HAMPDEN INTERSTATE
PENOBSCOT COUNTY

SOILS REPORT 61-25

COLD BROOK BRIDGE
I-95-7 (16)

SUBSURFACE INVESTIGATION FOR
PROPOSED COLD BROOK ROAD BRIDGE IN
HAMPDEN, MAINE

I-95-7(16)

State Highway Commission

Soils Division

SEPTEMBER 1961

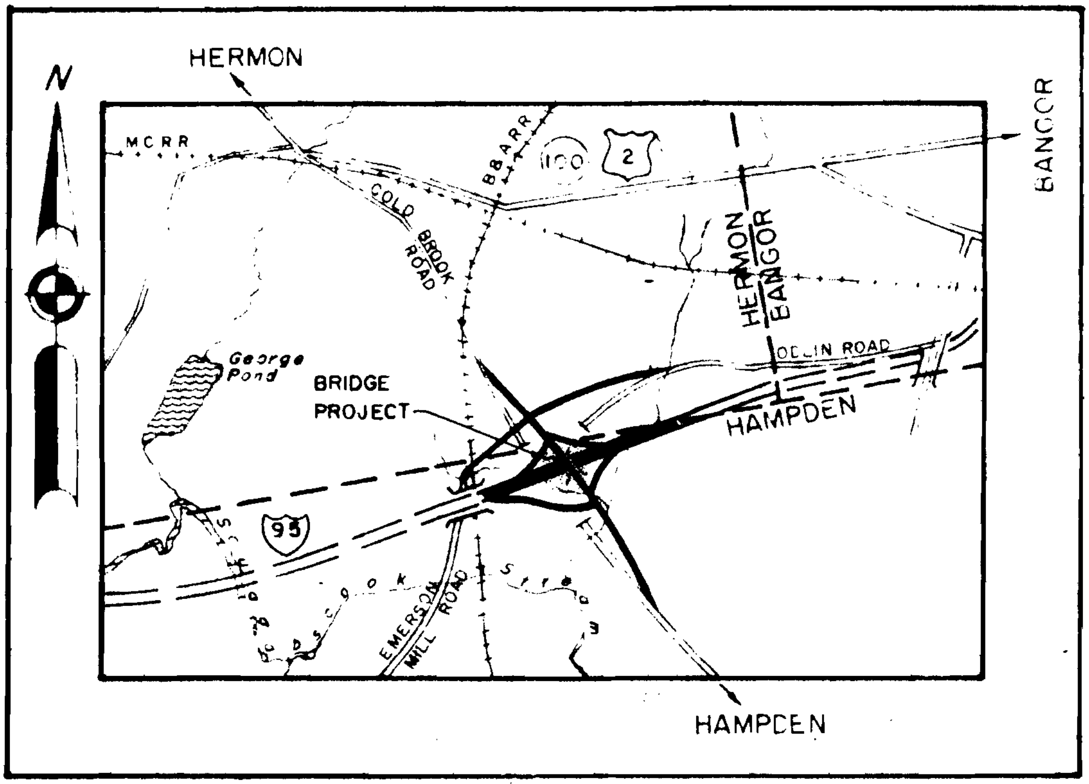
HAMPDEN

PENOBSCOT COUNTY

PROJECT NUMBER I-95-7 (16)

COLD BROOK ROAD BRIDGE

1961



LOCATION MAP

Scale 1" = 1 Mile

KEY MAP

CONTENTS

INTRODUCTION

A subsurface investigation has been completed for the proposed substructure units and approach fills for the bridge to carry the Cold Brook Road traffic over the Interstate Highway in Hampden, Maine. This bridge is to be part of the construction project, I-95-7(16). The proposed bridge is located near Station 3655+00 on the Interstate Highway or seven hundred feet southeasterly of the present intersection of the Odlin Road and existing Cold Brook Road. Preliminary borings for the determination of the subsoils were made in the Fall of 1960. Based upon the subsurface conditions, the original grade line which was to have cut through the area to a depth of fifteen to twenty-five feet was raised. With the completion of the highway grade line, the bridge plans were initiated and borings for the substructure units were made by a drilling crew under the supervision of Mr. Carlisle in April of this year.

Since soft soils were noted with depth, samples obtained by the drilling crews were tested in the laboratory and the results of the consolidation curves are shown on Sheet 1 while direct shear diagrams are shown on Sheets 2 and 3. In order to provide adequate clearance over the Interstate Highway, it has been necessary to raise or fill behind both abutments. This increased weight of roadway will create new stresses on the subsoils. Shear summaries have been completed showing the minimum factors of safety from this analysis and are shown on Sheets 4 and 5. The details for all the borings are shown on Sheets 6 and 7 while the plan and soils profile interpreted from the borings are shown on Sheet 8. The boring notes are shown on Sheet 9.

GENERAL CONDITIONS

A cut of ten to twenty feet through the existing knoll or terrace on which the Cold Brook Road lies was first believed most economical. This grade line would minimize the fill in order to provide satisfactory approaches for the relocated Cold Brook Road. Preliminary borings, however, indicated that within the area the subsoils consisted of between thirty and thirty-five feet of clay extending from the surface downward. The top ten to twelve feet of this clay has been weathered as was noted by the brown rust stains (evidence of drying or oxidation of the iron) and the material was noted to be in a stiff consistency. This stiff layer is characterized by a shear strength of 0.8 tons per square foot, a water content of twenty to twenty-five per cent, a liquid limit of thirty-five per cent, and a plastic limit of eighteen per cent. This layer should therefore aid in distributing the weight of the new embankments over the adjacent softer soils much as a spread footing transmits the load to a smaller unit pressure.

This stiff overlying clay layer becomes more plastic with depth changing to a gray soft, sensitive silty clay. This sensitive clay appears to increase in shear strength with depth; however, the top portion of the deposit has an average shear strength between 0.24 and 0.30 tons per square foot. This soil is further characterized by an existing water content of 36 to 39 percent, a liquid limit of 35 percent and a plastic limit of 18 per cent. Since the existing water content is well above the liquid limit, if the material is remoulded, it will tend to act like a liquid. It is in this layer which causes the most difficulty in designing an adequate factor of safety against shearing for the new embankments. This is further complicated since the Interstate Highway will be in a cut section, and in so doing, the resisting moment normally afforded stiff layers will be lost. It has been this reduction which has caused an extensive office analysis for the embankment design.

The soft sensitive clay becomes of medium consistency with depth and the water content decreasing and the shear strength increasing to 0.32 to 0.38 tons/sq. ft. This deposit of clay was not varved nor were there any thin sand streaks to afford lateral drainage; whereas, a deposit of clay which underlies this soft to medium clay had large bandings of thin sand streaks which does afford the lateral drainage.

The underlying clay with banded sand streaks was noted to be considerably higher shear strength than previously noted with a shear strength near 0.50 tons/sq. ft., and an existing water content of near 30 per cent. Thus, it appears that the lateral drainage within this area has allowed this material to consolidate or squeeze out the water, thus increasing the grain to grain contact of the clay particles resulting in a high shear strength. This stiff varved clay was in turn underlain by a pebbly silty sand which in turn was underlain by ledge, a phyllite with a high angle of foliation as is normal within this area and with thin streaks of quartz and calcite.

Thus the subsoils at the proposed substructure units and for the approach fills behind the abutments are classified not only as compressible but highly sensitive and care must be exercised in building any embankments within the area since the shear strengths are low. In order to minimize difficulties and because of unknowns as to the quantity or exact boundaries of the stiff layer as well as variation of the shear strength within the soft layer, it is recommended that the approach fills be completed and allowed to set for at least 30 days after completion of the excavation of the Interstate Highway. At this point, the completion of excavation of the Interstate embankments and the abutment fills, the factor of safety against shearing should be at its lowest and any additional time would not only allow the material to consolidate, but for the material to stiffen up due to drying. Sufficient strengths should then be realized to withhold the embankments and allow the construction of the substructure units.

It is recommended that the substructures for the bridge be supported by piles driven into the underlying dense soils or ledge. Because of the extensive length and heavy driving resistence anticipated, steel piles would be recommended.

DETAILED CONDITIONS

Southerly Approach Fill

The existing ground at the proposed location of Abutment No. 1 is at elevation 138 with the finished grade in the vicinity of elevation 153 or a fill of fifteen feet is proposed above the present ground surface. The finished grade of the highway along the northbound lane is in the vicinity of elevation 132.5 or an excavation must be made along the Interstate northbound lane in order to provide for the base and drainage for the new roadway. Boring AC-24, the details of which are shown on Sheet 6, was made fifteen feet right of the centerline of Cold Brook Road relocated at Station 143+19.2. From this boring it can be seen that ten feet of very stiff brown sandy clayey silt was encountered, below which a deposit of clay varying from very soft to medium consistency with some black spots was noted to extend from the ten foot depth of the 32 foot depth. Below this clay was a seven foot layer of stiff consistency gray varved clay with embedded sand layers. A layer of dense gray pebbly silty sands underlies the stiff clay and is eleven feet in thickness, below which rock was cored. The boring operations stopped after 1.5 feet of rock was cored when the core barrel broke. The rock is believed to be ledge and closely coincides with the refusals and other ledge borings within the area.

As was previously noted in the General Conditions, the disturbing feature of the soils within this area is the soft sensitive clay lying between elevation 115 and 128. This deposit of clay causes two difficulties, that of settlement and that of shearing. The primary concern would be of shearing. A detailed shear analysis was therefore completed for the proposed abutment fills and the summary of this analysis is shown on Sheet 5. On this analysis it can be seen that the minimum safety factor of 1.20 was realized in tangent to the bottom of the soft layer, whereas a deeper shear tangent to the bottom of the medium consistency clay had a minimum factor of safety of 1.21. This factor of safety is the minimum usually required for embankment construction. Since the embankments will be within a structure area, extreme caution must be utilized. The layer of stiff clay between elevations 128 and 138 should ordinarily support and carry the embankment over the softer soils, but as noted on the shear analysis and previously noted, the northbound roadway is to be excavated and thus the stiff layer will be lost. It is this lost stiff layer which causes the high loss of strength in shearing value and keeps the factor of safety very small. The proposed figures are believed to be on the conservative side. However, if the stiff layer cracks, all shear strengths in the stiff layer are lost imposing larger loads on the underlying layers, which would tend to induce a shear. It is therefore recommended that the approach fill be constructed in conjunction with the highway cut along the centerline of the northbound roadway and that the embankment be allowed to set for a minimum period of thirty days upon completion of the fill to subbase grade as well as the complete excavation along the northbound roadways to the minimum depth. The addition of gravel base and pavement will be within the resisting area of the shear analysis and should increase the factor of safety. Thus, the critical time for the embankment or the time when the minimum factor of safety will be realized should be when the fill is completed and the excavation to the subgrade along the northbound lane is completed.

The settlement analysis indicates that a probable fifteen inch anticipated settlement should occur with fifty per cent of the settlement occuring within eight months upon completion of the fill and the majority of all settlement being completed nearly two years after the embankments have been constructed.

Abutment No. 1

Boring AC-24, the details of which are shown on Sheet 6, was made on the right end of the proposed location of Abutment No. 1 at Station 143+19.2. The plan, as well as the soils profile, is shown on Sheet 8. As was previously noted in the approach fill, the subsoils consist of stiff clay underlain by very soft to medium consistency clays. The settlement analysis indicated that up to fifteen inches of settlement should be anticipated to occur within two years after completion of the embankment fill. It was also recommended in the approach fills that the embankments be constructed prior to the construction of the substructure units for this bridge and allowed to remain for at least thirty days after completion of the cut along the Interstate Highway. The soft compressible soils within this area therefore require that the substructure be supported by piles driven through the approach fill and into firmer underlying soils. It is believed that piles can be driven into the dense underlying silty sands with scattered boulders and the piles should stop in the vicinity of elevation 98. Steel or cast in place concrete piles would be recommended with the former being recommended due to high anticipated driving resistence through the approach fill.

Pier No. 1

Boring AC-23 was made along the left end of the proposed location of Pier No. 1 at Station 143+70.2. The details for this boring are shown on Sheet 6 while the plan and centerline profile are shown on Sheet 8. This proposed pier is to be located near the low point of the highway ditch which has been lowered in order to adequately drain the entire area. The bottom portion of the pier will therefore extend within this medium consistency silty clay and silty sticky clay should be anticipated in excavation. A minimum amount of excavation should be made within this area since, as noted on Sheet 5 (the summary of the shear analysis), the pier is within the resisting side of the circle and any material removed will temporarily tend to lower the factor of safety. These soft compressible subsoils indicate that the substructures should be supported by piles driven into the underlying firm sand and gravel. It is believed that piles will be stopped in the vicinity of elevation 95 if cast in place piles are used; whereas, if steel piles are used, the piles can be driven to the ledge surface at elevation 87.5.

Pier No. 2

Boring AC-22 was made on the right end of the proposed location of Pier No. 2 at Station 144+31.9. The details for this boring are shown on Sheet 6 while the plan and centerline profiles are shown on Sheet 8. The subsoils are similar to those encountered at Pier 1 and it is recommended that the substructure for this pier be supported by piles driven through the underlying soft materials. Because the underlying sand and gravel layer decreases in thickness, it is believed that piles can be driven directly to the ledge surface at elevation 92.5. Steel piles or cast in place piles would be recommended.

Pier No. 3

Boring AC-21 was made on the left end of the proposed location of Pier No. 3 at Station 145+10. The subsoils are those similarly encountered at the two previous pier locations in that the substructure should be supported by piles driven through the underlying sensitive clays to the ledge surface. The deposit of sand and gravel was noted to be very thin within this boring and ledge was noted to be at elevation 95.7. Steel piles or cast in place piles should easily reach this elevation.

Pier No. 4

Boring AC-20 was made on the right end of the proposed location of Pier No. 4 at Station 145+72.7. The details for this boring are shown on Sheet 7 while the plan and centerline profile are shown on Sheet 8. As was similarly encountered in the previous pier location, the subsoils are highly compressible and it is recommended that the substructures be supported by piles driven to the ledge surface which was noted to be at elevation 100.6. The deposit of sand and gravel lying directly above the ledge surface was noted to be slightly thicker in this boring, but piles should be able to reach elevation 100.6. Steel or cast in place would be recommended.

Abutment No. 2

Boring AC-19 was made along the left end of the proposed location of Abutment No. 2 at Station 146+46.7. The details for this boring are shown on Sheet 7 with the plan and centerline profile shown on Sheet 8. The ground surface is noted to be at or near elevation 140 with the finished grade at elevation 157 or a seventeen foot fill is proposed behind the abutment. Since the subsoils are the same as encountered within the piers, soft compressible clays, it is recommended that the abutment structure be supported by piles driven through the approach fill into the underlying dense sand and gravel. Because the density of the sand and gravel was noted to be high, it is believed that piles will be stopped within the vicinity of elevation 103 with the ledge being noted at elevation 99.4. Steel piles would be recommended.

Northerly Approach Fill

As was previously noted at the substructure units for Abutment No. 2, a fill of seventeen feet is proposed behind this abutment. The stiff layer which overlies the soft underlying clays is to be severed and removed by the new grade line of the Interstate southbound lane. This loss of the stiff layer has caused a similar shear analysis requirement as was encountered at Abutment No. 1 and the southerly approach fill. The shear analysis is summarized and shown on Sheet 4. It is noted that the stiff layer has the same shear strength as used on the southerly approach fill. The underlying clays have a higher strength, as was noted within the borings, and this is attributed to some possible drainage to the north through the granular esker which lies buried and probably offers some lateral drainage. From this analysis it can be seen that the minimum factor of safety for a circle tangent to the bottom of the soft layer is of 1.28 whereas a deeper seated shear tangent to the underlying stiffer soil had a factor of safety of 1.26. The factor of safety is not sufficiently large for a structure to be constructed within the area. If the overlying stiff layer becomes cracked during construction, then complete loss of strength would occur and the embankments would probably shear. While the subsoils, as shown, are believed to be representative, there are certain variations which do occur and which are difficult to anticipate. It is therefore recommended that the approach fill be constructed on this northerly side in a similar manner as was encountered on the southerly approach; that is, that the minimum factor of safety is to be realized when the embankment for the Cold Brook Road is at its maximum height while the excavation for the Interstate is at its lowest point. Any further addition of materials to the Interstate Highway, such as the base, will materially aid as a resisting moment to raise the minimum factor of safety. Another item which will be beneficial from this initial waiting period would be the hardening up of the top layer of the softer compressible soils. It is therefore recommended that this approach fill be allowed to stand thirty days prior to the construction of the substructure units and with the Interstate Highway southbound lane excavated to its lowest point. It is estimated that up to twelve inches of settlement should be anticipated with the majority of this to occur within two years.

SUMMARY

The subsoils within this area consist of a layer of stiff consistency gray clay underlain by soft to medium consistency clays. These underlying clays have a low shear strength. Under normal conditions where embankments are to be constructed, this stiff layer should adequately support the proposed embankment as shown on the plan. Within this area, however, the northbound and southbound lanes are to be excavated almost to the bottom of the stiff layer and thus, in effect, will reduce the spreading value of this stiff layer. The minimum factor of safety should be realized when the embankments are at their full height along the Cold Brook Road, whereas the Interstate Highway is excavated to the subgrade elevation. After this excavation is completed and with the addition of granular borrow and base for the Interstate Highway and as well as time for the clay to dry up near the surface, the minimum factor of safety should increase materially. It is therefore recommended that the approach fills both behind Abutments 1 and 2 be constructed and allowed to settle for at least thirty days after the Interstate Highway has been cut to its lowest elevation for the roadway and ditch. The time of waiting should minimize any shearing of the embankments within the area. Further increased strengths should occur quite rapidly due to the high angle of friction of the clay as was encountered in the direct shear diagram as shown on Sheet 3.

A settlement of fifteen inches is anticipated behind Abutment No. 1 and is to be substantially completed within two years of the construction of the embankments; whereas, twelve inches is anticipated behind Abutment No. 2 with the majority of this settlement completed within the two year period. Fifty per cent of these settlement figures should be completed within eight months along the southerly fills and within six months along the northerly fills.

Since the subsoils are highly compressible and low in shear strength, it is recommended that the substructures for the bridge be supported by piles driven through the compressible soils into the firm underlying sand and gravel or directly to the ledge surface. Since the piles must be driven through the approach fill on the abutments, steel piles would be recommended. It is believed that piles can be driven to the following elevation.

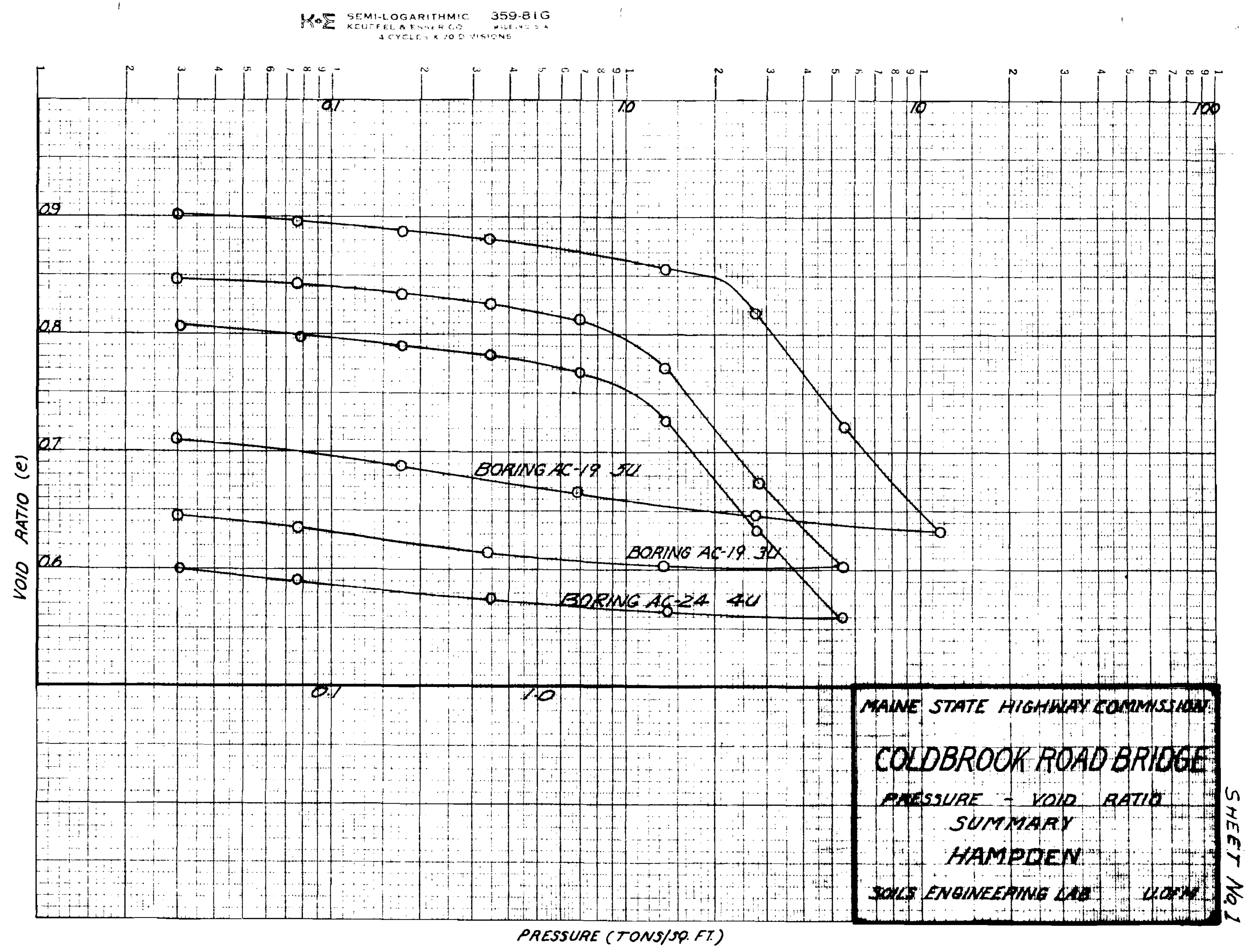
Structure	Elevation	
Abutment No. 1	97	
Pier No. 1	95 87.5	(cast in place) (Steel piles)
Pier No. 2	92.5	(ledge)
Pier No. 3	95.7	(ledge)
Pier No. 4	100.6	(ledge)
Abutment No. 2	103	

Respectfully submitted,

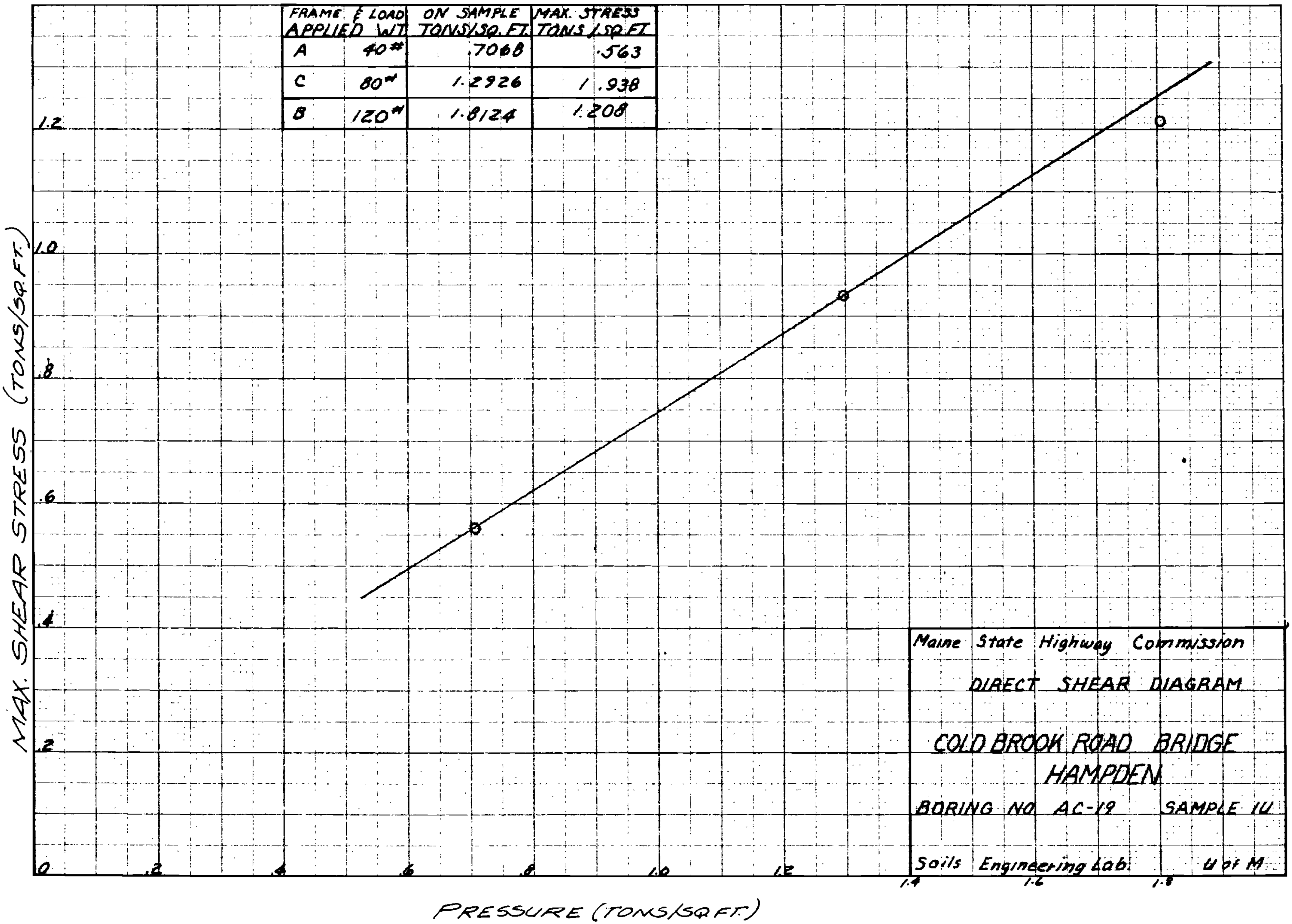
Fred M Boyce

Frederick M. Boyce, Jr.
Soils Engineer

FMB:aw



K+E SEMI-LOGARITHMIC 359-81G
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS
0.1
1.0
10
100
0.9
0.8
0.7
0.6
VOID RATIO (e)
BORING AC-19 5U
BORING AC-19 3U
BORING AC-24 4U
0.1
1.0
PRESSURE (TONS/SQ. FT.)
MAINE STATE HIGHWAY COMMISSION
COLDBROOK ROAD BRIDGE
PRESSURE - VOID RATIO
SUMMARY
HAMPDEN
SOILS ENGINEERING LAB U. OF M.
SHEET No. 1



FRAME & LOAD APPLIED WT		ON SAMPLE TONS/SQ.FT.	MAX. STRESS TONS/SQ.FT.
A	40#	.7068	.563
C	80#	1.2926	1 .938
B	120#	1.8124	1.208

Maine State Highway Commission

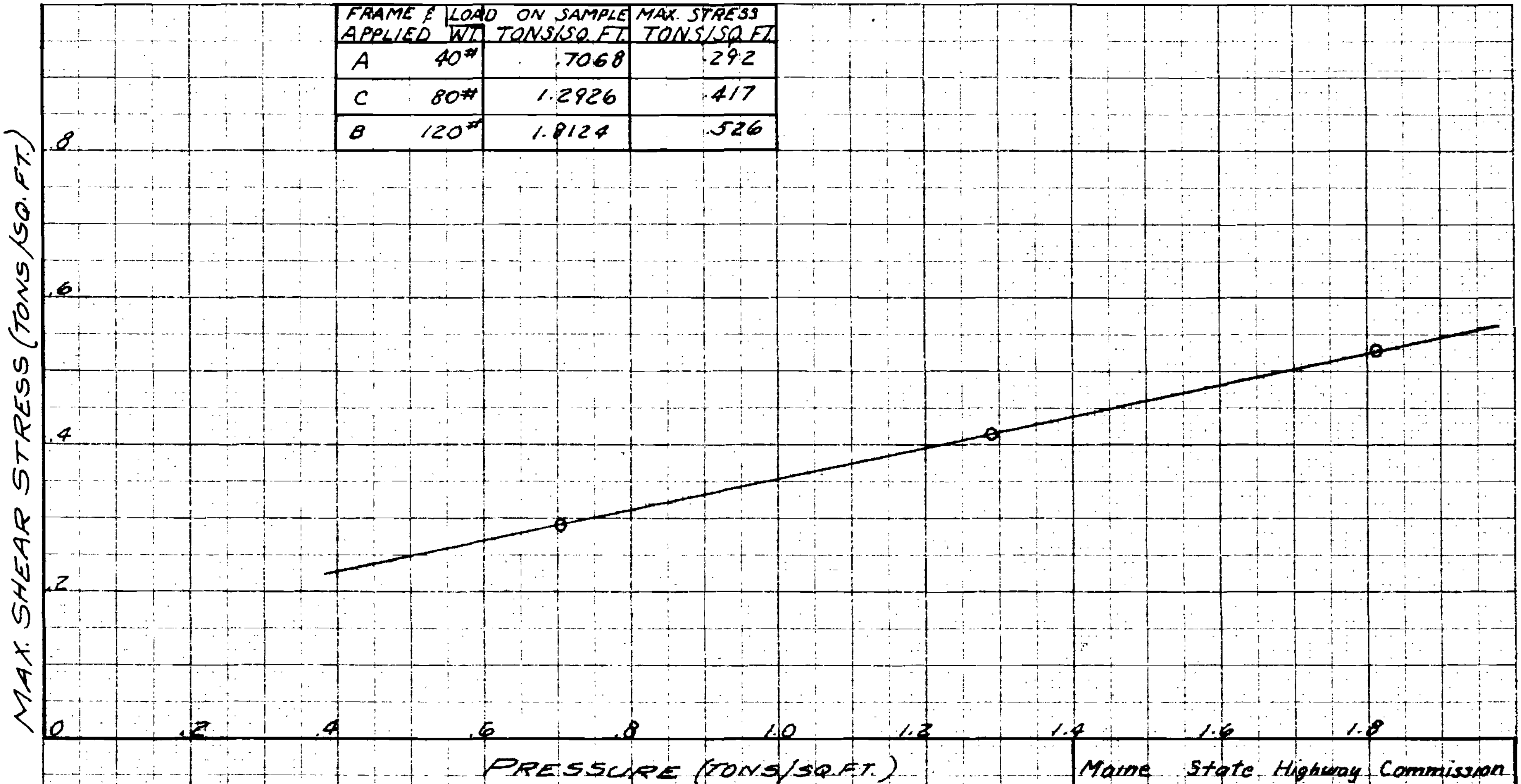
DIRECT SHEAR DIAGRAM

COLD BROOK ROAD BRIDGE
HAMPDEN

BORING NO AC-19 SAMPLE 1U

Soils Engineering Lab. U of M

SHEET No. 2



FRAME & APPLIED	LOAD WT.	ON SAMPLE TONS/SQ.FT.	MAX. STRESS TONS/SQ.FT.
A	40#	.7068	.292
C	80#	1.2926	.417
B	120#	1.8124	.526

Maine State Highway Commission

DIRECT SHEAR DIAGRAM

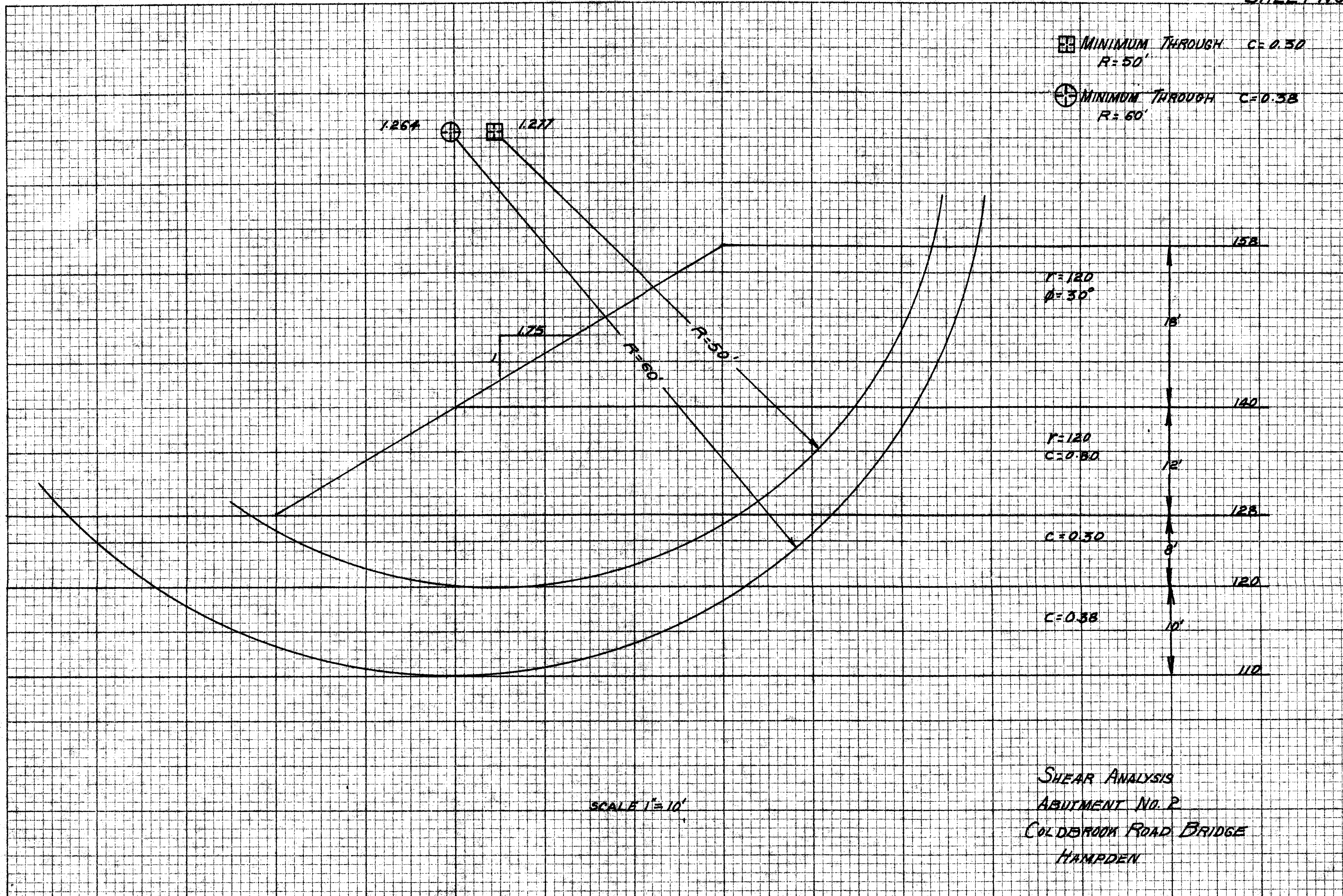
COLD BROOK ROAD BRIDGE

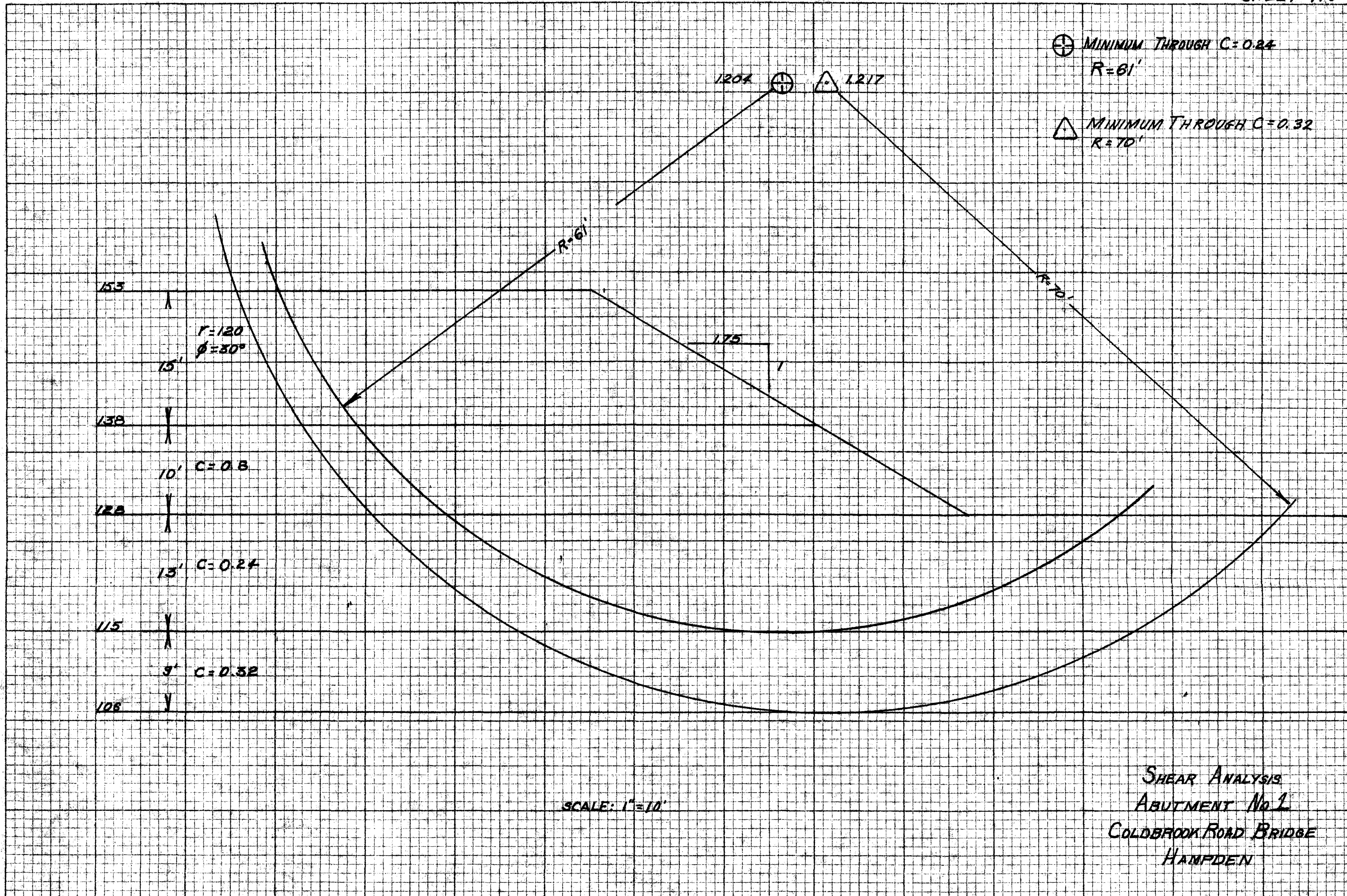
HAMPDEN

BORING NO. AC-19 SAMPLE 4U

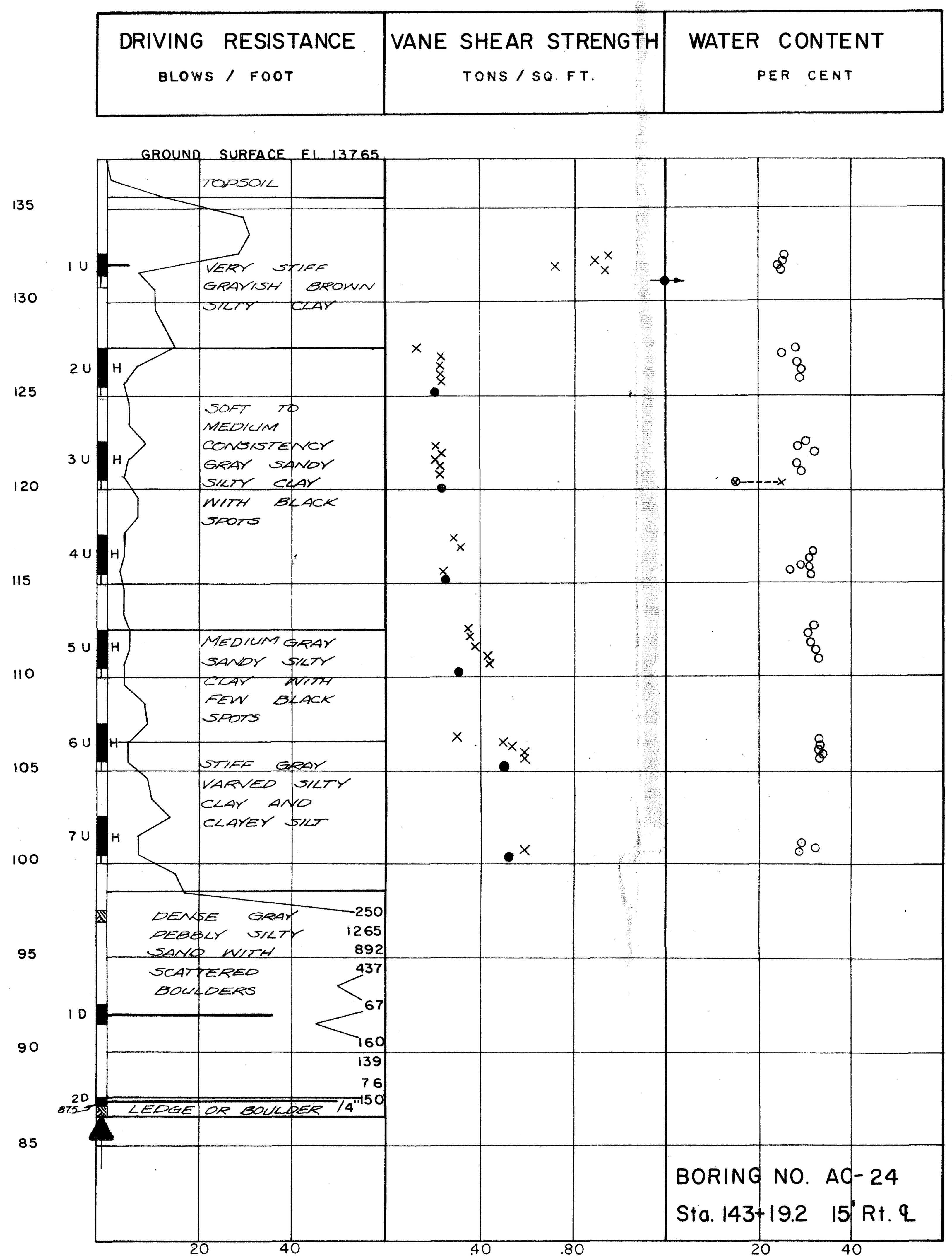
Soils Engineering Lab. U of M

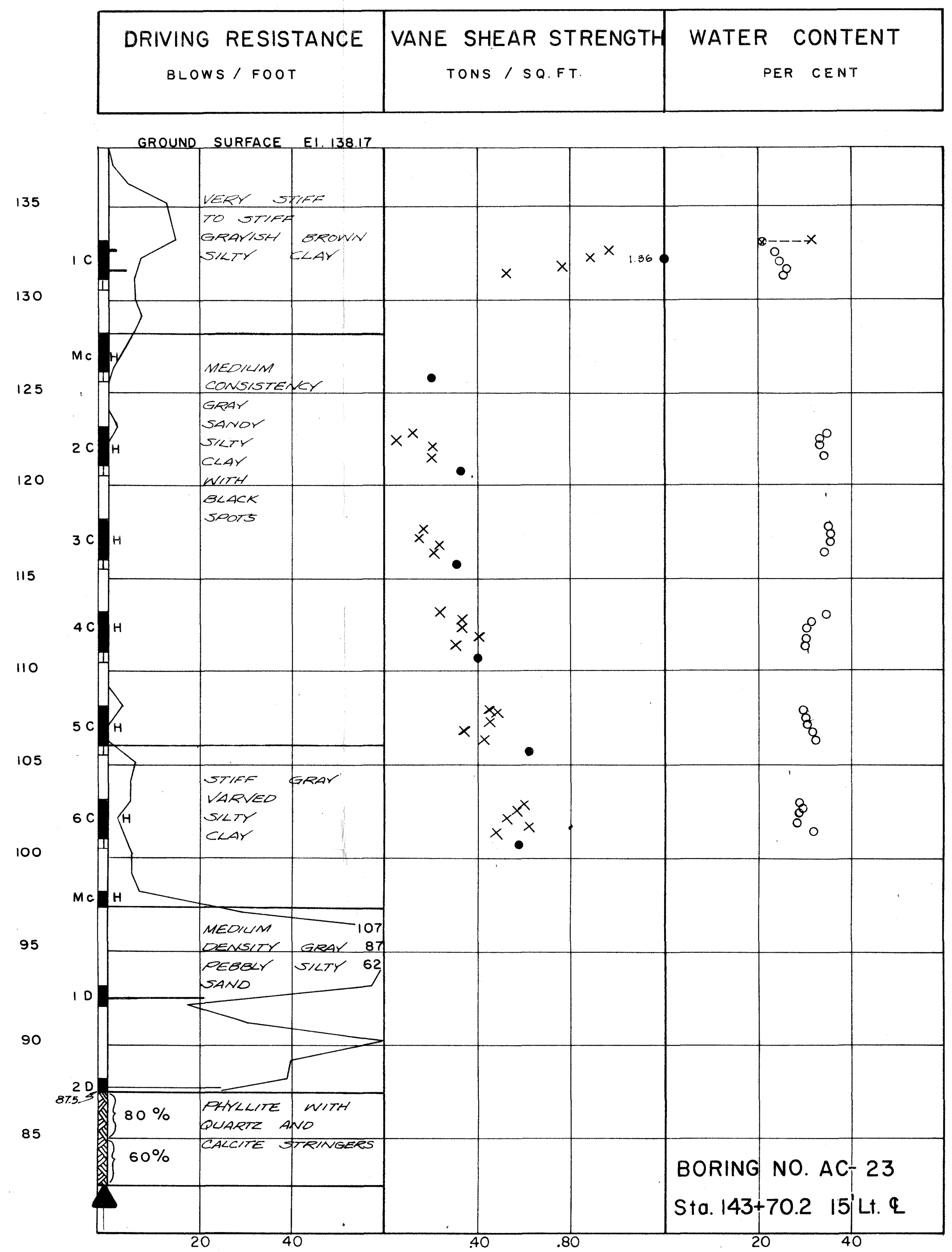
SHEET No. 3

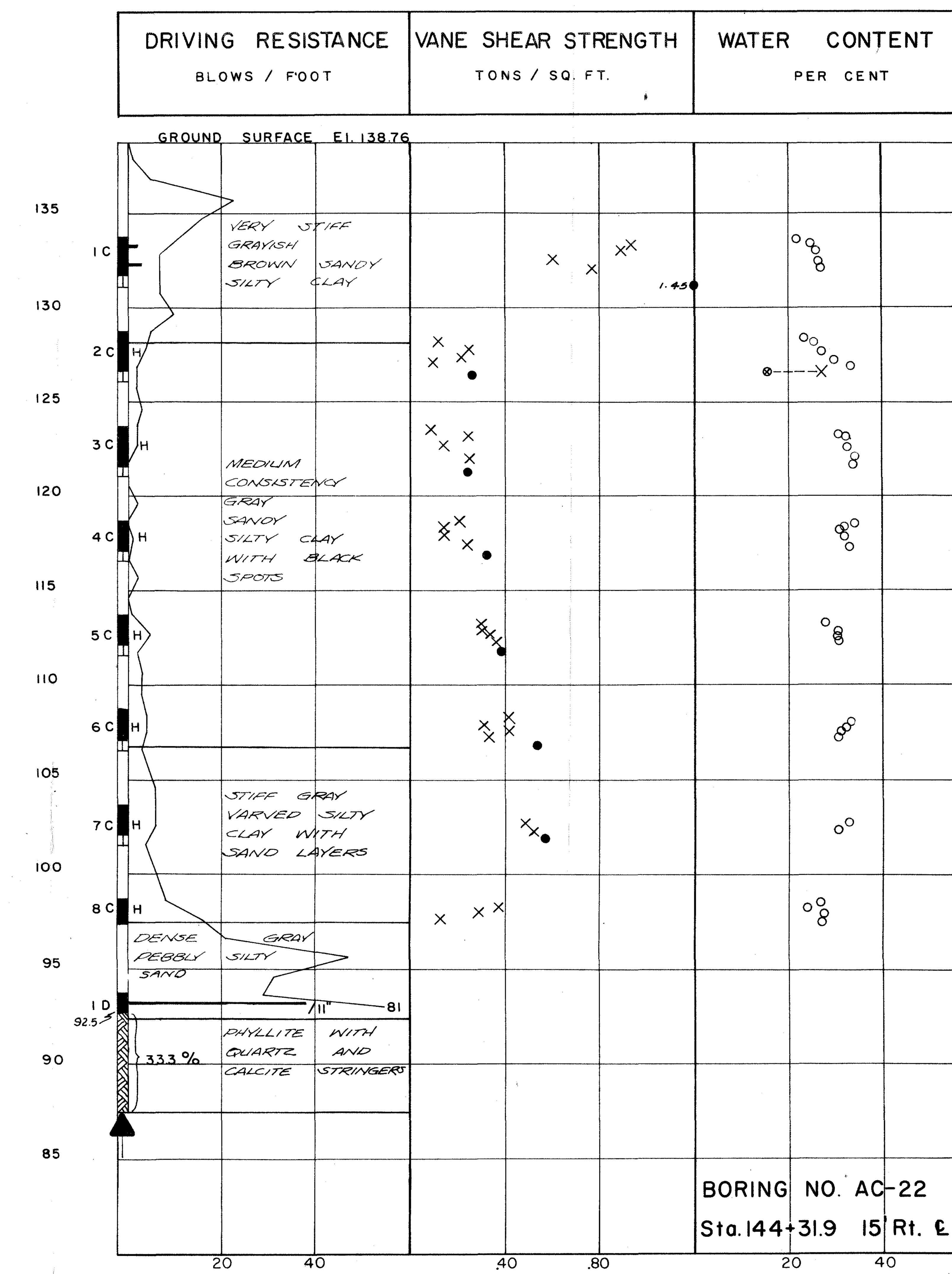

MINIMUM THROUGH C=0.30
R=50'
MINIMUM THROUGH C=0.38
R=60'
1.264
1.277
R=50'
R=60'
1.75
1
158
140
128
120
110
r=120
ϕ=30°
18'
r=120
C=0.80
12'
C=0.30
8'
C=0.38
10'
SCALE 1"=10'
SHEAR ANALYSIS
ABUTMENT NO. 2
COLDBROOK ROAD BRIDGE
HAMPDEN



MINIMUM THROUGH C=0.24
R=61'
MINIMUM THROUGH C=0.32
R=70'
1.204
1.217
R=61'
R=70'
153
r=120
ϕ=30°
15'
1.75
1
138
10'
C=0.8
128
13'
C=0.24
115
9'
C=0.32
106
SCALE: 1"=10'
SHEAR ANALYSIS
ABUTMENT No 1
COLDBROOK ROAD BRIDGE
HAMPDEN







BORING NOTES

- ALL SAMPLE AND VANES ARE MADE AHEAD OF CASING
- NUMBER OF BLOWS REQUIRED TO DRIVE EXTRA HEAVY CASING ONE FOOT WITH 400 FT. LBS. OF ENERGY PER BLOW
- LOCATION OF SAMPLE OR SAMPLE ATTEMPT
- NUMBER AND TYPE OF DRY SAMPLE
  - 1D S & H SAMPLER NO. 1290's
  - 1C 2" O.D. 16 GA. SEAMLESS TUBING
  - 1U 3 1/2" O.D. 16 GA. SEAMLESS TUBING
- M_D UNSUCCESSFUL SAMPLE ATTEMPT AND TYPE OF SAMPLER
- NUMBER OF BLOWS REQUIRED TO DRIVE SPOON OR TUBING ONE FOOT WITH 350 FT. LBS. OF ENERGY PER BLOW
- H SAMPLING SPOON OR TUBE DRIVEN BY STATIC WEIGHT OF DRILL RODS AND HAMMER
- FIELD VANE TEST
- BOTTOM OF BORING (MAY NOT BE BOTTOM OF SOIL STRATA)
- 71% LOCATIONS CORED BY DIAMOND BIT AND PER CENT RECOVERY OF ROCK

SHEAR NOTES

- ● FIELD VANE SHEAR STRENGTHS
- × LABORATORY VANE SHEAR STRENGTHS
- → SHEAR STRENGTHS IN EXCESS OF EQUIPMENT
- ○ ONE HALF UNCONFINED COMPRESSIVE STRENGTHS

WATER CONTENT NOTES

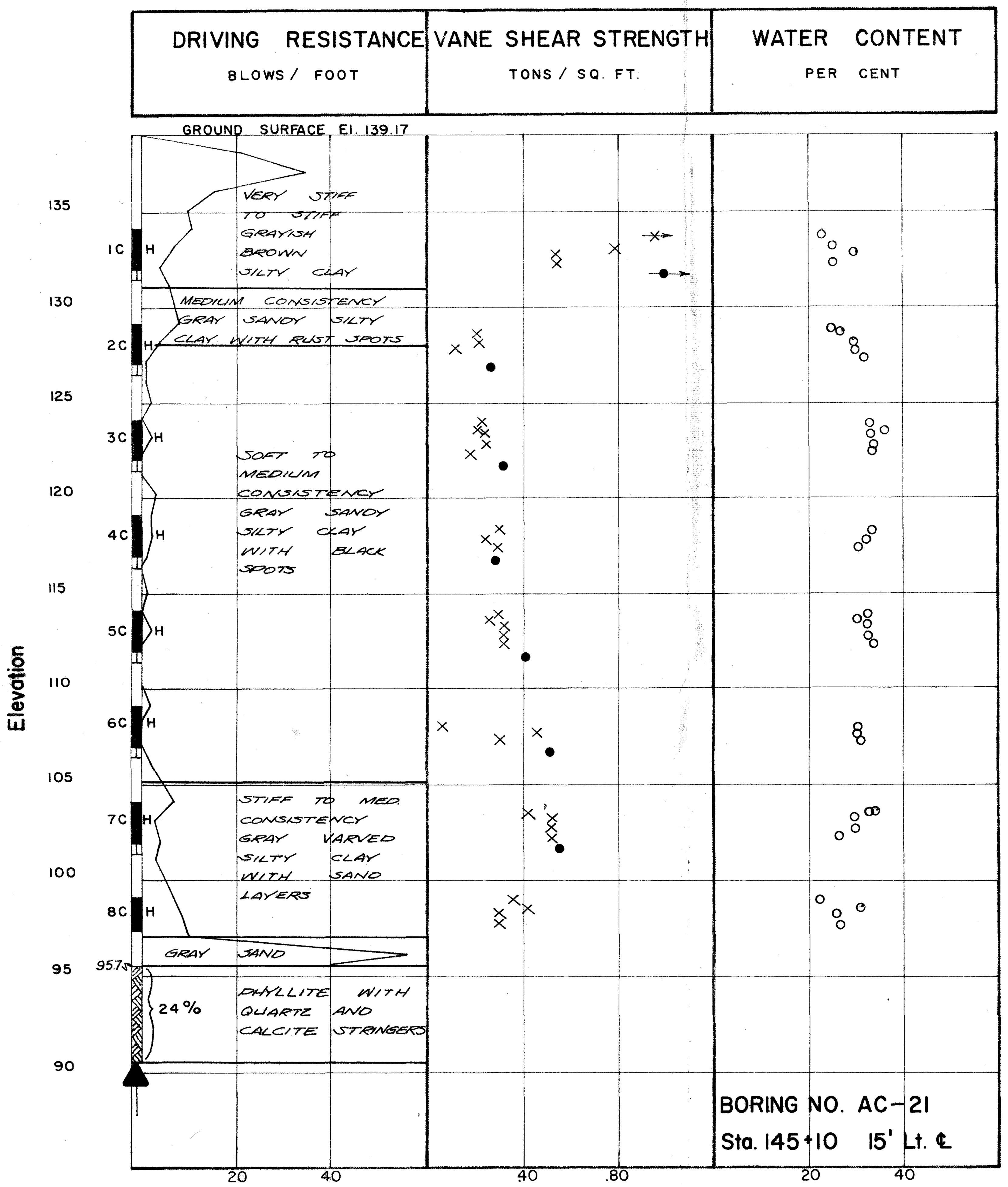
- ○ NATURAL WATER CONTENTS, GIVEN AS PER CENT OF DRY WEIGHT
- ⊗--× PLASTIC AND LIQUID LIMITS

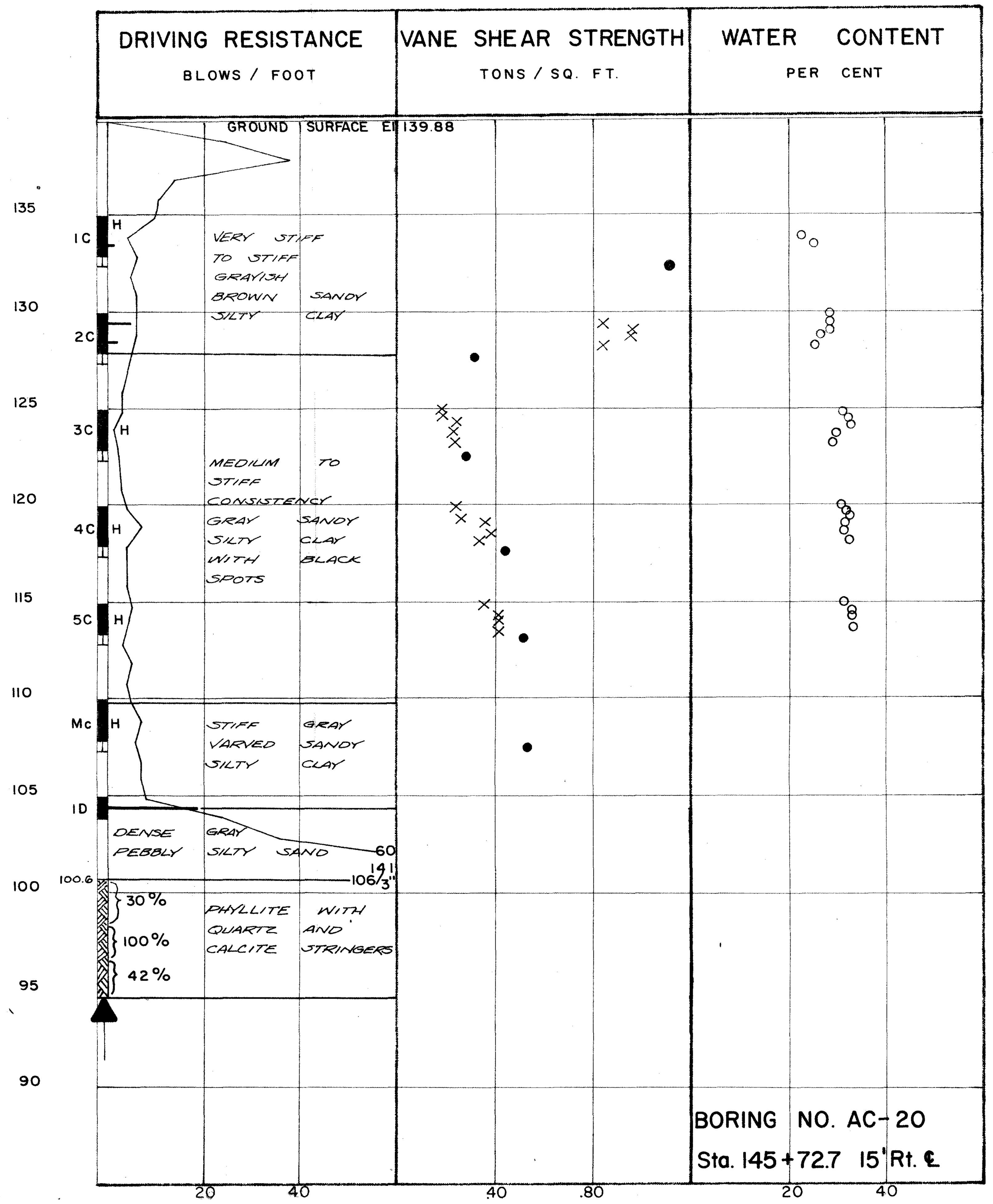
STATE HIGHWAY COMMISSION
BRIDGE DIVISION

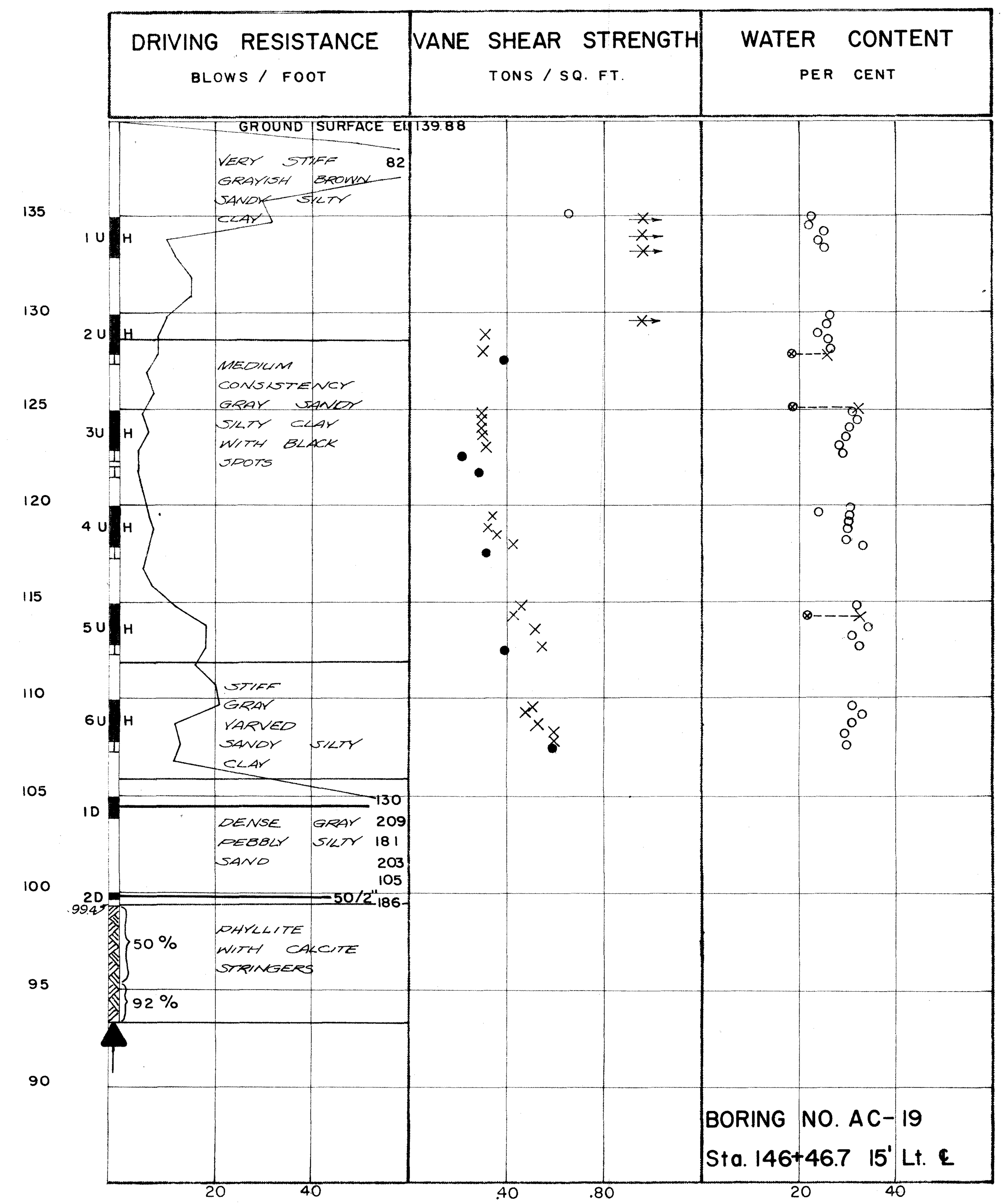
COLD BROOK ROAD BRIDGE
IN THE TOWN OF
HAMPDEN
PENOBSCOT COUNTY
BORING DETAILS

SHEET OF AUGUSTA, MAINE

B. P. R. REG. NO.	STATE	PROJECT NUMBER	SHEET NO.	TOTAL SHEETS
1	MAINE			







STATE HIGHWAY COMMISSION
BRIDGE DIVISION

COLD BROOK ROAD BRIDGE

IN THE TOWN OF

HAMPDEN

PENOBSCOT COUNTY

BORING DETAILS

SHEET OF AUGUSTA, MAINE

C. B. CO. NO. 3718 21186

SHEET No. 8

B. P. R. REG. NO.	STATE	PROJECT NUMBER	SHEET NO.	TOTAL SHEETS
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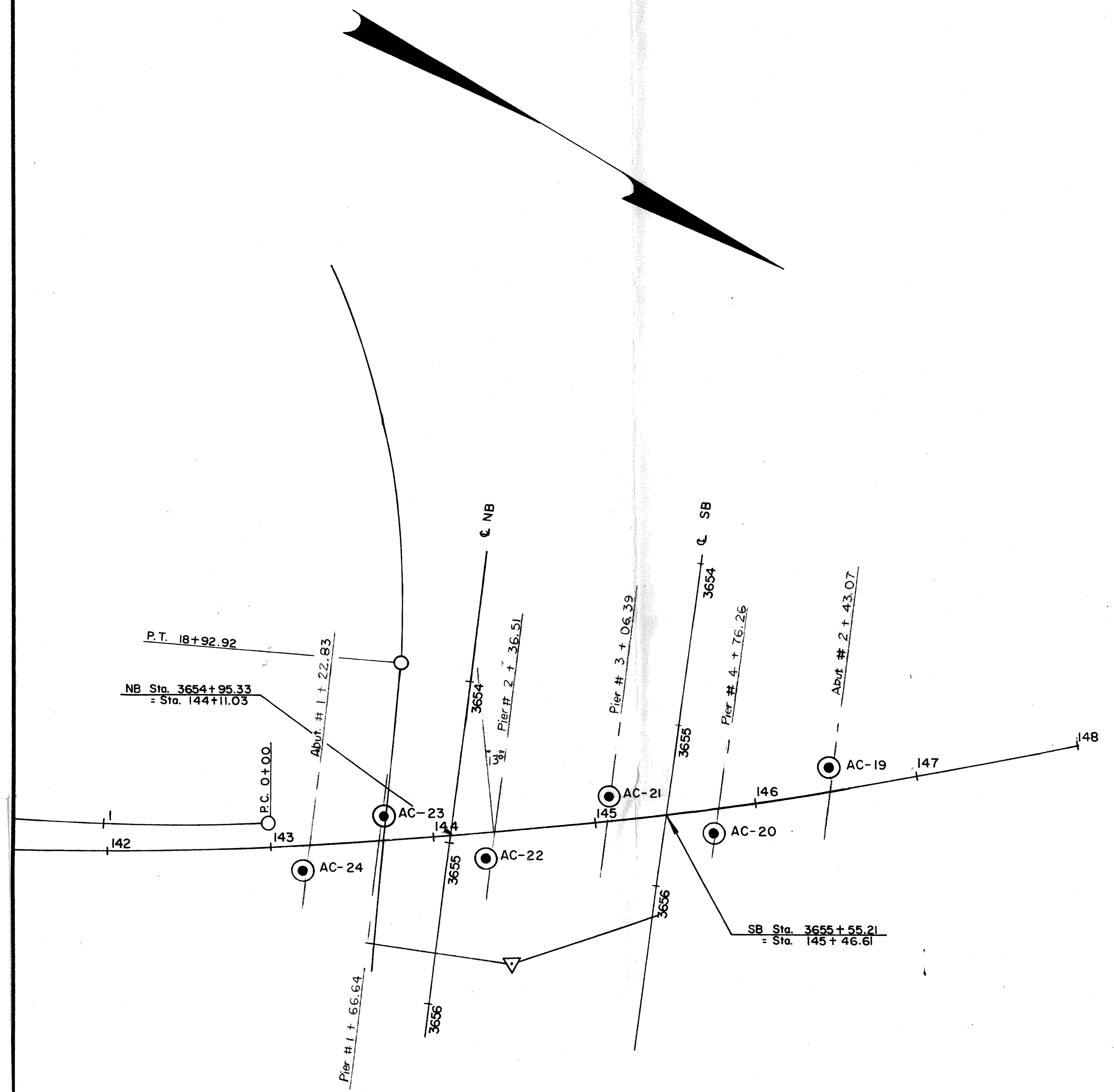
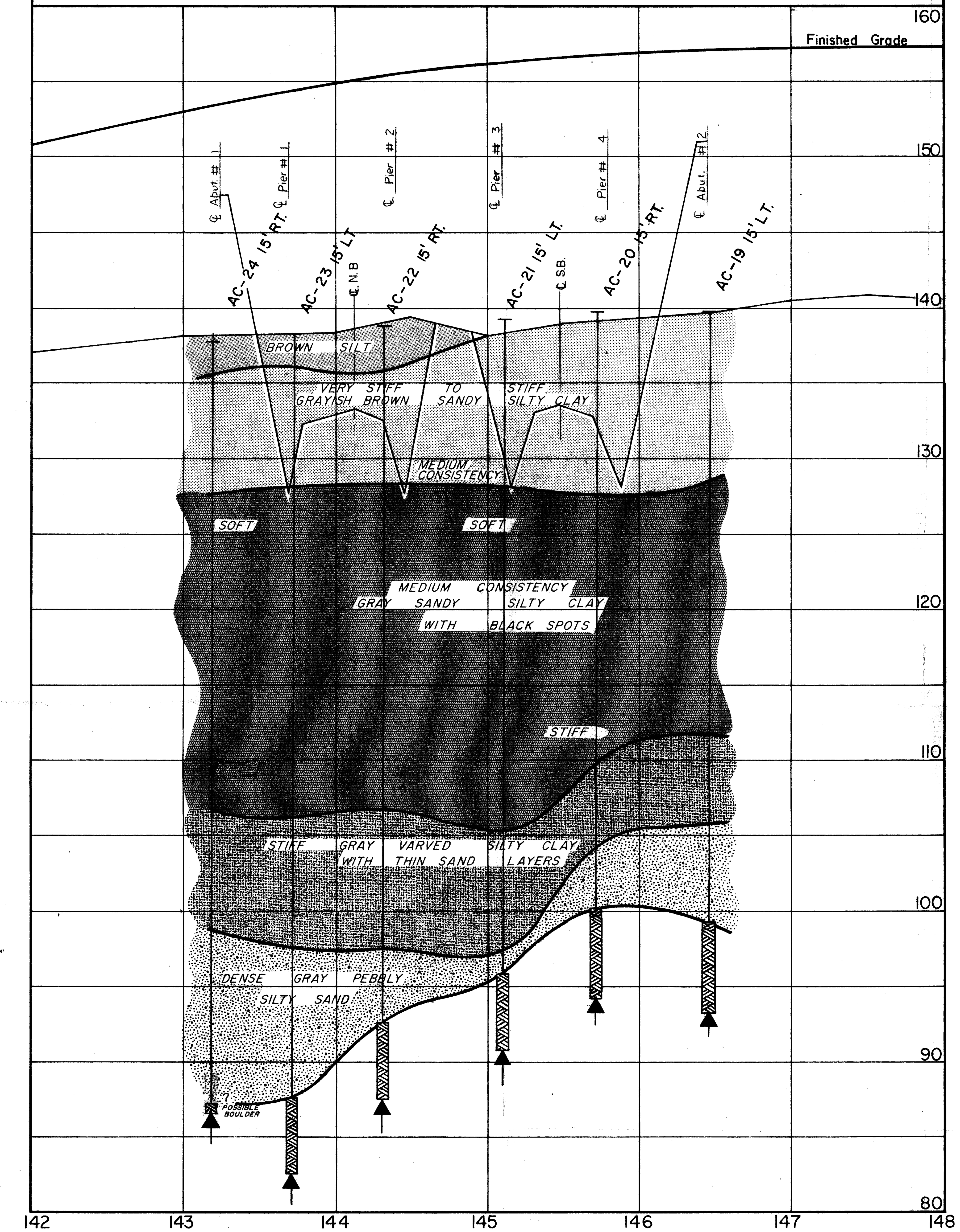


℄ PROFILE



Profile Scale
Horiz. 1" = 50'
Vert. 1" = 5'

DESIGN–
TRACE–
CHECK–

BRIDGE NO.
SURVEY–
PLOT–

STATE HIGHWAY COMMISSION
BRIDGE DIVISION

COLD BROOK ROAD BRIDGE

IN THE TOWN OF

HAMPDEN

PENOBSCOT COUNTY

FOUNDATION SURVEY

SHEET OF AUGUSTA, MAINE