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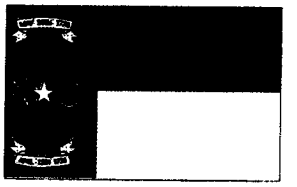

North Carolina

LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection
Section 371028, Elizabeth City
North Carolina

Report No. FHWA-TS-96-37-01

June 1996

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LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection
Section 371028, Elizabeth City, North Carolina

Report No. FHWA-TS-96-37-01

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The report is a cooperative effort between North Carolina Department of Transportation (NCDOT) Research and Development Unit, 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 371028 on RT 17 near Elizabeth City, North Carolina. This asphalt concrete surface pavement test section was instrumented on May 17, 1995. The instrumentation installed included time domain reflectometry probes for moisture content, thermistor probes for temperature, tipping bucket rain gauge, piezometer to monitor the ground water table, and an on-site data logger. Initial data was collected on May 18, 1995 which consisted of Falling Weight Deflectometer deflection, elevation, temperature, TDR, and water table measurements. Longitudinal profile data is collected during scheduled visits with the LTPP profiler. 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, LTPP profiler, Time Domain Reflectometry, Thermistor, Piezometer, Bench mark.	

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I. Introduction

The installation of the LTPP instrumentation on seasonal site 371028 near Elizabeth City, North Carolina was performed on May 17 - May 18, 1995. The test section is a GPS-1 experiment, located on Northbound Route 17, approximately 2.6 km South of the Virginia State border, and 7.0 km North of SR 1226. The highway consists of two 3.7 m wide lanes in each direction divided by a grass median with 1.0 m wide paved shoulders.

The pavement structure, which elevates the roadway in a wet low lying plain, consists of 267 mm of asphalt concrete on sand base. The underlying native material consists of a saturated grey sand with a swampy smell. Pavement structure information from the GPS material drilling logs is presented in Appendix A, 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 LTPP profiler longitudinal profile measurements, and Falling Weight Deflectometer deflection values as monitored since March 01, 1989. The uniformity survey results are summarized in Table A-2. The deflection values and analysis results from FWDCHECK are also presented in Appendix A.

The site is in a wet-no freeze zone and resides in cell 14 (thick AC on coarse subgrade) of the Seasonal Monitoring Program. Even though this site is categorized under the 'no-freeze' cell it is in the border of being in the 'freeze' cell. Below is a summary from the LTPP climate database based on nine years of data:

- Freezing Index (C-Days) 34
- Precipitation (mm) 1194
- No. of Freeze/Thaw Cycles 62
- Days Above 32°C 28
- Days Below 0°C 57
- Wet Days 146

This portion of route 17 was constructed and opened to traffic in 1982. The estimated annual average daily traffic (AADT) in 1995 was 4508 (GPS lane). Truck traffic consisted of approximately 3.4% of the traffic in the GPS lane. The estimate of annual KESALS in the GPS direction using vehicle ESALS is 51.3. These figures are based on 78 days of AVC coverage and 11 days of WIM data in 1995.

Installation of the instrumentation was a cooperative effort between North Carolina Department of Transportation (NCDOT), Federal Highway Administration (FHWA) Long Term Pavement Performance (LTPP) Division, and Pavement Management

Systems Limited (PMSL) LTPP North Atlantic Region Coordination Office (NARCO) staff. The following personnel participated in the instrumentation installation:

Mrinmay Biswas (LTPP Coordinator)	NCDOT - Research and Development
Aiman Kuzmar	NCDOT - Research and Development
Kevin Ray Blaylock	NCDOT - Geotechnical Unit
Donald Larry Newsome	NCDOT - Geotechnical Unit
Felton George	NCDOT - Maintenance District 1
Marsette Gregory	NCDOT - Maintenance District 1
J.T. Holley	NCDOT - Maintenance District 1
N.C. Russell	NCDOT - Maintenance District 1
R.T. Smithson	NCDOT - Maintenance District 1
Garry Whitehurst	NCDOT - Maintenance District 1
Robert Winslow	NCDOT - Maintenance District 1
Brandt Henderson	Pavement Management Systems (NARCO)
Alfred Lip	Pavement Management Systems (NARCO)
Douglas Marshall	Pavement Management Systems (NARCO)
James Orzulak	Pavement Management Systems (NARCO)
Dilan Singaraja	Pavement Management Systems (NARCO)

Table 1. Material Properties

Description	Surface	Base **
Material (Code)	Dense Graded HMAC (01)	Silty Sand (214)
Thickness (mm)	267	
Lab Max. Dry Density (kg/m^3)		1730
Lab Opt Moisture Content (%)		13
In-situ Wet Density (kg/m^3) *		1707
In-situ Dry Density (kg/m^3) *		1417
In-situ Moisture Content (%) *		16.95
Bulk Specific Gravity	2.28	
Max. Specific Gravity	2.44	
Liquid Limit		0
Plastic Limit		0
Plasticity Index		NP
% Passing # 200		8.5

* Note: Test pit @ station 5+62

** Note: The road base extended to the full depth of the boreholes since the road is elevated.

II. Instrumentation Installation

Site Inspection and Meeting with Highway Agency

A uniformity survey was conducted on January 27, 1993, which shows that the entire site is fairly uniform. The results of this test are presented in Appendix A. The zero end was picked for traffic safety reasons because of the presence of a small road near the end of the site. A preliminary planning meeting was held at the conference facility of the Pavement Management Unit in Raleigh, North Carolina on April 11, 1995 to discuss the seasonal monitoring program and the installation specifics. The attendees at the meeting were:

- Mrinmay Biswas — NCDOT Research and Development
- Pat Strong — NCDOT Research and Development
- Jerry Blackwelder — NCDOT Pavement Management
- Wm. Kenneth Creech — NCDOT Pavement Management
- Jim Trogdon — NCDOT Maintenance Unit
- Max Tate — FHWA
- Brandt Henderson — Pavement Management Systems, NARCO
- Bill Phang — Pavement Management Systems, NARCO

A presentation on the installation of seasonal monitoring instrumentation and monitoring requirements was provided by Bill Phang and Brandt Henderson of Pavement Management Systems. This was followed by a review and discussion on the seasonal site near Elizabeth City. Plans for the installation on May 17 and May 18, 1995 were discussed. A site inspection was done on April 27, 1996. The installation and test locations were defined. Installation locations were marked with paint and stakes for utility clearance purposes. Correspondence from the site inspection and planning meeting are presented in Appendix B.

A pre-installation meeting was conducted on May 16, 1995 at the North Carolina Department of Transportation district office in Elizabeth City. Brandt Henderson of Pavement Management Systems presented the installation schedule. Arrangements were made to meet on site on May 17, 1995 at 0800 hours with traffic control to be in place by 0830 hours.

Equipment Installed

The equipment installed at the test site included instrumentation for measuring air, pavement, and subsurface temperatures, precipitation, subsurface moisture content, 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	37ET
CRREL Resistivity Probe	N/A	N/A
TDR Probes	10	37E01-37E10
Equipment Cabinet		
Campbell Scientific CR10 Datalogger	1	16549
Campbell Scientific PS12 Power Supply	1	5624
Weather Station		
TE525MM Tipping Bucket Rain Gauge	1	12058-693
Campbell Scientific 107-L Air Temperature Probe	1	37EAT
Observation Well/Bench Mark	1	N/A

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 473 ml 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 473 ml of water, the tipping bucket should measure 100 tips $\pm$ 3 tips. The results were 100 tips, which was within 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 hot water. In order for the probes to pass this check, the temperatures for each probe needed to 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 respectively, therefore the probes were considered to be functioning correctly. The results from the calibration of the air temperature and the thermistor probes along with the spacing between the thermistors are presented in Appendix B.

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 at 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 tests indicated that all probes were functioning properly. The probe connectors were dipped in a rubberized sealing compound for water proofing. A

's-loop' was placed just above the connector and tie wrapped to protect the connector during installation. Results of the TDR measurements are presented in Appendix B.

Equipment Installation

Final details for the installation and initial monitoring were discussed during the pre-installation meeting on the afternoon of May 16, 1995. The installation was confirmed for 0830 hours on May 17, 1995. Traffic control for the installation and monitoring was provided by North Carolina Department of Transportation district 1 maintenance facility in Elizabeth City. The pavement surface drilling, augering of the piezometer hole, and instrumentation hole were done by agency equipment and drilling crew from the geotechnical unit, materials department in Raleigh. The sawing of the trench and cut for the pavement surface temperature probe were done by R.T. Smithson and J.T. Holley of NCDOT maintenance district 1. The installation of the measurement equipment, observation piezometer, weather station pole, and cabinet was performed by PMSL staff. Assistance was provided by Mrinmay Biswas and Aiman Kuzmar from NCDOT research and development group and NCDOT local district personnel.

The instrumentation was installed on the South end of GPS 371028, in the Northbound lane of route 17, approximately 2.6 km South of the Virginia state border in Elizabeth City, North Carolina. The combination bench mark/piezometer was placed in the shoulder at station 1+00. The in-pavement instrumentation was installed in the outer wheel path at station 0-12. The cabling from the instrumentation was placed in a 51 mm flexible conduit and buried in a trench running from the instrument hole to an equipment cabinet installed on the slope of the roadway embankment, 8.23 m from the instrumentation hole. The weather pole was installed immediately behind the equipment cabinet. A temporary state bench mark (PK nail 150 mm from the pavement edge) was placed at station 0+50. The elevation of this nail is 6.969 m. Figure 1 provides the location and distances for the various instrumentation and equipment installed.

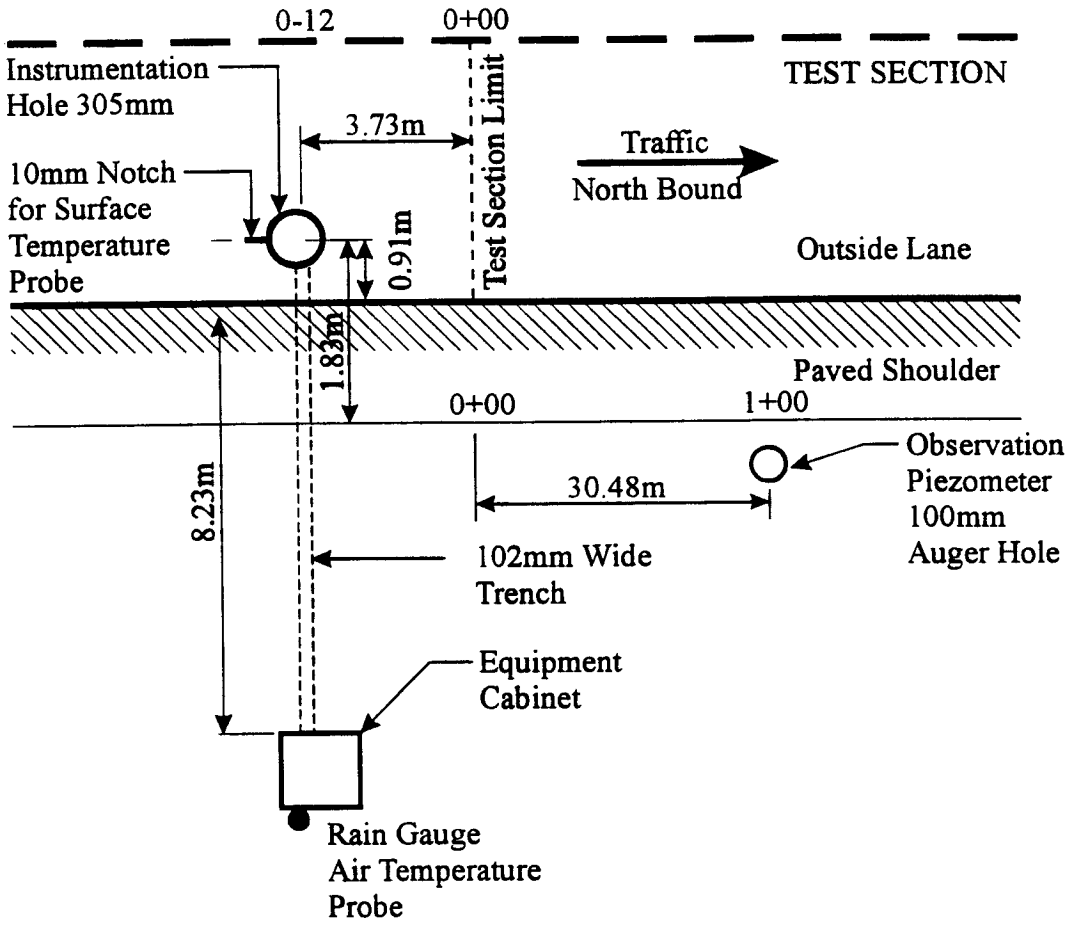
The installation generally followed the procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". The combination piezometer/bench mark was installed just off the edge of the paved shoulder to a depth of 3.71 m. A 102 mm flight auger was used for drilling the hole. The depth of the piezometer was reduced from 4.27 m to 3.71 m because water was encountered at approximately 2.0 m depth during the drilling. In placing the piezometer stability was a problem as the underlying soil was saturated. A sealed bag of cement was dropped to the base of the hole to provide support for the piezometer pipe. After the piezometer was placed in the hole the material around it collapsed to a depth of 2.5 m. The filling of the hole proceeded from this point on. No bentonite clay was used to plug the hole as the sandy material had already reached the level of the frost sleeve. Extensive compaction was applied around the piezometer pipe to secure it to the native material.

A core hole was drilled in the pavement surface, located in the outside wheel path 0.91 m from the edge of the travel lane at station 0-12, using a 356 mm thin wall diamond core

barrel, attached to the truck mounted drilling unit. A 102 mm wide by 267 mm deep trench was saw cut between the core hole and the edge of the pavement using a heavy duty pavement sawing machine. The blade of the pavement saw was used to notch a location for the pavement surface temperature probe at the South edge of the core hole. The remainder of the material from the trench was removed with a pick and shovels.

The instrumentation hole was excavated using a 254 mm hollow stem auger with the hollow end blocked so that material mixing did not occur. Care was taken to ensure that the excavated material was stored in the order that it was removed. A standard proctor test of a representative sample was conducted in the field to determine the dry density of the soil, which was 1540 kg/m^3. The sample was taken from pail 5 at a depth of approximately 1.3 m. The road base consisted of silty sand fill to the depth of the bottom TDR sensor (2.09 m below the surface). The drilling was stopped approximately 70 mm below this depth and the installations began. The findings from the excavation of the instrumentation hole at station 0-12 are presented in Figure 2. All the material excavated from the instrument hole was placed and compacted in the order of removal with the TDR probes and the thermistor probe placed at the specified locations. The location and elevation information of the instrumentation are presented in figure 2. 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 NCDOT Materials and Tests unit. All moisture data from the installation is summarized in Table 5. A little additional material remained after the hole was filled and compacted.

The equipment cabinet and pole for the rain gauge and air temperature probe were installed as per manual guidelines. The wiring of the equipment was done the same day as the installations. Excess washed sand from the piezometer installation was used as bedding material for the equipment cabinet and also in the trench from the instrument hole to the equipment cabinet. This trench was extended past the equipment cabinet towards the ditch at a downward slope to help drain excess surface water away from the equipment cabinet. The grading, packing of the trench material, and clean-up was completed by 1900 hours on the day of installation.



- Height of Air Temperature Probe: 2.84m
- Height of Tipping Bucket Rain Gauge: 2.85m
- Depth of Piezometer: 3.71m

Figure 1. Location of Seasonal Monitoring Instrumentation Installed at GPS 371028

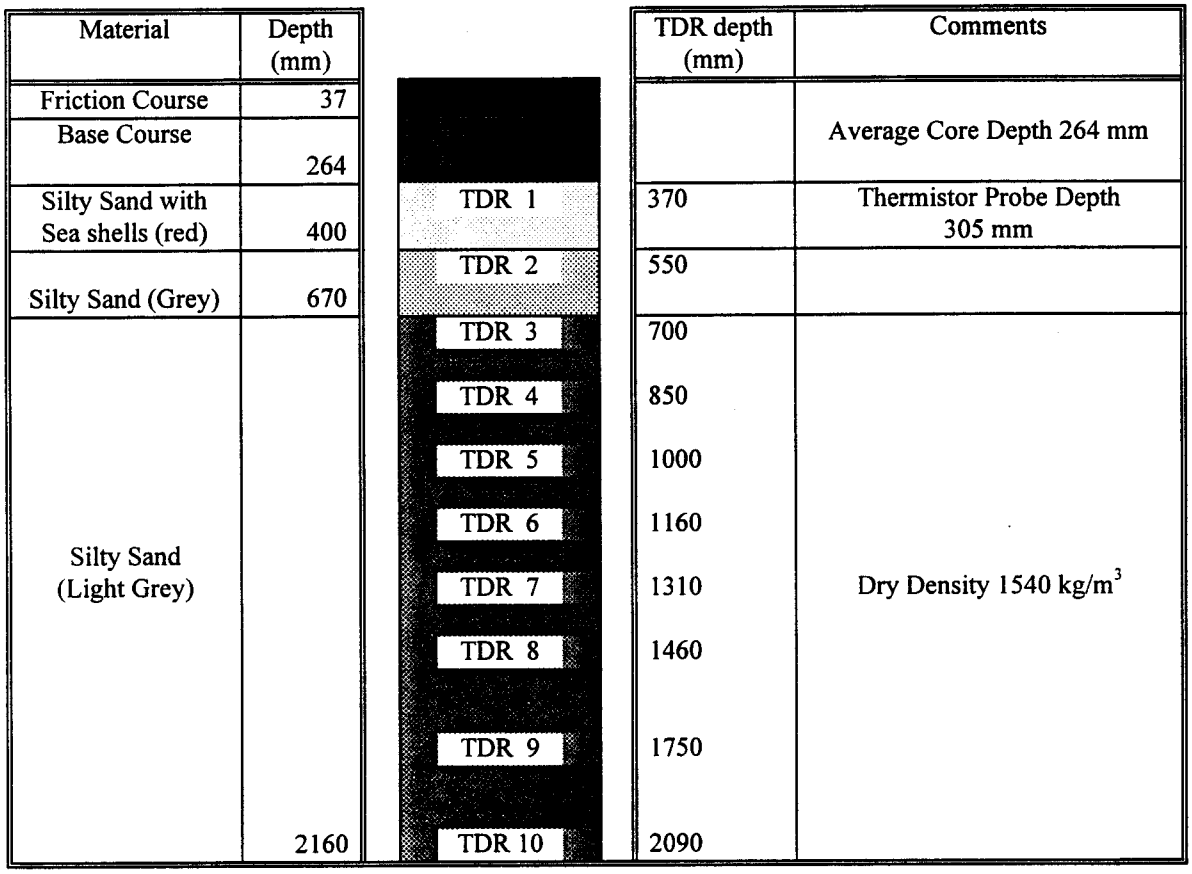


Figure 2. Profile of Pavement Structure and Probe Depths, Station 0-12

To check for breakage of the TDR probes during installation, each probe was connected to the cable tester and it's wave form monitored during compaction of the material around it. The TDR traces are included in Appendix C. The cables coming from the TDR probes were staggered along the perimeter of the instrument hole to avoid water migrating along a bundle of cables. The top TDR probe was placed with the cabling and printed circuit facing downward to avoid contact with the asphalt surface. The top of the thermistor probe was 0.305 m below the pavement surface. The cables from all instrumentation installed converged at the opening of the flexible conduit pipe which was placed about 50 mm 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, and 4 present the installed depths of the TDR probes, and the thermistor sensors respectively. Table 5 gives TDR, field, and laboratory measured moisture content from samples taken during installation. A comparison of the moisture content from the TDR traces, field, and laboratory determination indicate some discrepancies. The TDR and laboratory moisture contents generally compare more favorably. Some moisture could have been released during drilling and handling of the soil because of the high temperatures on the day of installations. This would explain the consistently lower

readings obtained from the field and laboratory testing as opposed to the TDR readings. It should also be noted that the calculation of moisture is dependent on the calibration inputs to the TDR model. Differences of moisture content in the range of 1 to 2% are not uncommon.

Table 3. Installed Depths of TDR Sensors

Sensor #	Depth from Pavement Surface (m)	Layer
37E01	0.370	Base
37E02	0.550	Sub base
37E03	0.700	
37E04	0.850	
37E05	1.000	
37E06	1.160	
37E07	1.310	
37E08	1.460	
37E09	1.750	
37E10	2.090	

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	0.133	
	3	0.241	
2	4	0.325	This unit was installed below the AC layer into the subgrade.
	5	0.398	
	6	0.475	
	7	0.551	
	8	0.627	
	9	0.779	
	10	0.930	
	11	1.084	
	12	1.237	
	13	1.388	
	14	1.541	
	15	1.693	
	16	1.845	
	17	1.999	
	18	2.149	

Table 5. 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)*
37E01	0.370	Base	12.2%	10.4%	11.3%
37E02	0.550	Sub base	8.6%	5.6%	7.9%
37E03	0.700		10.9%	7.5%	8.0%
37E04	0.850		9.0%	6.9%	7.7%
37E05	1.000		9.0%	7.4%	8.0%
37E06	1.160		7.8%	6.7%	6.8%
37E07	1.310		8.6%	7.6%	6.7%
37E08	1.460		9.4%	10.7%	8.2%
37E09	1.750		10.9%	8.7%	8.2%
37E10	2.090		10.2%	5.9%	8.5%

* Note: Raw data given in Appendix C

Site Repair and Cleanup

The instrumentation hole was repaired by reinstalling the 305 mm core. During installation the surface coarse separated from the rest of the core. Once the core was leveled it was removed from the hole and the bottom 100 mm 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 hole. A thin cold mix patch was used to replace the friction coarse. In addition a mixture of sand and epoxy was used to seal and level the circumference of the hole and stainless steel probe area. 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 filled with the native silty sand. A cold mix was compacted to the level of the existing surface. The remainder of the trench from the edge of pavement to the equipment cabinet was filled with washed sand and native backfill and compacted. All loose particles were removed from the pavement surface. Traffic control was removed at 1900 hours and the lane reopened to traffic. Removal of the asphalt trench material and other disposable items were handled by the NCDOT district 1 maintenance crew.

Patch/Repair Area Assessment

When the site was visited on July 10, 1995, the trench had sunk in a little. This was fixed by applying cold asphalt patching material. Photos of the instrumentation hole area were taken as shown in Appendix E. Although the bond/seal of the main asphalt core is intact, the surface patch is starting to ravel away. This location will be maintained and repaired as needed with cold mix patch during the site visits to collect monitoring data.

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 an elevation survey. A sample of the data collected by the onsite datalogger is presented in Appendix D (Table D-1).

Air Temperature, Subsurface Temperature, Rain-fall Data

The air temperature, pavement subsurface temperature profile, and rainfall data collected on May 18 by the CR10 datalogger was examined. The equipment and datalogger appeared to be functioning properly. The battery voltages were checked and found to be acceptable. The plots of the temperature profiles are presented in Appendix D (figures D-1 and D-2).

The tipping bucket rain gauge was checked by determining the number of tips recorded from 473 ml 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 was 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 2.2 of the MOBILE program was used to collect and record the TDR wave form traced for each sensor.

Figure D-3 shows the initial TDR traces collected with the MOBILE data acquisition system for all 10 sensors. Only the second set of TDR traces are shown in the appendix because the first set of traces were used to adjust the starting locations of the traces. The figures indicate that the multiplexers of the mobile system and TDR sensors were working properly.

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 tests have been conducted once every month with the exception of August 1995 when there was no site visit.

Longitudinal Profile Data

Since the site is in a no-freeze area, four surveys should be conducted each year. To this date there have been two surveys conducted one on February 27, 1996 with an IRI of 58.79 inches/mile and one in April 18, 1996 with an IRI of 58.50 inches/mile.

Elevation Surveys

One set of the surface elevations was gathered the guidelines. It was assumed that the elevation at the top of the piezometer pipe was 1.000 meters. The survey was conducted on May 18, 1995 and the results are presented in Appendix D. Since then, four more sets of the surface elevation surveys have been performed, the first on July 10, 1995, then on October 18, 1995, January 18, 1996, and April 18, 1996. The NCDOT transferred an elevation from a permanent fixture onto a nail that was placed within the section to be used as a temporary bench mark. This nail is being used to monitor if there is any movement of the piezometer / bench mark. There is no significant movement to this point.

Water Depth

The water level on May 18, 1995 was approximately 2.10 m below the top of the piezometer. Since then the lowest level of 2.59 m was recorded on September 03, 1995 and the highest level of 1.796 m was recorded on May 14, 1996.

IV. Summary

The installation of the seasonal monitoring instrumentation at the GPS site 371028 near Elizabeth City, NC was completed on May 18, 1995. A check of the equipment and initial data collection was completed on May 19, 1995. The instrumentation, permanently installed at the site, were:

- Time domain reflectometer probes for moisture measurements,
- Thermistor probes for pavement and soil gradient temperature measurements,
- Air temperature, thermistor probe, and tipping bucket rain gauge 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 is to be collected during each site visit (12 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 Northbound route 17, 2.6 km South of the Virginia state border. The site is located in a flat low lying area. The tree line starts at the roads right of way on both sides of the road. The pavement resides in a slightly elevated platform and consists of four 3.7 m wide lanes with a large grass median separating traffic in either direction. The paved shoulder is 1.0 m wide. There was some water present at the bottom of the ditch on the side of the road. The ditch in the median had more standing water in it. The pavement structure consists of 267 mm of asphalt concrete over silty sand base with sea shells. This resides on a gray silty sand over a highly saturated sand with the water table at 2.1 meters.

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 the installation and the following day indicated that all instrumentation were functioning properly. The air temperature and gradient temperatures measured in the pavement surface compared favourably with the hand held Omega temperature gauge. The temperature profile for the pavement soils appeared reasonable with no outlying sensors. A check of the tipping bucket indicated it was functioning correctly with tips corresponding to the amount of water supplied.

Moisture content of the soil was determined by TDR method, field moisture at the time of installation by soil drying, and laboratory results provided by NCDOT Materials and Tests Unit. There were slight differences between the moisture content determined by the TDR method and gravimetric moisture content determined from the samples taken. Some of the differences may be attributed to the hot temperature conditions prevalent at

the site on the day of installation and the loss of moisture during handling of the soil. These differences were within the acceptable tolerance.

The installation generally proceeded as expected with only a few minor problems. The installation was completed and the section was opened to traffic by 1900 hours on May 18, 1995. The placement of the combination piezometer/bench mark was complicated by the lack of stability of the saturated sandy subgrade and the high water table. The standard 4.27 m pipe was replaced by a 3.71 m pipe. No bentonite clay was used during the installation of the piezometer because of the collapsing soil. Extra compactive effort was required.

The removal/replacement of the material from the instrumentation hole was successful, with the material being well consolidated around the instrumentation. The surface friction course became unbonded from the core during the installation. This material was replaced with a thin cold mix patch bonded on the circumference with a mixture of sand and epoxy. The core was level with the existing pavement surface at completion.

The initial monitoring of the site on May 18, 1995 was successful. The temporary state bench mark was referenced during the level surveys and will be used to determine the stability of the combination piezometer/bench mark over time.

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 January 27, 1993)
Table A-3	Subgrade Modulus and Structural Number from FWDCHECK (Test Date January 27, 1993)

SHRP–LTPP NORTH CAROLINA TEST SITE LOCATIONS
GPS–SPS PAVEMENT STUDIES

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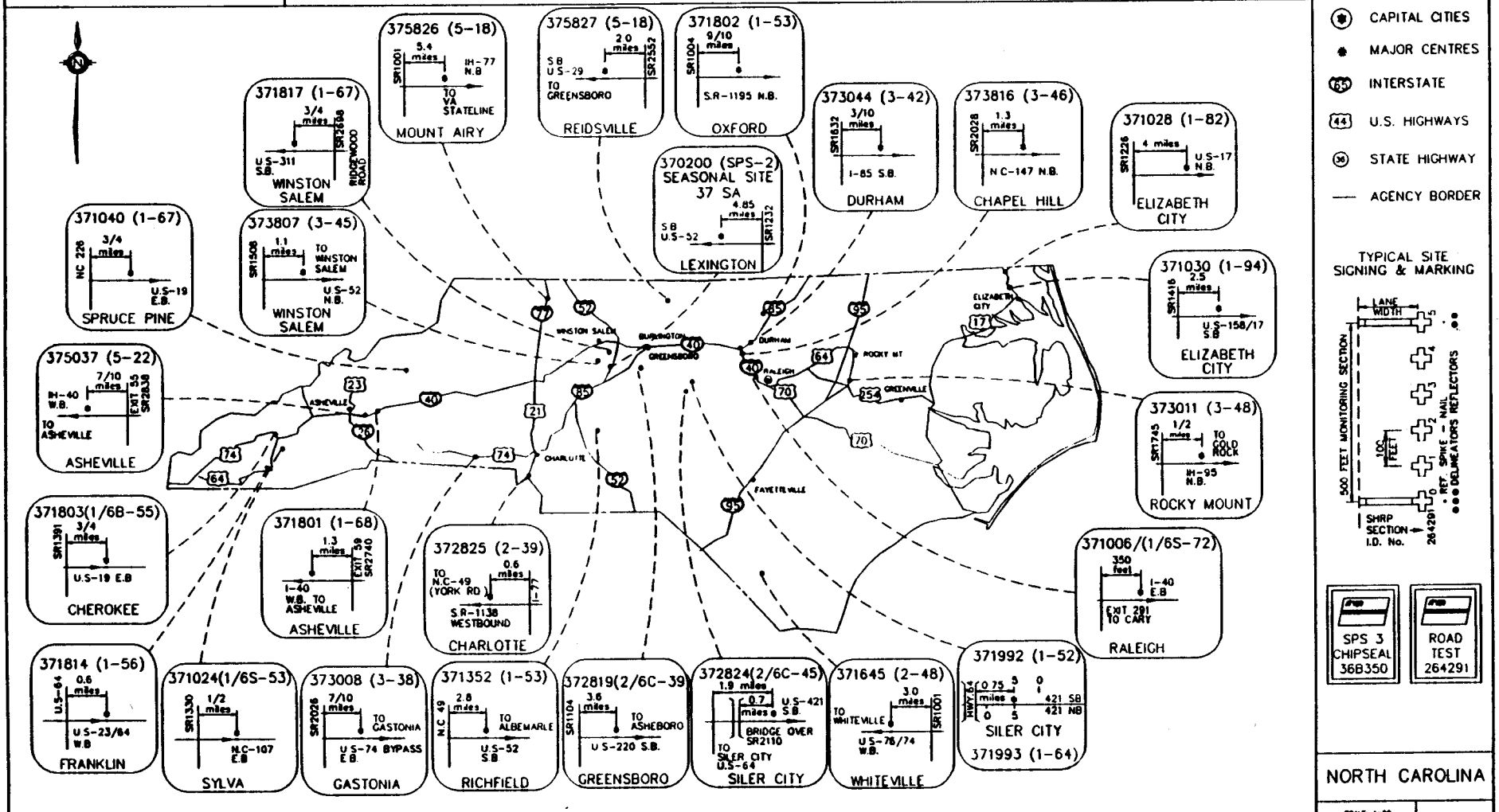


FIGURE A-1 SITE LOCATION MAP - SECTION 371028

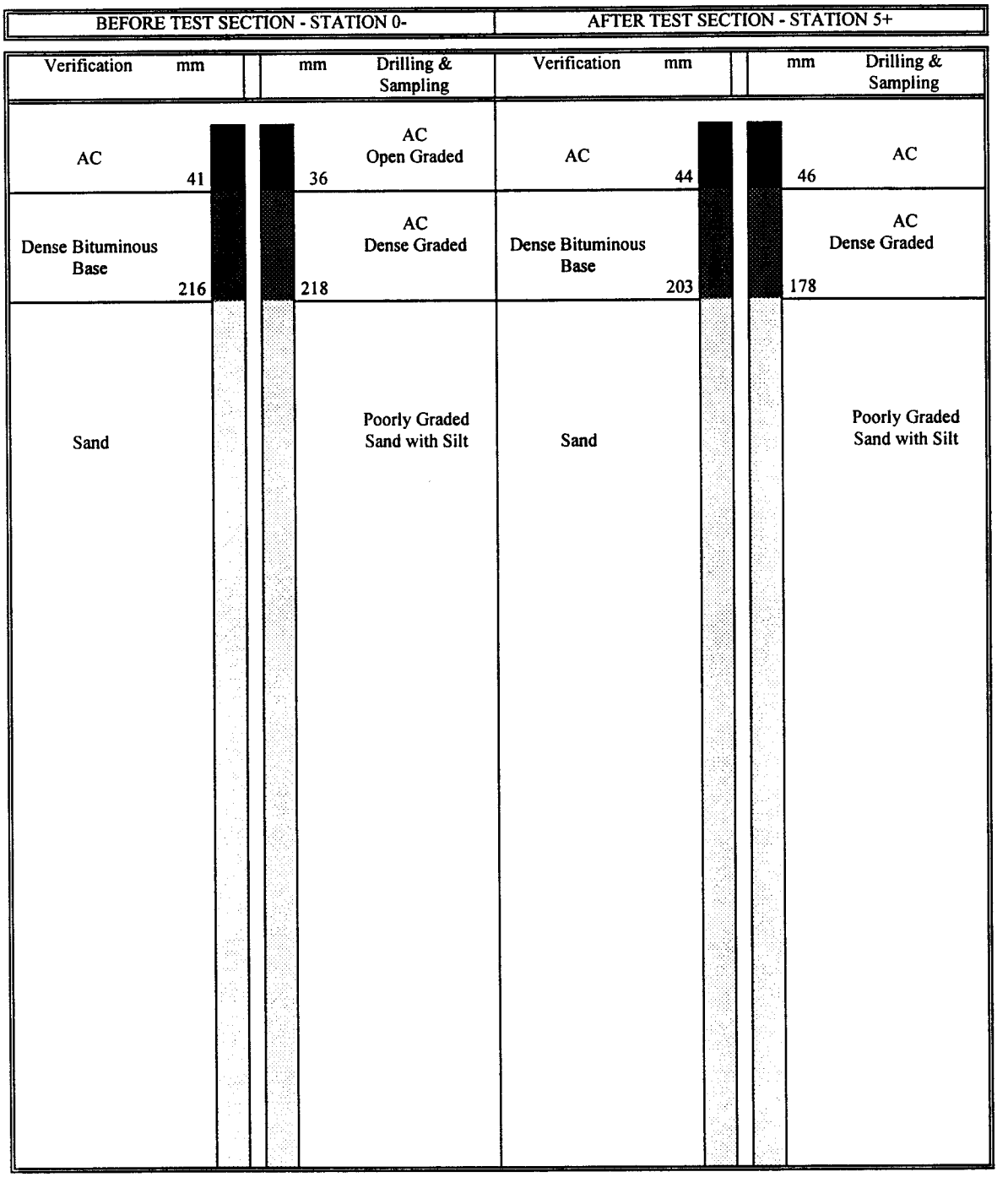


Figure A-2. Profile of Pavement Structure

Table A-1. Site Performance Summary

Distress and Profile Summary		
Distress Summary April 18, 1995	Profile Summary	
	Date (dd-mm-yy)	IRI (in/mi)
Low Sev. Fatigue Cracking - 5 m^2	11-12-89	61.46
Low Sev. Long. Crack.(wheel path)-211m	30-01-90	52.68
Low Sev. Long. Crack.(non-w.path)-18m	09-12-90	53.56
Low Sev. Trans. Crack.- 38 Cracks (30.5m)	08-03-91	56.25
Cracking is very fine - just visible	03-06-92	58.76
	21-04-93	58.25
	17-12-94	57.89
	15-12-95	62.08

Falling Weight Deflectometer Data Summary						
Date	Mean Value for Drop HT 2 (mils)					
dd-mm-yy	Sensor 1	Sensor 1 std. dev.	Sensor 7	Sensor 7 std. dev.	Mean Temp D1 (F)	Min/Max TempD1 (F)
01-03-89	8.47	1.33	1.97	0.07	51	41/66
27-01-93	9.22	1.17	2.07	0.16	61	51/65

dd-mm-yy	Effective SN	SN std dev	Subgrade Modulus (psi)	Modulus std dev (psi)	Test Pit Mod. (psi) 1	2
01-03-89	4.42	0.35	19623	613	21507	20566
	3.64	0.31	19799	898		
27-01-93	4.12	0.27	18585	1386		
	3.57	0.38	19429	1202		

Note: FWD subsection boundaries at 290 ft as entered into RIMS.

Table A-2. Uniformity Survey Results

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 371028	Data Collection and
Date Surveyed: January 27, 1993	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	Effective SN	SN std dev
-100 - 275	8.28	0.97	2.05	0.16	19100	1359	4.28	0.38
275 - 580	9.61	1.14	1.95	0.12	20021	1133	3.67	0.32

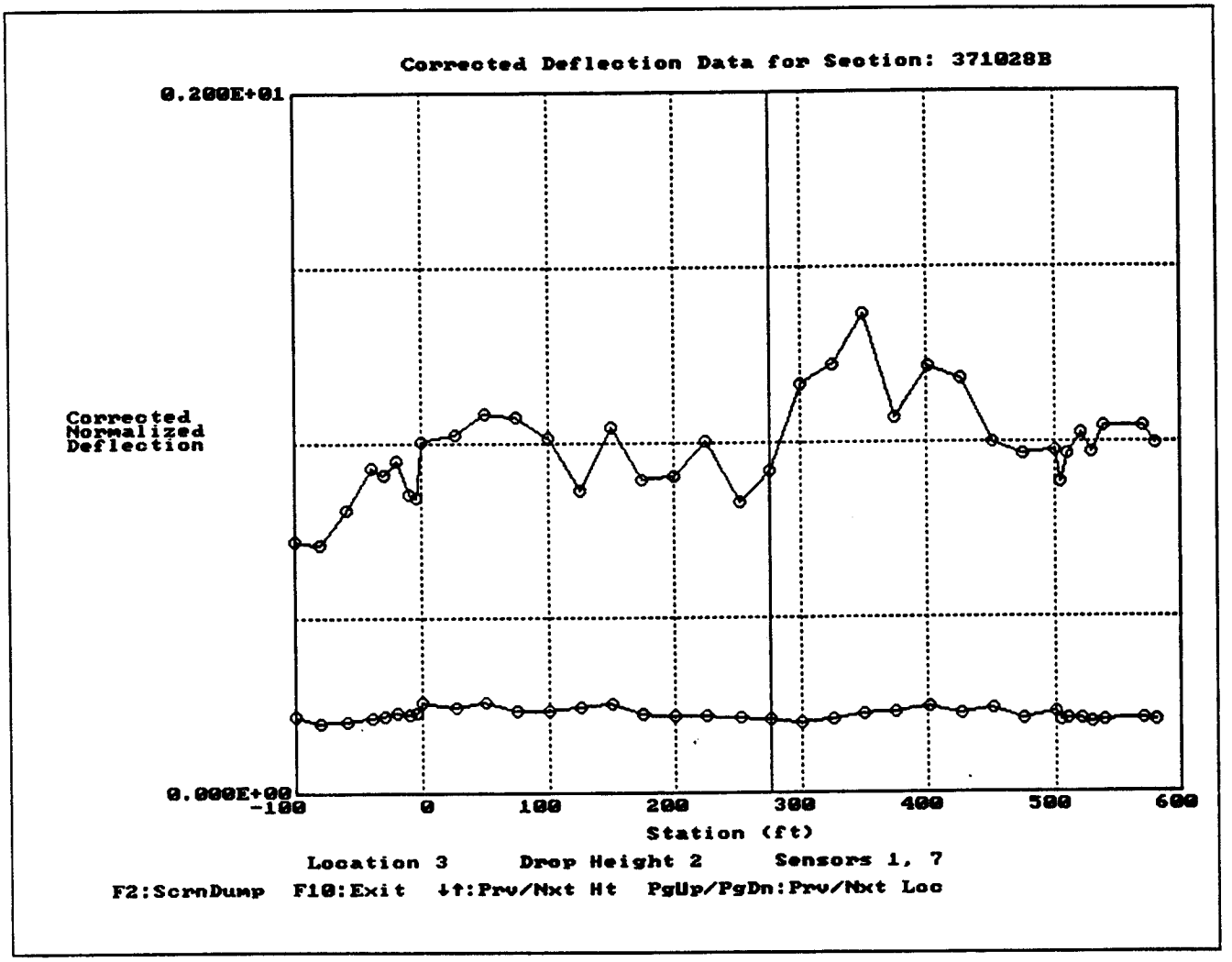


Figure A-3. Deflection Profile from FWDCHECK
(Test Date January 27, 1993)

Table A-3. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date January 27, 1993)

Flexible Pavement Thickness Statistics - 371028B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-100	19540	5.20
	-80	21335	5.00
	-60	21183	4.50
	-40	20090	4.05
	-30	19522	4.20
	-20	19018	4.15
	-10	19306	4.50
	-5	18971	4.60
	0	16763	4.20
	26	17674	4.00
	50	16868	3.90
	75	18479	3.75
	100	18475	3.95
	125	17794	4.65
	150	16979	4.05
	175	19404	4.30
	200	19853	4.20
	225	19861	3.85
	251	20296	4.50
	275	20580	4.05
2	300	21537	3.25
	325	20489	3.20
	350	19179	3.05
	375	18923	3.75
	401	17788	3.45
	426	19359	3.40
	451	18265	4.05
	475	20529	3.90
	501	18794	4.05
	505	21192	4.15
	510	20558	3.90
	521	20662	3.70
	530	20877	3.85
	540	20809	3.60
	570	20347	3.65
	580	21034	3.75
Subsection 1	Overall Mean	19100	4.28
	Standard Deviation	1359	0.38
	Coeff of Variation	7.11%	8.88%
Subsection 2	Overall Mean	20021	3.67
	Standard Deviation	1133	0.32
	Coeff of Variation	5.66%	8.84%

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

APPENDIX B

Supporting Site Visit and Installed Instrument Information

Appendix B contains the following supporting information:

Correspondence from the Site Inspection and the 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. TDR Probes Calibration

Figure B-1. TDR Traces Obtained During Calibration

PAVEMENT
MANAGEMENT
SYSTEMS

ORIGINAL

August 24, 1994
50451025-12.18

Mr. Marvin Patrick Strong
State Research Engineer
North Carolina Department of Transportation
P.O. Box 25201
Raleigh, North Carolina 25201

Dear Mr. Strong:

The LTPP program is preparing to recruit the second round of seasonal site nominations. In accordance with your previous discussions with Brandt Henderson of our staff, we plan to perform installations at Lexington on May 15-16, 1995, and at Elizabeth City on May 17-18, 1995.

For your information we have enclosed a "Seasonal Monitoring Program Guideline" as well as a sample of one of our existing installation reports. Also enclosed is the State Participation Synopsis, with accompanying site data sheet. Please complete and return this datasheet, for both sites. We must forward this information to the FHWA as a part of the seasonal site approval process.

One change to the "Synopsis" which merits pointing out is that data is generally collected monthly; therefore, under the Core Experiment Item #2, this will be the frequency of traffic control needed. In a wet freeze environment, this would be increased to bi-weekly during the thaw period, only.

In general, the seasonal instrumentation consists of moisture, temperature, water table depth, and frost depth measurements beneath the pavement. Along with this are climatic measurements of air temperature and precipitation. Pages II-36-39 of the "Guidelines" indicate areas of responsibility for the FHWA, RCOC, and agency.

If your agency desires to collect additional data to that called for by the LTPP seasonal program, it may do so at it's own expense. For example, a wind speed indicator or a solar radiation collector can be added to the weather data collection. This additional data then can be downloaded to the datalogger, as well.

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

General items required of the agency for installation are a drill rig with the capability to drill a 6" diameter hole to a 15' depth for installation of a piezometer. In addition, the cover for the observation hole, bentonite, and filter sand to fill the hole are to be provided by the agency. The agency is also to provide coring and auguring equipment for holes 10 and 12" in diameter up to a maximum depth of 7'. In addition, a concrete pavement saw must be provided to cut a trench from the observation hole to the pavement edge. This trench will carry the instrumentation cabling to the equipment cabinet adjacent to the roadway.

The agency will also be responsible for traffic control for collecting the monthly data. This will require a lane closure approximately 300' in length at the instrument hole, for essentially one day each month.

The addition of the seasonal monitoring data, at different geographical locations promises to significantly enhance the LTPP database, and increase the potential analysis of the data.

Thank you for supporting seasonal data sites.

Yours Sincerely,

Dave A. Main

Pavement Management Systems Limited

DM/tf

enclosure

C.C. I.J. Pecnik
B. Phang
B. Henderson

Brandt Henderson

COPY

MAR 31 1995

FILE # 12.18

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
P.O. BOX 25201. RALEIGH. N.C. 27611-5201

JAMES B. HUNT. JR.
GOVERNOR

R. SAMUEL HUNT III
SECRETARY

March 27, 1995

MEMORANDUM TO: Shin Wu, Ph.D., P.E.
Jerry Blackwelder, P.E.
Jim Trogdon, P.E.
Pat Strong, P.E.

FROM: Moy Biswas

SUBJECT: LTPP Seasonal Monitoring Program

To discuss plans and procedures for upcoming activities regarding LTPP seasonal monitoring sites in North Carolina, Messrs. Bill Phang and Brandt Henderson of Pavement Management Systems, Ltd., will be here and meet with us.

The meeting is scheduled at 9:00 AM on Tuesday, April 11, 1995 in the conference facility (Room 129) of the Pavement Management Unit.

MB/adj
cc: Max Tate, P.E. (FHWA)
Bill Phang, (PMS, Ltd.)
✓ Brandt Henderson, (PMS, Ltd.), with attachment

PAVEMENT MANAGEMENT SYSTEMS

FAX MEMO

TO	Dr. 'Moy' Biswas (919) 715-0137	**DATE**	April 20, 1995
		PAGES	1
FROM	Brandt Henderson	**PROJECT**	50451025
SUBJECT	Seasonal Site 371028 (US17) Elizabeth City Pre-Installation Inspection	**FILE**	12.18

As per our discussion, I will be visiting the LTPP seasonal site 371028 on US 17 northbound on April 27, 1995 to establish a suitable location for the instrumentation/equipment cabinet and review site condition pertinent to installation and data collection.

On my way to the site, I will stop in at the District facility and contact Carl Skinner/Alex Russel regarding the site review. My plans are to arrive at the District office at 10:30am.

As part of the site review, I will install a stake in the location for the equipment cabinet to provide a reference for clearance of underground utilities.

A site plan view with comments will follow.

C.C. I.J. Pecnik, RE, NARO
W.A. Phang, NARO
J. Jennings, District Engineer, NC DOT

415 LAWRENCE BELL DRIVE, Unit 3, Amherst, N.Y. 14221 Tel. (716) 632-0804; Fax (716) 632-4808

PAVEMENT
MANAGEMENT
SYSTEMS

ORIGINAL

April 20, 1995
50451010-12.18

Dr. Mrinmay "Moy" Biswas
Pavement and Materials Research Engineer
North Carolina Department of Transportation
Division of Highways
P.O. Box 25201
Raleigh, North Carolina 27611-5201

RE: Seasonal Monitoring Program - Supplemental Monitoring

Dear Dr. Biswas:

At our Meeting of April 11, 1995 in Raleigh to discuss plans to install moisture, frost, and temperature sensors at GPS 371028, Elizabeth City, NC, the concept was discussed, of the agency carrying on the monitoring of the GPS site in Year 2, as a supplemental site.

In the normal planned sequence of seasonal monitoring at the GPS site, the data is collected monthly for twelve months of the year, and twice in the Spring months of March and April. The cycle begins in September or October of the year. At the end of the cycle, the above ground sensor connections are removed from the cabinet and the terminal strips and CR10 data recorders cleaned and stored ready for re-installation at the beginning of Year 3 for the next cycle of observations.

If however the agency intends to continue the monitoring during Year 2 as a supplemental site, then these fittings would be left in place. In order to continue the monitoring, the agency would have to acquire the hardware and software to download the CR10 datalogger, and a cable tester to carry out measurement with TDR probes. The agency would also have to have an FWD which was calibrated at the Harrisburg calibration station. The agency profilometer may be used or arrangements can be made with NARO to conduct what measurements are practical with their profilometer.

Details of what measurements and observations are to be made during this period are contained in the FHWA "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines", FHWA-RD-94-110, April 1994. QA/QC software "SMPCHECK" is currently under test and review.

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

It would certainly be of great value to the SMP to have continuous monitoring at a few sites, and your consideration is requested of adopting this 'supplemental' monitoring for GPS 371028 or for SPS site 370201.

Yours Sincerely,

William A. Phang.

William A. Phang
Program Manager
Pavement Management Systems Limited

WAP/tf

C.C. I.J. Pecnik, RE, NARO
B. Henderson, PMSL
P. Strong, NC DOT

Research & Development Unit
North Carolina Department of Transportation
Division of Highways
Room 508, Highway Building
One South Wilmington Street
Post Office Box 25201
Raleigh, NC 27611-6201
Telephone: (919)733-9790
FAX: (919)715-0457

4/24/95

RECEIVED

Facsimile Transmittal Sheet

TO: Brandt Henderson
PMS Ltd.
Cambridge, Ontario

FAX # (519) 622-2580

DATE: Monday, April 24, 1995

NUMBER OF PAGES BEING TRANSMITTED [INCLUDING COVER SHEET]: 1

FROM: Mrinmay (MOY) Biswas (919) 715-2485

PROJECT #: SHRP/LTPP/Seasonal Monitoring Site 371028.1 (near Elizabeth City, NC)

SUBJECT: Survey point @ the site

Message:

The site is approximately 2 miles south of the Va./NC state-line, and 4 miles north of SR-1226, on the north bound lane of US Route 17.

At this location, a red-top stake is driven in the shoulder area. Here, a nail is driven in the paved shoulder, 6 inches away from the edge of the north-bound lane. There is white paint around the nail and the elevation is written on the hard shoulder area in large white painted numbers.

The elevation is 22.863 ft.

One should be able to readily locate the red-top stake and easily read off the elevation.

END

FAX TRANSMITTAL

To:	**Dr. Moy Biswas**	**Fax No.:**	**919-715-0137**
		Date:	**May 8, 1995**
		Project No.:	**5-045-10-25**
Sender:	**Brandt Henderson**		
		Includes cover sheet plus 3 pages	
Reference:	**Seasonal Site Review**	☑	**Original will follow by mail**

MESSAGE:

To follow up the site visit of April 27, 1995, please find enclosed a site plan view and diagram of projected instrument placement in the outer wheel path of US 17 northbound at station 0-12 GPS 371028.

Prior to visiting the site I went over the details for this installation with Allen Russel of the district office.

The drilling and sampling records from 1989 field sampling did not include a shoulder bore identifying the depth to water table. From the site review the pavement is elevated approximately 6 ft from the adjacent forest area. The grade lowers significantly in the area north of Ponderosa Road where it intersects US 17. Visually there was nothing to indicate that we may encounter the water table within the 7 ft depth proposed for the instrument hole.

The location of the piezometer, instrumentation, equipment cabinet and weather instrumentation pole as identified in the planview have been marked with stakes and white paint for utility clearance identification. There does not appear to be any buried cables or pipes at this location but I would suggest the district office check with the local utilities. If there is any problem with clearances we can review and arrange alternate locations as part of the preinstallation meeting on May 16, 1995.

From our recent discussion it sounds like preparation for arranging equipment and supplies for the installation are well underway. The following summarizes the supply items requested from the agency.

Cold or Hot Mix Patching Material
Filter Sand
Bentonite
Concrete Mix (Sacrete)
Surface Access Cover for Piezometer

If you are unable to obtain a large saw for the trench cut we can proceed with the 12" blade saw (6" cut) if a pneumatic or electric chisel is available. This will require extra effort although we have done this for one of the round one unit installations.

We also require the loan of a standard procter mold, hammer and balance (capacity 11.5 kg readable 5 gm) for density determination of the subgrade material. We are also requesting the agency provided laboratory moisture values for soil samples taken at each TDR installation location (10 in total) to verify field moisture values. We will supply these samples in ziploc baggies unless your laboratory has special requirements for receiving samples (ie, tins or jars). The Pavement Management System employees coming for the installation are:

Brandt Henderson	Team Leader
Alfred Lip	Engineering Assistant
Doug Marshall	FWD Operator
James Orzulak	Instrument Technician
Dilan Singaraja	Engineering Assistant

The pre installation meeting is scheduled for Tuesday, May 16 at 2:00 pm at the district office north of Elizabeth City on US 17. This meeting is to review the equipment and supply status along with a discussion on the installation day schedule of activities.

If you have any questions or need further information do not hesitate to call. I can be reached through our Amherst, NY office. As I will be out of the office I will return your call.

We look forward to seeing you and your coworkers on May 15 at the Lexington SPS2 site.

Copies: J. Jennings, District Engineer, NCDOT

Table B-1. Air Temperature Thermistor Calibration

LTPP Seasonal Monitoring Study	State Code	[3 7]
Air Temperature Thermistor Calibration	Test Section Number	[1 0 2 8]

Before Operation Checks	Calibration Date dd-mm-yy	05-05-95
	Probe S/N	37EAT
	Operator	JO

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
23.93	22.70	32.68	24.7	1400	0.210	1300	58.80	1500	y

Probe Accepted	J.O.	(Initials)

Table B-2. MRC Probe Calibration

LTPP Seasonal Monitoring Study	State Code	[37]
MRC Probe Calibration	Test Section Number	[1028]

Before Operation Checks	Calibration Date dd-mm-yy	05-05-95
	Probe S/N	37ET
	Operator	JO

	Mobile Datalogger (24 hour)			Water Room Temp Time 1400	Ice Bath 0 °C (+/- 1 °C) Time 1300	Hot Water 50 °C (+/-) Time 1243	ok
No.	Mean	Min.	Max.	Reading	Reading	Reading	y/n
1	22.46	20.93	32.54	24.6	-0.114	58.4	y
2	22.88	21.23	32.55	24.9	-0.114	58.8	y
3	23.10	21.40	32.61	24.8	0.114	58.6	y
4	24.19	22.66	32.54	23.9	0.119	50.7	y
5	24.37	22.62	34.08	24.6	-0.039	52.1	y
6	24.30	22.52	34.07	24.6	-0.018	53.0	y
7	24.25	22.58	34.05	24.9	-0.114	53.1	y
8	24.10	22.22	33.94	24.8	-0.150	53.4	y
9	23.91	22.08	34.03	24.7	-0.114	53.6	y
10	23.84	21.87	33.56	24.5	-0.114	53.2	y
11	24.05	21.97	33.42	24.8	-0.115	53.8	y
12	23.91	21.86	33.04	24.6	-0.077	53.5	y
13	24.05	21.96	33.78	24.6	-0.114	53.1	y
14	23.80	22.32	33.17	24.3	-0.114	53.5	y
15	23.90	22.13	32.28	23.8	-0.151	51.9	y
16	24.20	21.84	32.15	23.8	-0.002	52.1	y
17	23.90	22.11	32.44	23.3	0.550	52.0	y
18	24.10	21.14	32.24	22.4	0.367	53.0	y

Probe Accepted:	J.O.	(Initials)
Probe Length:	1.851	(meters)

Thermistor distance from top of probe: (meters)									
4	0.020	7	0.246	10	0.625	13	1.083	16	1.540
5	0.093	8	0.322	11	0.779	14	1.236	17	1.694
6	0.170	9	0.474	12	0.932	15	1.388	18	1.844

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

Unit	Channel No.	Distance from Top of Unit(m)	Remarks
1	1	0.025	0.3302 m long by 6.35 mm stainless steel probe installed in the AC layer.
	2	0.177	
	3	0.327	
2	4	0.020	1.851 m long by 25.4 mm PVC tube installed in the base and subgrade.
	5	0.093	
	6	0.170	
	7	0.246	
	8	0.322	
	9	0.474	
	10	0.625	
	11	0.779	
	12	0.932	
	13	1.083	
	14	1.236	
	15	1.388	
	16	1.540	
	17	1.694	
	18	1.844	

Table B-4. TDR Probes Calibration

LTPP Seasonal Monitoring Study	State Code	[37]
TDR Probes	Test Section Number	[1028]

Before Operation Checks	AL/JO	Initial	Calibration Date (dd-mm-yy)	10-05-95
			Seasonal Site	37SE

No.	Probe (S/N)	Resistance (ohms) Core	Shield	Probe Shorted Begin Length	End Length	Air Begin Length	Alcohol Begin Length	Water Begin Length
1	37E01	0.4	0.3	16.440	16.630	16.440	16.480	16.460
2	37E02	0.4	0.3	16.350	16.550	16.350	16.380	16.380
3	37E03	0.4	0.3	15.880	16.090	15.880	15.920	15.920
4	37E04	0.4	0.3	15.870	16.080	16.080	15.910	15.910
5	37E05	0.4	0.3	16.150	16.360	16.150	16.180	16.180
6	37E06	0.4	0.3	16.160	16.360	16.160	16.190	16.190
7	37E07	0.5	0.3	16.540	16.740	16.540	16.540	16.540
8	37E08	0.4	0.3	16.470	16.690	16.470	16.510	16.510
9	37E09	0.4	0.3	16.140	16.340	16.140	16.170	16.170
10	37E10	0.4	0.3	15.870	16.070	15.870	15.930	15.930

NOTE: Record lengths from TDR

Calculation of Dielectric Constant

Probe Length 0.203 m

V_p Setting 0.99 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	0.19	0.89	y	1.17	33.89	y	1.85	84.74	y
2	0.20	0.99	y	1.17	33.89	y	1.85	84.74	y
3	0.21	1.09	y	1.16	33.32	y	1.85	84.74	y
4	0.21	1.09	y	1.17	33.89	y	1.85	84.74	y
5	0.21	1.09	y	1.16	33.32	y	1.85	84.74	y
6	0.20	0.99	y	1.18	34.47	y	1.83	82.90	y
7	0.20	0.99	y	1.10	29.96	y	1.85	84.74	y
8	0.22	1.19	y	1.15	32.74	y	1.84	83.80	y
9	0.20	0.99	y	1.19	35.06	y	1.85	84.74	y
10	0.20	0.99	y	1.15	32.74	y	1.85	84.74	y

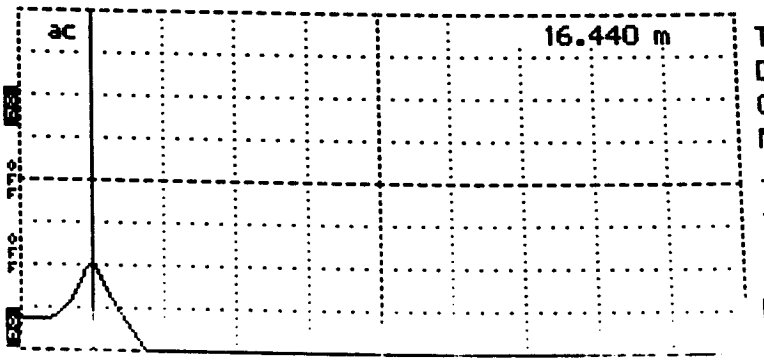
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37E01 **Date (dd/mm/yy):** 10/05/95

Probe Number 01

Trace 1 - Probe Shorted at Start

Cursor ..... 16.440 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

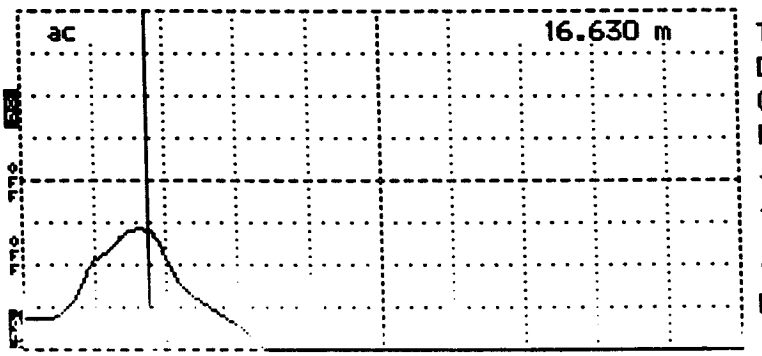


Tektronix 1502B TDR
Date 05-10-95
Cable #1
Notes 371028
short start

Input Trace ———
Stored Trace - - - - -
Difference Trace ····

Trace 2 - Probe Shorted at End

Cursor ..... 16.630 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #1
Notes 371028
short end

Input Trace ———
Stored Trace - - - - -
Difference Trace - - -

Figure B-1. TDR Traces Obtained During Calibration

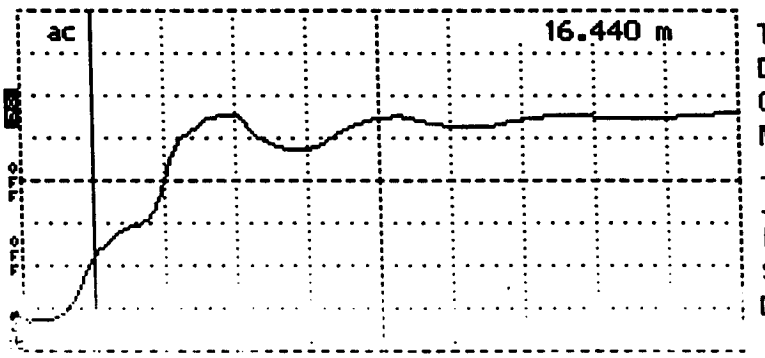
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [32] LTPP Section ID: [1C35]

Probe Number 01

Trace 3 - Probe in Air

Cursor ..... 16.440 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

0.19



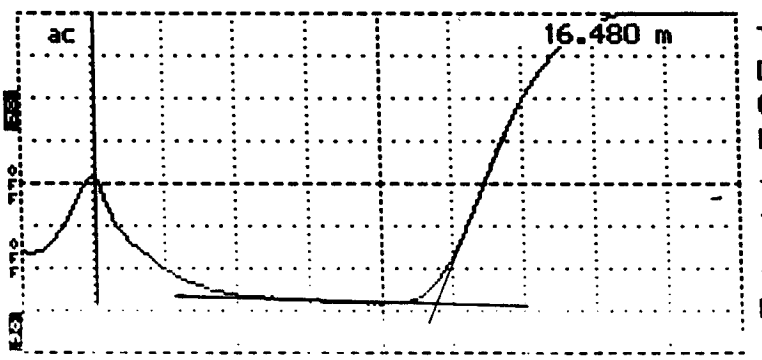
Tektronix 1502B TDR
Date 05-10-95
Cable #1
Notes 37028
Air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 16.480 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

1.17



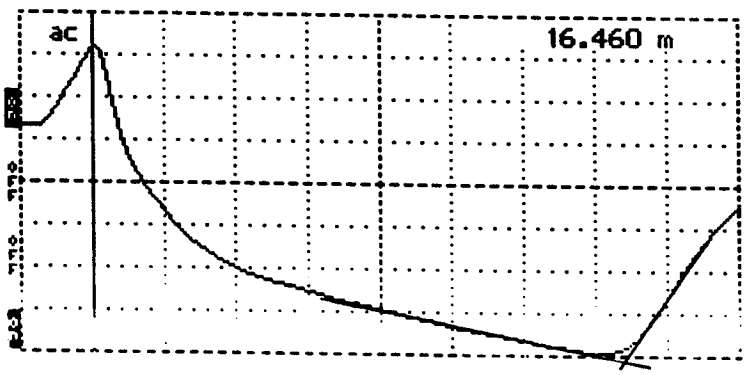
Tektronix 1502B TDR
Date 05-10-95
Cable #1
Notes 37028
Alcohol

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 16.460 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

1.85



Tektronix 1502B TDR
Date 05-10-95
Cable #1
Notes 37028
Water

Input Trace
Stored Trace
Difference Trace

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

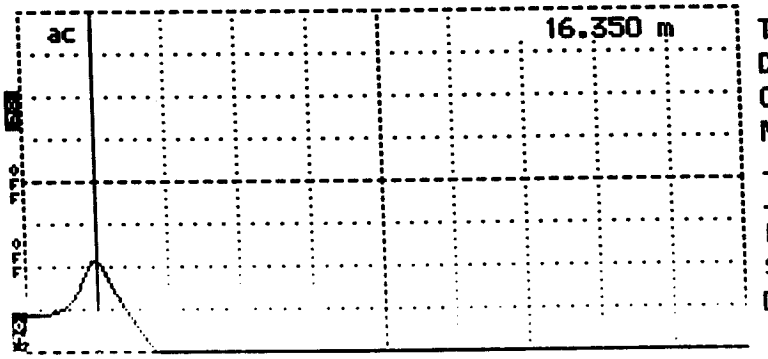
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37E02 **Date (dd/mm/yy):** 10/05/95

Probe Number 02

Trace 1 - Probe Shorted at Start

Cursor ..... 16.350 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

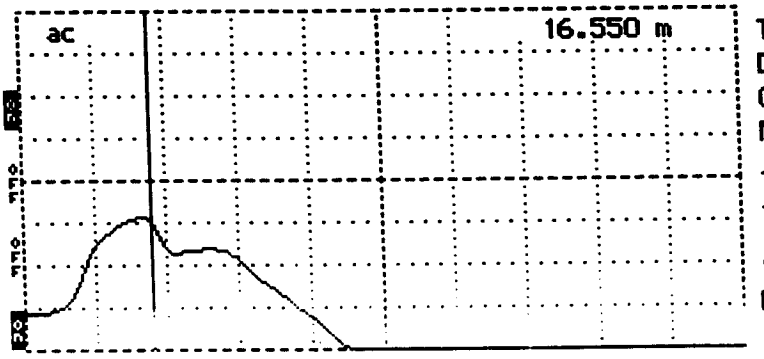


Tektronix 1502B TDR
Date 05-10-95
Cable #2
Notes 37028
short start

Input Trace ———
Stored Trace .....
Difference Trace ----

Trace 2 - Probe Shorted at End

Cursor ..... 16.550 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #2
Notes 37028
short end

Input Trace ———
Stored Trace .....
Difference Trace ----

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

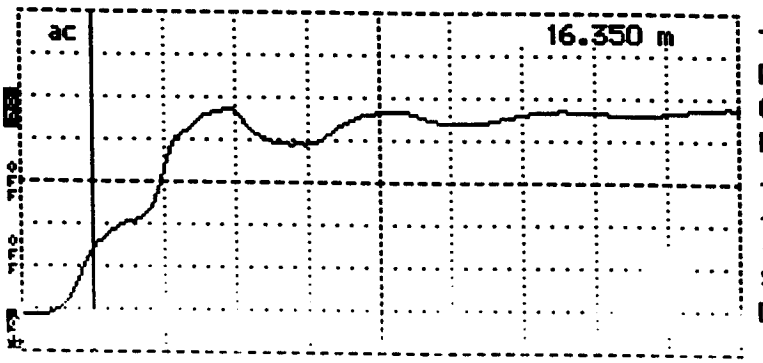
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Number 02

Trace 3 - Probe in Air

Cursor ..... 16.350 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

0.70



Tektronix 1502B TDR
Date 05-10-95
Cable #2
Notes 371028
AC

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 16.380 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

1.17

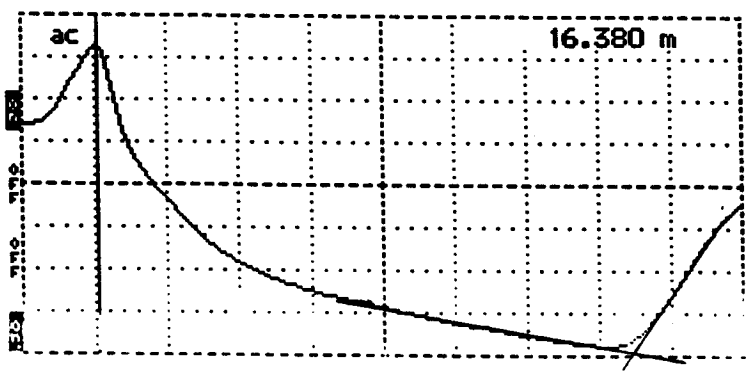
Tektronix 1502B TDR
Date 05-10-95
Cable #2
Notes 371028
Alcohol

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 16.380 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

1.85



Tektronix 1502B TDR
Date 05-10-95
Cable #2
Notes 371028
Water

Input Trace
Stored Trace
Difference Trace

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

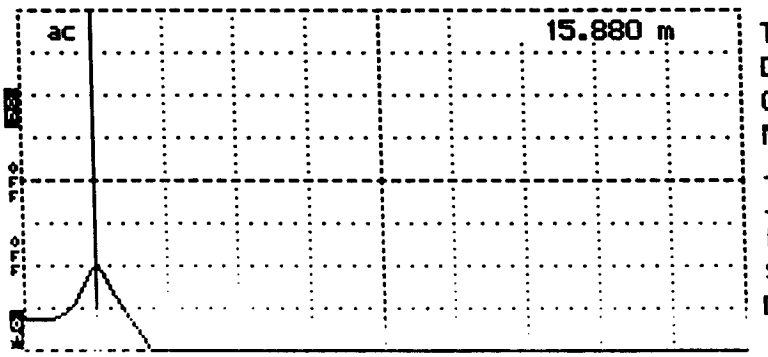
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37E03 **Date (dd/mm/yy):** 10/05/95

Probe Number 03

Trace 1 - Probe Shorted at Start

Cursor ..... 15.880 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avs
Power..... ac

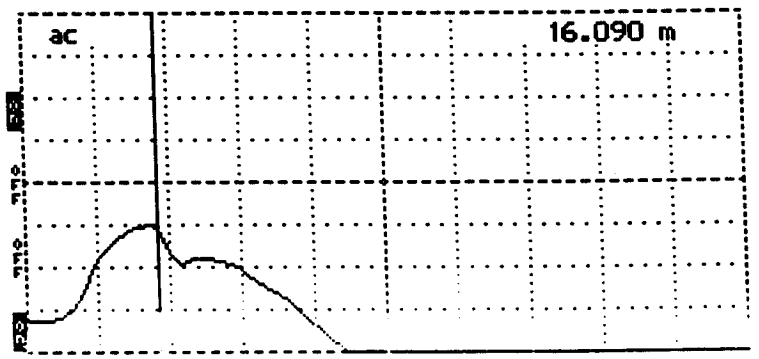


Tektronix 1502B TDR
Date 05-10-95
Cable #3
Notes 37/028
short start

Input Trace
Stored Trace
Difference Trace

Trace 2 - Probe Shorted at End

Cursor ..... 16.090 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avs
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #3
Notes 37/028
short end

Input Trace
Stored Trace
Difference Trace

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

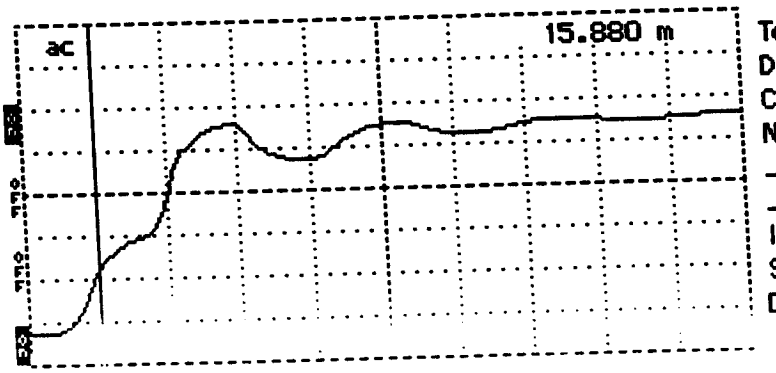
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [32] LTPP Section ID: [1 0 3 8]

Probe Number 03

Trace 3 - Probe in Air

Cursor ..... 15.880 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power ..... ac

0.11

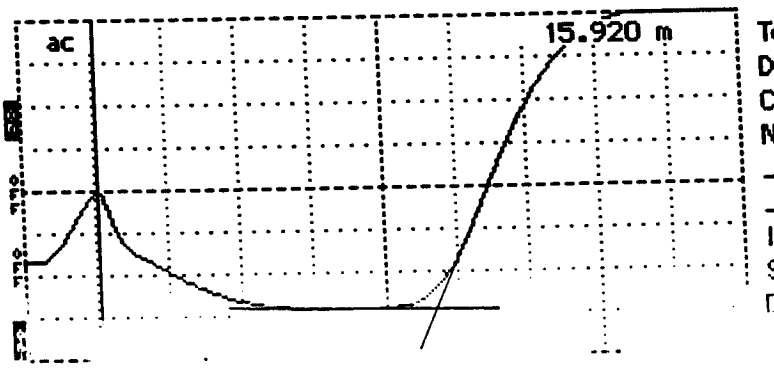


Tektronix 1502B TDR
Date 05-10-95
Cable #3
Notes 371028
Air
Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 15.920 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power ..... ac

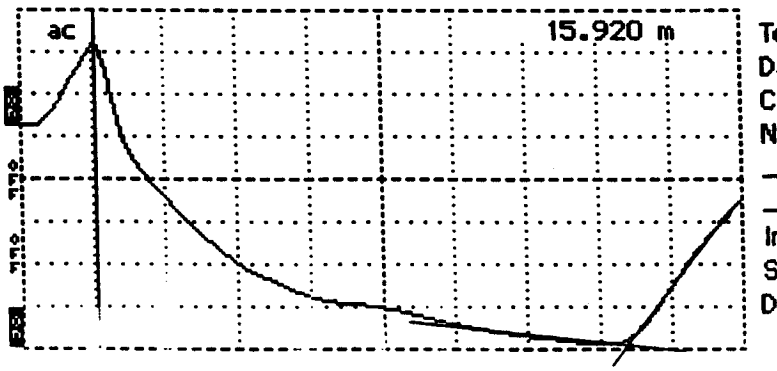
1.16



Tektronix 1502B TDR
Date 05-10-95
Cable #3
Notes 371028
Alcohol
Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 15.920 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power ..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #3
Notes 371028
Water
Input Trace
Stored Trace
Difference Trace

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

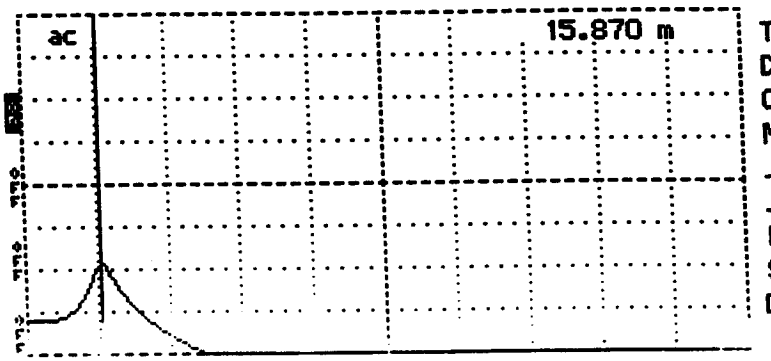
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37E04 **Date (dd/mm/yy):** 10/05/95

Probe Number 04

Trace 1 - Probe Shorted at Start

Cursor ..... 15.870 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mV/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

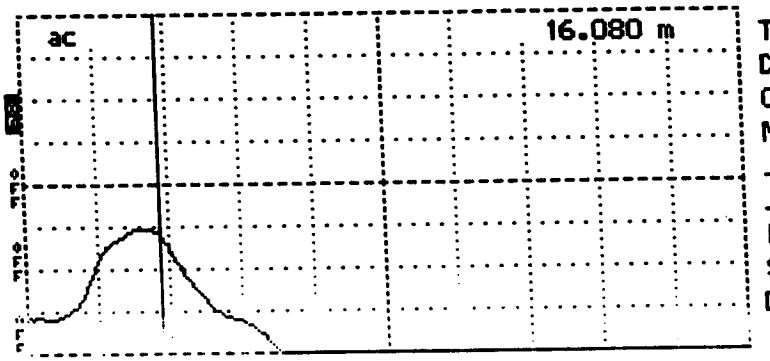


Tektronix 1502B TDR
Date 05-10-95
Cable #4
Notes 37/028
Short start

Input Trace ———
Stored Trace .....
Difference Trace ----

Trace 2 - Probe Shorted at End

Cursor ..... 16.080 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mV/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #4
Notes 37/028
Short end

Input Trace ———
Stored Trace .....
Difference Trace ----

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

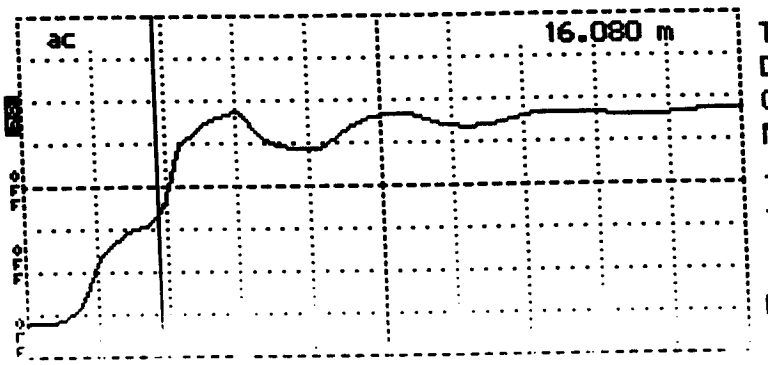
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1C25]

Probe Number 04

Trace 3 - Probe in Air

Cursor ..... 16.080 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

0.21

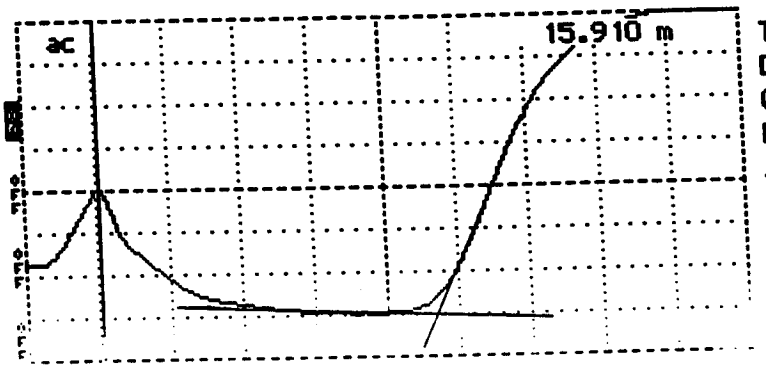


Tektronix 1502B TDR
Date 05-10-95
Cable #4
Notes 37028
Air
Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 15.910 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

1.17

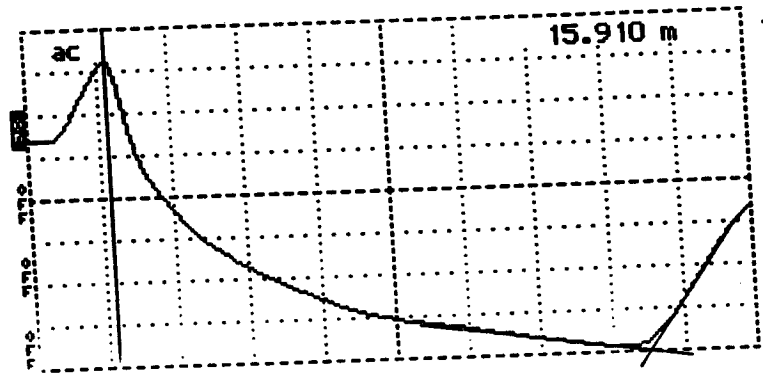


Tektronix 1502B TDR
Date 05-10-95
Cable #4
Notes 37028
Alcohol
Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 15.910 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

1.85



Tektronix 1502B TDR
Date 05-10-95
Cable #4
Notes 37028
Water
Input Trace
Stored Trace
Difference Trace

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

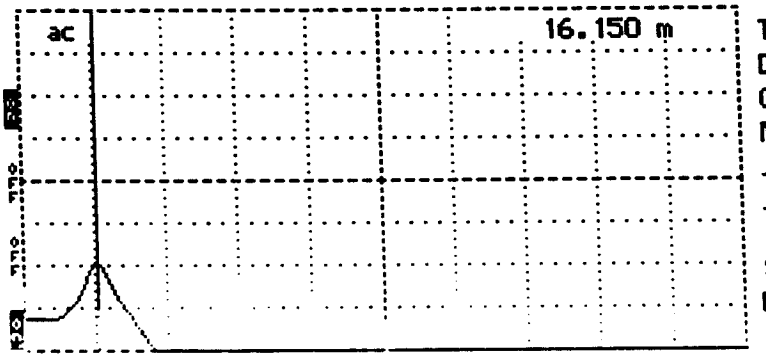
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37E05 **Date (dd/mm/yy):** 10/05/95

Probe Number 05

Trace 1 - Probe Shorted at Start

Cursor ..... 16.150 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

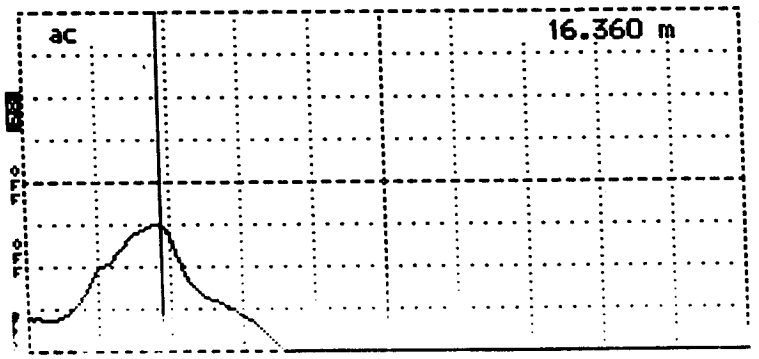


Tektronix 1502B TDR
Date 05-10-95
Cable #05
Notes 37/028
short start

Input Trace ———
Stored Trace .....
Difference Trace ---

Trace 2 - Probe Shorted at End

Cursor ..... 16.360 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #05
Notes 37/028
short end

Input Trace ———
Stored Trace .....
Difference Trace ---

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

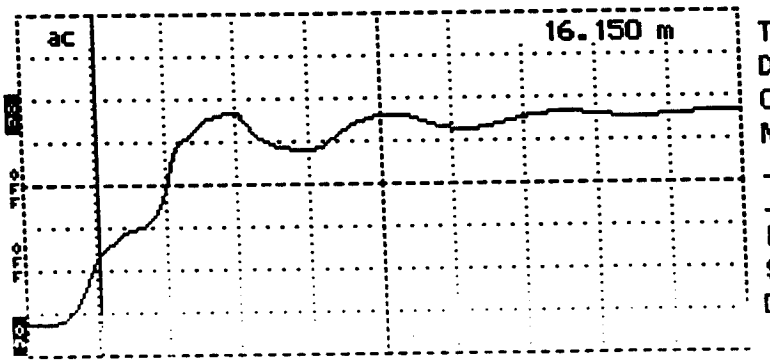
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1C35]

Probe Number 05

Trace 3 - Probe in Air

Cursor ..... 16.150 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

0.21



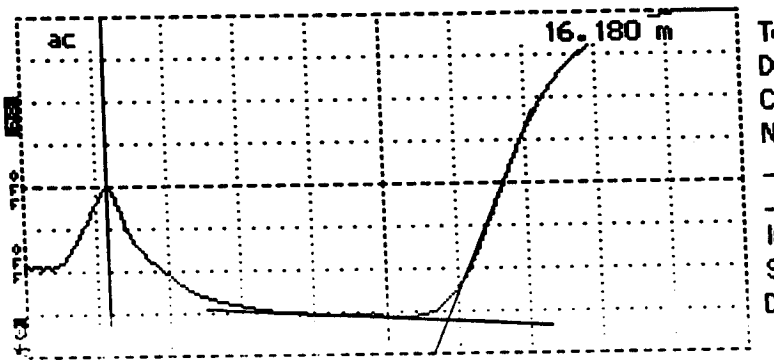
Tektronix 1502B TDR
Date 05-10-95
Cable #05
Notes 371078
Air

Input Trace ——
Stored Trace ----
Difference Trace ---

Trace 4 - Probe in Alcohol

Cursor ..... 16.180 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

1.16

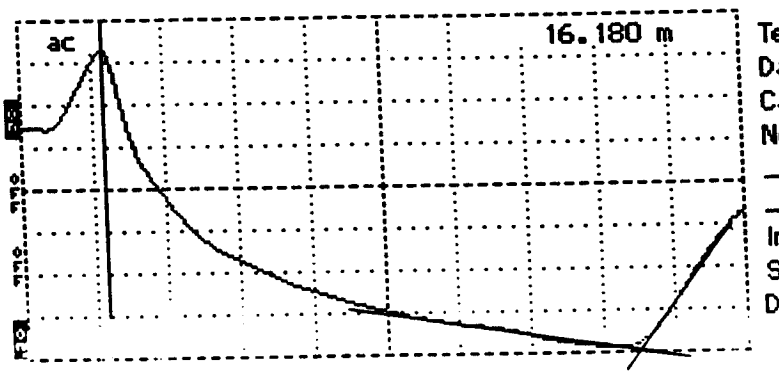


Tektronix 1502B TDR
Date 05-10-95
Cable #05
Notes 371078
Alcohol

Input Trace ——
Stored Trace ----
Difference Trace ---

Trace 5 - Probe in Water

Cursor ..... 16.180 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #05
Notes 371078
Water

Input Trace ——
Stored Trace ----
Difference Trace ---

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

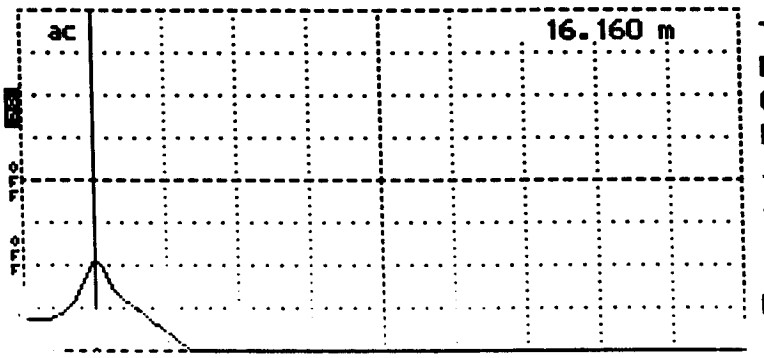
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37606 **Date (dd/mm/yy):** 10/05/95

Probe Number 06

Trace 1 - Probe Shorted at Start

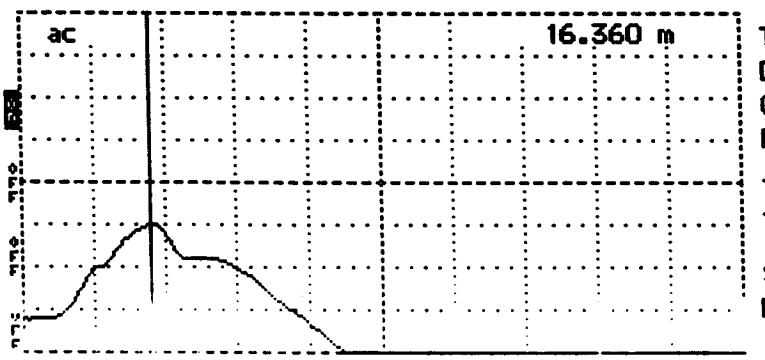
Cursor ..... 16.160 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power ..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #6
Notes 37606
short start
Input Trace
Stored Trace
Difference Trace

Trace 2 - Probe Shorted at End

Cursor ..... 16.360 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power ..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #6
Notes 37606
short end
Input Trace
Stored Trace
Difference Trace

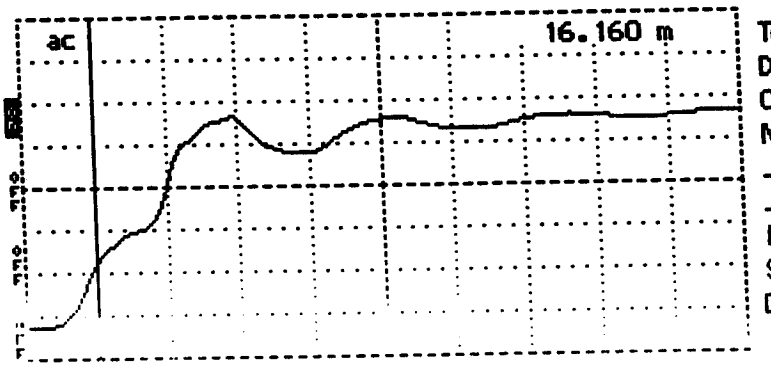
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [32] LTPP Section ID: [ ]

Probe Number 06

Trace 3 - Probe in Air

Cursor ..... 16.160 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

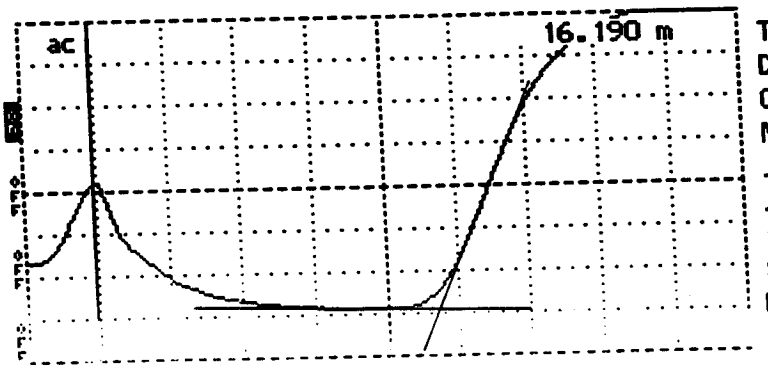


Tektronix 1502B TDR
Date 05-10-95
Cable #6
Notes 371028
Air
Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 16.190 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

1.18

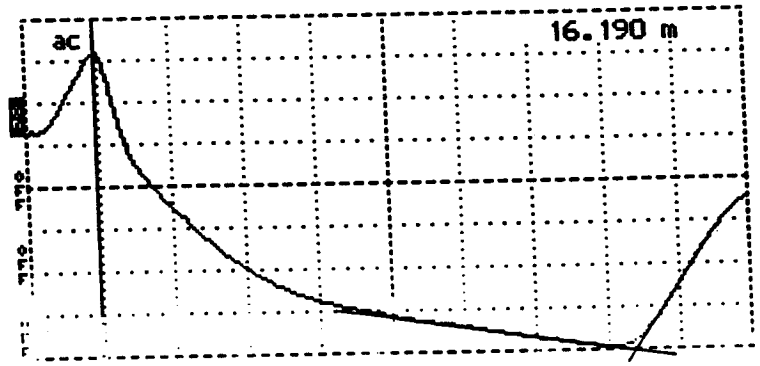


Tektronix 1502B TDR
Date 05-10-95
Cable #6
Notes 371028
Alcohol
Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 16.190 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

1.83



Tektronix 1502B TDR
Date 05-10-95
Cable #6
Notes 371028
Water
Input Trace
Stored Trace
Difference Trace

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

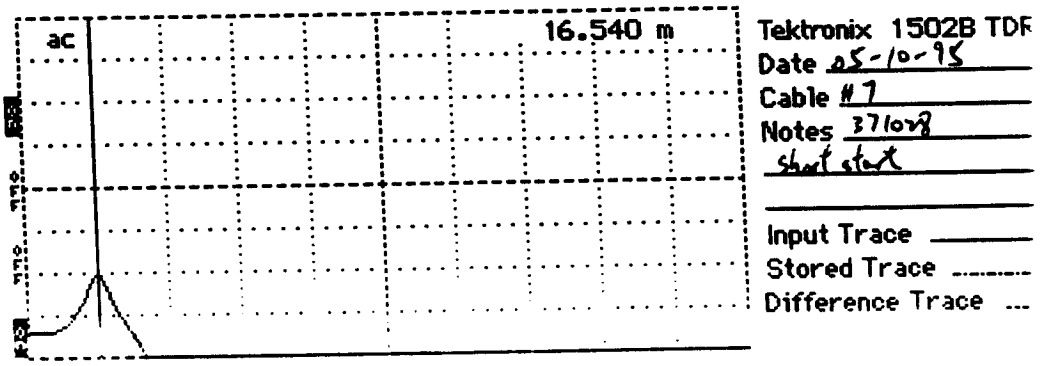
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37E07 **Date (dd/mm/yy):** 10/05/95

Probe Number 07

Trace 1 - Probe Shorted at Start

Cursor ..... 16.540 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mΩ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Trace 2 - Probe Shorted at End

Cursor ..... 16.740 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mΩ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

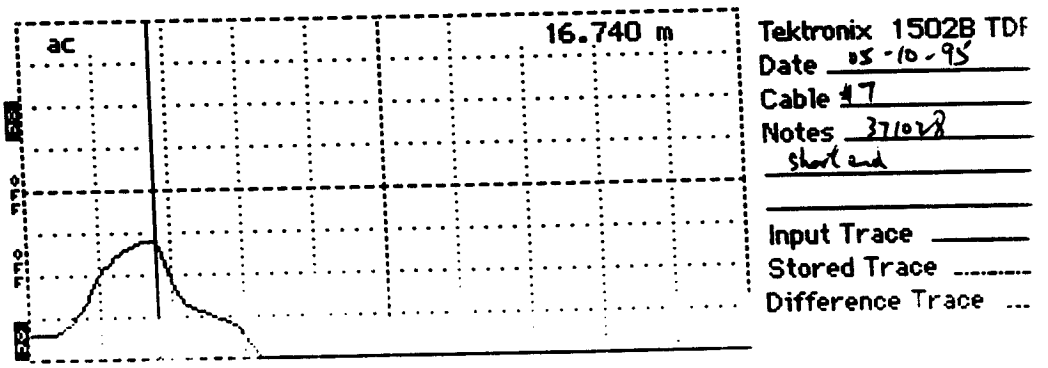


Figure B-1(cont.). TDR Traces Obtained During Calibration

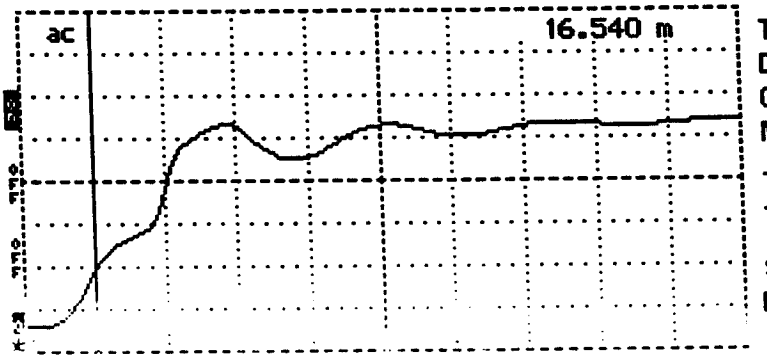
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1C25]

Probe Number 07

Trace 3 - Probe in Air

Cursor ..... 16.540 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mΩ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

0-10

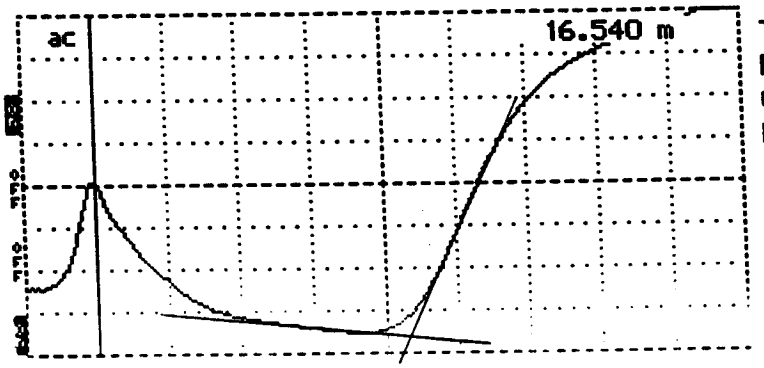


Tektronix 1502B TDR
Date 05-10-95
Cable #7
Notes 37028
Air
Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 16.540 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mΩ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

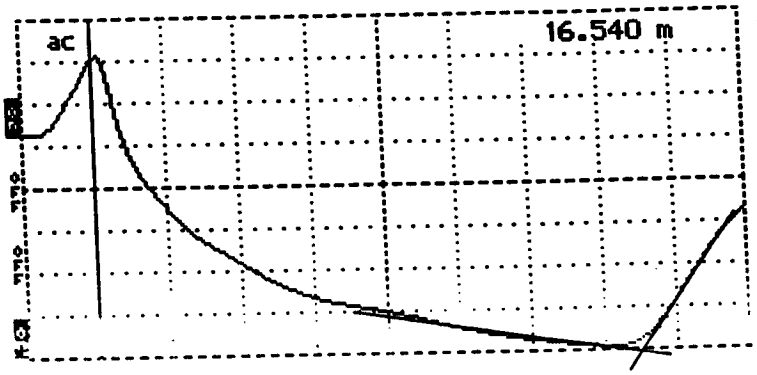
1-10



Tektronix 1502B TDR
Date 05-10-95
Cable #7
Notes 37028
Alcohol
Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 16.540 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mΩ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #7
Notes 37028
Water
Input Trace
Stored Trace
Difference Trace

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

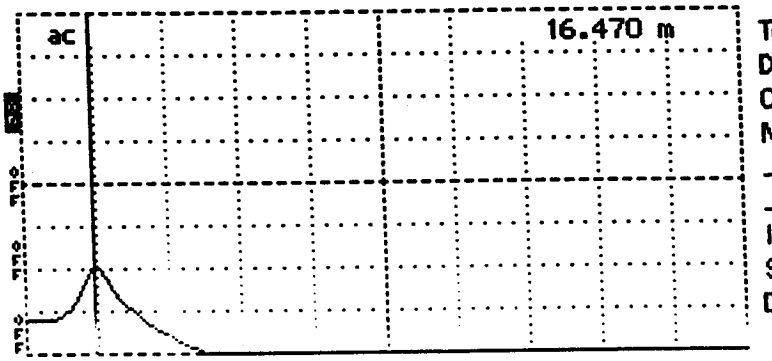
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37E08 **Date (dd/mm/yy):** 10/05/95

Probe Number 08

Trace 1 - Probe Shorted at Start

Cursor ..... 16.470 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

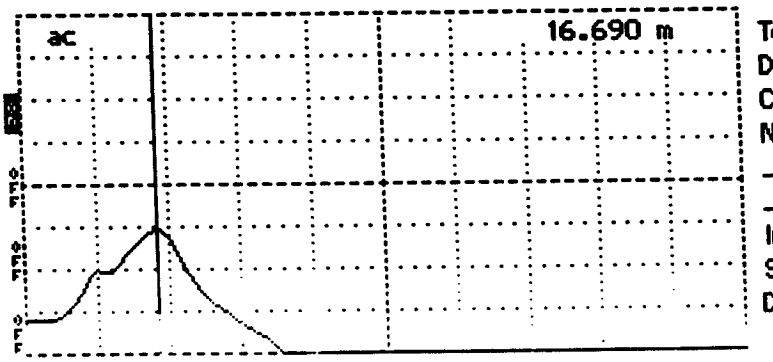


Tektronix 1502B TDR
Date 05-10-95
Cable #9
Notes 37E08
Short Start

Input Trace ———
Stored Trace - - - - -
Difference Trace ----

Trace 2 - Probe Shorted at End

Cursor ..... 16.690 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #9
Notes 37E08
Short end

Input Trace ———
Stored Trace - - - - -
Difference Trace ----

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

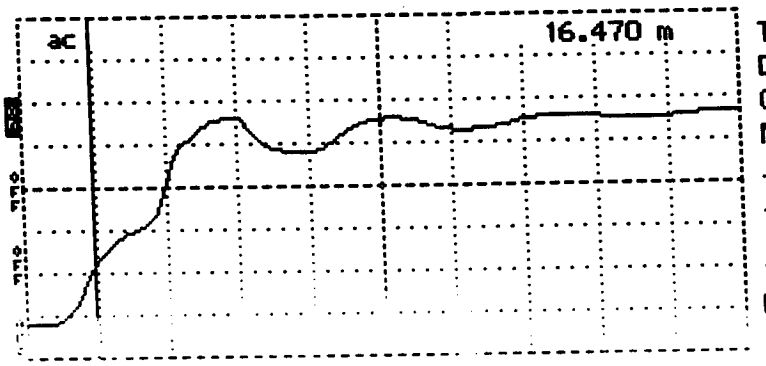
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1 C 3 S]

Probe Number 08

Trace 3 - Probe in Air

Cursor ..... 16.470 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

0.22

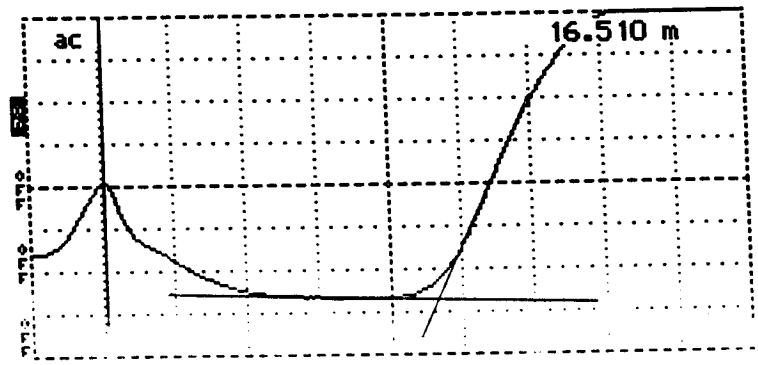


Tektronix 1502B TDR
Date 05-10-95
Cable #8
Notes 37108
Air
Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 16.510 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

1.15

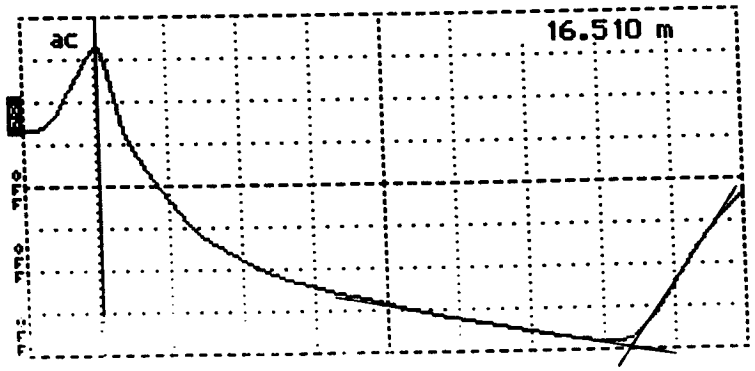


Tektronix 1502B TDR
Date 05-10-95
Cable #8
Notes 37108
Alcohol
Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 16.510 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

1.84



Tektronix 1502B TDR
Date 05-10-95
Cable #8
Notes 37108
Water
Input Trace
Stored Trace
Difference Trace

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

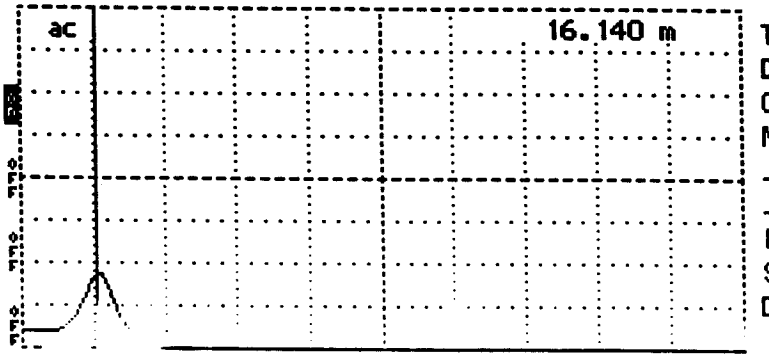
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37E09 **Date (dd/mm/yy):** 10/05/95

Probe Number 09

Trace 1 - Probe Shorted at Start

Cursor ..... 16.140 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

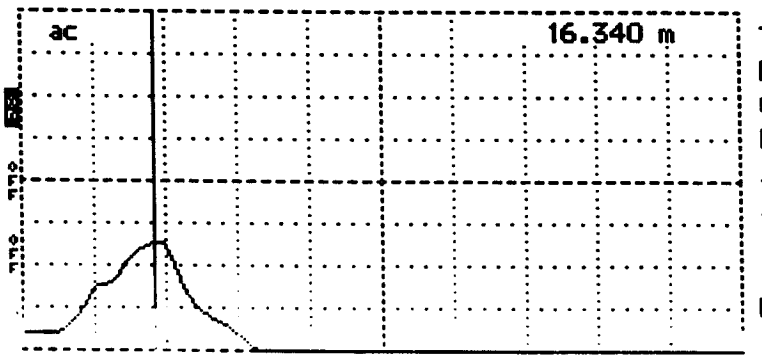


Tektronix 1502B TDR
Date 05-10-95
Cable #9
Notes 37E09
short start

Input Trace _____
Stored Trace .....
Difference Trace .....

Trace 2 - Probe Shorted at End

Cursor ..... 16.340 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #9
Notes 37E09
short end

Input Trace _____
Stored Trace .....
Difference Trace .....

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

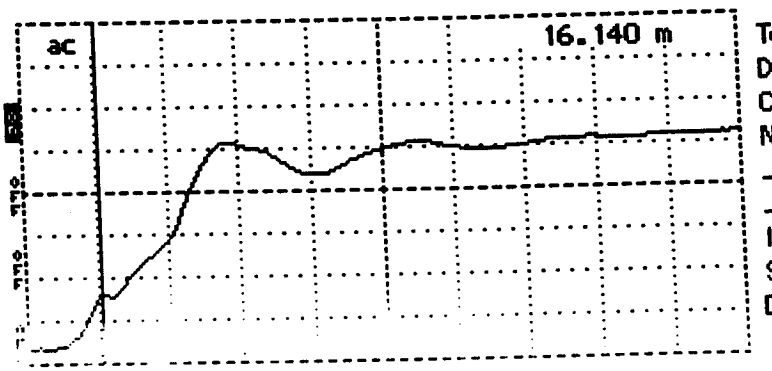
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1035]

Probe Number 09

Trace 3 - Probe in Air

Cursor ..... 16.140 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

0.00

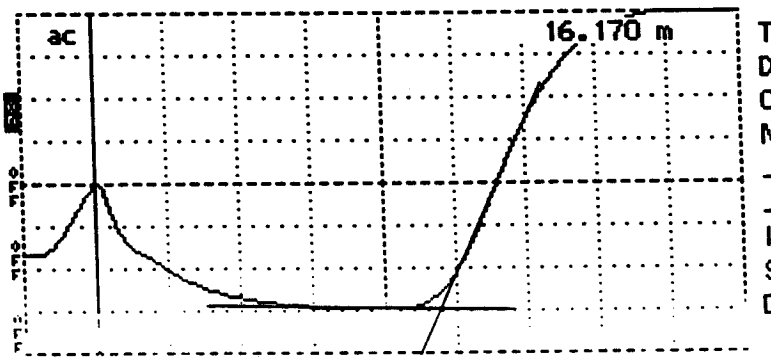


Tektronix 1502B TDR
Date 05-10-95
Cable #9
Notes 3710 28
Air
Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 16.170 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

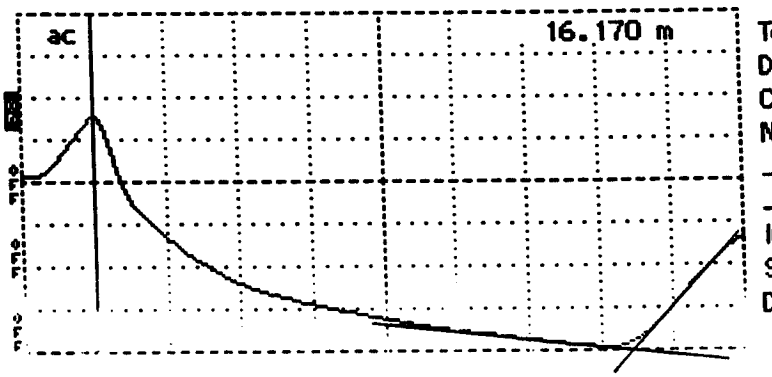
1.19



Tektronix 1502B TDR
Date 05-10-95
Cable #9
Notes 3710 28
Alcohol
Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 16.170 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable #9
Notes 3710 28
Water
Input Trace
Stored Trace
Difference Trace

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

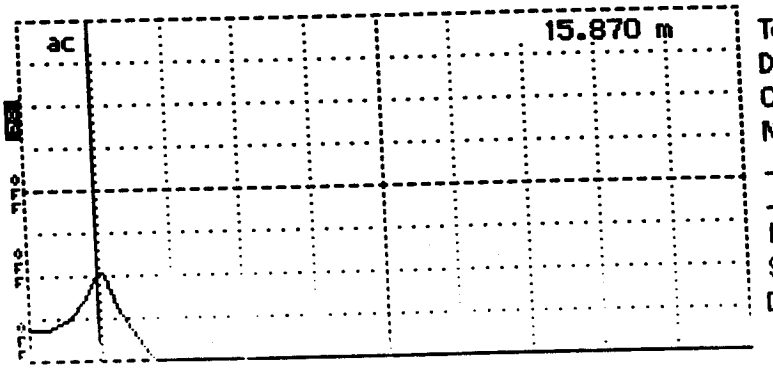
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1028]

Probe Serial Number: 37E10 **Date (dd/mm/yy):** 10/05/95

Probe Number 10

Trace 1 - Probe Shorted at Start

Cursor ..... 15.870 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

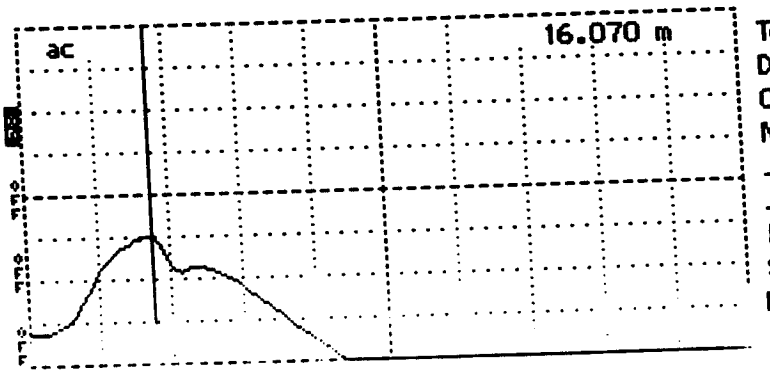


Tektronix 1502B TDR
Date 05-10-95
Cable 10
Notes 37 10 28
short start

Input Trace ———
Stored Trace .....
Difference Trace ----

Trace 2 - Probe Shorted at End

Cursor ..... 16.070 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 05-10-95
Cable 10
Notes 37 10 28
Short end

Input Trace ———
Stored Trace .....
Difference Trace ----

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

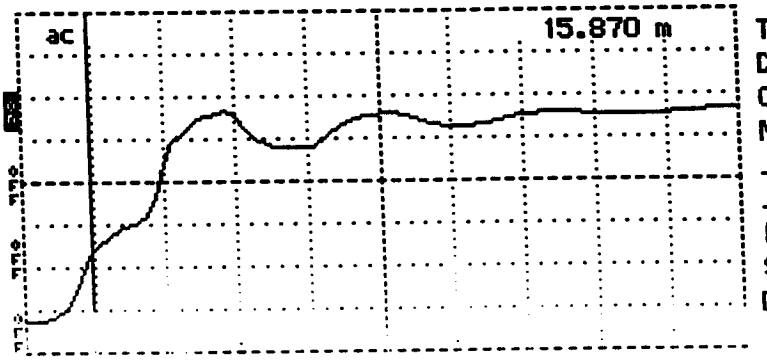
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [37] LTPP Section ID: [1023]

Probe Number 10

Trace 3 - Probe in Air

Cursor ..... 15.870 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power ..... ac

0.70

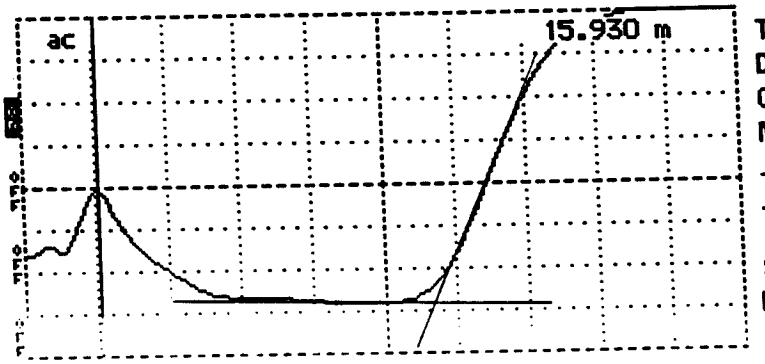


Tektronix 1502B TDR
Date 05-10-95
Cable 9/0
Notes 37/028
Air
Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 15.930 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power ..... ac

1.15



Tektronix 1502B TDR
Date 05-10-95
Cable 10
Notes 37/028
Alcohol
Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 15.930 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power ..... ac

1.85

Tektronix 1502B TDR
Date 05-10-95
Cable 10
Notes 37/028
Water
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

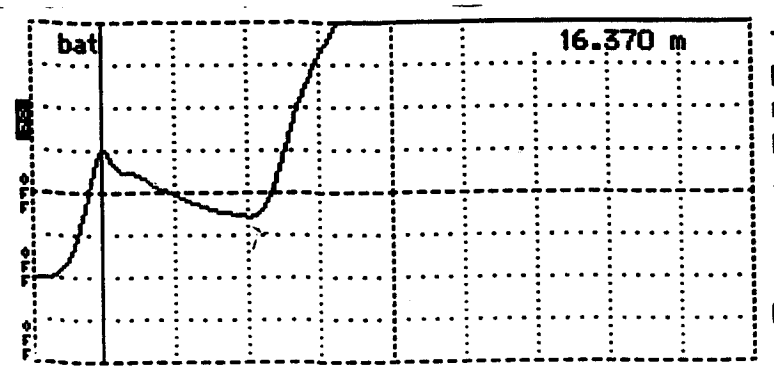
Laboratory Moisture Samples' Results as Received from the State

Cursor ..... 16.460 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mΩ/div
VP 0.99
Noise Filter..... 8 avg
Power..... bat/low

Tektronix 1502B TDR
Date May 17/95
Cable #1
Notes 37/028
Inst.

Input Trace
Stored Trace
Difference Trace

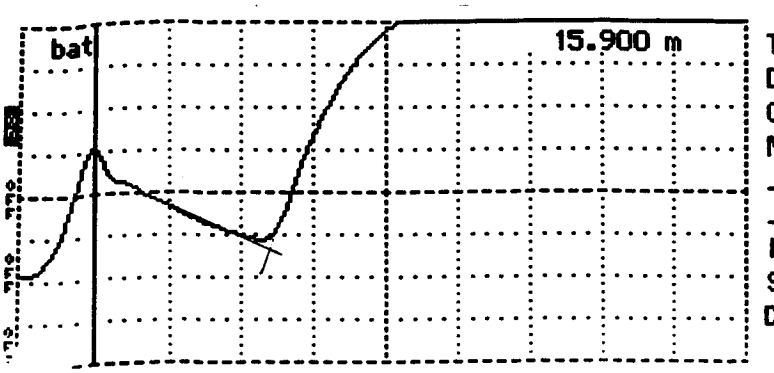
Cursor ..... 16.370 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mΩ/div
VP 0.99
Noise Filter..... 8 avg
Power..... bat/low



Tektronix 1502B TDR
Date May 17/95
Cable #2
Notes 37/028
Inst.

Input Trace
Stored Trace
Difference Trace

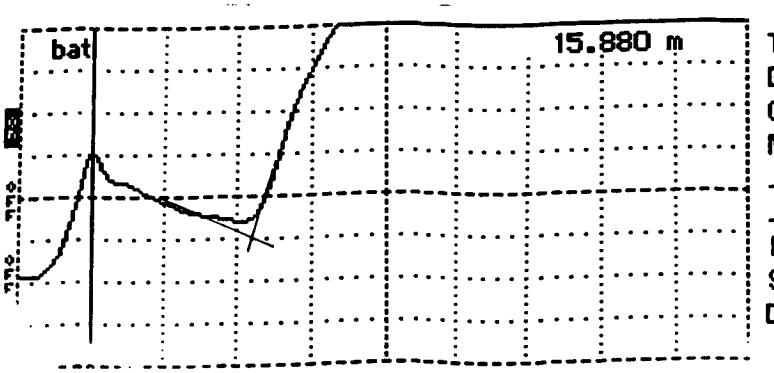
Cursor ..... 15.900 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mΩ/div
VP 0.99
Noise Filter..... 8 avg
Power..... bat



Tektronix 1502B TDR
Date May 17/95
Cable #3
Notes 37/028
Inst.

Input Trace
Stored Trace
Difference Trace

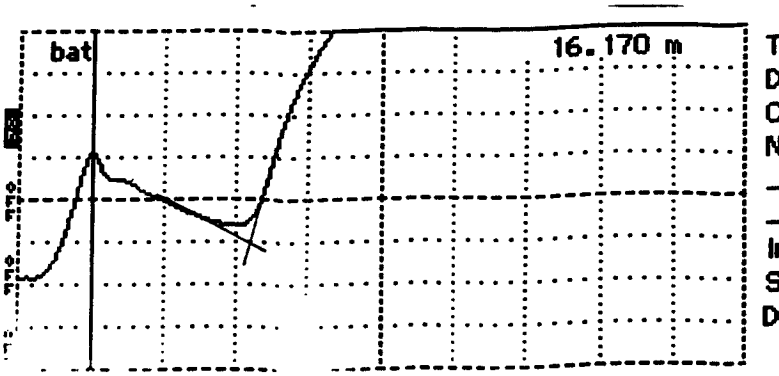
Cursor ..... 15.880 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mΩ/div
VP 0.99
Noise Filter..... 8 avg
Power..... bat



Tektronix 1502B TDR
Date May 17/95
Cable #4
Notes 37/028
Inst.

Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.170 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mΩ/div
VP 0.99
Noise Filter..... 8 avg
Power..... bat

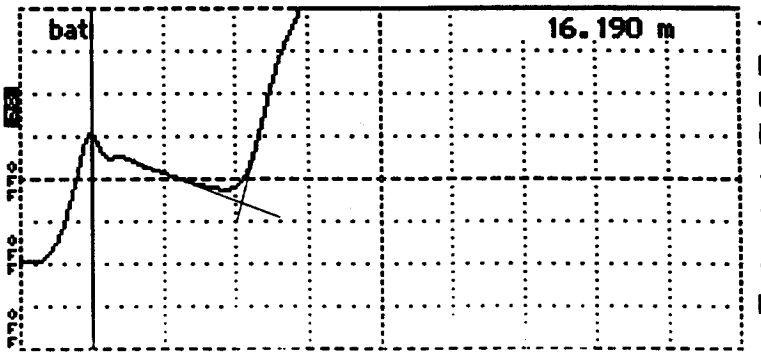


Tektronix 1502B TDR
Date May 17/95
Cable #5
Notes 37/028
Inst.

Input Trace
Stored Trace
Difference Trace

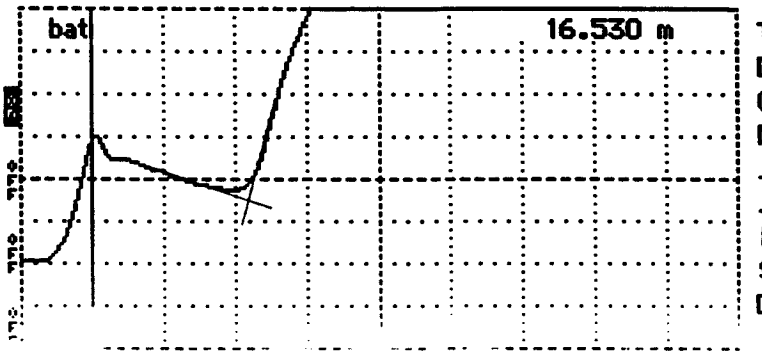
Figure C-1. TDR Traces Measured Manually During Installation

Cursor ..... 16.190 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mρ/div
Vp 0.99
Noise Filter..... 8 avg
Power..... bat



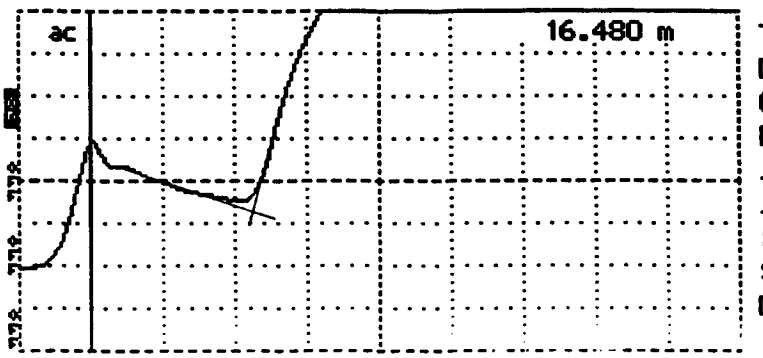
Tektronix 1502B TD
Date May 17/95
Cable #6
Notes 371028
Inst.
Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.530 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mρ/div
Vp 0.99
Noise Filter..... 8 avg
Power..... bat



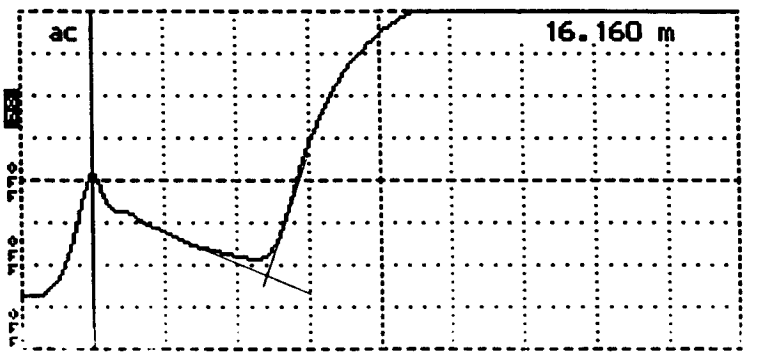
Tektronix 1502B TD
Date May 17/95
Cable #7
Notes 371028
Inst.
Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.480 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mρ/div
Vp 0.99
Noise Filter..... 8 avg
Power..... ac



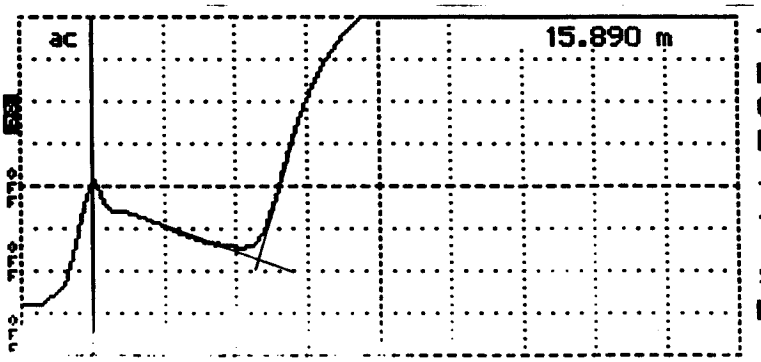
Tektronix 1502B TD
Date May 17/95
Cable #8
Notes 371028
Inst.
Input Trace
Stored Trace
Difference Trace

Cursor ..... 16.160 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mρ/div
Vp 0.99
Noise Filter..... 8 avg
Power..... ac



Tektronix 1502B TD
Date May 17/95
Cable #9
Notes 371028
Inst.
Input Trace
Stored Trace
Difference Trace

Cursor ..... 15.890 m
Distance/Div..... .25 m/div
Vertical Scale.... 74.8 mρ/div
Vp 0.99
Noise Filter..... 8 avg
Power..... ac



Tektronix 1502B TD
Date May 17/95
Cable #10
Notes 371028
Inst.
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.	Depth (m)	TDR Length (m)	Dielectric Constant (ε)	Volumetric Moisture Content (%)	In-Situ Dry Density (kg/m³) *	Gravimetric Moisture Content (%)
37E01	0.37	0.63	9.83	18.60	1540	12.15
37E02	0.55	0.58	8.33	13.15	1540	8.59
37E03	0.70	0.61	9.21	16.74	1540	10.93
37E04	0.85	0.55	7.49	13.74	1540	8.97
37E05	1.00	0.57	8.04	13.74	1540	8.97
37E06	1.16	0.55	7.49	11.97	1540	7.82
37E07	1.31	0.54	7.22	13.15	1540	8.59
37E08	1.46	0.56	7.76	14.33	1540	9.36
37E09	1.75	0.60	8.91	16.74	1540	10.93
37E10	2.09	0.63	9.83	15.54	1540	10.15

* Note: The In-situ dry density value was taken from the standard proctor test conducted on a sample collected at a 1.3m depth on the date of installation

Table C-2. Field Measured Moisture Content

LTPP Seasonal Monitoring Study	State Code	[37]
In-Situ Moisture Tests	Test Section Number	[1028]

Weight (gm)	Probe 1	Probe 2	Probe 3	Probe 4	Probe 5
Weight of Pan + Wet Soil	237.0	295.0	263.0	333.0	279.0
Weight of Pan + Dry Soil	230.0	288.0	256.0	322.0	271.0
Weight of Pan	163.0	163.0	163.0	163.0	163.0
Weight of Dry Soil	67.0	125.0	93.0	159.0	108.0
Weight of Wet Soil	74.0	132.0	100.0	170.0	116.0
Weight of Moisture	7.0	7.0	7.0	11.0	8.0
Wt of Moisture/Dry Wt x 100	10.4	5.6	7.5	6.9	7.4

Weight (gm)	Probe 6	Probe 7	Probe 8	Probe 9	Probe 10
Weight of Pan + Wet Soil	274.0	262.0	281.0	300.0	270.0
Weight of Pan + Dry Soil	230.0	288.0	256.0	289.0	271.0
Weight of Pan	163.0	163.0	163.0	163.0	163.0
Weight of Dry Soil	104.0	92.0	107.0	126.0	101.0
Weight of Wet Soil	111.0	99.0	118.0	137.0	107.0
Weight of Moisture	7.0	7.0	11.0	11.0	6.0
Wt of Moisture/Dry Wt x 100	6.7	7.6	10.7	8.7	5.9

Prepared by:	DM	Employer:	PMSL
Date (dd/mm/yy)	17/05/96		

Table C-3. Field Measured Dry Density

LTPP Seasonal Monitoring Program Data Sheet SMP-I07 Representative Dry Density	Agency Code [37] LTPP Section ID [1028]

Depth of Representative Sample (from pavement surface): 1.3 m

Dry Density Determination:

a.	Tare Weight of Empty Mold:	1863 g	(4.11 lb)
b.	Weight of Mold and Compacted Soil:	3424 g	(7.55 lb)
c.	Weight of Compacted Soil (b-a):	1561 g	(3.44 lb)
d.	Unit Weight of Compacted Soil = (c/943.0) =		1.66 g/cm^3
	= [c/(1/30)] =		(103.7 lb/ft^3)
e.	Dry Density of Compacted Soil = [d/(1+r/100)] =		1.54 g/cm^3
			(95.6 lb/ft^3)

Moisture Content Determination:

m	Tare Weight of Pan:	163 g
n.	Weight of Pan and Moisture Sample:	340 g
o.	Weight of Pan and Dry Sample:	327 g
p.	Weight of Moisture (n -o):	13 g
q.	Weight of Dry Sample (o - m):	164 g
r.	Moisture Content by Weight = [(p/q)*100] =	7.9 %

Prepared by:	BR	Employer:	DEL DOT
Date (dd/mm/yy):	04/10/95		

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAY
MATERIALS & TESTS UNIT
SOILS LABORATORY

T. I. P. No. _____

REPORT ON SAMPLES OF SOIL FOR MOISTURE

Project	5.022	**County**	CAMDEN	**Owner**	NCDOT
Date: Sampled	5/17/95	**Received**	5/22/95	**Reported**	5/25/95
Sampled from	PAVEMENT			**By**	D. MARSHAL
Submitted by	MOY BISWAS				1990 **Standard Specifications**

598896 TO 598905
5/24/95

TEST RESULTS

Proj. Sample No.		1	2	3	4	5	6
Lab. Sample No.		598896	598897	598898	598899	598900	598901
Retained #4 Sieve	%	-	-	-	-	-	-
Passing #10 Sieve	%						
Passing #40 Sieve	%						
Passing #200 Sieve	%						

MINUS NO. 10 FRACTION

SOIL MORTAR - 100%							
Coarse Sand Ret - #60	%						
Fine Sand Ret - #270	%						
Silt 0.05 - 0.005 mm	%						
Clay < 0.005 mm	%						
Passing #40 Sieve	%	-	-	-	-	-	-
Passing #200 Sieve	%	-	-	-	-	-	-

L. L.						
P. I.						
AASHTO Classification						
Station						
Hole No.						
Depth (Ft)						
to						
MOISTURE	11.3	7.9	8	7.7	8	6.8

cc: MOY BISWAS
Soils File

Soils Engineer

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAY
MATERIALS & TESTS UNIT
SOILS LABORATORY

T. I. P. No. _____

REPORT ON SAMPLES OF SOIL FOR MOISTURE

Project	5.022	**County**	CAMDEN	**Owner**	NCDOT
Date: Sampled	5/17/95	**Received**	5/22/95	**Reported**	
Sampled from	PAVEMENT			**By**	D. MARSHAL
Submitted by	MOY BISWAS				1990 **Standard Specifications**

598896 TO 598905
5/24/95

TEST RESULTS

Proj. Sample No.		7	8	9	10		
Lab. Sample No.		598902	598903	598904	598905		
Retained #4 Sieve	%	-	-	-	-		
Passing #10 Sieve	%						
Passing #40 Sieve	%						
Passing #200 Sieve	%						

MINUS NO. 10 FRACTION

SOIL MORTAR - 100%							
Coarse Sand Ret - #60	%						
Fine Sand Ret - #270	%						
Silt 0.05 - 0.005 mm	%						
Clay < 0.005 mm	%						
Passing #40 Sieve	%	-	-	-	-		
Passing #200 Sieve	%	-	-	-	-		

L. L.						
P. I.						
AASHTO Classification						
Station						
Hole No.						
Depth (Ft)						
to						
MOISTURE	6.7	8.2	8.2	8.5		

_____
Soils Engineer

APPENDIX D

Initial Data Collection

Appendix D contains the following supporting information:

Table D-1. Sample Data from the Onsite Datalogger During Initial Data Collection, May 19, 1995

5,1995,139,100,12.68,24.37,0
6,1995,139,100,27.76,28.93,29.67,29,28.27
5,1995,139,200,12.68,23.77,0
6,1995,139,200,26.98,28.15,29.06,28.77,28.18
5,1995,139,300,12.67,23.29,0
6,1995,139,300,26.35,27.48,28.51,28.51,28.05
5,1995,139,400,12.67,23.2,0
6,1995,139,400,25.88,26.93,28.02,28.25,27.9
5,1995,139,500,12.67,23.09,0
6,1995,139,500,25.44,26.47,27.58,27.99,27.73
5,1995,139,600,12.67,23.01,0
6,1995,139,600,25.1,26.04,27.19,27.73,27.55
5,1995,139,700,12.67,23.46,0
6,1995,139,700,24.99,25.7,26.83,27.48,27.38
5,1995,139,800,12.67,24.58,0
6,1995,139,800,25.75,25.72,26.56,27.25,27.21
5,1995,139,900,12.67,24.93,0
6,1995,139,900,26.9,26.13,26.48,27.05,27.04
5,1995,139,1000,12.67,24.83,0
6,1995,139,1000,28.17,26.88,26.63,26.89,26.89
5,1995,139,1100,12.67,21.6,.9
6,1995,139,1100,27.05,27.11,26.88,26.81,26.77
5,1995,139,1200,12.67,21.61,0
6,1995,139,1200,27,26.63,26.82,26.78,26.7
5,1995,139,1300,12.67,20.79,.3
6,1995,139,1300,25.92,26.4,26.7,26.72,26.64
5,1995,139,1400,12.67,21.83,0
6,1995,139,1400,27.38,26.25,26.48,26.63,26.57
5,1995,139,1500,12.67,23.22,0
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5,1995,139,1600,12.67,24.55,0
6,1995,139,1600,35.02,30.06,27.25,26.48,26.41
5,1995,139,1700,12.68,24.94,0
6,1995,139,1700,35.21,31.53,28.33,26.57,26.39
5,1995,139,1800,12.68,24.46,0
6,1995,139,1800,34.22,32.11,29.13,26.82,26.46
5,1995,139,1900,12.68,21.97,2.8
6,1995,139,1900,30.84,31.18,29.22,27.12,26.63
5,1995,139,2000,12.67,17.43,1.2
6,1995,139,2000,26.04,28.28,27.45,27.45,26.85
5,1995,139,2100,12.67,17.39,0
6,1995,139,2100,24.35,26.38,27.62,27.41,26.99
5,1995,139,2200,12.66,15.94,0
6,1995,139,2200,23.58,25.29,26.86,27.21,26.96
5,1995,139,2300,12.66,15.1,0
6,1995,139,2300,22.92,24.53,26.18,26.96,26.86
1,1995,139,2400,12.67,12.69,1817,12.65,2358,21.83,25.61,1650,14.17,2349,5.2,4067
2,1995,139,2400,27.32,27.31,27.4,27.29,27.07,26.66,26.29,25.81,24.97,23.98,23.18,22.53,21.93,21.3,20.76,20.41,19.98,19.55
3,1995,139,2400,35.74,1655,32.21,1718,29.98,1,29.12,1,28.3,1,27.35,123,26.64,250,26.01,537,25.11,1029,24.14,2352,23.36,2208,22.69,2315,22.04,2218,21.39,2309,20.84,2351,20.48,2227,20.03,2239,19.61,2211
4,1995,139,2400,21.86,0,23.55,0,24.97,1903,26.45,1551,26.37,1619,26.15,1644,25.94,1753,25.6,1902,24.58,2,23.66,6,22.99,5,22.43,5,21.86,105,21.26,3,20.71,154,20.37,23,19.93,106,19.51,25
5,1995,139,2400,12.66,14.55,0
6,1995,139,2400,22.29,23.89,25.6,26.66,26.69

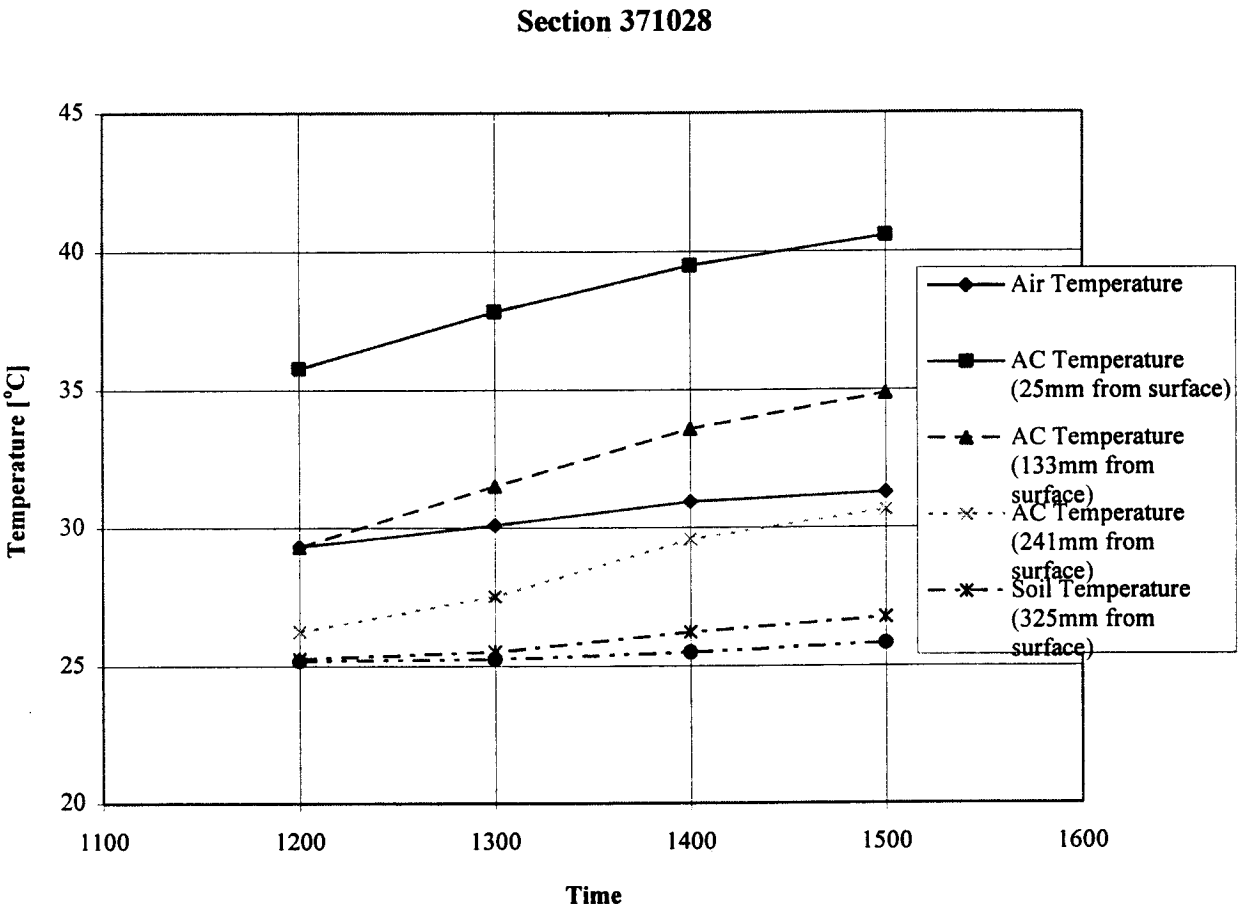

Figure D-1. Air Temperature and First Five Sub-Surface Temperatures From Initial Data Collection, May 18, 1995

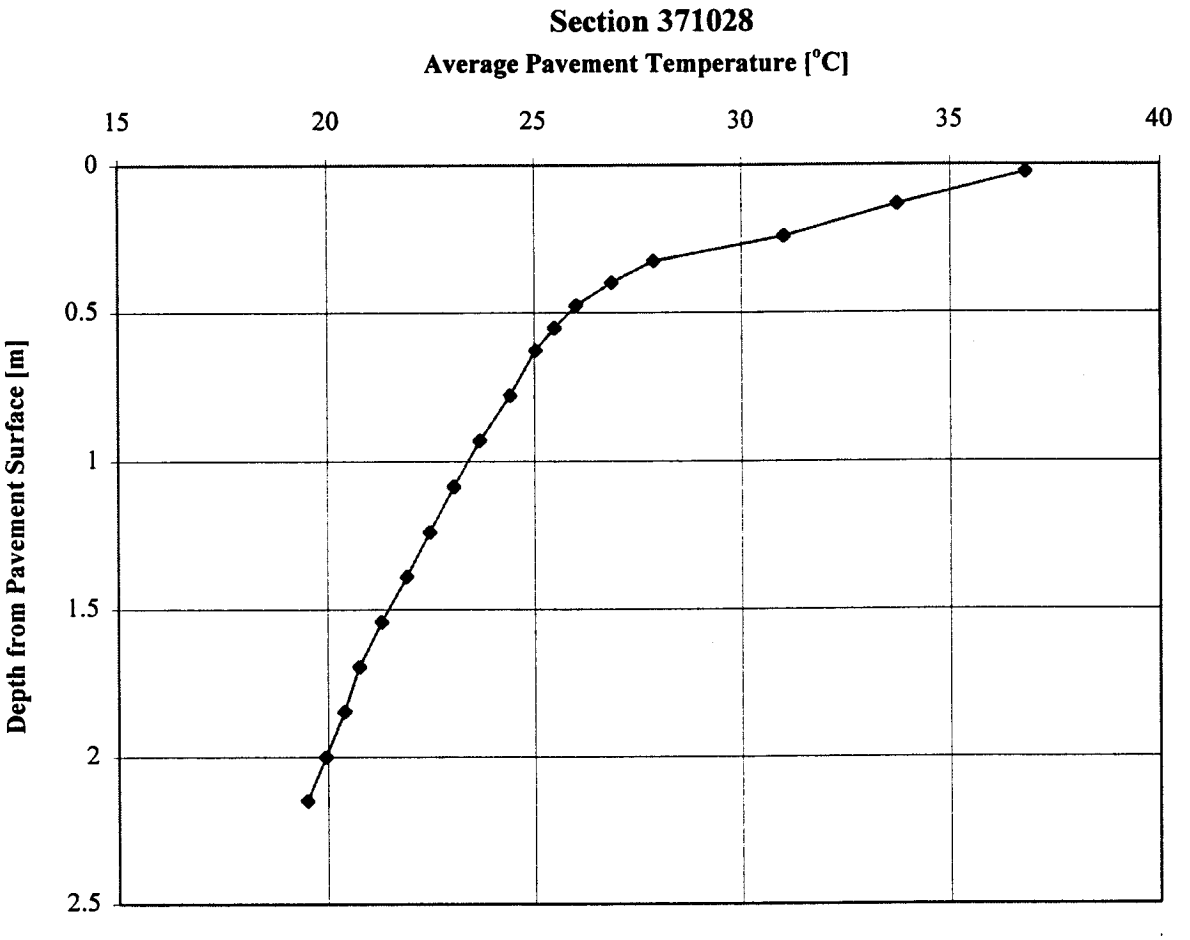

Figure D-2. Average Subsurface Temperature for all 18 Sensors
From Initial Data Collection, May 18, 1995

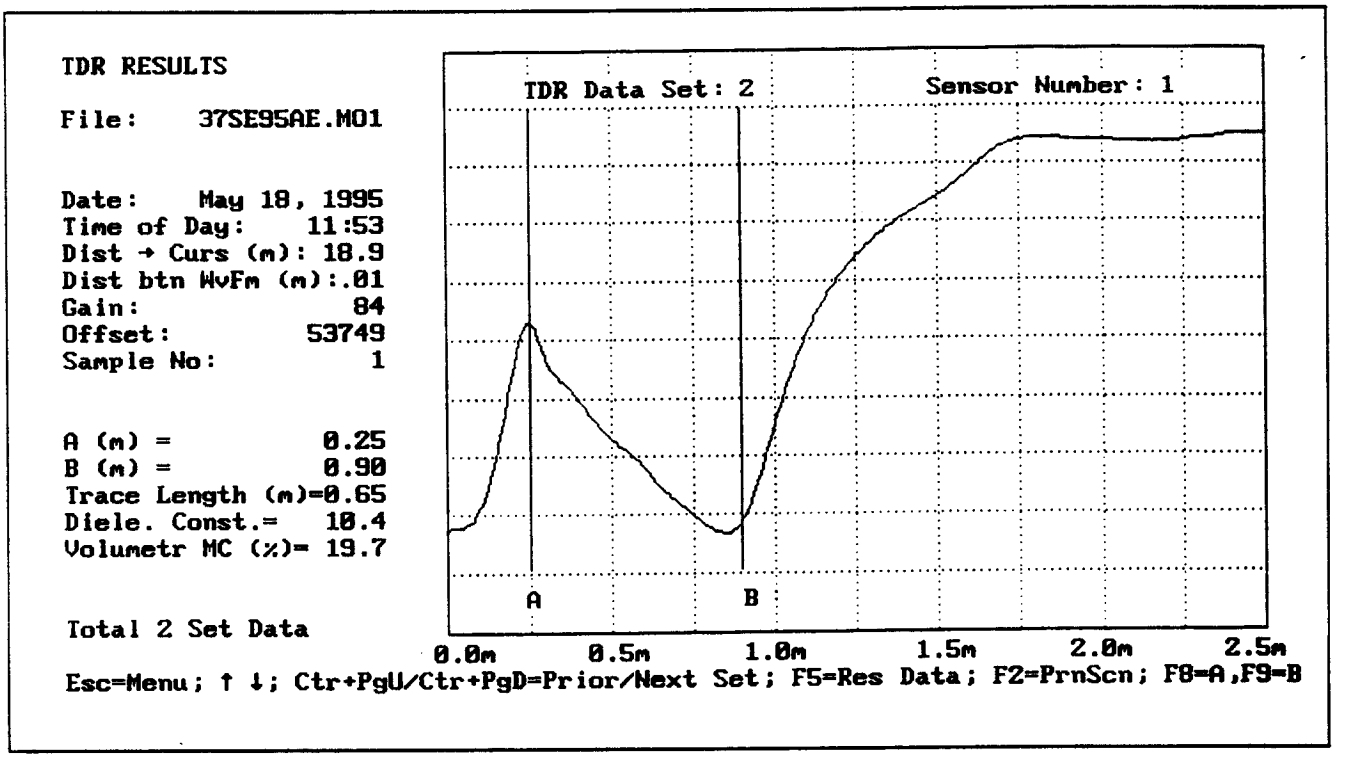

Figure D-3. Initial Set of TDR Traces Measured with the Mobile Unit

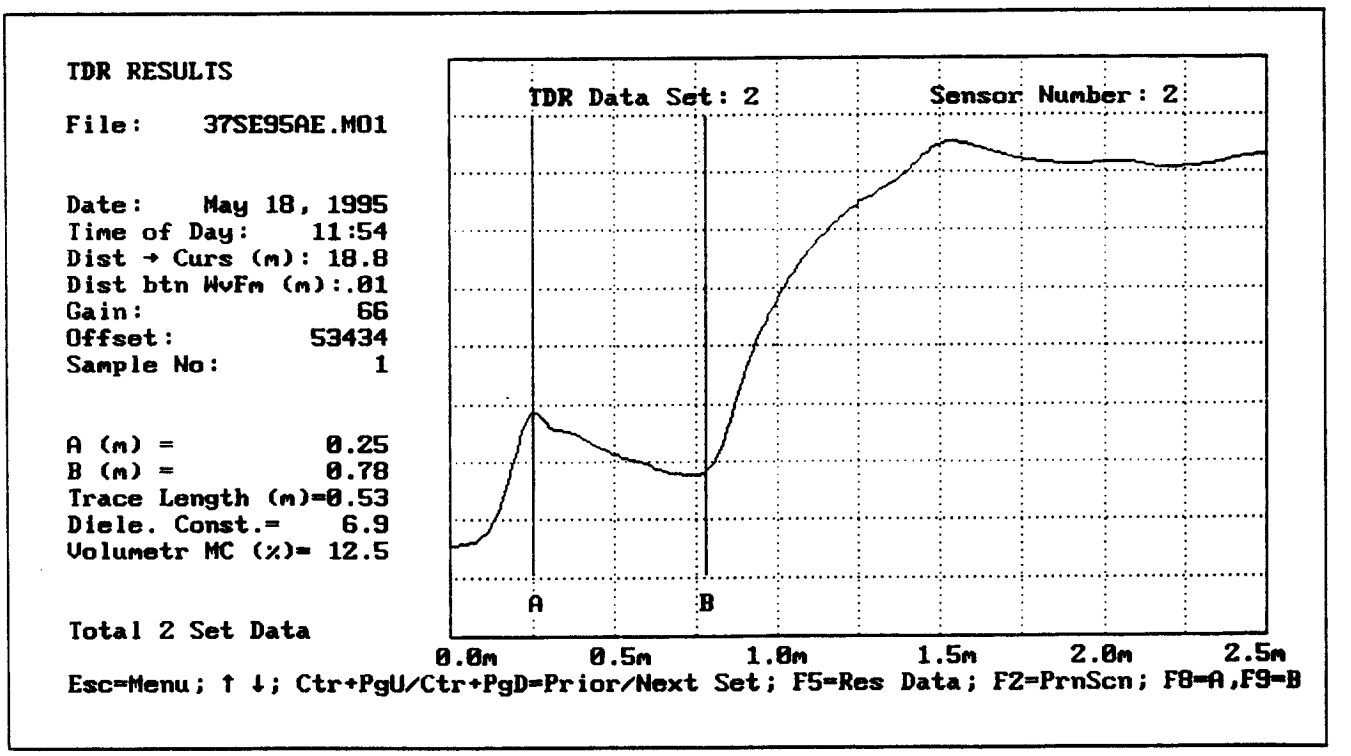

Figure D-3(cont.). Initial Set of TDR Traces Measured with the Mobile Unit

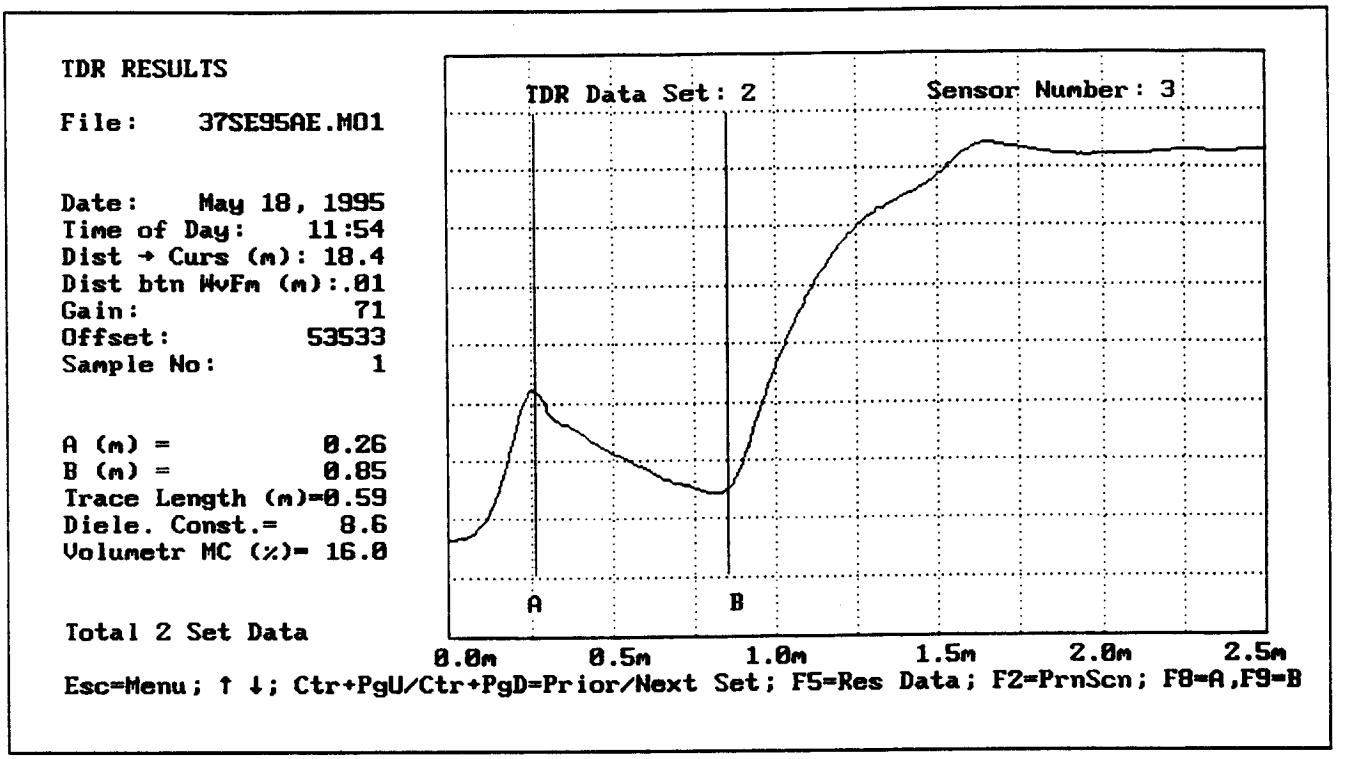

Figure D-3(cont.). Initial Set of TDR Traces Measured with the Mobile Unit

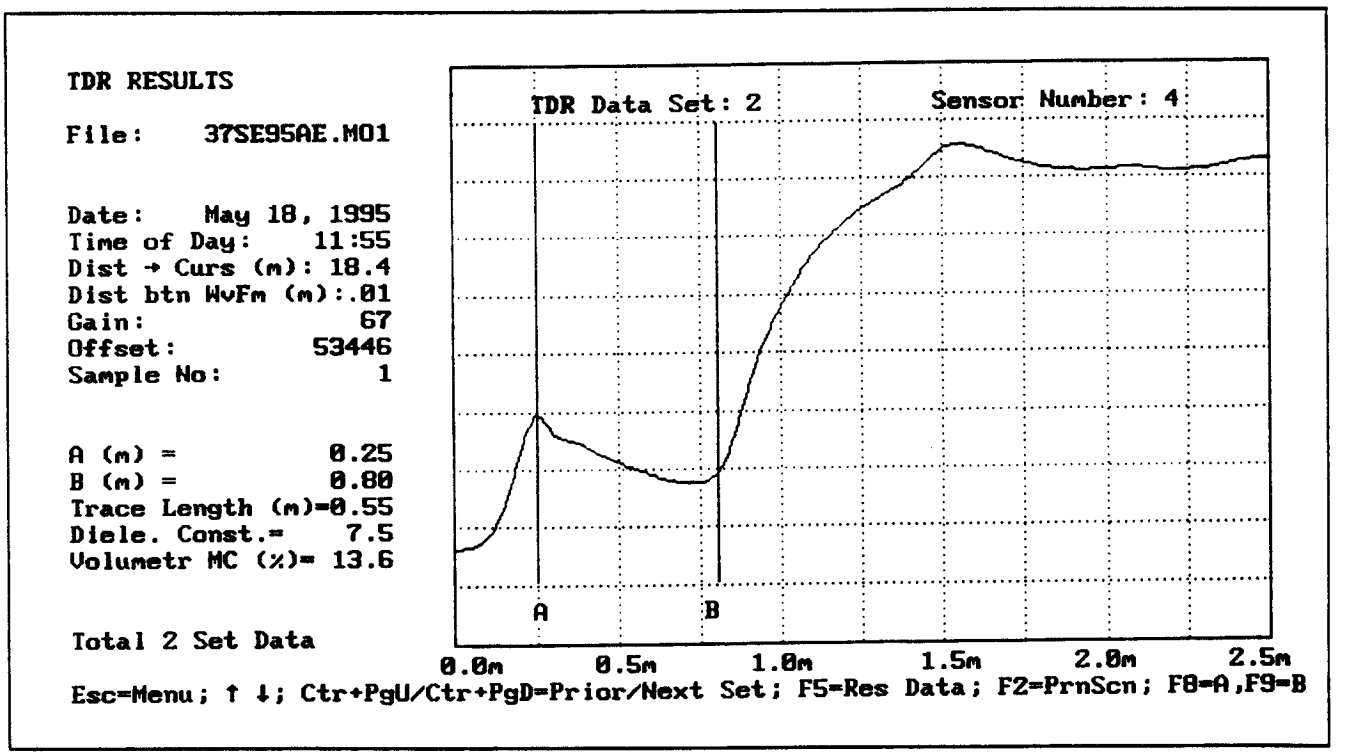

Figure D-3(cont.). Initial Set of TDR Traces Measured with the Mobile Unit

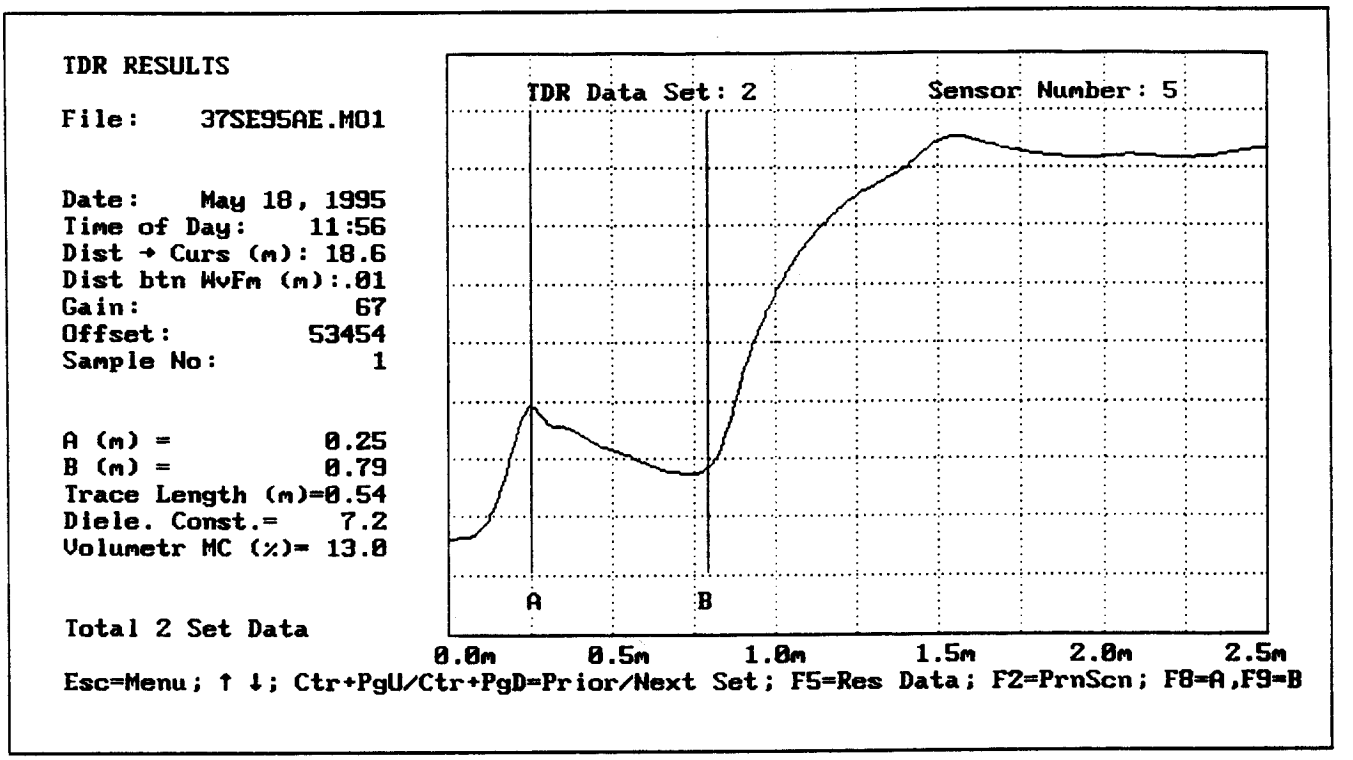

Figure D-3(cont.). Initial Set of TDR Traces Measured with the Mobile Unit

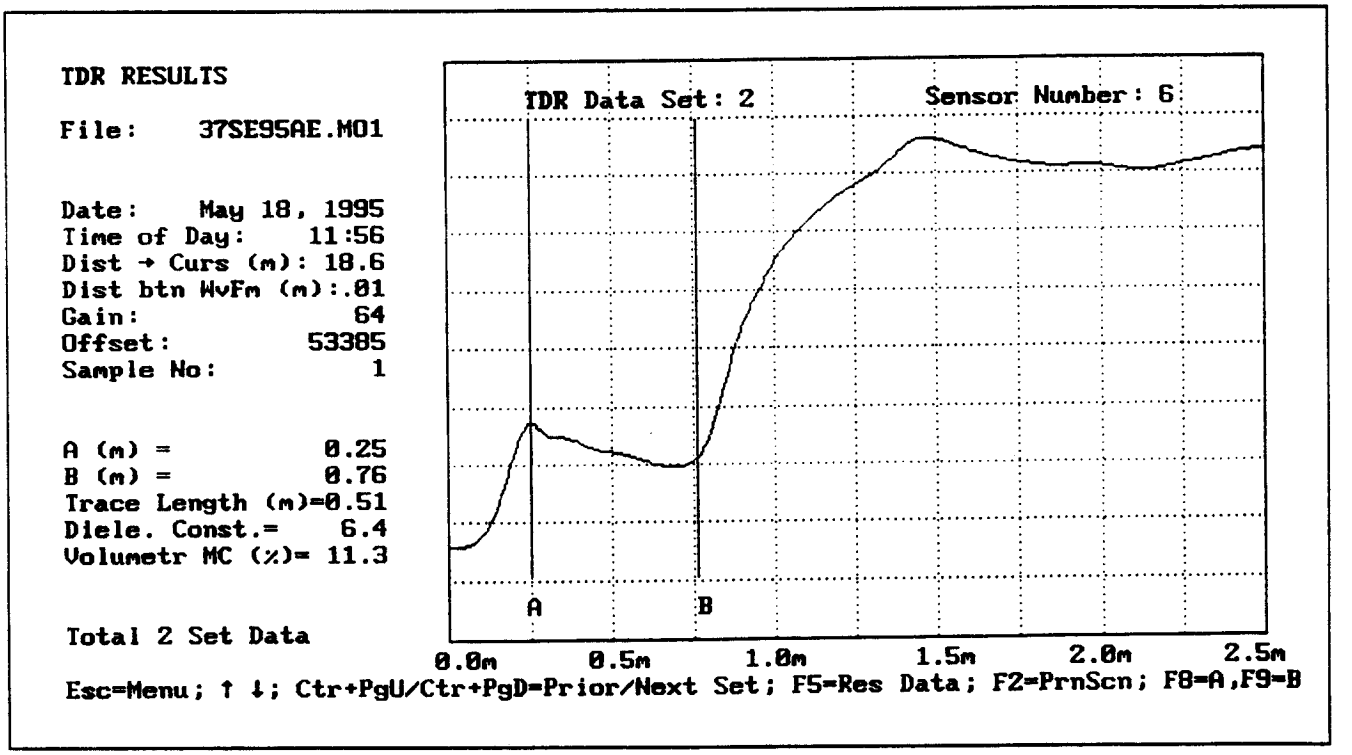

Figure D-3(cont.). Initial Set of TDR Traces Measured with the Mobile Unit

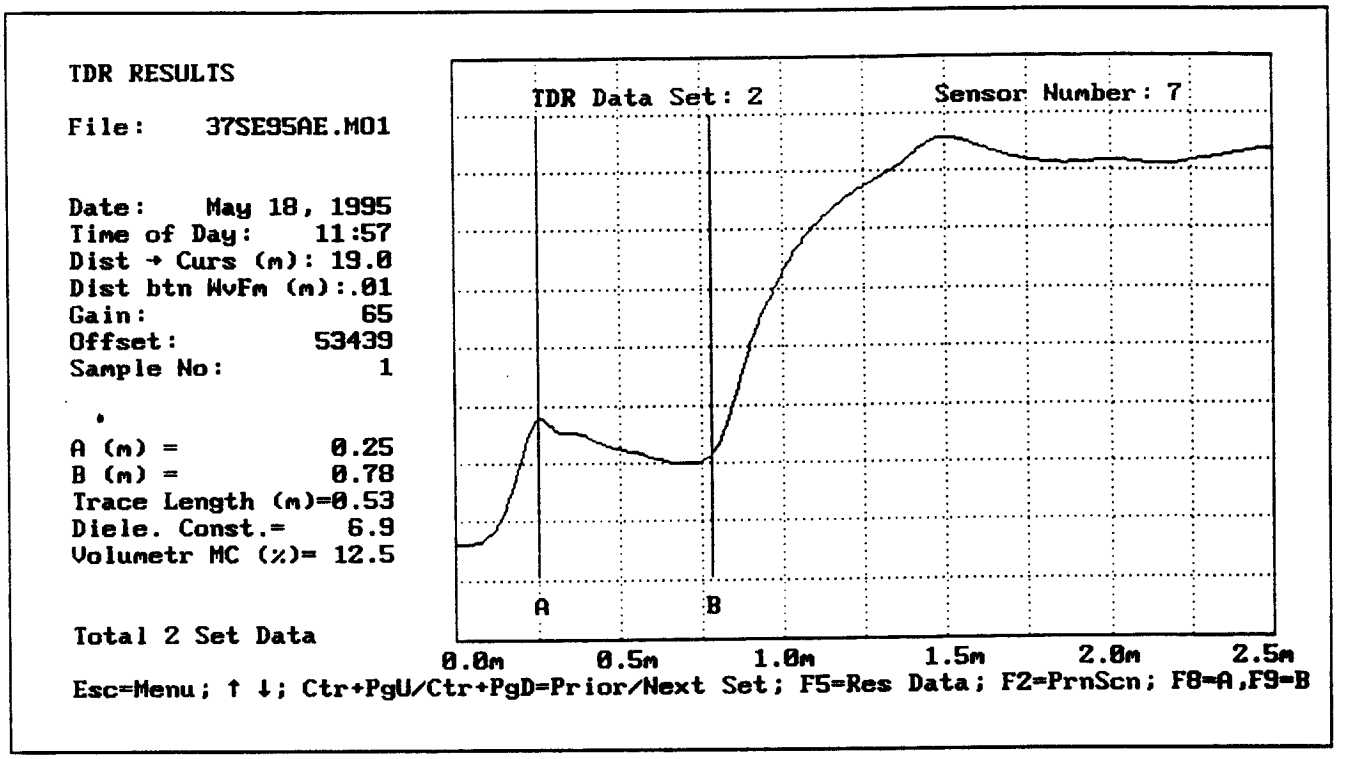

Figure D-3(cont.). Initial Set of TDR Traces Measured with the Mobile Unit

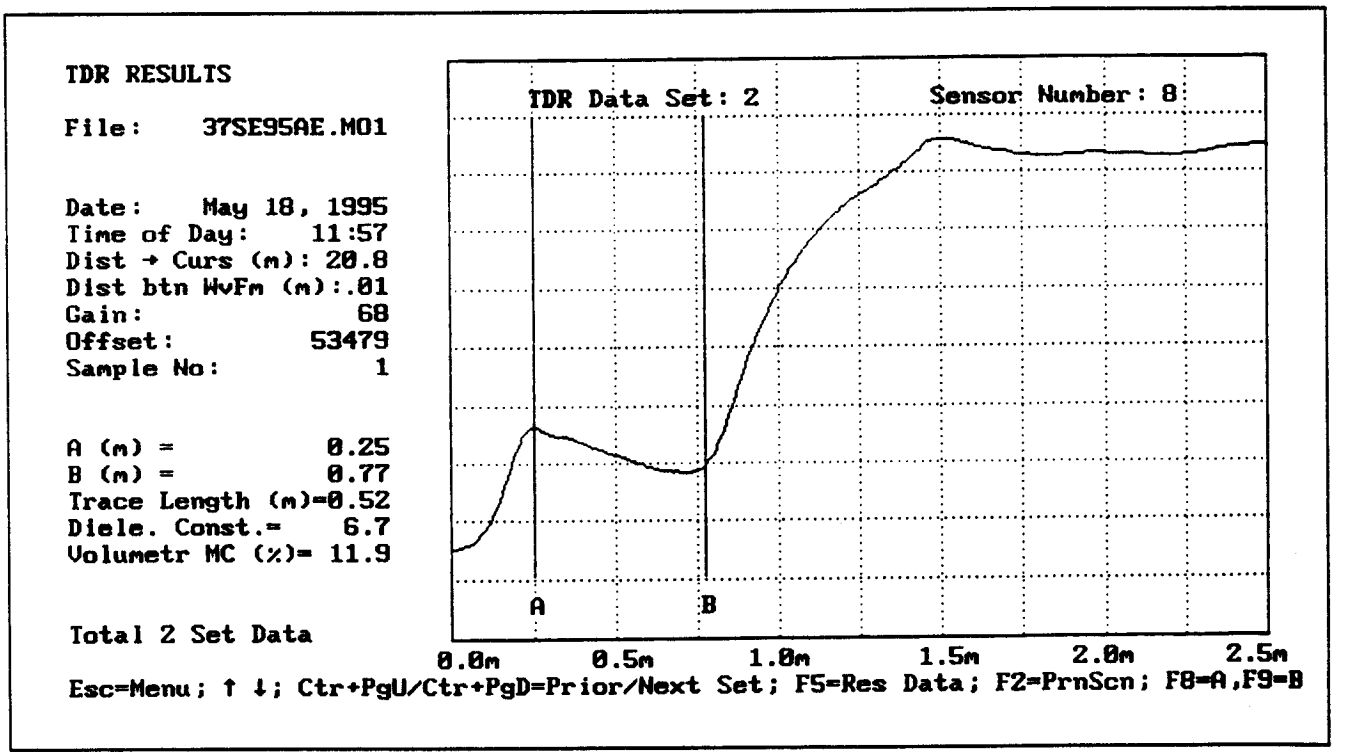

Figure D-3(cont.). Initial Set of TDR Traces Measured with the Mobile Unit

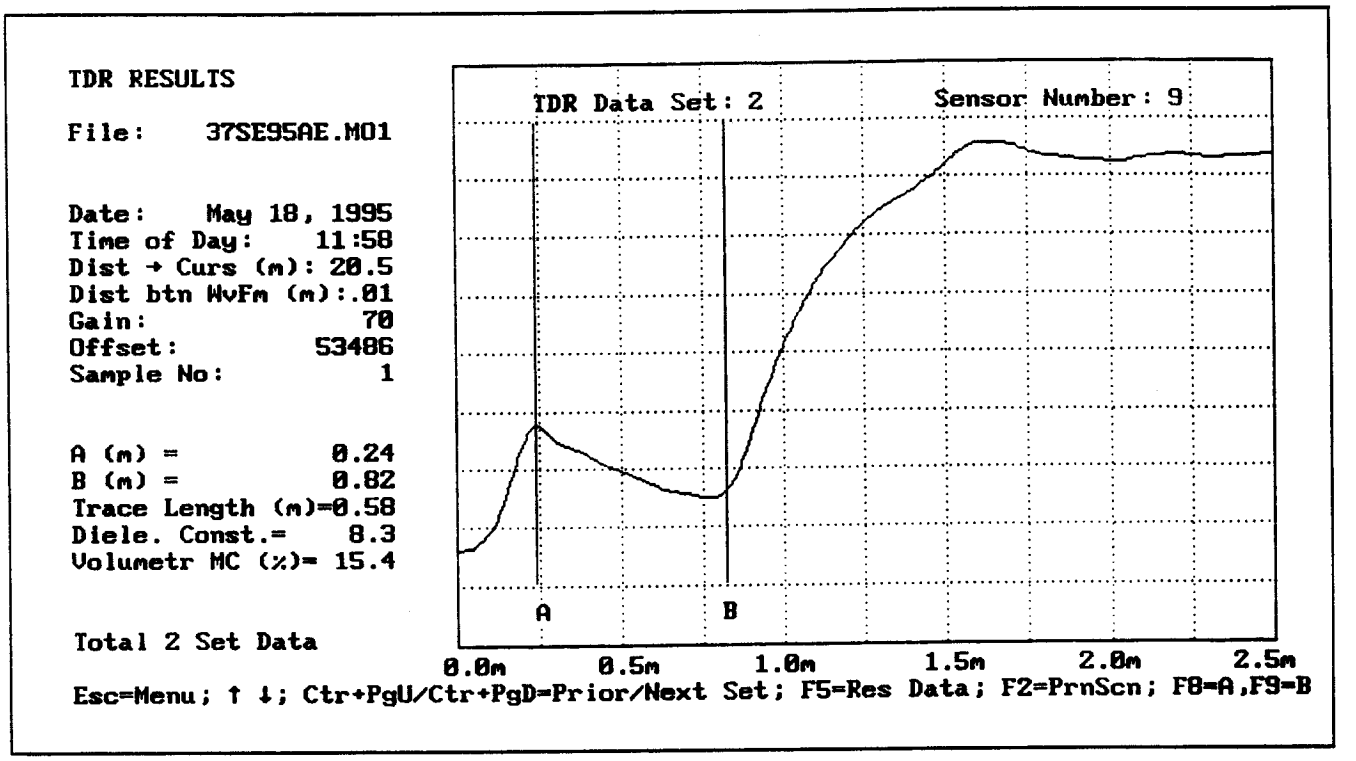

Figure D-3(cont.). Initial Set of TDR Traces Measured with the Mobile Unit

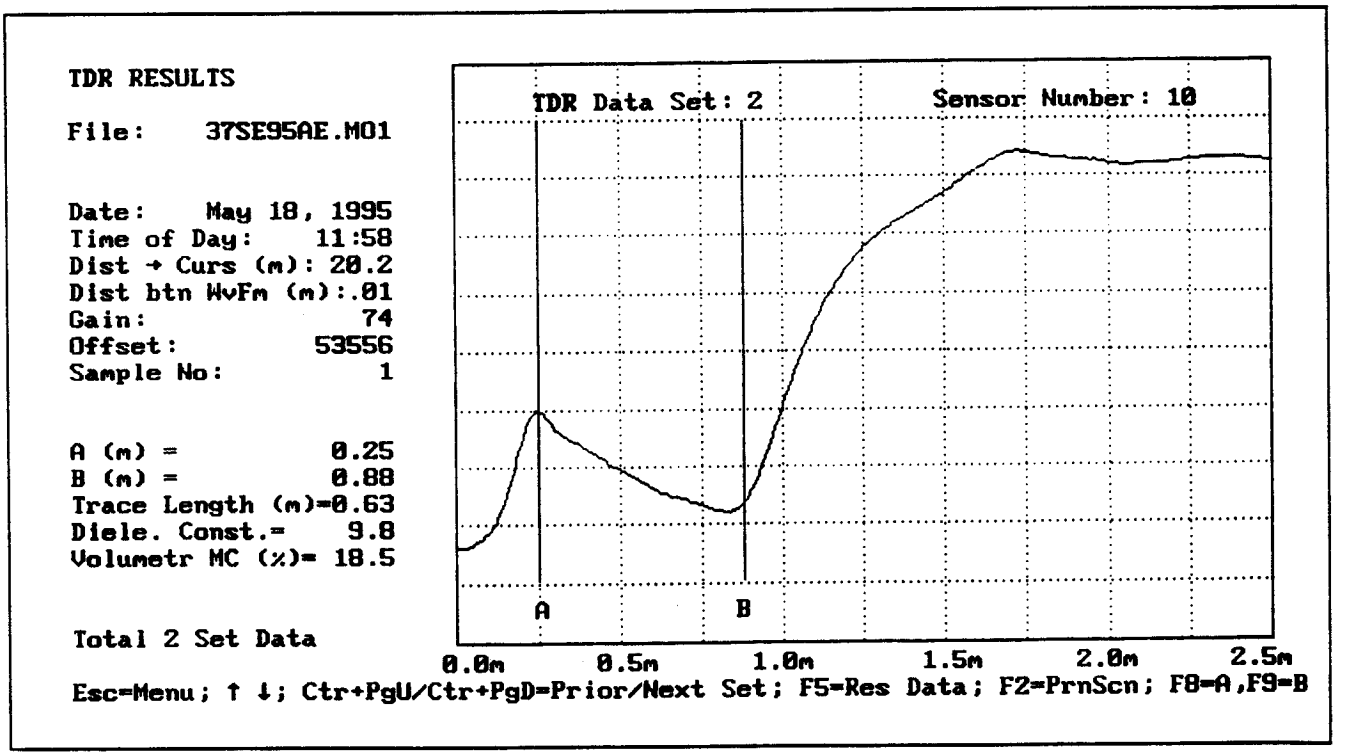

Figure D-3(cont.). Initial Set of TDR Traces Measured with the Mobile Unit

Table D-2. Uniformity Survey Results Before and After Installation

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 371028	Data Collection and
Date Surveyed: May 17 - May 18, 1995	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	
-18 to 200 **May 17** @ 0841	10.24	0.79	1.93	0.72 *	21478	4030	3.42	0.58	80.6
-18 to 200 **May 18** @ 0815	10.34	1.10	1.69	0.08	22936	1076	3.22	0.29	79.0
-18 to 200 **May 18** @0949	11.01	0.81	1.71	0.11	22645	1420	3.06	0.13	85.5
-18 to 200 **May 18** @1109	11.26	1.10	1.75	0.07	22150	963	3.05	0.24	98.1
-18 to 200 **May 18** @1235	12.03	0.69	1.76	0.08	22054	983	2.89	0.11	105.1

* Note: The high standard deviation was caused by a bad reading at station 2+00. Repeat tests were not conducted because of time constraints.

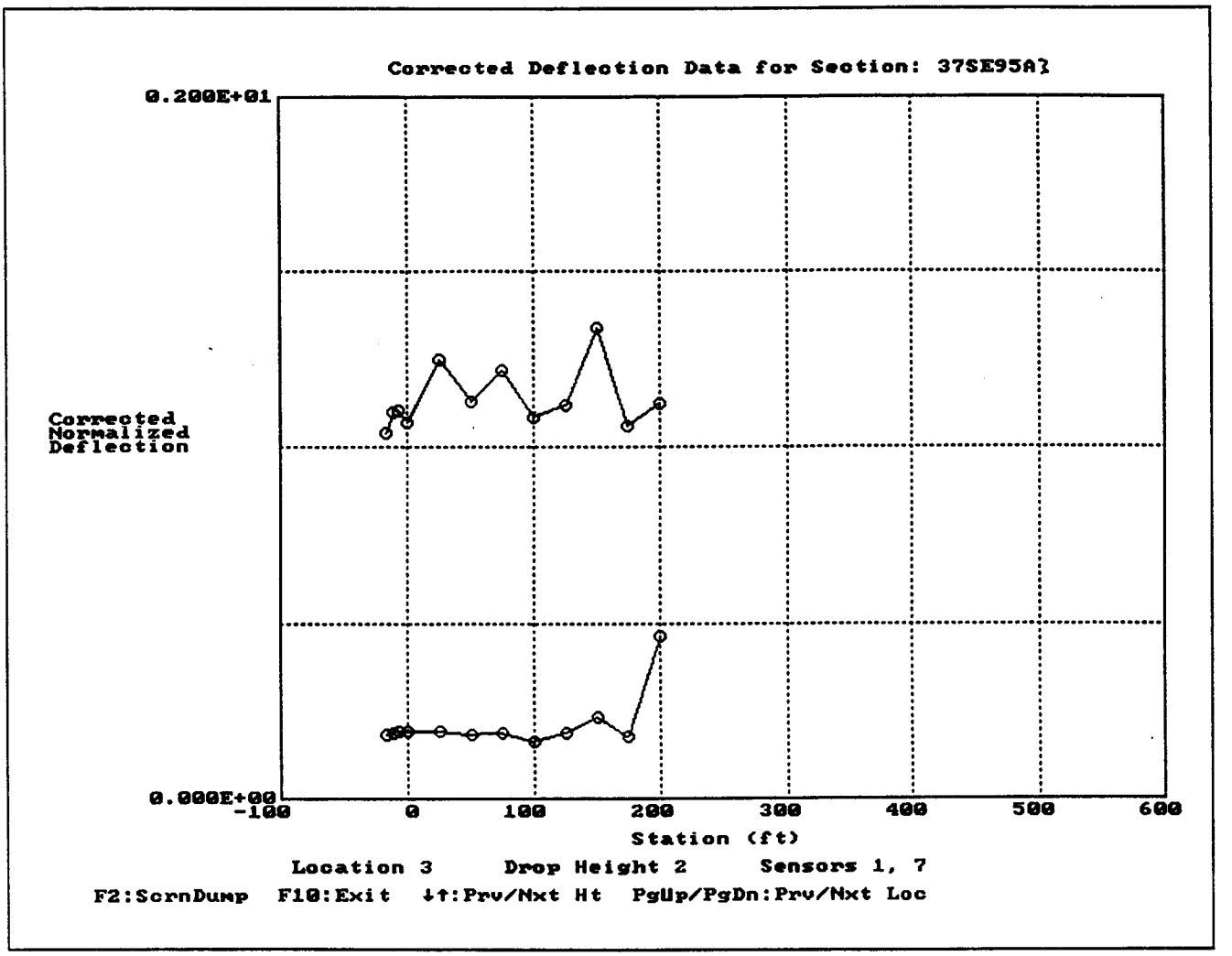

Figure D-4. Deflection Profiles from FWDCHECK
(Test Date and Time May 17, 1995 @ 0841)

Table D-3. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time May 17, 1995 @ 0841)

Flexible Pavement Thickness Statistics - 37SE95A - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-18	22885	3.45
	-12	22507	3.35
	-7	22044	3.35
	0	22243	3.45
	25	22236	3.00
	50	22975	3.25
	75	22713	3.05
	100	25513	3.15
	125	22772	3.25
	150	18376	3.15
	175	23725	3.35
	200	9744 *	5.20 *
Subsection 1	Overall Mean	21478	3.42
	Standard Deviation	4030	0.58
	Coeff of Variation	18.76%	16.98%

* Note: The readings taken at station 2+00 were highly irregular. The tests were not repeated because of time constraints.

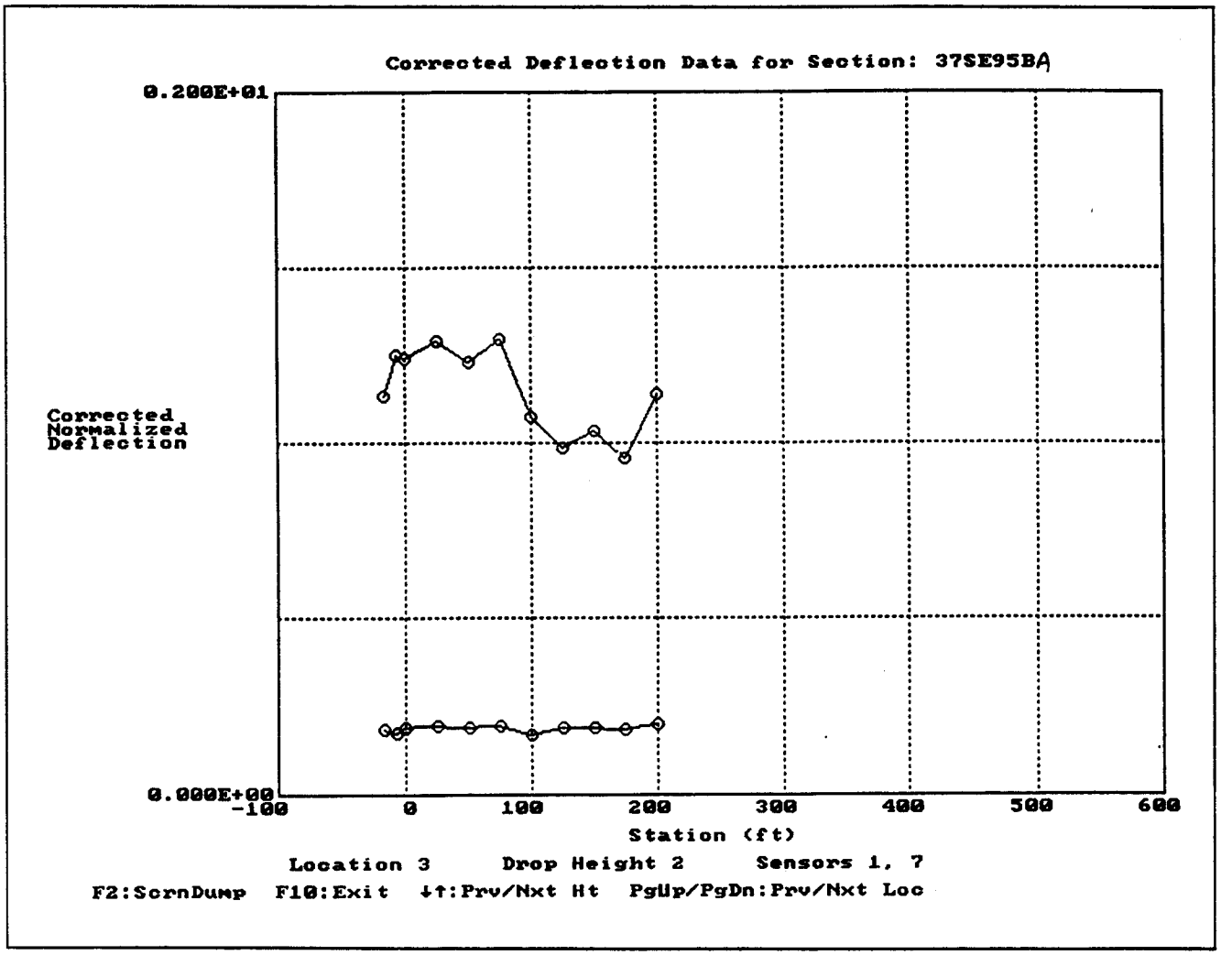

Figure D-5. Deflection Profiles from FWDCHECK
(Test Date and Time May 18, 1995 @ 0815)

Table D-4. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time May 18, 1995 @ 0815)

Flexible Pavement Thickness Statistics - 37SE95BA - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-18	23184	3.20
	-7	24101	2.90
	0	22578	3.00
	25	22135	2.95
	50	22547	3.05
	75	22033	2.95
	100	25413	3.20
	125	22838	3.65
	150	22616	3.50
	175	23336	3.70
	200	21518	3.30
Subsection 1	Overall Mean	22936	3.22
	Standard Deviation	1076	0.29
	Coeff of Variation	4.69%	8.93%

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

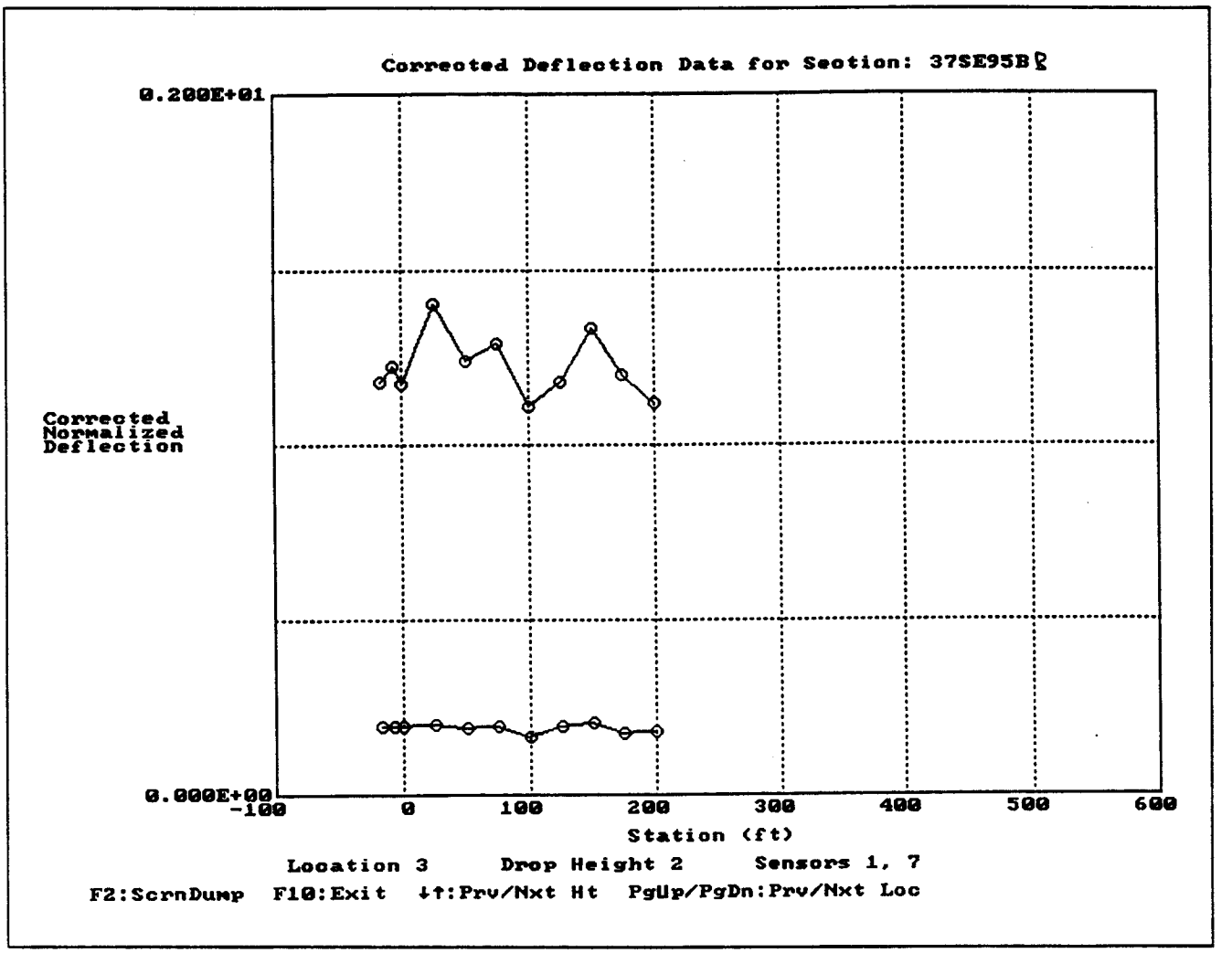

Figure D-6. Deflection Profiles from FWDCHECK
(Test Date and Time May 18, 1995 @ 0949)

Table D-5. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time May 18, 1995 @ 0949)

Flexible Pavement Thickness Statistics - 37SE95BB - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-18	21957	3.20
	-7	21966	3.10
	0	21926	3.20
	25	21547	2.80
	50	22796	3.00
	75	21937	2.95
	100	26014	3.10
	125	22034	3.20
	150	21206	2.95
	175	24217	3.00
	200	23494	3.20
Subsection 1	Overall Mean	22645	3.06
	Standard Deviation	1420	0.13
	Coeff of Variation	6.27%	4.38%

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

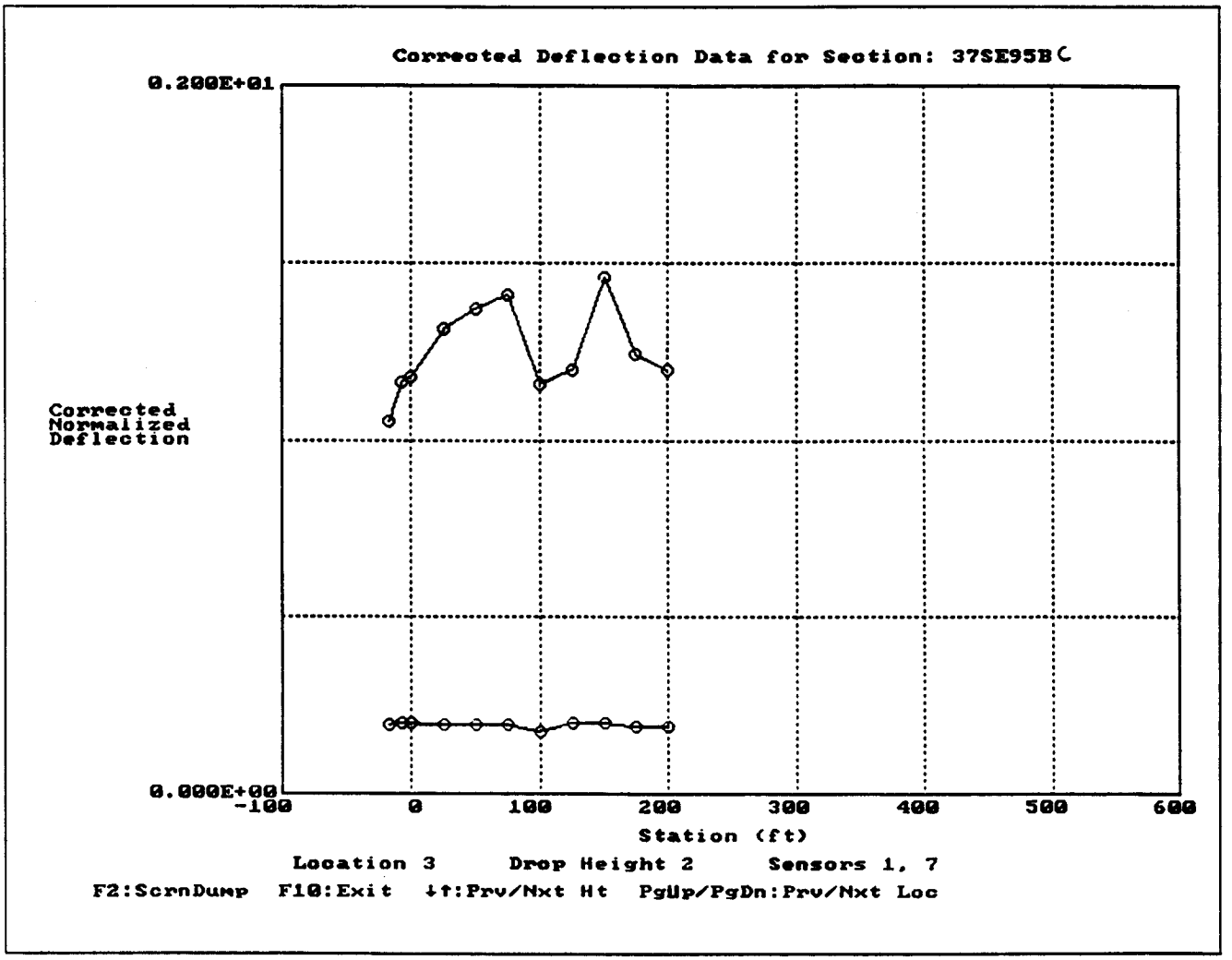

Figure D-7. Deflection Profiles from FWDCHECK
(Test Date and Time May 18, 1995 @ 1109)

Table D-6. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time May 18, 1995 @ 1109)

Flexible Pavement Thickness Statistics - 37SE95BC - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-18	21959	3.50
	-7	21487	3.25
	0	21431	3.20
	25	21798	2.95
	50	21816	2.85
	75	21977	2.75
	100	24715	3.05
	125	21472	3.20
	150	21570	2.70
	175	22758	3.00
	200	22671	3.10
Subsection 1	Overall Mean	22150	3.05
	Standard Deviation	963	0.24
	Coeff of Variation	4.35%	7.72%

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

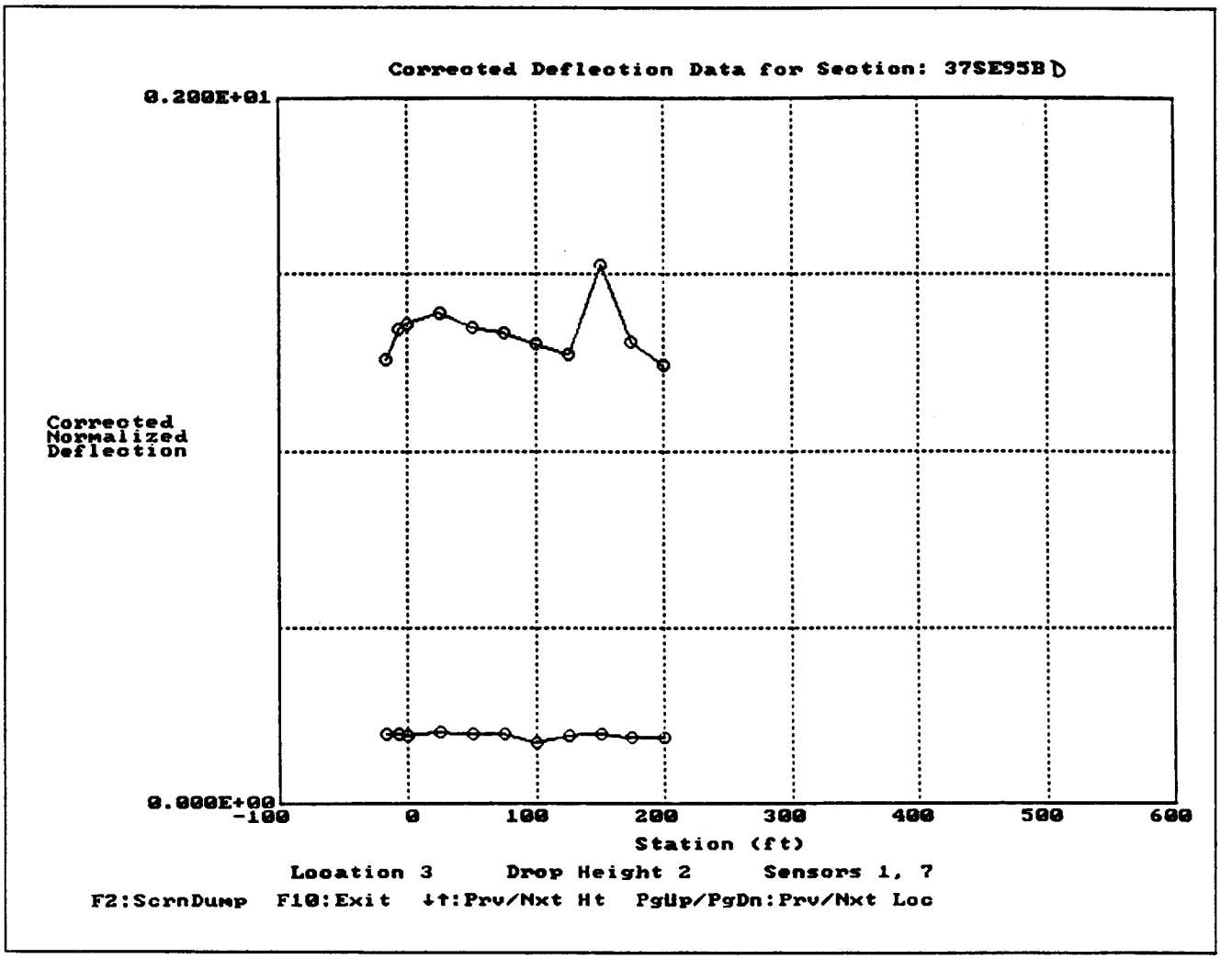

Figure D-8. Deflection Profiles from FWDCHECK
(Test Date and Time May 18, 1995 @ 1235)

Table D-7. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time May 18, 1995 @ 1235)

Flexible Pavement Thickness Statistics - 37SE95BD - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-18	21593	3.05
	-7	21595	2.90
	0	21835	2.85
	25	21152	2.85
	50	21754	2.85
	75	21371	2.90
	100	24685	2.80
	125	22027	3.00
	150	21465	2.65
	175	22435	2.90
	200	22683	3.00
Subsection 1	Overall Mean	22054	2.89
	Standard Deviation	983	0.11
	Coeff of Variation	4.46%	3.80%

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

Table D-8. Surface Elevation Measurements

LTPP Seasonal Monitoring Study	State Code	[37]
Surface Elevation Measurements	Test Section Number	[1028]

Survey Date	May 18, 1995
Surveyed By	DS/AL
Surface Type	A/C
Benchmark	Observation Piezometer - 1.000 meters - assumed

STATION		PE m offset 0.15m	OWP m offset 0.81m	ML m offset 1.83m	IWP m offset 3.35m	ILE m offset 3.63m
0-18	3+00	1.2050	1.2150	1.2525	1.2550	1.2875
0-12	3+25	1.2025	1.2150	1.2550	1.2575	1.2875
0-07	3+50	1.2050	1.2125	12450	1.2575	1.2900
0+00	3+75	1.2100	1.2175	1.2450	1.2560	1.2950
0+25	4+00	1.2175	1.2300	1.2625	1.2725	1.3050
0+50	4+25	1.2125	1.2200	1.2575	1.2675	1.3000
0+75	4+50	1.2150	1.2275	1.2600	1.2725	1.3025
1+00	4+75	1.2175	1.2300	1.2625	1.2750	1.3025
1+25	5+00	1.2200	1.2300	1.2625	1.2775	1.3050
1+50	5+10	1.2100	1.2200	1.2550	1.2725	1.3000
1+75	5+20	1.2100	1.2150	1.2450	1.2600	1.2925
2+00	5+30	1.2100	1.2175	1.2575	1.2575	1.2925

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

APPENDIX E

Photographs

Figure E-1. Instrument hole location before installation

Figure E-2. Piezometer location before installation

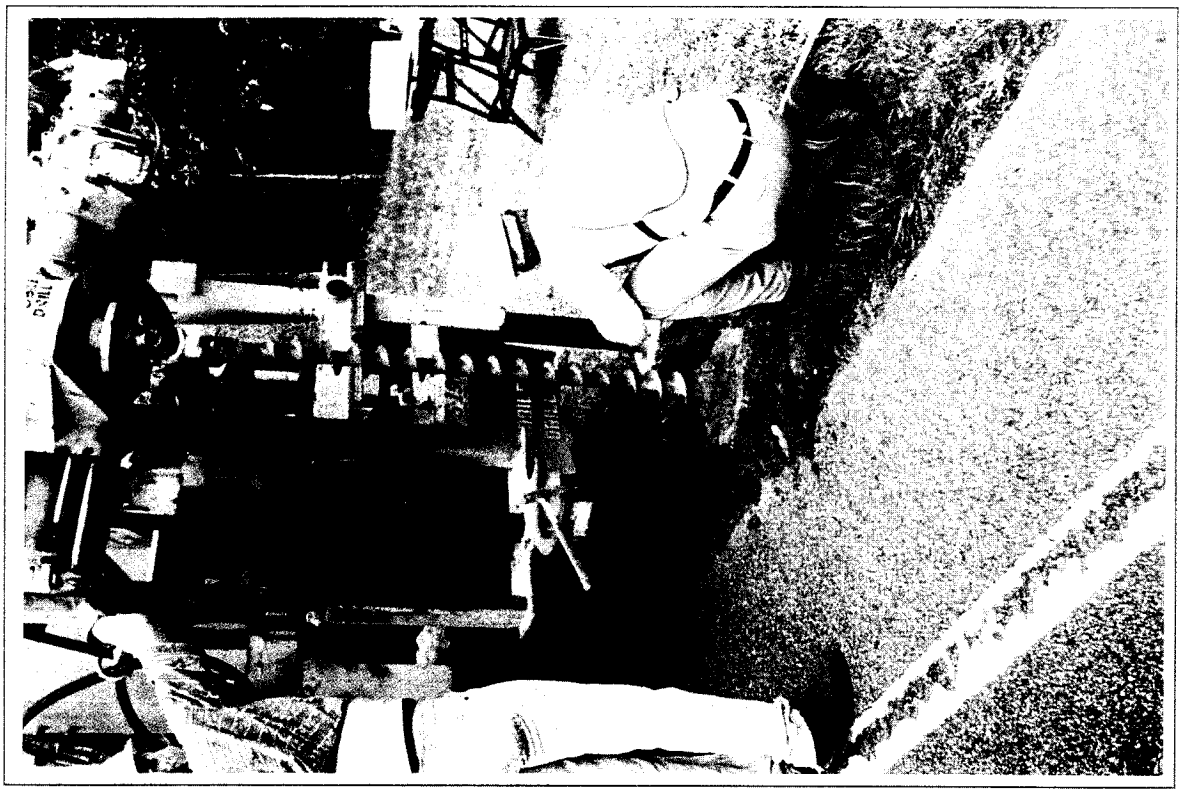

Figure E-3. Augering the piezometer hole

Figure E-4. Coring the instrument hole

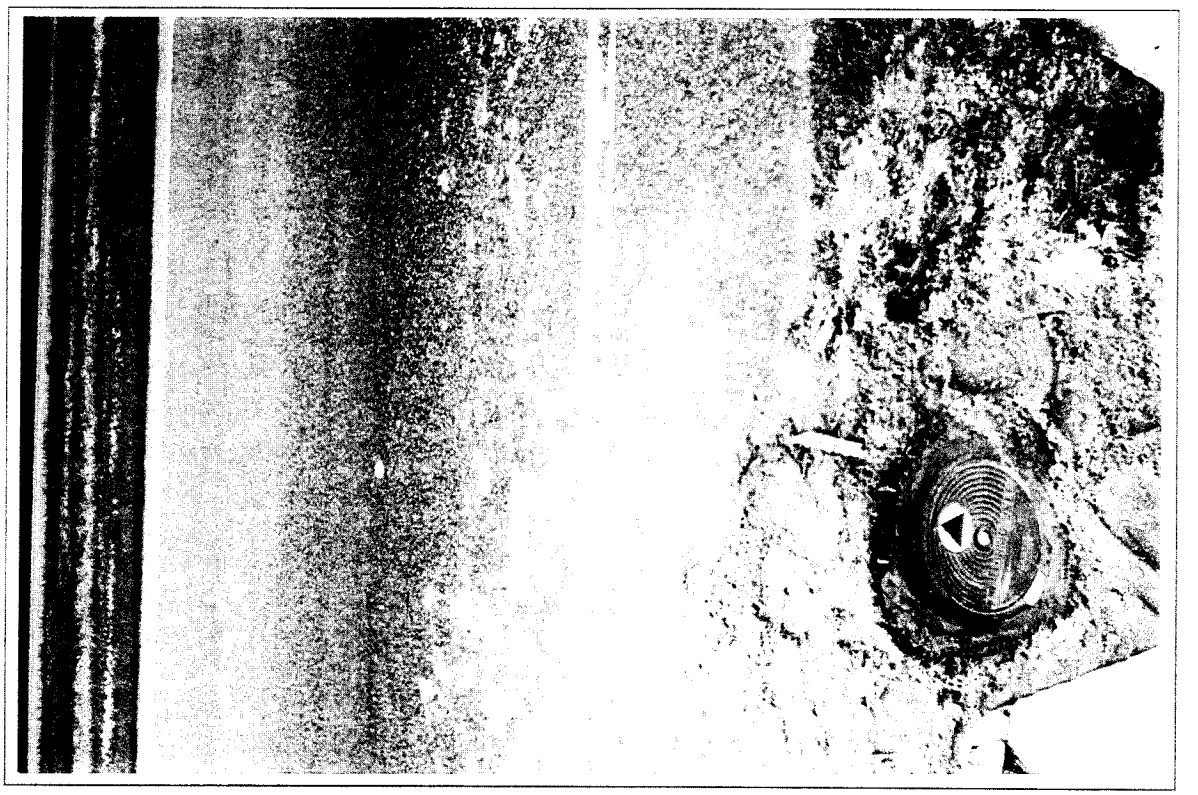

Figure E-5. Completed piezometer access

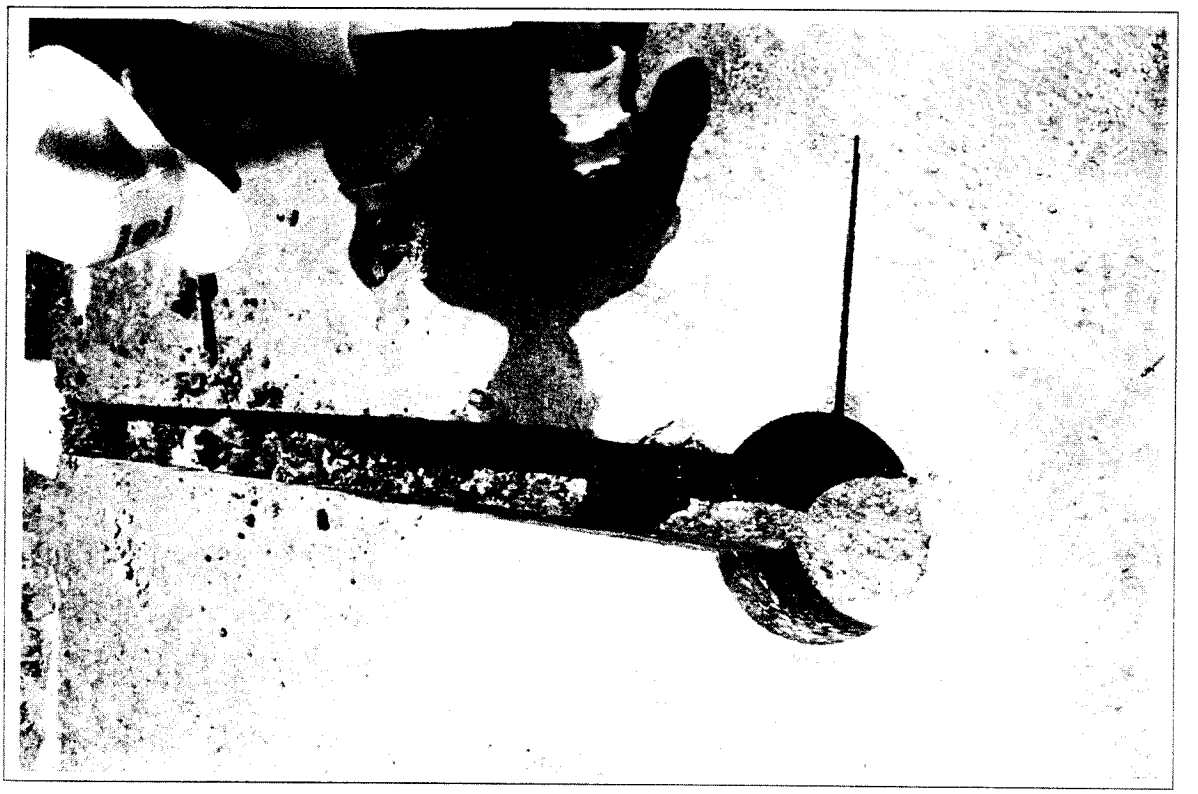

Figure E-6. Instrumentation hole and trench before augering

Figure E-7. Instrument hole during the placement of TDR probe #5

Figure E-8. Trench and equipment cabinet

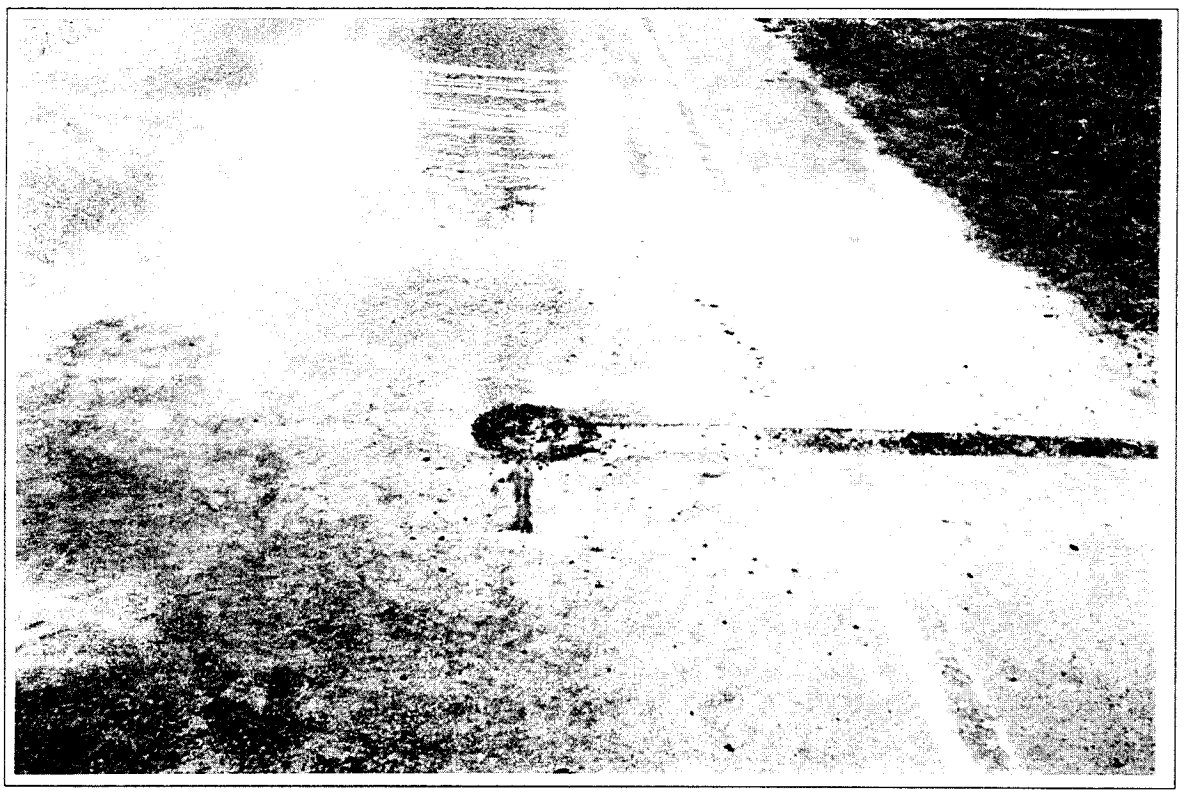

Figure E-9. Instrument hole area - facing North

Figure E-10. Equipment cabinet and weather station

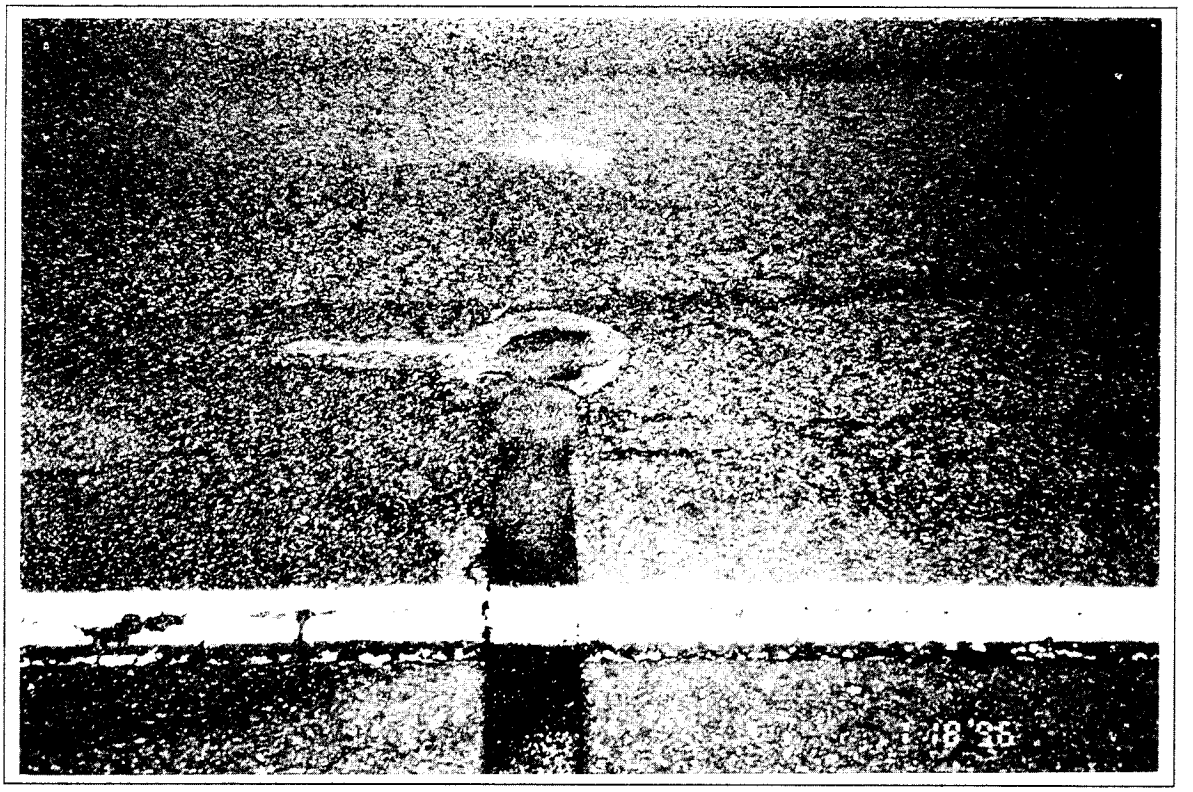

Figure E-11. Instrument hole location - January 18, 1996