








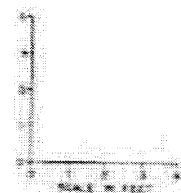


## EXPLANATION

- 
 FULLY BOUNDED, SOME SAND, PLASTIC CLAY  
 SOME MATRIX WITH AGGREGATE OF  
 RANDOMLY ORIENTED SLTSTONE  
 AND SHALE FRAGMENTS.
- 
 FULLY BOUNDED STRONGER AGGREGATE. FRAIL  
 BROWN INDICATE DIRECTION OF RELATIVE  
 MOVEMENT
- 
 JUMP / FRACTURE PATTERNS.
- 
 SLTSTONE.
- 
 SLTSTONE LAMINA, DAMAGED WHERE BEDDING  
 PLANE CONTINUOUSLY RAPPED BUT SLTSTONE  
 LITHOLOGY THICKENED OUT.
- 
 SHALE.
- 
 SHALE LAMINA, OR LAMINATED.
- 
 INDENTURE CONCRETIONS
- 
 MICRO-CRACK SAMPLE LOCATION NUMBERS GIVEN



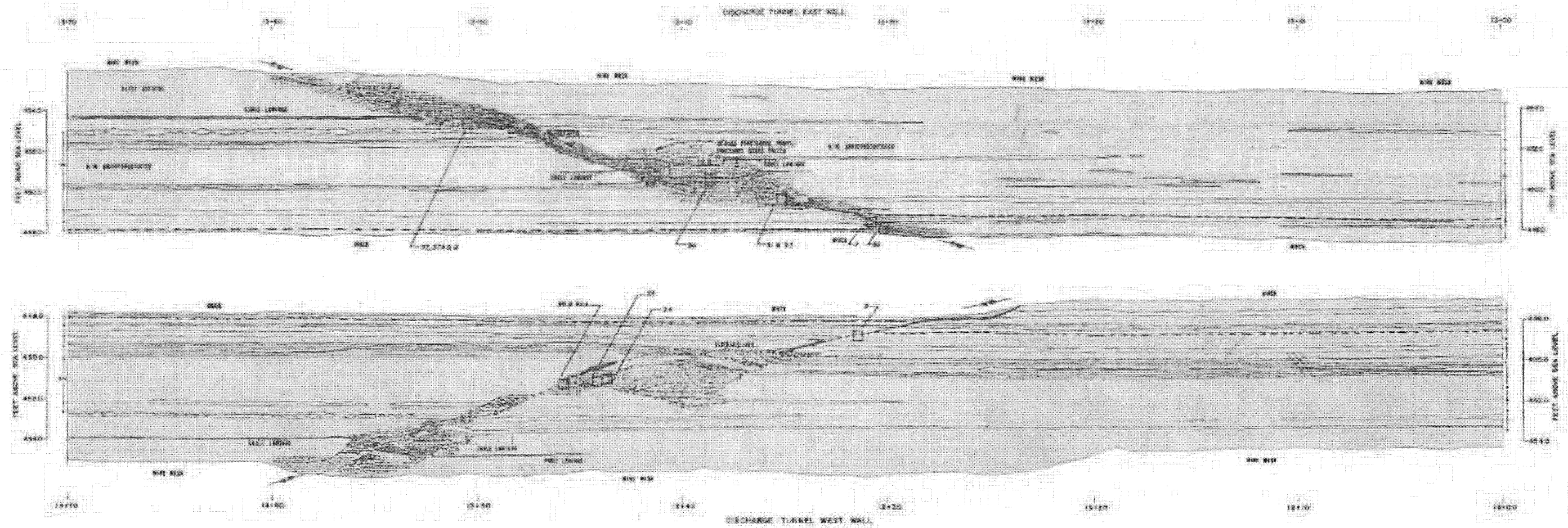
(Rev. 12-1-03)



PERRY NUCLEAR POWER PLANT

### Intake Tunnel Fault Map

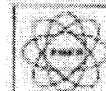
Figure 2.5-50



#### EXPLANATION

- FAULT SOURCE ZONE, GRAY, PLASTIC CLAY, GOUGE MATRIX WITH AGGREGATE OF RANDOMLY ORIENTED SILTSTONE AND SHALE FRAGMENTS.
- FAULT SOURCE, STRIPPED 400 FT. THICK, ARROWS INDICATE DIRECTION OF RELATIVE MOVEMENT.
- JOINT/FRACTURE PATTERN.
- SILTSTONE.
- SILTSTONE LAMINAR, DASHED WHERE BEDDING PLANE CONTINUOUSLY MAPPED BUT SILTSTONE LITHOLOGY PINCHED OUT.
- SHALE.
- SHALE LAMINAR, AS LABELED.
- CONCRETE.
- MICRO-GRAIN SAMPLE LOCATION: NUMBER GIVEN.

(Rev. 12/1/63)

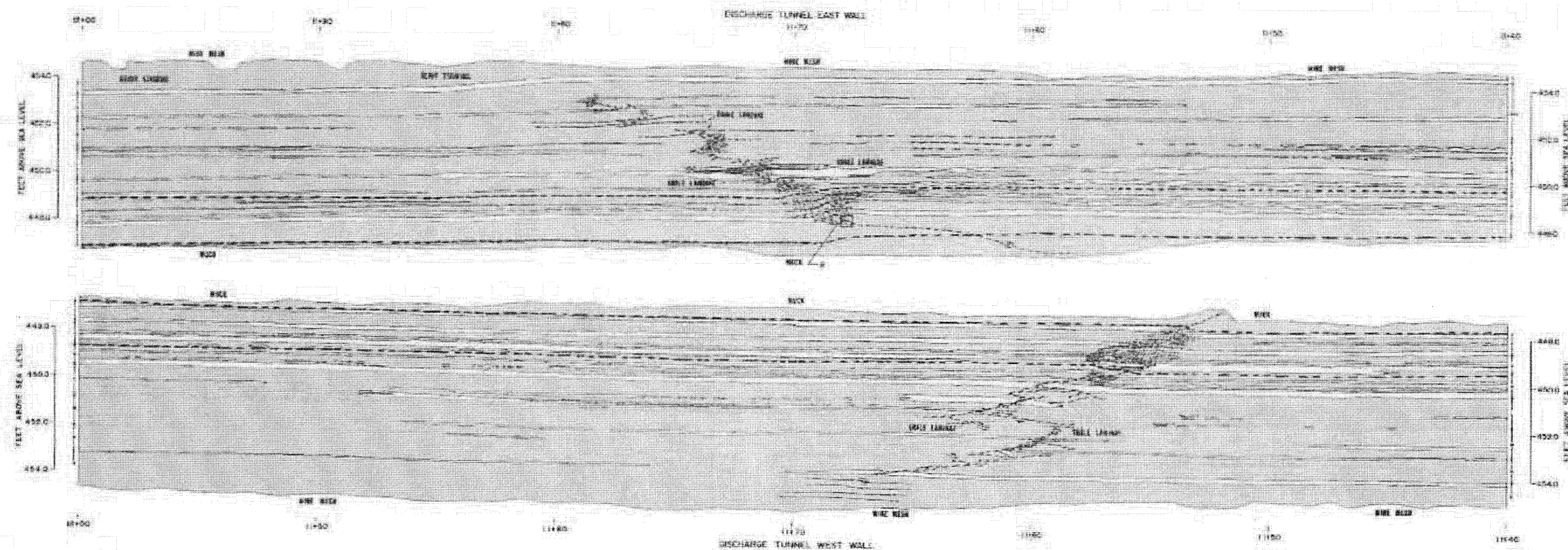


PERRY NUCLEAR POWER PLANT

Discharge Tunnel Fault Map

Figure 2.5-51





- EXPLANATION**
- FAULT SCOUR ZONE. GRAY, PLASTIC CLAY SOUSE MATRIX WITH AGGREGATE OF RANDOMLY ORIENTED SILTSTONE AND SHALE FRAGMENTS.
  - FAULT SCOUR STRINGER. 40-60 FT. THICK. ARROWS INDICATE DIRECTION OF RELATIVE MOVEMENT.
  - JOINT/FRACTURE PATTERN.
  - SILTSTONE.
  - SILTSTONE LAMINA, CARVED WHERE BEDDING PLANE CONTINUOUSLY MAPPED BUT SILTSTONE LITHOLOGY FINISHED OUT.
  - SHALE.
  - SHALE LAMINA, AS LABELED.
  - IRONSTONE CONCRETIONS.
  - MICRO-CRACK SAMPLE LOCATION. NUMBER GIVEN.

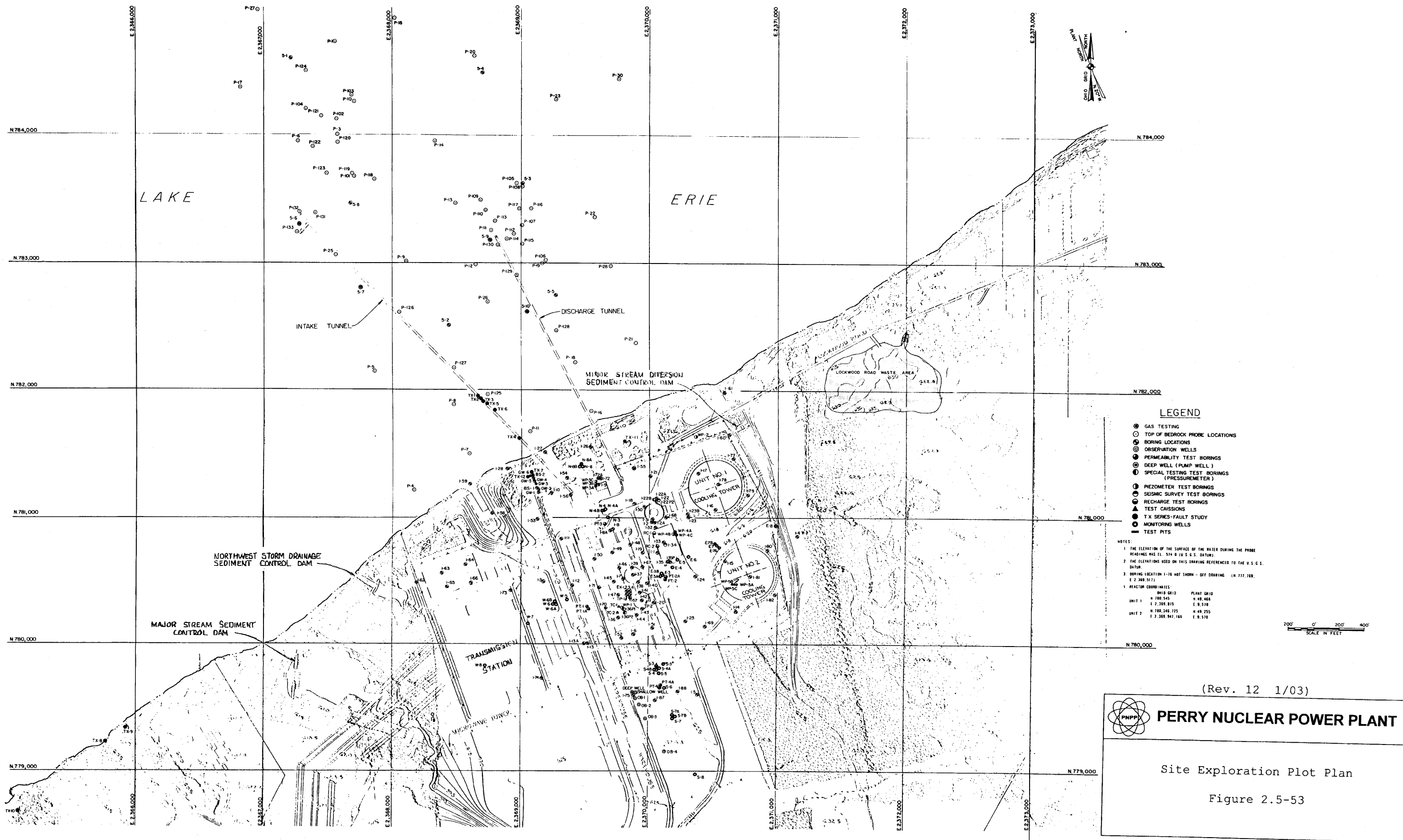
(Rev. 12-1/83)



**PERRY NUCLEAR POWER PLANT**




Discharge Tunnel Fracture Zone Map

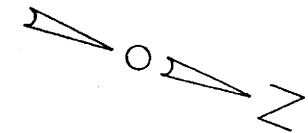
Figure 2.5-52



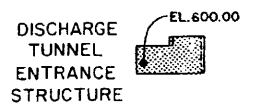
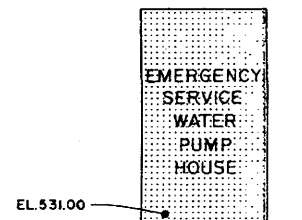
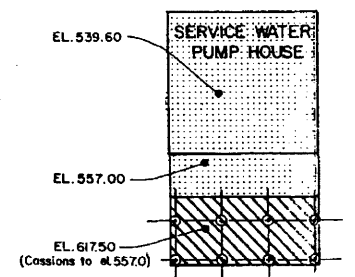
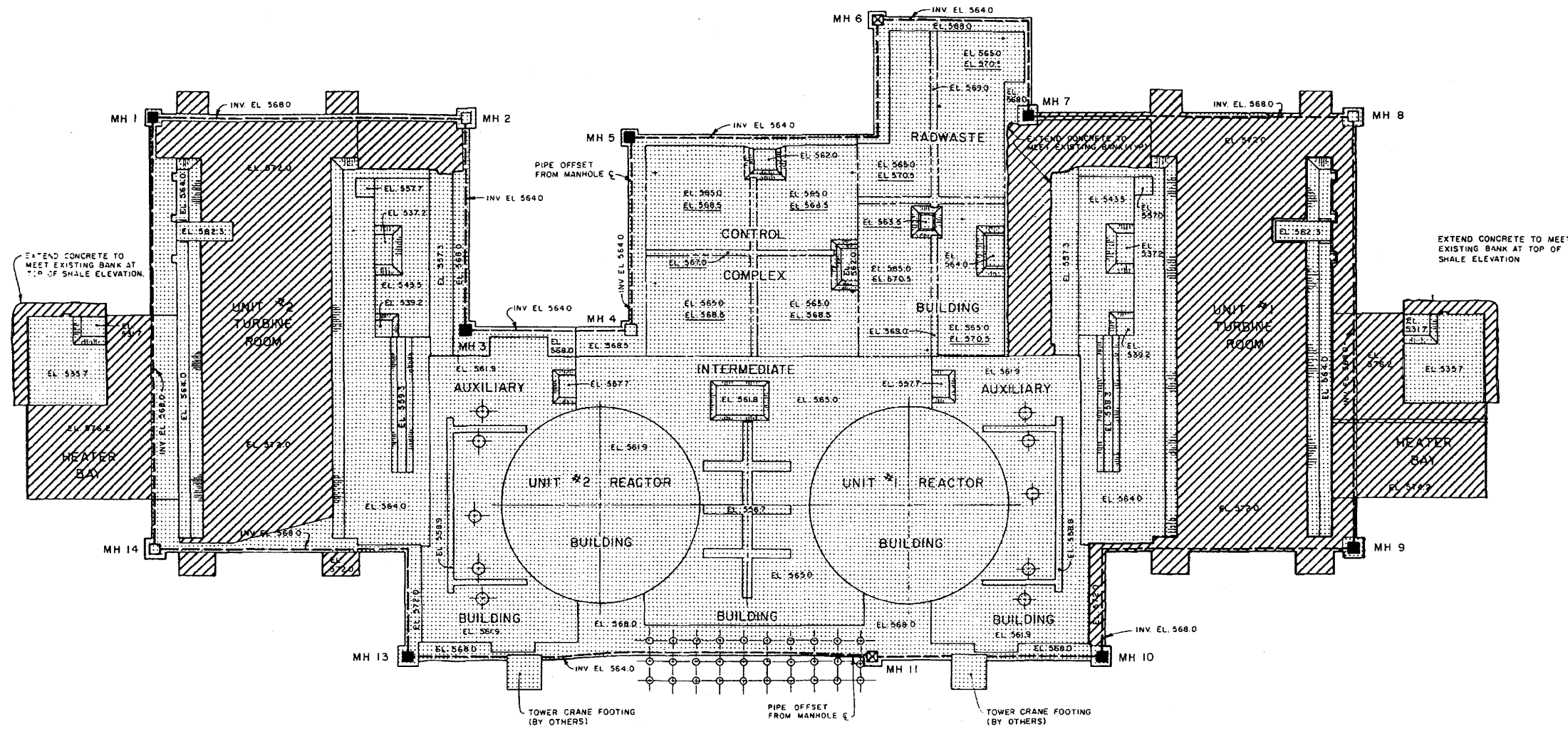


# LEGEND

-  SHALE
-  LOWER TILL
-  UPPER TILL / LACUSTRINE




40 0 40 80  
SCALE IN FEET



NOTE:  
EACH COOLING TOWER RESTS ON  
498 PILES. THE PILES ARE SEATED  
IN SHALE.

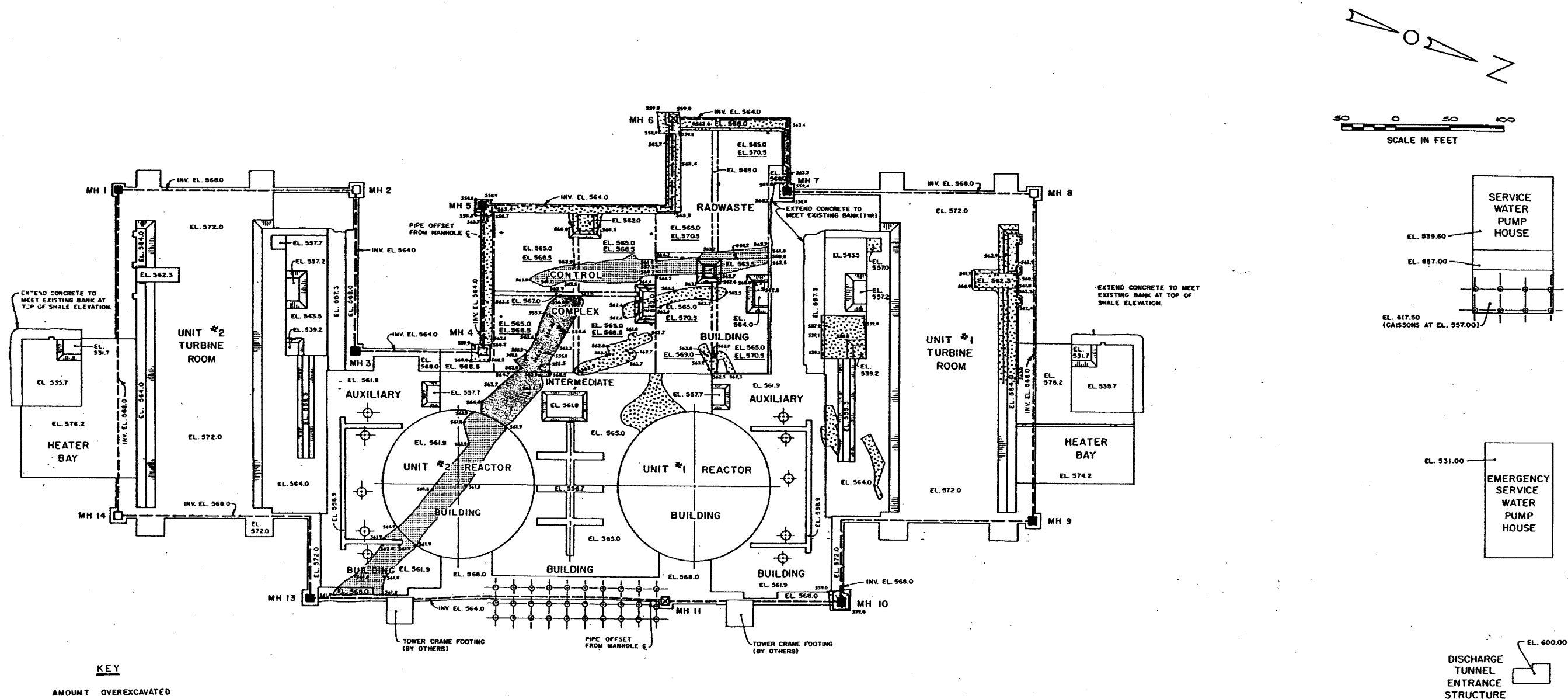
(Rev. 12 1/03)



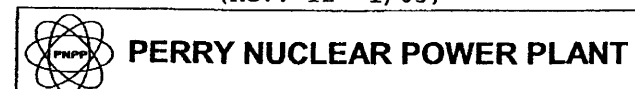
**PERRY NUCLEAR POWER PLANT**

Plant Structures Foundation  
Grade Materials

Figure 2.5-54



(Rev. 12 1/03)

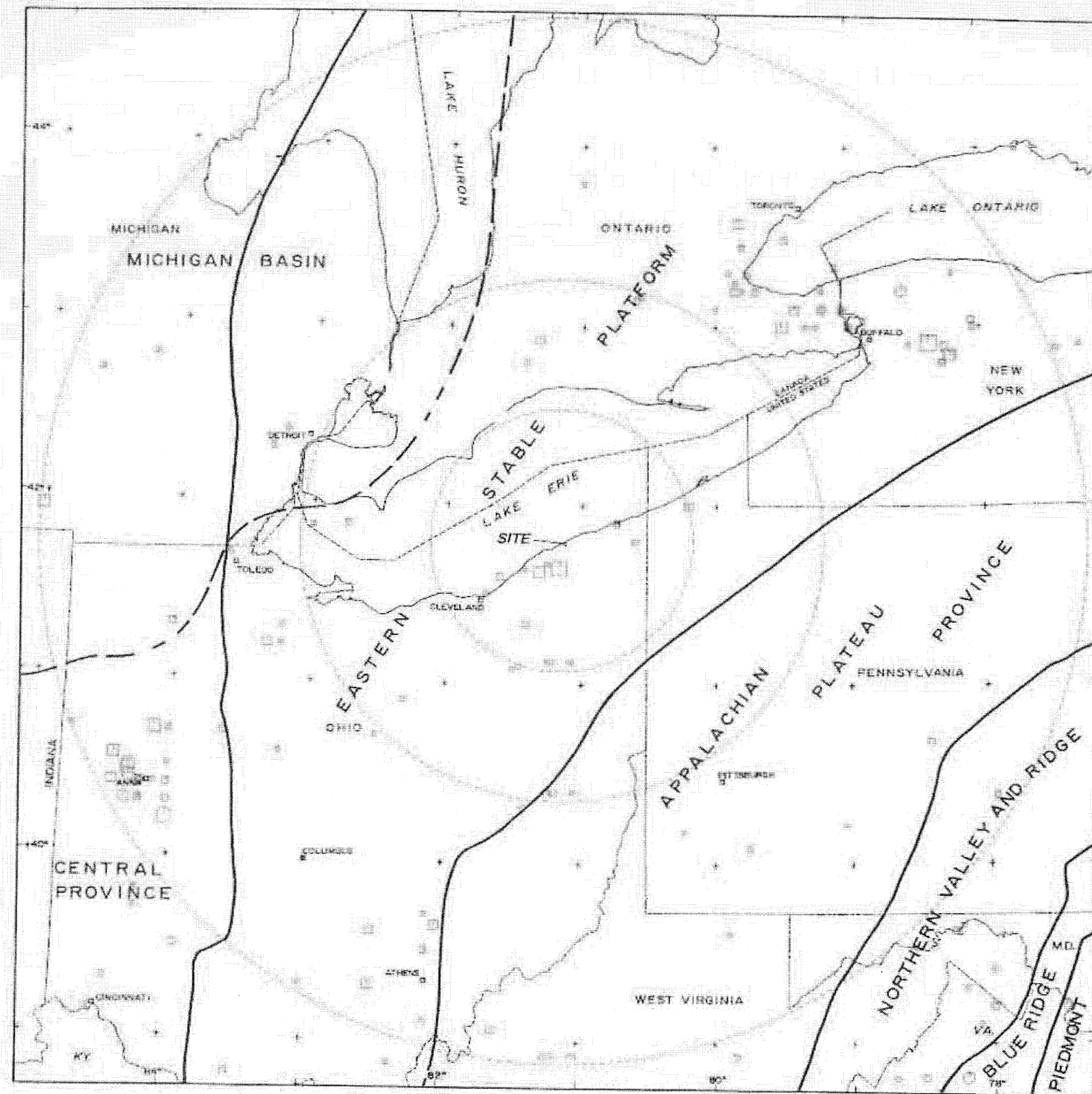


**PERRY NUCLEAR POWER PLANT**

Foundation Overexcavation  
Plan

Figure 2.5-55





#### REGIONAL TECTONIC PROVINCES

- Province Boundary
- Michigan Basin Tectonic Province Boundary constructed from Midland ASLB LBP-85-2 (72, 271)

#### EARTHQUAKES

TIME WINDOW BEGINNING JULY 1986, ENDING DEPT. 1991

MAGNITUDE		INTENSITY	
2	3	I	III
3	4	II	IV
4	5	III	V
5	6	IV	VI
6	7	V	VII
7	8	VI	VIII

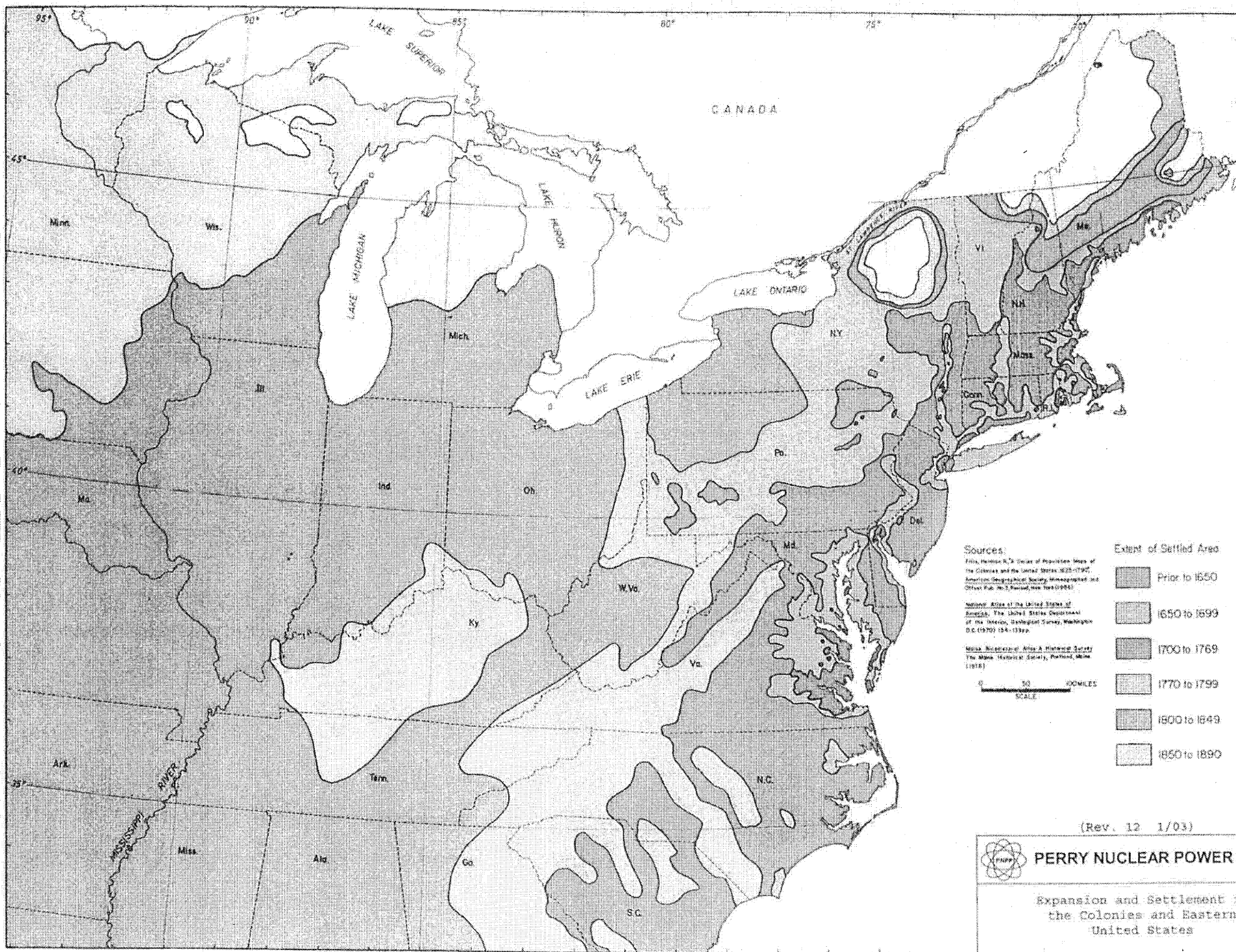
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Tectonic Provinces and Earthquakes

Figure 2.3-56



#### Sources:

Fries, Herman R. A Series of Population Maps of the Colonies and the United States 1625-1790. American Geographical Society, Holographed and Offset Pub. No. 5, New York (1905).

National Atlas of the United States of America. The United States Department of the Interior, Geological Survey, Washington D.C. (1970) 124-139p.

Wells, Nicholas. Atlas of Historical Survey. The Johns Hopkins University, Baltimore, Md. (1918).

0 50 100 MILES  
SCALE

#### Extent of Settled Area

- Prior to 1650
- 1650 to 1699
- 1700 to 1769
- 1770 to 1799
- 1800 to 1849
- 1850 to 1890

(Rev. 12 1/03)

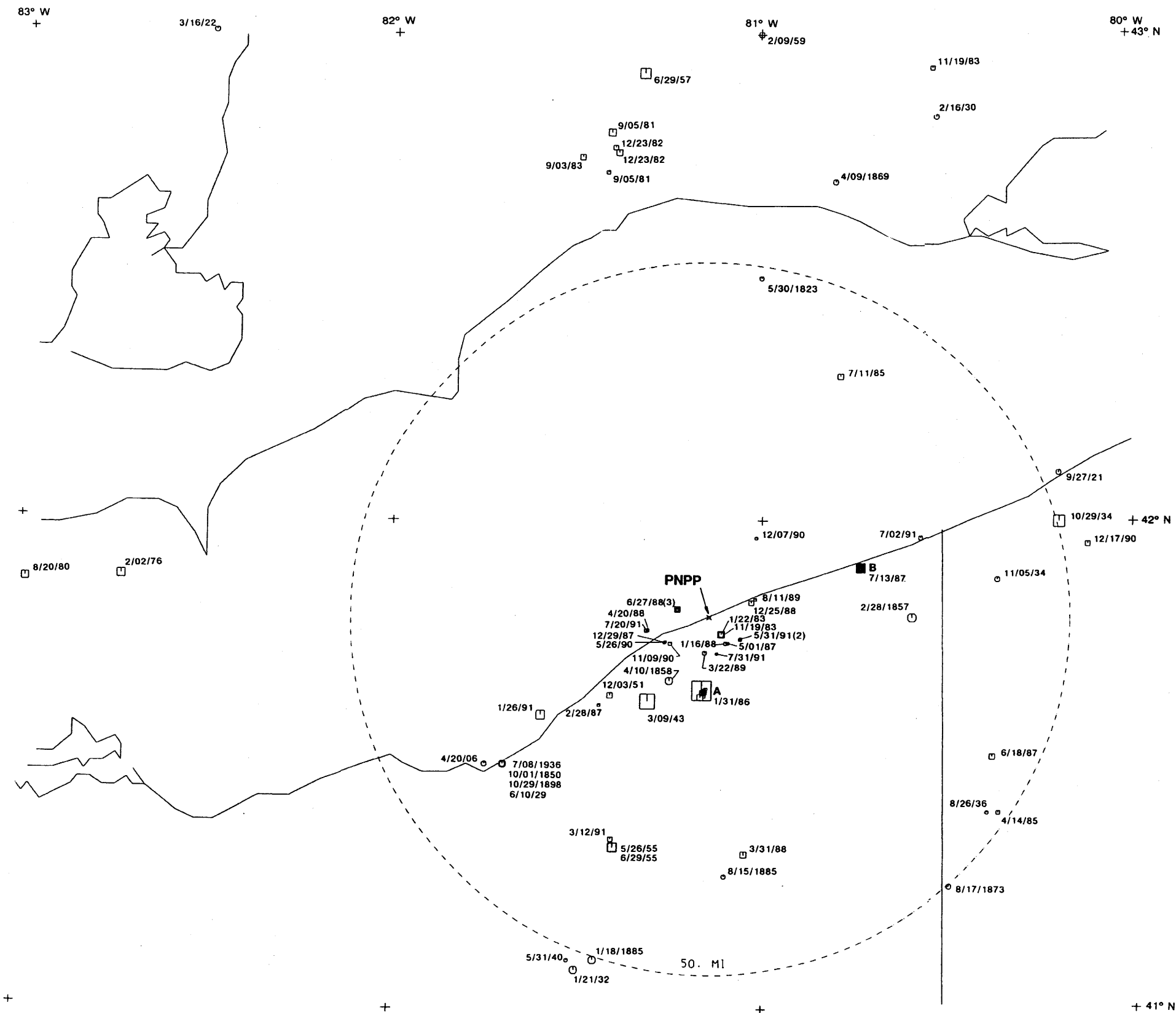


**PERRY NUCLEAR POWER PLANT**

Expansion and Settlement in  
the Colonies and Eastern  
United States

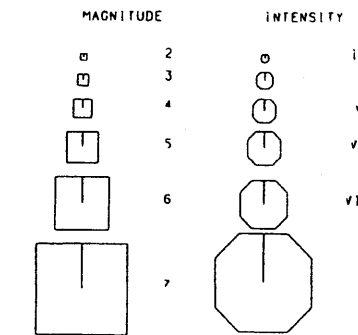
Figure 2.5-87





# LEGEND

MAGNITUDE RANGES FROM 1.0 TO 10.0  
INTENSITY RANGES FROM I TO XII  
TIME WINDOW BEGINS 1500 ENDS 2000



## A

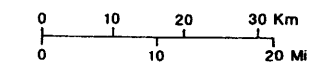
1/31/86  
2/01/86  
2/03/86  
2/06/86  
2/07/86  
3/24/86  
2/12/87  
12/28/88  
9/01/90

## B

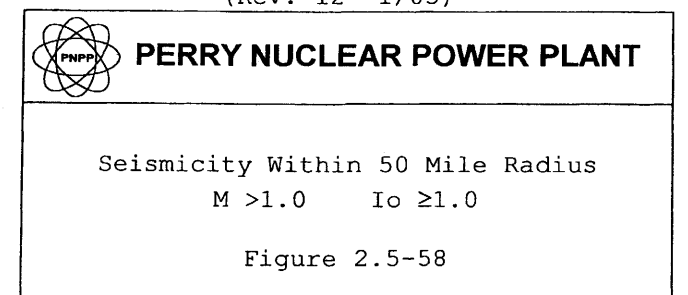
7/13/87 (12)  
7/14/87 (2)  
7/16/87 (5)  
8/13/87  
12/19/87  
12/25/87  
8/01/89 (5)  
8/02/89 (4)  
8/03/89  
8/04/89  
1/01/90  
7/13/90  
7/24/90  
9/25/90  
9/26/90 (4)  
11/18/90  
5/02/91

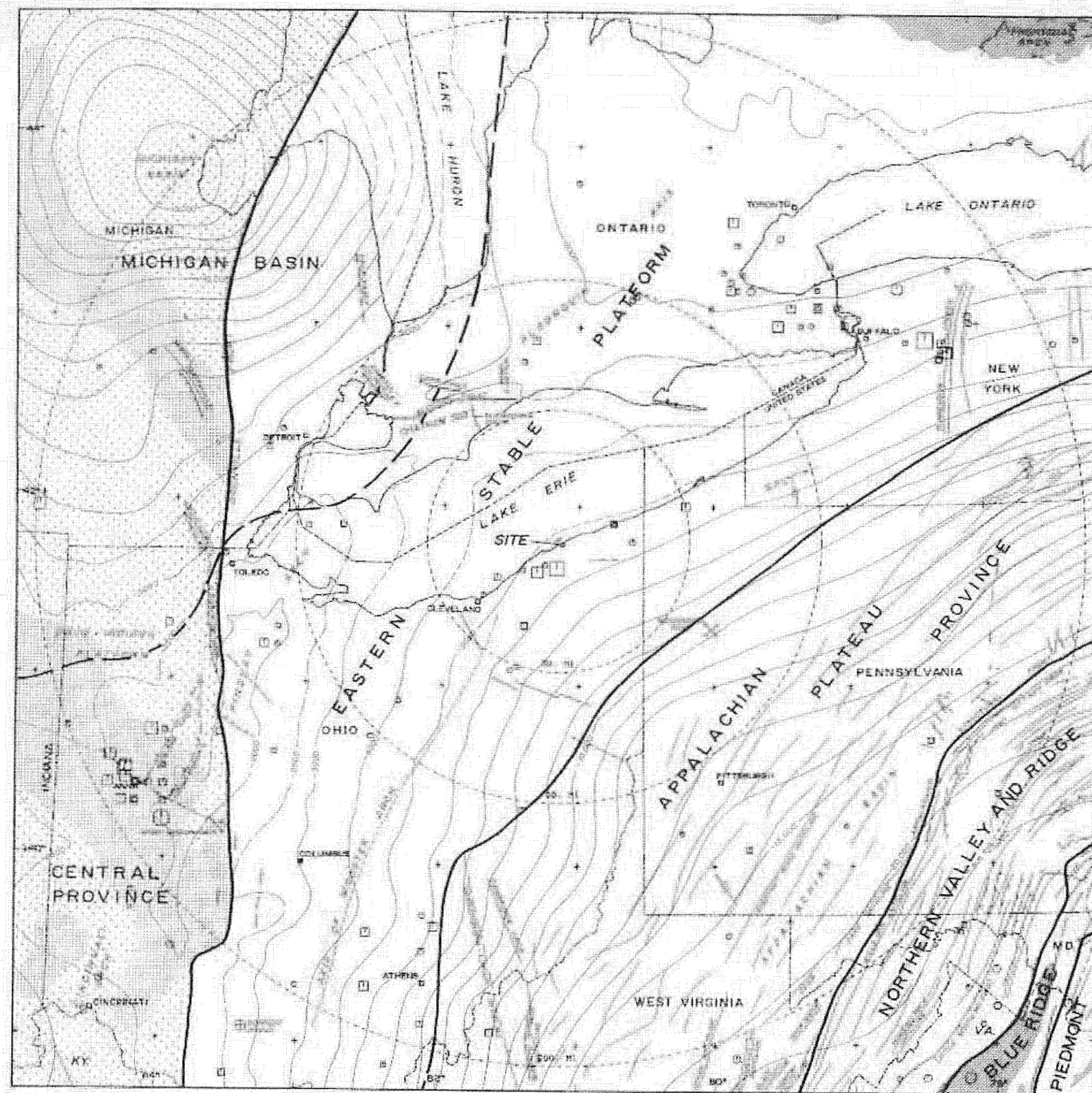
For further details on aftershock  
sequence, see Figure 2.5-67  
and Table 2.5-18.

This earthquake sequence of more  
than 60 tremors is probably induced.  
(Armbruster et al., 1987)



(Rev. 12 1/03)





#### REGIONAL TECTONIC ELEMENTS

- Great Lakes Basin - light gray shaded area (Stable, Expanded, Non-patterned Basin)
- Appalachian Basin - dark gray shaded area (Stable, Expanded, Non-patterned Basin)
- Eastern Basin - light gray shaded area (Stable, Expanded, Non-patterned Basin)

Structure contours in feet from surface of present-day basement surface

Thrust fault - north on upper plate

Normal fault - north on downthrown side

High angle fault

Anticline axis

Intensely deformed "Synclinal" structure

Structure contours in feet from surface of present-day basement surface



#### REGIONAL TECTONIC PROVINCES

- Province Boundary
- Michigan Basin Tectonic Province Boundary constructed from Midland ASLB LBP-85-2 (72, 271)

#### EARTHQUAKES

TIME WINDOW BEGINS DEC. 1796,  
ENDS SEPT. 1991

MAGNITUDE	INTENSITY
2	III
3	V
4	VI
5	VII
6	VIII

(Rev. 12 1/83)

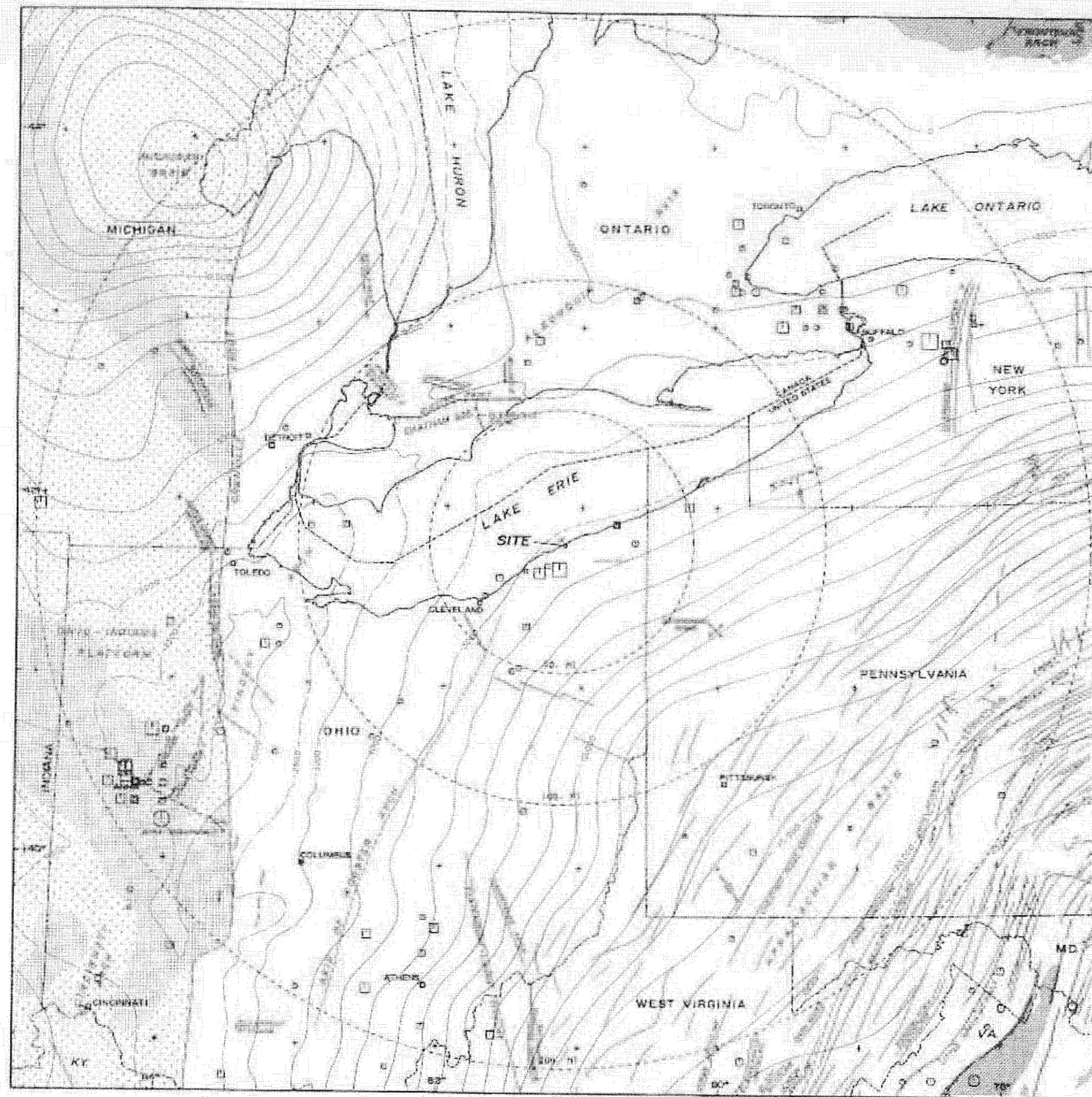


**PERRY NUCLEAR POWER PLANT**

Regional Tectonics  
Earthquake Tectonic Provinces

Figure 2.5-39





#### REGIONAL TECTONIC ELEMENTS

- Grenville Basement - Ages around 550 million years (Stippled, horizontal, horizontal, horizontal)
- Mesozoic Basement - Ages around 100 million years
- Algonquin Basement - Ages around 450 million years
- Structure introduced in last phase of the top of Precambrian basement surface
- Thrust fault - north on upper plate
- Normal fault - north on downthrown side
- High angle fault
- Basal shear zone
- Weakly deformed "Cretaceous" strata

SPRING 1991: GEORGE L. BROWN, JR. & RICHARD L. BROWN, JR.  
 WITH STYLING BY L. J. BROWN, JR.



#### EARTHQUAKES

TIME WINDOW BEGINS DEC. 1796,  
 ENDS SEPT. 1991

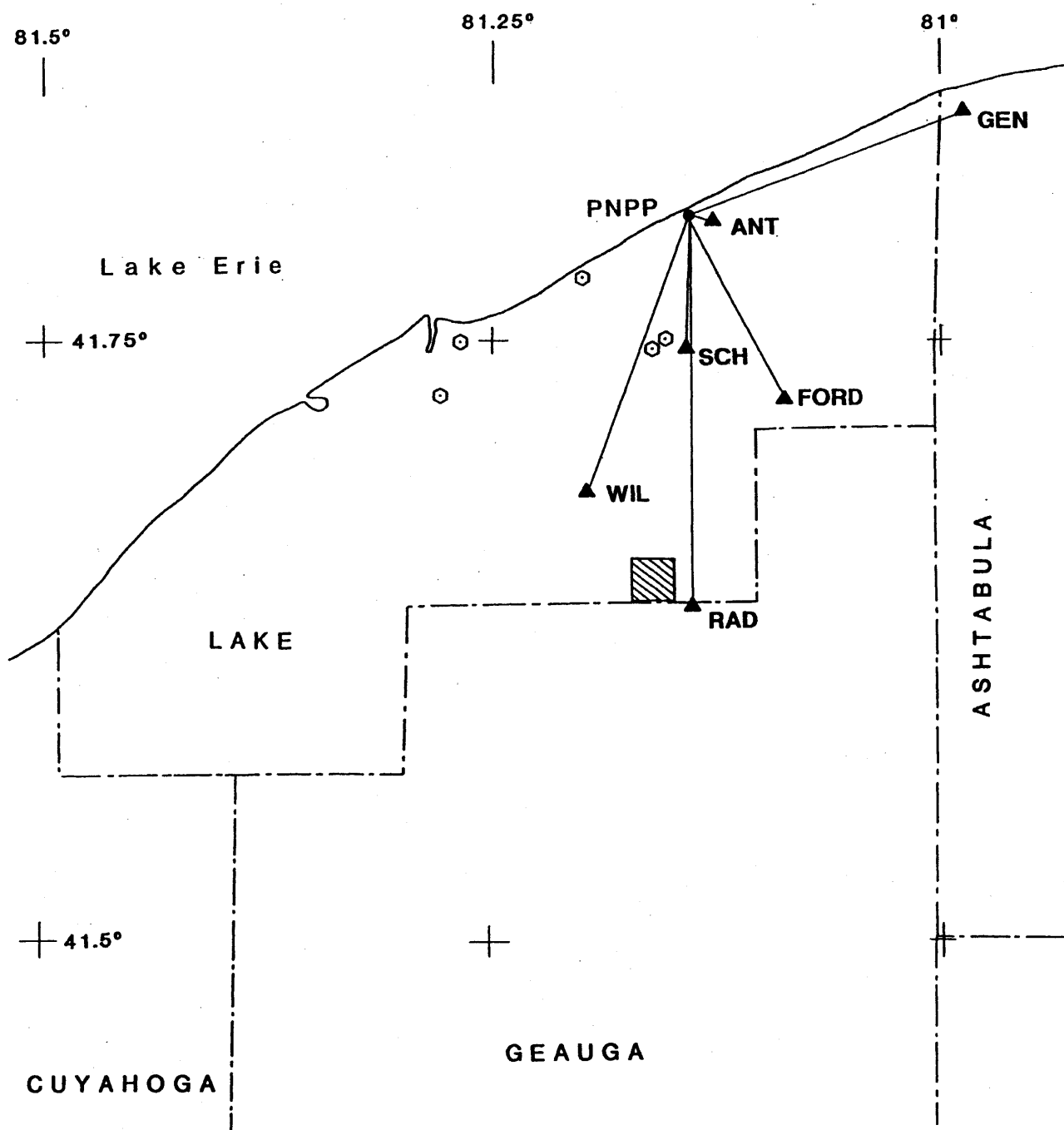
MAGNITUDE	INTENSITY
2	III
3	V
4	VI
5	VII
6	VIII

(Rev. 12 1/63)

**PERRY NUCLEAR POWER PLANT**

Regional Tectonics and  
 Earthquakes

Figure 2.3-60

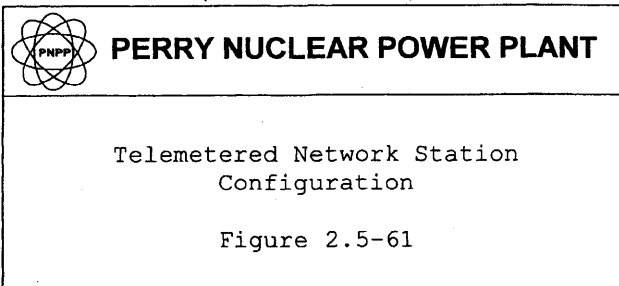


(Rev. 12 1/03)

- ▲ Station
- Injection Well
- ▨ Epicenter of Mainshock January 31, 1986

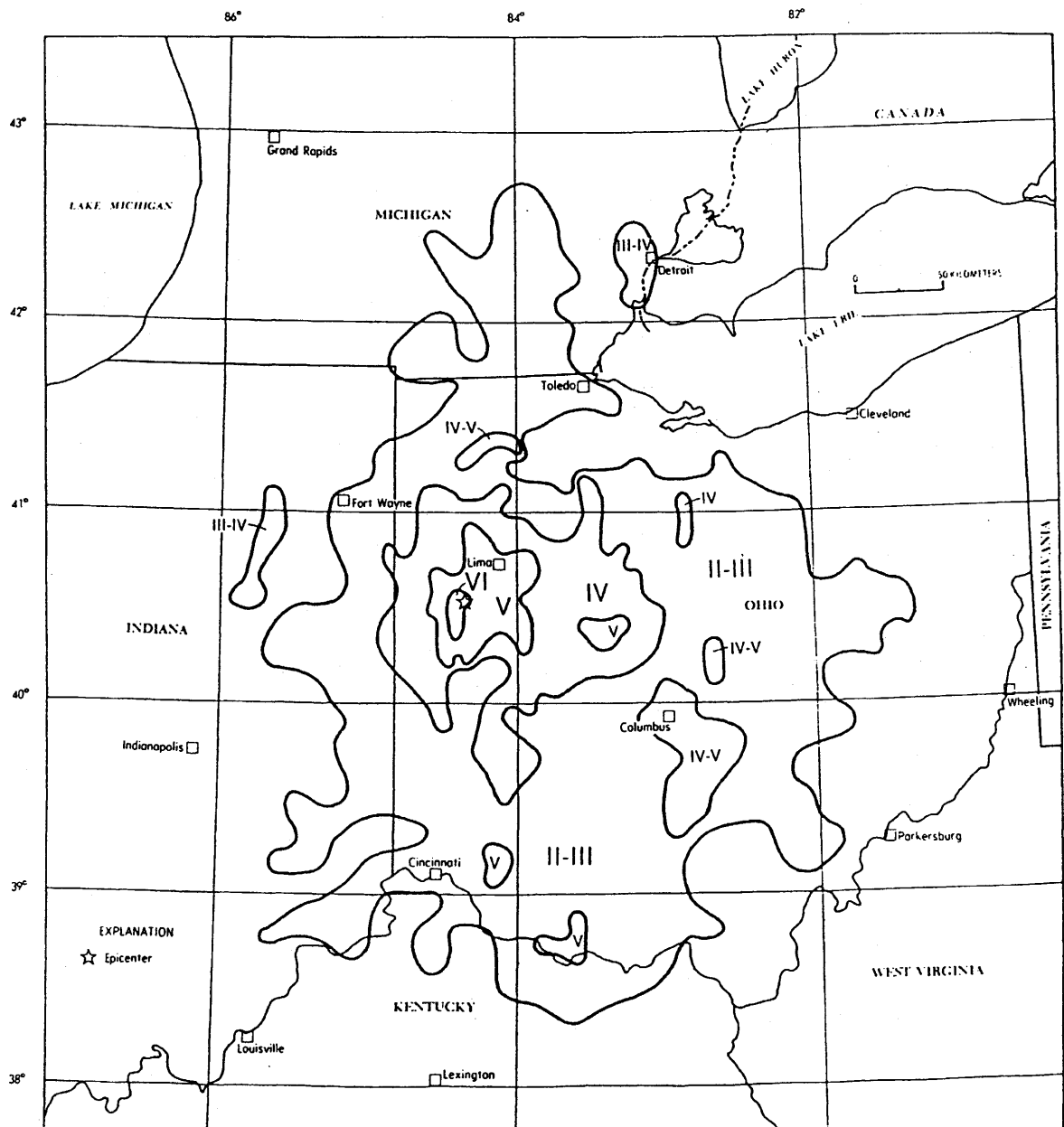
0 5 Miles

0 5 Km









Source: C. W. Stover, U.S.G.S. in (2)

(Rev. 12 1/03)

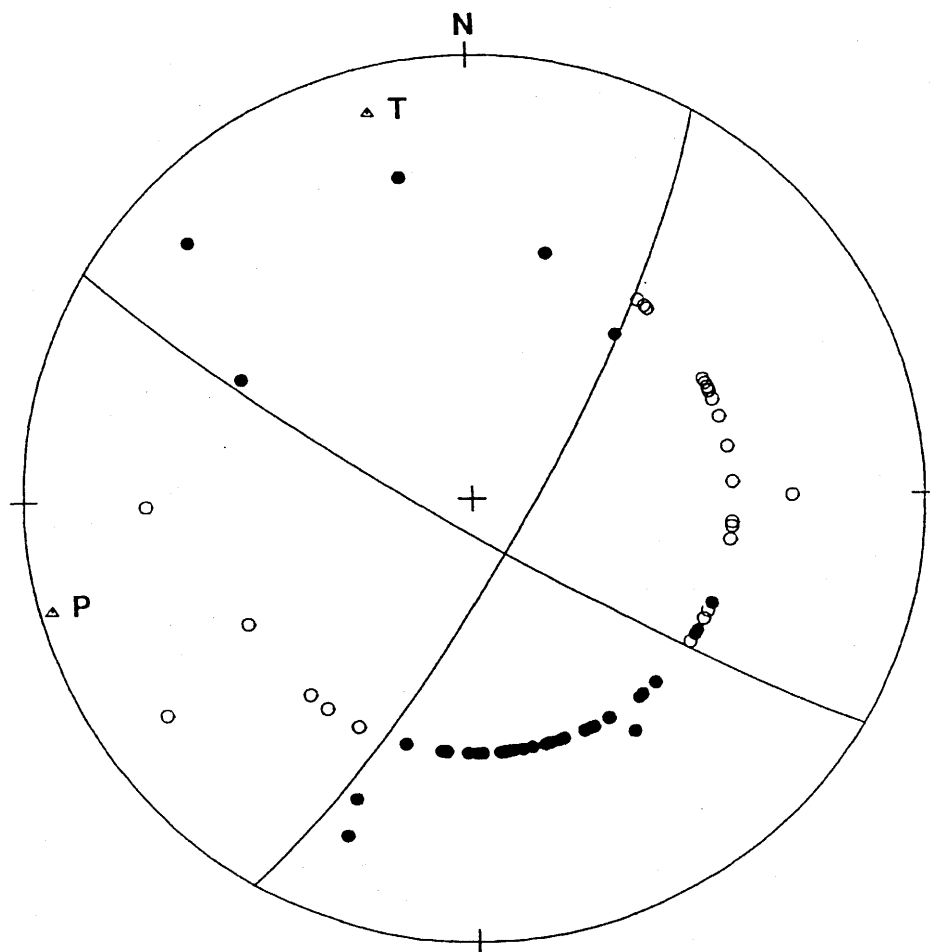


## PERRY NUCLEAR POWER PLANT

Isoseismal Map of the  
July 12, 1986  
St. Marys' Earthquake

Figure 2.5-63

ST MARYS EVENT  
7/12/86



Focal Mechanism for the July 12, 1986, St. Marys, Ohio Earthquake. Compressional arrivals are shown as solid symbols and tensional as open symbols. The P and T axes are also shown.

( Source: Christensen, et al., March 1987 ) (2)

(Rev. 12 1/03)

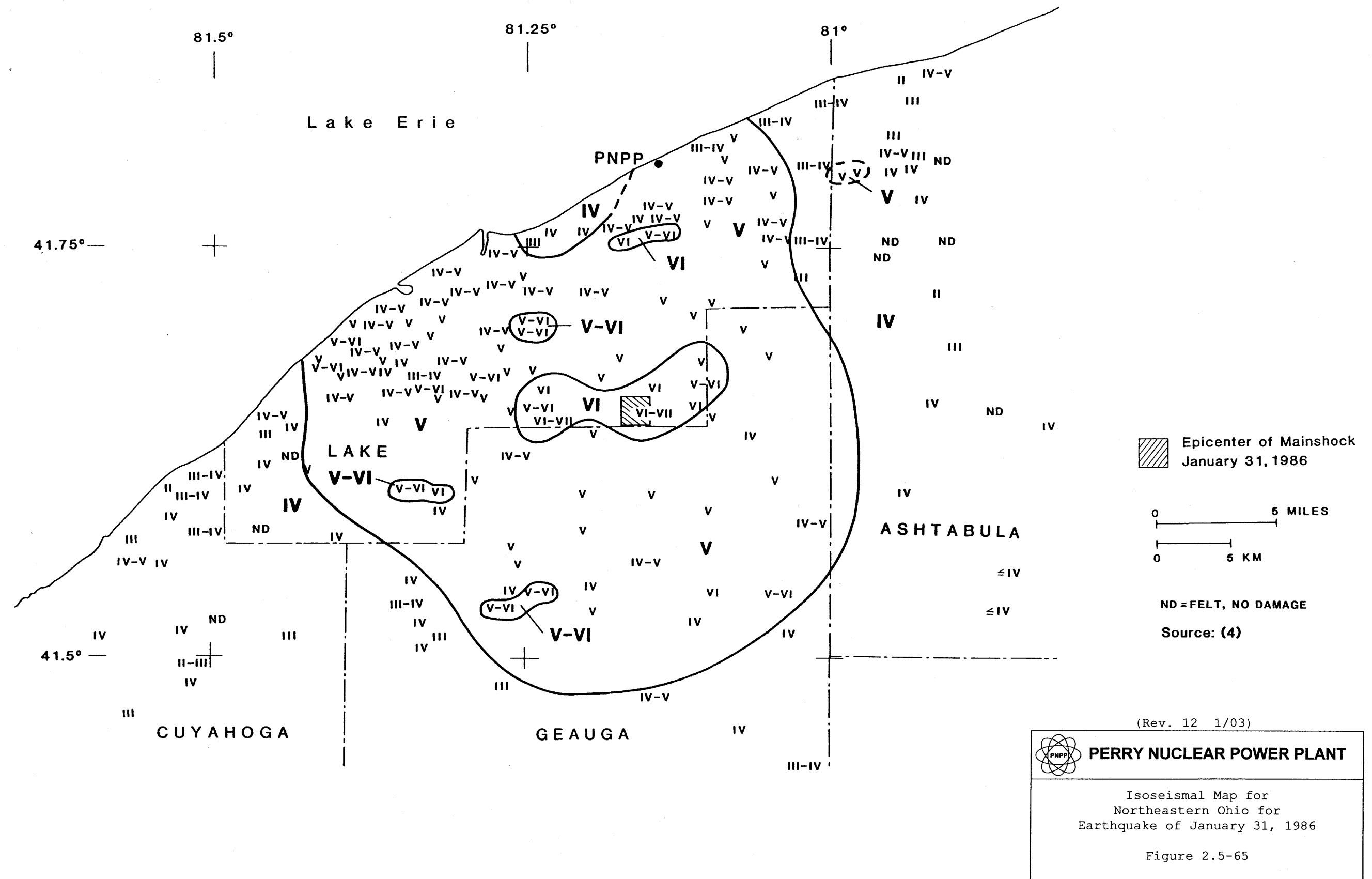


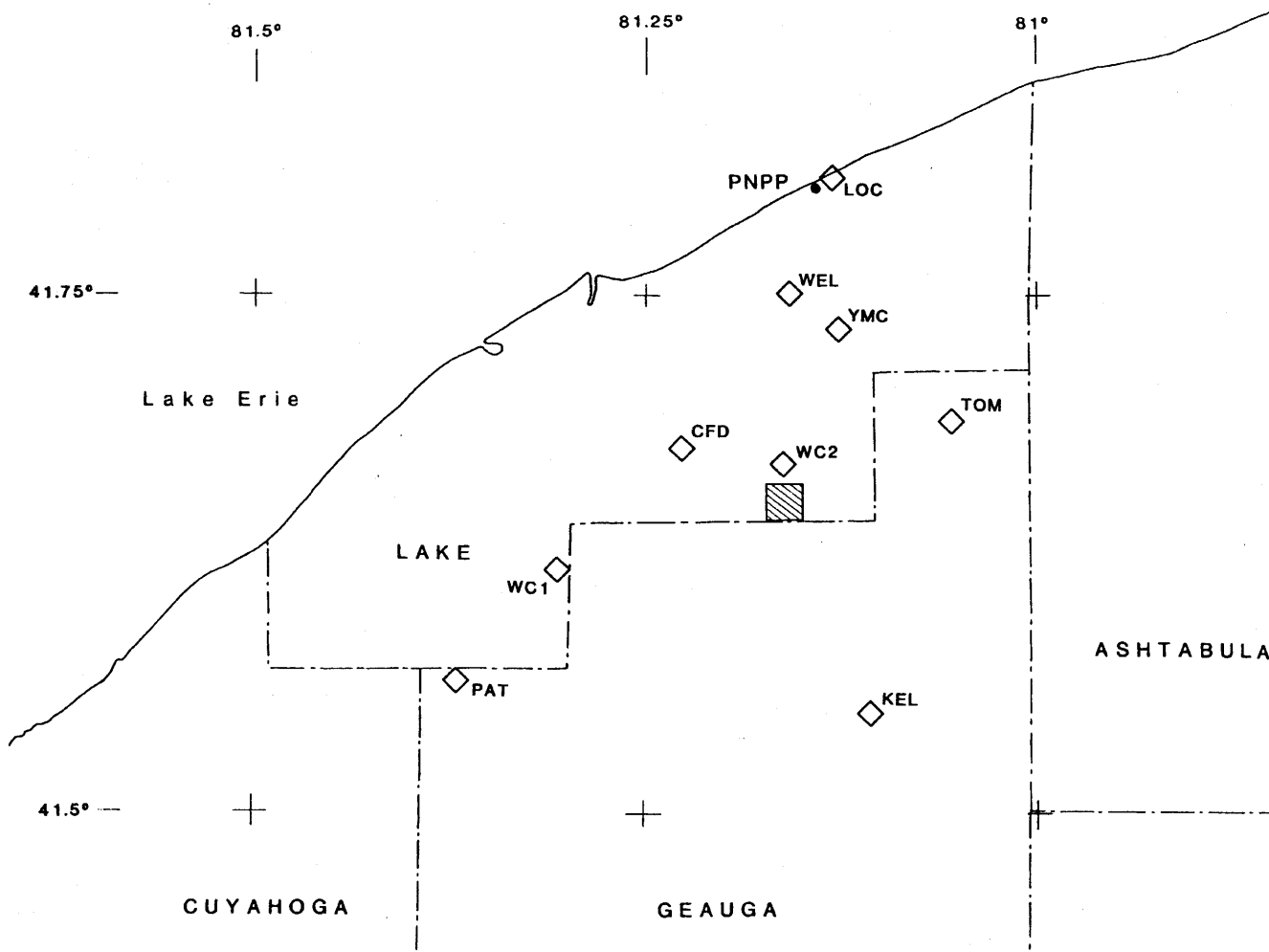
**PERRY NUCLEAR POWER PLANT**


Focal Mechanism for the  
July 12, 1986 Earthquake

Figure 2.5-64







 Epicenter of Mainshock  
January 31, 1986

0 ————— 5 MILES  
0 ————— 5 KM

(Rev. 12 1/03)



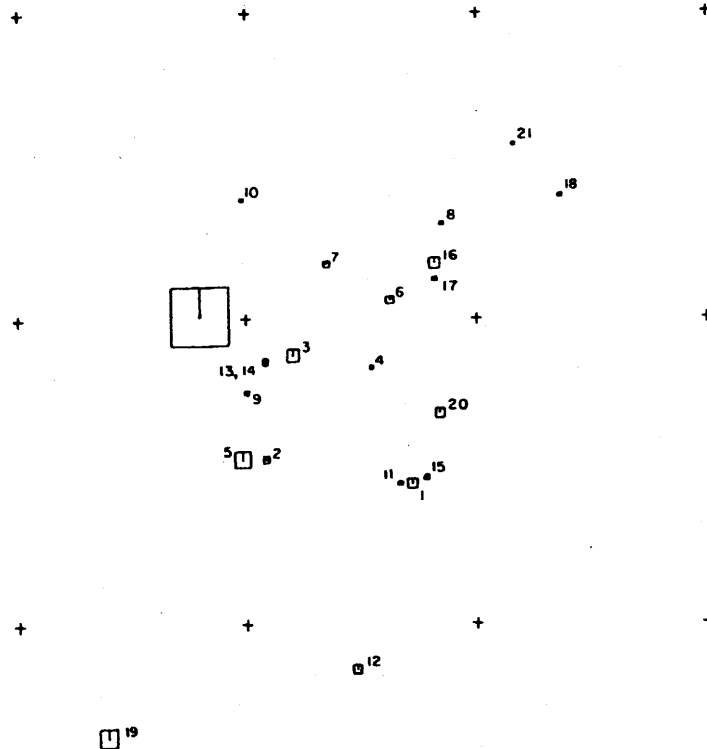
## PERRY NUCLEAR POWER PLANT

Typical Portable Network  
Configuration from  
March to October 1986

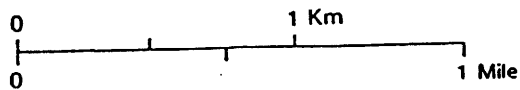
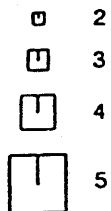
Figure 2.5-66

81.17W  
+

81.14W  
+ 41.67N



Magnitude



Note: See Table 2.5-18 for  
identification of events.

(Rev. 12 1/03)



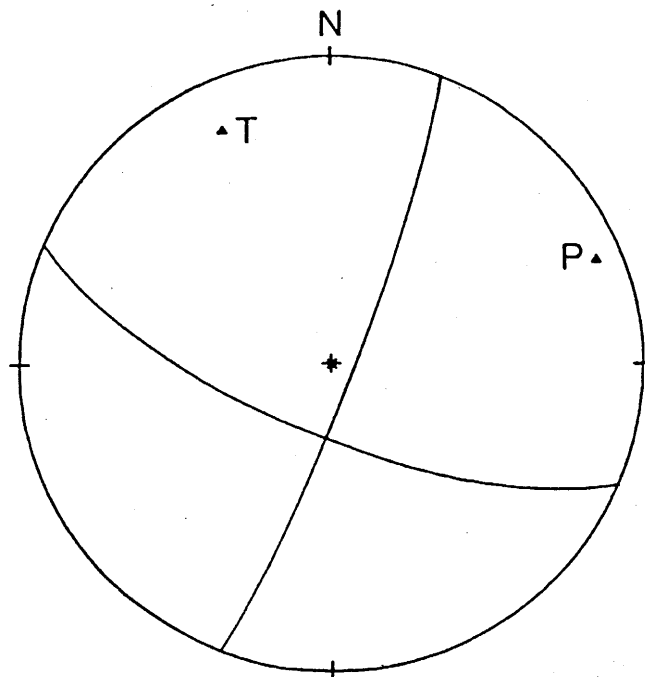
**PERRY NUCLEAR POWER PLANT**

January 31, 1986  
Aftershock Sequence

Figure 2.5-67



# PERRY EARTHQUAKE 01/31/86



Focal Mechanism for the January 31, 1986 Perry Earthquake Near Cleveland, Ohio (from the Harvard group as found in the PDE monthly listing). The compressional (P) and tensional (T) axes are shown.

( Source: Christensen, et al., March 1987 )(2)

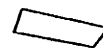
(Rev. 12 1/03)



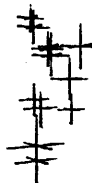
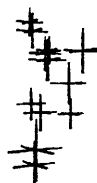
## PERRY NUCLEAR POWER PLANT

Focal Mechanism for the  
January 31, 1986 Earthquake

Figure 2.5-68



CENTER POINT COORDS = 41.646 -81.156  
CENTER POINT ELEV = -4.5 km  
VIEW POINT COORDS = 41.623 -81.070  
VIEW POINT ELEV = -4.5 km  
SURF. DISTANCE (km) = 8.  
AZIMUTH = 110.



CENTER POINT COORDS = 41.646 -81.156  
CENTER POINT ELEV = -4.5 km  
VIEW POINT COORDS = 41.590 -81.200  
VIEW POINT ELEV = -4.5 km  
SURF. DISTANCE (km) = 7.  
AZIMUTH = 211.

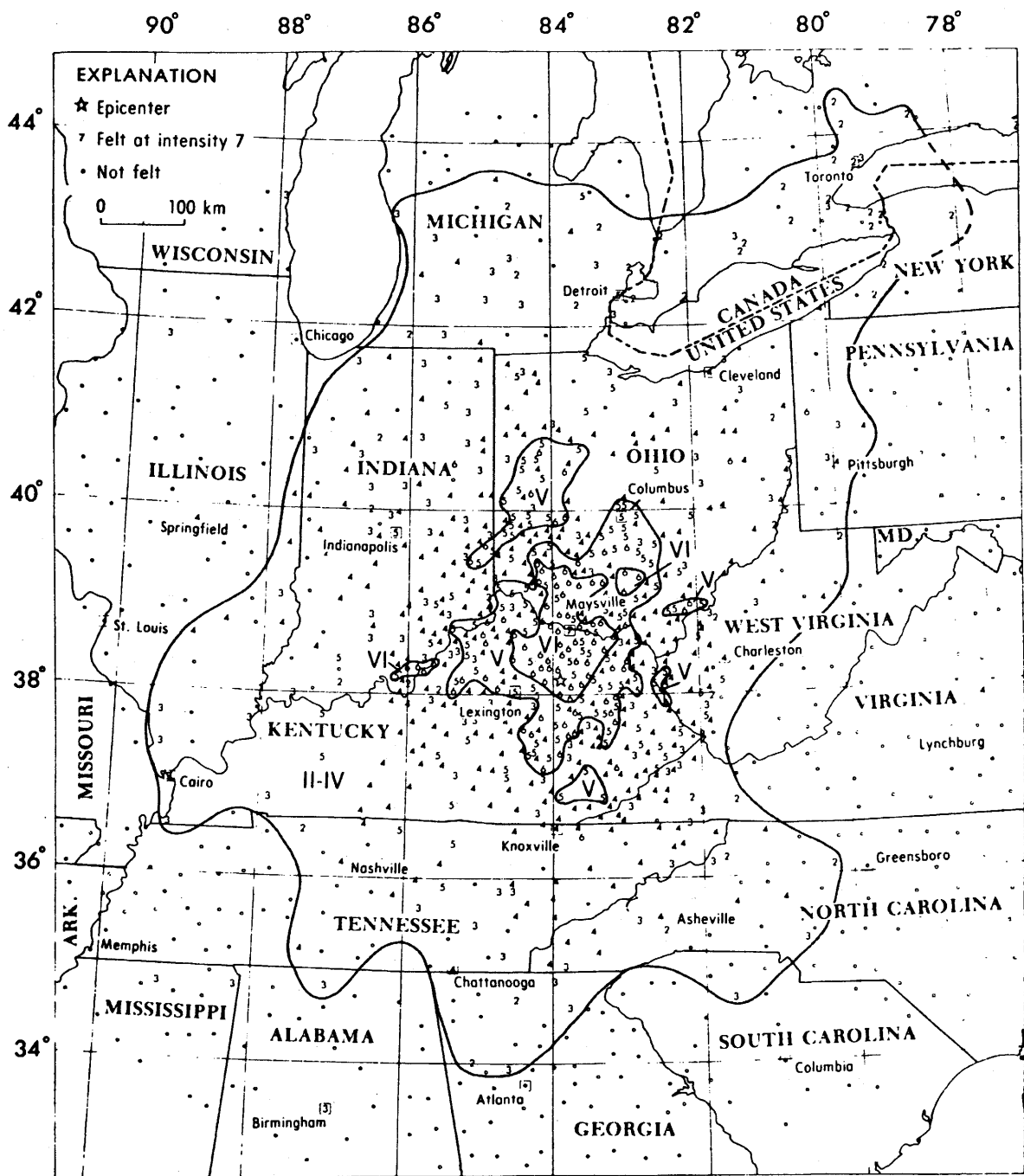
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Stereo View of the  
Aftershock Sequence

Figure 2.5-69



(Source: Stover and von Hake, 1982)(276)

(Rev. 12 1/03)

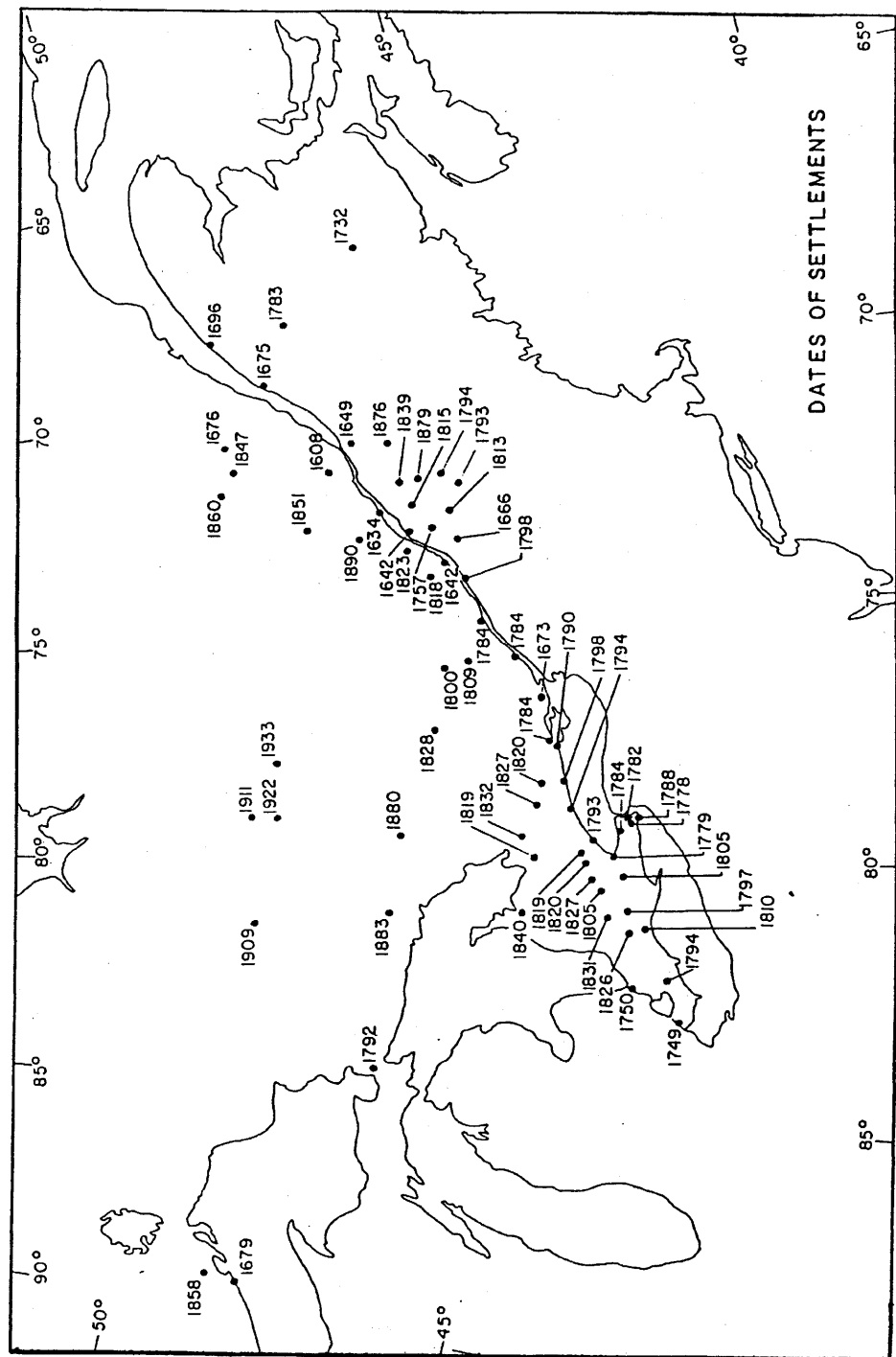


# **PERRY NUCLEAR POWER PLANT**

Isoseismal Map for the  
Sharpsburg, Kentucky Earthquake  
of July 27, 1980

Figure 2.5-70





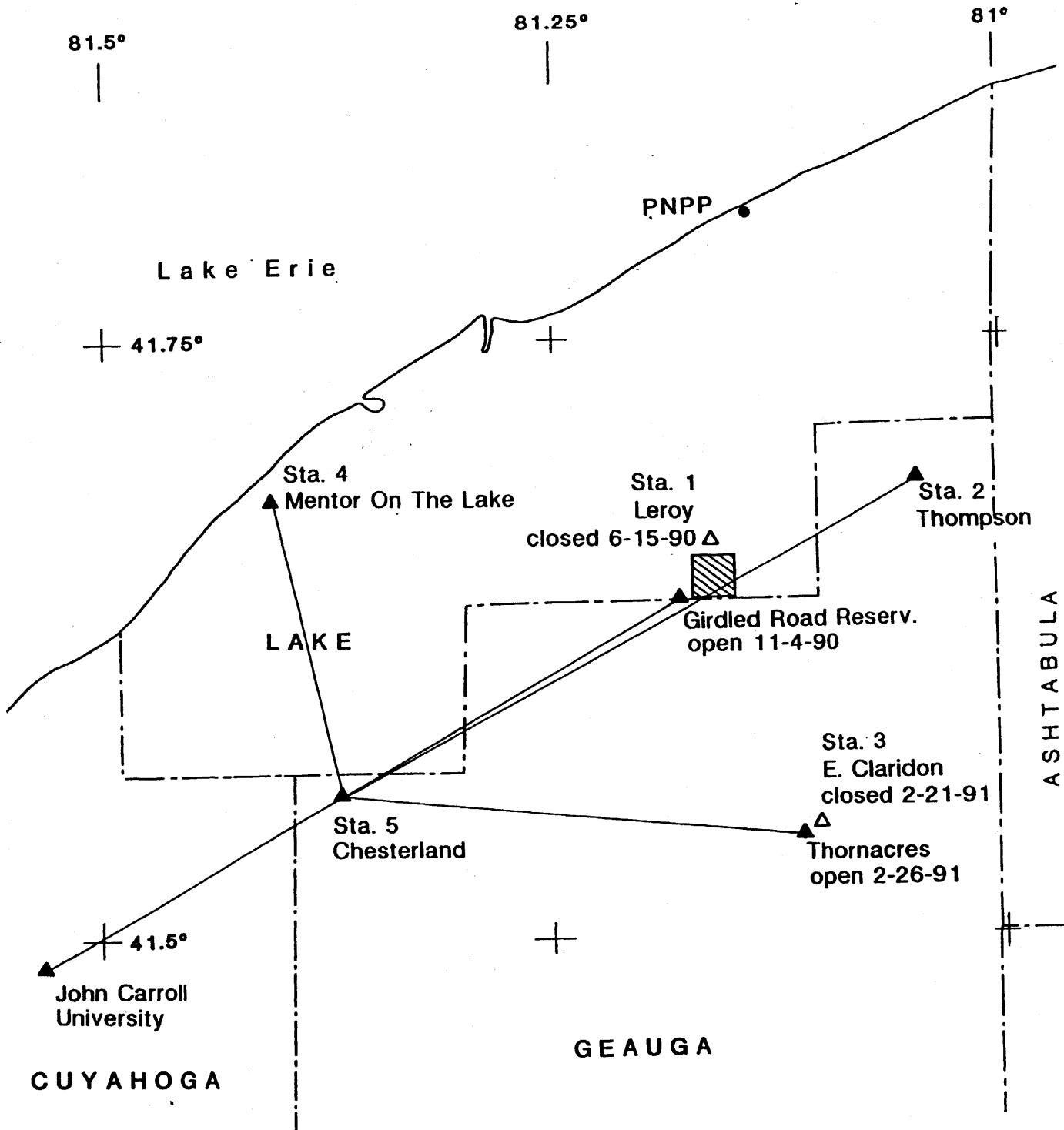
(Rev. 12 1/03)




## PERRY NUCLEAR POWER PLANT

Dates of Settlement in  
Eastern Canada

Figure 2.5-71

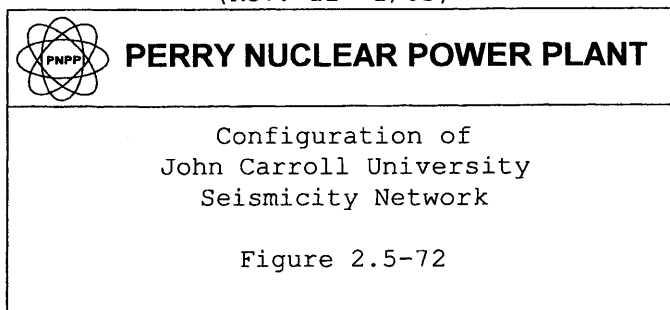


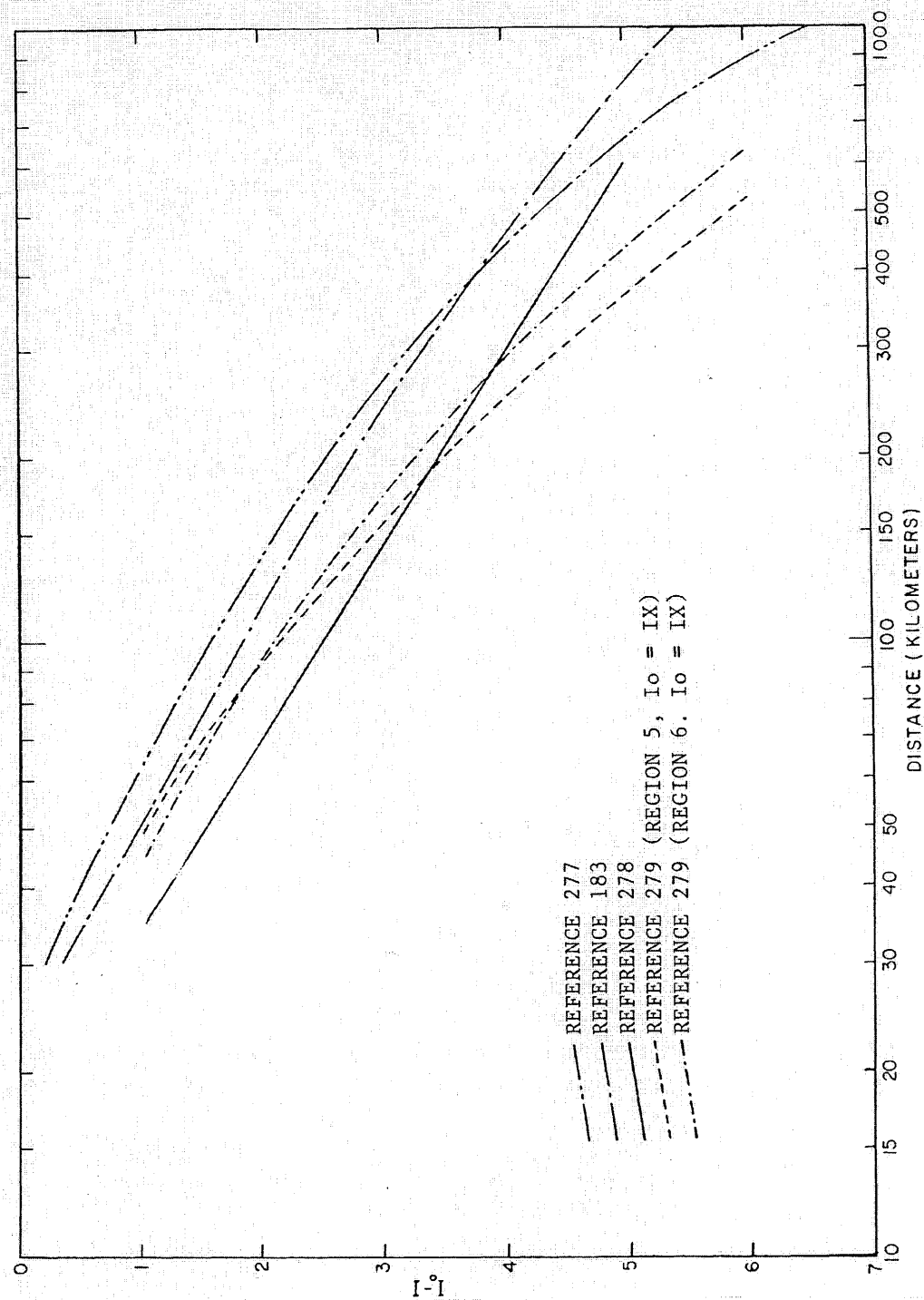
(Rev. 12 1/03)

 Epicenter of Mainshock  
January 31, 1986

0 5 Miles

0 5 Km





(Rev. 12 1/03)

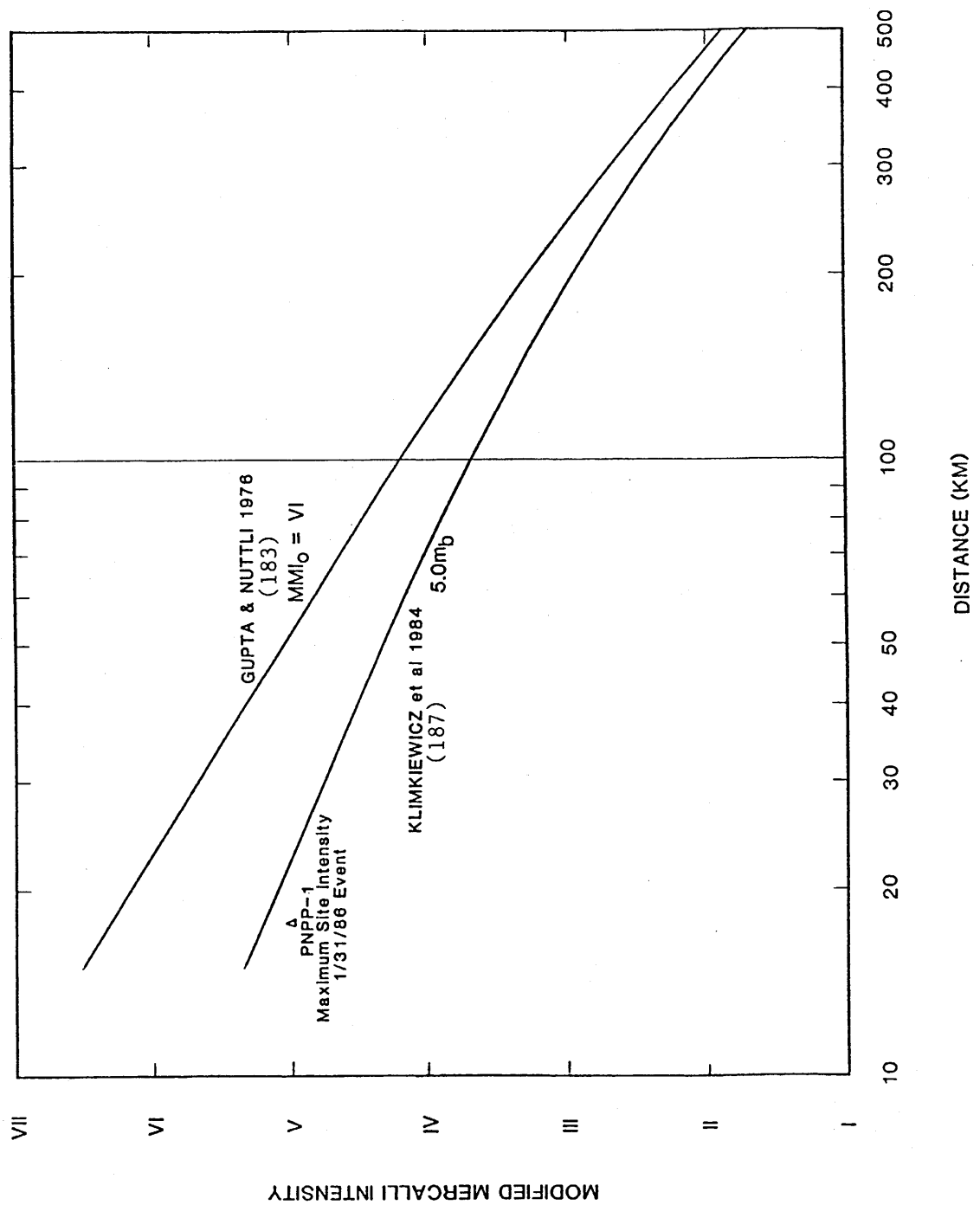


## PERRY NUCLEAR POWER PLANT

Intensity Attenuation Curves  
for Eastern North America

Figure 2.5-73





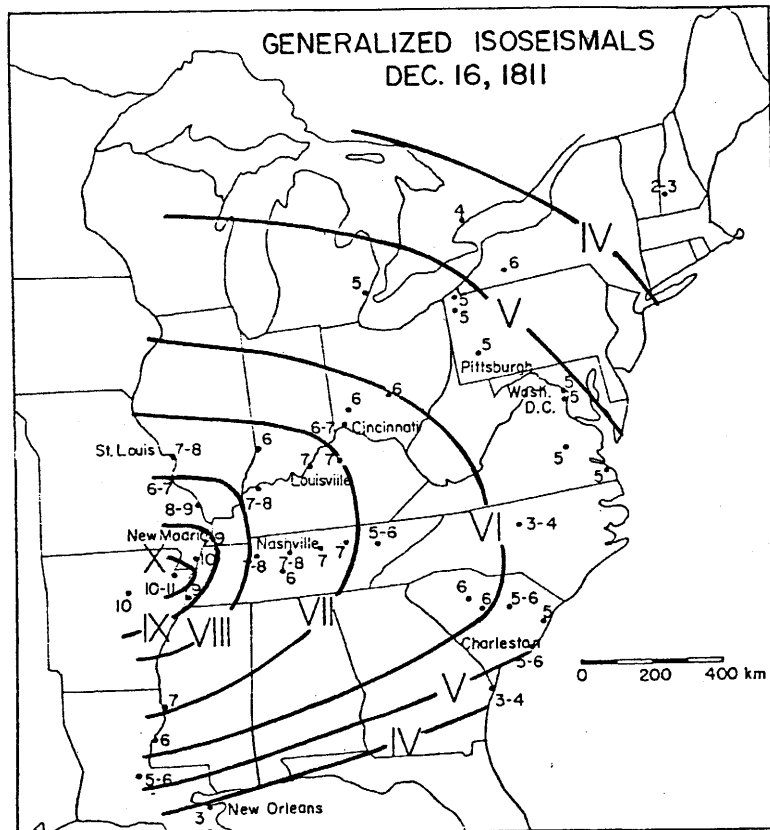
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Comparison of Attenuation  
Models Used to Estimate Site  
Intensities for Historical Events

Figure 2.5-74



Generalized isoseismal map of the earthquake of December 16, 1811 at 08<sup>h</sup>15<sup>m</sup> GMT. MM intensity values at individual points are given in Arabic numerals. The isoseisms, labeled with Roman numerals, indicate the outer bound of the region of specified intensity.

REFERENCE 280

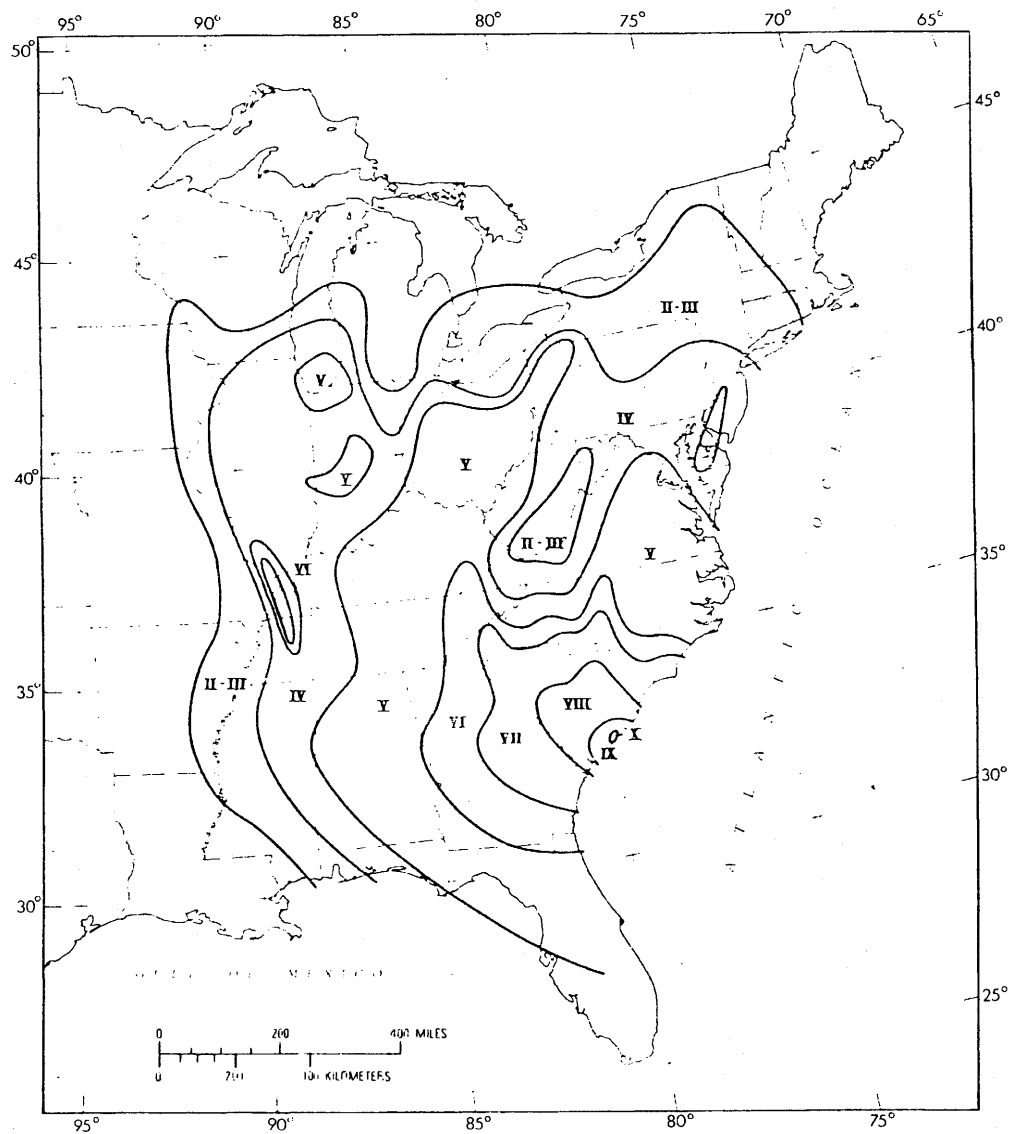
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Isoseismal Map - Mississippi  
Valley Earthquake of  
1811 and 1812

Figure 2.5-75



Isoseismal map of the Eastern United States contoured to show the broad regional patterns of the reported intensities for the 1886 Charleston earthquake. Contoured intensity levels are shown in Roman numerals.

REFERENCE 281

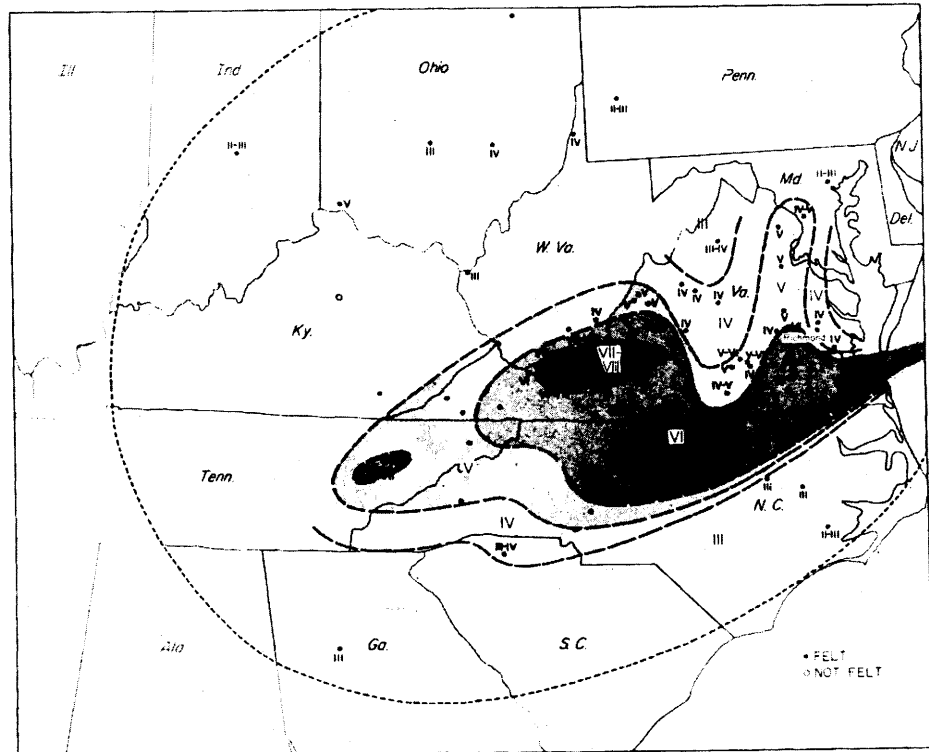
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Isoseismal Map - 1886  
Charleston Earthquake

Figure 2.5-76



Earthquake of May 31, 1897

REFERENCE 150

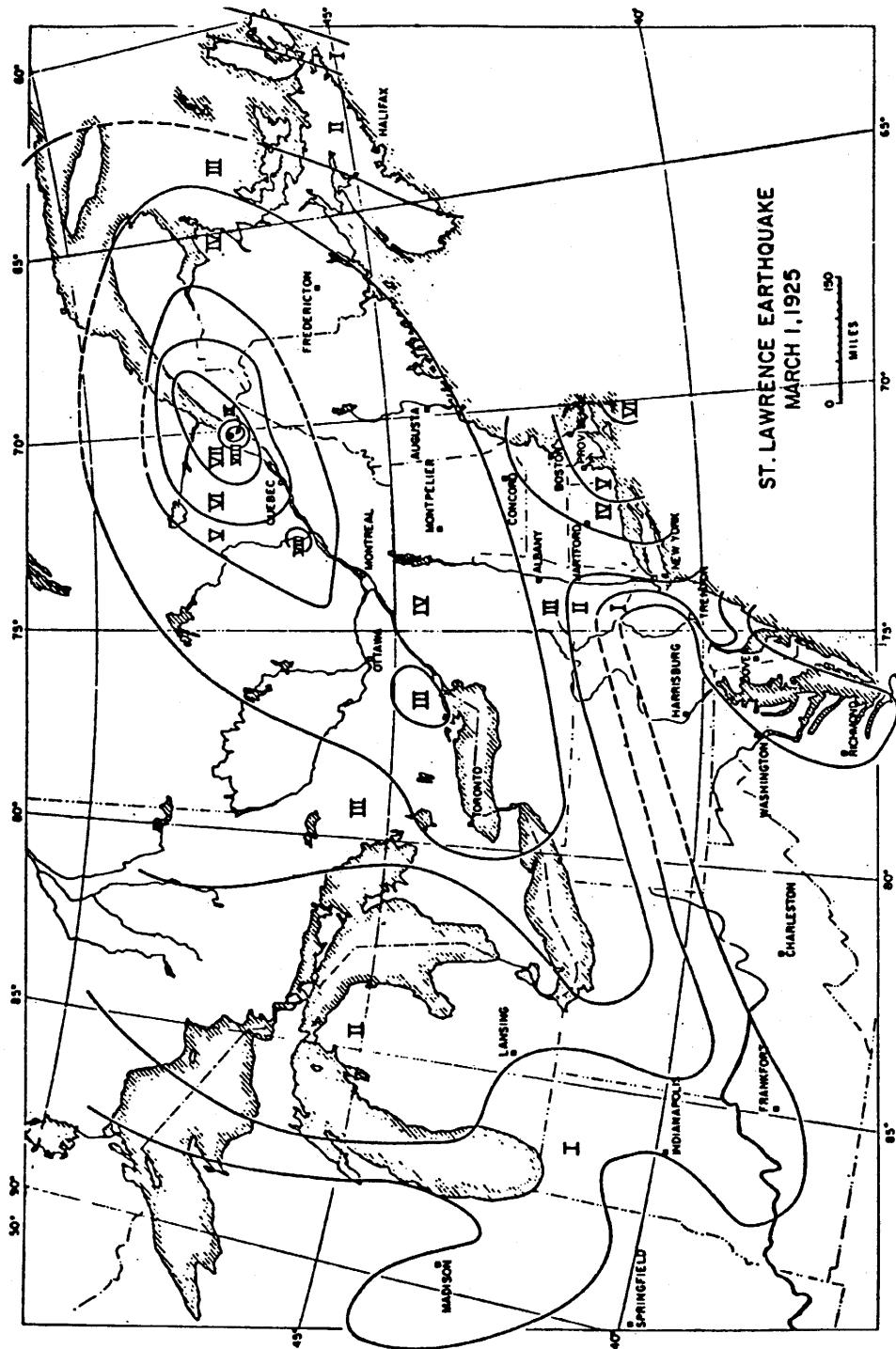
(Rev. 12 1/03)



# PERRY NUCLEAR POWER PLANT

Isoseismal Map - Virginia  
Earthquake of May 31, 1897

Figure 2.5-77



REFERENCE 282

(Rev. 12 1/03)

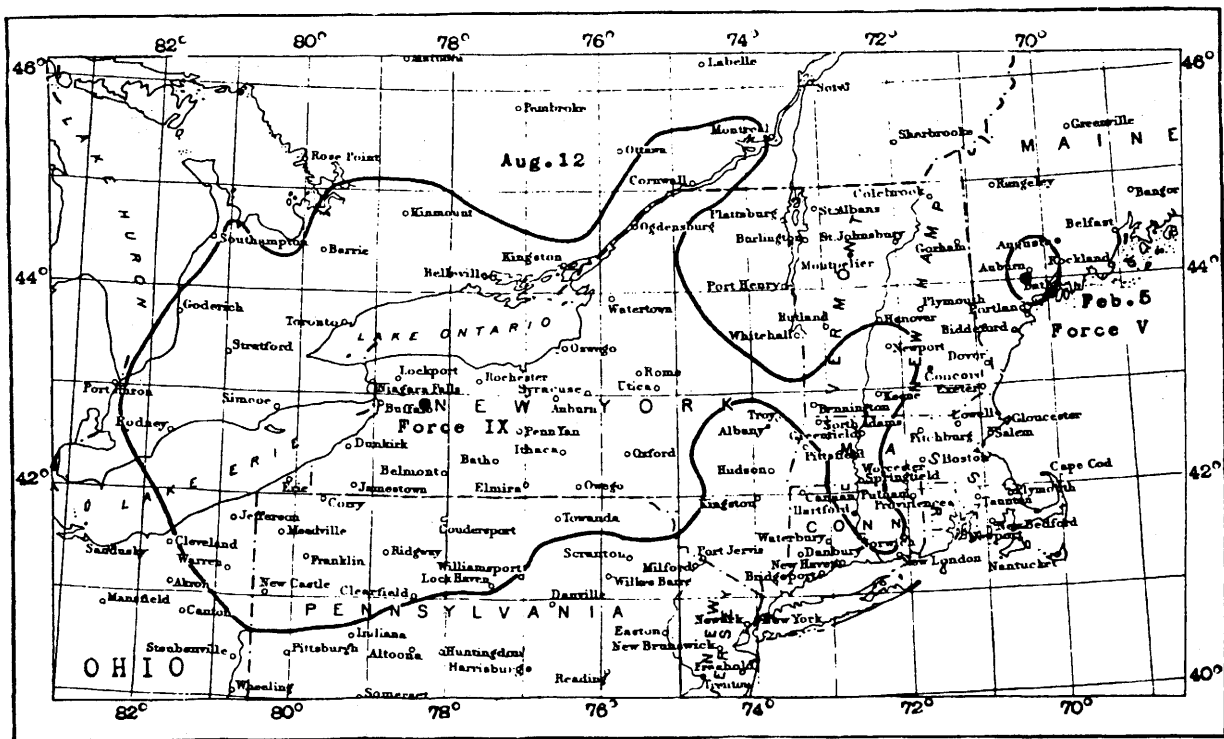


## PERRY NUCLEAR POWER PLANT

Isoseismal Map - St. Lawrence  
Earthquake, March 1, 1925

Figure 2.5-78





Areas affected by shocks of February 5 and August 12

REFERENCE 283

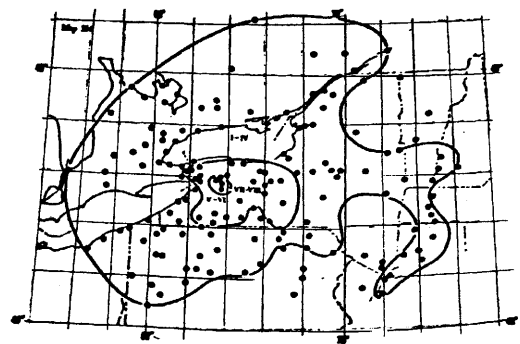
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Isoseismal Map - United States  
(Eastern, Attica, New York)  
Earthquakes, 1929

Figure 2.5-79



The Attica, New York, Earthquake of  
August 12, 1929.

A Modification of REFERENCE 283  
(Figure 3):  
125,000 square miles.

REFERENCE 147

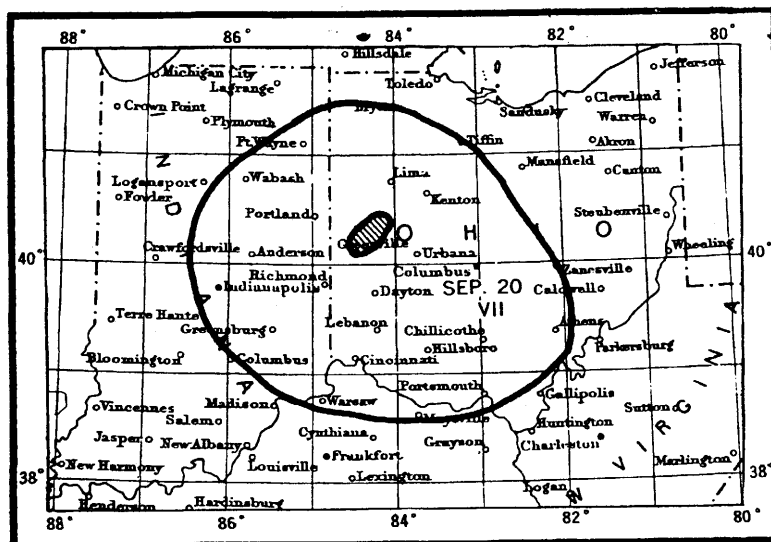
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Isoseismal Map - Attica, New York  
Earthquake of August 12, 1929

Figure 2.5-80



Area affected by Anna, Ohio, shock of September 20

REFERENCE 284

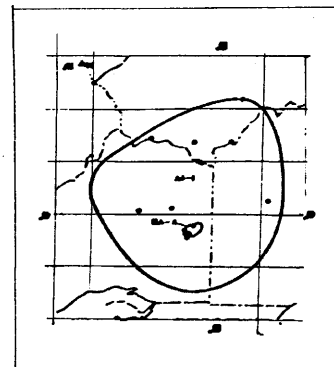
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Isoseismal Map - Area Affected by  
Anna, Ohio Earthquake  
September 20, 1931

Figure 2.5-81



The Anna, Ohio, Earthquake of  
September, 1931.

A Modification of REFERENCE 215  
(Figure 3):  
45,000 square miles.

REFERENCE 147, Page 135

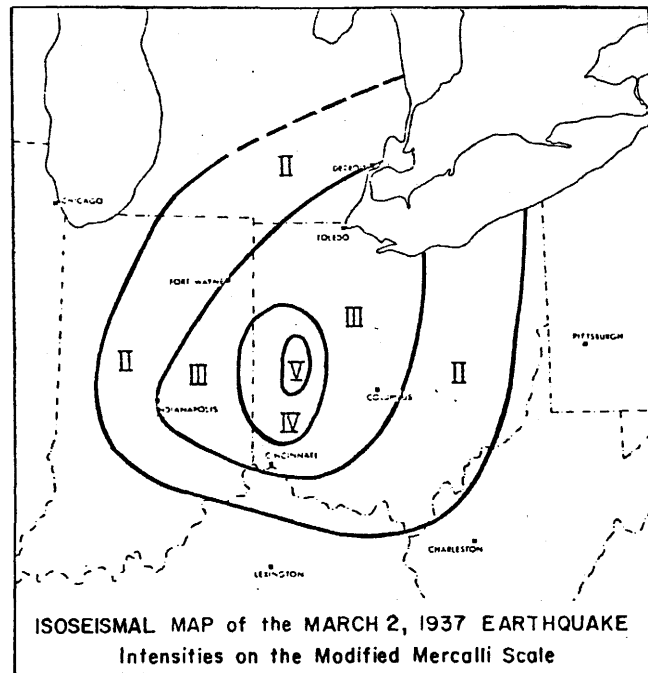
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Isoseismal Map - Area Affected by  
Anna, Ohio Earthquake  
September 20, 1931

Figure 2.5-82



REFERENCE 1, P.12 (AFTER REFERENCE 160)

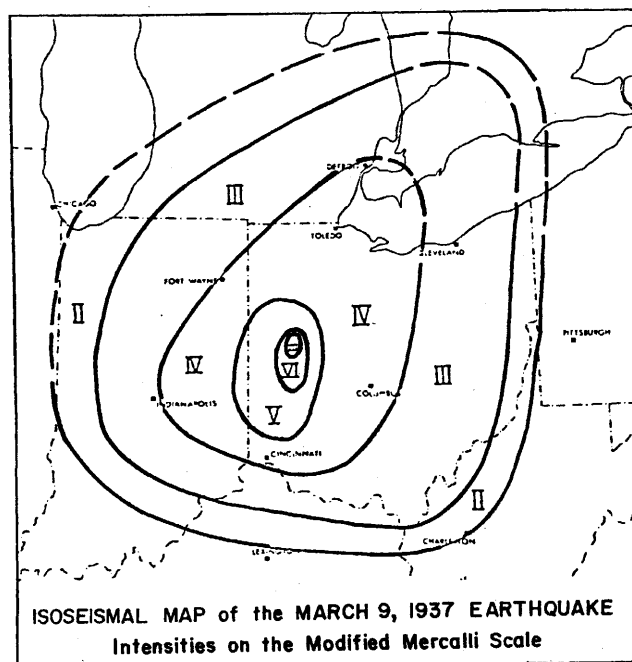
(Rev. 12 1/03)



# **PERRY NUCLEAR POWER PLANT**

Isoseismal Map - Area Affected by  
 Anna, Ohio Earthquake,  
 March 2, 1937

Figure 2.5-83



REFERENCE 285 (AFTER REFERENCE 160)

(Rev. 12 1/03)

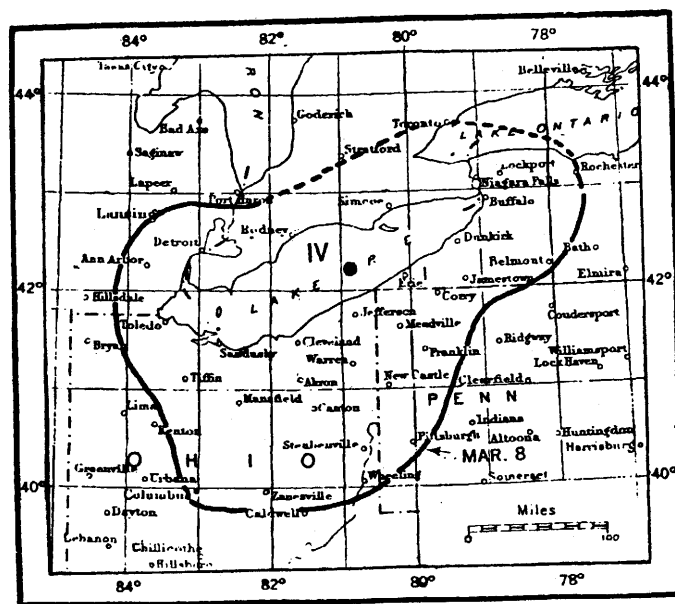


## PERRY NUCLEAR POWER PLANT

Isoseismal Map - Area Affected by  
Anna, Ohio Earthquake,  
March 2, 1937

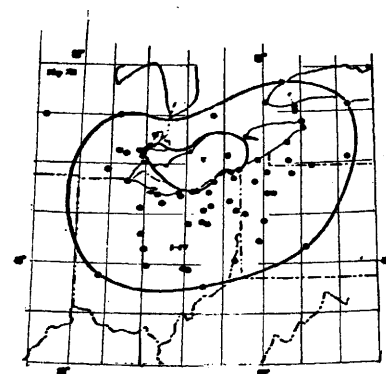
Figure 2.5-84





Area affected by the Lake Erie earthquake of March 8, 1943.

REFERENCE 286



The Lake Erie Earthquake March 8, 1943.

A Modification REFERENCE 217 (Figure 4):  
85,000 square miles.

REFERENCE 147, page 135.

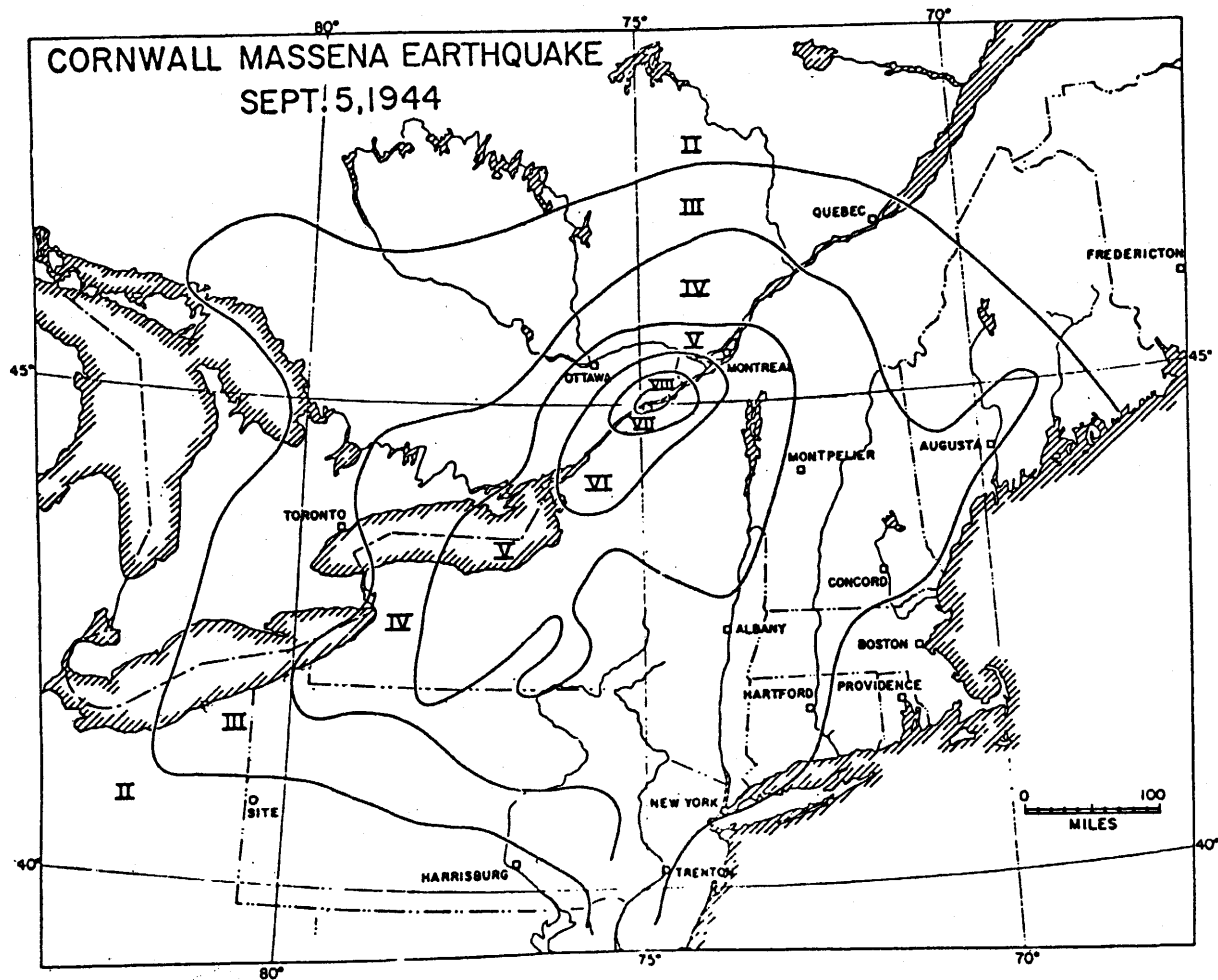
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Isoseismal Map - The Lake Erie  
Earthquake of March 8, 1943

Figure 2.5-85



REFERENCE 147, page 135.

(Rev. 12 1/03)

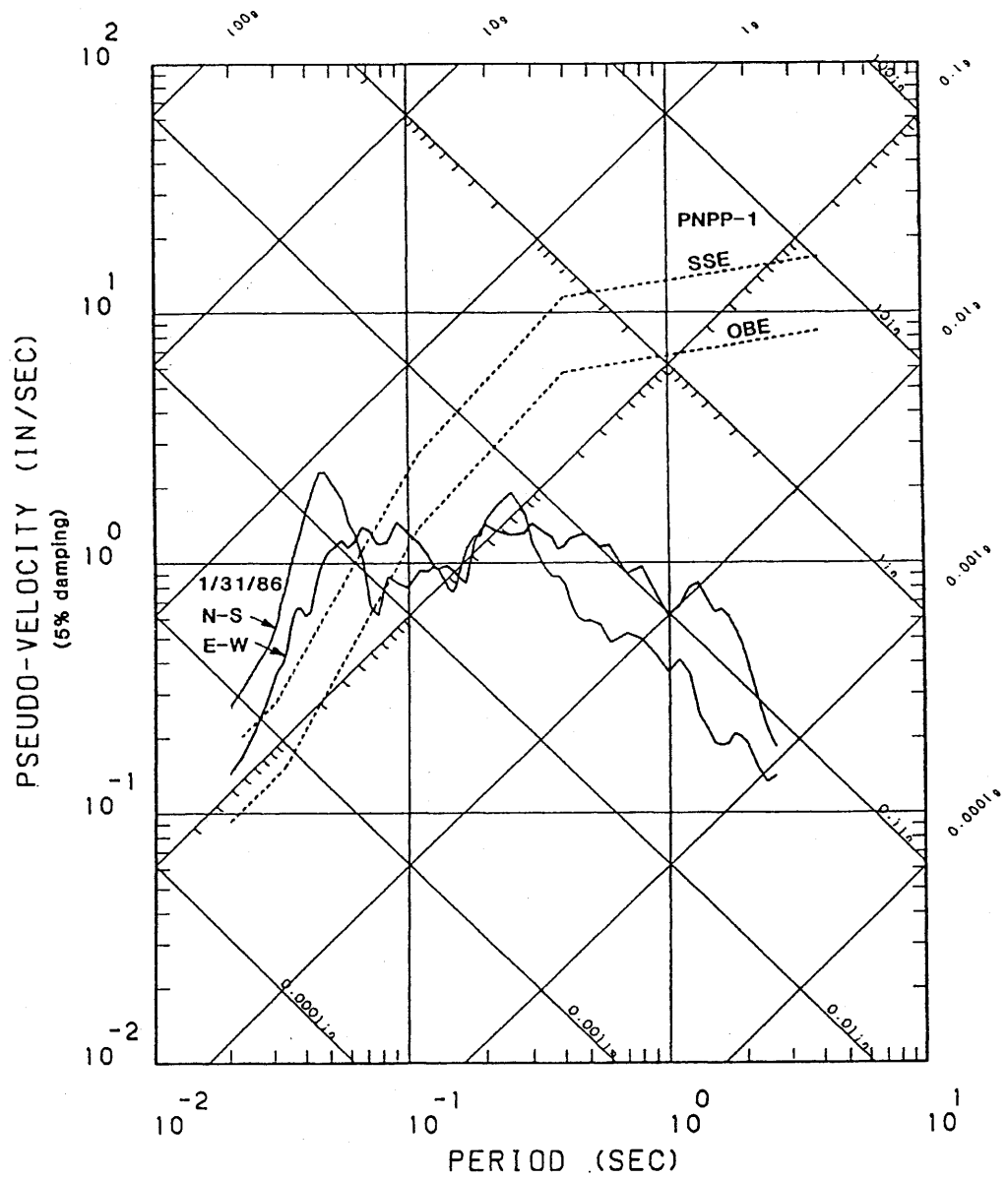


## PERRY NUCLEAR POWER PLANT

Isoseismal Map - Cornwall  
Massena Earthquake of  
September 5, 1944

Figure 2.5-86





(Rev. 12 1/03)

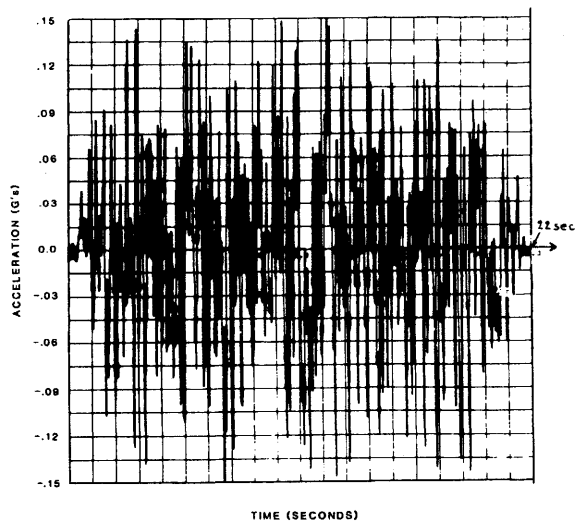


## PERRY NUCLEAR POWER PLANT

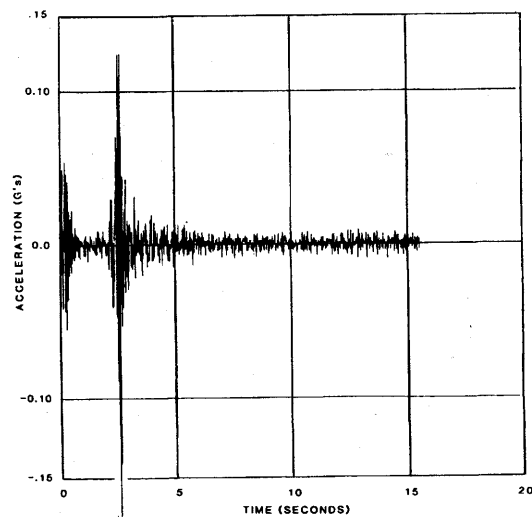
Comparison of PNPP-1 OBE and  
SSE Horizontal Spectra with  
January 31, 1986, Horizontal  
Spectra at Reactor Foundation

Figure 2.5-88

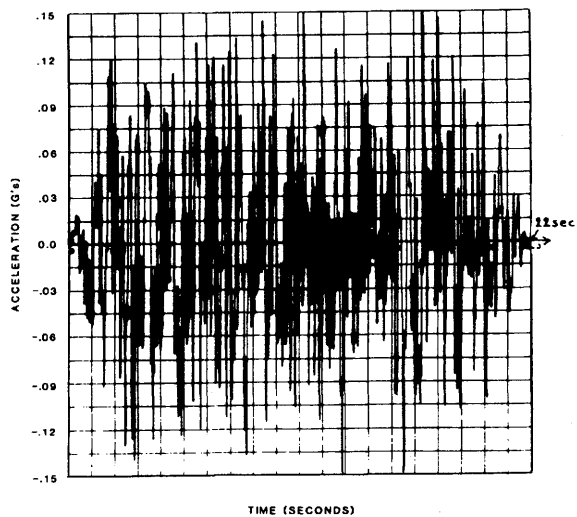
ACCELERATION TIME HISTORY MOTION - H1



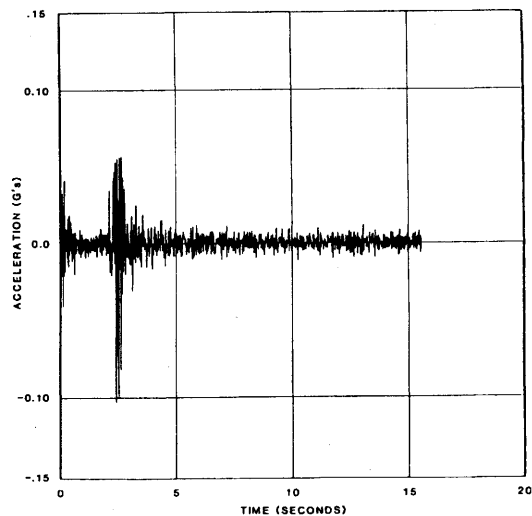
JANUARY 31, 1986 EARTHQUAKE ACCELEROGRAM  
HORIZONTAL (N-S)



ACCELERATION TIME HISTORY MOTION - H2



JANUARY 31, 1986 EARTHQUAKE ACCELEROGRAM  
HORIZONTAL (E-W)



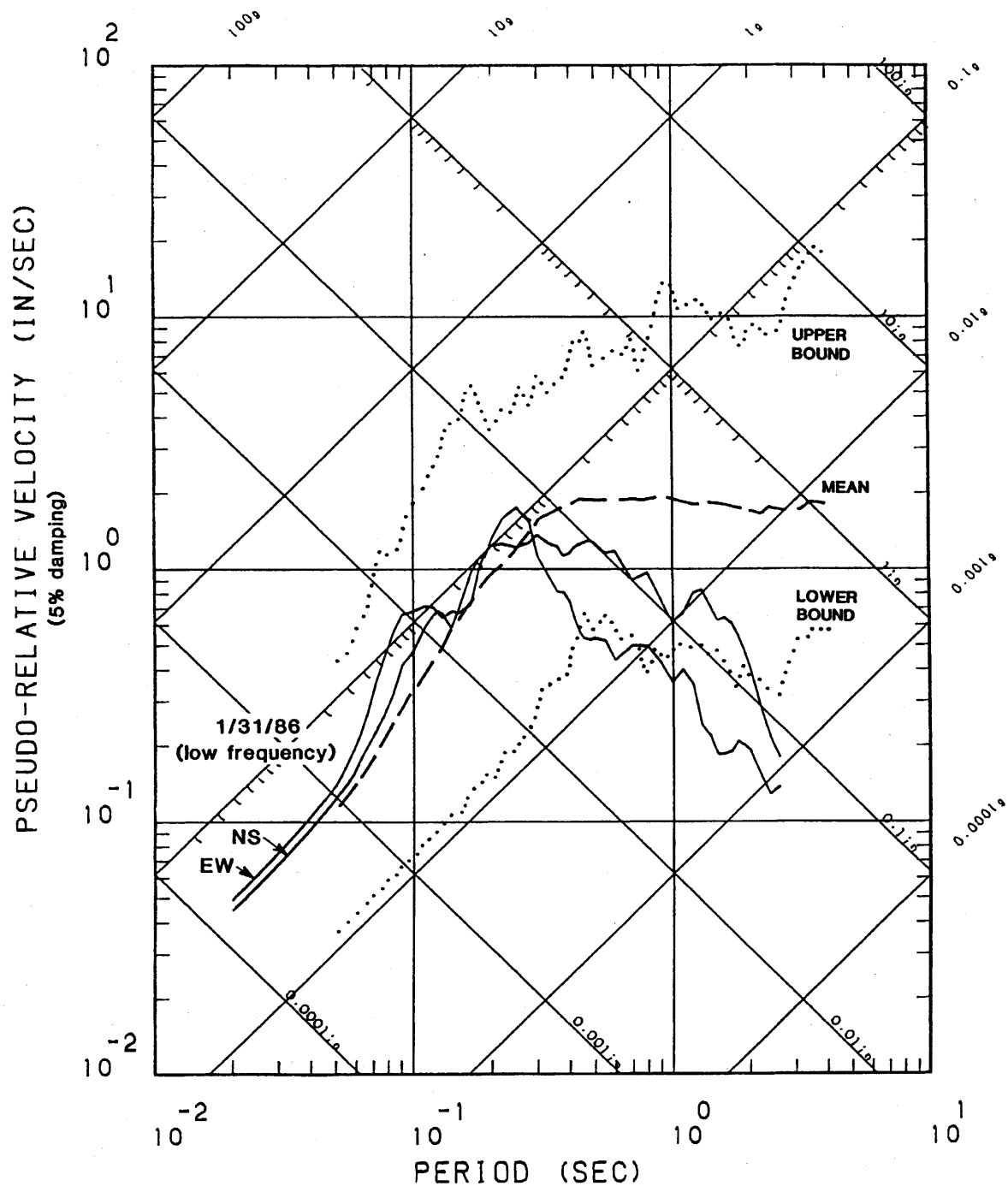
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Comparison of Design Time History -  
H1 and January 31, 1986 - (N-S)  
H2 and January 31, 1986 - (E-W)

Figure 2.5-89



R1651S.L10  
R1651W.L10

Mean, upper and lower  
bounds for V MM  
after O'Brien (1980)

(Rev. 12 1/03)

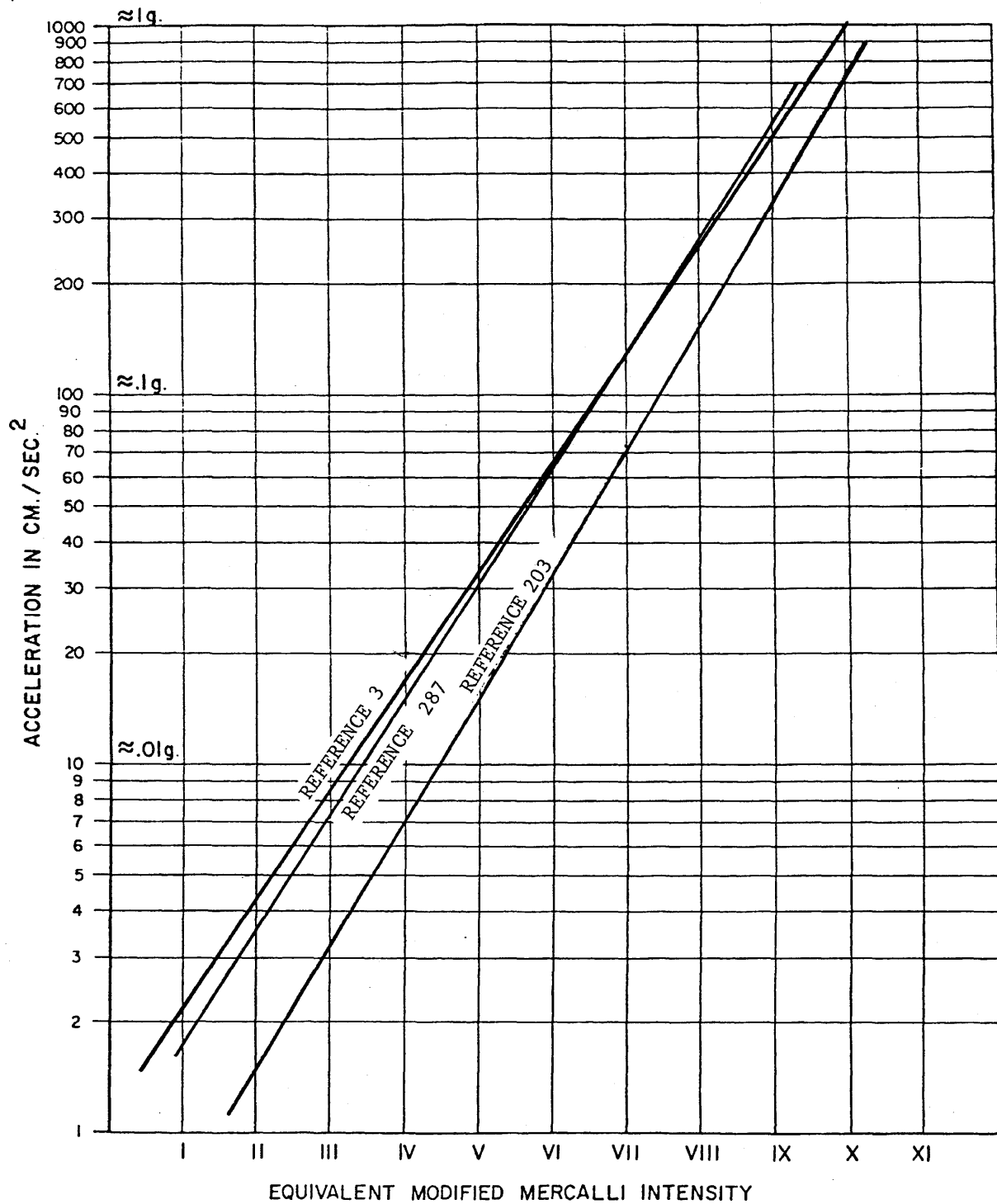


## PERRY NUCLEAR POWER PLANT

Comparison of January 31, 1986,  
Low Frequency Horizontal Response  
Spectra with Response Spectra  
for MM Intensity V

Figure 2.5-90





(Rev. 12 1/03)

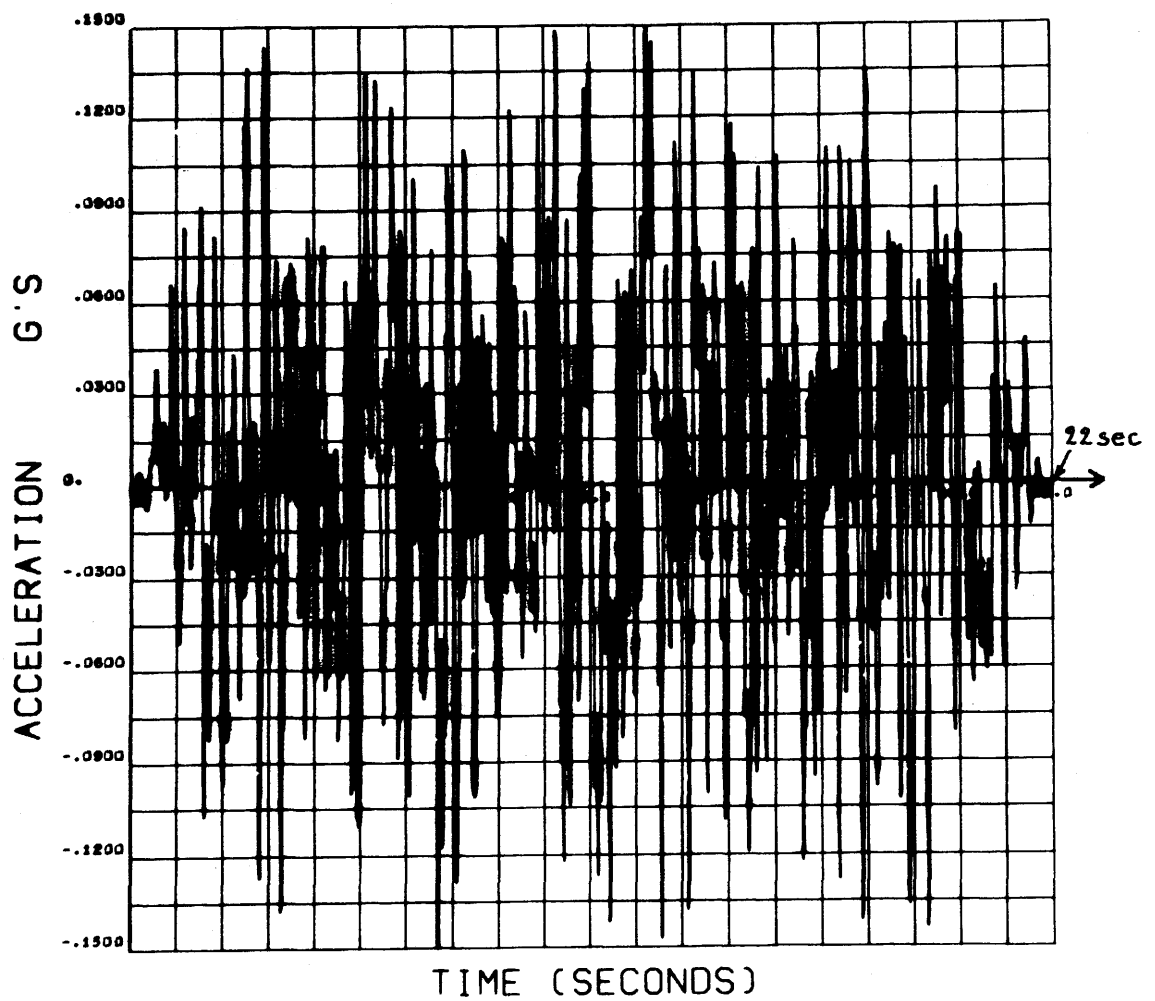


**PERRY NUCLEAR POWER PLANT**

Intensity Acceleration  
Relationships

Figure 2.5-91

## ACCELEROGRAM - H1



(Rev. 12 1/03)

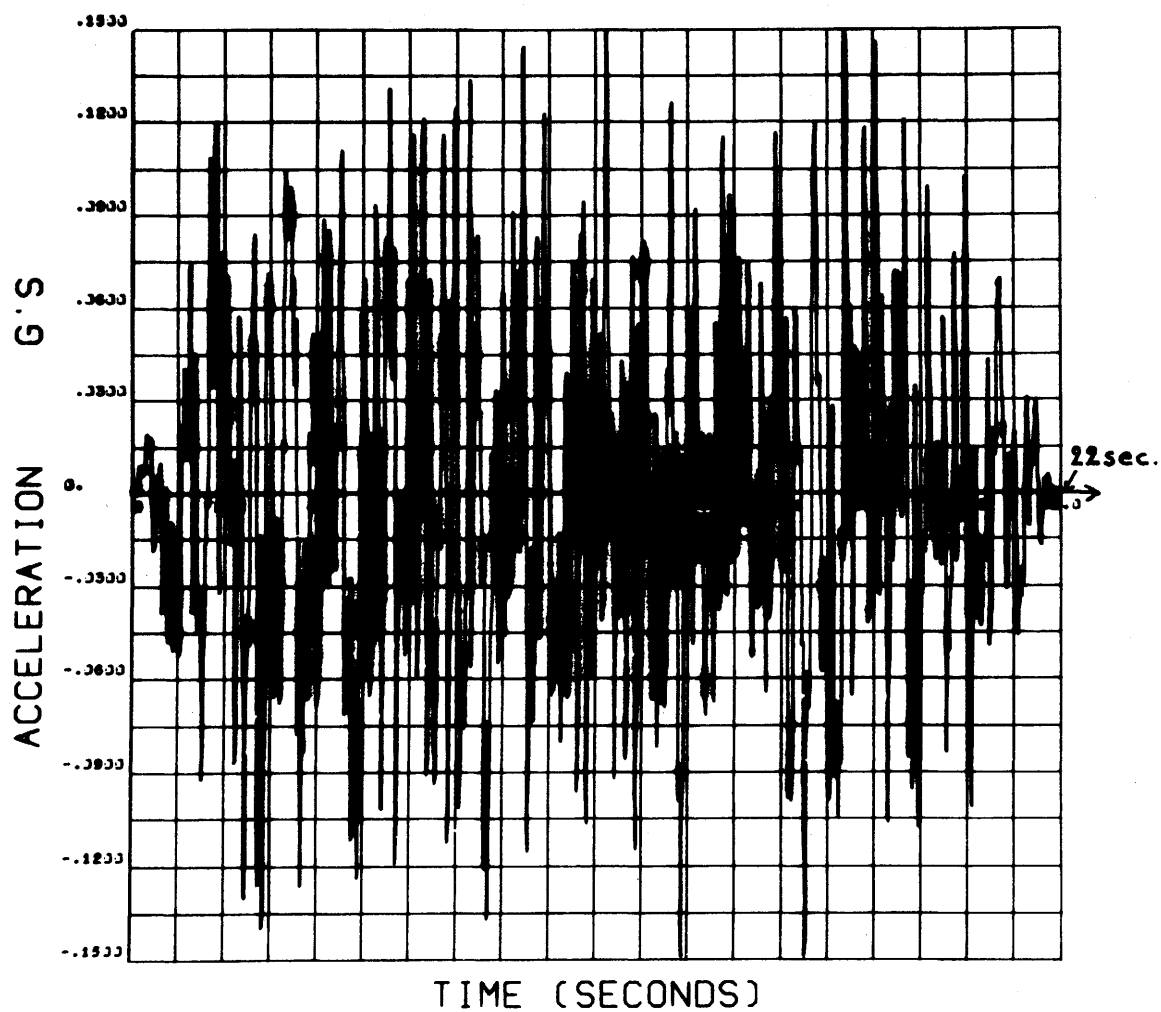


**PERRY NUCLEAR POWER PLANT**

Acceleration Time History -  
Motion H1

Figure 2.5-92

## ACCELEROGRAM - H 2



(Rev. 12 1/03)

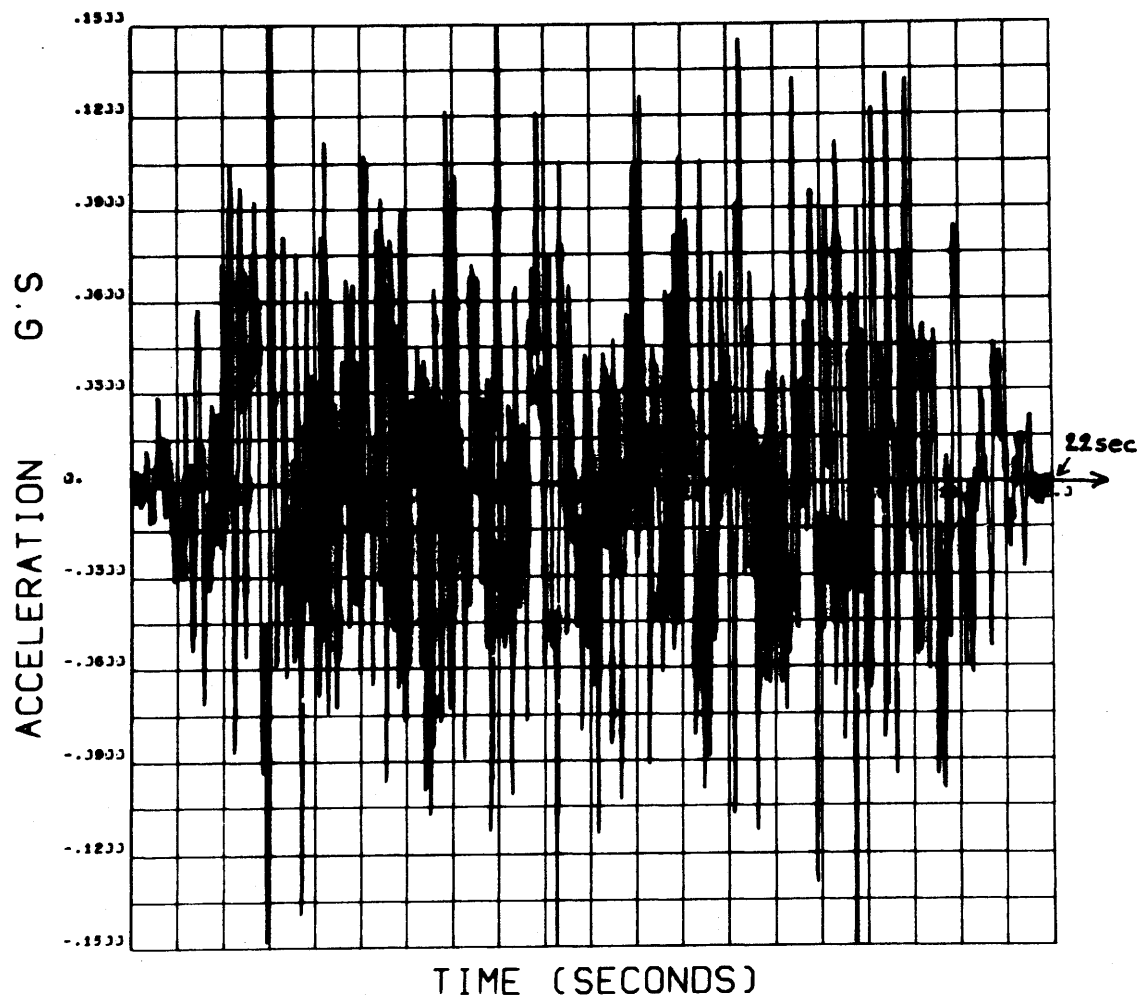


**PERRY NUCLEAR POWER PLANT**

Acceleration Time History -  
Motion H2

Figure 2.5-93

## ACCELEROGRAM - V



(Rev. 12 1/03)

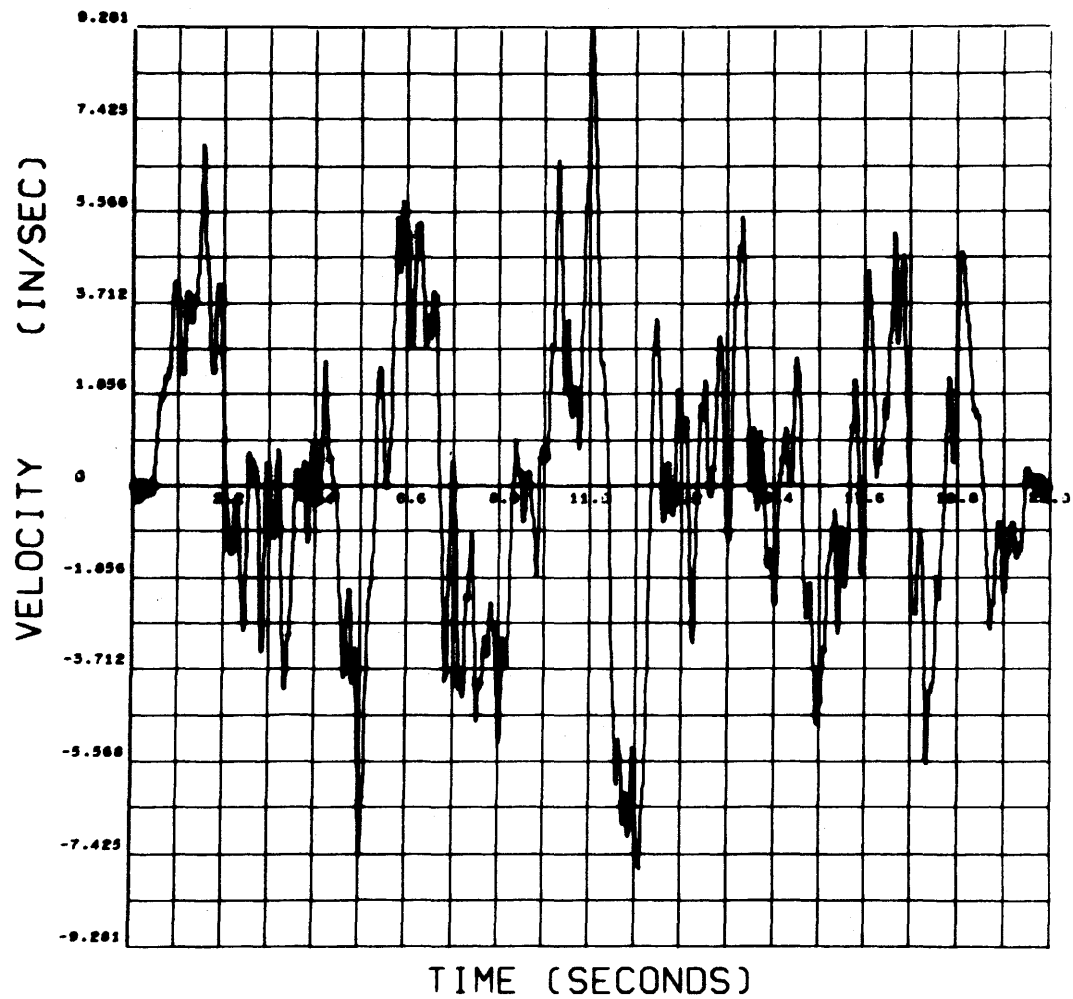


**PERRY NUCLEAR POWER PLANT**

Acceleration Time History -  
Vertical Motion

Figure 2.5-94

## VELOCITY TIME HISTORY - H 1



(Rev. 12 1/03)

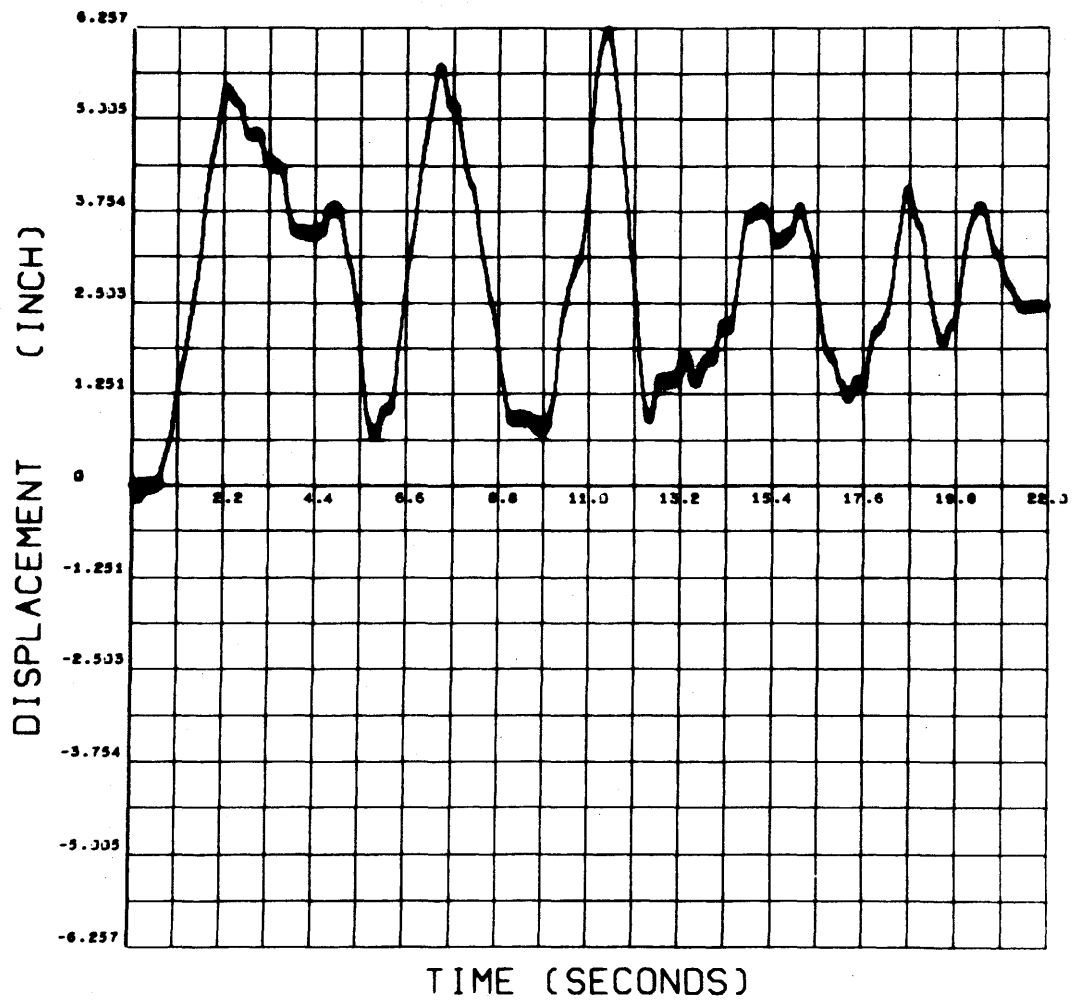


**PERRY NUCLEAR POWER PLANT**

Vertical Time History -  
Motion H1

Figure 2.5-95

## DISPLACEMENT TIME HISTORY - H1



(Rev. 12 1/03)



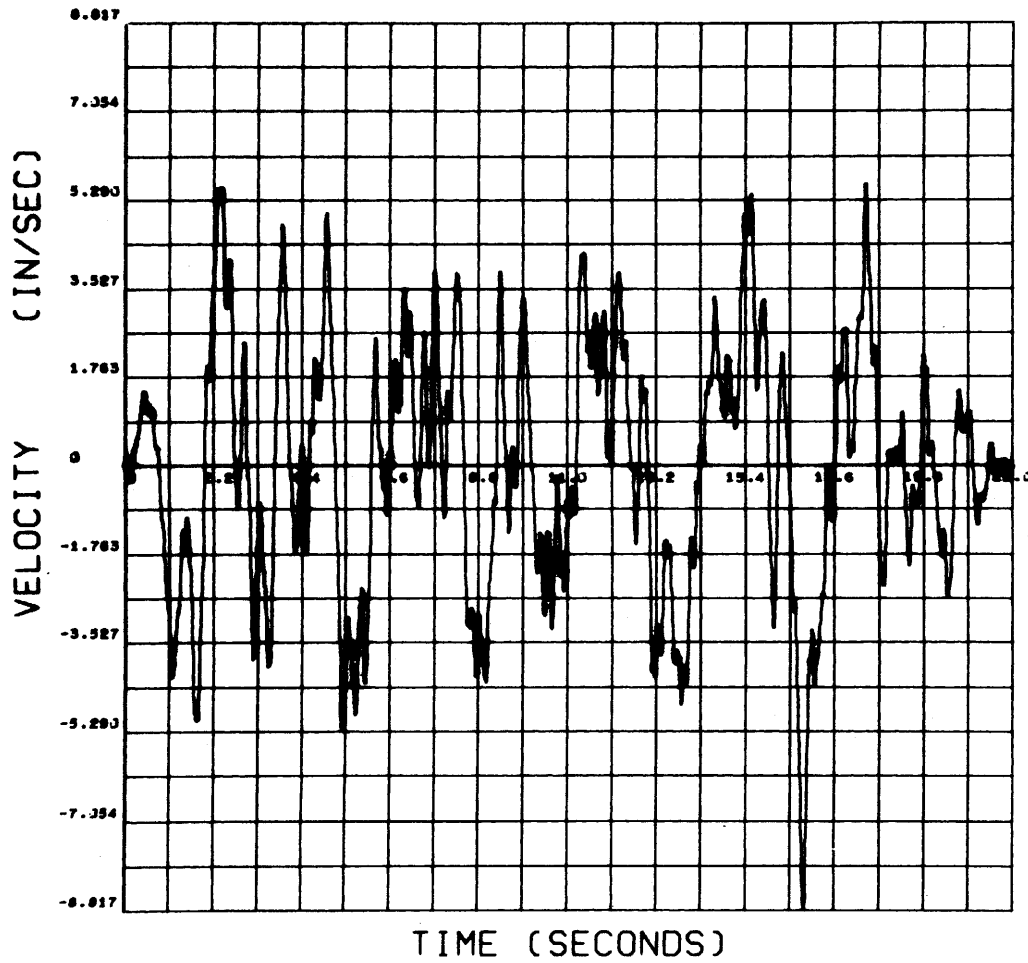
**PERRY NUCLEAR POWER PLANT**

Displacement Time History -  
Motion H1

Figure 2.5-96



## VELOCITY TIME HISTORY - H2



(Rev. 12 1/03)

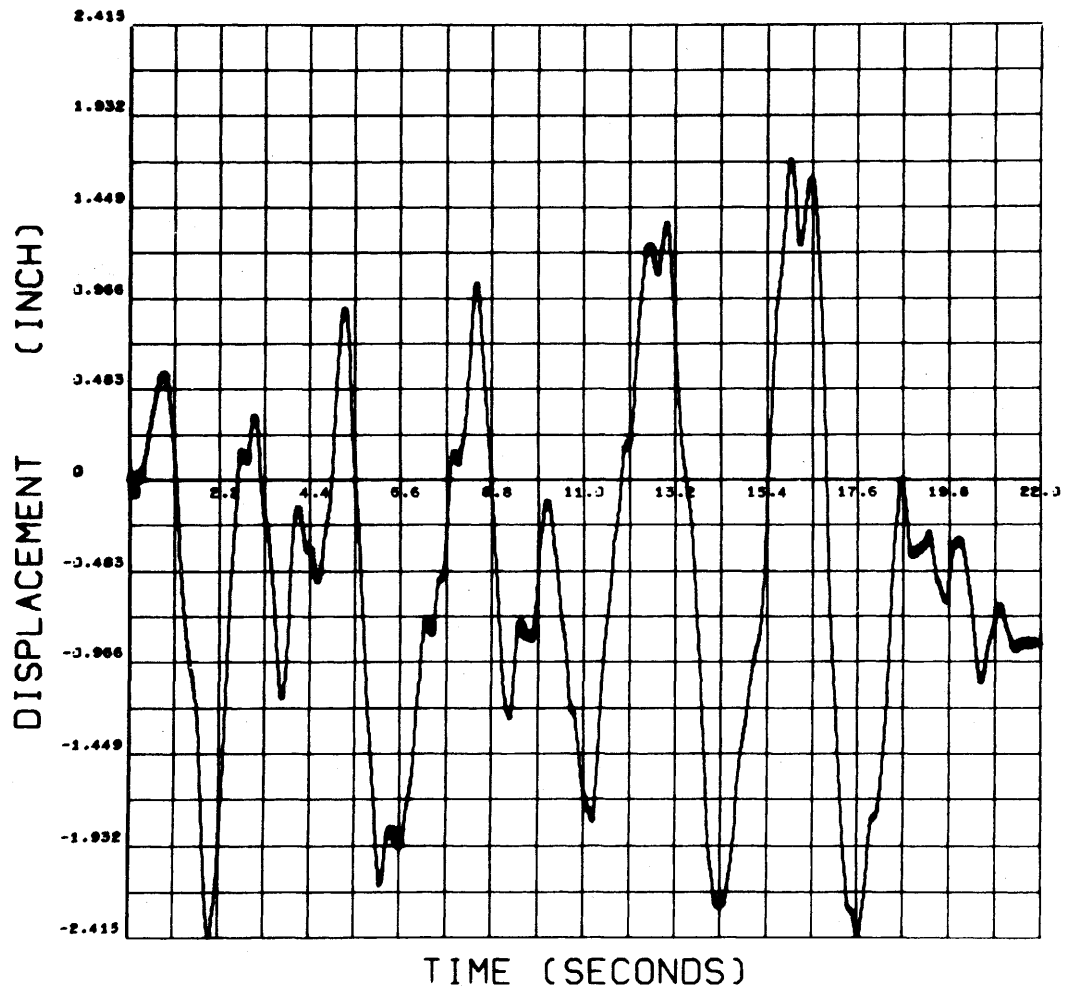


**PERRY NUCLEAR POWER PLANT**

Vertical Time History -  
Motion H2

Figure 2.5-97

## DISPLACEMENT TIME HISTORY - H2



(Rev. 12 1/03)

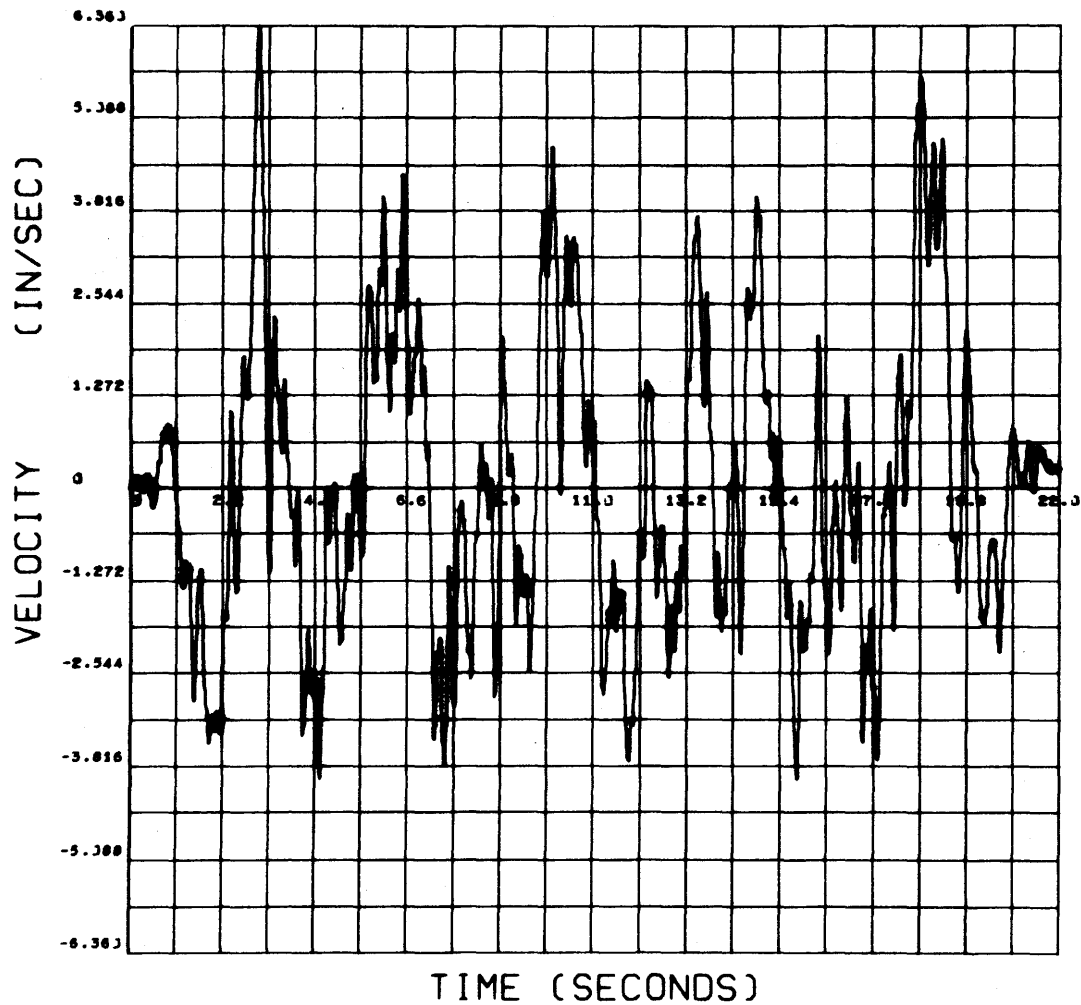


**PERRY NUCLEAR POWER PLANT**

Displacement Time History -  
Motion H2

Figure 2.5-98

## VELOCITY TIME HISTORY - V



(Rev. 12 1/03)

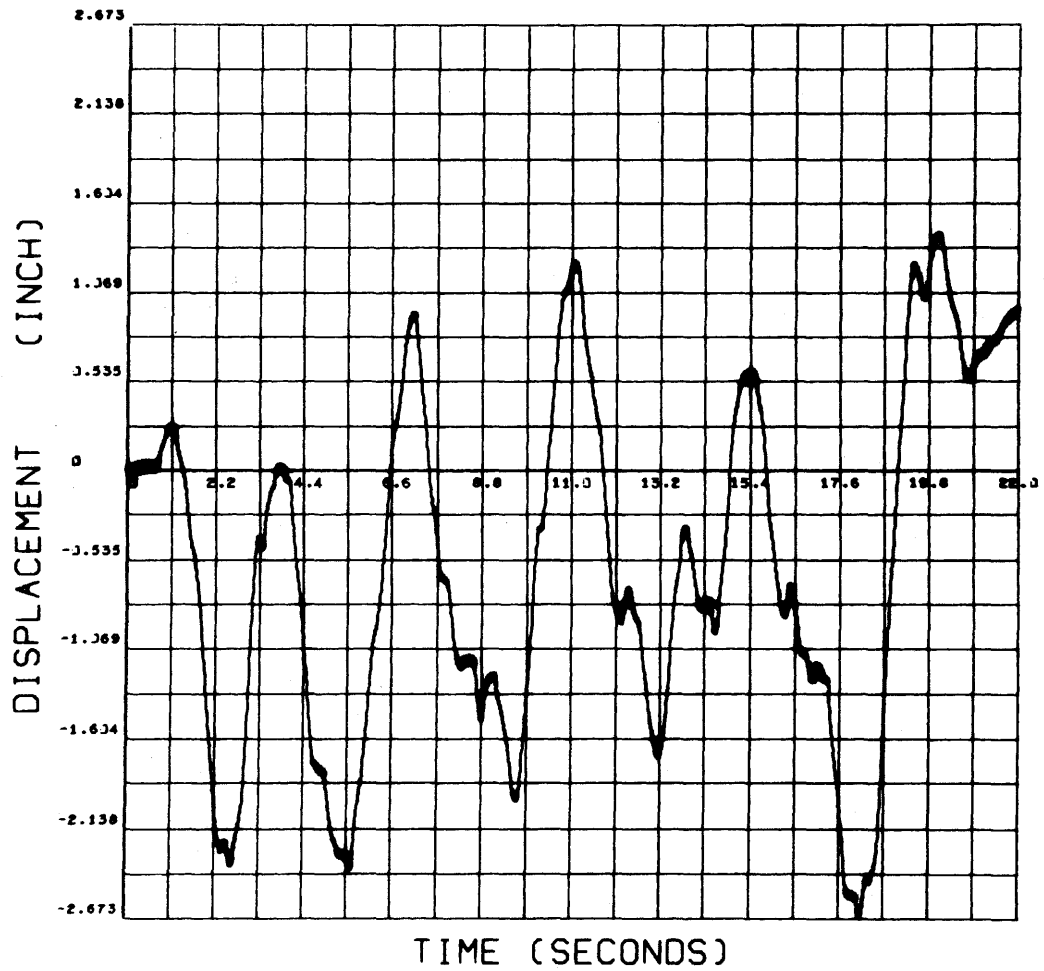


**PERRY NUCLEAR POWER PLANT**

Velocity Time History -  
Vertical Motion

Figure 2.5-99

# DISPLACEMENT TIME HISTORY - V



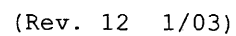
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

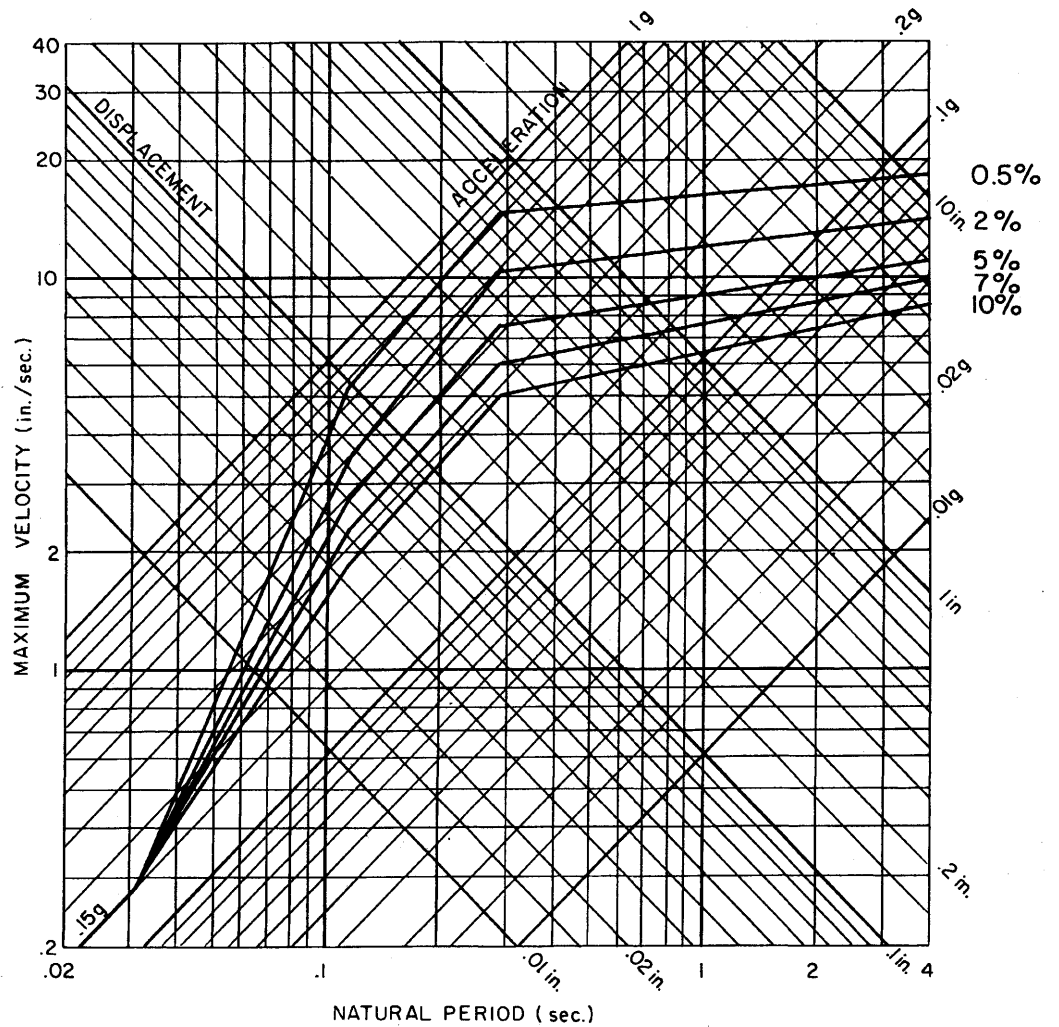
Displacement Time History -  
Vertical Motion

Figure 2.5-100



# Safe Shutdown Earthquake Design Response Spectra - Horizontal Motion

Figure 2.5-101



(Rev. 12 1/03)

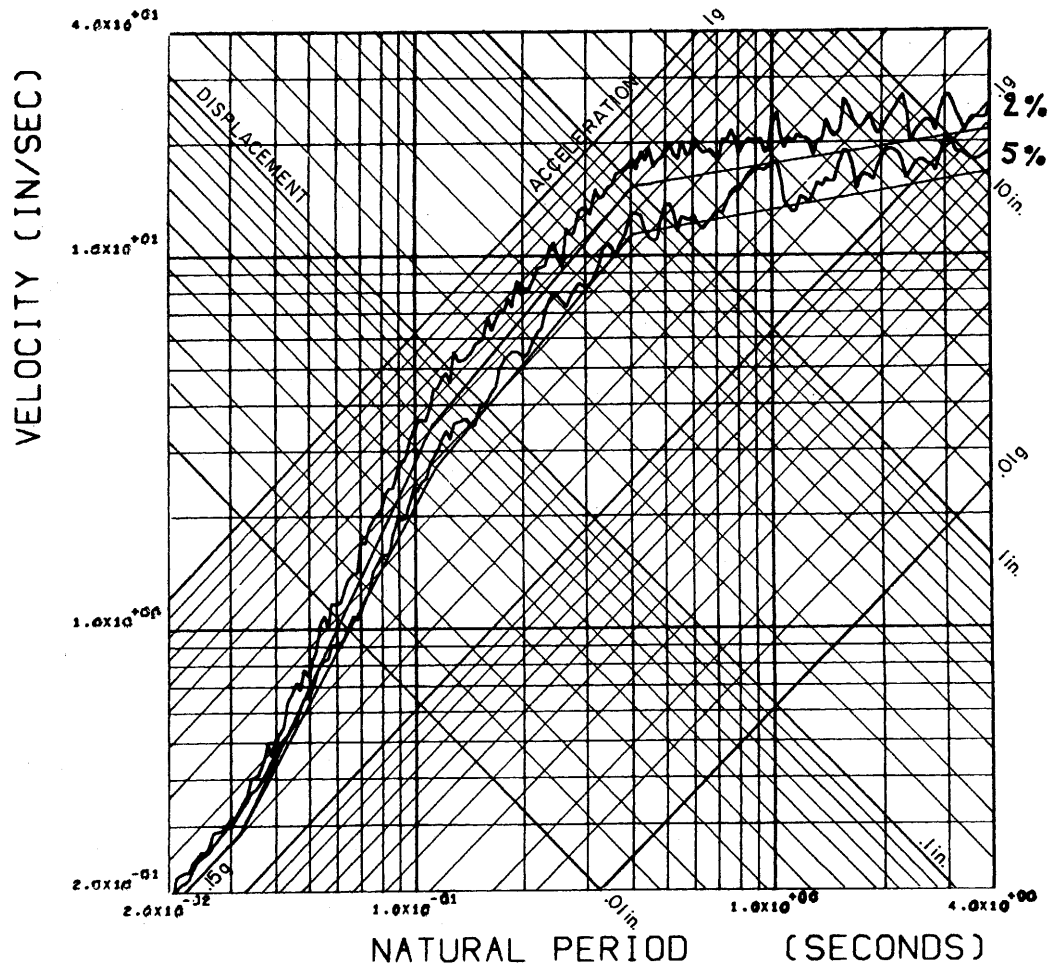


## PERRY NUCLEAR POWER PLANT

Safe Shutdown Earthquake  
Design Response Spectra -  
Vertical Motion

Figure 2.5-102

# RESPONSE SPECTRUM - H1



(Rev. 12 1/03)

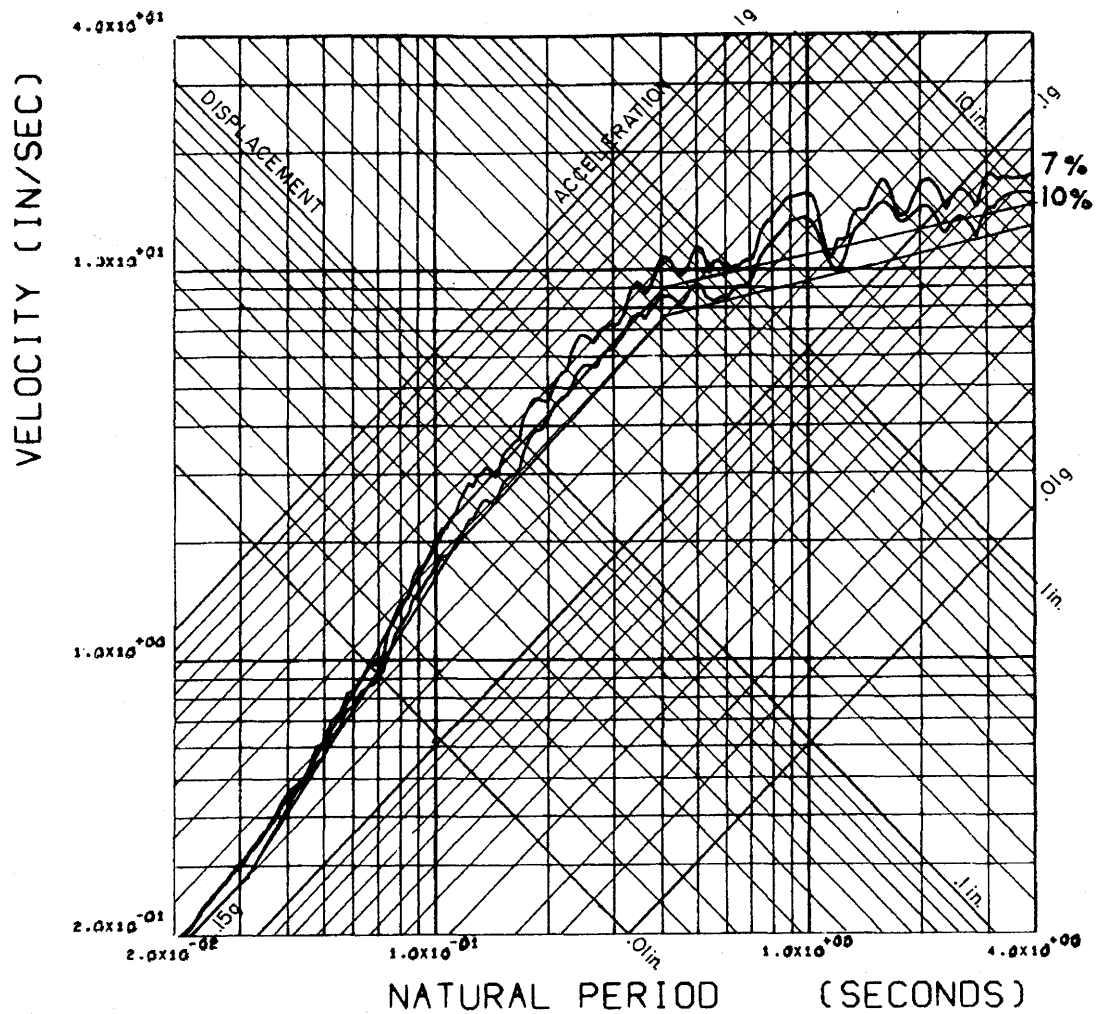


**PERRY NUCLEAR POWER PLANT**

Response Spectra - Horizontal  
Motion H1 (2% and 5% Damping)

Figure 2.5-103

# RESPONSE SPECTRUM - H1



(Rev. 12 1/03)



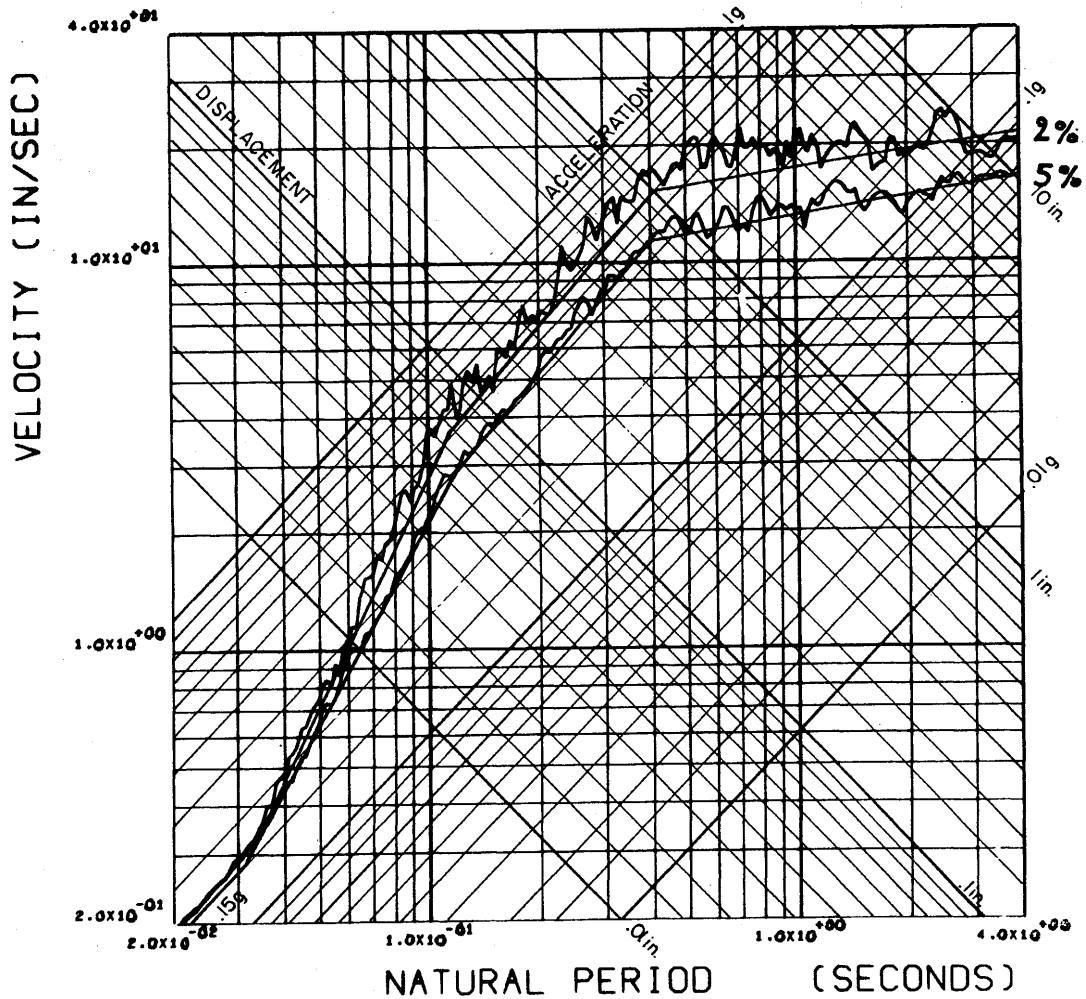
**PERRY NUCLEAR POWER PLANT**

Response Spectra - Horizontal  
Motion H1 (7% and 10% Damping)

Figure 2.5-104



## RESPONSE SPECTRUM - H2



(Rev. 12 1/03)

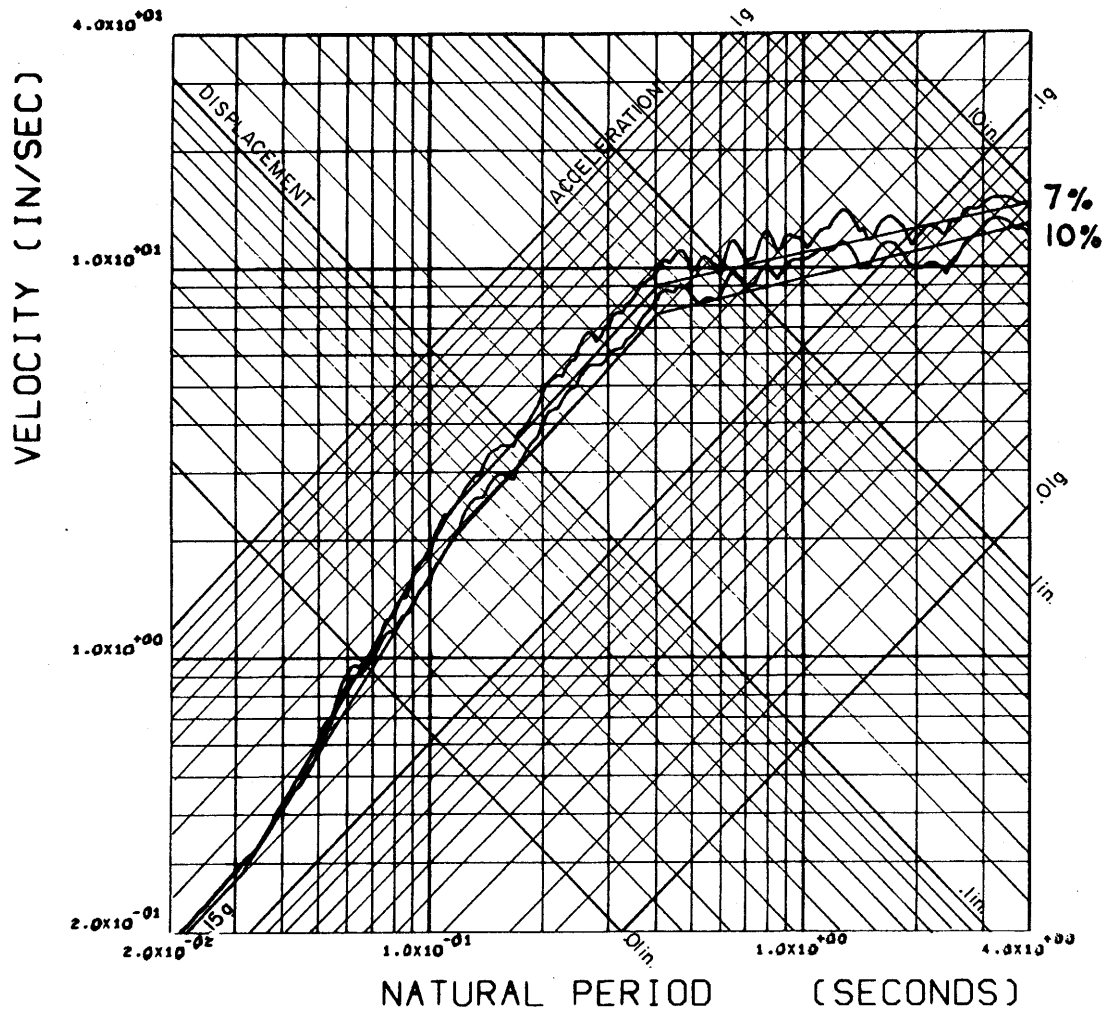


**PERRY NUCLEAR POWER PLANT**

Response Spectra - Horizontal  
Motion H2 (2% and 5% Damping)

Figure 2.5-105

## RESPONSE SPECTRUM - H2



(Rev. 12 1/03)

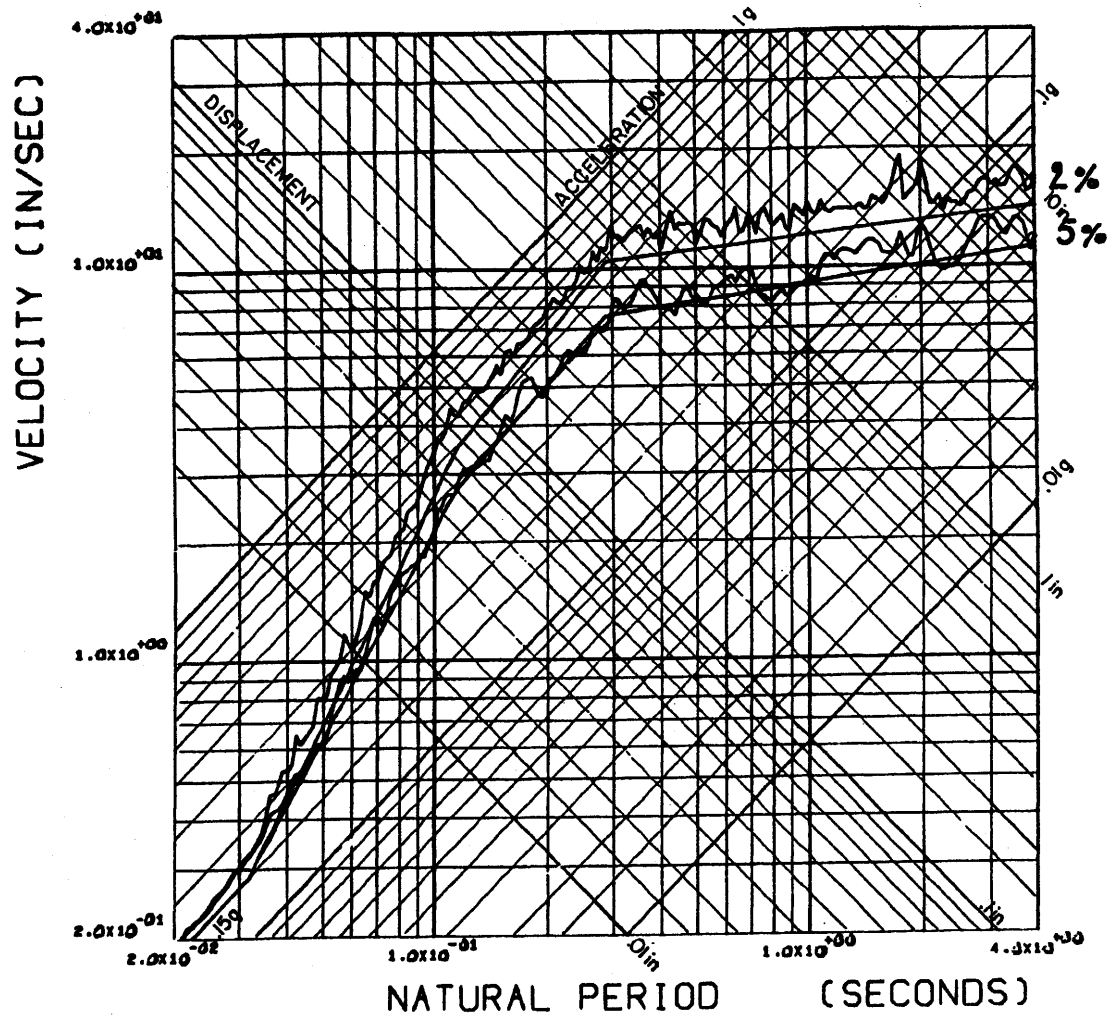


**PERRY NUCLEAR POWER PLANT**

Response Spectra - Horizontal  
Motion H2 (7% and 10% Damping)

Figure 2.5-106

# RESPONSE SPECTRUM - V



(Rev. 12 1/03)

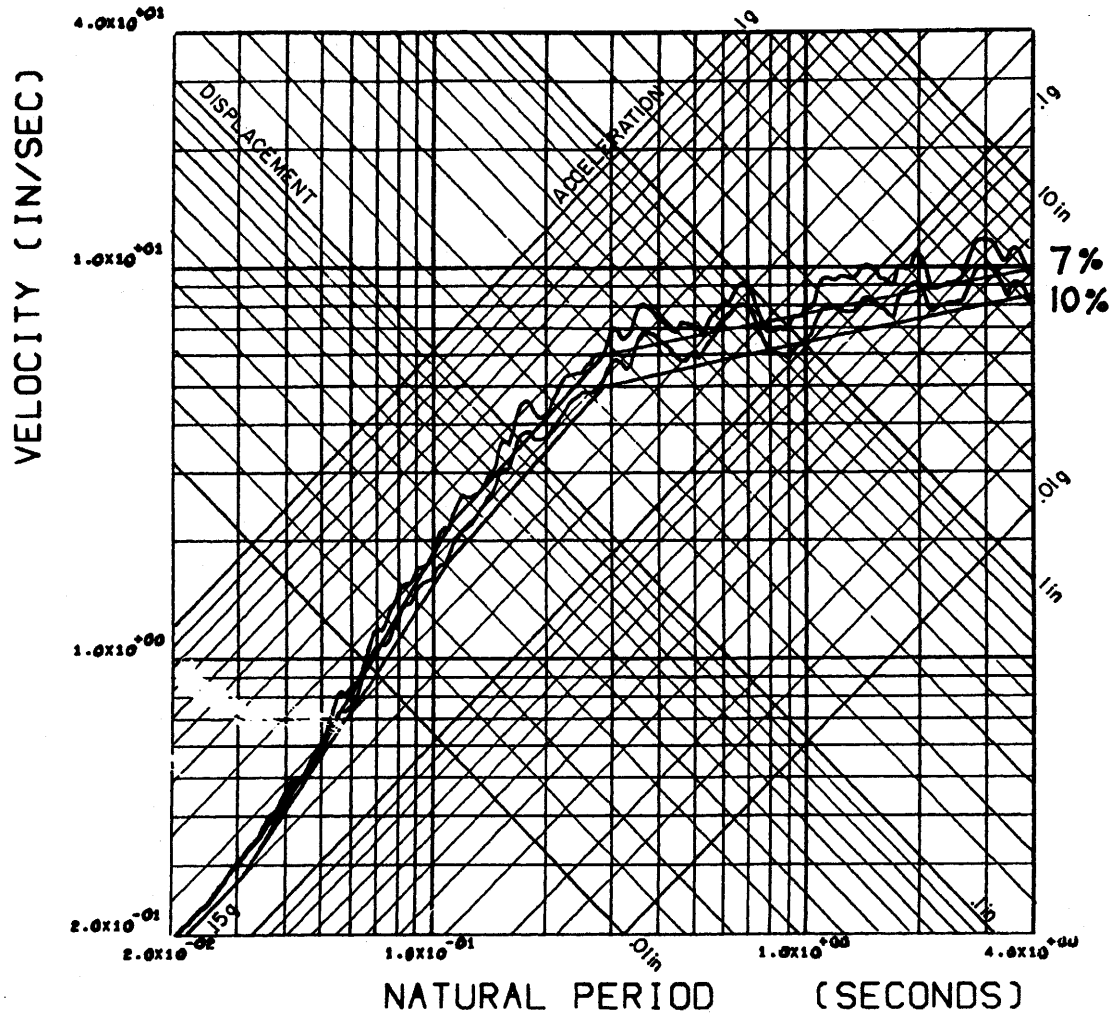


**PERRY NUCLEAR POWER PLANT**

Response Spectra - Vertical  
Motion (2% and 5% Damping)

Figure 2.5-107

# RESPONSE SPECTRUM - V



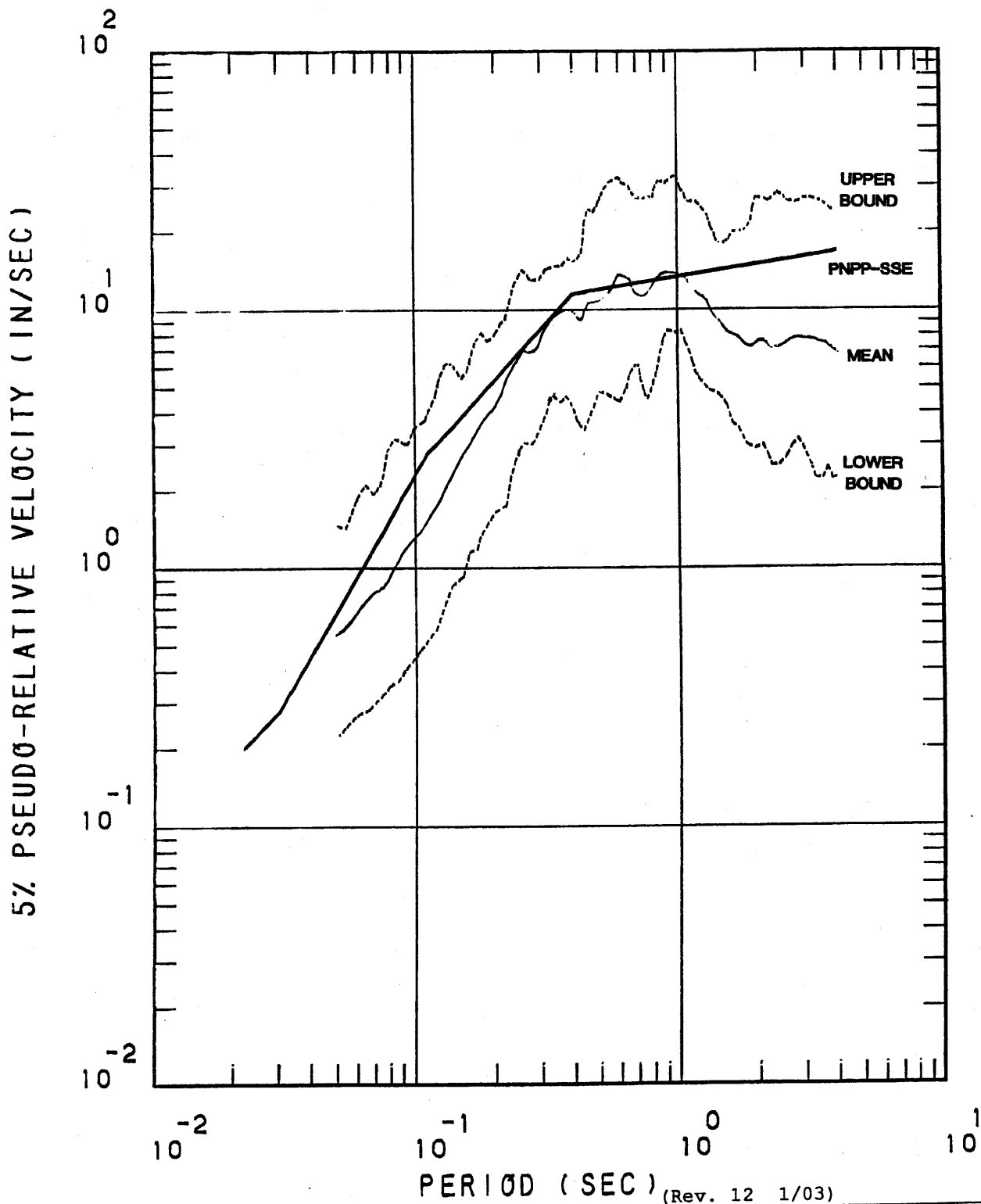
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Response Spectra - Vertical  
Motion (7% and 10% Damping)

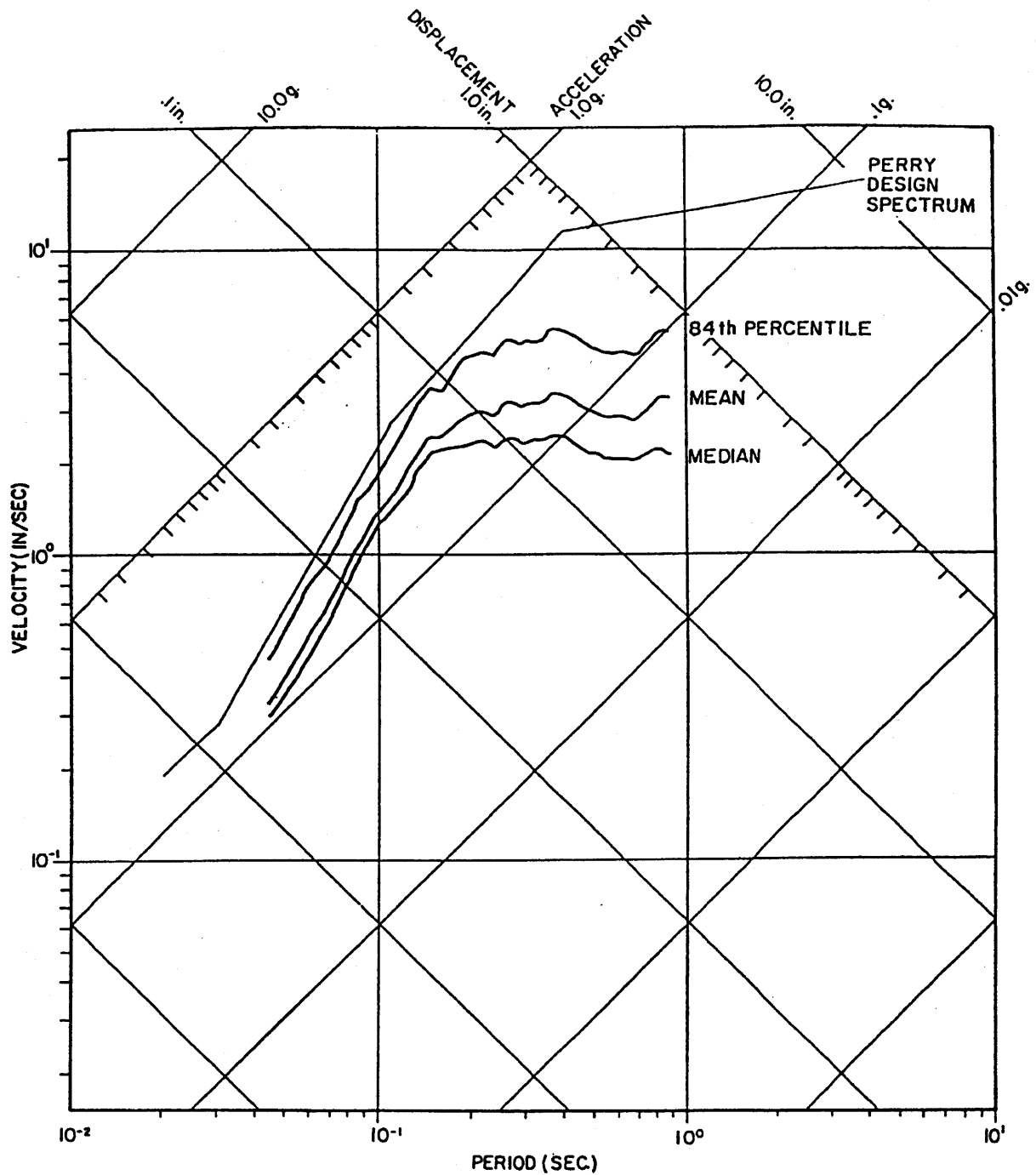
Figure 2.5-108



# **PERRY NUCLEAR POWER PLANT**

Observed Response Spectra for  
Intensity VIII Effects vs. Design  
Response Spectra

Figure 2.5-109



AVERAGE MAGNITUDE OF 5.7  
AVERAGE DISTANCE OF 13 KM  
ROCK FOUNDATIONS  
(BASIC SUBSET, MAGNITUDE RANGE  
EXTENDED TO INCLUDE THREE EVENTS  
WITH MAGNITUDE  $M_L$  = 6.0, 6.0 AND  
6.1, 5% DAMPING)

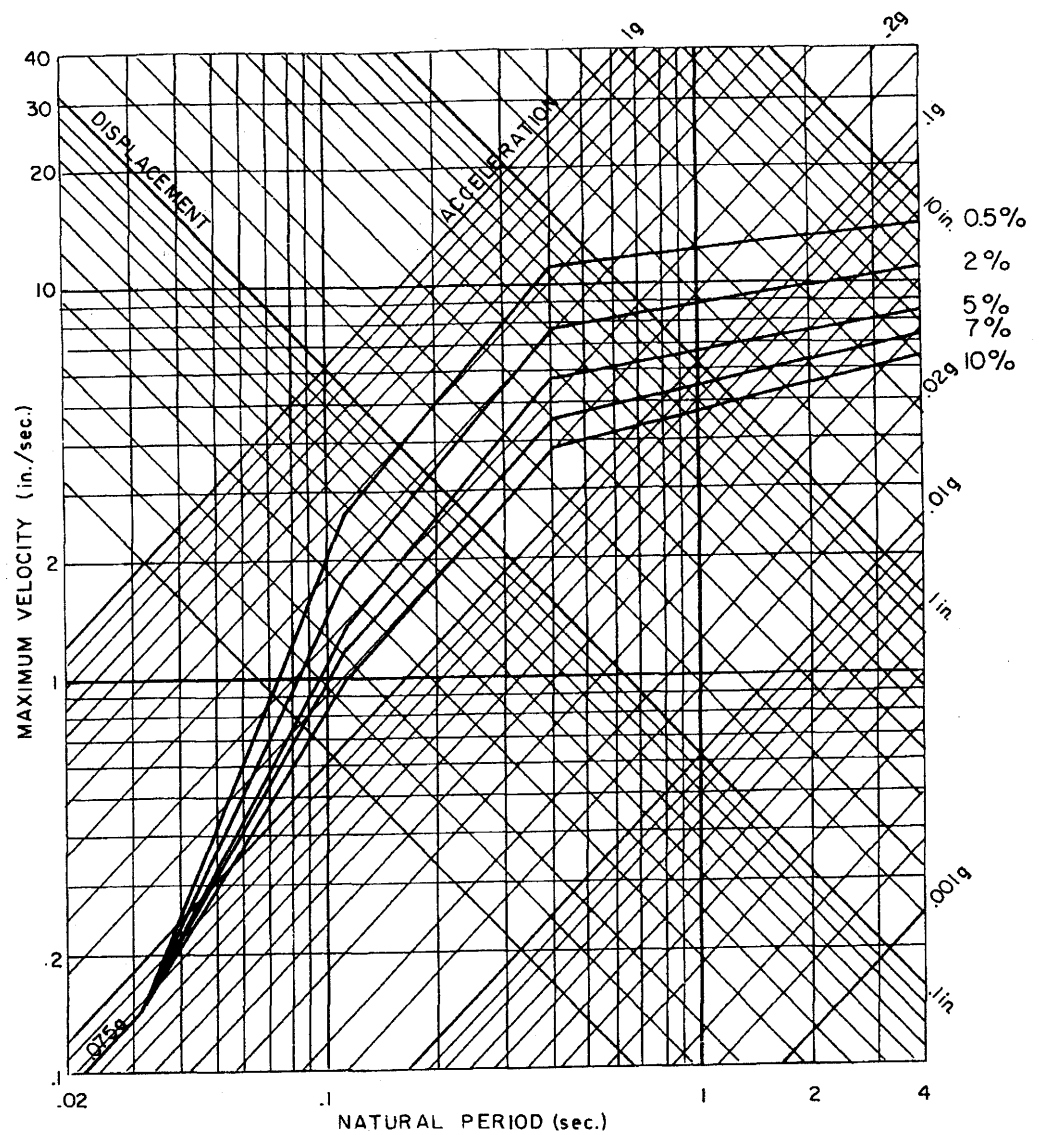
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Site Specific Response Spectra  
for the Perry Site  
(5% Damping)

Figure 2.5-110



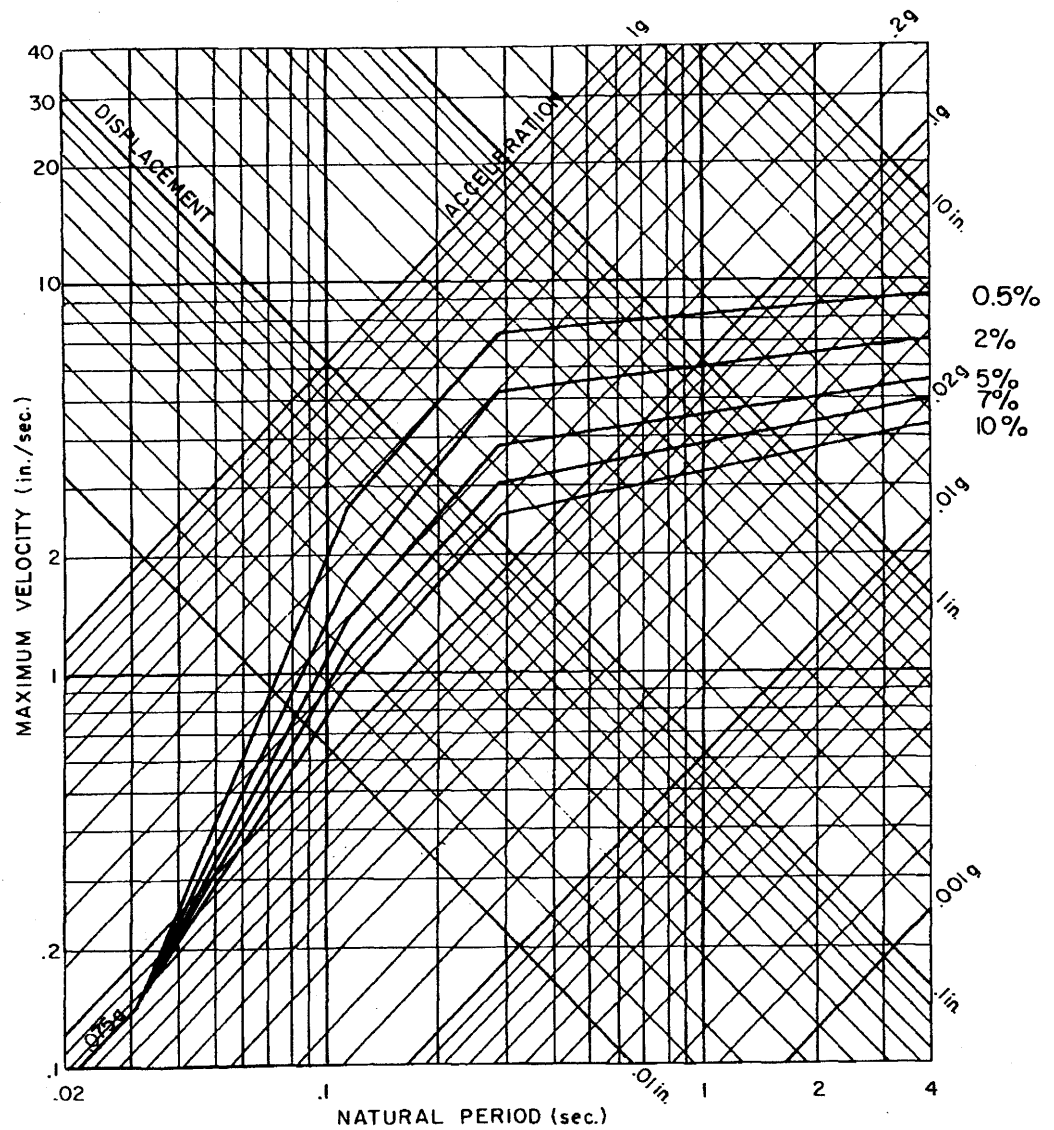
(Rev. 12 1/03)



# **PERRY NUCLEAR POWER PLANT**

Operating Basis Earthquake Design  
Response Spectra - Horizontal  
Motion

Figure 2.5-111



(Rev. 13 12/03)

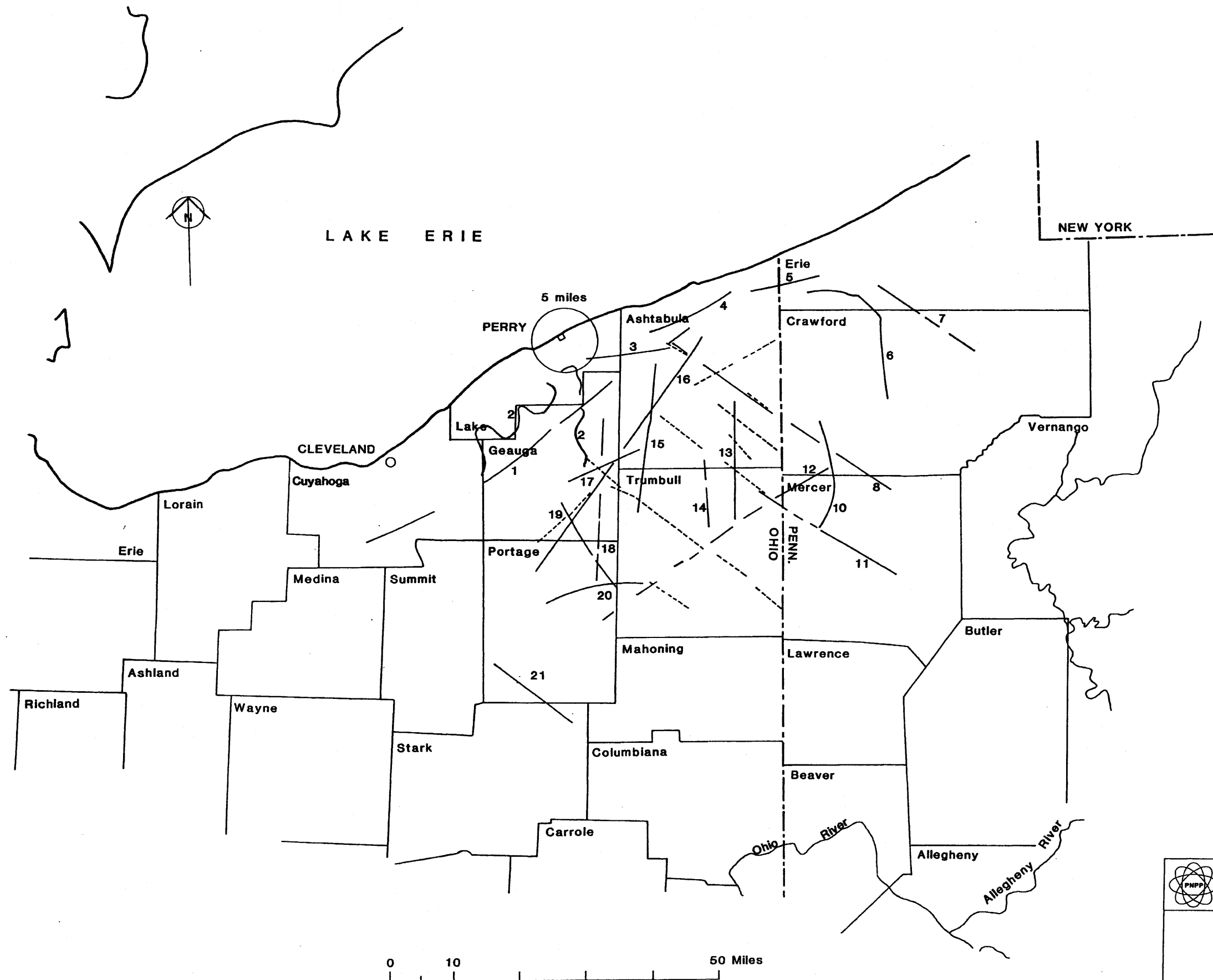


## PERRY NUCLEAR POWER PLANT

Operating Basis Earthquake Design  
Response Spectra - Vertical  
Motion

Figure 2.5-112





NOTE:

Numbers next to solid lineaments referred to in Section 2.5.3.2.

Dashed lineaments from Synthetic Aperture Radar Imagery, Cleveland 2° sheet, 1984.

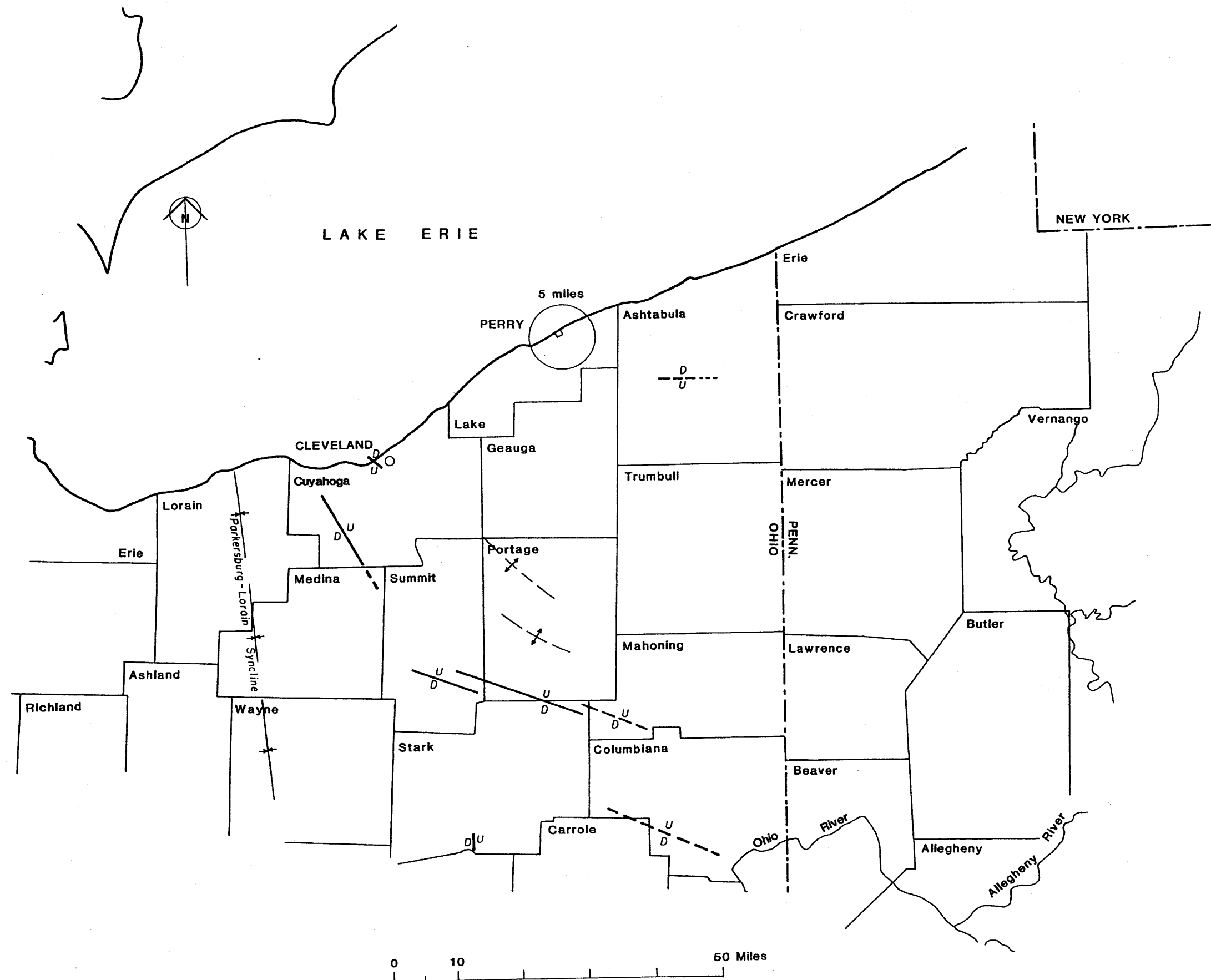
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

ERTS and SAR Lineaments

Figure 2.5-113



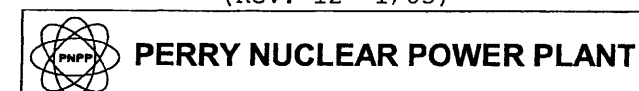
# EXPLANATION

- Anticline
- Syncline
- Fault with displacement indicated

Note: All structures dashed where inferred.

Source: ( 52 and 212 )

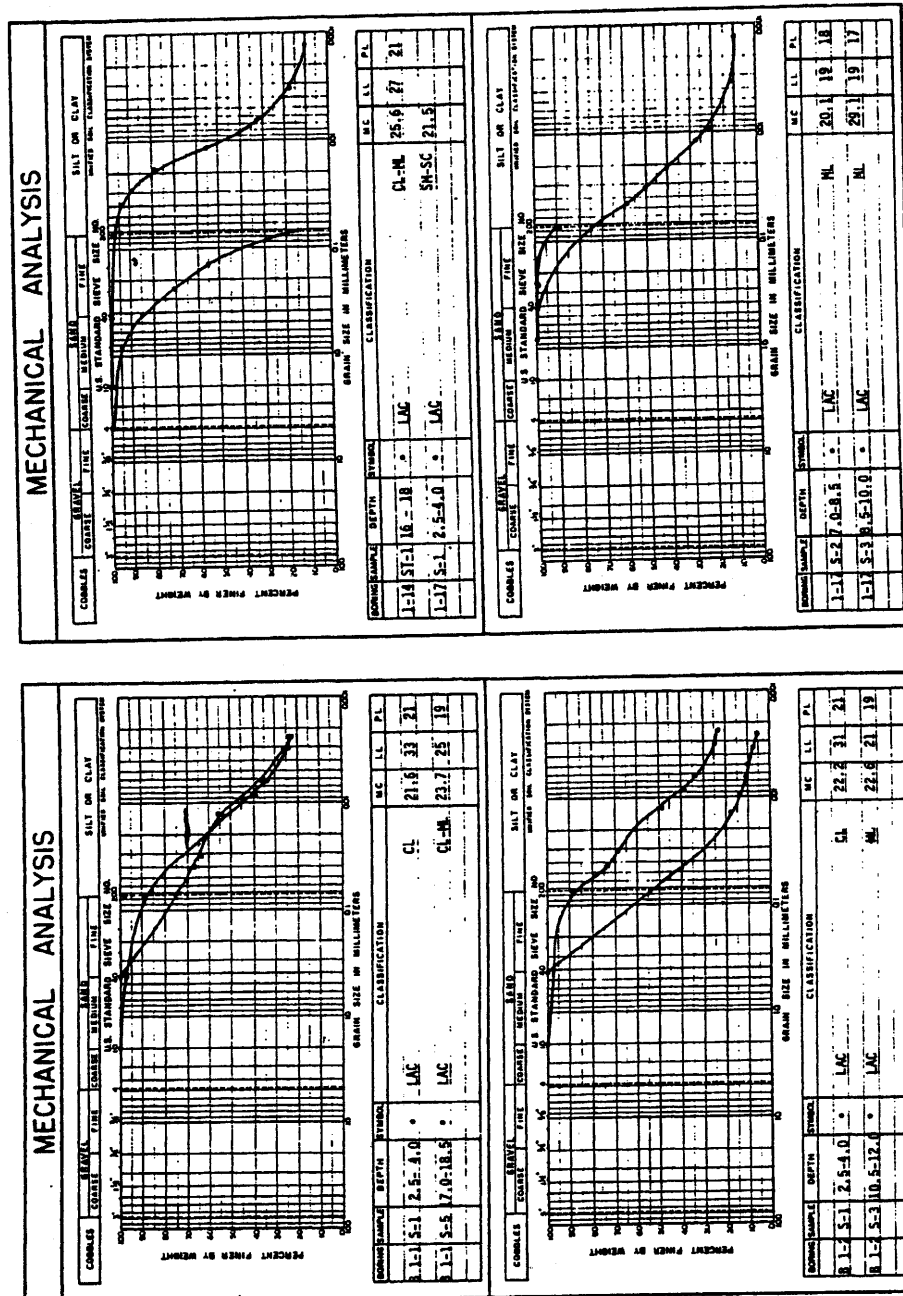
(Rev. 12 1/03)



PERRY NUCLEAR POWER PLANT

Structure Map of Northeastern Ohio

Figure 2.5-114



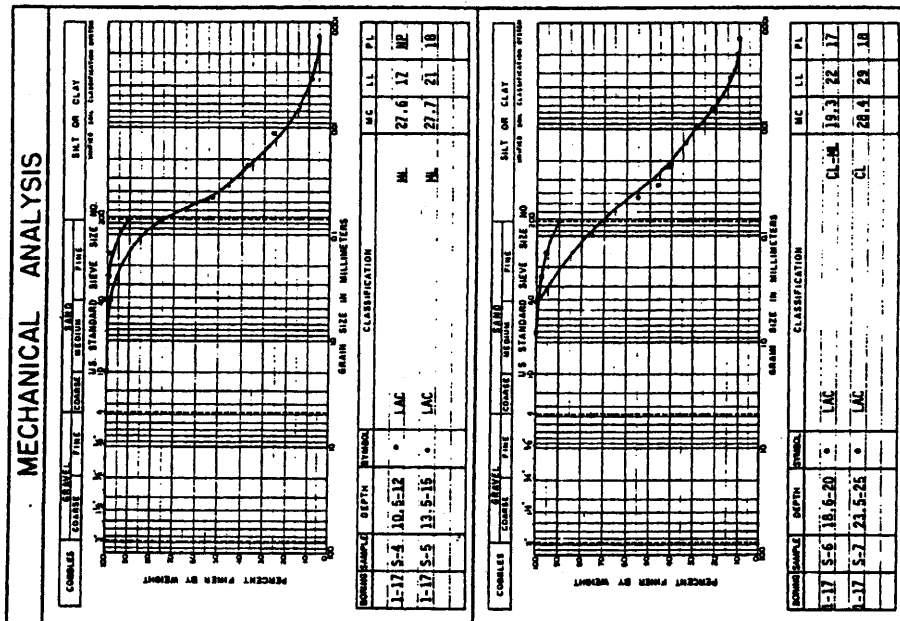
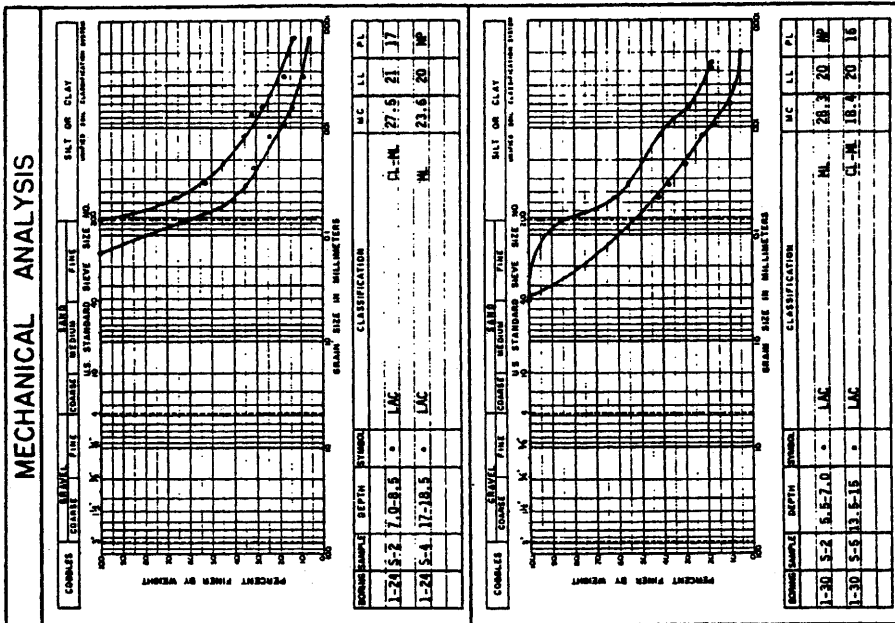
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Lacustrine Sediments

Figure 2.5-115 (Sheet 1 of 6)



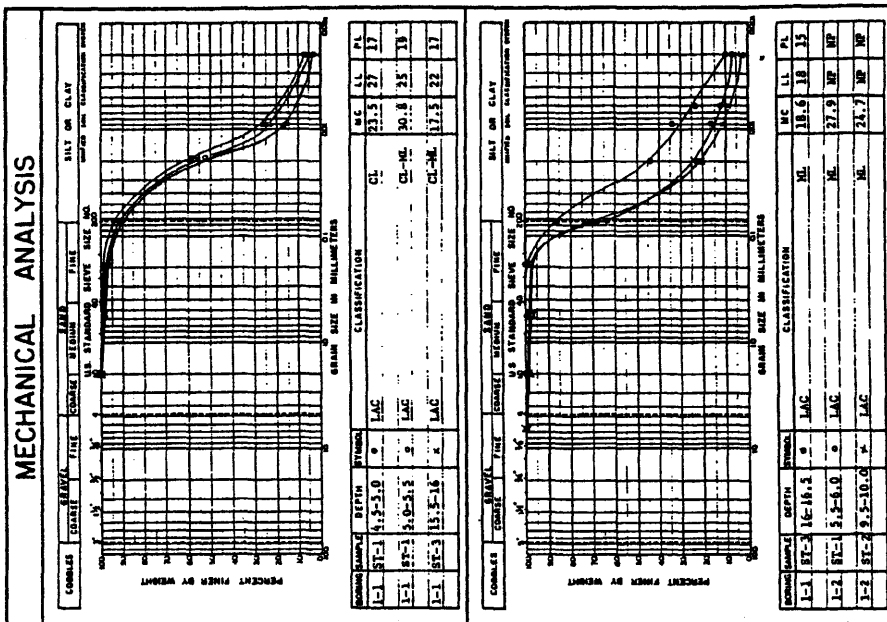
(Rev. 12-1-03)



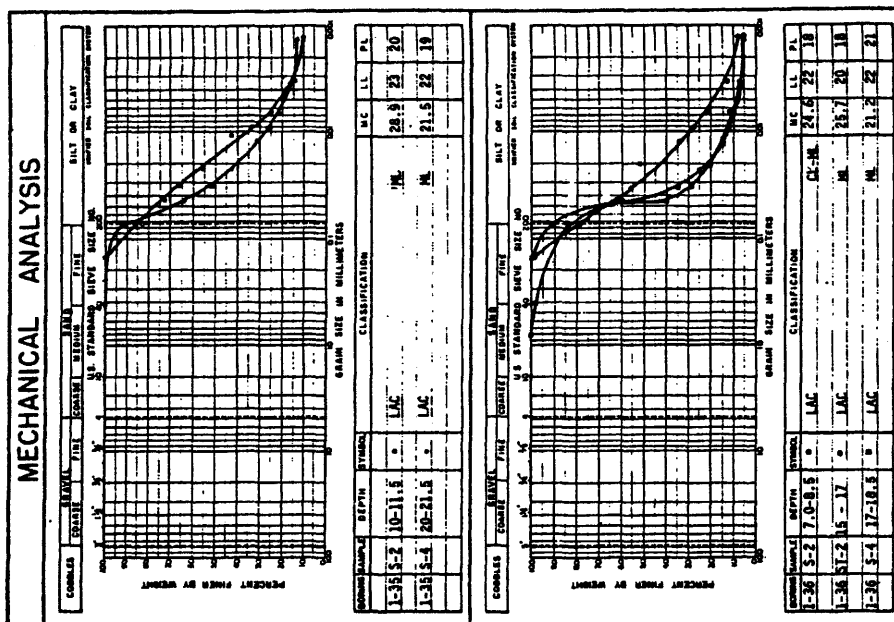
**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Lacustrine Sediments

Figure 2.5-115 (Sheet 2 of 6)



(Tested by Heron Testing Laboratories)



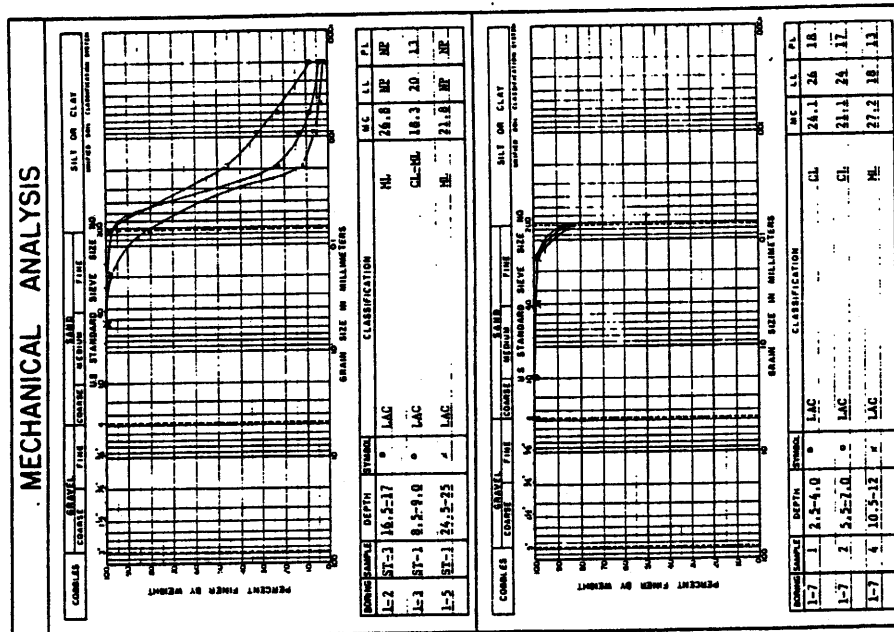
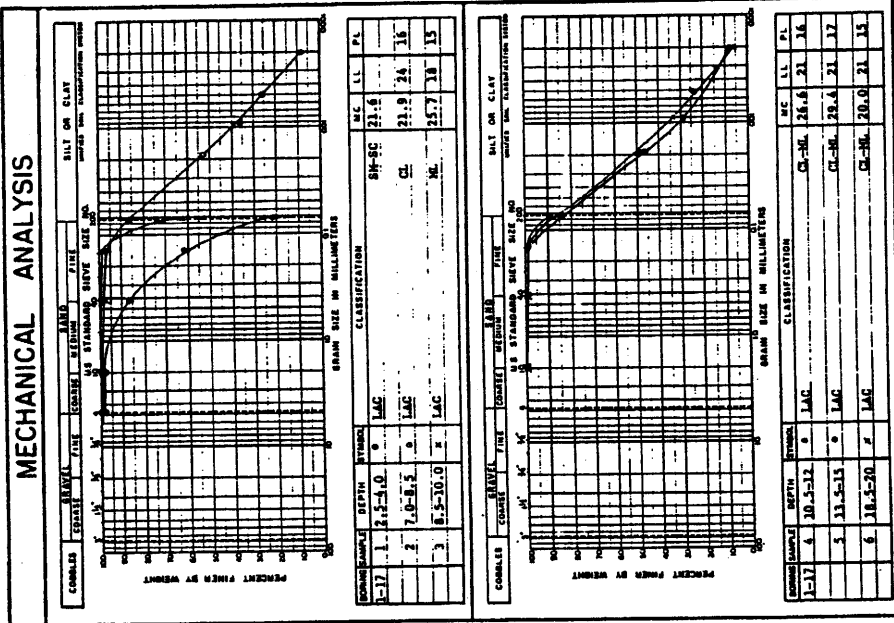
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Lacustrine Sediments

Figure 2.5-115 (Sheet 3 of 6)



(Tested by Hannon Testing Laboratories)

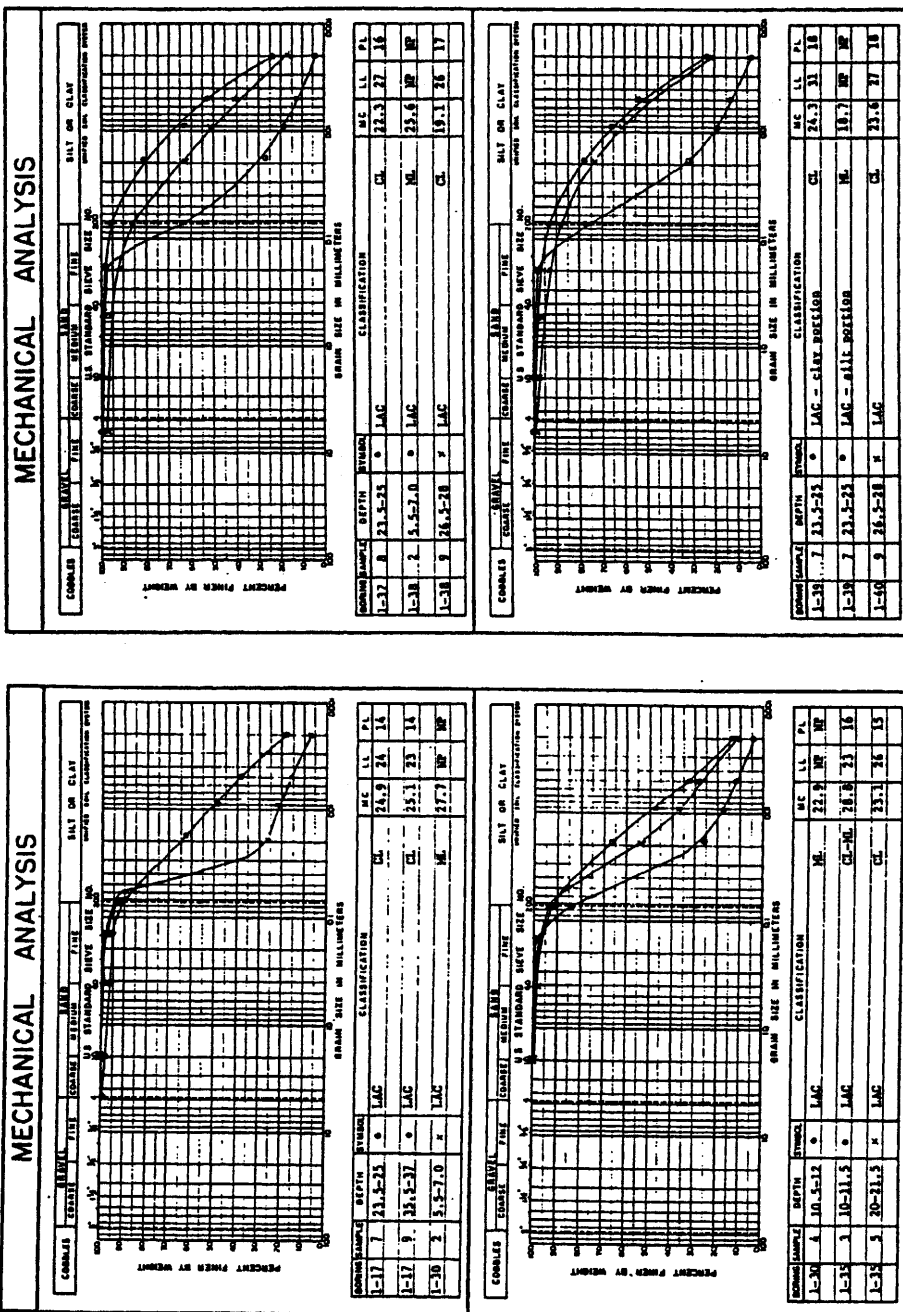


**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Lacustrine Sediments

Figure 2.5-115 (Sheet 4 of 6)

(Rev. 12 1/03)



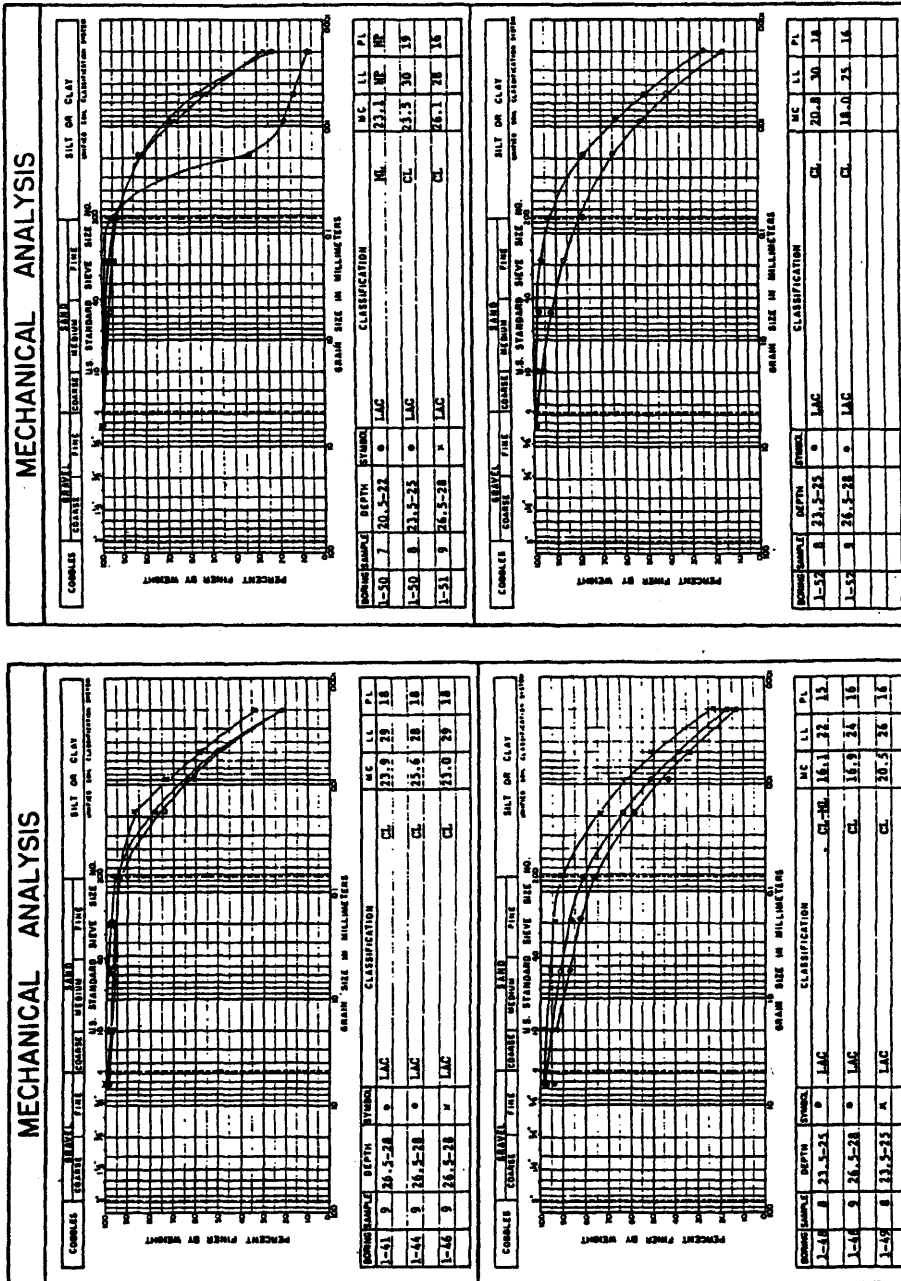
(Tested by Herron Testing Laboratories)

(Rev. 12 1/03)

## PERRY NUCLEAR POWER PLANT

Grain Size Distribution Curves -  
Lacustrine Sediments

Figure 2.5-115 (Sheet 5 of 6)



(Tested by Heron Testing Laboratories)

(Rev. 12 1/03)

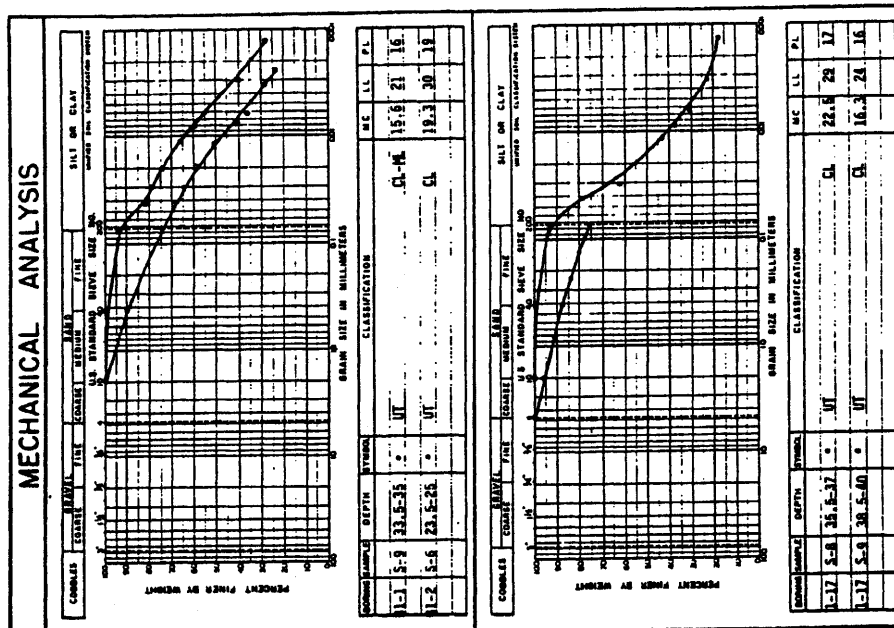
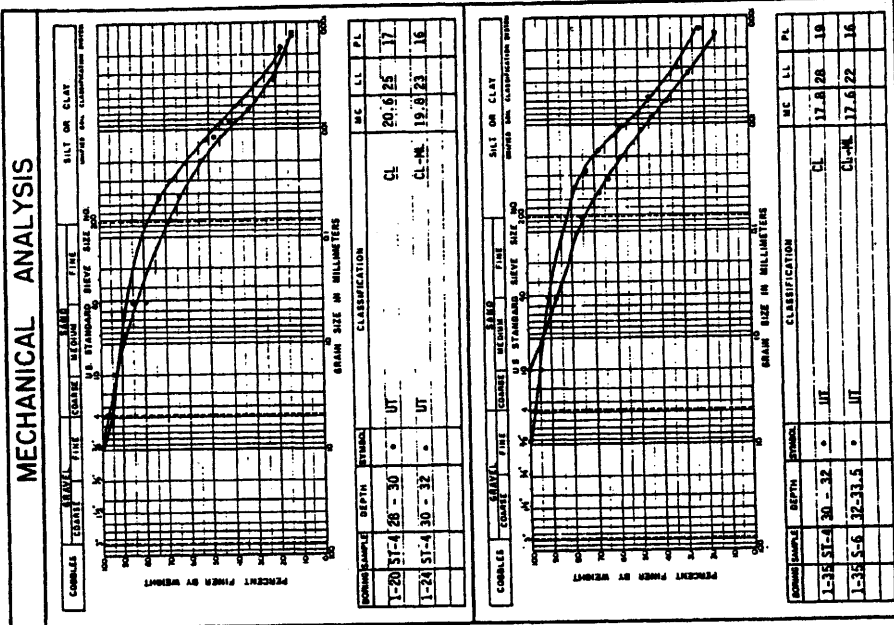


**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Lacustrine Sediments

Figure 2.5-115 (Sheet 6 of 6)





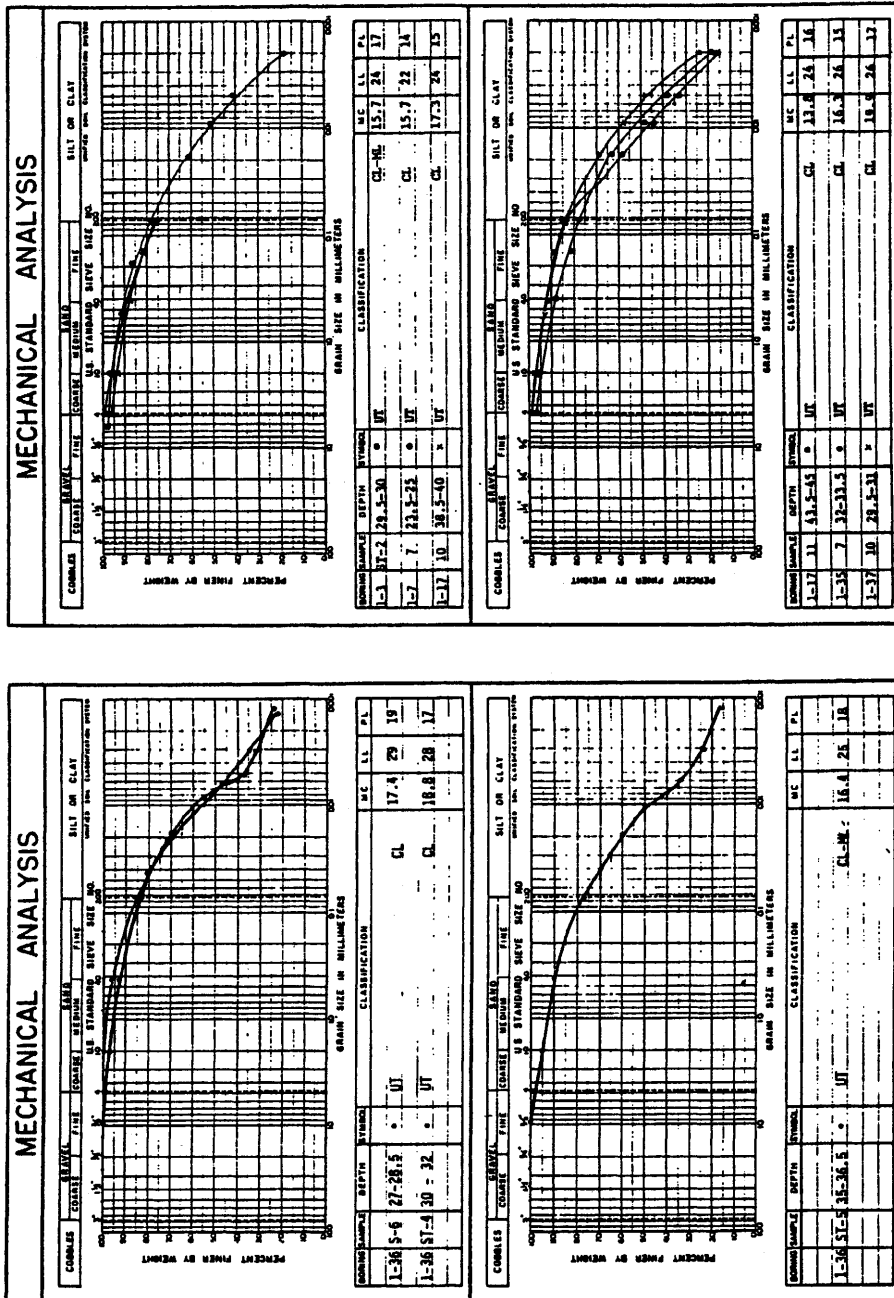
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Upper Till

Figure 2.5-116 (Sheet 1 of 5)



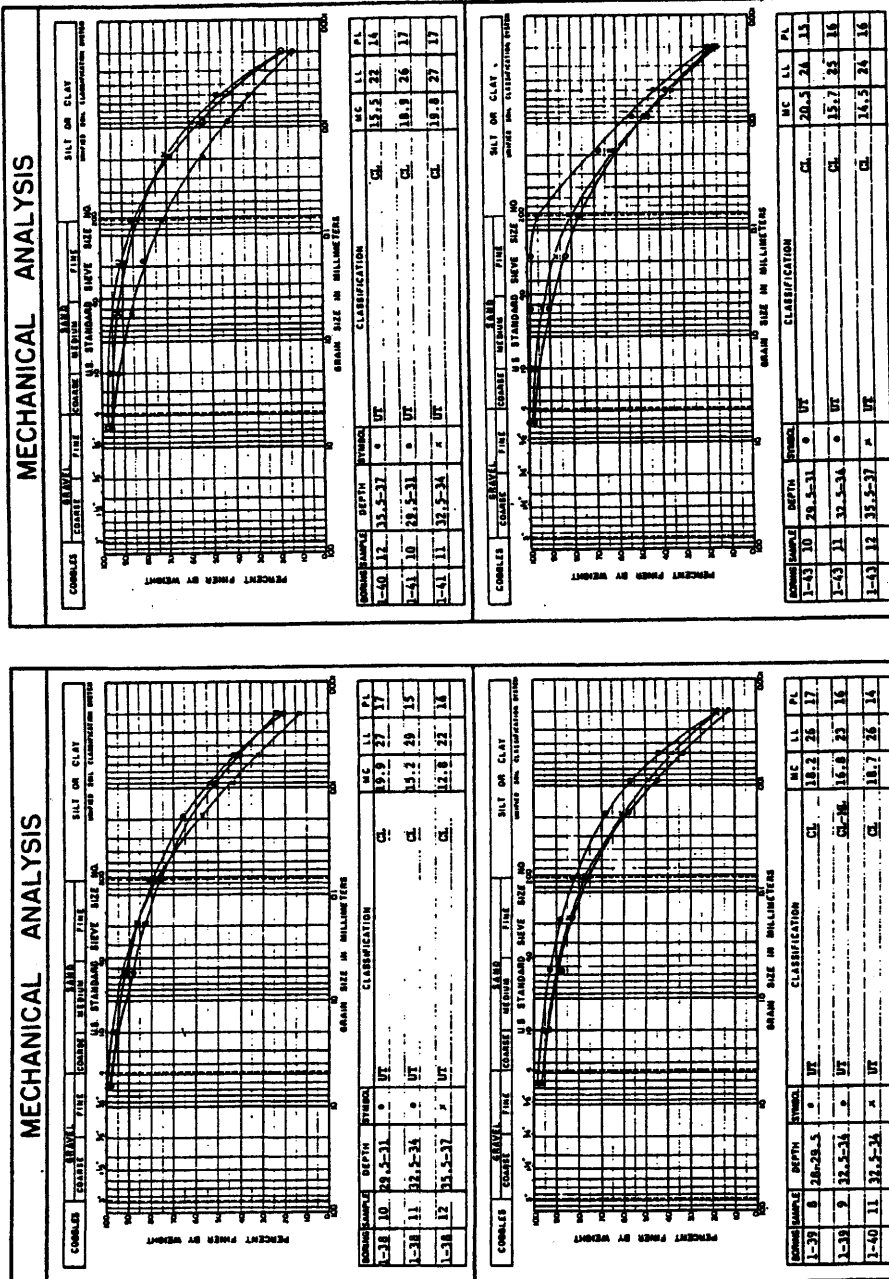
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Upper Till

Figure 2.5-116 (Sheet 2 of 5)



(Tested by Herron Testing Laboratories)

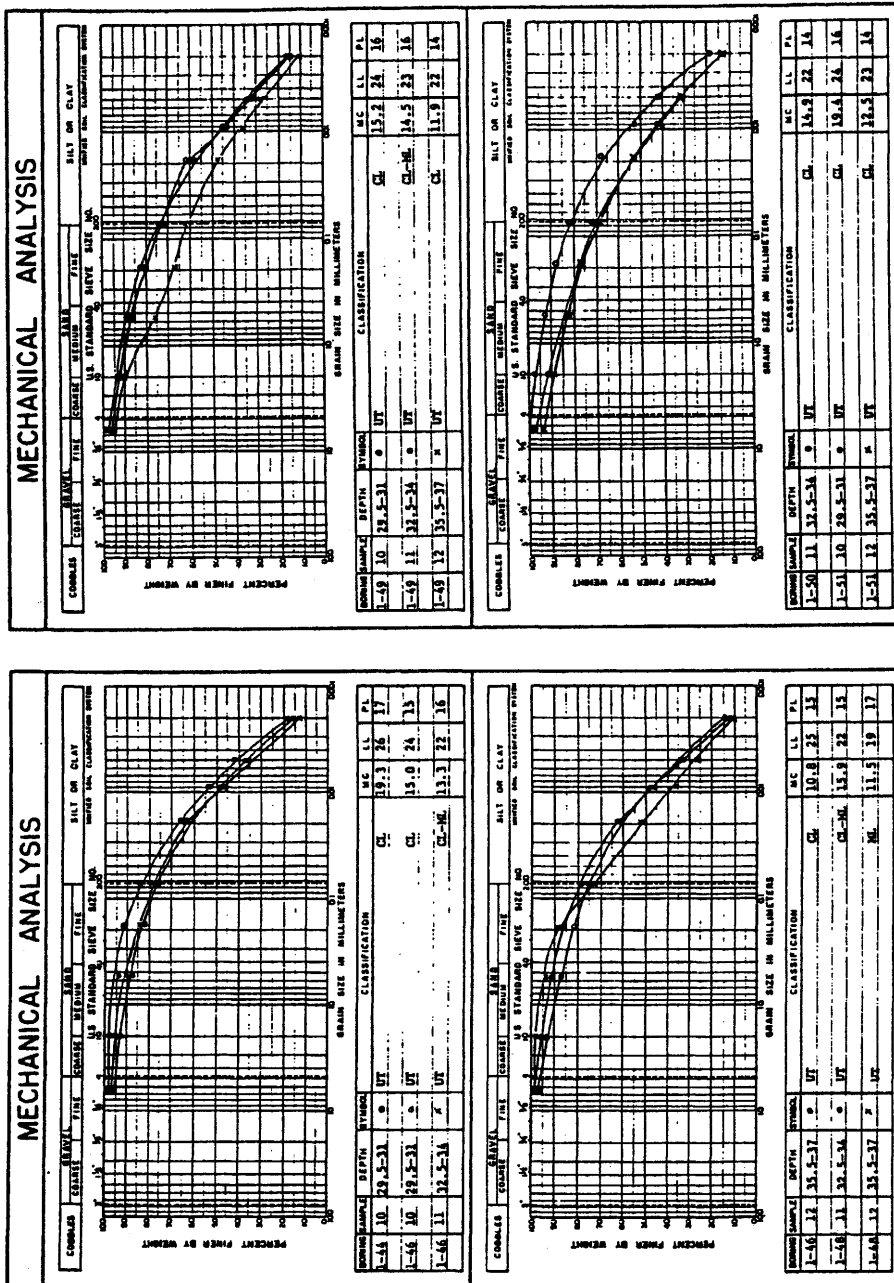
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Upper Till

Figure 2.5-116 (Sheet 3 of 5)



(Tested by Hannon Testing Laboratories)

(Rev. 12 1/03)

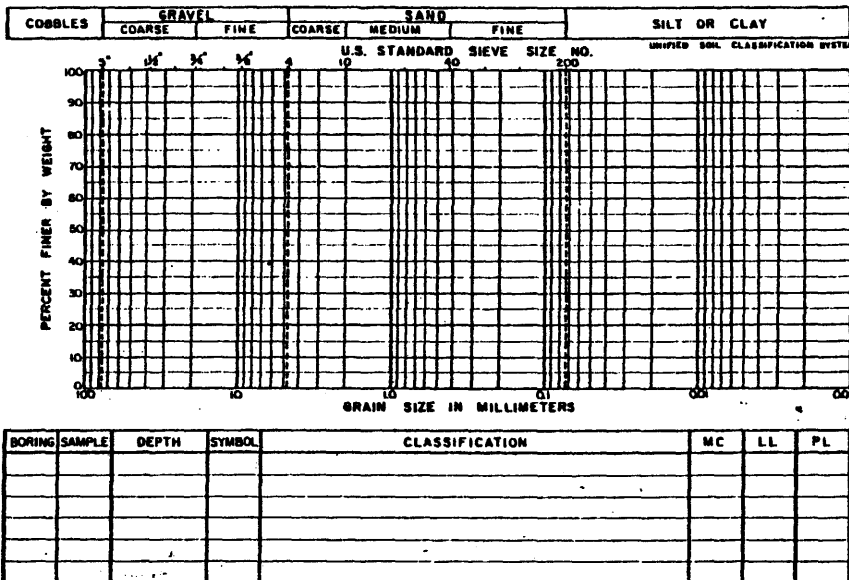
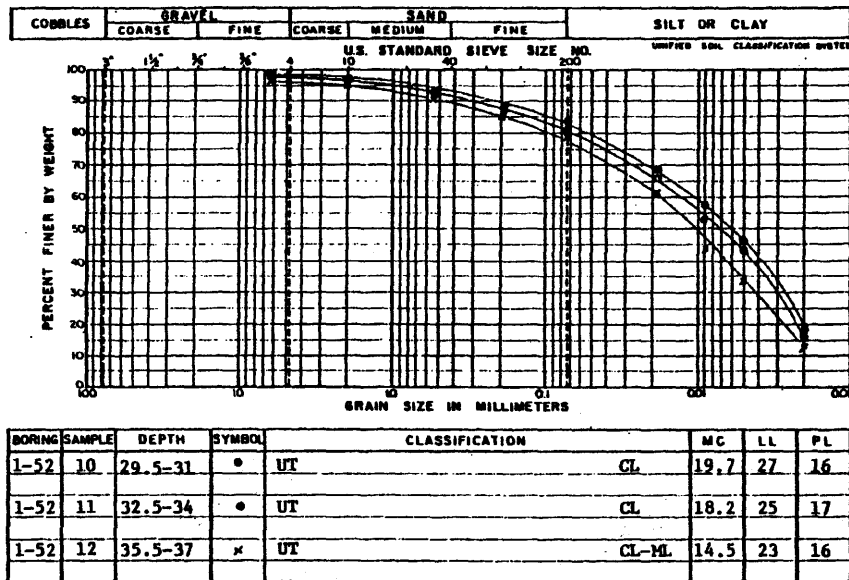


**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Upper Till

Figure 2.5-116 (Sheet 4 of 5)

# MECHANICAL ANALYSIS



(Tested by Herron Testing Laboratories)

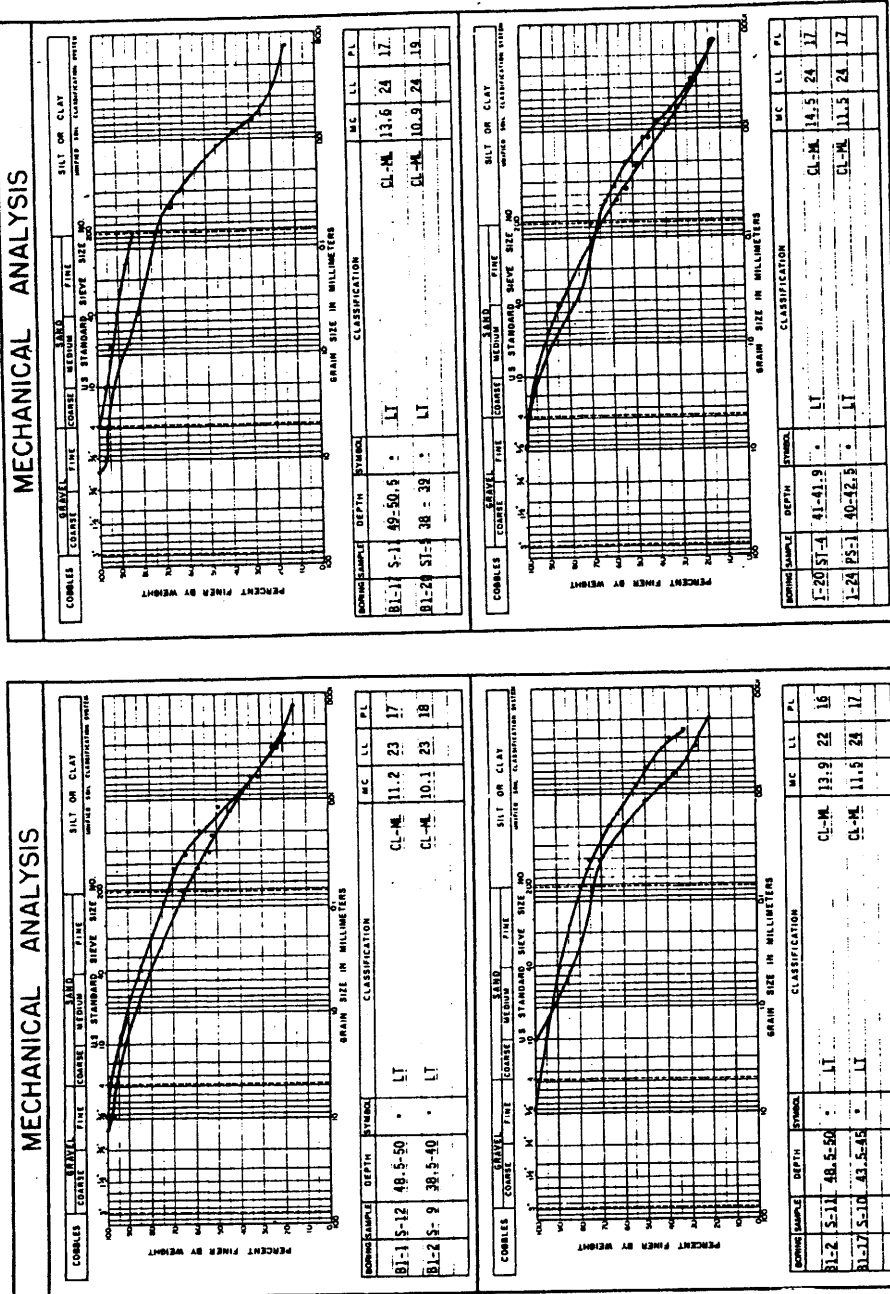
(Rev. 12 1/03)



PERRY NUCLEAR POWER PLANT

Grain Size Distribution Curves -  
Upper Till

Figure 2.5-116 (Sheet 5 of 5)



(Rev. 12 1/03)

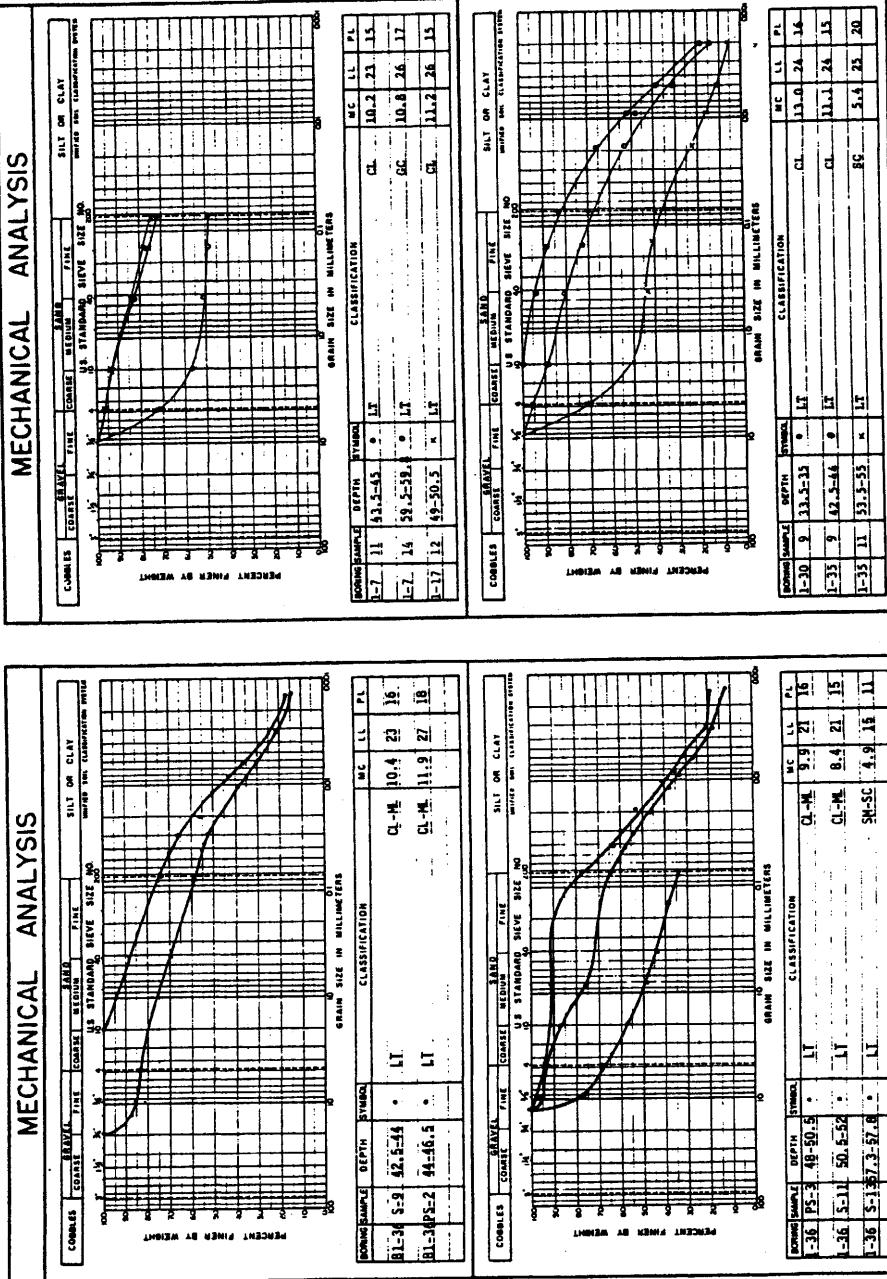


**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Lower Till

Figure 2.5-117 (Sheet 1 of 6)





(Tested by Harrop Testing Laboratories)

(Rev. 12 1/03)

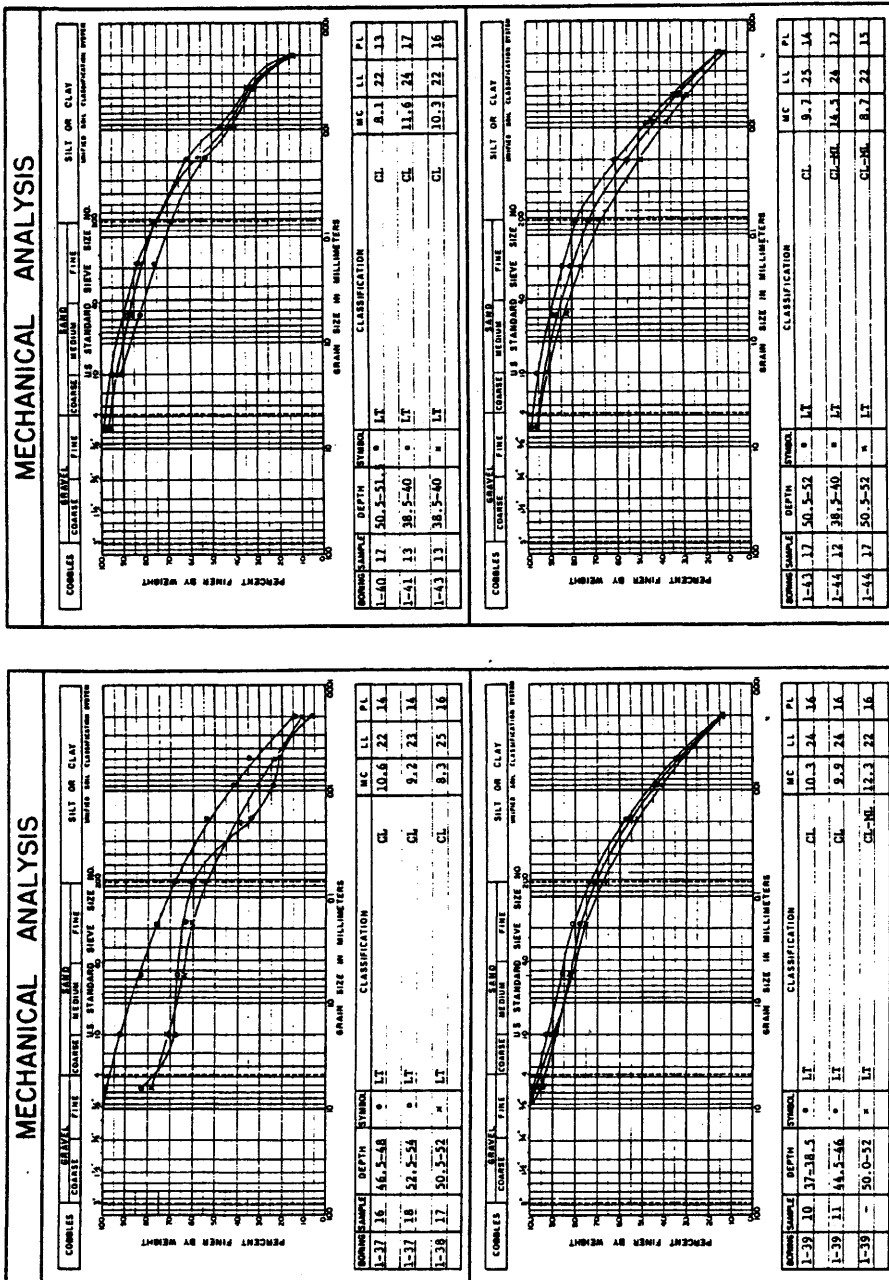


**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Lower Till

Figure 2.5-117 (Sheet 3 of 6)





(Rev. 12 1/03)



PERRY NUCLEAR POWER PLANT

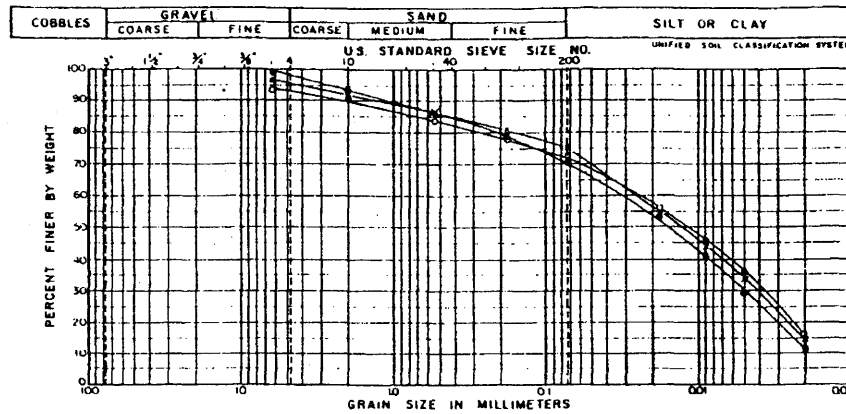
Grain Size Distribution Curves -  
Lower Till

Figure 2.5-117 (Sheet 4 of 6)

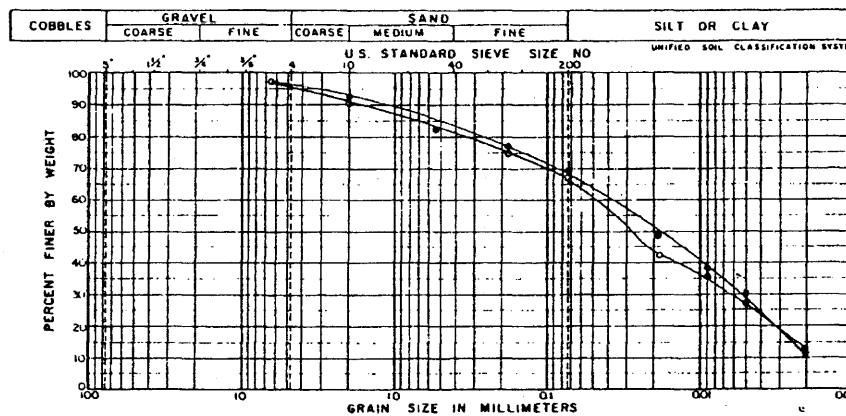
(Tested by Herron Testing Laboratories)



# MECHANICAL ANALYSIS



BORING	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
1-52	13	38.5-40	•	LT CL	11.5	23	14
1-52	14	41.5-43	°	LT CL-ML	11.9	21	15
1-52	15	44.5-46	x	LT CL	10.9	24	16



BORING	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
1-52	16	47.5-49	°	LT CL	8.0	20	12
1-52	17	50.5-52	•	LT CL	8.3	22	13

(Tested by Herron Testing Laboratories)

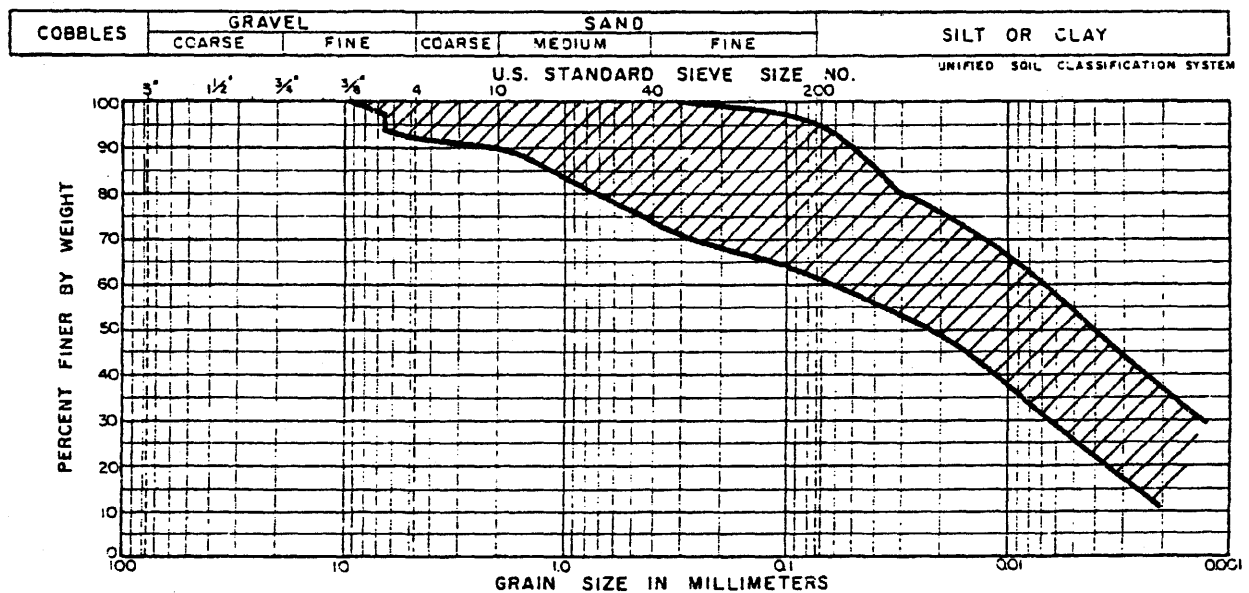
(Rev. 12 1/03)



PERRY NUCLEAR POWER PLANT

Grain Size Distribution Curves -  
Lower Till

Figure 2.5-117 (Sheet 6 of 6)



NOTE: RANGE REPRESENTS THE RESULTS OF 44 TESTS

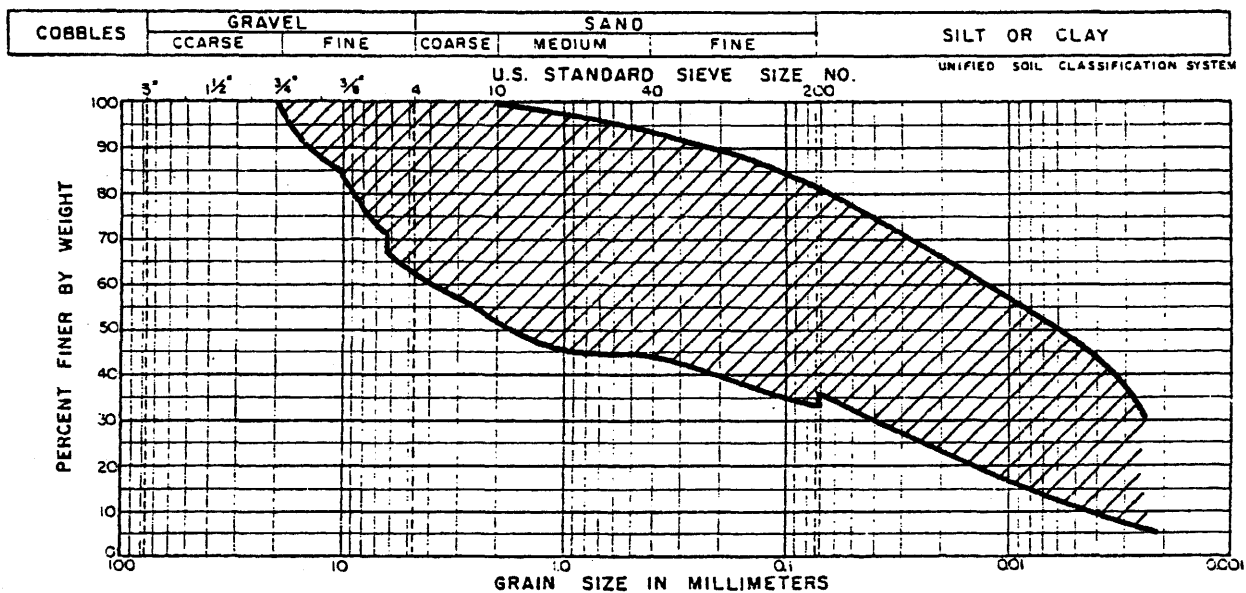
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Range of Grain Size Distribution  
Test Results for Upper Till

Figure 2.5-118



NOTE: RANGE REPRESENTS THE RESULTS OF 56 TESTS

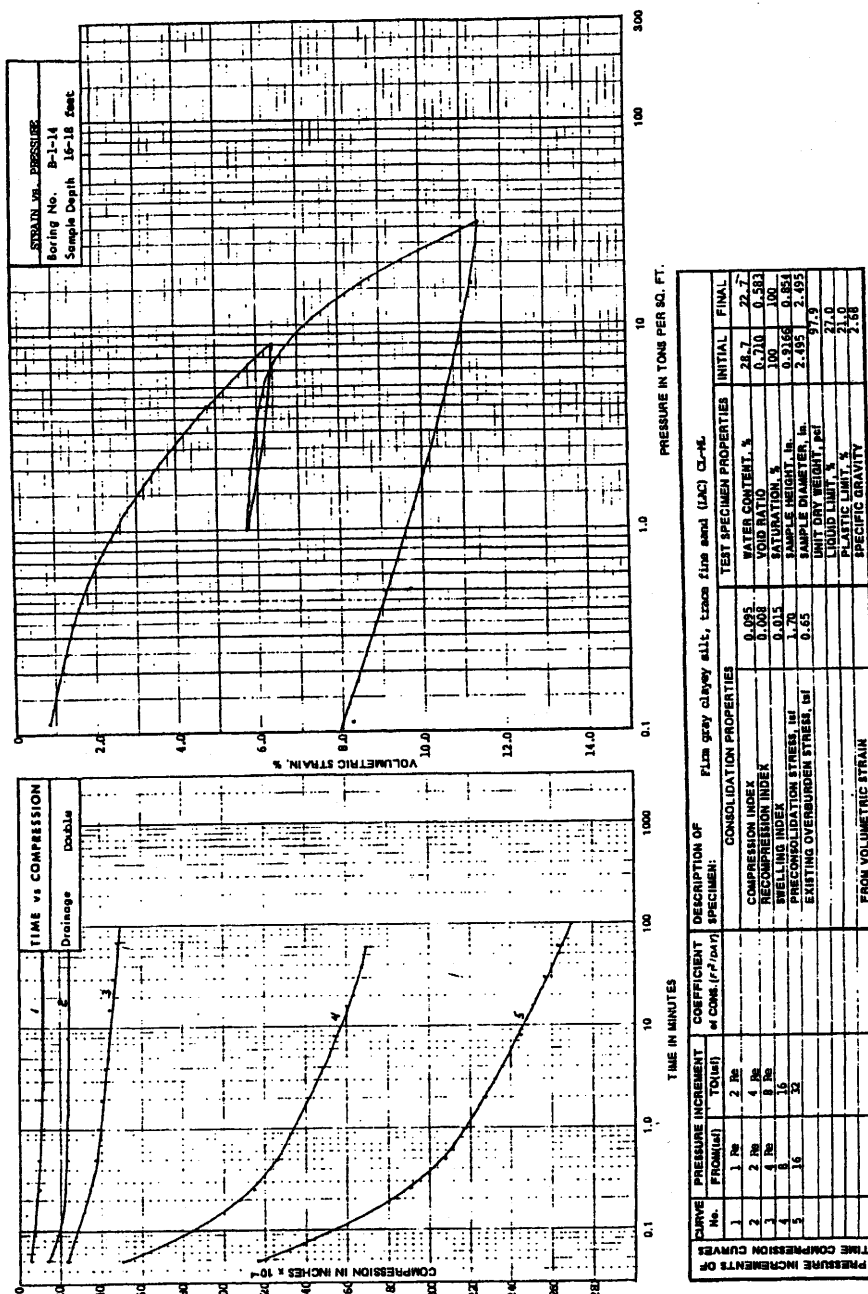
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Range of Grain Size Distribution  
Test Results for Lower Till

Figure 2.5-119



CURVE No.	PRESSURE INCREMENT FROM (psi)	TIME IN MINUTES	COEFFICIENT OF COM. (C <sub>v</sub> /100)	DESCRIPTION OF SPECIMEN	CONSOLIDATION PROPERTIES		TEST SPECIMEN PROPERTIES	
					COMPRESSION INDEX	EXPANSION INDEX	WATER CONTENT, %	VOID RATIO
1	1 ps	2 ps		COMPRESSION INDEX	0.095		28.7	0.583
2	2 ps	4 ps		EXPANSION INDEX	0.008		0.710	0.583
3	4 ps	8 ps		WELLING INDEX	0.015		100	100
4	8 ps	16 ps		PRECONSOLIDATION STRESS, psi	1.70		0.9368	0.851
5	16 ps	32 ps		EXISTING OVERBURDEN STRESS, psi	0.65		2.495	2.495
				UNIT WEIGHT, pcf			77.0	
				WATER CONTENT, %			27.0	
				PLASTIC LIMIT, %			21.0	
				SPECIFIC GRAVITY			2.58	
				FROM VOLUMETRIC STRAIN				

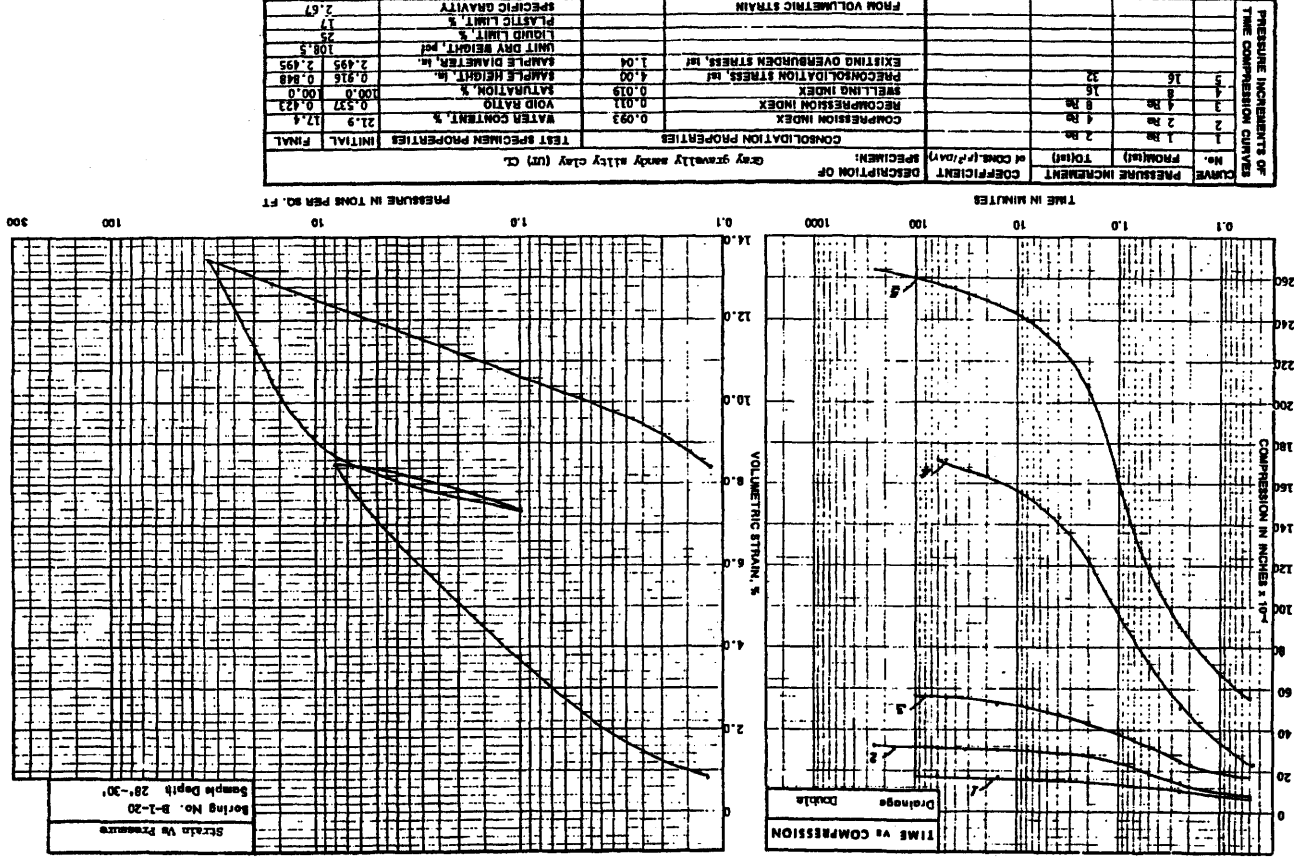
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Typical Consolidation Test  
Curves - Lacustrine Sediments

Figure 2.5-120



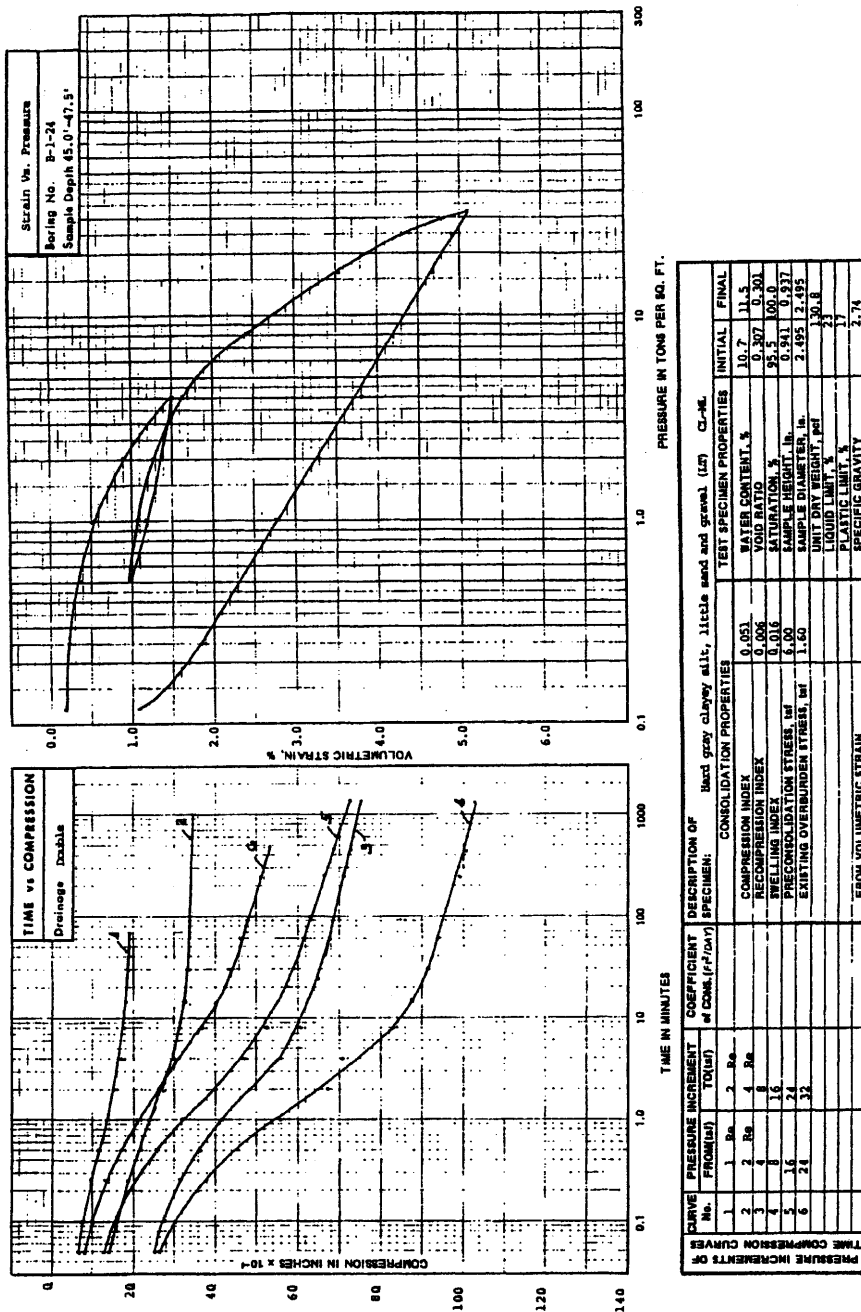
(Rev. 12 1/03)



# PERRY NUCLEAR POWER PLANT

Typical Consolidation Test  
Curves - Upper Till

Figure 2.5-121



(Rev. 12 1/03)

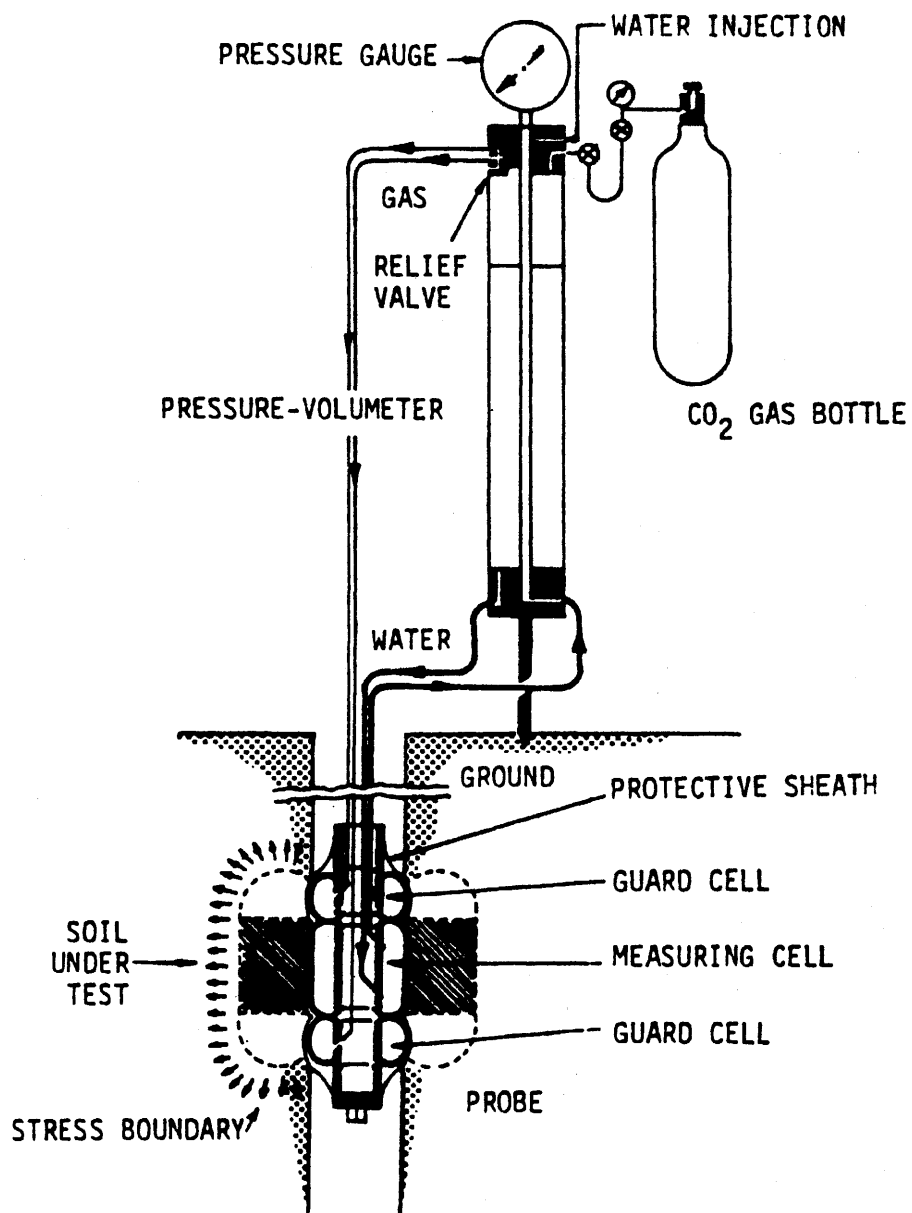


## PERRY NUCLEAR POWER PLANT

Typical Consolidation Test  
Curves - Lower Till

Figure 2.5-122





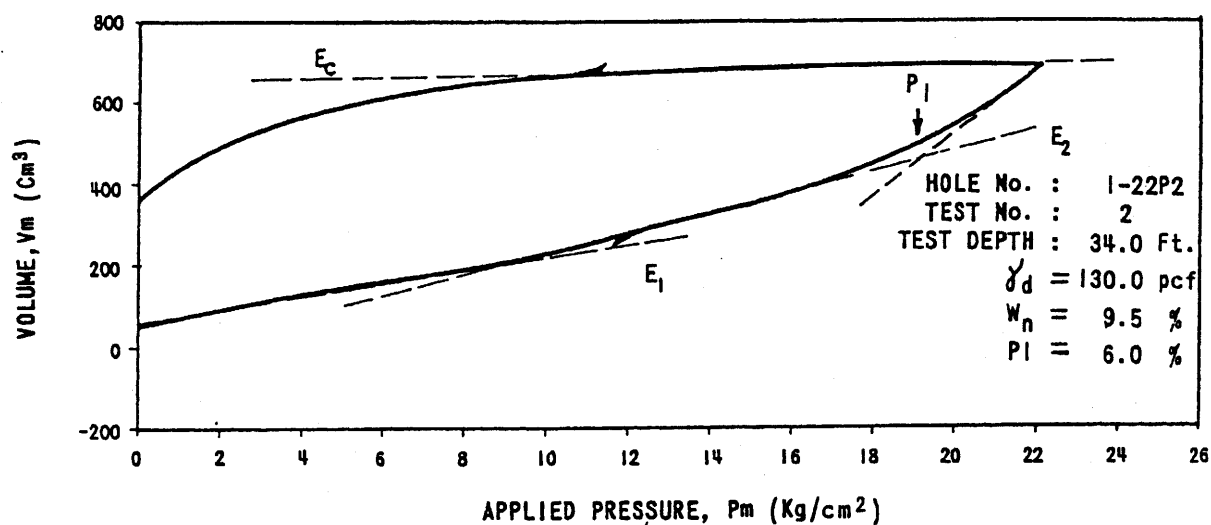
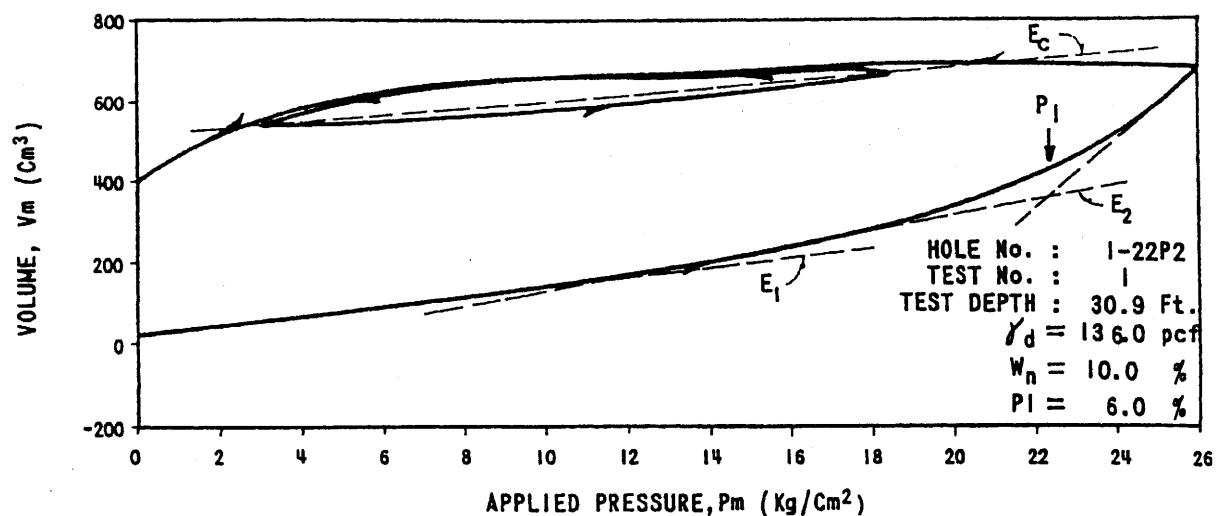
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Schematic Representation of  
Pressuremeter

Figure 2.5-123



(Rev. 12 1/03)



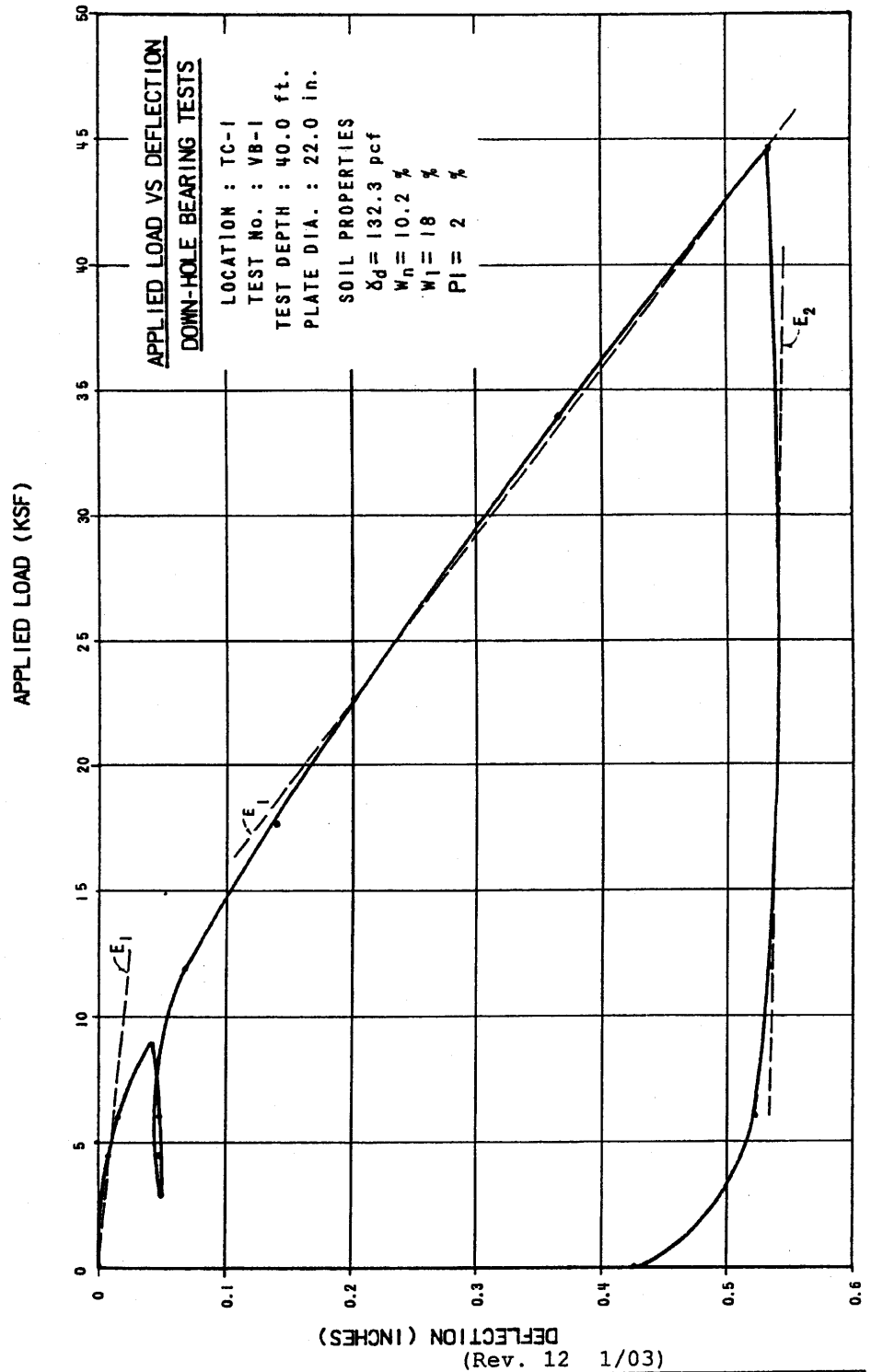
**PERRY NUCLEAR POWER PLANT**

Typical Pressuremeter Test  
 Curves - Lower Till

Figure 2.5-124



Figure 2.5-125



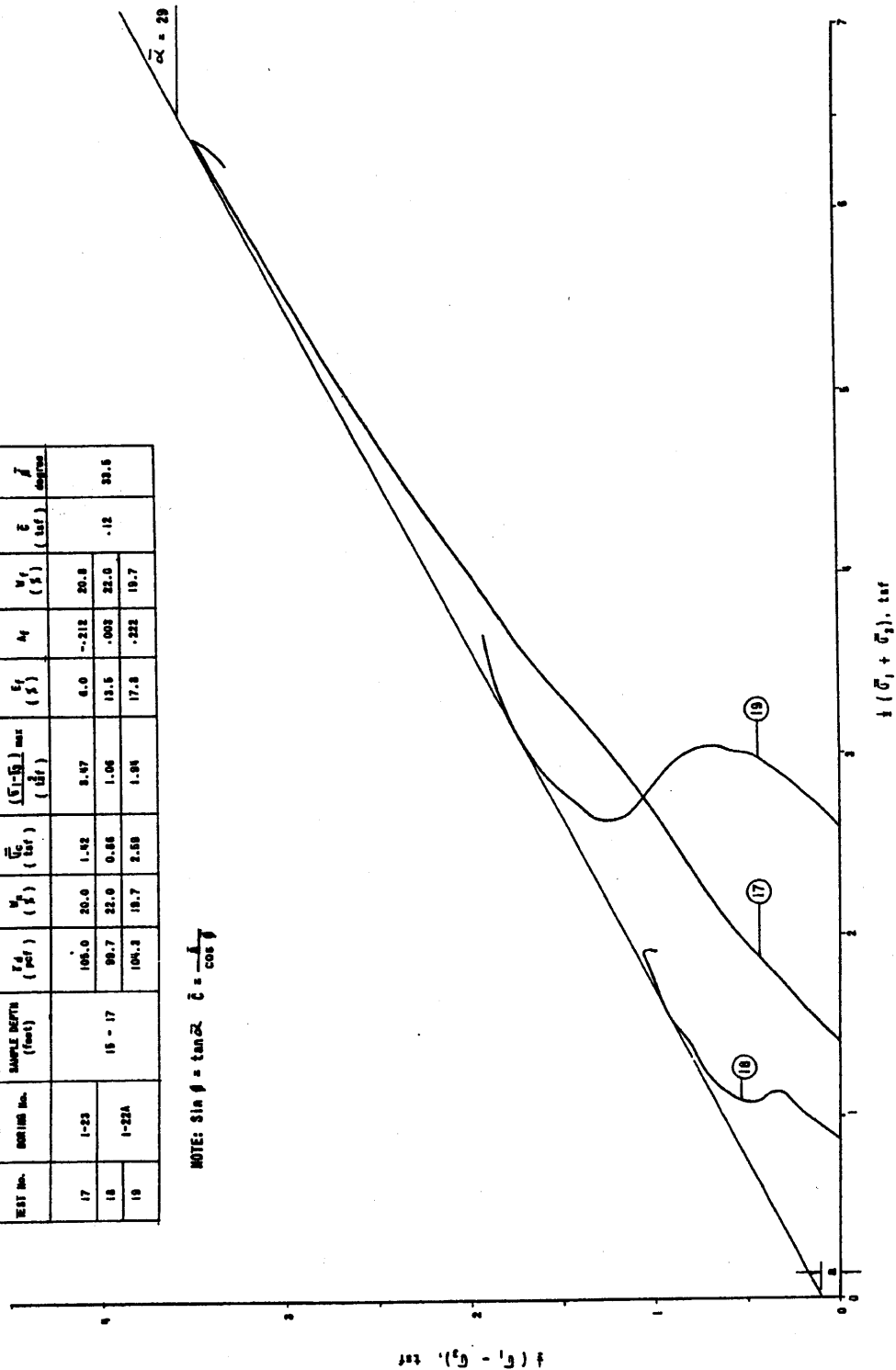
**PERRY NUCLEAR POWER PLANT**

Typical Plate Loading Test  
Curve - Lower Till

Figure 2.5-126

TEST No.	SOIL No.	SAMPLE DEPTH (feet)	$\gamma_d$ (pcf)	$\bar{u}_v$ (pcf)	$\frac{(\bar{u}_v - \bar{u}_h)}{\bar{u}_v}$	$\bar{u}_h$ (pcf)	$E_t$ (psi)	$A_v$	$W_t$ (%)	$\bar{e}$ (pcf)	$\bar{f}$ degrees
17	1-23		106.0	1.42	0.47	6.0	20.8	-.212	20.8		
18	15-17		99.7	0.86	1.06	13.5	22.0	.003	22.0	.12	
19	1-22A		104.2	2.55	1.96	17.8	19.7	-.222	19.7		

NOTE:  $\sin \phi = \tan \alpha$   $\bar{c} = \frac{A_v}{\cos \phi}$



(Rev. 12 1/03)



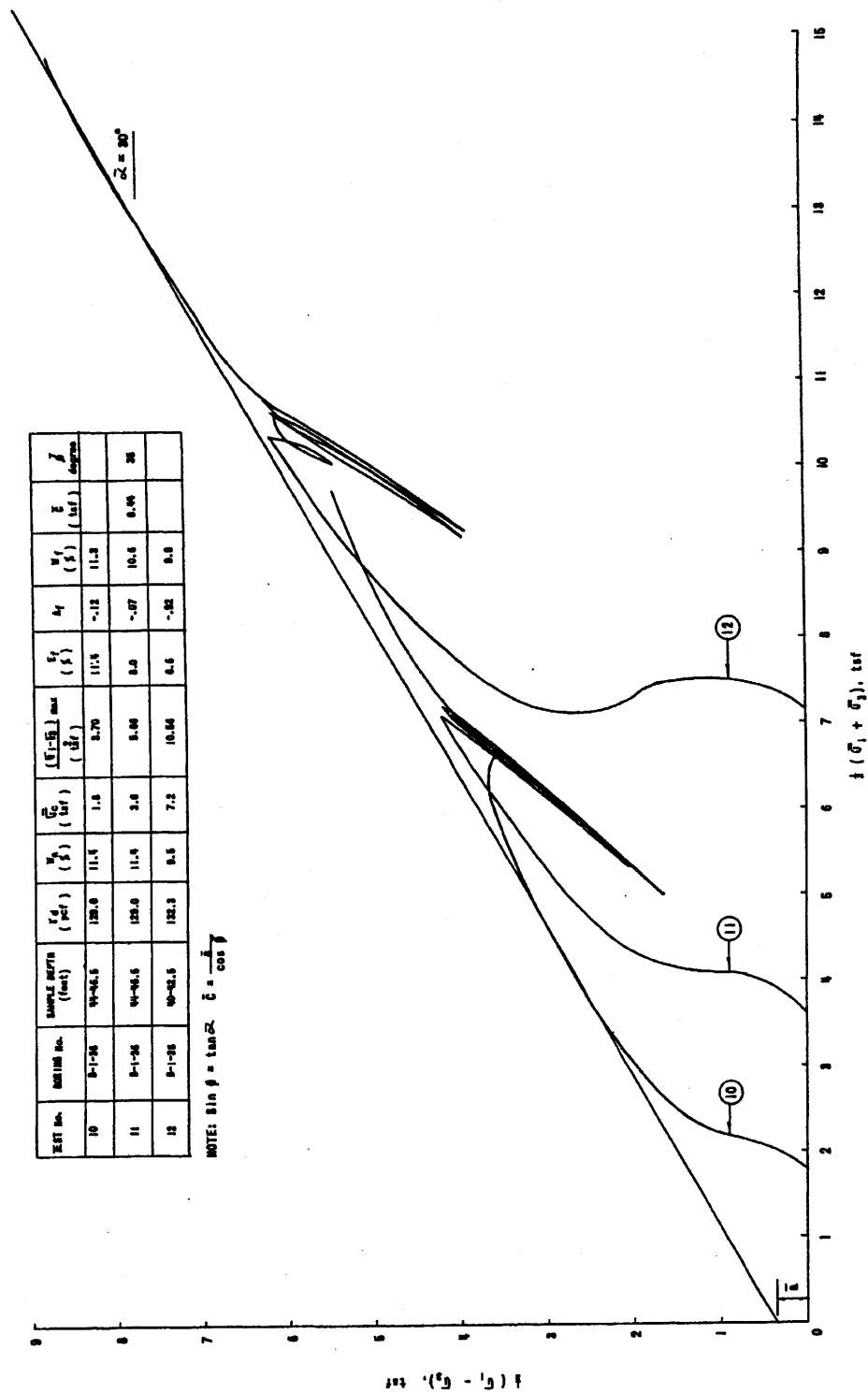
PERRY NUCLEAR POWER PLANT

Typical Effective Stress Paths -  
Lacustrine Sediments

Figure 2.5-127



Figure 2.5-128



†  $\frac{1}{2} (\sigma_1 - \sigma_3)$

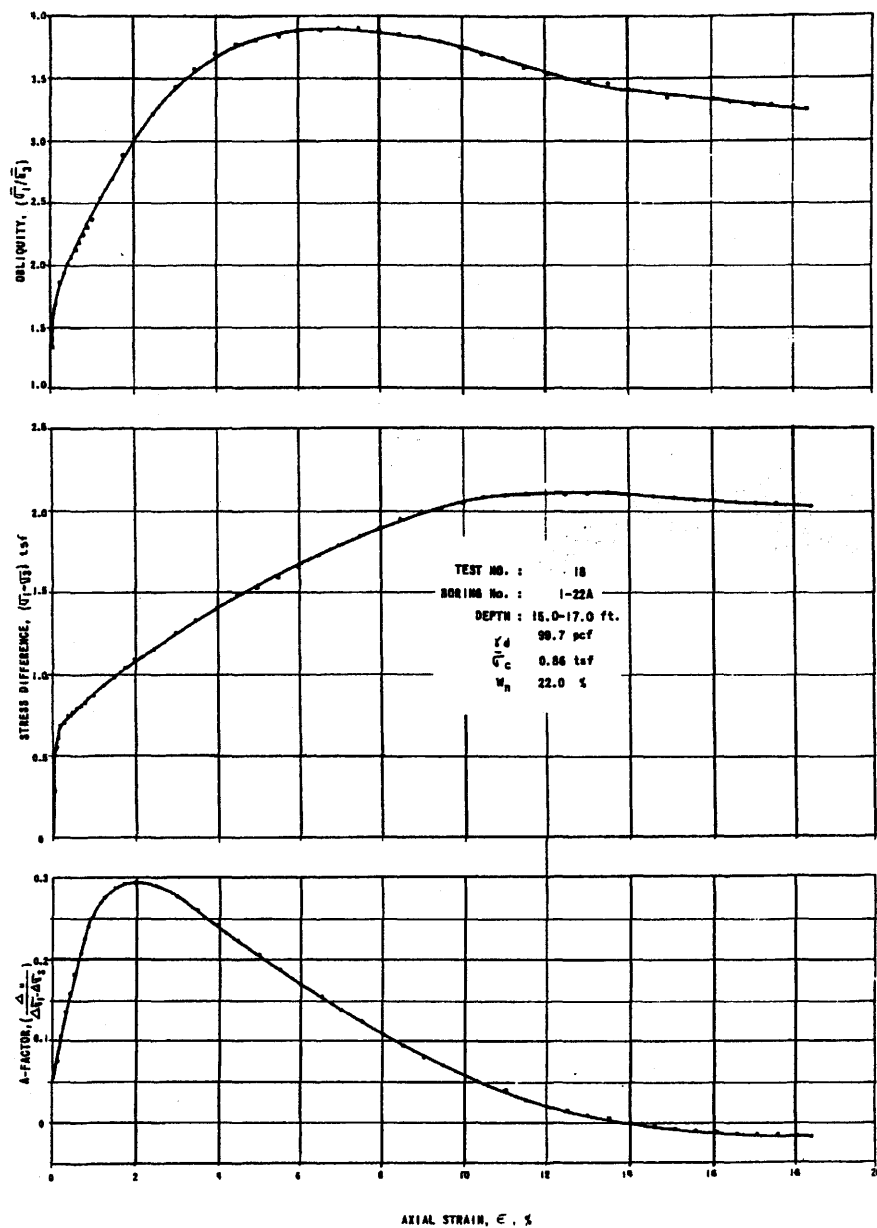
(Rev. 12 1/03)



PERRY NUCLEAR POWER PLANT

Typical Effective Stress Paths -  
Lower Till

Figure 2.5-129



(Rev. 12 1/03)

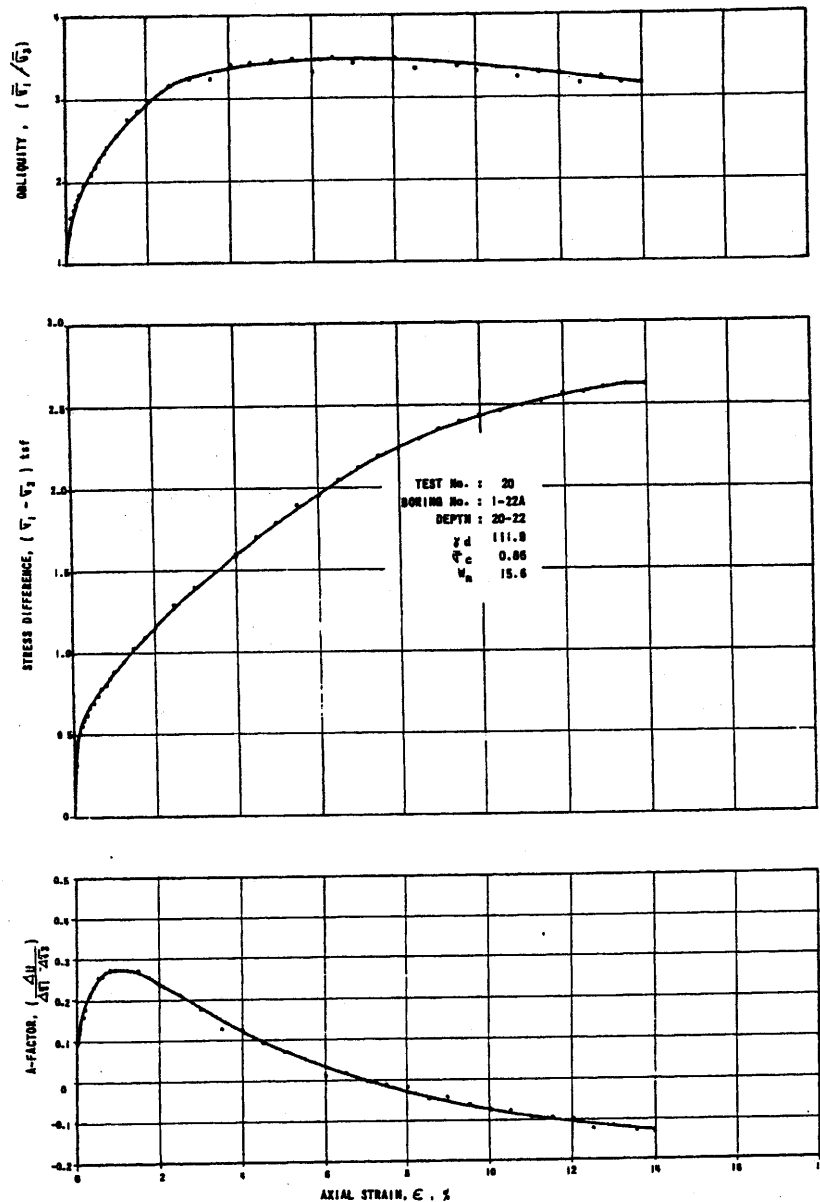


**PERRY NUCLEAR POWER PLANT**

Typical Effective Stress -  
 Strength Characteristics of  
 Lacustrine Sediments

Figure 2.5-130





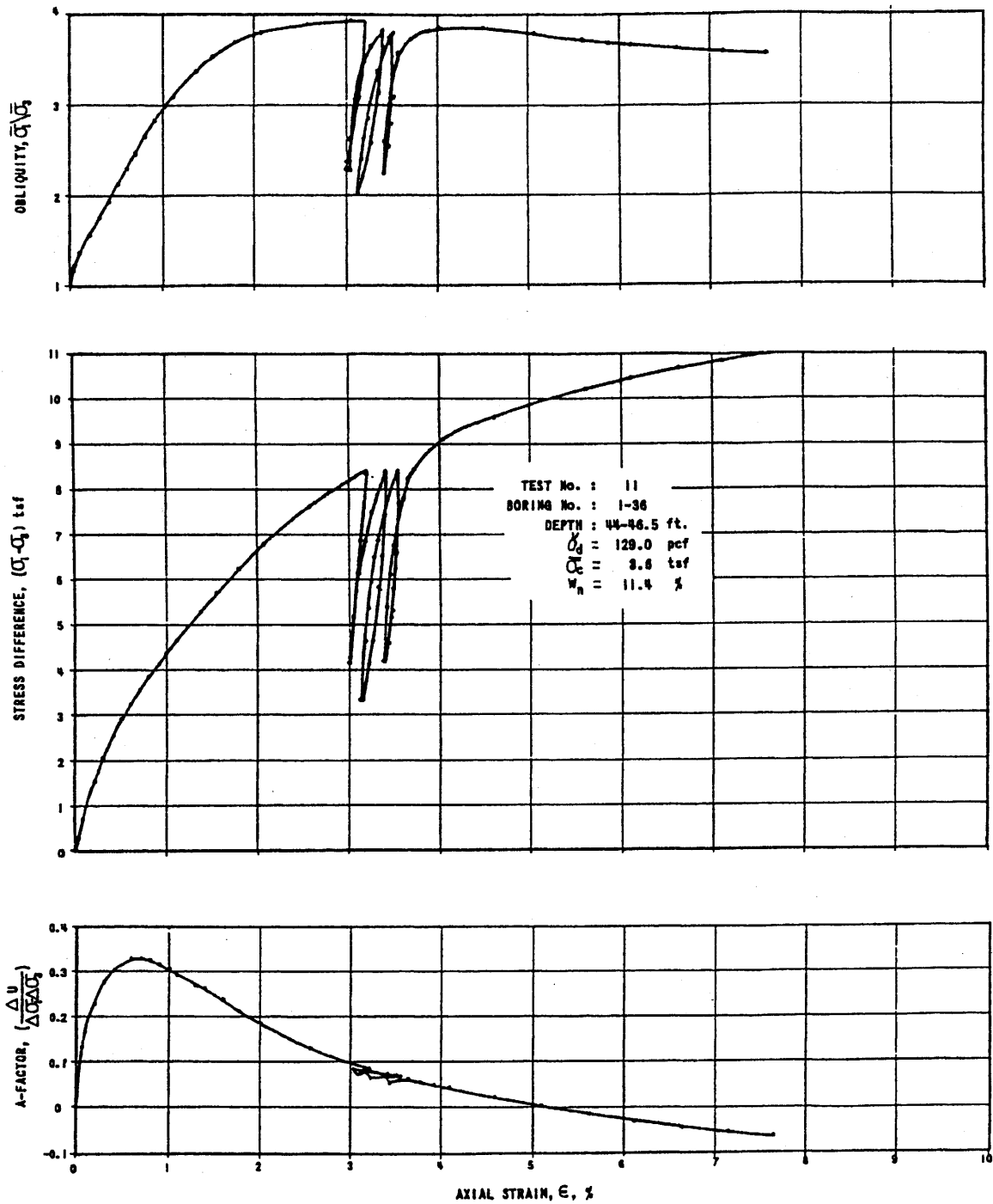
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Typical Effective Stress -  
Strength Characteristics of  
Lower Till

Figure 2.5-131



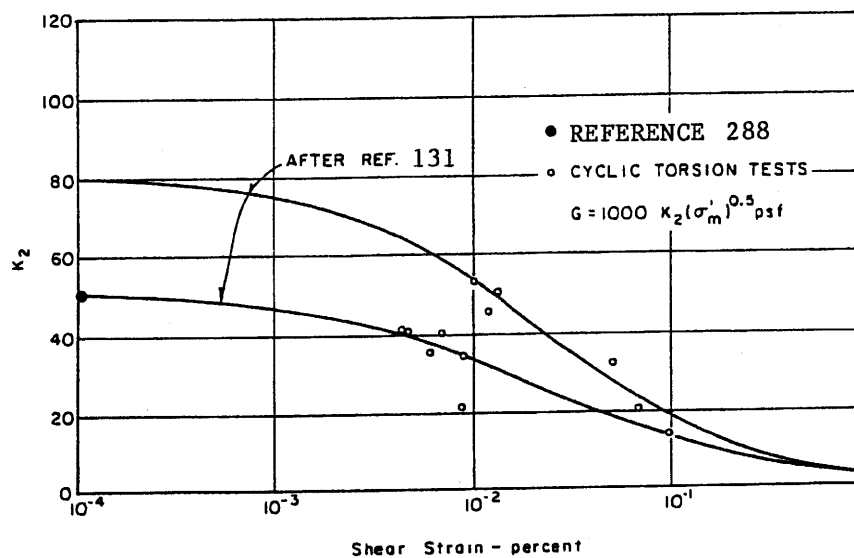
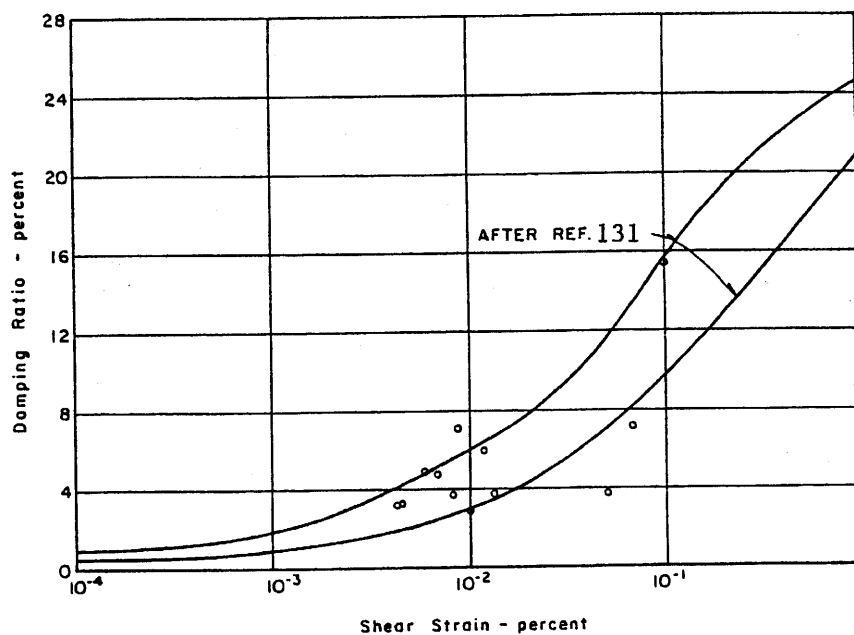
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Typical Effective Stress -  
 Strength Characteristics of  
 Upper Till

Figure 2.5-132



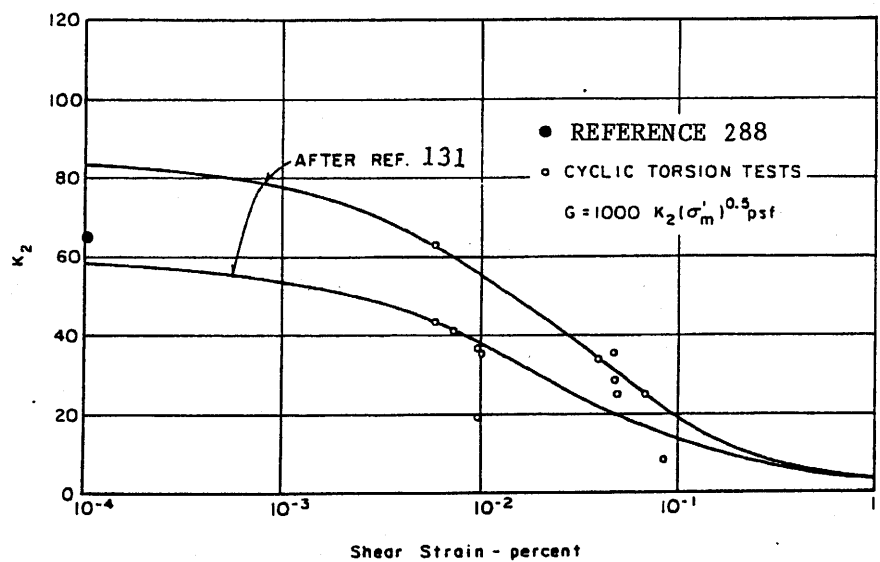
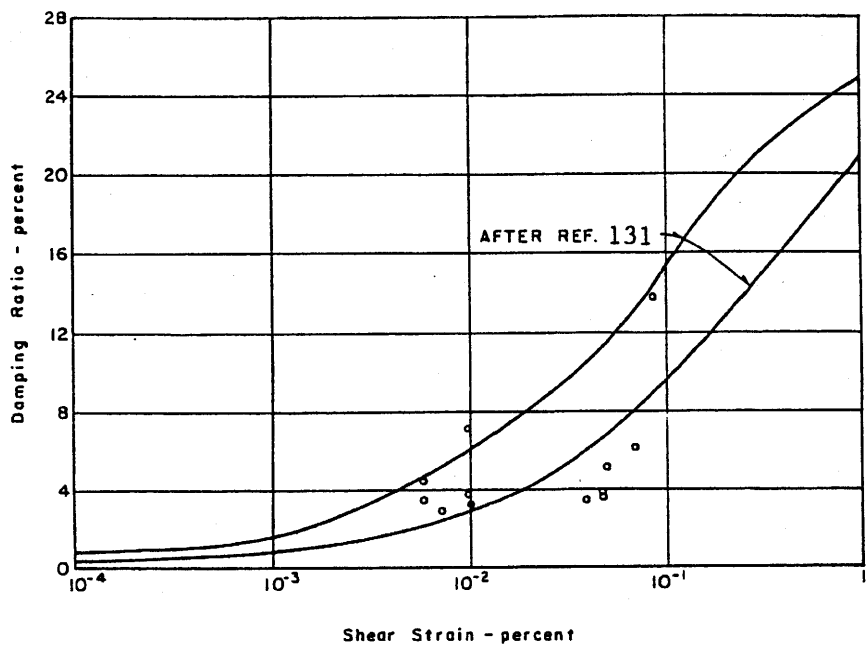
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Dynamic Properties of  
Lacustrine Sediments

Figure 2.5-133



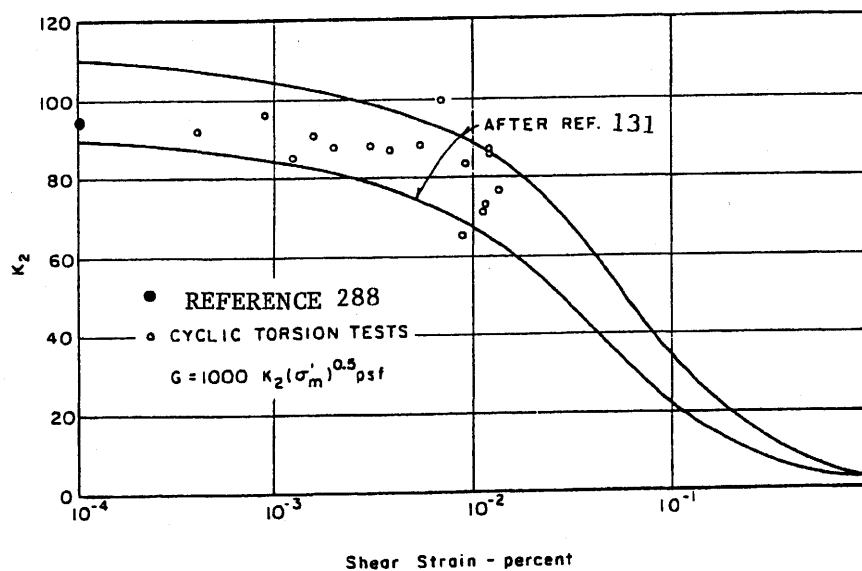
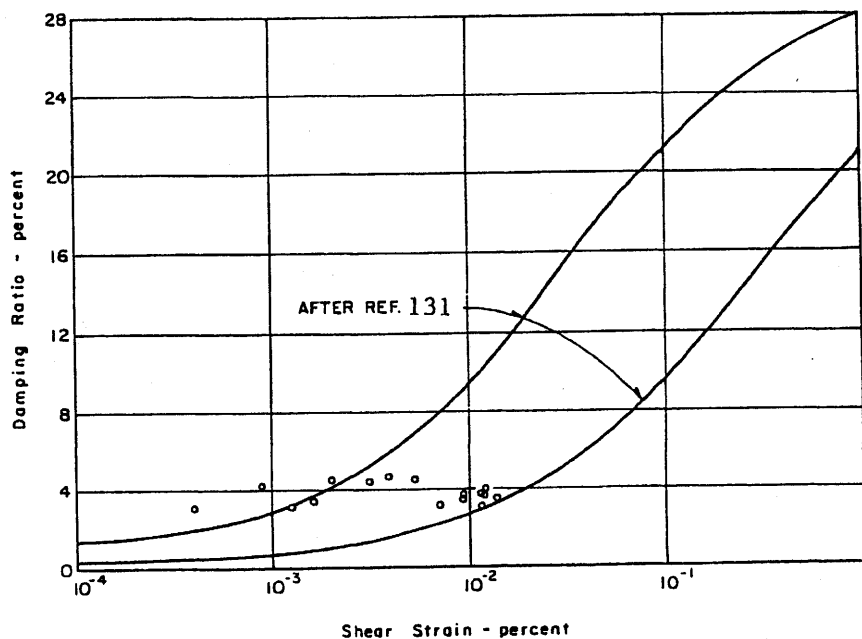
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Dynamic Properties of Upper Till

Figure 2.5-134



(Rev. 12 1/03)

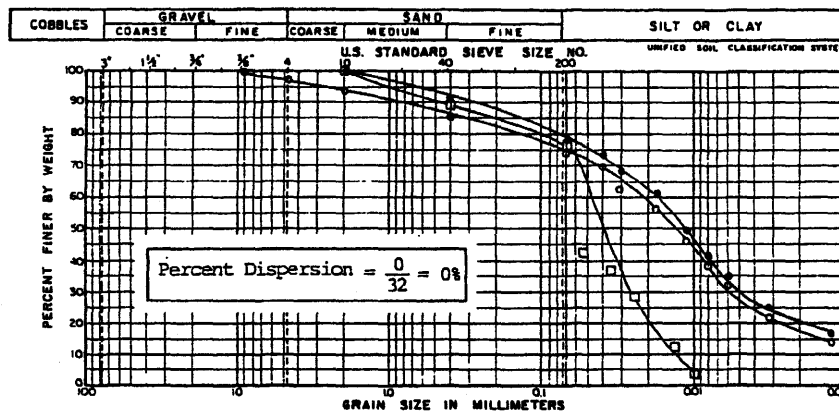


**PERRY NUCLEAR POWER PLANT**

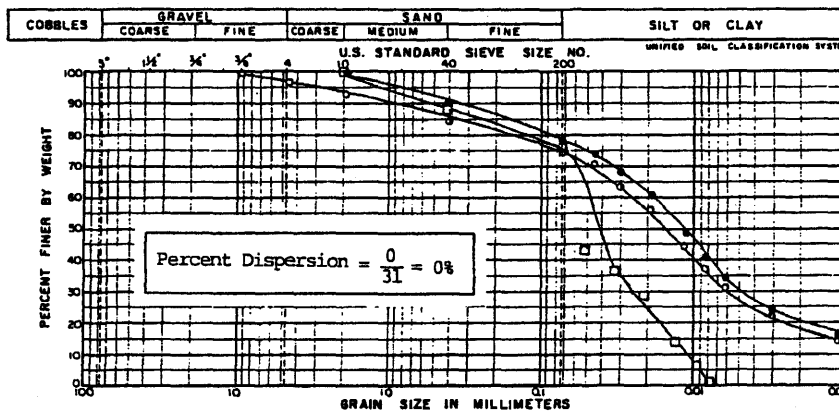
Dynamic Properties of Lower Till

Figure 2.5-135

# MECHANICAL ANALYSIS



BORING	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
	S-1		○	Standard Grain Size Distribution - Entire Sample	10.0	21	14
	S-1		•	Standard Grain Size Distribution - Minus No. 10			
	S-1		□	Grain Size Distribution - Minus No. 10 without Deflocculation			



BORING	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
	S-2		○	Standard Grain Size Distribution - Entire Sample	9.9	20	15
	S-2		•	Standard Grain Size Distribution - Minus No. 10			
	S-2		□	Grain Size Distribution - Minus No. 10 without Deflocculation			

(Rev. 12 1/03)

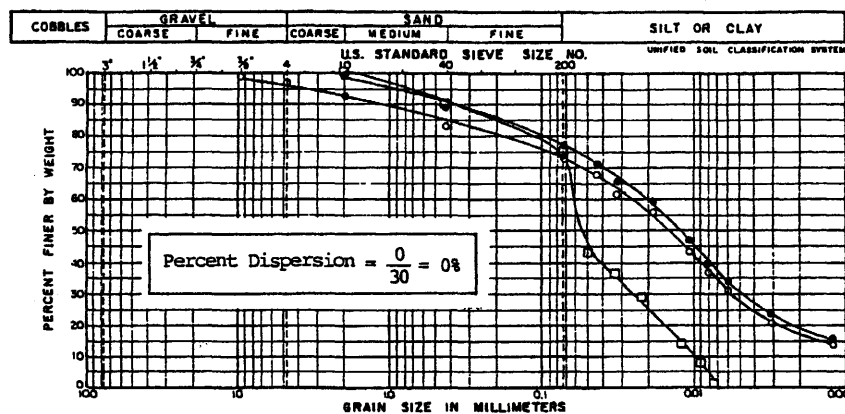


**PERRY NUCLEAR POWER PLANT**

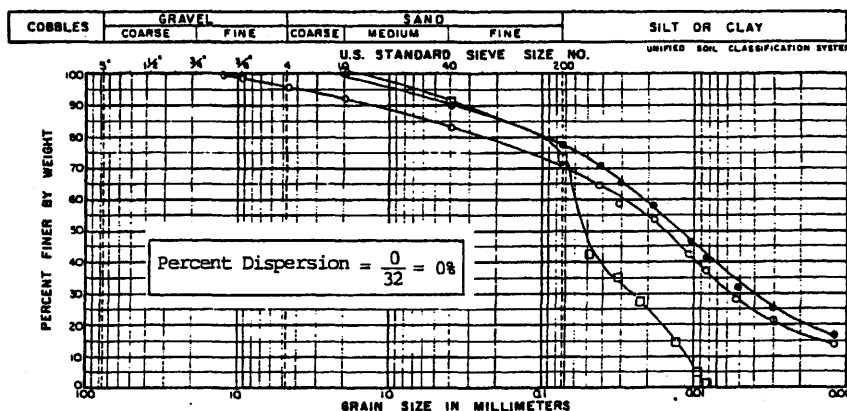
Soil Conservation Service  
Tests on Lower Till

Figure 2.5-136 (Sheet 1 of 3)

# MECHANICAL ANALYSIS



BORING	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
	S-3		○	Standard Grain Size Distribution - Entire Sample	10.2	21	15
	S-3		•	Standard Grain Size Distribution - Minus No. 10			
	S-3		□	Grain Size Distribution - Minus No. 10 without Deflocculation			



BORING	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
	S-4		○	Standard Grain Size Distribution - Entire Sample	10.1	20	16
	S-4		•	Standard Grain Size Distribution - Minus No. 10			
	S-4		□	Grain Size Distribution - Minus No. 10 without Deflocculation			

(Rev. 12 1/03)

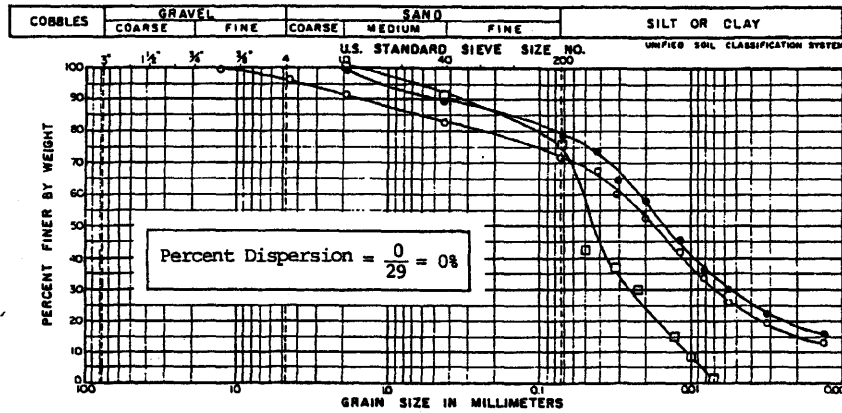


**PERRY NUCLEAR POWER PLANT**

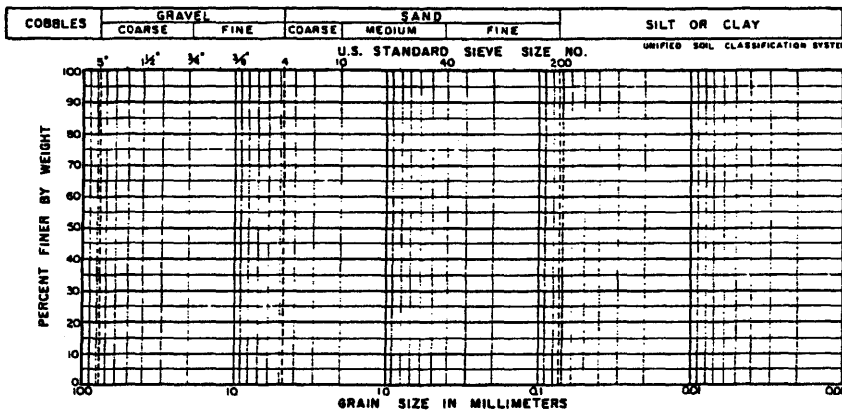
Soil Conservation Service  
Tests on Lower Till

Figure 2.5-136 (Sheet 2 of 3)

# MECHANICAL ANALYSIS



BORING	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
	S-5		o	Standard Grain Size Distribution - Entire Sample	9.8	20	17
	S-5		•	Standard Grain Size Distribution - Minus No. 10			
	S-5		□	Grain Size Distribution - Minus No. 10 without Deflocculation			



BORING	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL

(Rev. 12 1/03)

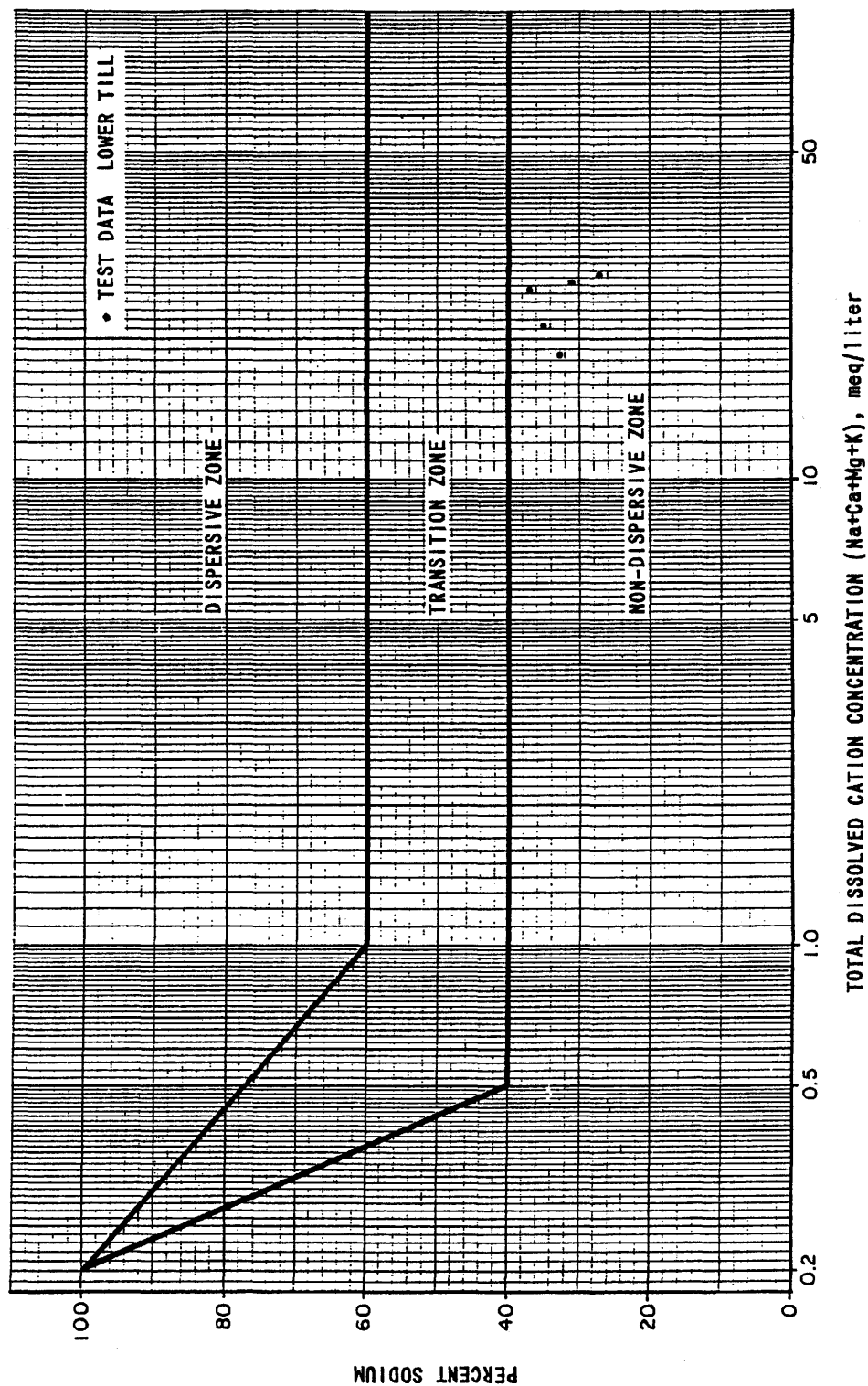


PERRY NUCLEAR POWER PLANT

Soil Conservation Service  
Tests on Lower Till

Figure 2.5-136 (Sheet 3 of 3)





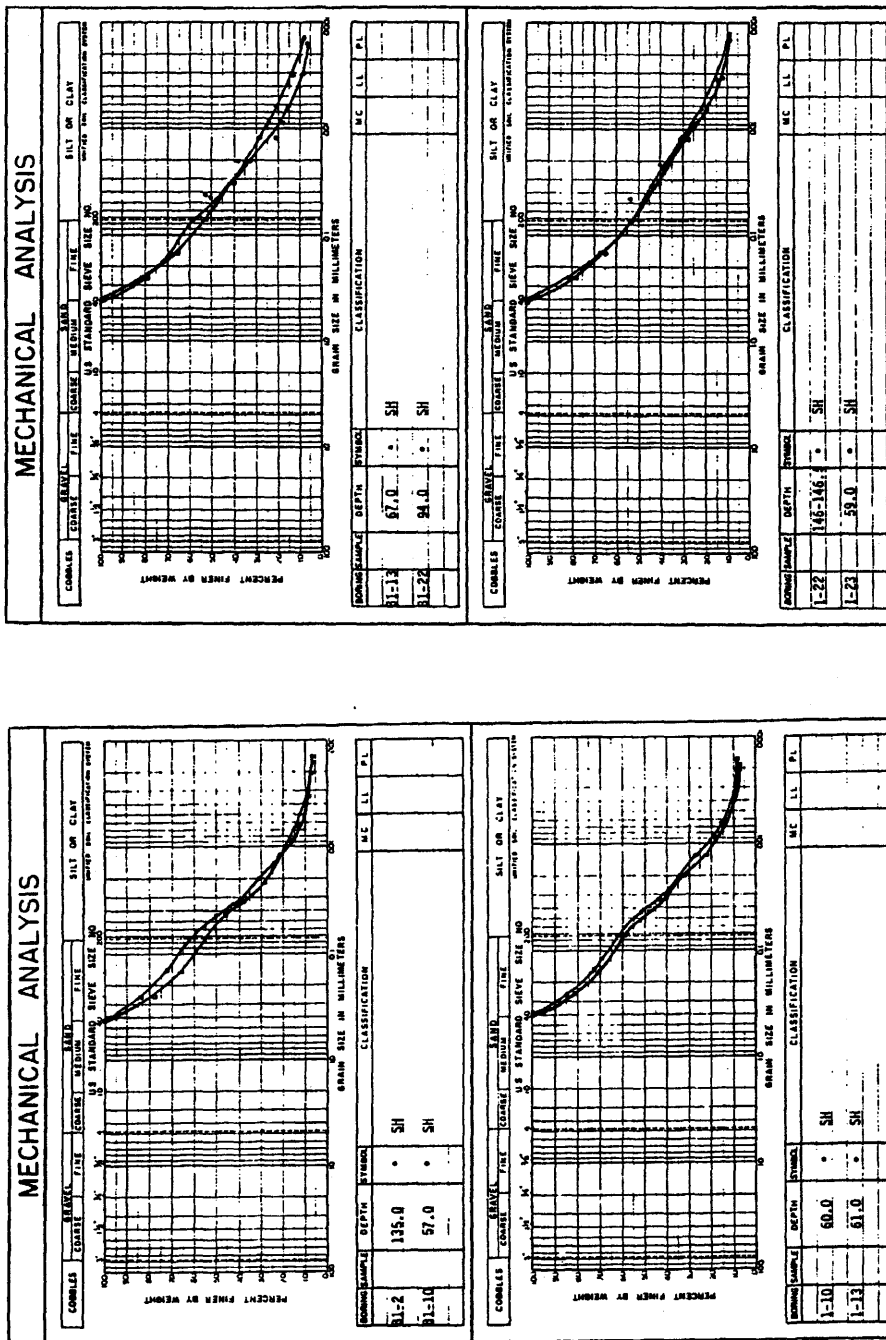
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Dissolved Salts in  
Saturation Extract

Figure 2.5-137



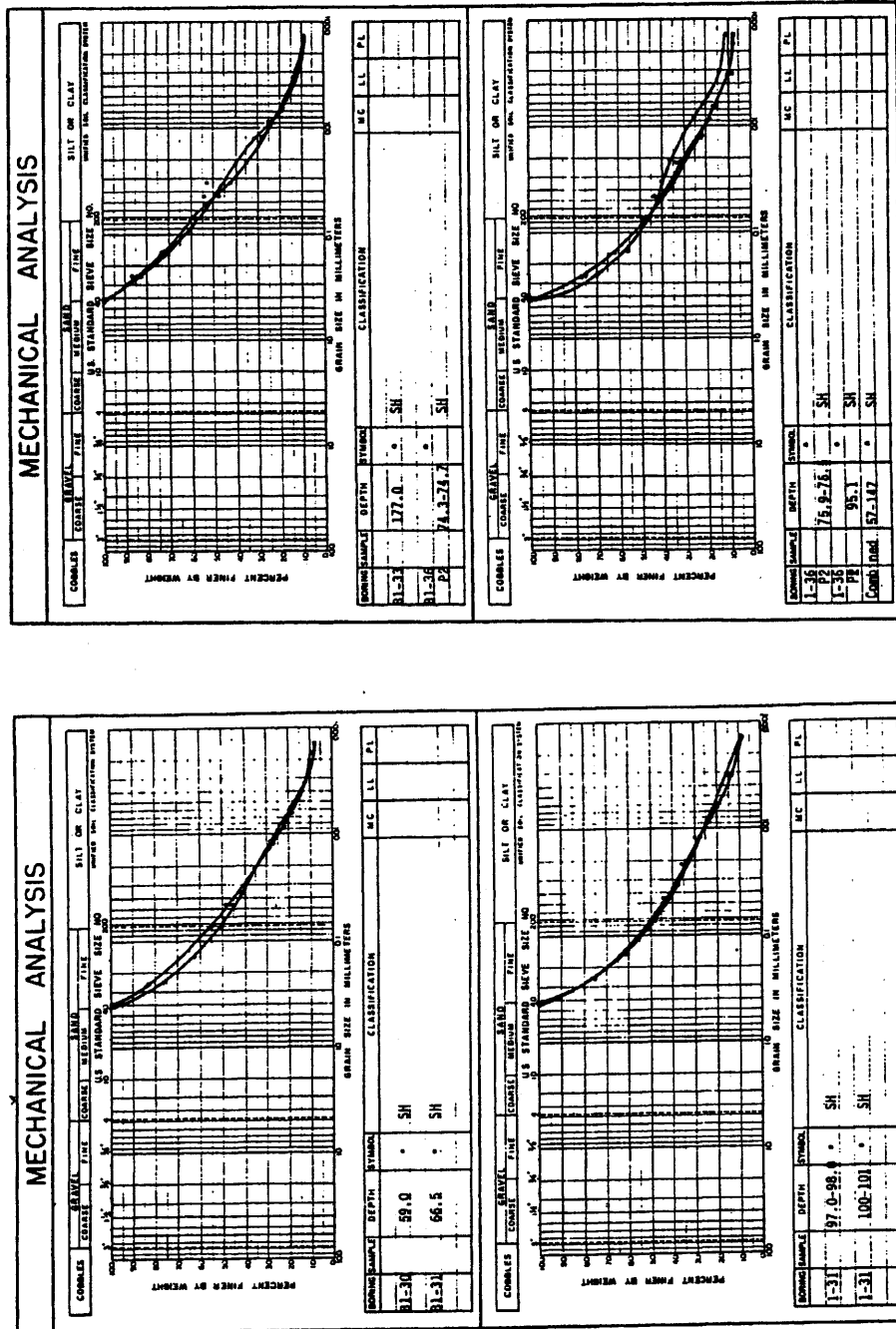
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Chagrin Shale

Figure 2.5-138 (Sheet 1 of 2)



(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution Curves -  
Chagrin Shale

Figure 2.5-138 (Sheet 2 of 2)

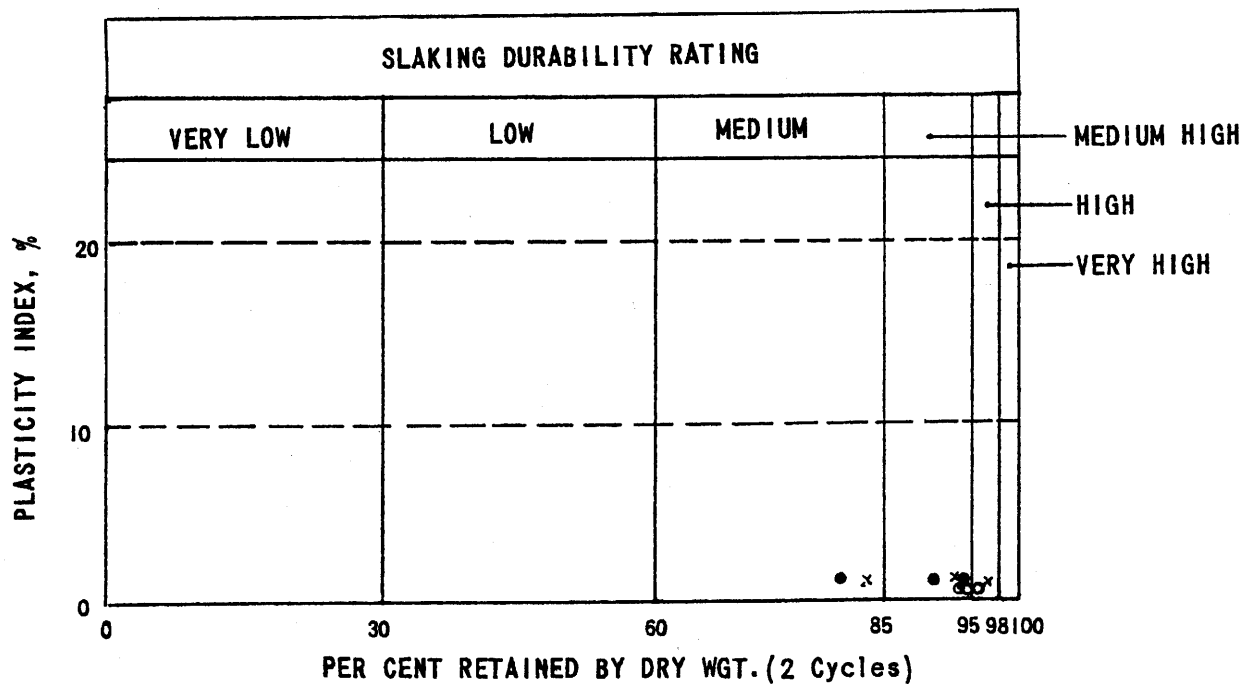
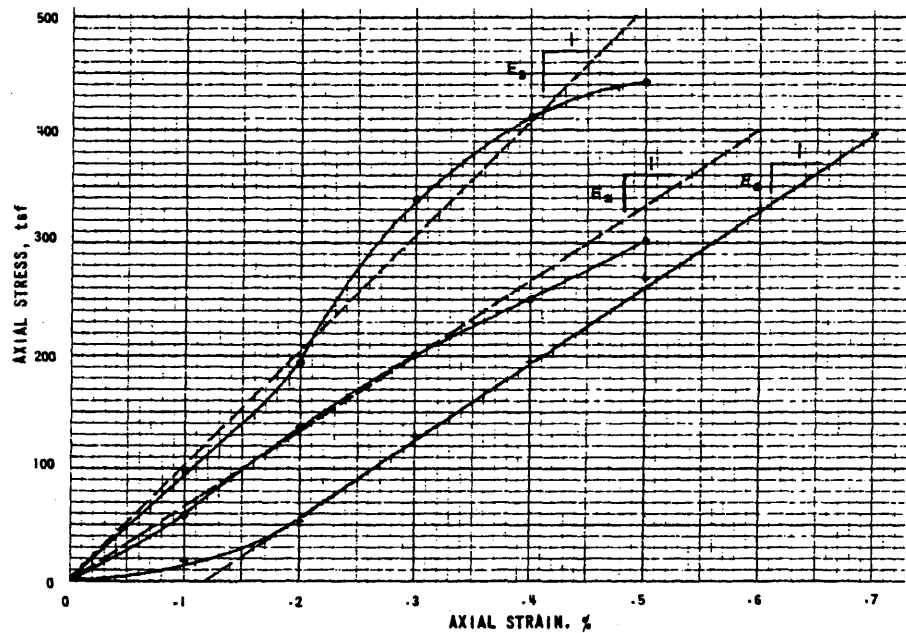


Figure 2.5-139

TYPICAL STRESS - STRAIN CHARACTERISTICS OF SHALE IN UNIAXIAL COMPRESSION

SYMBOL	BORING No.	SAMPLE DEPTH (Ft)	$\gamma_d$ (pcf)	$w_n$ (%)	ULTIMATE STRESS (tsf)	ULTIMATE STRAIN (%)	$E_s$ (tsf $\times 10^3$ )
•	1 - 33	152	158.0	4.5	302	0.50	67
•	1 - 33	161	150.0	4.7	442	0.50	102
+	1 - 1	124	164.7	2.1	542	0.91	53

ALL SAMPLES EXHIBITED AN ABRUPT BRITTLE FAILURE



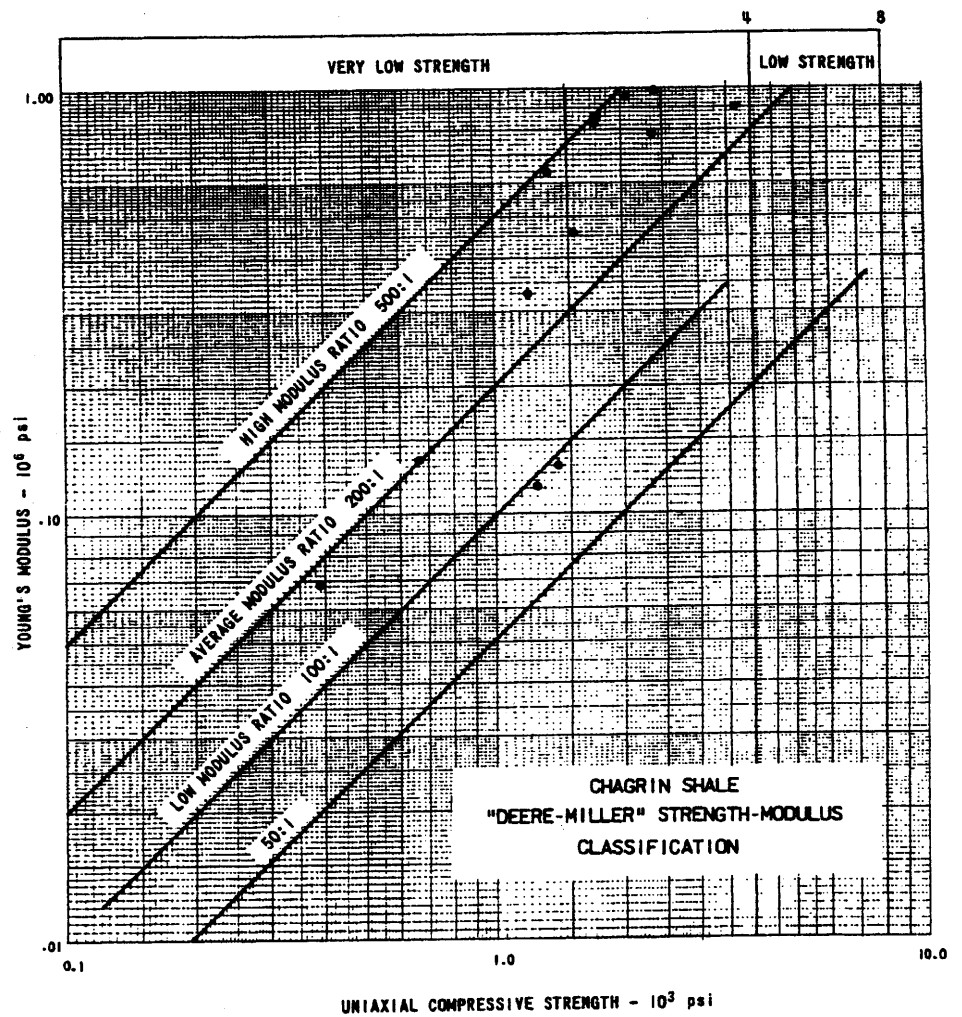
(Rev. 12 1/03)



PERRY NUCLEAR POWER PLANT

Typical Stress - Strain  
Characteristics of Shale in  
Uniaxial Compression

Figure 2.5-140



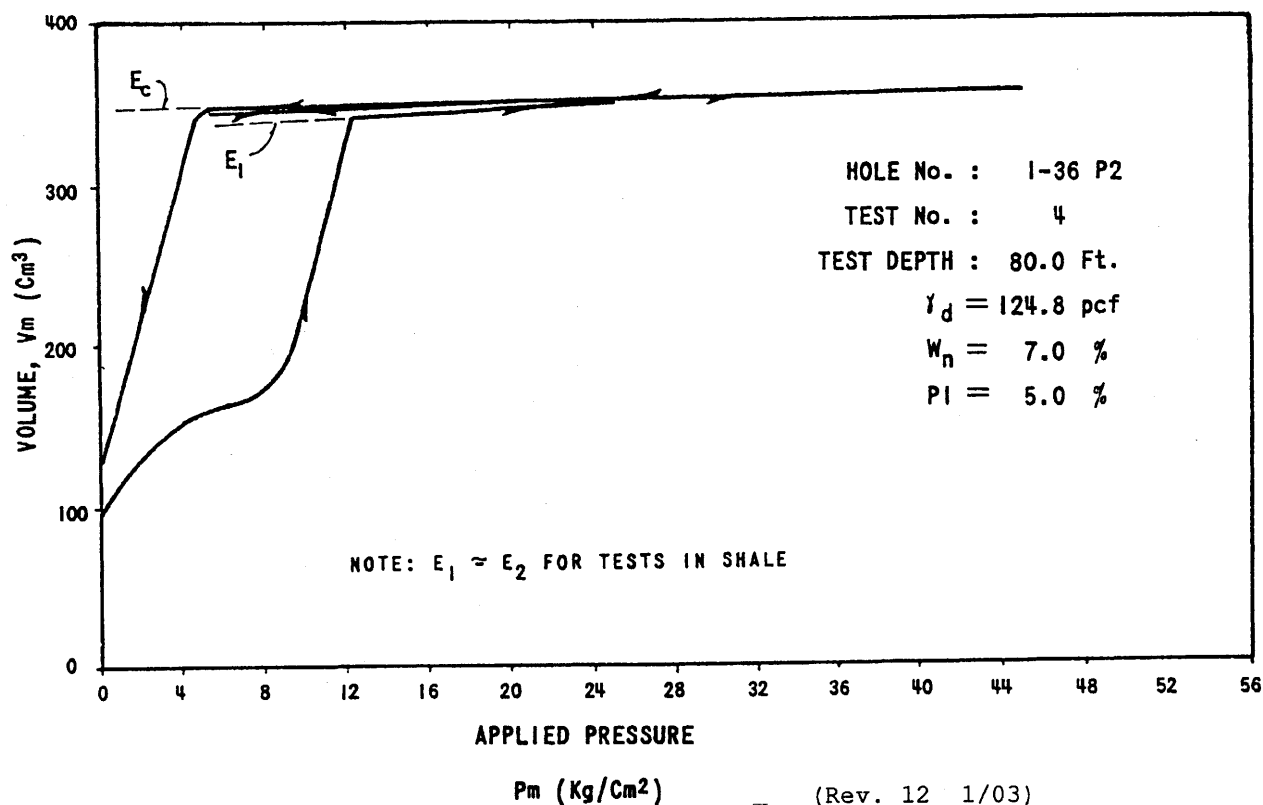
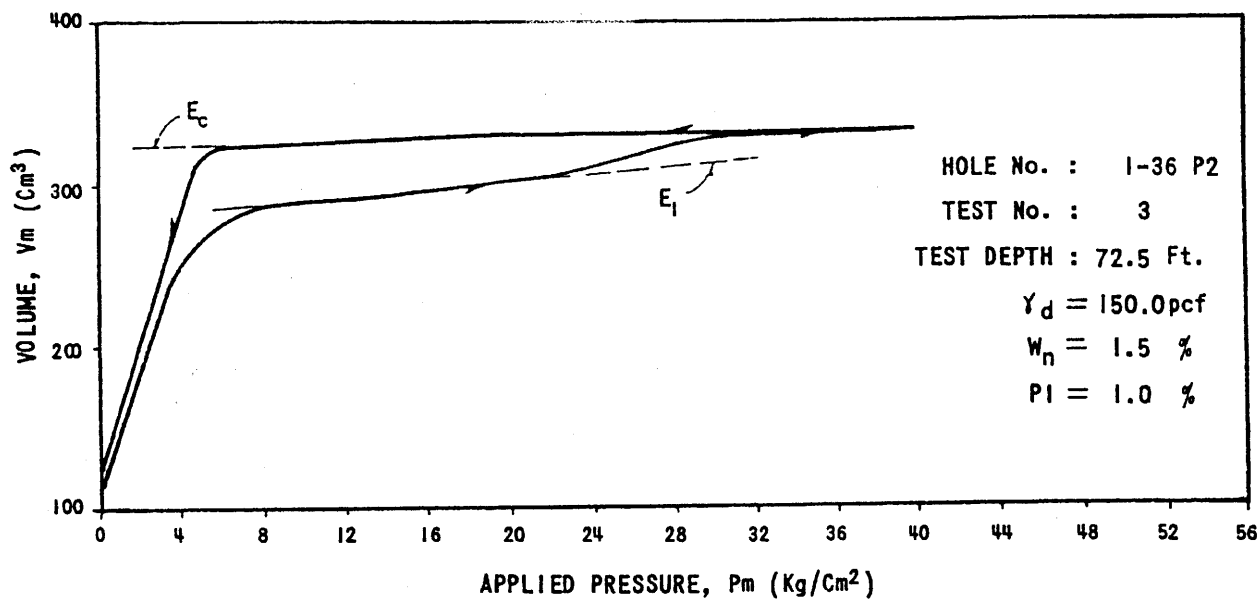
(Rev. 12 1/03)




**PERRY NUCLEAR POWER PLANT**

Deere-Miller Strength -  
Modulus Classification of  
Chagrin Shale

Figure 2.5-141

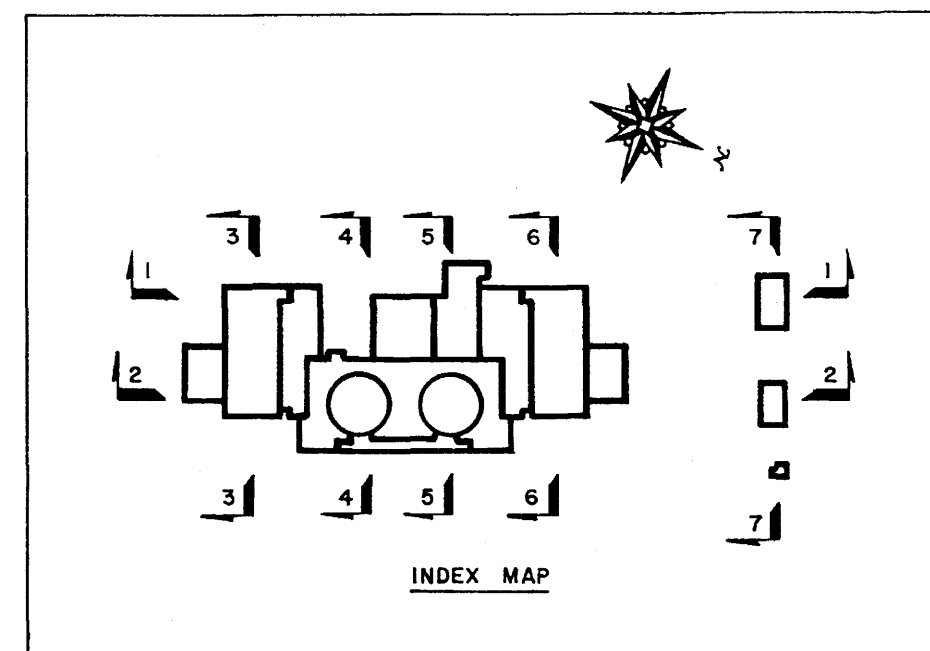
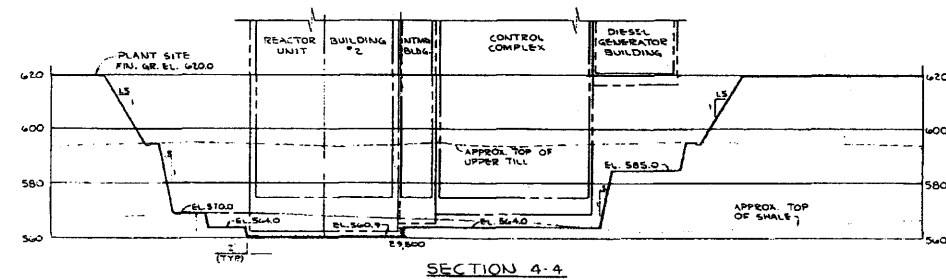
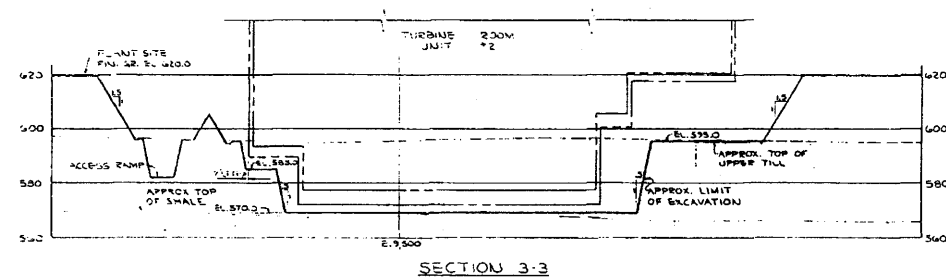
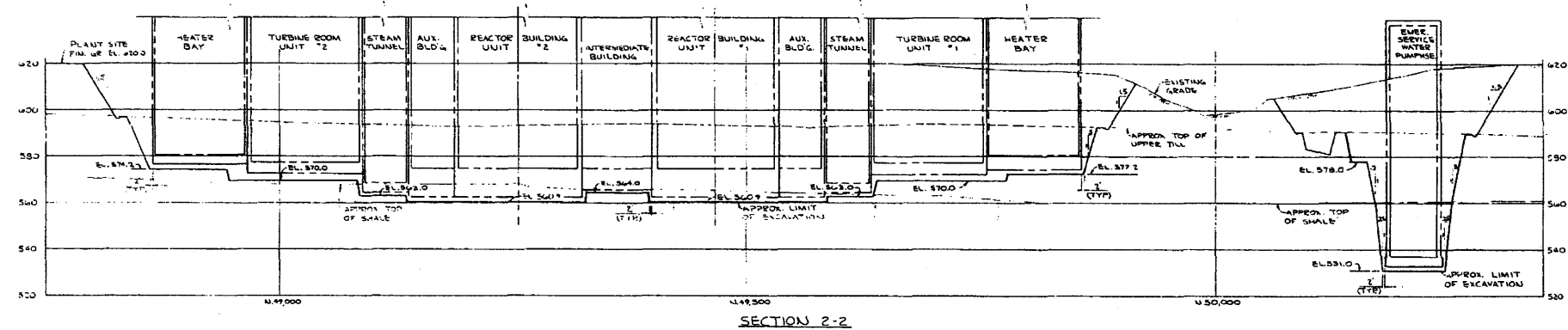
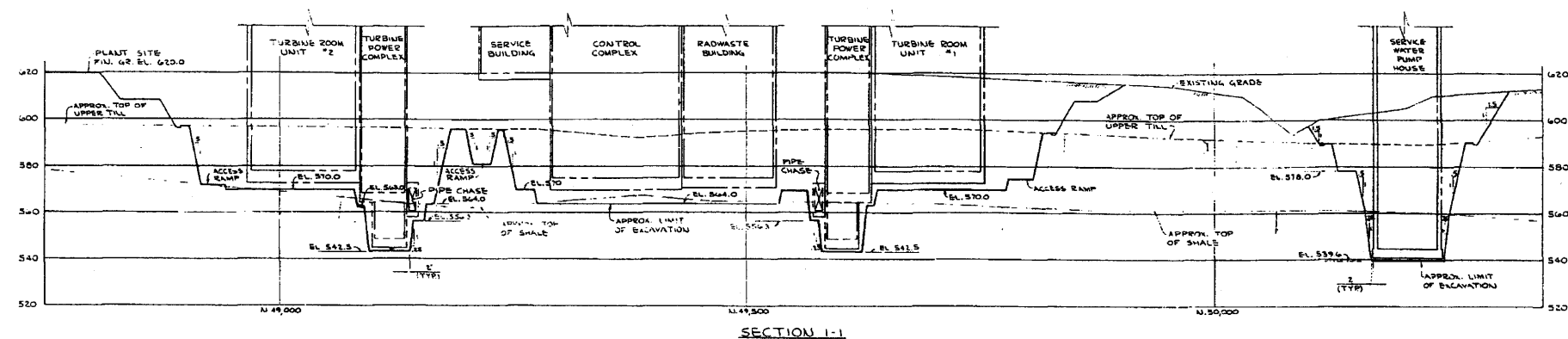




**PERRY NUCLEAR POWER PLANT**

Typical Pressuremeter Test  
Results in Chagrin Shale

Figure 2.5-142



(Rev. 12 1/03)

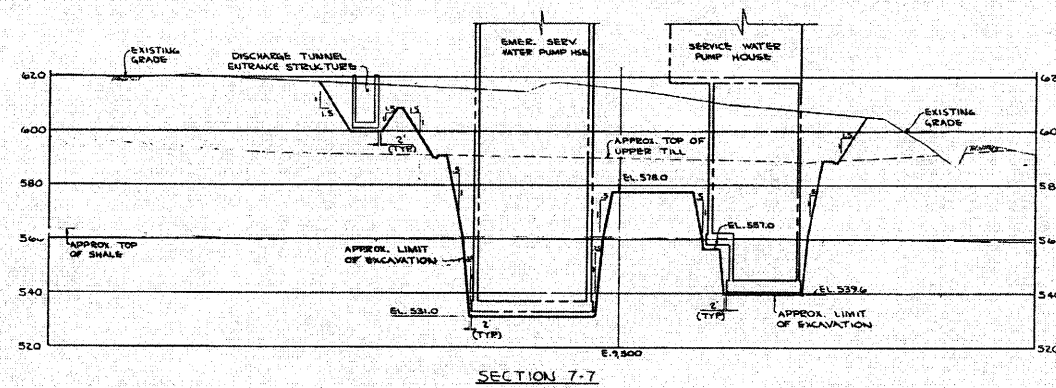
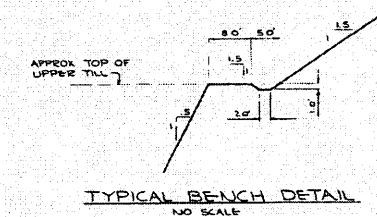
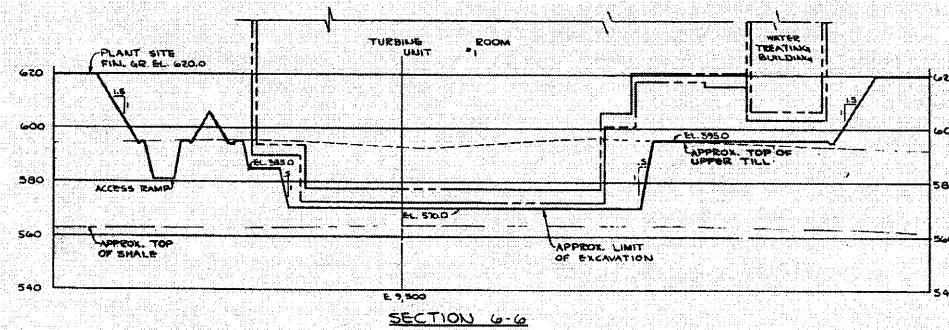
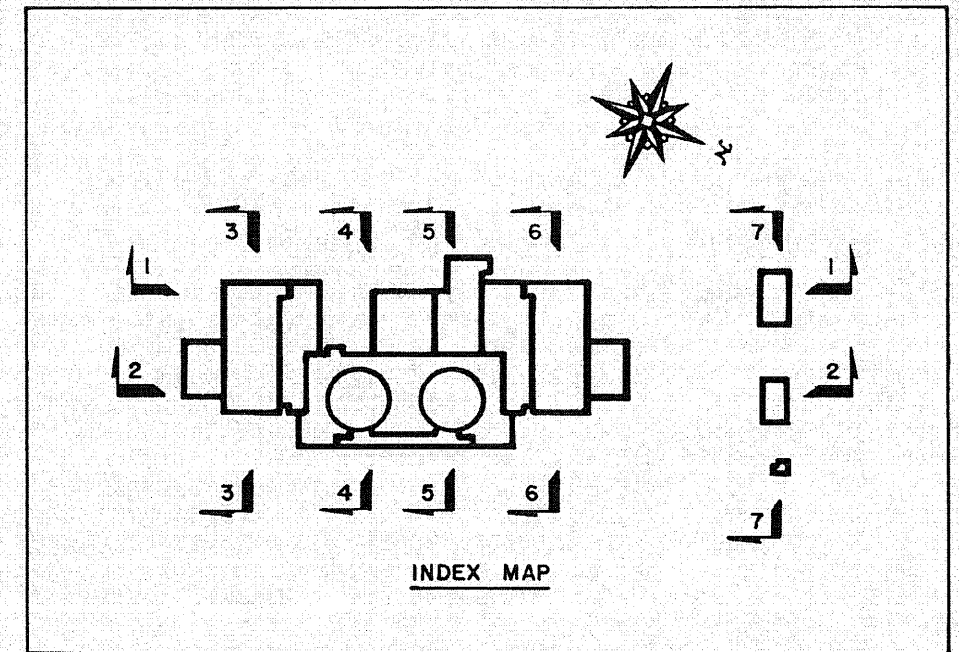
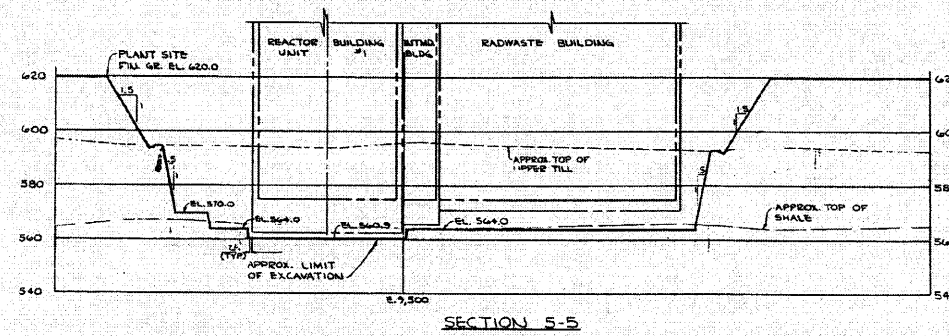


**PERRY NUCLEAR POWER PLANT**

Subsurface Stratigraphy and  
Excavation Sections  
(Preconstruction)

Figure 2.5-143 (Sheet 1 of 2)





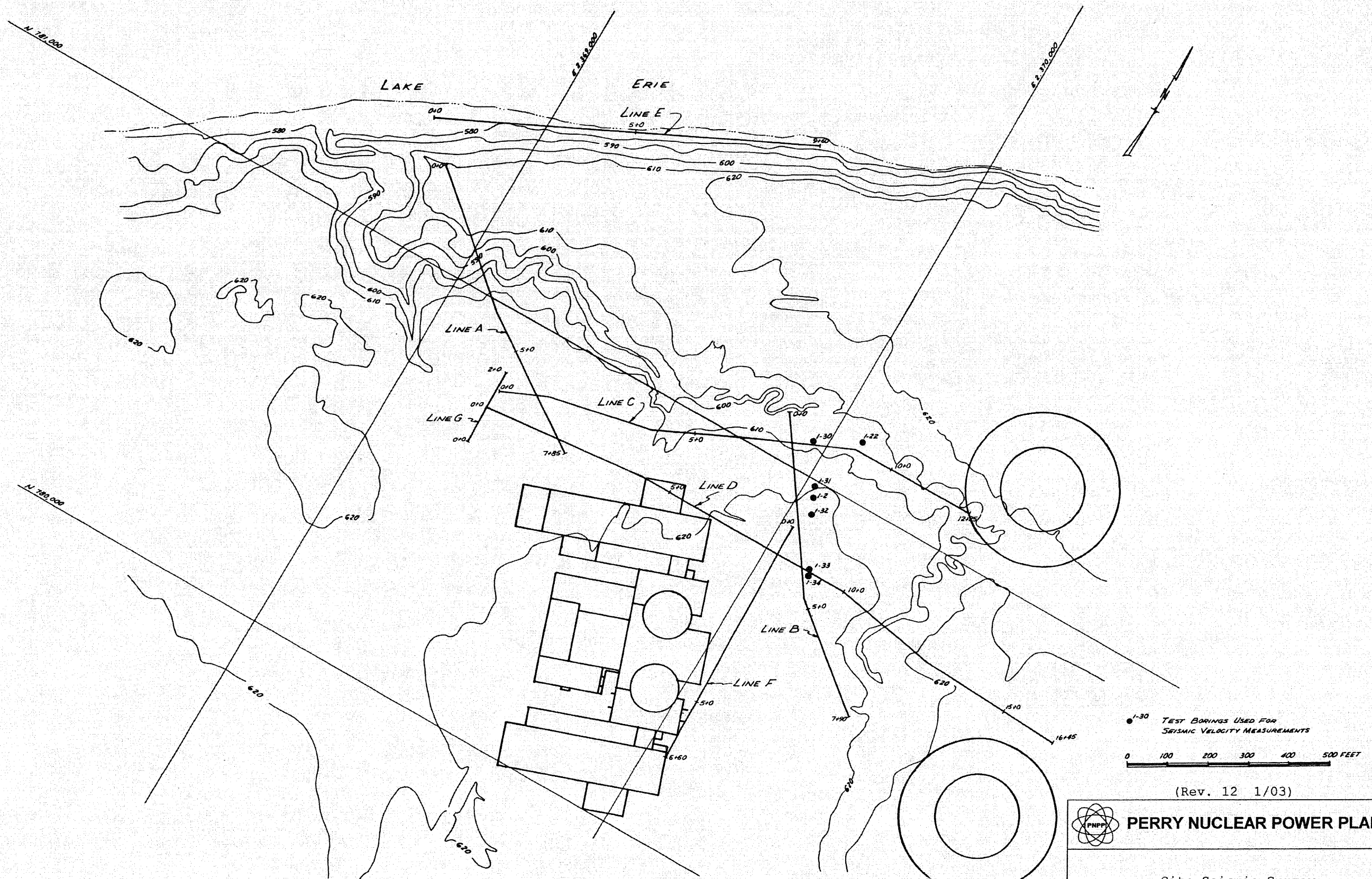
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Subsurface Stratigraphy and  
Excavation Sections  
(Preconstruction)

Figure 2.5-143 (Sheet 2 of 2)



(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Site Seismic Survey

Figure 2.5-144



(Rev. 12 1/03)

Anticlinal fold and overthrust fault in Bedford formation on Bates Creek, southeast of Painesville.

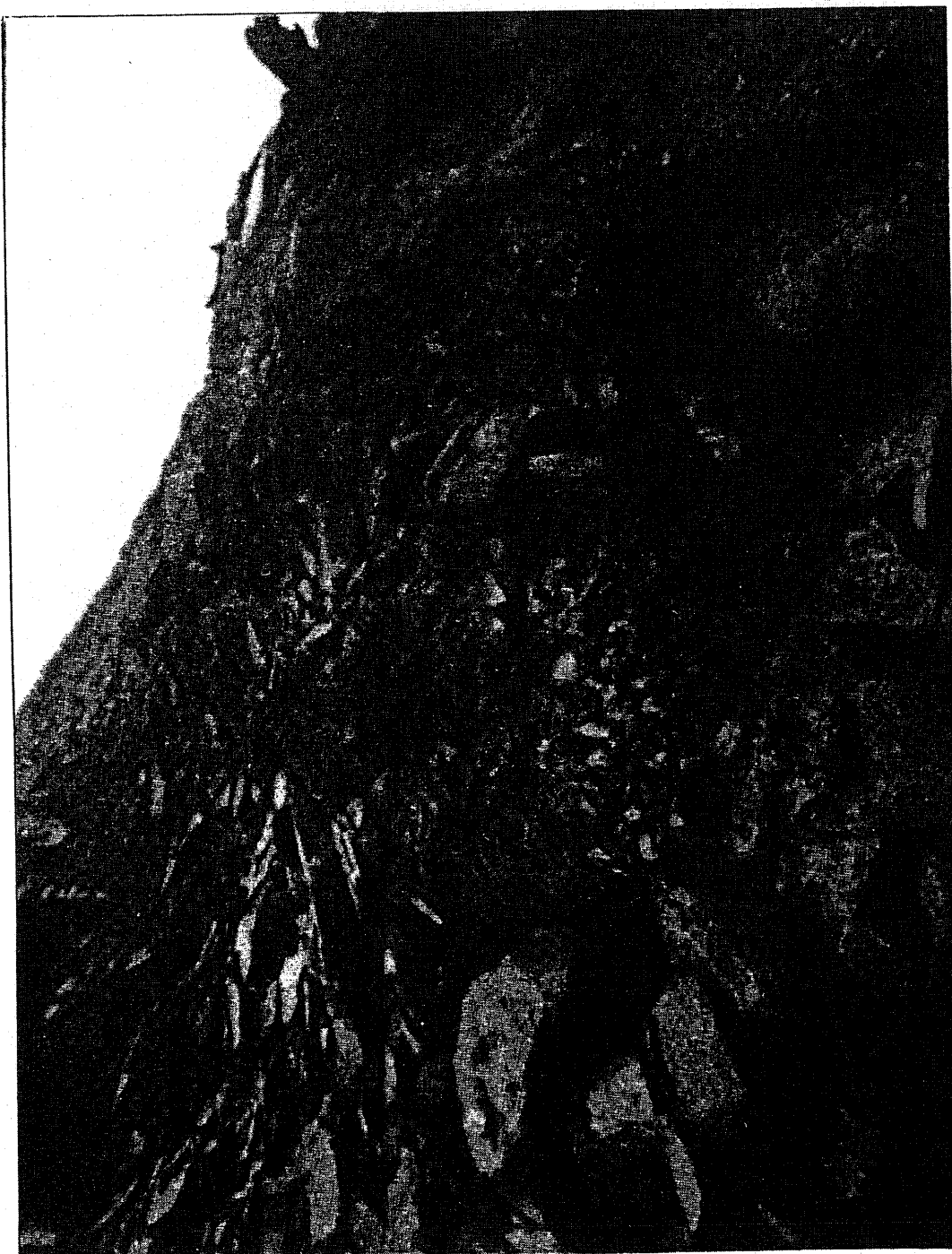
(Reference 289)



**PERRY NUCLEAR POWER PLANT**

Warners Creek Thrust  
Fault from Prosser

Figure 2.5-145



Anticline produced by buckling of the shales at the base of the landslide at Cleveland, Ohio. (Reference 289)

(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Anticline Produced by Sliding  
from Van Horn

Figure 2.5-146





UNSYMMETRICAL ANTICLINE

This shows 5 feet of disturbed shale overlain by 2 feet of glacial drift. (Reference 290)

(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Anticline in Shale from  
Van Horn

Figure 2.5-147



UNSYMMETRICAL ANTICLINE WITH BOTTOM LAYERS HORIZONTAL

Eight feet of shale are covered by 2 feet of glacial drift. (Reference 290)

(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Anticline in Shale from  
Van Horn

Figure 2.5-148



This view shows 3 feet of glacial sand and 5 feet of folded iron-stained shale having 3 well defined concretionary ironstone bands, 3 feet of blue shale with less folding, and 3 feet of horizontal shale. (Reference 290)

(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Anticline in Shale from  
Van Horn

Figure 2.5-149



(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Aerial Photograph of Warners  
(Bates) Creek Fault

Figure 2.5-150





(Rev. 12 1/03)

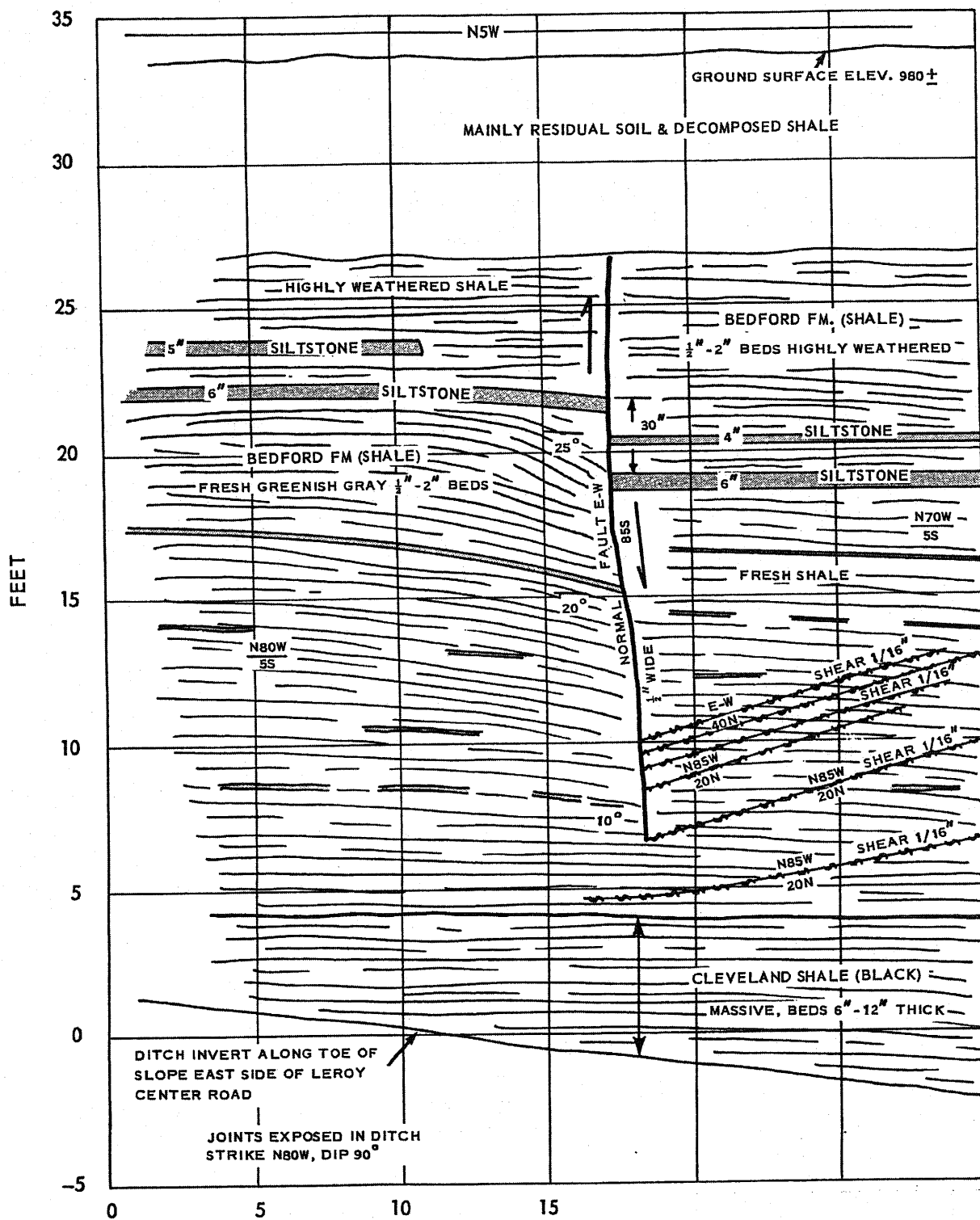


**PERRY NUCLEAR POWER PLANT**

Aerial Photograph of Hell  
Hollow Faults

Figure 2.5-151





(APPROXIMATELY TO SCALE)

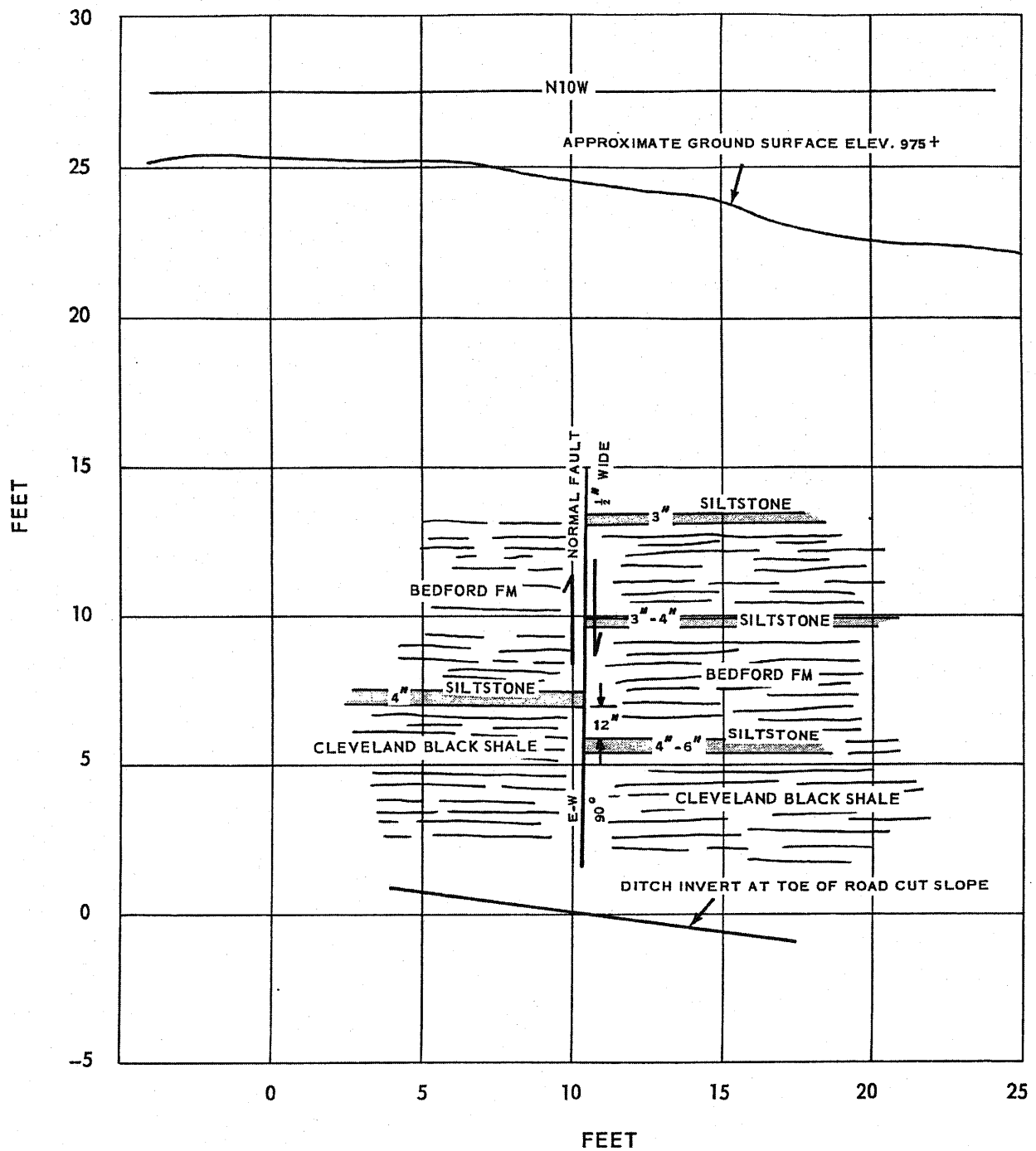
NOTE: FAULT #1 IS 7 MILES SE OF PERRY SITE



**PERRY NUCLEAR POWER PLANT**

Sketch of Excavated Rock Slope  
Showing Hell Hollow Fault #1

Figure 2.5-153



(APPROXIMATELY TO SCALE)

NOTE: FAULT #2 IS 40 FT SOUTH OF FAULT #1

(Rev. 12 1/03)

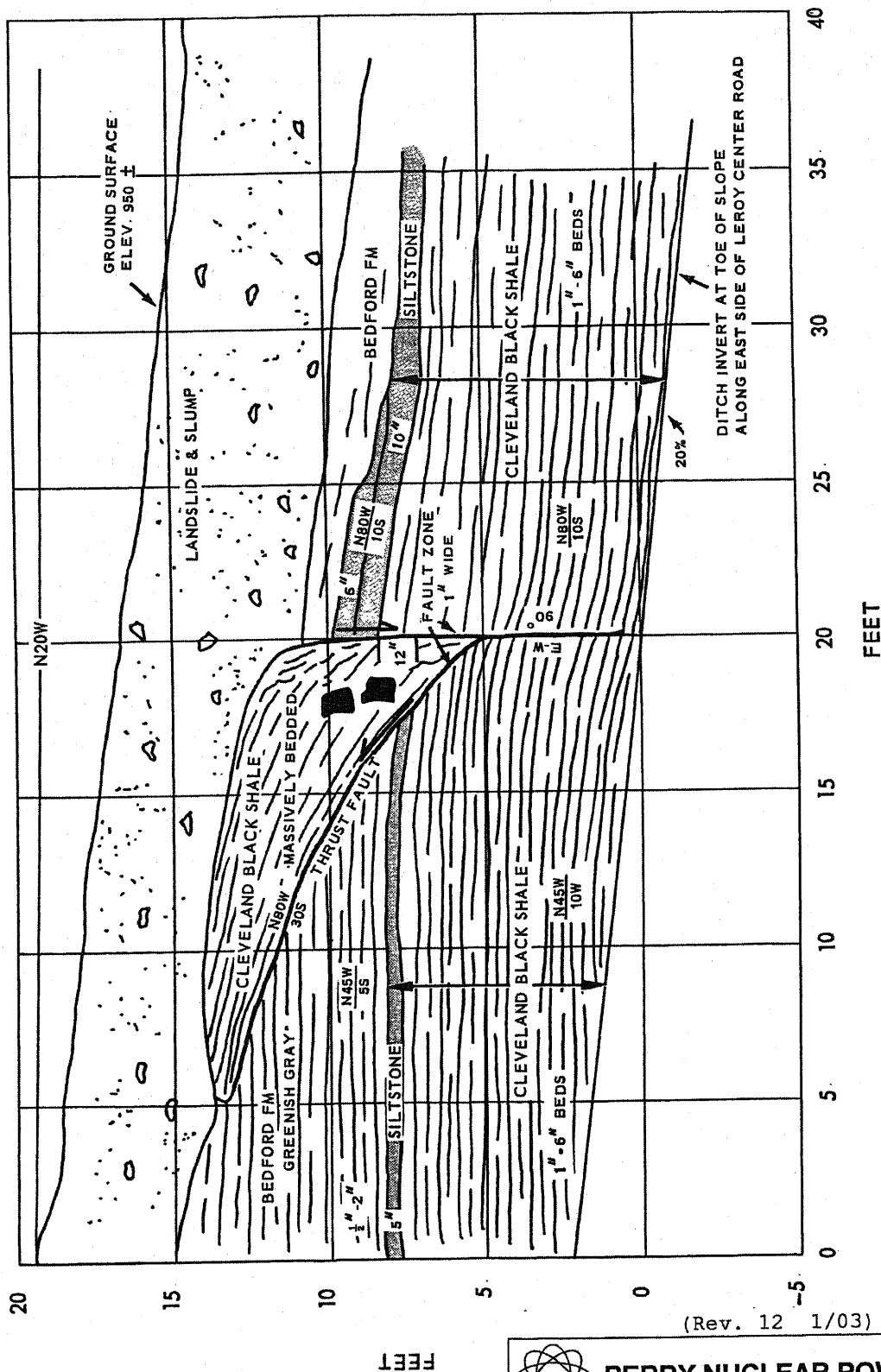


**PERRY NUCLEAR POWER PLANT**

Sketch of Excavated Rock Slope  
Showing Hell Hollow Fault #2

Figure 2.5-154





(APPROXIMATELY TO SCALE)

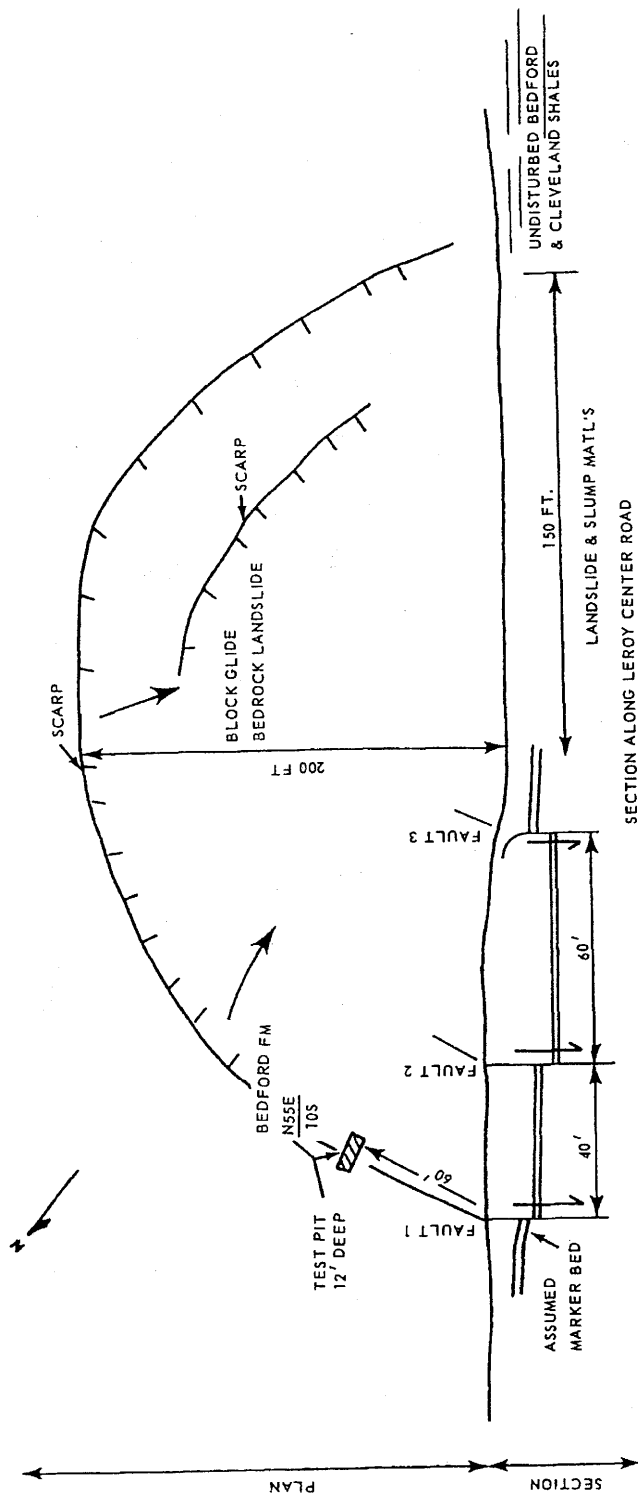
NOTE: FAULT #3 IS 60 FT SOUTH OF FAULT #2 AND 100 FT SOUTH OF FAULT #1



**PERRY NUCLEAR POWER PLANT**

Sketch of Excavated Rock Slope  
Showing Hell Hollow Fault #3

Figure 2.5-155



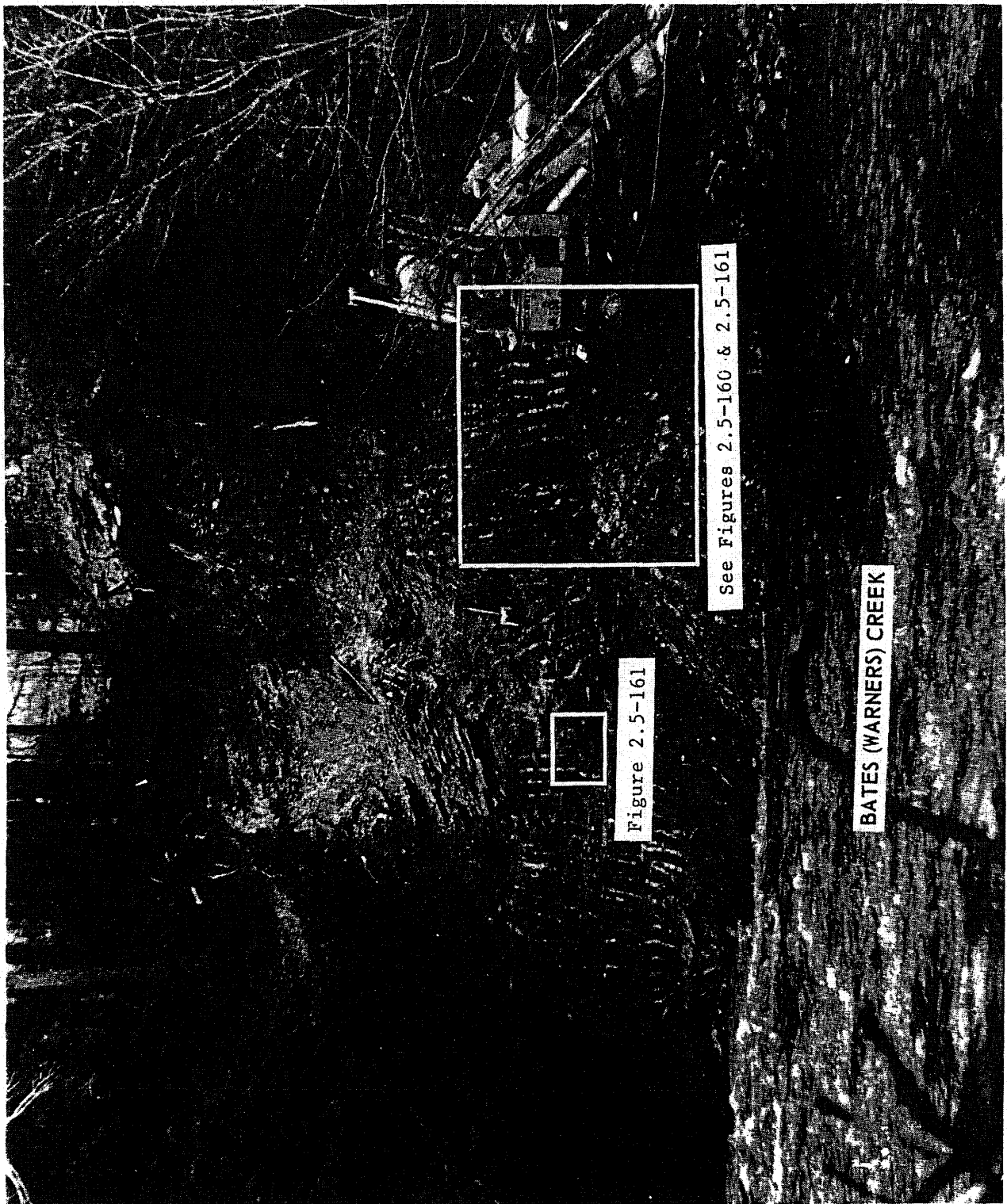
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Interpretative Sketch of  
Hell Hollow Faults  
Related to Slumping

Figure 2.5-156



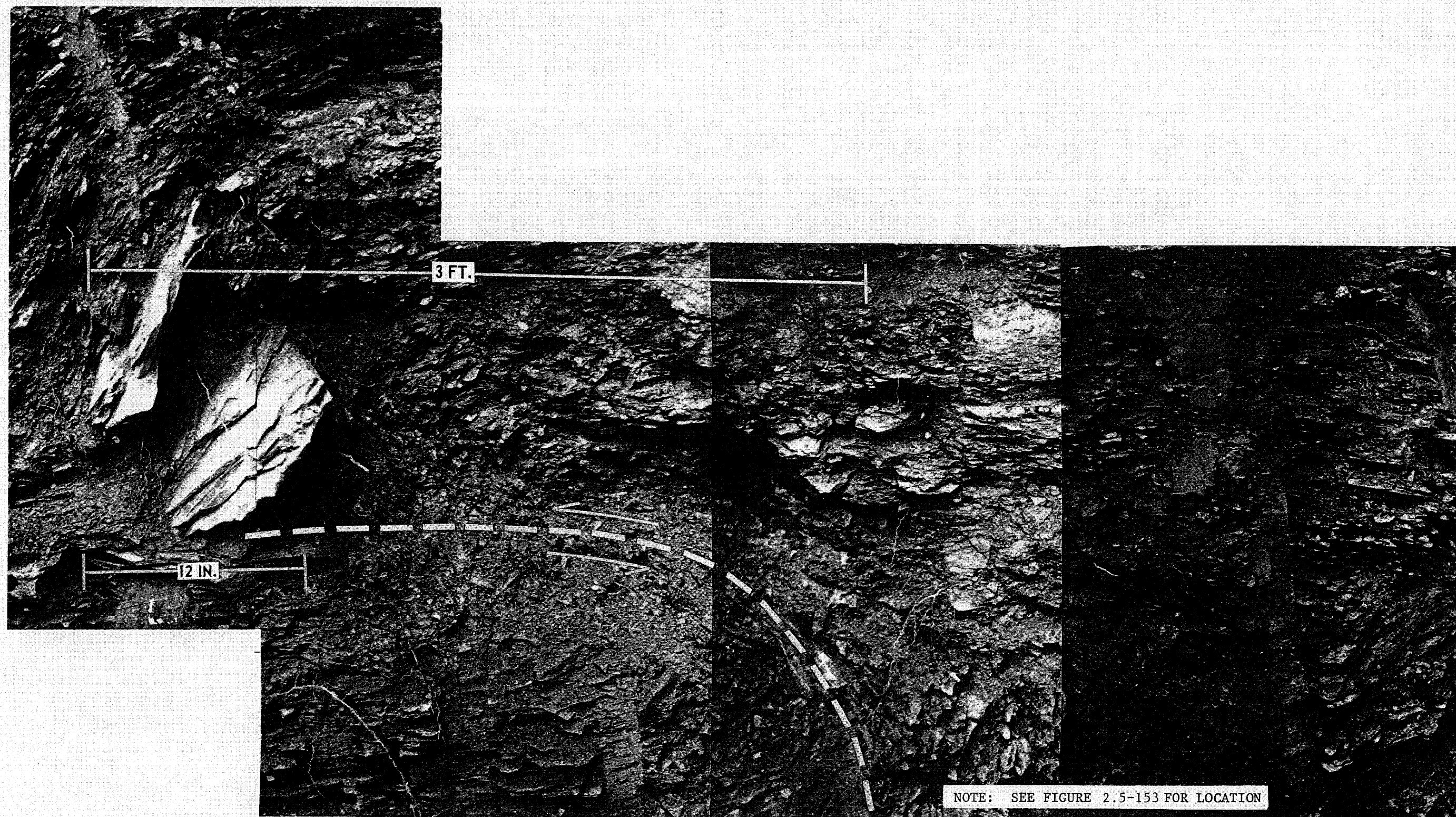
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Photograph of Warners  
(Bates) Creek Exposure

Figure 2.5-157



(Rev. 12 1/03)

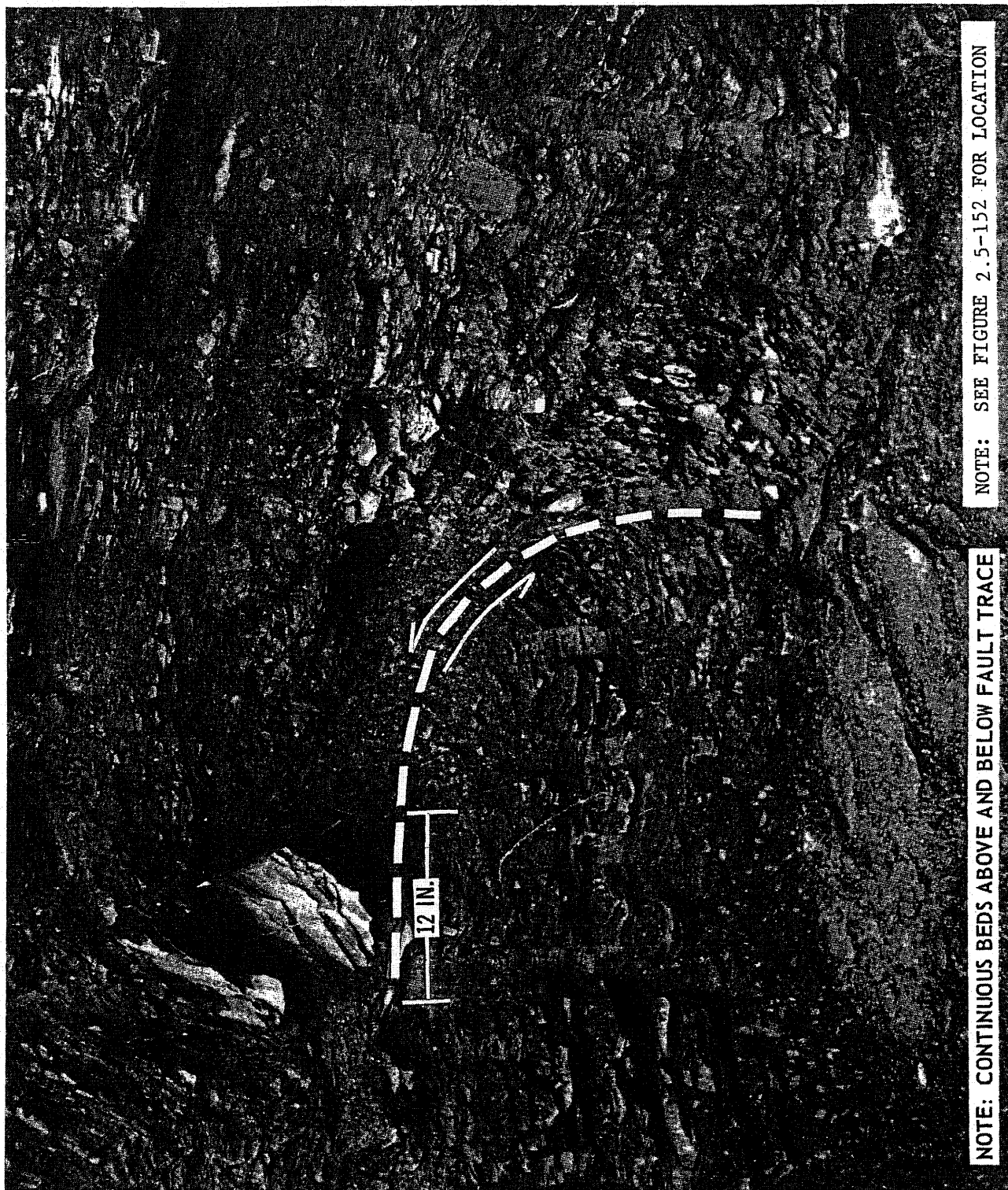


**PERRY NUCLEAR POWER PLANT**

Photographic Enlargement of Fault  
of Warners (Bates) Creek

Figure 2.5-158





NOTE: SEE FIGURE 2.5-152 FOR LOCATION

NOTE: CONTINUOUS BEDS ABOVE AND BELOW FAULT TRACE

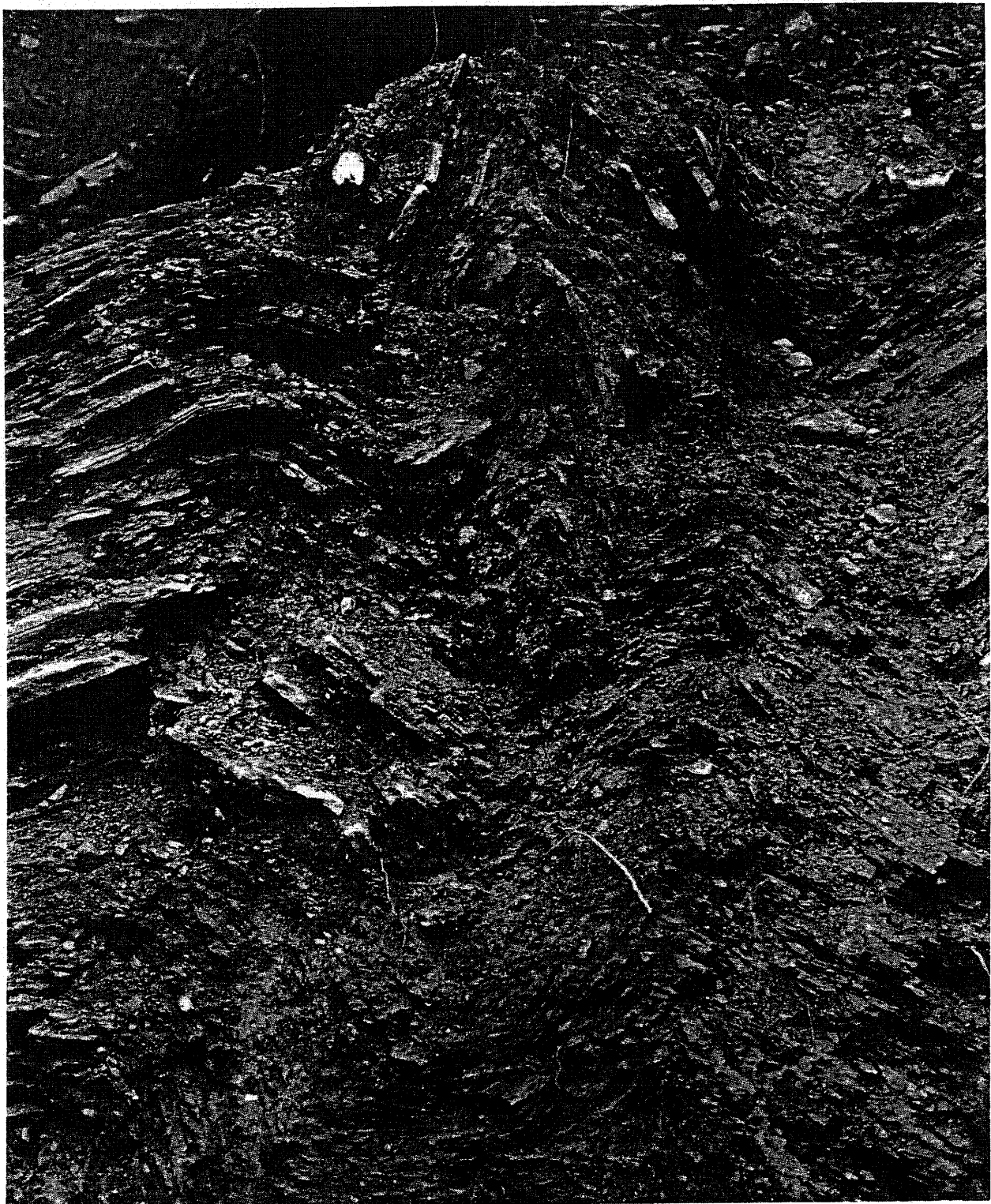
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Photographic Enlargement of Fault  
of Warners (Bates) Creek

Figure 2.5-159



(Rev. 12 1/03)

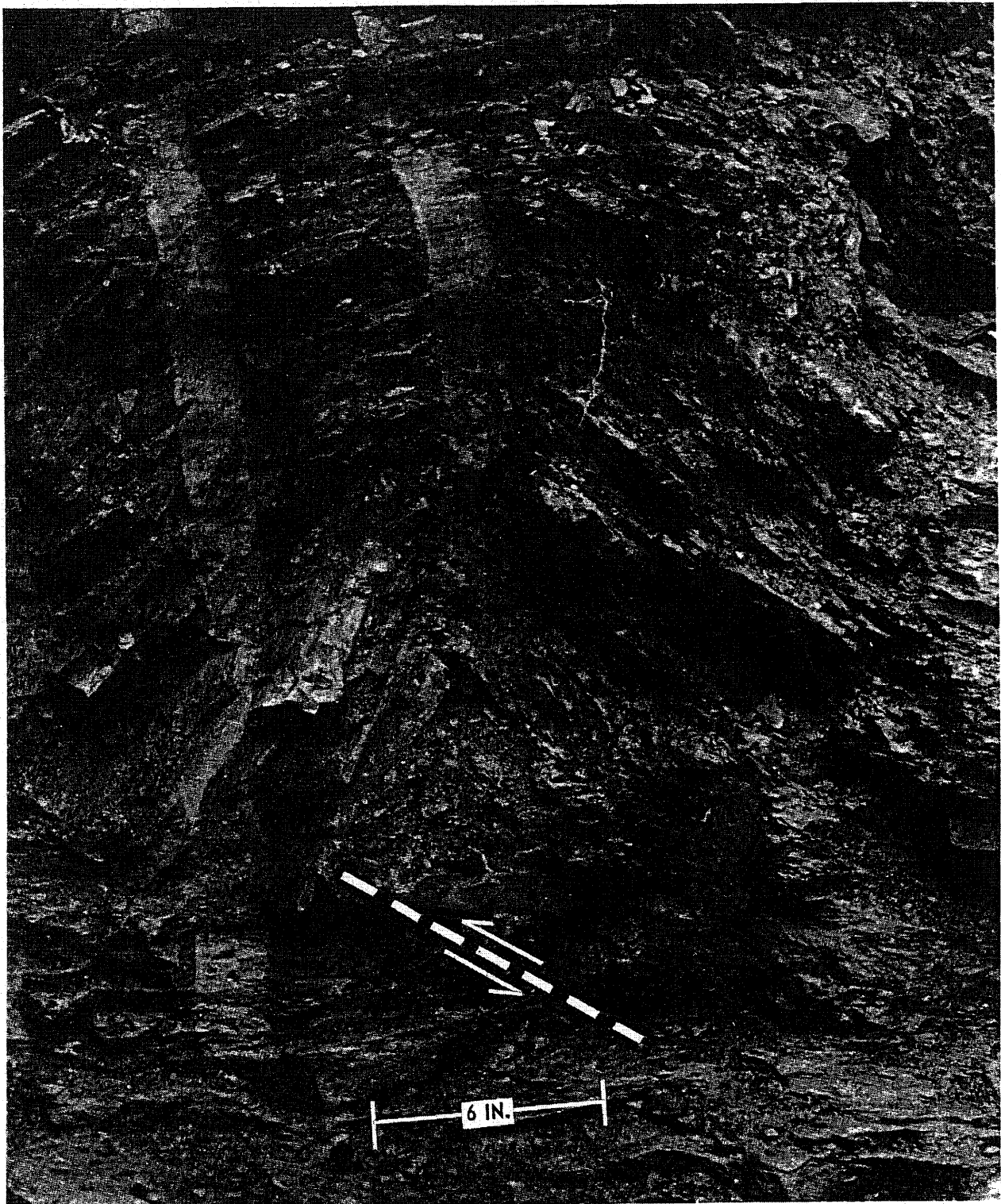
NOTE: See Figure 2.5-152 for Location.



## **PERRY NUCLEAR POWER PLANT**

Photographic Enlargement of  
Tightly Folded Strata at  
Warners (Bates)

Figure 2.5-160



Note: See Figure 2.5-152 for Location.

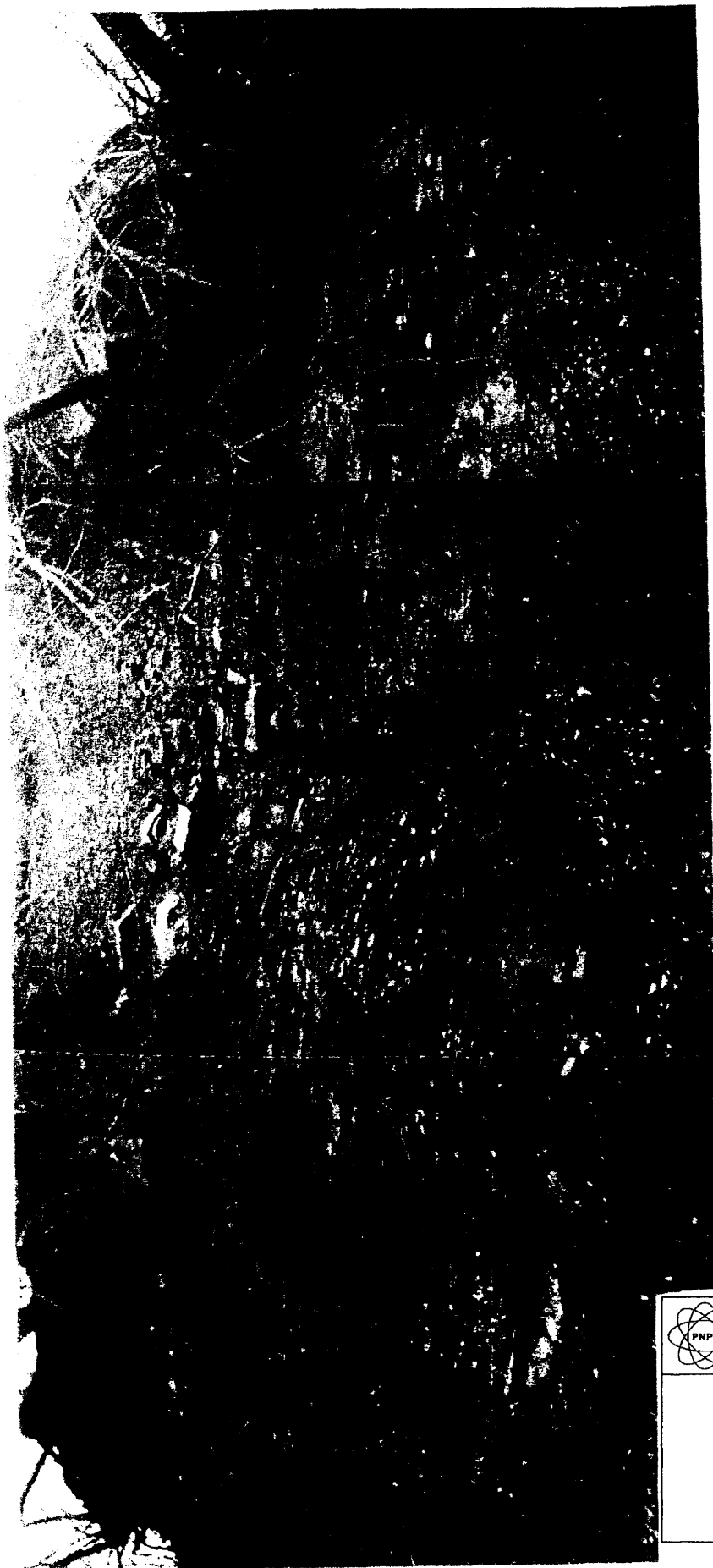
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Photograph of Minor Thrust Fault,  
20 ft North of Warners  
(Bates) Creek Fault

Figure 2.5-161



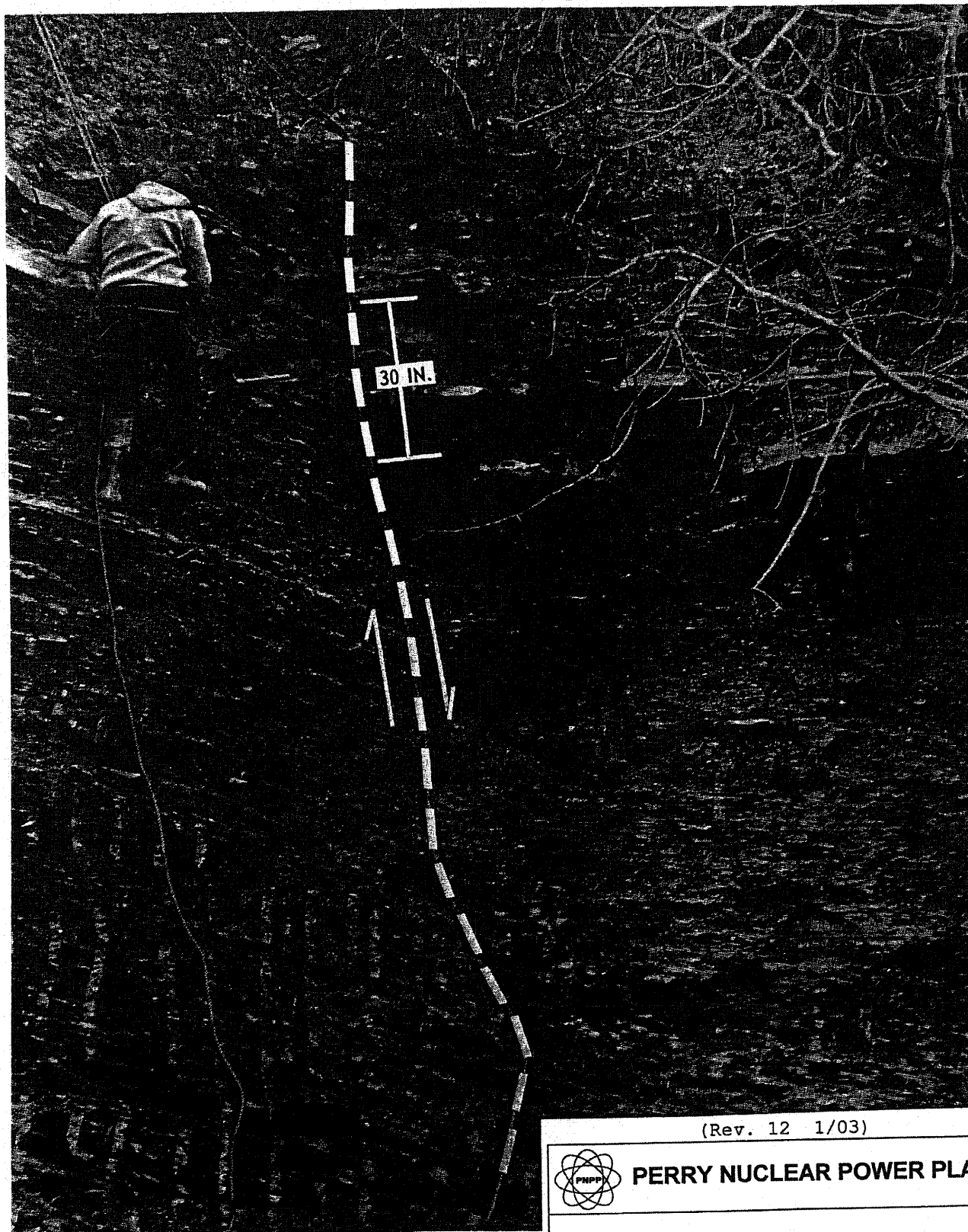
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Photograph of Hell Hollow  
Fault #1 Prior to Excavation

Figure 2.5-162



(Rev. 12 1/03)

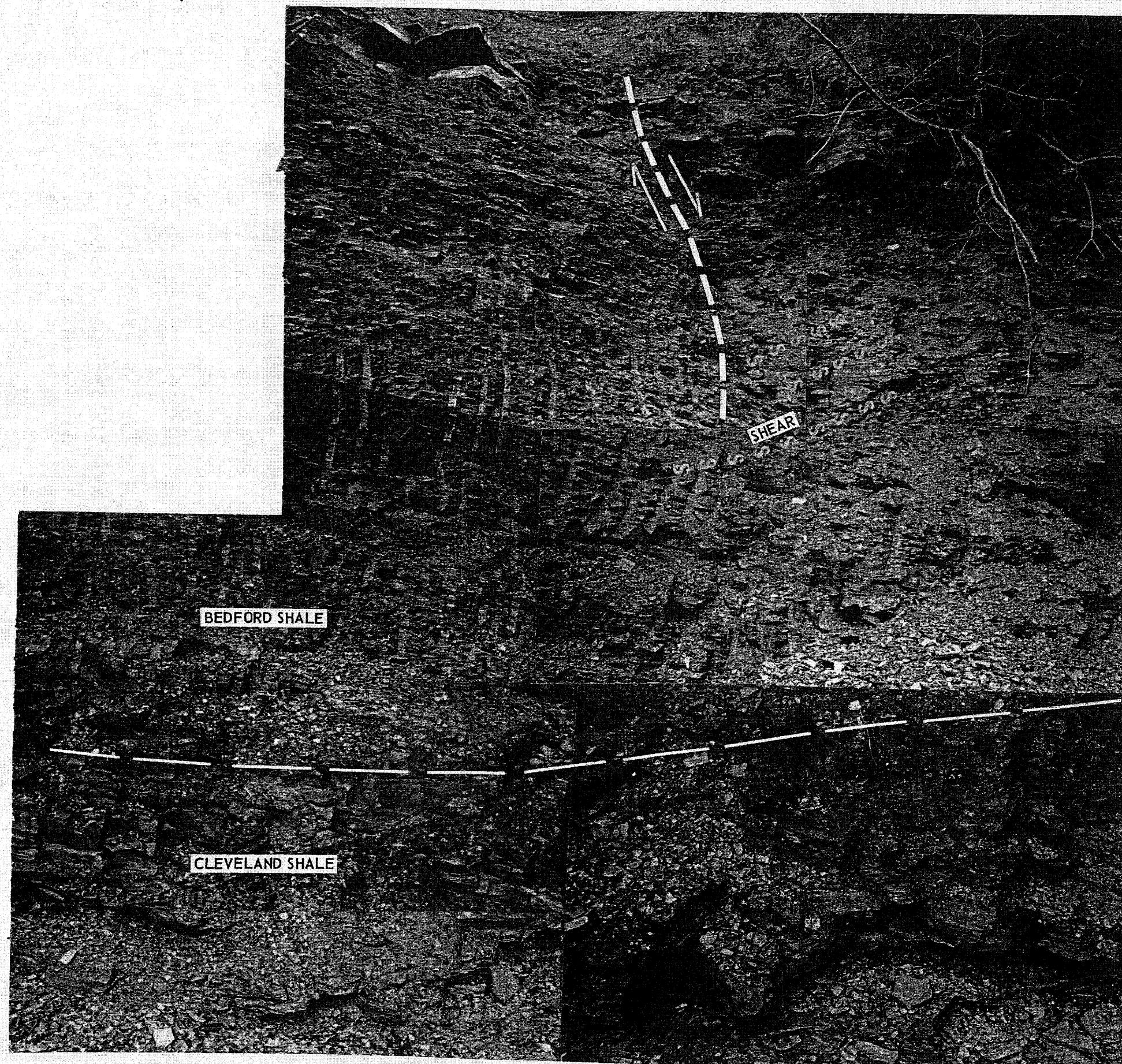


**PERRY NUCLEAR POWER PLANT**

Photograph of Hell Hollow  
Fault #1 After Excavation

Figure 2.5-163





(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Photographic Enlargement of  
Hell Hollow Fault #1  
After Excavation

Figure 2.5-164



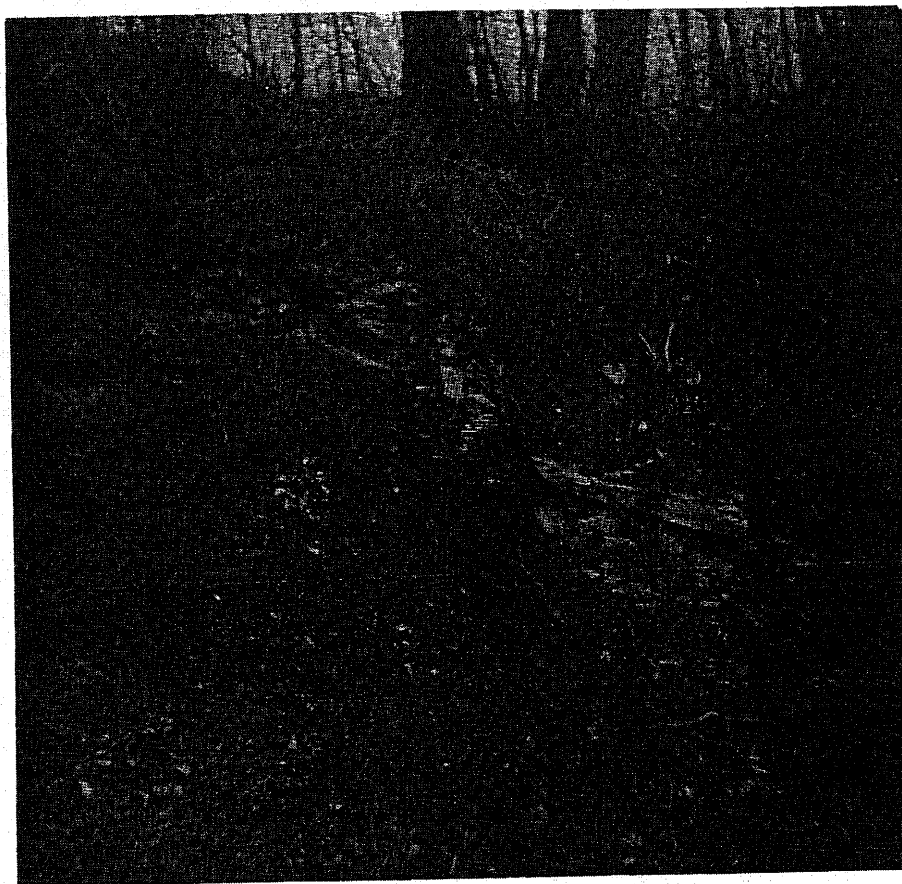
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Photograph of Hell Hollow  
Fault #2 After Excavation

Figure 2.5-165



(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Photograph of Hell Hollow  
Fault #3 Prior to Excavation

Figure 2.5-166





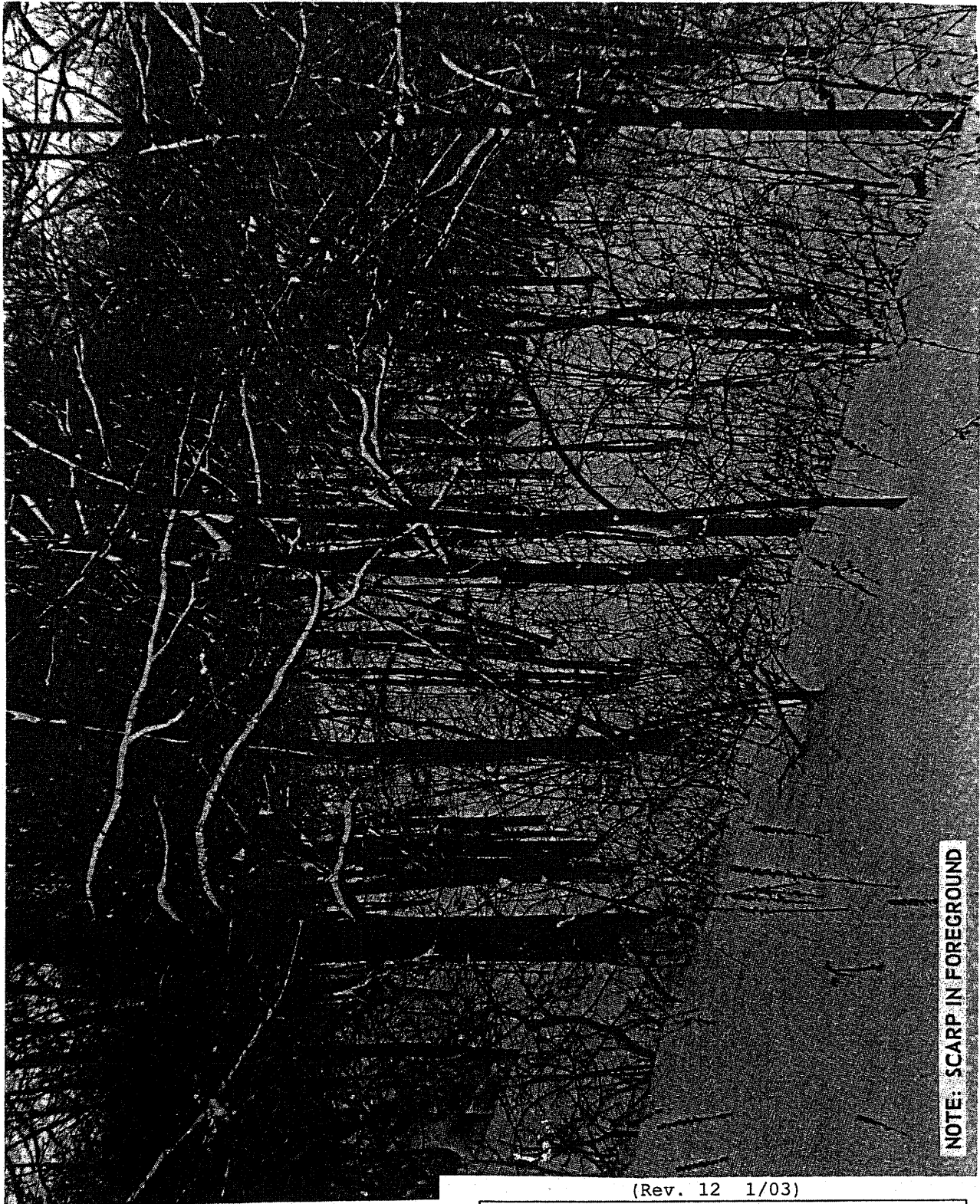
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Photograph of Hell Hollow  
Fault #3 After Excavation

Figure 2.5-167



NOTE: SCARP IN FOREGROUND

(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Photograph of Hell Hollow Slump  
Area Facing South

Figure 2.5-168



NOTE: SCARP IN BACKGROUND

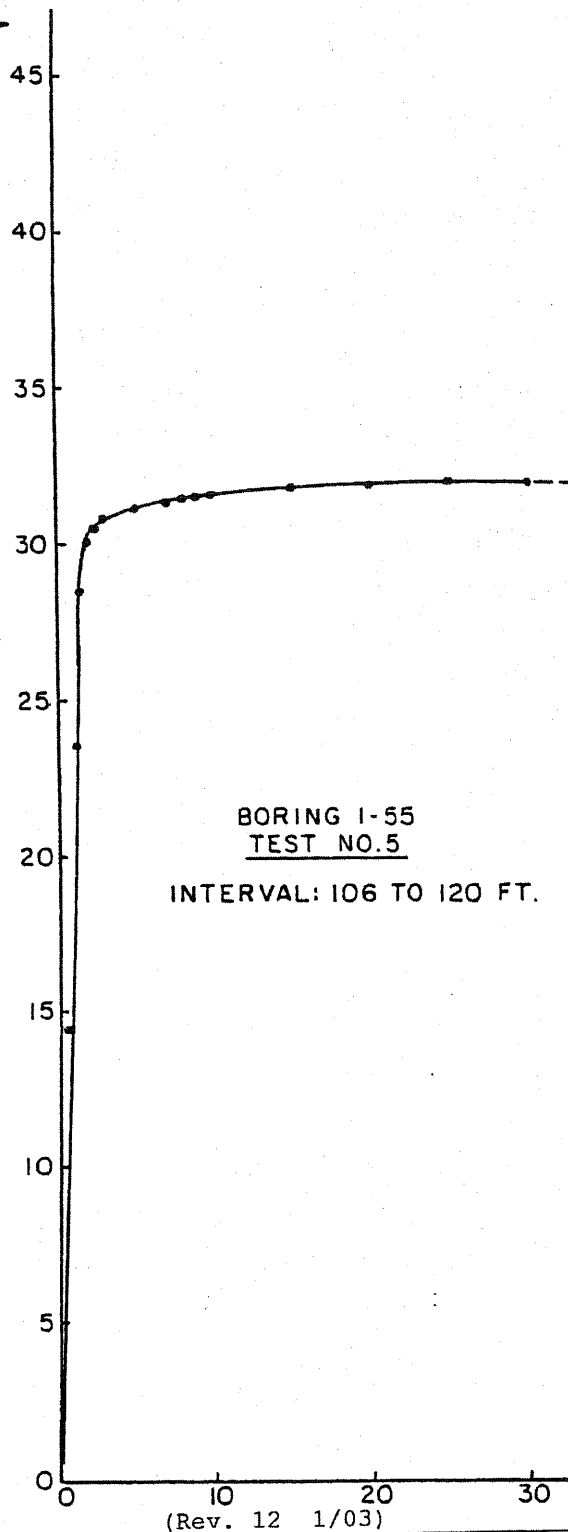
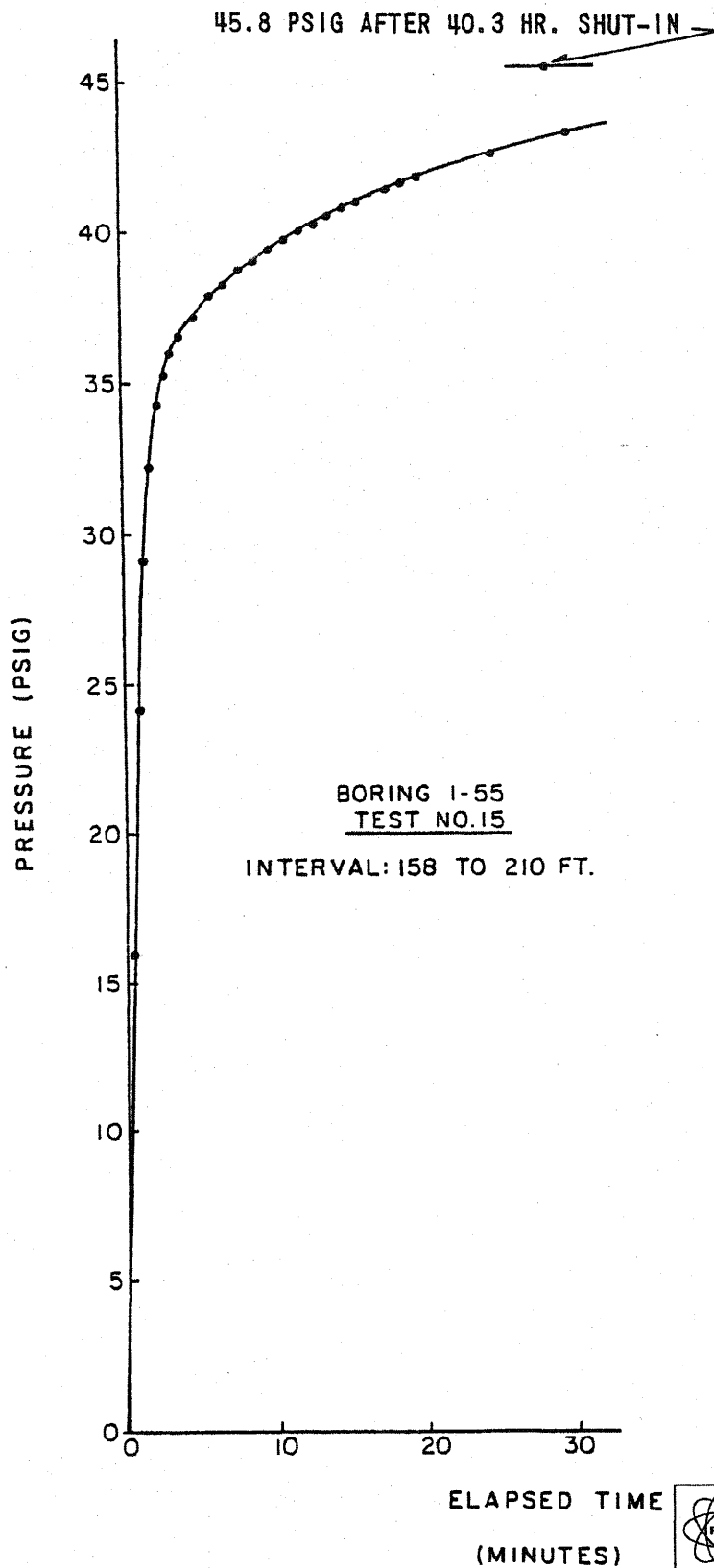
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Photograph of Hell Hollow Slump  
Area Facing East

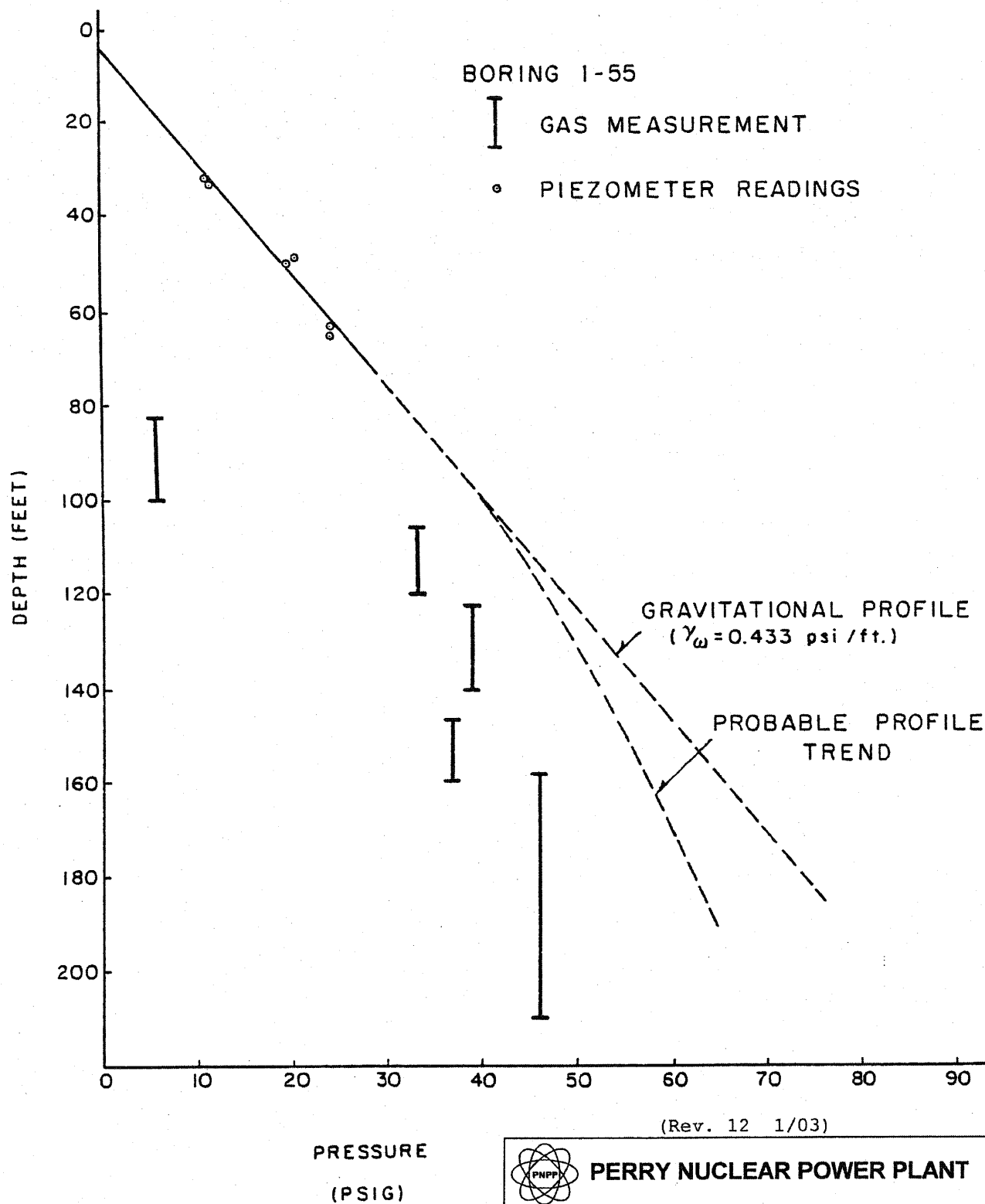
Figure 2.5-169



PERRY NUCLEAR POWER PLANT

Representative Records of  
Pressure vs. Shut-in Time

Figure 2.5-170



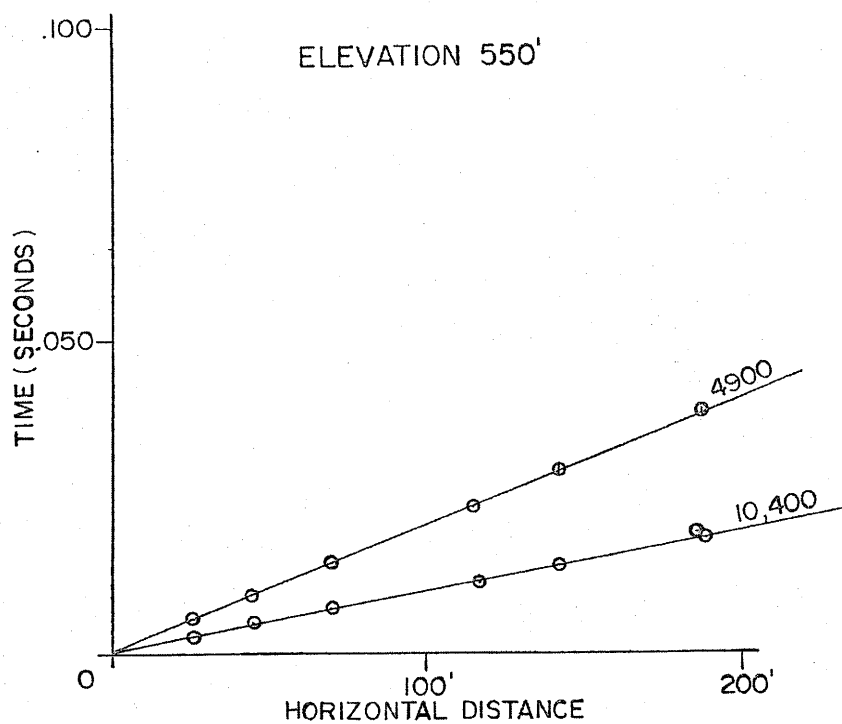
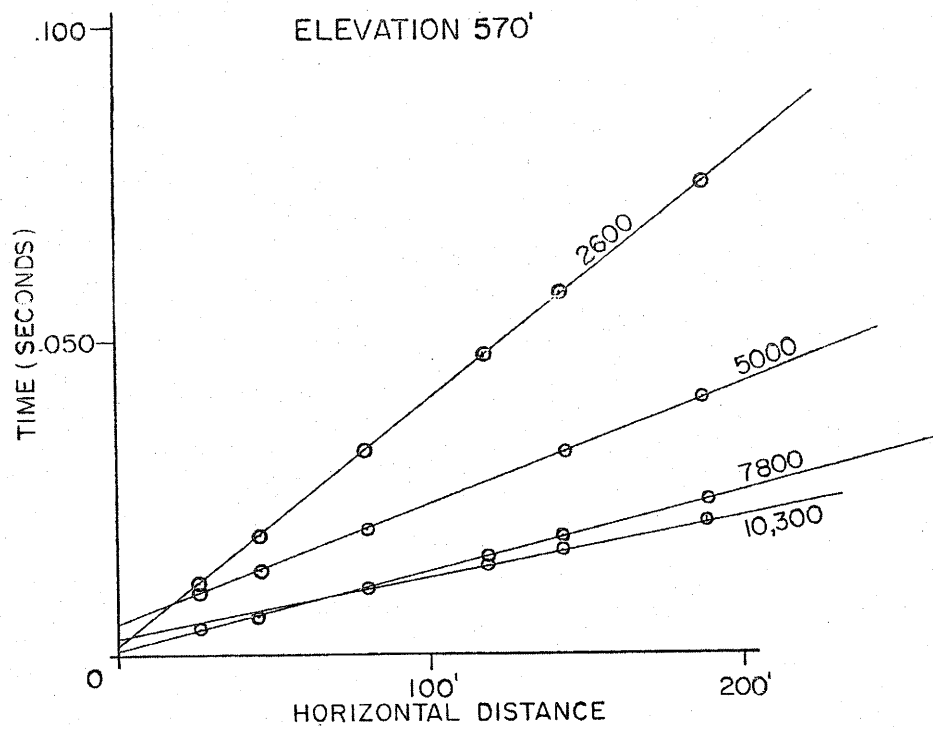
(Rev. 12 1/03)



PERRY NUCLEAR POWER PLANT

Pressure vs. Depth

Figure 2.5-171



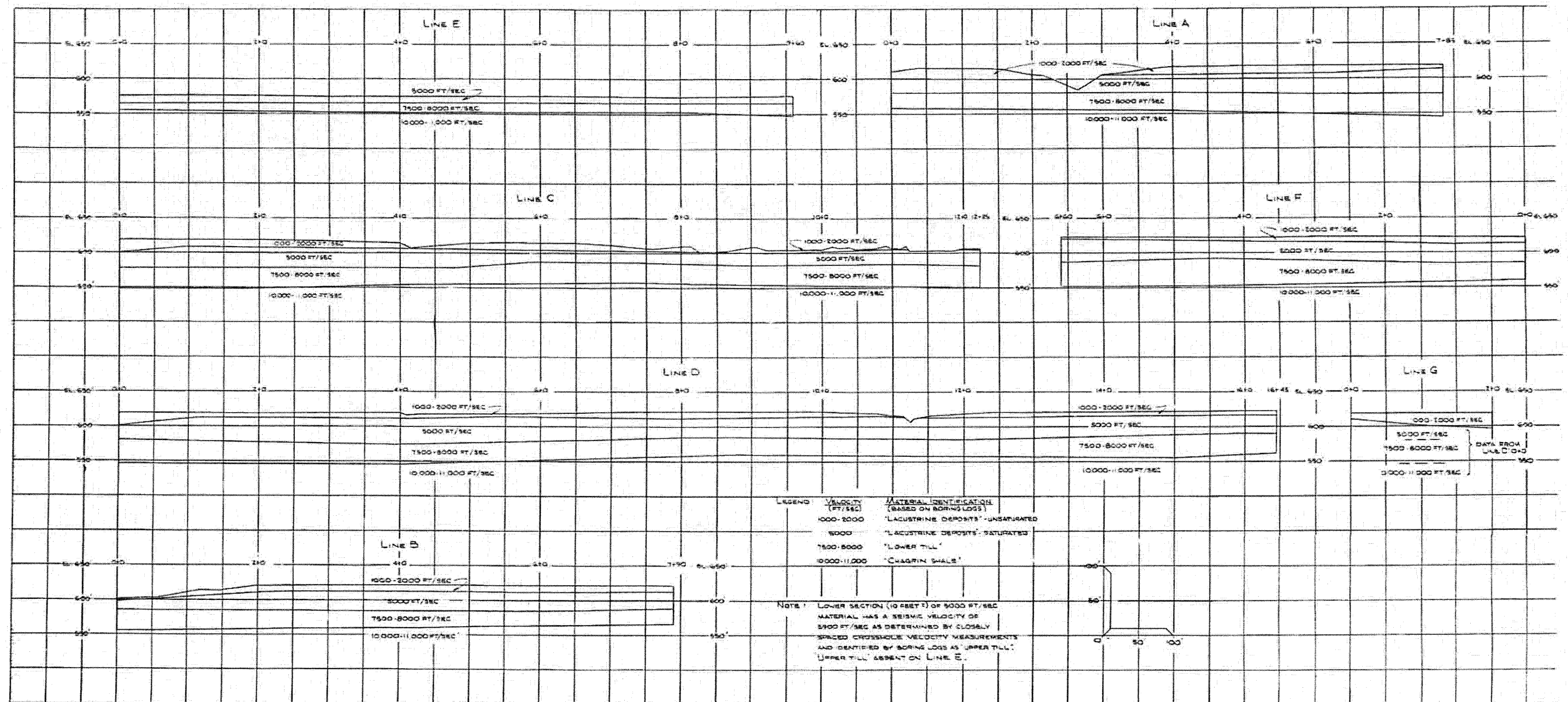
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Arrival Time vs. Distance

Figure 2.5-172



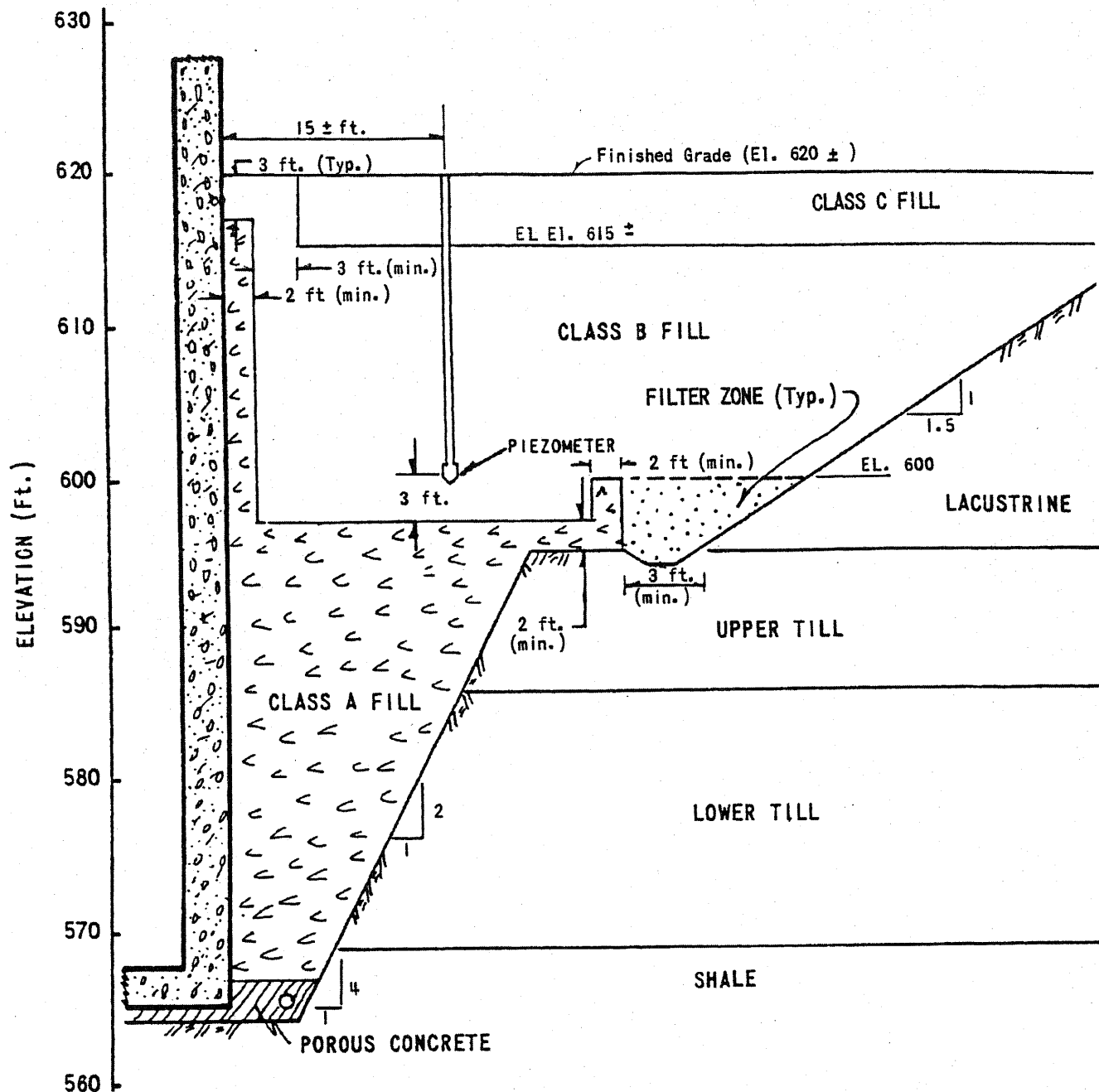
NOTE: See Figure 2.5-144 for Survey Line Traces.

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**PERRY NUCLEAR POWER PLANT**

Seismic Survey Profile

Figure 2.5-173



Note: As per section 2.5.4.5.5 the backfill materials shown in this figure may be replaced with Controlled Low Strength Material (CLSM).

(Rev. 12 1/03)

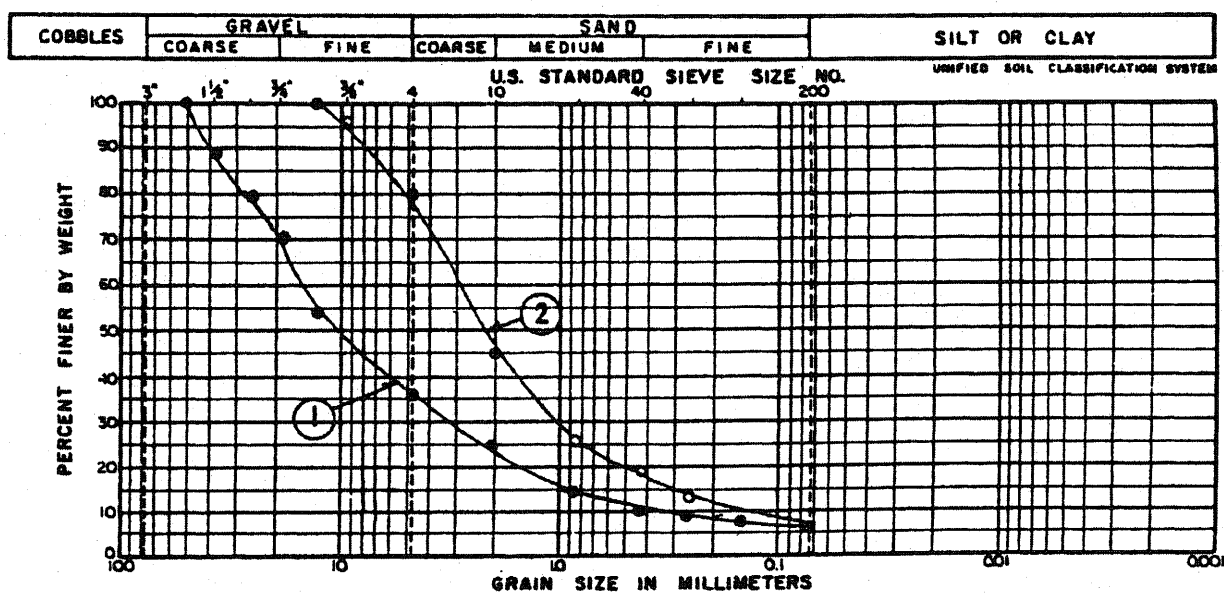


**PERRY NUCLEAR POWER PLANT**

Typical Backfill Section

Figure 2.5-174





- ① - QUARRY - RUN, CRUSHED DOLOMITIC LIMESTONE
- ② - TEST SAMPLE

(Rev. 12 1/03)



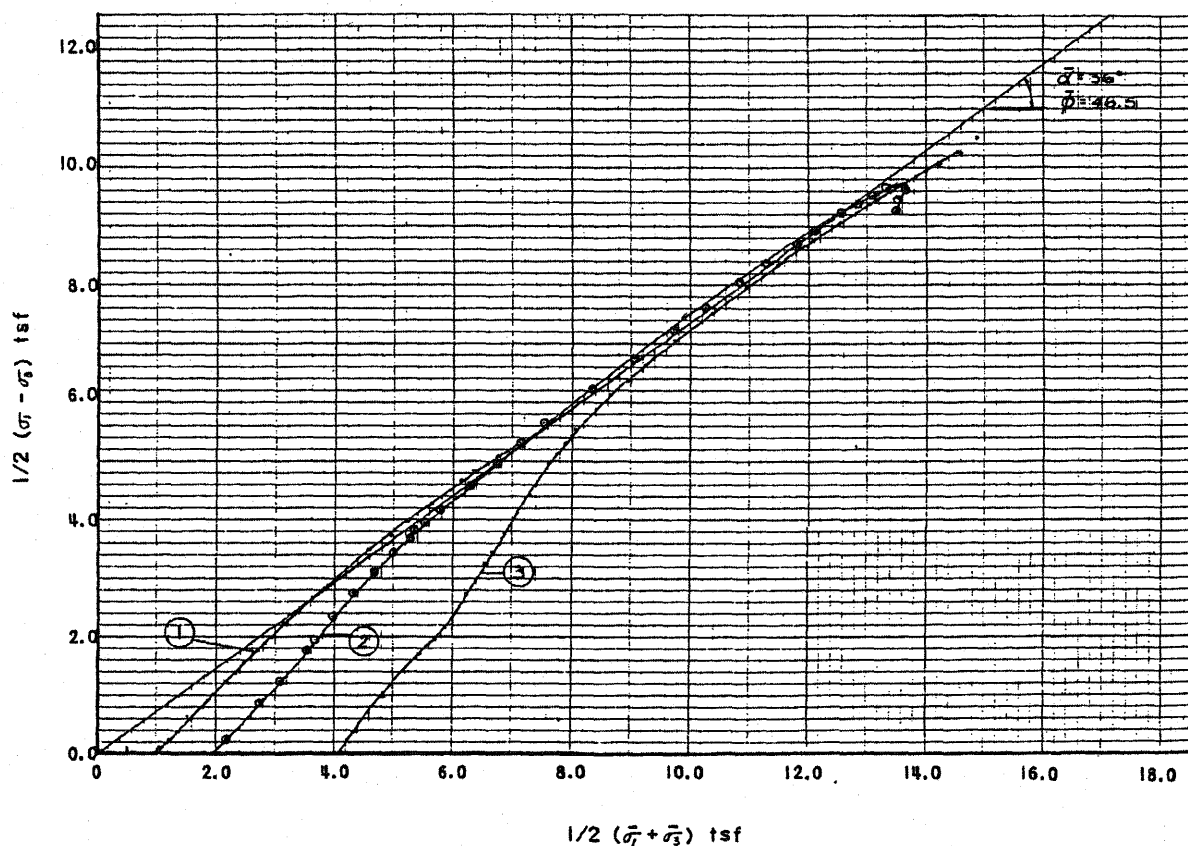
**PERRY NUCLEAR POWER PLANT**

Grain Size Distribution,  
Class A Fill Design

Figure 2.5-175

Test No.	Unit Dry Wgt. (pcf)	Relative Density (%)	Effective Consol. Pressure (ksf) $\bar{\sigma}_c$	Max. Stress Difference (ksf) $(\sigma_1 - \sigma_3)_f$	Failure Strain $\epsilon_f$ (%)
①	120.7	85.0	2	31.3	12.9
②	120.6	85.0	4	37.4	9.0
③	120.9	86.0	6	42.0	8.3

NOTES: Maximum Density = 125 pcf  
Minimum Density = 101 pcf



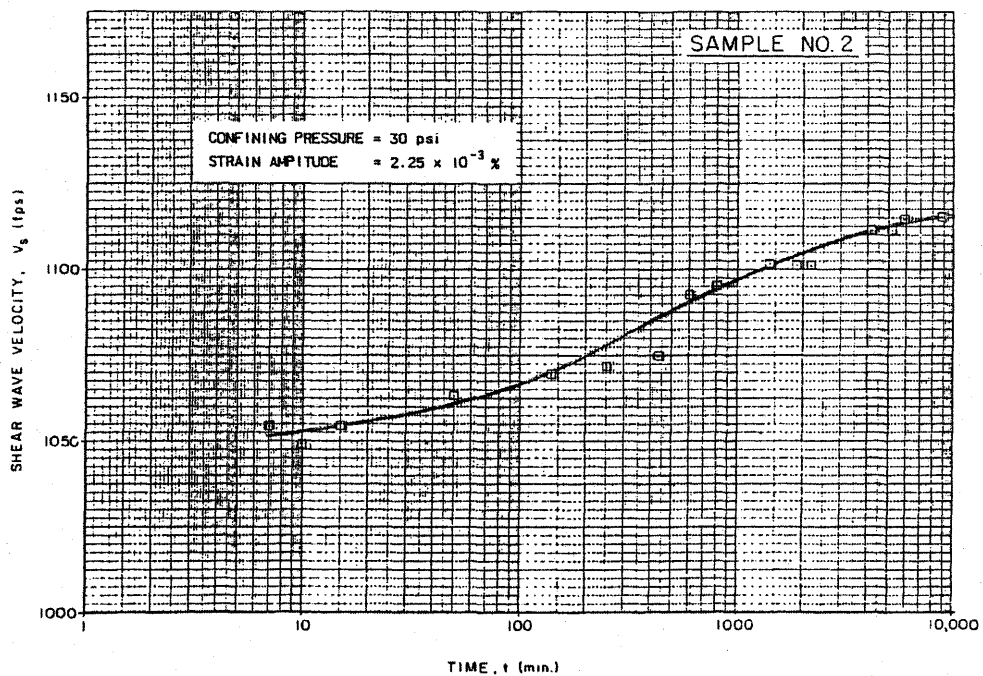
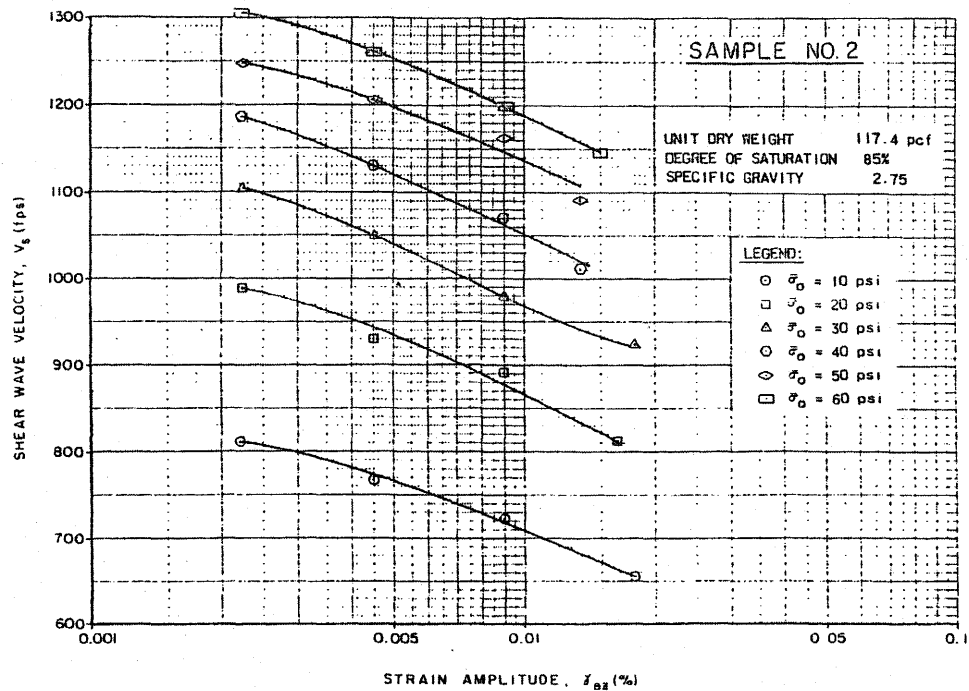
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Triaxial Compression  
Test Results, Class A  
Fill Design Investigation

Figure 2.5-176



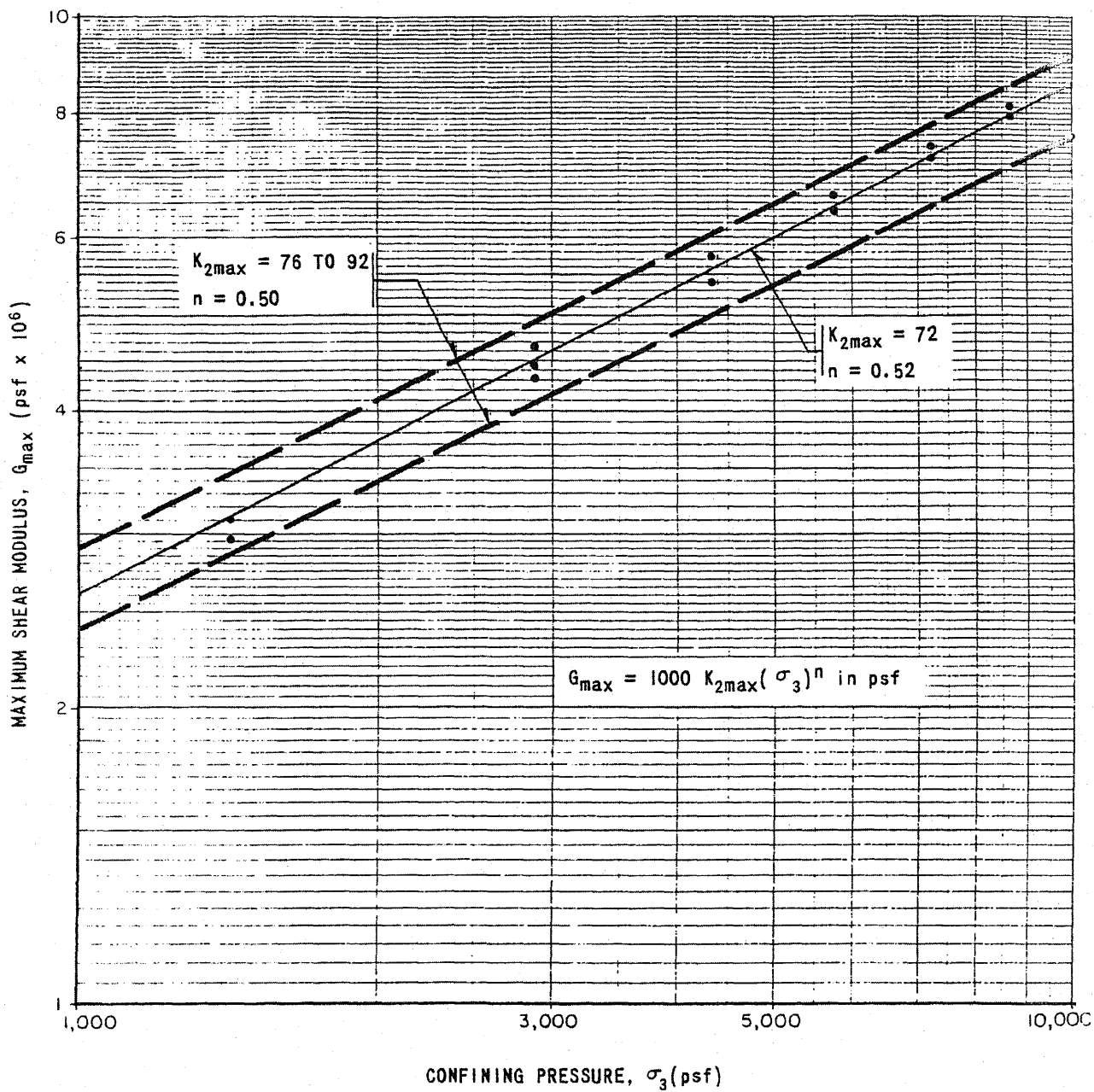
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Typical Results of High  
Amplitude Cyclic Torsion Tests,  
Class A Fill Design Investigations

Figure 2.5-177



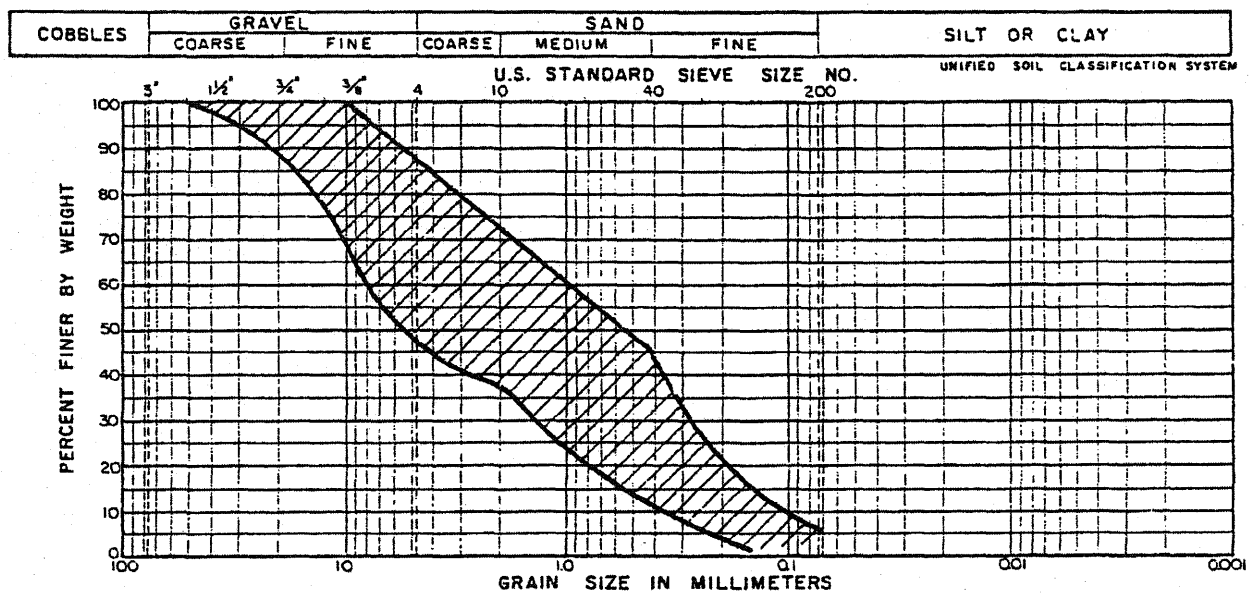
(Rev. 12 1/03)



# PERRY NUCLEAR POWER PLANT

Maximum Shear Modular vs.  
Confining Pressure, Class A  
Fill Design Investigation

Figure 2.5-178



NOTE: RANGE IS ESTIMATED BASED ON A RANDOM SAMPLING  
OF APPROXIMATELY 675 TESTS

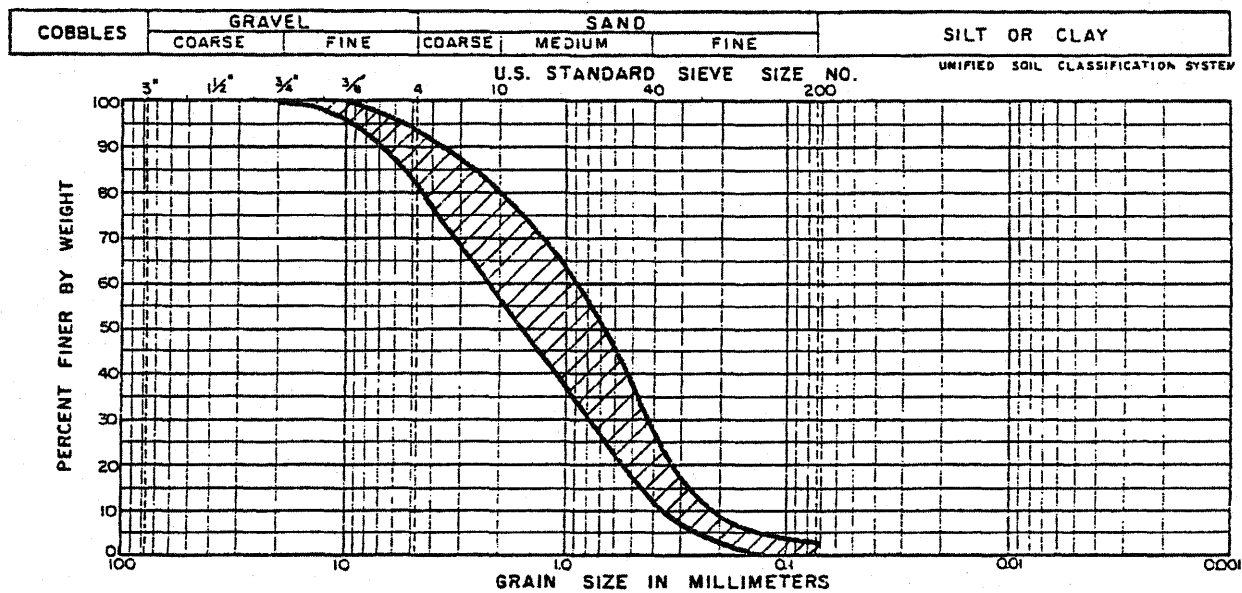
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Range of Grain Size Distribution  
Test Results for Class A Fill  
(Bestone Quarry)

Figure 2.5-179



NOTE: RANGE IS ESTIMATED BASED ON A RANDOM SAMPLING  
OF APPROXIMATELY 5500 TESTS

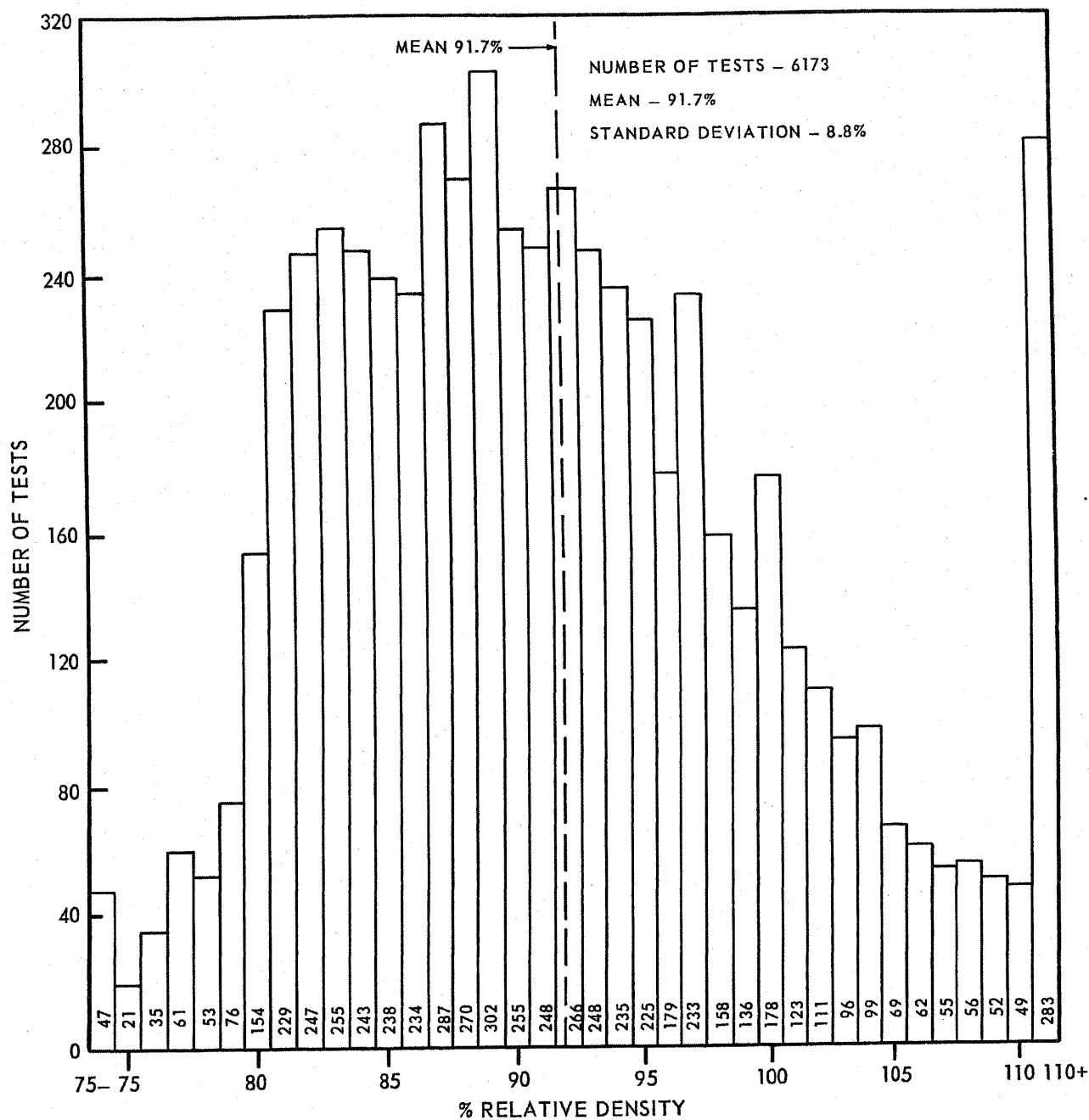
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Range of Grain Size Distribution  
Test Results for Class A Fill  
(Sidley Quarry)

Figure 2.5-180



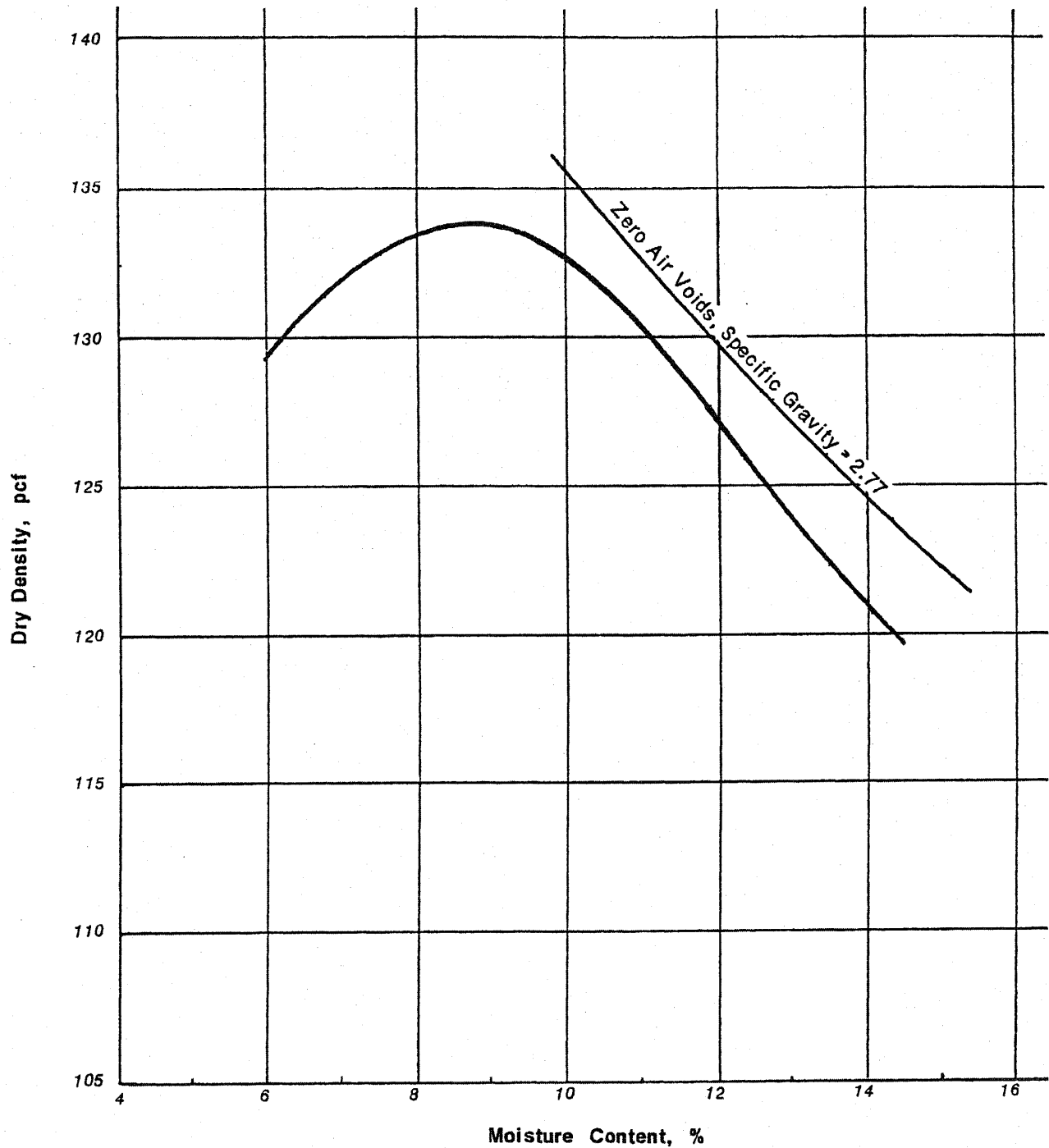
(Rev. 12 1/03)



# PERRY NUCLEAR POWER PLANT

Class A Fill - Field  
Density Tests

Figure 2.5-181



(Rev. 12 1/03)

Maximum Dry Density: 133.7 pcf  
Optimum Moisture: 8.9 %

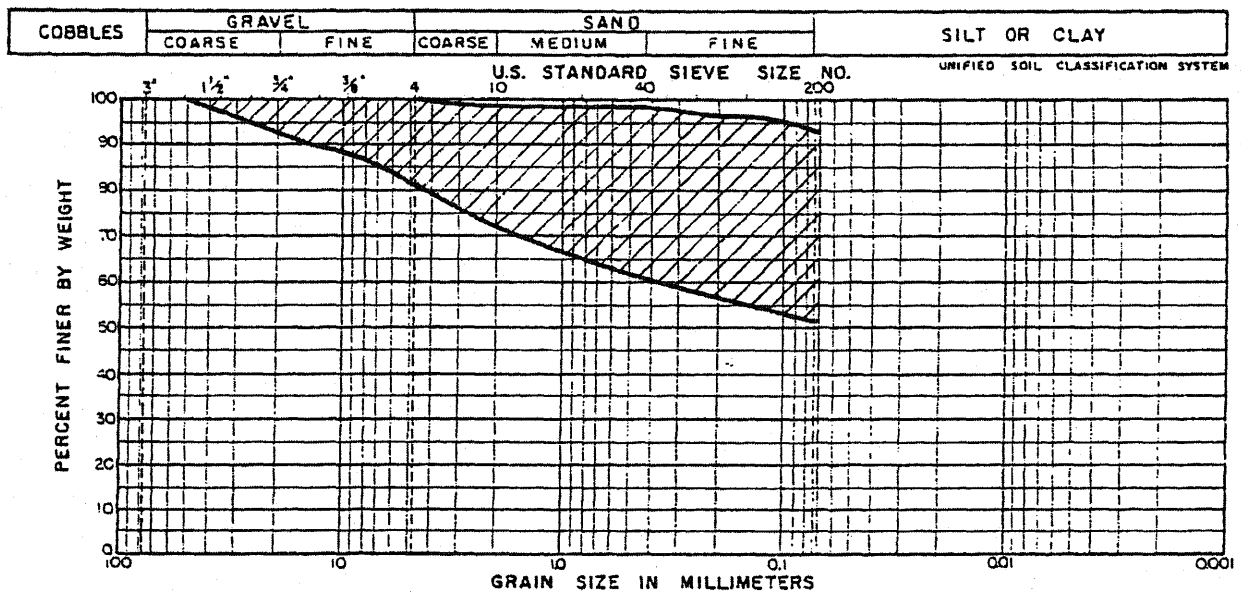


**PERRY NUCLEAR POWER PLANT**

Typical Compaction Curve,  
Class B Fill

Figure 2.5-182





NOTE: RANGE IS ESTIMATED BASED ON A RANDOM SAMPLING  
OF APPROXIMATELY 200 TESTS

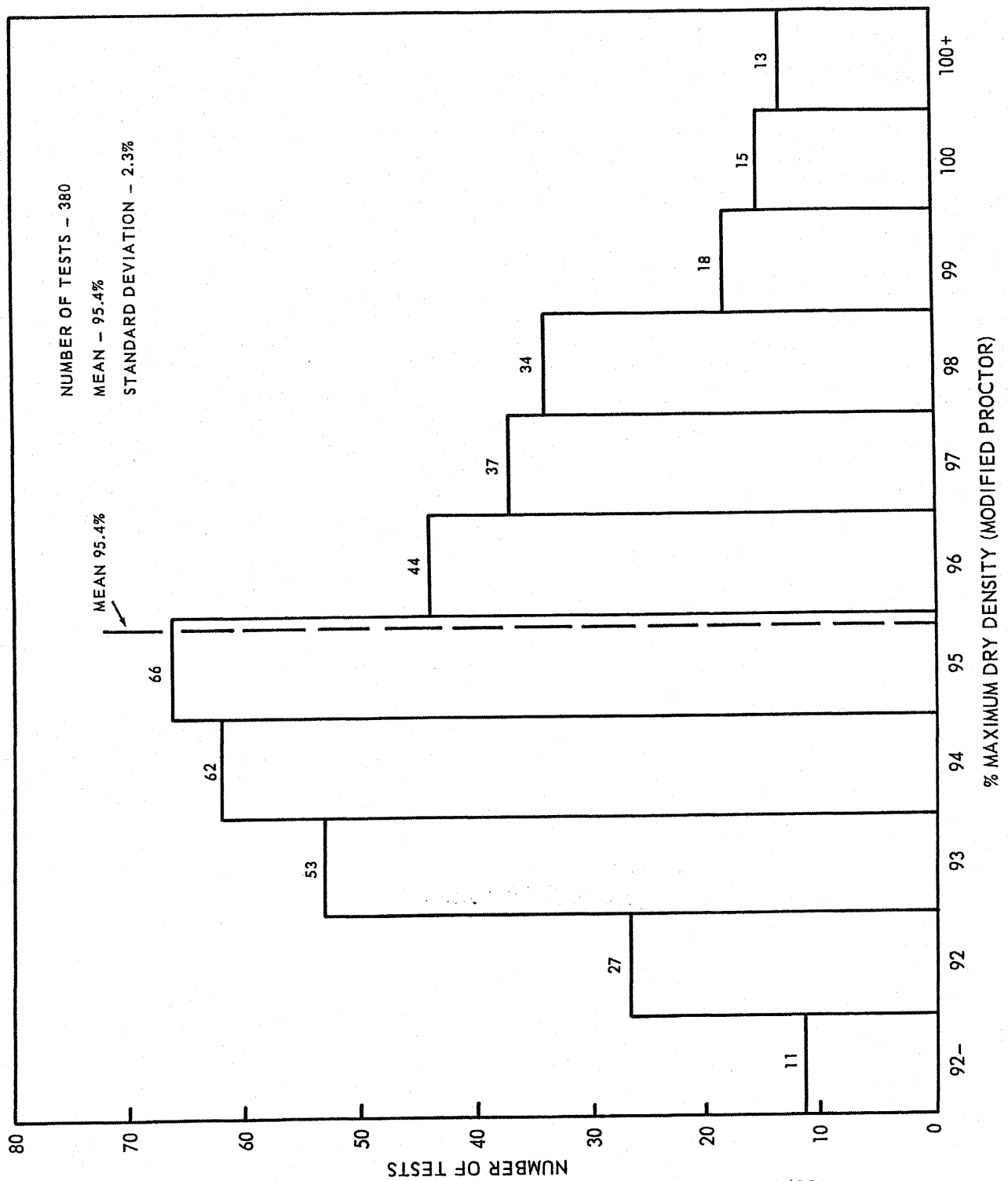
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Range of Grain Size Distribution  
Test Results for Class B Fill

Figure 2.5-183



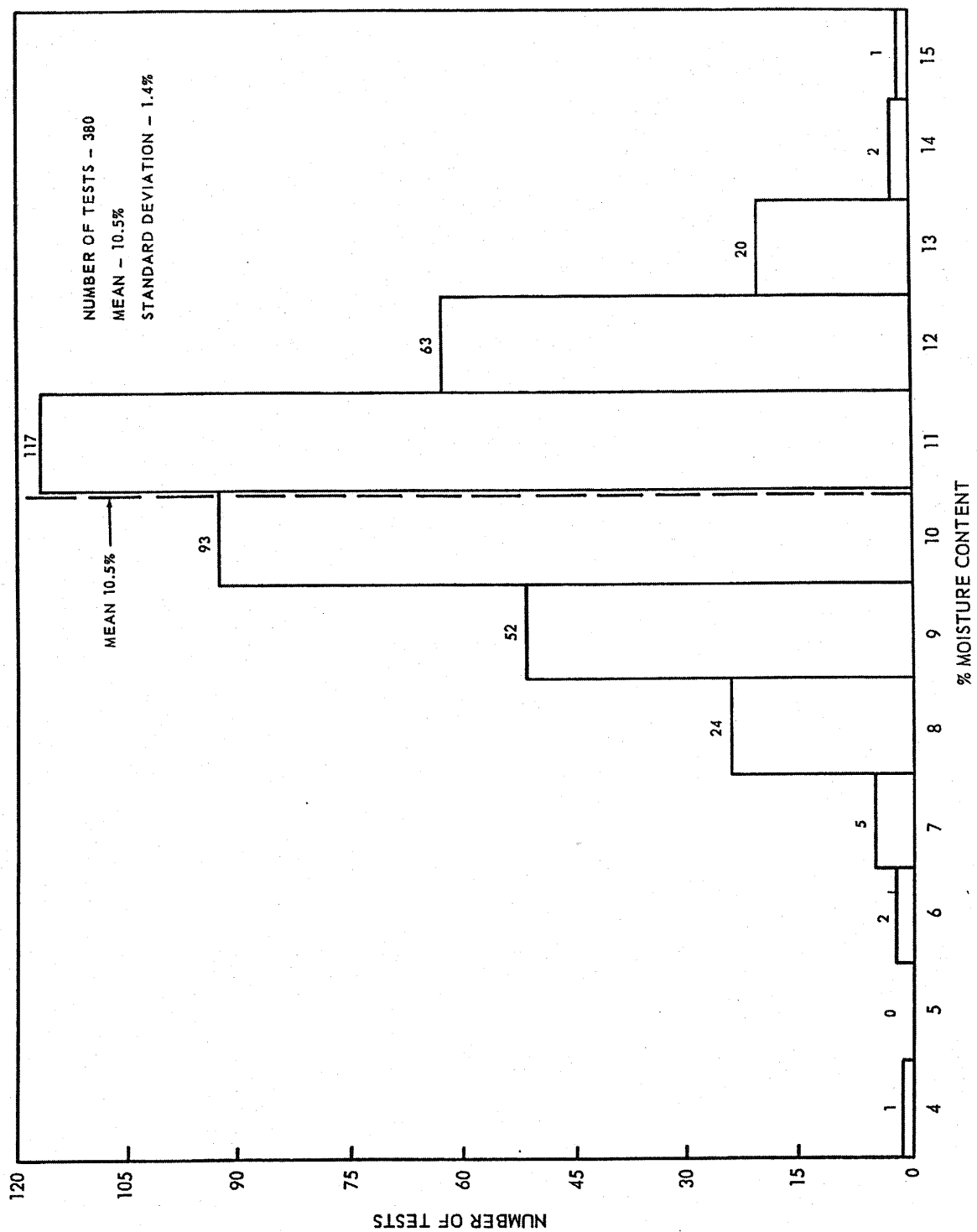
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Class B Fill - Field  
Density Tests

Figure 2.5-184



(Rev. 12 1/03)

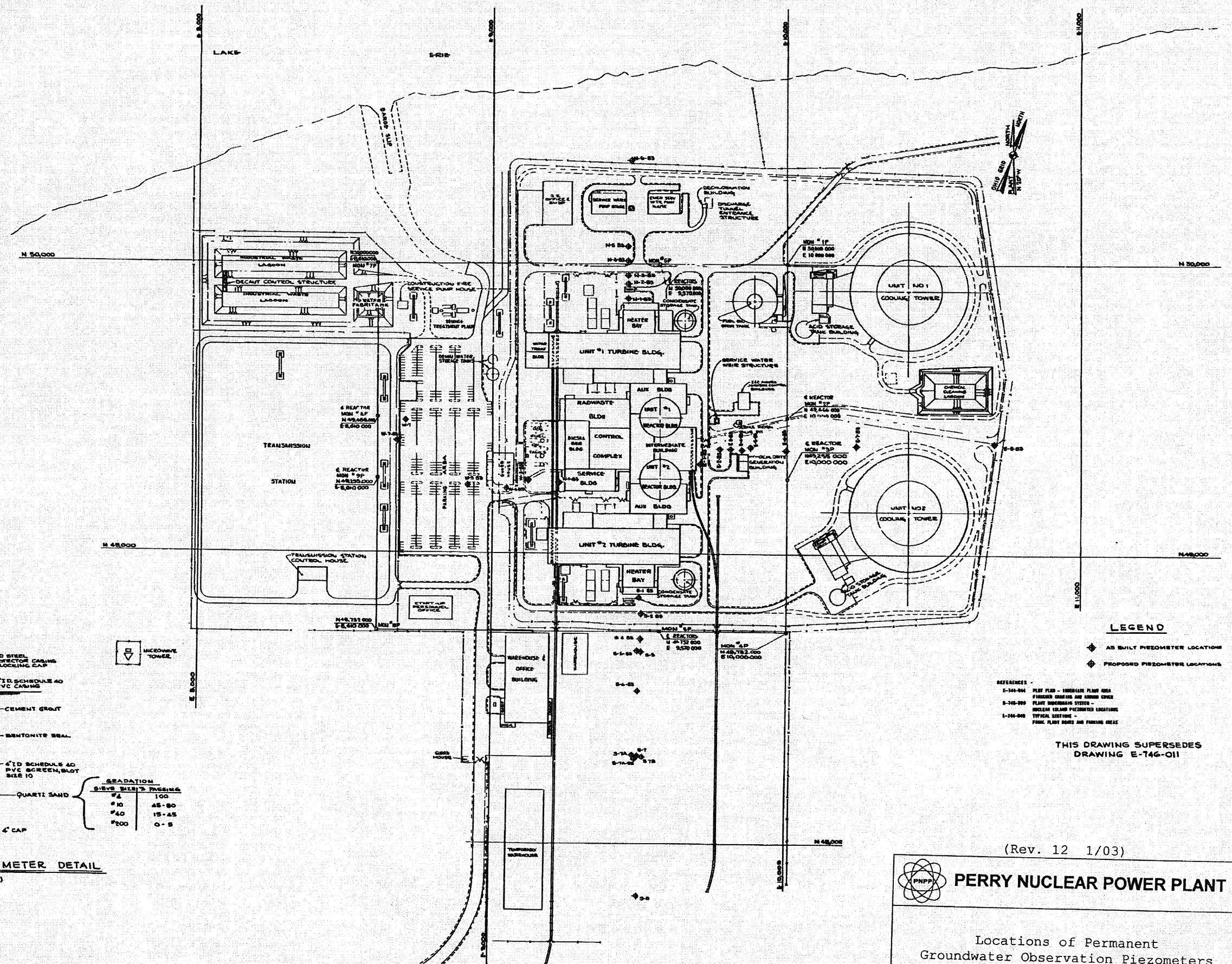
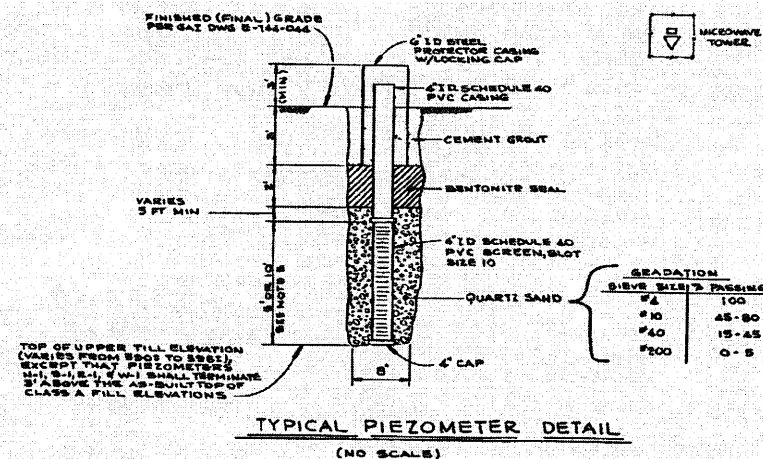


**PERRY NUCLEAR POWER PLANT**

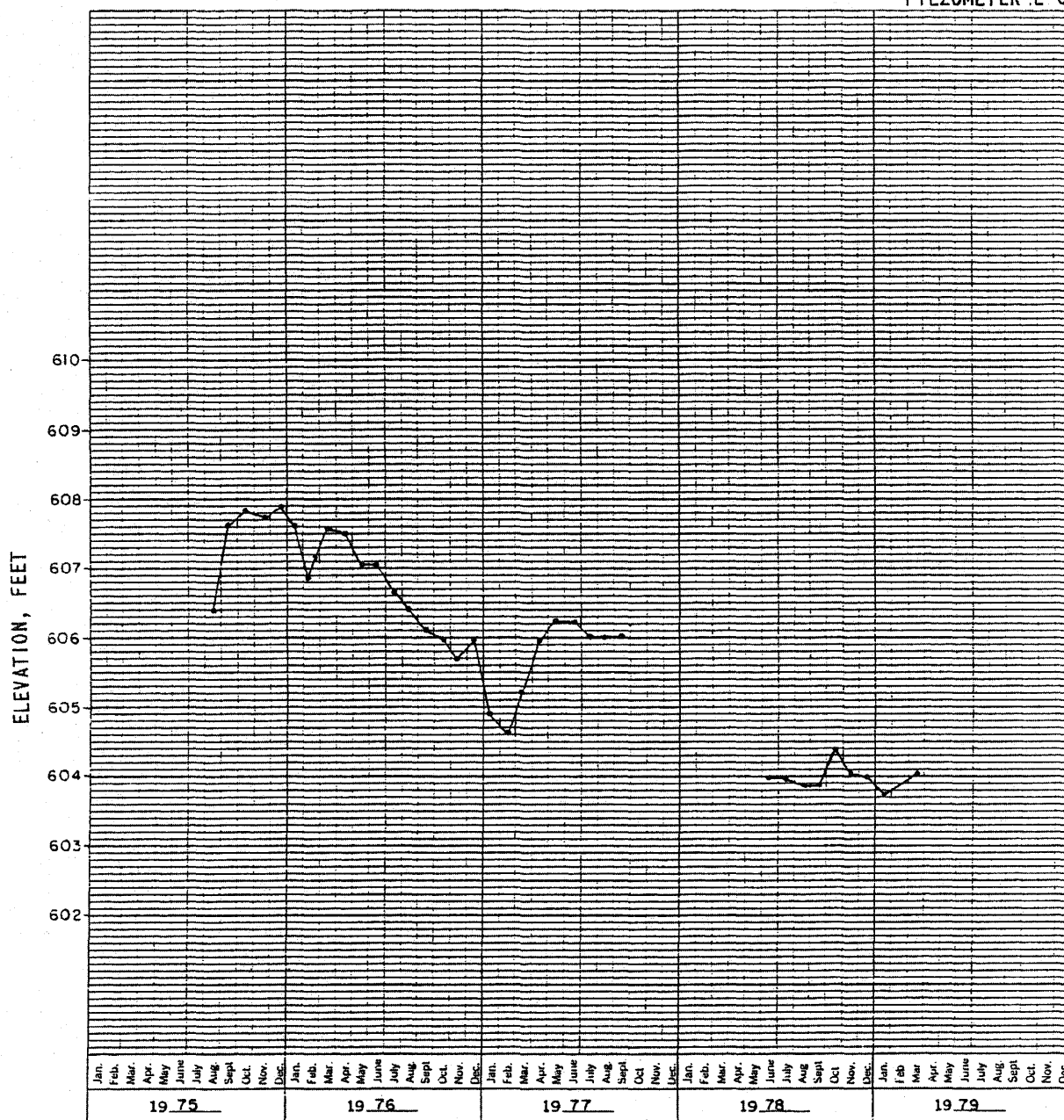
Class B Fill - Field  
Moisture Tests

Figure 2.5-185

PIEZOMETER LOCATION SCHEDULE		
PIEZOMETER	N. COORD	E. COORD
N-1-B3	49,880.63	9,459.89
N-2-B3	49,889.81	9,460.04
N-3-B3	49,899.31	9,460.43
N-4-B3	50,009.13	9,460.39
N-5-B3	50,039.40	9,458.34
N-6-B3	50,051.61	9,471.80
S-1-B3	48,848.38	9,500.16
S-2-B3	48,790.46	9,505.26
S-4-B3	48,708.22	9,508.04
S-5	48,660.00	9,500.00
S-6-B3	48,662.99	9,498.40
S-6-B3	48,579.57	9,488.34
S-7	48,500.11	9,498.00
S-7A	48,502.71	9,494.00
S-7A-B3	48,501.62	9,488.31
S-7B	48,187.00	9,501.00
S-8	47,880.41	9,500.00
S-1-B3	48,508.33	9,708.00
S-2-B3	48,540.22	9,749.30
S-3-B3	48,559.81	9,803.52
S-4-B3	48,588.80	9,847.05
S-5-B3	48,569.48	9,877.00
S-6-B3	48,536.40	9,996.38
S-7-B3	48,510.71	10,238.94
S-8-B3	48,382.11	10,708.47
W-1-B3	49,744.80	9,376.15
W-2-B3	49,721.71	9,311.01
W-3-B3	49,722.21	9,047.24
W-4-B3	49,736.34	9,916.30
W-1	49,458.11	9,706.00
W-2	49,586.95	9,678.50



PIEZOMETER E-3



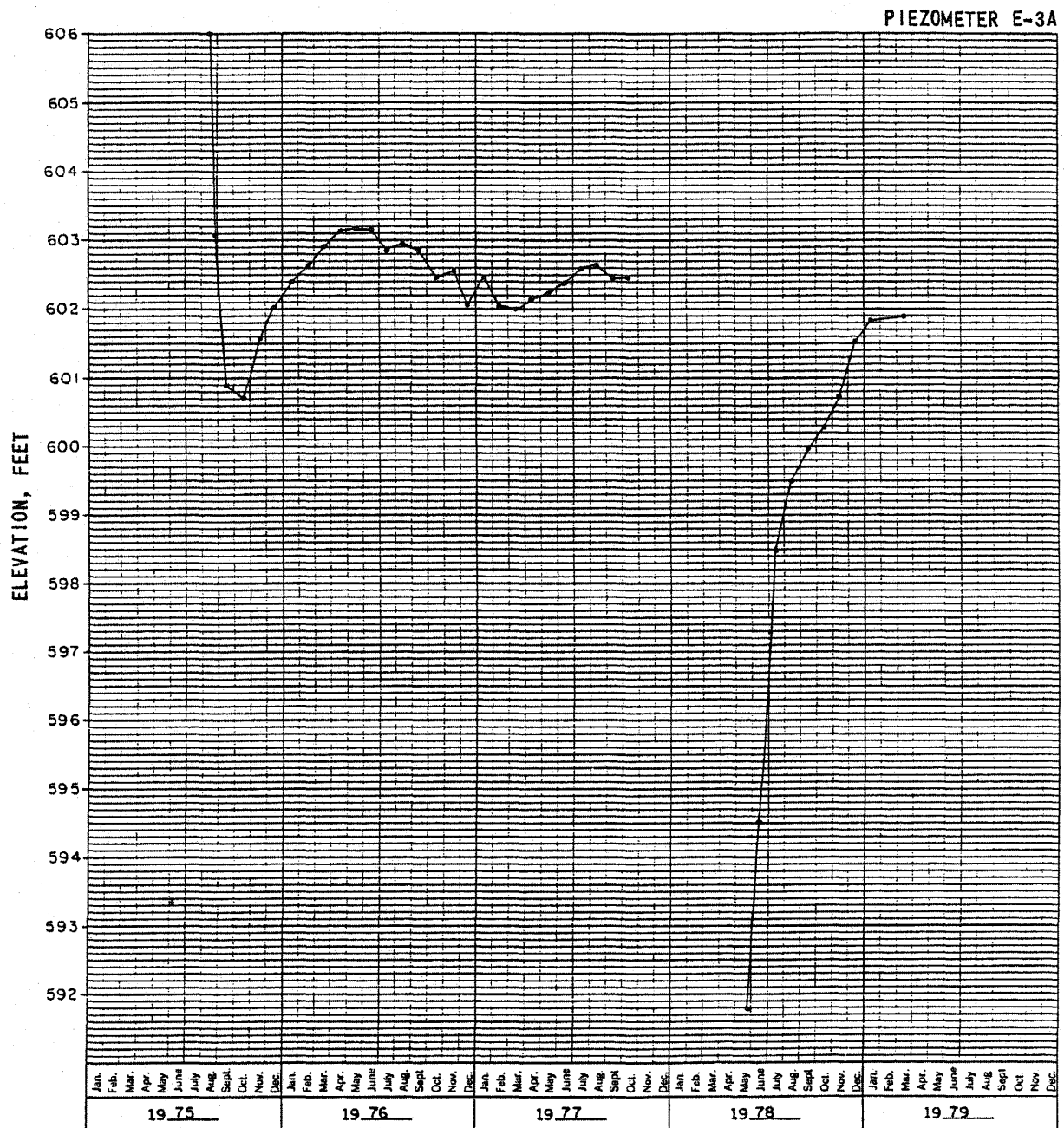
(Rev. 12 1/03)



# PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 1 of 34)



(Rev. 12 1/03)

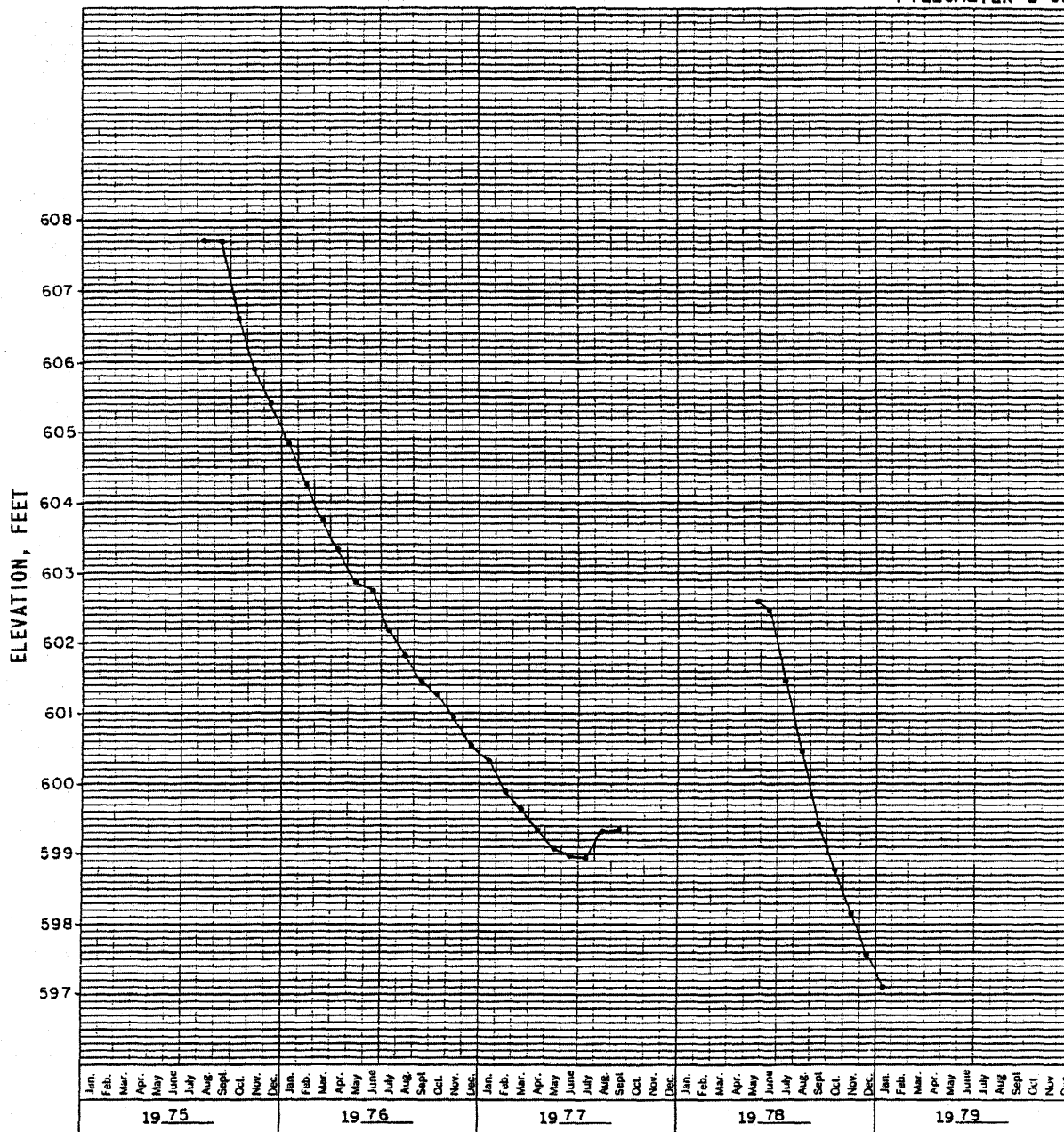


## PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 2 of 34)

PIEZOMETER E-3B



(Rev. 12 1/03)



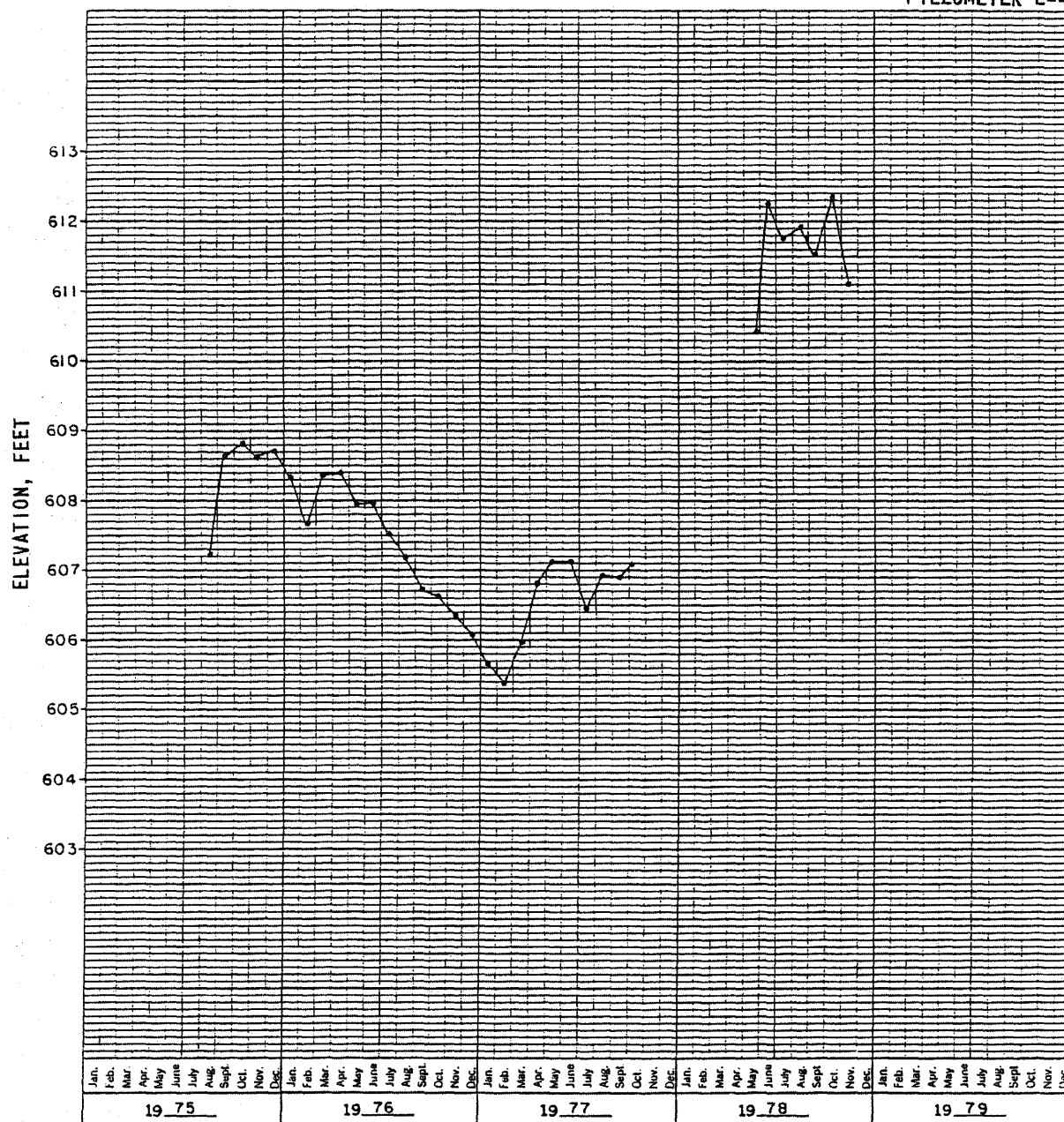
**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 3 of 34)



PIEZOMETER E-4



(Rev. 12 1/03)



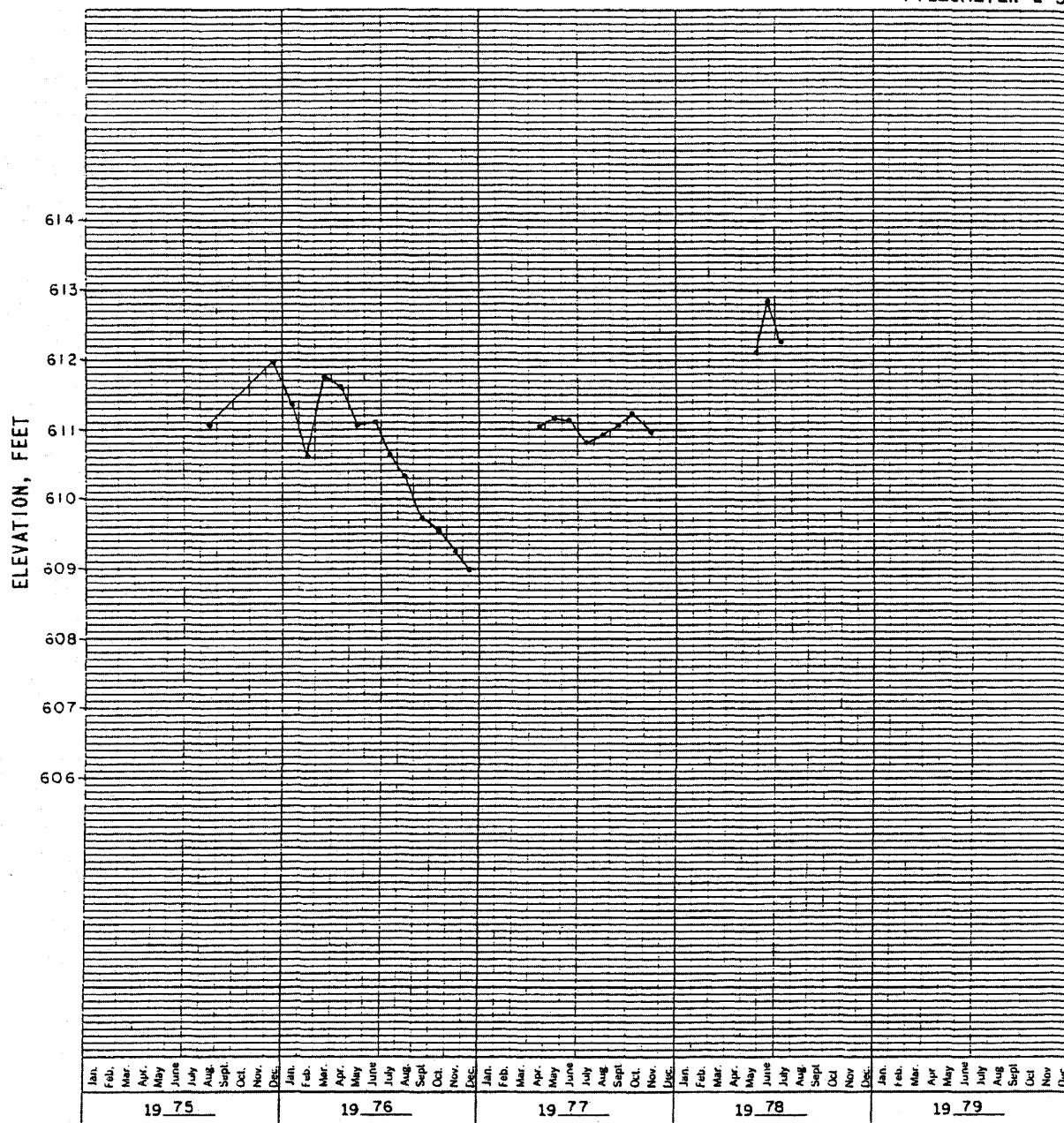
**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 4 of 34)



PIEZOMETER E-5



(Rev. 12 1/03)

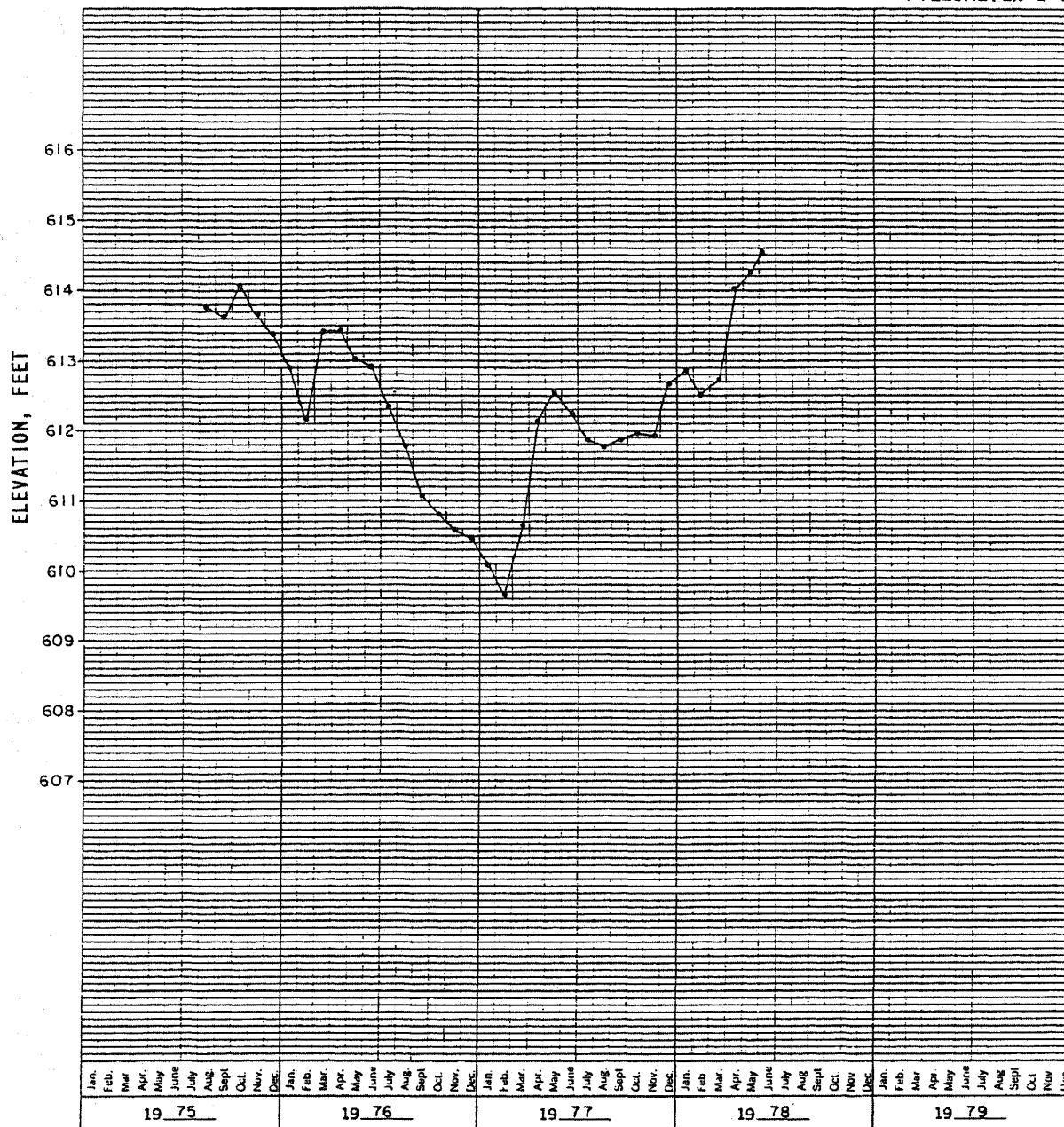


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 5 of 34)

PIEZOMETER E-6



(Rev. 12 1/03)

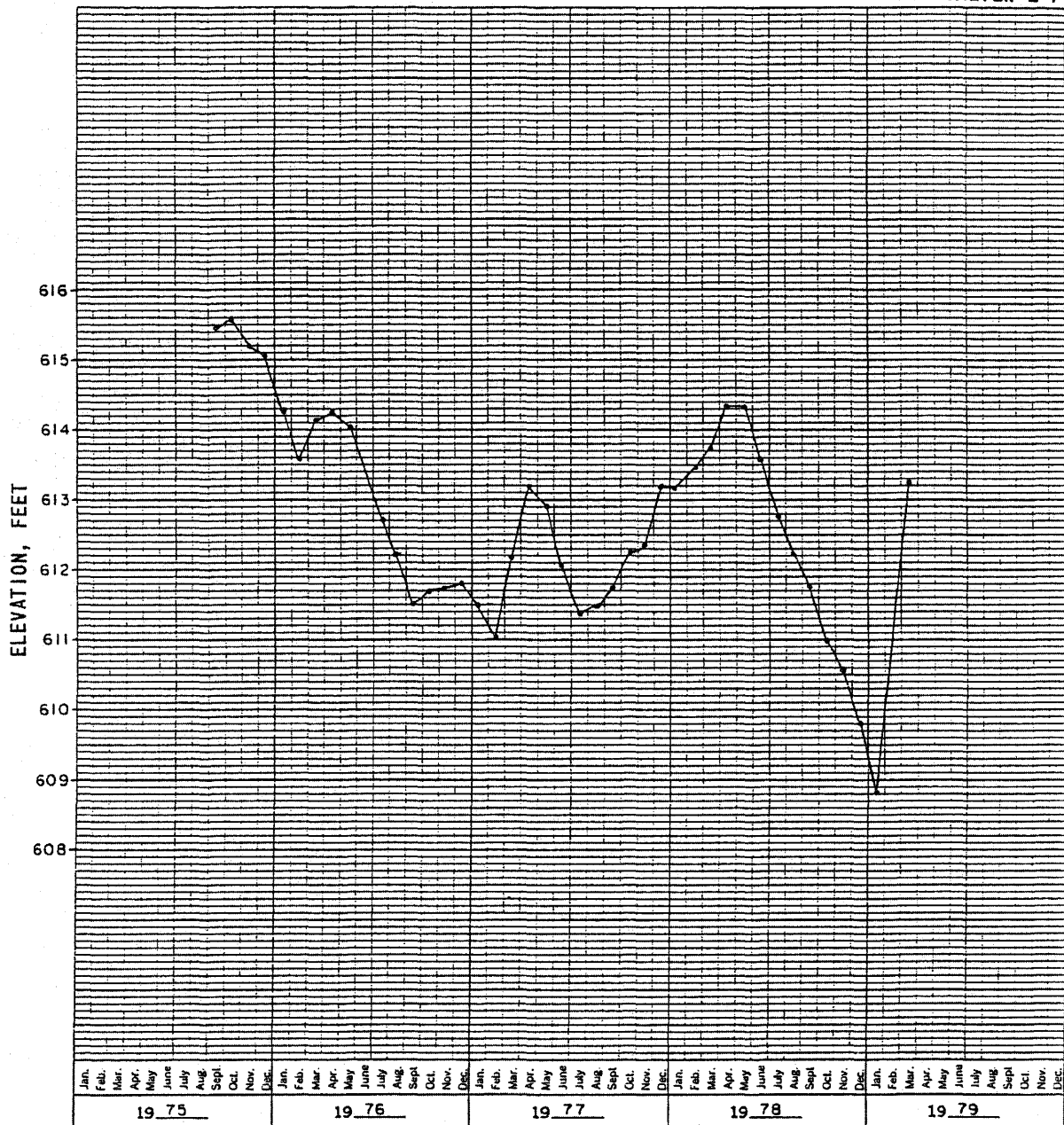


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 6 of 34)

PIEZOMETER E-7



(Rev. 12 1/03)

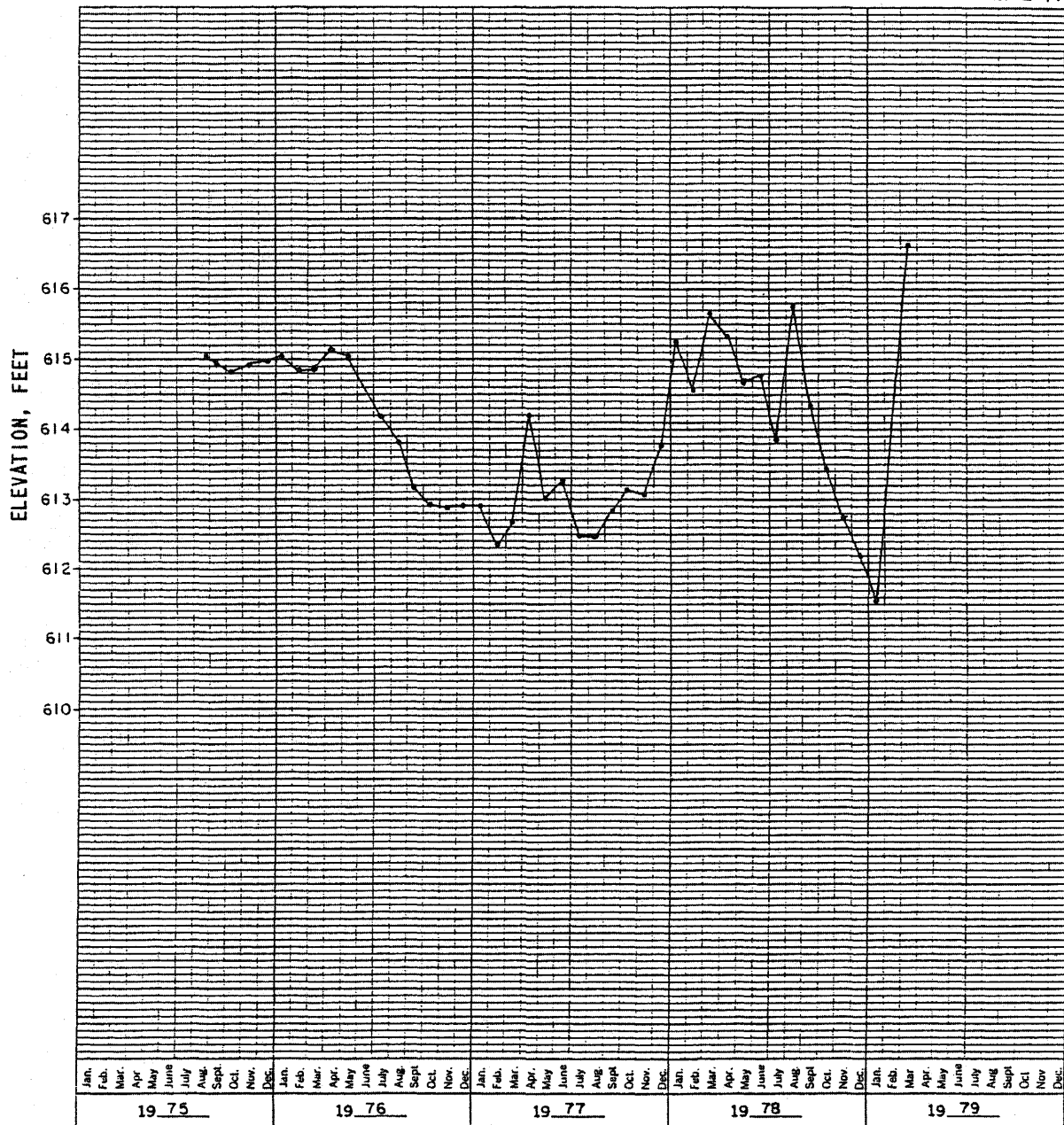


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 7 of 34)

PIEZOMETER E-7A



(Rev. 12 1/03)

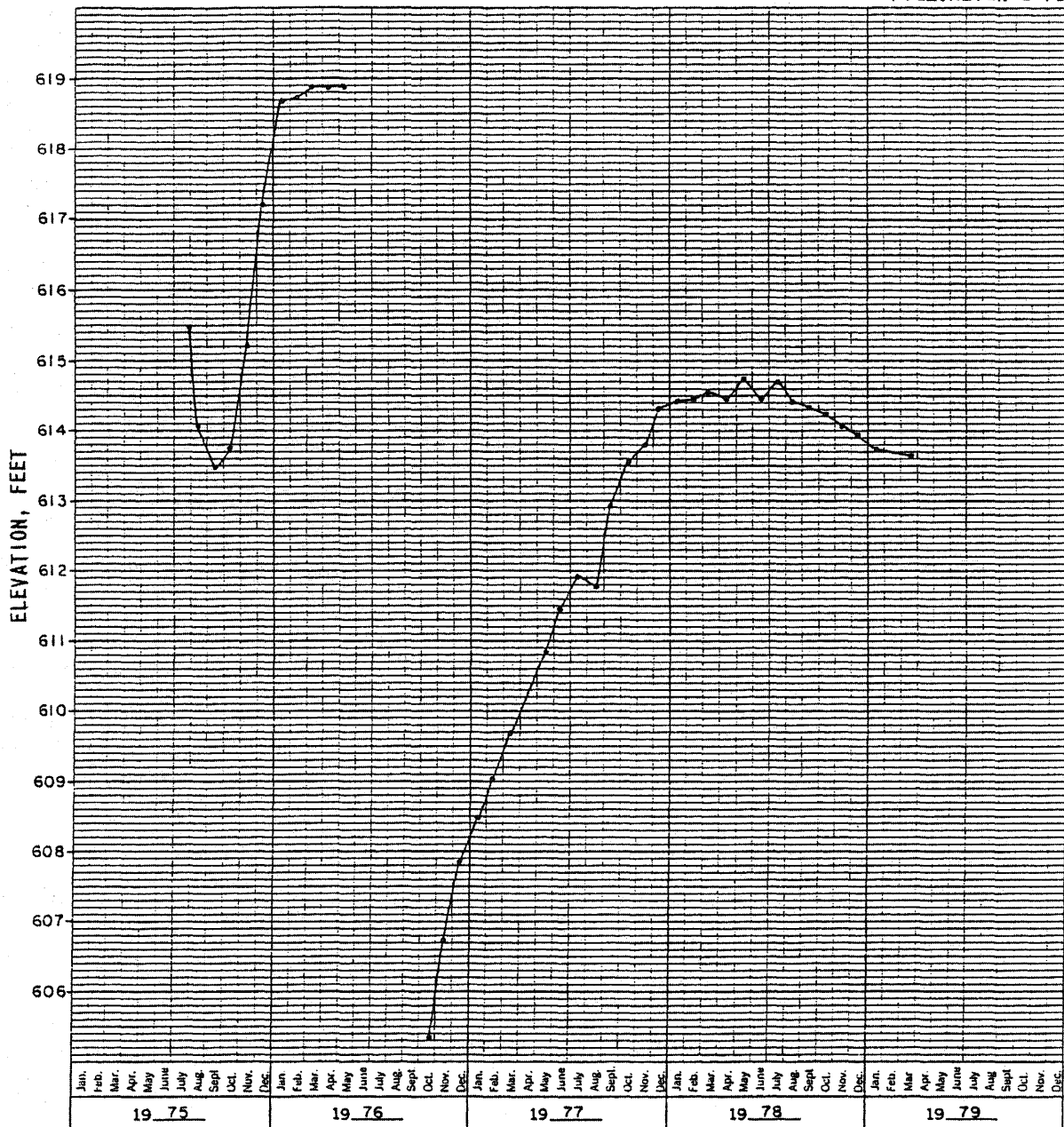


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 8 of 34)

PIEZOMETER E-7B



(Rev. 12 1/03)

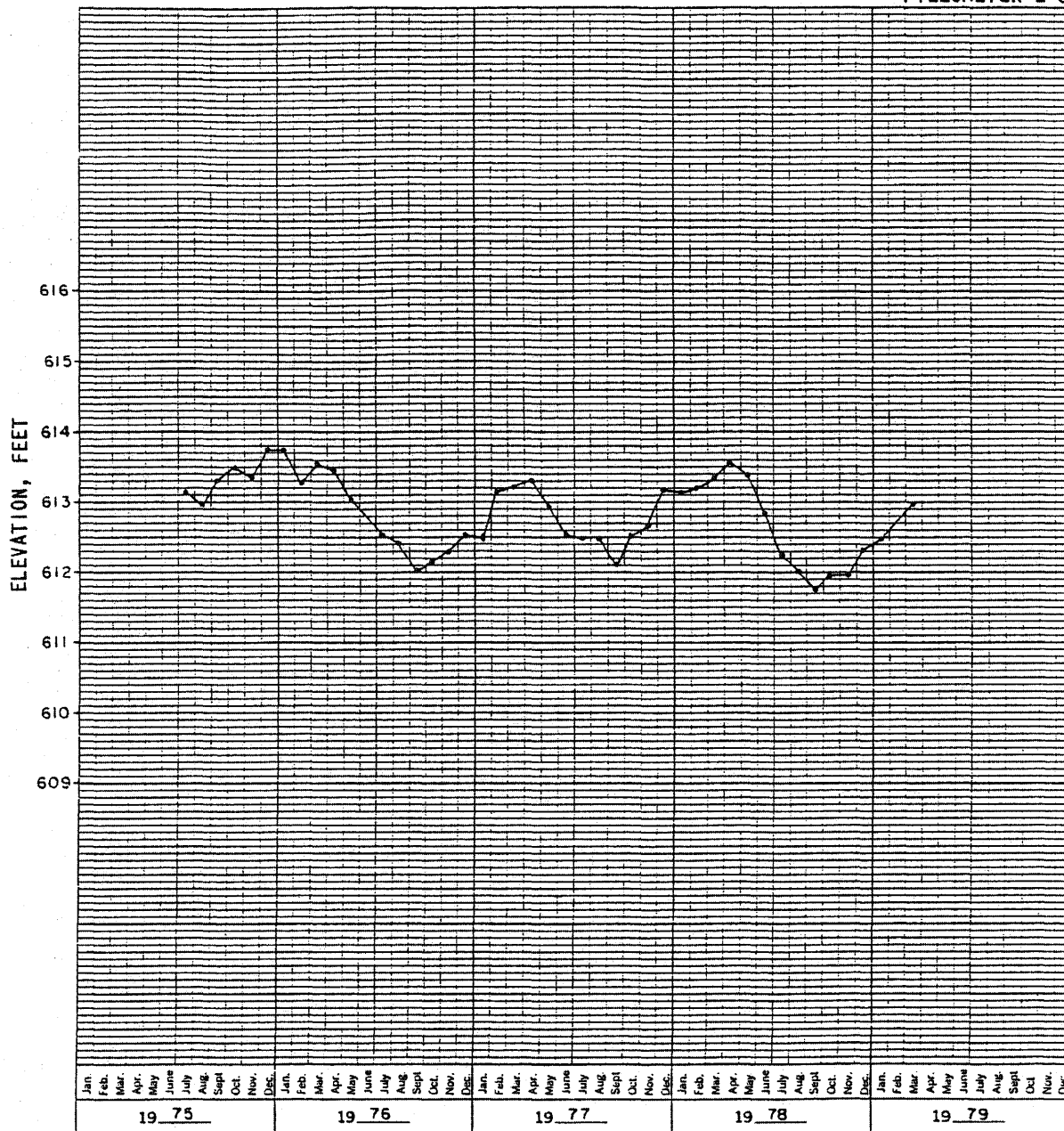


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 9 of 34)

PIEZOMETER E-8



(Rev. 12 1/03)

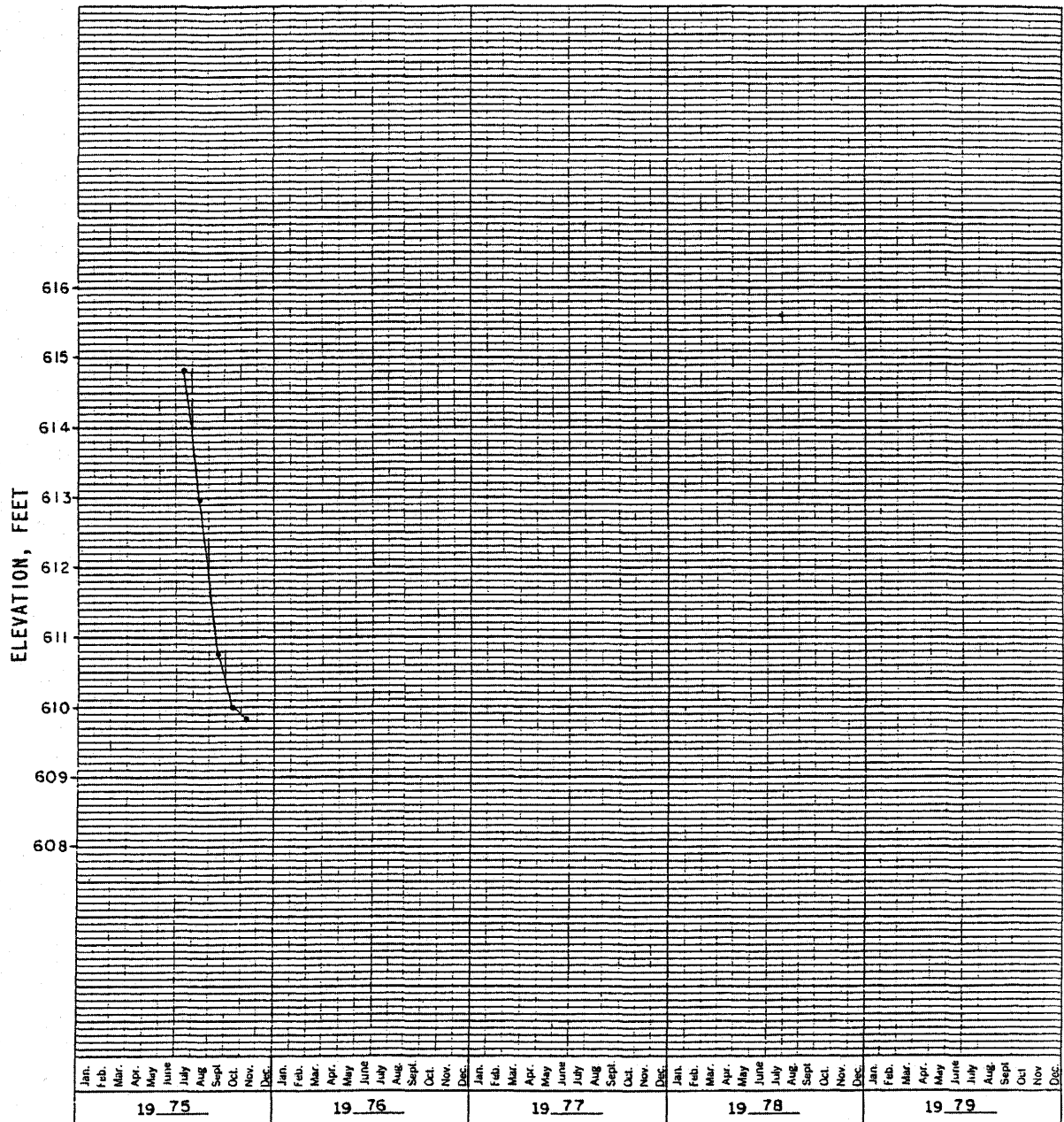


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 10 of 34)

PIEZOMETER W-4



(Rev. 12 1/03)



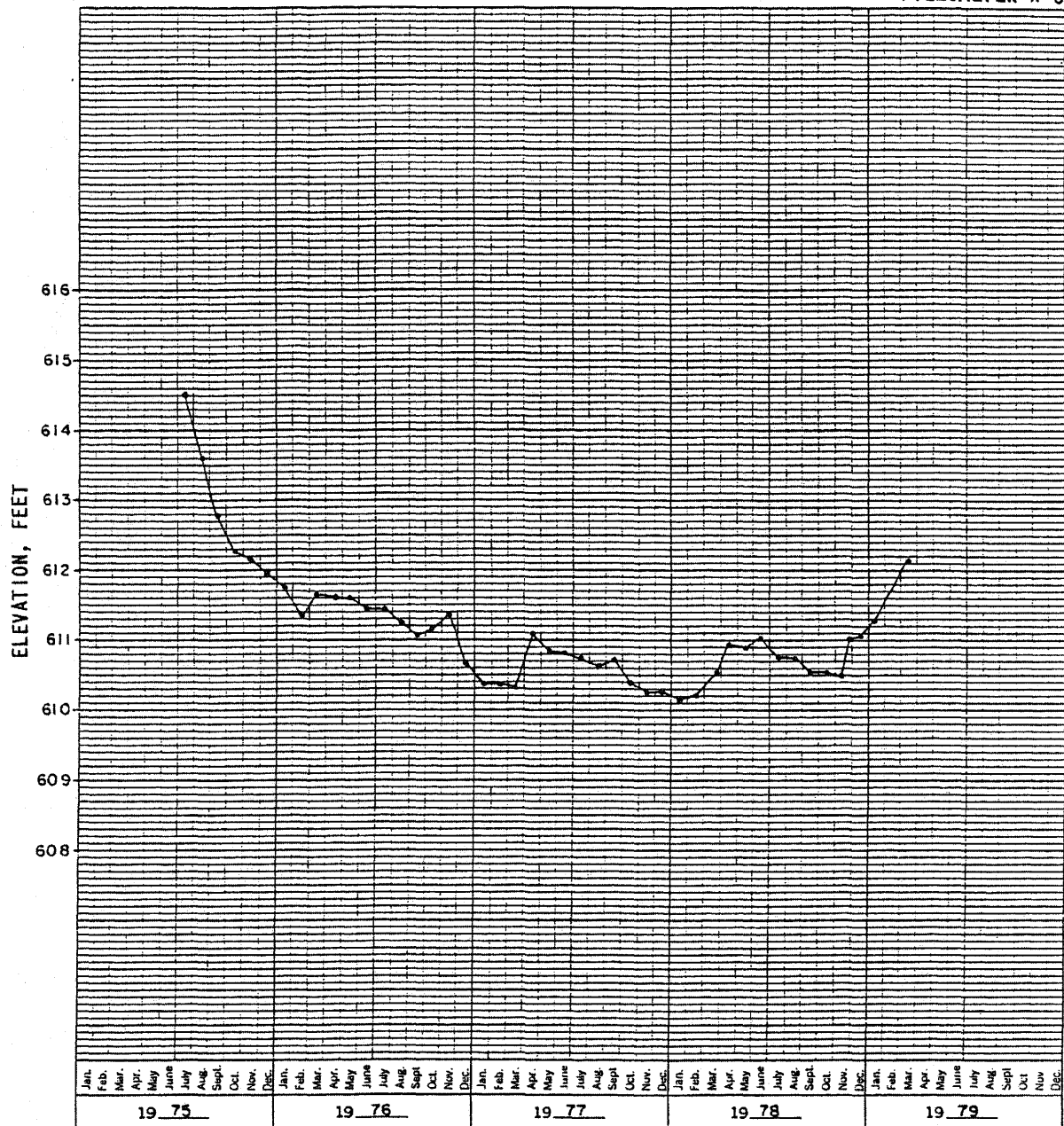
**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 11 of 34)



# PIEZOMETER W-5



(Rev. 12 1/03)



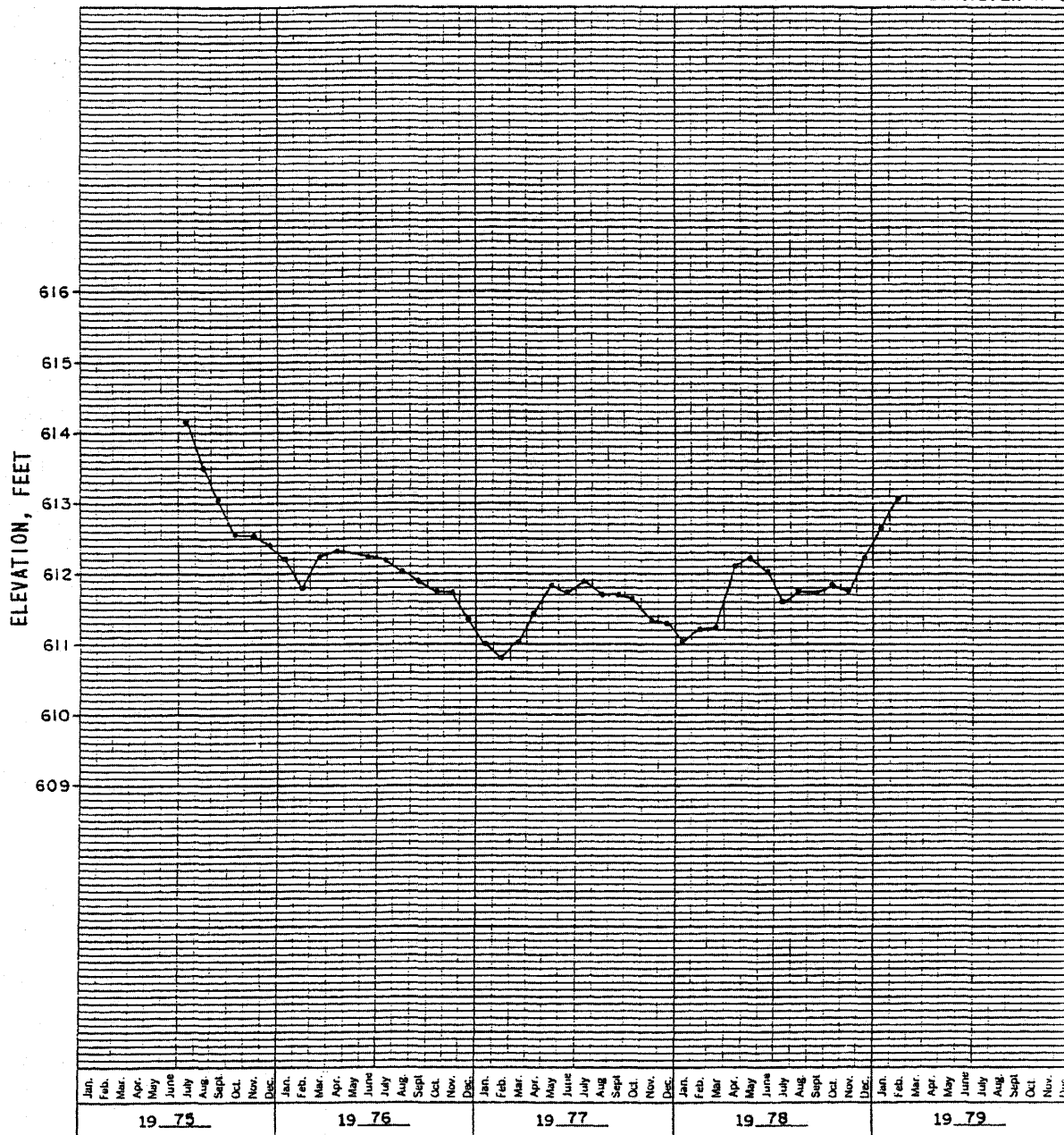
## PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 12 of 34)



PIEZOMETER W-6



(Rev. 12 1/03)

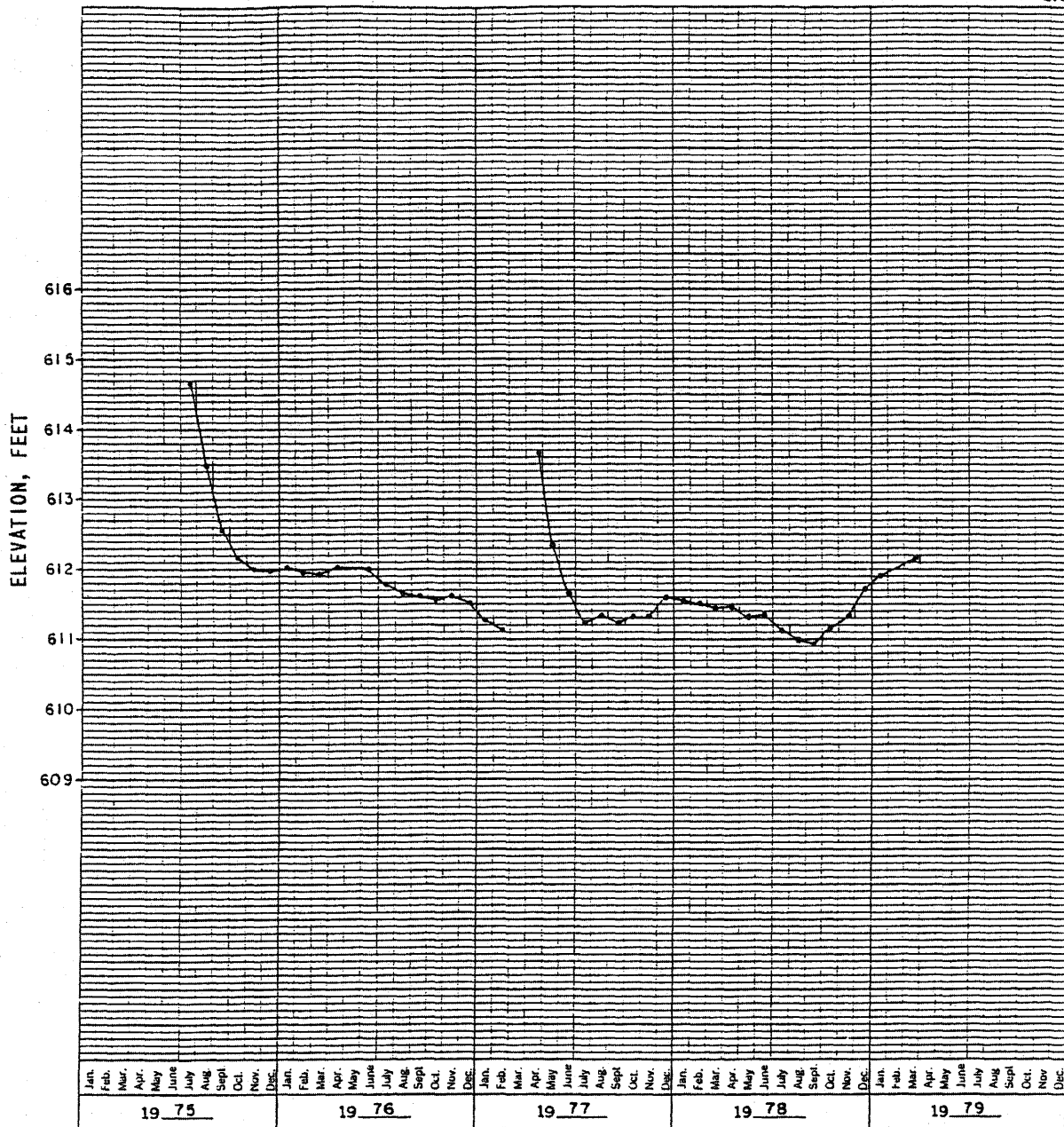


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 13 of 34)

PIEZOMETER W-6A



(Rev. 12 1/03)

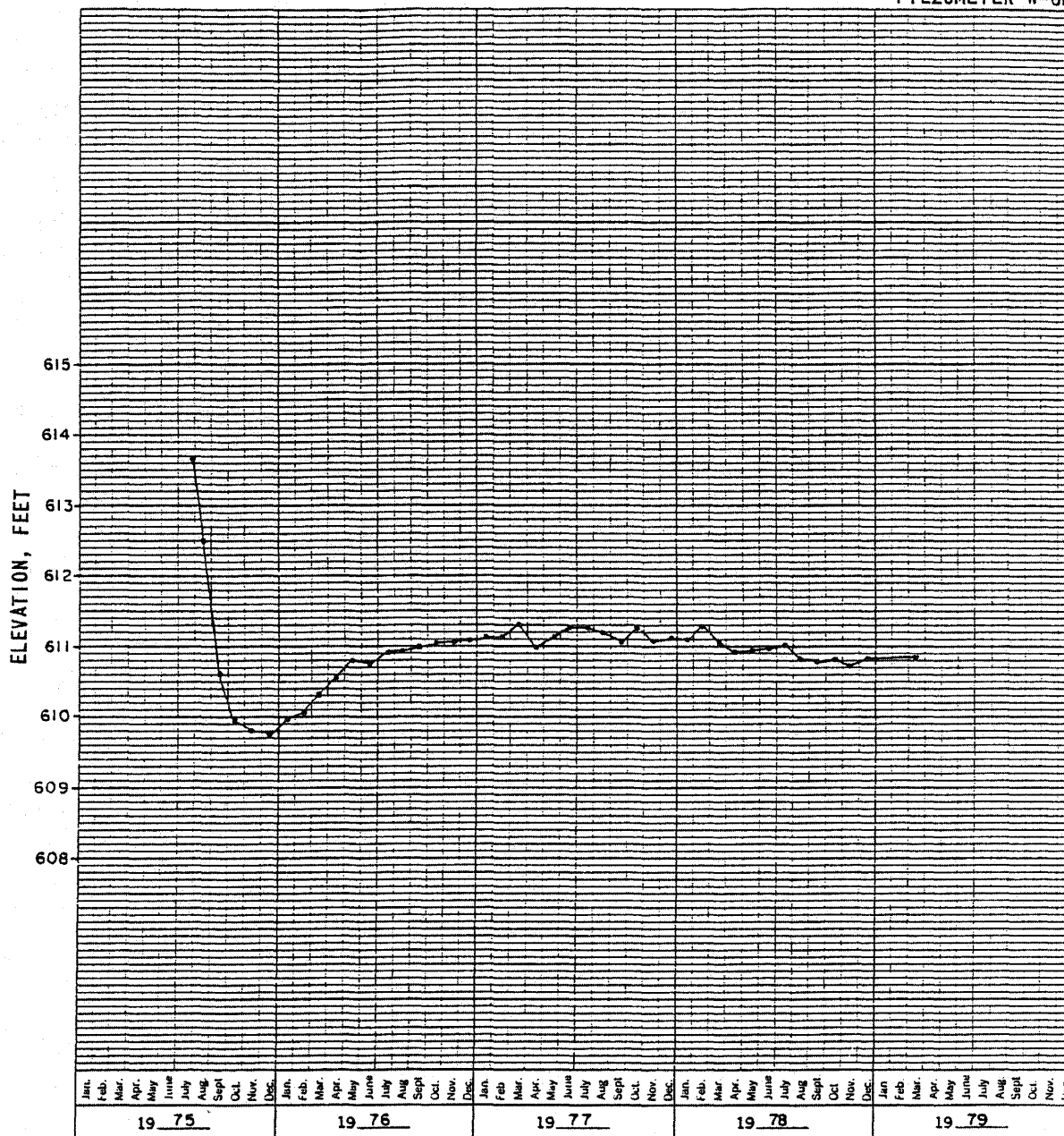


## PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 14 of 34)

PIEZOMETER W-6B



(Rev. 12 1/03)

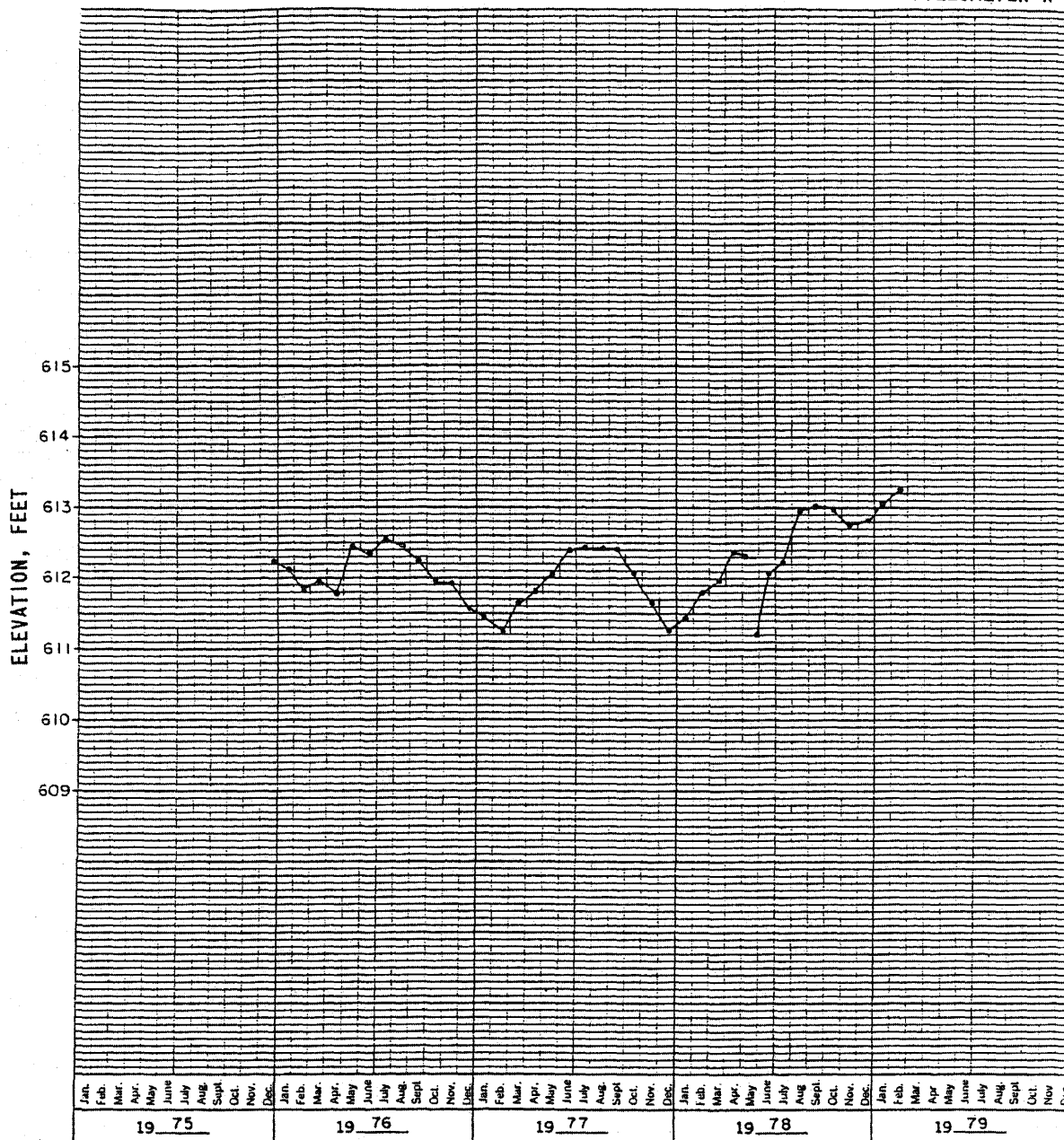


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 15 of 34)

PIEZOMETER W-7



(Rev. 12 1/03)

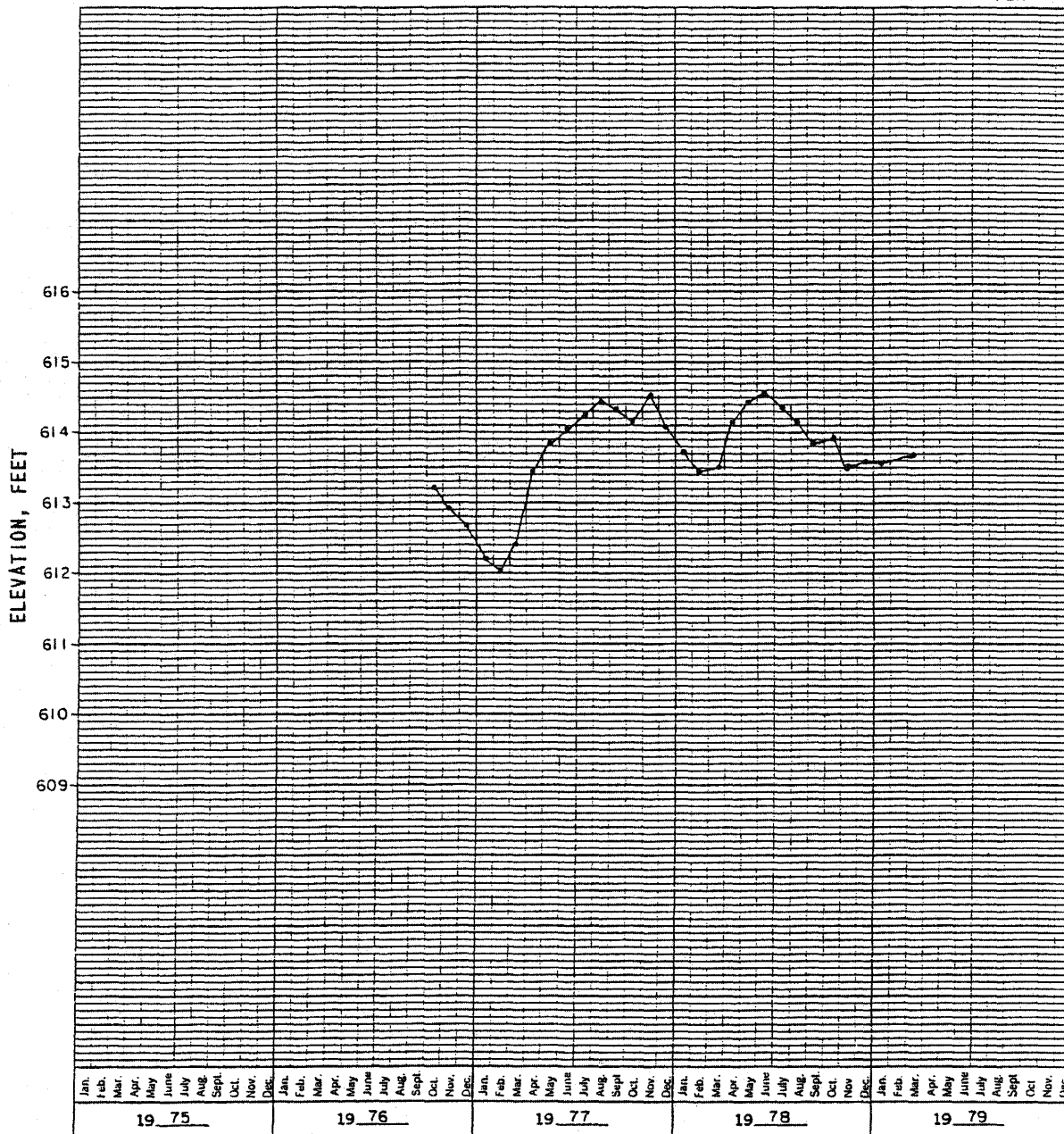


# PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 16 of 34)

PIEZOMETER W-8



(Rev. 12 1/03)

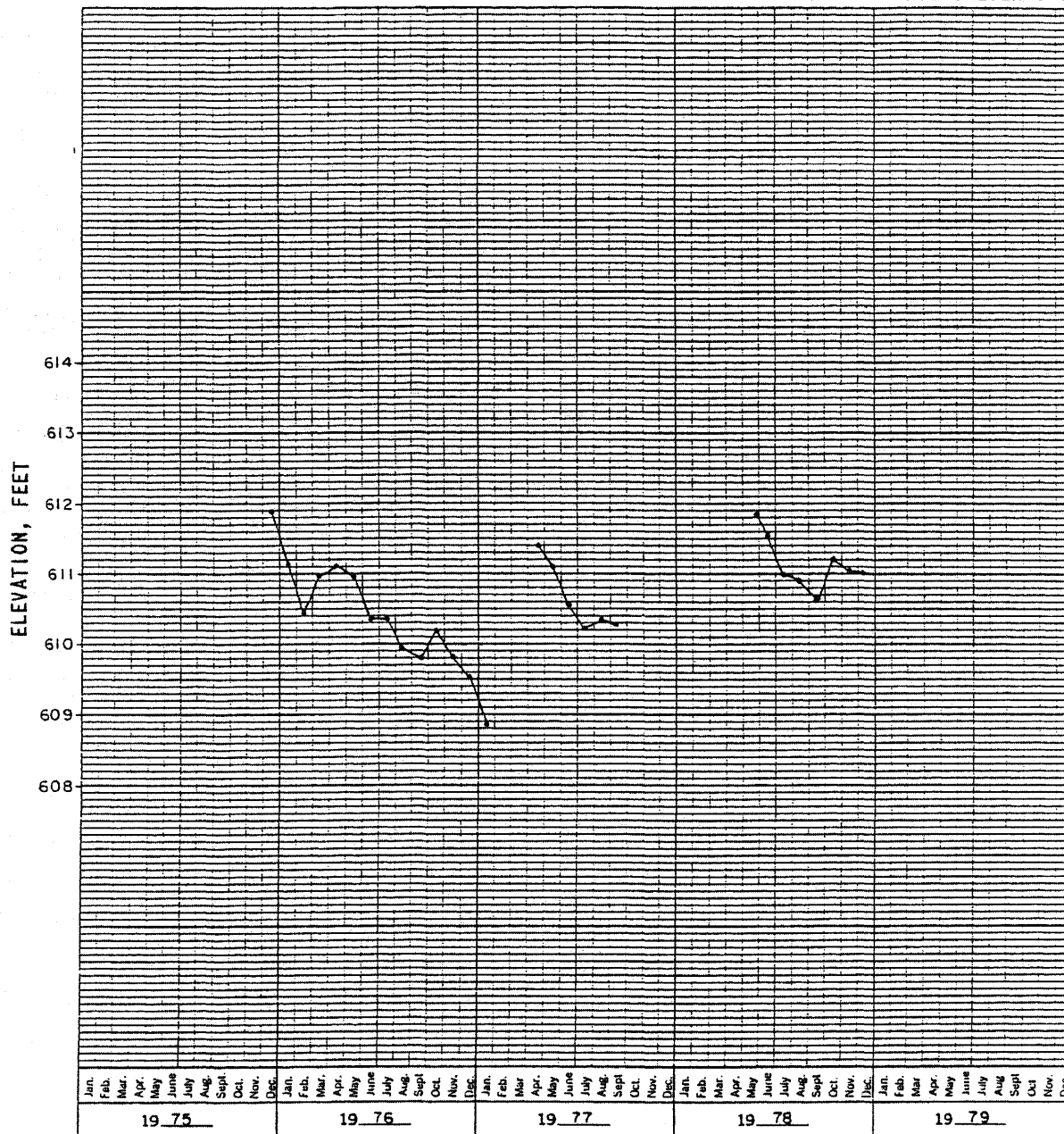


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 17 of 34)

PIEZOMETER S-3



(Rev. 12 1/03)

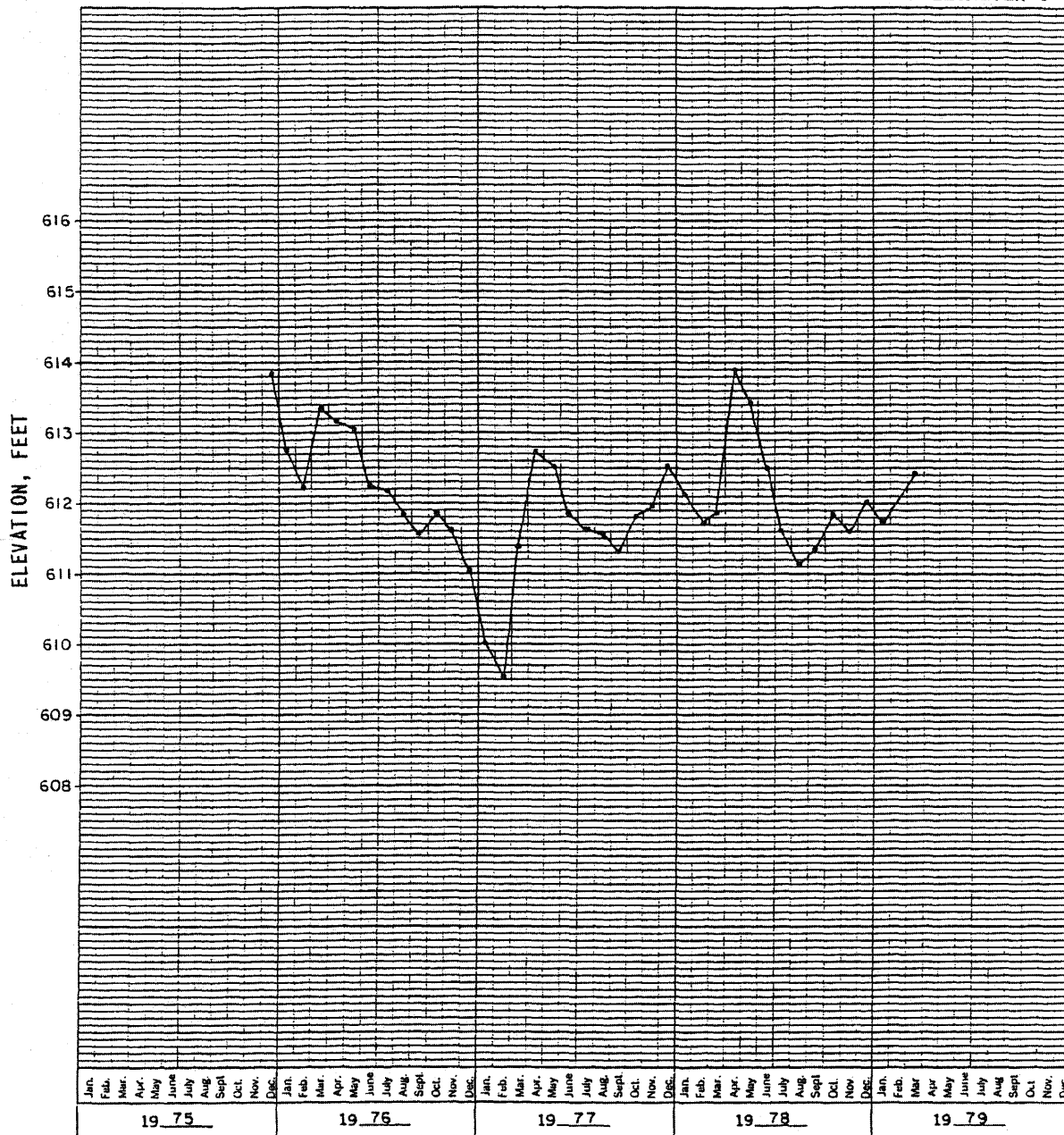


# PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 18 of 34)

PIEZOMETER S-4



(Rev. 12 1/03)

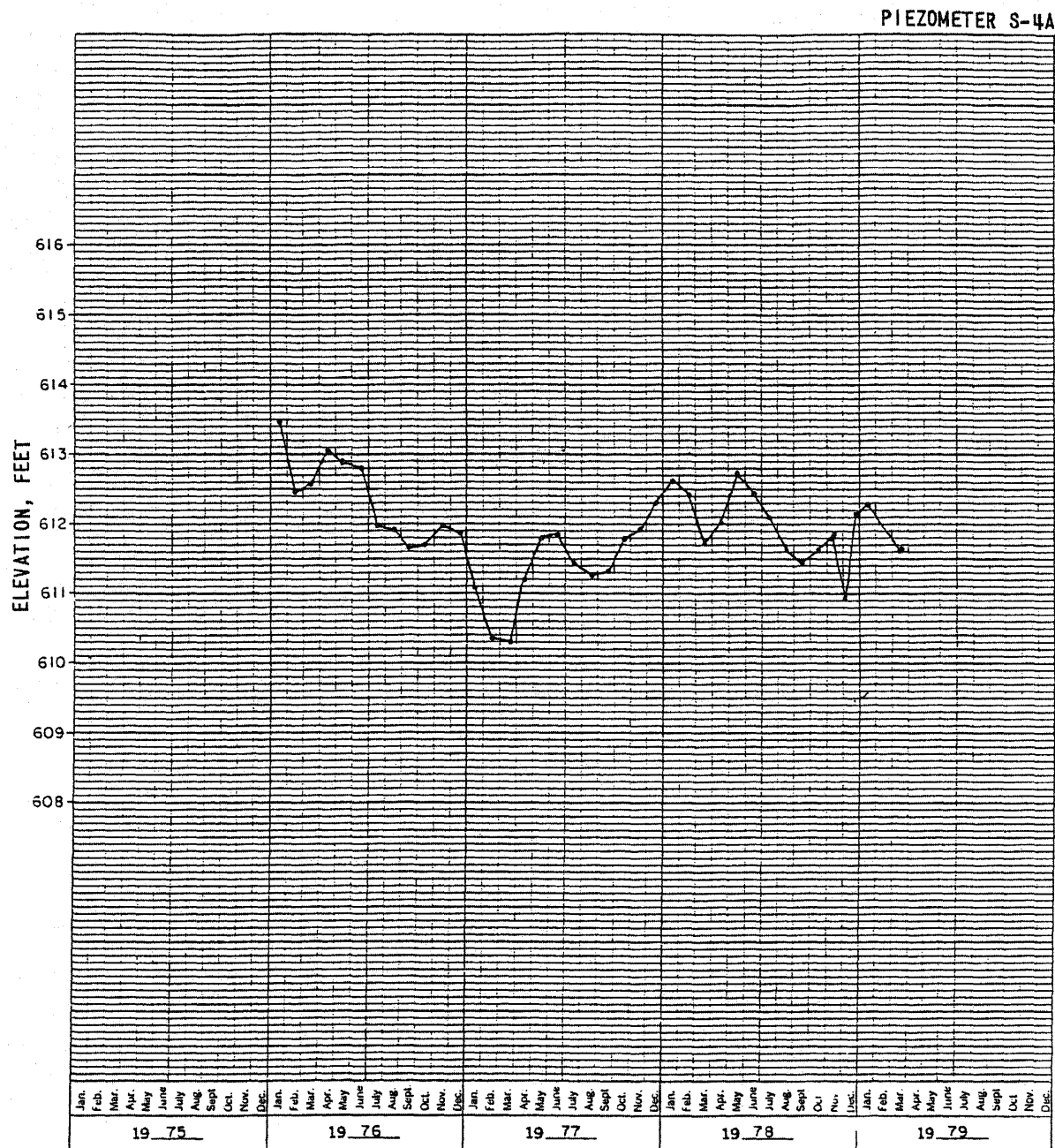


# PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 19 of 34)





(Rev. 12 1/03)



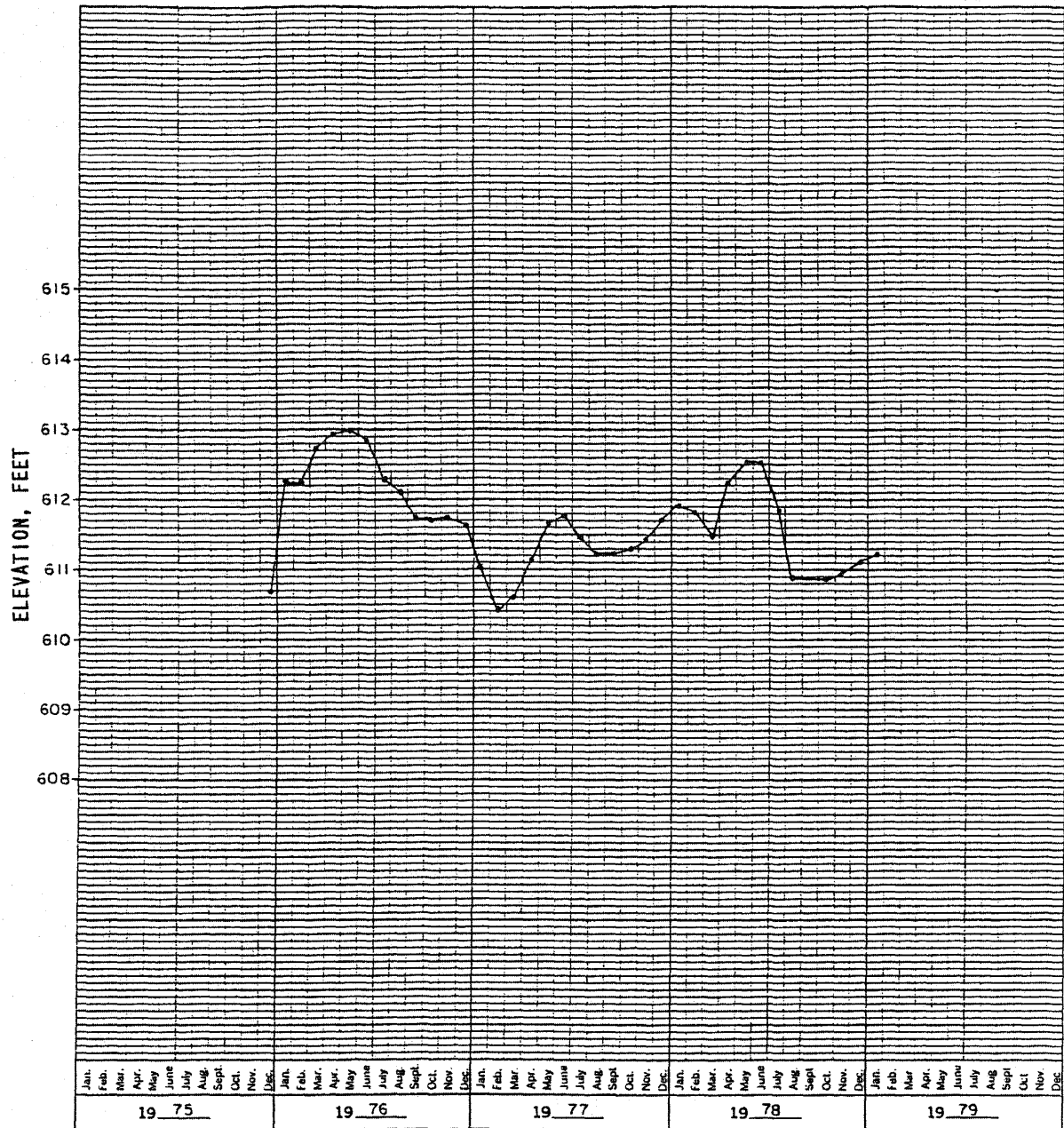
## PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 20 of 34)



PIEZOMETER S-48



(Rev. 12 1/03)

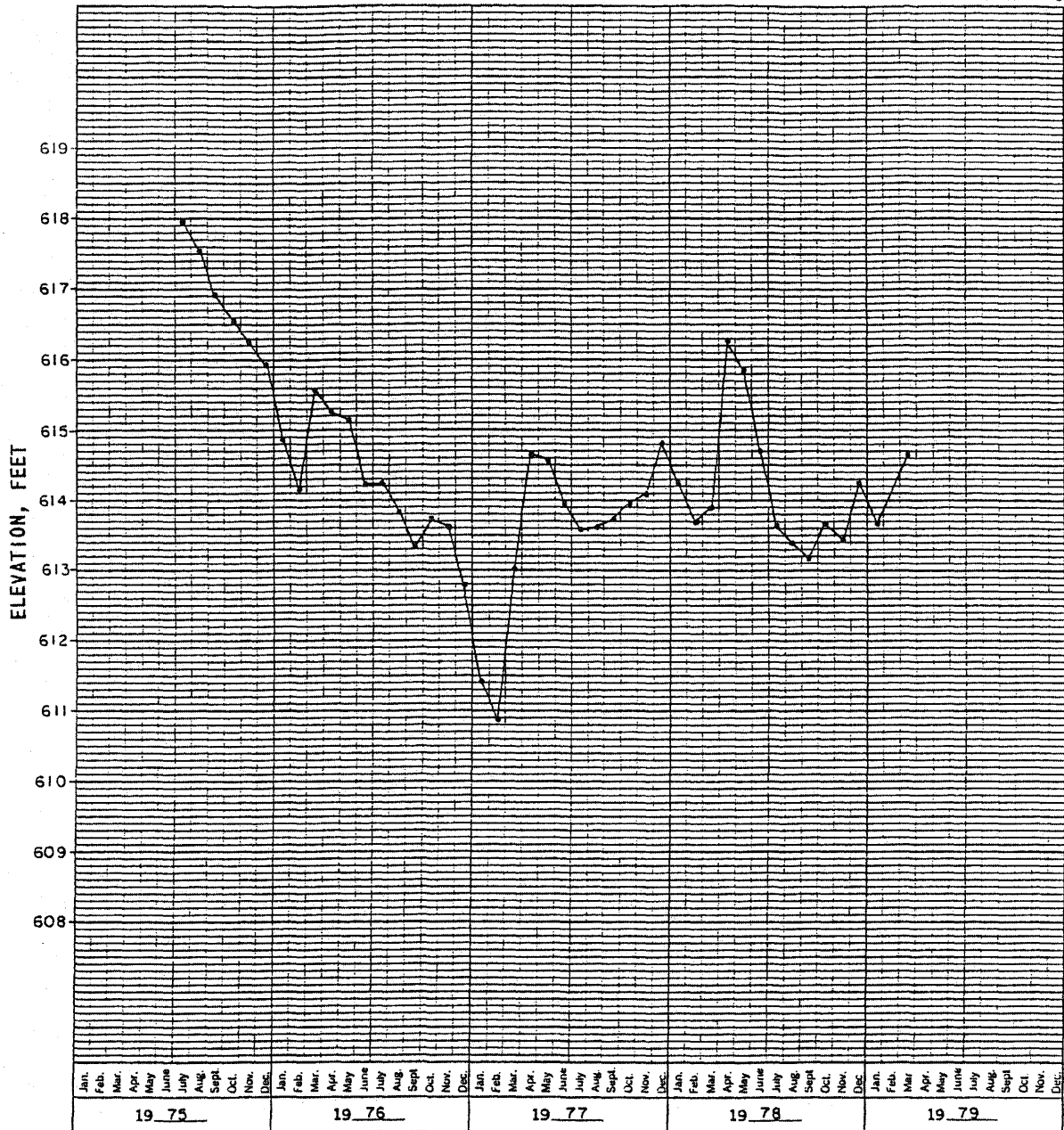


## PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 21 of 34)

PIEZOMETER S-5



(Rev. 12 1/03)

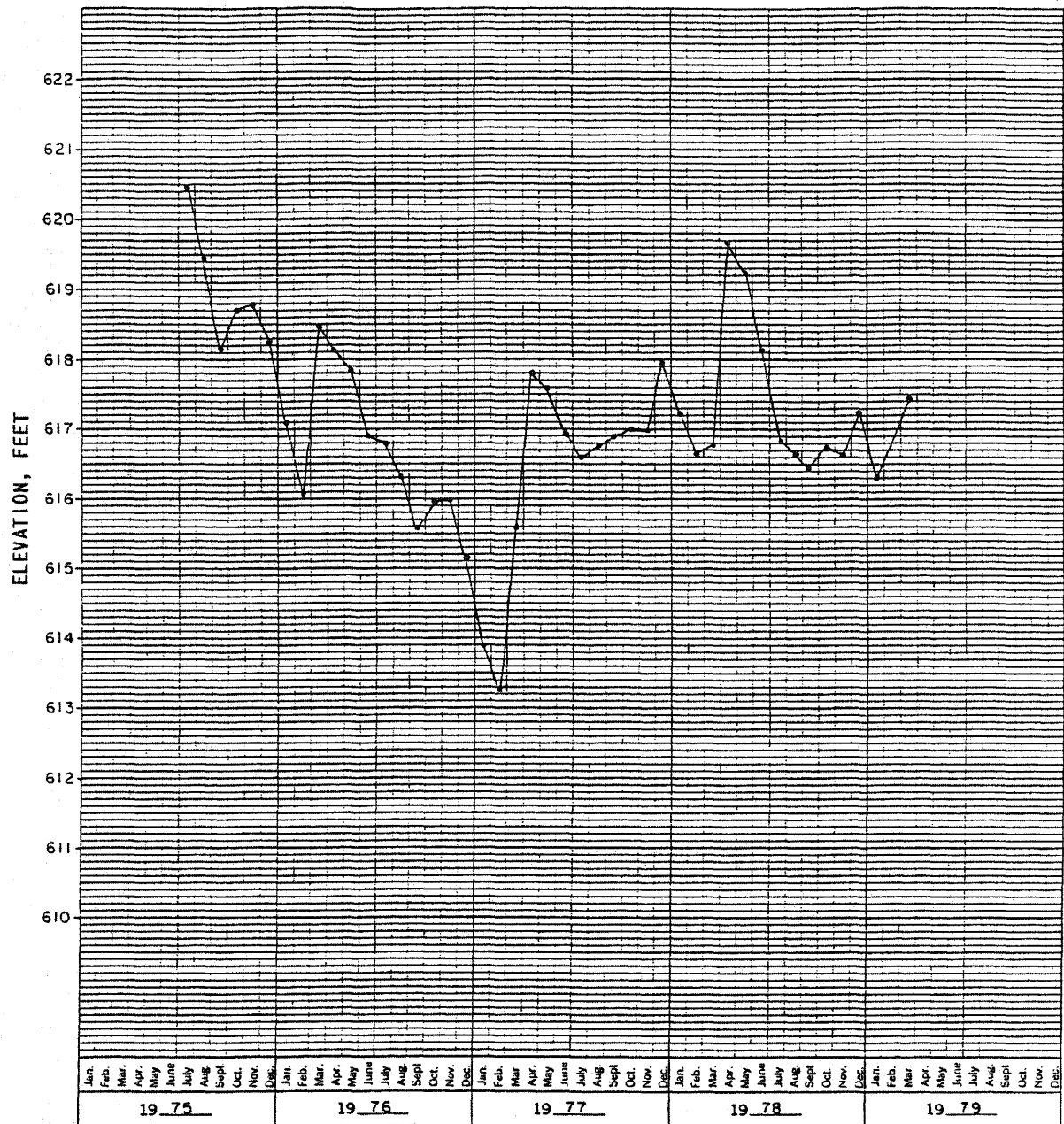


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 22 of 34)

PIEZOMETER S-6



(Rev. 12 1/03)

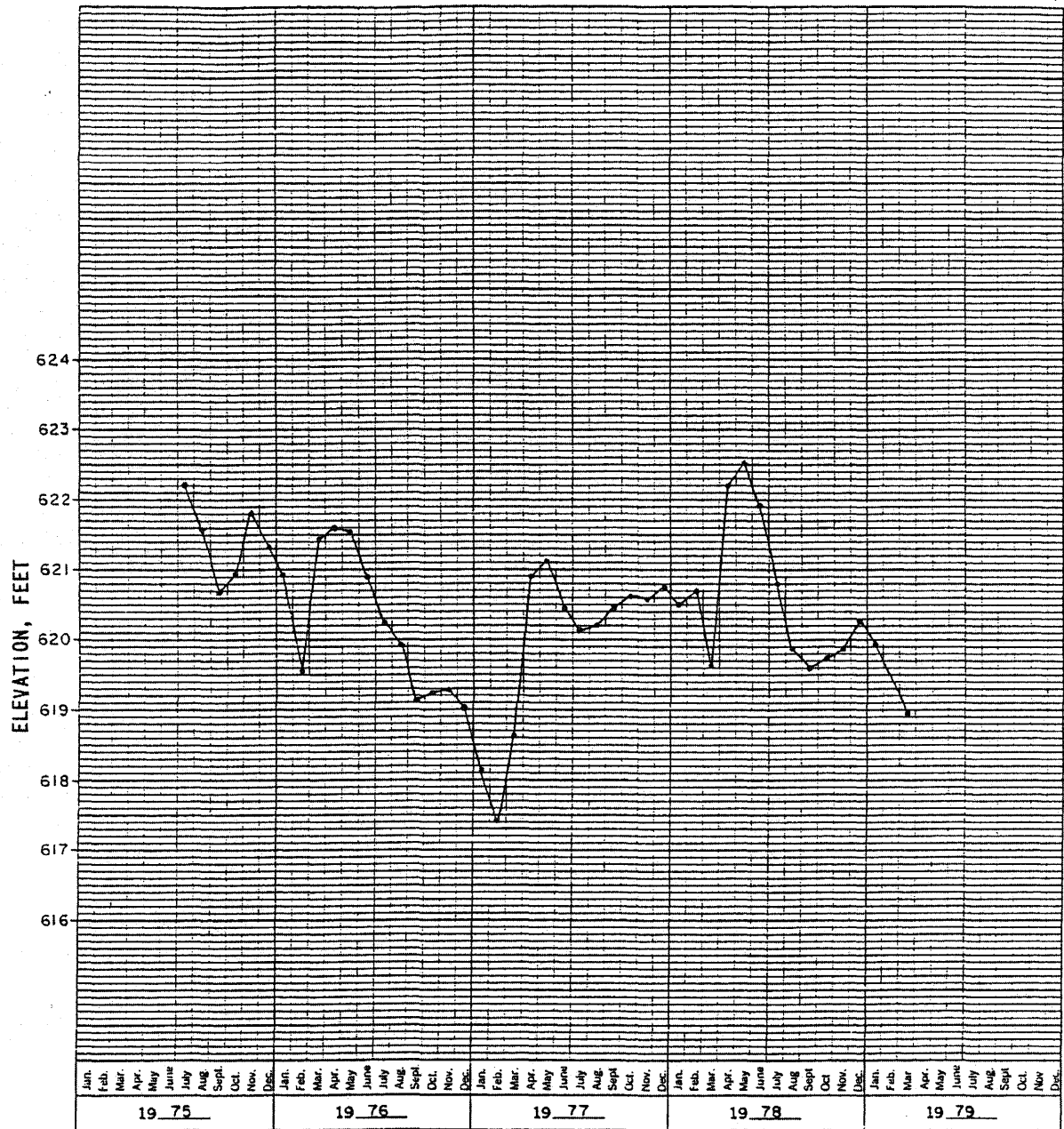


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 23 of 34)

PIEZOMETER S-7



(Rev. 12 1/03)

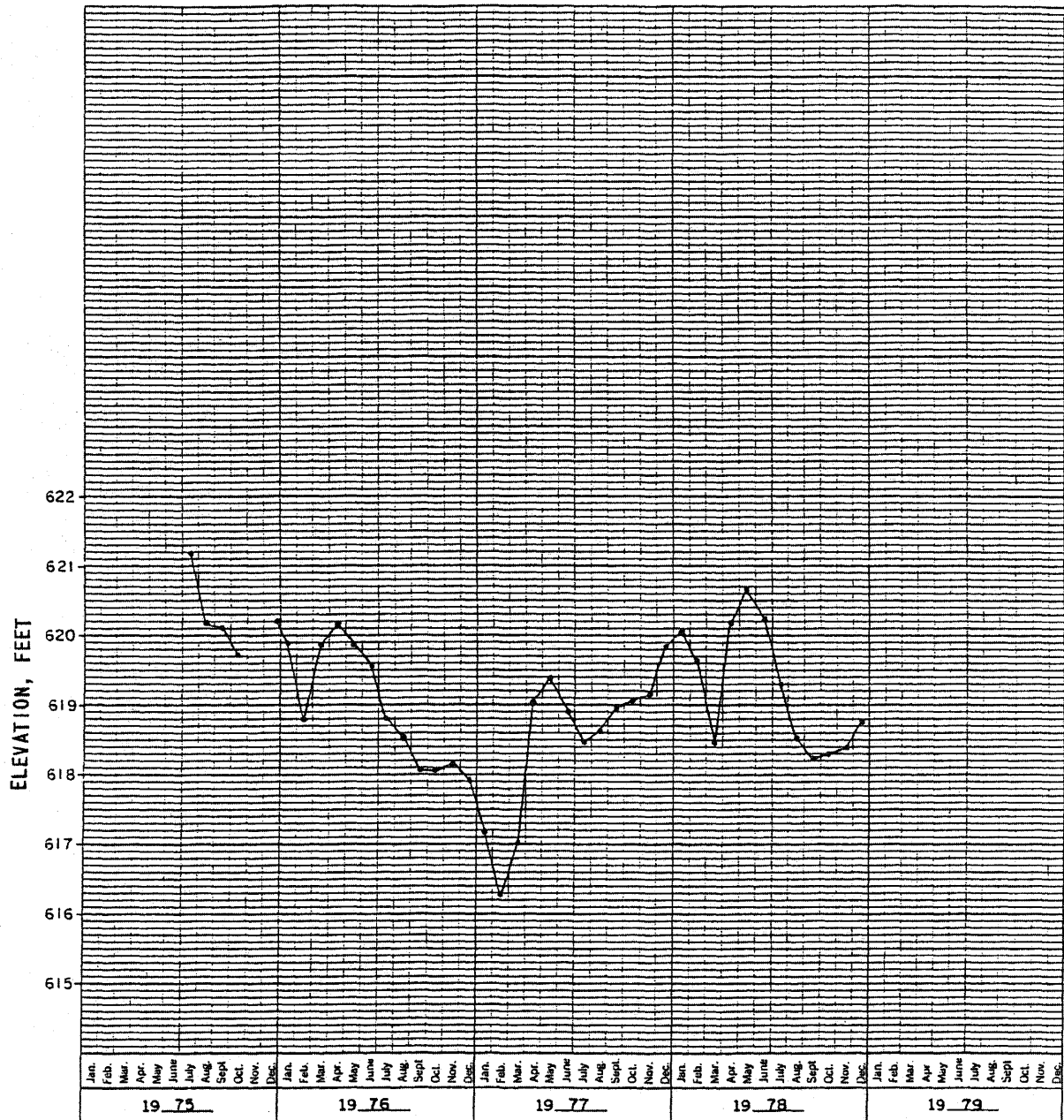


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 24 of 34)

PIEZOMETER S-7A



(Rev. 12 1/03)

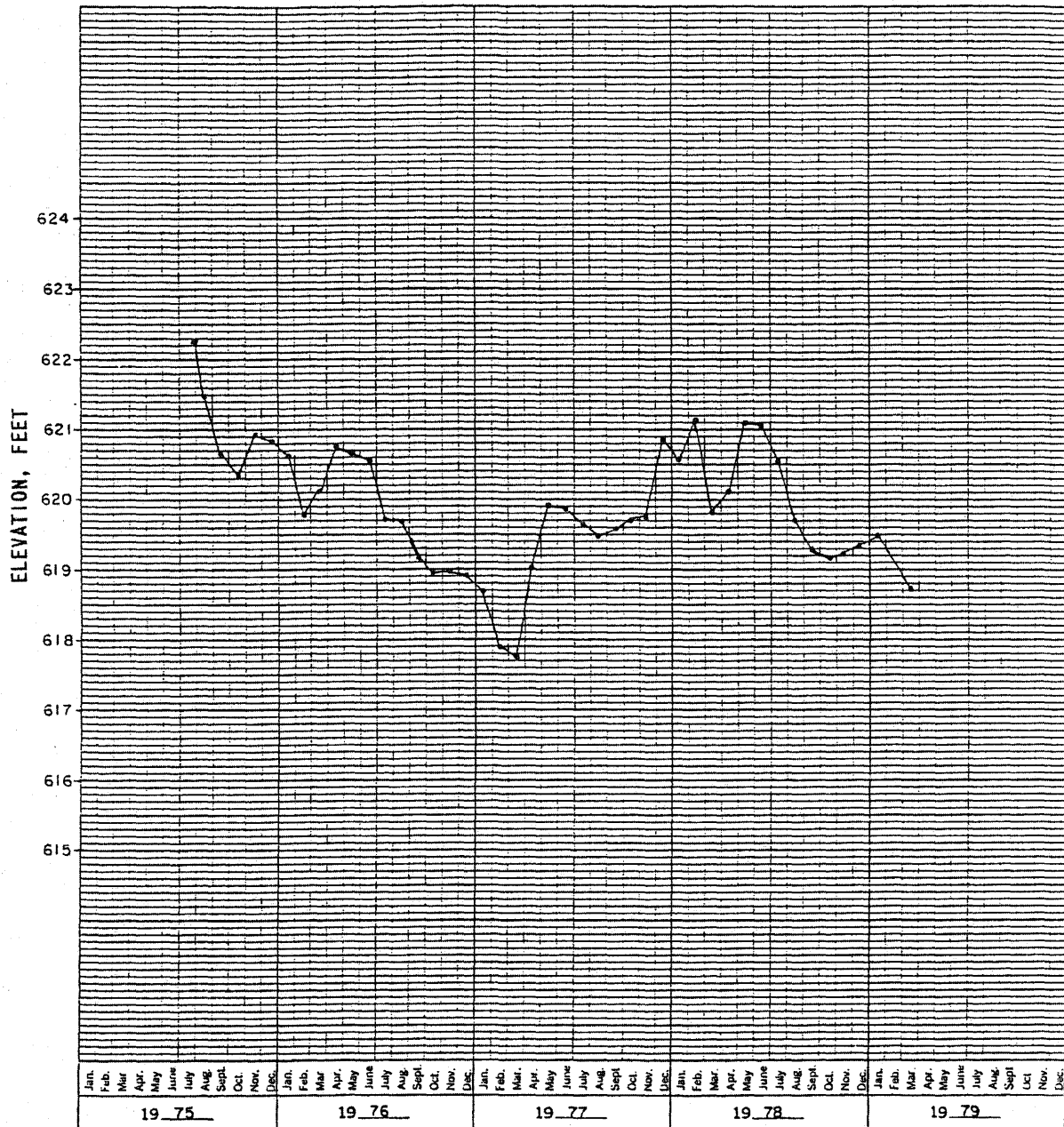


## PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 25 of 34)

PIEZOMETER S-7B



(Rev. 12 1/03)



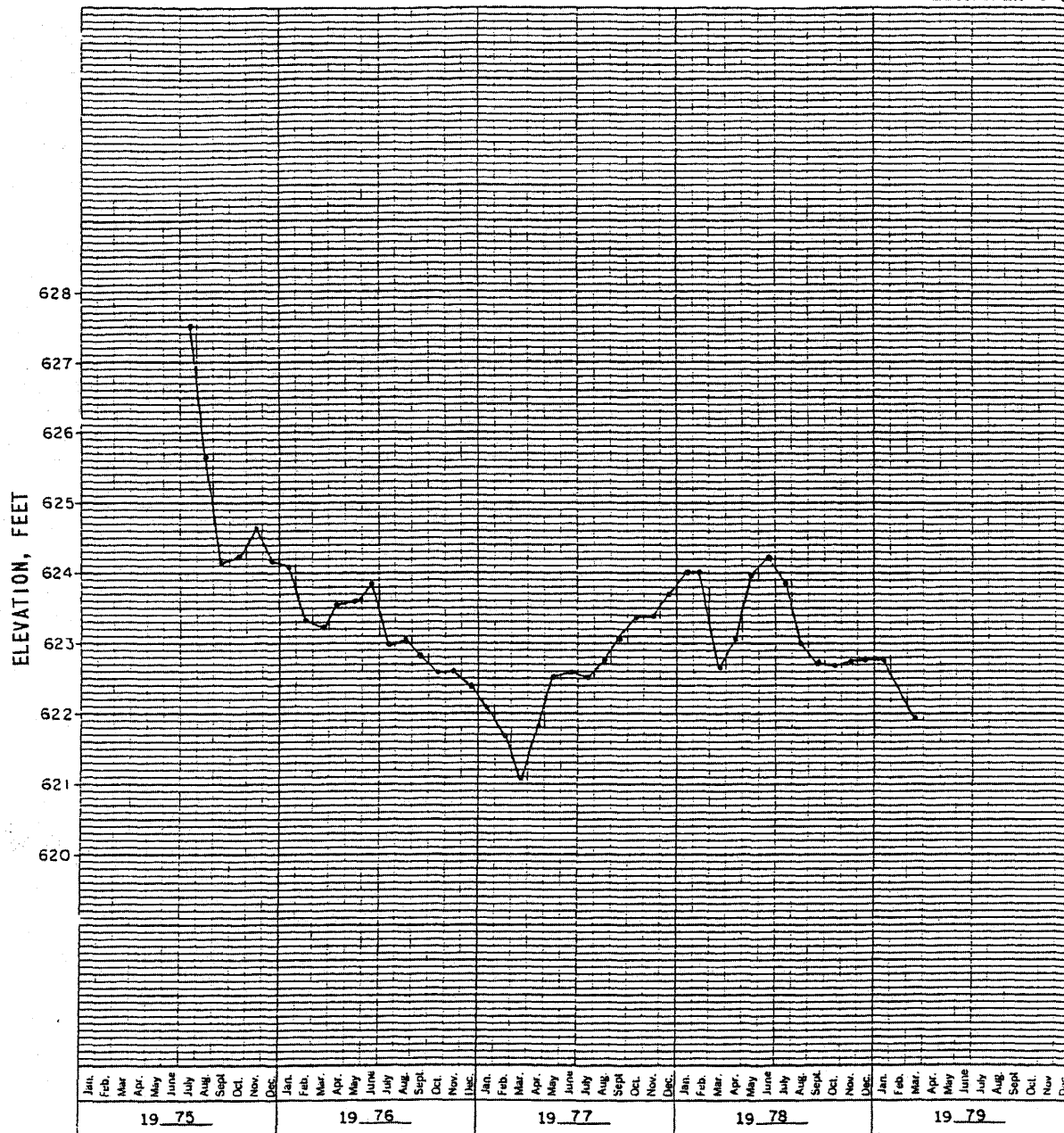
**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 26 of 34)



PIEZOMETER S-8



(Rev. 12 1/03)

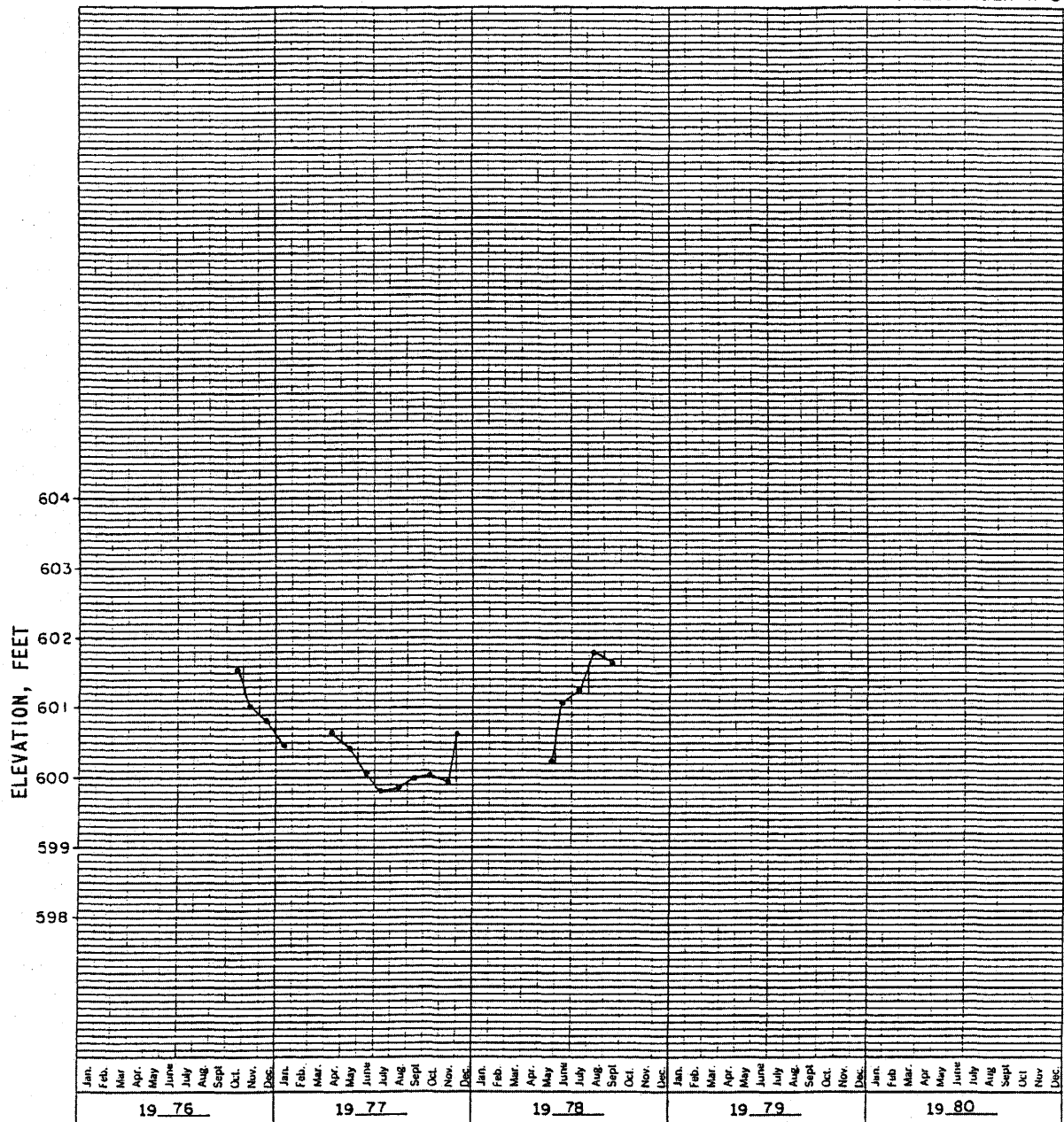


# PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 27 of 34)

PIEZOMETER N-3



(Rev. 12 1/03)



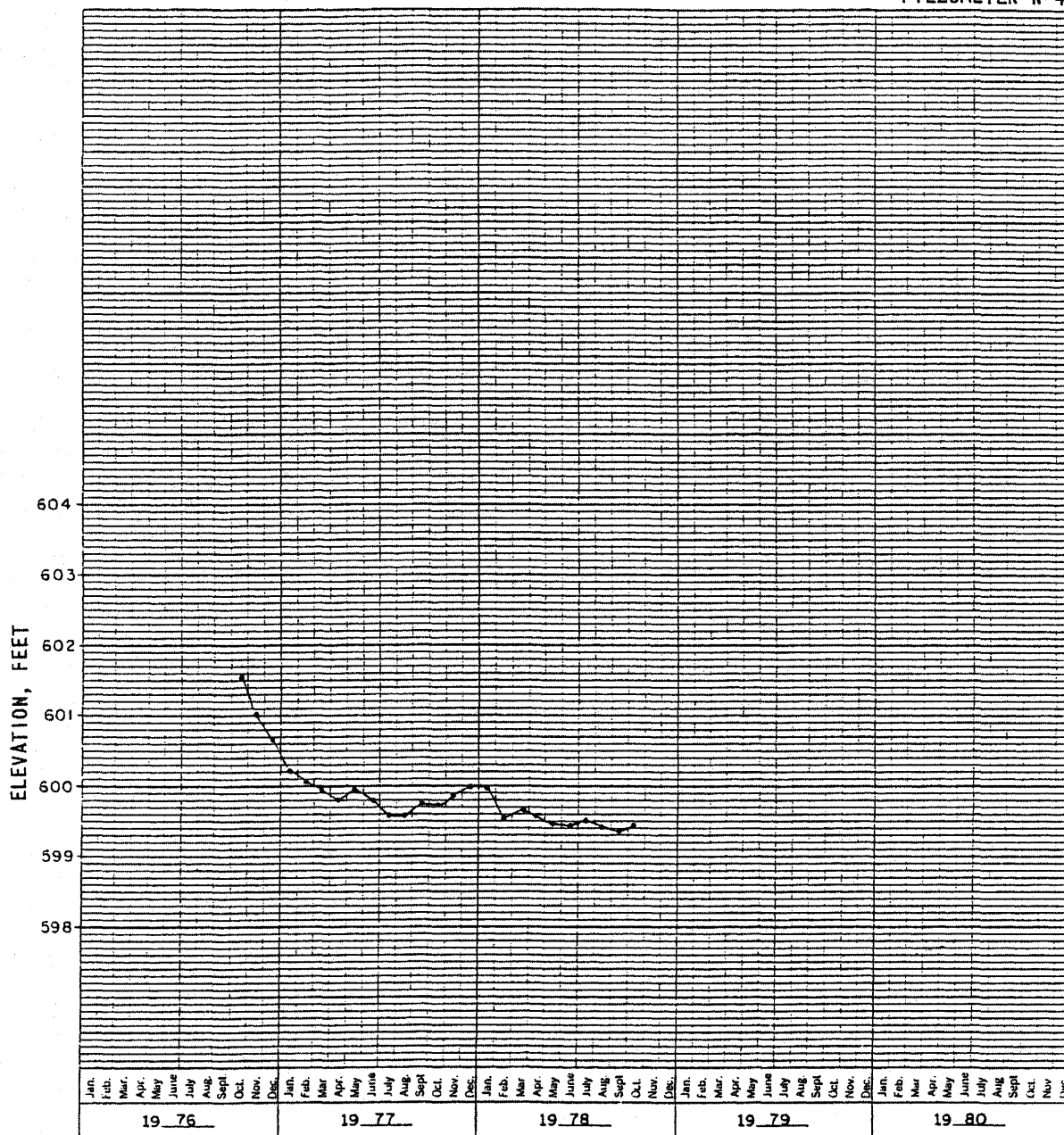
**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 28 of 34)



PIEZOMETER N-4



(Rev. 12 1/03)

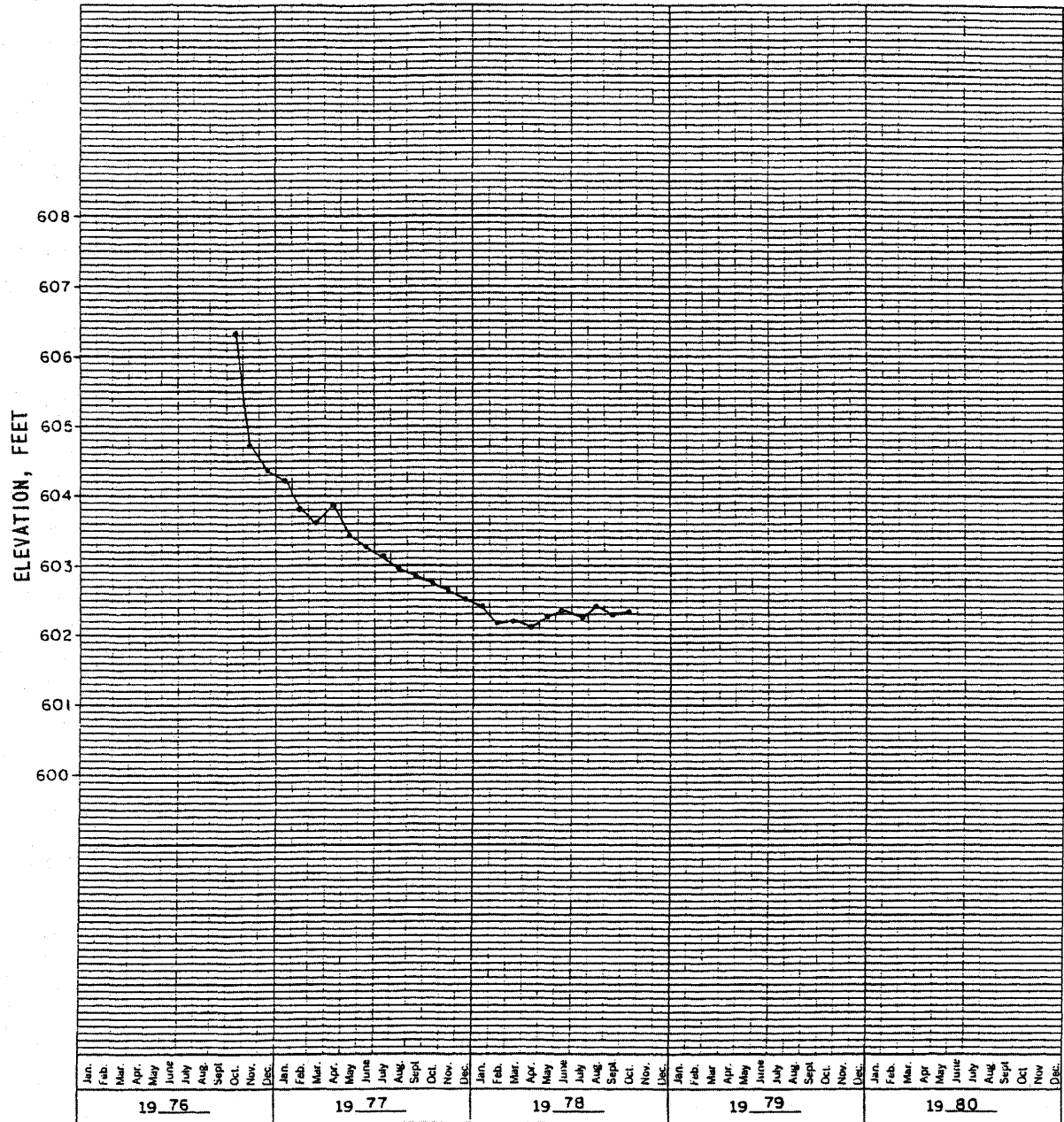


# PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 29 of 34)

PIEZOMETER N-4A



(Rev. 12 1/03)

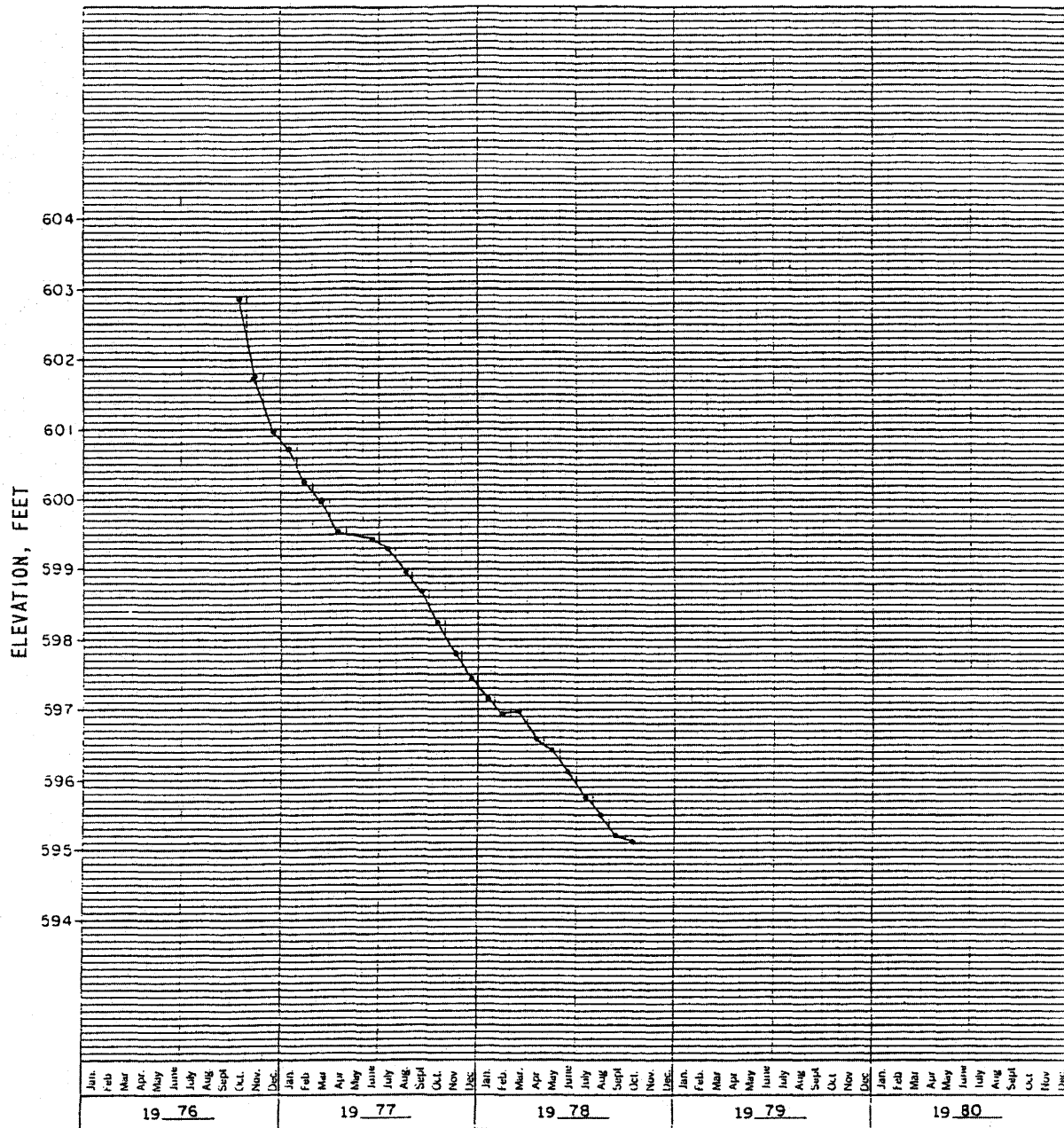


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 30 of 34)

PIEZOMETER N-48



(Rev. 12 1/03)

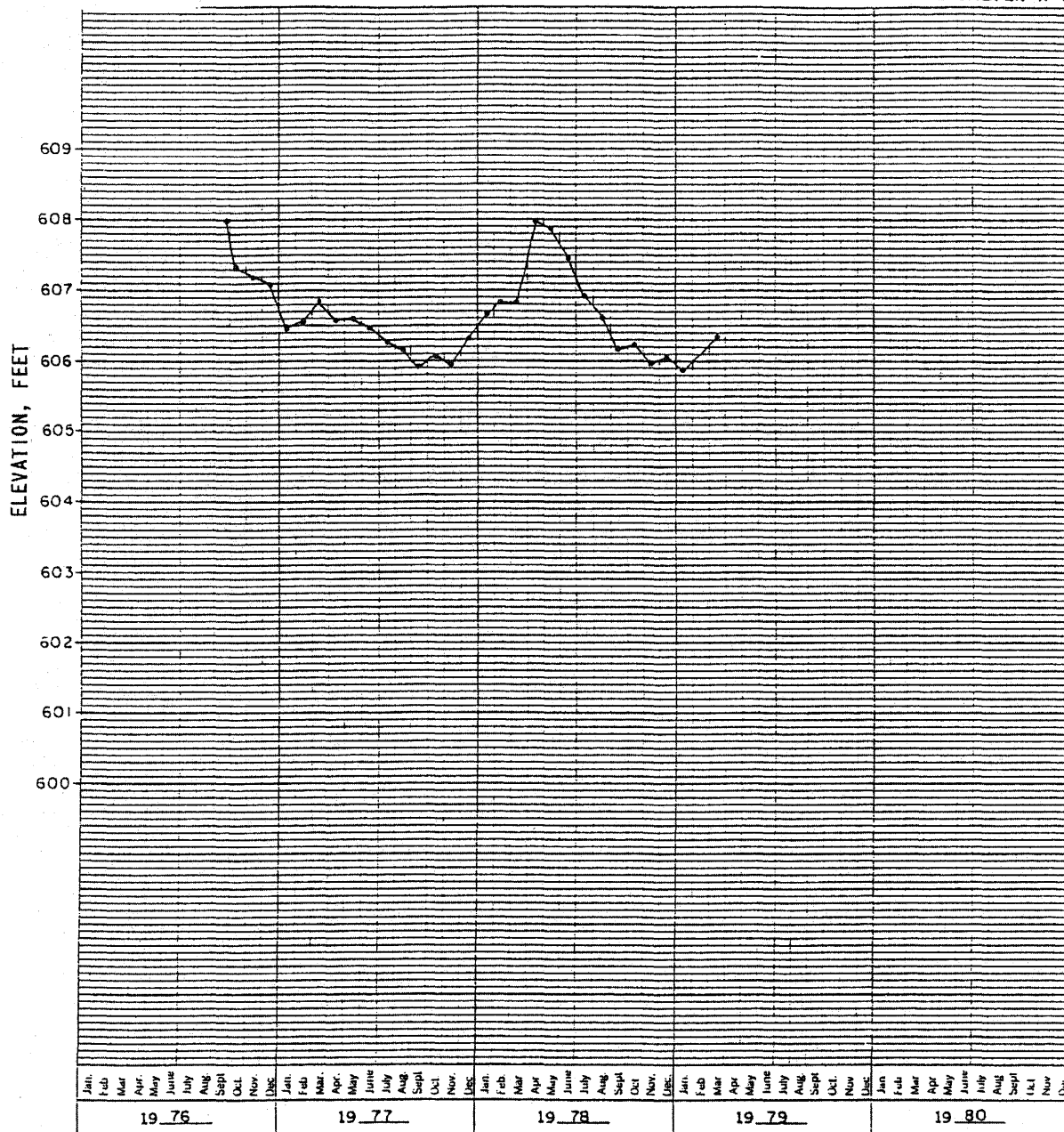


**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 31 of 34)

PIEZOMETER N-8



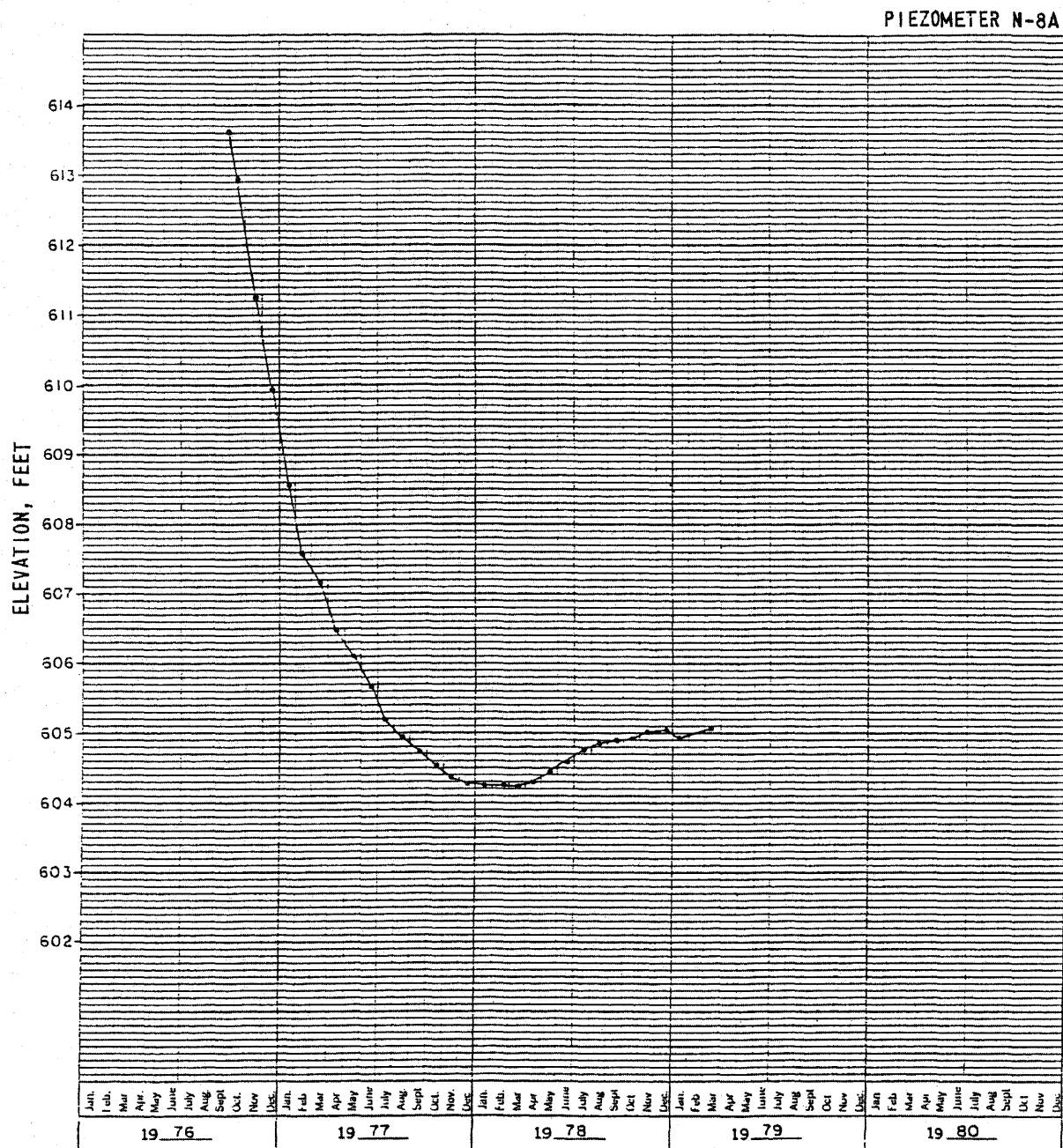
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 32 of 34)



(Rev. 12 1/03)

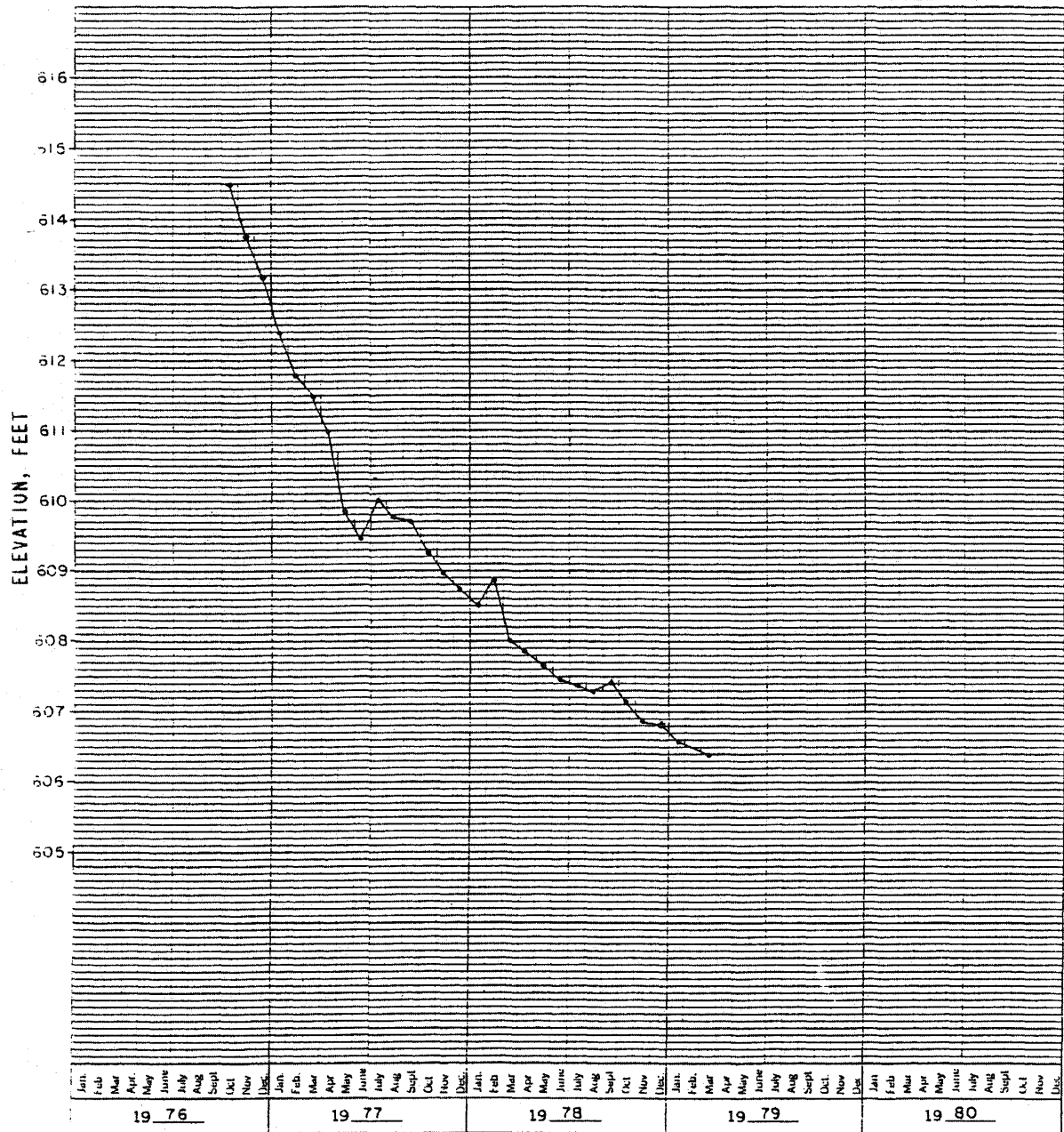


## PERRY NUCLEAR POWER PLANT

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 33 of 34)

PIEZOMETER N-88



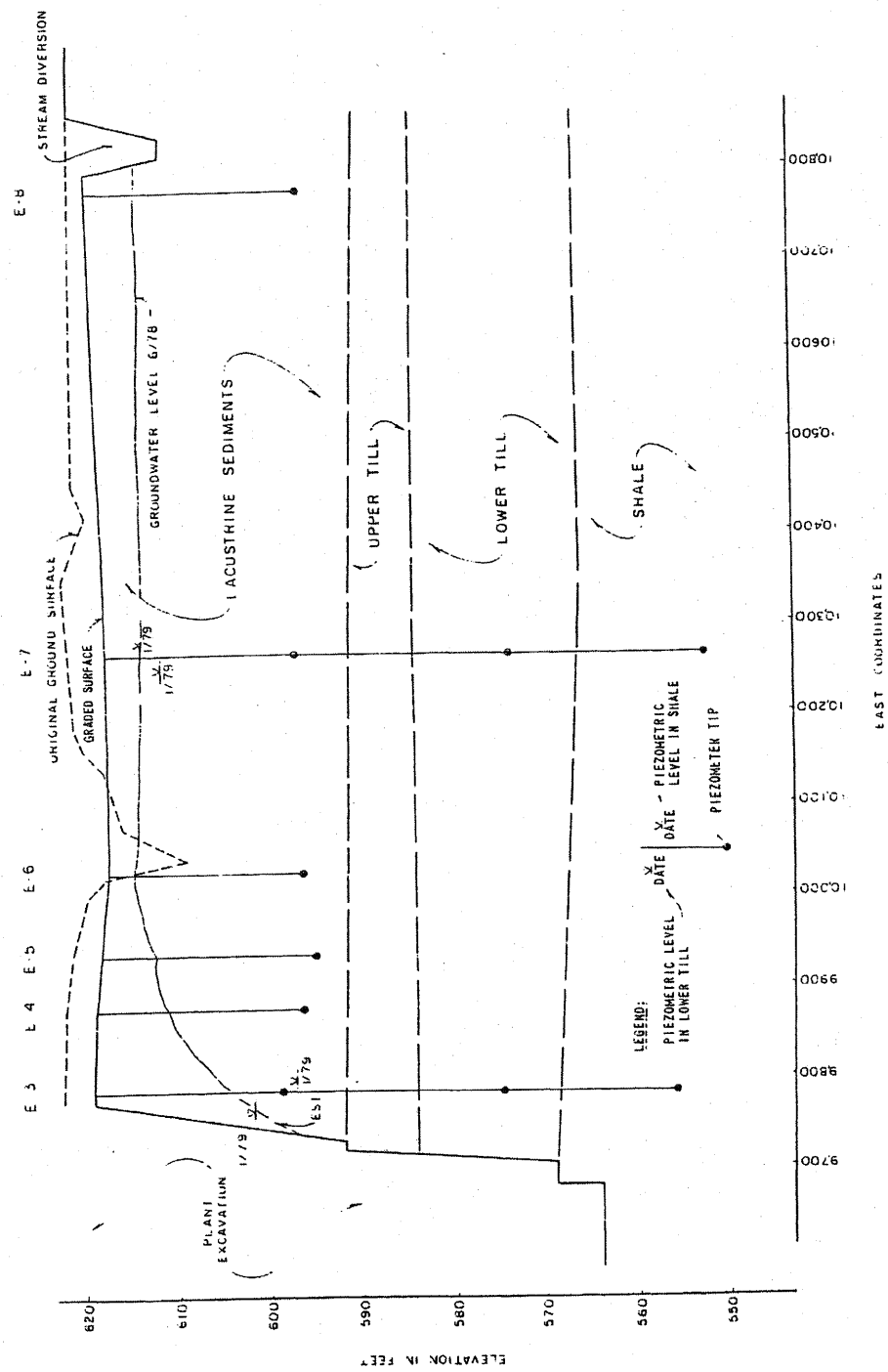
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Groundwater Observation  
Piezometric Readings

Figure 2.5-187 (Sheet 34 of 34)



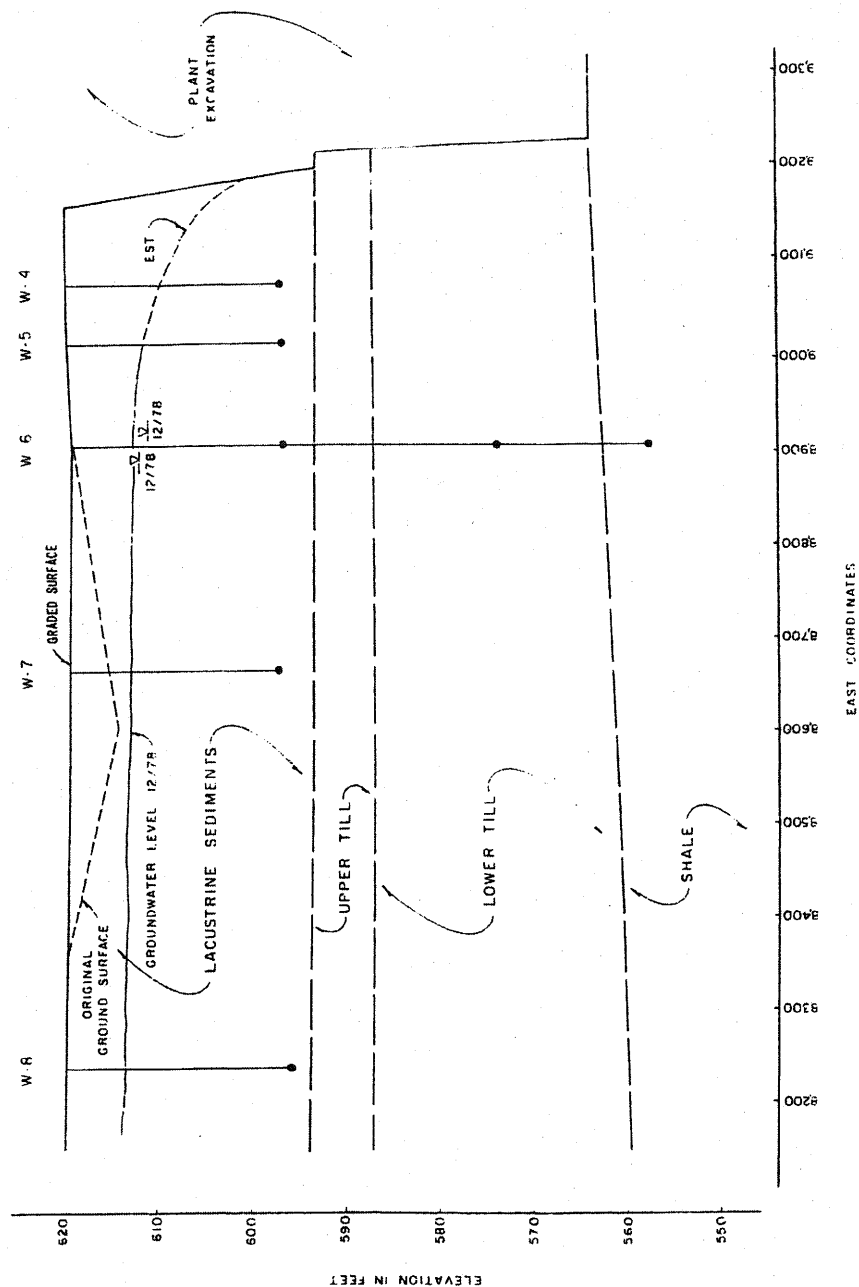
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Groundwater Profiles

Figure 2.5-188 (Sheet 1 of 4)



(Rev. 12 1/03)

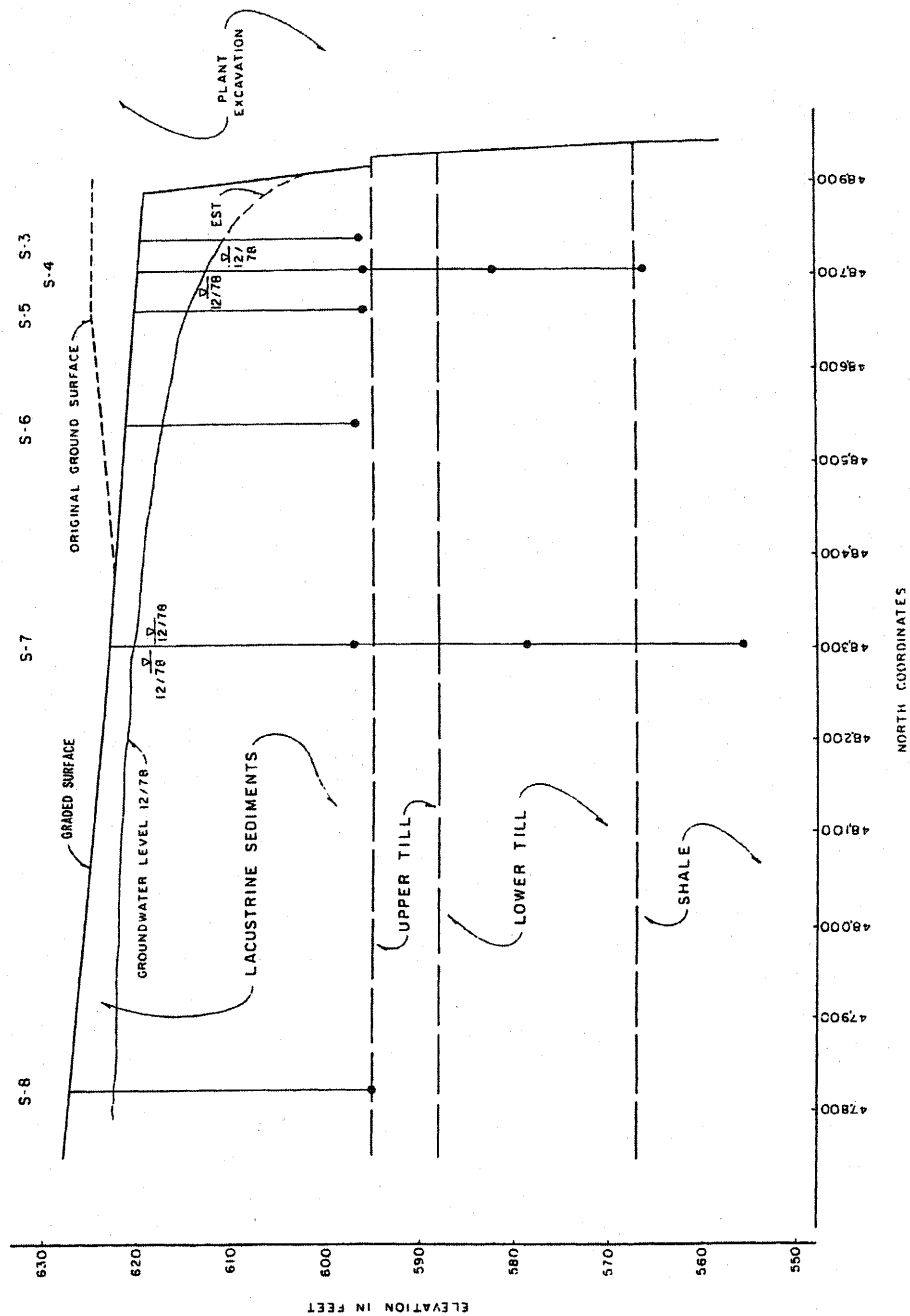


**PERRY NUCLEAR POWER PLANT**

Groundwater Profiles

Figure 2.5-188 (Sheet 2 of 4)





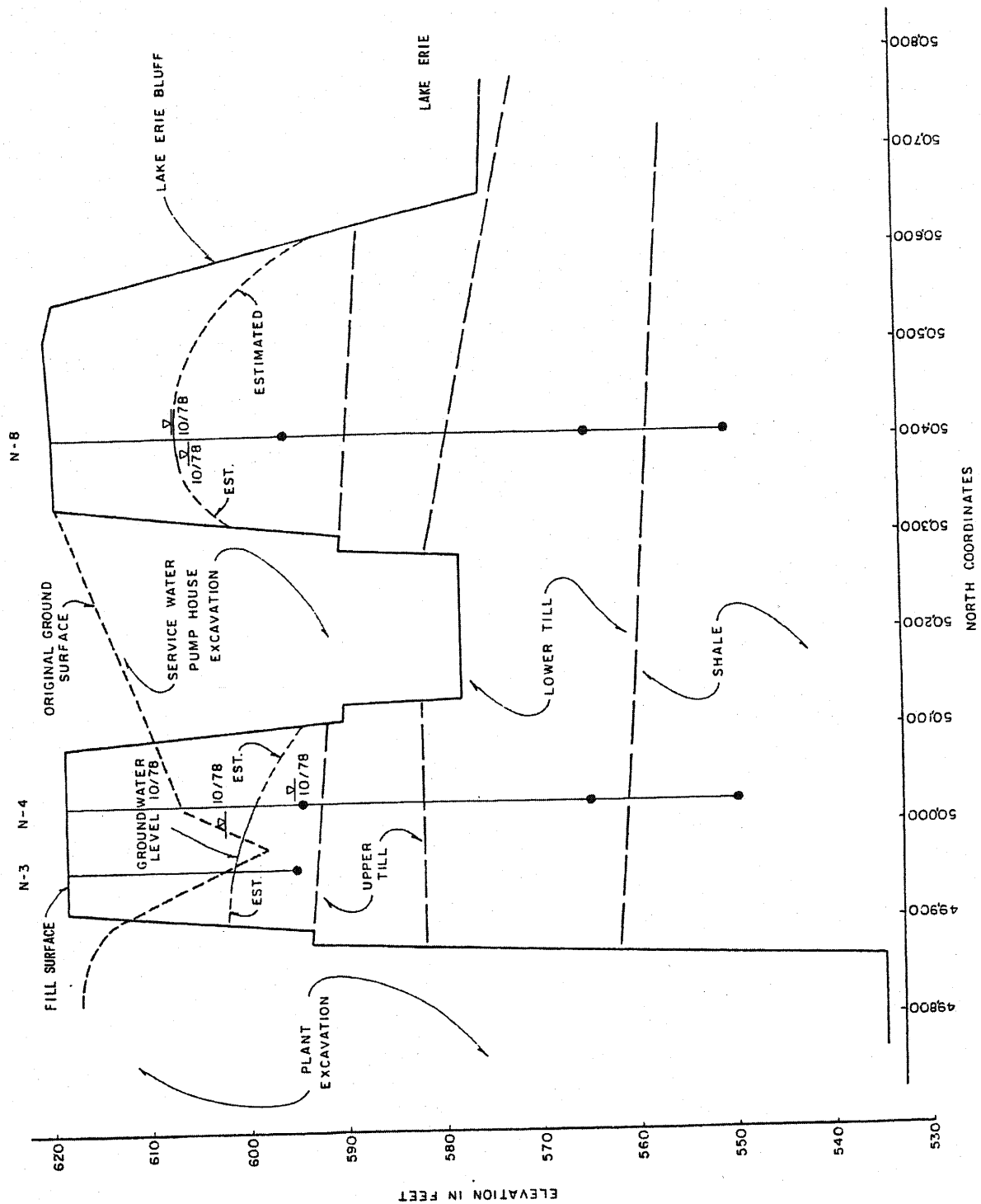
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Groundwater Profiles

Figure 2.5-188 (Sheet 3 of 4)



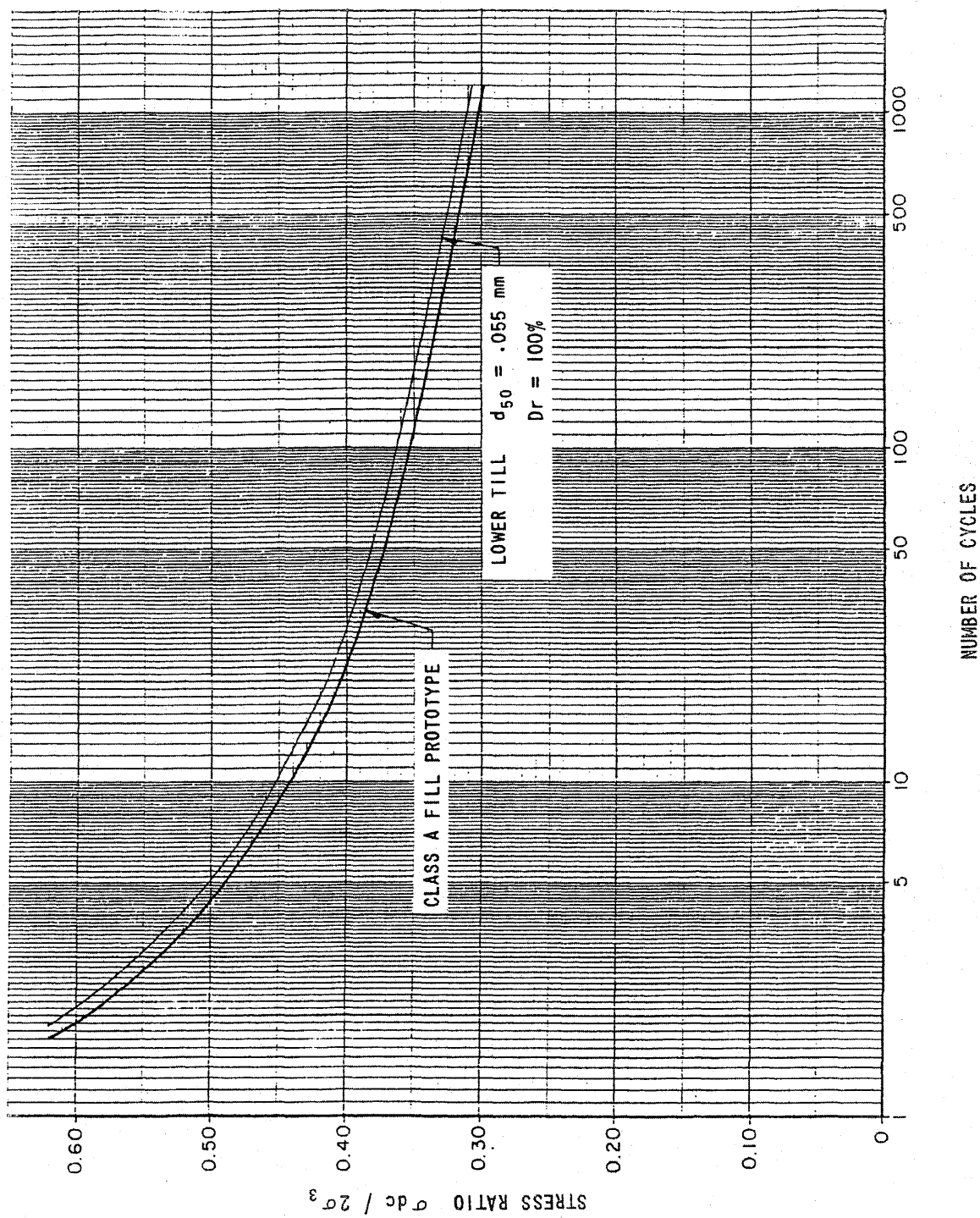
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Groundwater Profiles

Figure 2.5-188 (Sheet 4 of 4)



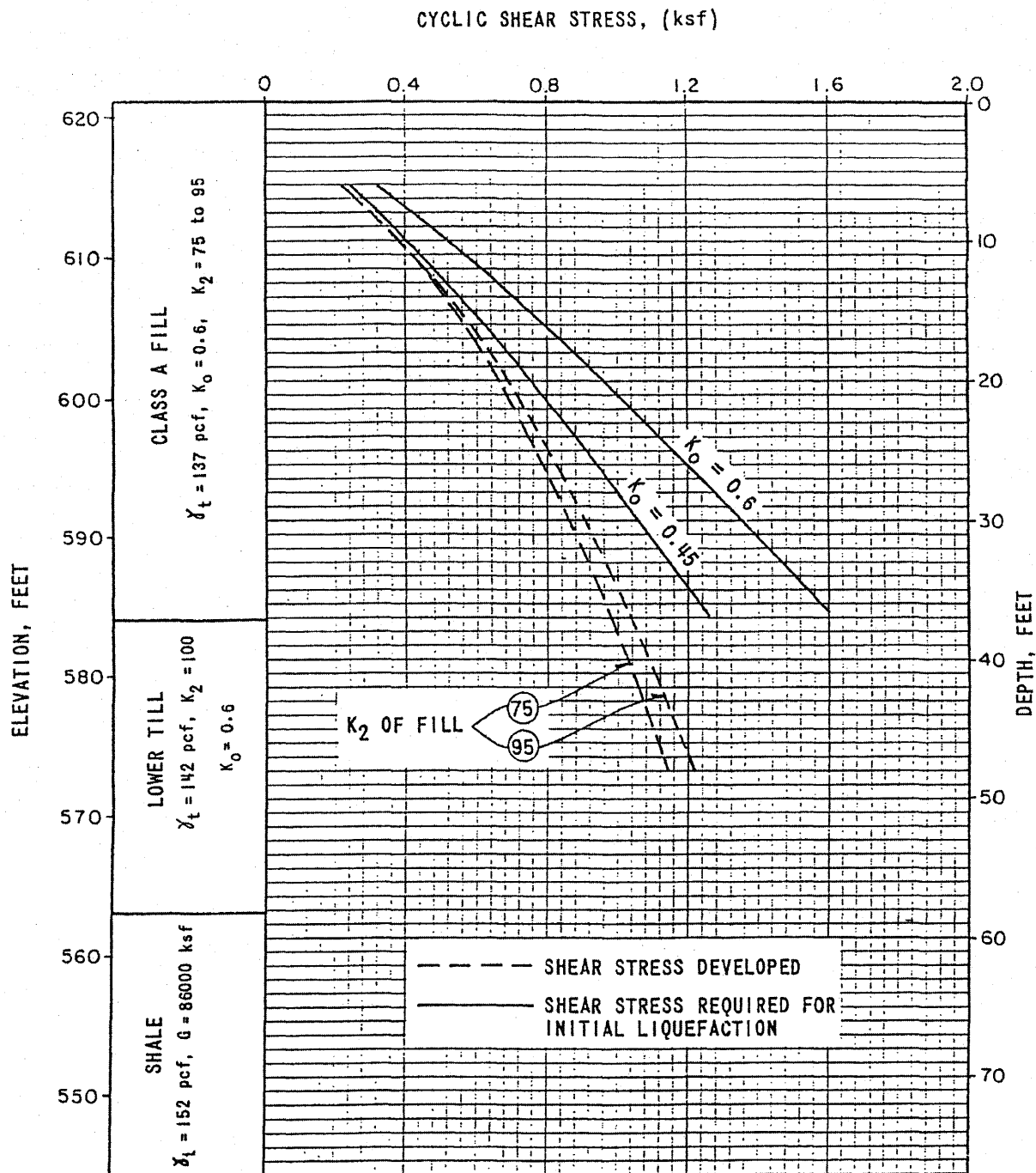
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Number of Cycles Required  
for Initial Liquefaction

Figure 2.5-189



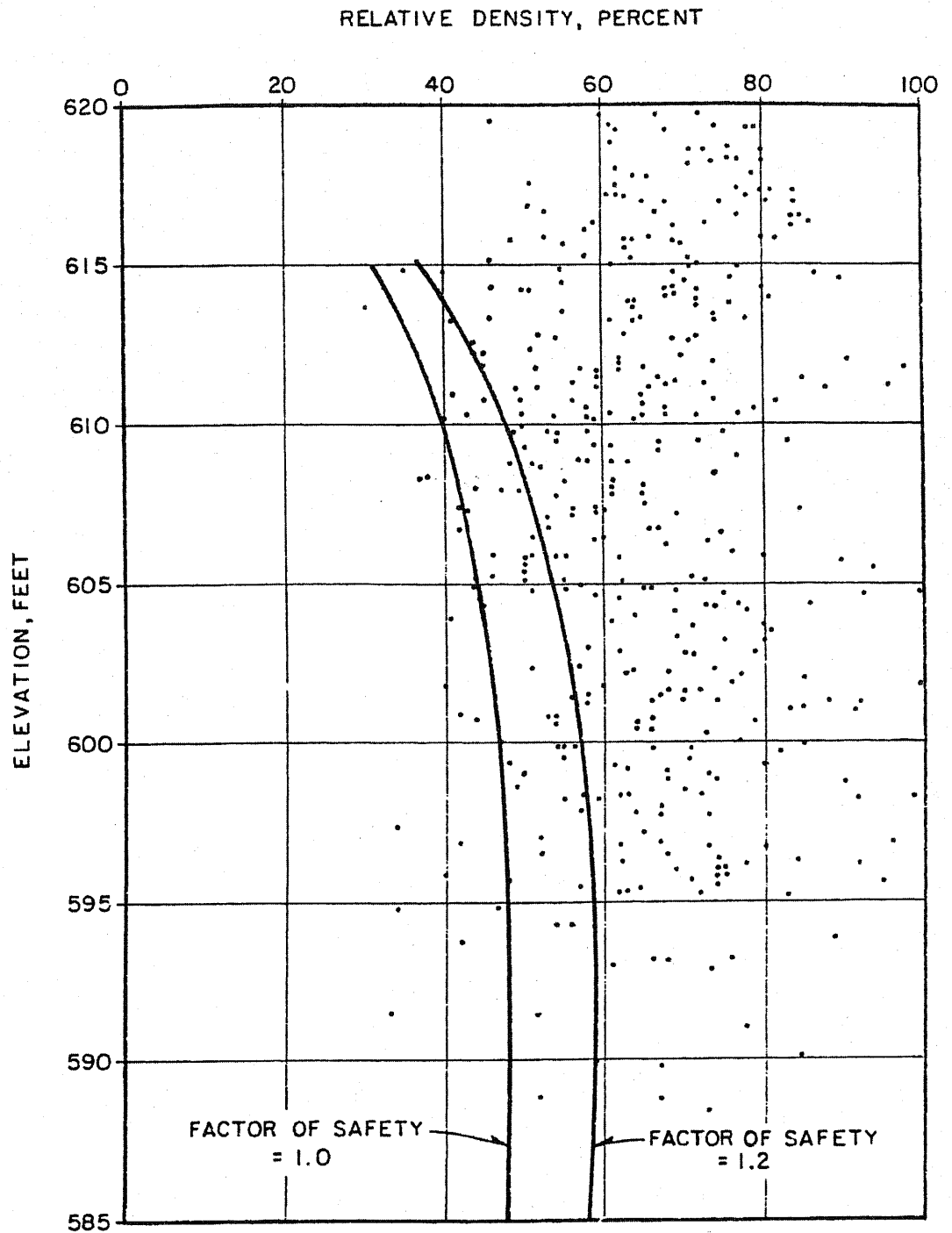
(Rev. 12 1/03)



# PERRY NUCLEAR POWER PLANT

Cycle Stress Developed and  
 Required for Initial  
 Liquefaction in 10 Stress Cycles

Figure 2.5-190



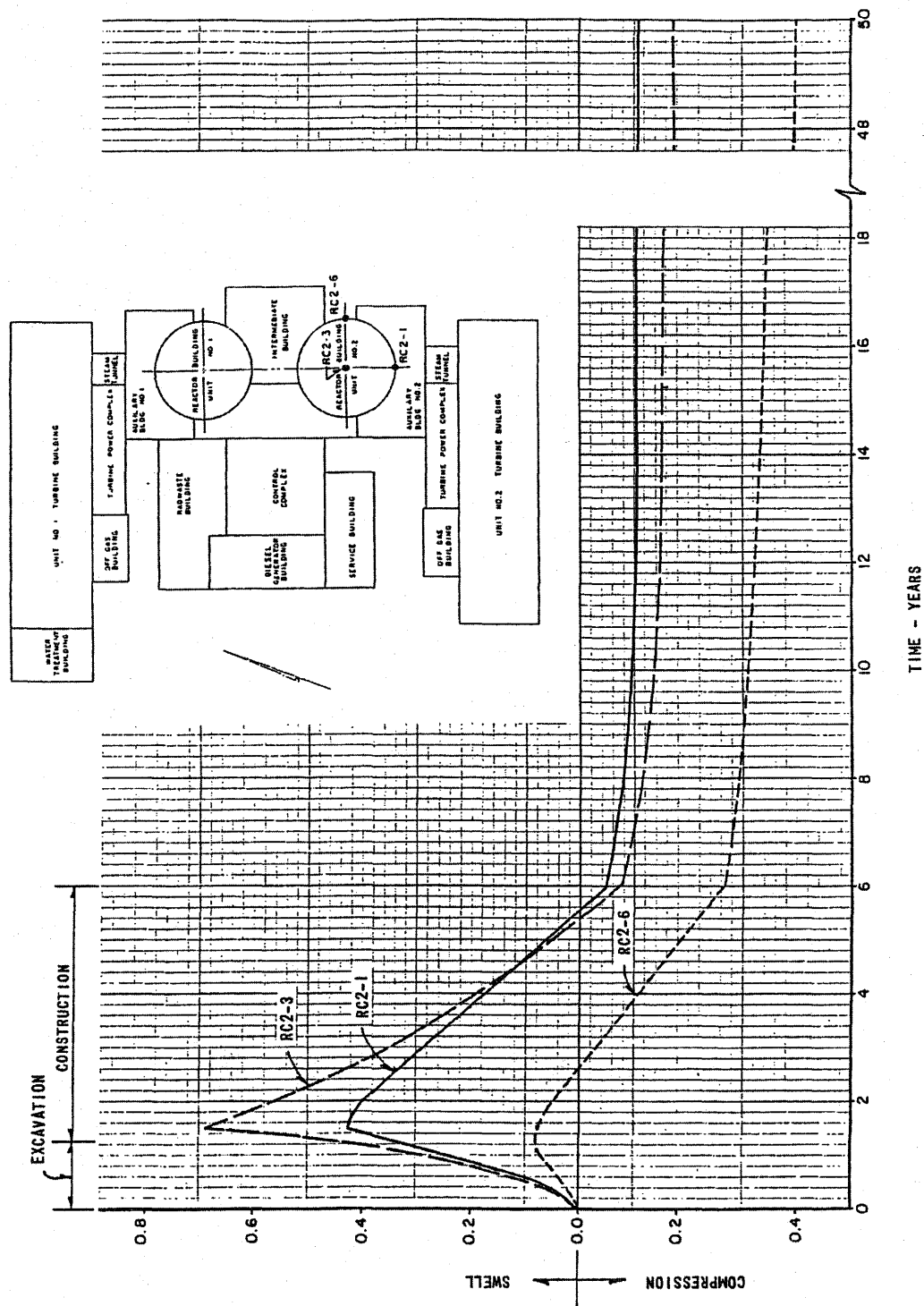
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Liquefaction Potential Analysis  
of Lacustrine Sediments

Figure 2.5-191



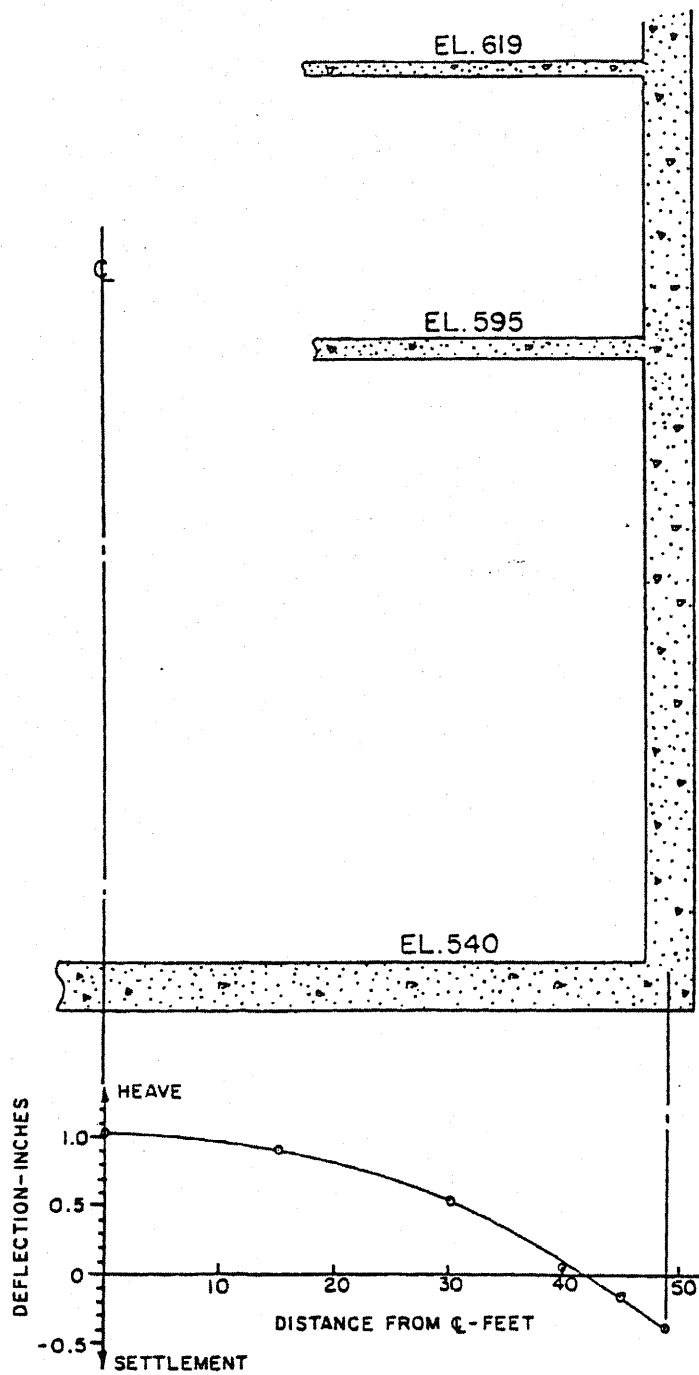
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Time-Deformation Analysis for  
Reactor Building Complex

Figure 2.5-192



**NOTES:**

- (1)  $K_0$  (SHALE) = 2.0
- (2)  $K_0$  (FILL) = 1.0
- (3) ANALYSIS ASSUMES 33% OF TOTAL SHALE SWELL OCCURS BEFORE MAT PLACEMENT.
- (4) DEFLECTION SHOWN IS FOR END OF CONSTRUCTION CONDITION PRIOR TO SERVICE LOADING.

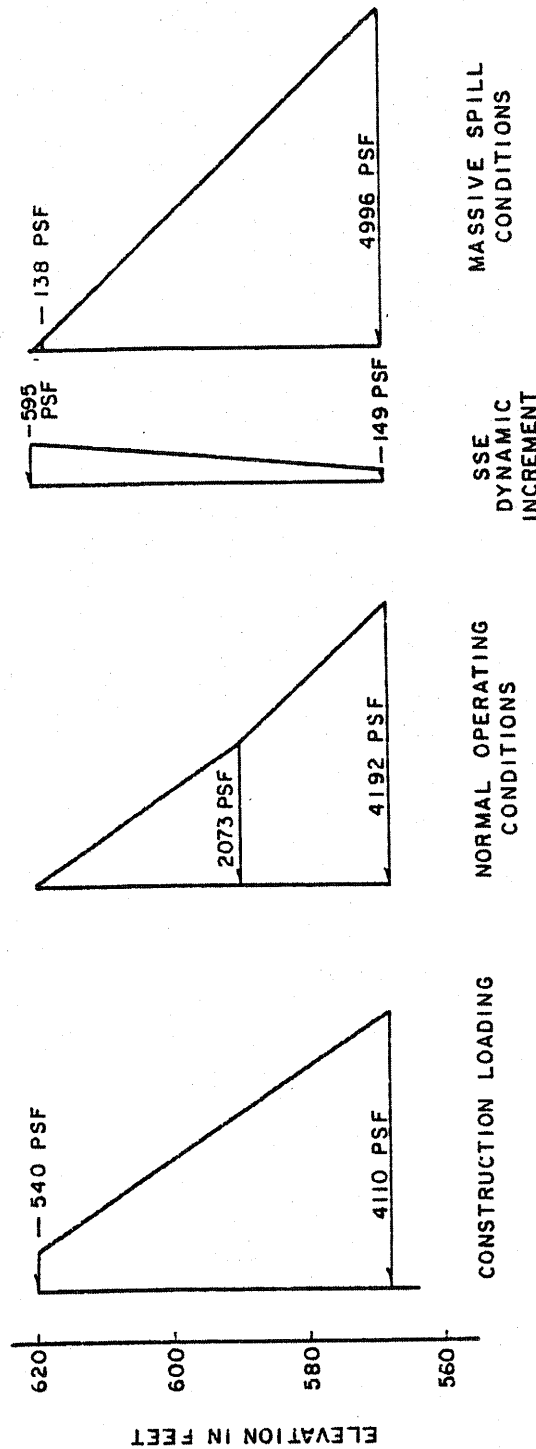
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Deformation Analysis for  
Emergency Service Water Pumphouse

Figure 2.5-193



- NOTE: 1. DYNAMIC INCREMENT ADDED TO NORMAL OPERATING CONDITIONS FOR SSE EVENT
2. ADDITIONAL LOADINGS DUE TO SURCHARGE FROM CRANES, RAILROADS OR ADJACENT FOUNDATIONS ADDED AS REQUIRED
3. FOR LOADS APPLICABLE TO EMERGENCY SERVICE WATER PUMPHOUSE SEE FIGURE 2.5-195

(Rev. 12 1/03)

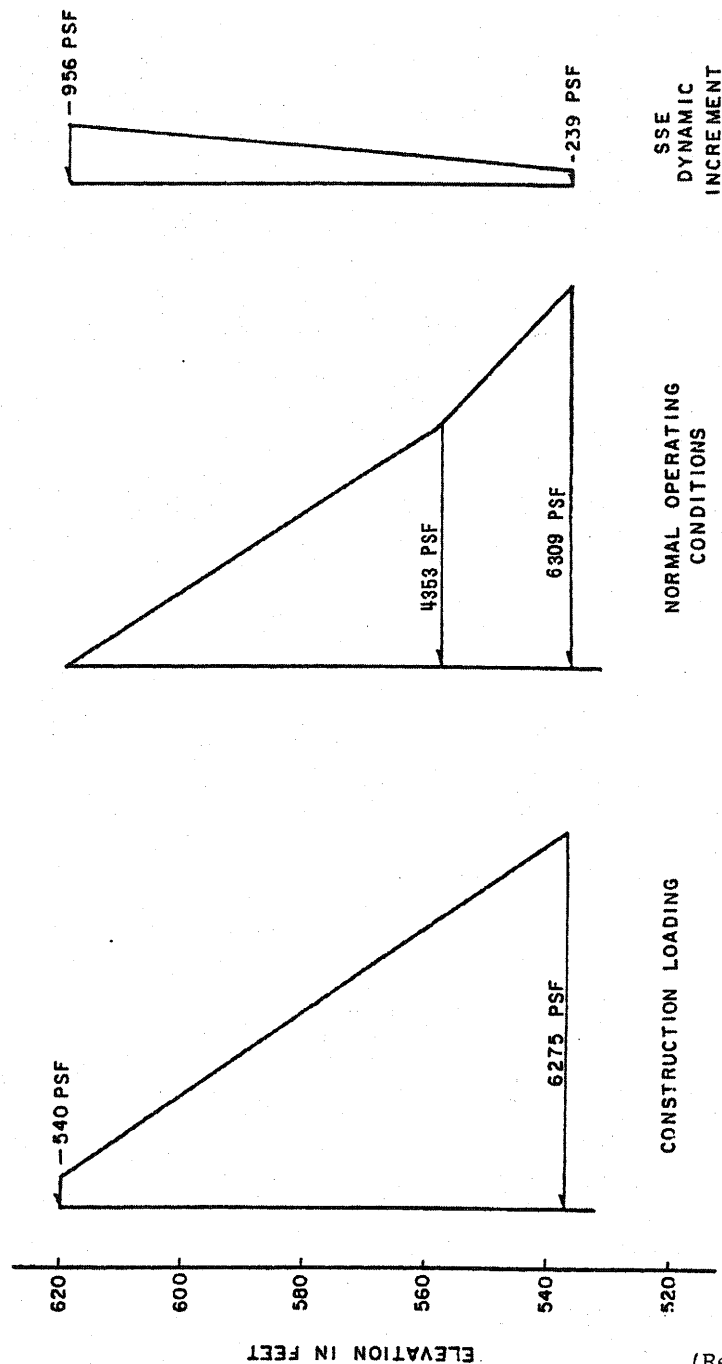


**PERRY NUCLEAR POWER PLANT**

Earth Pressure Diagrams for  
Rigid Subsurface Walls

Figure 2.5-194





NOTE: DYNAMIC INCREMENTS ADDED TO NORMAL OPERATIONS CONDITIONS FOR SSE EVENT

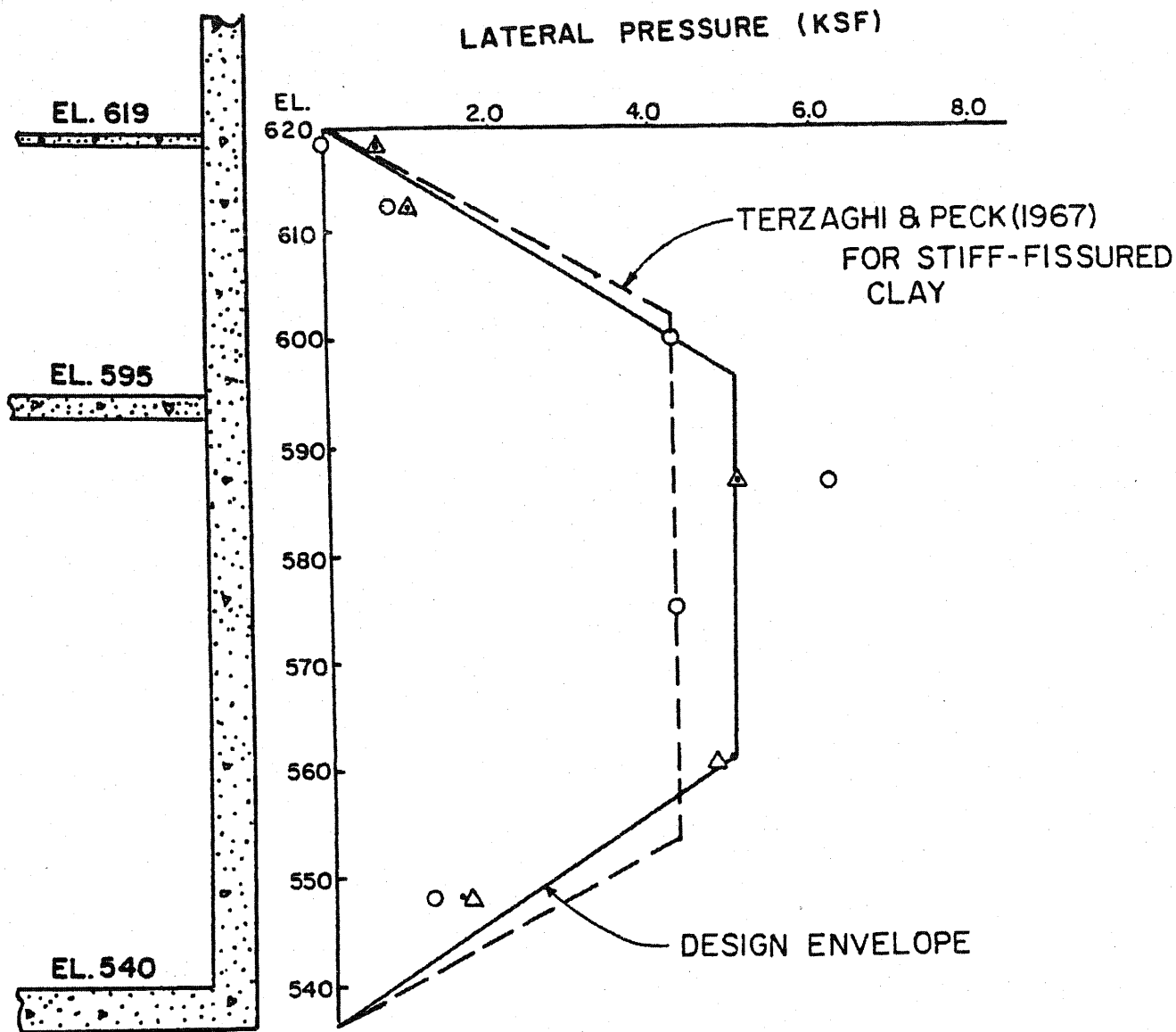
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Earth Pressure Diagrams  
for Emergency Service Water  
Pumphouse Subsurface Walls

Figure 2.5-195



**LEGEND:**

- CASE 1;  $K_0(\text{SHALE}) = 2$ ,  $K_0(\text{FILL}) = 1$  INCREMENTAL WALL CONSTRUCTION
- △ CASE 2;  $K_0(\text{SHALE}) = 2$ ,  $K_0(\text{FILL}) = 1$
- CASE 3;  $K_0(\text{SHALE}) = 1$ ,  $K_0(\text{FILL}) = 0.5$

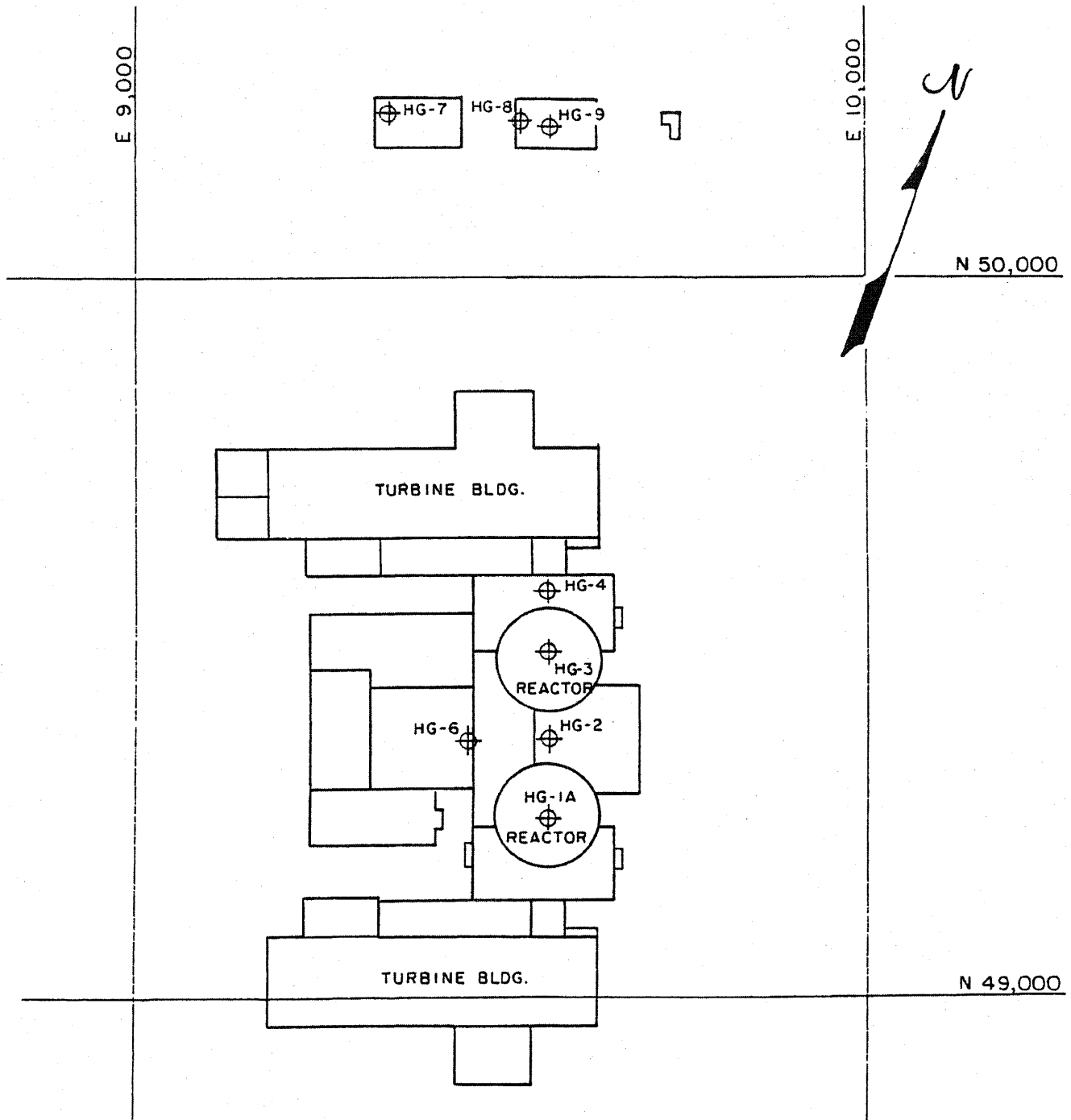
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Lateral Pressure - Emergency  
Service Water Pumphouse

Figure 2.5-196



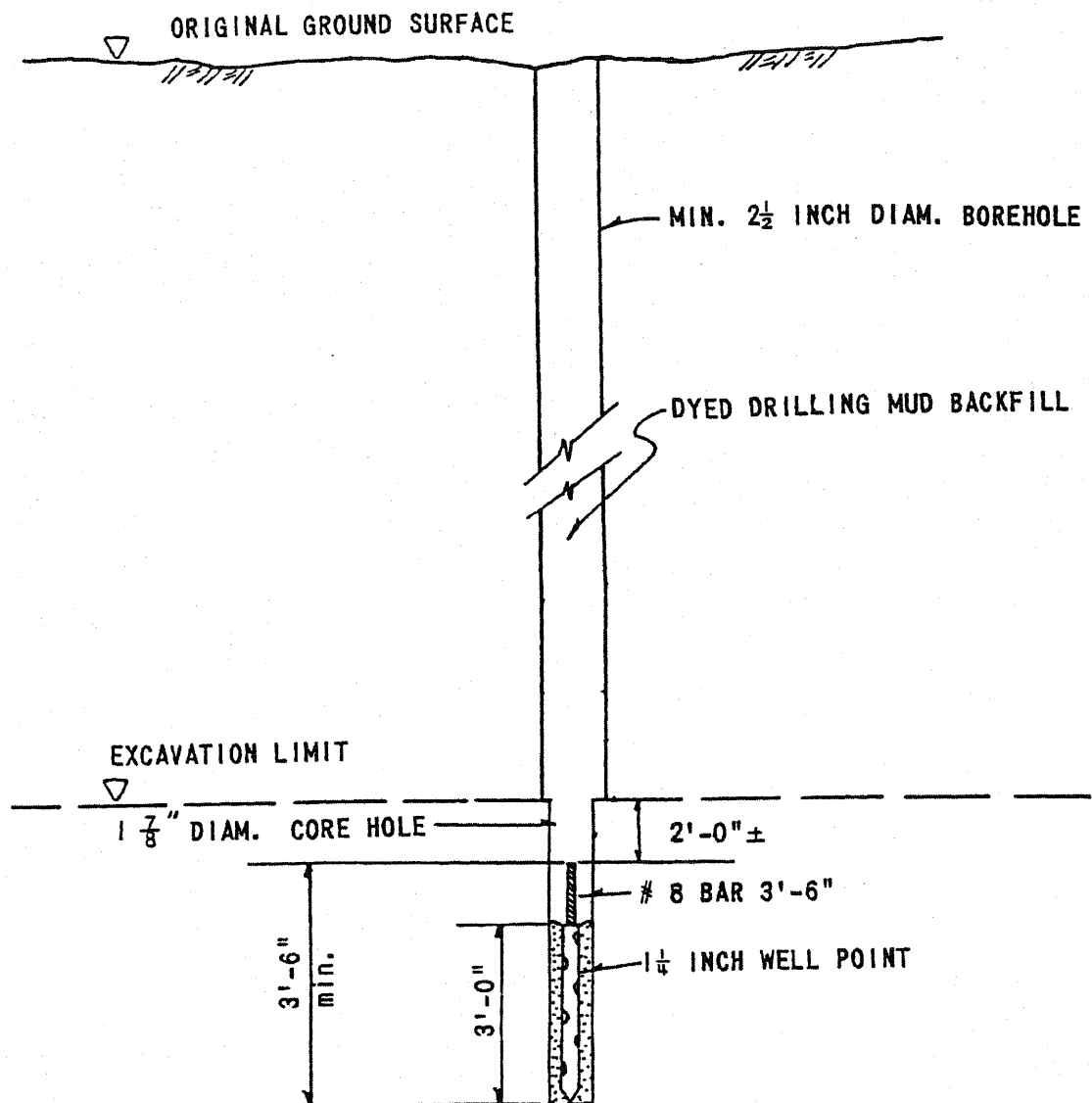
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Shale Heave Gauge  
Location Plan

Figure 2.5-197



NOTE: # 8 BAR PLACED WITH AND DRIVEN INTO  $1\frac{1}{4}$  INCH WELL POINT  
ELEVATION OF TOP OF BAR ESTABLISHED FROM SURFACE

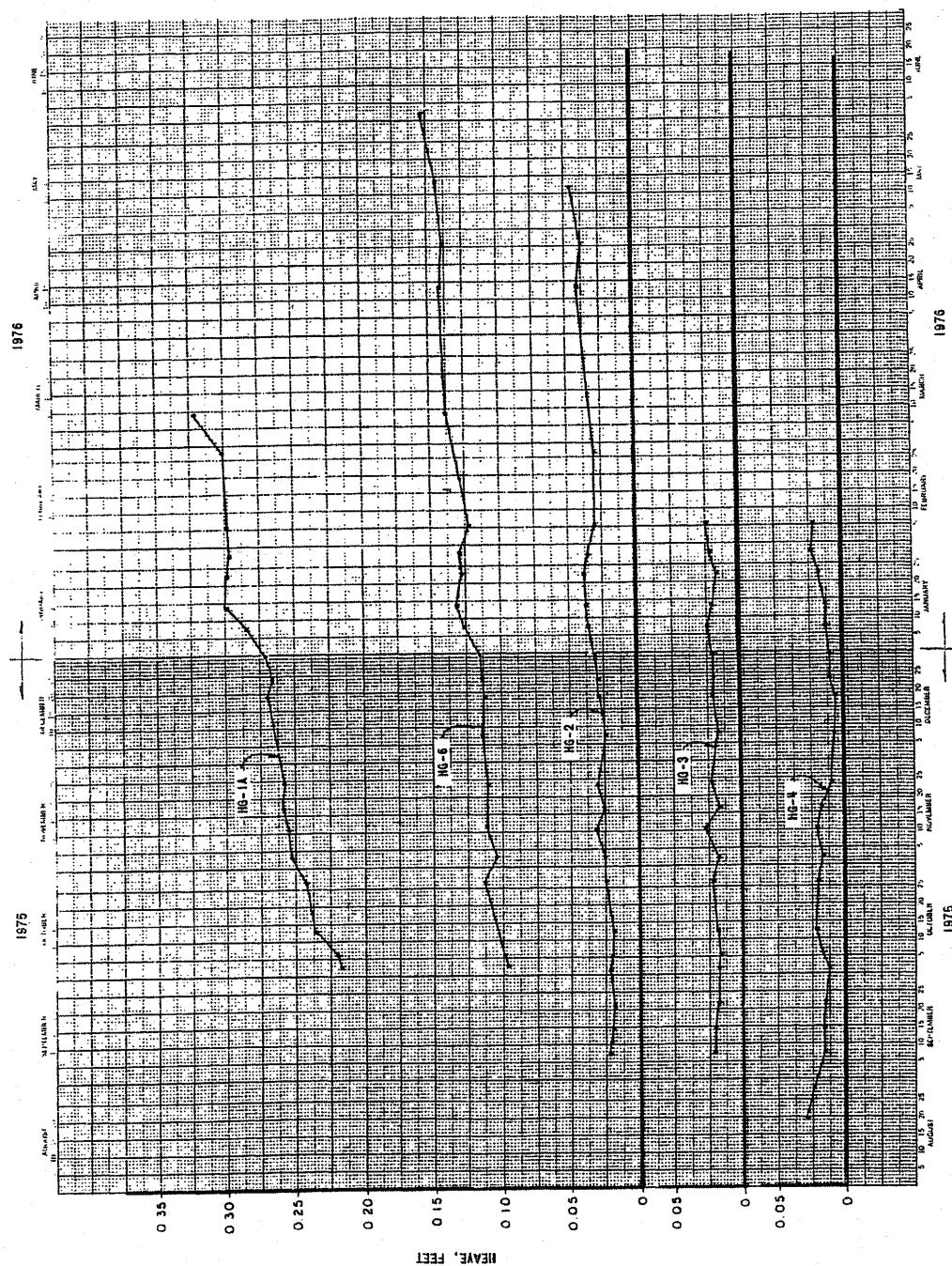
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Shale Heave Gauge Detail

Figure 2.5-198



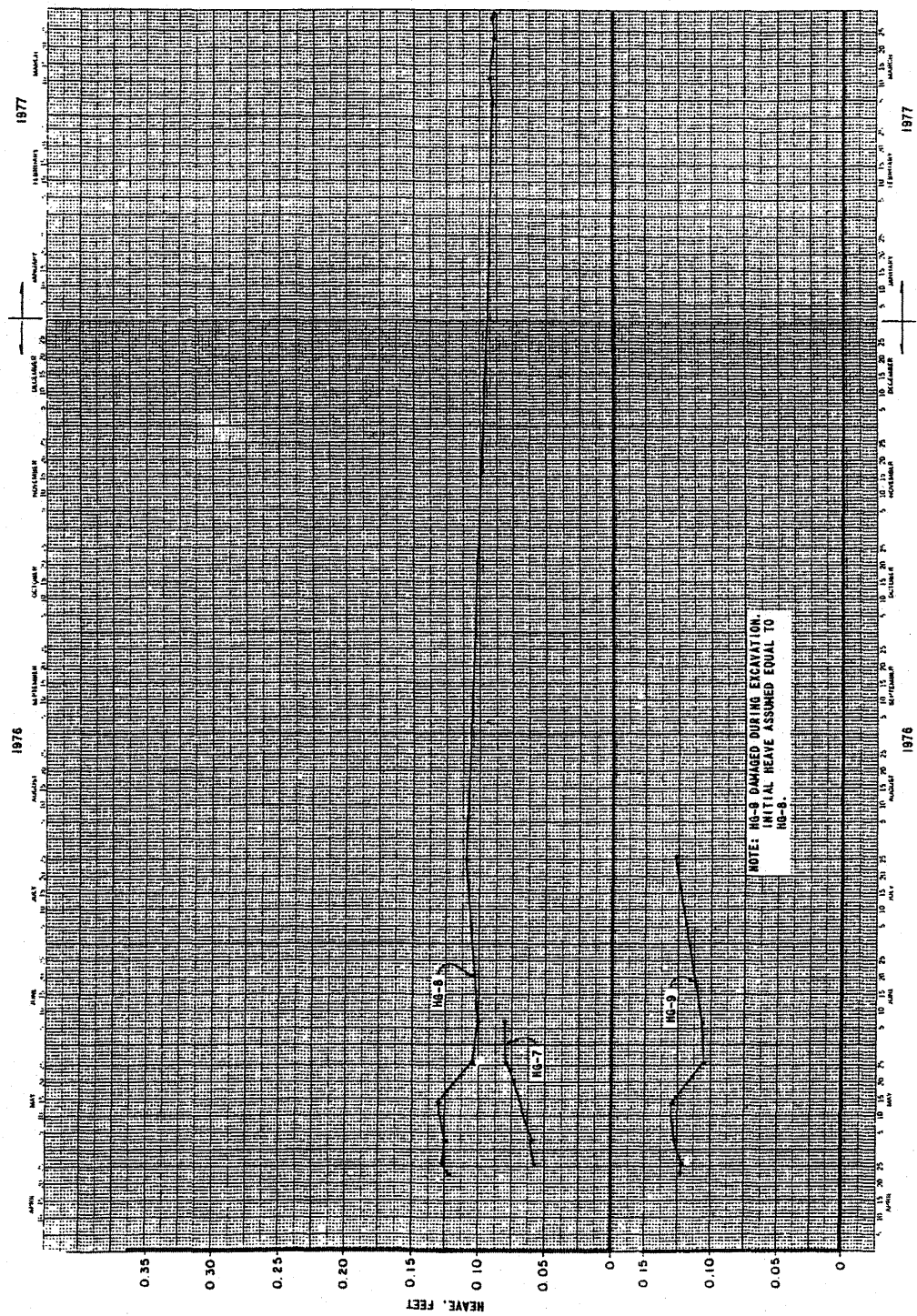
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Shale Heave Gauge Monitoring Data

Figure 2.5-199 (Sheet 1 of 2)



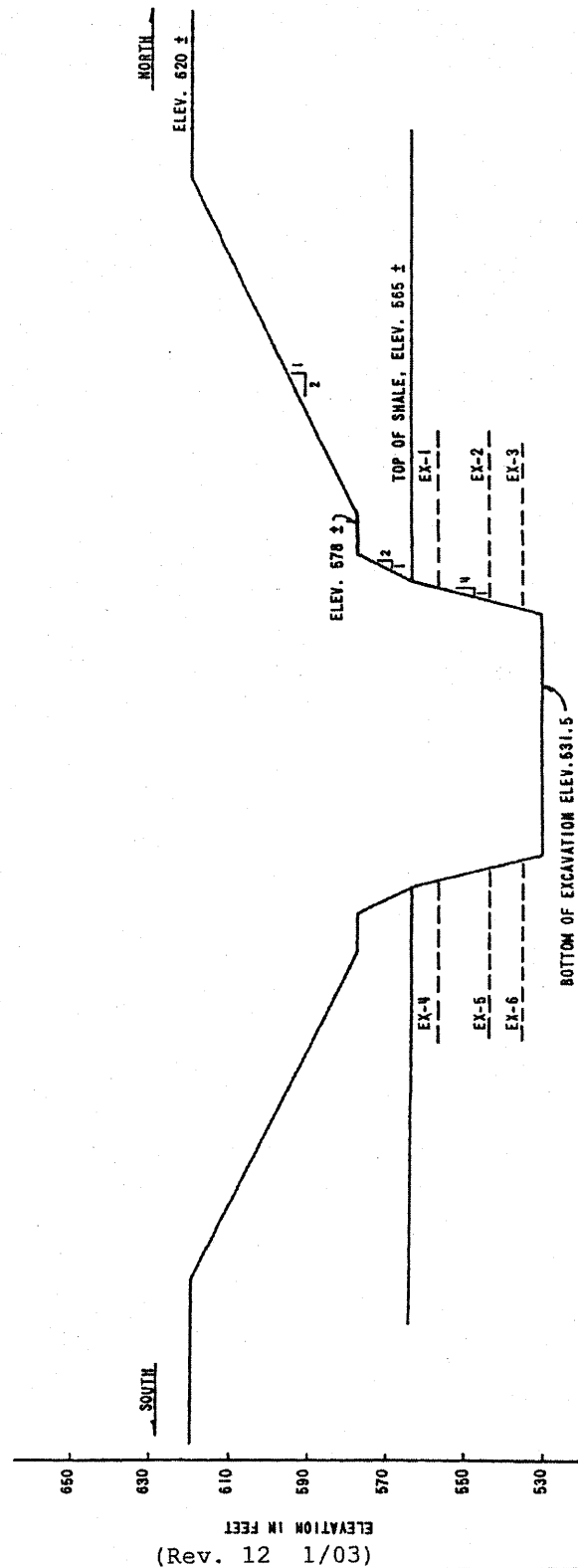
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Shale Heave Gauge Monitoring Data

Figure 2.5-199 (Sheet 2 of 2)



## PERRY NUCLEAR POWER PLANT

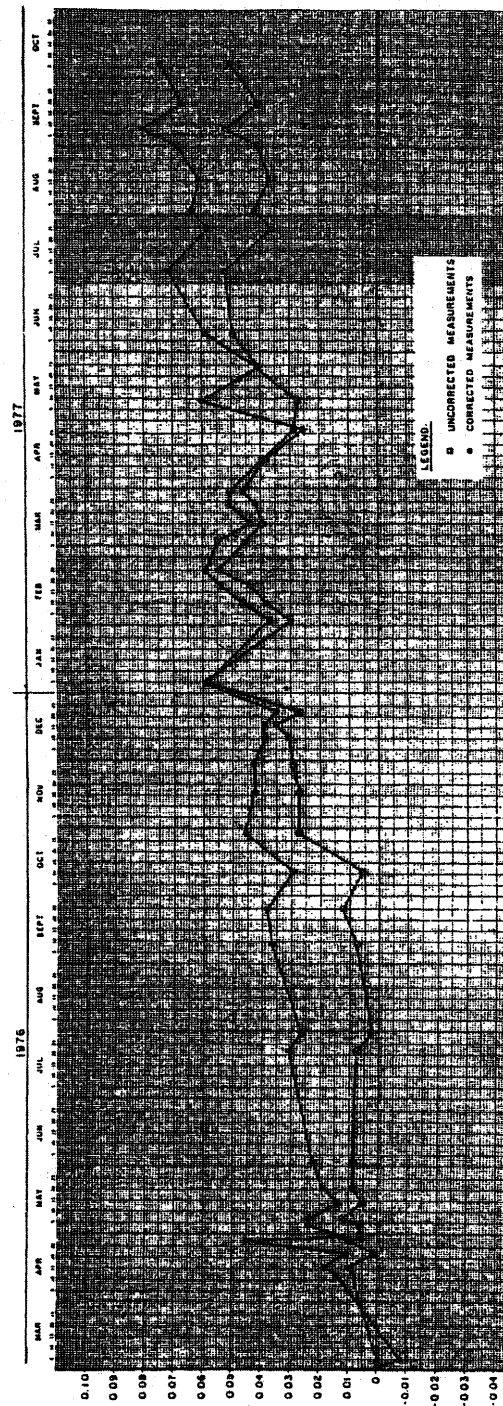
Shale Extensometer Locations  
in Emergency Service Water  
Pumphouse Excavation

Figure 2.5-200





# EXTENSOMETER EX-1



RELATIVE DEFORMATION (INCHES)  
 (Rev. 12 1/03)

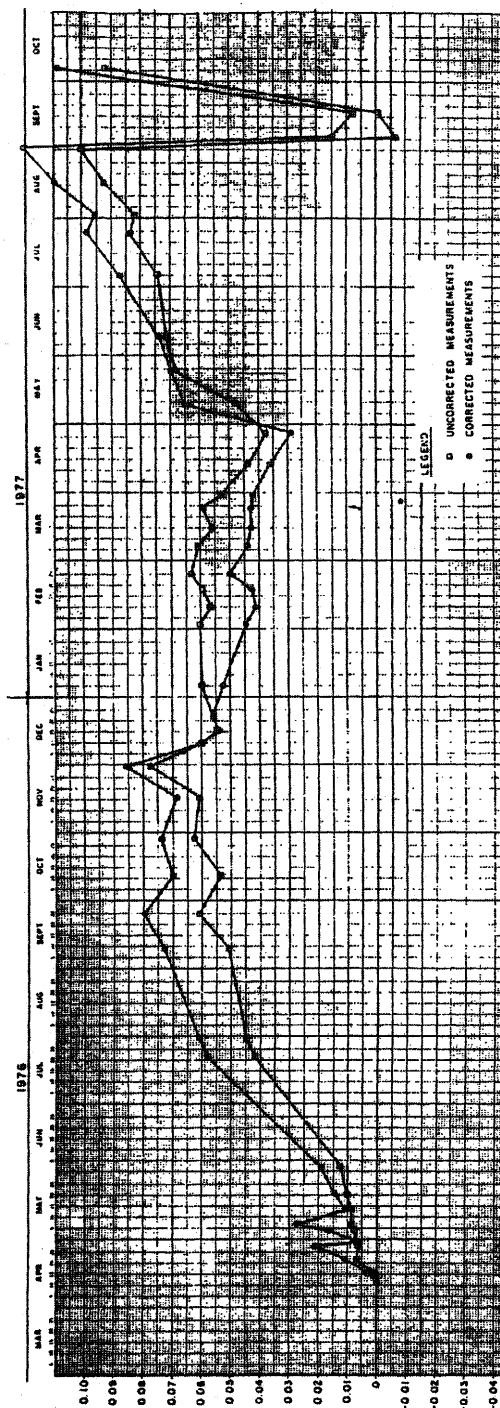


**PERRY NUCLEAR POWER PLANT**

Shale Extensometers Monitoring  
 Data

Figure 2.5-202 (Sheet 1 of 6)

# EXTENSOMETER EX-2



RELATIVE DEFORMATION (INCHES)  
 (Rev. 12 1/03)

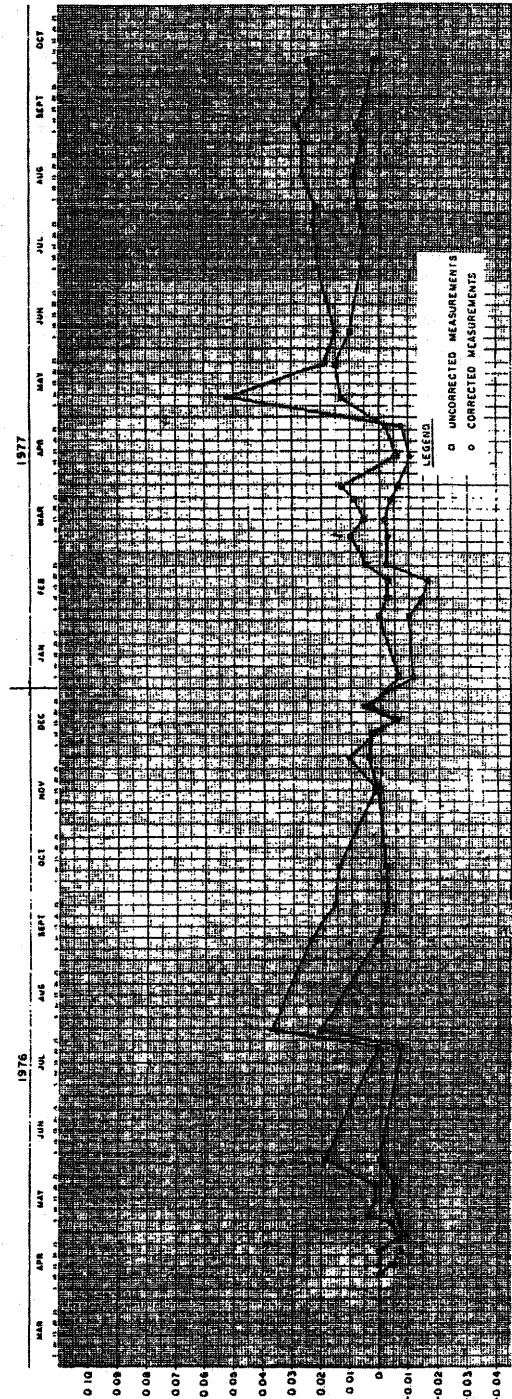


PERRY NUCLEAR POWER PLANT

Shale Extensometers Monitoring  
 Data

Figure 2.5-202 (Sheet 2 of 6)

# EXTENSOMETER EX-3



RELATIVE DEFORMATION (INCHES)  
 (Rev. 12 1/03)

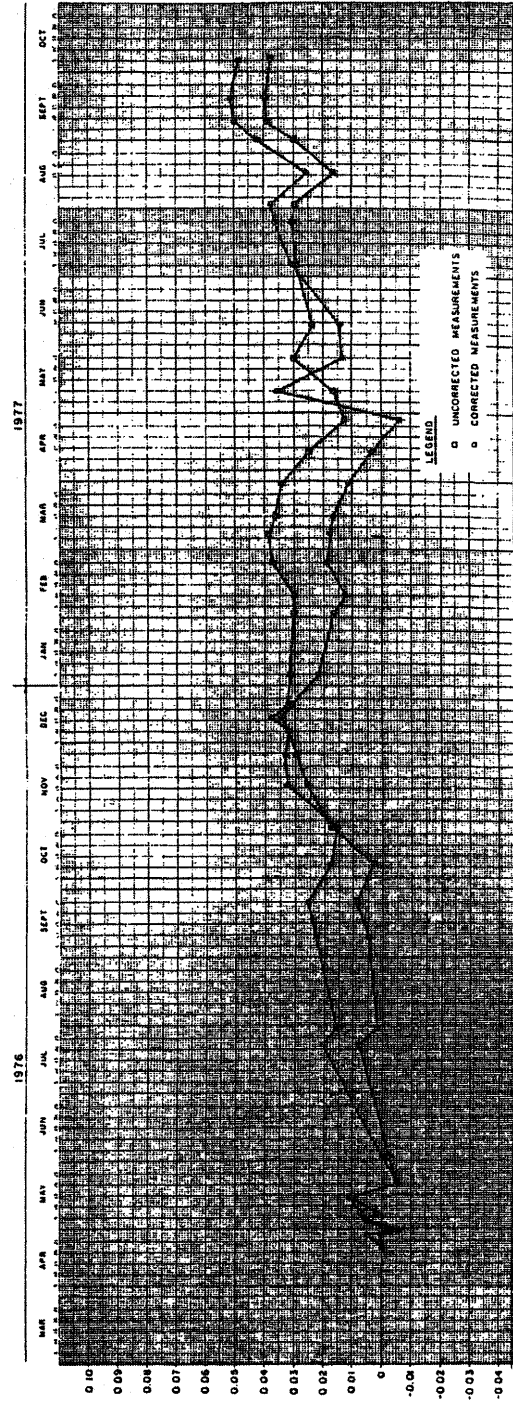


**PERRY NUCLEAR POWER PLANT**

Shale Extensometers Monitoring  
 Data

Figure 2.5-202 (Sheet 3 of 6)

# EXTENSOMETER EX-4



RELATIVE DEFORMATION (INCHES)  
 (Rev. 12 1/03)

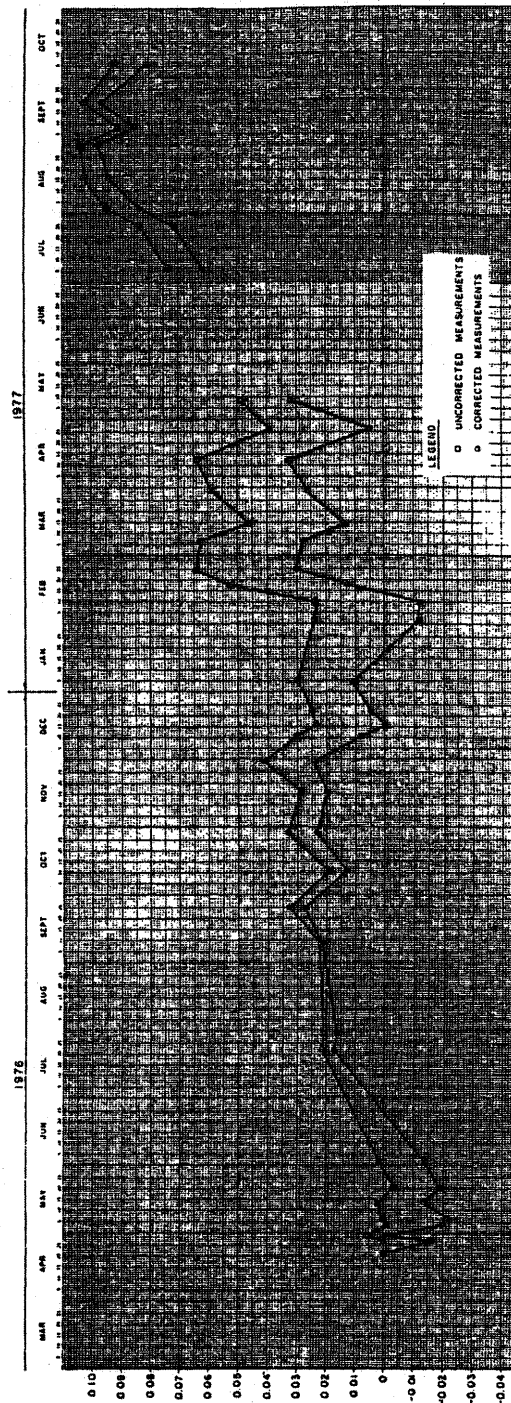


PERRY NUCLEAR POWER PLANT

Shale Extensometers Monitoring  
 Data

Figure 2.5-202 (Sheet 4 of 6)

# EXTENSOMETER EX-5



RELATIVE DEFORMATION (INCHES)  
(Rev. 12 1/03)

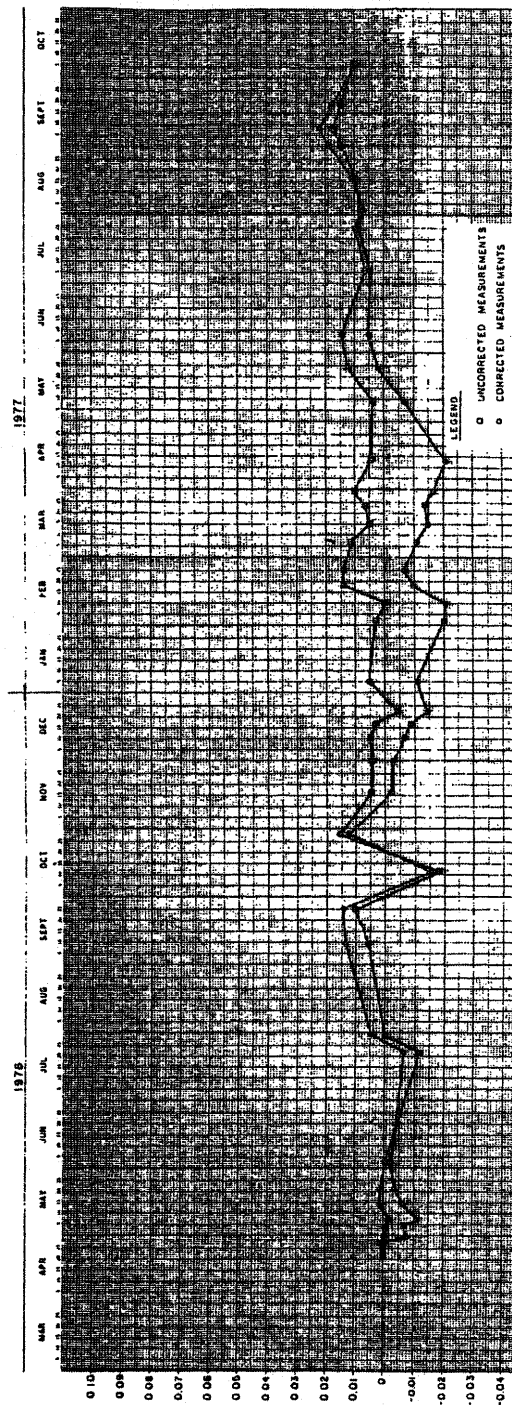


**PERRY NUCLEAR POWER PLANT**

Shale Extensometers Monitoring  
Data

Figure 2.5-202 (Sheet 5 of 6)

# EXTENSOMETER EX-6



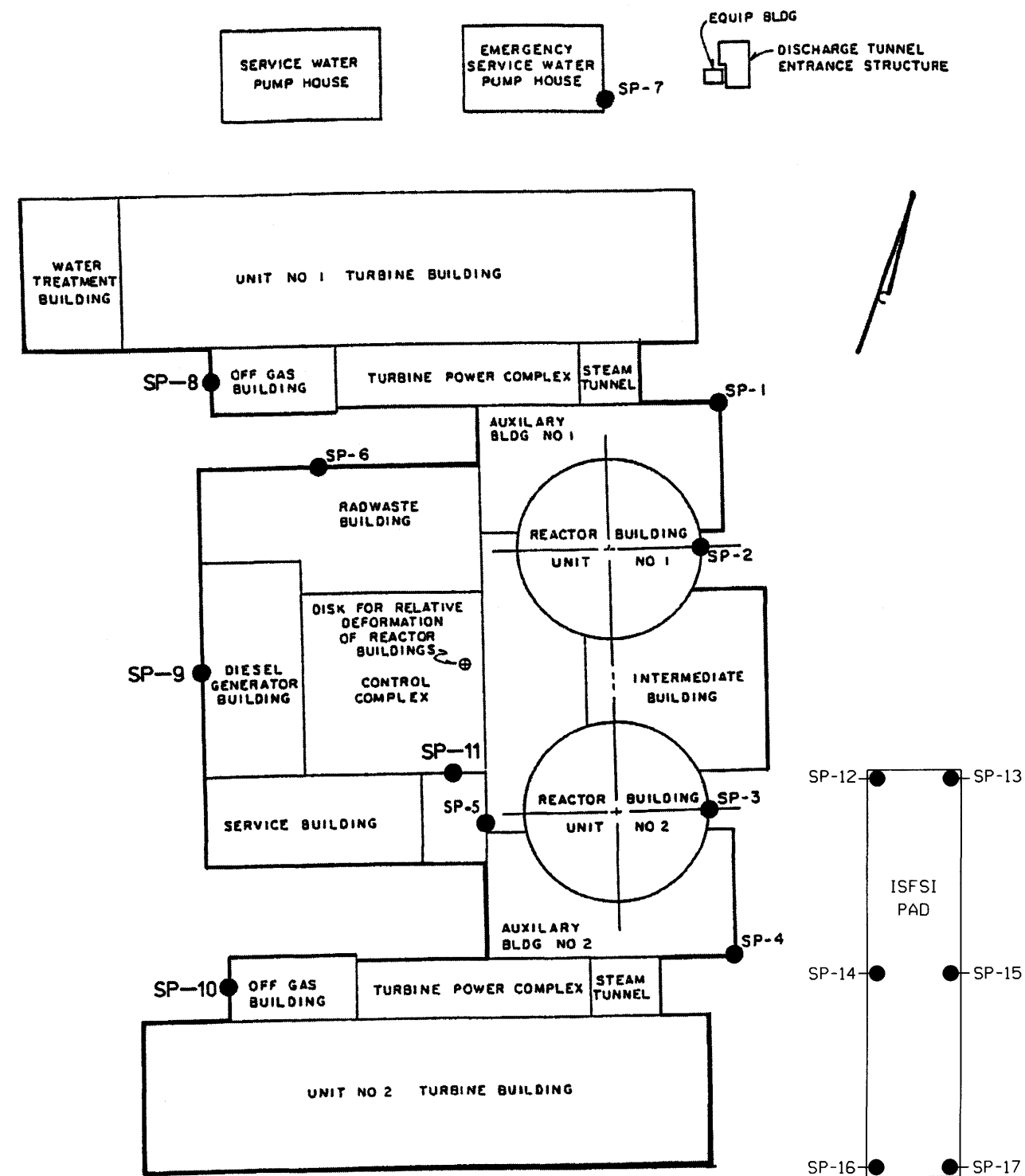
RELATIVE DEFORMATION (INCHES)  
(Rev. 12 1/03)



PERRY NUCLEAR POWER PLANT

Shale Extensometers Monitoring  
Data

Figure 2.5-202 (Sheet 6 of 6)

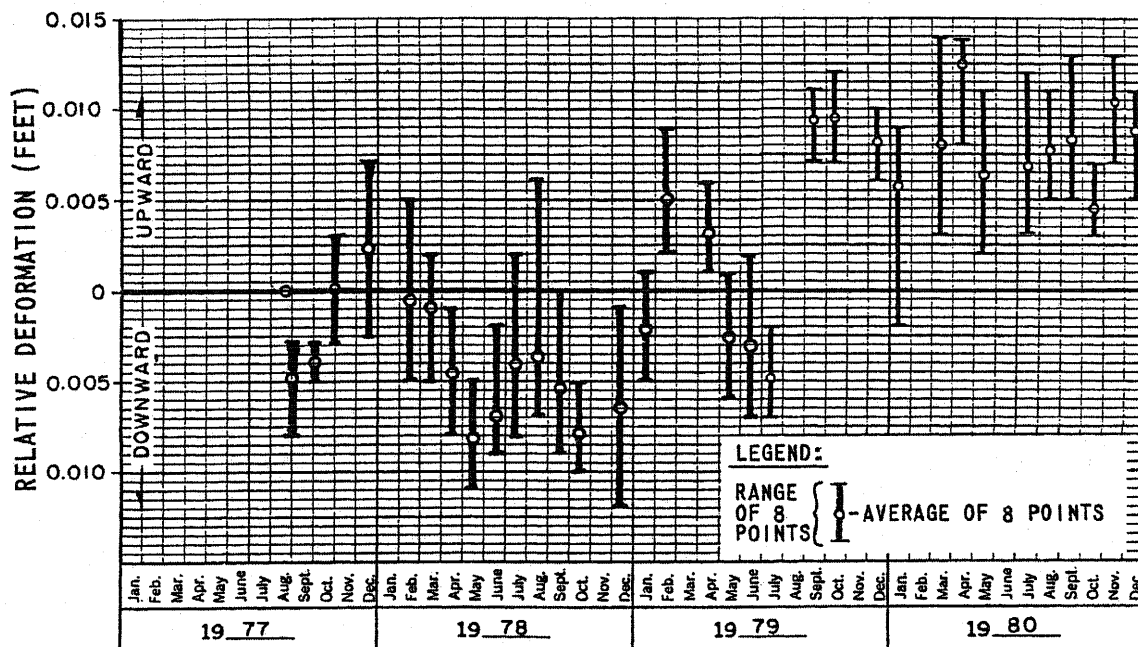
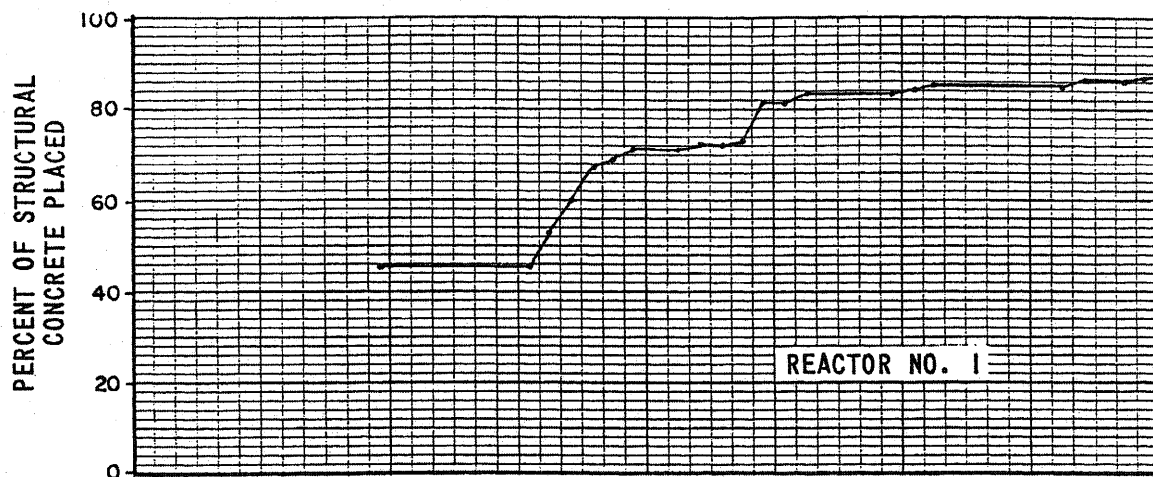


(REV. 19 10/2015)

**PERRY NUCLEAR POWER PLANT**  
10 CENTER RD., PERRY, OHIO 44081

SETTLEMENT MONUMENT  
LOCATION PLAN

FIGURE 2.5-203



NOTE: MEASURED DEFORMATION IS RELATIVE TO  
MONUMENT WITHIN CONTROL COMPLEX

(Rev. 12 1/03)

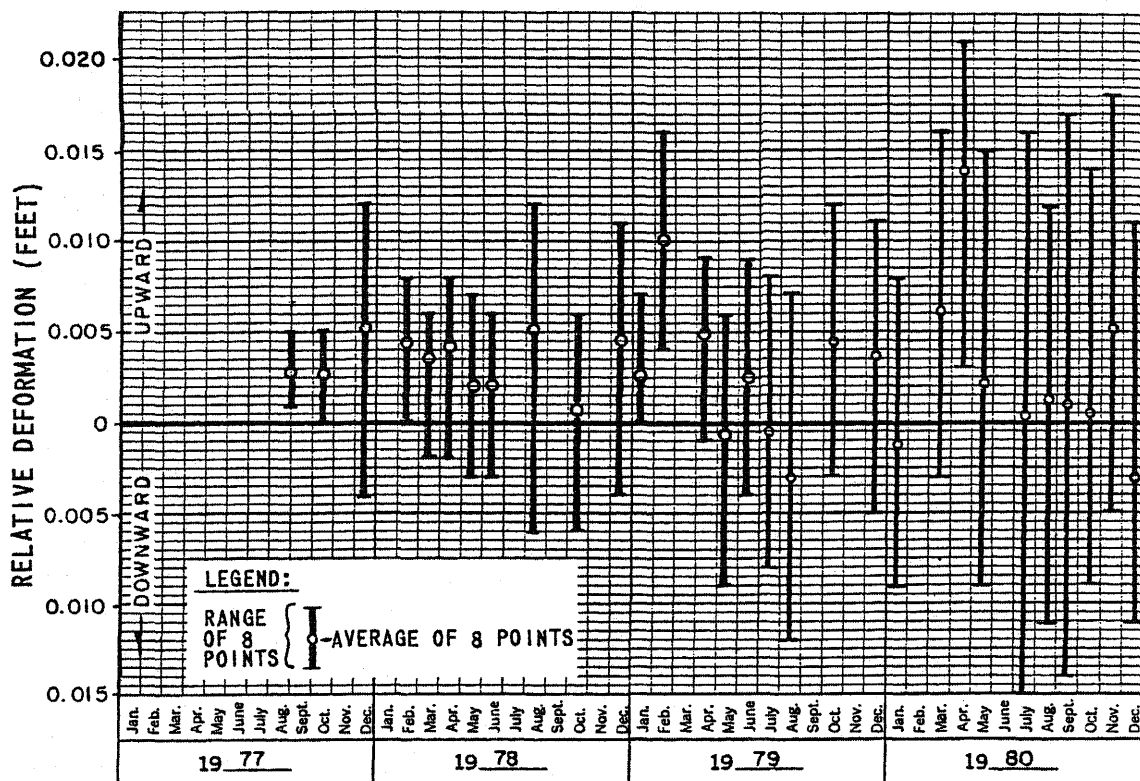
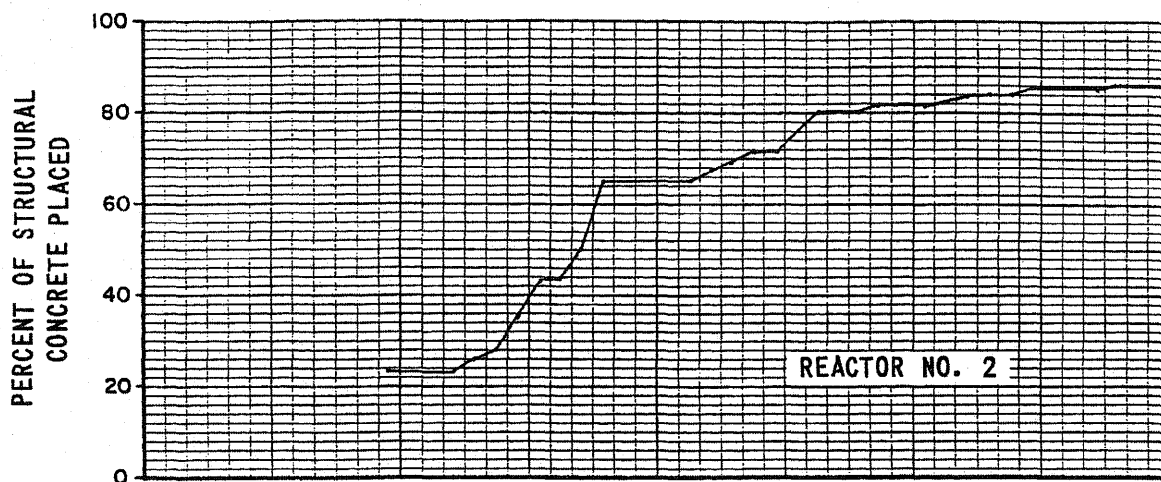


**PERRY NUCLEAR POWER PLANT**

Reactor Mat Deformation

Figure 2.5-204 (Sheet 1 of 2)





NOTE: MEASURED DEFORMATION IS RELATIVE TO MONUMENT WITHIN CONTROL COMPLEX

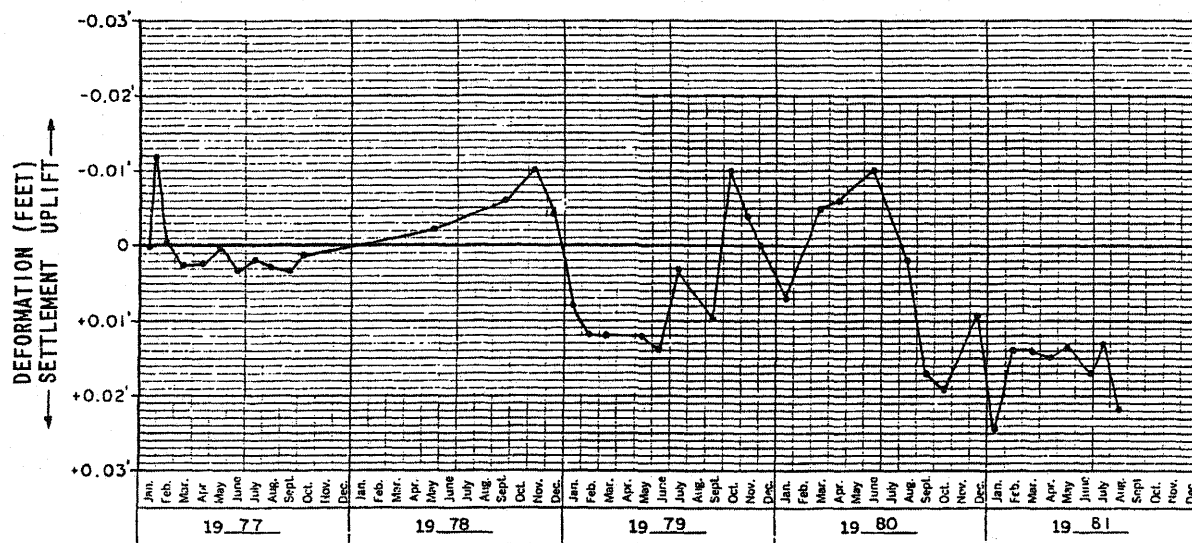
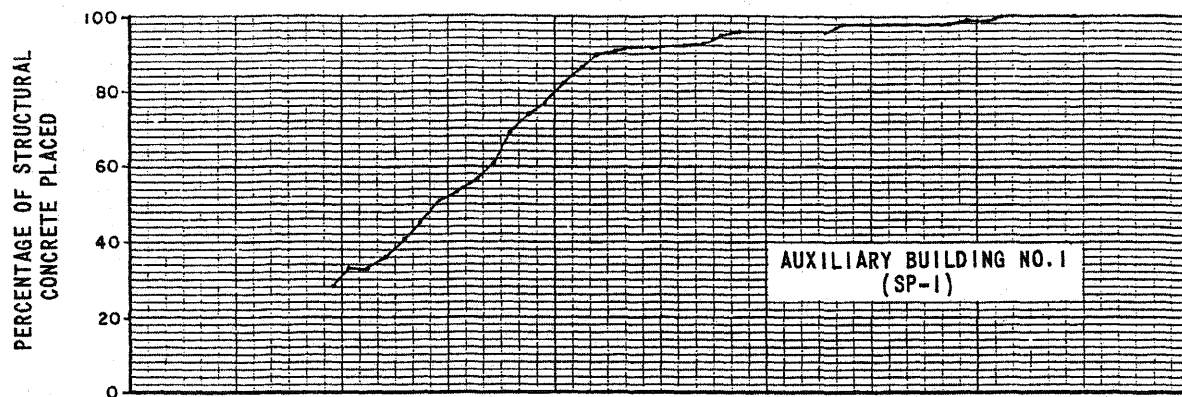
(Rev. 12 1/03)



PERRY NUCLEAR POWER PLANT

Reactor Mat Deformation

Figure 2.5-204 (Sheet 2 of 2)



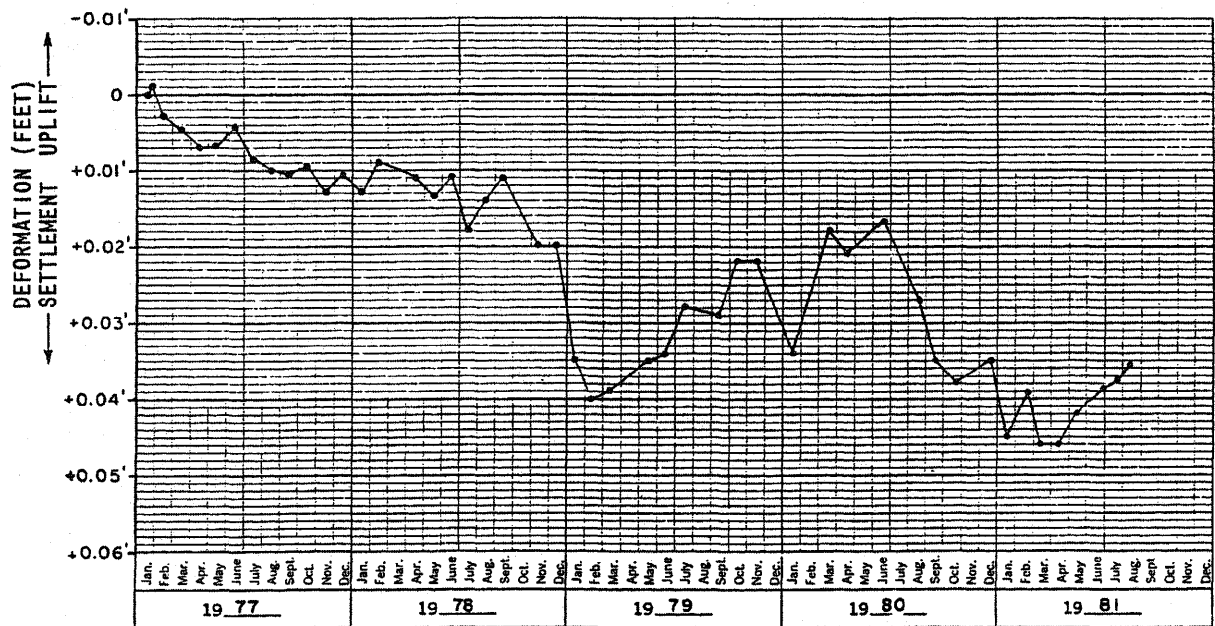
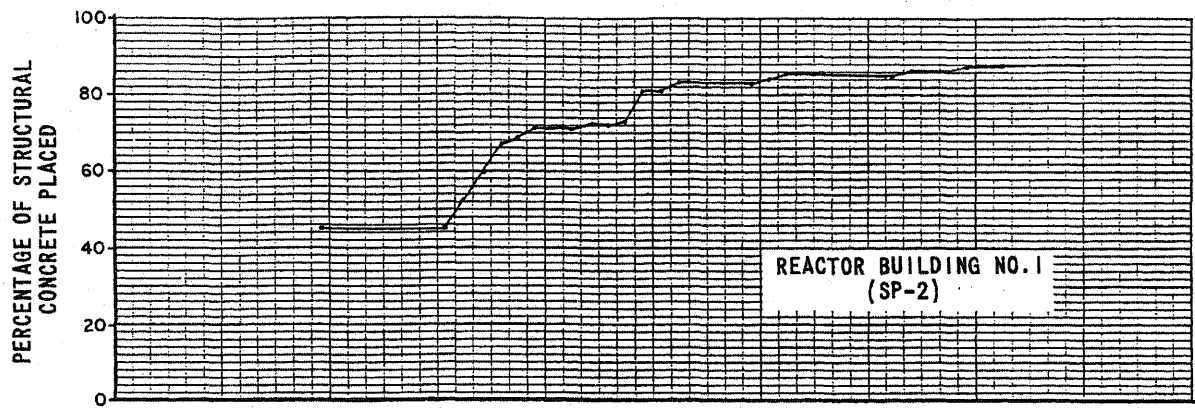
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Settlement Observation Data

Figure 2.5-205 (Sheet 1 of 6)



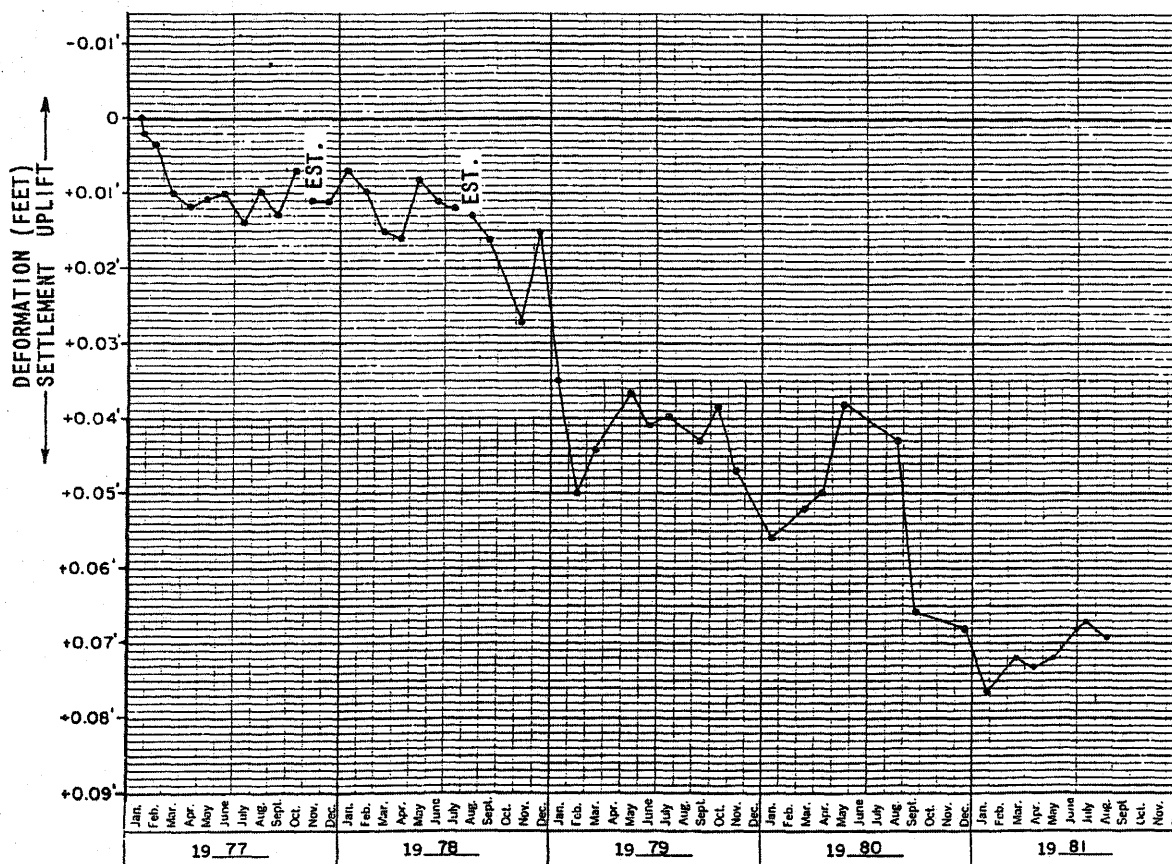
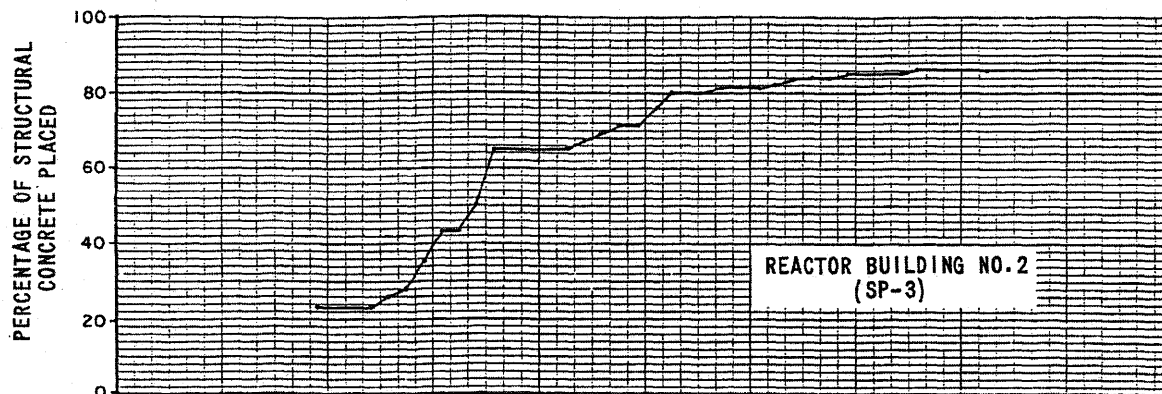
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Settlement Observation Data

Figure 2.5-205 (Sheet 2 of 6)



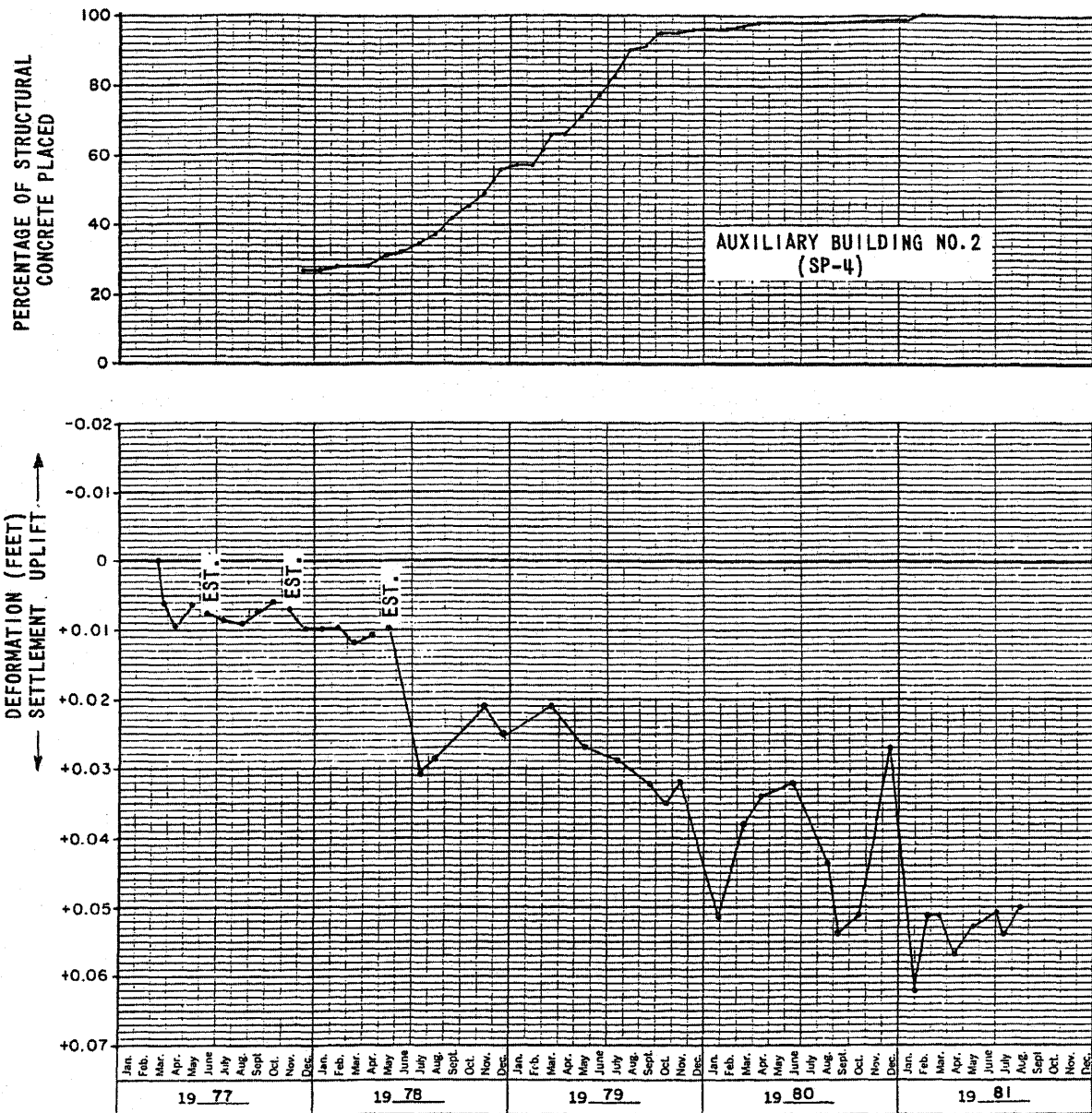
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

Settlement Observation Data

Figure 2.5-205 (Sheet 3 of 6)



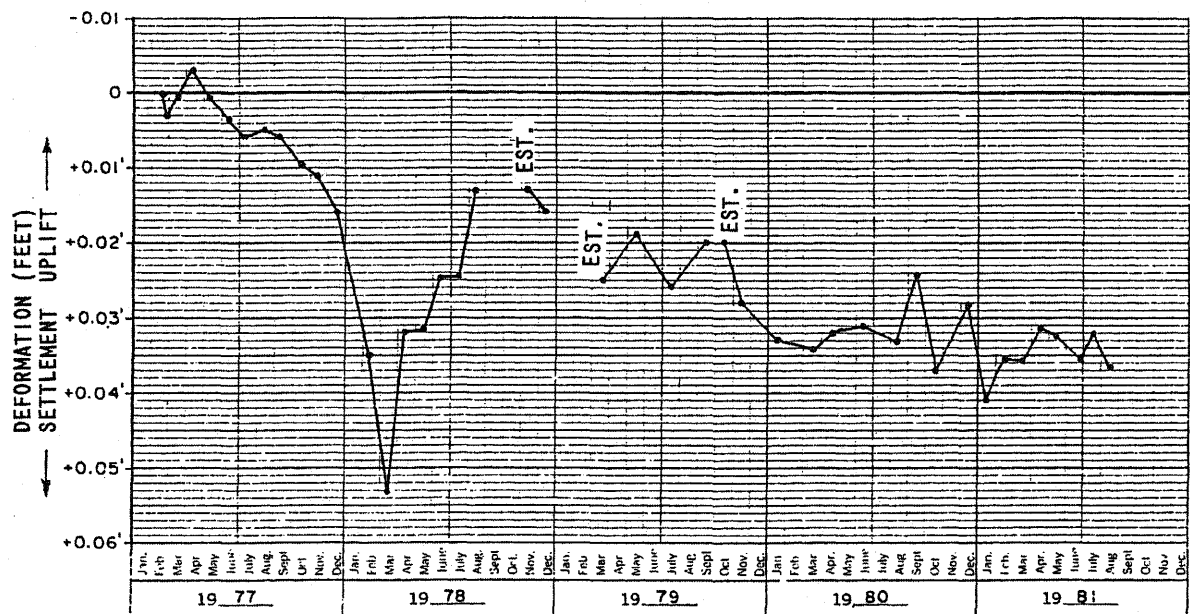
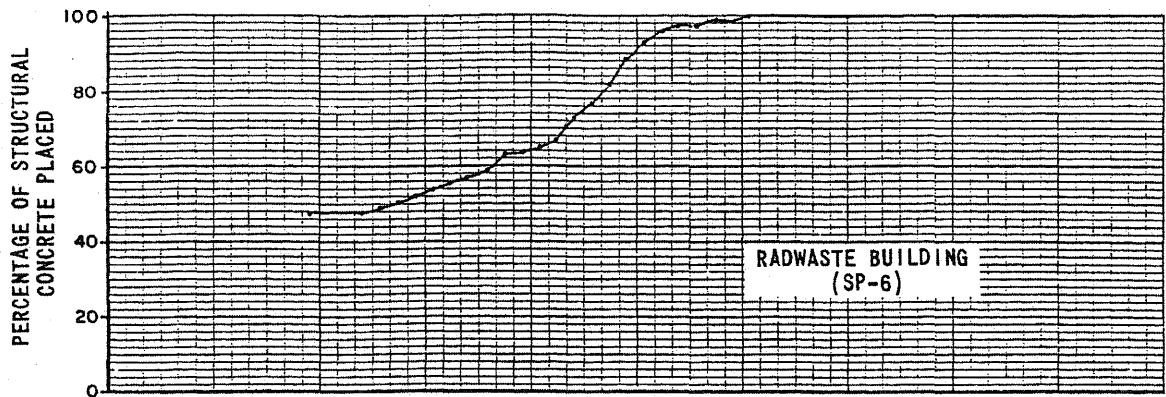
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Settlement Observation Data

Figure 2.5-205 (Sheet 4 of 6)



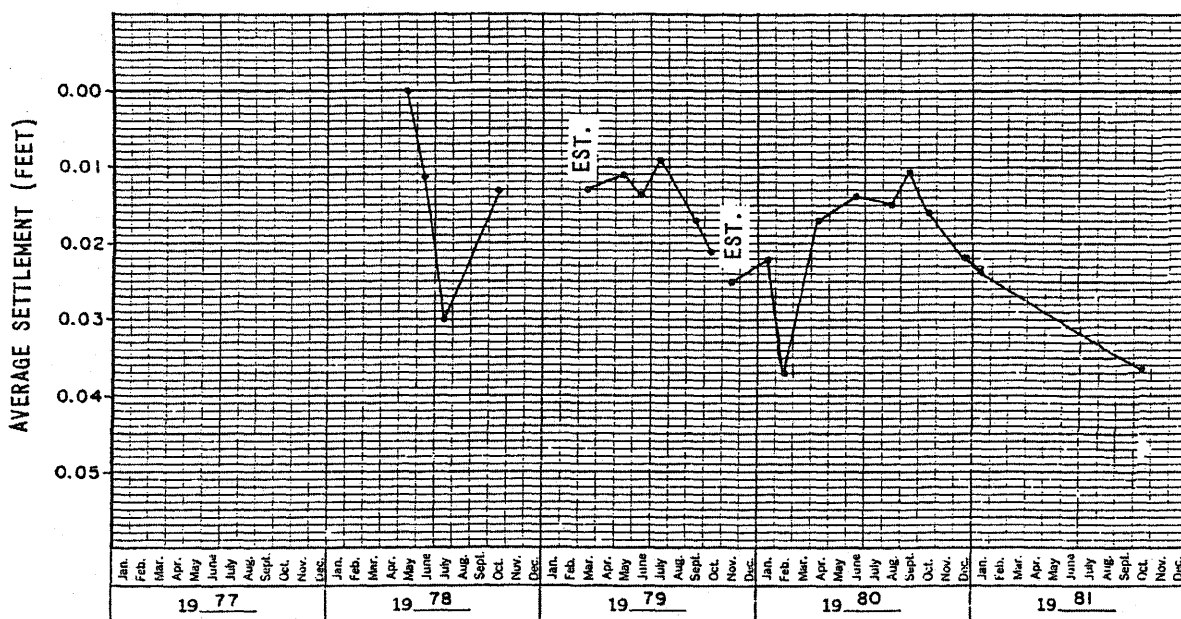
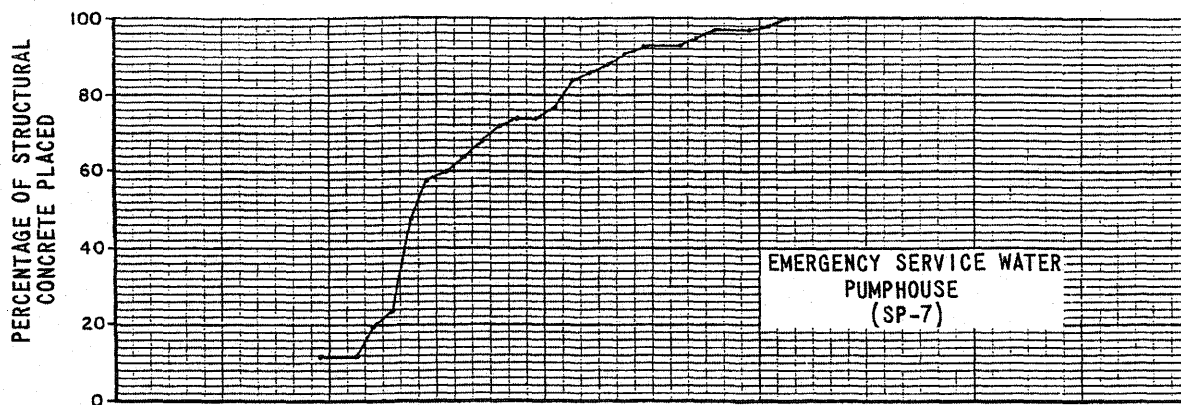
(Rev. 12 1/03)



# PERRY NUCLEAR POWER PLANT

Settlement Observation Data

Figure 2.5-205 (Sheet 5 of 6)



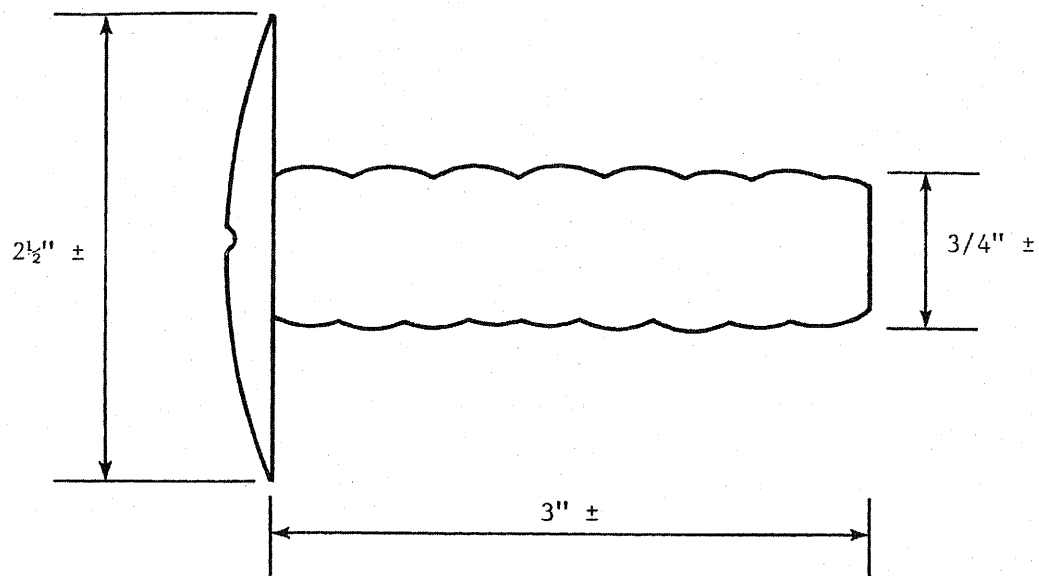
(Rev. 12 1/03)



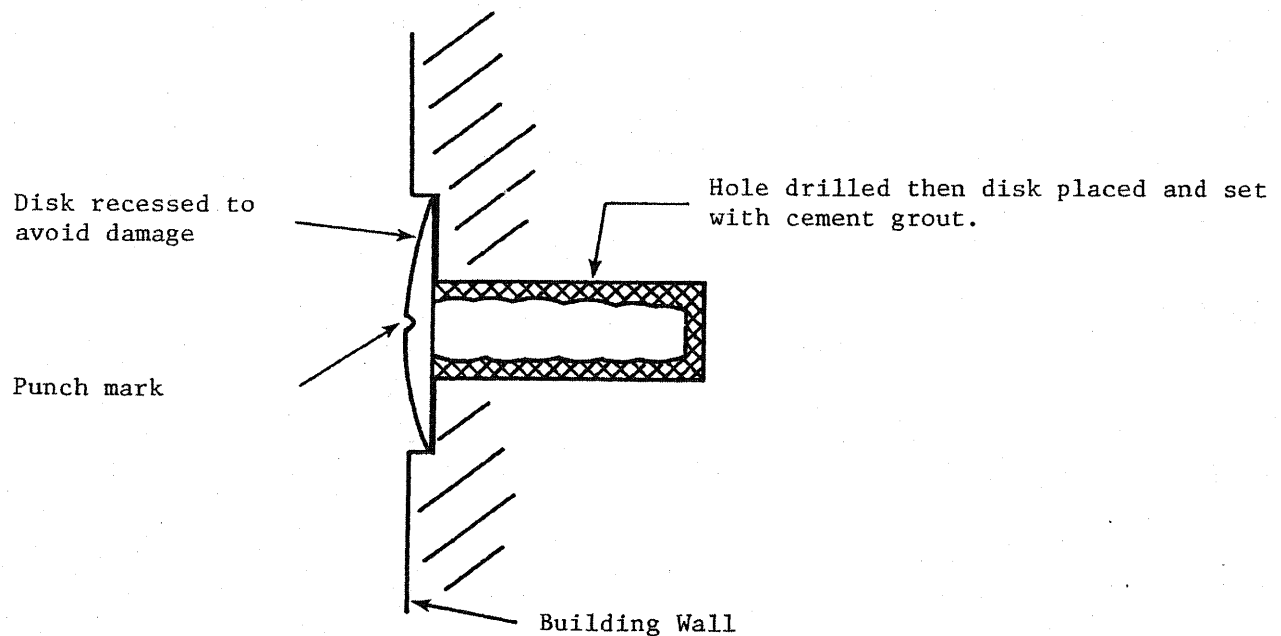
## PERRY NUCLEAR POWER PLANT

Settlement Observation Data

Figure 2.5-205 (Sheet 6 of 6)



BRASS DISK DIMENSIONS



TYPICAL DISK INSTALLATION

(Rev. 12 1/03)

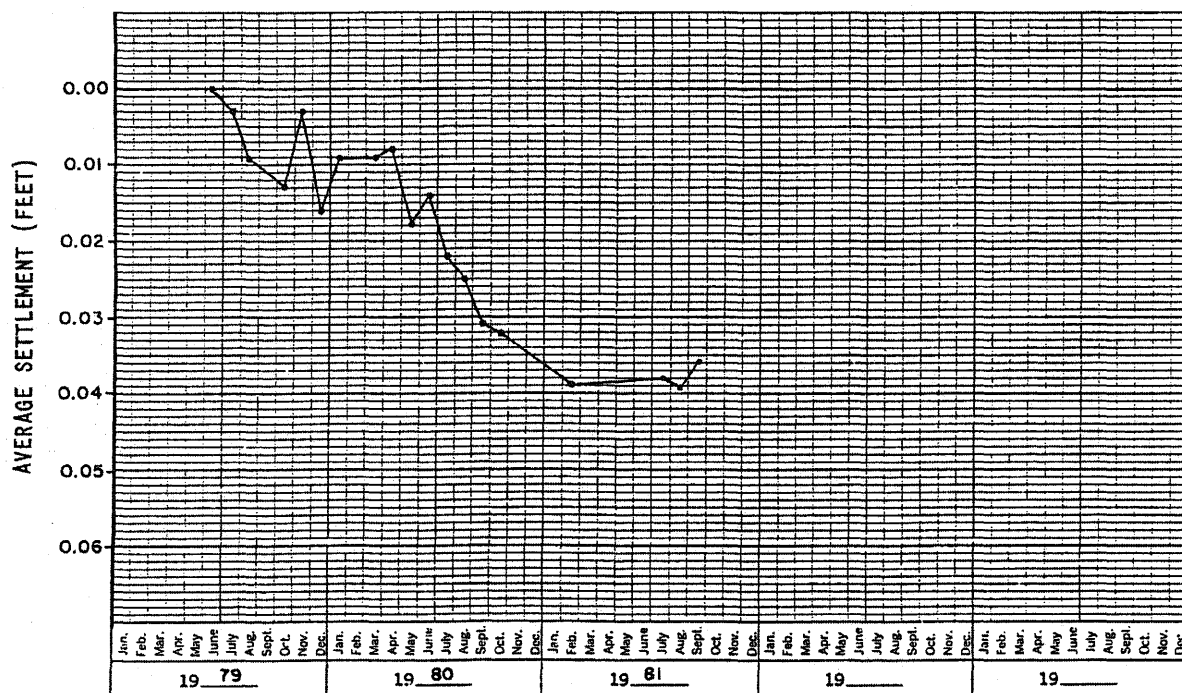
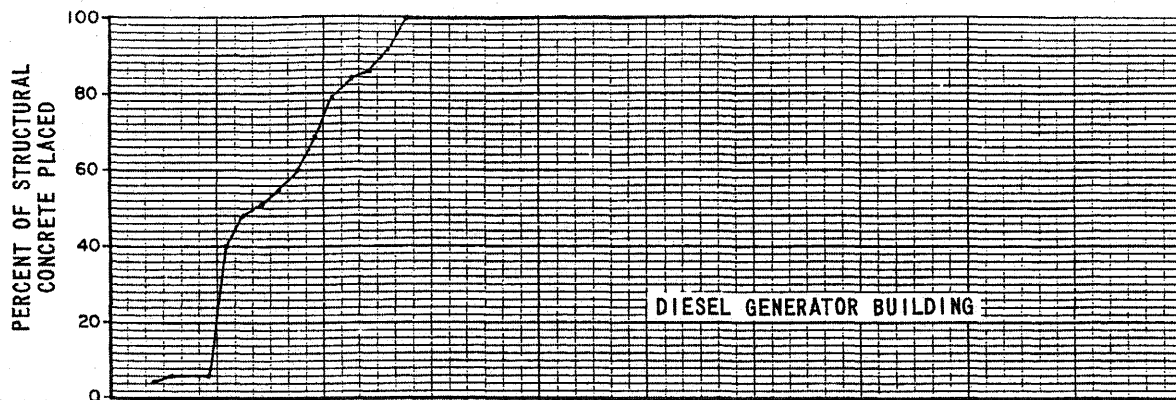


**PERRY NUCLEAR POWER PLANT**

Building Settlement  
Monitoring Disks

Figure 2.5-206





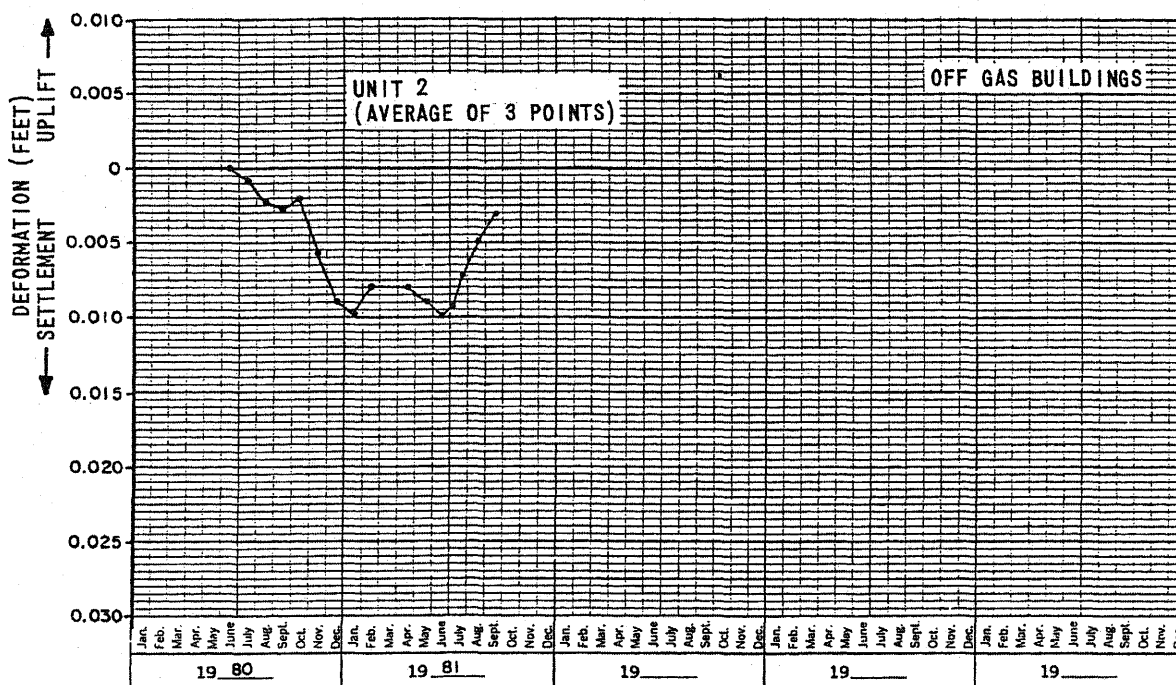
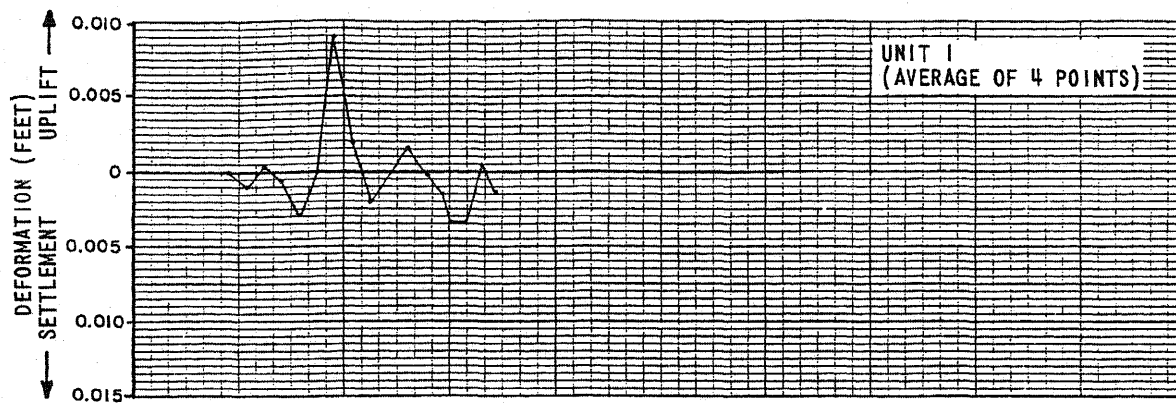
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**


Settlement Observation Data

Figure 2.5-207

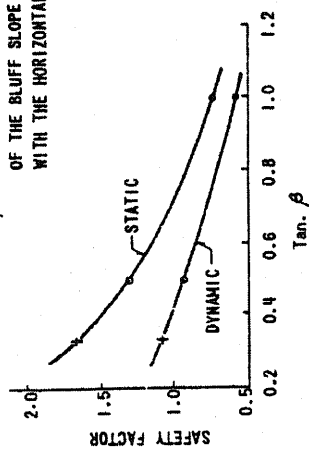


NOTE: STRUCTURAL CONCRETE PLACEMENT  
COMPLETED PRIOR TO SETTLEMENT  
MONITORING.

(Rev. 12 1/03)

	<b>PERRY NUCLEAR POWER PLANT</b>
	<p>Settlement Observation Data</p> <p>Figure 2.5-208</p>

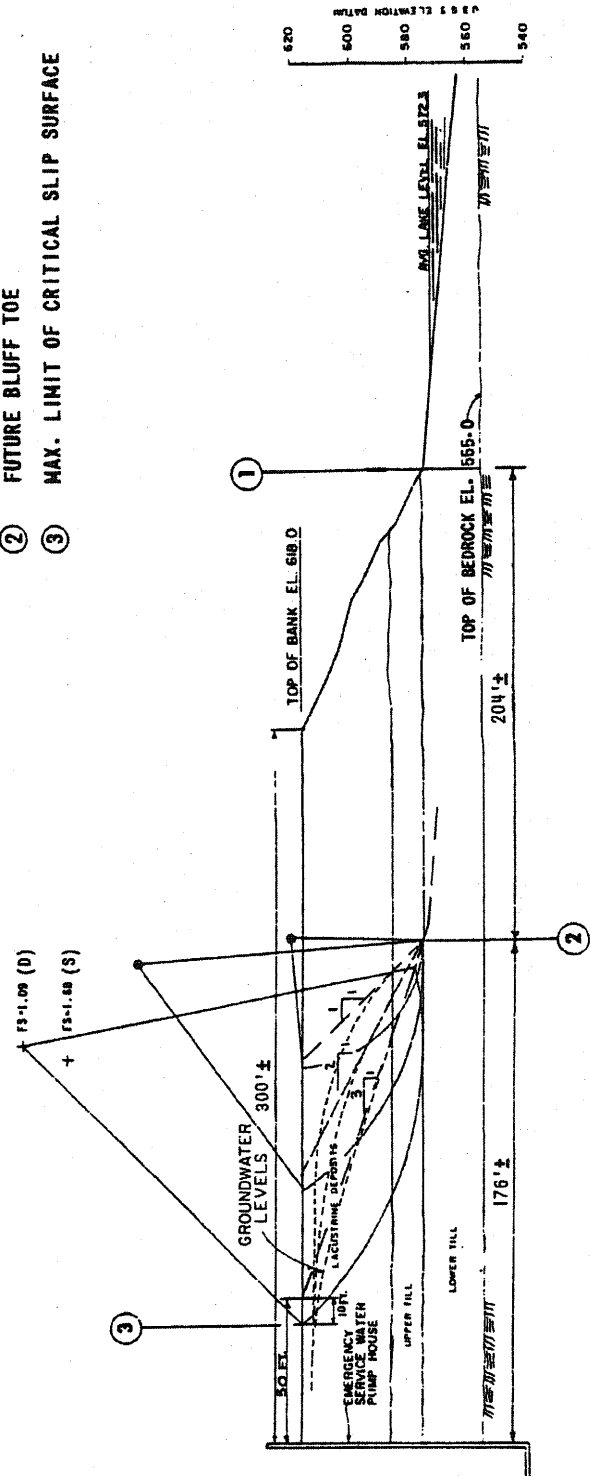
NOTE:  $\beta$  = ANGLE OF INCLINATION  
OF THE BLUFF SLOPE  
WITH THE HORIZONTAL



SYMBOL	AVERAGE SLOPE	FACTOR OF SAFETY		MAX. ②-③ DISTANCE (Ft.)
		STATIC	DYNAMIC*	
●	1:1	0.73	0.56	46
○	2:1	1.32	0.94	86
+	3:1	1.68	1.09	136

\*  $k_s = 0.15$

- ① EXISTING TOE OF BLUFF SLOPE
- ② FUTURE BLUFF TOE
- ③ MAX. LIMIT OF CRITICAL SLIP SURFACE



(Rev. 12 1/03)



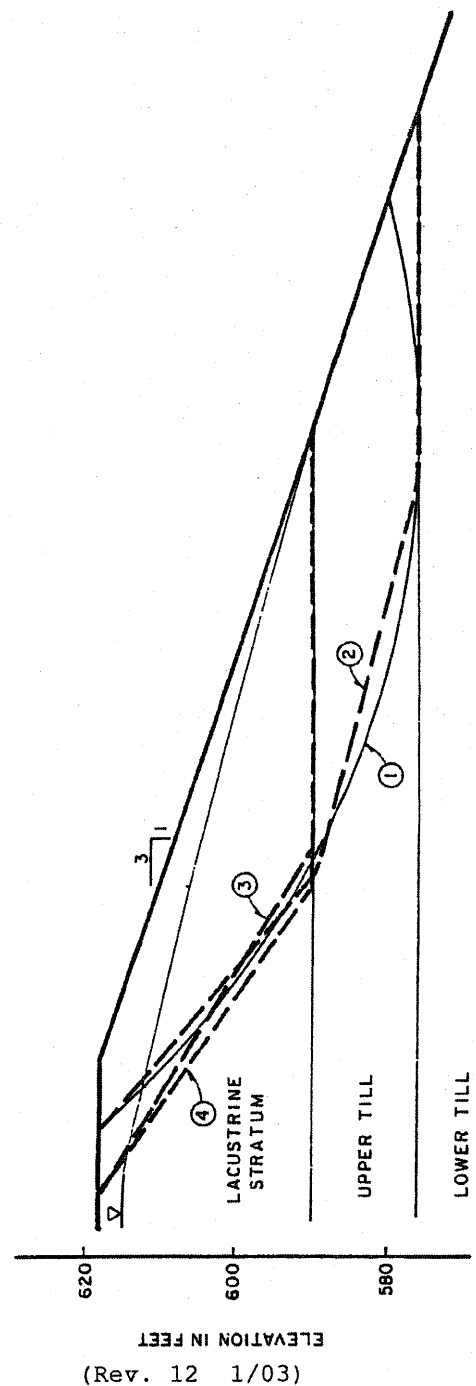
PERRY NUCLEAR POWER PLANT

Bluff Stability Analysis

Figure 2.5-209

FAILURE SURFACE NO.	METHOD	SEISMIC COEFFICIENT	FACTOR OF SAFETY
①	B	0.00	1.68
①	B	0.15q	1.09
②	M-P	0.00	1.69
②	M-P	0.15q	1.18
③	M-P	0.00	2.16
④	M-P	0.15q	1.45

NOTE: B = BISHOP METHOD  
M-P = MORGENSTERN - PRICE METHOD



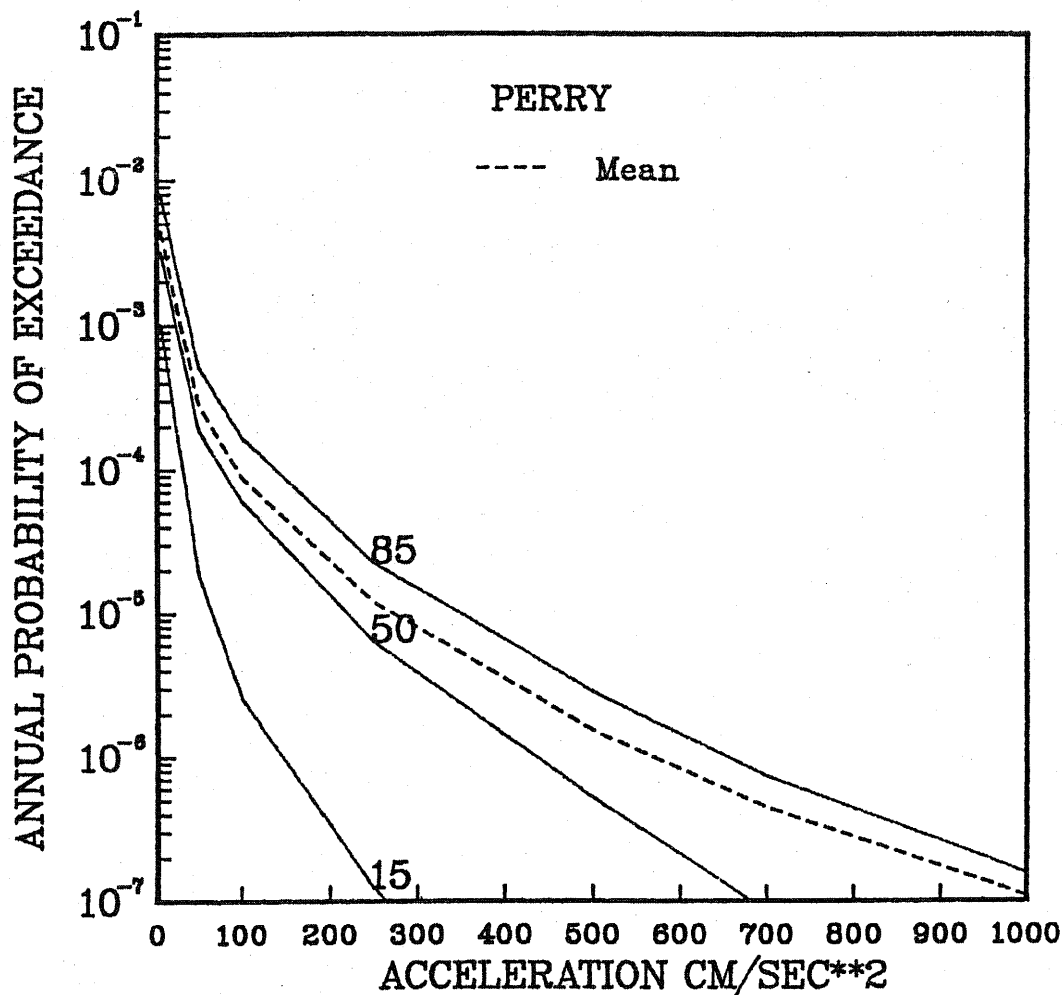
(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Stability Analysis of  
Lake Erie Bluff

Figure 2.5-210



15th, 50th, 85th fractiles and mean annual probability of exceedance of peak ground acceleration from EPRI Report RP 101-53 <sup>(308)</sup>

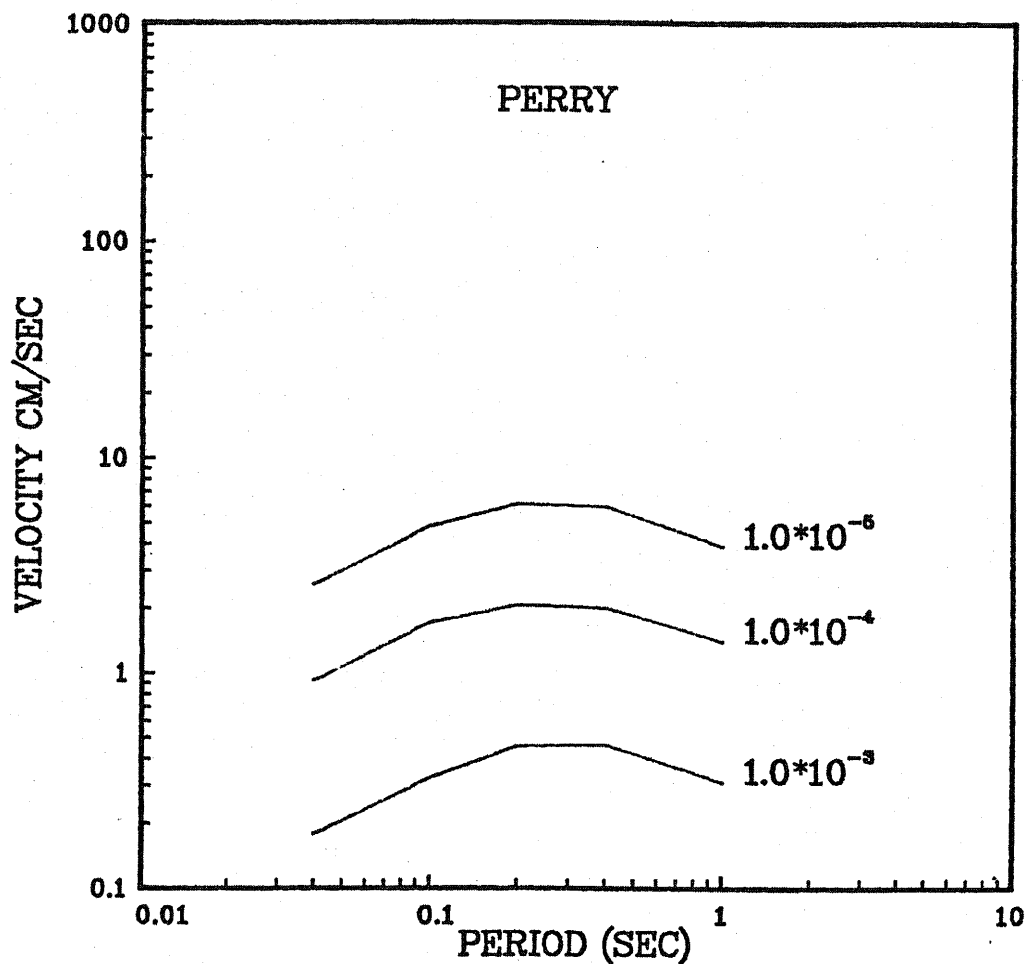
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

EPRI Seismic Hazard  
Calculations Results  
for PNPP

Figure 2.5-211



Median uniform hazard spectra at the  
 $1.0\text{E-}3$ ,  $1.0\text{E}4$  and  $1.0\text{E}5$  annual probability  
of exceedance from EPRI Report RP 101-53<sup>(308)</sup>

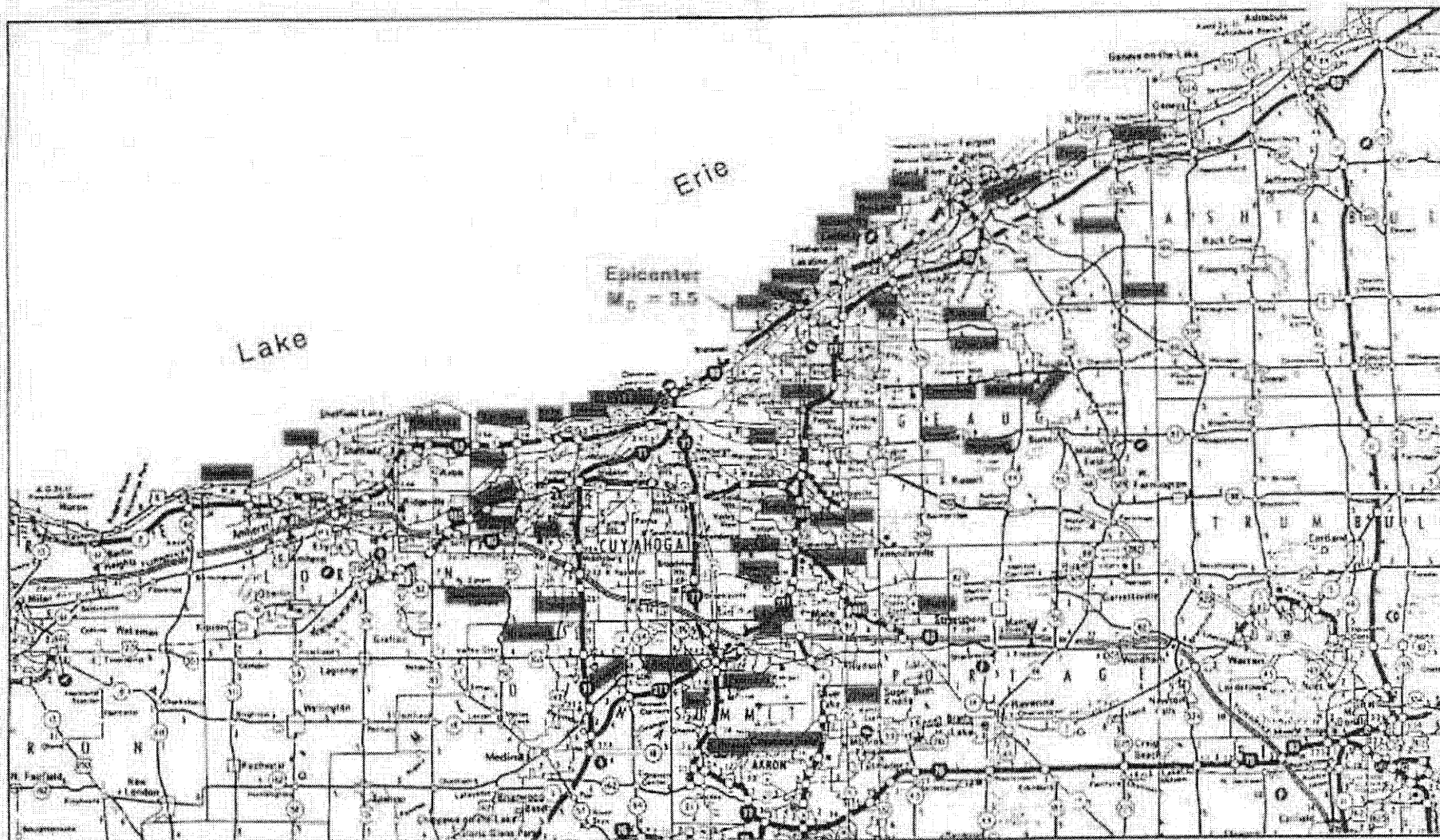
(Rev. 12 1/03)



**PERRY NUCLEAR POWER PLANT**

EPRI Seismic Hazard  
Calculations Results  
for PNPP

Figure 2.5-212



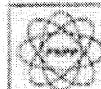
Base map: Official Transportation Map, Ohio Department of Transportation, 1987.



■ Felt report location  
(per police/sheriff, newspapers or  
phone calls to area residents)

Note: Epicentral symbol equivalent  
to uncertainty.

(Rev. 12 1/03)

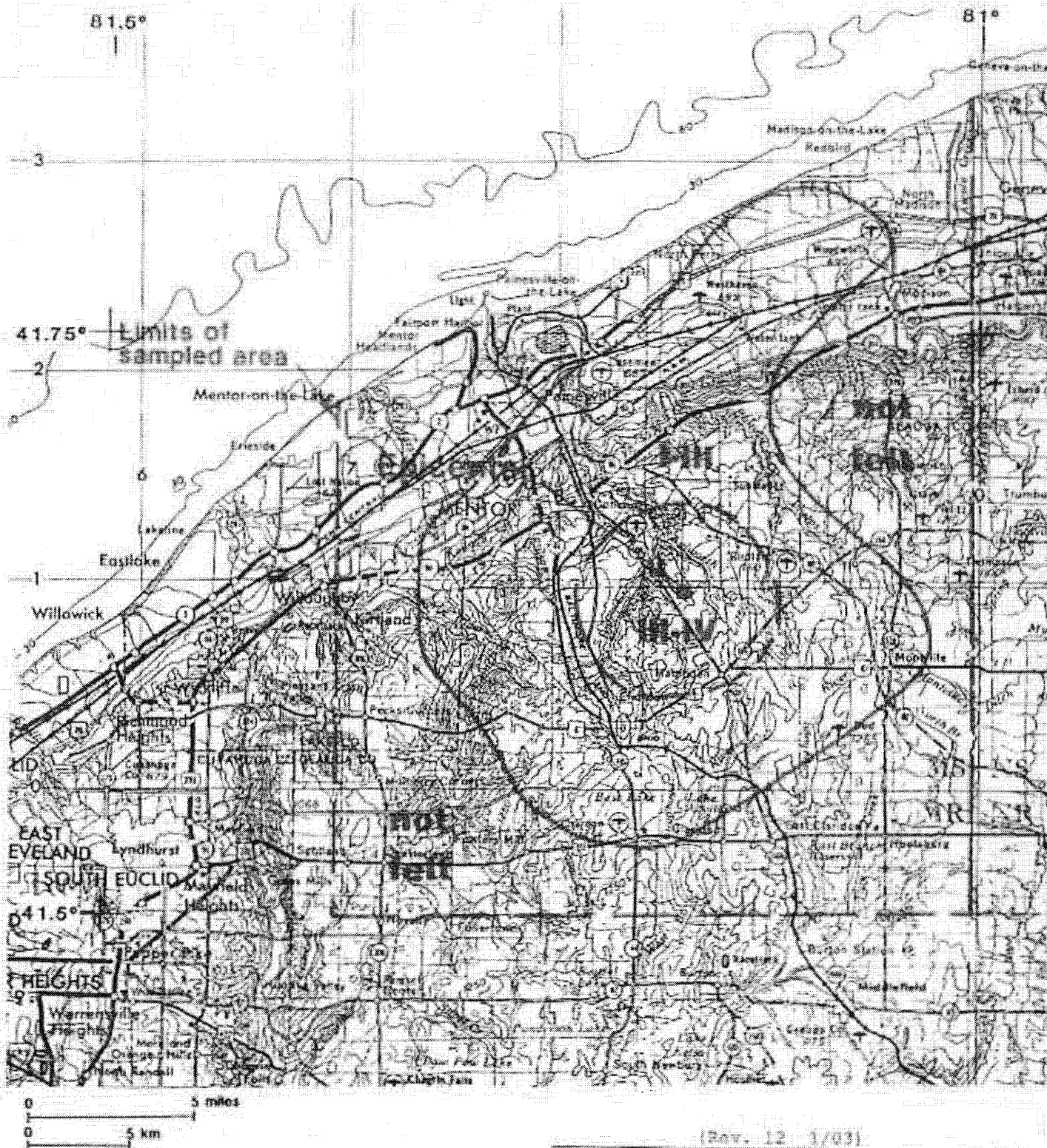


**PERRY NUCLEAR POWER PLANT**

Distribution of Felt Reports  
1/26/1991 Earthquake

Figure 2.5-213





(Rev. 12 1/03)

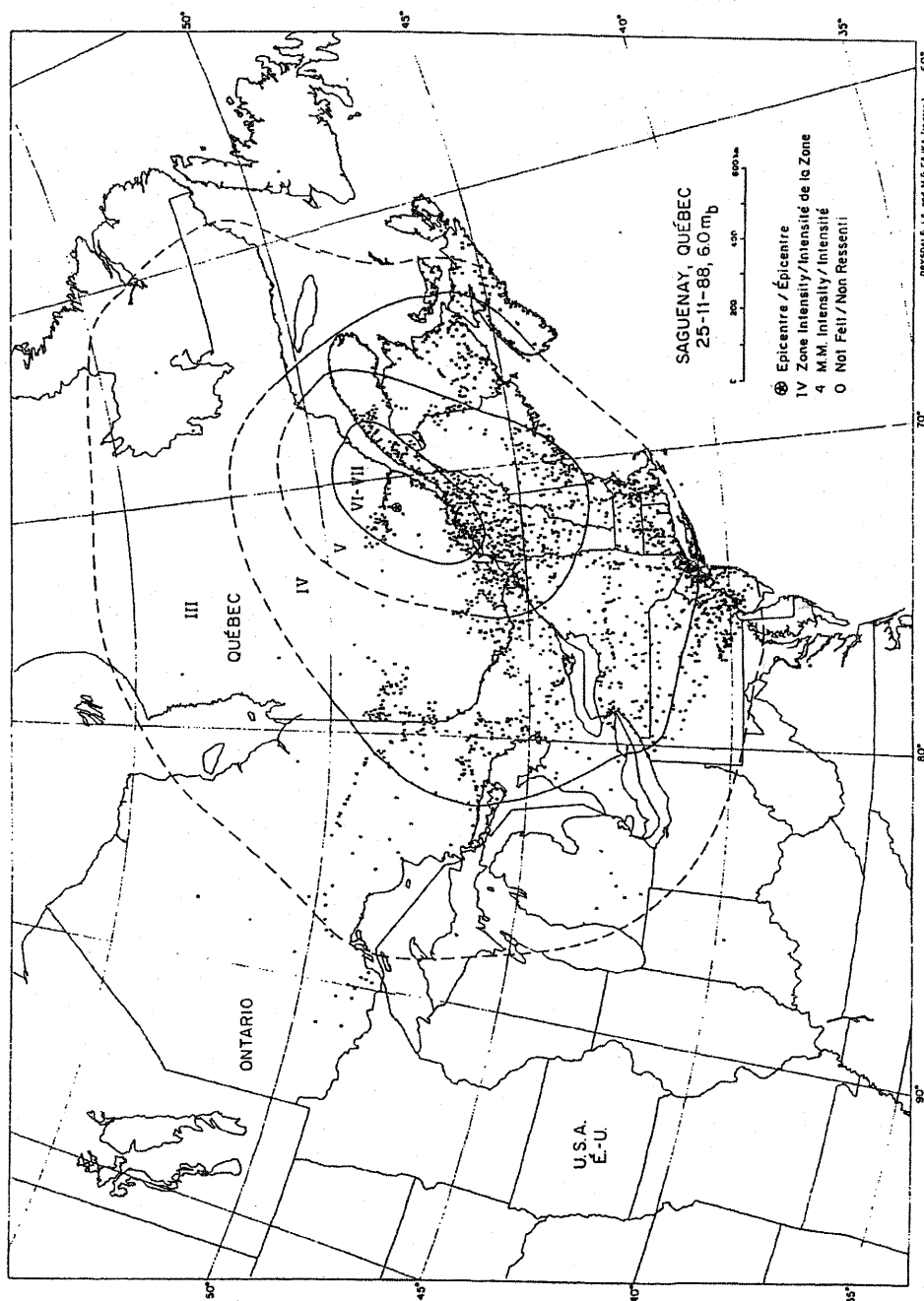


## PERRY NUCLEAR POWER PLANT

Total Felt Area of  
Dec. 28, 1989 (23:29 UT)  
Microearthquake  $M_c=2.5$

Figure 2.6-214





(Rev. 12 1/03)



## PERRY NUCLEAR POWER PLANT

Isoseismal Map  
Saguenay Earthquake  
November 25, 1988

Figure 2.5-215