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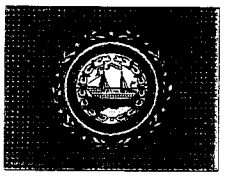

LTPP Seasonal Monitoring Program

Site Installation and Initial
Data Collection
Section 331001, Concord
New Hampshire

Report No. FHWA-TS-94-33-01

June 1994

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LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection
Section 331001, Concord New Hampshire

Report No. FHWA-TS-94-33-01

Prepared by

Pavement Management Systems Limited
415 Lawrence Bell Drive - Suite 3
Amherst, New York 14221

Prepared for

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

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15. Supplementary Notes

The report is a cooperative effort between New Hampshire Department of Transportation Bureau of Materials and Research, Long Term Pavement Performance (LTPP) Division Federal Highway Administration, and Pavement Management Systems Limited LTPP North Atlantic Region Coordination Office.

16. Abstract

This report provides a description of the installation of seasonal monitoring instrumentation and initial data collection for the seasonal experimental study conducted as part of the Long Term Pavement Performance (LTPP) program at the General Pavement Study (GPS) section 331001 on I 393 in Concord New Hampshire. This asphalt concrete surface pavement test section was instrumented on October 13, 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 gage, piezometer to monitor the ground water table, and an on-site data logger. Initial data collection was performed on October 14, 1993 which consisted of deflection measurements with a Falling Weight Deflectometer, 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
Instrumentation, Monitoring, Survey, FWD, Profilometer, Time Domain Reflectometry, Thermistor, Piezometer, Electrical Resistance, Electrical Resistivity.	

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SEASONAL INSTRUMENTATION STUDY
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NEW HAMPSHIRE SECTION 331001

I. Introduction

The installation of instrumentation on seasonal site 331001 near Concord, New Hampshire was performed on October 13 - October 14, 1993.

The test section is a GPS-1 experiment, located on eastbound Interstate 393, approximately two miles east of Concord city limits (Figure A-1 in Appendix A). The highway consists of two 3.7m wide lanes in each direction with a 3.4m wide outside and a 1.2m wide inside paved shoulders.

The site is in a fill area with a pavement structure consisting of 213mm of asphalt concrete, 490mm of uncrushed gravel base and 366mm of soil aggregate mixture subbase over a coarse poorly graded sand with silt. The fill embankment is approximately 10m above the natural ground level. The depth to rock below road surface is more than 30m. Pavement structure information from the GPS material drilling logs is presented in Figure A-2. Properties determined from the laboratory material tests are shown in Table 1.

Table A-1 in Appendix A summarizes the distress, IRI values from the Profilometer longitudinal profile measurements, and Falling Weight Deflectometer deflection values as monitored since 1989. The uniformity survey results are summarizes in Appendix A, Table A-2 and the deflection values and analysis results from the FWDCHECK are also presented in Appendix A.

The site is in a wet-freeze zone and resides in cell 16 (thick AC on coarse subgrade) of the seasonal monitoring program. The annual average frost depth is 1.4m and the maximum is 1.8m. Salt is frequently used for ice control at this location. Below is a summary from the LTPP climate database based on ten years of data:

Freezing Index (C-Days)	571
Precipitation (mm)	1016
No. of Freeze/Thaw Cycles	122
Days Above 32C	7
Days Below 0C	160
Wet Days	142

The road was opened in 1981. The estimated annual average daily traffic (AADT) in 1992 was 21492 (two way) of which 4.8% was truck traffic on the GPS lane. The Traffic in the GPS direction carried approximately 50% and the GPS lane carried 41.1% of the total AADT. The estimated annual kESALs on the GPS lane in 1992 were 97.6 using vehicle

ESALs. These figures are based on 195 days of AVC coverage and 206 days of WIM data in 1992.

Installation of the instrumentation was a cooperative effort between New Hampshire Department of Transportation, Federal Highway Administration, and Pavement Management Systems Limited (PMSL) LTPP North Atlantic Region Coordination Office staff.. The following personnel participated in the instrumentation installation:

Alan Rawson	NHDOT
Edward Coffern	NHDOT
Douglass McNeil	NHDOT
Robert Yeaton	NHDOT
Robert Backus	NHDOT
Stacy Lane	L&S Concrete Cutting
Robert McGlashan	Con-Tel Inc.
John Klemunes	FHWA_LTPP Division
Brandt Henderson	Pavement Management Systems (NARO)
Perry Zabaldo	Pavement Management Systems (NARO)
Mike Zawisa	Pavement Management Systems (NARO)
Doug Marshall	Pavement Management Systems (NARO)

Table 1. Material Properties

Description	Surface	Base	Subbase	Subgrade
Material (Code)	Dense Graded HMAC (01)	Uncrushed Grav (302)	Soil Agg Mix. (308)	Sand (204)
Thickness (mm)	213	490	366	
Lab Max Dry Density (kg/m^3)		2198	2061	1845
Lab Opt Moisture Content (%)		7.0	6.5	12.0
In-situ Wet Density (kg/m^3) *		2371		2039
In-situ Dry Density (kg/m^3) *		2153	2105	1858
In-situ Moisture Content (%) *		4.6	4.0	6.5
Bulk Specific Gravity	2.386			
Max Specific Gravity	2.518			
Liquid Limit		0		0
Plastic Limit		0		0
Plasticity Index		NP		NP
% Passing # 200		4.55	6.45	11.35

* Note: Test pit @ station 5+60

II. Instrumentation Installation

Site Inspection and Meeting with Highway Agency

A site inspection was done on July 29, 1992 in conjunction with the FWD uniformity survey. The review was conducted by Brandt Henderson (NARO) and Alan Rawson (NHDOT). The information for the design of the seasonal monitoring instrumentation was completed, along with a review of the present site conditions and potential location for the instrumentation. The site is in overall good condition with no current plans for rehabilitation. The FWD uniformity survey indicated the section to be acceptable from a deflection standpoint, with either end being suitable for instrumentation installation. The west end of the site (station 0+00) was preferable from a traffic control perspective due to the close proximity to East Side Drive, RT. 132 (exit #2) at the 5+00 end.

During the site visit, the FWD was demonstrated to groups of state employees from the materials and pavement management group. There was particular interest from the materials department as they were about to embark on a study of recycled asphalt pavement with the Cold Region Research and Engineering Lab (CRREL) utilizing CRREL FWD.

A preliminary planning meeting was held with NHDOT officials on September 10, 1994. This meeting was held at NHDOT Material and Research Laboratory, Concord with Alan Rawson - NHDOT, Bill Phang - NARO, Brandt Henderson - NARO, and other personnel from the NHDOT Materials staff. A presentation on the installation of seasonal monitoring instrumentation and monitoring requirements were provided by Bill Phang and Brandt Henderson. This was followed by a review and discussion on the seasonal site. Plans for the installation on October 13-14, 1993 were discussed; which covered tasks to be done by state resources and material requirements. Correspondence from the site inspection and planning meeting are provided in Appendix B.

A pre-installation meeting was held on the afternoon of October 12, 1993 at the Materials and Research Laboratory, Concord, NH. Plans for the following day were discussed along with a verification check of the equipment to be used for coring the asphalt layer, augering the instrumentation hole, cutting the trench to the instrumentation cabinet and the various supplies necessary to complete the installation and patch the pavement. Arrangements were made to have traffic control setup for 7:30 a.m. with the sawing and cutting contractor and the drilling contractor to be onsite by 8:00 a.m.

Equipment Installed

The equipment installed at the test site included instrumentation for measuring air and subsurface temperature, subsurface moisture content, frost depth, and water table. An equipment cabinet was installed to hold the datalogger, battery pack, and all electrical connections from the instrumentation. The equipment installed are shown in Table 2.

Table 2. Equipment Installed

Equipment	Quantity	Serial Number
Instrumentation Hole		
MRC Thermistor Probe	1	33AT
CRREL Resistivity Probe	1	33AR
TDR Probes	10	33A01-33A10
Equipment Cabinet		
Campbell Scientific CR10 Datalogger	1	16565
Campbell Scientific PS12 Power Supply	1	5613
Weather Station		
TE525MM Tipping Bucket Rain Gage	1	12079-693
Campbell Scientific 107-L Air Temperature Probe	1	33AAT
Observation Well/Bench Mark	1	none

Equipment Check/Calibration

Prior to installation, each measurement instrument was checked or calibrated. The tipping bucket rain gauge was connected to the CR10 datalogger for calibration. A plastic container with 473ml of water was placed in the tipping bucket. The container had a small hole in the bottom, which allowed all the water to be drained out in 45 minutes. For the 473ml of water, the tipping bucket should measure 100 tips $\pm$ 3 tips. The results showed 97 tips, which was in specification.

The air temperature and thermistor probes were connected to the CR10 datalogger simultaneously. They were checked by placing the probes in ice, room temperature, and boiling water. In order for the probes to pass this check, the temperatures for each probe should correspond to the water temperature. The check indicated that the air temperature and thermistor probes were working properly. A second check was done where the air temperature and thermistor probes were connected to the datalogger and run ,in air, for 24 hours. The minimum, maximum, and mean temperature for each sensor were checked. All 18 thermistors were similar in their minimum, maximum, and mean readings respectfully, therefore the probes were considered functioning correctly. The results of the air temperature and thermistor probes along with the spacing between the thermistors are presented in Appendix B.

The wiring of the resistivity probe was checked using continuity measurements between each electrode and the corresponding pins on the connector. The distance between each electrode was measured and recorded as shown in Table B-4 in Appendix B. Contact resistance measurements were performed with the probe immersed in a salt water bath. The results of these measurements are also shown in Appendix B. Due to defects in the manufacturing, clear silicon sealant was used to cover exposed wires to the electrodes. The checks on the resistivity probe indicated all electrodes were functioning.

The functioning of the TDR probes were checked by performing measurements in air, water, methyl alcohol, and with the prongs shorted at the circuit board and the end of the probe. The traces were taken and the dielectric constant was calculated for the water, air, and methyl alcohol. These values were checked against expected dielectric constants for each medium. The test indicated that all probes were functioning properly. Results of the TDR measurements are presented in Appendix B.

Equipment Installation

Final details for the installation and initial monitoring were discussed in a meeting on the afternoon of October 12, 1993. The installation was confirmed for 8:00 a.m. on October 13, 1993. Traffic control for the installation and monitoring was provided by the NHDOT district 5 office, Concord. The pavement surface drilling and sawing were done by Stacey Lane of L and S Concrete Cutting, Epson, NH. The augering of the piezometer and instrumentation hole was done by Robert McGlashan of Con-Tec Inc., Concord, NH. The installation of the measurement equipment, the observation piezometer, weather station pole, and cabinet was performed by FHWA-LTPP and PMSL staff with assistance from the NHDOT materials and research group and the local district personnel.

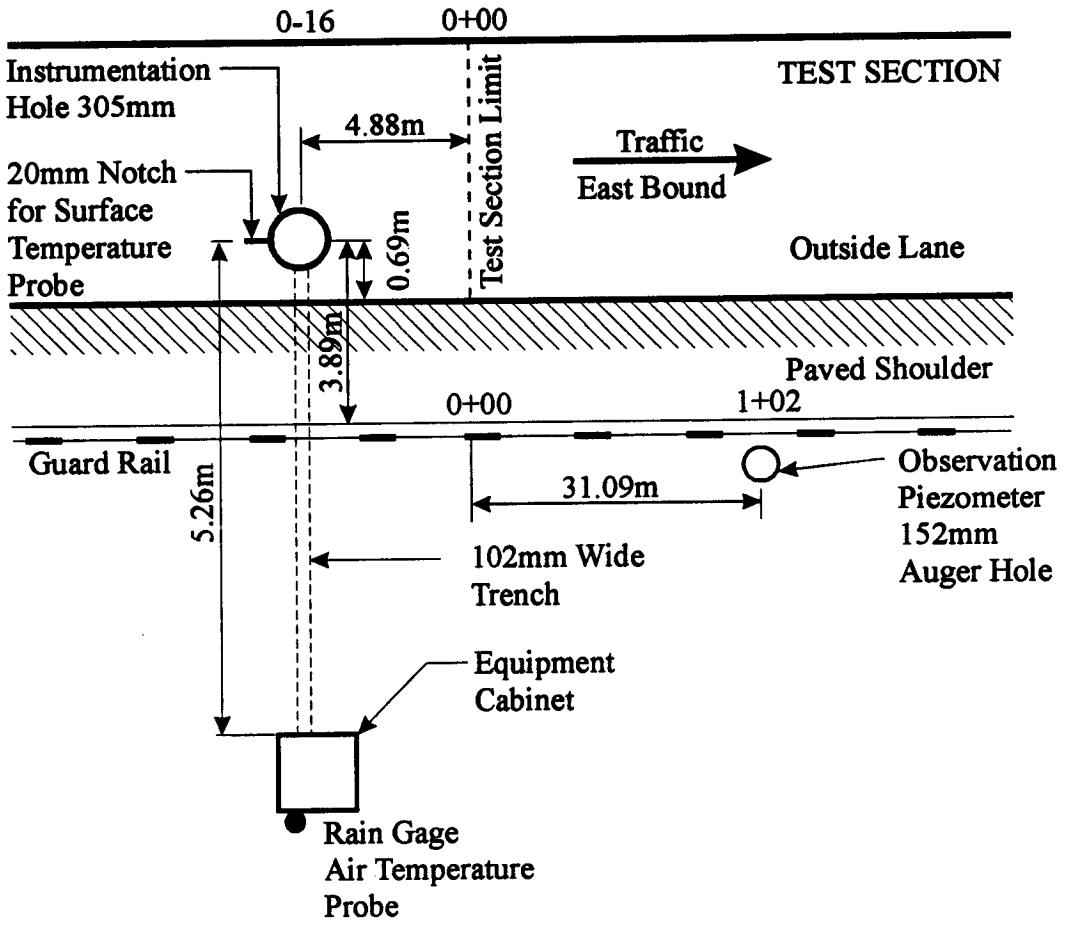
The instrumentation was installed on the east end of GPS 331001, in the outside lane of I-393 near Concord, New Hampshire. The combination benchmark/piezometer was placed in the shoulder at station 1+02. The in-pavement instrumentation was installed in the outer wheel path at station 0-16. The cabling from the instrumentation was placed in a 51mm flexible conduit and buried in a trench running from the instrument hole to an equipment cabinet installed behind the guardrail on the slope of the roadway embankment, 5.26m from the instrumentation hole. The weather pole was installed immediately behind the equipment cabinet. Figure 1 provides the location and distances for the various instrumentation and equipment installed.

The installation generally followed the procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". The combination piezometer/benchmark was installed just off the edge of the paved shoulder to a depth of 4.44m using a 152mm flight auger for drilling the hole. It was necessary to remove a section of the guardrail for the drill truck to obtain access to the area were the drilling was to be done. A sample of the material was retained from approximately .5 to 1.5m below the surface. The hole was slightly over bored due to material collapsing into the hole. The 25.4mm galvanized pipe was firmly pressed into the hole, followed by 1.9m

of filter sand, a .33m bentonite plug with the remainder of the hole filled with the native material removed. The final elevation for the pipe was 152mm below the natural ground level at the location of the installation. A pyramid well cap, held in location by approximately 25kg of concrete mix, was used to cover and protect the piezometer/benchmark.

A core hole was drilled in the pavement surface, located in the outside wheel path, 0.76m from the edge of the travel lane at station 0-16, using a portable electric drill and a 305mm thin wall diamond core barrel. A 102mm wide by 225mm deep saw cut was done between the core hole and the edge of the pavement, using a heavy duty pavement cutting machine, to accommodate the instrumentation cabling. The blade of the pavement saw was used to notch a location for the pavement surface temperature probe at the west edge of the core hole.

A combination of methods were used to excavate the instrumentation hole. The driller used a 290mm flight auger to loosen the base material, which was removed by hand. The subbase material could not be easily distinguished from that of the base material as defined from the drilling and sampling. The sand with silt and stone encountered below the subbase material, was removed with the auger to a depth of 2.10m. The findings from the excavation of the instrumentation hole at station 0-16 are presented in Figure 2. All the material excavated from the instrument hole was placed and compacted in order of removal. Samples of the material placed around the TDR probes were retrieved to determine the gravimetric moisture at these locations. A field moisture determination was done at the site with sample material retained for laboratory moisture determination by the NHDOT Materials and Research laboratory. No additional material remained from the instrumentation hole with some material from the trench area required to top up and level the instrumentation hole. The equipment cabinet and pole for the rain gage and air temperature probe were installed as per manual guidelines. The excavation of the trench, aside from the need to remove the guardrail, went fairly smooth as the material was a generally clean sand without cobbles or boulders. The wiring of the instrumentation to the equipment cabinet was completed on the same day as installed.



- Height of Air Temperature Probe (center): 3.07m
- Height of Tipping Bucket Rain Gage (center): 3.05m
- Total Depth of Piezometer: 4.29m
- Distance of Piezometer Below Ground Level: 152mm

Figure 1. Location for Seasonal Monitoring Instrumentation Installed at GPS 331001

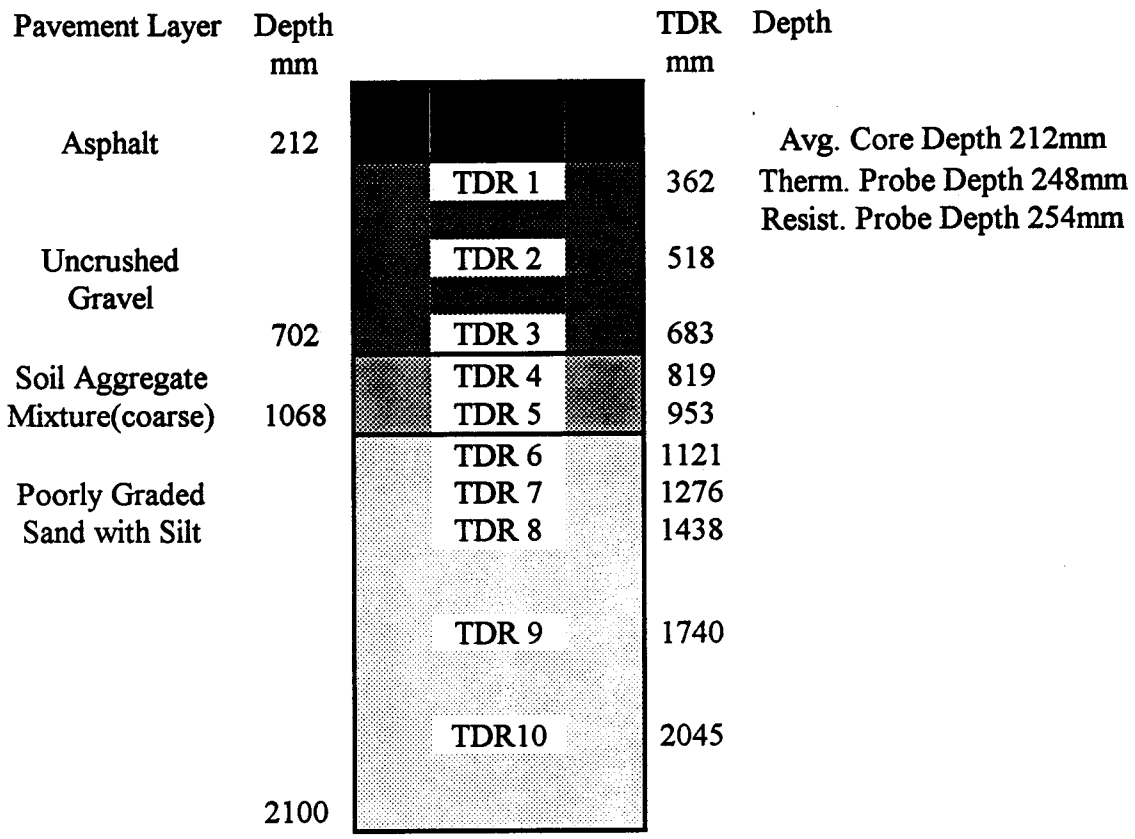


Figure 2. Profile of Pavement Structure and Probe Depths from Surface, Station 0-16

To check for breakage of the TDR probes during installation, each probe was connected to the cable tester and its wave form monitored during compaction of the material around it. The TDR traces are included in Appendix C. By alternating the TDR probes within the instrument hole we were able to keep the cables separate to avoid water from migrating along a bundle of cables attached to the probes placed at various depths. The thermistor and resistivity probes were installed at opposite sides of the instrumentation hole with the thermistor probe .248m and the resistivity probe .254m below the pavement surface. The cables were kept spaced as best as possible until they converged at the opening of the flexible conduit pipe, placed about 50mm from the edge of the core hole. The cables were then tie wrapped and passed through the conduit to the equipment cabinet. The ends of the conduit were plugged with a mastic pipe sealant.

Tables 3, 4, and 5 present the installed depths of the TDR probes, thermistor sensors, and the resistivity probe respectively. Table 6 gives TDR moisture content and field measured moisture content during installation. Moisture samples were also collected to take to the laboratory but were never delivered.

Table 3. Installed Depths of TDR Sensors

Sensor #	Depth from Pavement Surface (m)	Layer
33A01	0.362	Base
33A02	0.518	
33A03	0.683	
33A04	0.819	Subbase
33A05	0.953	
33A06	1.121	Subgrade
33A07	1.276	
33A08	1.438	
33A09	1.740	
33A10	2.045	

Table 4. Installed Location of MRC Thermistor Sensor

Unit	Channel Number	Depth from Pavement Surface (m)	Remarks
1	1	0.025	This unit was installed in the AC layer.
	2	0.106	
	3	0.187	
2	4	0.266	This unit was installed below the AC layer into the subgrade.
	5	0.342	
	6	0.418	
	7	0.496	
	8	0.570	
	9	0.723	
	10	0.874	
	11	1.028	
	12	1.178	
	13	1.332	
	14	1.482	
	15	1.634	
	16	1.787	
	17	1.941	
	18	2.090	

Table 5. Location of Electrodes of the Resistivity Probe

Connector Pin Number	Electrode Number	Depth from Pavement Surface (m)
36	1	0.284
35	2	0.333
34	3	0.384
33	4	0.436
32	5	0.486
31	6	0.536
30	7	0.587
29	8	0.639
28	9	0.689
27	10	0.740
26	11	0.790
25	12	0.840
24	13	0.891
23	14	0.941
22	15	0.991
21	16	1.041
20	17	1.092
19	18	1.143
18	19	1.193
17	20	1.244
16	21	1.294
15	22	1.345
14	23	1.394
13	24	1.448
12	25	1.497
11	26	1.547
10	27	1.597
9	28	1.647
8	29	1.697
7	30	1.749
6	31	1.799
5	32	1.850
4	33	1.899
3	34	1.949
2	35	2.001
1	36	2.050

Table 6. TDR, Field, and Laboratory Moisture Content During Installation

Sensor Number	Sensor Depth (m)	Layer	TDR Moisture Content (by wt)*	Field Moisture Content (by wt)*	Lab Moisture Content (by wt)**
33A01	0.368	Base	4.26%	2.55%	
33A02	0.521		4.26%	2.16%	
33A03	0.660		6.12%	3.75%	
33A04	0.813	Subbase	10.91%	10.75%	
33A05	0.953		10.91%	11.00%	
33A06	1.118	Subgrade	11.66%	9.73%	
33A07	1.270		7.07%	6.16%	
33A08	1.435		7.07%	5.85%	
33A09	1.756		7.71%	6.99%	
33A10	2.045		5.22%	7.89%	

* Note: Raw data given in Appendix C

** Note: Moisture samples collected but never delivered to Lab

Site Repair and Cleanup

The instrumentation hole was repaired by reinstalling the 305mm asphalt core. Some juggling was required to get the core level with the existing pavement surface. Once the core was leveled it was removed from the hole and the bottom 100mm was heavily covered with a two part epoxy (PC-7) and reset into the hole forcing the epoxy against the side and up along the wall of the core hole. The weight of the state dump truck, which slowly moved back and forth over the core, was used to firmly seat the core into the hole.

The trench for the cabling from the instrumentation hole to the edge of pavement was leveled with crushed gravel to the existing bottom of the paved layer and a cold mix was compacted to the level of the existing surface. The remainder of the trench was filled with native material and compacted, followed by a cleanup of loose material from the paved area. The guardrails were reinstalled by the state district personnel. Traffic control was removed at 6:00 p.m. and the lane reopened to traffic. During the next day the instrument hole and edge of the trench were sealed using Corning self-leveling 888 crack sealing compound. Removal of the asphalt trench material and other disposable items were handled by the NHDOT district personnel.

Patch/Repair Area Assessment

When the site was visited on December 28, 1993 two and a half months after installation, the instrumentation hole patch was checked. There was some settlement in the patched areas and the sealant did not hold properly, but the core remained relatively level with the existing pavement.

III. Initial Data Collection

The second day activities included initial data collection on the site and checks on functioning of installed equipment. This consisted of examination of the data collected over the day by the onsite datalogger, data collection and check of the mobile CR10 datalogger, deflection testing, and elevation survey.

Air Temperature, Subsurface Temperature, Rain-fall Data

The air temperature, pavement subsurface temperature profile, and rainfall data, collected on October 14 by the CR10 datalogger, were examined. The equipment and datalogger appeared to be functioning properly. The battery voltages were checked and found to be acceptable. Raw data collected at the site are presented in Appendix D.

The data collected for October 14, 1993 was not sufficient to show change in temperatures. This was due to the fact that the onsite.dld program, that was downloaded to the datalogger, only records hourly averages (only field 5 data collected). The d_onsite.dld, which stores data every minute, should have been used to collect the data.

The tipping bucket rain gauge was checked by determining the number of tips recorded from 473ml of water discharged into the gauge over a 1 hour time period. The rain gauge was found to be operating properly.

TDR Measurements

TDR data were collected using the mobile system provided by FHWA. The mobile system contains a CR10 datalogger, battery pack, two TDR multiplexers, and a resistance multiplexer circuit board. Version 1.0 of the MOBILE program was used to collect and record the TDR wave form traced for each sensor.

Figures D-1 and D-2 show the initial TDR wave form traces collected with the MOBILE data acquisition system for all 10 sensors. The figures indicate that the multiplexers of the mobile system and TDR sensors were working properly.

Resistance Measurement Data

Resistance data were collected in two modes, automated and manual. The MOBILE data acquisition system automatically performs two point contact resistance measurements and stores the values in terms of millivolts between adjacent electrodes. Figure D-3 shows pavement depth versus measured voltage produced by the MOBILE system.

Manual contact resistance and resistivity measurements were performed using a Simpson Model 420d function generator, two Fluke 87 digital multimeters, to measure voltage and amperage, and a manual electrode switching board. The measured contact resistance data are plotted in Figure D-4 and in Figure D-5 for the 4-point resistivity. Tables D-1 and D-2 in Appendix D show the raw data for the 2-point and the 4-point resistance respectively.

Comparison between Figure D-3 (contact resistance results from automated mode) and Figure D-4 (contact resistance results from manual mode) indicates that there was a problem with either the mobile system or the manual test setup. Comparison of Figure D-4 and Figure D-5 (4-point resistance results from manual mode) shows that the resistance profiles are similar but do not match the automated mode (Figure D-3). An examination of the MOBILE output appears to indicate a significant change for contacts 7-8 and 8-9 which is not consistent with the manually collected data. This may lead us to believe a problem may have existed with the multiplexer board. It will be necessary to examine subsequent data collected at this site to determine which are the actual representative profiles.

Deflection Measurement Data

Deflection measurements followed procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". The analysis results from the FWDCHECK program from the day of installation and the following day are presented in Appendix D. Since then, four more measurements have been collected with the FWD, the first on March 21, 1994, the second on April 14, 1993, the third on May 5, 1994, and the fourth on May 26, 1994.

Longitudinal Profile Data

According to the guidelines, since this is in a frost area, the survey should be performed on five different occasions; one survey during the middle of each season and one survey during the late winter period (fully frozen condition). Two surveys have already been performed on this site, the first during the fully frozen condition (February 20, 1994) and the second in the spring season (April 14, 1994).

Elevation Surveys

One set of the surface elevation survey was performed following the guidelines. It was assumed that the elevation at the top of the piezometer pipe was 1.000 meters. The survey was conducted on October 14, 1993, the day after the installation, and the results are presented in Appendix D. Since then, one more set of the surface elevation survey has been performed, this was on April 14, 1994.

Water Depth

A check of the piezometer indicated that there was no water present. This was expected as the piezometer at a depth of 4.5m would reside within the fill material, approximately 5.5m above existing ground level.

IV. Summary

The installation of the seasonal monitoring instrumentation at the GPS site 331001 near Concord, NH was completed on October 13, 1993. A check of the equipment and initial data collection was completed on October 14, 1993. The instrumentation, permanently installed at the site, were:

- Time domain reflectometer probes for moisture measurements
- Electric resistivity probes for frost location
- Thermistor probes for soil gradient temperature measurements
- Air temperature thermistor probe and tipping bucket rain gage to record local climatic conditions, and
- Combination piezometer (well) and bench mark to determine changes in water level and pavement elevations.

The pavement gradient temperature and local climatic data are to have continuous data collection stored in an on-site datalogger. The moisture and electrical resistivity are to be collected during each site visit (14 times per year) using a mobile datalogger system. The water level and elevation data are to be collected manually during site visits.

The test section is on eastbound Interstate 393, approximately two miles east of Concord city limits. The section is on a divided highway consisting of two 3.7m wide travel lanes in each direction with a 3.4m wide outside and 1.2m wide inside paved shoulders. The east bound lanes are busiest in the morning as the traffic enters the city with the high traffic period for the west bound lanes occurring between 3:00 and 6:00 p.m. as the commuters head home. The pavement structure consists of 212mm of asphalt concrete over 490mm of uncrushed gravel base and 366mm of soil aggregate mixture subbase on a coarse poorly graded sand and silt fill material. The embankment slopes to existing ground at about 10 meters below grade at the west end of the site where the instrumentation is installed.

All instrumentation was checked prior to installation at the PMSL facility in Amherst, NY. These initial checks indicated that the instrumentation was within specifications, as required for the seasonal monitoring program. Operational checks during installation and the following day indicated that all instrumentation was functioning properly, although the resistivity checks did not provide the expected results. This could be due to a number of factors, as the manual switching box was a proto type which was experiencing some switch problems, or there could have been a problem with the automated multiplexing system between electrodes 7-9, which appeared out of range when compared with the manual two point resistance and the four point resistivity checks. Further development in equipment and procedure are required to ensure consistent quality data for frost/thaw determination measurements.

The installation generally went as expected except for a number of delays that extended the installation beyond the day 1 target completion time of 3:30 p.m. Traffic control lane

closure was not ready till close to 9:00 a.m., which resulted in a late start for the coring/cutting operation and the augering of the piezometer and instrumentation hole. There was a slight delay in the augering operation as the driller returned to his facility to pick up a more suitable auger. Additional time was also required to replace the guard rail removed to access the piezometer hole and instrumentation cabinet. The delays resulted in a major traffic jam at the I93 - I393 interchange and slowed the traffic on I393 eastbound to a crawl starting about 4:00 p.m. in the afternoon. Although we did consider packing up the operation to allow the congested traffic to clear, this was not practical as it would have required nearly as much time to prepare the lane for re-opening as completing the installation. For future installations on high volume/commuter routes, more consideration has to be given to prompt timing of installation events to avoid any major inconvenience, or safety related problems. For this type of facility it may be more feasible to do the installation over a two day period.

The removal/replacement of the material for the instrumentation hole went very well, with the material being well consolidated around the instrumentation and the core level with the existing pavement surface at completion. The material retained for laboratory moisture determination was not dropped off at the NHDOT materials laboratory, and by the time it was located at the PMSL facility, it had been sitting for too long to provide reliable results. The moisture determination comparison between the TDR method and the field moisture indicated comparable results with the TDR method slightly higher.

The ongoing monitoring of this section, except for the problems encountered due to weather and technical difficulties with the FWD, has gone fairly well.

APPENDIX A

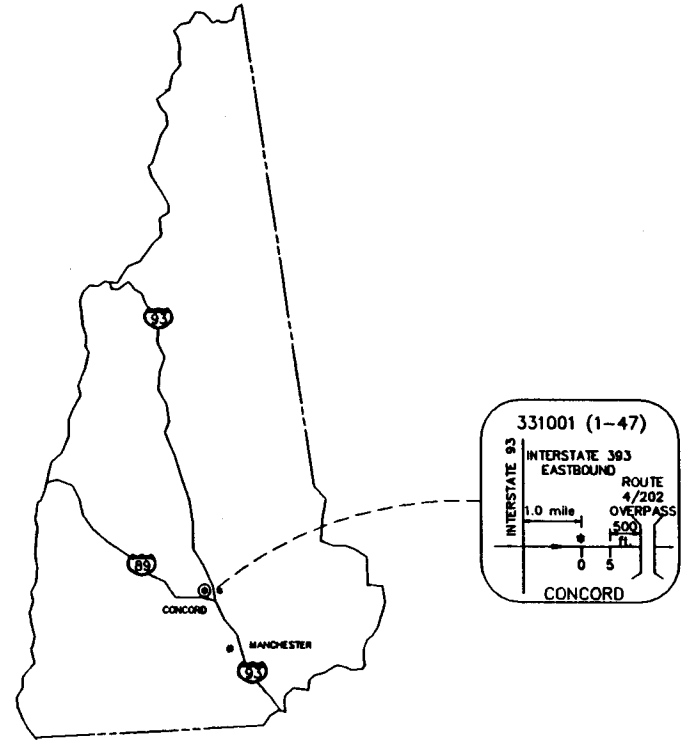
Test Section Background Information

Appendix A contains the following supporting information:

Figure A-1	Site Location Map
Figure A-2	Profile of Pavement Structure
Table A-1	Site Performance Summary
Table A-2	Uniformity Survey Results
Figure A-3	Deflection Profiles from FWDCHECK (Test Date July 29, 1992)
Table A-3	Subgrade Modulus and Structural Number from FWDCHECK (Test Date July 29, 1992)

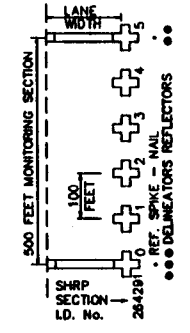
FHWA–LTPP NEW HAMPSHIRE TEST SITE LOCATIONS
GPS–SPS PAVEMENT STUDIES

PMS™ PAVEMENT MANAGEMENT SYSTEMS LIMITED



- CAPITAL CITIES
- MAJOR CENTRES
- INTERSTATE
- U.S. HIGHWAYS
- STATE HIGHWAY
- AGENCY BORDER

TYPICAL SITE SIGNING & MARKING



SPS 3 CHIPSEAL 36B350

ROAD TEST 264291

NEW HAMPSHIRE

12.10

FIGURE A-1 SITE LOCATION MAP - SECTION 331001

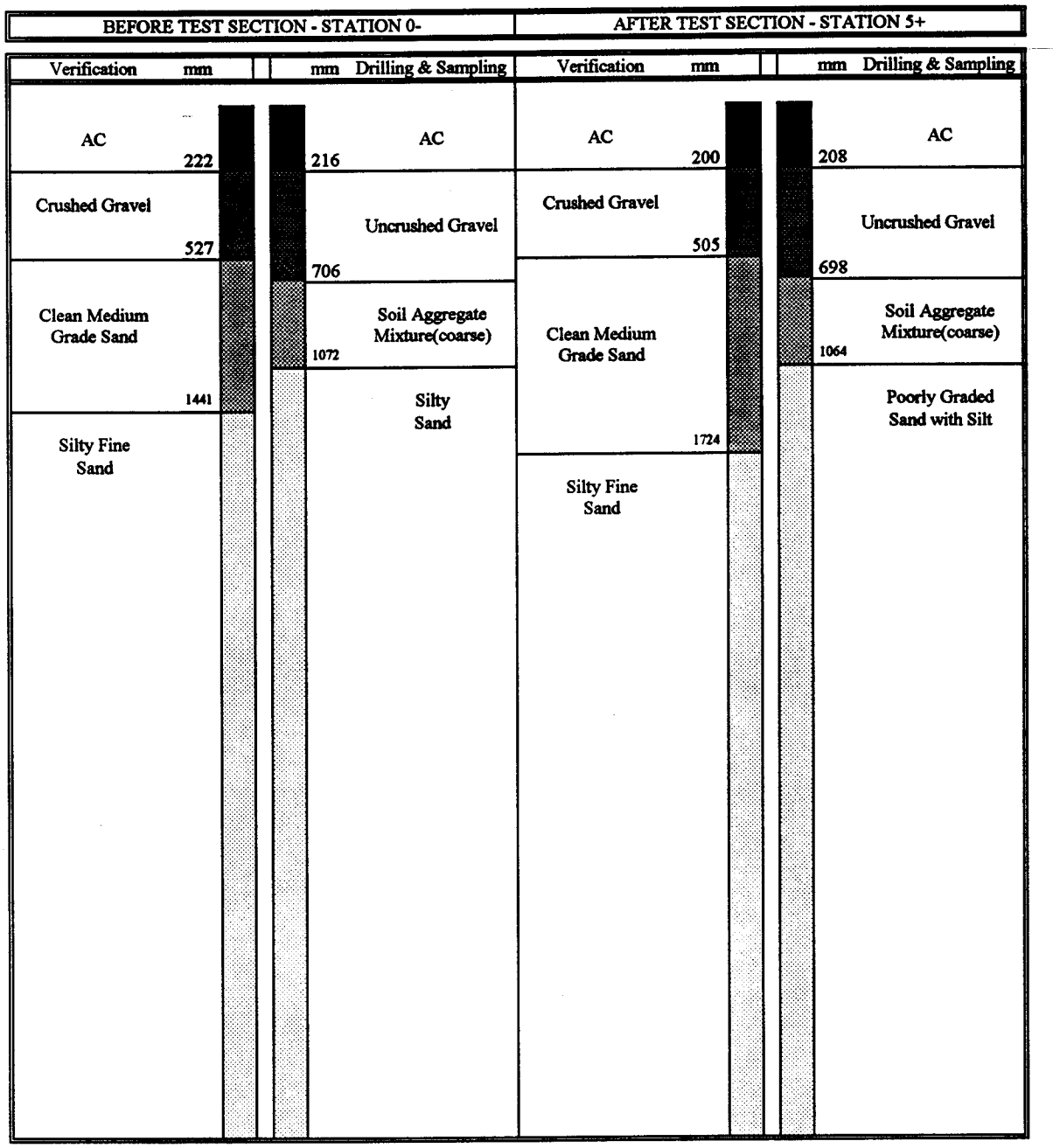


Figure A-2. Profile of Pavement Structure

Table A-1. Site Performance Summary

Distress and Profile Summary		
Distress Summary 1990	Profile Summary	
	Date (mm-dd-yy)	IRI (in/mi)
Low Sev. Long. Cracks - 23.61 ft.	10-16-89	36.63
Low Sev. Trans. Cracks - 1 @ 3.08 ft.	09-28-90	47.07
	08-13-91	39.09
	07-21-92	38.72
	09-16-93	41.29

Falling Weight Deflectometer Data Summary						
Date	Mean Value for Drop HT 2 (mils)					
	Sensor 1	Sensor 1 std. dev.	Sensor 7	Sensor 7 std. dev.	MeanTemp D1 (F)	Min/Max TempD1(F)
06-21-89	8.28	0.45	0.93	0.08	89	79/98
07-29-92	8.43	0.45	1.08	0.09	102	86/113

	Effective SN	SN std dev	Subgrade Modulus (psi)	Modulus std dev (psi)	Test Pit Mod. (psi)	
					1	2
06-21-89	8.83 8.67	0.10 0.12	40725 38203	1871 3222	37648	35506
07-29-92	8.94	0.21	34226	2564	-	-

Table A-2. Uniformity Survey Results

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 331001	Data Collection and
Date Surveyed: July 29, 1992	Processing Summary

Section Interval (ft)	Mean Deflection Values for HT 2 (mils) - Corrected							
	Sensor 1	Sensor 1 std dev	Sensor 7	Sensor 7 std dev	Subg modulus (psi)	Subg modulus std dev	Effecive SN	SN std dev
-100 to 0	6.93	0.34	1.11	0.05	33204	1509	8.99	0.20
0 to 250	7.00	0.17	1.08	0.09	34192	2618	8.91	0.08
250 to 500	6.93	0.55	1.07	0.09	34260	2650	8.97	0.30
500 to 600	7.30	0.24	1.06	0.07	34575	2161	8.73	0.10

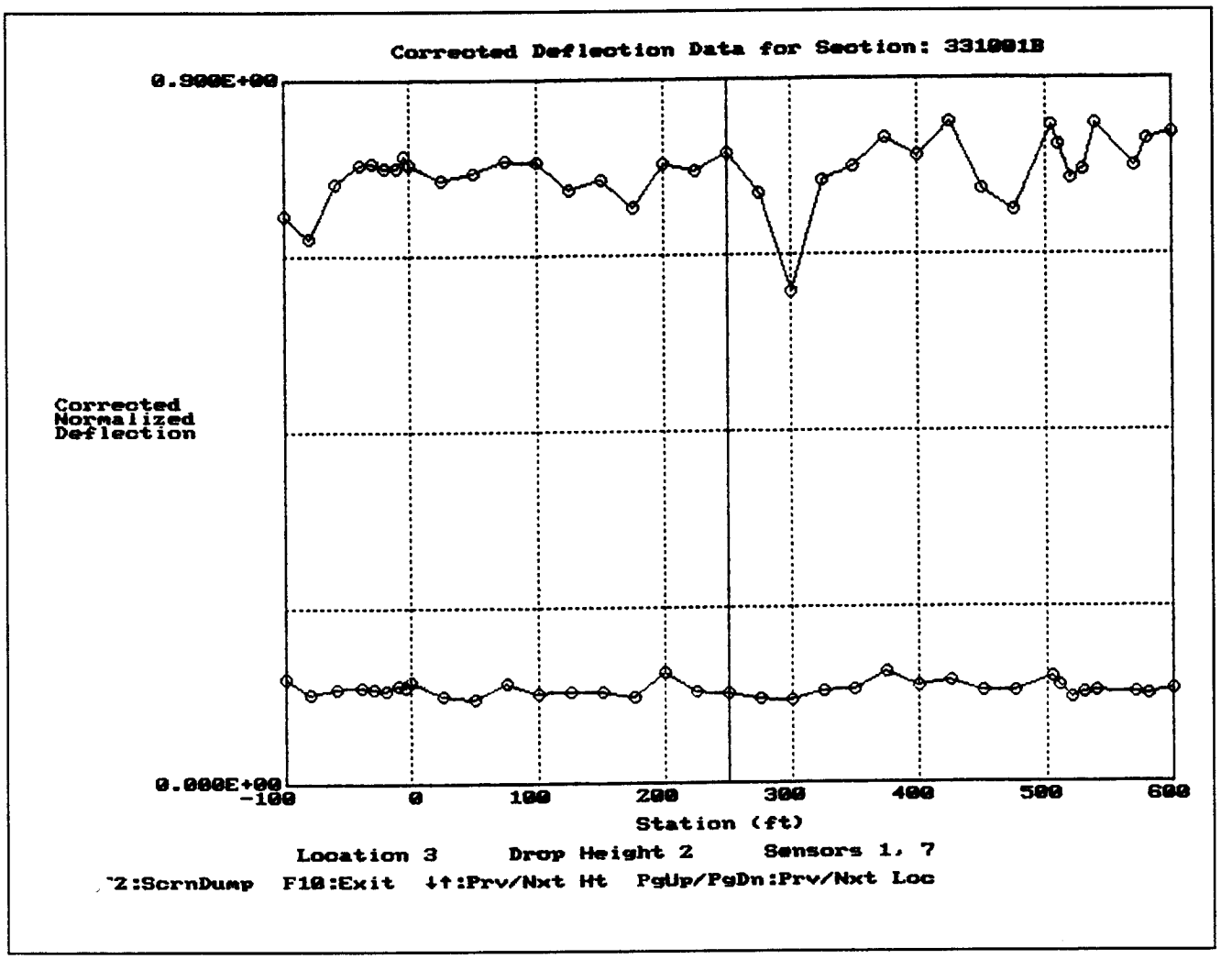


Figure A-3. Deflection Profile from FWDCHECK
(Test Date July 29, 1992)

Table A-3. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date July 29, 1992)

Flexible Pavement Thickness Statistics - 331001B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	0	31411	8.90
	25	36316	8.90
	50	37095	8.80
	75	31730	8.90
	100	35199	8.80
	125	34918	9.00
	150	34664	8.90
	175	36772	9.05
	200	29070	9.00
	225	34744	8.85
2	250	35663	8.70
	275	37305	8.95
	300	38201	9.70
	325	34563	8.95
	350	34242	8.85
	375	29193	8.85
	400	32874	8.85
	425	31348	8.65
	450	34735	9.00
	475	34473	9.15
Subsection 1	Overall Mean	34192	8.91
	Standard Deviation	2618	0.08
	Coeff of Variation	7.66%	0.95%
Subsection 2	Overall Mean	34260	8.97
	Standard Deviation	2650	0.30
	Coeff of Variation	7.74%	3.29%

Note: No test pit data found, therefore no results exist...
Note: Station 500 not tested.

APPENDIX B

Supporting Site Visit and Installed Instrument Information

Appendix B contains the following supporting information:

Correspondence from the Site Inspection and Planning Meeting

Table B-1. Air Temperature Thermistor Calibration

Table B-2. MRC Probe Calibration

Table B-3. Description of MRC Thermistor Probe and Sensor Spacing

Table B-4. Resistivity Probe and Sensor Spacing

Table B-5. Contact Resistance Calibraion

Table B-6. TDR Probes Calibration

Figure B-1. TDR Traces Obtained During Calibration

PAVEMENT MANAGEMENT SYSTEMS

MEMORANDUM

TO: C. Dougan, CT
T. Karasopolous, ME
L. Kenison, NH
R. Cauley, VT
G. Jones, ON
G. Dore, QE
P. Hughes, MA

DATE: May 07, 1992

PROJECT: 50450732

FILE: 6.01

FROM: Bill Phang

SUBJECT: SHRP Seasonal Monitoring
Reconfirming Participation

COPIES TO: See Below

Planning for the SHRP Seasonal Monitoring program has now progressed to the stage where preliminary schedules for installation of temperature, moisture, and frost depth penetration need to be determined.

The results of the measurements made at the pilot seasonal testing site at Syracuse, N.Y., and at Boise, ID, are to be examined and recommendations made regarding the instrumentation which will be used at other seasonal testing sites by the end of May 1992. These recommendations will be discussed and the instrumentation finalized by the Instrumentation ETG in June 1992. Acquisition of equipment and plans for installation over the next few months imply that field installation will begin in September 1992.

In the meantime, in order to develop and test the schedules for FWD testing, a trial run of the testing circuit will be made in July. At this juncture the eight (8) first round GPS seasonal testing sites include:

Cell No.	Agency	SHRP ID	SHRP Expt.	Subgrade	AC Thickness	Traffic
4 *	ON **	871620	1	Fine	4.5	High
12	NY **	361011	1	Fine	10.7	Low
12	VT	510002	1	Fine	8.1	Low
16	CT **	091803	1	Coarse	7.0	Low
16	MA	251003	1	Coarse	8.5	High
16	NH	331001	1	Coarse	8.3	High
20	QE	893015	3	Fine	8.5	High
24	ME	233014	3	Coarse	10.0	Low

* To be rehabilitated in May 1992 ** 1992 Confirmation

415 LAWRENCE BELL DRIVE
UNIT #3
AMHERST, N.Y. 14221
TEL. (716) 632-0804
FAX (716) 632-4808

THE STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION

RLES P. O'LEARY, JR.
COMMISSIONER

DATE REC. MAY 29 1992
JOB #
FILE #

May 18, 1992

Bill Phang
Pavement Management Systems
415 Lawrence Bell Drive
Unit #3
Amherst, N.Y. 14221

Dear Mr. Phang:

I was asked to responded to your memorandum of May 7th addressed to Leon Kenison asking for a final commitment from New Hampshire to participate in the SHRP seasonal monitoring program.

We do want to take part in this program and ask only that you try to give us adequate lead time to schedule equipment, manpower and any necessary traffic control.

When you are ready to discuss the planning necessary for the installation of the monitoring instrumentation please contact myself.

In the interim if I can be of any assistance please call.

Sincerely,

Alan D. Rawson, P.E.
Administrator
Bureau of Materials & Research

ADR/de

cc: Robert Greer

COPY

JOHN O. MORTON BUILDING - HAZEN DRIVE - P.O.BOX 483 - CONCORD, N.H. 03302-0483 - TELEPHONE 603-271-3734
FAX 603-271-3914 - TDD ACCESS: RELAY NH 1-800-735-2964

PAVEMENT MANAGEMENT SYSTEMS

MEMORANDUM

TO:	Guy Dore, QE Dick Haupt, VT Warren Foster, ME Alan Rawson,. NH Charles Dougan, CT	**DATE:**	June 29, 1992
		PROJECT:	50450732
FROM:	Bill Phang	**FILE:**	6.01
SUBJECT:	Seasonal Testing Preliminary FWD Investigation	**COPIES TO:**	See Below

One of the findings of the seasonal testing pilot at Syracuse, NY was that the FWD results near the points where the sensors were installed outside of the test section were somewhat different to results within the GPS test section.

It was subsequently decided that for future seasonal testing installations, a preliminary FWD test series would be conducted in the areas adjacent to the test sections. This would help to fix on a location for sensor installation that more closely represents the part of the test section being monitored for seasonal effects.

The FWD has been scheduled to carry out these preliminary tests beginning July 21 at GPS 893015 in Trois Riviere, QE. Other sites are 501683 in Charlotte, VT, on July 24, 237028 in Bethel, ME on July 28, 331001 in Concord, NH on July 29 and 091803 in Groton, CT July 30.

A copy of the FWD schedule is attached. Would you please make necessary arrangements for traffic control. Please call Brandt Henderson of you have any questions.

Distribution to:
I.J. Pecnik
B. Henderson

415 LAWRENCE BELL DRIVE
UNIT #3
AMHERST, N.Y. 14221
TEL. (716) 632-0804
FAX (716) 632-4808

Table B-1. Air Temperature Thermistor Calibration

LTPP Seasonal Monitoring Study	State Code	[3 3]
Air Temperature Thermistor Calibration	Test Section Number	[1 0 0 1]

Before Operation Checks	Calibration Date mm-dd-yy	10-11-93
	Probe S/N	33AAT
	Operator	PZ

Mobile Datalogger (24 hour)	Water Room Temperature	Ice Bath 0 C (+/- 1 C)	Hot Water 50 C (+/-)	ok

Mean	Min.	Max.	Reading	Time	Reading	Time	Reading	Time	y/n
11.72	10.96	13.40	16.10	11:10	0.209	10:16	52.80	12:15	y

Probe Accepted	PZ&MZ	(Initials)

Table B-2. MRC Probe Calibration

LTPP Seasonal Monitoring Study	State Code	[33]
MRC Probe Calibration	Test Section Number	[1001]

Before Operation Checks	Calibration Date mm-dd-yy	10-11-93
	Probe S/N	33AT
	Operator	PZ

	Mobile Datalogger (24 hour)			Water Room Temp Time 11:10	Ice Bath 0 C(+/- 1 C) Time 10:18	Hot Water 50 C (+/-) Time 12:15	ok
No.	Mean	Min.	Max.	Reading	Reading	Reading	y/n
1	11.56	10.76	13.13	15.8	0.21	49.7	y
2	11.48	10.55	13.13	15.5	0.39	49.5	y
3	11.40	10.59	13.1	15.7	0.99	49.2	y
4	11.31	10.53	13.07	15.4	1.26	49.8	y
5	11.52	10.79	13.22	15.4	0.24	51.9	y
6	11.63	10.81	13.27	15.5	0.35	50.7	y
7	11.67	10.97	13.3	15.5	0.43	51.7	y
8	11.71	11.03	13.33	15.6	0.65	51.7	y
9	11.76	11.03	13.33	15.5	0.21	51.7	y
10	11.65	10.97	13.24	15.5	0.65	51.1	y
11	11.70	11.03	13.27	15.5	0.57	50.1	y
12	11.76	11.12	13.33	15.6	0.90	49.7	y
13	11.74	11.09	13.30	15.4	0.68	49.8	y
14	11.77	11.12	13.36	15.5	0.90	49.6	y
15	11.82	11.12	13.41	15.4	0.76	49.7	y
16	11.93	11.29	13.5	15.5	0.72	49.2	y
17	11.92	11.23	13.55	15.4	0.28	51.1	y
18	11.53	11.90	14.09	15.6	0.61	51.8	y

Probe Accepted:	PZ	(Initials)
Probe Length:	1.852	(meters)

Thermistor distance from top of probe: (meters)									
4	.018	7	.248	10	.626	13	1.084	16	1.539
5	.094	8	.322	11	.780	14	1.234	17	1.693
6	.170	9	.475	12	.930	15	1.386	18	1.842

Table B-3. Description of MRC Thermistor Probe and Sensor Spacing

Unit	Channel No.	Distance from Top of Unit(m)	Remarks
1	1	.013	0.3302m long by 63.5mm stainless steel probe installed in the AC layer
	2	.165	
	3	.318	
2	4	.018	1.854m long by 25.4mm PVC tube installed in the base and subgrade.
	5	.094	
	6	.170	
	7	.248	
	8	.322	
	9	.475	
	10	.626	
	11	.780	
	12	.930	
	13	1.084	
	14	1.234	
	15	1.386	
	16	1.539	
	17	1.693	
	18	1.842	

Table B-4. Resistivity Probe and Sensor Spacing

Connector Pin No.	Electrode Number	Continuity x	Measure-ment	Spacing (mm)			Dist. from Top (m)
				Line 1	Line 2	Avg.	
36	1	x	Top-1	30	32	31.0	.030
35	2	x	1-2	49	49	49.0	.079
34	3	x	2-3	51	50	50.5	.130
33	4	x	3-4	52	50	51.0	.182
32	5	x	4-5	50	51	50.5	.232
31	6	x	5-6	50	49	49.5	.282
30	7	x	6-7	51	51	51.0	.333
29	8	x	7-8	52	53	52.5	.385
28	9	x	8-9	50	50	50.0	.435
27	10	x	9-10	51	51	51.0	.486
26	11	x	10-11	50	51	50.5	.536
25	12	x	11-12	50	50	50.0	.586
24	13	x	12-13	51	50	50.5	.637
23	14	x	13-14	50	50	50.0	.687
22	15	x	14-15	50	50	50.0	.737
21	16	x	15-16	50	50	50.0	.787
20	17	x	16-17	51	52	51.5	.838
19	18	x	17-18	51	51	51.0	.889
18	19	x	18-19	50	50	50.0	.939
17	20	x	19-20	51	52	51.5	.990
16	21	x	20-21	50	50	50.0	1.040
15	22	x	21-22	51	51	51.0	1.091
14	23	x	22-23	49	49	49.0	1.140
13	24	x	23-24	54	52	53.0	1.194
12	25	x	24-25	49	49	49.0	1.243
11	26	x	25-26	50	50	50.0	1.293
10	27	x	26-27	50	51	50.5	1.343
9	28	x	27-28	50	52	51.0	1.393
8	29	x	28-29	50	50	50.0	1.443
7	30	x	29-30	52	52	52.0	1.495
6	31	x	30-31	50	51	50.5	1.545
5	32	x	31-32	51	50	50.5	1.596
4	33	x	32-33	49	51	50.0	1.645
3	34	x	33-34	50	49	49.5	1.695
2	35	x	34-35	52	52	52.0	1.747
1	36	x	35-36	49	49	49.0	1.796
			36-End	25	25	25.0	1.821

Table B-5. Contact Resistance Calibration

LTPP Seasonal Monitoring Study					State Code		[33]
Data Sheet R1							
Contact Resistance Measurements					Test Section Number		[1001]
1. Date (Month - Day - Year)							[10-11-93]
2. Time Measurements Began (Military)							[13:50]
3. Comments							In Salt Water Prior to Installation
Test Position	Connections		Voltage (ACV)		Current (ACA)		Notes
	I V	I V	Range Setting	Reading	Range Setting	Reading	
1	1	2	mV	244.9	uA	152.6	
2	3	2	mV	240.5	uA	158.8	
3	3	4	mV	243.0	uA	154.8	
4	5	4	mV	243.5	uA	154.1	
5	5	6	mV	238.1	uA	162.3	
6	7	6	mV	240.5	uA	158.7	
7	7	8	mV	241.7	uA	157.1	
8	9	8	mV	235.3	uA	165.6	
9	9	10	mV	231.6	uA	170.0	
10	11	10	mV	230.8	uA	171.2	
11	11	12	mV	230.0	uA	172.4	
12	13	12	mV	229.7	uA	173.1	
13	13	14	mV	228.5	uA	174.7	
14	15	14	mV	229.8	uA	172.6	
15	15	16	mV	232.7	uA	169.3	
16	17	16	mV	234.7	uA	166.5	
17	17	18	mV	232.7	uA	169.0	
18	19	18	mV	226.8	uA	177.0	
19	19	20	mV	227.0	uA	176.4	
20	21	20	mV	223.9	uA	181.7	
21	21	22	mV	222.6	uA	183.2	
22	23	22	mV	221.5	uA	184.3	
23	23	24	mV	223.4	uA	181.0	
24	25	24	mV	220.2	uA	186.0	
25	25	26	mV	224.0	uA	180.2	
26	27	26	mV	223.1	uA	181.7	
27	27	28	mV	224.3	uA	180.0	
28	29	28	mV	222.1	uA	183.6	
29	29	30	mV	221.1	uA	184.0	
30	31	30	mV	219.3	uA	186.2	
31	31	32	mV	221.3	uA	184.0	
32	33	32	mV	221.5	uA	183.9	
33	33	34	mV	220.0	uA	184.2	
34	35	34	mV	224.4	uA	178.6	
35	35	36	mV	220.4	uA	184.3	
36	37	38	mV		uA		
37	38	39	mV		uA		
38	39	40	mV		uA		
Preparer :		Michael Zawisa			Employer :		PMSL

Table B-6. TDR Probes Calibration

LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probes	Test Section Number	[1001]

Before Operation Checks	P.Z.	Initial	Calibration Date (mm-dd-yy)	10-09-93
			Seasonal Site	33SA

No.	Probe (S/N)	Resistance (ohms) Core	Shield	Probe Shorted Begin Length	End Length	Air Begin Length	Alcohol Begin Length	Water Begin Length
1	33A01	1.00	0.70	16.230	16.420	16.240	16.260	16.260
2	33A02	0.80	0.90	16.230	16.410	16.220	16.280	16.290
3	33A03	0.90	1.00	16.250	16.420	16.230	16.250	16.280
4	33A04	0.80	0.70	16.230	16.340	16.250	16.270	16.270
5	33A05	0.60	0.60	16.460	16.540	16.470	16.490	16.490
6	33A06	0.80	0.90	15.880	15.990	15.880	15.910	15.910
7	33A07	1.00	0.90	15.930	16.010	15.920	15.940	15.940
8	33A08	0.80	0.50	15.880	16.010	15.900	15.920	15.920
9	33A09	0.80	0.60	15.900	16.040	15.930	15.940	15.940
10	33A10	1.00	0.80	15.890	16.010	15.900	15.920	15.920

NOTE: Record lengths from TDR

Calculation of Dielectric Constant

Probe Length .203 m

V_p Setting .99 V_p

$$\varepsilon = \left[\frac{TDRL}{(PL)\,(V_p)} \right]^2$$

No.	Air TDR Length	Air Dielectric Constant	Air In Spec. (?)	Alcohol TDR Length	Alcohol Dielectric Constant	Alcohol In Spec. (?)	Water TDR Length	Water Dielectric Constant	Water In Spec. (?)
1	.21	1.07	y	1.21	35.5	y	1.86	84.0	y
2	.21	1.07	y	1.20	35.0	y	1.86	84.0	y
3	.20	0.97	y	1.20	35.0	y	1.87	84.9	y
4	.20	0.97	y	1.20	35.0	y	1.87	84.9	y
5	.20	0.97	y	1.19	34.4	y	1.86	84.0	y
6	.23	1.28	y	1.20	35.0	y	1.86	84.0	y
7	.20	0.97	y	1.18	33.8	y	1.86	84.0	y
8	.20	0.97	y	1.20	35.0	y	1.87	84.9	y
9	.20	0.97	y	1.18	33.8	y	1.86	84.0	y
10	.21	1.07	y	1.20	35.0	y	1.87	84.9	y

LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probe Calibration	Test Section Number	[1001]

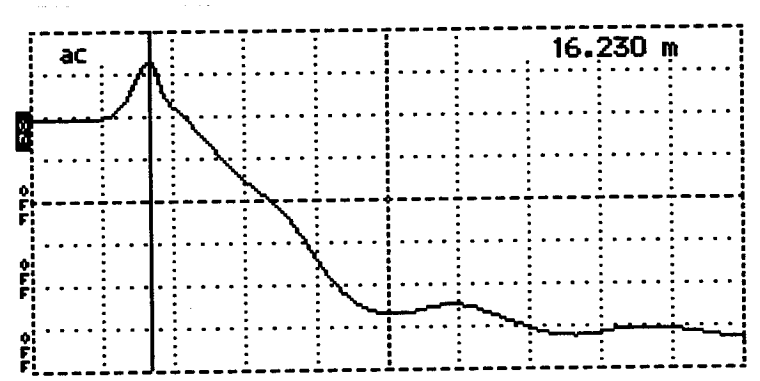
Before Operation Checks

- Calibration Date 10/9/93
- Probe S/N 33A01

Probe Number 1

TDR Trace 1 - Beginning Probe Shorted

rsor ..... 16.230 m
stance/Div..... .25 m/div
rtical Scale.... 149 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

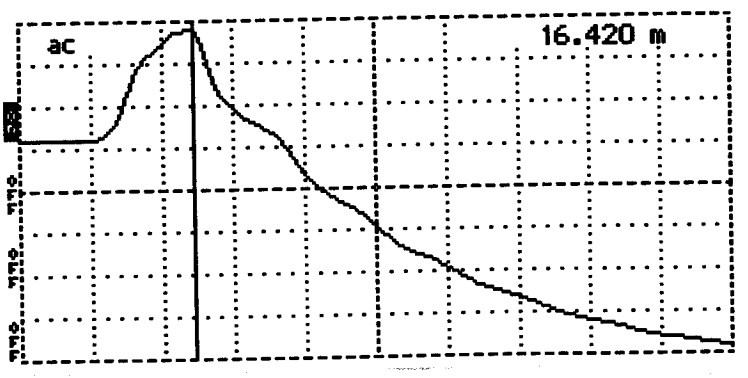


Tektronix 1502B TDR
Date 10/9/93
Cable 1
Notes Short CB

Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

ursor ..... 16.420 m
istance/Div..... .25 m/div
ertical Scale.... 149 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



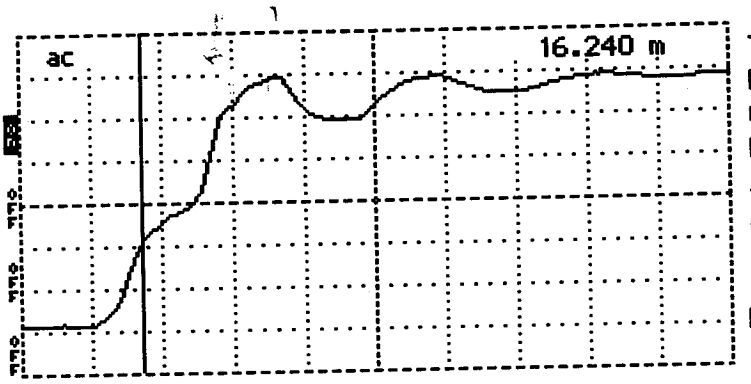
Tektronix 1502B TDR
Date 10/9/93
Cable 1
Notes Short End

Input Trace
Stored Trace
Difference Trace

Figure B-1. TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

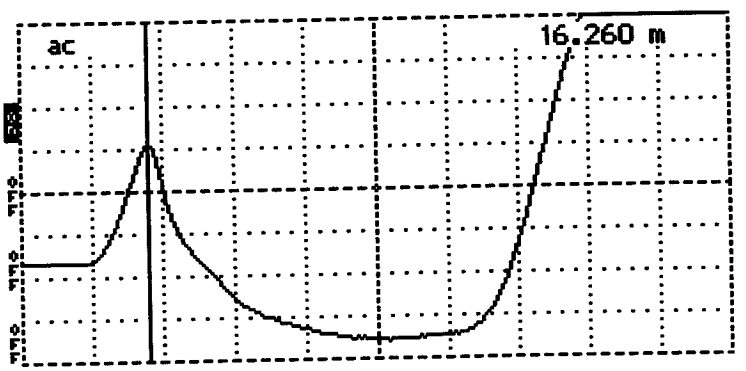
sor ..... 16.240 m
ance/Div..... .25 m/div
tical Scale.... 149 mΩ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 1
Notes Air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

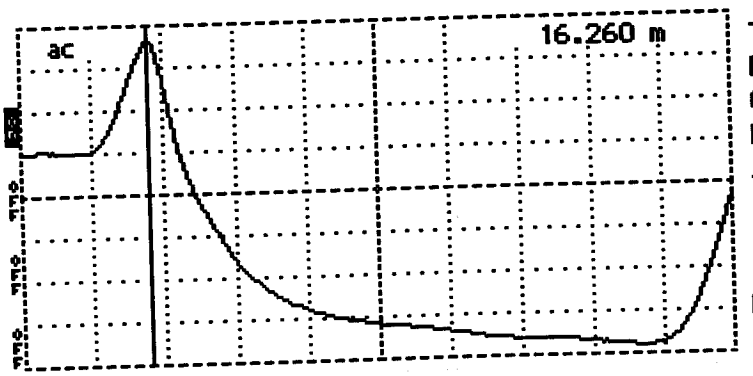
Cursor ..... 16.260 m
tance/Div..... .25 m/div
vertical Scale.... 64.8 mΩ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 1
Notes Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

ursor ..... 16.260 m
istance/Div..... .25 m/div
ertical Scale.... 64.8 mΩ/div
p 0.99
loise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 1
Notes H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probe Calibration	Test Section Number	[1001]

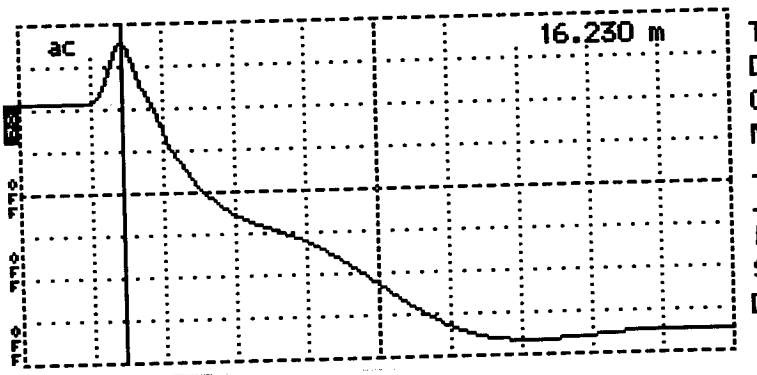
Before Operation Checks

- Calibration Date: 10/9/93
- Probe S/N: 33AD2

Probe Number 2

TDR Trace 1 - Beginning Probe Shorted

ursor ..... 16.230 m
istance/Div..... .25 m/div
ertical Scale.... 145 mρ/div
p 0.99
oise Filter..... 1 avg
ower..... ac

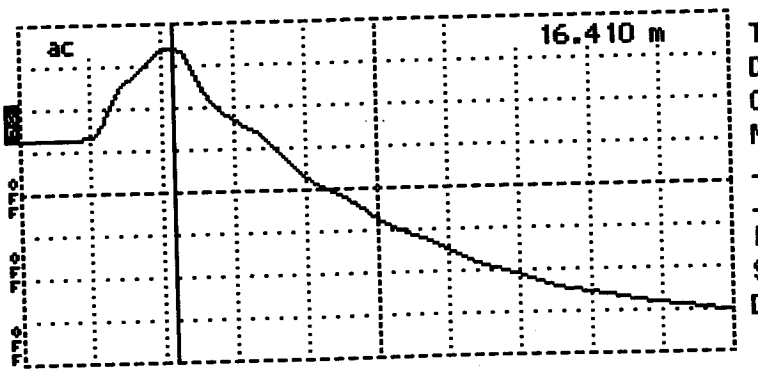


Tektronix 1502B TDR
Date 10/9/93
Cable 2
Notes ShortCB

Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

Cursor ..... 16.410 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



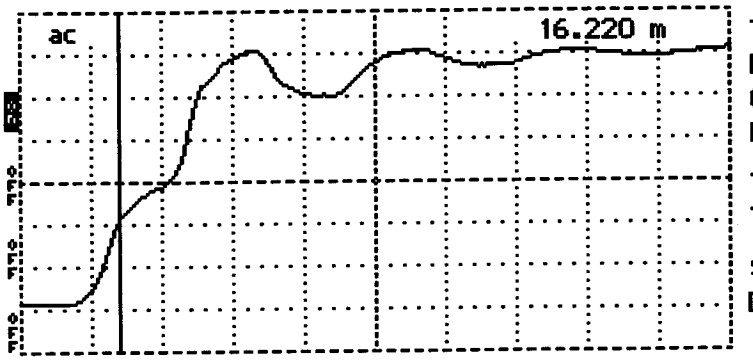
Tektronix 1502B TDR
Date 10/9/93
Cable 2
Notes Shorted

Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

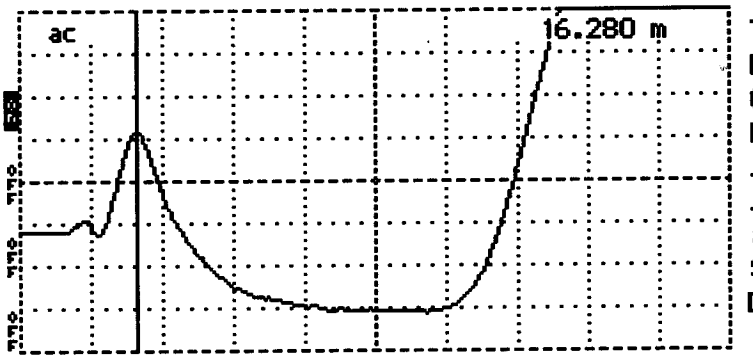
rsor ..... 16.220 m
stance/Div..... .25 m/div
rtical Scale.... 145 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 10/19/93
Cable 2
Notes Air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

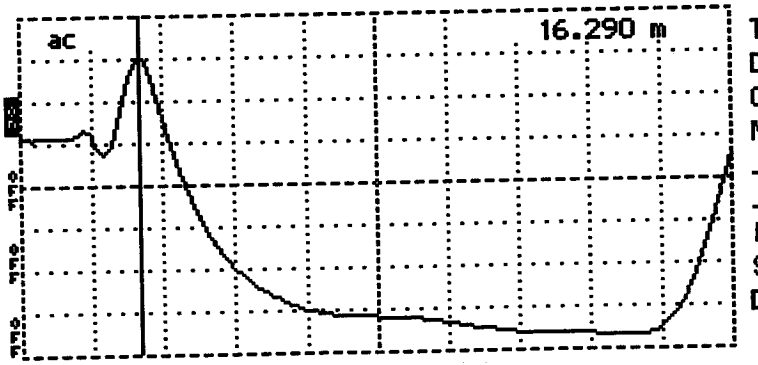
ursor ..... 16.280 m
istance/Div..... .25 m/div
tical Scale.... 64.8 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/19/93
Cable 2
Notes Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

sor ..... 16.290 m
ance/Div..... .25 m/div
tical Scale.... 64.8 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 10/19/93
Cable 2
Notes Water
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probe Calibration	Test Section Number	[1001]

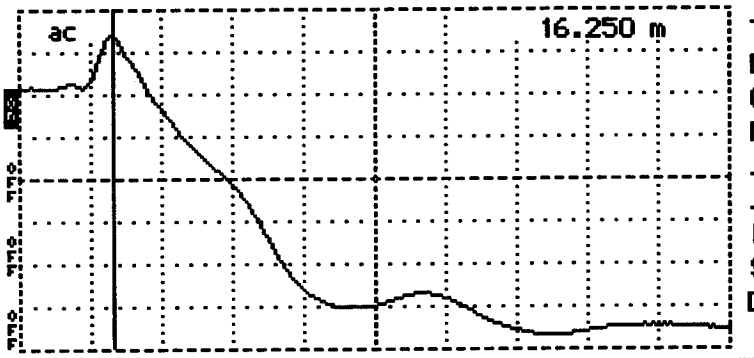
Before Operation Checks

- Calibration Date 10/9/93
- Probe S/N 33A03

Probe Number 3

TDR Trace 1 - Beginning Probe Shorted

sor ..... 16.250 m
ance/Div..... .25 m/div
ical Scale.... 145 mΩ/div
..... 0.99
e Filter..... 1 avg
er..... ac

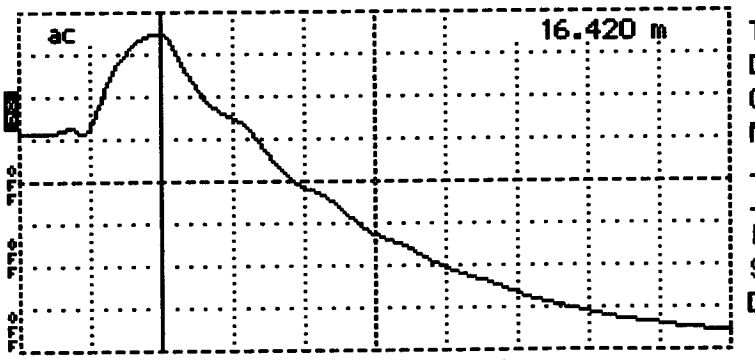


Tektronix 1502B TDR
Date 10/9/93
Cable 3
Notes Short CB

Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

sor ..... 16.420 m
ance/Div..... .25 m/div
tical Scale.... 163 mΩ/div
..... 0.99
e Filter..... 1 avg
er..... ac



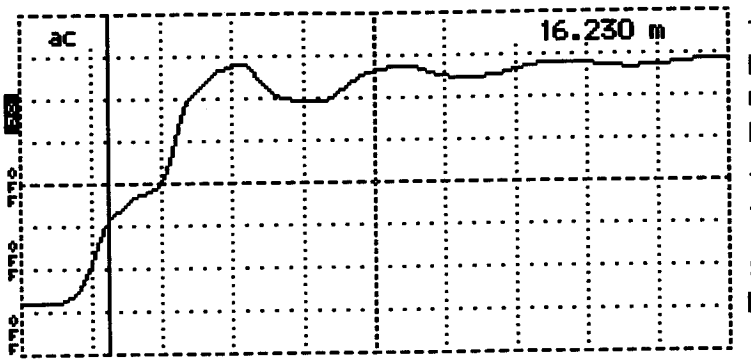
Tektronix 1502B TDR
Date 10/9/93
Cable 3
Notes Short end

Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

sor ..... 16.230 m
tance/Div..... .25 m/div
tical Scale.... 154 mΩ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 3
Notes Air
Input Trace
Stored Trace
Difference Trace

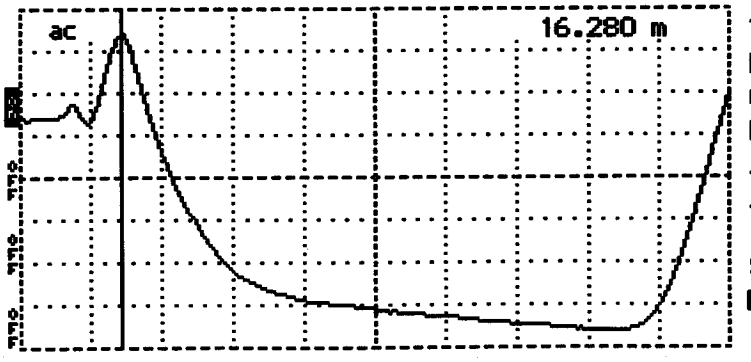
Trace Number 4 - Probe in Alcohol

sor ..... 16.250 m
nce/Div..... .25 m/div
al Scale.... 62.9 mΩ/div
..... 0.99
e Filter..... 1 avg
er..... ac

Tektronix 1502B TDR
Date 10/9/93
Cable 3
Notes Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

rsor ..... 16.280 m
stance/Div..... .25 m/div
rtical Scale.... 62.9 mΩ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 3
Notes H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probe Calibration	Test Section Number	[1001]

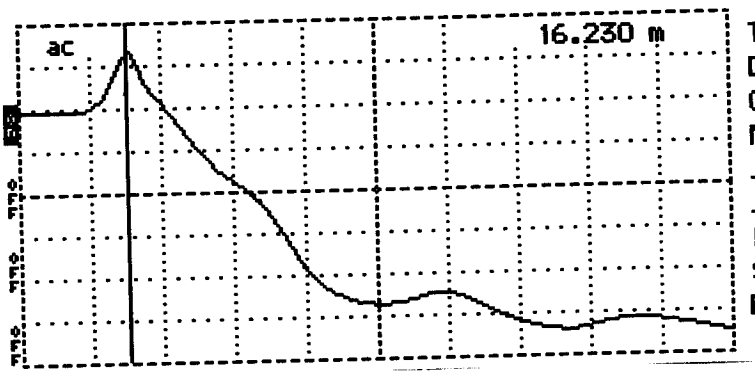
Before Operation Checks

- Calibration Date 10/9/93
- Probe S/N 33A04

Probe Number 4

TDR Trace 1 - Beginning Probe Shorted

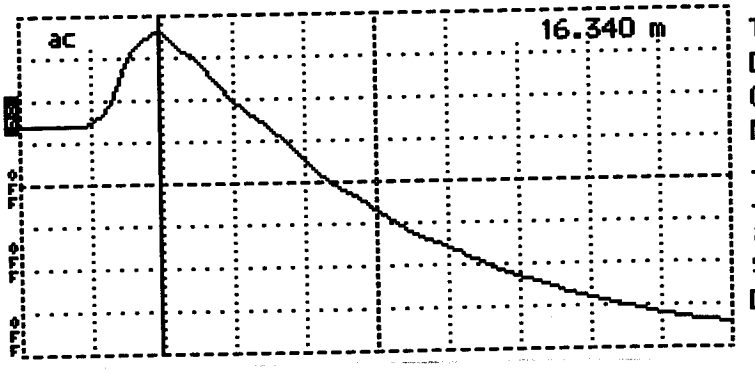
rsor ..... 16.230 m
stance/Div..... .25 m/div
rtical Scale.... 158 mΩ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 4
Notes Short CB
Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

ursor ..... 16.340 m
istance/Div..... .25 m/div
ertical Scale.... 158 mΩ/div
p 0.99
oise Filter..... 1 avg
ower..... ac

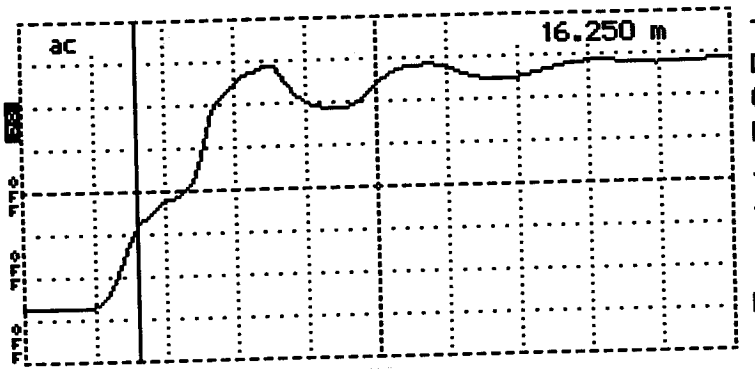


Tektronix 1502B TDR
Date 10/9/93
Cable 4
Notes Short end
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

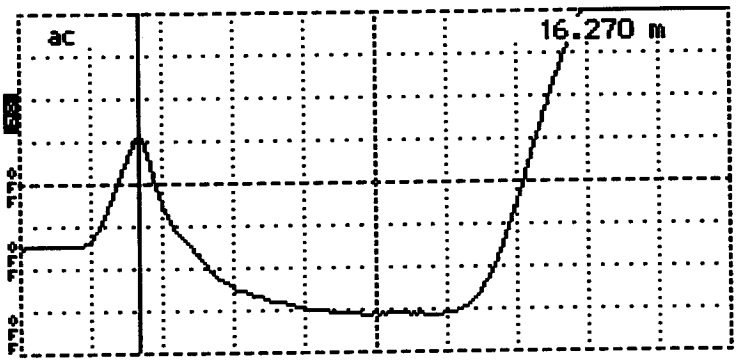
ursor ..... 16.250 m
stance/Div..... .25 m/div
ertical Scale.... 154 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 4
Notes Air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

ursor ..... 16.270 m
tance/Div..... .25 m/div
tical Scale.... 72.7 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 4
Notes Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

Cursor ..... 16.270 m
Distance/Div..... .25 m/div
Vertical Scale.... 70.6 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

Tektronix 1502B TDR
Date 10/9/93
Cable 4
Notes H_2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probe Calibration	Test Section Number	[1001]

Before Operation Checks

- Calibration Date 10/9/93
- Probe S/N 33A05

Probe Number 5

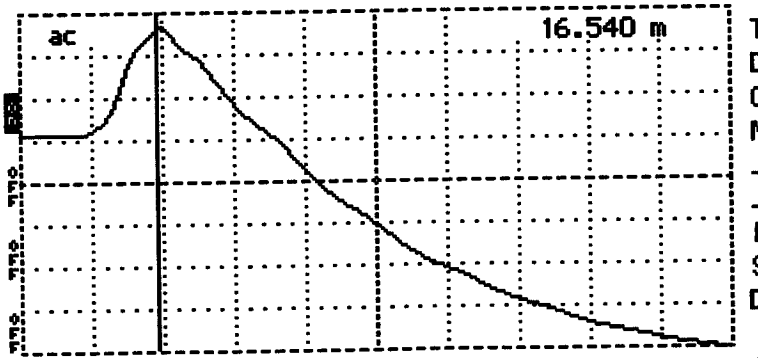
TDR Trace 1 - Beginning Probe Shorted

ursor ..... 16.460 m
stance/Div..... .25 m/div
ertical Scale.... 145 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac

Tektronix 1502B TDR
Date 10/9/93
Cable 5
Notes Short CB
Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

rsor ..... 16.540 m
stance/Div..... .25 m/div
rtical Scale.... 145 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

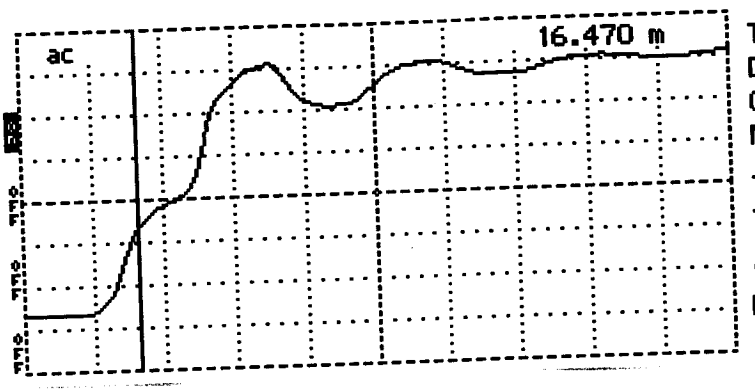


Tektronix 1502B TDR
Date 10/9/93
Cable 5
Notes Short End
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

rsor ..... 16.470 m
stance/Div..... .25 m/div
rtical Scale.... 149 mρ/div
..... 0.99
ise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 5
Notes Air
Input Trace
Stored Trace
Difference Trace

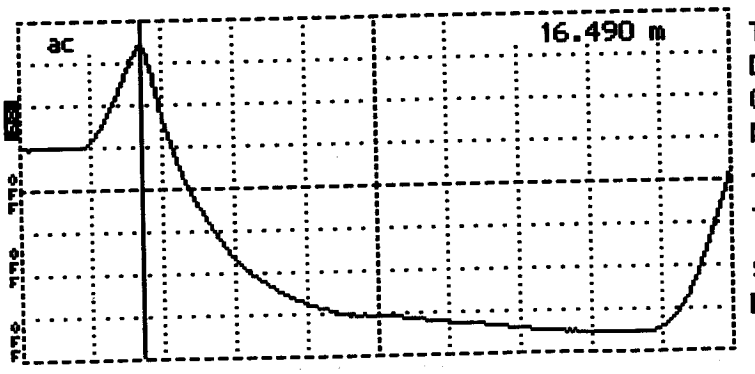
Trace Number 4 - Probe in Alcohol

ursor ..... 16.490 m
tance/Div..... .25 m/div
tical Scale.... 59.4 mρ/div
..... 0.99
oise Filter..... 1 avg
ower..... ac

Tektronix 1502B TDR
Date 10/9/93
Cable 5
Notes Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

rsor ..... 16.490 m
stance/Div..... .25 m/div
rtical Scale.... 68.6 mρ/div
..... 0.99
ise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 5
Notes H_2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

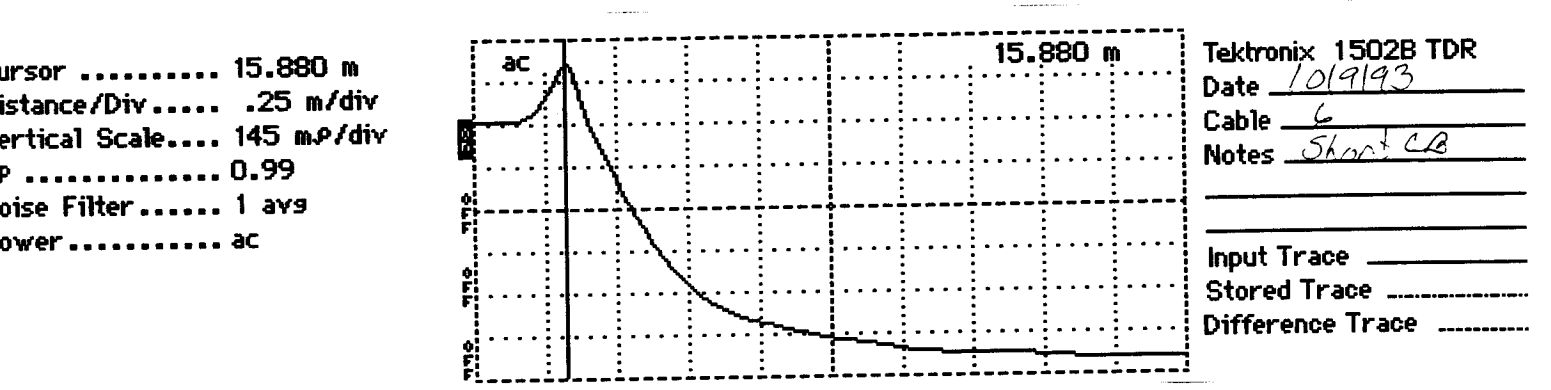
LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probe Calibration	Test Section Number	[1001]

Before Operation Checks

- Calibration Date 10/9/93
- Probe S/N 33A06

Probe Number 6

TDR Trace 1 - Beginning Probe Shorted



Trace Number 2 - Ending Probe Shorted

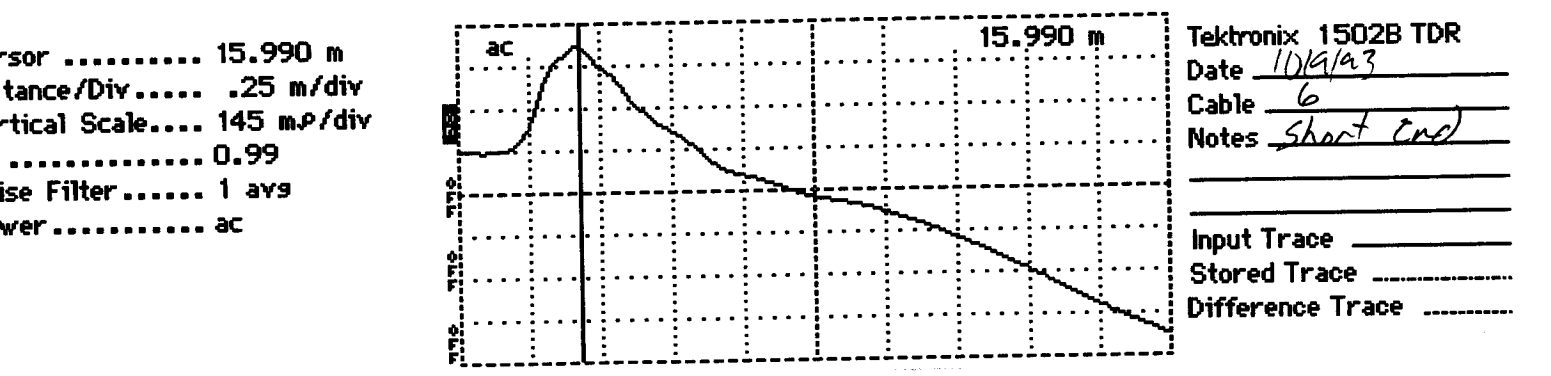
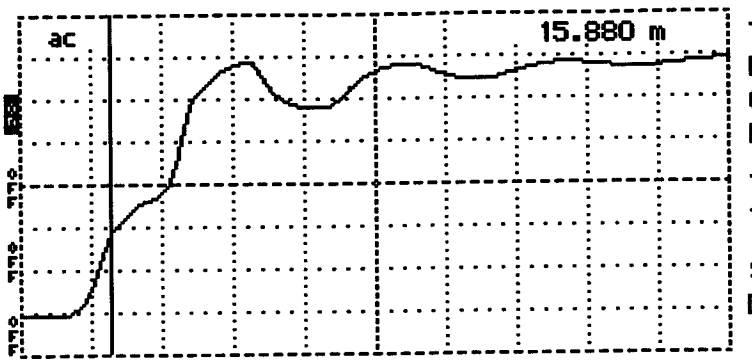


Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

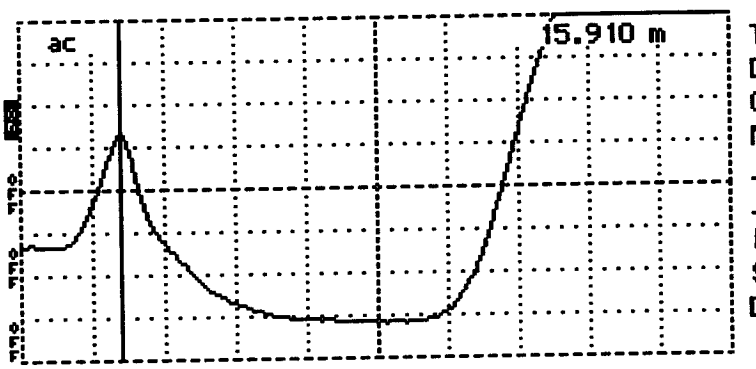
Cursor ..... 15.880 m
Distance/Div..... .25 m/div
Vertical Scale.... 145 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 6
Notes Air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

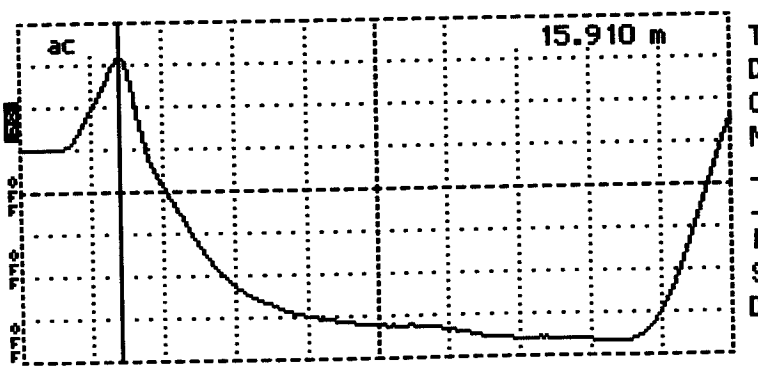
Cursor ..... 15.910 m
tance/Div..... .25 m/div
tical Scale.... 68.6 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 6
Notes Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

ursor ..... 15.910 m
stance/Div..... .25 m/div
ertical Scale.... 68.6 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 6
Notes H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

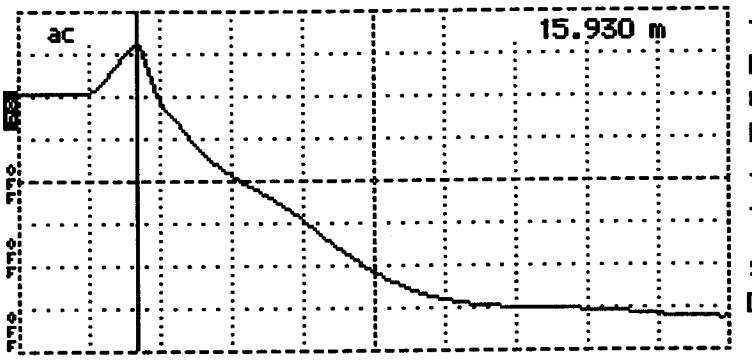
LTPP Seasonal Monitoring Study	State Code	[32]
TDR Probe Calibration	Test Section Number	[1001]

Before Operation Checks
- Calibration Date 10/9/93
- Probe S/N 33A07

Probe Number 7

TDR Trace 1 - Beginning Probe Shorted

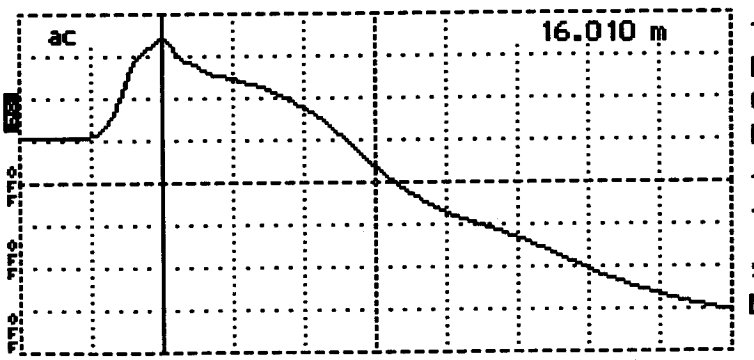
ursor ..... 15.930 m
istance/Div..... .25 m/div
ertical Scale.... 154 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 7
Notes Short CB
Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

sor ..... 16.010 m
ance/Div..... .25 m/div
tical Scale.... 154 mρ/div
..... 0.99
se Filter..... 1 avg
er..... ac

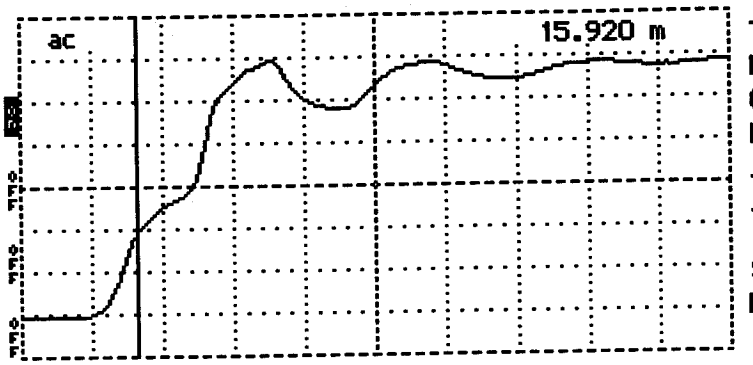


Tektronix 1502B TDR
Date 10/9/93
Cable 7
Notes Short end
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

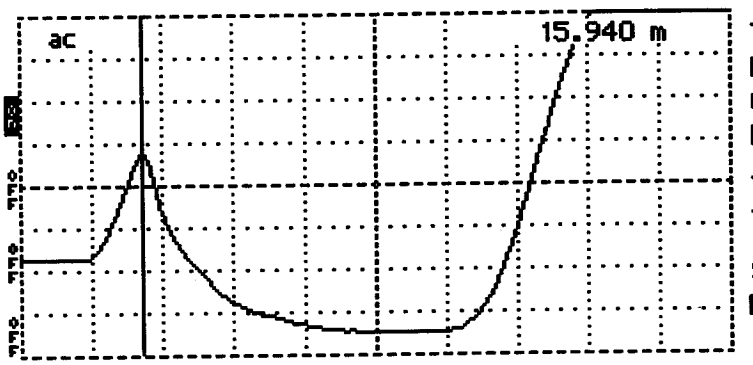
ursor ..... 15.920 m
stance/Div..... .25 m/div
ertical Scale.... 145 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 7
Notes In Air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

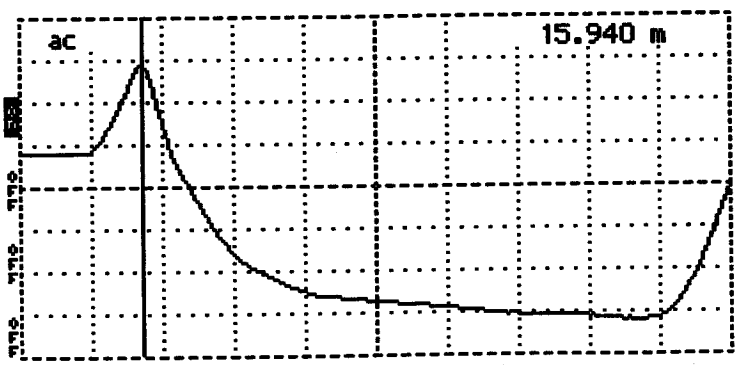
sor ..... 15.940 m
ce/Div..... .25 m/div
ical Scale.... 72.7 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 7
Notes In Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

ursor ..... 15.940 m
stance/Div..... .25 m/div
ertical Scale.... 79.2 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 7
Notes In H_2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

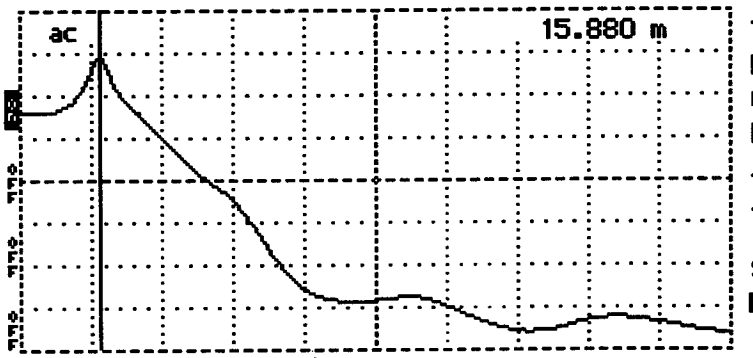
LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probe Calibration	Test Section Number	[1001]

Before Operation Checks
- Calibration Date 10/9/93
- Probe S/N 33A08

Probe Number 8

TDR Trace 1 - Beginning Probe Shorted

sor ..... 15.880 m
tance/Div..... .25 m/div
tical Scale.... 163 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac

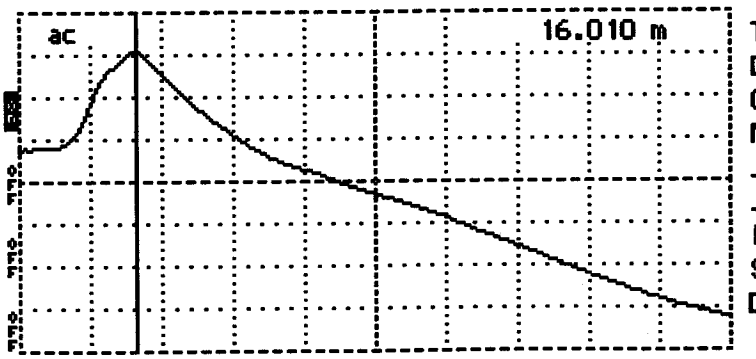


Tektronix 1502B TDR
Date 10/9/93
Cable 8
Notes 15 Foot CB

Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

sor ..... 16.010 m
tance/Div..... .25 m/div
tical Scale.... 163 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



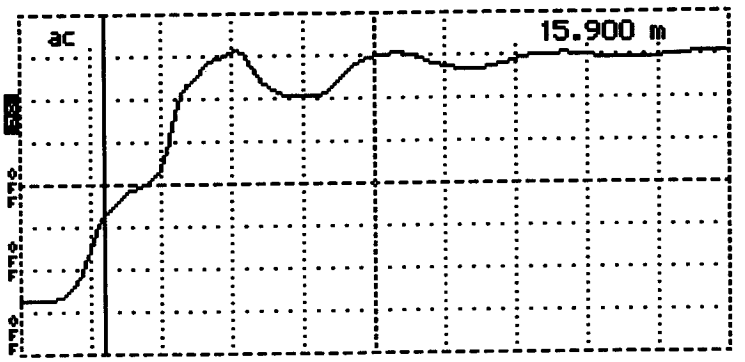
Tektronix 1502B TDR
Date 10/9/93
Cable 8
Notes Short end

Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

rsor ..... 15.900 m
stance/Div..... .25 m/div
rtical Scale.... 149 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

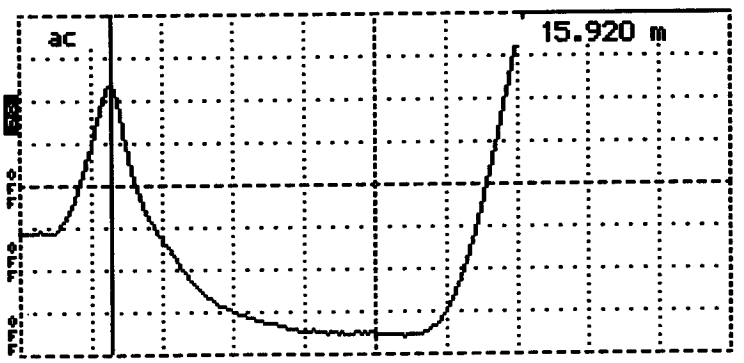


Tektronix 1502B TDR
Date 10/9/93
Cable 8
Notes Air

Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

rsor ..... 15.920 m
nce/Div..... .25 m/div
.cal Scale.... 51.5 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac

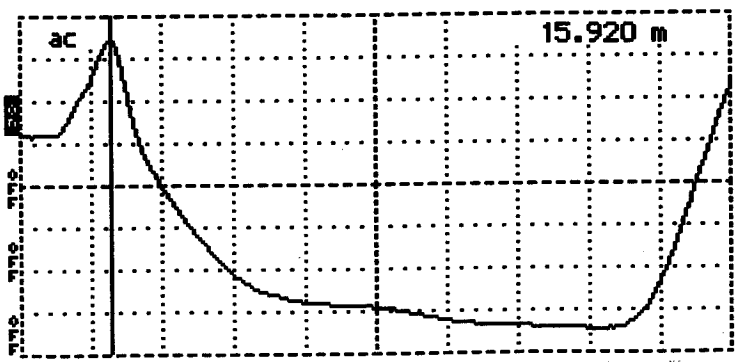


Tektronix 1502B TDR
Date 10/9/93
Cable 8
Notes Alcohol

Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

rsor ..... 15.920 m
stance/Div..... .25 m/div
rtical Scale.... 68.6 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 8
Notes H2O

Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probe Calibration	Test Section Number	[1001]

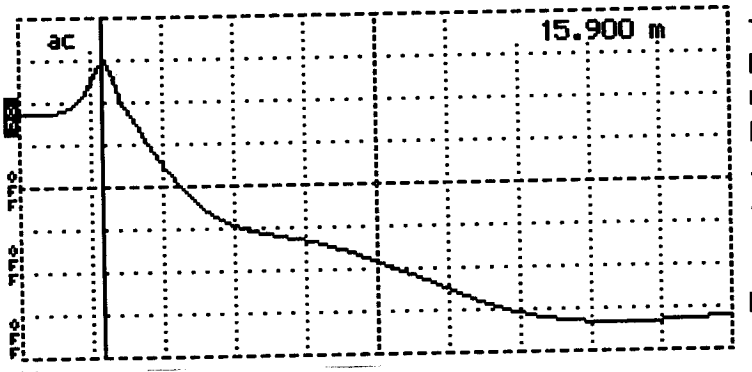
Before Operation Checks

- Calibration Date: 10/9/93
- Probe S/N: 33A09

Probe Number 9

TDR Trace 1 - Beginning Probe Shorted

ursor ..... 15.900 m
istance/Div..... .25 m/div
ertical Scale.... 172 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac

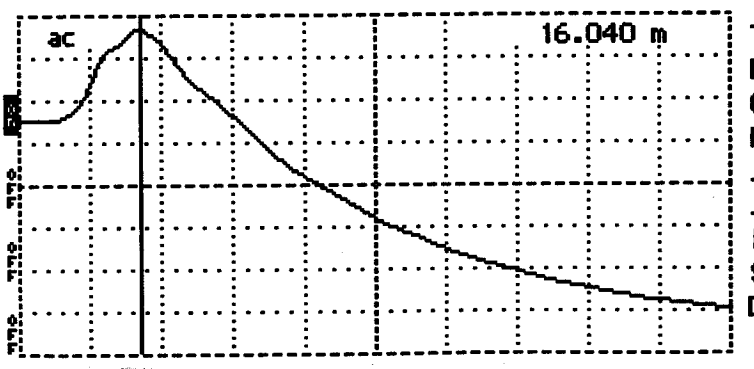


Tektronix 1502B TDR
Date 10/9/93
Cable 9
Notes Short CB

Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

ursor ..... 16.040 m
stance/Div..... .25 m/div
rtical Scale.... 172 mρ/div
ρ 0.99
ise Filter..... 1 avg
wer..... ac



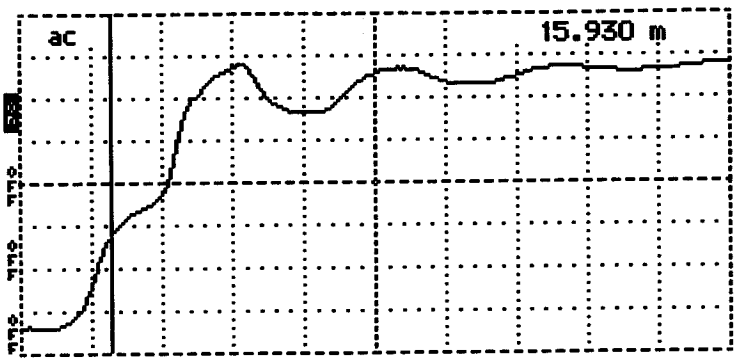
Tektronix 1502B TDR
Date 10/9/93
Cable 9
Notes Short end

Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

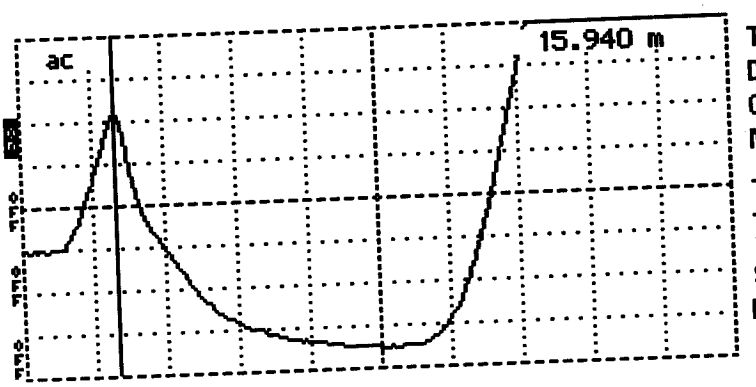
rsor ..... 15.930 m
tance/Div..... .25 m/div
rtical Scale.... 141 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 9
Notes Air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

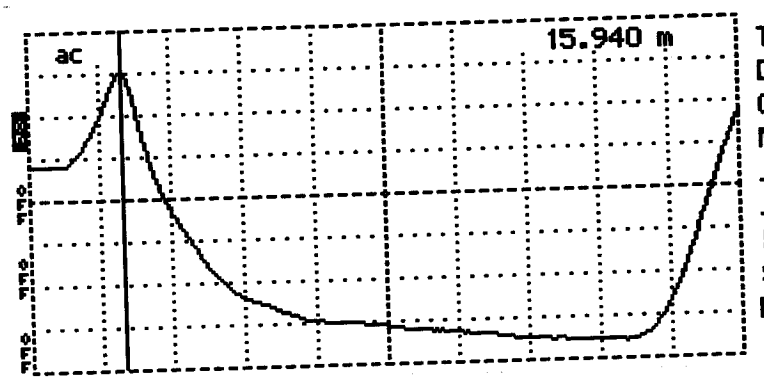
rsor ..... 15.940 m
nce/Div..... .25 m/div
rtical Scale.... 53.0 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 9
Notes Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

rsor ..... 15.940 m
tance/Div..... .25 m/div
rtical Scale.... 72.7 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 9
Notes H_2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Study	State Code	[33]
TDR Probe Calibration	Test Section Number	[1001]

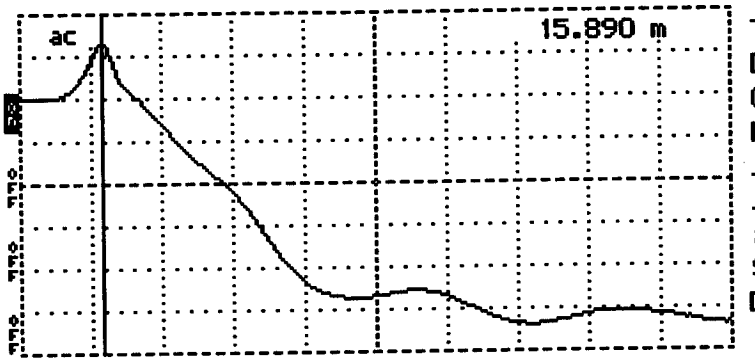
Before Operation Checks

- Calibration Date 10/9/93
- Probe S/N 33A10

Probe Number 10

TDR Trace 1 - Beginning Probe Shorted

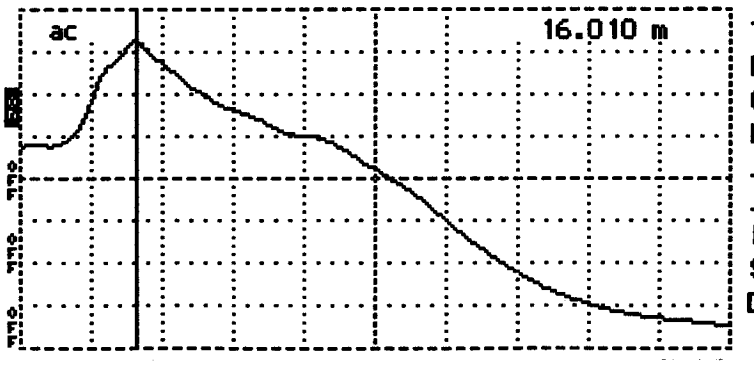
ursor ..... 15.890 m
stance/Div..... .25 m/div
ertical Scale.... 158 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/9/93
Cable 10
Notes Short CB
Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

rsor ..... 16.010 m
tance/Div..... .25 m/div
rtical Scale.... 149 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac

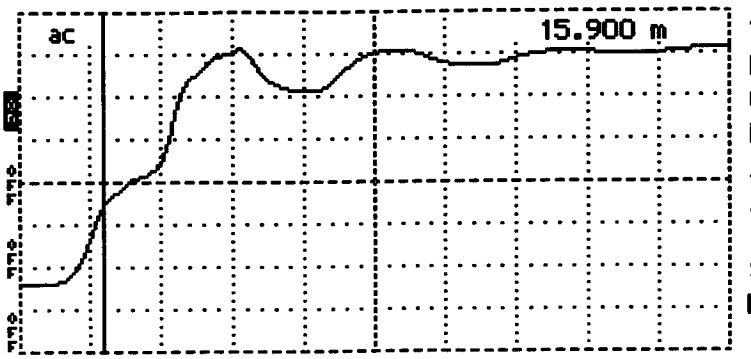


Tektronix 1502B TDR
Date 10/9/93
Cable 10
Notes Shortend
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

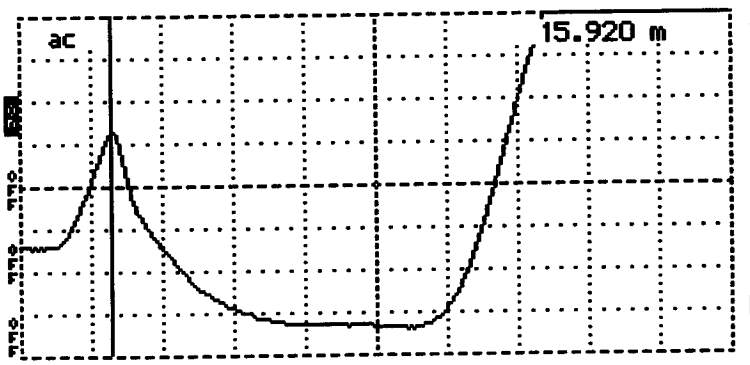
ursor ..... 15.900 m
istance/Div..... .25 m/div
ertical Scale.... 158 mρ/div
'P 0.99
loise Filter..... 1 avg
'ower..... ac



Tektronix 1502B TDR
Date 101993
Cable 10
Notes Air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

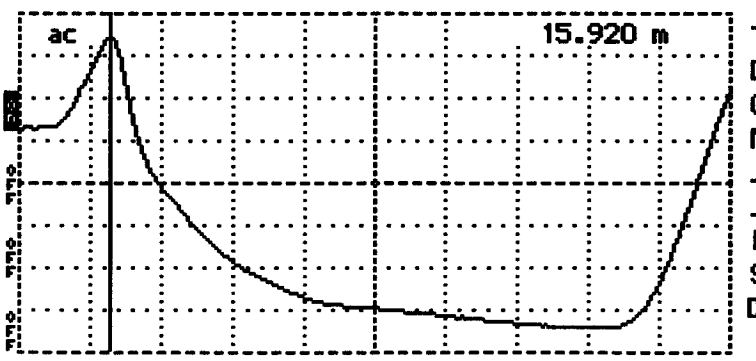
rsor ..... 15.920 m
nce/Div..... .25 m/div
.ical Scale.... 64.8 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 101993
Cable 10
Notes Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

rsor ..... 15.920 m
stance/Div..... .25 m/div
rtical Scale.... 66.7 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 101993
Cable 10
Notes H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

APPENDIX C

Supporting Instrumentation Installation Information

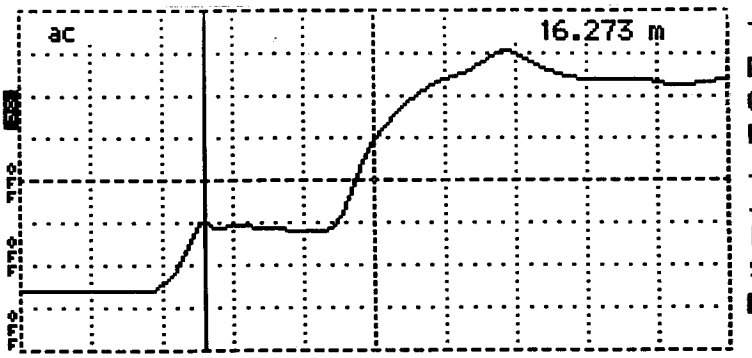
Appendix C contains the following supporting information:

Figure C-1 TDR Traces Measured Manually During Installation

Table C-1 TDR Moisture Content During Installation

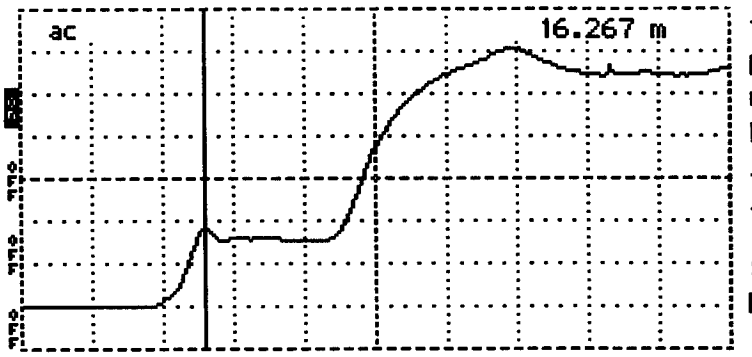
Table C-2 Field Measured Moisture Content During Installation

rsor ..... 16.273 m
stance/Div..... .25 m/div
rtical Scale.... 141 mρ/div
..... 0.99
:e Filter..... 1 avg
wer..... ac



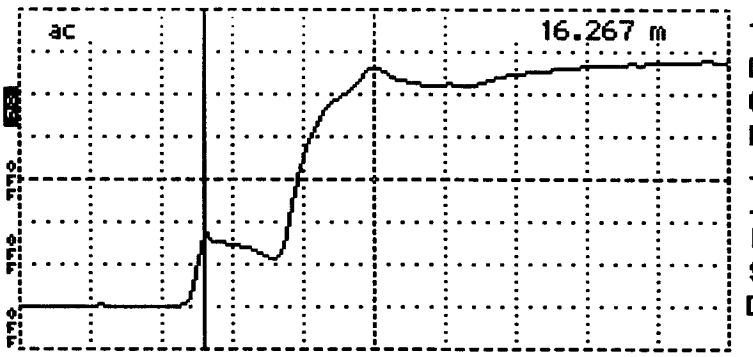
Tektronix 1502B TDR
Date 10/13/93
Cable 335A01
Notes
Input Trace
Stored Trace
Difference Trace

rsor ..... 16.267 m
stance/Div..... .25 m/div
rtical Scale.... 122 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



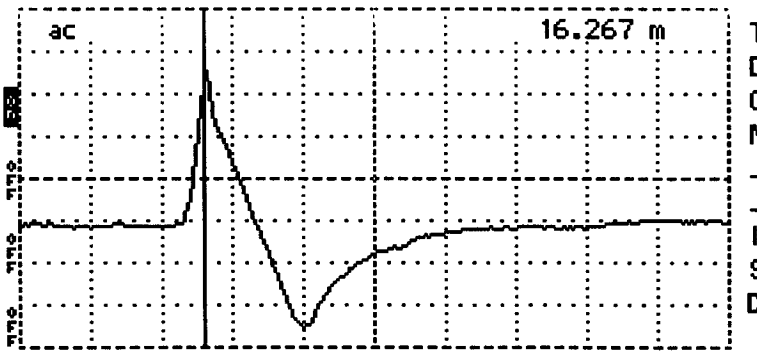
Tektronix 1502B TDR
Date 10/13/93
Cable 335A02
Notes
Input Trace
Stored Trace
Difference Trace

rsor ..... 16.267 m
stance/Div..... 0.5 m/div
rtical Scale.... 115 mρ/div
..... 0.99
se Filter..... 1 avg
er..... ac



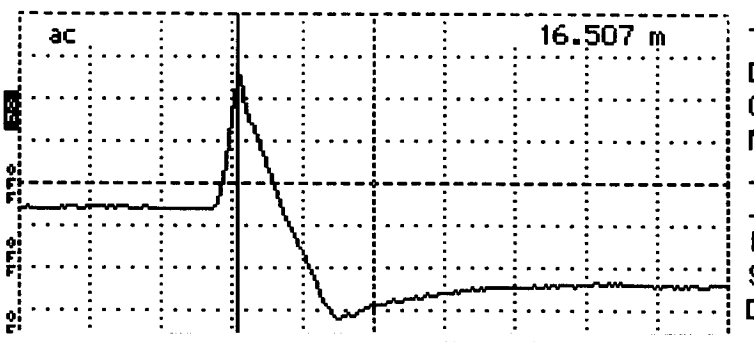
Tektronix 1502B TDR
Date 10/13/93
Cable 335A03
Notes
Input Trace
Stored Trace
Difference Trace

rsor ..... 16.267 m
stance/Div..... 0.5 m/div
rtical Scale.... 53.0 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 10/13/93
Cable 335A04
Notes
Input Trace
Stored Trace
Difference Trace

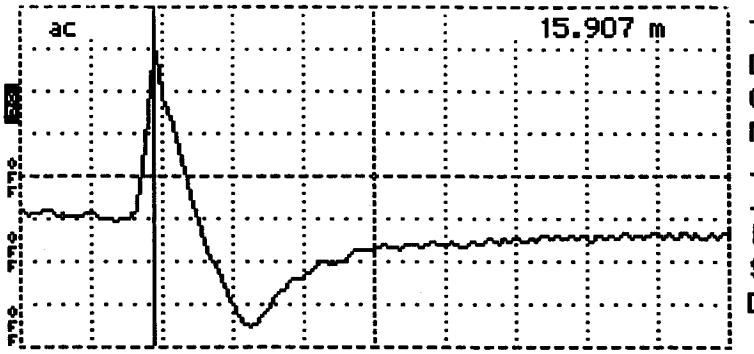
rsor ..... 16.507 m
tance/Div..... 0.5 m/div
rtical Scale.... 62.9 mρ/div
..... 0.99
se Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 10/13/93
Cable 335A05
Notes
Input Trace
Stored Trace
Difference Trace

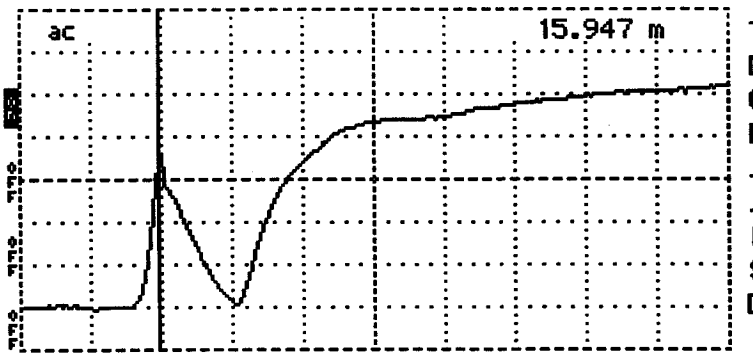
Figure C-1. TDR Traces Measured Manually During Installation

ursor ..... 15.907 m
istance/Div..... 0.5 m/div
ertical Scale.... 50.0 mρ/div
P 0.99
ise Filter..... 1 avg
ower..... ac



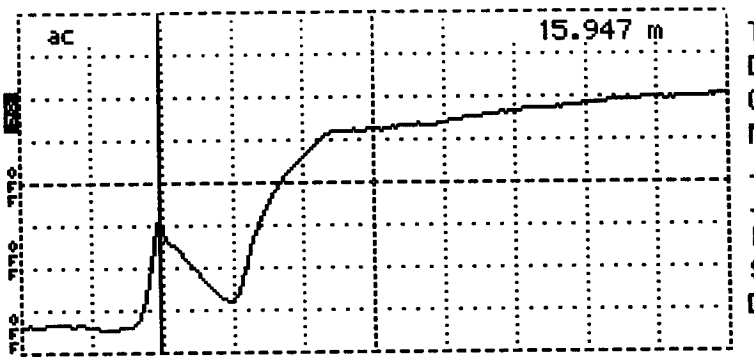
Tektronix 1502B TDR
Date 10/13/93
Cable 335A06
Notes
Input Trace
Stored Trace
Difference Trace

ursor ..... 15.947 m
istance/Div..... 0.5 m/div
ertical Scale.... 59.4 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



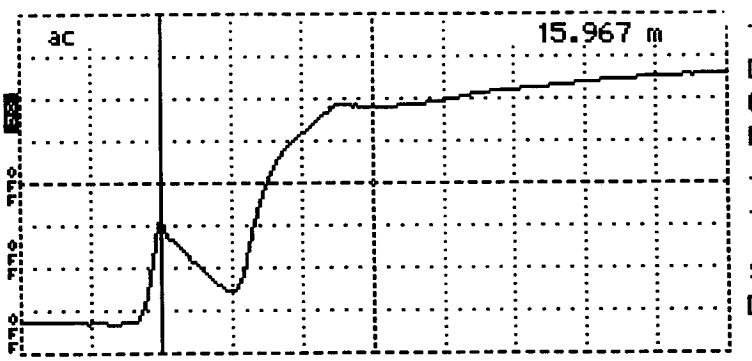
Tektronix 1502B TDR
Date 10/13/93
Cable 335A07
Notes
Input Trace
Stored Trace
Difference Trace

ursor ..... 15.947 m
istance/Div..... 0.5 m/div
ertical Scale.... 83.9 mρ/div
P 0.99
ise Filter..... 1 avg
ower..... ac



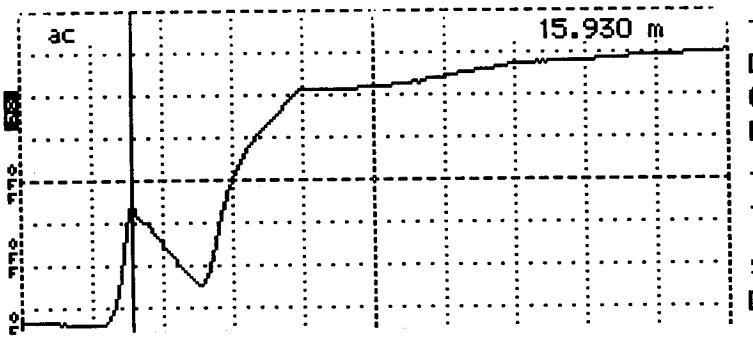
Tektronix 1502B TDR
Date 10/13/93
Cable 335A08
Notes
Input Trace
Stored Trace
Difference Trace

ursor ..... 15.967 m
istance/Div..... 0.5 m/div
ertical Scale.... 88.9 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/13/93
Cable 335A09
Notes
Input Trace
Stored Trace
Difference Trace

ursor ..... 15.930 m
istance/Div..... 0.5 m/div
ertical Scale.... 79.2 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 10/13/93
Cable 335A10
Notes
Input Trace
Stored Trace
Difference Trace

Figure C-1(cont.). TDR Traces Measured Manually During Installation

Table C-1. TDR Moisture Content During Installation

TDR No.	TDR Length (m)	Dielectric Constant	Volumetric Moisture Content (%)	In-Situ Dry Density	Gravametric Moisture Content (%)
33A01	0.470	5.47	9.15	2.15	4.26
33A02	0.470	5.47	9.15	2.15	4.26
33A03	0.540	7.22	13.15	2.15	6.12
33A04	0.700	12.13	22.92	2.10	10.91
33A05	0.700	12.13	22.92	2.10	10.91
33A06	0.680	11.45	21.68	1.86	11.66
33A07	0.540	7.22	13.15	1.86	7.07
33A08	0.540	7.22	13.15	1.86	7.07
33A09	0.560	7.76	14.34	1.86	7.71
33A10	0.480	5.70	9.70	1.86	5.22

Table C-2. Field Measured Moisture Content During Installation

LTPP Seasonal Monitoring Study	State Code	[23]
In-Situ Moisture Tests	Test Section Number	[1026]

Weight (gms)	Probe 1	Probe 2	Probe 3	Probe 4	Probe 5
Weight of Pan + Wet Soil	289.0	295.9	236.1	203.3	199.2
Weight of Pan + Dry Soil	284.8	292.2	231.9	195.3	191.4
Weight of Pan	120.0	120.9	120.0	120.9	120.5
Weight of Dry Soil	164.8	171.3	111.9	74.4	70.9
Weight of Wet Soil	169.0	175.0	116.1	82.4	78.7
Weight of Moisture	4.2	3.7	4.2	8.0	7.8
Wt of Moisture/Dry Wt x 100	2.55	2.16	3.75	10.75	11.00

Weight (gms)	Probe 6	Probe 7	Probe 8	Probe 9	Probe 10
Weight of Pan + Wet Soil	228.0	248.1	245.7	234.2	229.9
Weight of Pan + Dry Soil	218.5	240.7	238.8	226.8	221.9
Weight of Pan	120.9	120.5	120.9	120.9	120.5
Weight of Dry Soil	97.6	120.2	117.9	105.9	101.4
Weight of Wet Soil	107.1	127.6	124.8	113.3	109.4
Weight of Moisture	9.5	7.4	6.9	7.4	8.0
Wt of Moisture/Dry Wt x 100	9.73	6.16	5.85	6.99	7.89

APPENDIX D

Initial Data Collection

Appendix D contains the following supporting information:

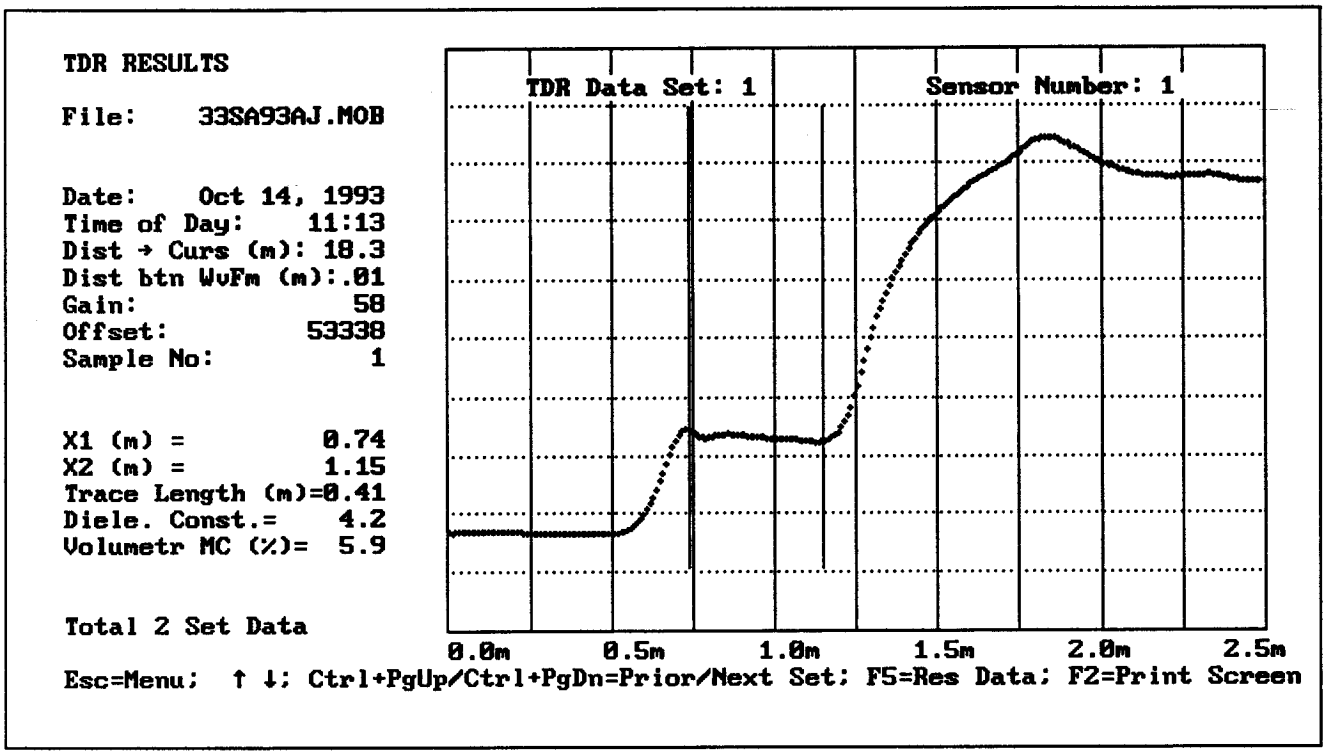


Figure D-1. Initial First Set of TDR Traces Measured with the Mobile Unit

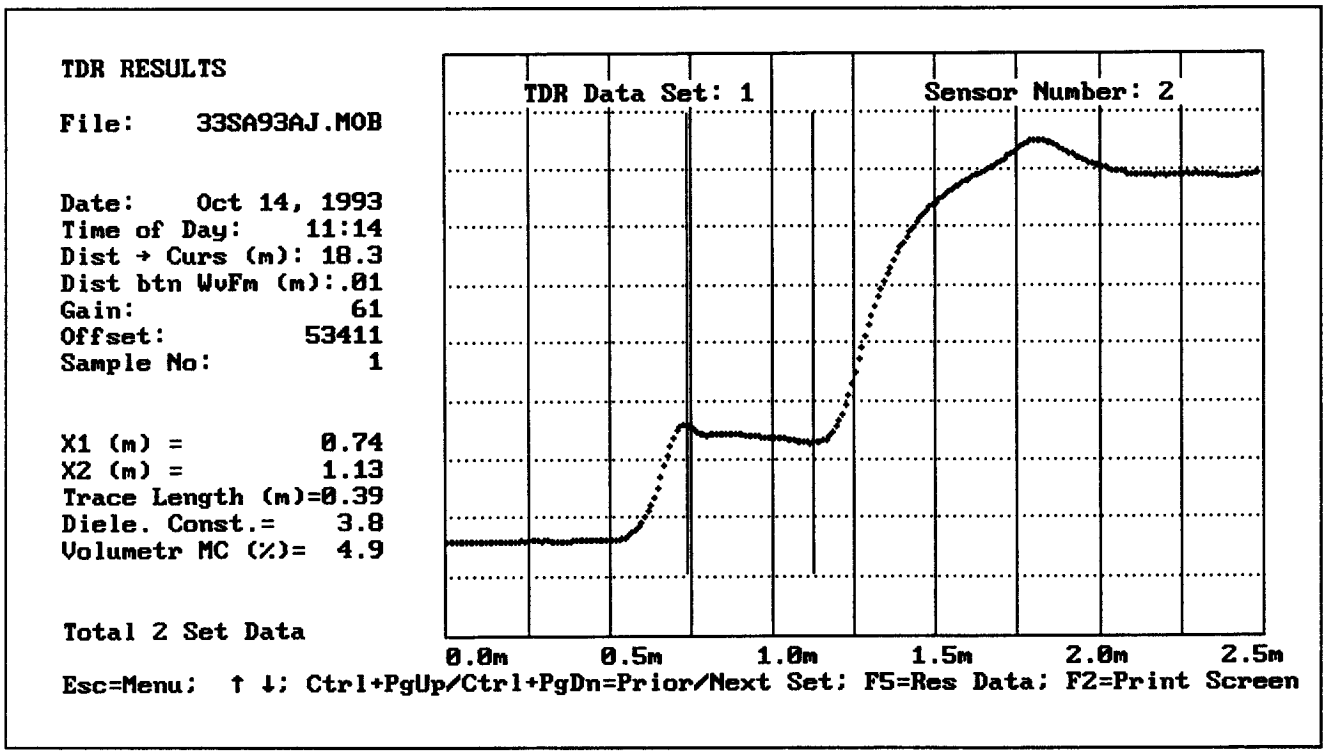


Figure D-1(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

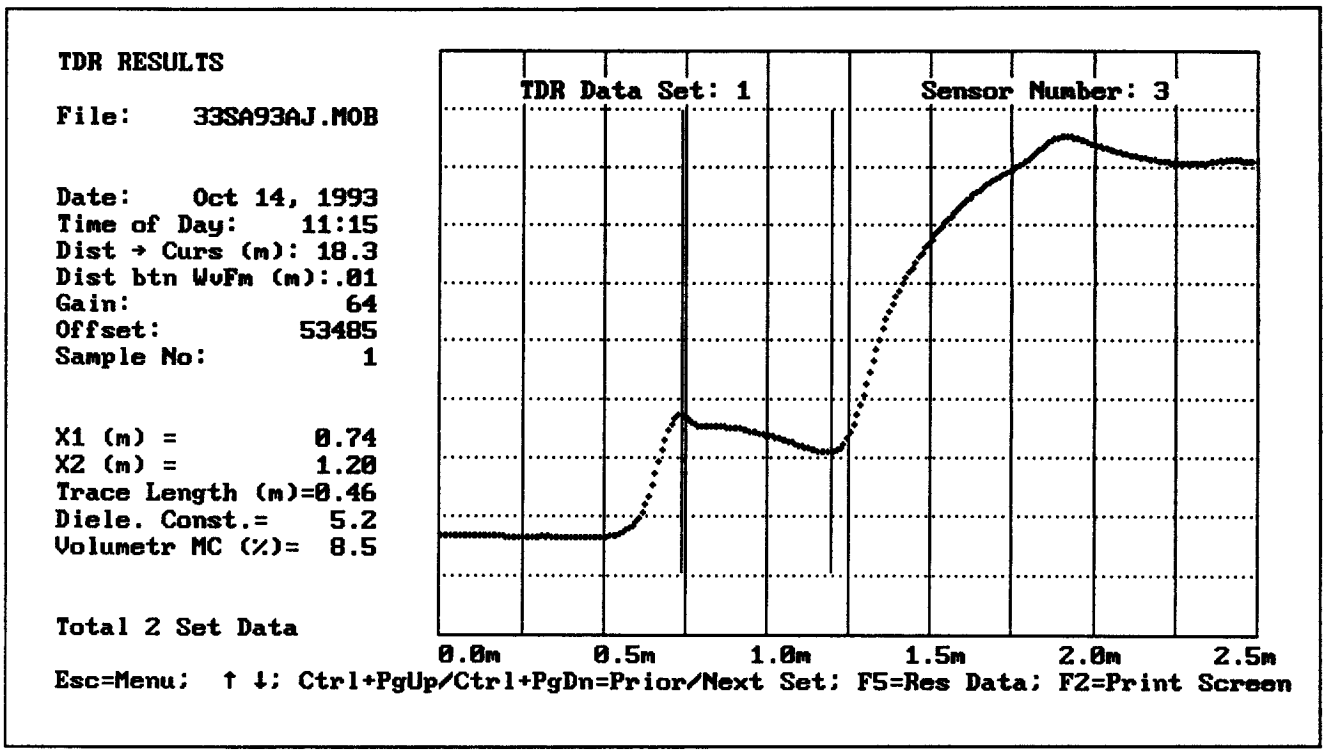


Figure D-1(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

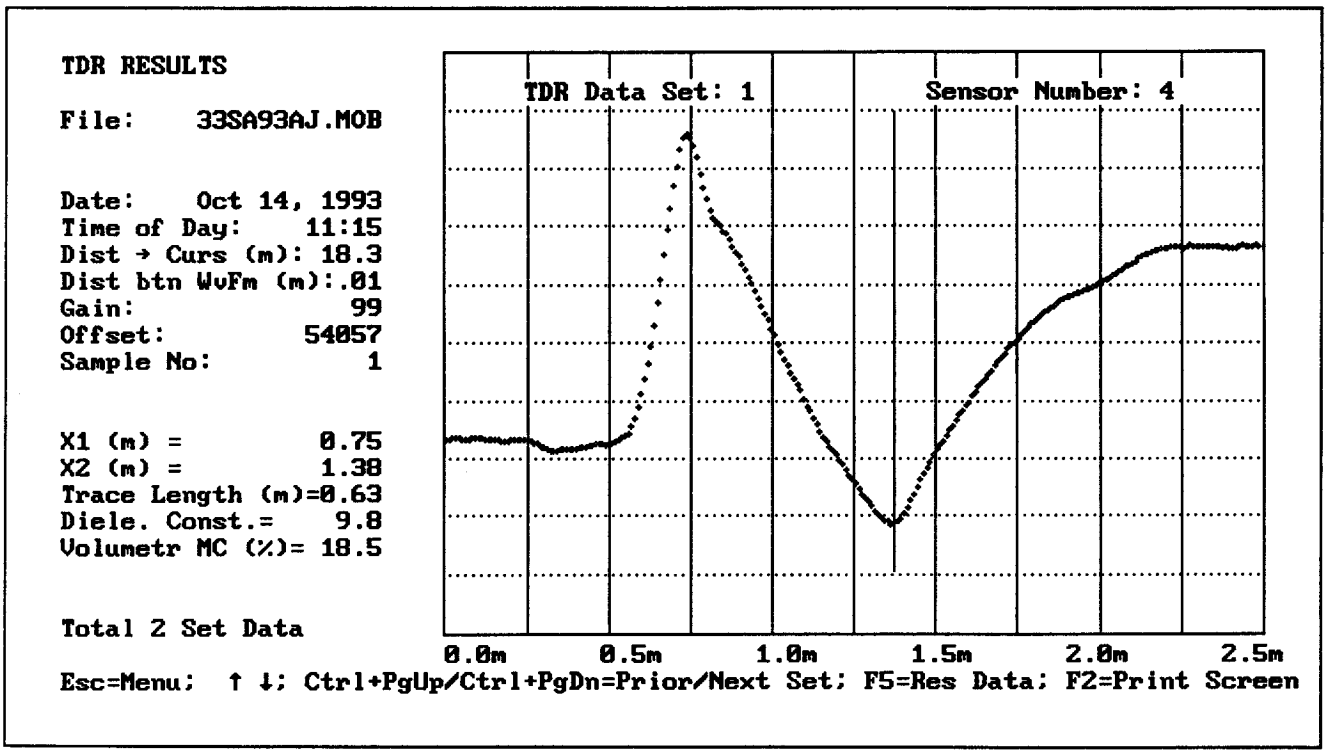


Figure D-1(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

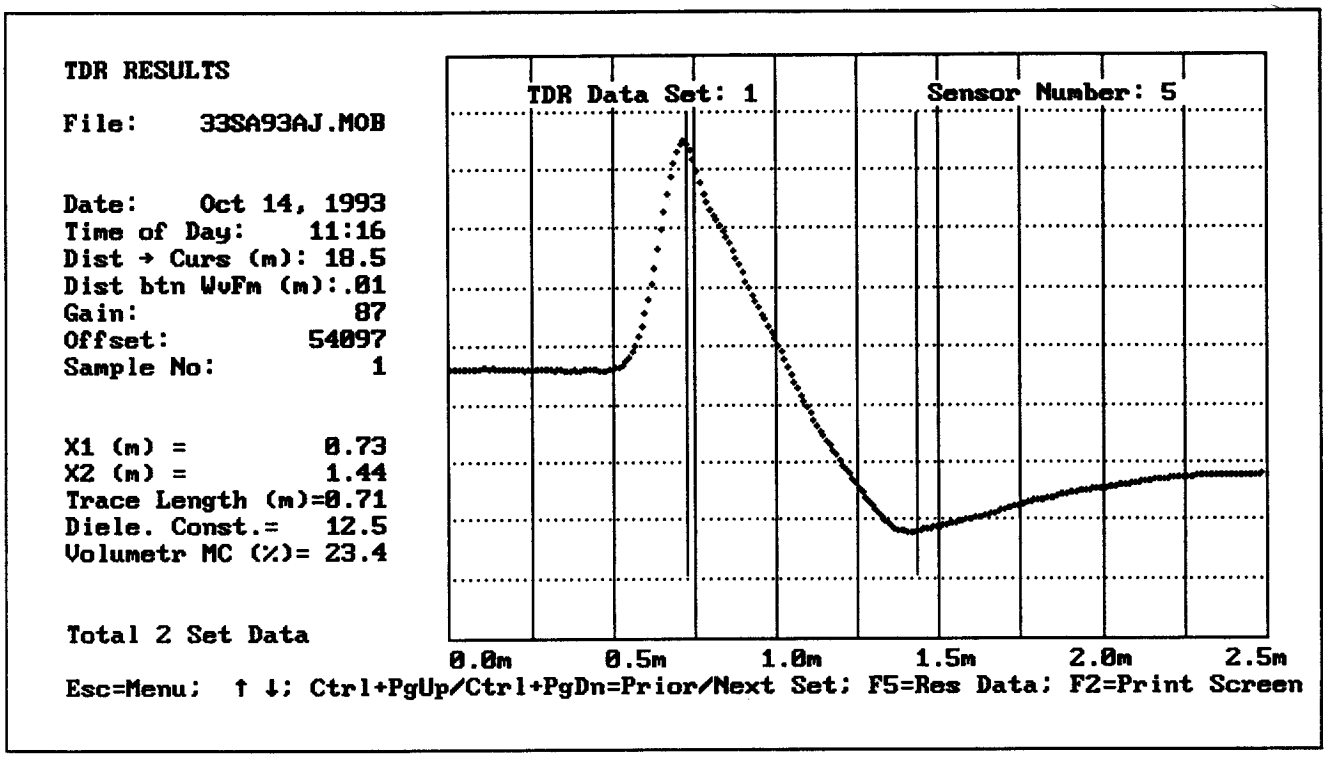


Figure D-1(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

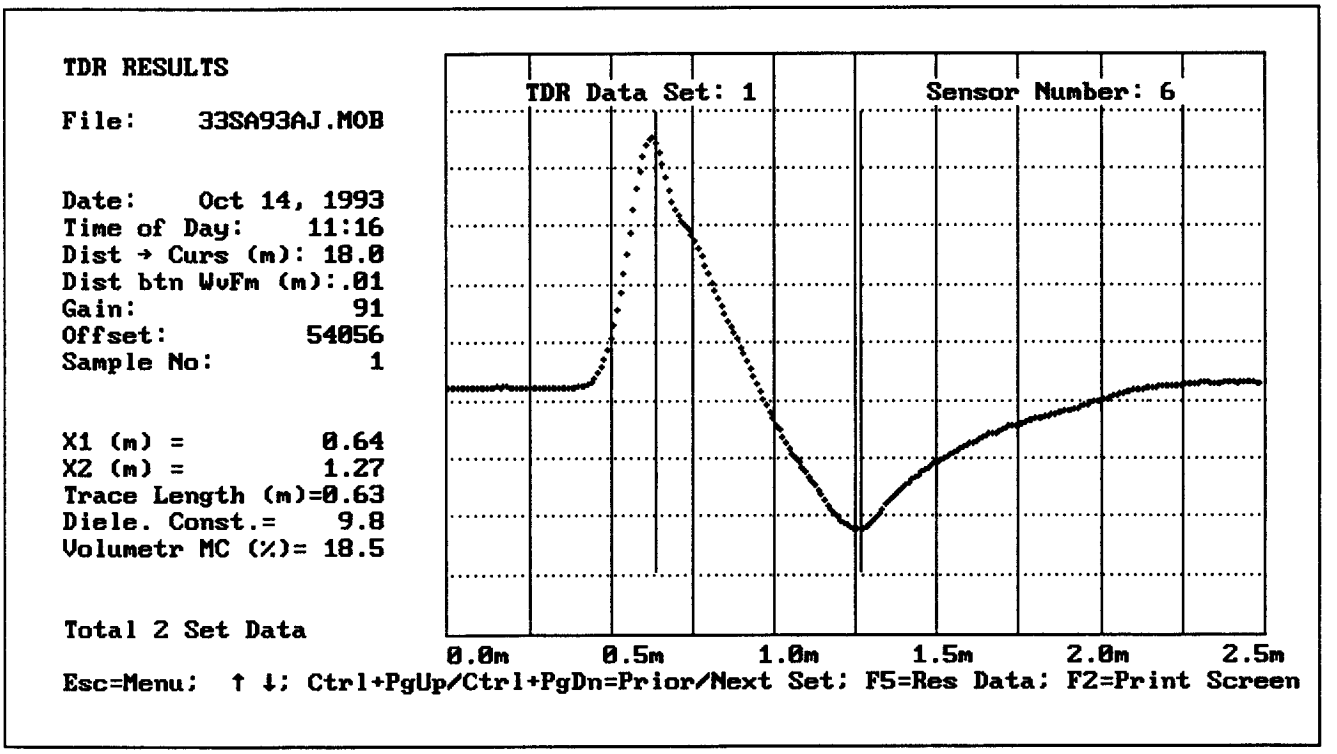


Figure D-1(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

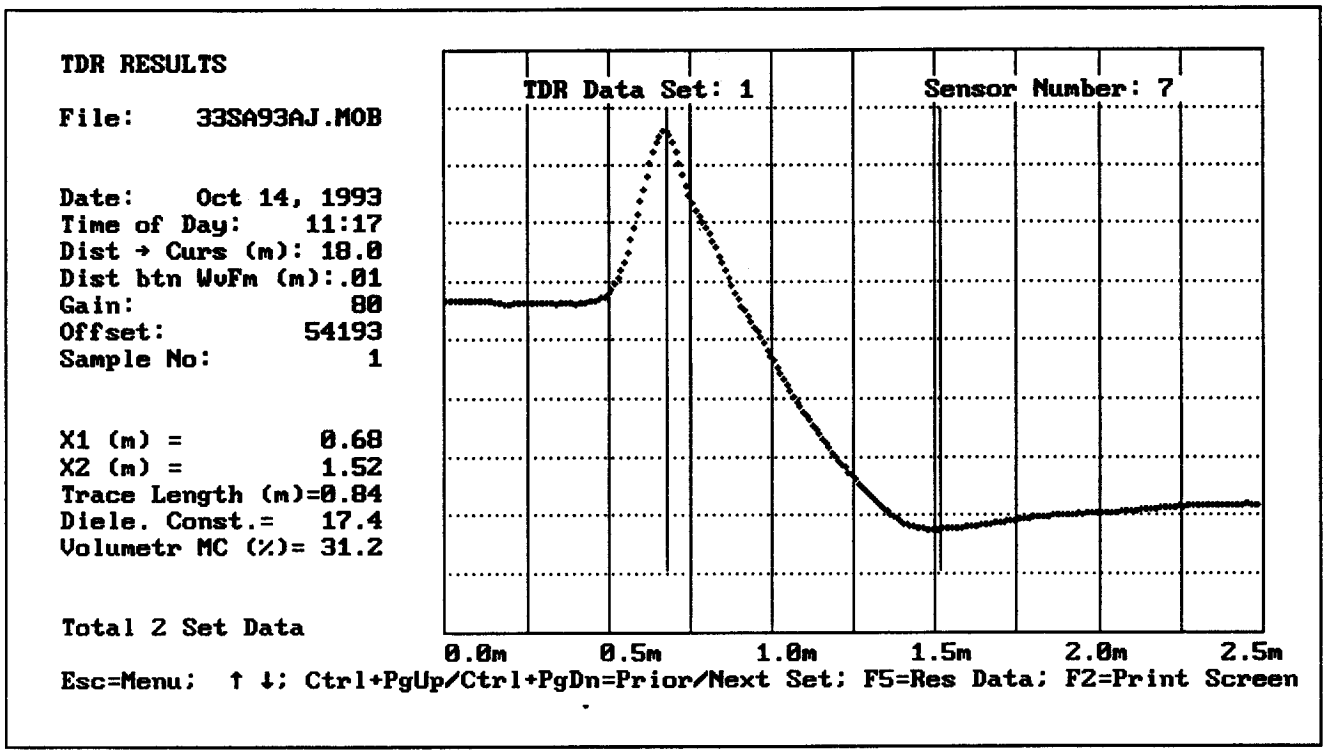


Figure D-1(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

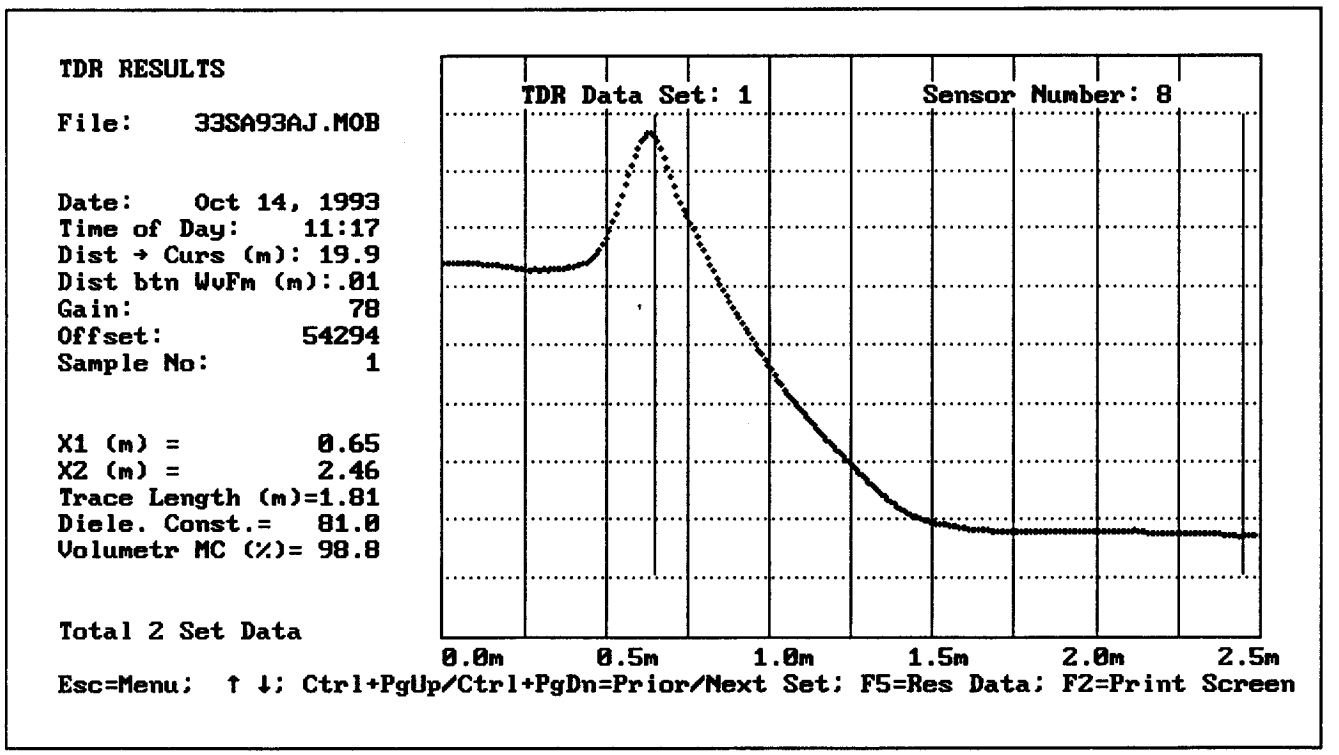


Figure D-1(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

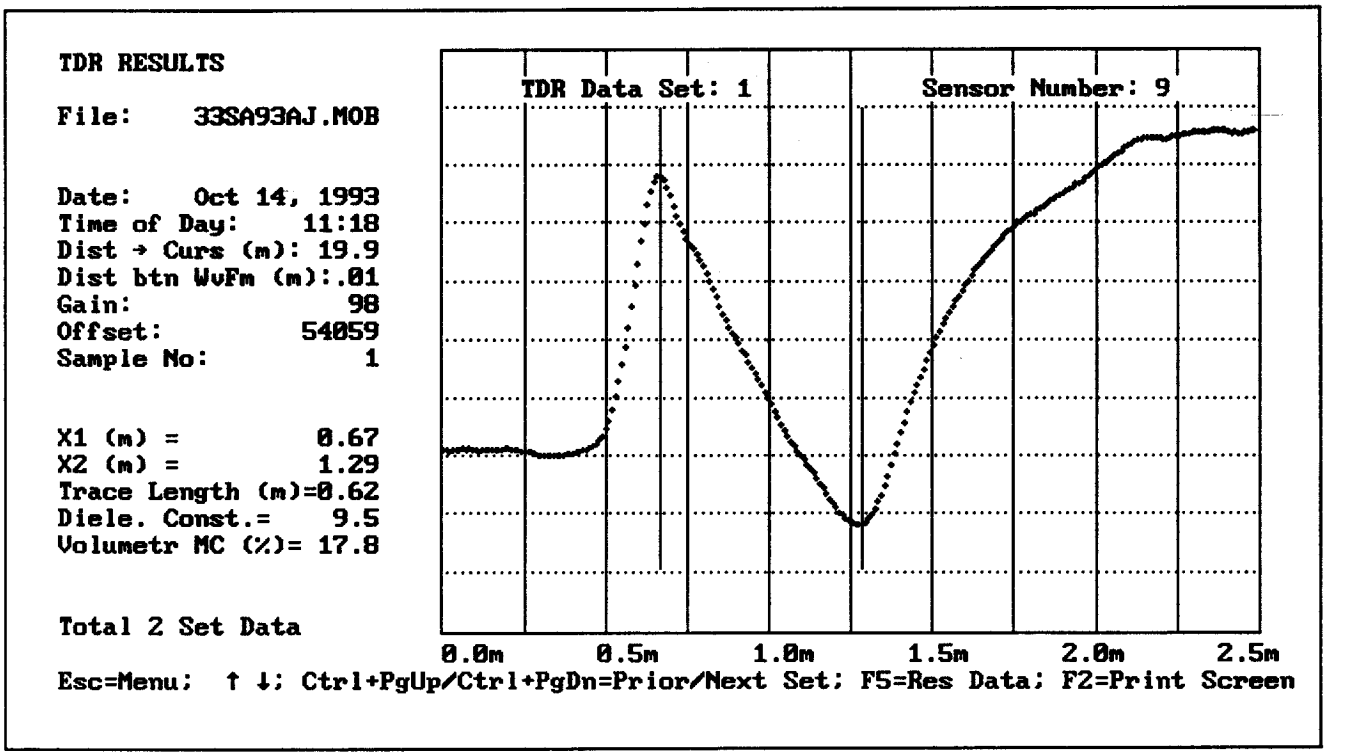


Figure D-1(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

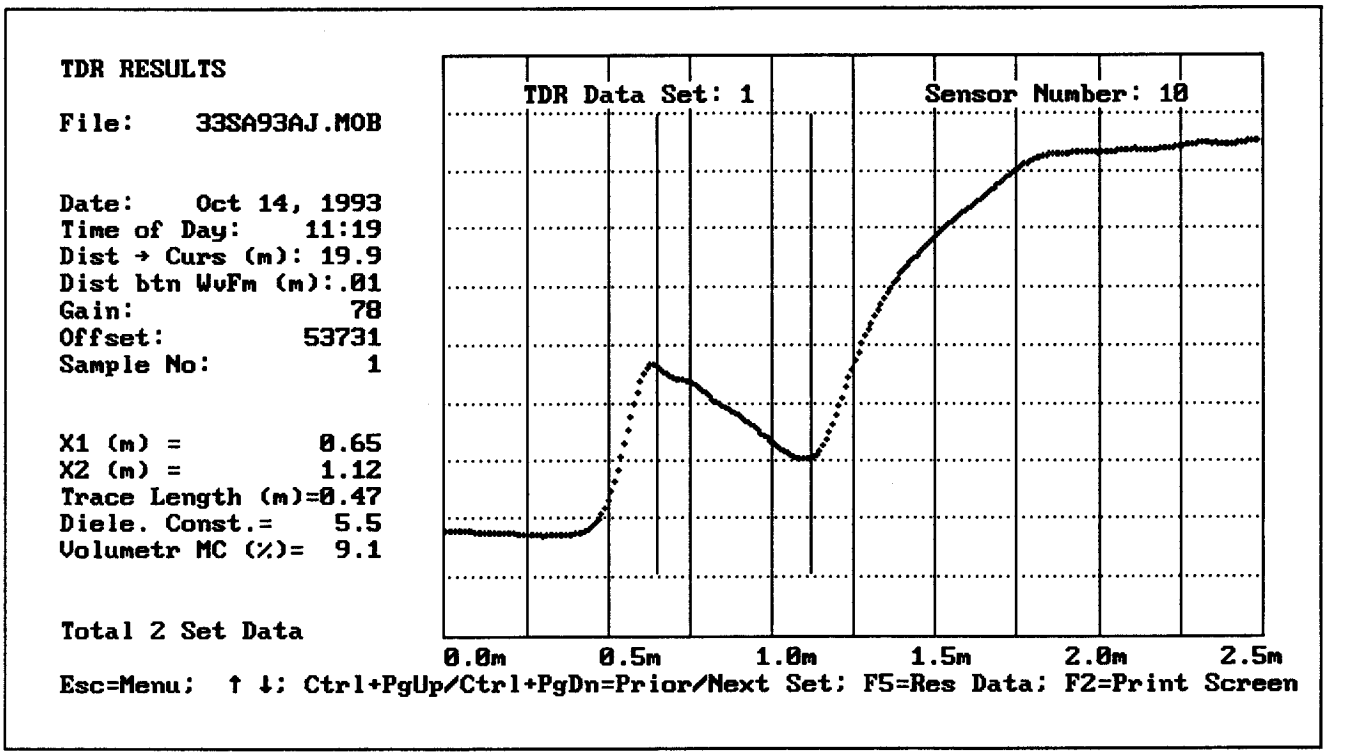


Figure D-1(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

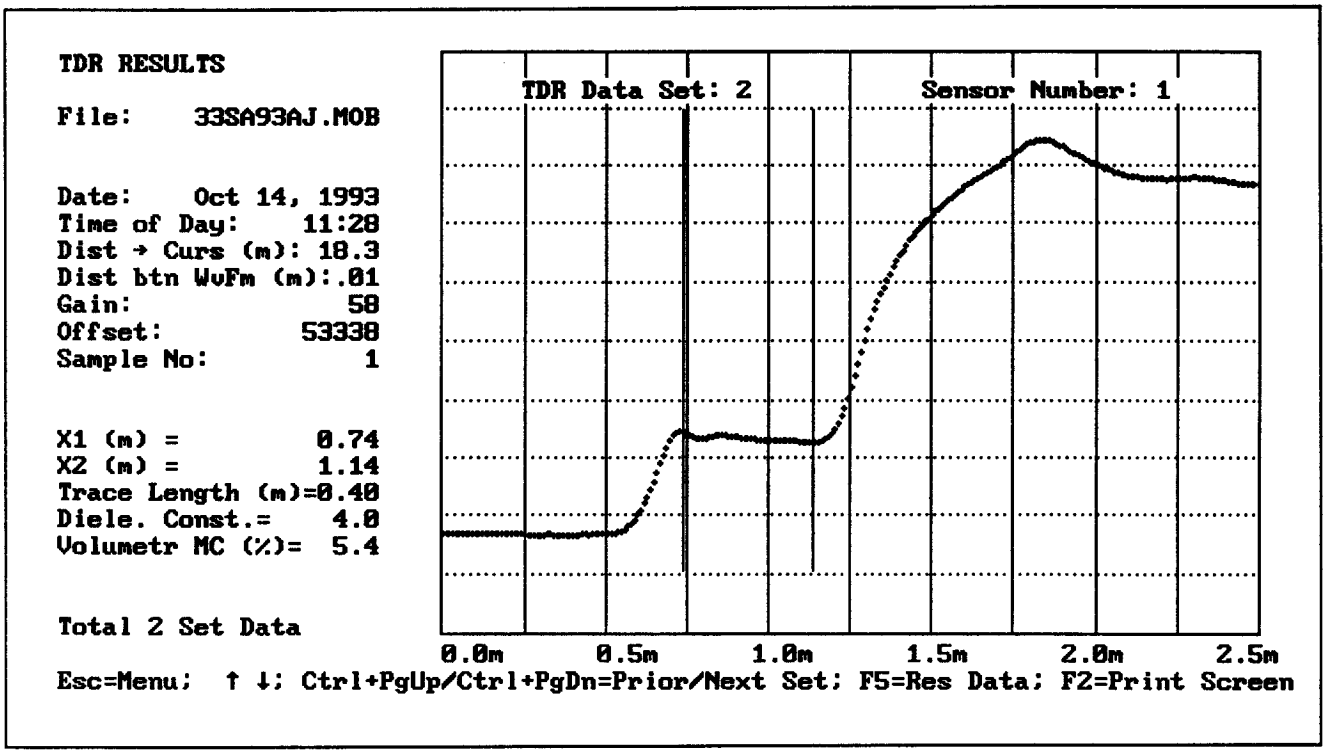


Figure D-2. Initial Second Set of TDR Traces Measured with the Mobile Unit

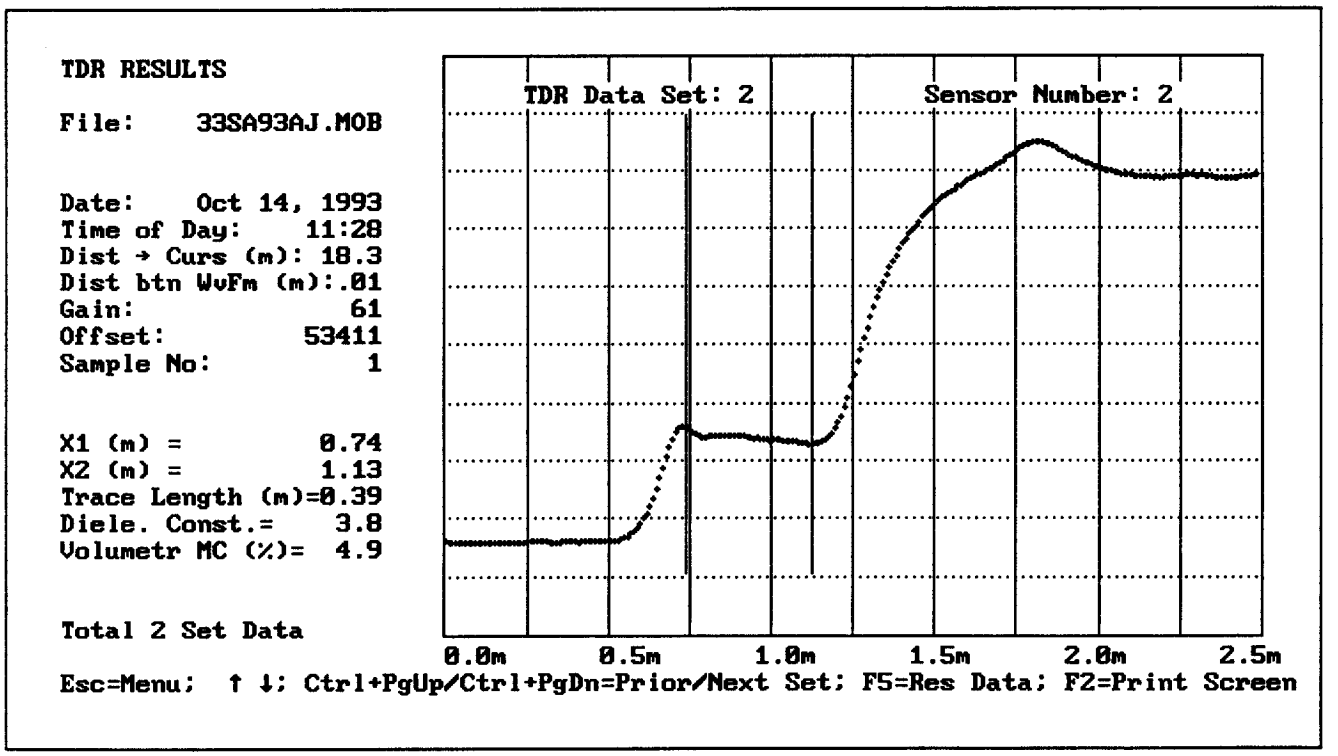


Figure D-2(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

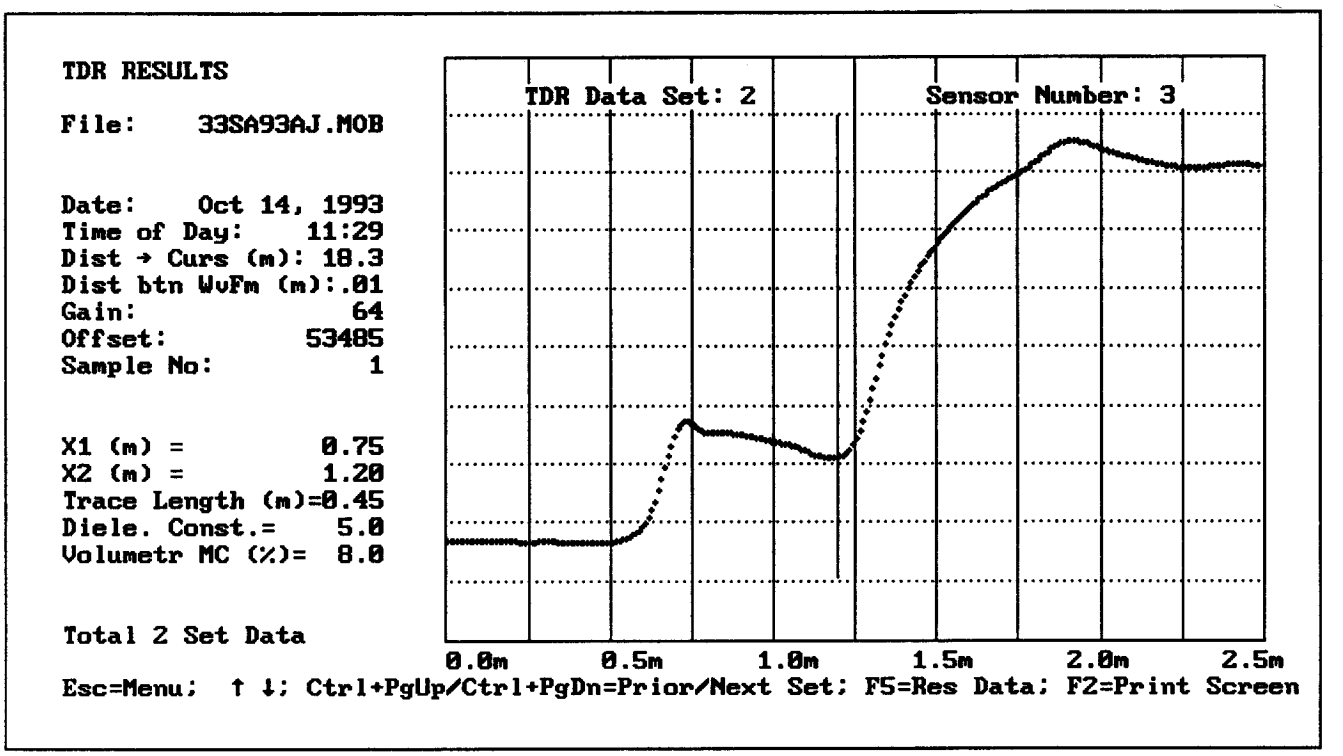


Figure D-2(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

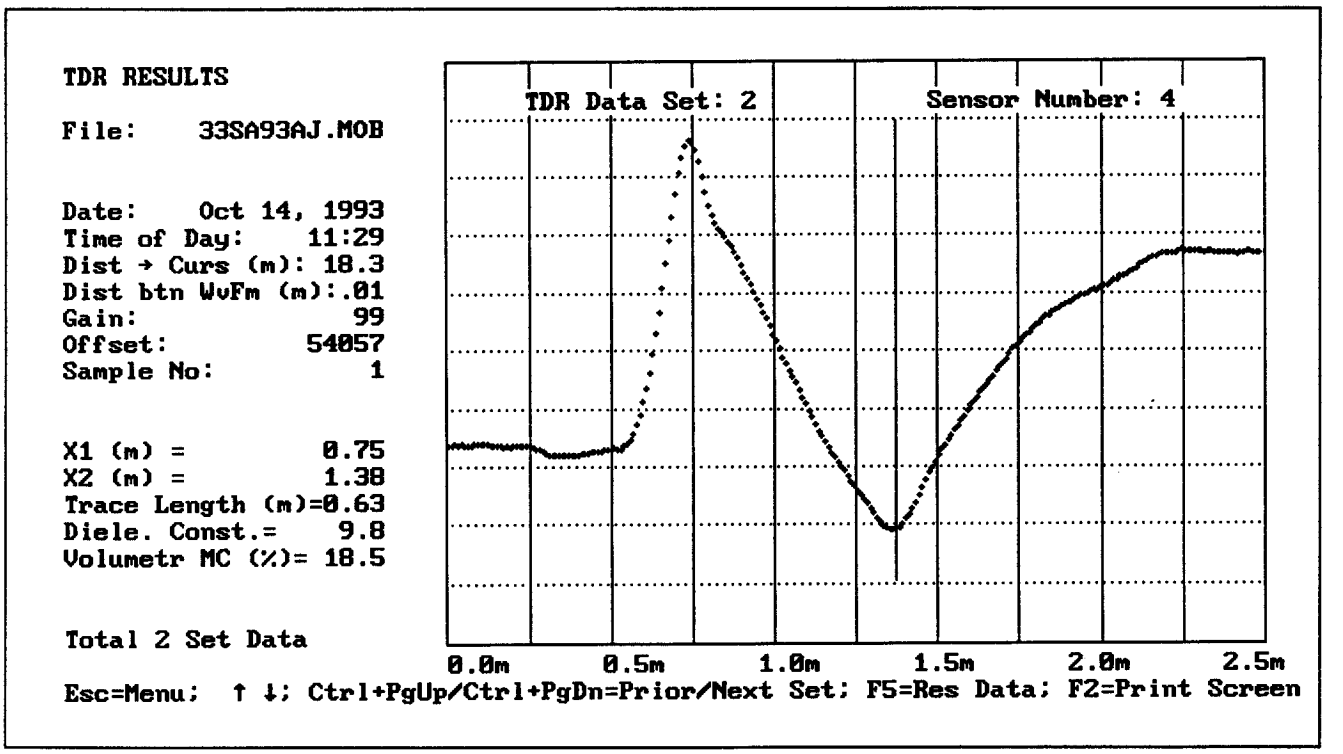


Figure D-2(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

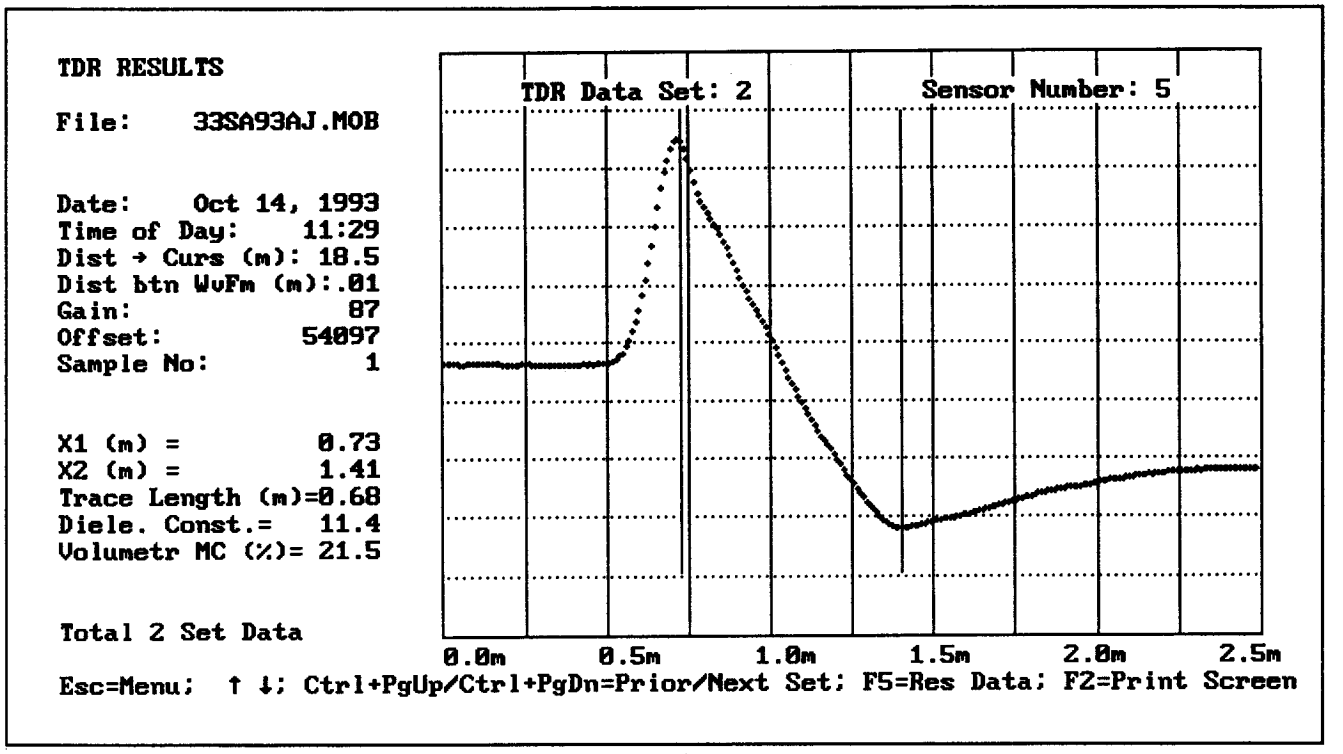


Figure D-2(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

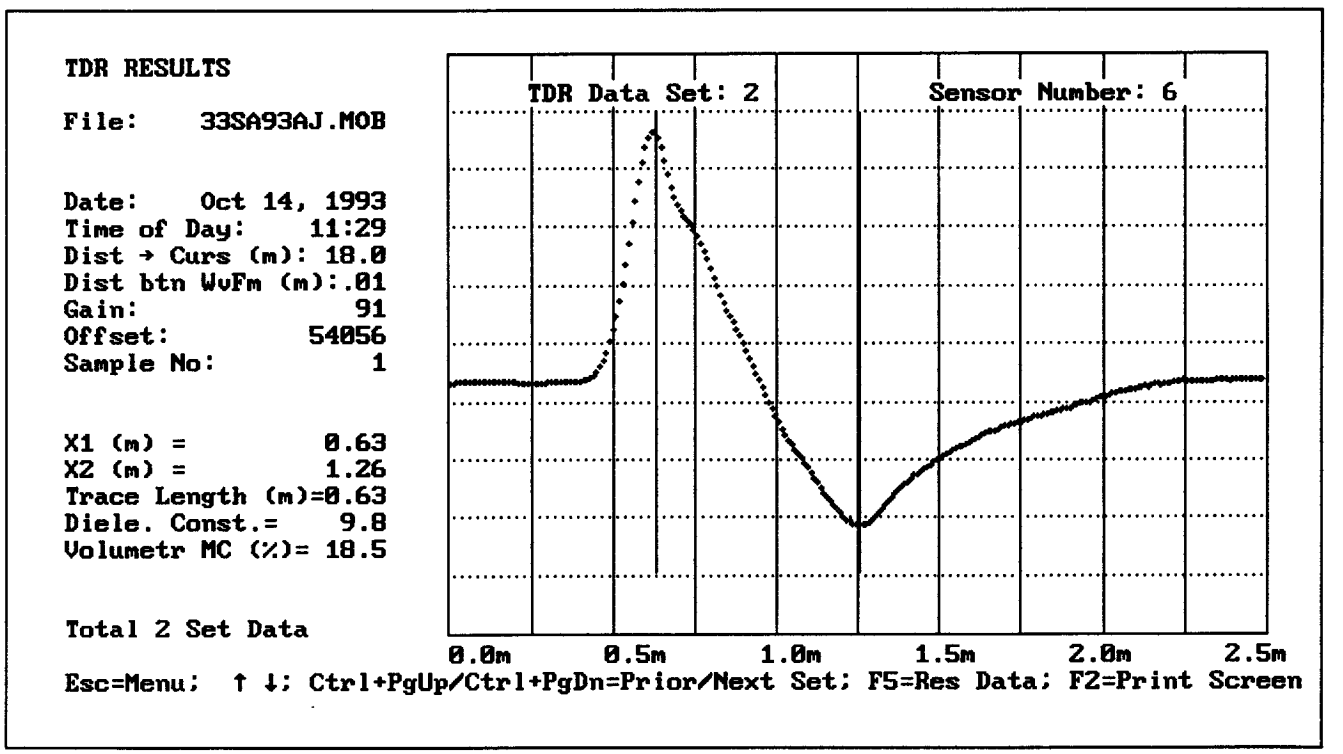


Figure D-2(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

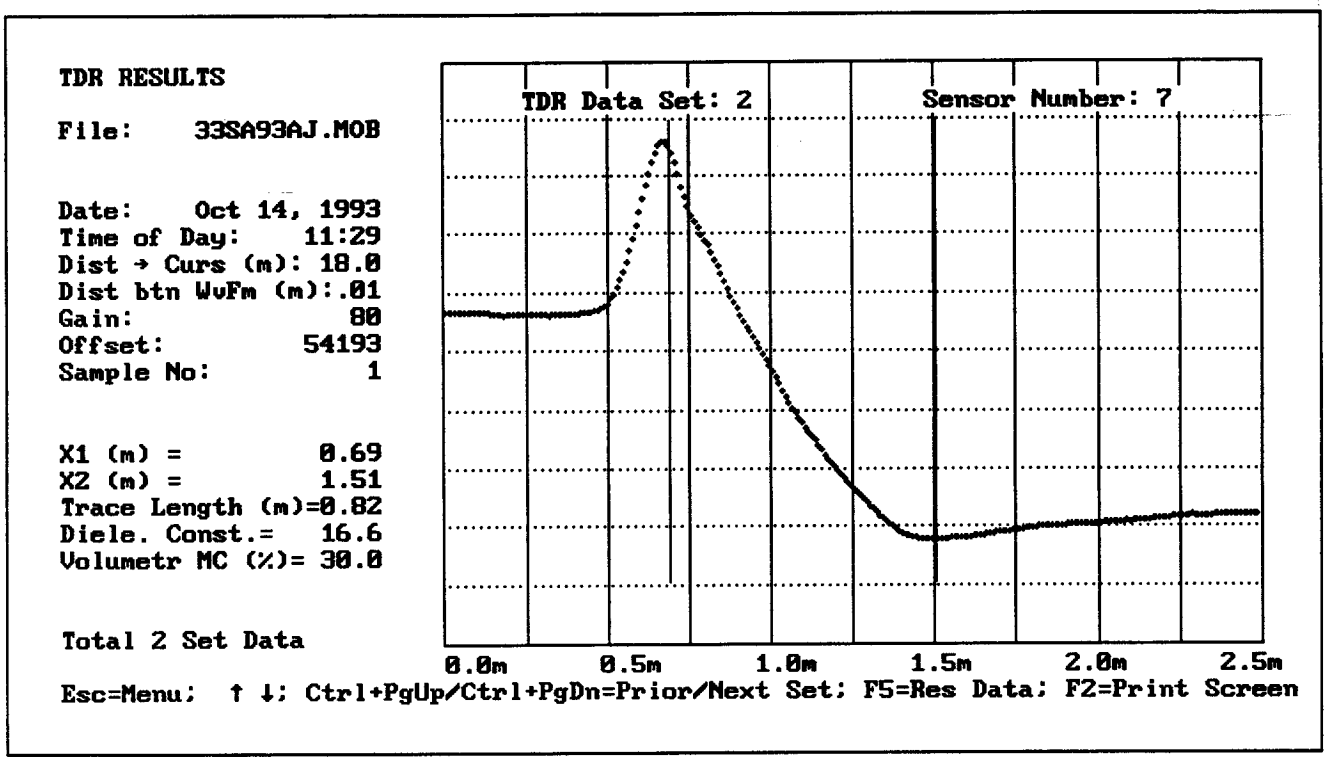


Figure D-2(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

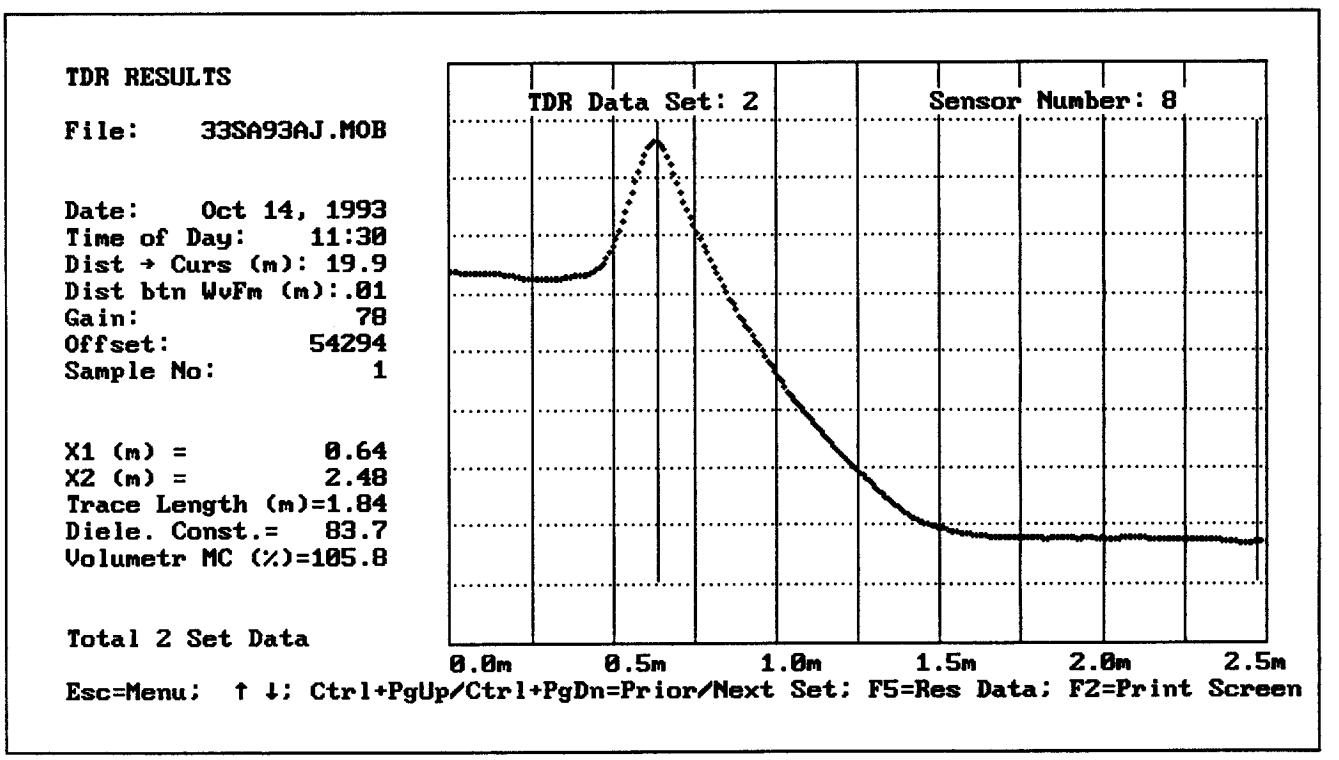


Figure D-2(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

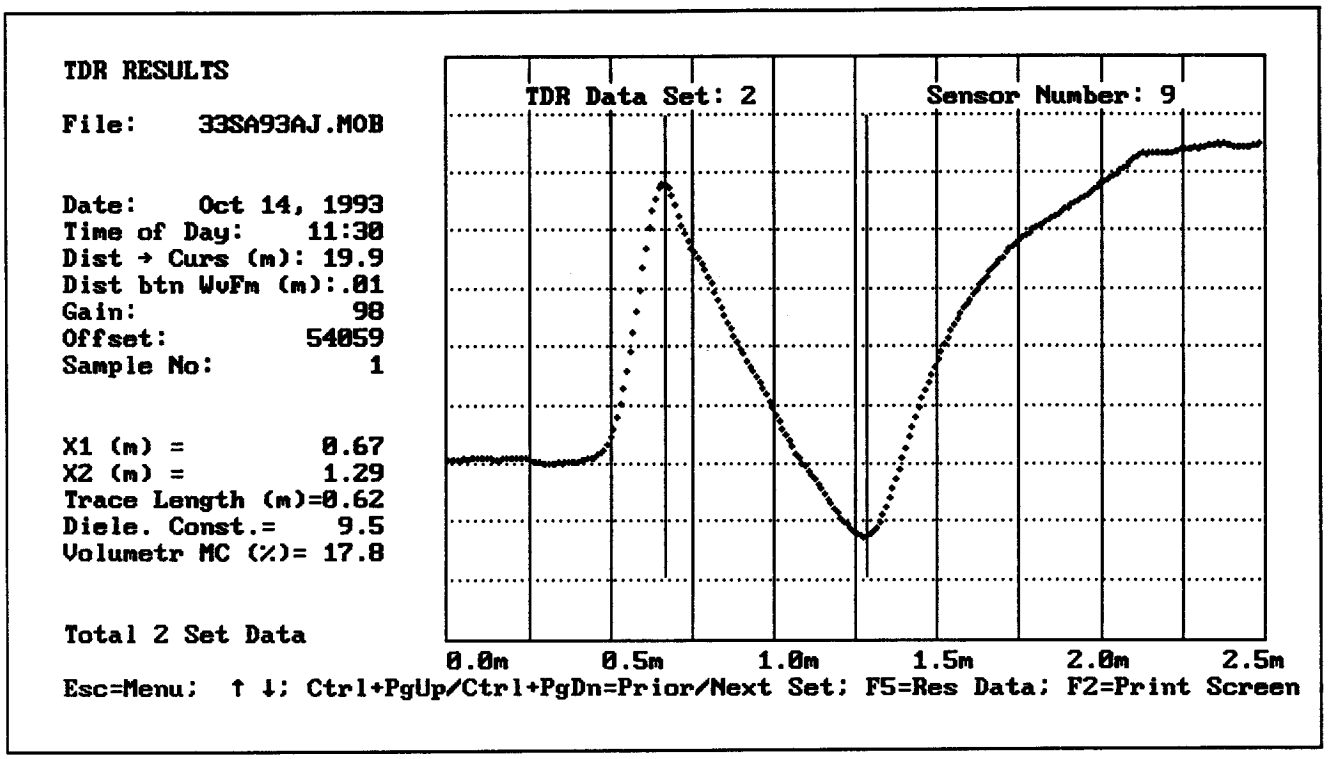


Figure D-2(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

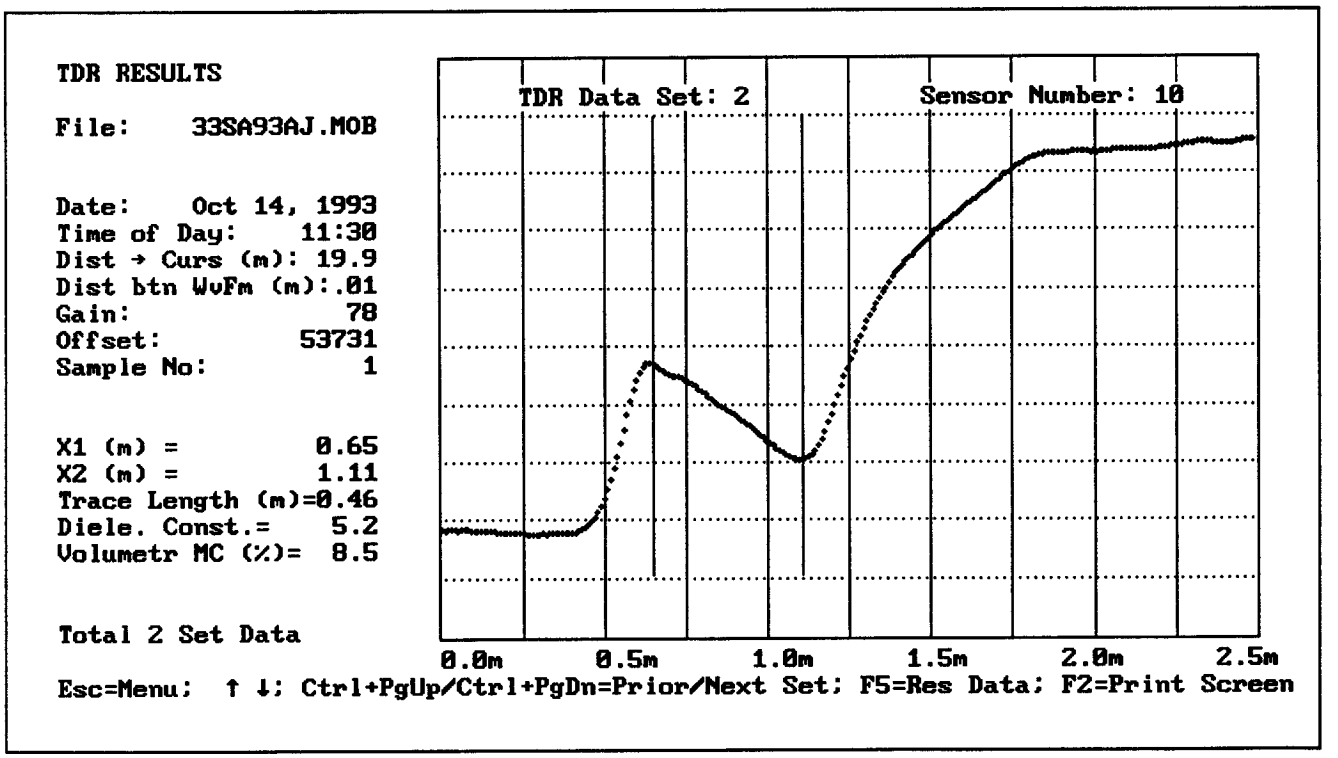


Figure D-2(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

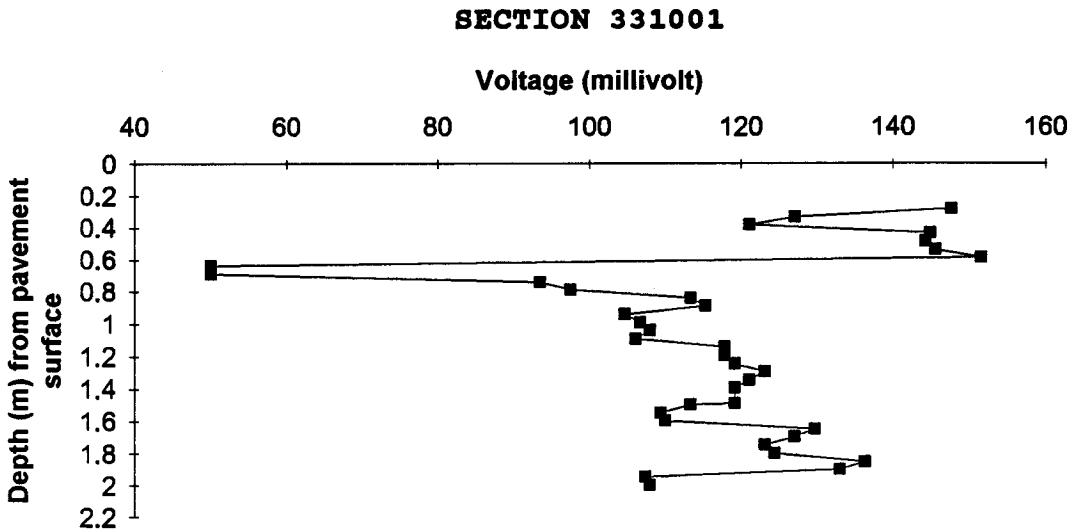


Figure D-3. Voltages Measured Using the Mobile System During Initial Data Collection, October 14, 1993

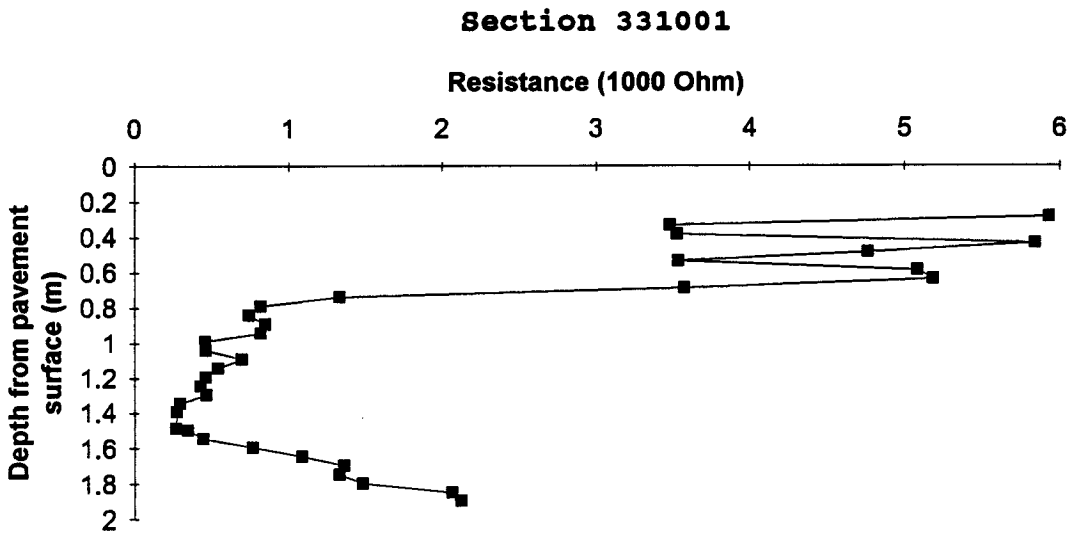


Figure D-4. Manually Collected Contact Resistance During Initial Data Collection, October 14, 1993

Figure D-5. Manually Collected Four Point Resistivity
During Initial Data Collection, October 14, 1993

Table D-1. Contact Resistance After Installation

LTPP Seasonal Monitoring Study	State Code	[33]
Data Sheet R1		
Contact Resistance Measurements	Test Section Number	[1001]

1. Date (Month-Day-Year)		[10-14-93]
2. Time Measurements Began (Military)		[11:50]
3. Comments	After Installation	* Note: Known Resistors

Test Position	Connections		Voltage (ACV)		Current (ACA)		notes
	I V	I V	Range Setting	Reading	Range Setting	Reading	
1	1	2	mV	320.8	uA	54.1	
2	3	2	mV	299.9	uA	86.2	
3	3	4	mV	300.6	uA	85.3	
4	5	4	mV	320.5	uA	54.9	
5	5	6	mV	313.3	uA	65.8	
6	7	6	mV	301.0	uA	85.2	
7	7	8	mV	316.1	uA	62.2	
8	9	8	mV	316.5	uA	61.1	
9	9	10	mV	301.0	uA	84.3	
10	11	10	mV	260.4	uA	145.3	
11	11	12	mV	197.2	uA	241.1	
12	13	12	mV	189.2	uA	254.7	
13	13	14	mV	182.8	uA	215.6	
14	15	14	mV	197.6	uA	241.8	
15	15	16	mV	102.1	uA	222.6	
16	17	16	mV	112.0	uA	241.2	
17	17	18	mV	185.4	uA	265.7	
18	19	18	mV	163.3	uA	300.3	
19	19	20	mV	149.3	uA	323.3	
20	21	20	mV	145.2	uA	339.1	
21	21	22	mV	128.2	uA	375.0	
22	23	22	mV	115.1	uA	390.4	
23	23	24	mV	109.0	uA	396.7	
24	25	24	mV	107.8	uA	397.7	
25	25	26	mV	128.7	uA	372.0	
26	27	26	mV	151.9	uA	340.1	
27	27	28	mV	199.9	uA	260.2	
28	29	28	mV	228.7	uA	209.8	
29	29	30	mV	245.5	uA	180.0	
30	31	30	mV	241.8	uA	181.7	
31	31	32	mV	250.1	uA	168.7	
32	33	32	mV	273.5	uA	132.2	
33	33	34	mV	274.4	uA	129.0	
34	35	34	mV	276.2	uA	125.3	
35	35	36	mV	286.2	uA	109.6	
36 *	37	38	mV		uA		
37 *	38	39	mV		uA		
38 *	39	40	mV		uA		

Preparer:	Michael Zawisa	Employer:	PMSL

Table D-2. Four-Point Resistivity After Installation

LTPP Seasonal Monitoring Study	State Code	[3 3]
Data Sheet R2		
Four-Point Resistivity Measurements	Test Section Number	[1 0 0 1]

1. Date (Month-Day-Year)	[10-14-93]
2. Time measurements Began (Military)	[12:15]
3. Comments	After Installation

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	mV	20.9	uA	49.7	
2	2	3	4	5	mV	18.1	uA	52.8	
3	3	4	5	6	mV	50.2	uA	58.9	
4	4	5	6	7	mV	18.7	uA	63.8	
5	5	6	7	8	mV	15.4	uA	47.9	
6	6	7	8	9	mV	20.7	uA	78.2	
7	7	8	9	10	mV	23.5	uA	79.0	
8	8	9	10	11	mV	15.3	uA	83.4	
9	9	10	11	12	mV	13.5	uA	103.5	
10	10	11	12	13	mV	10.3	uA	144.2	
11	11	12	13	14	mV	10.7	uA	240.9	
12	12	13	14	15	mV	8.0	uA	225.9	
13	13	14	15	16	mV	8.8	uA	235.3	
14	14	15	16	17	mV	9.3	uA	256.9	
15	15	16	17	18	mV	7.6	uA	38.1	
16	16	17	18	19	mV	7.9	uA	261.6	
17	17	18	19	20	mV	5.5	uA	279.3	
18	18	19	20	21	mV	5.4	uA	308.1	
19	19	20	21	22	mV	4.6	uA	247.5	
20	20	21	22	23	mV	3.9	uA	350.6	
21	21	22	23	24	mV	3.6	uA	373.8	
22	22	23	24	25	mV	4.4	uA	385.6	
23	23	24	25	26	mV	4.7	uA	365.4	
24	24	25	26	27	mV	5.3	uA	355.8	
25	25	26	27	28	mV	4.9	uA	275.6	
26	26	27	28	29	mV	5.0	uA	255.2	
27	27	28	29	30	mV	6.5	uA	212.8	
28	28	29	30	31	mV	8.8	uA	206.5	
29	29	30	31	32	mV	7.7	uA	163.8	
30	30	31	32	33	mV	7.3	uA	137.4	
31	31	32	33	34	mV	8.4	uA	158.8	
32	32	33	34	35	mV	8.0	uA	124.9	
33	33	34	35	36	mV	7.7	uA	109.6	

Preparer	MZ	Employer	PMSL

Table D-3. Uniformity Survey Results Before and After Installation

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 331001	Data Collection and
Date Surveyed: October 13-October 14, 1993	Processing Summary

Section Interval (ft)	Mean Deflection Values for HT 2 (mils) Corrected								Mean Temp D1 (F)
	Sensor 1	Sensor 1 std dev	Sensor 7	Sensor 7 std dev	Subg modulus (psi)	Subg modulus std dev	Effective SN	SN std dev	
-23 to 200 **Oct 13** @ 09:46	6.64	0.60	1.15	0.10	32332	4305	10.88	0.27	54.5
-23 to 200 **Oct 14** @ 09:24	6.45	0.56	1.17	0.14	32509	4638	11.02	0.24	45.3
-23 to 200 **Oct 14** @ 11:30	6.78	0.47	1.08	0.11	33459	4342	10.74	0.20	60.6
-23 to 200 **Oct 14** @ 13:19	6.86	0.26	1.04	0.10	33952	3631	10.66	0.12	67.7

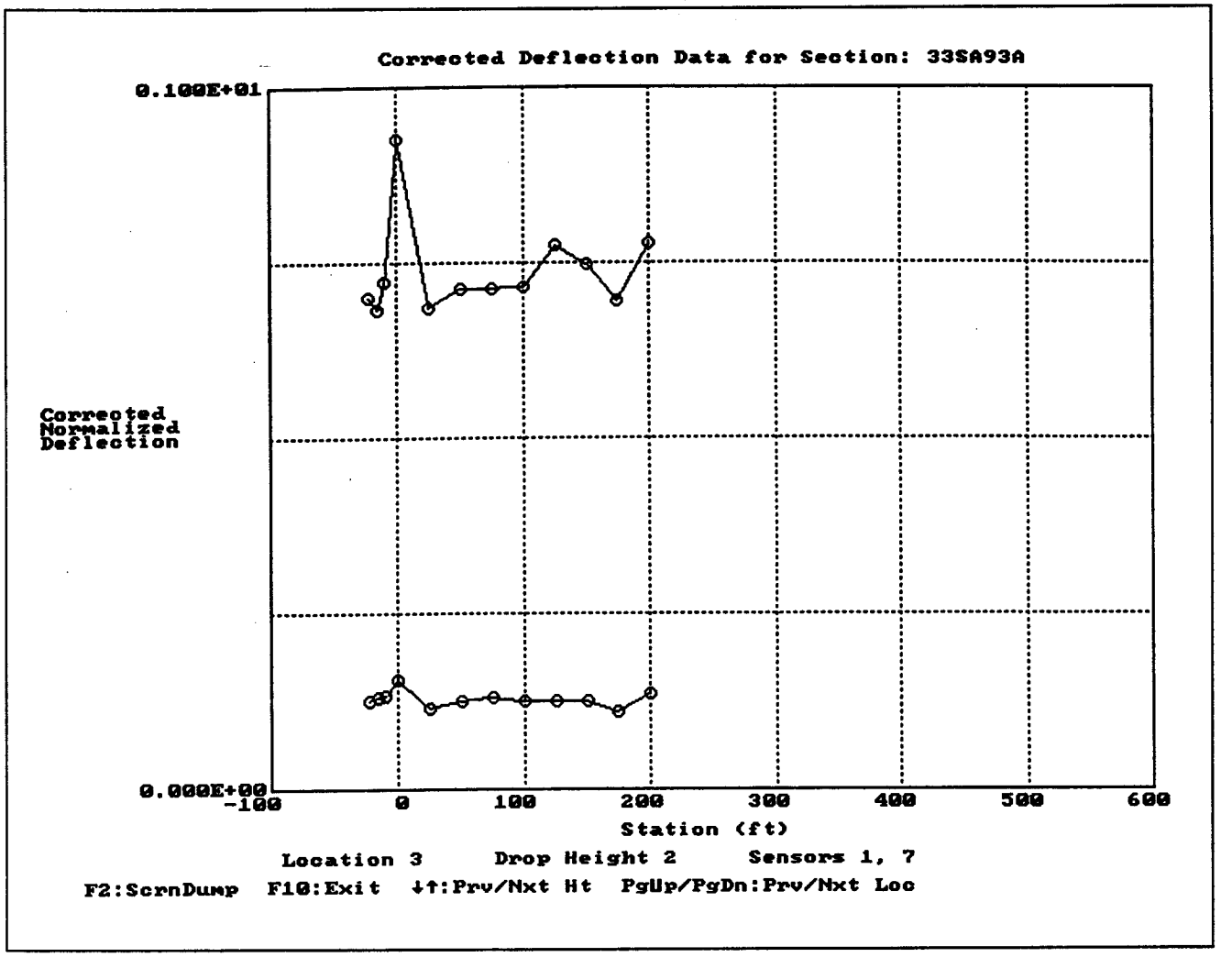


Figure D-6. Deflection Profiles from FWDCHECK
(Test Date and Time October 13, 1993 @ 09:46)

Table D-4. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time October 13, 1993 @ 09:46)

Flexible Pavement Thickness Statistics - 33SA93A - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-23	33897	11.05
	-16	32683	11.20
	-10	29883	11.05
	0	22429	10.20
	25	36233	11.05
	50	34441	10.95
	75	31268	11.05
	100	33528	10.95
	125	31676	10.65
	150	33897	10.75
	175	39788	10.90
	200	28264	10.75
Subsection 1	Overall Mean	32332	10.88
	Standard Deviation	4305	0.27
	Coeff of Variation	13.32%	2.44%

Note: No test pit data found, therefore no results exist...

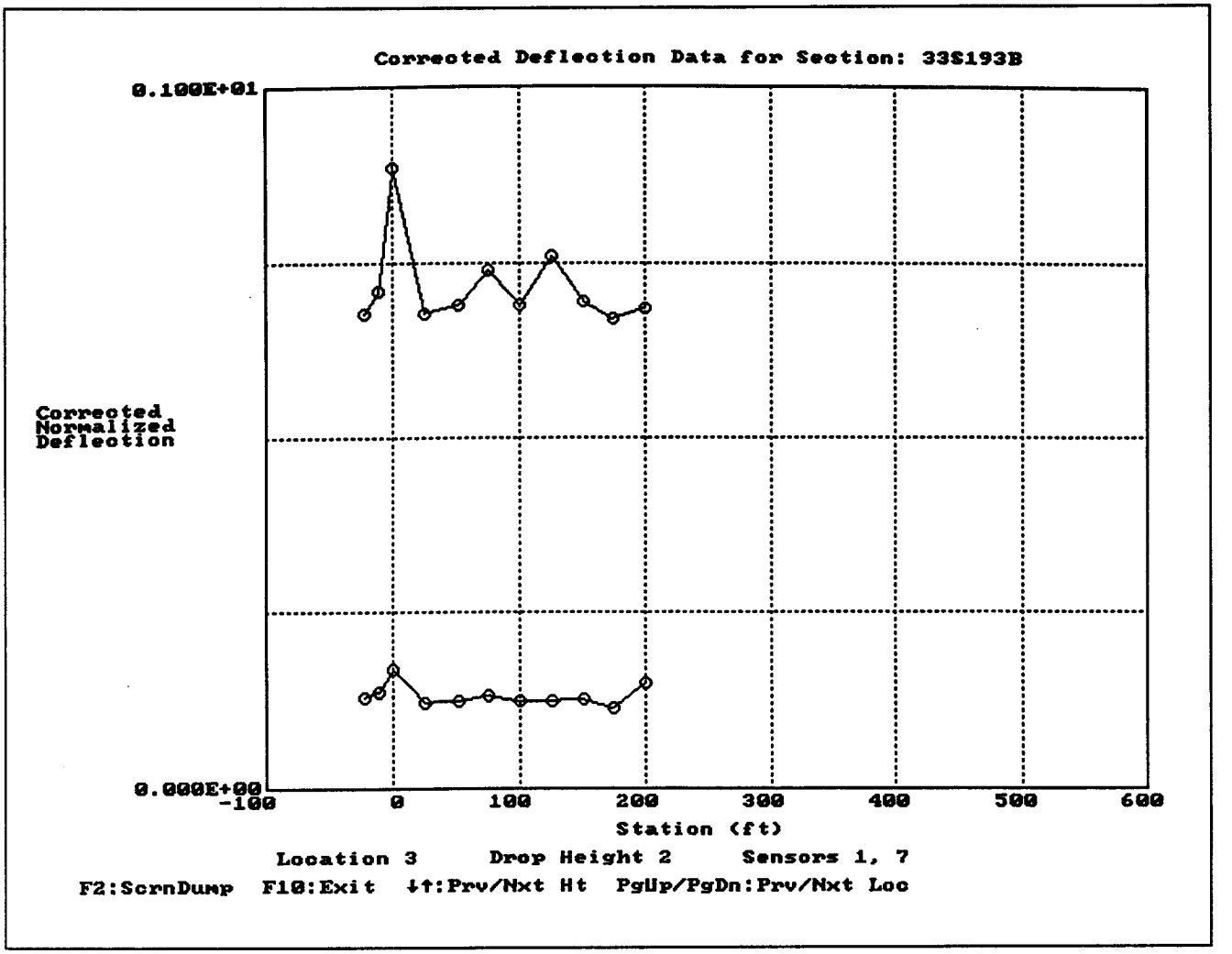


Figure D-7. Deflection Profiles from FWDCHECK
(Test Date and Time October 14, 1993 @ 09:24)

Table D-5. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time October 14, 1993 @ 09:24)

Flexible Pavement Thickness Statistics - 33S193B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-23	32606	11.25
	-10	30778	11.10
	0	21145	10.50
	25	35984	11.15
	50	34211	11.10
	75	32391	10.85
	100	35007	11.05
	125	33152	10.70
	150	33231	11.10
	175	39671	11.10
	200	29428	11.30
Subsection 1	Overall Mean	32509	11.02
	Standard Deviation	4638	0.24
	Coeff of Variation	14.27%	2.18%

Note: No test pit data found, therefore no results exist...

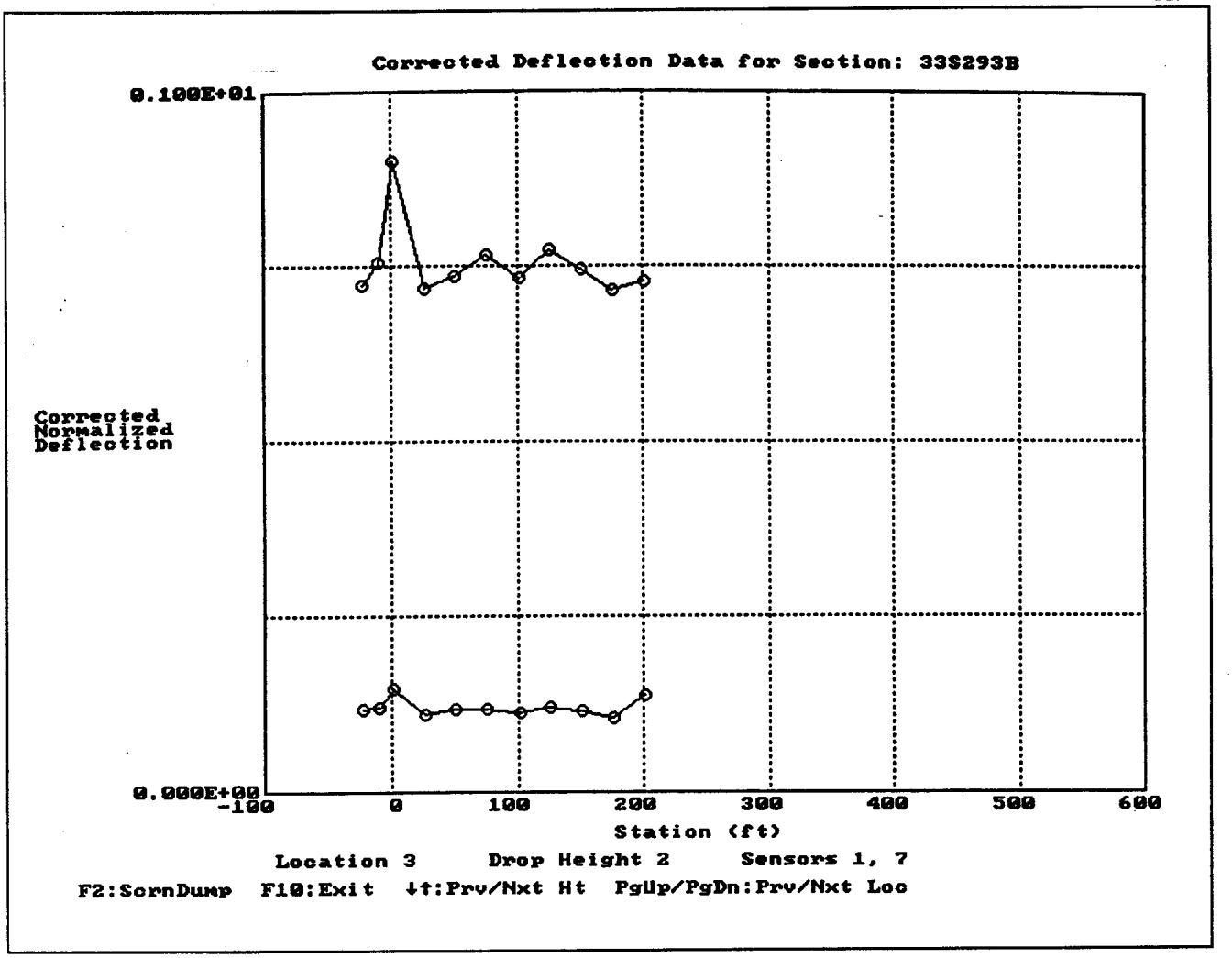


Figure D-8. Deflection Profiles from FWDCHECK
(Test Date and Time October 14, 1993 @ 11:30)

Table D-6. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time October 14, 1993 @ 11:30)

Flexible Pavement Thickness Statistics - 33S293B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-23	32470	10.95
	-10	32872	10.75
	0	23493	10.30
	25	37817	10.80
	50	35905	10.75
	75	33352	10.65
	100	36008	10.75
	125	34066	10.55
	150	33477	10.75
	175	39523	10.80
	200	29070	11.05
Subsection 1	Overall Mean	33459	10.74
	Standard Deviation	4342	0.20
	Coeff of Variation	12.98%	1.83%

Note: No test pit data found, therefore no results exist...

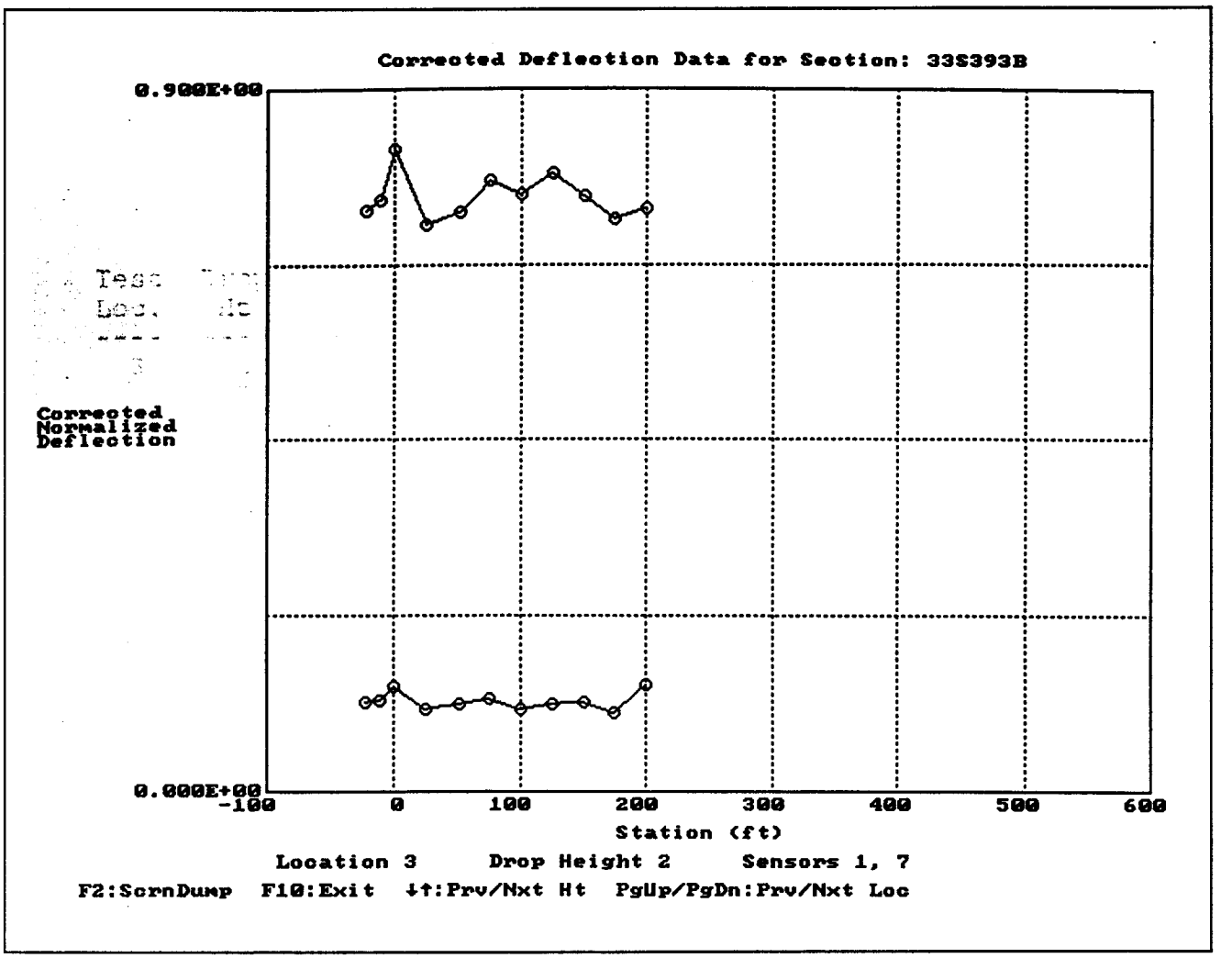


Figure D-9. Deflection Profiles from FWDCHECK
(Test Date and Time October 14, 1993 @ 13:19)

Table D-7. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time October 14, 1993 @ 13:19)

Flexible Pavement Thickness Statistics - 33S393B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-23	33786	10.75
	-10	33409	10.70
	0	26261	10.55
	25	36675	10.80
	50	35683	10.70
	75	33546	10.55
	100	36726	10.55
	125	33508	10.50
	150	34960	10.60
	175	39576	10.65
	200	29345	10.90
Subsection 1	Overall Mean	33952	10.66
	Standard Deviation	3631	0.12
	Coeff of Variation	10.69%	1.16%

Note: No test pit data found, therefore no results exist...

Table D-8. Surface Elevation Measurements

LTPP Seasonal Monitoring Study	State Code	[33
Surface Elevation Measurements	Test Section Number	[1001

Survey Date	October 14, 1993
Surveyed By	MZ & PZ
Surface Type	A/C
Benchmark	Observation Piezometer - 1.000 meters - assumed

STATION	PE m offset 0.15m	OWP m offset 0.76m	ML m offset 1.68m	IWP m offset 2.59m	ILE m offset 3.20m
0-23	3+00	0.256	0.268	0.290	0.302	0.332
0-17	3+25	0.287	0.308	0.332	0.345	0.360
0-12	3+50	0.336	0.348	0.372	0.381	0.482
0+00	3+75	0.418	0.433	0.451	0.461	0.482
0+25	4+00	0.278	0.308	0.634	0.643	0.662
0+50	4+25	0.787	0.793	0.817	0.826	0.851
0+75	4+50	0.973	0.957	1.009	1.018	1.043
1+00	4+75	1.168	1.177	1.204	1.213	1.244
1+25	5+00	1.375	1.387	1.411	1.421	1.448
1+50	5+10	1.588	1.597	1.378	1.372	1.689
1+75	5+20	1.802	1.814	1.835	1.841	1.872
2+00	5+30	2.018	2.027	2.055	2.064	2.094

PE	Pavement Edge
OWP	Outer Wheel Path
ML	Mid Lane
IWP	Inner Wheel Path
ILE	Inner Lane Edge

APPENDIX E

Photographs

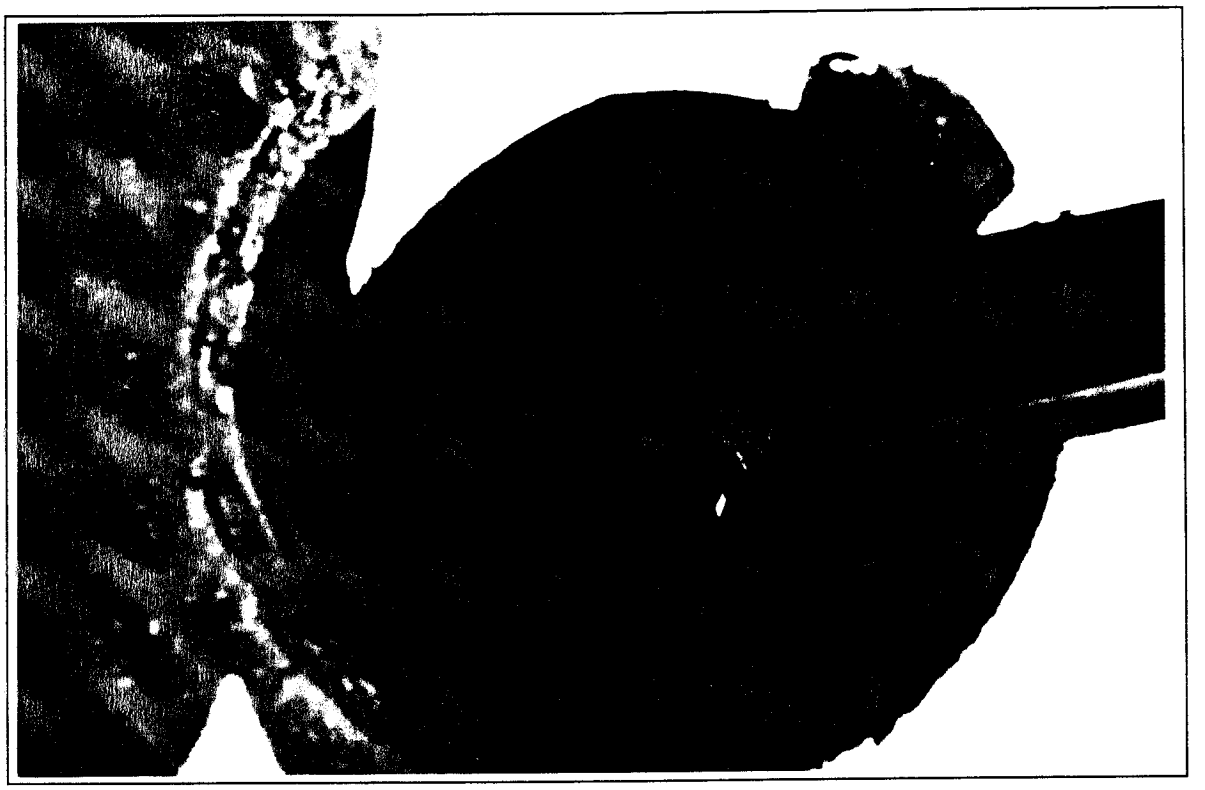


Figure E-1. Instrumentation Hole and Trench

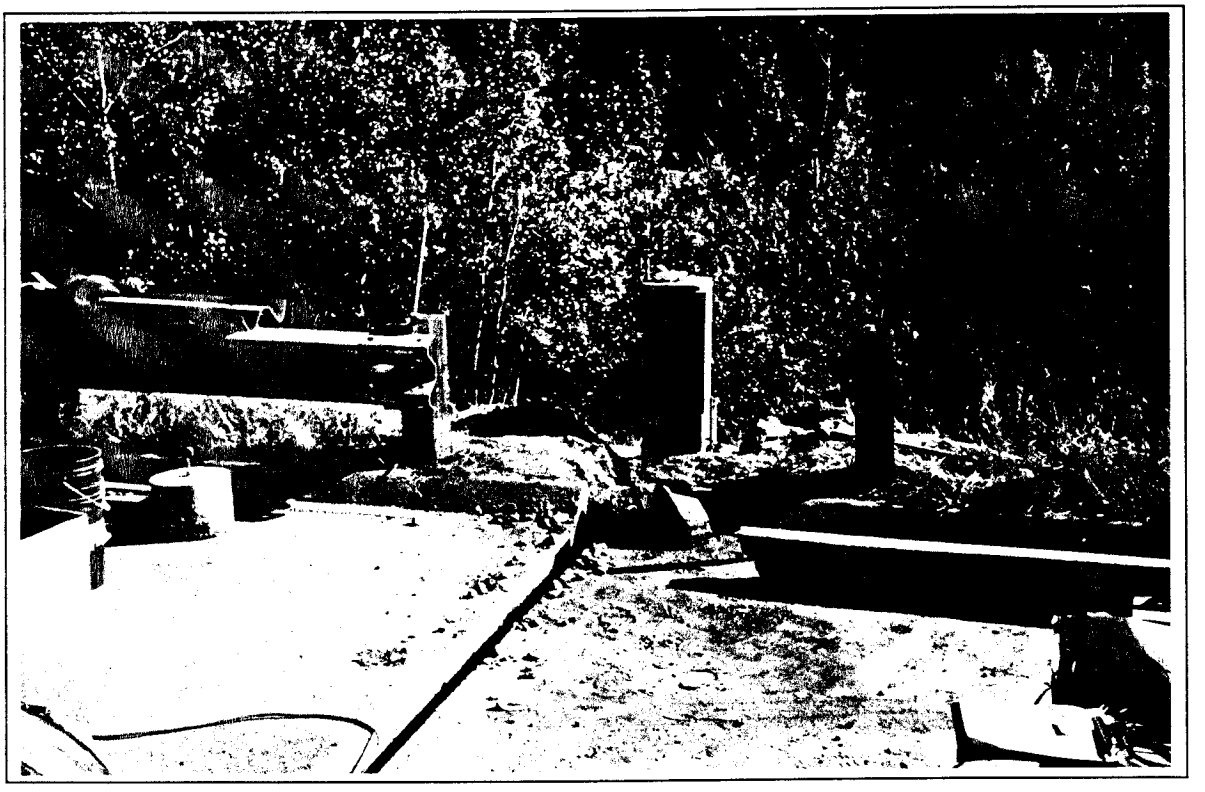


Figure E-2. Trench from Instrumentation Hole to Equipment Cabinet

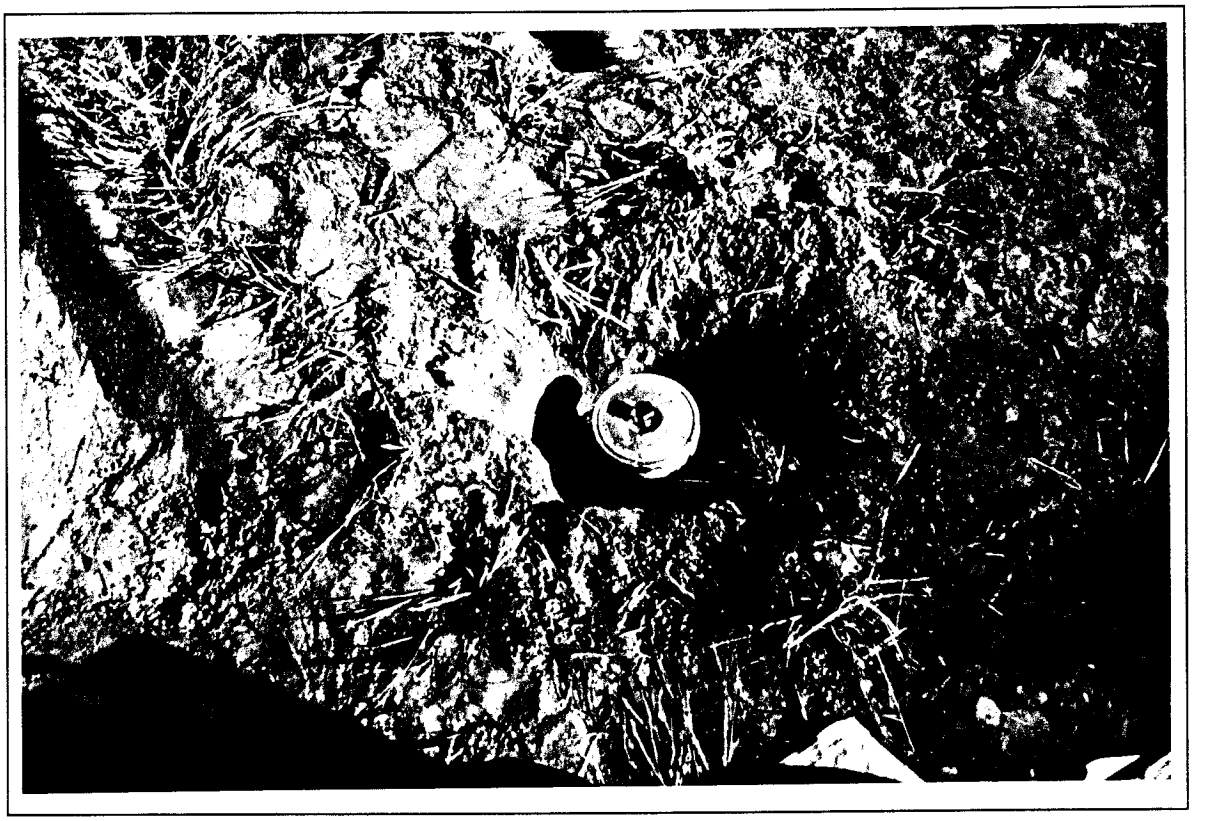


Figure E-3. Observation Well

Figure E-4. Equipment Cabinet, Air Temperature Probe, and Rain Gage

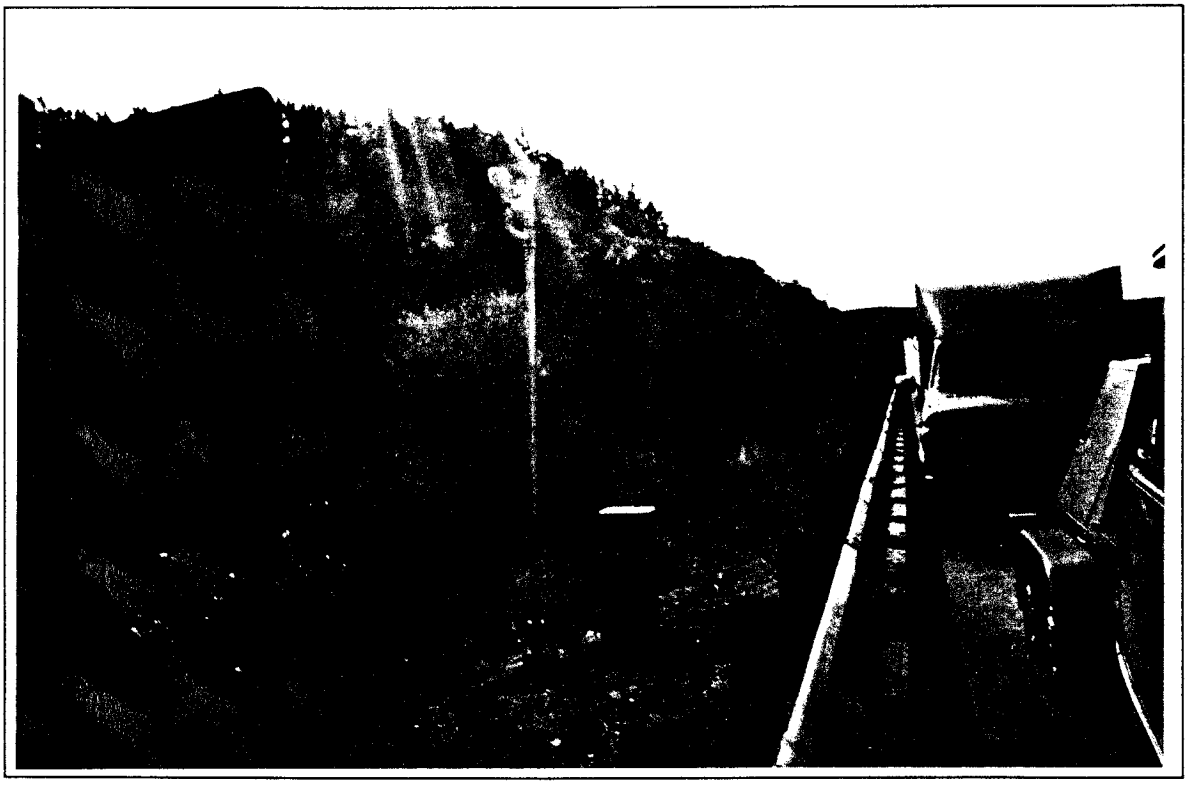


Figure E-5. Equipment Cabinet, Air Temperature Probe, and Rain Gage

Figure E-6. Patch Area, the Day After Installation

Figure E-7. Patch Area, the Day After Installation