

# INFLUENCE OF WEAK PENNSYLVANIAN SYSTEM SHALES IN OHIO AND KENTUCKY ON TRANSPORTATION PROJECTS

**Richard Williams, Ph.D., P.E.**  
Senior Geotechnical Engineer

**Eric Kistner, P.E.**  
Associate

**Luis Arduz, P.E.**  
Geotechnical Engineer

**Stantec Consulting Services Inc.**

Prepared For

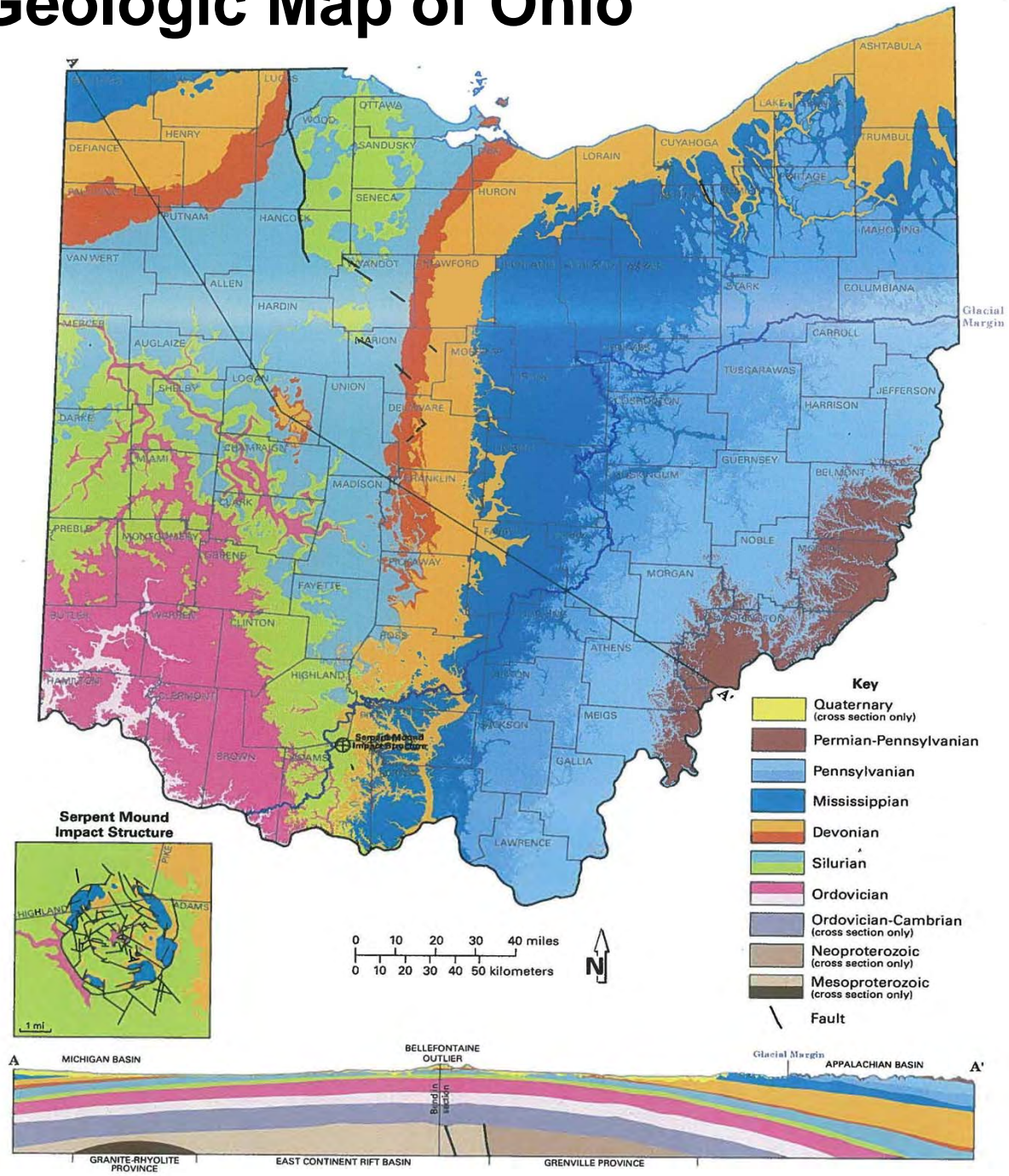
**11<sup>TH</sup> ANNUAL TECHNICAL FORUM – GEOHAZARDS IMPACTING  
TRANSPORTATION IN THE APPALACHIAN REGION,  
CHATTANOOGA, TN      AUGUST, 2011**



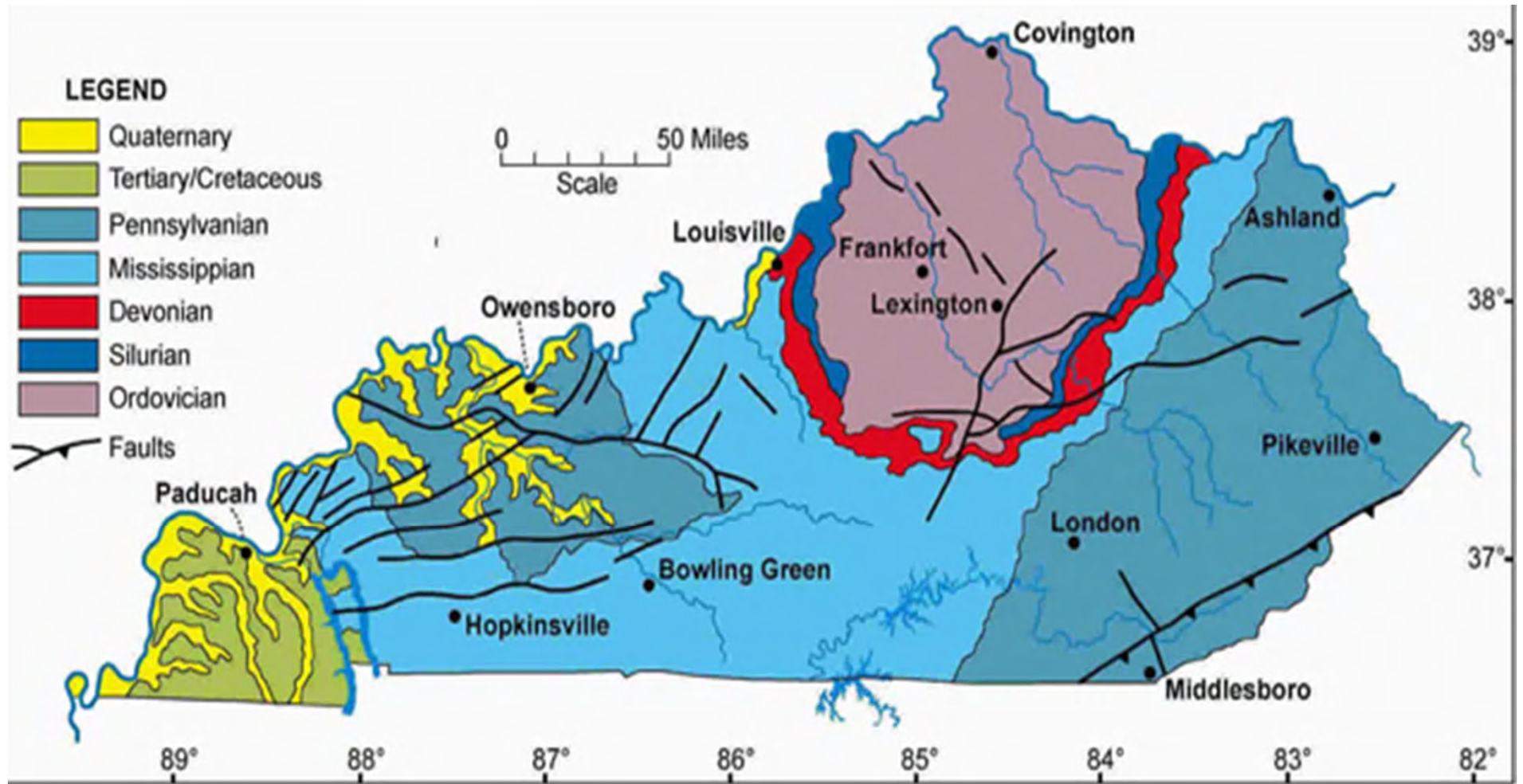
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# Bedrock Geologic Map of Ohio



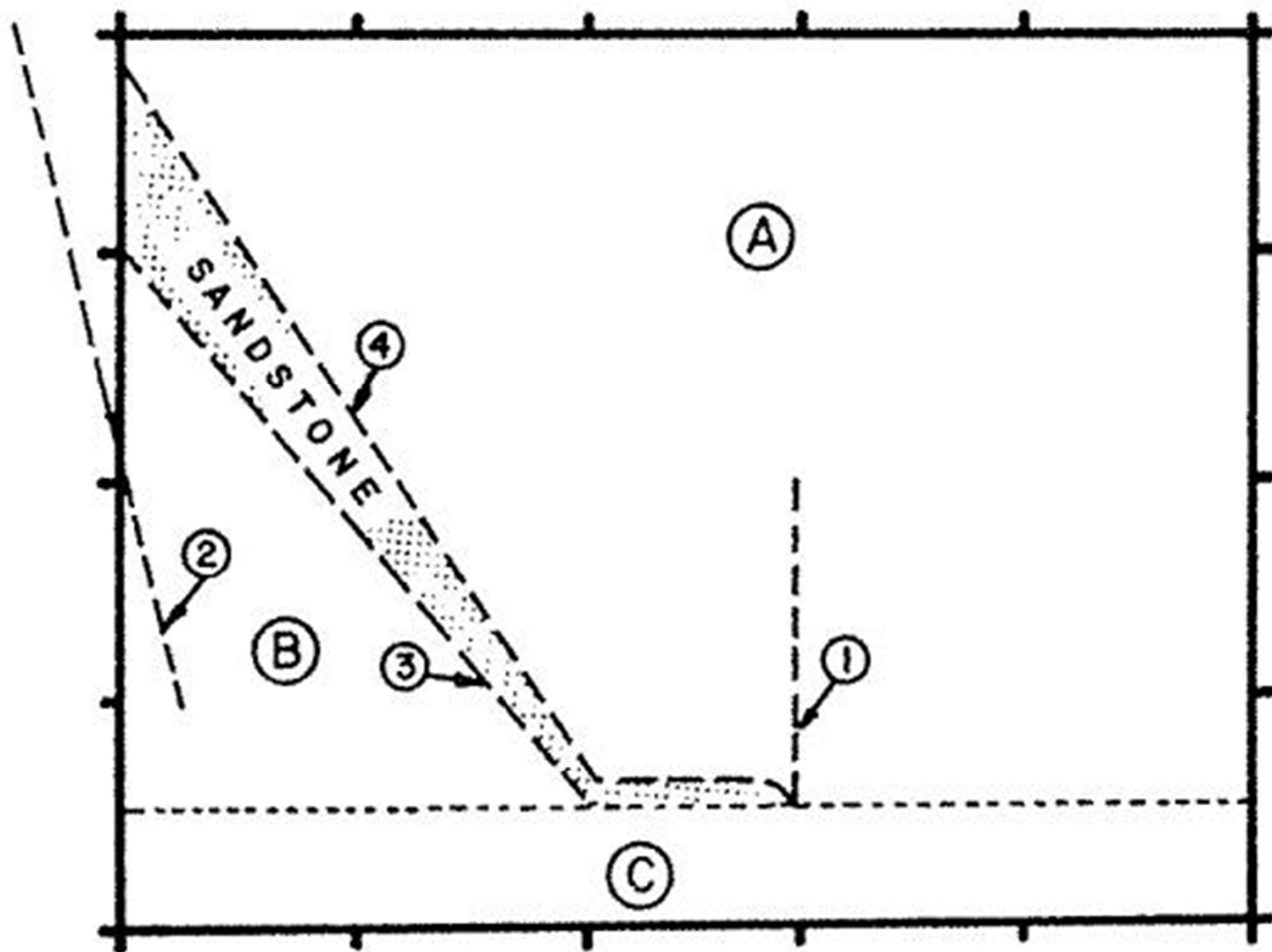
# Geology of Kentucky











### DISCONTINUITIES

- SLICKENSIDES (IDENTIFIED BY NUMBERS)
- - - - PARTINGS (IDENTIFIED BY NUMBERS)
- - - - BOUNDARY OF AREAS (IDENTIFIED BY LETTERS) CONTAINING BEDDING PLANES OR PARTINGS

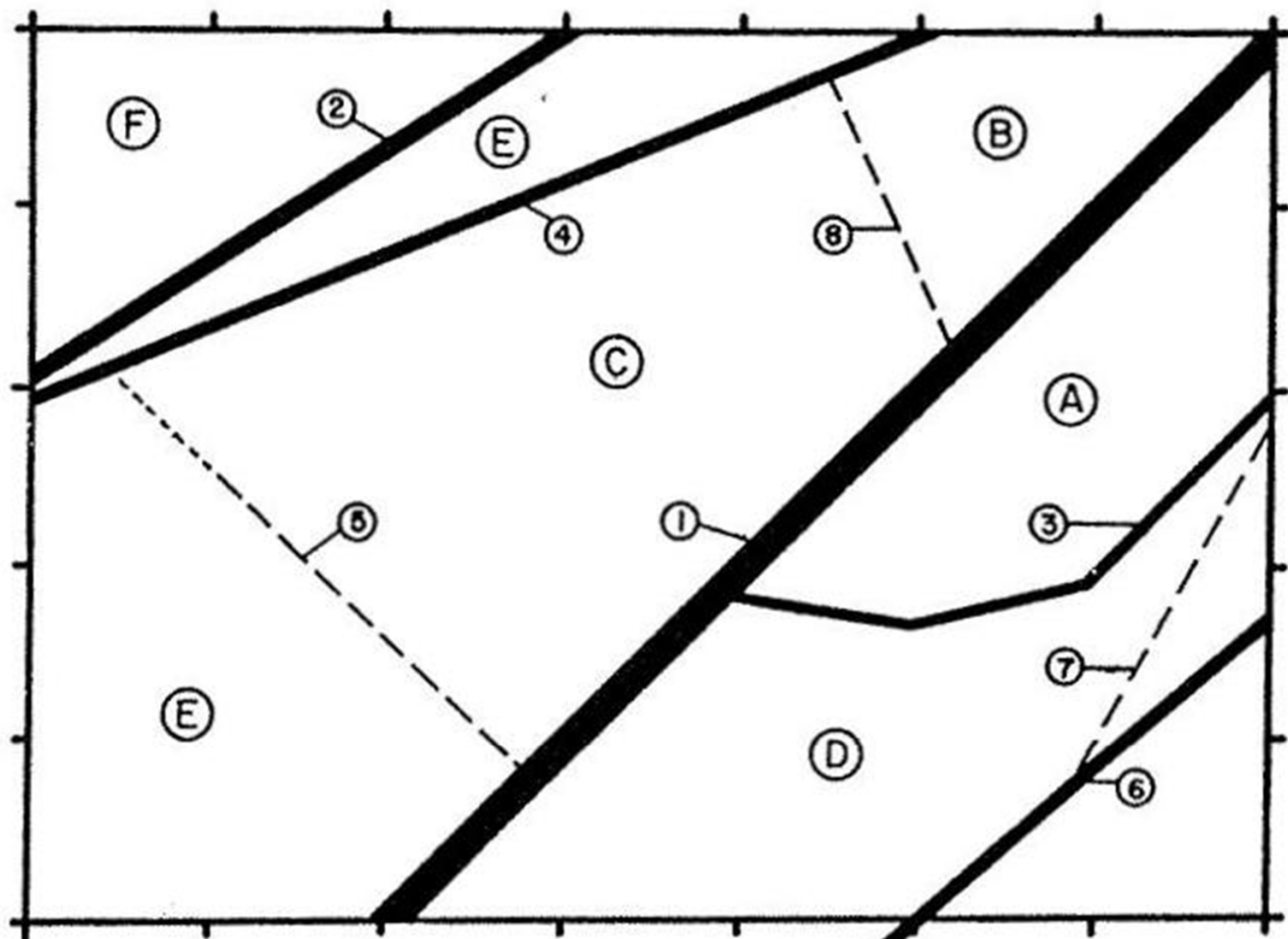
**Discontinuities in Window in Morgantown Shale, West Slope of U.S. 33 and 50,  
Station 644+50, Athens, Ohio**

**Grid is located 1 foot below top of member**

<b>Feature</b>	<b>Strike</b>	<b>Dip</b>	<b>Thickness of Gouge</b>	<b>Comments</b>
<b>1</b>	<b>N 40° W</b>	<b>90°</b>	<b>None</b>	<b>Parting, irregular gray dry surface</b>
<b>2</b>	<b>S 52° E</b>	<b>69° N</b>	<b>None</b>	<b>Parting, irregular gray dry surface</b>
<b>3</b>	<b>S 35° E</b>	<b>80° N</b>	<b>None</b>	<b>Parting, irregular gray surface</b>
<b>4</b>	<b>S 35° E</b>	<b>85° N</b>	<b>None</b>	<b>Parting, irregular surface</b>
<b>A</b>	<b>N 89° E</b>	<b>5° S</b>		<b>Bedding planes, gray dry surface, .125 - .188 inch average spacing</b>
<b>B</b>	<b>N 20° E</b>	<b>6.5° SE</b>		<b>Bedding planes, gray dry surface, .25 inch average spacing</b>
<b>C</b>	<b>S 89° E</b>	<b>7° S</b>		<b>Bedding planes, gray shaley surfaces, .188 inch average spacing</b>



EXTENDS  
2.0 FT.  
BEYOND  
BORDER



EXTENDS  
1.0 FT.  
BEYOND  
BORDER

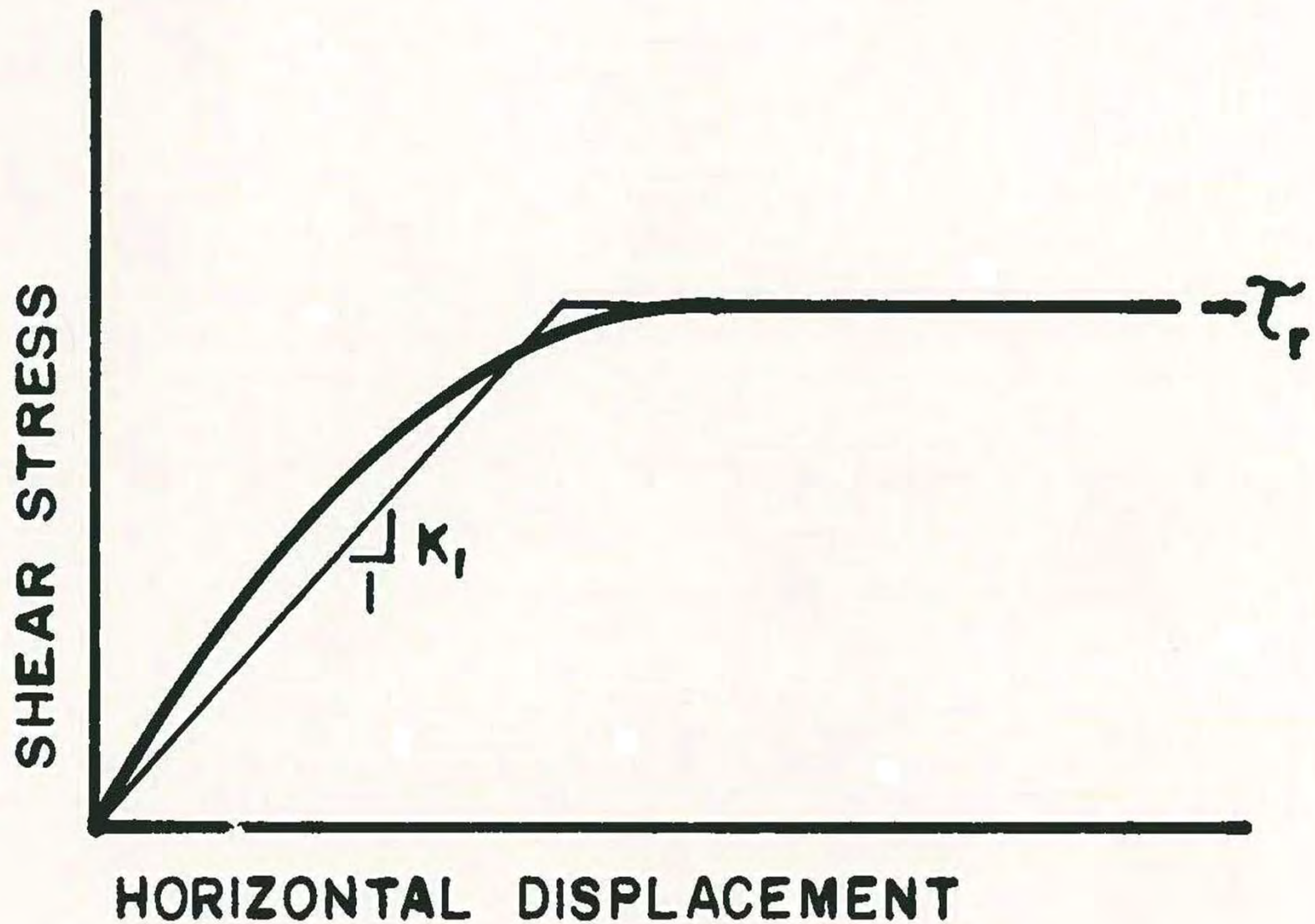
### DISCONTINUITIES

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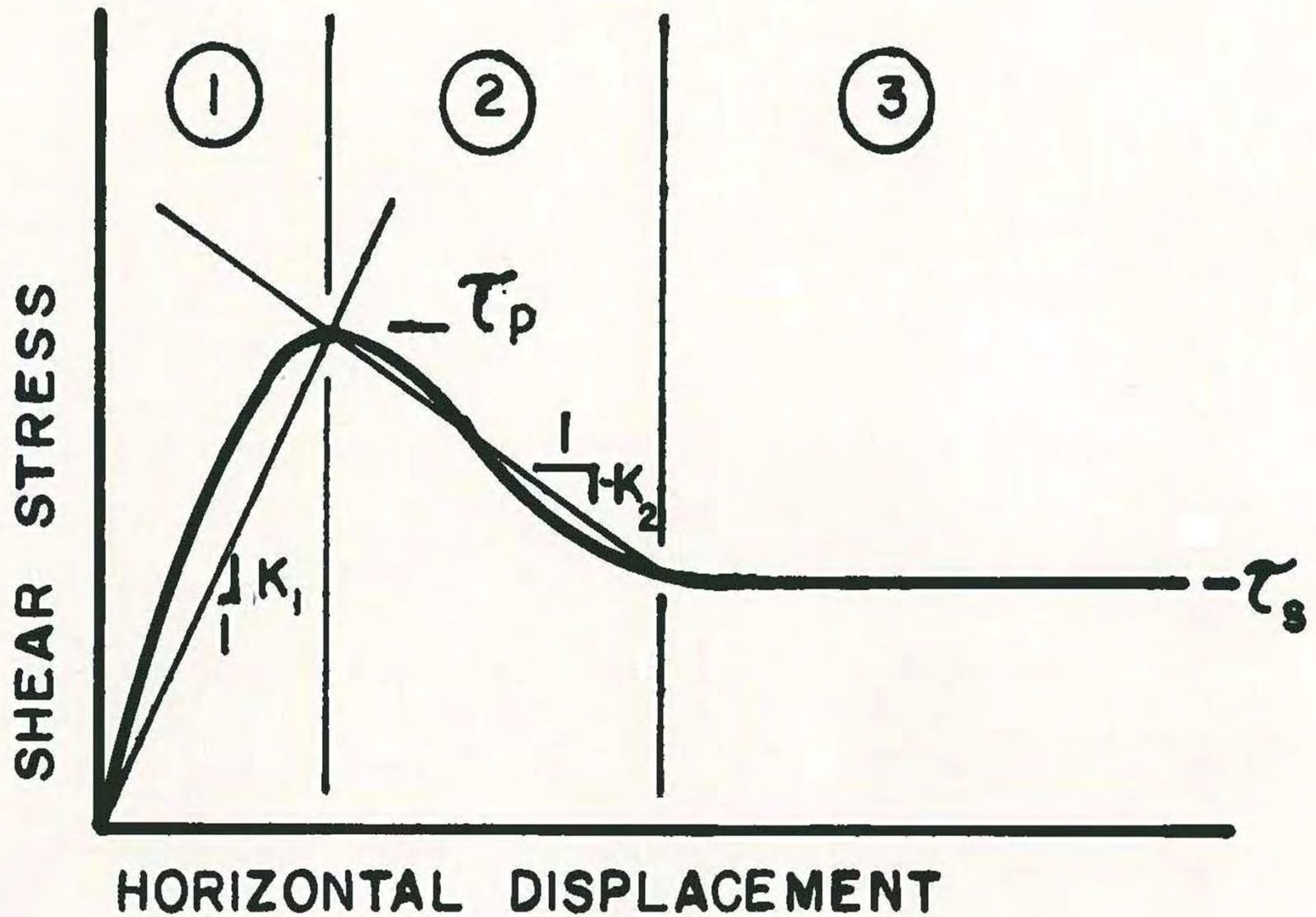
## Discontinuities in Window in Round Knob Shale, West Slope of U.S. 33 and 50, Station 644+70, Athens, Ohio

**Grid is located 2 feet above base of member**

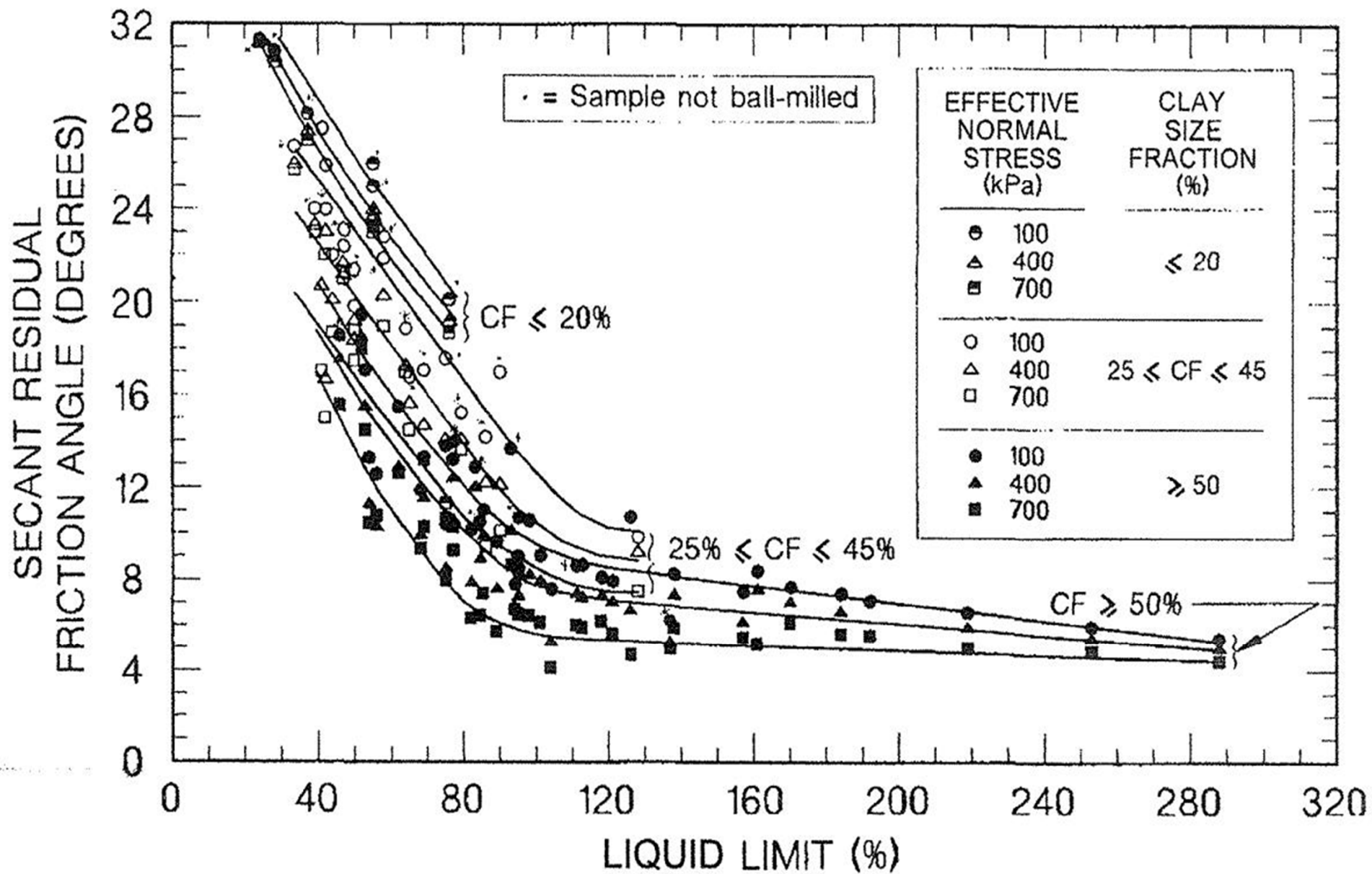
Feature	Strike	Dip	Thickness of Gouge	Comments
1	N 80° W	37.5° S	1.0 inch	Slickenside, gouge comprised of gray shale arranged in thin plates parallel to slickenside surface, extends 2 feet into slope
2	N 50° W	31.75° S	0.5 inch	Slickenside, same as Discontinuity 1, extends 4 feet into slope
3	N 52° E	35° S	0.25 inch	Slickenside, very smooth planar surface, gouge comprised of gray shale
4	N 66° E	20.25° S	0.25 inch	Slickenside, gouge comprised of gray shale
5	N 27° W	24.75° E	0.125 inch	Parting
6	N 86° W	30.5° S	0.25 inch	Slickenside, gouge comprised of wet gray shale, slickenside surface is moist
7	N 15° W	75° NE	None	Parting, red smooth surface
8	N 78° W	54° N	None	Parting
A	N 86° E	42.5° S		Bedding planes, red rough surface, .25 inch average spacing
B	N 78° E	9.5° S		Bedding planes, red surface, .068 - .125 inch average spacing
C	N 15° W	24° E		Bedding planes, red surface, .125 inch average spacing
D				Bedding planes, oriented parallel to Discontinuity 1, .25 inch average spacing
E				Bedding planes, oriented parallel to Discontinuity 4, .125 inch average spacing
F				Bedding planes, oriented parallel to Discontinuity 2, .125 inch average spacing

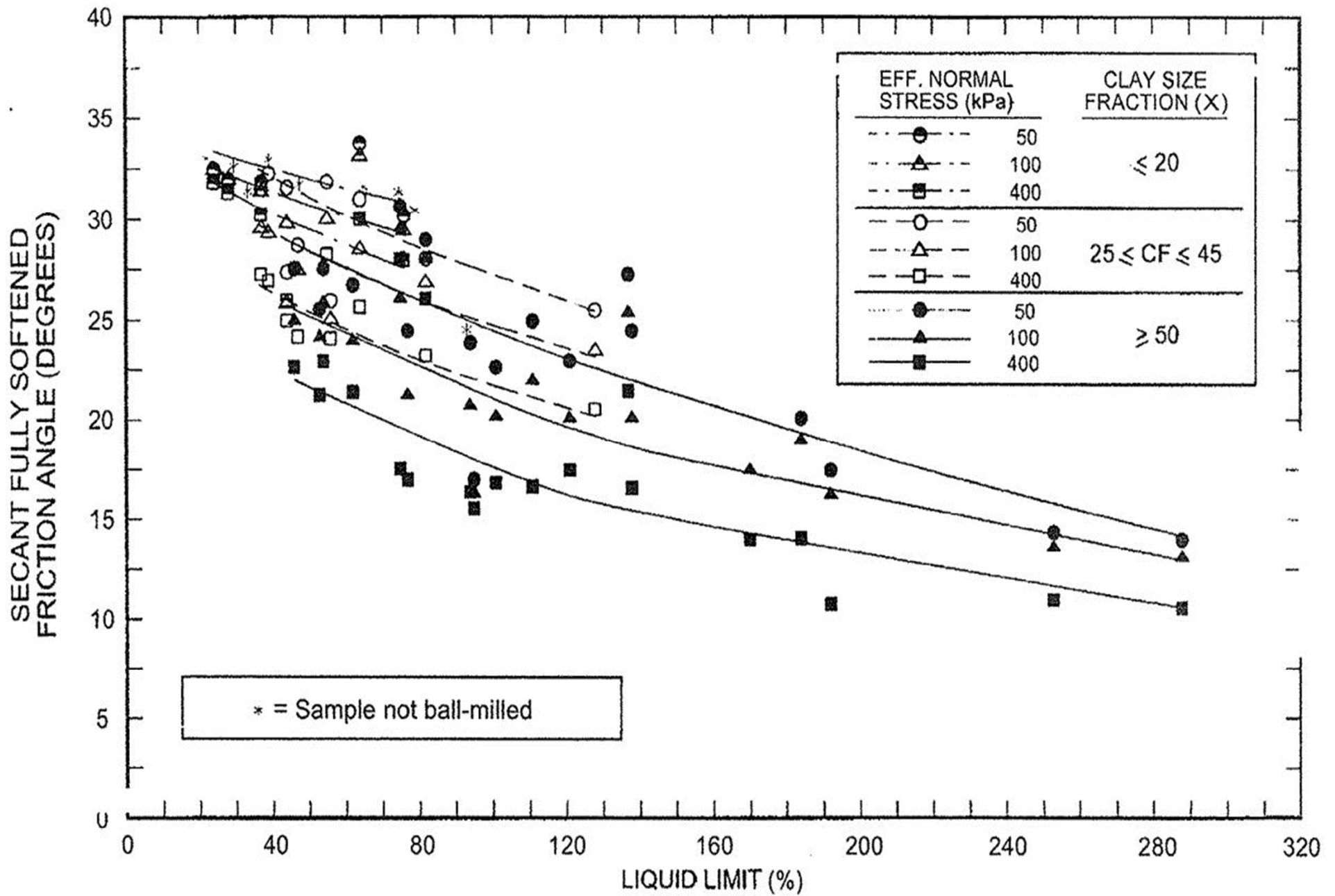


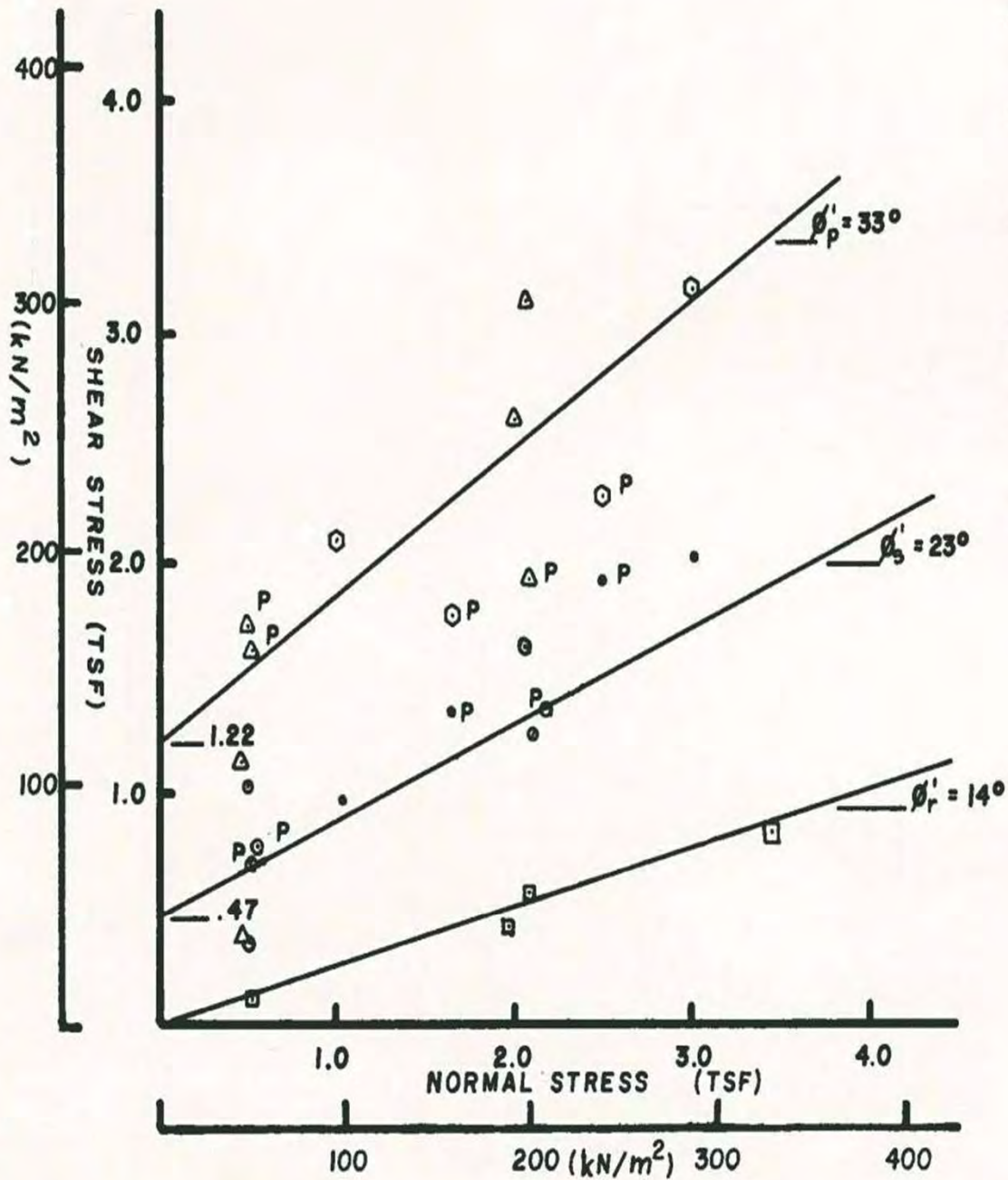
- b) Stress-displacement relationship for elastic-perfectly plastic material



- a) Stress-displacement relationship for strain-softening material







$\Delta$  PEAK SHEAR STRENGTH; BLOCK SAMPLE - INTACT, STATE ROUTE 682, STATION 19+50, ATHENS.

$\circ$  FULLY SOFTENED SHEAR STRENGTH, BLOCK SAMPLE - INTACT, STATE ROUTE 682, STATION 19+50, ATHENS.

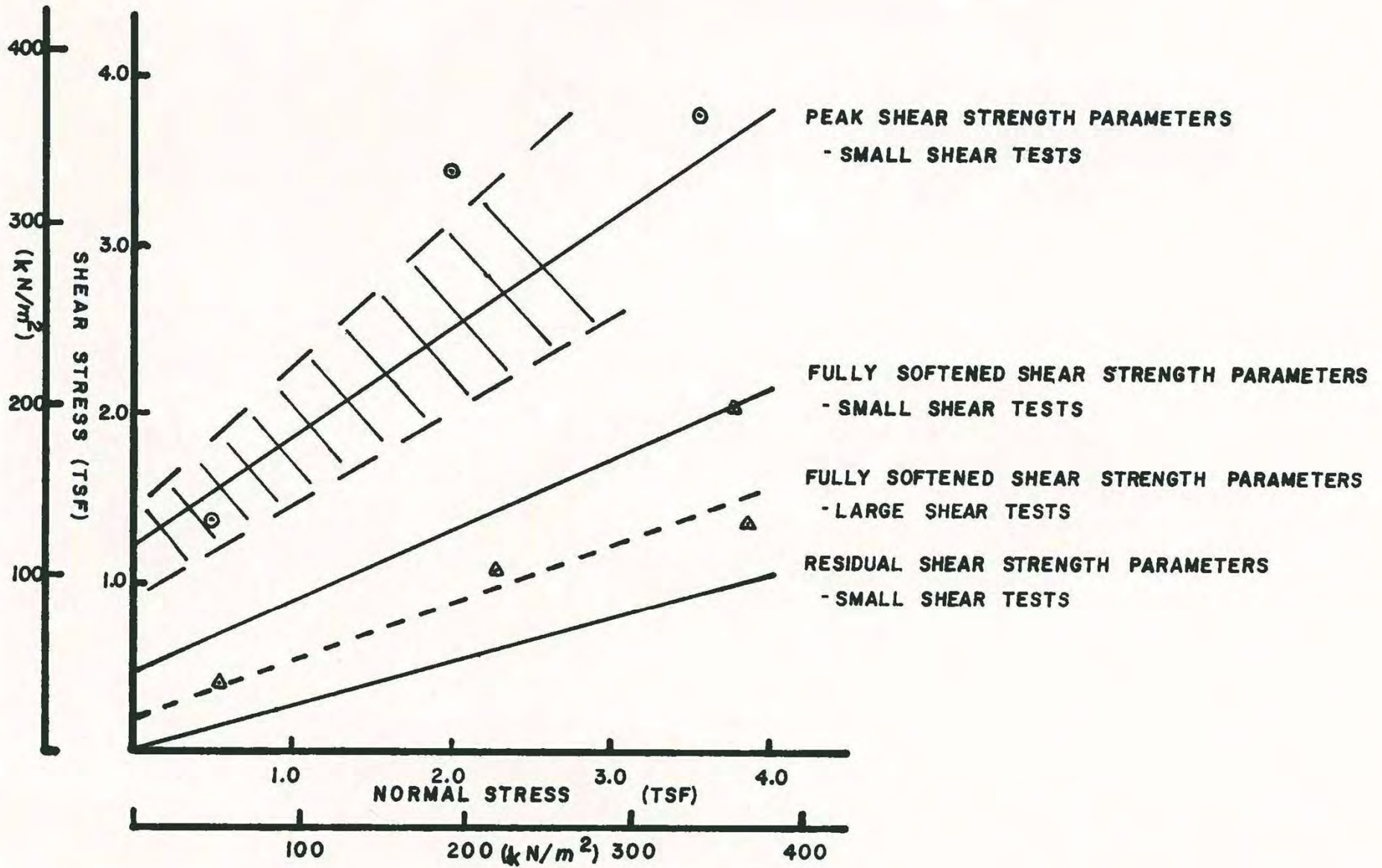
$\square$  RESIDUAL SHEAR STRENGTH, BLOCK SAMPLE - SLICKENSIDE, U.S. 33 & 50, STATION 31+50, ATHENS.

$\bigcirc$  PEAK SHEAR STRENGTH, CORE SAMPLE - INTACT 1-70, MILE 188.9.

$\bullet$  FULLY SOFTENED SHEAR STRENGTH, CORE SAMPLE INTACT, 1-70, MILE 188.9.

P PARTING NOTED BEFORE TESTING, PARTING ALIGNED WITH SHEAR ZONE.

- ⊙ PEAK SHEAR STRENGTH; BLOCK SAMPLE - INTACT, U.S. 33 & 50, STATION 31+50, ATHENS
- △ FULLY SOFTENED SHEAR STRENGTH; BLOCK SAMPLE - INTACT, U.S. 33 & 50, STATION 31+50, ATHENS





**SOUTH**

**7**



















































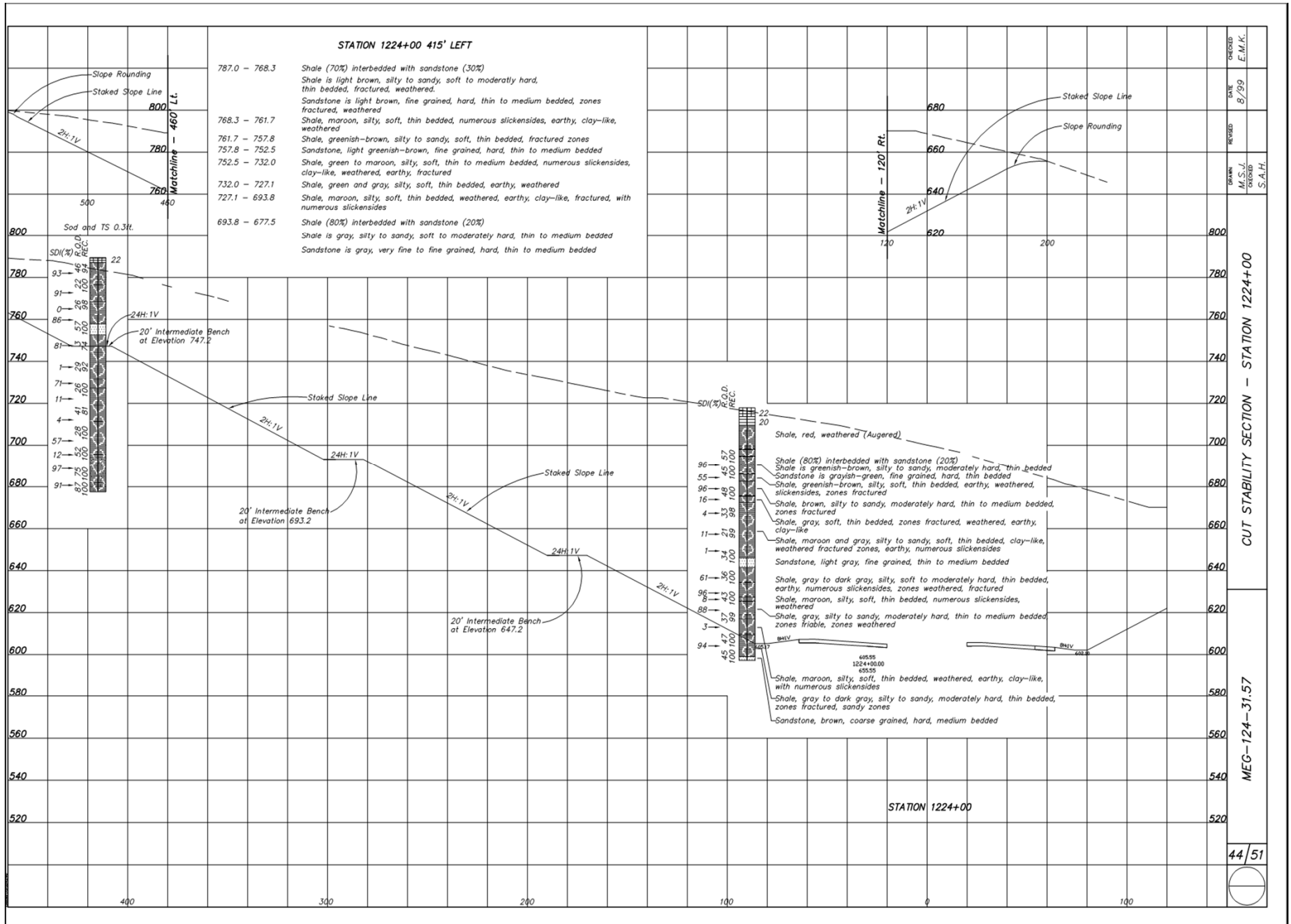


Core Box Containing Redbed Shale Sample





**Example of Slickensided Bedrock Surface**



**Cut Section Design**



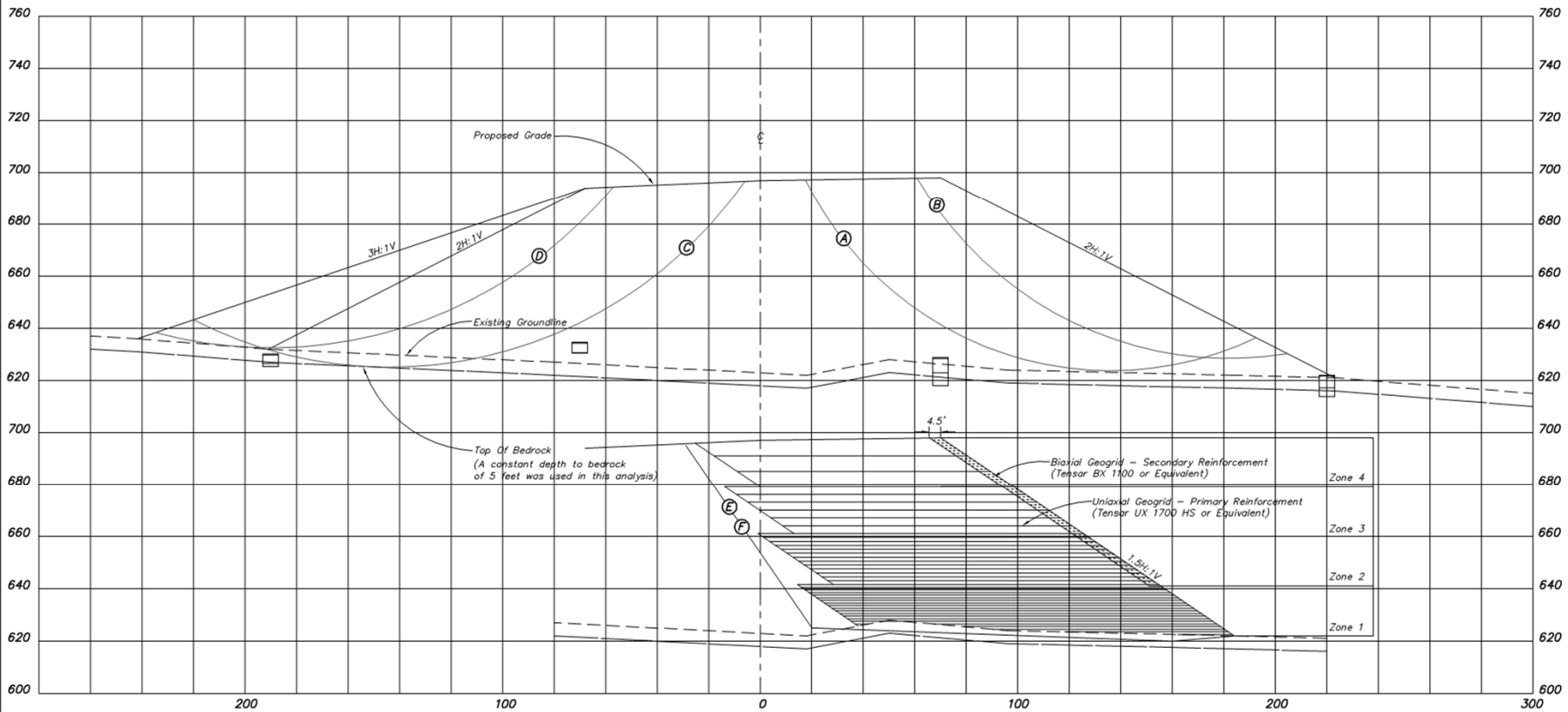




Geogrid Specifications			
Zone	Primary Reinforcement Spacing (ft.)	Secondary Reinforcement Spacing (ft.)	Length of Geogrid Embedment (ft.)
1	1.0	—	140.4
2	1.5	1' Spacing 1.5' Max.	126.4
3	3.0	1' Spacing 1.5' Max.	112.4
4	9.0	1' Spacing 1.5' Max.	98.4

Soil Parameters			
Soil	Unit Weight (p.c.f.)	Total Stress	Effective Stress
Embankment Fill	125	$c = 1500$ p.s.f.	$c = 200$ p.s.f.
		$\phi = 0$	$\phi = 20$
Silt And Clay	125	$c = 2000$ p.s.f.	$c = 300$ p.s.f.
		$\phi = 0$	$\phi = 30$

Summary Of Stability Analysis						
Failure Surface	Failure Mode	Condition	Factor Of Safety	X	Y	R
(A)	Circular	Short Term 2H : 1V Slope	1.3	136.0	756.0	132.3
(B)	Circular	Long Term 2H : 1V Slope	1.1	182.0	769.0	140.5
(C)	Circular	Short Term 3H : 1V Slope	1.9	-144.0	794.0	168.9
(D)	Circular	Long Term 3H : 1V Slope	1.5	-190.0	806.0	173.5
(E)	Translational	Short Term With Geogrid	1.8	N/A	N/A	N/A
(F)	Translational	Long Term With Geogrid	3.1	N/A	N/A	N/A



CHECKED: E.M.K. DATE: 8/99  
 REVISIONS: M.S./S.A.H.  
 DRAWN: S.A.H.  
 EMBANKMENT STABILITY SECTION - STATION 1277+00  
 MEG-124-31.57  
 29/51

## Embankment Section Design



**Constructed Reinforced Soil Slope**

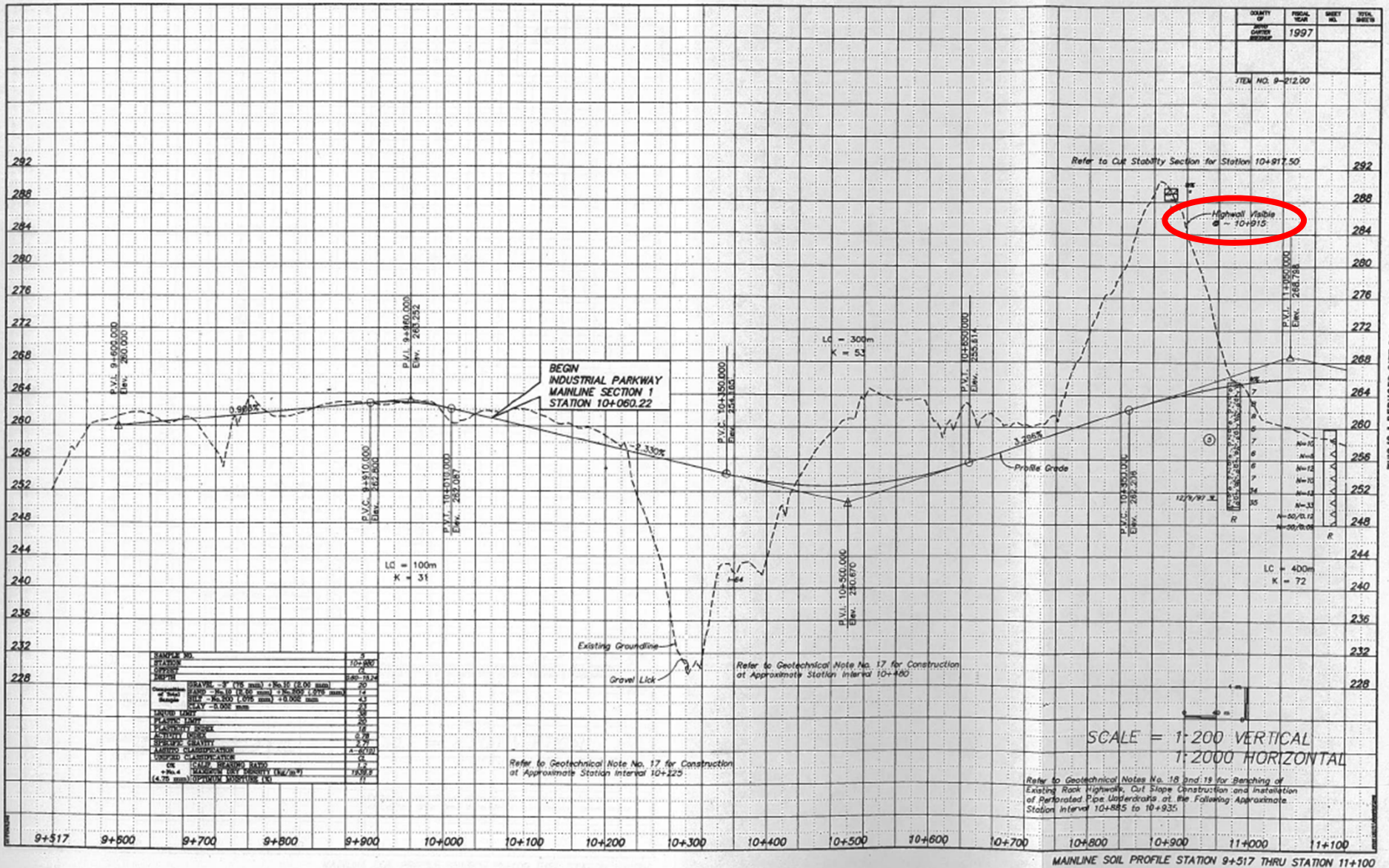


Back-Stacked Highwall Area



**Back-Stacked Highwall Area**





THIS IS A REDUCED SIZE PRINT-NOT TO SCALE

**Industrial Parkway Profile depicting Back-Stacked Highwall Position near Station 10+915**

COUNTY OF	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
ROD/CARTER	1997		

ITEM NO. 9-212.00

**CORE LOG Sta. 10+917.50, 20.4 Rt.**

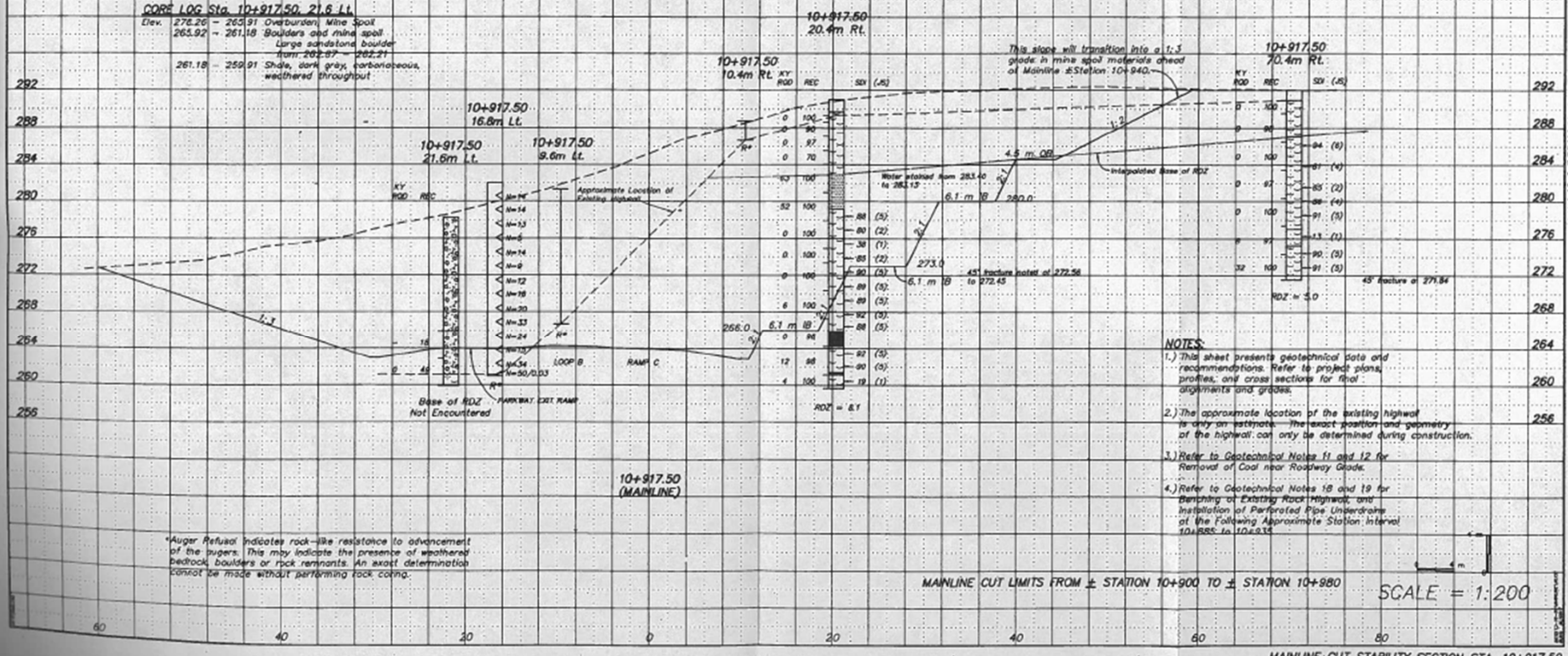
Elev. 291.00 - 289.49	Soil Overburden
289.49 - 282.94	Shale, gray brown and reddish brown, clay-like, thin to medium bedded, highly weathered to weathered (Auger test 289-291)
282.94 - 279.20	Sandstone, gray fine to medium grained, thin to medium bedded, micaceous with occasional shale streaks and partings
279.20 - 265.83	Shale, gray silty, zones sandy laminated to thin bedded, zones with sandy streaks (partings) and a few
265.83 - 264.23	Cool, block, vitreous, zones bony, with shale partings
264.23 - 261.43	Shale, gray to dark gray silty to sandy, thin bedded
261.43 - 259.66	Cool, block
259.66 - 258.66	Shale, gray silty, zones sandy, thin bedded, zones partially claylike

**CORE LOG Sta. 10+917.50, 70.4 Rt.**

Elev. 291.99 - 290.92	Overburden
290.92 - 287.04	Shale, brown to gray, silty to sandy, thin bedded, zones clay-like, highly weathered to weathered throughout, water stained
287.04 - 277.02	Shale, gray silty, sandy zones, laminated to thin bedded, zones irregular bedded, slightly weathered to weathered, zones water stained to 284.73, occasional localized near vertical fractures
277.02 - 275.19	Shale (Underclay), gray to dark gray, silty to clayey, weathered throughout
275.19 - 271.24	Shale, gray to dark gray, sandy thin bedded, locally micaceous

**CORE LOG Sta. 10+917.50, 21.6 Lt.**

Elev. 278.26 - 265.91	Overburden Mine Spoil
265.92 - 261.18	Boulders and mine spoil Large sandstone boulder from 202.07 - 262.21
261.18 - 259.91	Shale, dark gray, carbonaceous, weathered throughout



- NOTES:**
- 1.) This sheet presents geotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final arguments and grades.
  - 2.) The approximate location of the existing highway is only an estimate. The exact position and geometry of the highway can only be determined during construction.
  - 3.) Refer to Geotechnical Notes 11 and 12 for Removal of Coal near Roadway Grade.
  - 4.) Refer to Geotechnical Notes 18 and 19 for Benching of Existing Road Highway, and Installation of Perforated Pipe Underdrains of the Following Approximate Station Interval 10+985 to 10+935.

\*Auger Refusal indicates rock-like resistance to advancement of the auger. This may indicate the presence of weathered bedrock boulders or rock remnants. An exact determination cannot be made without performing rock coring.

MAINLINE CUT LIMITS FROM ± STATION 10+900 TO ± STATION 10+980  
SCALE = 1:200

MAINLINE CUT STABILITY SECTION STA. 10+917.50

THIS IS A REDUCED SIZE PRINT-NOT TO SCALE

# Designed Cut Section through Mine Spoil Back-Stacked Highwall



**Silt Pond and Mine Bench Area Encountered at Project Site**



**Typical Hollow Fill Encountered Along the Project**

**Table 1. Results of CU Triaxial Tests – Industrial Pkwy.**

<b>Sample Description and USCS Classification</b>	<b>Range of Values Obtained</b>	
	<b>Cohesion, <math>\bar{c}</math> (psf)</b>	<b>PHI, <math>\bar{\phi}</math> (degrees)</b>
Lean Clay – CL	210 - 240	25 - 28
Silty Clay, Sandy Lean Clay, or Clayey Sand – CL, SC	0 - 70	31 - 32
Mine Spoils – CL	0	26

**Table 2. Slope Geometries for  
Soil/Mine Spoil Cuts – Industrial Pkwy.**

<b>Approximate Depth of Cut</b>	<b>Recommended Slope Grade (H:V)</b>
Less than 10 feet	2:1
10 feet to 30 feet	2.5:1
30 feet to 120 feet	3:1

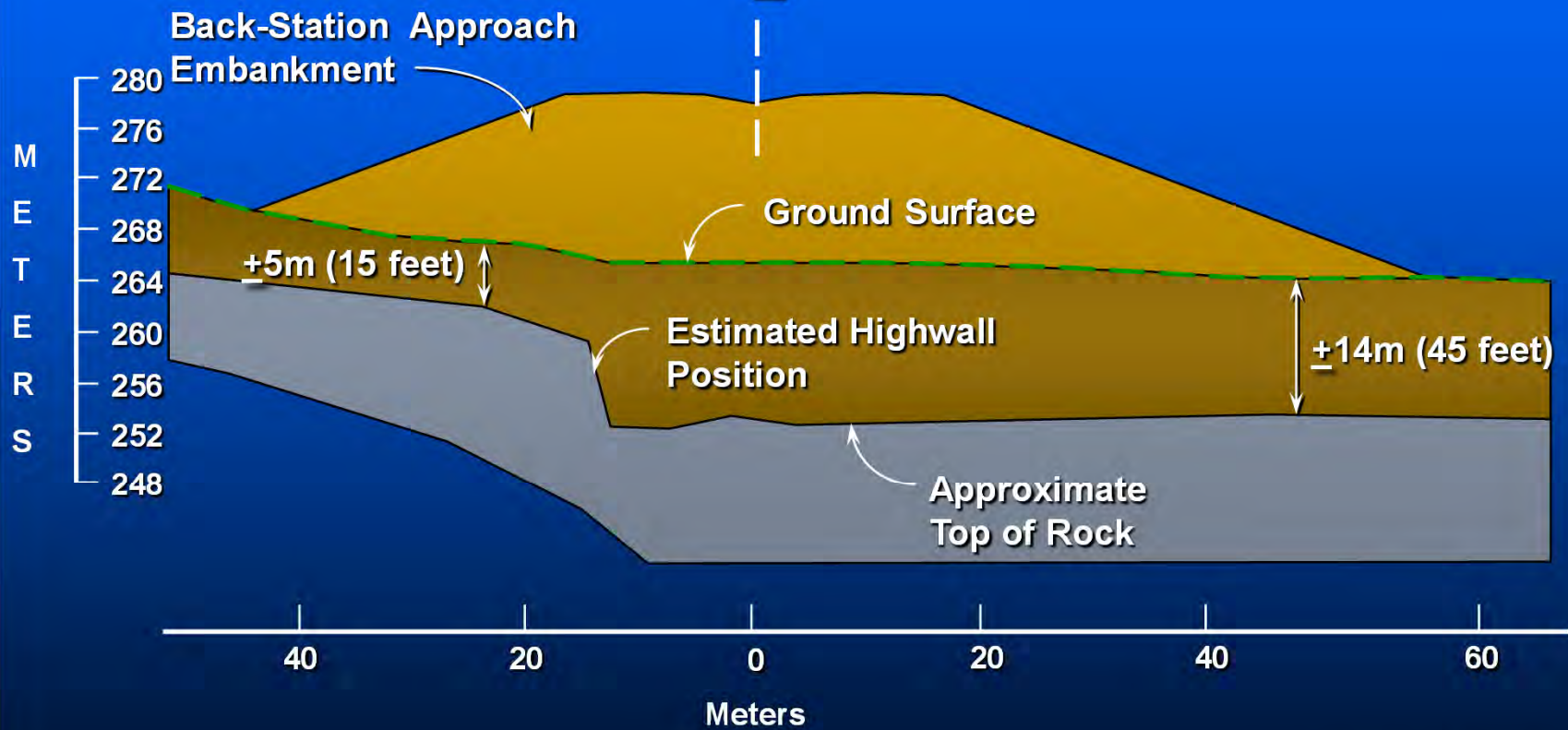


**Roadway Cut being Constructed within Non-Durable Shales**

# Recommendations

## Sta. 13+720

CG



**JMSM**  
ENGINEERS

Approach Embankment Modeled for Stability Analysis







**View of Approach Embankment after Construction**



**Industrial Parkway / I-64 Interchange**

# ***SPECIAL THANKS***

- **OHIO DEPARTMENT OF TRANSPORTATION,  
OFFICE OF GEOTECHNICAL ENGINEERING**



- **KENTUCKY TRANSPORTATION CABINET  
DIVISION OF STRUCTURAL DESIGN –  
GEOTECHNICAL BRANCH**



**THANK  
YOU**

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**Stantec**