Slope Stability Evaluation of the Baldhill Dam Right Abutment

Presentation for the

2005 Tri-Service Infrastructure Systems Conference

by

Neil T. Schwanz

RTS Geotechnical Engineer

4 August 2005

Motivation

History of Right Abutment Displacement

Continued Movements

Expanded Record of Instrumentation

Establish Slope Stability Models

- ✓ **Recent Conditions**
- ✓ **Predict Future Loading Conditions**

Acknowledgments

MVP Geologists and Instrumentation Group

Omaha District and Local Testing Labs

MWH (formerly Harza Engineering)

University of Minnesota

Topics

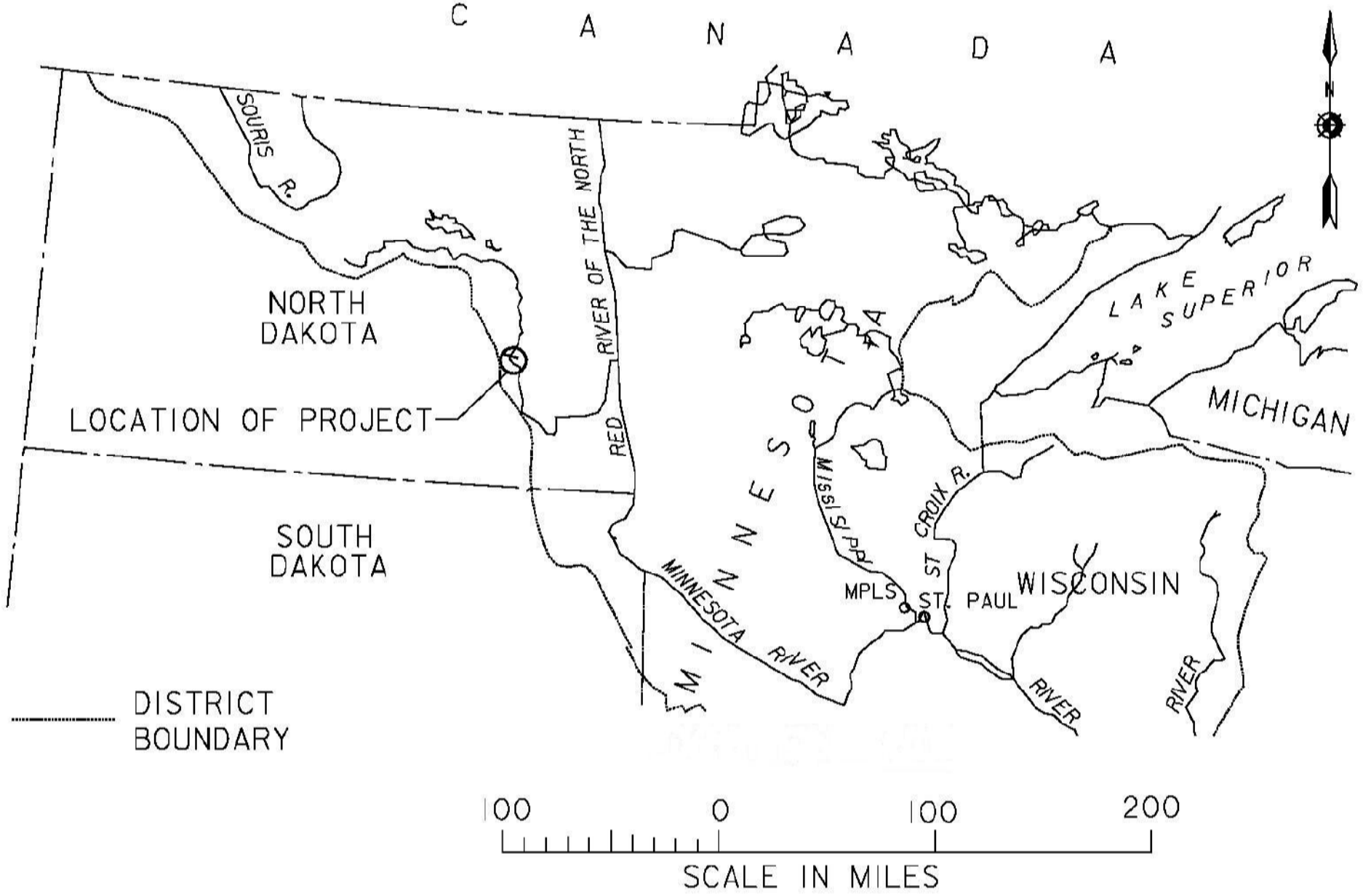
Project Background

Pressuremeter Testing

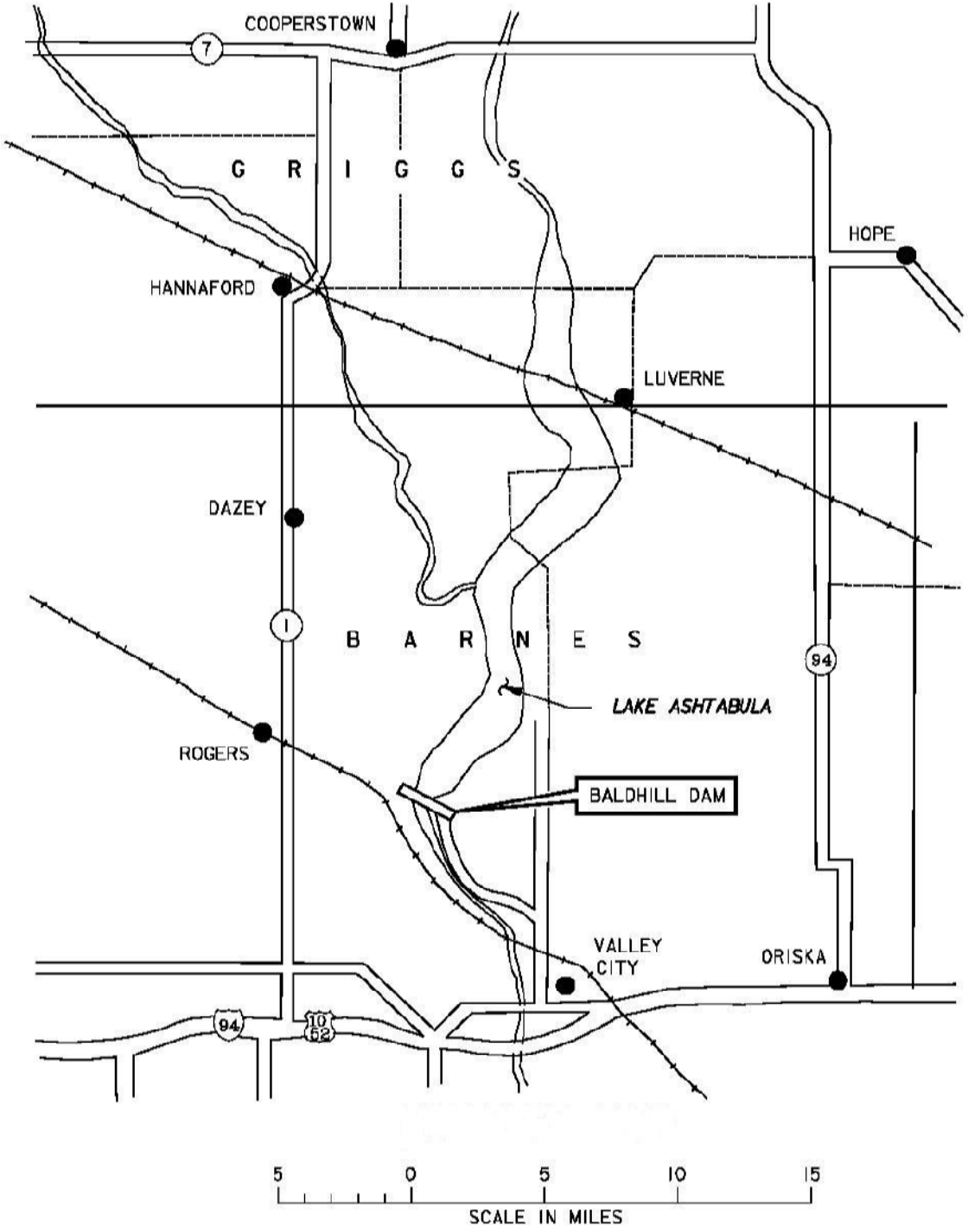
Laboratory Testing Data Interpretation

Slope Stability Analyses

- ✓ **Limit Equilibrium**
- ✓ **Numerical**


C A N A D A
SOURIS R.
RIVER OF THE NORTH
RED
NORTH DAKOTA
LOCATION OF PROJECT
SOUTH DAKOTA
MINNESOTA
MISSISSIPPI
ST CROIX R.
MINNESOTA RIVER
MPLS
ST. PAUL
WISCONSIN
LAKE SUPERIOR
MICHIGAN
DISTRICT BOUNDARY
100 0 100 200
SCALE IN MILES

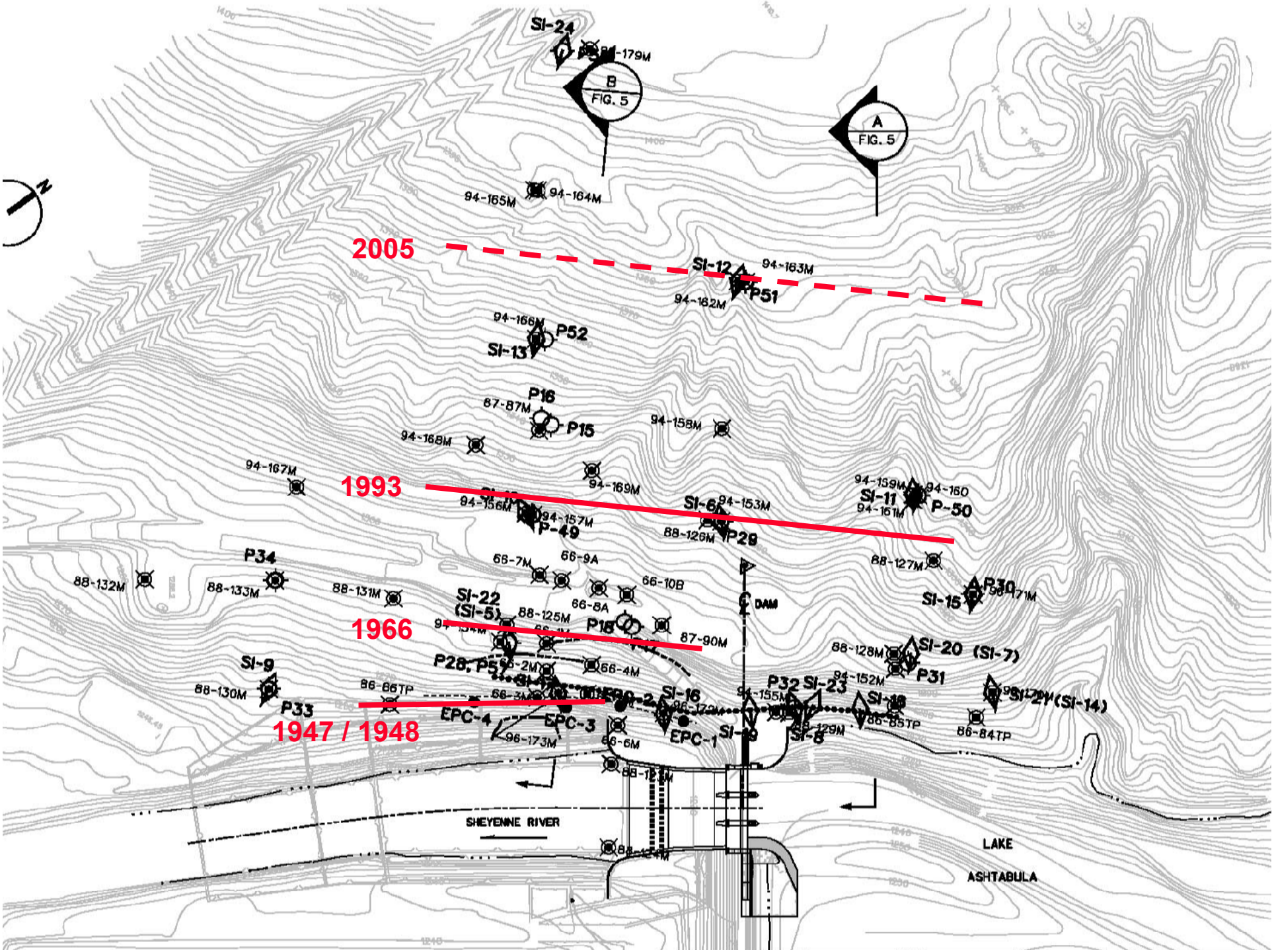
US Army Corps of Engineers®
Mississippi Valley Division
Mississippi River Commission



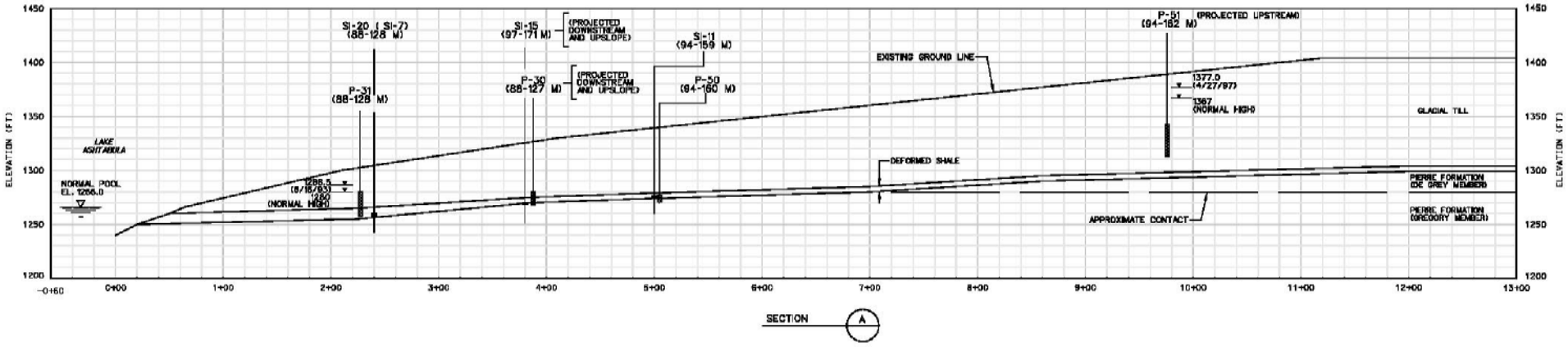
US Army Corps
of Engineers®
Mississippi Valley Division
Mississippi River Commission

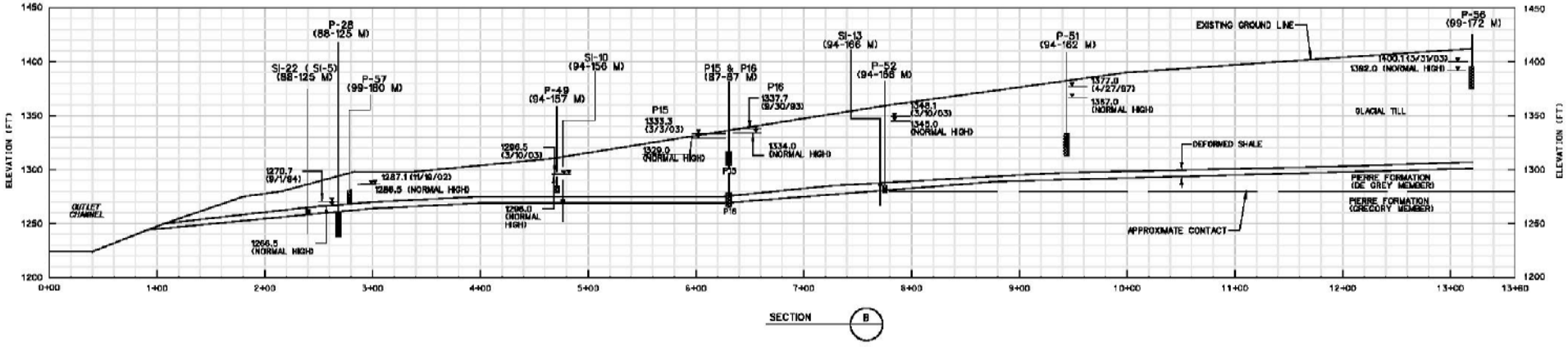
Main Features


Right Abutment Area
of Concern


2005
1993
1966
1947 / 1948
SI-24
B
FIG. 5
A
FIG. 5
94-165M
94-164M
SI-12
94-163M
P51
94-162M
94-166M
P52
SI-13
P16
87-87M
P15
94-168M
94-158M
94-167M
94-169M
94-156M
94-157M
P-49
SI-6
94-153M
88-126M
P29
94-159M
94-160
SI-11
94-161M
P-50
88-127M
P34
88-132M
88-133M
88-131M
66-7M
66-9A
66-10B
66-8A
SI-22
(SI-5)
88-125M
P18
87-90M
DAM
SI-15
P30
SI-9
88-130M
P33
86-86TP
P28, P57
66-2M
66-4M
66-3M
EPC-4
EPC-3
96-173M
66-6M
EPC-2
SI-16
EPC-1
SI-17
P32
SI-23
94-155M
SI-18
88-129M
SI-8
88-128M
SI-20 (SI-7)
P31
94-152M
SI-21 (SI-14)
86-85TP
86-84TP
SHEYENNE RIVER
LAKE
ASHTABULA

Stratigraphy

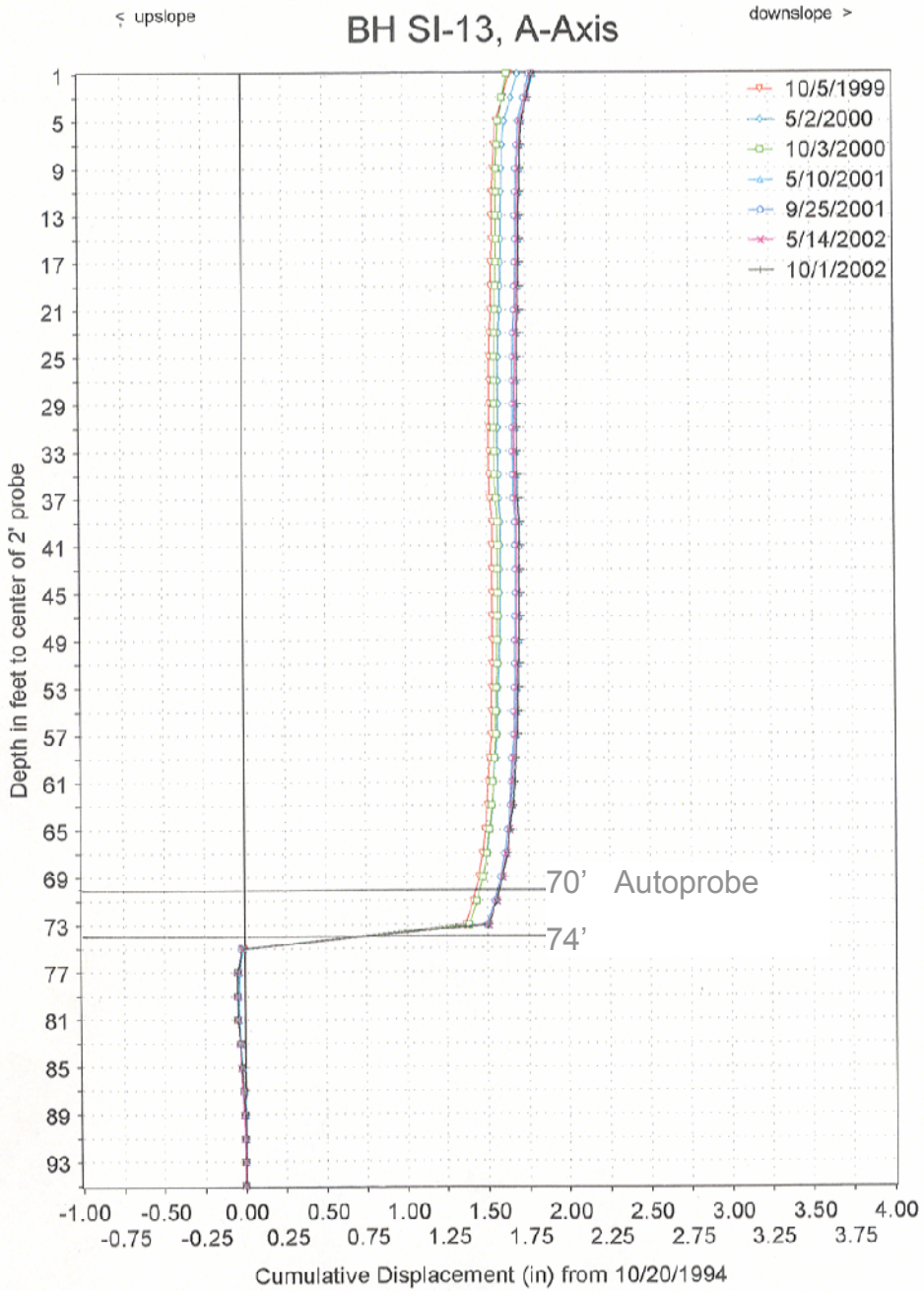




BALDHILL DAM, LAKE ASHTABULA

INCLINOMETER DATA

BH SI-13, A-Axis



US Army Corps
of Engineers®
Mississippi Valley Division
Mississippi River Commission

Inclinometer Displacement

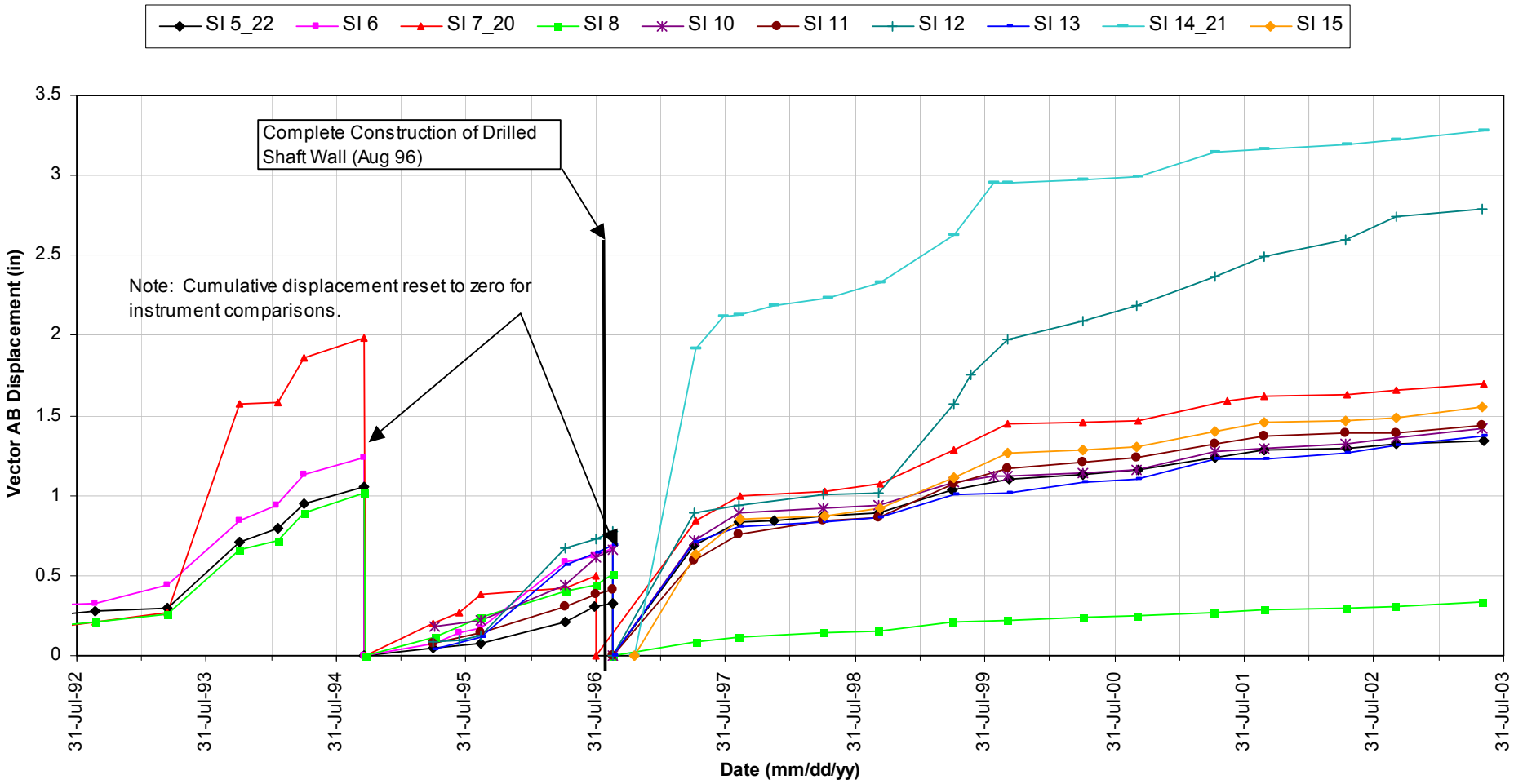
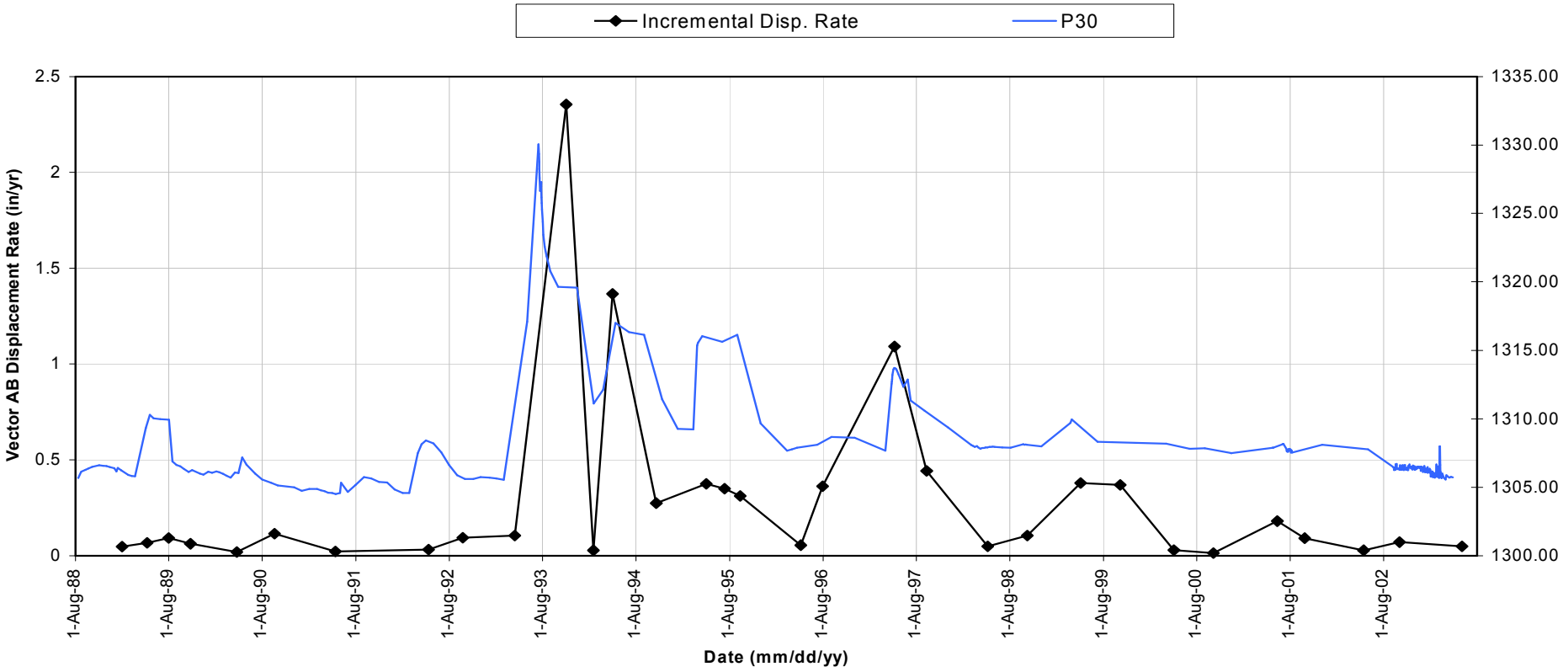


Fig. 2.8. Inclinometer Displacement Rate Comparison

US Army Corps of Engineers®
Mississippi Valley Division
Mississippi River Commission

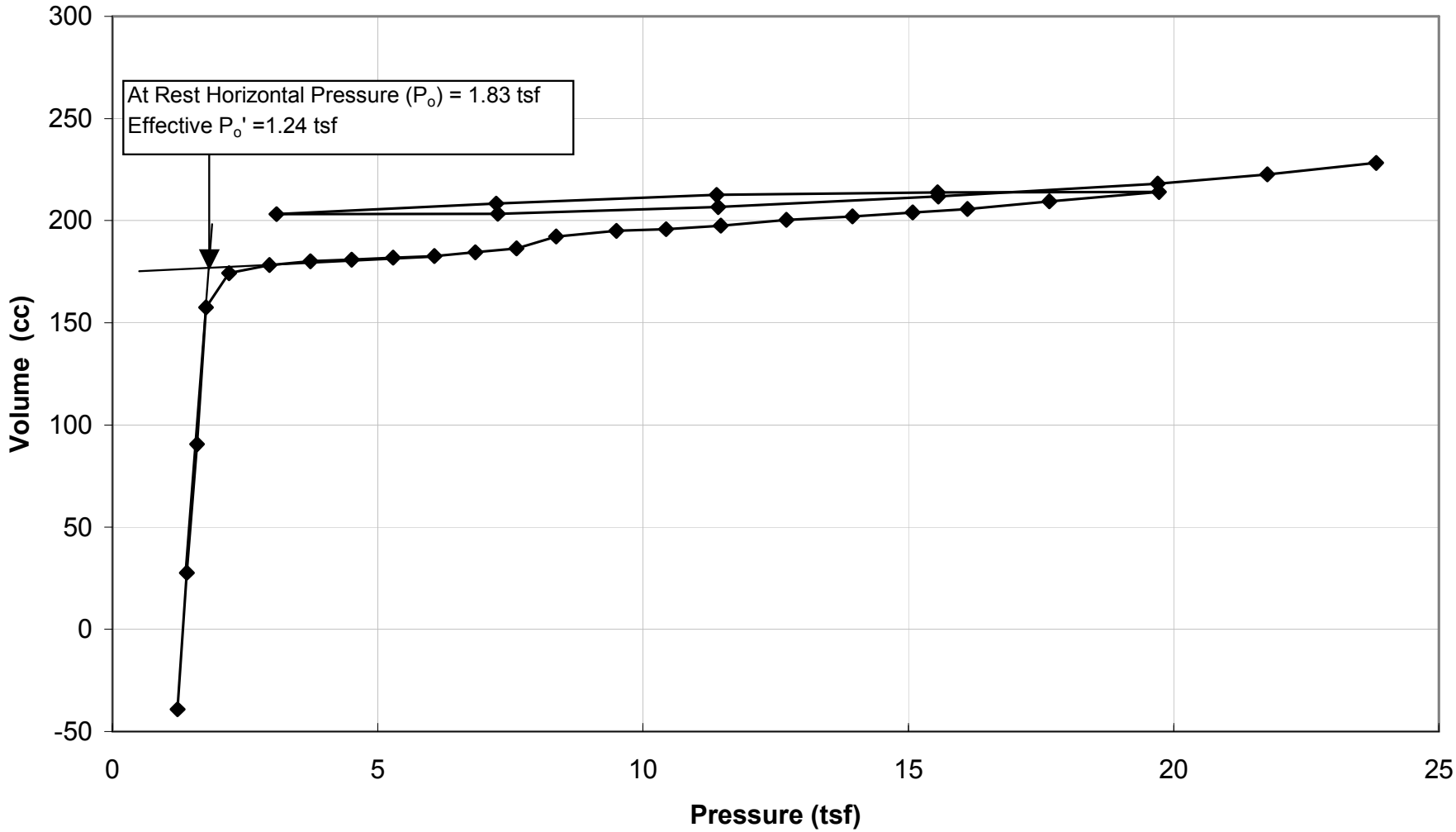
Displacement vs Pore Water Cond.



SI-7 and SI-20 (43' depth)

US Army Corps of Engineers®
Mississippi Valley Division
Mississippi River Commission

Pressuremeter Data (D.Shale)



US Army Corps
of Engineers®
Mississippi Valley Division
Mississippi River Commission

Shear Modulus (D.Shale)

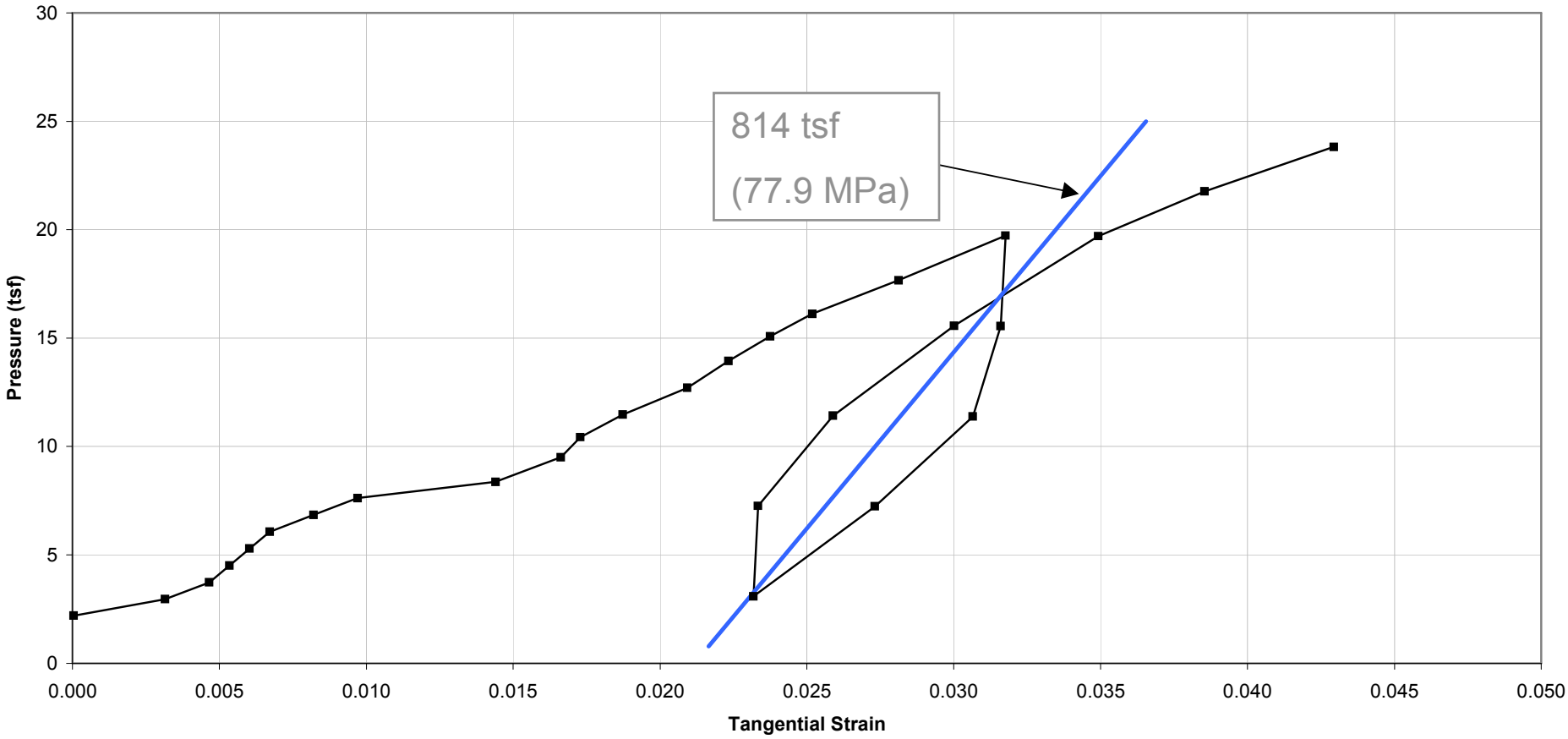


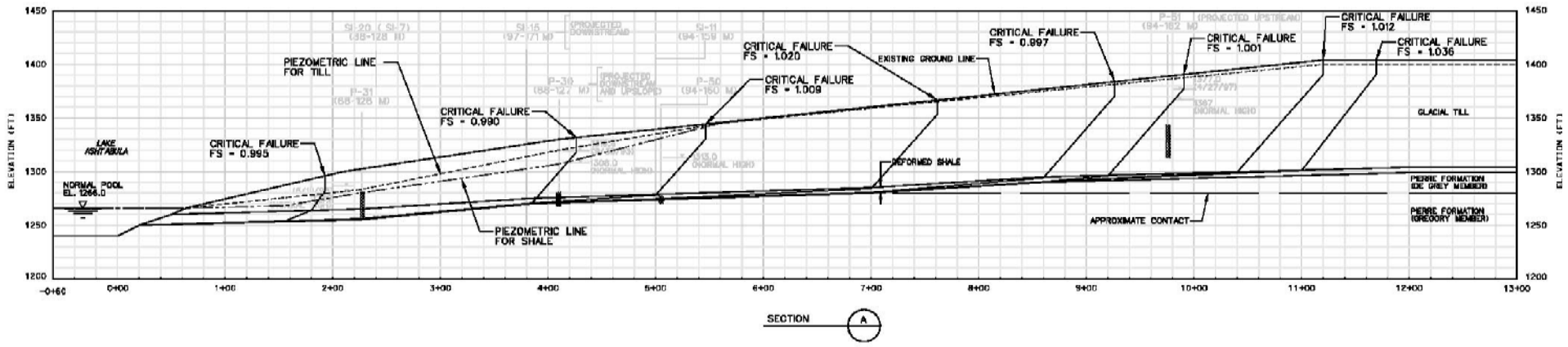
Figure D-4b. Pressuremeter Results (Deformed Shale)
Boring 02-156PM, 34.0 feet

Laboratory Testing

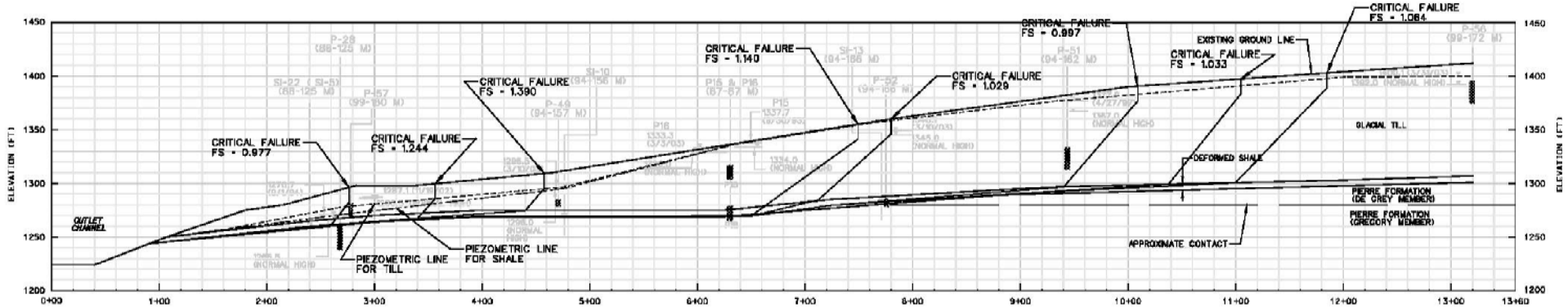
- **Unconfined Compression**
- **Triaxial Shear Strength**
  - ✓ **Unconsolidated-Undrained**
  - ✓ **Consolidated-Undrained w/PP**
- **Direct Shear**
- **Residual Direct Shear**

Effective Shear Strength Parameters

Material	Peak				15% Strain/0.2 or 0.5 in. Displacement				Residual
	Triaxial		Direct Shear		Triaxial		Direct Shear		
	c′ (psf) [kPa]	ϕ′ (deg)	c′ (psf) [kPa]	ϕ′ (deg)	c′ (psf) [kPa]	ϕ′ (deg)	c′ (psf) [kPa]	ϕ′ (deg)	ϕ'_{res} (deg)
Till	500 [23.9]	25	650 [31.2]	24	600 [28.7]	23	350 [16.8]	23	16
D. Shale	1100 [52.7]	26	325 [15.6]	29	850 [40.7]	23	250 [12.0]	21	9.5
I. Shale	1975 [94.6]	35	575 [27.5]	23	375 [18.0]	23	0	16	6.3



SECTION A



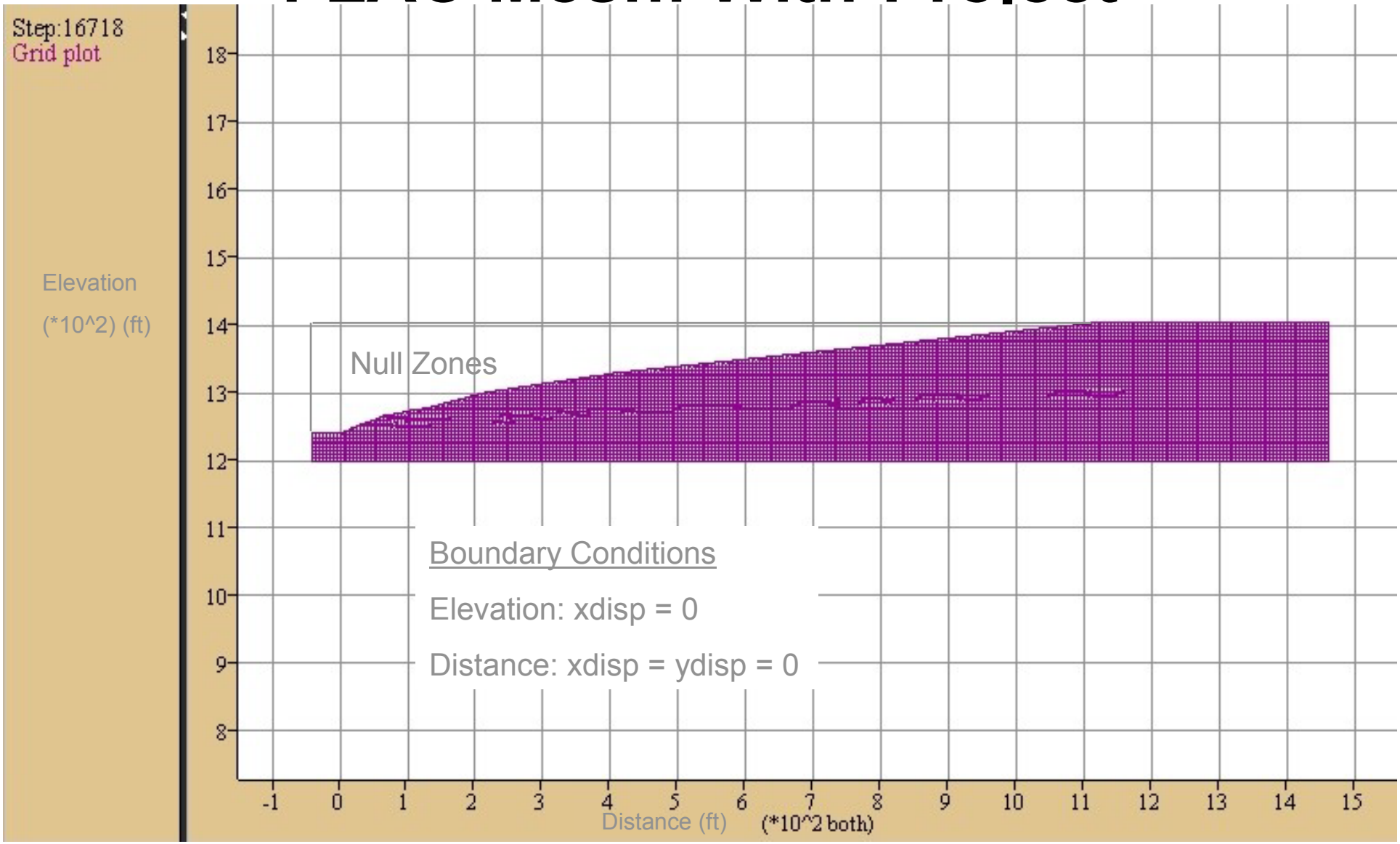
SECTION B

MATERIAL PARAMETERS

MATERIAL	SAT. UNIT WT. (PCF)	EFF. COHESION (PSF)	EFF. FRICTION ANGLE (DEG)
TILL	123	650	24
DEFORMED SHALE - SECTION A	125	0	9.2
DEFORMED SHALE - SECTION B	125	0	9.9
INTACT SHALE	128	600	24

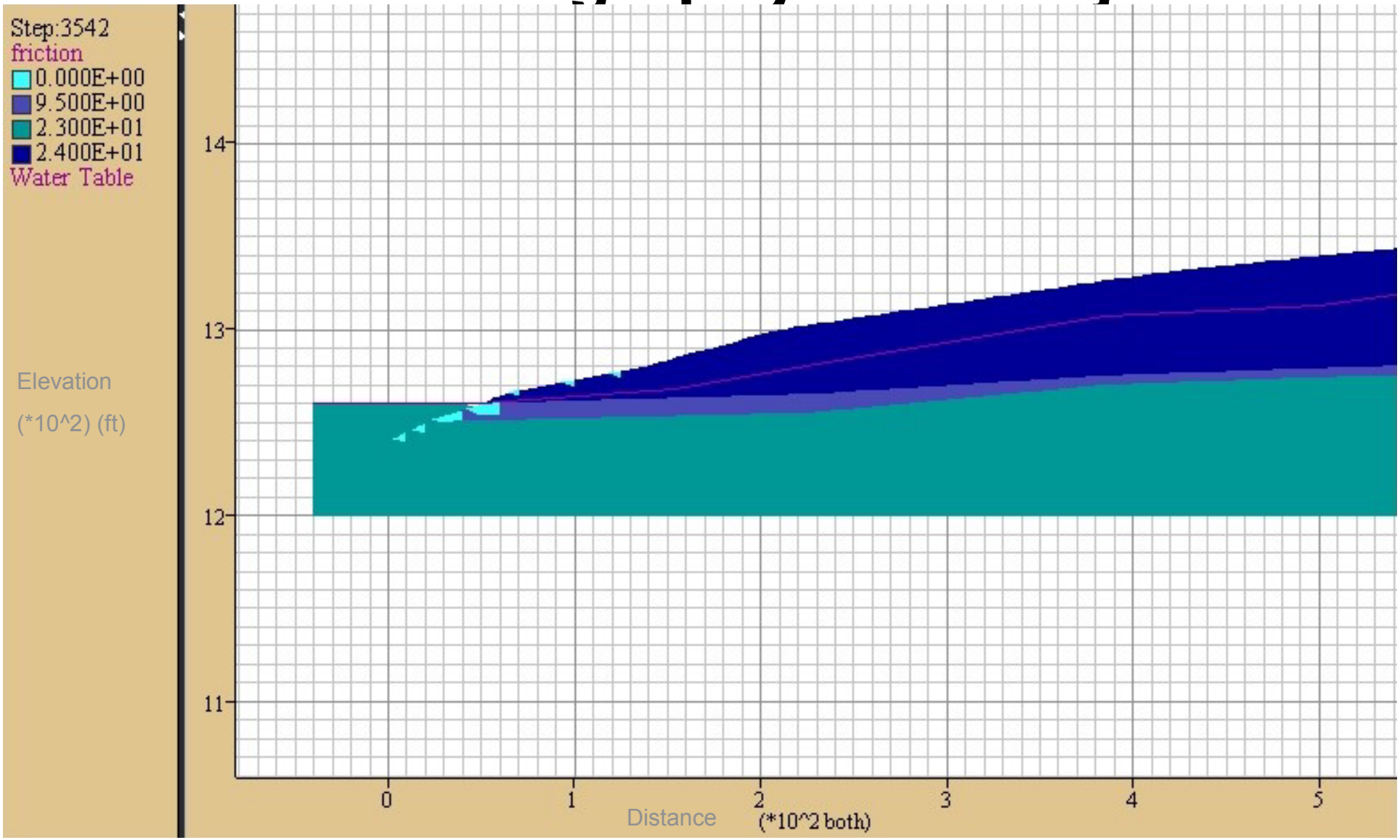
US Army Corps
of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC Mesh: With-Proiect



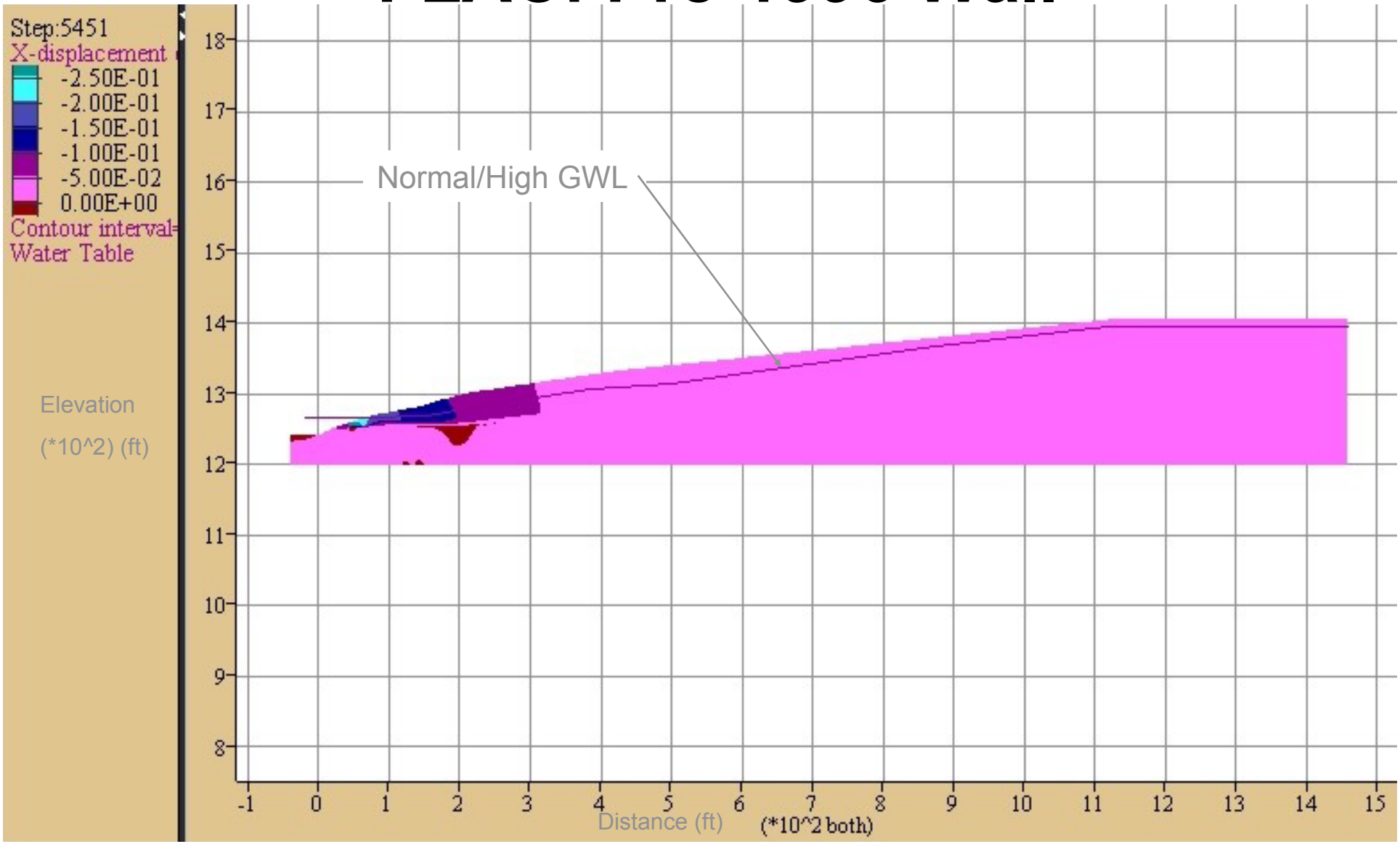
US Army Corps
of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC Stratigraphy: Pre-Project



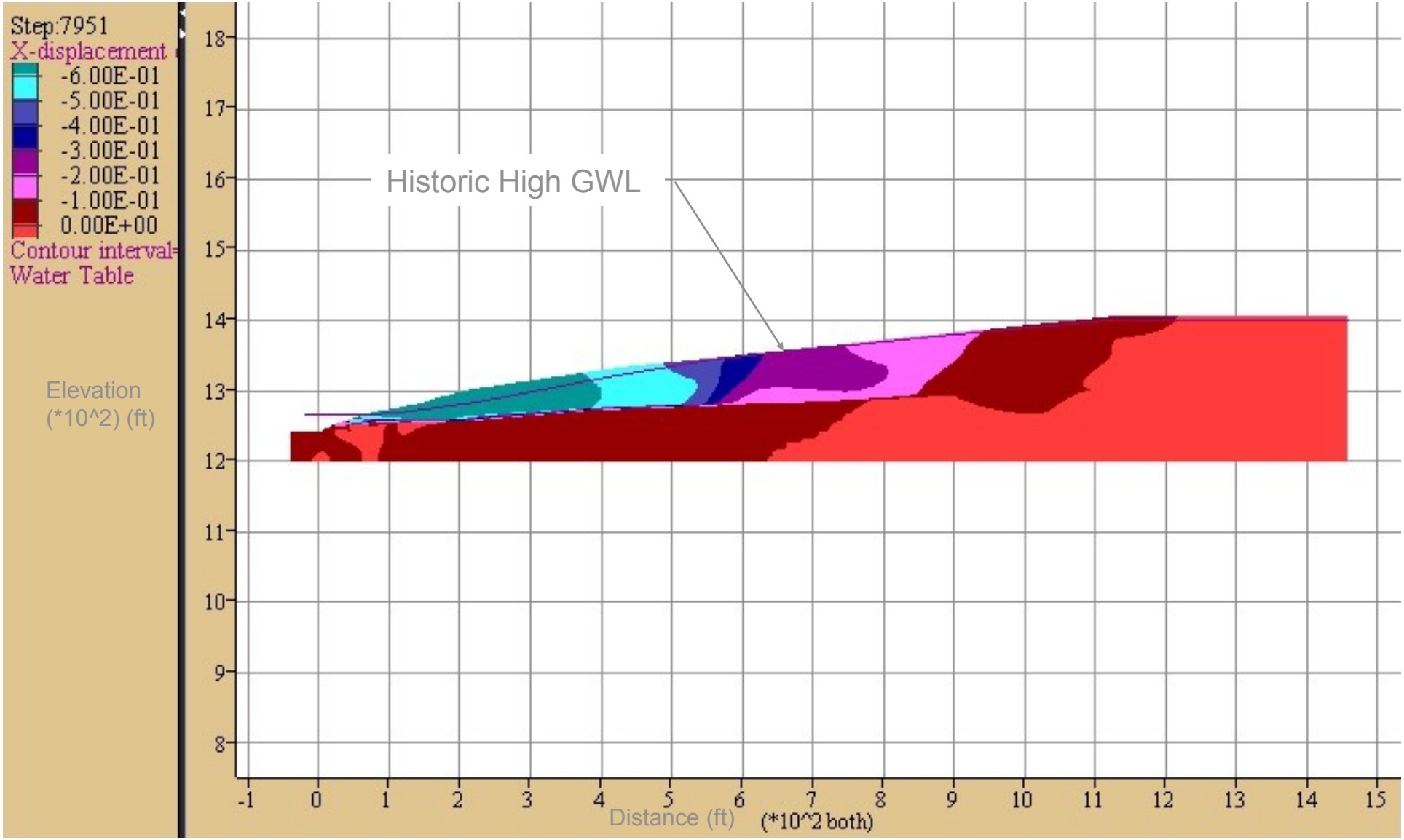
US Army Corps
of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC: Pre-1996 Wall



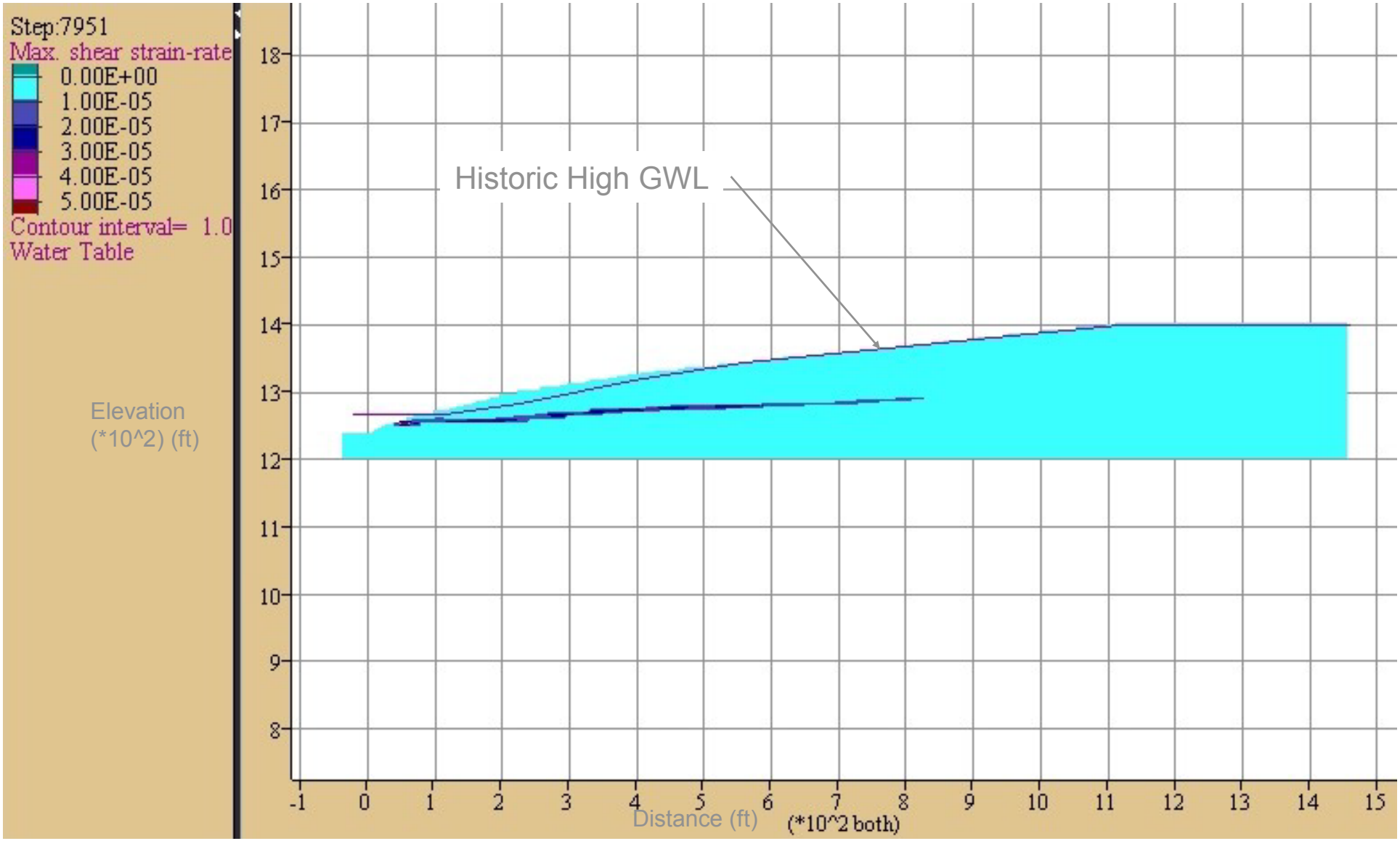
US Army Corps
of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC: Pre-1996 Wall



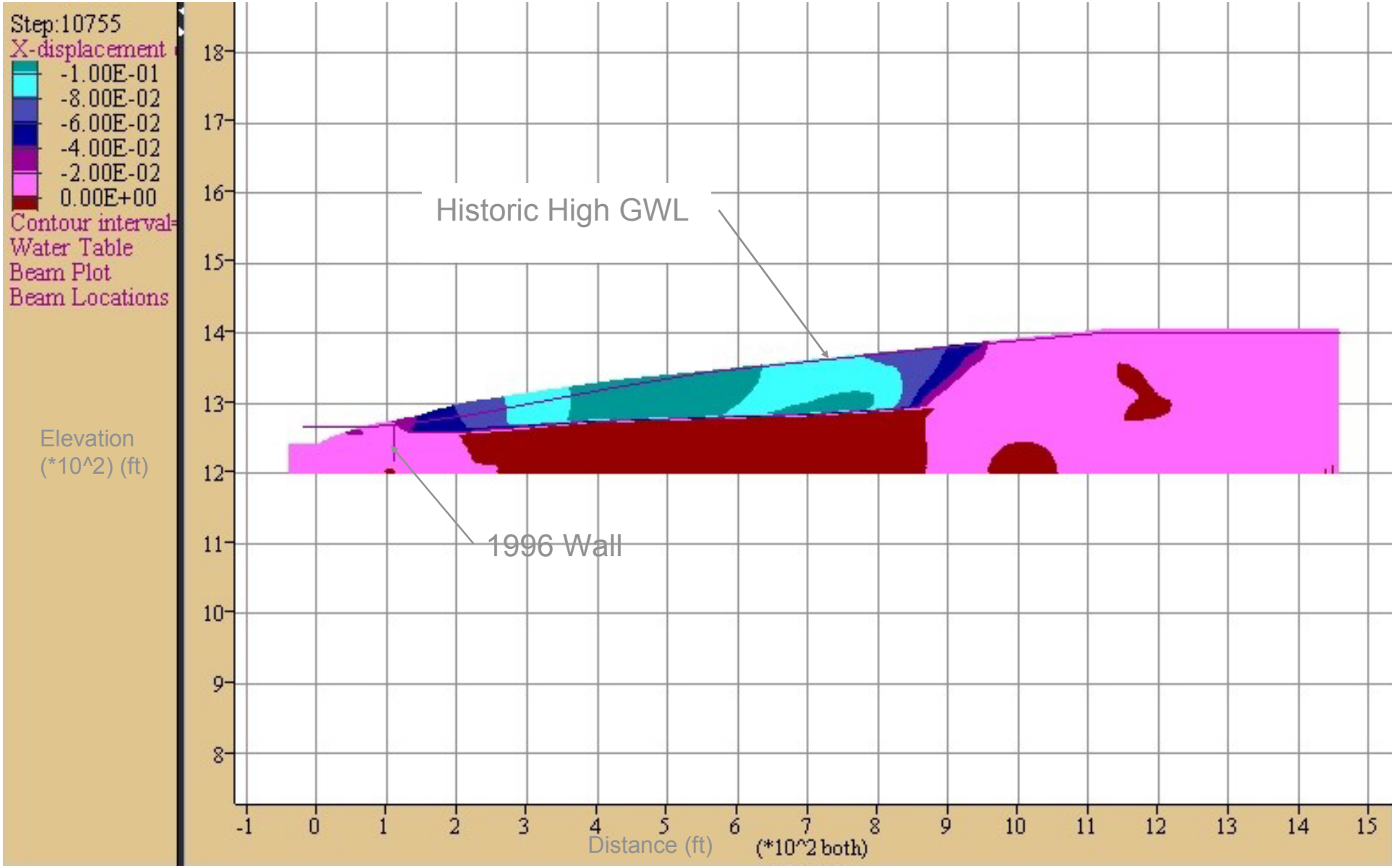
US Army Corps
of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC: Pre-1996 Wall



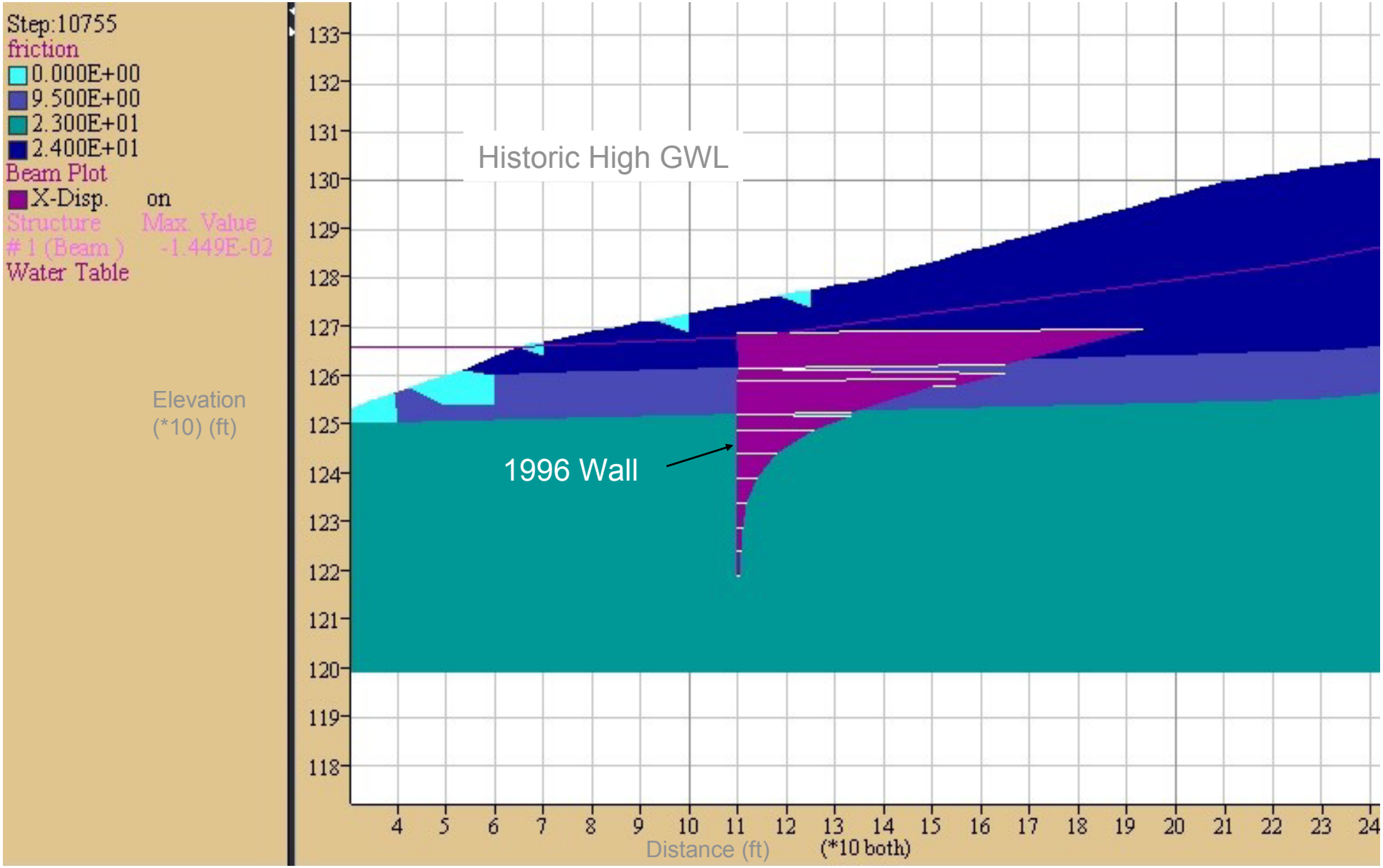
US Army Corps of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC: 1996 Wall



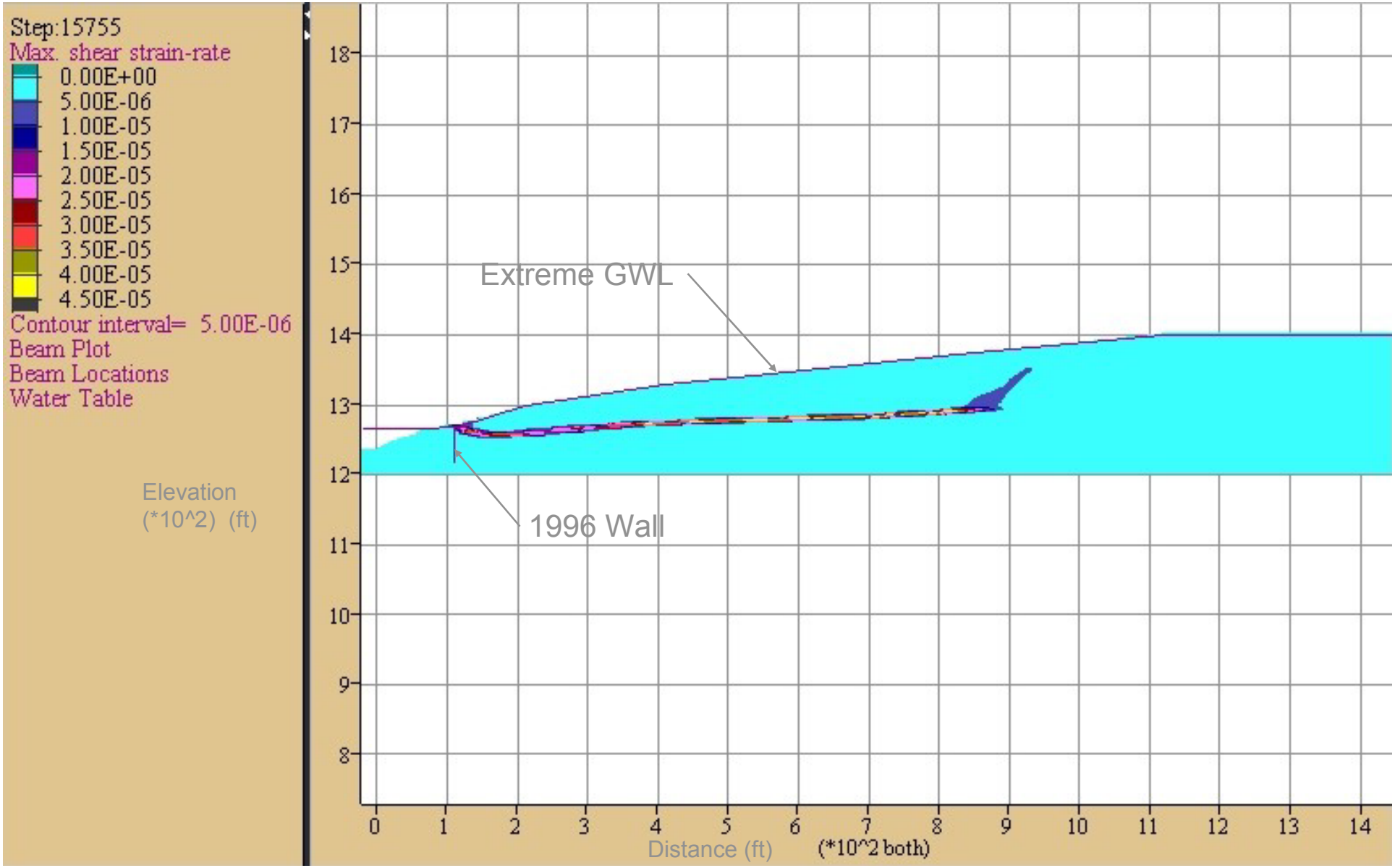
US Army Corps of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC: 1996 Wall



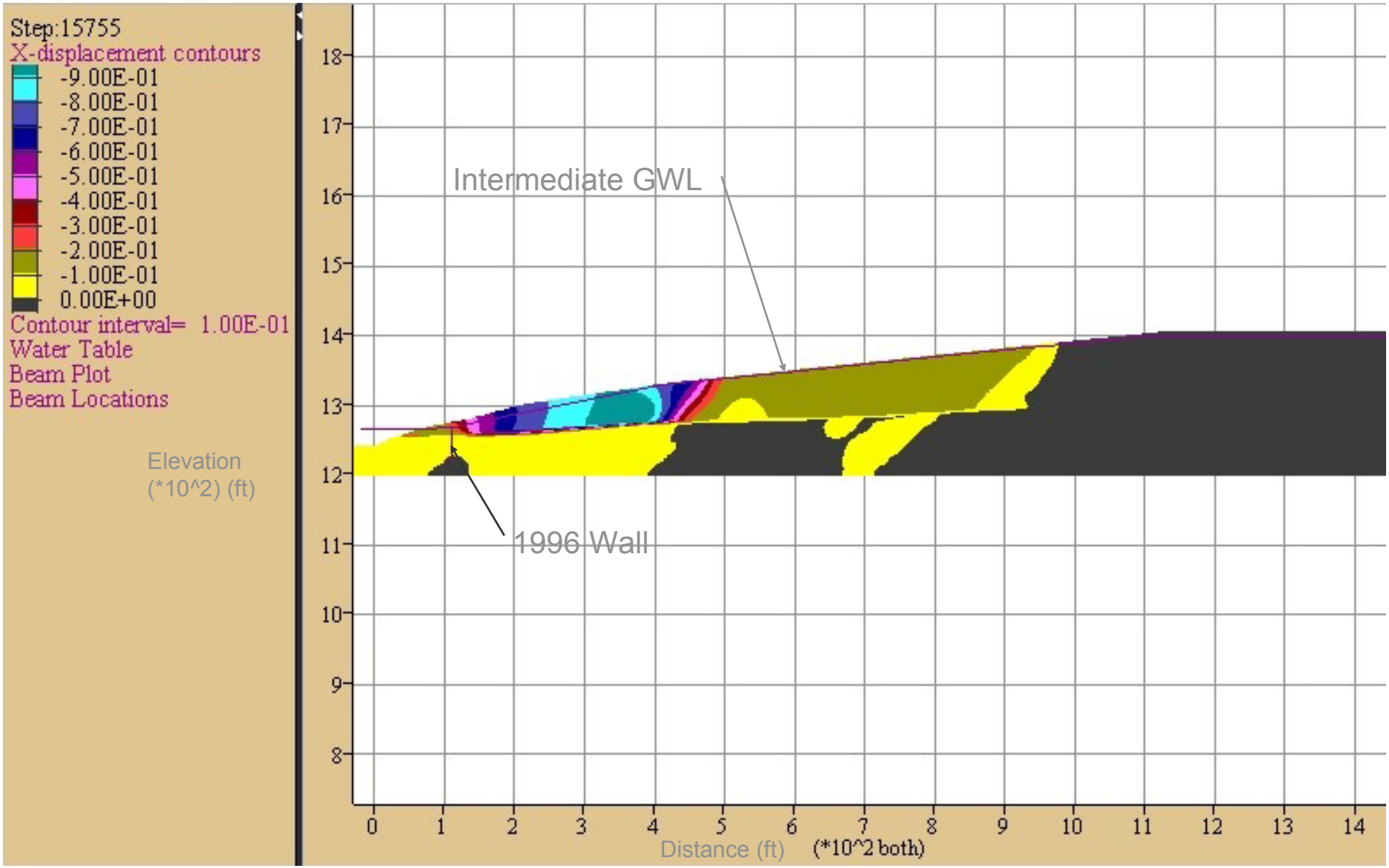
US Army Corps of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC: 1996 Wall



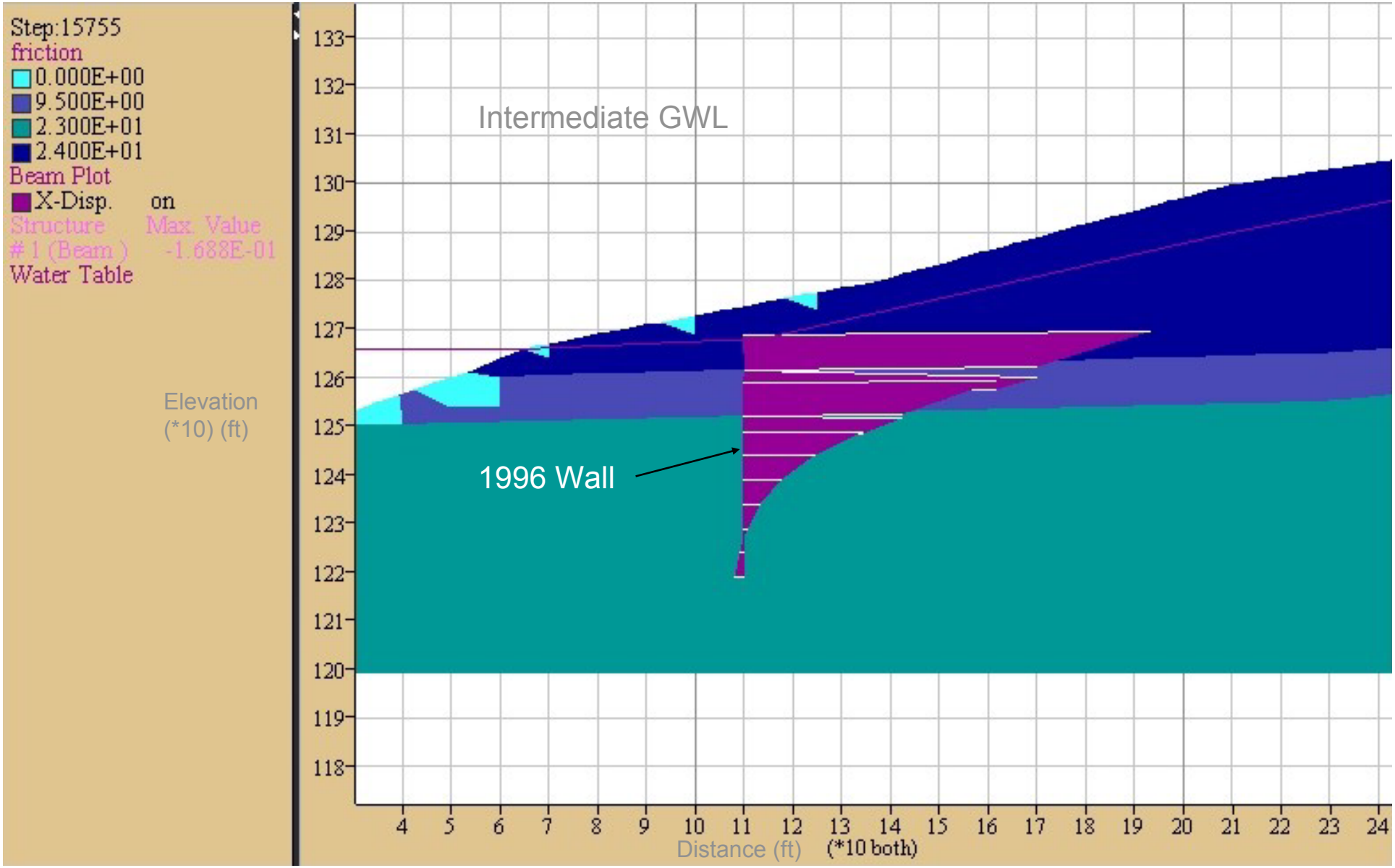
US Army Corps of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC: 1996 Wall



US Army Corps of Engineers®
Mississippi Valley Division
Mississippi River Commission

FLAC: 1996 Wall



Summary

- History of problems
- Instrumentation extremely important
  - ✓ Understanding mechanism of displacement
  - ✓ Identifying geometry of failure surface
- Pressuremeter testing (elastic properties)
- Laboratory testing (shear strength)
- Limit equilibrium (back calculation)

Summary (con't)

FLAC results

- ✓ No searching for the critical failure surface
- ✓ Compute displacements with visual representation
- ✓ Helps in understanding problem
- ✓ General agreement with limit equilibrium results
- ✓ Abutment is stable to past historic high GWL's
- ✓ Abutment is at risk of failure to extreme GWL's
- ✓ At an intermediate GWL, abutment may be stable, but with much more deflection of the 1996 drilled shaft wall


QUESTIONS?