LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection
Section 481077, Estelline, Texas

Prepared by

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Prepared for

Federal Highway Administration
LTPP Division, HNR-40
Turner-Fairbanks Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101

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16. Abstract

This report contains a description of the instrumentation installation activities and initial data collection for test section 481077, which is a part of the LTPP Core Seasonal Monitoring Program. This asphalt concrete surfaced pavement test section, which is located on US-287 in the southbound lanes, approximately 0.5 km south of the Estelline city limits, was instrumented on October 25-26, 1993. The instrumentation installed included time domain reflectometry probes for moisture content, electrical resistivity probes for frost location, thermistor probes for temperature, tipping-bucket rain gauge, observation well to monitor the ground water table, and an on-site data logger. Initial data collection was performed on October 25, 1993, which consisted of deflection measurements with a Falling Weight Deflectometer (FWD), elevation measurements, temperature measurements, TDR measurements, and electrical resistance and resistivity measurements. The report contains a description of the test site and its location, the instruments installed at the site and their locations, characteristics of the installed instruments and probes, problems encountered during installation, specific site circumstances and deviations from the standard guidelines, and a summary of the initial data collection.

17. Key Words	18. Distribution Statement
Pavement, Highway, Instrumentation, Monitoring, Time Domain Reflectometry, Thermistor, Electrical, Resistance, Electrical Resistivity, Observation Well, Test Equipment, Field Tests.	

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SEASONAL INSTRUMENTATION STUDY
INSTRUMENTATION INSTALLATION
TEXAS SECTION 481077/48SA

I. Introduction

The seasonal instrumentation installation of Section 481077 was performed on October 25-26, 1993, and was the first one completed in the Southern Region.

The GPS-1 test section resides in Seasonal Cell 1 and is located in a dry-no freeze zone. The site (see Figure A-1) is in the southbound lanes on US-287, approximately 0.5 km south of the Estelline, Texas city limits. The divided highway consists of two 3.7 m wide travel lanes in each direction. The outside shoulder is 3.0 m wide.

The average maximum daily temperature for the months of June through August is 34°C and the average minimum daily temperature for the months of December through February is -3°C. The average annual precipitation is 579 mm.

The pavement is a flexible structure consisting of approximately 147 mm of asphalt concrete over 254 mm of granular aggregate base. The subgrade is classified as a sandy silt. The typical soil profile under the pavement is illustrated in Figure A-2. This information was obtained from bore holes drilled during the GPS material sampling and testing. The dry densities of the unbound layers are given in Table 1.

Table 1. Layer Thicknesses and Dry Densities of the Unbound Layers

Material	Layer Thickness (mm)	In Situ Dry Density (kg/m^3)
Asphalt Concrete	147	---
Base	254	2139
Subgrade	---	1721

The annual average daily traffic (AADT) in the GPS lane is almost 2700, of which 25% is truck traffic. The estimated annual ESALs on the GPS lane were 184,131. This information is based on traffic data collected on site.

Installation of the instrumentation was completed through the cooperative efforts of the Texas Department of Transportation (TX-DOT), Federal Highway Administration (FHWA) Southern Region Coordination Office (SRCO) staff from Brent Rauhut Engineering Inc. (BRE), and FHWA staff from the Long Term Pavement Performance (LTPP) Division. The following is a list of the personnel who participated in the installation:

Larry Peirce	SRCO, Brent Rauhut Engineering
Jon Peacock	SRCO, Brent Rauhut Engineering
Steve Davis	SRCO, Brent Rauhut Engineering
Henry Usher	SRCO, Brent Rauhut Engineering
Richard Zamora	Federal Highway Administration
Aramis Lopez	Federal Highway Administration, LTPP Division
Gary Elkins	WRCO, Nichols Consulting Engineers
Jeff Jackson	Texas Department of Transportation

II. Instrumentation Installation

Pre-Installation Activities

A pre-installation meeting was held at the BRE offices on October 18, 1993. The meeting agenda appears in Appendix B. The Texas Department of Transportation elected to contract out both traffic control services and drilling and augering services to private firms for all seven sites in the state. Therefore, the participants at the meeting were personnel from the Southern Region Coordination Office, the Texas Department of Transportation, Campbell Industries (traffic control services) and Jones & Neuse, Inc. (drilling and augering services). No support was required from the Districts where the seasonal sites reside. At the planning meeting, roles and responsibilities for all the various tasks to be performed during installation were assigned. A slide presentation was given, highlighting the order of operations for the installations in Delta, Colorado and Grand Rapids, Minnesota.

A site inspection and a manual distress survey were performed on May 20, 1993 by Jerry Daleiden (SRCO). Deflection testing was conducted on September 8, 1993, and on October 25, 1993. The 5+00 end of the test section was selected for instrumentation, based on the amount of distress present and uniformity of the deflection profile. Both the deflection plots and distress survey data can be found in Appendix A.

Equipment Installed

The equipment installed at the test site included instrumentation for measuring air and subsurface temperature, rainfall, subsurface moisture contents and frost depth. An equipment cabinet was installed to house the cable leads from the instrumentation, the data logger and the battery pack. In addition, an observation well was set to measure the depth to the water table. A benchmark was also set by the Texas Department of Transportation. A list of the equipment installed, with the respective serial numbers, is in Table 2.

Table 2. Equipment Installed

Equipment	Quantity	Serial №.
Instrument Hole		
MRC Thermistor Probe	1	181 (48AT)
TDR Sensors	10	48A01-48A10
CRREL Resistivity Probe	1	48AR
Equipment Cabinet		
CR10 Data Logger	1	16547
Battery Package	1	5653
Weather Station		
Tipping-Bucket Rain Gauge	1	12087-693
Air Temperature Probe	1	421316
Observation Well	1	None

Equipment Check/Calibration

Prior to installation, all instrumentation was checked or calibrated. The CR10 Data Logger was wired according to the Guidelines and the air temperature probe and thermistor probe were connected and monitored over a period of several hours to ensure that the sensors were working. The tipping-bucket was also connected to the data logger and the calibration was checked according to the method recommended by the manufacturer. These tests indicated that the air temperature probe and thermistor probe were working properly and that the tipping-bucket measurement was within the manufacturer's specifications.

In addition to the above tests, the distances between sensors in the thermistor and resistivity probes were measured and are presented in Tables 3 and 4. The resistivity probe was also checked for continuity and resistivity in water.

Table 3. Sensor Spacing in MRC Thermistor Probe

Unit	Channel №.	Distance from Top of Unit (mm)	Remarks
1	1	Not Measured	This unit was installed in the AC layer.
	2	Not Measured	
	3	Not Measured	
2	4	19	This unit was installed in the base and subgrade.
	5	94	
	6	171	
	7	247	
	8	323	
	9	475	
	10	627	
	11	778	
	12	933	
	13	1085	
	14	1237	
	15	1390	
	16	1541	
	17	1695	
	18	1844	

Table 4. Electrode Spacing on CRREL Resistivity Probe

Electrode №.	Distance from Top of Probe (mm)
1	30
2	80
3	131
4	180
5	232
6	282
7	332
8	384
9	434
10	485
11	536
12	585
13	637
14	688
15	739
16	789
17	840
18	891
19	942
20	992
21	1044
22	1093
23	1144
24	1195
25	1246
26	1297
27	1348
28	1398
29	1449
30	1499
31	1551
21	1600
33	1651
34	1704
35	1753
36	1804

Location of Instrumentation

The instrumentation was installed at Station 5+21 of the test section. Approximately 914 mm from the lane edge, in the outside wheel path, a 457 mm square was removed from the pavement and a 254 mm diameter hole, 2.05 m deep, was drilled to install the thermistor probe, resistivity probe and TDR sensors. Cables from the instrumentation were placed in a 51 mm diameter flexible conduit and buried in a 102 mm wide trench leading to the equipment cabinet located approximately 7.6 m from the lane edge.

The observation well was installed at Station 3+98 of the test section approximately 3.7 m from the lane edge. A permanent benchmark was also set at Station 0+00 approximately 3.9 m from the lane edge.

Installation

Installation of the monitoring equipment was completed on October 25, 1993. Verification that the instrumentation was working was made the following day. The Texas Department of Transportation provided the pavement sawing, pavement repair materials and a permanent benchmark. TX-DOT elected to contract the traffic control to Campbell Industries and the augering operations to Jones and Neuse, Inc.. The observation well was also drilled by Jones and Neuse due to licensing and construction requirements mandated by the Texas Water Commission. The monitoring equipment and cabinet installation was performed by the SRCO staff.

The first day of operations included traffic control; site layout and marking; installation of the thermistor probe, resistivity probe, TDR probes, air temperature probe, and rain gauge; and wiring of the cabinet. The installation of all equipment was performed according to the procedures outlined in the "LTPP Seasonal Monitoring Program: Instrumentation and Data Collection Guidelines."

To ensure functioning of the TDR sensors during installation, the 1502B cable tester was connected to each sensor as backfilling of the instrumentation hole was performed. If a reasonable trace was displayed, it was assumed the sensor was functioning properly. The trace was printed for each TDR and the moisture content was determined using Topp's equation. The field moisture content was also measured by drying the soil on a propane stove. The TDR moisture contents, position of the TDR sensors and field moisture contents appear in Table 5. The field printed traces appear in Appendix C. Tables 6 and 7 show the distance from the top of the pavement to each individual thermistor and resistivity sensor.

When backfilling of the instrumentation hole was completed, the original asphalt concrete block was re-installed using PC-7 epoxy sealant. The overcuts from the pavement sawing operation (including the groove for the temperature probe) were also sealed with Dow-Corning 888 crack sealant.

Upon completion of the installation, the ONSITE program was downloaded to the onsite CR10 data logger and data from the air temperature probe, rain gauge and thermistor probe were collected overnight and evaluated the second day.

The second day activities included traffic control setup, evaluation of the data collected the previous night, monitoring of the TDR sensors, deflection testing and elevation surveys. The following sections describe these operations.

Table 5. Location of TDR Sensors and Measured Moisture Contents

Sensor №.	Sensor Depth (mm)	TDR Moisture Content (%, by wt)	Measured Moisture Content (%, by wt)
48A01	305	3.42	2.00
48A02	457	6.10	2.71
48A03	610	7.40	7.82
48A04	762	7.40	7.55
48A05	914	9.07	9.67
48A06	1067	8.40	9.38
48A07	1219	8.06	9.22
48A08	1372	7.40	9.52
48A09	1676	7.40	8.95
48A10	1981	6.74	8.55

Table 6. Thermistor Sensor Locations

Unit	Channel №.	Depth from Pavement Surface (mm)	Remarks
1	1	25	This unit was installed in the AC layer.
	2	69	
	3	112	
2	4	182	This unit was installed in the base and subgrade.
	5	257	
	6	334	
	7	410	
	8	486	
	9	638	
	10	790	
	11	941	
	12	1096	
	13	1248	
	14	1400	
	15	1553	
	16	1704	
	17	1858	
	18	2007	

Table 7. Location of Electrodes of the Resistivity Probe

Connector Pin Nº.	Electrode Nº.	Depth from Pavement Surface (mm)
1	1	193
20	2	243
2	3	294
21	4	343
3	5	395
22	6	445
4	7	495
23	8	547
5	9	597
24	10	648
6	11	696
25	12	748
7	13	800
26	14	851
8	15	902
27	16	952
9	17	1003
28	18	1054
10	19	1105
29	20	1155
11	21	1207
30	22	1256
12	23	1307
31	24	1358
13	25	1409
32	26	1456
14	27	1511
33	28	1561
15	29	1612
34	30	1662
16	31	1714
35	32	1764
17	33	1815
36	34	1867
18	35	1916
37	36	1967

III. Initial Data Collection

Onsite Data Logger

The air temperature, subsurface temperatures and rainfall data were collected by the onsite CR10 Data Logger. The version of the ONSITE program used reads the thermistor probe (18 sensors) every minute. The average temperatures for the first five sensors are recorded hourly and the average temperature for every sensor is saved daily. The maximum and minimum temperature for all sensors are also saved on a daily basis.

The air temperature is read every minute by the ONSITE program and the average temperature is saved both daily and hourly. The maximum and minimum temperatures are saved daily. The precipitation is recorded on both an hourly and daily basis.

Figure D-1 shows the average hourly ambient air temperatures which were collected the night of October 25, 1993. Figure D-2 shows hourly average subsurface temperatures for the first five sensors for the same data collection period. Figure D-3 shows the measured average subsurface temperatures for all 18 sensors during the initial data collection.

Resistance Measurements using Resistivity Probe

Resistance data was collected using the manual method. This method utilizes a function generator, two digital multi-meters and a manual switching board. The measured contact resistance data is plotted in Figure D-4. The measured resistance data for the 4-point resistivity is shown in Figure D-5. The raw data is also shown in Appendix D.

The system is designed to collect and store contact resistance values automatically, but at the time of installation the required multiplexor was defective and was not installed. At the time of this report, no correlations have been made between the manual and automated modes.

Moisture Content Measurement by TDR Sensors

TDR data was collected using the mobile datalogging system provided by the FHWA. The mobile system consists of a CR10 Data Logger, battery pack and two multiplexors for TDR data collection.

To begin data collection using the mobile system the TDR cable leads and 1502B cable reader were connected to the proper channels and the MOBILE program was downloaded from the notebook computer to the CR10 Data Logger. After approximately five minutes, the cable reader was triggered by the MOBILE program and the TDR traces were displayed. The data collection process was completed in approximately five minutes and was automatically repeated four hours later. The data was then uploaded to the notebook computer. Traces displayed on the cable reader indicated that the sensors were working properly. Figures D-6 through D-15 show the plots of the TDR traces obtained approximately 24 hours after installation.

Deflection Measurements

Deflection measurements were made according to the procedures outlined in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines." At this time no analysis has been performed on this data.

Elevation Surveys

The elevation of the benchmark was assumed to be 0.000 meters and surface elevations were measured following the guidelines. These elevations were measured using a Spectra-Physics Laser Plane 350 level and Lenker rod, and were converted to the SI system using soft conversion factors. The elevations are contained in Appendix D.

IV. Summary

The instrumentation installation on Section 481077 was completed on October 25, 1993 and initial data collection was completed on October 26, 1993. Instrumentation and equipment currently at the site includes time domain reflectometry probes for moisture content measurements; an electrical resistivity probe for determining depth of frost penetration; a thermistor probe for monitoring temperature gradient changes in the pavement, base and subgrade layers; a tipping-bucket rain gauge; an air temperature probe; an observation well to monitor ground water table movement; a permanent swell and frost-free benchmark; and an on-site data logger and battery pack.

At the time of this report, all of the equipment installed on-site appears to be functioning properly. As previously noted, the multiplexor needed for automated collection of resistivity data was not functioning properly, but is expected to be in working order prior to the next round of data collection.

It should be noted that the instrumentation area was milled just prior to our arrival for installation. We were not made aware of this by the District because it was out of the test section boundary. The decision was made to proceed with the installation after discussing the situation with the State LTPP Contact for the District. Photograph E-2 in Appendix E illustrates the milling that occurred.

Considering this was the first installation in the Southern Region, the operation went quite smoothly for all parties involved.

APPENDIX A

Test Section Background Information

Appendix A contains the following information:

Figure A-1. Site Location Map

Figure A-2. Profile of Test Section Layers

Figure A-3 thru Figure A-8. Plots from FWDCHECK

Figure A-9. Manual Distress Survey Data

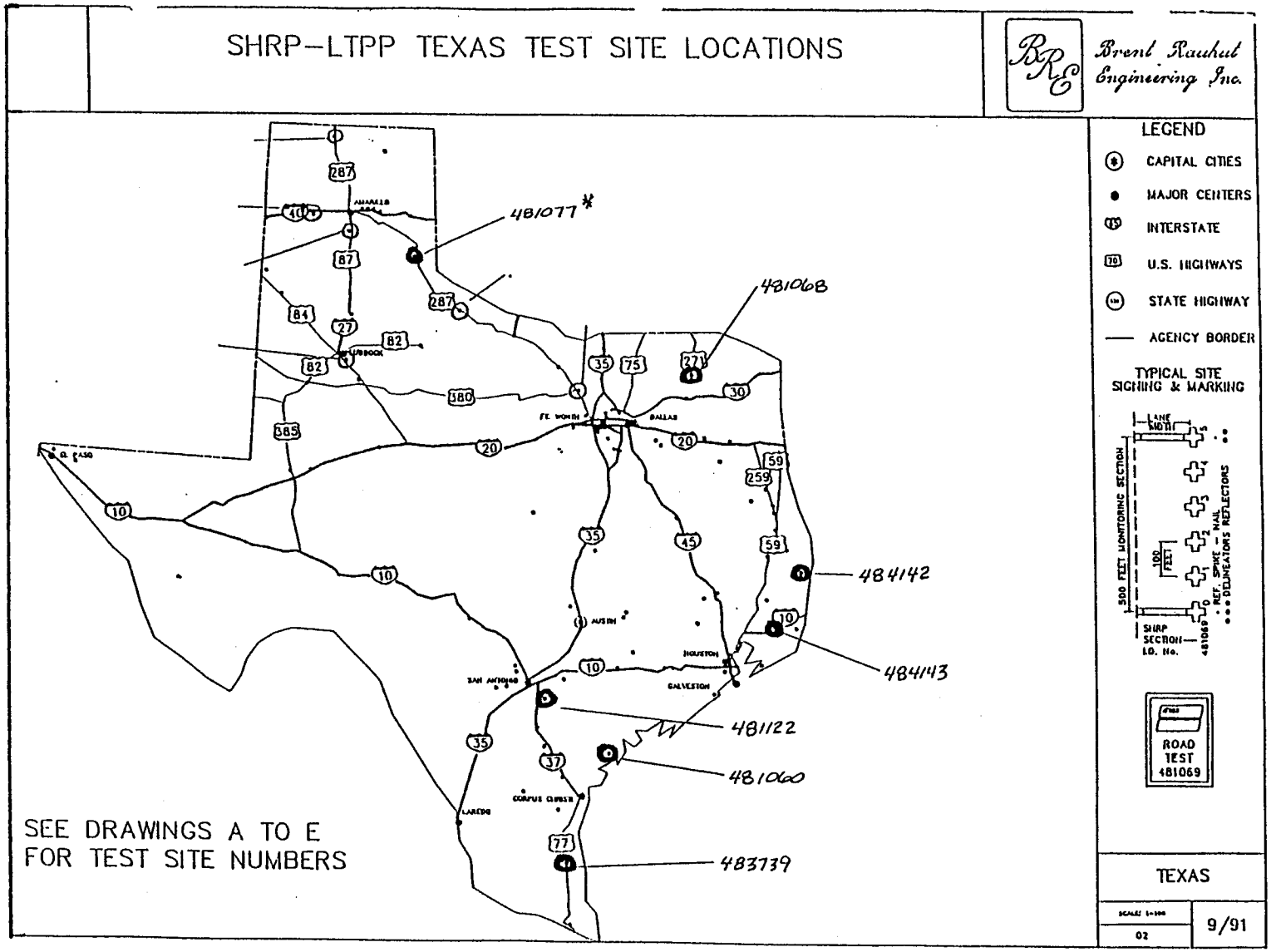


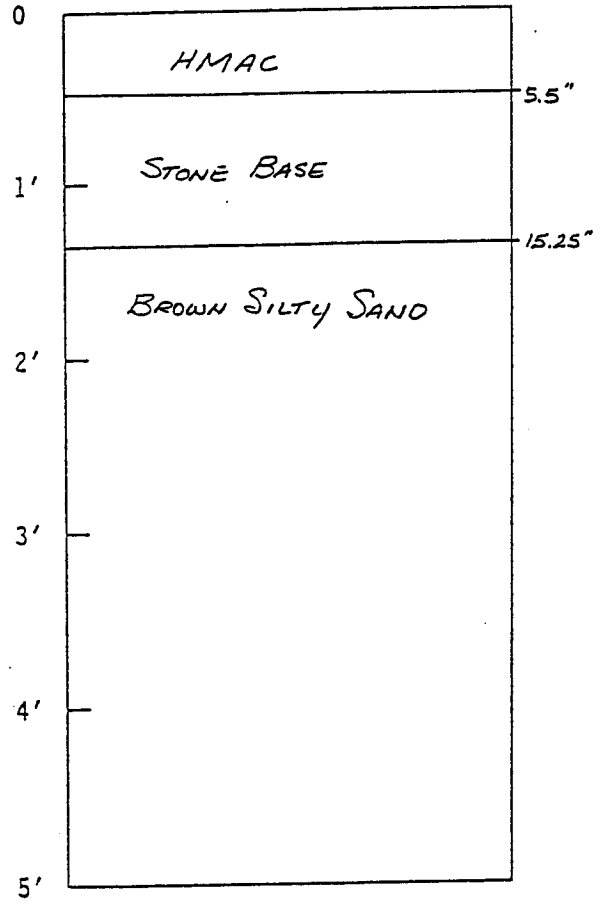
Figure A-1. Location of Test Site, GPS Test Section 481077

APPROXIMATE
SUMMARY OF FIELD LOGS
GPS TEST SECTIONS

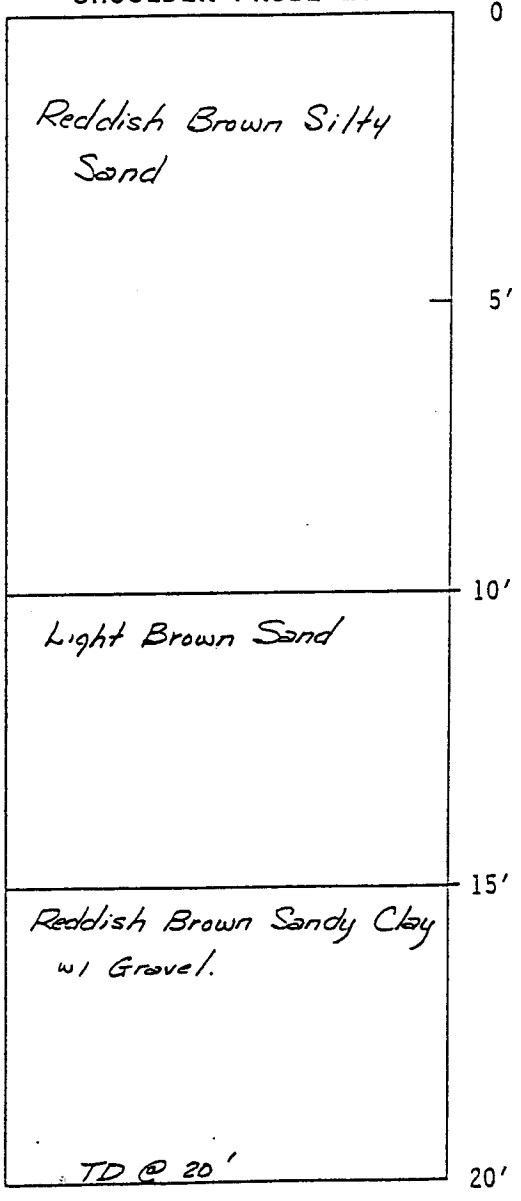
TEST SECTION I.D. NO. 481077
STATE TEXAS

EXPERIMENT NO. GPS-1
DATE SAMPLED 8-8-89

PAVEMENT LOG



SHOULDER PROBE LOG



Instuctions for Pavement Log:

1. Review logs of bore holes, cores, and test pit to establish approximate depths of layer changes.
2. Draw lines across log above to indicate approximate average layer depths and label to identify the materials.

Instructions for Shoulder Probe Log:
Same as for "Pavement Log," except depths are taken directly from field log.

Depth to Rigid Layer, >20 Ft.
(If Rigid Layer Not Encountered, Enter ">20.")

USE THIS FORM FOR ENTERING ONLY DEPTH TO RIGID LAYER INTO THE DATA BASE!

Figure A-2. Profile of Test Section Layers

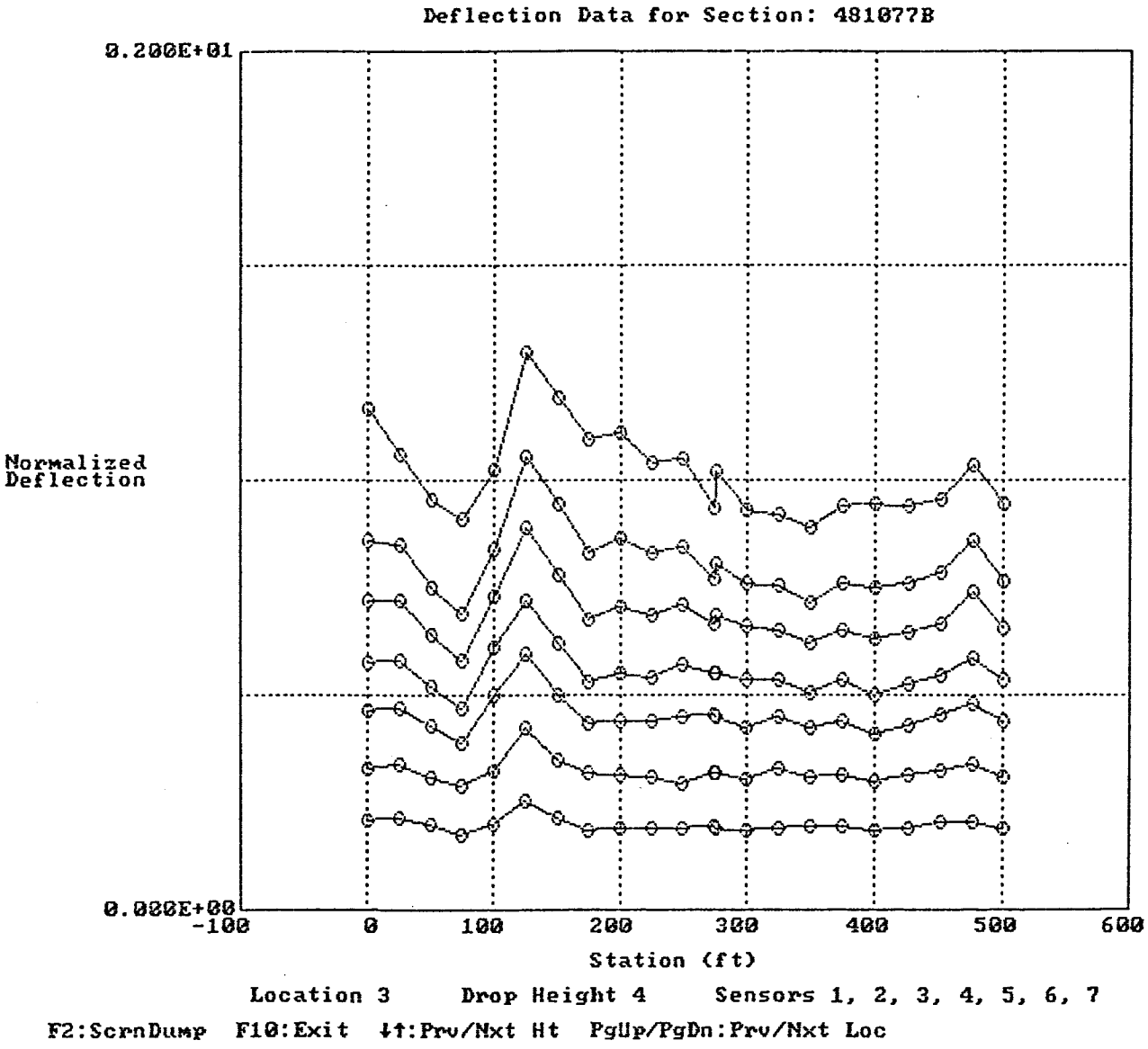


Figure A-3. Deflection Profiles from FWDCHECK

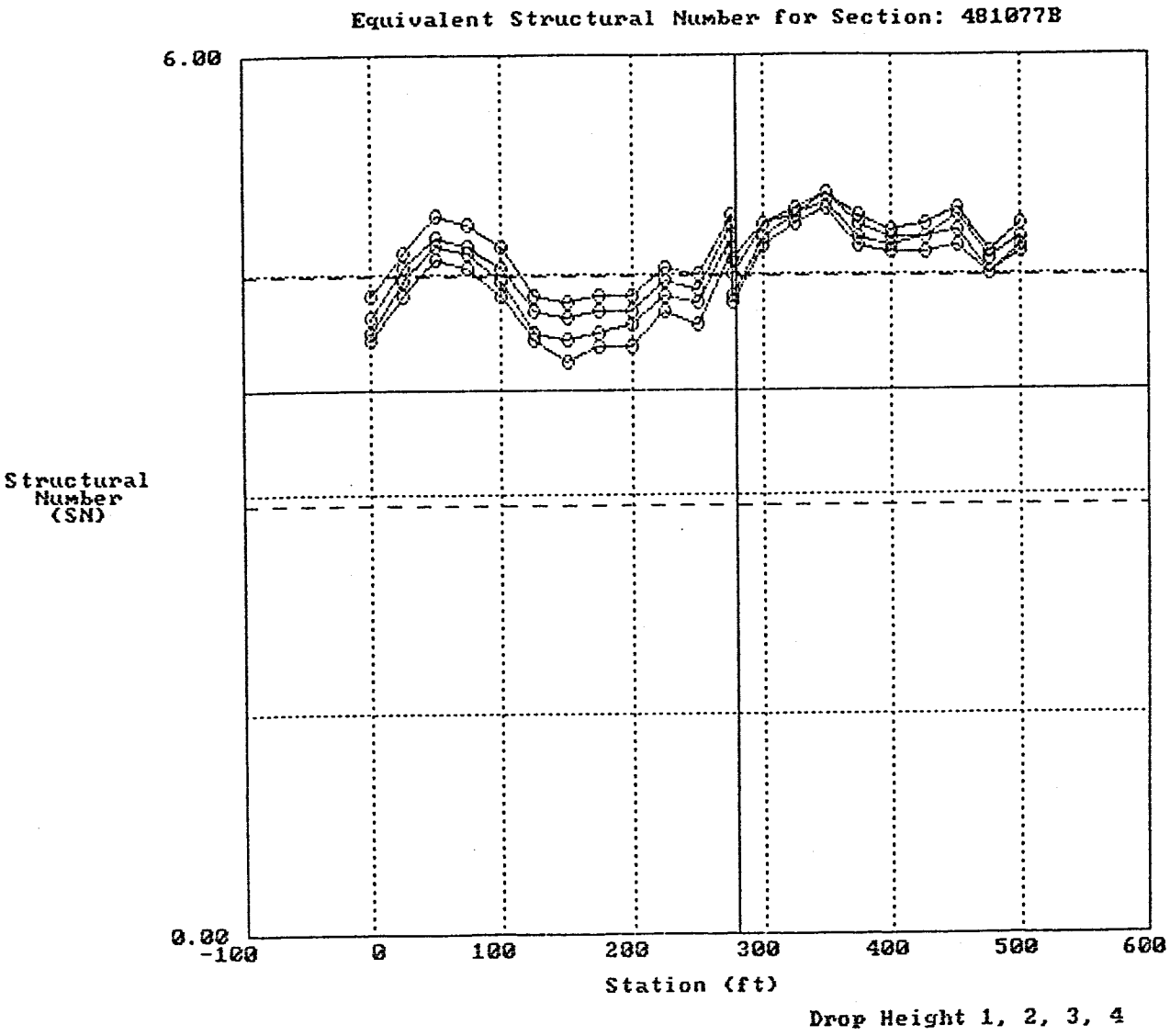


Figure A-4. Structural Number Profiles from FWDCHECK

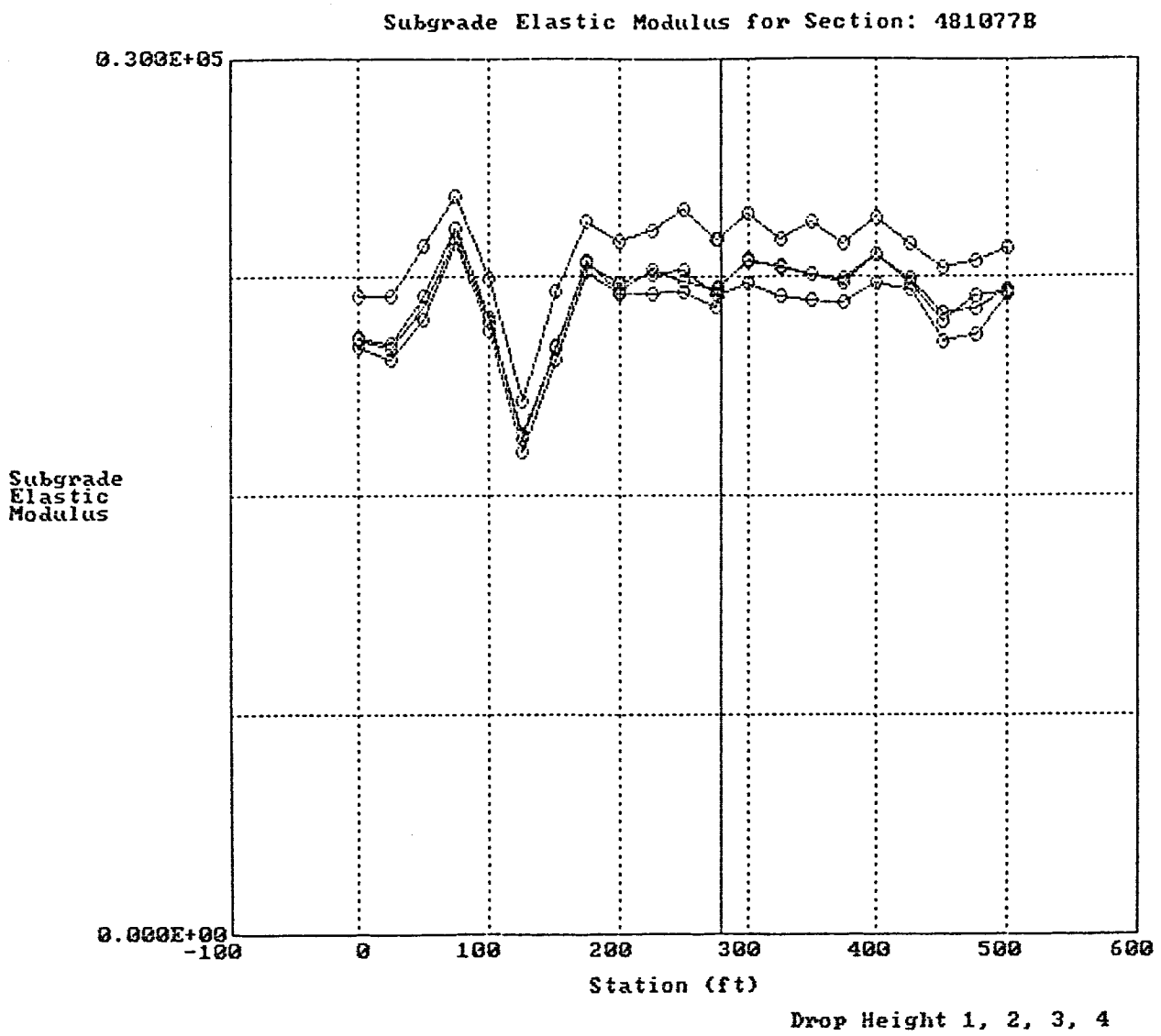


Figure A-5. Subgrade Modulus Profiles from FWDCHECK

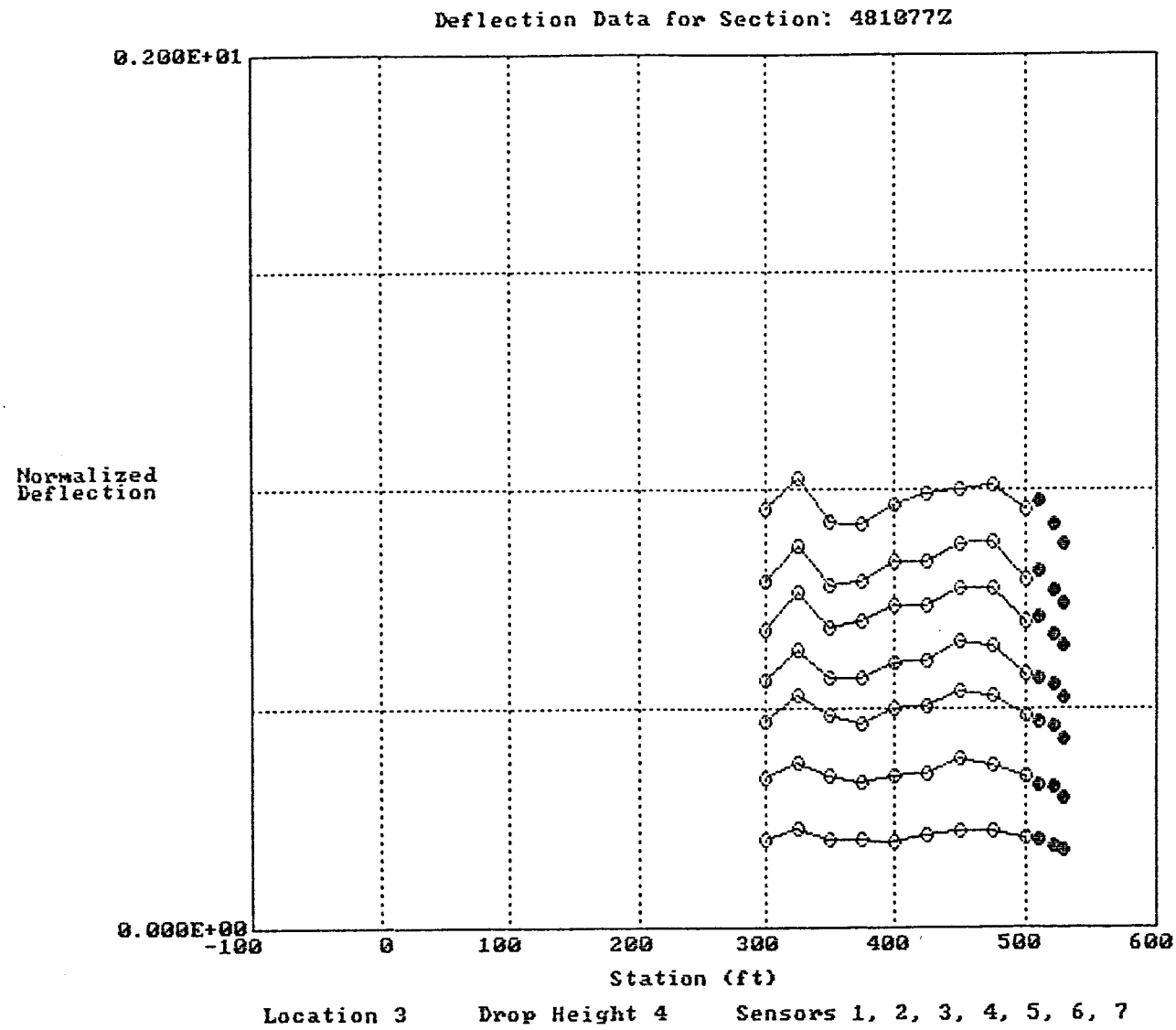


Figure A-6. Deflection Profiles from FWDCHECK on Installation Day

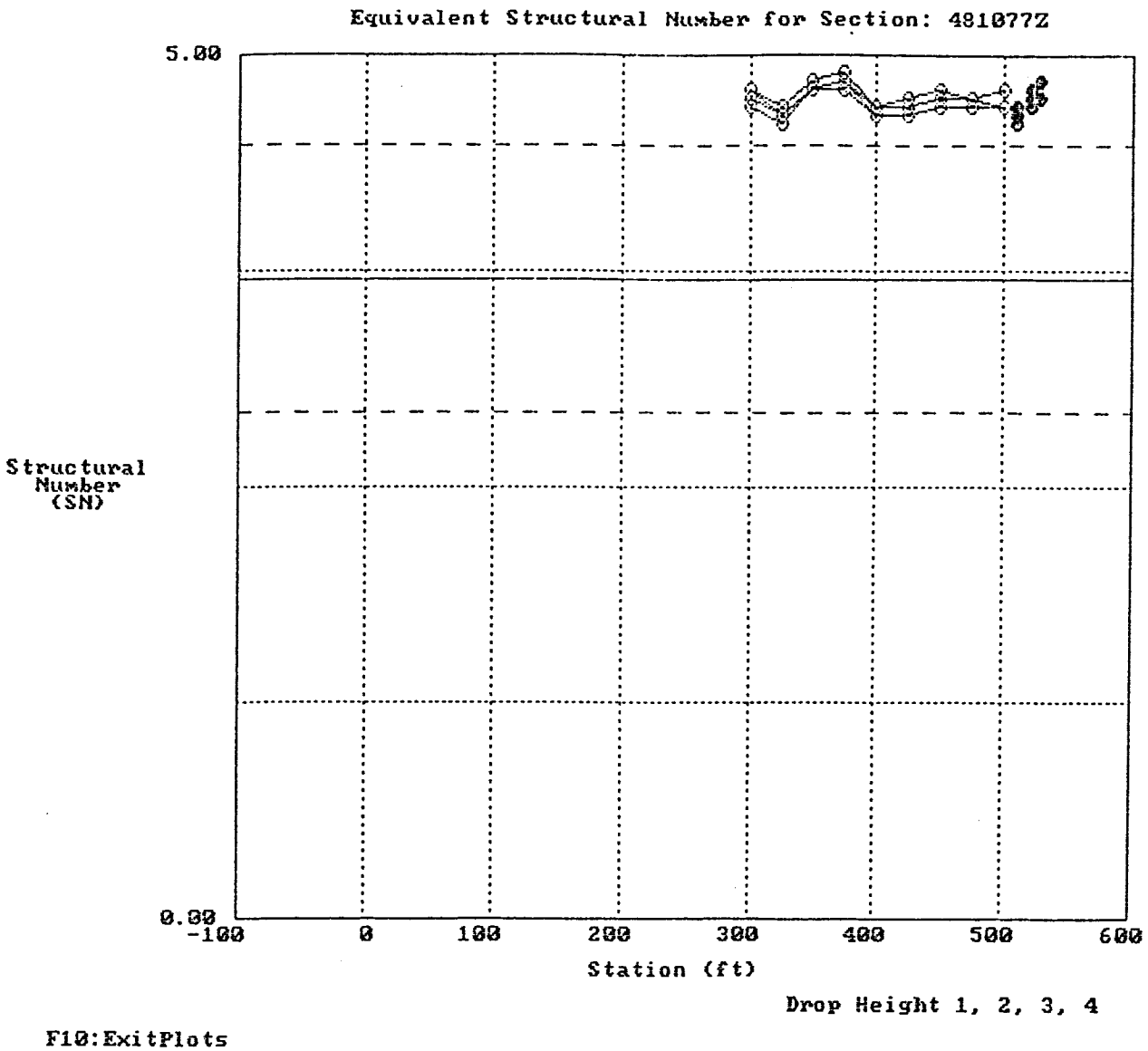


Figure A-7. Structural Number Profiles from FWDCHECK on Installation Day

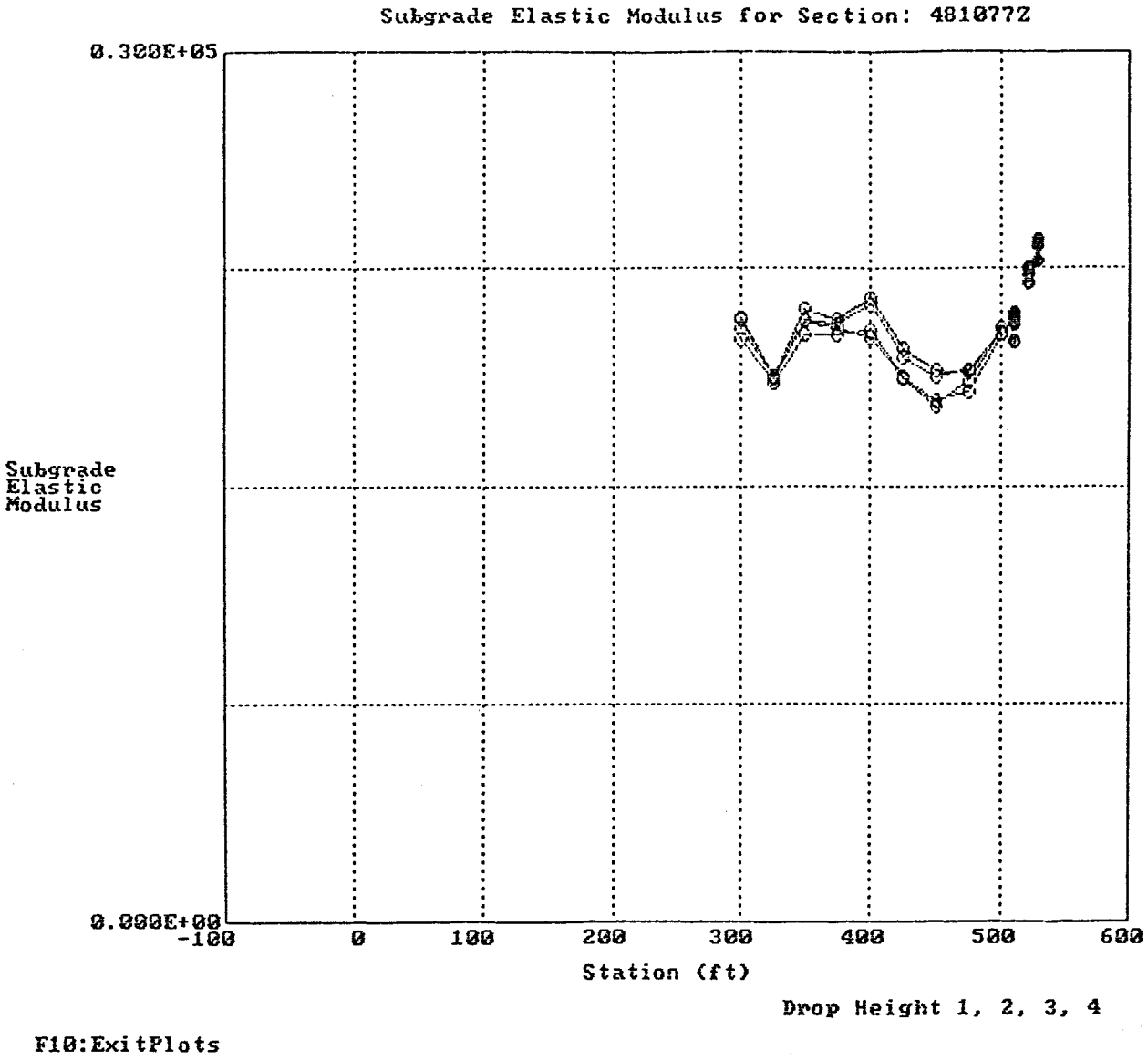


Figure A-8. Subgrade Modulus Profiles from FWDCHECK on Installation Day

Revised December 1, 1992

SHEET 1

DISTRESS SURVEY

LTPP PROGRAM

STATE ASSIGNED ID _ _ _ _

STATE CODE 48

SHRP SECTION ID 1077

DISTRESS SURVEY FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES

DATE OF DISTRESS SURVEY (MONTH/DAY/YEAR) 05/20/93

SURVEYORS: JFD, _ _ _ _ PHOTOS, VIDEO, OR BOTH WITH SURVEY (P, V, B) B

PAVEMENT SURFACE TEMP - BEFORE _ _ 20 °C; AFTER _ _ 20 °C

DISTRESS TYPE	SEVERITY LEVEL LOW	MODERATE	HIGH
CRACKING			
1. FATIGUE CRACKING (Square Meters)	0.0	0.0	0.0
2. BLOCK CRACKING (Square Meters)	0.0	0.0	0.0
3. EDGE CRACKING (Meters)	0.0	0.0	0.0
4. LONGITUDINAL CRACKING (Meters)			
4a. Wheel Path	37.7	0.0	0.0
Length Sealed (Meters)	2	0.0	0.0
4b. Non-Wheel Path	15.0	0.0	0.0
Length Sealed (Meters)	1.0	0.0	0.0
5. REFLECTION CRACKING AT JOINTS Number of Transverse Cracks	0	0	0
Transverse Cracking (Meters)	0.0	0.0	0.0
Length Sealed (Meters)	0.0	0.0	0.0
Longitudinal Cracking (Meters)	0.0	0.0	0.0
Length Sealed (Meters)	0.0	0.0	0.0
6. TRANSVERSE CRACKING Number of Cracks	7	2	0
Length (Meters)	11.8	7.3	0.0
Length Sealed (Meters)	0.0	0.0	0.0
PATCHING AND POTHOLES			
7. PATCH/PATCH DETERIORATION (Number)	0	0	0
(Square Meters)	0.0	0.0	0.0
8. Potholes (Number)	0	0	0
(Square Meters)	0.0	0.0	0.0

Figure A-9. Distress Survey Data

Revised December 1, 1992

SHEET 2

DISTRESS SURVEY

LTPP PROGRAM

STATE ASSIGNED ID _ _ _ _

STATE CODE 48

SHRP SECTION ID 1077

DATE OF DISTRESS SURVEY (MONTH/DAY/YEAR) 05/20/93

SURVEYORS: JED. _ _ _

DISTRESS SURVEY FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

DISTRESS TYPE	SEVERITY LEVEL LOW	MODERATE	HIGH
SURFACE DEFORMATION			
9. RUTTING - REFER TO SHEET 3 FOR SPS-3 OR Form S1 from Dipstick Manual			
10. SHOVING (Number) (Square Meters)			0 / 0.0
SURFACE DEFECTS			
11. BLEEDING (Square Meters)	0.0	0.0	0.0
12. POLISHED AGGREGATE (Square Meters)			0.0
13. RAVELING (Square Meters)	0.0	0.0	0.0
MISCELLANEOUS DISTRESSES			
14. LANE-TO-SHOULDER DROPOFF - REFER TO SHEET 3			
15. WATER BLEEDING AND PUMPING (Number)			0
Length of Affected Pavement (Meters)			0.0
16. OTHER (Describe) _____			

Figure A-9 (Continued). Distress Survey Data

SHEET 3

DISTRESS SURVEY

LTPP PROGRAM

STATE ASSIGNED ID ____

STATE CODE 48

SHRP SECTION ID 1077

DISTRESS SURVEY FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES (CONTINUED)

9. RUTTING (FOR SPS-3 SITE SURVEYS)

INNER WHEEL PATH			OUTER WHEEL PATH		
Point No.	Distance[1] (Meters)	Point Rut Depth (mm)	Point No.	Distance[1] (Meters)	Point Rut Depth (mm)
					NOT MEASURED
1	0.	___.	1	0.	___.
2	15.25	___.	2	15.25	___.
3	30.5	___.	3	30.5	___.
4	45.75	___.	4	45.75	___.
5	61.	___.	5	61.	___.
6	76.25	___.	6	76.25	___.
7	91.5	___.	7	91.5	___.
8	106.75	___.	8	106.75	___.
9	122.	___.	9	122.	___.
10	137.25	___.	10	137.25	___.
11	152.5	___.	11	152.5	___.

14. LANE-TO-SHOULDER DROPOFF

EST. ≤ ~0.4" (ON AVG)

Point No.	Point Distance[1] Meters	Lane-to-Shoulder Dropoff (mm)
		NOT MEASURED
1	0.	___.
2	15.25	___.
3	30.5	___.
4	45.75	___.
5	61.	___.
6	76.25	___.
7	91.5	___.
8	106.75	___.
9	122.	___.
10	137.25	___.
11	152.25	___.

Note 1: "Point Distance" is the distance in meters from the start of the test section to the point where the measurement was made. The values shown are SI equivalents of the 50 feet spacing used in previous surveys.

Figure A-9 (Continued). Distress Survey Data

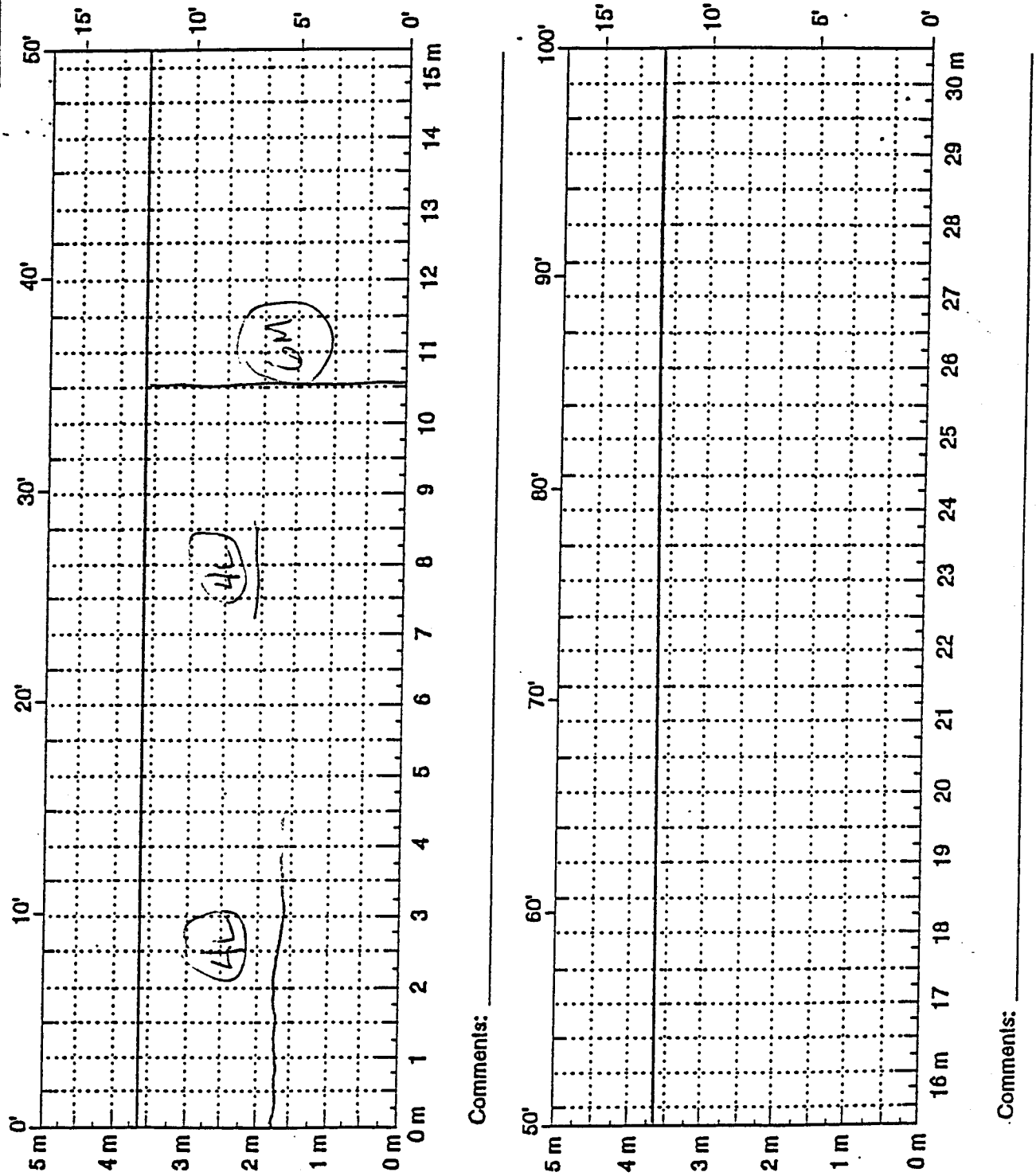
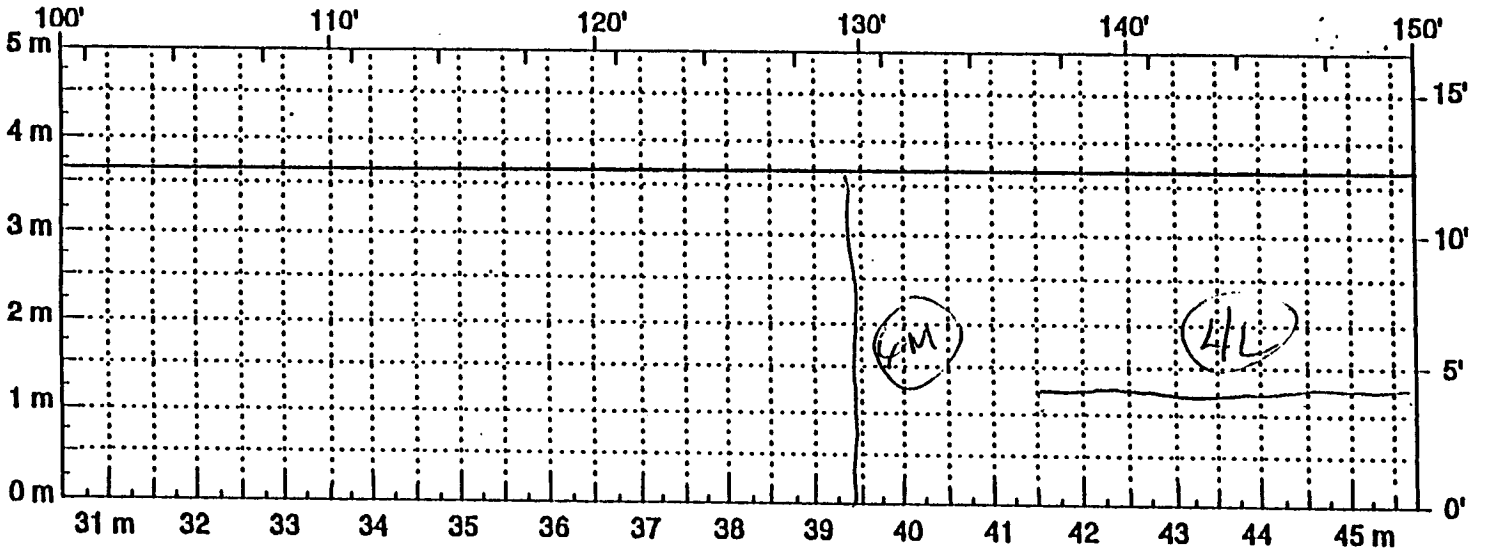


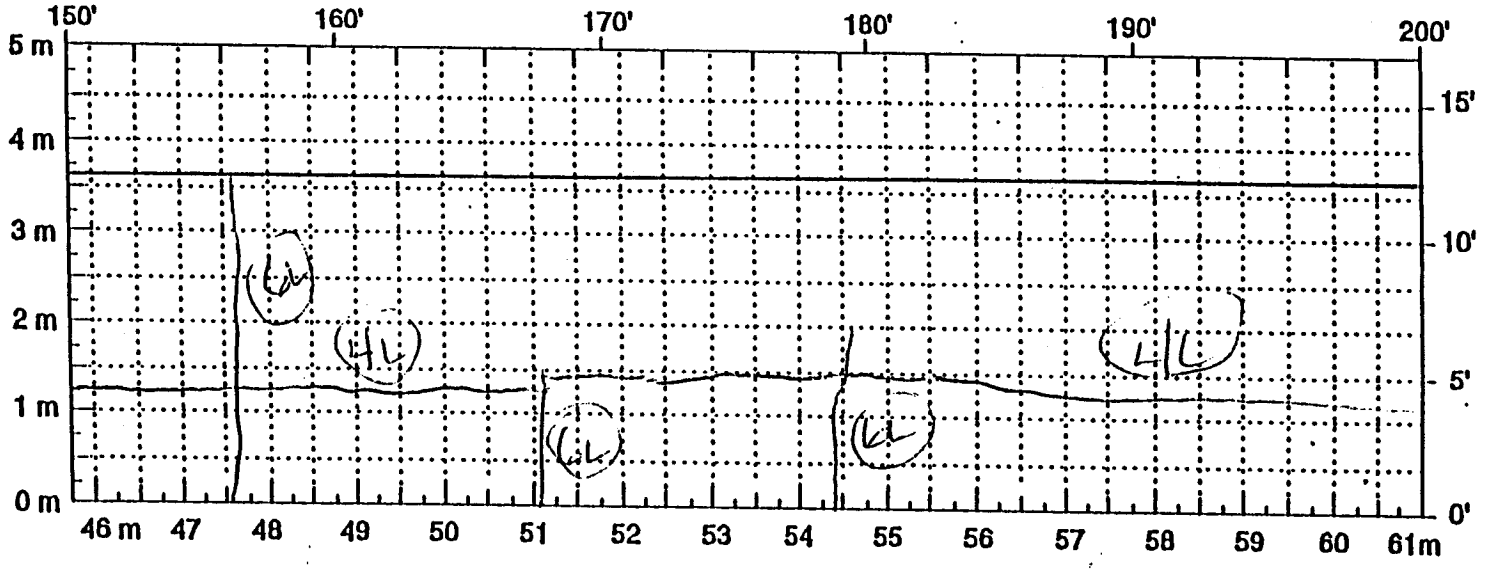
Figure A-9 (Continued). Distress Survey Data

State Code 48

SHRP Section ID 1077



Comments: _____

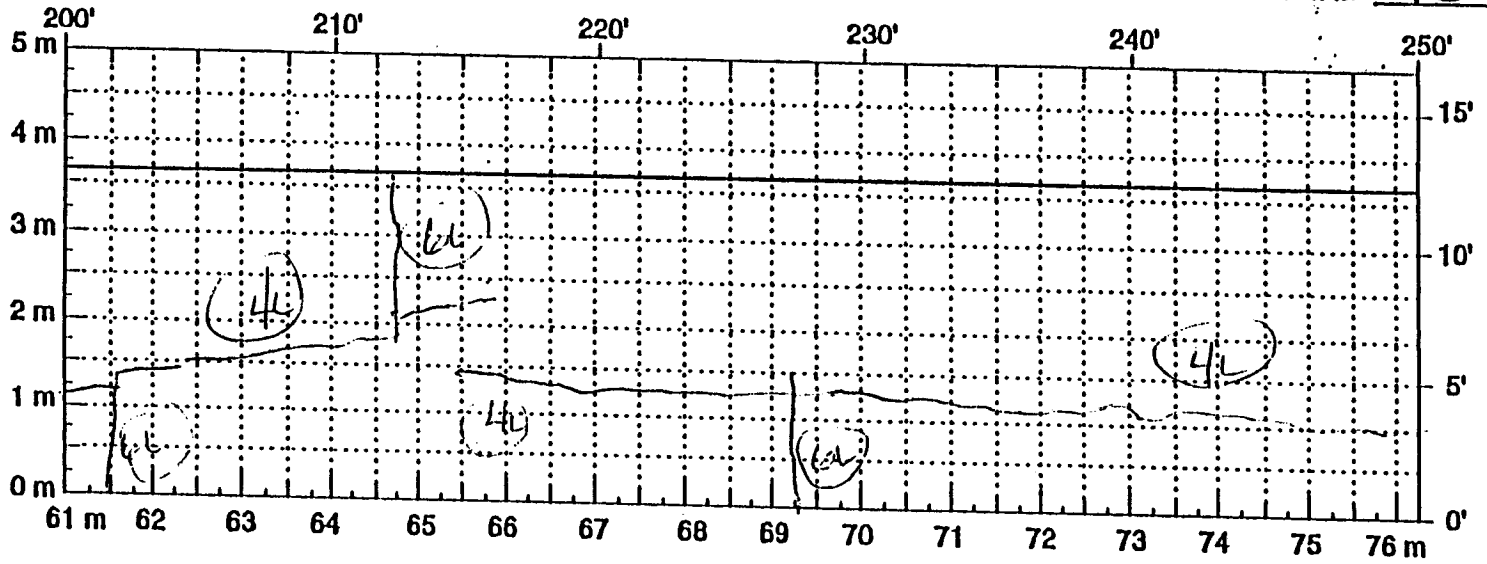


Comments: _____

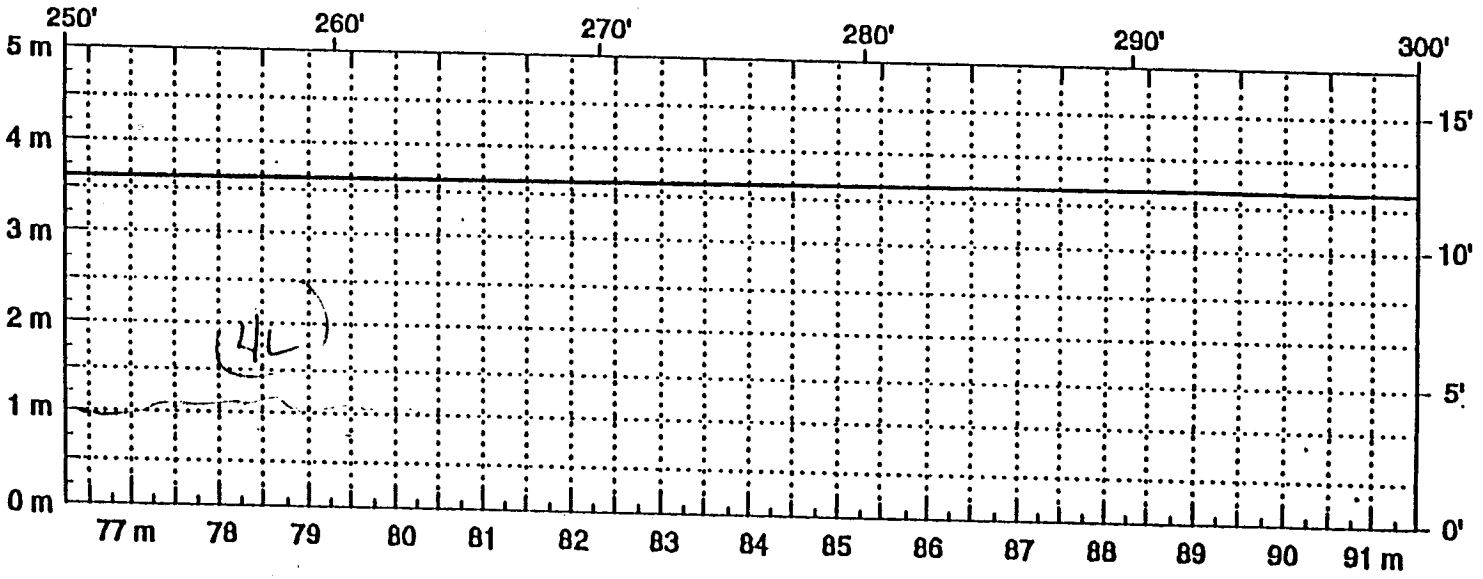
Figure A-9 (Continued). Distress Survey Data

State Code 48

SHRP Section ID 1077



Comments: _____



Comments: _____

Figure A-9 (Continued). Distress Survey Data

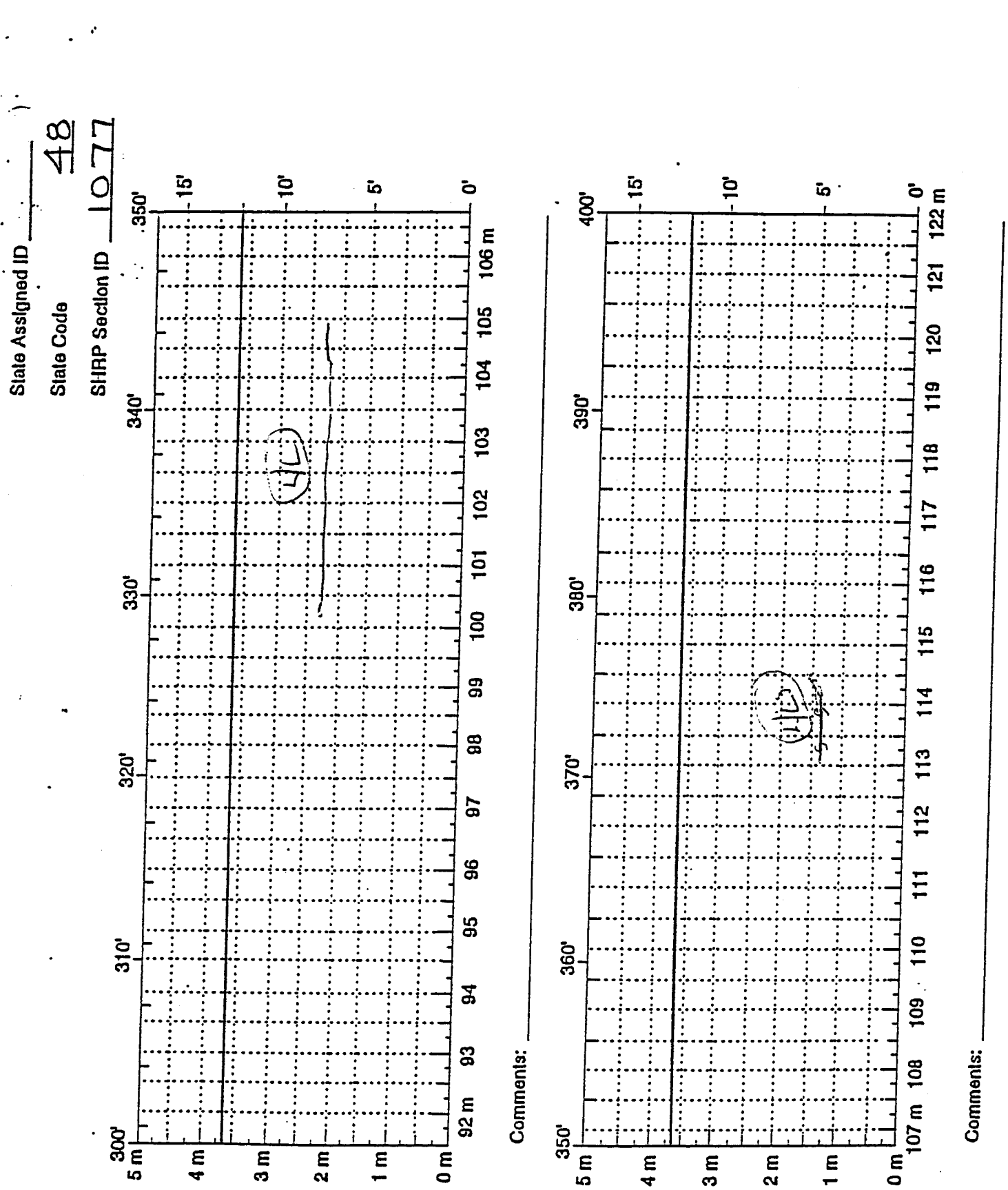
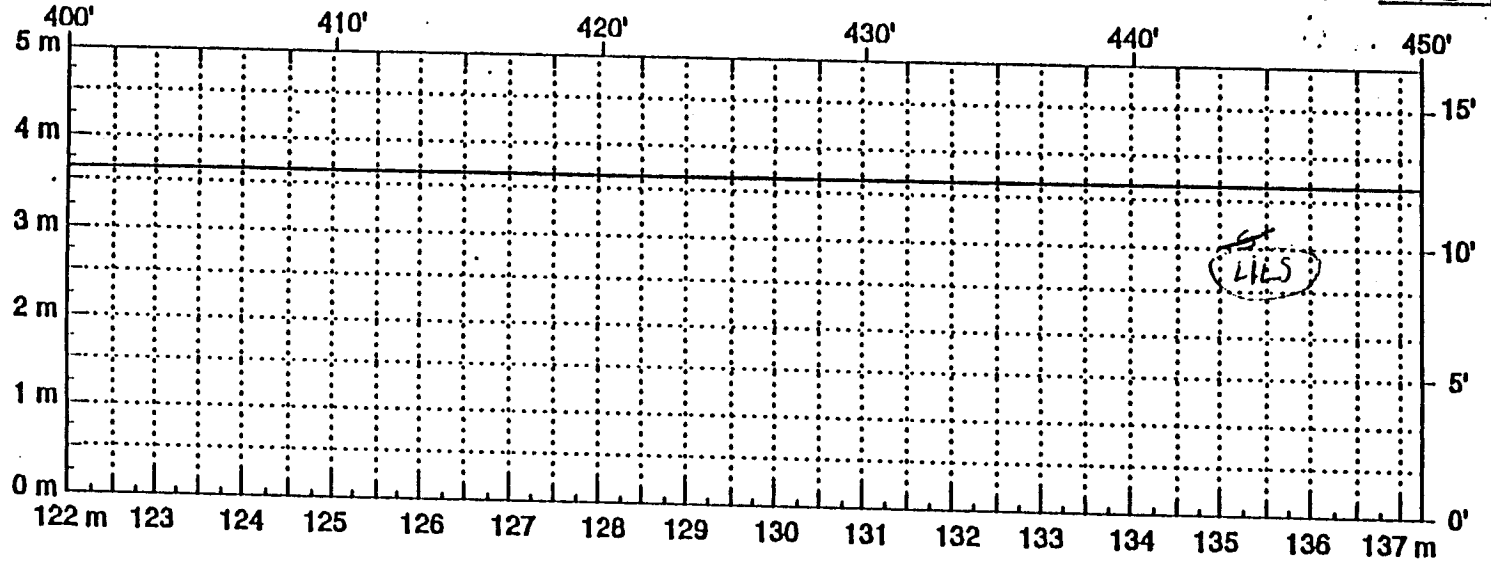


Figure A-9 (Continued). Distress Survey Data

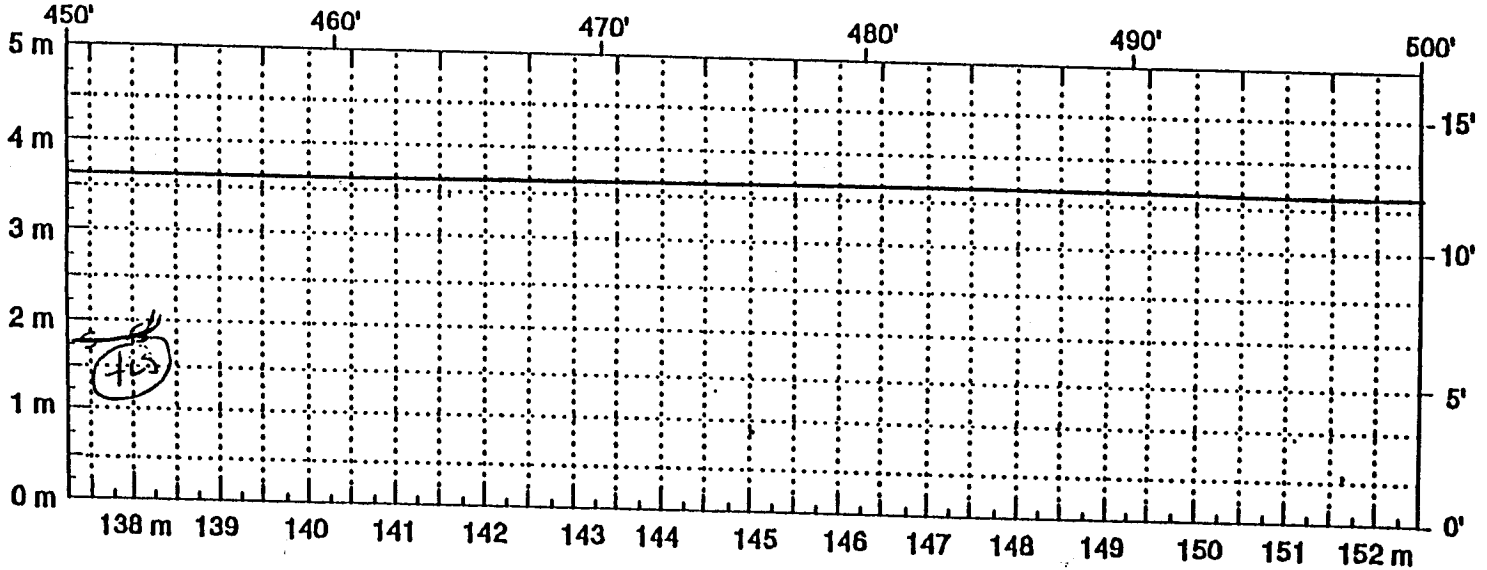
State Assigned ID _____

State Code 48

SHRP Section ID 1077



Comments: _____



Comments: _____ 20°C

RT CRK RUT (ON NB)

Figure A-9 (Continued). Distress Survey Data

APPENDIX B

Pre-installation Activities

Appendix B contains the following information:

Seasonal Monitoring Meeting Agenda

Seasonal Site Information

Figure B-1. Contact Resistance Measurements

Table B-1. Resistance Calibration Data Sheet

Figure B-2. Four-Point Resistivity Measurements

Table B-8. Resistivity Calibration Data Sheet

Figure B-3. TDR Traces Obtained During Calibration

AGENDA
Seasonal Monitoring Meeting
October 18, 1993

I. Introductions

II. Brief Overview of the Seasonal Program

III. Roles & Responsibilities

IV. Activities on Site - Day 1

- A. Arrival
- B. Traffic Control
- C. Marking Section
- D. FWD Testing
- E. Sawing/Coring
- F. Observation Well
- G. Instrumentation Hole
- H. Weather Station
- I. Hook-up all Electronics
- J. Patching/Clean-up

V. Activities on Site - Day 2

- A. Instrumentation Check
- B. Data Collection
  1. FWD Testing
  2. Rod/Level Elevations
  3. Download Instrumentation Data

VI. Questions/Discussion

TEXAS SEASONAL SITE INFORMATION

Type	SHRP ID	Hwy. Nº.	Location of Test Section
AC over Granular Base	481060	US-77, Refugio Co., Northbound	0.7 mi. S. of SH-289, 2 mi. S. of the Refugio/Victoria Co. line.
AC over Granular Base	481068	SH-19, Lamar Co., Northbound	2.1 mi. N. of the North Sulfur River, 1.3 mi. S. of FM-1184.
AC over Granular Base	481077	US-287, Hall Co., Southbound	2.1 mi. S. of the Red River, 1100' N. of FM-658.
AC over Granular Base	481122	US-181, Wilson Co., Northbound	4.9 mi. N. of Loop 181, 2.5 mi. S. of the Bexar/Wilson Co. line.
AC over Granular Base	483739	US-77, Kenedy Co., Northbound	Milepost 20.05-19.95. 26.6 mi. N. of the Kenedy/Willacy Co. line, 20.1 mi. S. of the Kenedy/Kleberg Co. line.
JRCP	484142	US-96, Jasper Co., Northbound	7.6 mi. N. of US-190, 1.9 mi. S. of Recreation Rd. 255.
JRCP	484143	US-90, Jefferson Co., Eastbound	2.2 mi. E. of FM-365/SH-326, 11.0 mi. W. of FM-364.

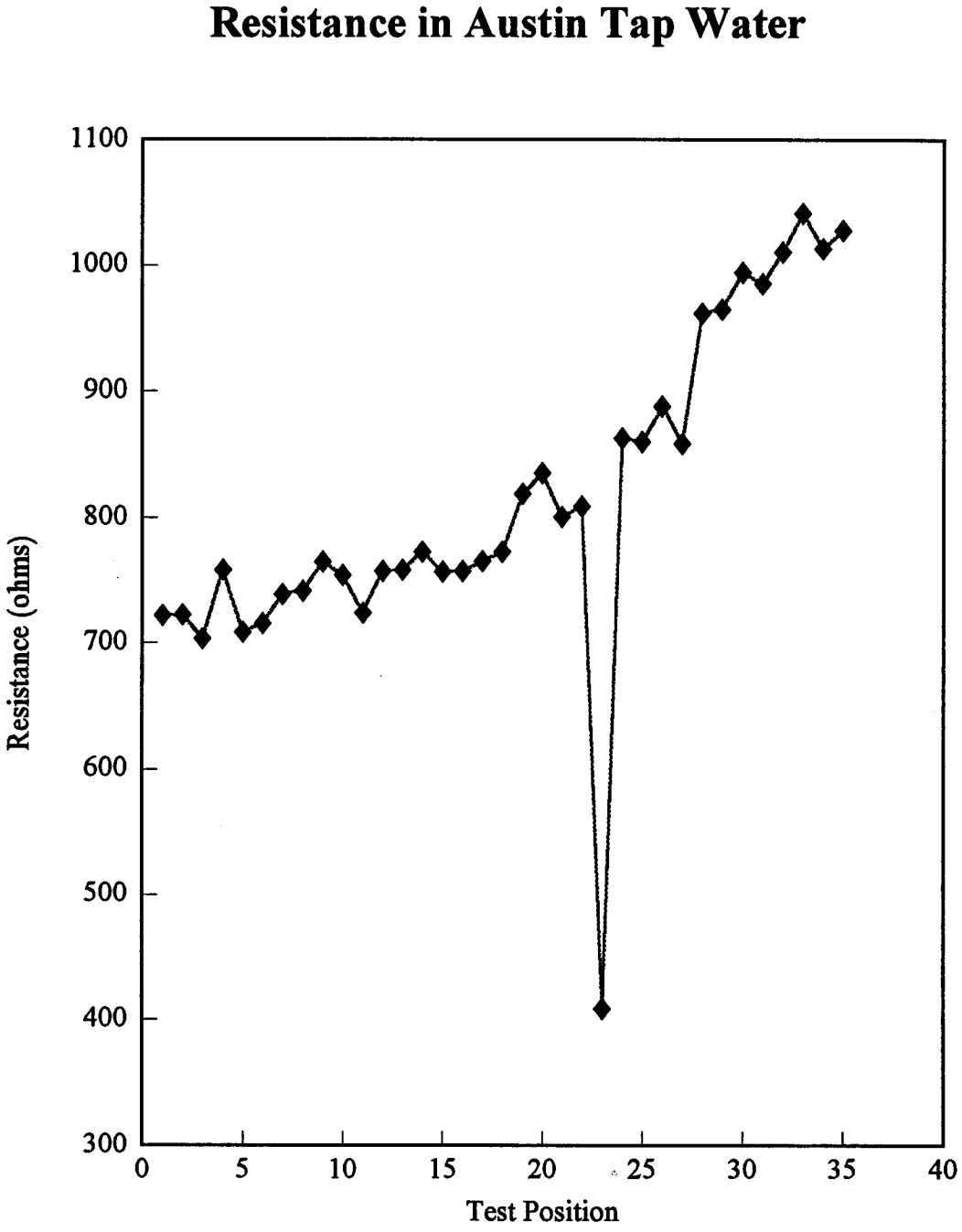


Figure B-1. Contact Resistance Measurements in Austin Tap Water

LTPP Seasonal Monitoring Study Data Sheet R1 Contact Resistance Measurements	* State Code [48] * Test Section Number [1077]

1. Date (Month - Day - Year) [10 - 22 - 93]

2. Time Measurements Began (Military) [:]

3. Comments 48AR

Test Position	Connections		Voltage (ACV)		Current (ACA)		Notes
	I_1 V_1	I_2 V_2	Range Setting	Reading	Range Setting	Reading	
1	1	2	20	10.56	30 m	14.63	
2	3	2		10.54		14.59	
3	3	4		10.48		14.90	
4	5	4		10.53		13.89	
5	5	6		10.47		14.78	
6	7	6		10.47		14.63	
7	7	8		10.49		14.20	
8	9	8		10.48		14.13	
9	9	10		10.50		13.73	
10	11	10		10.48		13.90	
11	11	12		10.44		14.42	
12	13	12		10.47		13.82	
13	13	14		10.47		13.81	
14	15	14		10.482		13.561	
15	15	16		10.458		13.820	
16	17	16		10.452		13.803	
17	17	18		10.458		13.669	
18	19	18		10.460		13.541	
19	19	20		10.501		12.816	
20	21	20		10.512		12.579	
21	21	22		10.476		13.087	
22	23	22		10.476		12.947	
23	23	24		5.168		12.647	* ← Questionable voltage
24	25	24		10.509		12.178	
25	25	26		10.504		12.209	
26	27	26		10.522		11.849	
27	27	28		10.495		12.222	
28	29	28		10.566		10.985	
29	29	30		10.566		10.947	
30	31	30		10.578		10.640	
31	31	32		10.571		10.726	
32	33	32		10.585		10.475	
33	33	34		10.601		10.180	
34	35	34		10.581		10.443	
35	35	36		10.588		10.303	
36	37	38					
37	38	39					
38	39	40					

Preparer Gary Elkins, Gary Peirce Employer _____

Table B-1. Resistance Calibration Data Sheet

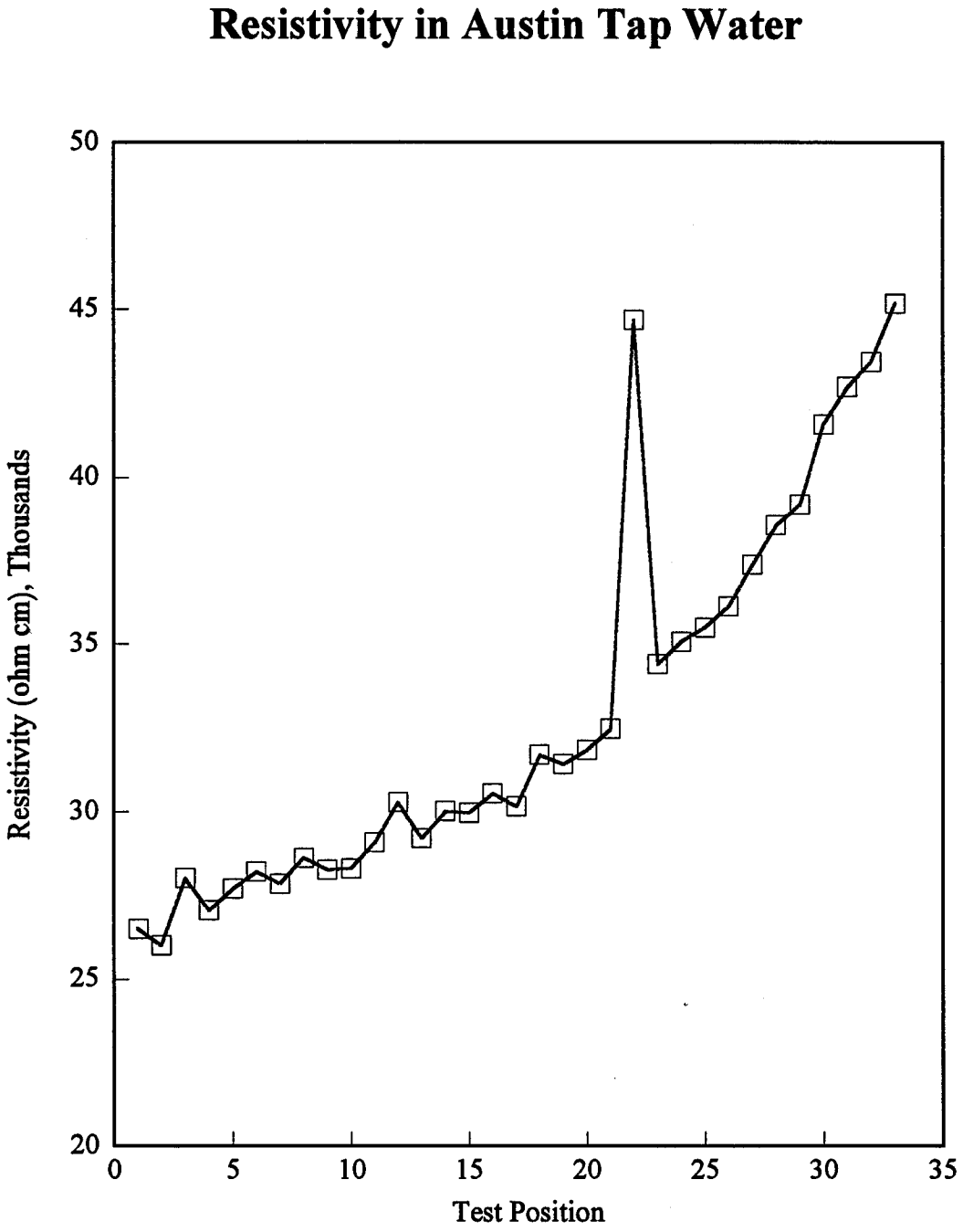


Figure B-2. Four-Point Resistivity Measurements in Austin Tap Water

LTPP Seasonal Monitoring Study Data Sheet R2 Four-Point Resistivity Measurements	* State Code [48] * Test Section Number [1077]

1. Date (Month - Day - Year) [10-22-93]
2. Time Measurements Began (Military) [__:__]
3. Comments 48AR

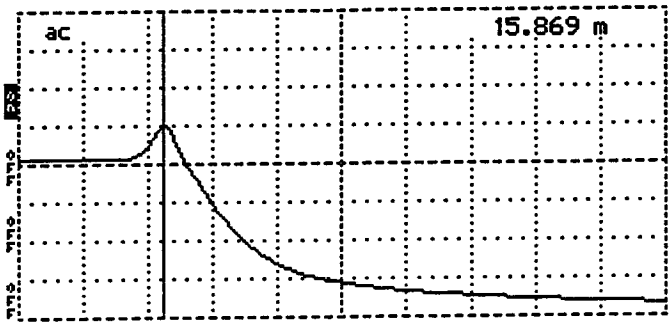
Test Position	Connections				Voltage (ACV)		Current (ACA)		Notes
	I_1	V_1	V_2	I_2	Range Setting	Reading	Range Setting	Reading	
1	1	2	3	4	20	2.908	20 m	6.820	
2	2	3	4	5		2.720		6.764	
3	3	4	5	6		3.087		6.833	
4	4	5	6	7		2.788		6.616	
5	5	6	7	8		2.886		6.669	
6	6	7	8	9		2.950		6.599	
7	7	8	9	10		2.833		6.514	
8	8	9	10	11		2.933		6.548	
9	9	10	11	12		2.935		6.471	
10	10	11	12	13		2.780		6.431	
11	11	12	13	14		2.985		6.396	
12	12	13	14	15		2.906		6.271	
13	13	14	15	16		2.966		6.361	
14	14	15	16	17		2.888		6.224	
15	15	16	17	18		2.944		6.231	
16	16	17	18	19		2.948		6.139	
17	17	18	19	20		2.856		6.038	
18	18	19	20	21		2.932		5.999	
19	19	20	21	22		3.002		5.884	
20	20	21	22	23		2.845		5.840	
21	21	22	23	24		2.962		5.727	
22	22	23	24	25		3.927		5.633	Bad channel * ?
23	23	24	25	26		3.021		5.588	
24	24	25	26	27		2.932		5.411	
25	25	26	27	28		3.080		5.400	
26	26	27	28	29		2.798		5.062	
27	27	28	29	30		3.121		5.142	
28	28	29	30	31		2.894		4.977	
29	29	30	31	32		3.058		4.784	
30	30	31	32	33		2.971		4.679	
31	31	32	33	34		3.043		4.595	
32	32	33	34	35		3.180		4.520	
33	33	34	35	36		3.074		4.433	

Preparer Gary Elkins, Larry Rice Employer BRE

Table B-2. Resistivity Calibration Data Sheet

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

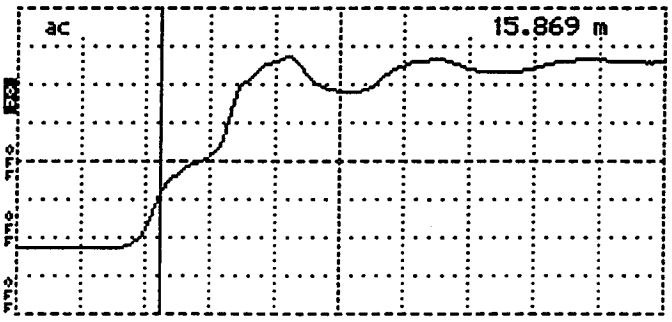
Cursor ..... 15.869 m
Distance/Div..... .25 m/div
Vertical Scale.... 217 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A01
Notes Shorted LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

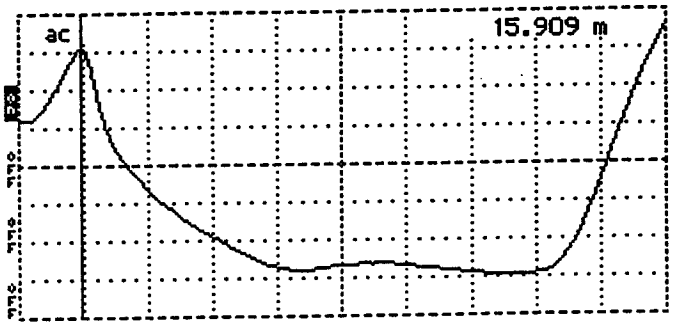
Cursor ..... 15.869 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A01
Notes In Air LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.25	1.46

Cursor ..... 15.909 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A01
Notes In Water Water Temp = 18.0 C LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.78	77.3

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

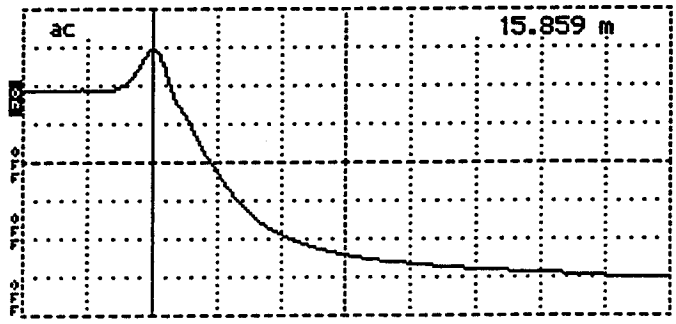
Prepared by: Larry Peirce Employer: BRE, Inc.

Date: 10/21/93

Figure B-3. TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

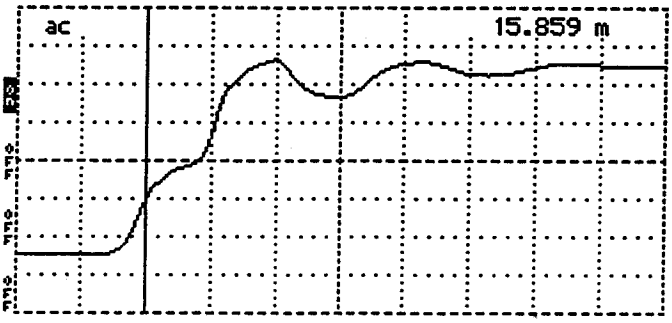
Cursor ..... 15.859 m
Distance/Div..... .25 m/div
Vertical Scale.... 172 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10-21-93
Cable 48A02
Notes Shorted
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

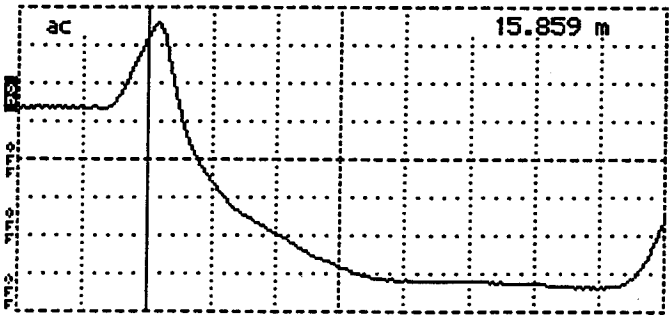
Cursor ..... 15.859 m
Distance/Div..... .25 m/div
Vertical Scale.... 172 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10-21-93
Cable 48A02
Notes IN AIR
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.24	1.40

Cursor ..... 15.859 m
Distance/Div..... .25 m/div
Vertical Scale.... 64.8 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10-21-93
Cable 48A02
Notes IN WATER
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.79	77.8

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

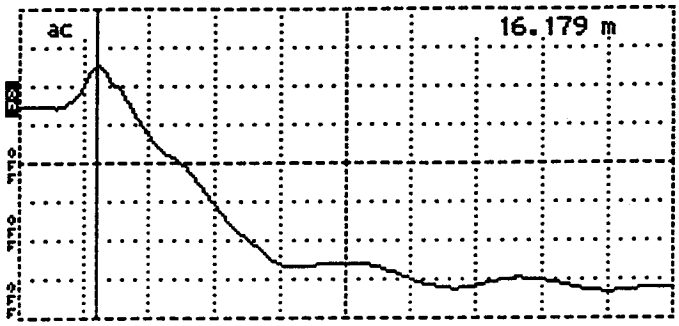
Prepared by: Larry Price Employer: BRE Inc.

Date: 10/21/93

Figure B-3 (Continued). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

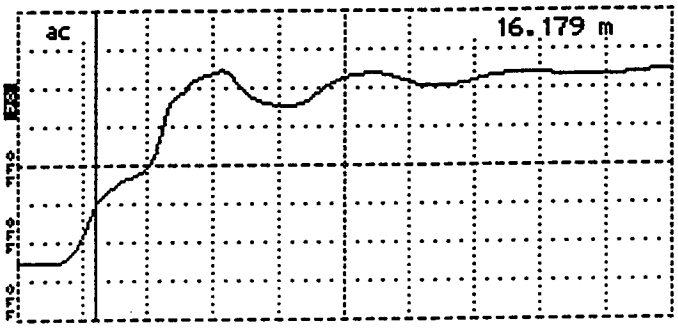
Cursor ..... 16.179 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A03
Notes shorted
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

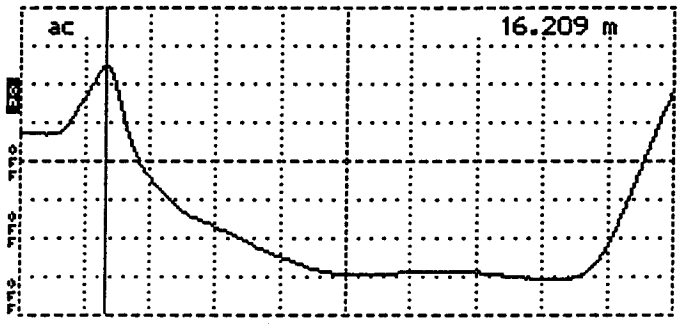
Cursor ..... 16.179 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A03
Notes IN AIR
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.24	1.40

Cursor ..... 16.209 m
Distance/Div..... .25 m/div
Vertical Scale.... 81.6 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A03
Notes IN WATER
18.4 C Temp
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.78	77.3

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

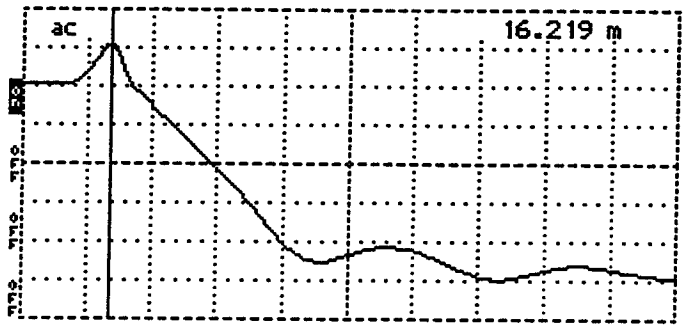
Prepared by: Larry Peirce Employer: BRE Inc.

Date: 10/21/93

Figure B-3 (Continued). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

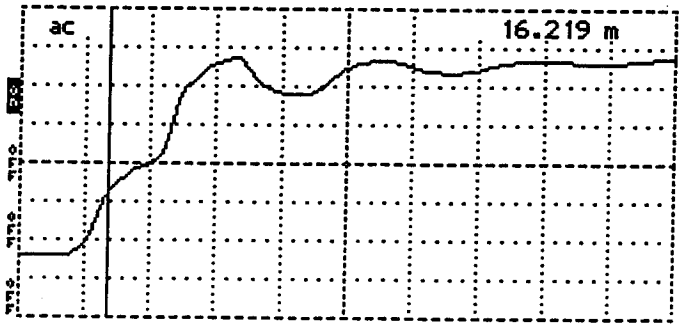
Cursor ..... 16.219 m
Distance/Div..... .25 m/div
Vertical Scale.... 172 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A04
Notes Shorted
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

Cursor ..... 16.219 m
Distance/Div..... .25 m/div
Vertical Scale.... 172 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A04
Notes IN AIR
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.24	1.40

Cursor ..... 16.249 m
Distance/Div..... .25 m/div
Vertical Scale.... 68.6 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

Tektronix 1502B TDR
Date 10/21/93
Cable 48A04
Notes IN WATER
Water Temp 18.
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.78	77.3

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

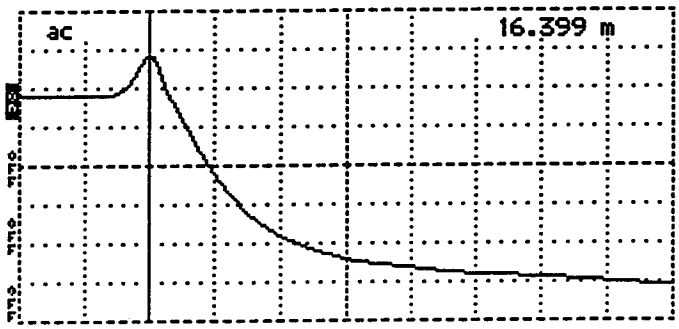
Prepared by: Larry Petro Employer: ERE, Inc.

Date: 10/21/93

Figure B-3 (Continued). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

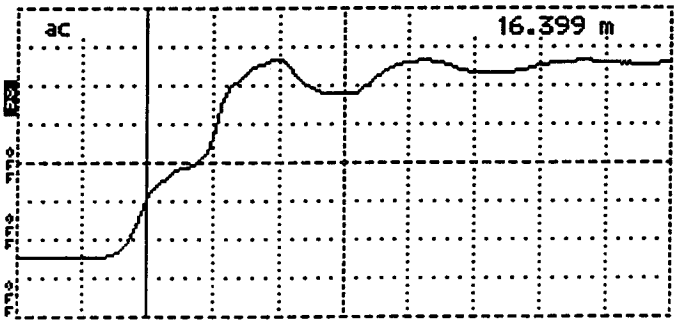
Cursor ..... 16.399 m
Distance/Div..... .25 m/div
Vertical Scale.... 172 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date ~~48A~~ 10/21/93
Cable 48A05
Notes shorted
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

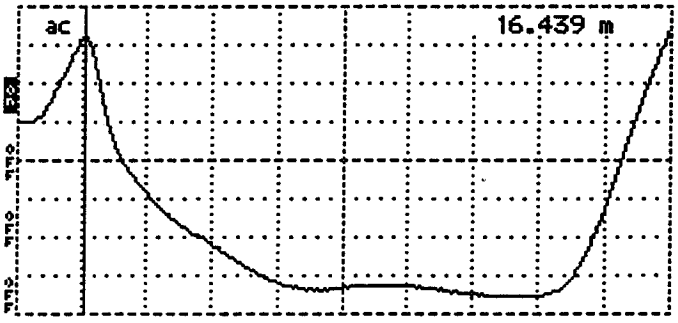
Cursor ..... 16.399 m
Distance/Div..... .25 m/div
Vertical Scale.... 172 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A05
Notes IN AIR
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.24	1.40

Cursor ..... 16.439 m
Distance/Div..... .25 m/div
Vertical Scale.... 66.7 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A05
Notes IN WATER
Water Temp 18
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.78	77.3

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

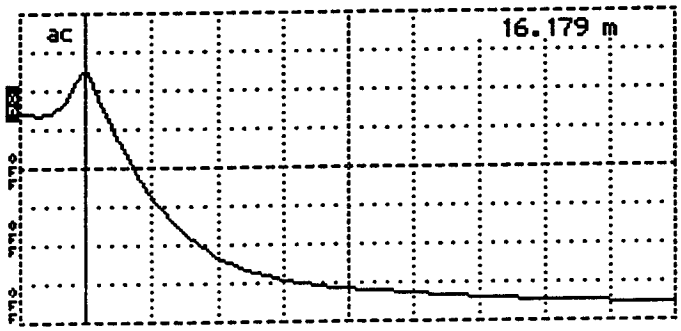
Prepared by: Larry Feirle Employer: BRE Inc

Date: 10/21/93

Figure B-3 (Continued). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

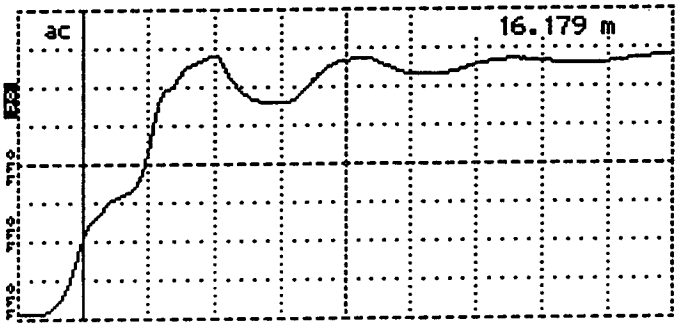
Cursor ..... 16.179 m
Distance/Div..... .25 m/div
Vertical Scale.... 172 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A06
Notes shorted
JF
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

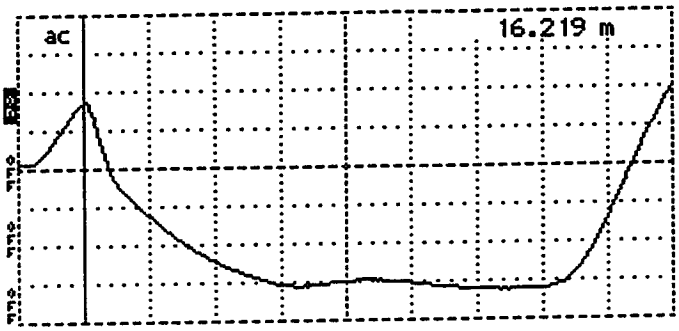
Cursor ..... 16.179 m
Distance/Div..... .25 m/div
Vertical Scale.... 133 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A06
Notes IN AIR
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.24	1.40

Cursor ..... 16.219 m
Distance/Div..... .25 m/div
Vertical Scale.... 91.5 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A06
Notes IN WATER
18.2 C° Water Temp
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.77	76.0

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

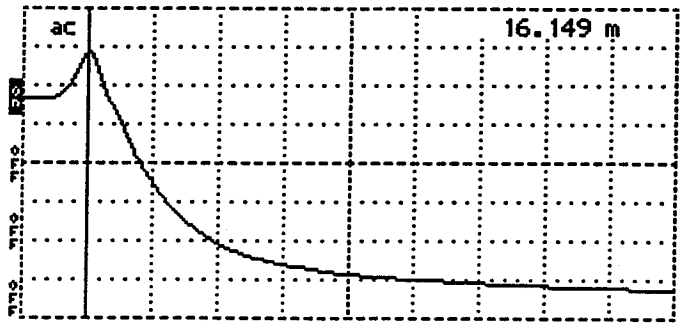
Prepared by: Larry Peirce Employer: BRE Inc.

Date: 10/21/93

Figure B-3 (Continued). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

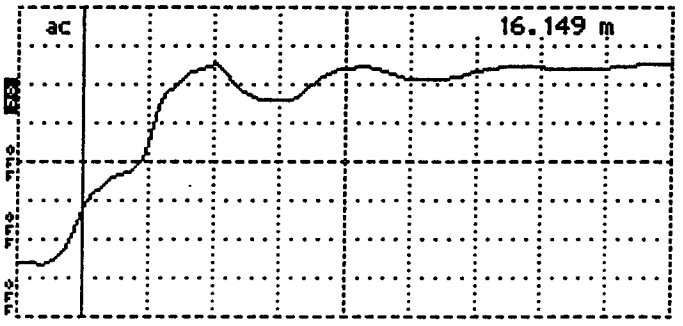
Cursor ..... 16.149 m
Distance/Div..... .25 m/div
Vertical Scale.... 172 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A07
Notes shorted
LS
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

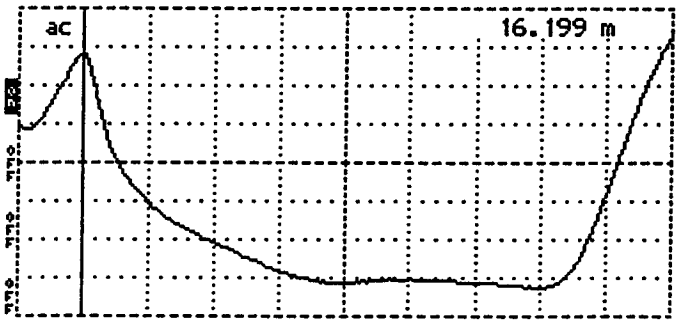
Cursor ..... 16.149 m
Distance/Div..... .25 m/div
Vertical Scale.... 172 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A07
Notes IN Air
LS
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.25	1.46

Cursor ..... 16.199 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A07
Notes IN WATER
18.4 °C mah-f
LS
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.78	77.3

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

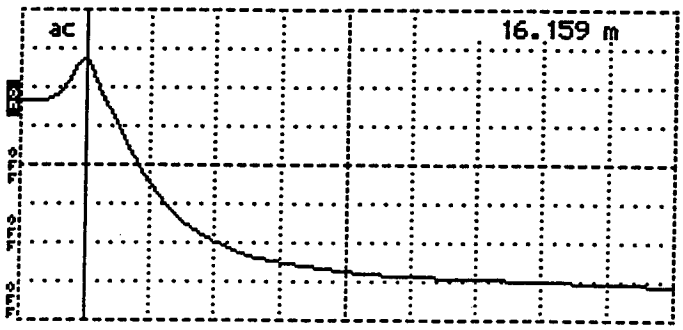
Prepared by: Larry Peirce Employer: BRE

Date: 10/21/93

Figure B-3 (Continued). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

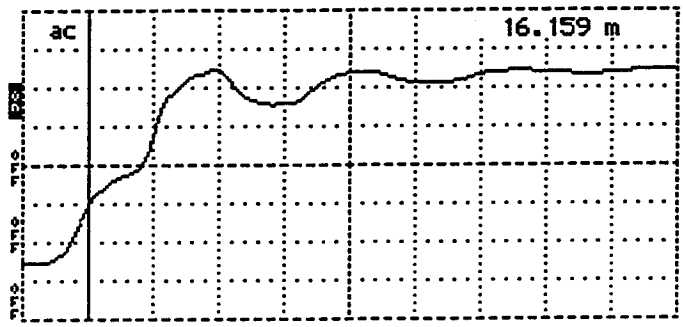
Cursor ..... 16.159 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A08
Notes Shorted
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

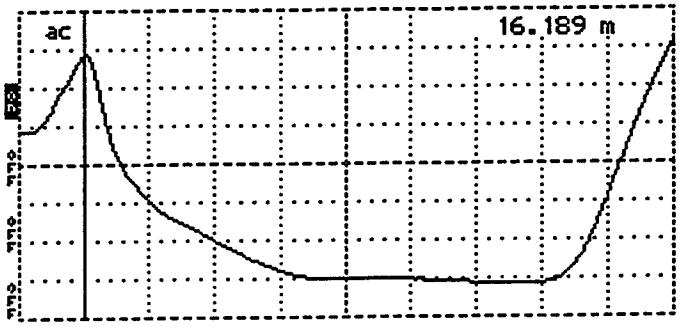
Cursor ..... 16.159 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A08
Notes IN Air
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.24	1.40

Cursor ..... 16.189 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A08
Notes IN WATER
8.3°C Water Temp
LP
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.77	76.0

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

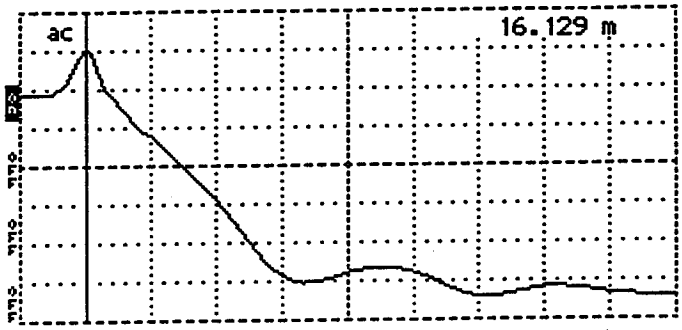
Prepared by: Larry Peirce Employer: BRE Inc.

Date: 10/21/93

Figure B-3 (Continued). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

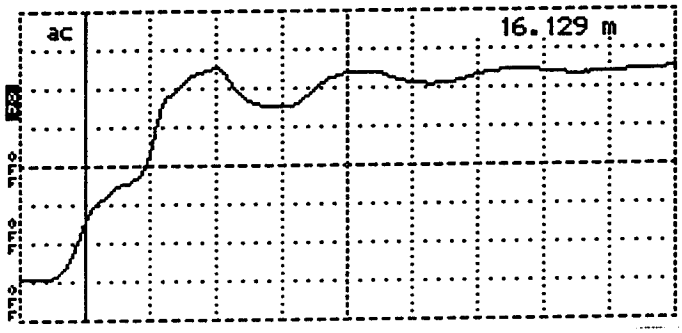
Cursor ..... 16.129 m
Distance/Div..... .25 m/div
Vertical Scale.... 163 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A09
Notes Shorted
L.
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

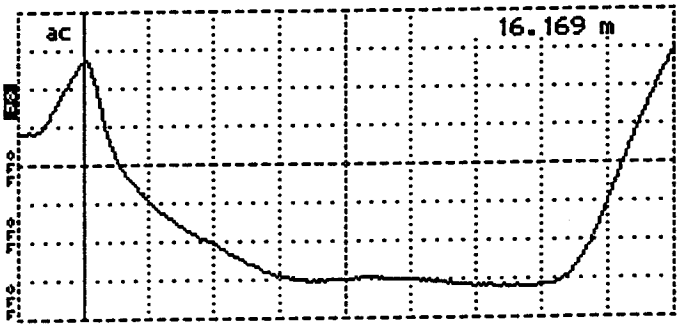
Cursor ..... 16.129 m
Distance/Div..... .25 m/div
Vertical Scale.... 163 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A09
Notes IN AIR
L.
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.24	1.40

Cursor ..... 16.169 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A09
Notes IN WATER
Water Temp 18.3
L.
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.78	77.3

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

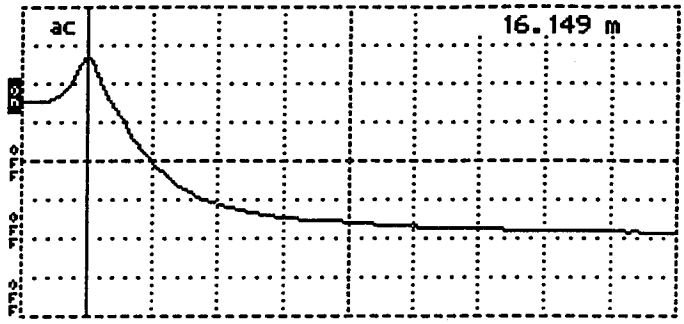
Prepared by: Larry Peirce Employer: BRE Inc

Date: 10/21/93

Figure B-3 (Continued). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program Data Sheet SMP-C01 TDR Probe Check	Agency Code [48] Test Section Number [1077]

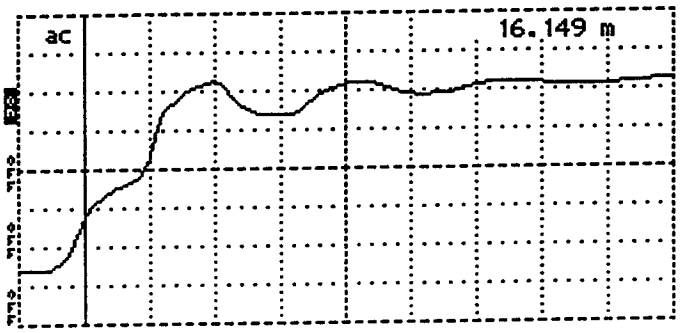
Cursor ..... 16.149 m
Distance/Div..... .25 m/div
Vertical Scale.... 182 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A10
Notes Shorted
L.P.
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant
"Shorted at Start"		

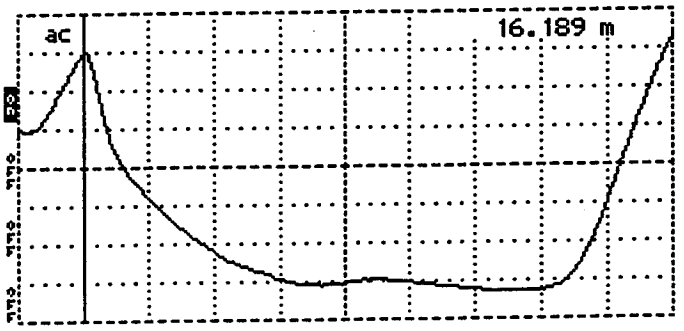
Cursor ..... 16.149 m
Distance/Div..... .25 m/div
Vertical Scale.... 182 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A10
Notes IN AIR
L.P.
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[1]
"In Air"	.25	1.46

Cursor ..... 16.189 m
Distance/Div..... .25 m/div
Vertical Scale.... 72.7 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/21/93
Cable 48A10
Notes IN WATER
18.3 °C water
L.P.
Input Trace
Stored Trace
Difference Trace

TDR Trace	Apparent Length, (m)	Dielectric Constant[2]
"In Water"	1.78	77.3

[1] Dielectric constant should be between 0.75 and 2.0; if not, contact FHWA LTPP Division
[2] Dielectric constant should be between 76 and 84; if not, contact FHWA LTPP Division

Prepared by: Larry Peirce Employer: BRE Inc

Date: 10/21/93

Figure B-3 (Continued). TDR Traces Obtained During Calibration

APPENDIX C

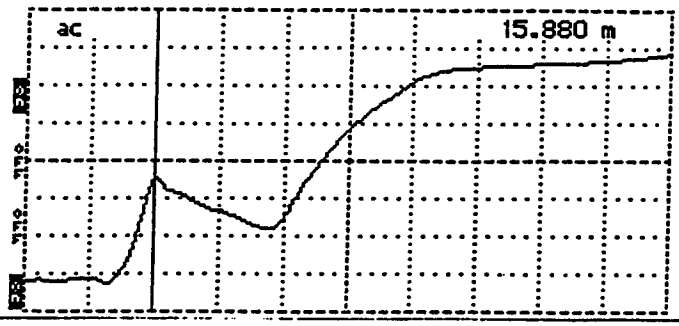
Instrumentation Installation Information

Appendix C contains the following information:

Figure C-1. TDR Traces During Installation

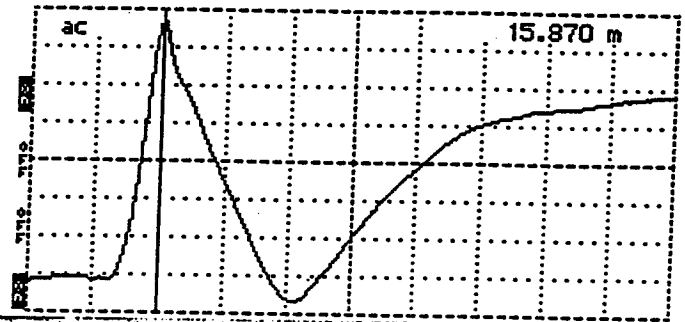
Table C-1. Field Measured Moisture Contents

Cursor ..... 15.880 m
Distance/Div..... .25 m/div
Vertical Scale.... 79.2 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



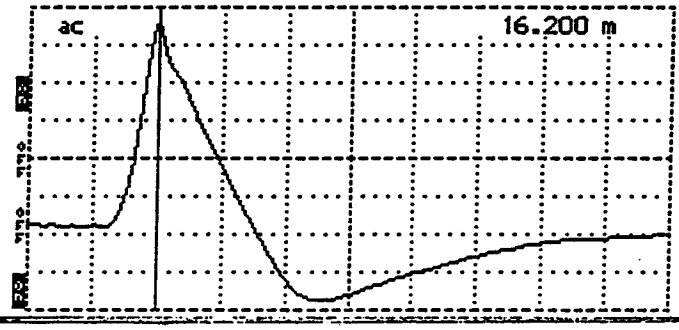
Tektronix 1502B TDR
Date OCT 25 1993
Cable 1
Notes DEPTH OF 12"
Input Trace
Stored Trace
Difference Trace

Cursor ..... 15.870 m
Distance/Div..... .25 m/div
Vertical Scale.... 30.6 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



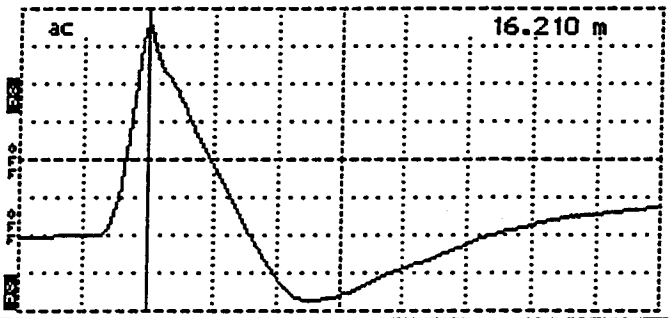
Tektronix 1502B TDR
Date OCT 25, 1993
Cable 2
Notes 48A
DEPTH OF 18"
Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.200 m
Distance/Div..... .25 m/div
Vertical Scale.... 39.7 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



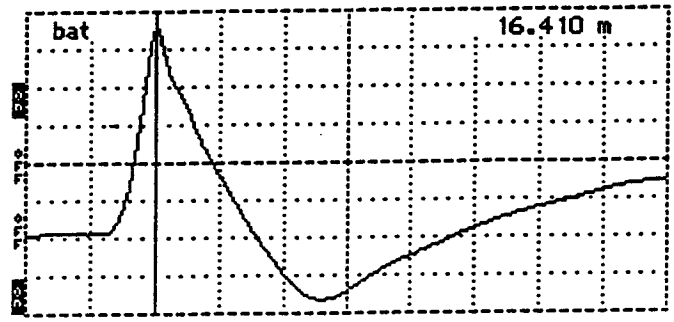
Tektronix 1502B TDR
Date OCT 25, 1993
Cable 3
Notes 48A
DEPTH OF 24"
Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.210 m
Distance/Div..... .25 m/div
Vertical Scale.... 38.6 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date OCT 25, 1993
Cable 4
Notes 48A
DEPTH OF 30"
Input Trace
Stored Trace
Difference Trace

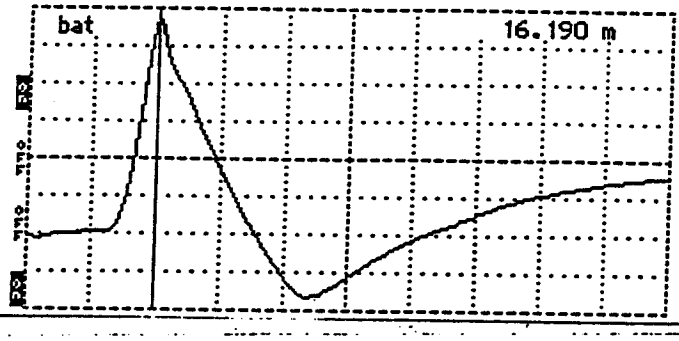
Cursor ..... 16.410 m
Distance/Div..... .25 m/div
Vertical Scale.... 39.7 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... bat/low



Tektronix 1502B TDR
Date OCT 25, 1993
Cable 5
Notes 48A
DEPTH OF 36"
Input Trace
Stored Trace
Difference Trace

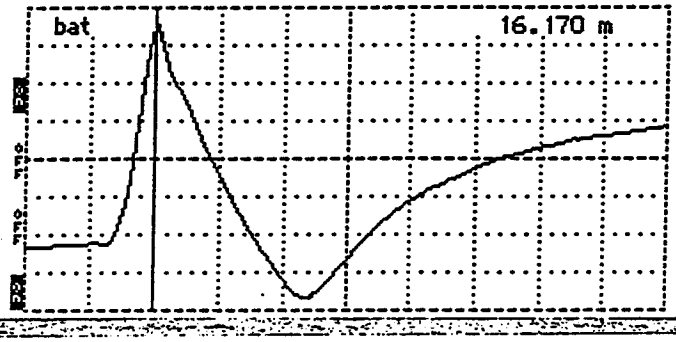
Figure C-1. TDR Traces During Installation

Cursor ..... 16.190 m
Distance/Div..... .25 m/div
Vertical Scale.... 37.5 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... bat/low



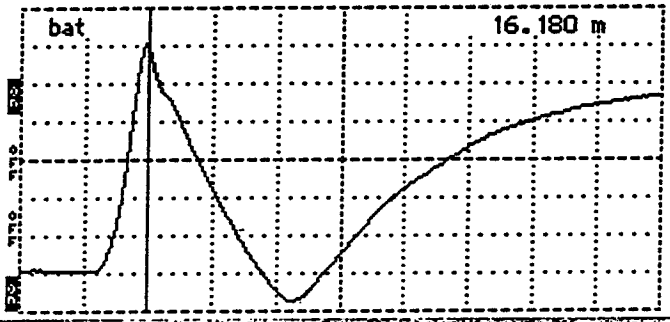
Tektronix 1502B TDR
Date OCT 25, 1993
Cable 6
Notes 48A
DEPTH OF 42"
Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.170 m
Distance/Div..... .25 m/div
Vertical Scale.... 35.4 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... bat/low



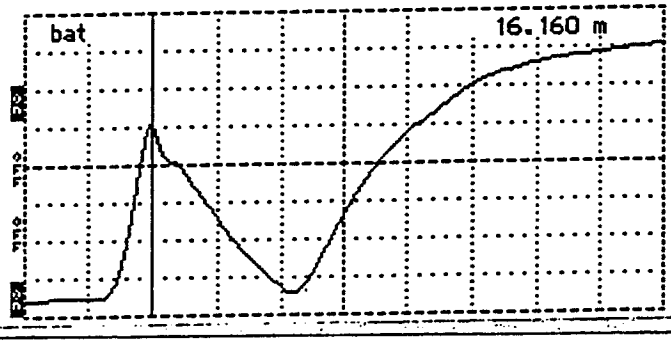
Tektronix 1502B TDR
Date OCT 25, 1993
Cable 7
Notes 48A
DEPTH OF 48"
Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.180 m
Distance/Div..... .25 m/div
Vertical Scale.... 37.5 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... bat



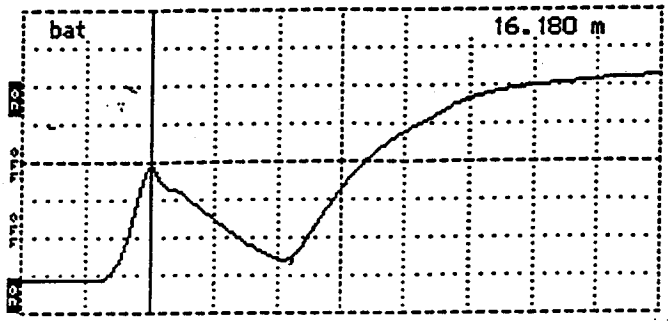
Tektronix 1502B TDR
Date OCT 25, 1993
Cable 8
Notes 48A
DEPTH OF 54"
Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.160 m
Distance/Div..... .25 m/div
Vertical Scale.... 48.6 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... bat



Tektronix 1502B TDR
Date OCT 25, 1993
Cable 9
Notes 48A
DEPTH OF 66"
Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.180 m
Distance/Div..... .25 m/div
Vertical Scale.... 72.7 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... bat



Tektronix 1502B TDR
Date OCT 25 1993
Cable 10
Notes 48A10
DEPTH OF 78"
Input Trace
Stored Trace
Difference Trace

Figure C-1 (Continued). TDR Traces During Installation

Table C-1. Field Measured Moisture Contents

SITE NO. 481077 10/25/93

MOISTURE CONTENTS FOR TDR

TDR #	WT. OF PAN(g)	(WET) PAN & SOIL(g)	(DRY) PAN & SOIL(g)	M.C. (%)
48A10	179.8	497.0	472.0	8.55%
48A09	179.4	481.0	456.2	8.95%
48A08	179.7	436.9	460.2	9.52%
48A07	178.3	557.4	525.4	9.22%
48A06	199.1	444.1	423.1	9.38%
48A05	204.0	558.0	526.8	9.67%
48A04	179.1	462.5	442.6	7.55%*
48A03	177.6	449.1	429.4	7.82%
48A02	179.3	531.9	522.6	2.71% PEBBLES
48A01	203.9	627.8	619.5	2.00% COBBLES

* BEGAN DRYING BEFORE WEIGHING

APPENDIX D

Initial Data Collection

Appendix D contains the following support information:

Table D-1. Raw Data from the On-site Data Logger

Figure D-1. Measured Air Temperature During Initial Data Collection

Figure D-2. Measured Average Subsurface Temperature for the First 5 Sensors During Initial Data Collection

Figure D-3. Measured Average Subsurface Temperature for all 18 Sensors During Initial Data Collection

Figure D-4. Contact Resistance Measurements in the Field

Table D-2. Contact Resistance Measurements Data Sheet

Figure D-5. Four-Point Resistivity Measurements in the Field

Table D-3. Four-Point Resistivity Measurements Data Sheet

Figure D-6. thru Figure D-15. Traces from TDR Sensor

Table D-4. Elevation Measurements from Installation

5,1993,299,1000,12.33,10.31,0
5,1993,299,1100,12.33,11.29,0
5,1993,299,1200,12.32,12.59,0
6,1993,299,1200,15.36,15.13,15.75,17.03,17.85
7,1993,299,1201,-571.9,-965,-1346,-1701,-1968,-2128,-2213,-2255,-2275,-2284,-2288,-2290,-2291,-2292,-2292,-2292,-2291,-2291,-2290,-2291,-2290,-2291,-2291,-2291,-2291,-2290,-2291,-2291,-2290,-2290,-2290,-2290,-2258,-2275,-2283
5,1993,299,1300,12.32,13.69,0
5,1993,299,1400,12.31,14.89,0
5,1993,299,1500,12.31,15.18,0
5,1993,299,1600,12.29,15.31,1.1
6,1993,299,1600,22.05,20.26,18.81,18,17.94
7,1993,299,1601,-563.9,-950,-1326,-1675,-1940,-2101,-2188,-2233,-2252,-2262,-2268,-2268,-2270,-2270,-2270,-2270,-2269,-2268,-2270,-2270,-2270,-2268,-2268,-2268,-2267,-2266,-2266,-2267,-2266,-2267,-2269,-2268,-2268,-2268,-2267
5,1993,299,1700,12.29,14.53,0
5,1993,299,1800,12.29,13.17,0
5,1993,299,1900,12.28,11.19,0
5,1993,299,2000,12.27,10.48,0
6,1993,299,2000,17.51,18.81,19.46,19.59,19.3
7,1993,299,2001,-597.2,-1010,-1411,-1779,-2042,-2194,-2272,-2279,-2281,-2314,-2329,-2335,-2338,-2339,-2341,-2341,-2343,-2345,-2343,-2341,-2339,-2339,-2340,-2341,-2342,-2340,-2339,-2339,-2339,-2311,-2328,-2335,-2339,-2339,-2339
5,1993,299,2100,12.26,10.03,0
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Table D-1. Raw Data from the On-Site Datalogger During Initial Data Collection

Site 481077

October 26, 1993

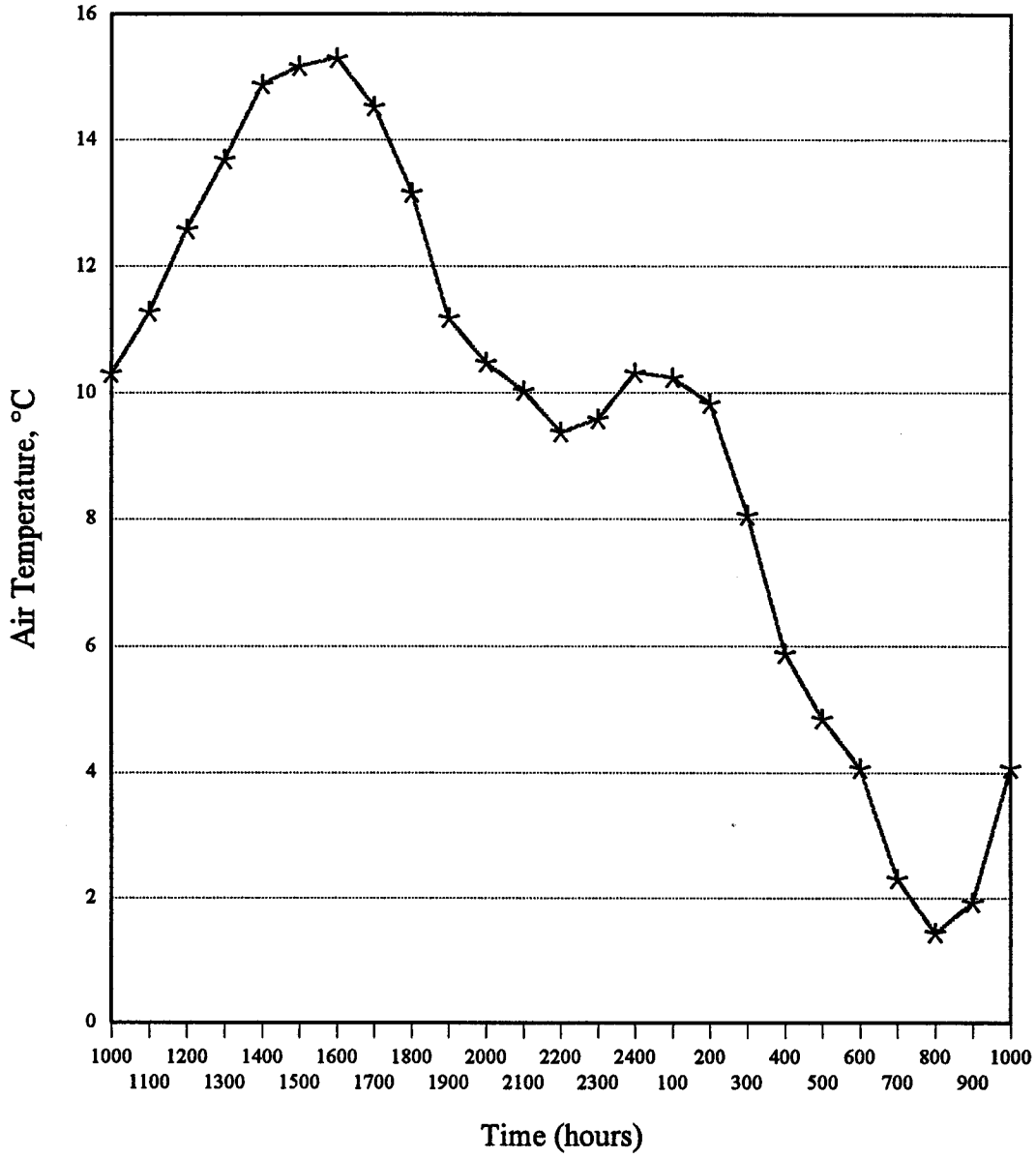

Figure D-1. Measured Air Temperature During Initial Data Collection

Site 481077

October 26, 1993

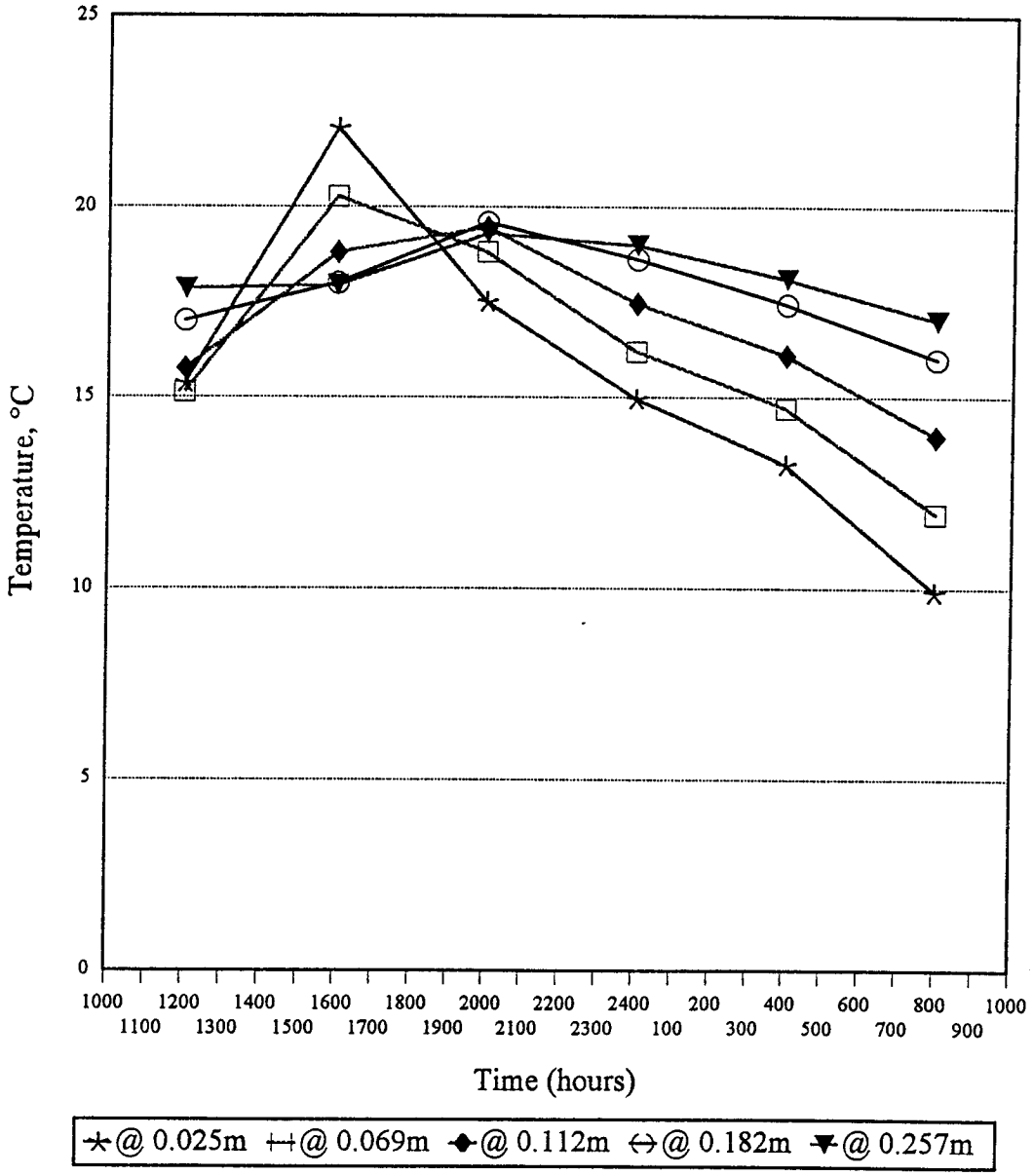

Figure D-2. Measured Average Subsurface Temperature for the First 5 Sensors During Initial Data Collection

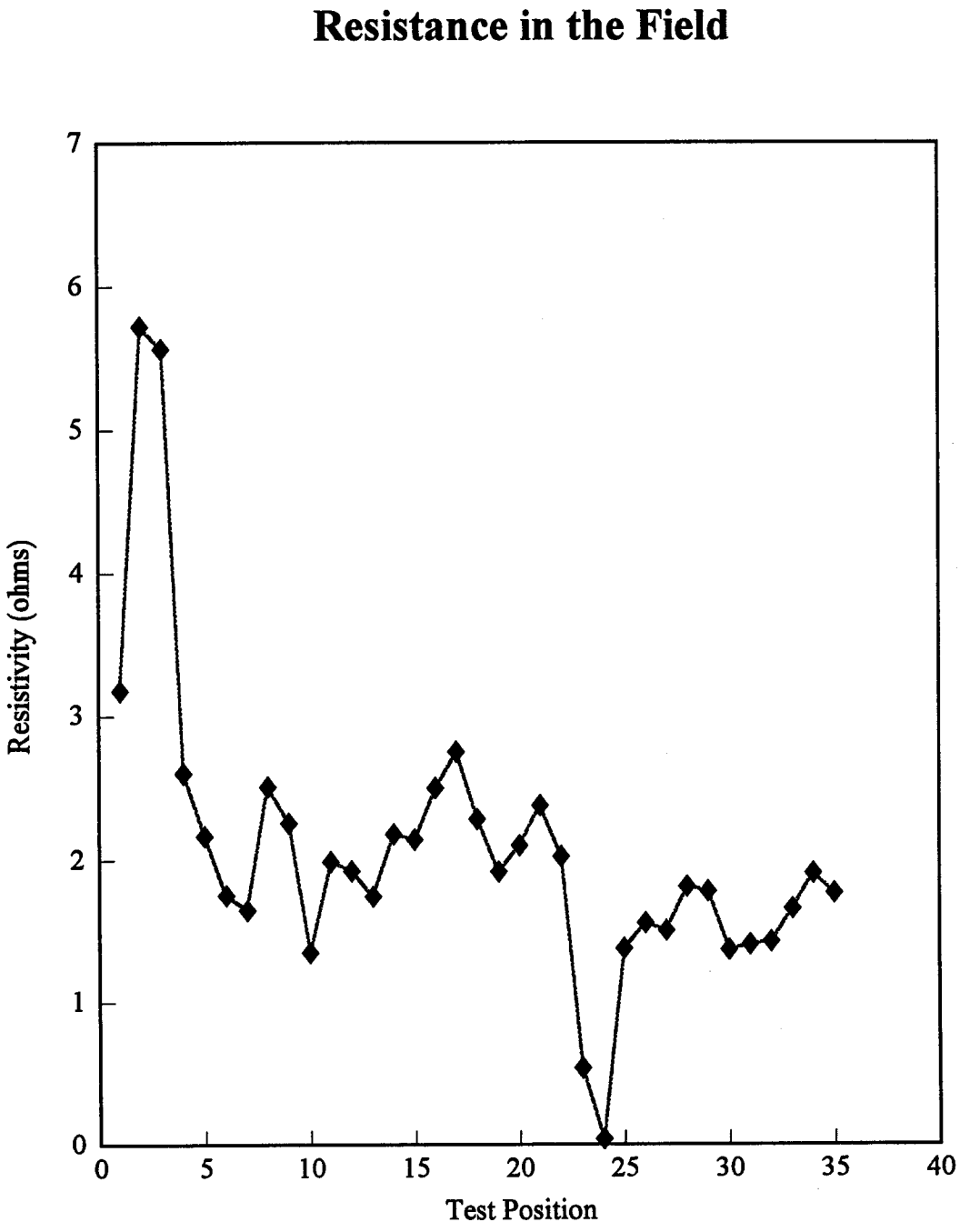

Figure D-4. Contact Resistance Measurements in the Field

LTPP Seasonal Monitoring Study Data Sheet R1 Contact Resistance Measurements	* State Code [48] * Test Section Number [1077]

1. Date (Month - Day - Year) [10-26-93]

2. Time Measurements Began (Military) [10:30]

3. Comments 485A

Test Position	Connections		Voltage (ACV)		Current (ACA)		Notes
	I_1 V_1	I_2 V_2	Range Setting	Reading	Range Setting	Reading	
1	1	2	20	11.121	20M	3.505	
2	3	2		11.196		1.957	
3	3	4		11.182		2.011	
4	5	4		11.033		4.236	
5	5	6		11.001		5.07	
6	7	6		10.908		6.226	
7	7	8		10.860		6.587	
8	9	8		10.964		4.369	
9	9	10		10.916		4.832	
10	11	10		10.709		7.937	
11	11	12		10.850		5.457	
12	13	12		10.834		5.637	
13	13	14		10.792		6.190	
14	15	14		10.861		4.985	
15	15	16		10.852		5.061	
16	17	16		10.890		4.356	
17	17	18		10.910		3.965	
18	19	18		10.857		4.749	
19	19	20		10.796		5.625	
20	21	20		10.821		5.150	
21	21	22		10.853		4.560	
22	23	22		10.800		5.333	
23	23	24		3.754		6.935	*
24	25	24		0.328	2M	9.021	*
25	25	26		10.564	20M	7.671	
26	27	26		10.614		6.812	
27	27	28		10.597		7.043	
28	29	28		10.665		5.881	
29	29	30		10.650		5.980	
30	31	30		10.534		7.691	
31	31	32		10.534		7.482	
32	33	32		10.526		7.389	
33	33	34		10.576		6.380	
34	35	34		10.614		5.568	
35	35	36		10.569		5.975	
36	37	38					
37	38	39					
38	39	40					

Preparer _____ Employer _____

Table D-2. Contact Resistance Measurements Data Sheet

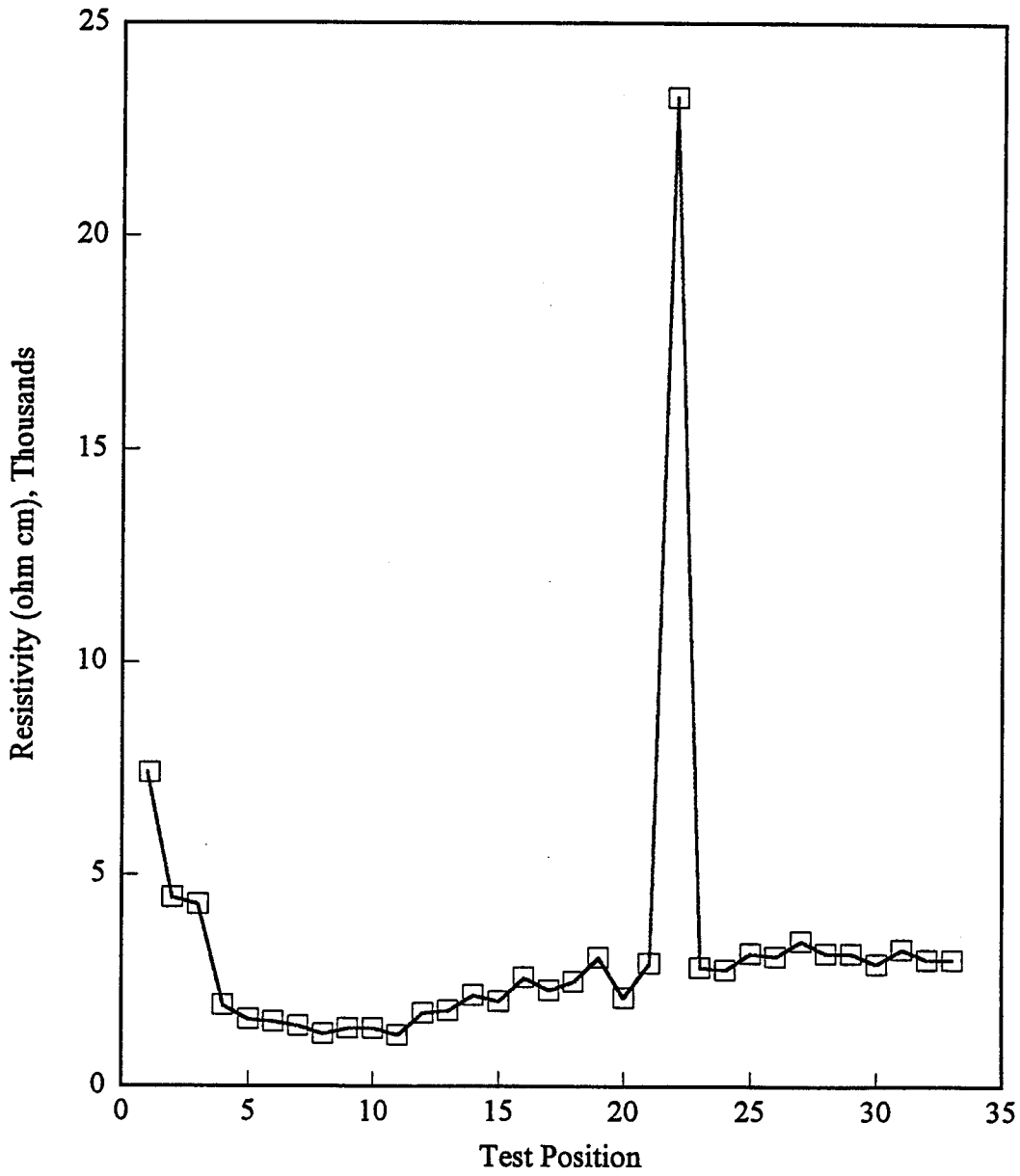

Figure D-5. Four-Point Resistivity Measurements in the Field

LTPP Seasonal Monitoring Study Data Sheet R2 Four-Point Resistivity Measurements	* State Code [48] * Test Section Number [1077]

1. Date (Month - Day - Year) [10-26-93]
2. Time Measurements Began (Military) [11:50]
3. Comments _____

Test Position	Connections				Voltage (ACV)		Current (ACA)		Notes
	I_1	V_1	V_2	I_2	Range Setting	Reading	Range Setting	Reading	
1	1	2	3	4	2M	.3393	20M	2.850	
2	2	3	4	5		.2325		3.367	
3	3	4	5	6		.1419		2.044	
4	4	5	6	7		.1124		3.737	
5	5	6	7	8		.1255		5.007	
6	6	7	8	9		.0963		3.923	
7	7	8	9	10		.1691		7.530	
8	8	9	10	11		.1208		6.161	
9	9	10	11	12		.0791		3.576	
10	10	11	12	13		.1621		7.647	
11	11	12	13	14		.1105		5.106	
12	12	13	14	15		.1177		4.390	
13	13	14	15	16		.1640		5.669	
14	14	15	16	17		.1359		4.043	
15	15	16	17	18		.1338		4.200	
16	16	17	18	19		.1973		4.854	
17	17	18	19	20		.1542		4.308	
18	18	19	20	21		.1582		4.108	
19	19	20	21	22		.2264		4.551	
20	20	21	22	23		.1456		5.736	
21	21	22	23	24		.2567		5.503	
22	22	23	24	25		1.937		5.335	*
23	23	24	25	26		.2766		6.224	
24	24	25	26	27		.2868		6.718	
25	25	26	27	28		.3850		7.583	
26	26	27	28	29		.2623		5.546	
27	27	28	29	30		.3836		6.857	
28	28	29	30	31		.3366		7.067	
29	29	30	31	32		.2926		5.668	
30	30	31	32	33		.3226		7.267	
31	31	32	33	34		.3036		6.003	
32	32	33	34	35		.2983		6.116	
33	33	34	35	36		.3063		6.606	

Preparer _____ Employer _____

Table D-3. Four-Point Resistivity Measurements Data Sheet

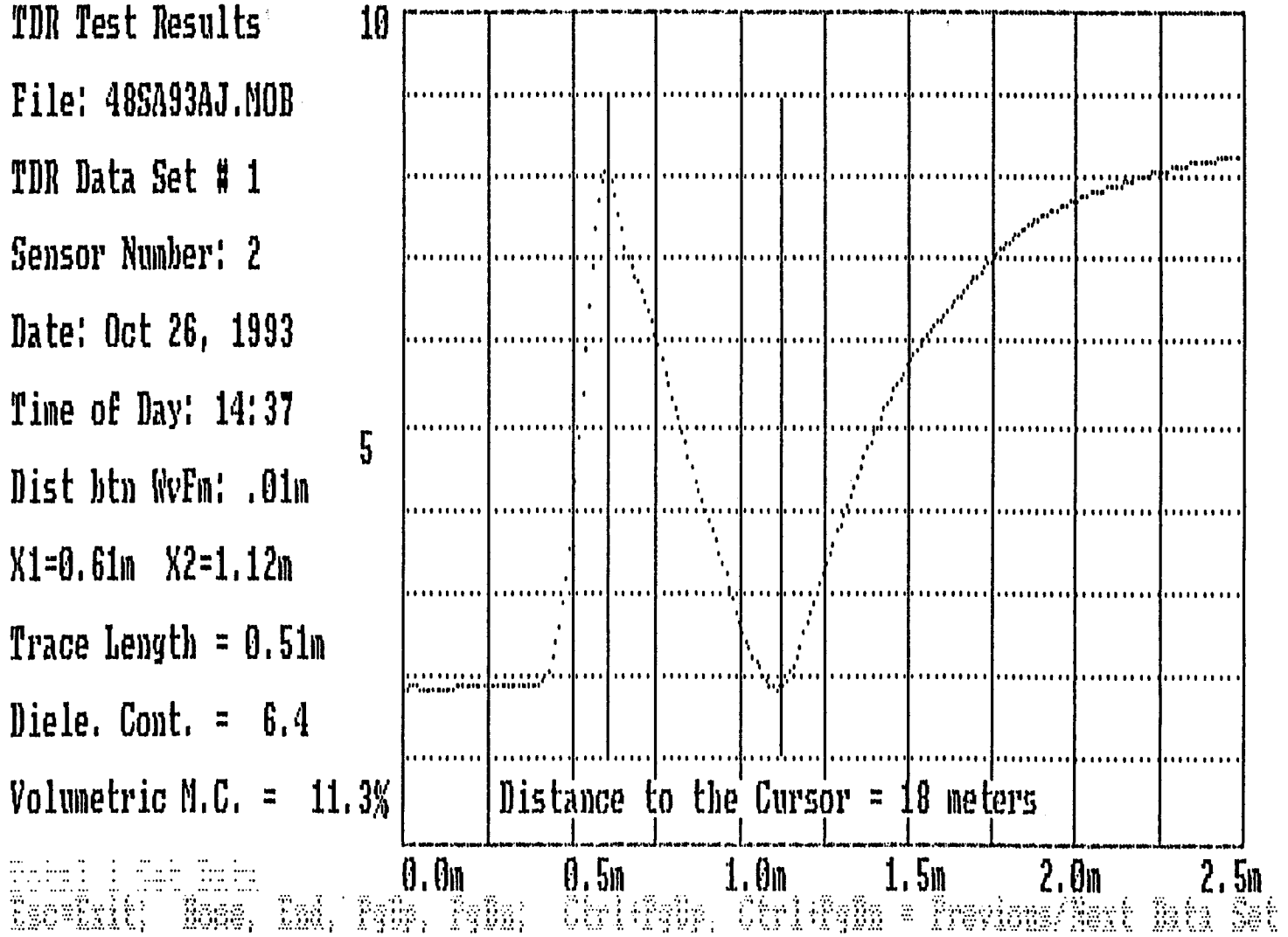

Figure D-7. Trace from TDR Sensor 2

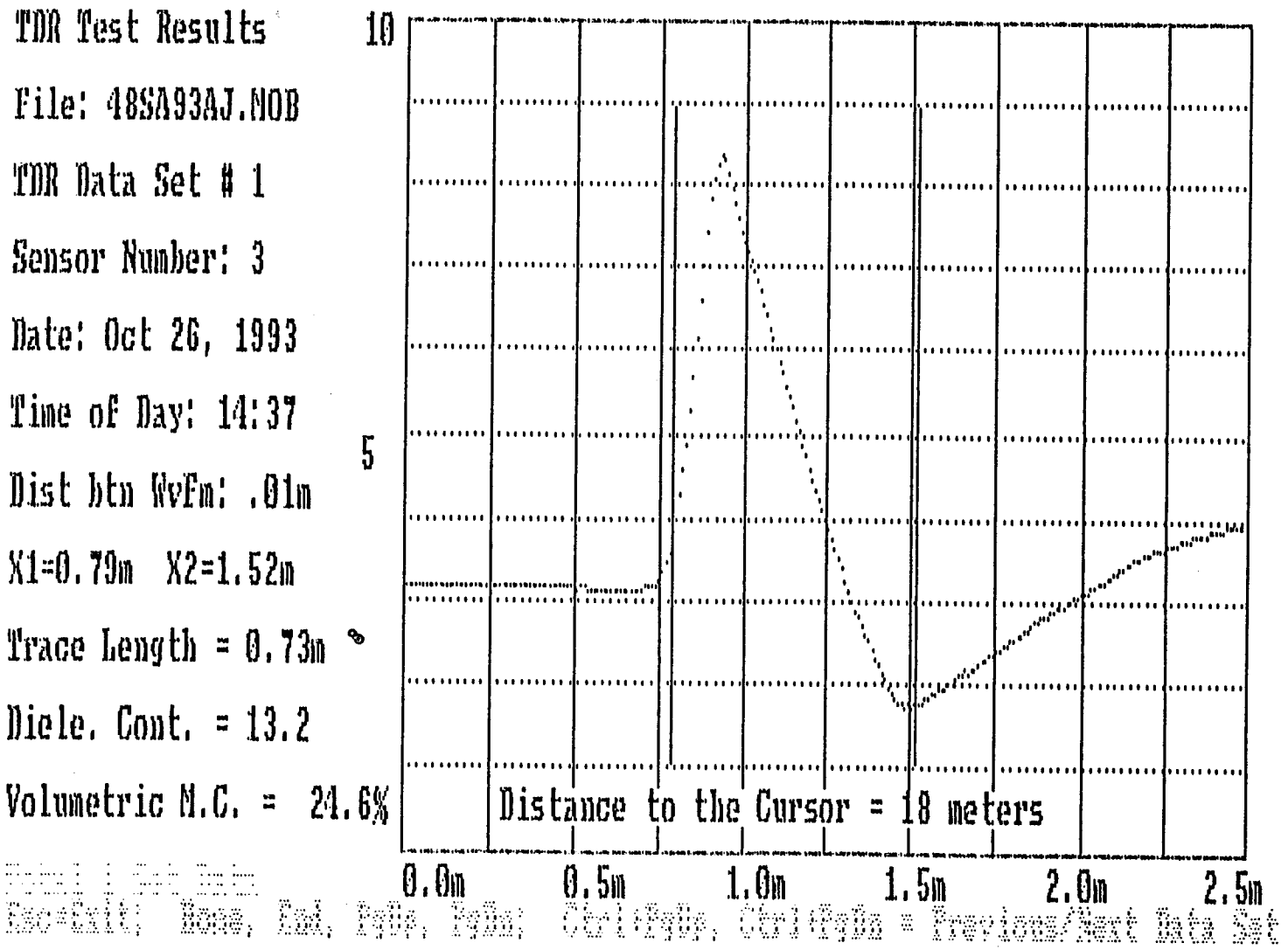

Figure D-8. Trace from TDR Sensor 3

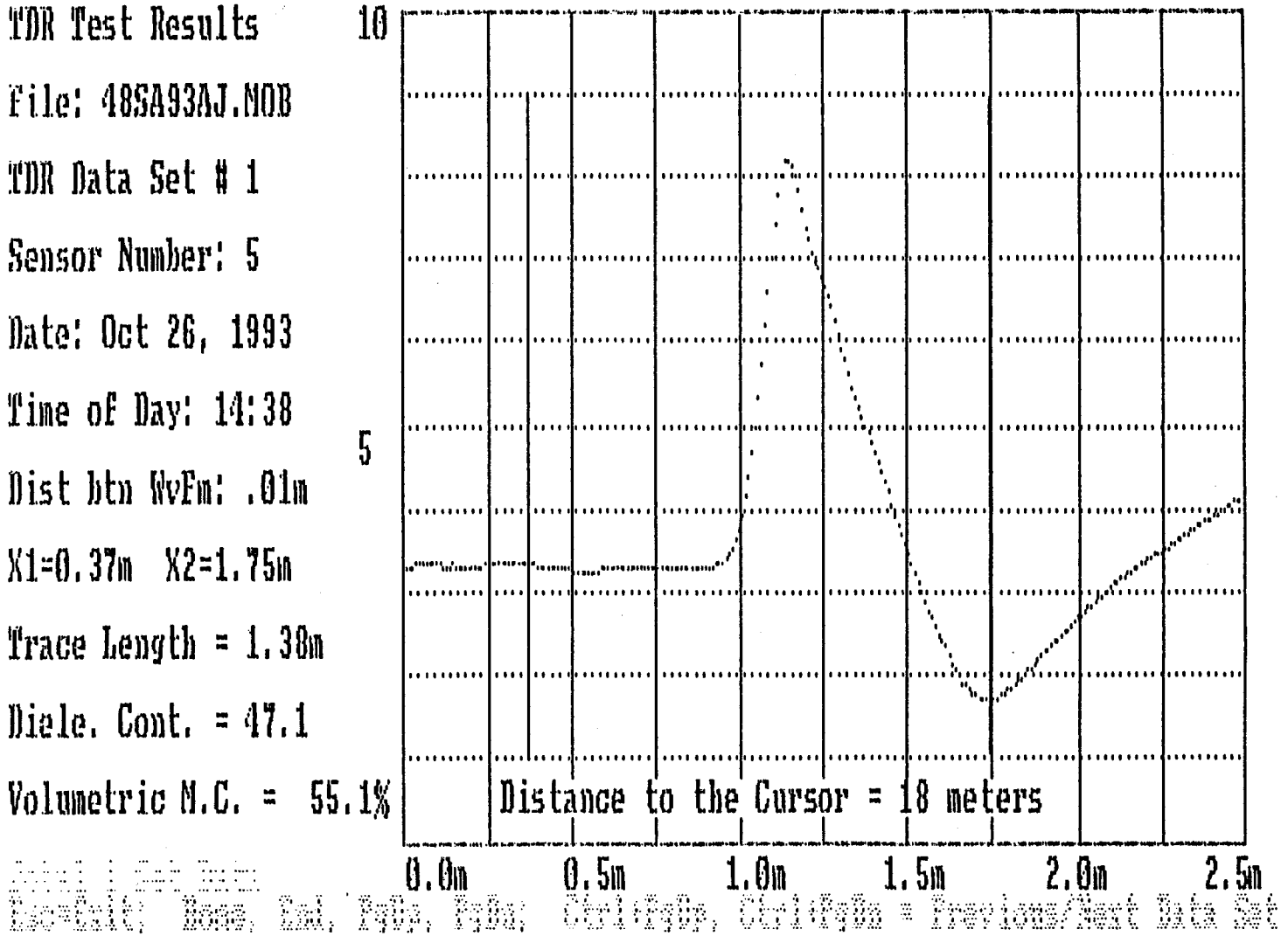

Figure D-10. Trace from TDR Sensor 5

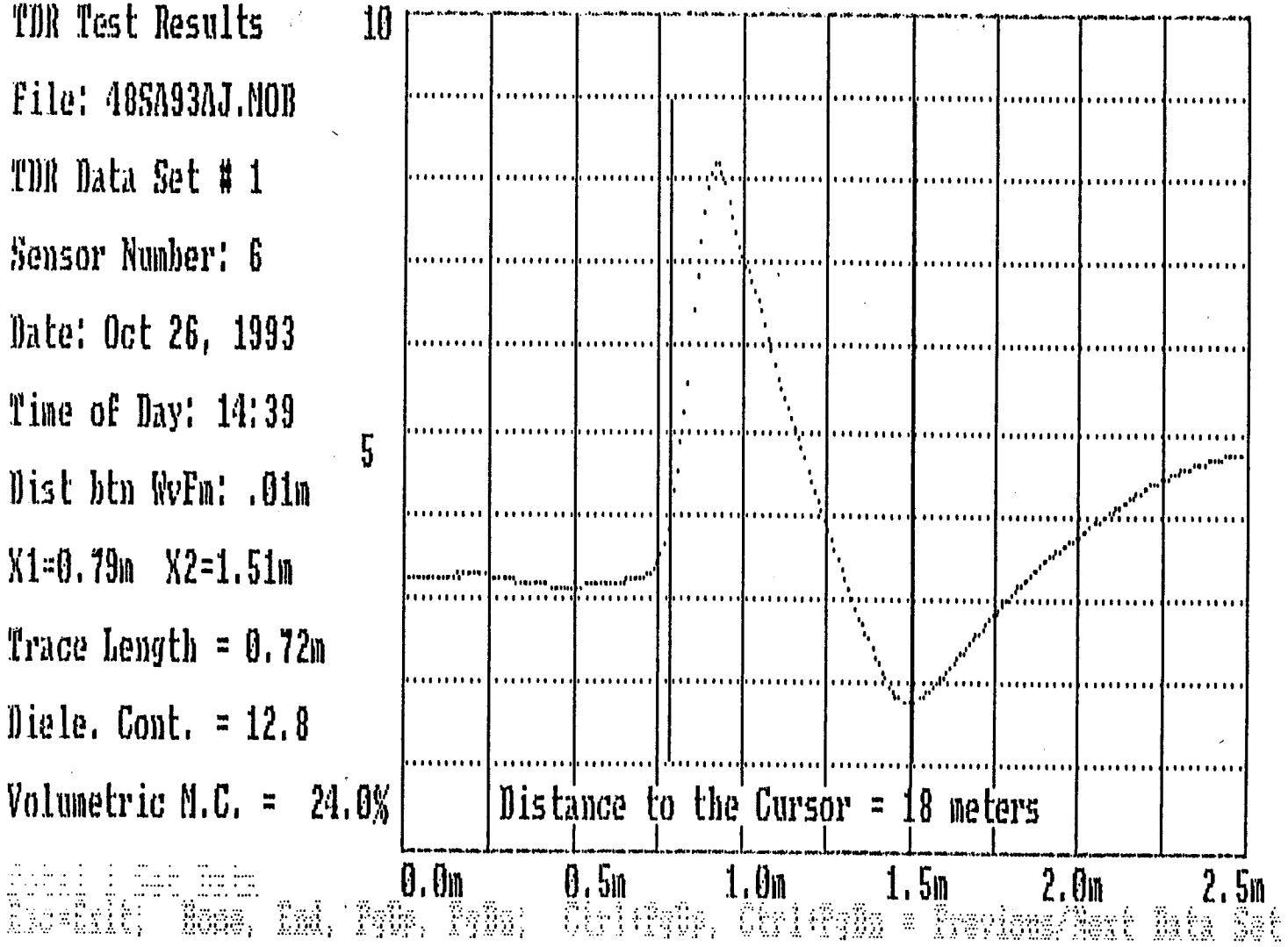

Figure D-11. Trace from TDR Sensor 6

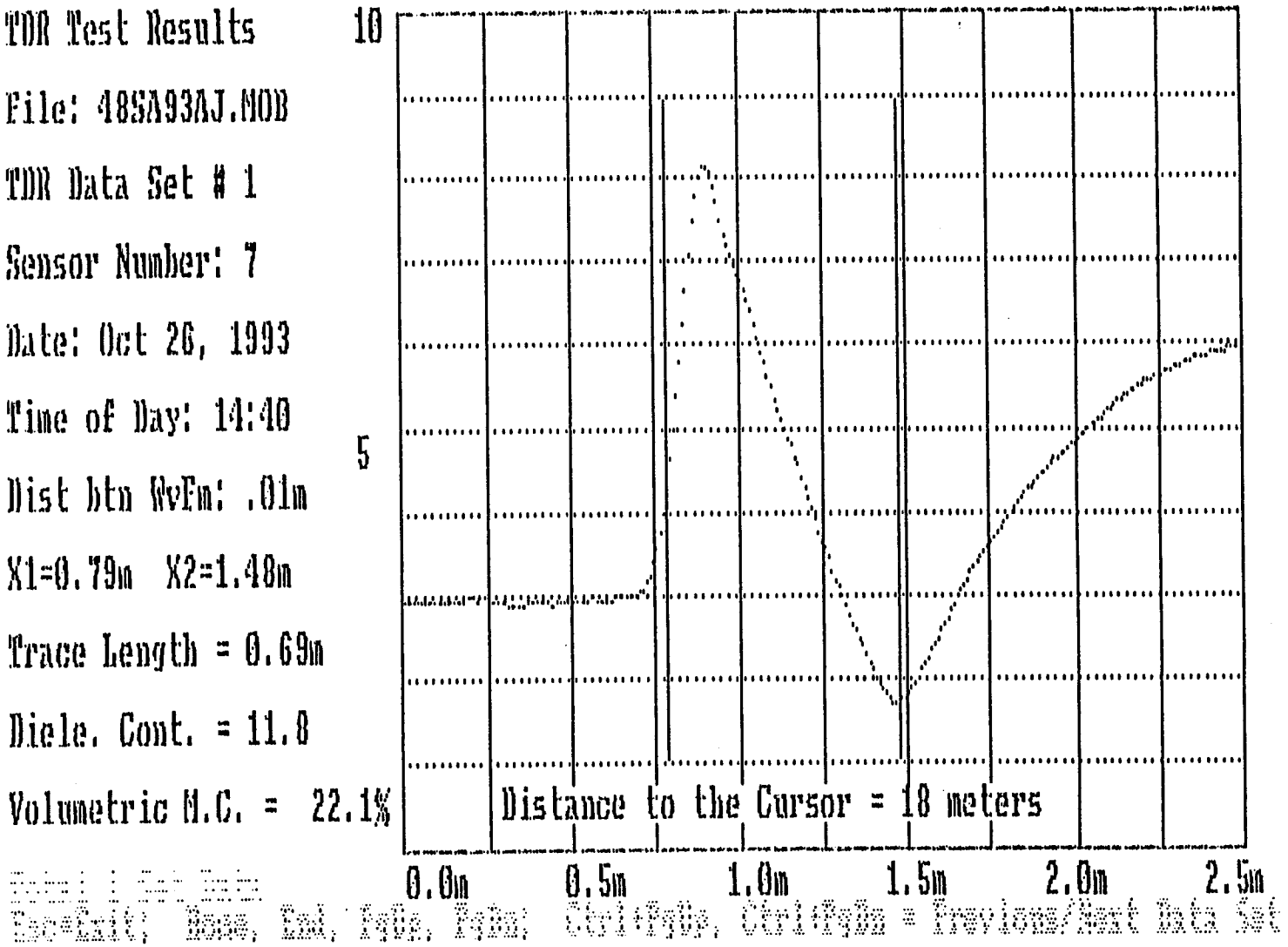

Figure D-12. Trace from TDR Sensor 7

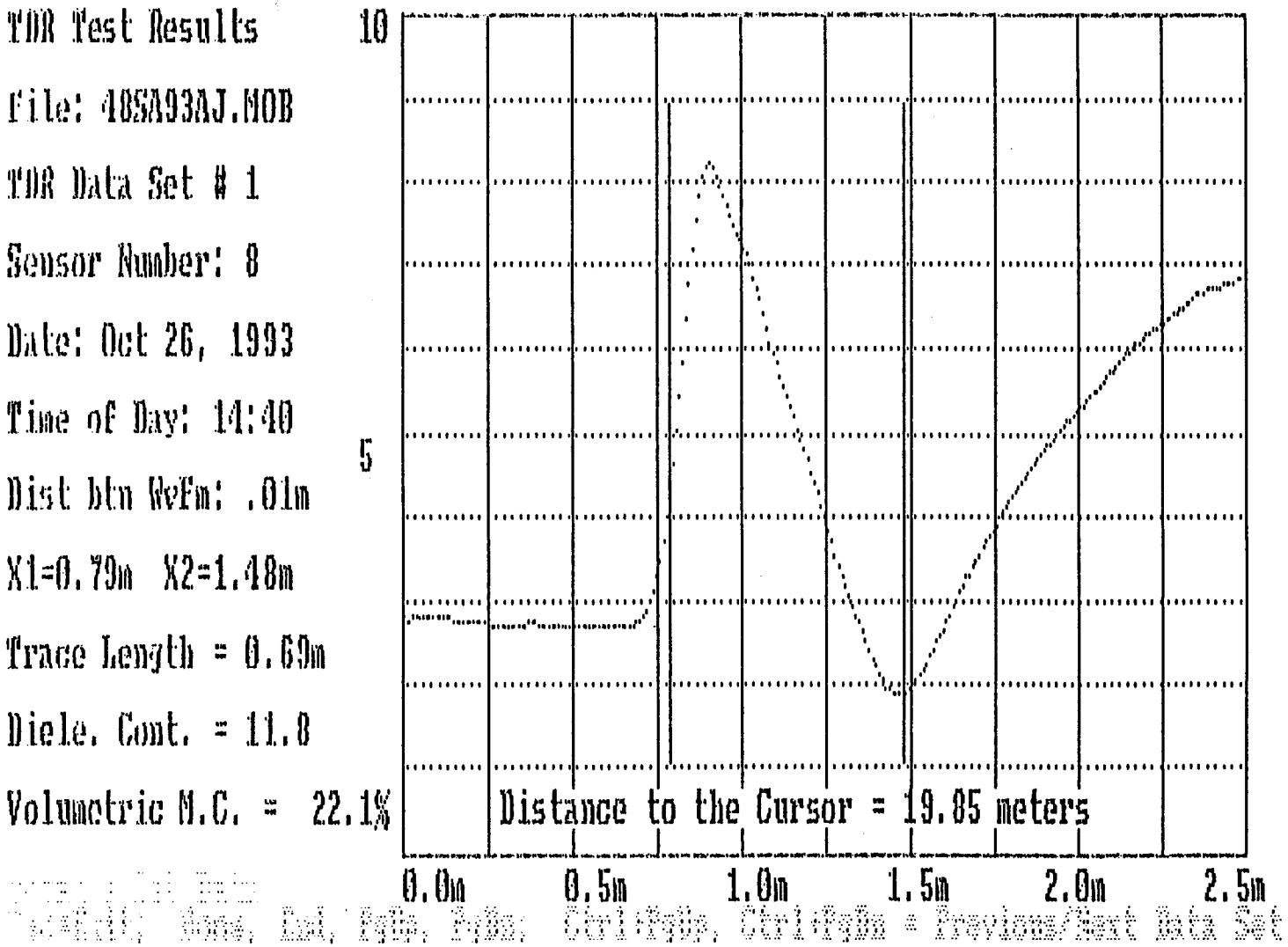

Figure D-13. Trace from TDR Sensor 8

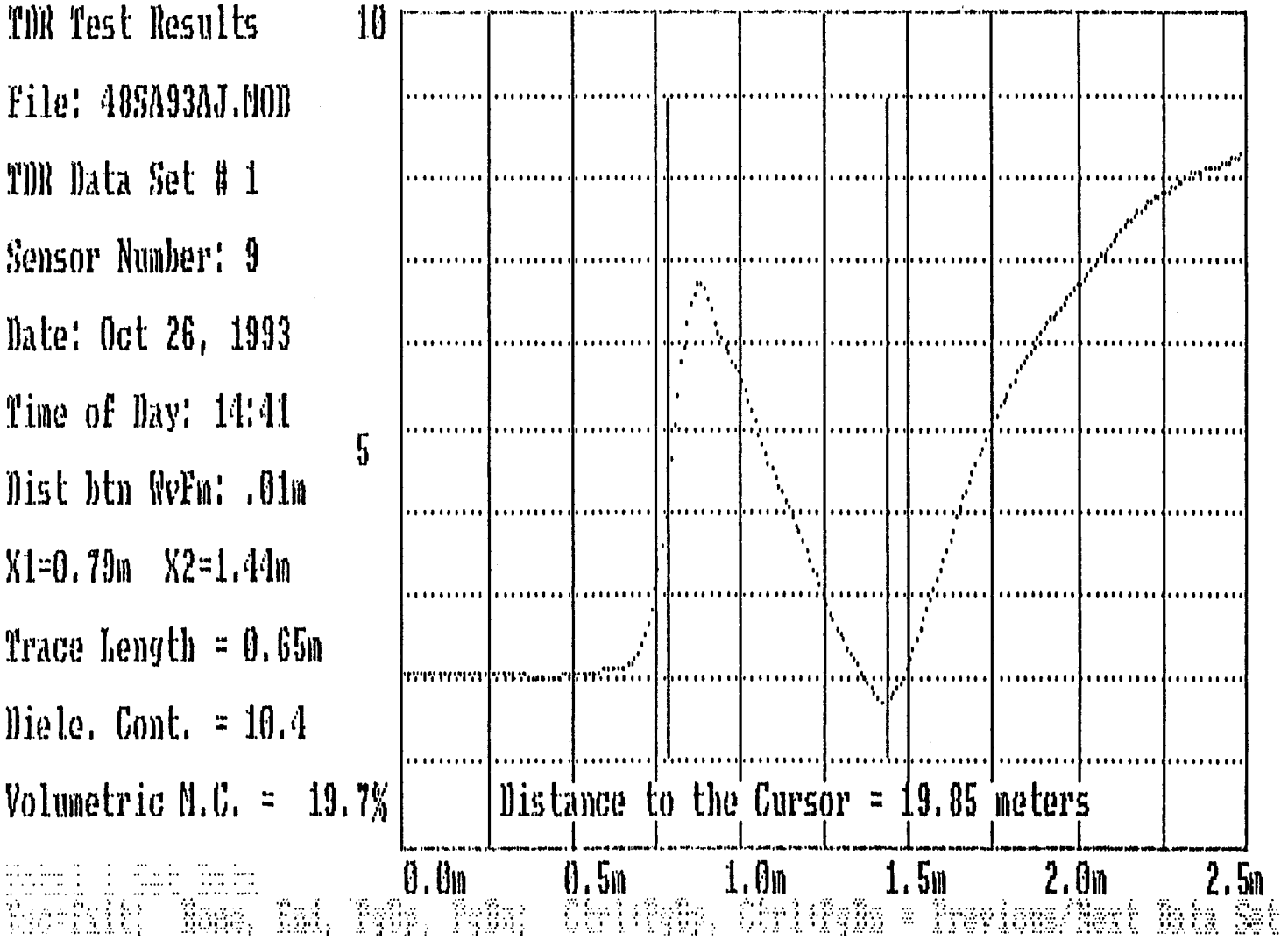

Figure D-14. Trace from TDR Sensor 9

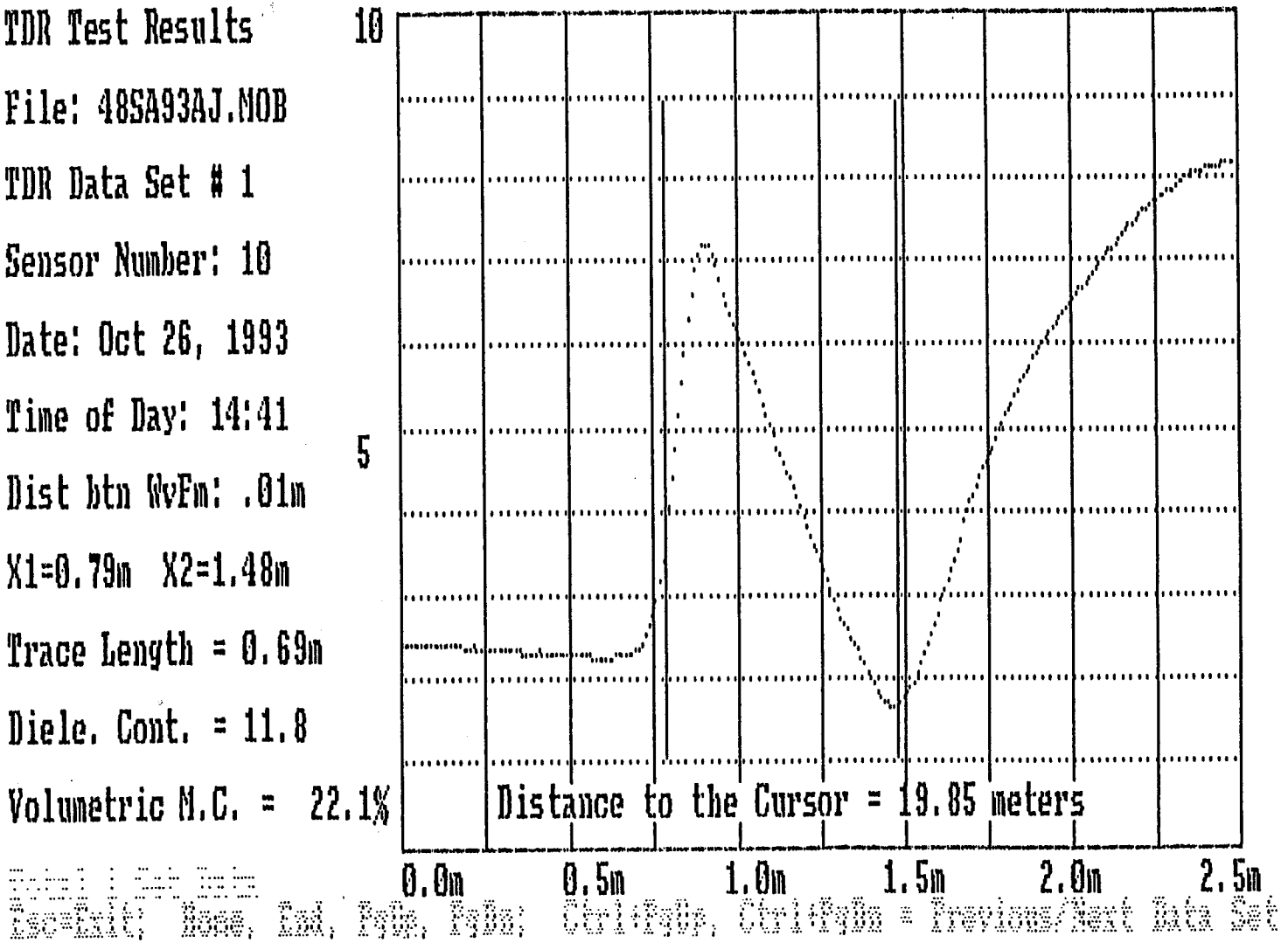

Figure D-15. Trace from TDR Sensor 10

48SA

SEASONAL MONITORING
"FLEX" TRANSVERSE ELEVATION MEASUREMENTS[1]

Station	Outside Edge		OWP		ML		IWP		Inside Edge	
	O/S	Elev.	O/S	Elev.	O/S	Elev.	O/S	Elev.	O/S	Elev.
3+00	.10M	1.0919	.90M	1.0828	1.93M	1.116	2.77M	1.115	3.73M	1.150
3+25	"	1.052	.87M	1.040	1.93M	1.077	2.85M	1.081	"	1.110
3+50	"	0.999	.89M	0.993	2.01M	1.031	"	1.029	"	1.064
3+75	"	0.946	.86M	0.955	"	0.9821	"	0.982	"	1.013
4+00	"	0.915	.84M	0.912	"	0.949	"	0.946	"	0.978
4+25	"	0.880	"	0.878	"	0.909	"	0.915	"	0.946
4+50	"	0.833	.82M	0.839	"	0.872	"	0.872	"	0.903
4+75	"	0.781	.79M	0.781	"	0.814	"	0.820	"	0.851
5+00	"	0.717	.84M	0.717	"	0.753	"	0.753	"	0.781
5+10			"	0.686						
5+20					1.91M	0.671				
5+30			.91M	0.622						

Bench Mark : TX. DOT MONUMENT OFF EDGE OF SHOULDER 3.25 M FROM OUTSIDE EDGE OF SHOULDER STRIPE, STA. 0+00, ELEV. PAINTED ON SHOULDER 1834.63FT. CONVERTED TO 559.56 M
INST. @ STA. ± 2+85 MID SHOULDER

Comments: P.K. NAILS SET @ STATIONS @ OUTSIDE EDGE OF SHOULDER STRIPE FOR BASELINE; P.K. NAILS SET @ 3.76 M FROM OUTSIDE ℄ FOR ℄ ℄
ACTUAL P.K. STA. TO PAINTED + PLUS 4 = -24"±; PAINTED + (PLUS) 3 = -12"; 5 PLUS TO 3 PLUS = 202'
WINDY, CLOUDY, PARTLY CLOUDY

Test Section No.	481077	**Date**	10/26/93
Time	10:20	**Device Used**	LASER PLANE LEVEL
Recorded By	JON. P. TØM	**Employer**	BRENT RAUHUT ENG.

[1] **OWP and ML readings to be taken at FWD test locations**

Table D-4. Elevation Measurements from Installation

APPENDIX E

Photographs

Appendix E contains the following photographs:

Photo E-1. General Photo of Test Section

Photo E-2. Location of Instrumentation Area

Photo E-3. Preparing for Instrumentation Installation

Photo E-4. Placement of Instrumentation Probes

Photo E-5. Setting Monitoring Well

Photo E-6. Preparing Weather Station for Installation

Photo E-7. Patched Instrumentation Area

Photo E-8. Monitoring and Data Collection After Installation

Photo E-9. Location of Benchmark

Photo E-10. Observation Well