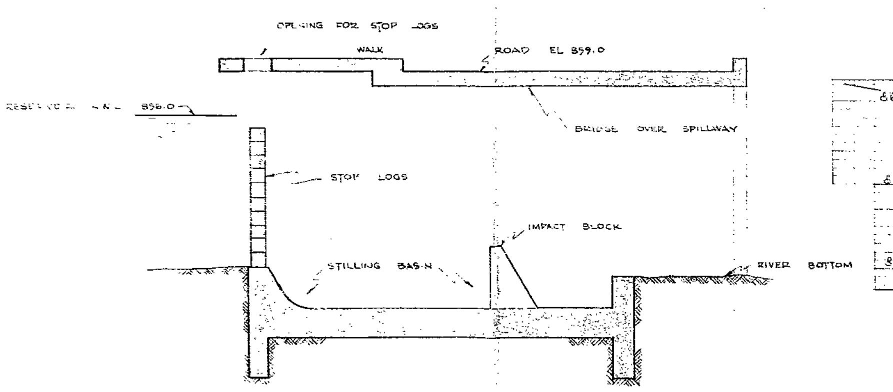


SITE PLAN

1 IN. = 40 FT.

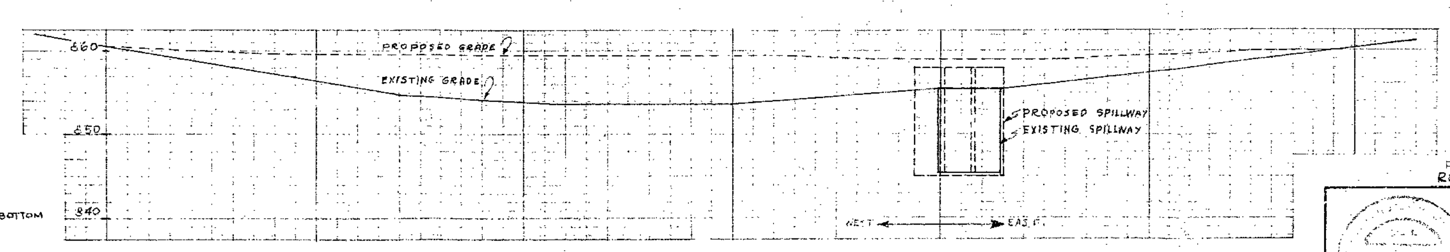
NOTE

ALL ELEVATIONS TO GEODETIC DATUM



SECTION A-A – THROUGH SPILLWAY

SCALE 1 IN. = 6 FT

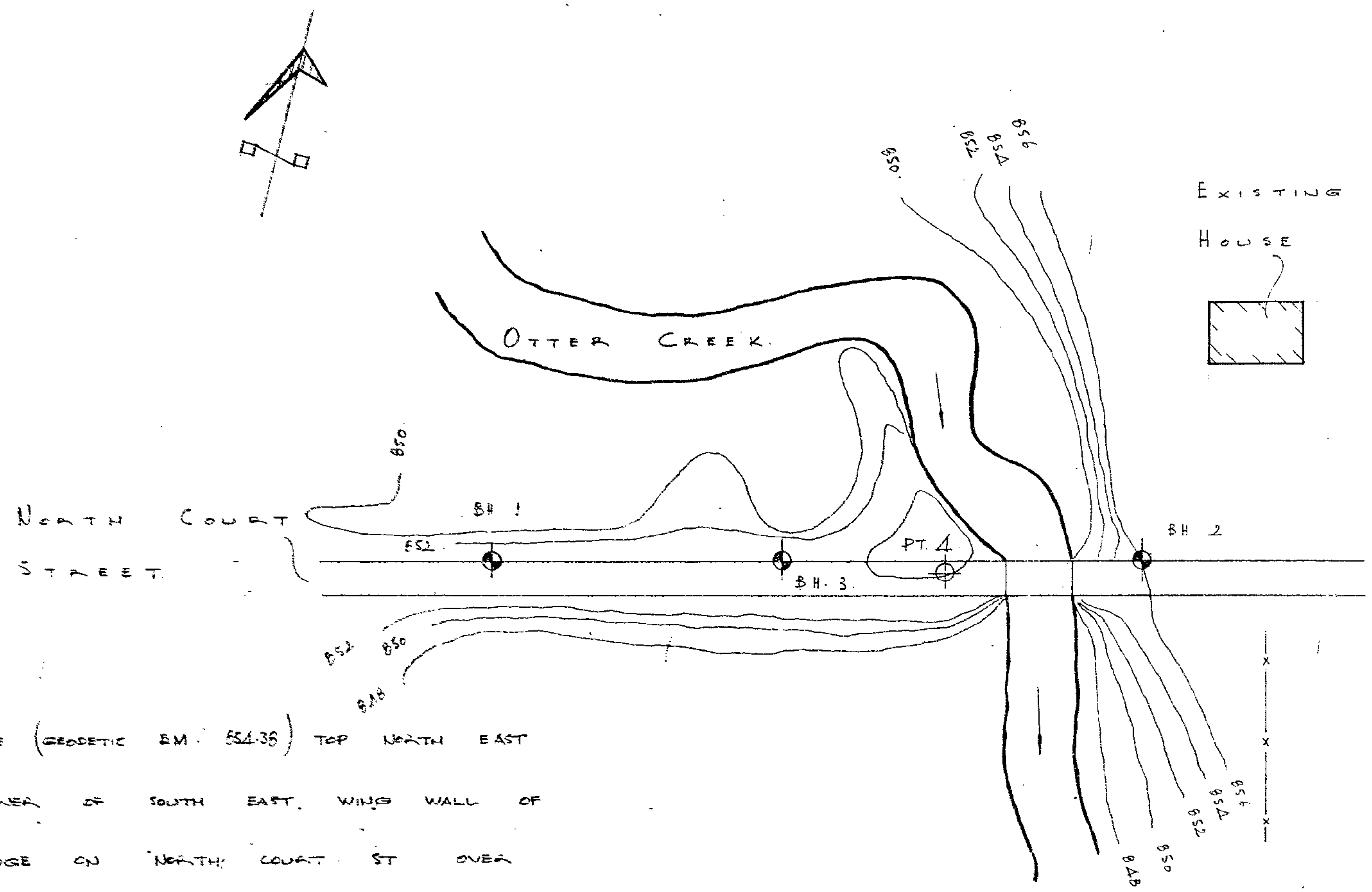


PROFILE

SCALE: HOR 1" = 40'
VER 1" = 10'

PROFILE ADDED AND ROAD WIDTH REVISED — APRIL 16, 1962

	OTTER CREEK CONSERVATION AUTHORITY
	SITE PLAN AND SPILLWAY for PROPOSED NORWICH DAM
app'd	CRYSLER, DAVIS & JORGENSEN, LIMITED CONSULTING ENGINEERS WILLOWDALE ONTARIO
drawn D. Kilner	scale: AS NOTED — date: JAN. 26. 1962 — dwg. no. **6158-2**
chk'd	



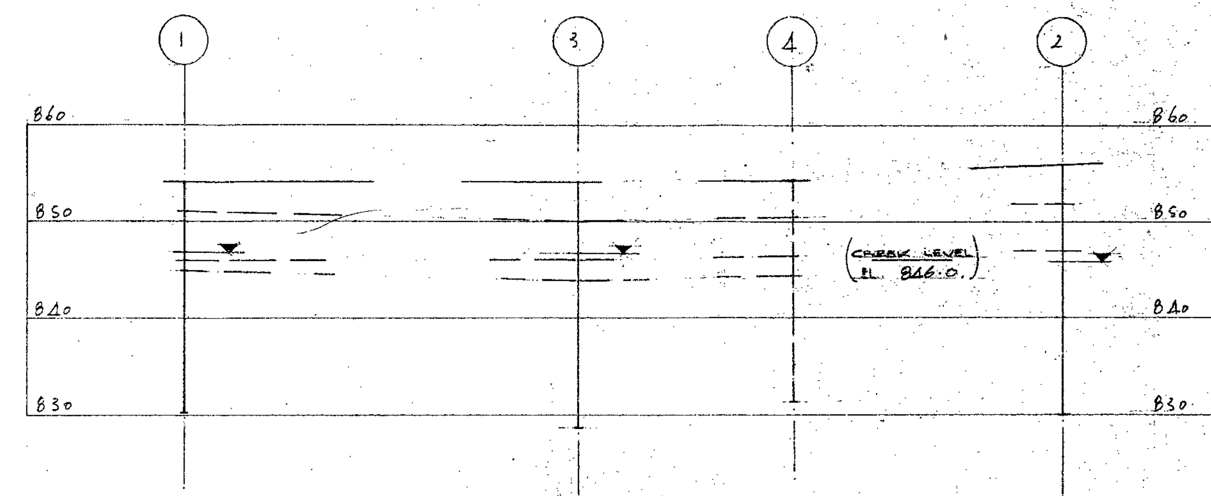
Note (Geodetic BM. 554.35) top north east corner of south east wing wall of bridge on North Court St over Otter Creek.

Site Plan.

(Scale 1" : 40')

Borehole and penetration test.

Penetration test.



Cross Section through Boreholes.

Scale { 1" : 30' horizontal
1" : 10' vertical.

Loose brown sandy fill.

Very loose to loose brown stratified silty fine sand to sandy silt.

Very loose to loose grey stratified sand.

Very dense brown oxidized silt.

Very dense grey brown silt.

Borehole and penetration test in elevation.

Penetration test in elevation.

Ground water level.

Job No.	PC. 1072.	Boring plan and soil stratigraphy for Norwich Dam.
Date	Jan. 62	
Scale	Noted.	
Dwg. by	[illegible]	
Ch'kd by	[illegible]	DRG. PC. 1072/1.
Approved	[signature] Project Engineer	Franki of Canada Ltd. 214 [illegible] St. [illegible]

FRANKI OF CANADA LTD. — BORING RECORD

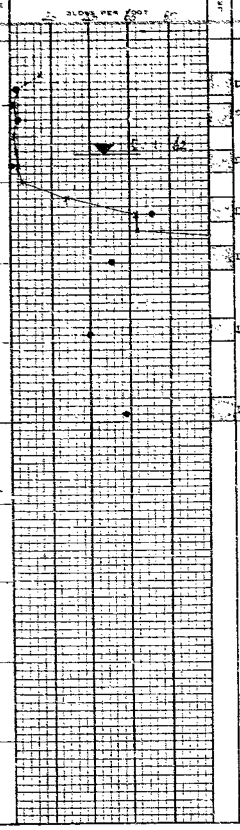
DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT

CONTRACT PC 1072 BORING 1 BORING DATE 3 1 62
DATUM GEODETIC DIAM. BX HAMMER 140 LBS. DROP 30 IN

Description	Elev. Depth	Elev. Scale	Sample Depth	Type	Number	% Recovery	Other Tests
GROUND LEVEL	854.0						
LOOSE BROWN SANDY FILL	0.0			DO	1	30	Kf
VERY LOOSE TO LOOSE BROWN STRATIFIED SILTY FINE SAND TO SANDY SILT	851.0 / 3.0	850		DO	2	30	Kf
	845.0	845		DO	3	100	Kf M.
VERY LOOSE TO LOOSE GREY STRATIFIED SAND	9.0			DO	4	100	Kf M γ 142
VERY DENSE GREY BROWN SILT		840		DO	5	100	
		835		DO	6	100	
		830		DO	7	100	
END OF HOLE	24.0	825					

Ground water level at time of boring: 5 1 62

STANDARD PENETRATION RESISTANCE / DYNAMIC PENETRATION RESISTANCE — BLOWS PER FOOT 20 40 60 80



LABORATORY TESTS — SHEAR STRENGTH LBS./SQ. FT. — WATER CONTENT % 10 20 30

SAMPLE TYPES
AS AUGER SAMPLE
DO DRIVE OPEN
DF DRIVE FOOT VALVE
SO SLEEVE OPEN
SF SLEEVE FOOT VALVE
TO THIN WALLED OPEN
TP THIN WALLED PISTON
WS WASHED SAMPLE

RC ROCK CORE
K_F FIELD PERMEABILITY TEST
▼ GROUND WATER LEVEL AT TIME OF BORING
REMARKS

O WATER CONTENT
|—| ATTERBERG LIMITS
γ IN SITU UNIT WEIGHT
M MECHANICAL ANALYSIS
K_F PERMEABILITY FIELD
K_L PERMEABILITY LAB.
d_R RELATIVE DENSITY
s.g. SPECIFIC GRAVITY
P COMPACTION
● UNCONFINED
▲ UNDRAINED TRIAXIAL
■ IN SITU VANE
□ LAB VANE
CU CONSOLIDATED UNDRAINED
CUP CONSOLIDATED UNDRAINED WITH PORE PRESSURE MEASUREMENTS
d CONSOLIDATED DRAINED
C CONSOLIDATION

FRANKI OF CANADA LTD. — BORING RECORD

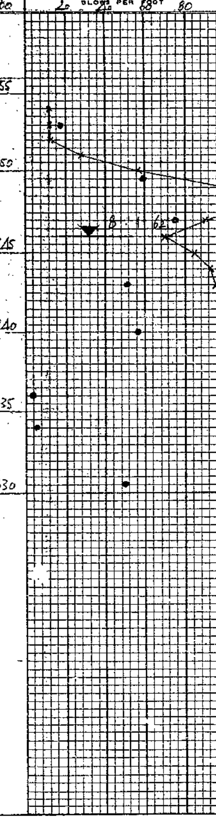
DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT

CONTRACT PC 1072 BORING 2 BORING DATE 4 1 62
DATUM GEODETIC DIAM. BX HAMMER 140 LBS. DROP 30 IN

Description	Elev. Depth	Elev. Scale	Sample Depth	Type	Number	% Recovery	Other Tests
GROUND LEVEL	856.0	860					
LOOSE TO COMPACT BROWN SANDY FILL	0.0	855		DO	1	100	Kf
	852.0			DO	2	50	Kf
VERY DENSE BROWN OXIDIZED SILT	4.0	850		DO	3	100	Kf
	847.0 / 9.0			DO	4	30	Kf
VERY DENSE GREY BROWN SILT		845		DO	5	100	
		840		DO	6	100	
		835		DO	7	100	
				DO	8	100	
		830		DO	9	100	
END OF HOLE.	26.0						

Ground water level at time of boring: 8 1 62

STANDARD PENETRATION RESISTANCE / DYNAMIC PENETRATION RESISTANCE — BLOWS PER FOOT 20 40 60 80



LABORATORY TESTS — SHEAR STRENGTH LBS./SQ. FT. — WATER CONTENT %

SAMPLE TYPES
AS AUGER SAMPLE
DO DRIVE OPEN
DF DRIVE FOOT VALVE
SO SLEEVE OPEN
SF SLEEVE FOOT VALVE
TO THIN WALLED OPEN
TP THIN WALLED PISTON
WS WASHED SAMPLE

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P COMPACTION
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▲ UNDRAINED TRIAXIAL
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□ LAB VANE
CU CONSOLIDATED UNDRAINED
CUP CONSOLIDATED UNDRAINED WITH PORE PRESSURE MEASUREMENTS
d CONSOLIDATED DRAINED
C CONSOLIDATION

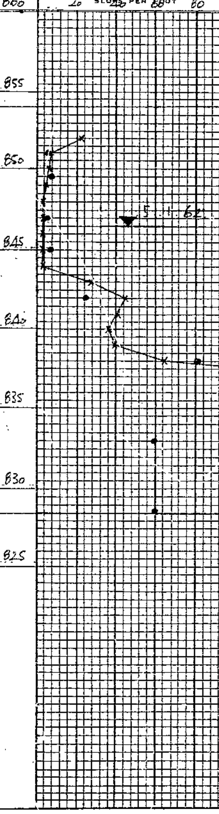
FRANKI OF CANADA LTD. — BORING RECORD

CONTRACT PC 1072 BORING 3 BORING DATE 5 1 62
DATUM GEODETIC DIAM. BX HAMMER 140 LBS. DROP 30 IN

Description	Elev. Depth	Elev. Scale	Sample Depth	Type	Number	% Recovery	Other Tests
GROUND LEVEL	854.0	860 / 855					
LOOSE BROWN SANDY FILL	0.0	850		DO	1	30	Kf
VERY LOOSE TO LOOSE BROWN STRATIFIED SILTY FINE SAND TO SANDY SILT	4.0			DO	2	0	Kf
	846.0			DO	3	30	Kf M
VERY LOOSE TO LOOSE GREY STRATIFIED SAND	8.0 / 844.0	845		DO	4	30	Kf M
VERY DENSE GREY BROWN SILT.	10.0			DO	5	100	M.
		840		DO	6	100	
		835		DO	7	100	
	829.5	830		DO	8	100	
END OF HOLE	24.5	825					

Ground water level at time of boring: 5 1 62

STANDARD PENETRATION RESISTANCE / DYNAMIC PENETRATION RESISTANCE — BLOWS PER FOOT 20 40 60 80



LABORATORY TESTS — SHEAR STRENGTH LBS./SQ. FT. — WATER CONTENT % 10 20 30 40 50

SAMPLE TYPES
AS AUGER SAMPLE
DO DRIVE OPEN
DF DRIVE FOOT VALVE
SO SLEEVE OPEN
SF SLEEVE FOOT VALVE
TO THIN WALLED OPEN
TP THIN WALLED PISTON
WS WASHED SAMPLE

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CUP CONSOLIDATED UNDRAINED WITH PORE PRESSURE MEASUREMENTS
d CONSOLIDATED DRAINED
C CONSOLIDATION