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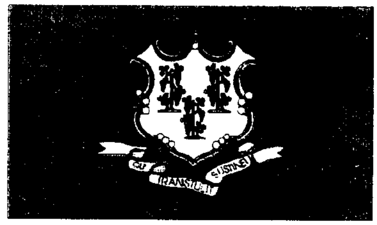

Connecticut

LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection Section 091803, Groton Connecticut

Report No. FHWA-TS-95-09-01

September 1995

Notice

LTPP Seasonal Monitoring Program

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15. Supplementary Notes

The report is a cooperative effort between Connecticut Department of Transportation Office of Research and Materials, 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 091803 on RT 117 in Groton Connecticut. This asphalt concrete surface pavement test section was instrumented on August 18, 1993. The instrumentation installed included time domain reflectometry probes for moisture content, electrical resistivity probe for frost location, thermistor probe for temperature, tipping bucket rain gage, piezometer to monitor the ground water table, and an on-site data logger. Initial data collection was performed on August 19, 1993 which consisted of deflection measurements with a Falling Weight Deflectometer, elevation measurements, temperature measurements, TDR measurements, and electrical resistance and resistivity measurements. Longitudinal profile data is collected during scheduled visits with the LTPP profilometer. The report contains a description of the test site and its location, the instruments installed at the site and their locations, characteristics of the installed instruments and probes, problems encountered during installation, specific site circumstances and deviations from the standard guidelines, and a summary of the initial data collection.

17. Key Words	18. Distribution Statement
Instrumentation, Monitoring, Survey, FWD, Profilometer, Time Domain Reflectometry, Thermistor, Piezometer, Electrical Resistance, Electrical Resistivity.	

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I. Introduction

The installation of instrumentation on seasonal site 091803 near Groton Connecticut was performed on August 18 - August 19, 1993.

The test section is a GPS-1 experiment, located on northbound RT 117, approximately 1.5 kilometers north of the Center Groton town limits and 5 kilometers north of the Groton city limits (Figure A-1 in Appendix A). This road is in a rural residential area and consists of one 3.7 m wide lane in each direction with a 0.9 m wide paved outside shoulder.

The pavement structure consists of 183 mm of asphalt concrete over 366 mm of uncrushed gravel base on a fine silty sand material with traces of gravel. The depth to bedrock below road surface is more than 2.1 m. 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. The materials and layers encountered during the installation differ slightly from what was encountered during the drilling and sampling done in 1990. A black loam material over a light brown silt material was encountered at 1.544 meters.

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

The site is in a wet-freeze zone with a thick AC surface over a fine subgrade in experimental cell 12 of the seasonal monitoring program. The annual average frost depth is 0.6 m and the maximum is 1.2 m. This section of pavement is salted frequently for ice control. Below is a summary from the LTPP climate database based on six years of data:

- Freezing Index (C-Days) 222
- Precipitation (mm) 1270
- No. of Freeze/Thaw Cycles 90
- Days Above 32C 1
- Days Below 0C 103
- Wet Days 112

The road was opened in 1985. The estimated annual average daily traffic (AADT) in 1992 was 4600 (two way) of which 2.4% was truck traffic on the GPS lane. The estimated annual kESALs (using vehicle ESALs) on the GPS lane in 1992 were 73.4. This is based on 284 days of vehicle classification and volume data from AVC and 35 days of vehicle classification data from WIM and 314 days of WIM data.

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

Tom Budney Jr.	Connecticut Department of Transportation (District 2)
Marge Dudka	Connecticut Department of Transportation (District 2)
Russell Hodgson	Connecticut Department of Transportation (District 2)
Corey Hutchings	Connecticut Department of Transportation (District 2)
Richard Klein	Connecticut Department of Transportation (District 2)
Fred Kofter	Connecticut Department of Transportation (District 2)
Rich Lepine	Connecticut Department of Transportation (District 2)
Joe Picco	Connecticut Department of Transportation (District 2)
Charlie Purdell	Connecticut Department of Transportation (District 2)
Don Willis	Connecticut Department of Transportation (District 2)
Aramis Lopez	FHWA LTPP Division
Andrew Brigg	Pavement Management Systems Limited (NARO)
Gabe Cimini	Pavement Management Systems Limited (NARO)
Brandt Henderson	Pavement Management Systems Limited (NARO)
Doug Marshall	Pavement Management Systems Limited (NARO)
Perry Zabaldo	Pavement Management Systems Limited (NARO)

Extensive assistance in coordination of activities was provided by Ann Marie MacKertich. Staff from the office of Research and Materials provided input and assistance with the installation, video and photos of installation activities and assistance with supplies and materials evaluation.

Aramis Lopez, FHWA LTPP Division provided input and assistance in making this a succesful first LTPP core seasonal installation in the North Atlantic region

Table 1. Material Properties

Description	Surface	Base	Subgrade
Material (Code)	Dense Graded HMAC (01)	Uncrushed Gravel (302)	Silty Sand w Gravel (142)
Thickness (mm)	183	305	**
Lab Max Dry Density (kg/m^3)		2198	
Lab Opt Moisture Content (%)		6.00	
Lab Moisture Content (%) *		3.70	
In-situ Wet Density (kg/m^3) *		2376	
In-situ Dry Density (kg/m^3) *		2264	
In-situ Moisture Content (%) *		4.98	
Bulk Specific Gravity	2.444		
Max Specific Gravity	2.539		
Liquid Limit		0	
Plastic Limit		0	
Plasticity Index		NP	
% Passing # 200		7.7	

* Note: Test pit @ station 5+60
** Note: Auger Refusal, insufficient material.

II. Instrumentation Installation

Site Inspection and Meeting with Highway Agency

A site inspection was done in July 30, 1992 in conjunction with the FWD uniformity survey. The review was conducted by Anne Marie MacKertich (CTDOT) and Brandt Henderson (NARO). The FWD uniformity survey indicated that either end was suitable from a deflection standpoint. An inspection of the pavement surface indicated some low to moderate severity longitudinal and transverse cracking with the surface being slightly aged and pitted. Local traffic, mainly consisting of commuters, is heaviest between 1500 and 1600 hours. Traffic in this area is expected to increase due to its proximity to the Foxwood casino, but with minimal increase in commercial content. There were no plans for rehabilitation of this location in the immediate future. From a traffic control perspective, the north end (5+00) is better for site distance as the south end starts on a curve in the road. The north end of the site is also located in an open area; whereas the south end (0+00) is in a built up area with no location for the equipment cabinet. Pictures providing an overview of site conditions are presented in Appendix E. From the initial drilling and sampling logs, refusal was encountered in a number of instances due to the large boulders used in the fill material during road construction. CTDOT agreed to do some initial auger probes in the area of the instrumentation hole and piezometer/benchmark to determine what might be encountered during installation. In addition a benchmark was to be established to confirm the stability of the combination piezometer/benchmark.

A preliminary planning meeting was held at the Connecticut Department of Transportation, Rocky Hill, Connecticut on the morning of July 19, 1993. This meeting was attended by the following personnel:

• Charlie Dougan	CTDOT, Research and Materials
• Anne Marie MacKertich	CTDOT, Research and Materials
• Don Larsen	CTDOT, Research and Materials
• Joe Obara	CTDOT, Design
• Colleen Kissane	CTDOT, Pavement Management
• Bruce Olmstead	CTDOT, Soils
• Michael MacKertich	CTDOT, Soils
• Ronald C. Benoit	CTDOT, Maintenance and Planning
• Lester Davis	CTDOT, Groton
• Russell Hodgson	CTDOT, Groton
• Don Brodeor	CTDOT, District II
• Don Willis	CTDOT, Supervisor Test Borings
• Tom Budney Jr.	CTDOT, Test Borings
• Brad Kezzer	FHWA
• William A. Phang	Pavement Management Systems Limited
• Brandt Henderson	Pavement Management Systems Limited

A presentation on the installation of seasonal monitoring instrumentation and monitoring requirements were provided by Bill Phang and Brandt Henderson. This was followed by a review and discussion on the proposed seasonal monitoring site (GPS 091803) near Groton, CT, and the tasks to be done by state resources and material requirements. Following the meeting the proposed seasonal site was visited by Anne Marie MacKertich, Lester Davis, Russel Hodgson, Brandt Henderson and Bill Phang to determine the location for the inground sewers, equipment cabinet and piezometer. Approval for the installation and monitoring was received on June 03, 1992, contingent on the installation being completed by August 31, 1993. The installation was planned for the week of August 16-20, 1993.

A pre-installation meeting was held on August 17, 1993 at the Groton District 2 office. Plans for the following day were discussed along with a verification check of the equipment to be used for cutting the asphalt layer for the instrument hole and trench to the equipment cabinet, augering the instrumentation and piezometer hole and the various supplies necessary to complete the installation and patch the pavement. The results of this meeting indicated all preparations were complete and we were ready for the installation on August 18, 1993.

Equipment Installed

A permanent bench mark (Elevation 171.357 Feet, 52.2297 Meters) was installed by the state in September 1992 and stamped 3211. It was set in an exposed rock ledge 610 mm by 457 mm, set 914 mm below the level of the road. Information on the permanent bench mark is provided in Appendix B.

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

Table 2. Equipment Installed

Equipment	Quantity	Serial Number
Instrumentation Hole		
MRC Thermistor Probe	1	09AT
CRREL Resistivity Probe	1	09AR
TDR Probes	10	09A01-09A10
Equipment Cabinet (Supplied by CTDOT)		
Campbell Scientific CR10 Datalogger	1	16586
Campbell Scientific PS12 Power Supply	1	5386
Weather Station		
TE525MM Tipping Bucket Rain Gage	1	11928-593
Campbell Scientific 107-L Air Temperature Probe	1	09AAT
Observation Well/Temporary Bench Mark	1	N/A
Permanent 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 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 should correspond to the temperature of the medium it was checked against (ie. ice, water, air). 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 of the air temperature and thermistor probes along with the spacing between the thermistors are presented in Appendix B.

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

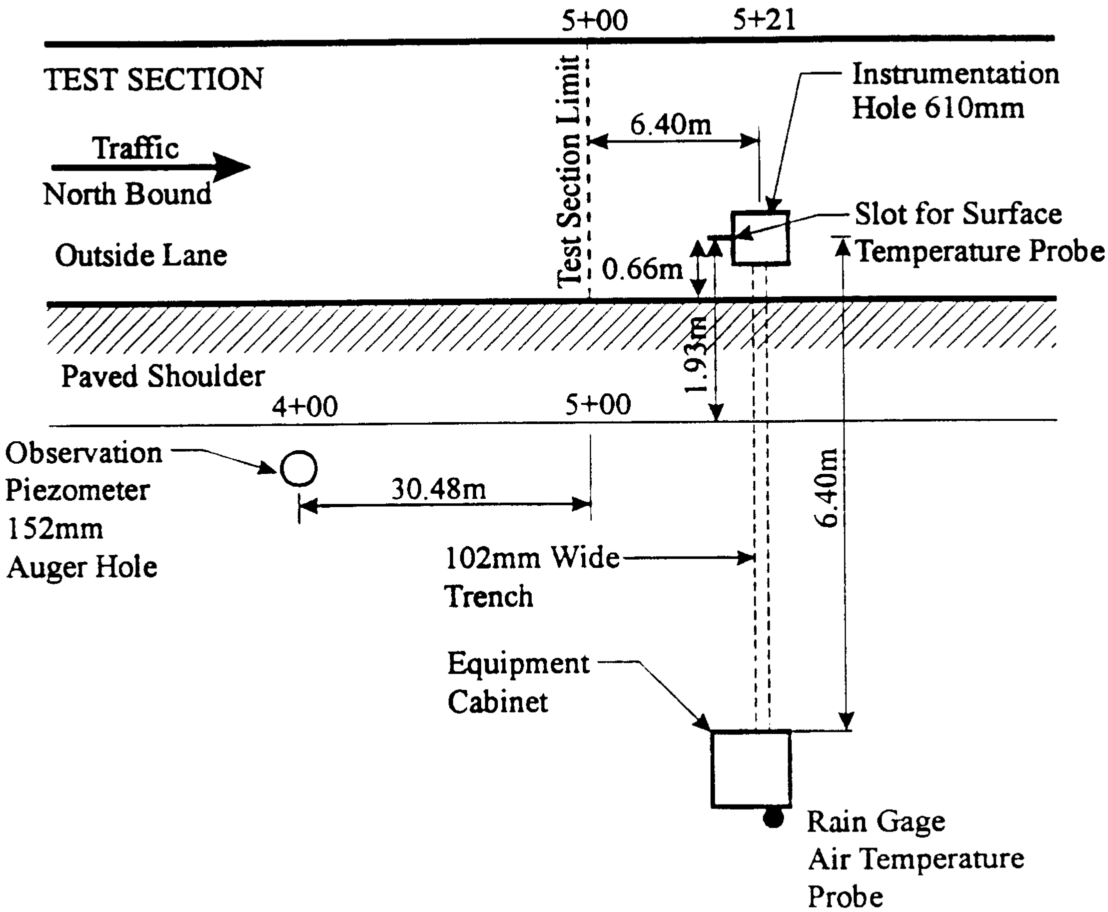
The functioning of the TDR probes were checked by performing measurements in air and water, and with the prongs shorted at the circuit board and the end of the probe. The traces were taken and the dielectric constant was calculated for water and air. These values were checked against expected dielectric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

Equipment Installation

Final details for the installation and initial monitoring were discussed in a meeting on the afternoon of August 17, 1993. The installation was confirmed for 0800 hours on August 18, 1993. On arrival at the site, on August 18 at 0800 hours the skies were overcast and the pavement was slightly wet. After a brief discussion it was decided to proceed with the installation as all the resources and equipment except for the pavement cutting saw were at the site and ready to proceed.

The instrumentation was installed on the north end of GPS 091803, in the northbound lane of state route 117 near the city of Groton. The combination benchmark/piezometer was placed in the shoulder at station 4+00. The in-pavement instrumentation was installed in the outer wheel path at station 5+21. 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, 6.40 m from the instrumentation hole. The cabinet supplied by CTDOT was placed approximately halfway between the edge of pavement and the treeline east of the roadway. The weather pole was installed immediately behind the equipment cabinet. Figure 1 provides the location and distances for the various instrumentation and equipment installed.

The installation generally followed the procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". The combination piezometer/benchmark was installed just off the edge of the paved shoulder to a depth of 3.11 m. A 152 mm flight auger was used for drilling the hole. An initial hole was drilled at the peizometer location prior to installation to ensure there wasn't going to be a problem with augering due to refusal on boulders in the roadbed material. No boulders were encountered at this location and the hole remained open (did not collapse) therefore no further drilling was required and the peizometer was installed in the existing hole location. No water was encountered during the drilling operation or installation. The 25.4 mm galvanized pipe was firmly pressed into the hole, followed by 0.75 m of filter



- Height of Air Temperature Probe (center): 3.58m
- Height of Tipping Bucket Rain Gage (center): 3.66m
- Total Depth of Piezometer: 3.06m
- Distance of Piezometer Below Ground Level: 51mm

Figure 1. Location for Seasonal Monitoring Instrumentation Installed at GPS 091803

sand, 1.47 m of native soil, a 0.36 m bentonite plug with the remainder of the hole filled with the native material removed. The final elevation for the pipe was 51 mm below the natural ground level at the location of the installation. A 200 mm cast iron monitoring well manhole, held in location by approximately 25 kg of concrete mix, was used to cover and protect the piezometer/benchmark.

A 610 mm square hole was cut into the AC surface, located in the outside wheel path, 0.66 m from the edge of the travel lane at station 5+21, using a heavy duty portable paving saw. A 20 mm notch was cut in the center of the south side of the instrumentation hole to accommodate the stainless steel thermistor probe for measuring the gradient temperature in the AC layer. A 102 mm wide saw cut was made between the instrumentation hole and the edge of the paved shoulder to accommodate the instrumentation cabling. A pick and shovel was used to remove the aggregate material from the pavement area. A backhoe was used to excavate a trench from the edge of pavement to the location of the equipment cabinet. A concrete base was installed to support the aluminum cabinet supplied by CTDOT for retaining the cabling, data logger and batter assembly.

A 250 mm hollow stem auger, with the plug removed, was used to excavate the instrumentation hole. Due to the extensive amount of rocks in the base material it was necessary to loosen the rocks with the auger and remove them either by hand or with a small scoop.

The fill material below the granular base was removed in three 400 mm lifts to a depth of 1.6 m. A black organic material was encountered at this level, followed by a light brown yellow silt. During the augering of the instrumentation hole there was a steady drizzle that made it difficult to retain the material characteristics. This was particularly true for the material removed at the top of the instrument hole. A small shop wet vac was used during the augering exercise to prevent free ground water from the pavement surface entering the instrument hole. The findings from the excavation of the instrumentation hole at station 5+21 are presented in Figure 2. The materials and thickness appear to be slightly different from those encountered during the drilling and sampling performed in 1990.

All the material excavated from the instrumentation hole was placed and compacted in order of removal with the exception of pail number one base material. Due to the wet conditions of this material, the particles were redistributed and could not be reconstituted to form a representative material. Replacement base material was acquired from the edge of the shoulder adjacent to the instrumentation cabling trench, by undermining this area with a pick and shovel. As this material was similar to that removed from the instrumentation hole there should be not difference in conditions relative to the monitoring activities or pavement performance.

Samples of material placed around the TDR probes were retained to determine the gravimetric moisture at these locations. Due to time constraints and the need to get the sensors and materials into the instrumentation hole as quickly as possible, not all TDR probes had moisture samples taken. The installation of the instrumentation was undertaken during a steady drizzle. A splicers tent along with circumferencing the instrumentation hole with local sandy material was used to prevent water from entering the instrumentation hole during installation. This worked as well as could be expected under the circumstances.

Due to the wet conditions not all tasks were completed on the day of installation. The pavement block was replaced, the cabling installed to the instrumentation cabinet and the trench area filled and compacted along with a cleanup of excess material prior to completion of the day 1 activities. Prior to the data collection activities on day 2, August 19, 1995 the weather station assembly was setup and leveled, the wiring the equipment cabinet was completed and the weather pole was secured to the equipment cabinet. Due to the general configuration of this setup, the instrumentation on the weather pole is approximately 0.6 m higher than a standard setup.

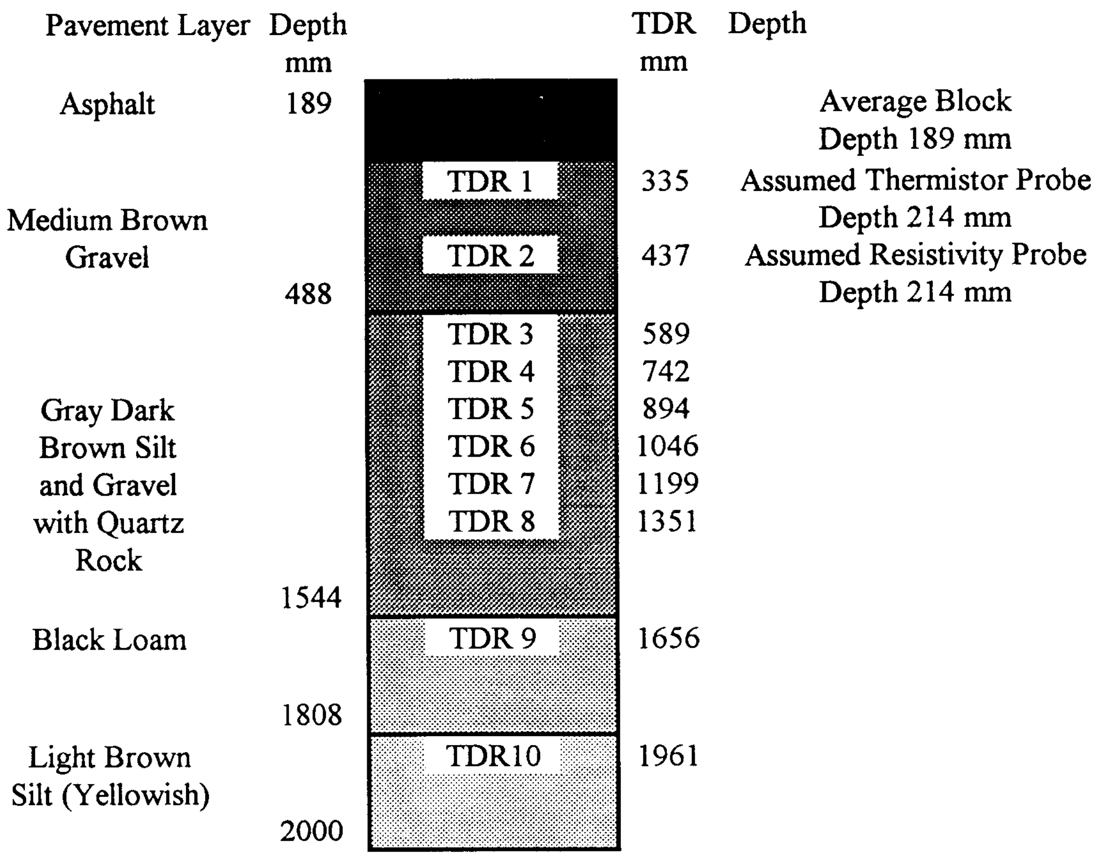


Figure 2. Profile of Pavement Structure and Probe Depths from Surface, Station 5+21

To check for breakage of the TDR probes during installation, each probe was connected to the cable tester and its wave form monitored during compaction of the material around it. The TDR traces are included in Appendix C. By alternating the TDR probes within the instrument hole we were able to keep the cables separate to avoid water from migrating along a bundle of cables attached to the probes placed at various depths. The thermistor and resistivity probes were installed at opposite sides of the instrumentation hole with the thermistor probe approximately 0.214 m and the resistivity probe approximately 0.214 m below the pavement surface. The cables were kept spaced to the degree possible until they converged at the opening of the flexible conduit pipe, placed about 50 mm from the edge of the block 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.

A comparison of the moisture contents from the TDR traces, and field moisture determination indicates the moisture content values are similar, but vary in a range of 1 to 4%. This could be due to the large concentration of rock in or near the probes which may not be in full contact with the surrounding material. More accurate moisture readings are generally obtained from probes in full contact with the soil material. The calculation of moisture content from TDR method is also dependent on the calibration inputs for the TDR model.

Tables 3, 4, and 5 present the installed depths of the TDR probes, thermistor sensors, and the resistivity probe respectively. Table 6 gives TDR moisture content and field moisture content determined during installation.

Table 3. Installed Depths of TDR Sensors

Sensor #	Depth from Pavement Surface (m)	Layer
09A01	0.335	Base
09A02	0.437	
09A03	0.589	Subbase
09A04	0.742	
09A05	0.894	
09A06	1.046	
09A07	1.199	
09A08	1.351	
09A09	1.656	Subgrade
09A10	1.961	

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	0.095	
	3	0.164	
2	4	0.239	This unit was installed below the AC layer into the subgrade.
	5	0.316	
	6	0.392	
	7	0.468	
	8	0.544	
	9	0.697	
	10	0.849	
	11	1.001	
	12	1.154	
	13	1.306	
	14	1.459	
	15	1.611	
	16	1.763	
	17	1.916	
	18	2.068	

Table 5. Location of Electrodes of the Resistivity Probe

Connector Pin Number	Electrode Number	Depth from Pavement Surface (m)
36	1	0.244
35	2	0.294
34	3	0.344
33	4	0.394
32	5	0.444
31	6	0.494
30	7	0.544
29	8	0.594
28	9	0.644
27	10	0.694
26	11	0.744
25	12	0.794
24	13	0.844
23	14	0.894
22	15	0.944
21	16	0.994
20	17	1.044
19	18	1.094
18	19	1.144
17	20	1.194
16	21	1.244
15	22	1.294
14	23	1.344
13	24	1.394
12	25	1.444
11	26	1.494
10	27	1.544
9	28	1.594
8	29	1.644
7	30	1.694
6	31	1.744
5	32	1.794
4	33	1.844
3	34	1.894
2	35	1.944
1	36	1.994

Table 6. TDR and Field Moisture Content During Installation

Sensor Number	Sensor Depth (m)	Layer	TDR Moisture Content (by wt) % *	Field Moisture Content (by wt) % *
09A01	0.335	Base	12.63	
09A02	0.437		15.15	11.40
09A03	0.589	Subbase	12.63	
09A04	0.742		11.57	14.70
09A05	0.894		4.68	7.80
09A06	1.046		5.92	5.00
09A07	1.199		4.68	7.00
09A08	1.351		7.51	9.00
09A09	1.656	Subgrade	15.15	
09A10	1.961		16.83	

* Note: Raw data given in Appendix C

Site Repair and Cleanup

The instrumentation hole was repaired by reinstalling the 610 mm square asphalt block. Some juggling was required to get the block level with the existing pavement surface. Once the block 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 block hole. The weight of the state dump truck, which slowly moved back and forth over the block, was used to firmly seat the block into the hole.

The trench for the cabling from the instrumentation hole to the edge of pavement was leveled with gravel to the existing bottom of the paved layer and a cold mix was compacted to the level of the existing surface. The remainder of the trench was filled with native material and compacted, followed by a cleanup of loose material from the paved area. Traffic control was removed at 1730 hours and the lane reopened to traffic. During the next day the instrument hole and edge of the trench were sealed with a cold emulsified crack sealing compound. Removal of the asphalt trench material and other disposable items was handled by the CTDOT division personnel.

Patch/Repair Area Assessment

When the site was visited on November 15, 1993 three months after installation, the instrumentation hole patch was checked and photos were taken as shown in Appendix E. There was minor settlement in the patched areas and the sealant did not hold properly. There were also some cracks propagating off of the corner cuts for the block. A Corning self leveling 888 crack sealing compound was used to seal the joints at the perimeter of the block.

III. Initial Data Collection

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

Air Temperature, Subsurface Temperature, Rain-fall Data

The air temperature, pavement subsurface temperature profile, and rainfall data, collected on August 19 by the CR10 datalogger, were examined. The equipment and datalogger appeared to be functioning properly. The battery voltages were checked and found to be acceptable. Raw data collected at the site are presented in Appendix D, Table D-1. Figure D-1 shows the air temperature data collected from 1420 hours (August 19) through 1443 hours (August 19). Figure D-2 shows the first set of subsurface temperatures for the first 5 sensors. Figure D-3 shows the first set of subsurface temperatures for all 18 sensors. There was no precipitation that day. All these results indicated that the onsite CR10 datalogger and measurement equipment were working properly. Only 24 minutes of data were taken to check for the functioning of the sensors.

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 one 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 1.0 of the MOBILE program was used to collect and record the TDR wave form traced for each sensor. Figures D-4 and D-5 show the initial TDR wave form traces collected with the MOBILE data acquisition system for only sensors 1 and 2 respectively. Figure D-6 shows the TDR wave form traces collected, with the MOBILE data acquisition system, two weeks after installation. The figures indicate that the multiplexers of the mobile system and TDR sensors were working properly.

Resistance Measurement Data

The MOBILE data acquisition system automatically performs two point contact resistance measurements and stores the values in terms of millivolts between adjacent electrodes. Figure D-7 shows pavement depth versus measured voltage produced by the MOBILE system the day after installation. The data indicates the resistance multiplexer of the mobile system was functioning properly.

Manual contact resistance and resistivity measurements were taken but the data was questionable and therefore was not included in this report.

Deflection Measurement Data

Deflection measurements followed procedures described in the Guidelines. Technical difficulties with the FWD resulted in only a partial data set for the day of installation. On day 2 a failure in the FWD system processor resulted in no data being collected. The analysis results from the FWDCHECK program from the day of installation are presented in Appendix D. Since then, twenty one measurements have been collected with the FWD, the first and second on November 15 and December 22, 1993, then on February 17, March 30, April 21, May 12, June 9, June 30, July 28, August 25, September 29, October 27, and the thirteenth on November 30, 1994. Then on January 26, March 2, March 15, March 29, April 12, April 26, May 25, and the twenty first and last time on June 22, 1995.

Longitudinal Profile Data

According to the guidelines, since this is in a frost area, the survey should be performed on five different occasions; one survey during the middle of each season and one survey during the late winter period (fully frozen condition). Eight surveys have been performed on this site, twice in the winter season (January 19, 1994 and January 9, 1995), twice during the fully frozen condition (February 22, 1994 and February 22, 1995), twice in the spring season (April 20, 1994 and May 19, 1995), once in the summer season (July 27, 1994), and once during the fall season (October 25, 1994).

Elevation Surveys

PK nails were used to mark out the site for surface elevations as per the LTPP guidelines. It was assumed that the elevation at the top of the piezometer pipe was 1.000 meters. The survey was conducted on August 19, 1993, the day after the installation, and the results are presented in Appendix D. Since then, nine sets of surface elevation surveys were performed on this site, the first on February 17, then on April 21, July 28, August 25, and the fifth on October 27, 1994. Then on January 26, March 2, May 25, and the ninth and last time on June 22, 1995.

Water Depth

During drilling of the piezometer test hole, no water was encountered. A check on the piezometer on the following day indicated no water again. The water table for this section varied extensively over the first round test period.

IV. Summary

The installation of the seasonal monitoring instrumentation at the GPS site 091803 on state route 117 near Groton was completed on August 18, 1993. A check of the equipment and initial data collection was completed on August 19, 1993. The instrumentation, permanently installed at the siteis as follows:

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

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

The test section is on northbound route 117, approximately 1.5 kilometers north of the Center Groton town limits and 5 kilometers north of the Groton city limits, CT. The section is on a two lane road consisting of 3.7 m wide travel lanes with 0.9 m paved shoulders. The pavement structure consists of 189 mm of asphalt concrete over uncrushed gravel base on a silty sand material with traces of gravel which resides on a light brown silt material as observed from the instrumentation hole. Although somewhat similar to the drilling and sampling logs, there are some variations in thickness and material description. The drilling and sampling conducted in 1990 encountered a number of refusals due to large boulders in the roadbed structure. In this regard the information on the subgrade type was incomplete.

All instrumentation was checked prior to installation at the PMSL facility in Amherst, NY. These initial checks indicated that the instrumentation was within specifications, as required for the seasonal monitoring program. Operational checks during installation and the following day indicated that all instrumentation was functioning properly. The manual resistivity checks did not provide expected results; this could be due to a number of factors. The switching box was a proto type for which we were experiencing some switching problems, and the Hewlett Packard multimeter was questionable when set to read amperage. Improvements in equipment and procedures are required to ensure reliable results for this test.

Although the installation generally went as expected and all instrumentation was in working order at completion, a few problems were encountered, in particular, with removal/replacement of material from the instrument hole, the operation of the FWD and installation of the equipment cabinet. The augering of the instrumentation hole and installation of the various inground sensors was conducted under a steady drizzle. This required extra precaution to keep the free standing water from the road surface entering the instrumentation hole. A small shop wet vac was used to clean water from around the instrumentation hole during the augering process. A splicers tent was used to cover the instrumentation hole during the installation of sensors. Despite these precautions the first pail of base material had to be discarded as the material was wet and the fines were washed from the coarse material making it impossible to reinstall this material as it was removed. Replacement material was obtained from underneath the shoulder pavement adjacent to the trench used to carry the instrumentation cabling to the equipment cabinet. This material was of the same type; therefore should not have any adverse affect on pavement conditions or monitoring activities. Technical difficulties with the FWD resulted in some delay on the day of installation with only a partial data set collected. Similarly on day 2, a failure in the FWD processor did not allow collection of any pavement response data. The equipment cabinet for the datalogger, cabling and power supply was provided by CTDOT. The cabinet required extra effort to install, but in the end resulted in a sturdy, easily accessible and dry place for the installed equipment. Due to the height of the cabinet the weather pole, which was attached to the back of the cabinet, was placed approximately 0.6 meters higher than the standard setup.

The ongoing monitoring of this section, except for the problems encountered due to weather and technical difficulties with the FWD, has gone fairly well. Traffic control has been available at 0730 hours in the morning and for the most part, full days of testing have been the norm.

APPENDIX A

Test Section Background Information

Appendix A contains the following supporting information:

FHWA-LTPP CONNECTICUT TEST SITE LOCATIONS
GPS-SPS PAVEMENT STUDIES

PAVEMENT MANAGEMENT SYSTEMS LIMITED

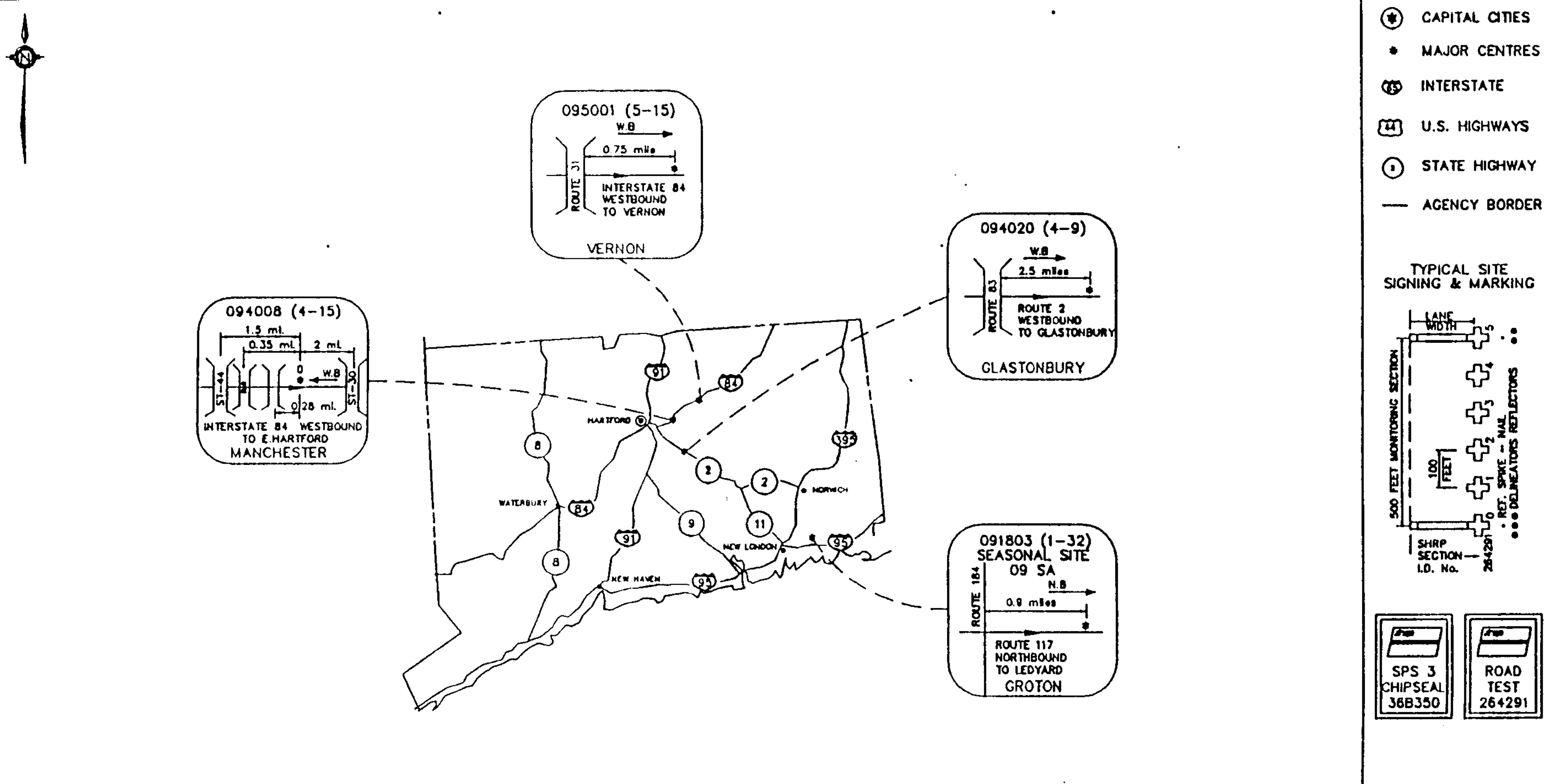


FIGURE A-1 SITE LOCATION MAP - SECTION 091803

CONNECTICUT

SCALE 1-30

12.07

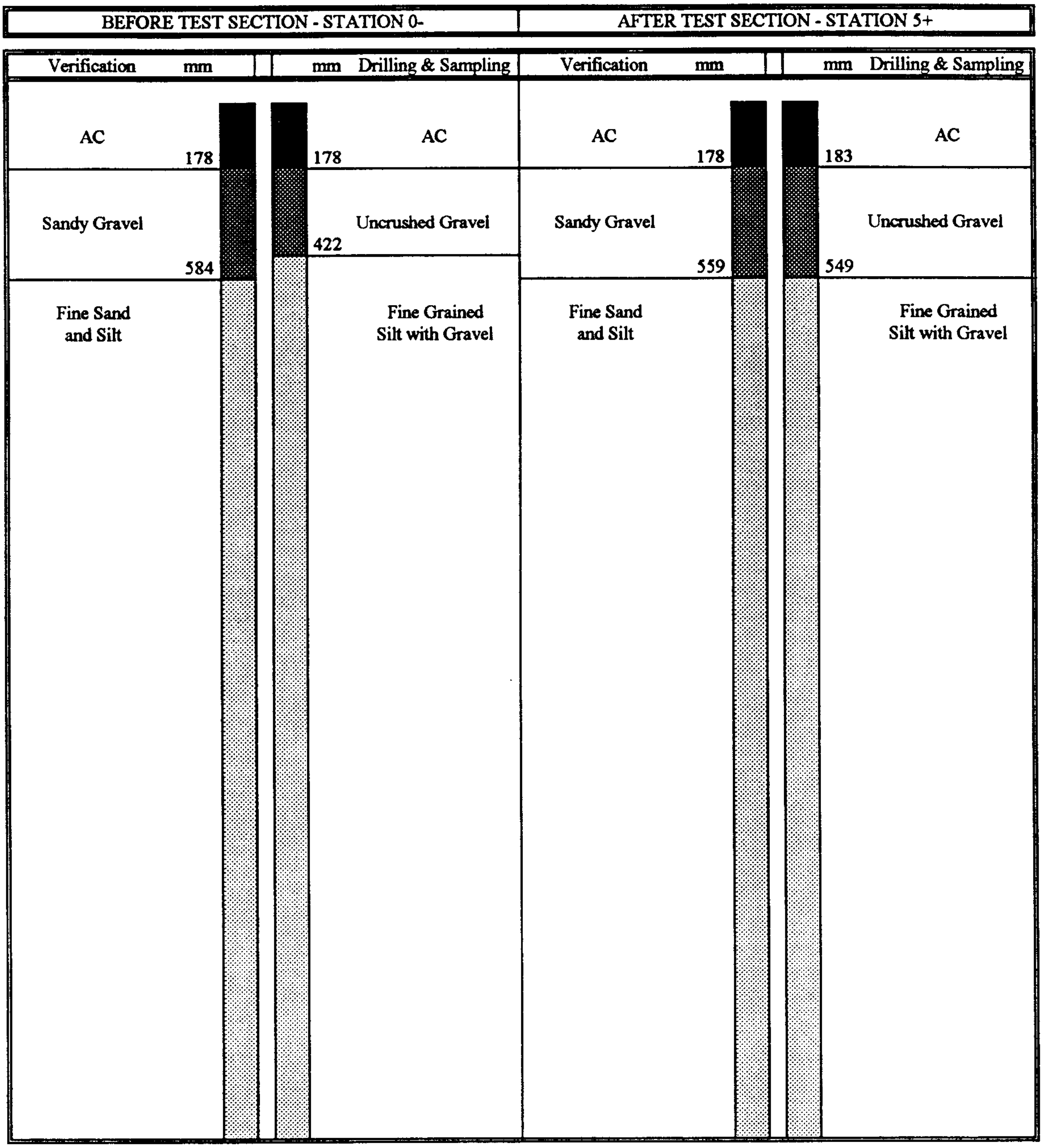


Figure A-2. Profile of Pavement Structure

Table A-1. Site Performance Summary

Distress and Profile Summary		
Distress Summary 1990	Profile Summary	
	Date (mm-dd-yy)	IRI (in/mi)
Low Sev. Trans. Cracks - 2 @ 16.30 ft.	10-26-89	94.68
Low Sev. Long. Cracks - 5.09 ft.	08-30-90	103.59
	07-26-91	100.67
	07-29-92	95.88
	07-28-93	97.81

Falling Weight Deflectometer Data Summary

Date	Mean Value for Drop HT 2 (mils)					
	Sensor 1	Sensor 1 std. dev.	Sensor 7	Sensor 7 std. dev.	Mean Temp D1 (F)	Min/Max TempD1(F)
07-18-89	6.87	0.70	0.72	0.16	72	70/75
07-30-92	7.88	0.61	0.84	0.19	92	78/107

	Effective SN	SN std dev	Subgrade Modulus (psi)	Modulus std dev (psi)	Test Pit Mod. (psi) 1	Test Pit Mod. (psi) 2
07-18-89	11.72 12.84	0.56 1.04	4834 5099	279 361	5087	4695
07-30-92	12.01 13.34	0.82 0.88	4576 4865	287 357	-	-

Note: FWD subsection boundaries at 140 ft as entered into RIMS.

Table A-2. Uniformity Survey Results

Seasonal Uniformity Survey	Falling Weight Deflectometer Data Collection and Processing Summary
Site Number: 091803	
Date Surveyed: July 30, 1992	

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 - 0	7.48	0.74	0.82	0.15	4784	294	11.51	0.89
0 - 250	7.07	0.61	0.94	0.16	4583	251	12.40	0.81
250 - 500	6.15	0.46	0.74	0.17	4963	351	13.47	0.99
500 - 600	7.10	0.74	0.98	0.10	4515	146	12.53	1.32

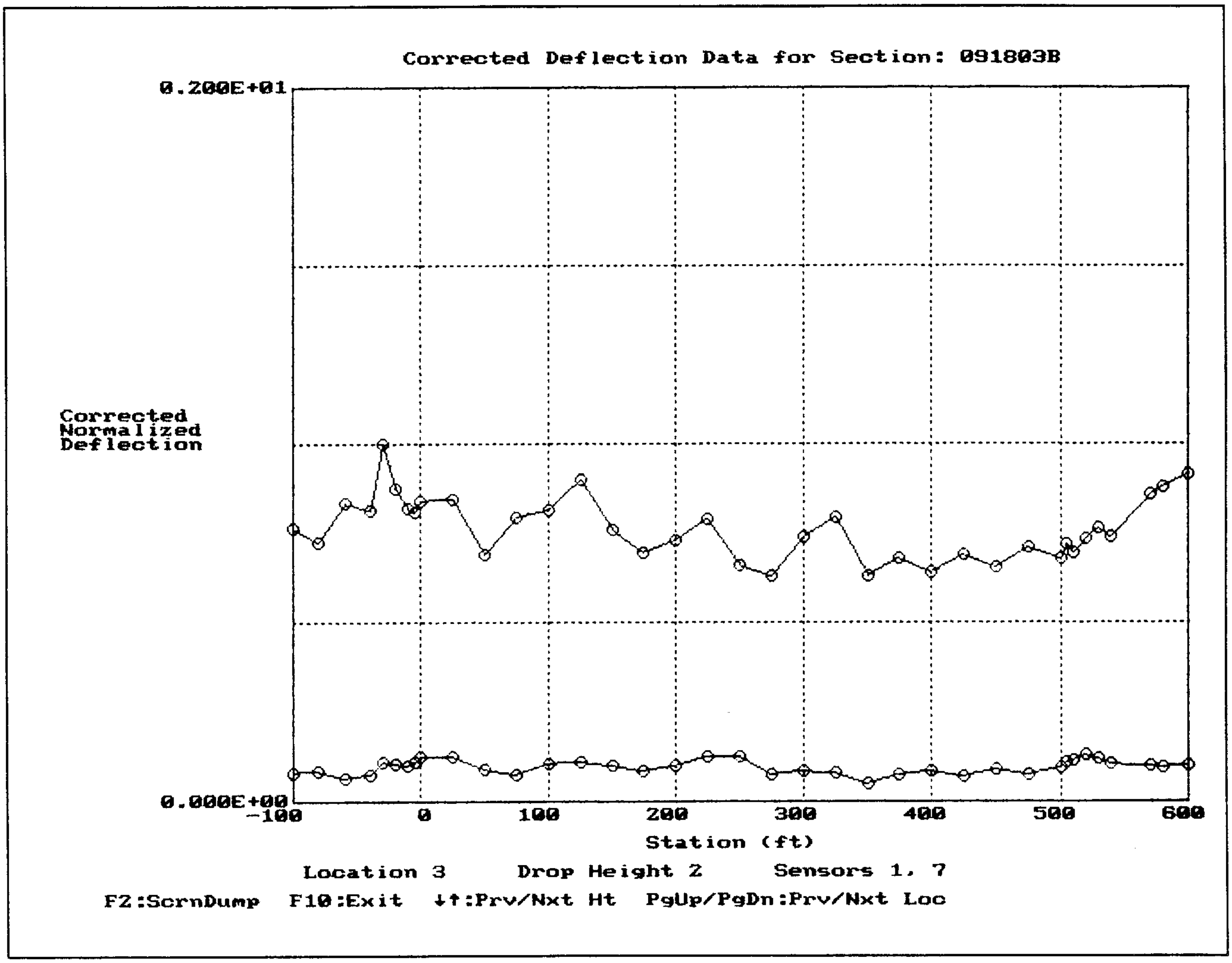


Figure A-3. Deflection Profile from FWDCHECK
(Test Date July 30, 1992)

Table A-3. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date July 30, 1992)

Flexible Pavement Thickness Statistics - 091803B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	0	4295	12.05
	25	4311	11.95
	50	4788	13.50
	75	5028	11.55
	100	4566	11.95
	125	4466	11.05
	150	4601	12.70
	175	4870	13.30
	200	4597	13.20
	225	4312	12.70
2	250	4318	15.05
	275	5035	14.35
	300	4829	12.65
	325	4976	11.60
	350	5753	13.20
	375	5108	13.20
	400	4877	14.35
	425	5133	13.00
	450	4818	14.15
	475	5070	12.70
	500	4681	13.90
Subsection 1	Overall Mean	4583	12.40
	Standard Deviation	251	0.81
	Coeff. of Variation	5.48%	6.54%
Subsection 2	Overall Mean	4963	13.47
	Standard Deviation	351	0.99
	Coeff. of Variation	7.07%	7.36%

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 Planning Meeting

Table B-1. Description of MRC Thermistor Probe and Sensor Spacing

Table B-2. Resistivity Probe and Sensor Spacing

Table B-3. TDR Probes Calibration

Figure B-1. TDR Traces Obtained During Calibration

PAVEMENT
MANAGEMENT
SYSTEMS

MEMORANDUM

TO:	Dr. Charles Dougan	**DATE:**	June 26, 1991
FROM:	Bill Phang	**PROJECT:**	05-045-07-30
SUBJECT:	FWD Seasonal Monitoring Program	**FILE:**	12.07.1
		COPIES TO:	See Below

Thank you for confirming Connecticuts' participation in the FWD Seasonal Monitoring Program at GPS site 091803, ST 117 NB, New London.

As soon as details of instrumentation at a site are finalized, this information will be passed on to you. SHRP will arrange a pilot installation prior to arranging installation at 091803. A likely time frame for the New London site is October '91. FWD testing would follow shortly thereafter. A schedule will be provided, and a procedure agreed on to deal with delays due to weather, etc.

<u>Distribution to:</u>

C. Richter
G. Rada
I. Pecnik
B. Henderson

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

BH

PAVEMENT MANAGEMENT SYSTEMS

MEMORANDUM

TO:	C. Dougan, CT T. Karasopolous, ME L. Kenison, NH R. Cauley, VT G. Jones, ON G. Dore, QE P. Hughes, MA	**DATE:**	May 07, 1992
		PROJECT:	50450732
		FILE:	6.01
FROM:	Bill Phang		
SUBJECT:	SHRP Seasonal Monitoring Reconfirming Participation	**COPIES TO:**	See Below

---

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

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

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

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

* To be rehabilitated in May 1992 ** 1992 Confirmation

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MANAGEMENT
SYSTEMS

MEMORANDUM

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

---

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

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

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

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

Distribution to:
I.J. Pecnik
B. Henderson

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UNIT #3
AMHERST, N.Y. 14221
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STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

24 WOLCOTT HILL ROAD, P.O. BOX A
WETHERSFIELD, CONNECTICUT 06129-0801

Phone: (203) 258-0372

July 16, 1992

D... REC. JUL 22 1992
JOB #
FILE #

COPY

Dr. William Phang
Pavement Management Systems
415 Lawrence Bell Drive, Unit #3
Amherst, NY 14221

Dear Dr. Phang: Bill

Subject: Seasonal Testing Instrumentation Site Information Planning

In response to your June 22, 1992 memorandum, the attached information has been gathered, as requested. Included in the informational package are copies of the following: plans from the reconstruction of the area; boring log; weather data; summary of ConnDOT drilling equipment; Connecticut Geological Survey Benchmark records; and, the completed site information form.

As requested in your May 7, 1992 memorandum, a verbal reconfirmation of participation was given on June 3, 1992 during your telephone conversation with Mr. Donald Larsen, of this Office. During this conversation, you had requested information as to the availability of specific equipment. The concrete saw and the 2400W generator are available, as will be traffic protection. More information is required, however, regarding the specific uses planned for this equipment. Whenever equipment is requested from the State, this information is necessary in order to obtain permission, the equipment, as well as the proper operators. It is requested that this information be provided at or before the pre-installation meeting. More information is also required regarding the installation of the "switch boxes mounted in telephone pedestals." The specific location of the test area would determine the installation requirements. Due to the residential area, it is preferred that the existing cabinet be used, if at all possible. If this is not possible, the specific placement of any boxes must be properly approved before installation.

We are pleased to have been selected to participate in this study and look forward to hearing from you to schedule the pre-installation meeting. If there are any further questions regarding the site, please contact Ms. Anne-Marie H. Mackertich at 258-0308.

Very truly yours,

Charlie

Charles E. Dougan, Ph.D., P.E.
Manager, Research & Materials
Bureau of Engineering and
Highway Operations

Attachment

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

24 WOLCOTT HILL ROAD, P.O. BOX A
WETHERSFIELD, CONNECTICUT 06129-0801

Phone: (203) 258-0372

DATE REC. OCT - 8 1992
JOB #
FILE # 12.07.1

ORIGINAL

October 2, 1992

Mr. William Phang
Pavement Management Systems
415 Lawrence Bell Drive, Unit #3
Amherst, NY 14221

Dear Mr. ~~Phang~~: Bell

Subject: Seasonal Testing Site Bench Mark

As required for the Seasonal Testing Program, a project/permanent bench mark has been established at the Groton (091803) LTPP test site. The bench mark was established in proximity to the area proposed by the July 1992 preliminary deflection testing. Attached are the specifics, as recorded by the Connecticut Geodetic Survey. I look forward to hearing more definite information about this project in the near future.

Very truly yours,

Charlie

Charles E. Dougan, Ph.D., P.E.
Manager, Research & Materials
Bureau of Engineering and
Highway Operations

Attachment

Copy for BH

PAVEMENT
MANAGEMENT
SYSTEMS

July 7, 1993

Ms Anne Marie Mackertich
Connecticut Department of Transportation
280 West Street
ROCKY HILL, CT 06067

Dear Anne Marie:

Please find enclosed a copy of the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". This is a pre-distribution "draft" copy. An updated version is to be distributed in early August which will form the basis for the installation and data collection for the seasonal monitoring program.

In preparation for the preliminary planning meeting scheduled for July 19, 1993, the installation guidelines (pages II 23 - 39, 44 - 54) will provide an idea of the requirements/activities involved in the installation of the seasonal monitoring program test sites.

A summary of the information available for GPS 091803 should be forwarded to you early next week. In the meantime, if you have any questions or require additional information, please do not hesitate to call the undersigned or Bill Phang at your convenience.

Yours truly,

PAVEMENT MANAGEMENT SYSTEMS LIMITED

Brandt Henderson
Manager, Field and Data Operations

BH/lh
Encl.

Copies: Bill Phang
Ivan Pecnik

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July 23, 1993
50450925-16.00

Ms. Anne-Marie Mackertich
Pavement Management Section
Office of Research and Materials
Connecticut Department of Transportation
280 West Street
Rocky Hill, Connecticut 06067

RE: Seasonal Monitoring Program - Installation of Instrumentation

Dear Charles,

Thank you for the arrangements you made to hold a planning meeting for the installation of instrumentation at a seasonal monitoring site, at your Rocky Hill, Connecticut office, 10:00 a.m. Monday July 19, 1993.

At the meeting the responsibilities of the Connecticut DOT for traffic control during installation (2 days) and monitoring every other year (monthly, and twice monthly in spring), the supply of drilling equipment and crew during installation, backfill materials for the piezometer, and hot or cold mix patching material, were discussed and were deemed acceptable to the DOT for the Groton site on SR 117 NB, GPS # 091803. Connecticut DOT will supply a traffic control type cabinet to house the above-ground instrumentation and CR-10 data-logger, complete with padlock (keys to be kept by Anne-Marie Mackertich). Connecticut DOT will also video the field operations (copy to the regional office), and do a yearly check of the temporary BM.

The location of the in-ground sensors was determined to be at sta. 5+20, and the piezometer at 4+00, during a site visit (Anne-Marie Mackertich, Lester Davis, Russell Hodgson, Brandt Henderson, and Bill Phang).

The schedule set for the installation is to have everyone assemble on Tuesday, August 17, 1993 at a nearby hotel to be briefed on their tasks and to check on readiness of equipment and available materials. In-ground installation would be done on Wednesday, August 18, 1993, and Thursday, August 19, 1993 would be available for completion of hook-up, and testing of the equipment.

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The schedule for monthly monitoring, which will begin in November will be determined in October.

Yours Sincerely,

PAVEMENT MANAGEMENT SYSTEMS LIMITED

W.A. Phang, D. Eng.
Program Manager, FHWA-LTPP

BP/tf

c.c. I.J. Pecnik
G. Rada
B. Henderson
A. Lopez

PAVEMENT
MANAGEMENT
SYSTEMS

July 23, 1993
50450925-16.00

Dr. Charles Dougan
Director of Research and Materials
Connecticut Department of Transportation
24 Wolcott Hill Road
P.O. Drawer A
Wethersfield, Connecticut 06109-0801

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The schedule for monthly monitoring, which will begin in November will be determined in October.

Yours Sincerely,

PAVEMENT MANAGEMENT SYSTEMS LIMITED

W.A. Phang, D. Eng.
Program Manager, FHWA-LTPP

BP/tf

c.c. I.J. Pecnik
G. Rada
B. Henderson
A. Lopez

Table B-1. Description of MRC Thermistor Probe and Sensor Spacing

Unit	Channel No.	Distance from Top of Unit(m)	Remarks
1	1	0.0127	0.3302 m long by 63.5 mm stainless steel probe installed in the AC layer
	2	0.1651	
	3	0.3175	
2	4	0.0254	1.854 m long by 25.4 mm PVC tube installed in the base and subgrade.
	5	0.1016	
	6	0.1778	
	7	0.2540	
	8	0.3302	
	9	0.4826	
	10	0.6350	
	11	0.7874	
	12	0.9398	
	13	1.0922	
	14	1.2446	
	15	1.3970	
	16	1.5494	
	17	1.7018	
	18	1.8542	

Table B-2. Resistivity Probe and Sensor Spacing

Connector Pin No.	Electrode Number	Continuity x	Measure-ment	Spacing (mm)			Dist. from Top (m)
				Line 1	Line 2	Avg.	
36	1	x	Top-1			30.0	0.030
35	2	x	1-2			50.0	0.080
34	3	x	2-3			50.0	0.130
33	4	x	3-4			50.0	0.180
32	5	x	4-5			50.0	0.230
31	6	x	5-6			50.0	0.280
30	7	x	6-7			50.0	0.330
29	8	x	7-8			50.0	0.380
28	9	x	8-9			50.0	0.430
27	10	x	9-10			50.0	0.480
26	11	x	10-11			50.0	0.530
25	12	x	11-12			50.0	0.580
24	13	x	12-13			50.0	0.630
23	14	x	13-14			50.0	0.680
22	15	x	14-15			50.0	0.730
21	16	x	15-16			50.0	0.780
20	17	x	16-17			50.0	0.830
19	18	x	17-18			50.0	0.880
18	19	x	18-19			50.0	0.930
17	20	x	19-20			50.0	0.980
16	21	x	20-21			50.0	1.030
15	22	x	21-22			50.0	1.080
14	23	x	22-23			50.0	1.130
13	24	x	23-24			50.0	1.180
12	25	x	24-25			50.0	1.230
11	26	x	25-26			50.0	1.280
10	27	x	26-27			50.0	1.330
9	28	x	27-28			50.0	1.380
8	29	x	28-29			50.0	1.430
7	30	x	29-30			50.0	1.480
6	31	x	30-31			50.0	1.530
5	32	x	31-32			50.0	1.580
4	33	x	32-33			50.0	1.630
3	34	x	33-34			50.0	1.680
2	35	x	34-35			50.0	1.730
1	36	x	35-36			50.0	1.780
			36-End			22.0	1.802

Table B-3. TDR Probes Calibration

LTPP Seasonal Monitoring Study	State Code		[09]
TDR Probes	Test Section Number		[1803]

Before Operation Checks	P.Z.	Initial	Calibration Date (mm-dd-yy)	08-16-93
			Seasonal Site	09SA

No.	Probe (S/N)	Probe Shorted Begin Length	Probe Shorted End Length	Air Begin Length	Water Begin Length
1	09A01	15.880	16.040	15.880	15.900
2	09A02	15.880	16.040	15.880	15.910
3	09A03	15.900	16.060	15.900	15.940
4	09A04	15.880	16.050	15.880	15.900
5	09A05	15.910	16.070	15.910	15.930
6	09A06	15.860	16.030	15.860	15.890
7	09A07	15.860	16.020	15.860	15.890
8	09A08	15.870	16.040	15.870	15.900
9	09A09	15.880	16.060	15.880	15.910
10	09A10	15.880	16.040	15.880	15.900

NOTE: Record lengths from TDR

Calculation of Dielectric Constant

Probe Length .205 m

V_p Setting .99 V_p

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

No.	Air TDR Length	Air Dielectric Constant	Air In Spec. (?)	Water TDR Length	Water Dielectric Constant	Water In Spec. (?)
1	0.17	0.70	y	1.82	80.42	y
2	0.17	0.70	y	1.80	78.67	y
3	0.17	0.70	y	1.83	81.31	y
4	0.17	0.70	y	1.82	80.42	y
5	0.16	0.62	y	1.83	81.31	y
6	0.17	0.70	y	1.81	79.54	y
7	0.17	0.70	y	1.82	80.42	y
8	0.17	0.70	y	1.81	79.54	y
9	0.17	0.70	y	1.80	78.67	y
10	0.17	0.70	y	1.81	79.54	y

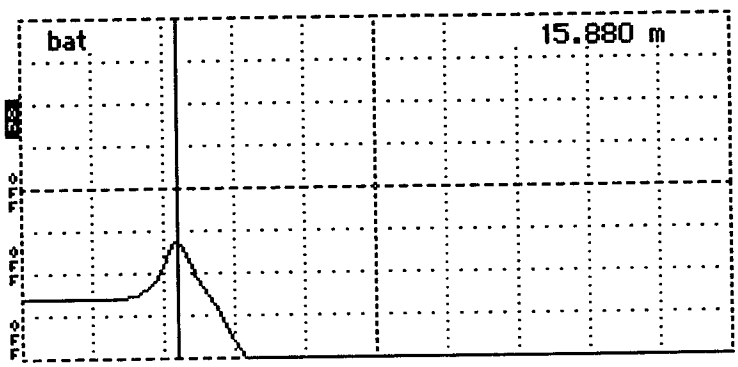
LTPP Seasonal Monitoring Study	State Code	[_ 1]
TDR Probe Calibration	Test Section Number	[1 2 0 3]

ore Operation Checks
- Calibration Date 8/1/93
- Probe S/N 0941

Probe Number 1

R Trace 1 - Beginning Probe Shorted

sor .... 15.880 m
ance/Div ..... .25 m/div
ical Scale.... 177 mρ/div
.... 0.99
e Filter...... 1 avg
er........... bat

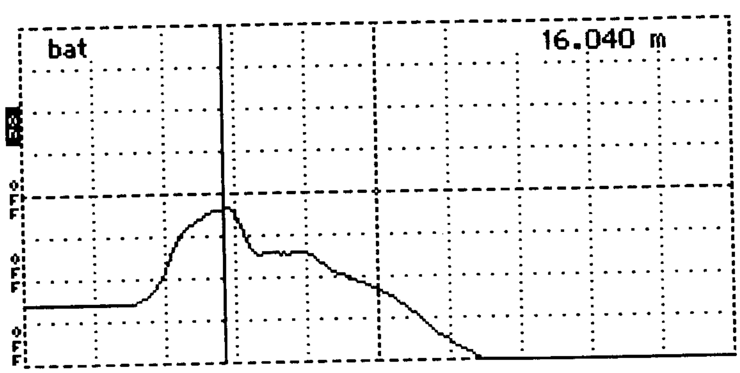


Tektronix 1502B TDR
Date 8/16/93
Cable 1
Notes Shorted at C.B.

Input Trace
Stored Trace
Difference Trace

ace Number 2 - Ending Probe Shorted

sor .... 16.040 m
ance/Div ..... .25 m/div
tical Scale.... 177 mρ/div
.... 0.99
e Filter...... 1 avg
er........... bat



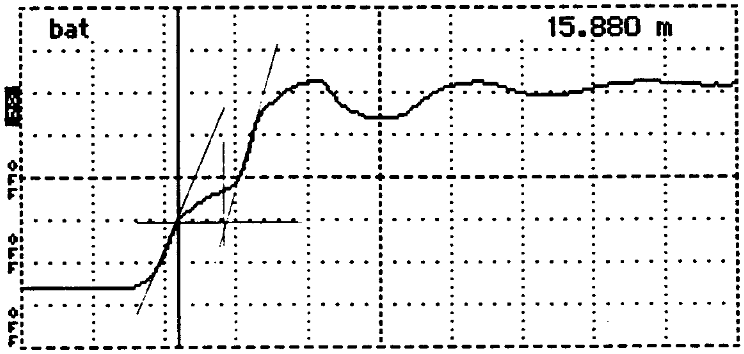
Tektronix 1502B TDR
Date 8/16/93
Cable 1
Notes Shorted at far end

Input Trace
Stored Trace
Difference Trace

Figure B-1. TDR Traces Obtained During Calibration

e Number 3 - Probe in Air

or .... 15.880 m
nce/Div..... .25 m/div
cal Scale.... 177 mρ/div
.... 0.99
Filter...... 1 avg
r........... bat



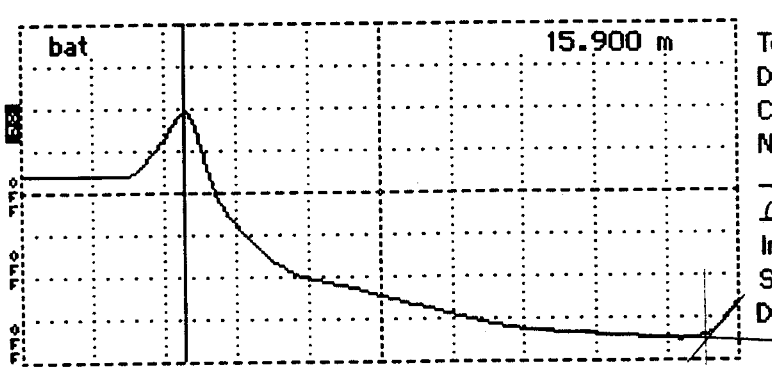
Tektronix 1502B TDR
Date 8/16/93
Cable 1
Notes in air @
24.6° C

Input Trace
Stored Trace
Difference Trace

ce Number 4 - Probe in Alcohol

nce Number 5 - Probe in Water

or .... 15.900 m
nce/Div..... .25 m/div
cal Scale.... 91.5 mρ/div
.... 0.99
Filter...... 1 avg
.... bat



Tektronix 1502B TDR
Date 8-16-93
Cable 1
Notes water @
24.0°C
Groton, CT
Input Trace
Stored Trace
Difference Trace

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

LTPP Seasonal Monitoring Study	State Code	[0 1]
TDR Probe Calibration	Test Section Number	[1 8 0 3]

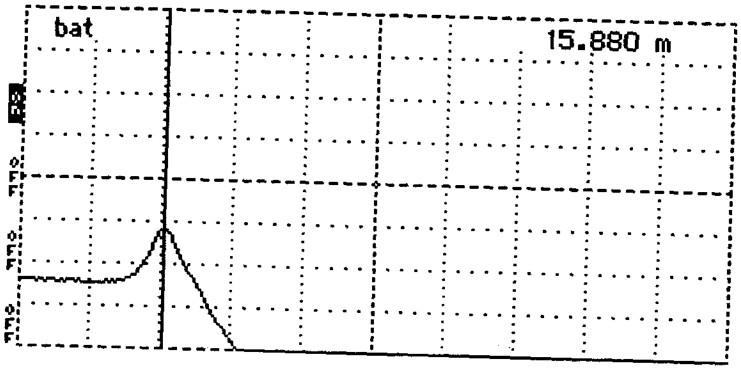
ɔre Operation Checks

- Calibration Date 8/16/93
- Probe S/N 0947

Probe Number 2

ı Trace 1 - Beginning Probe Shorted

-sor .... 15.880 m
tance/Div..... .25 m/div
-tical Scale.... 182 mρ/div
.... 0.99
se Filter...... 1 avg
wer.......... bat



Tektronix 1502B TDR
Date 8/16/93
Cable #2
Notes Shorted @ C.B.

Input Trace
Stored Trace
Difference Trace

ɔce Number 2 - Ending Probe Shorted

ɔr .... 16.040 m
nce/Div..... .25 m/div
cal Scale.... 182 mρ/div
.... 0.99
› Filter...... 1 avg
ɔr.......... bat

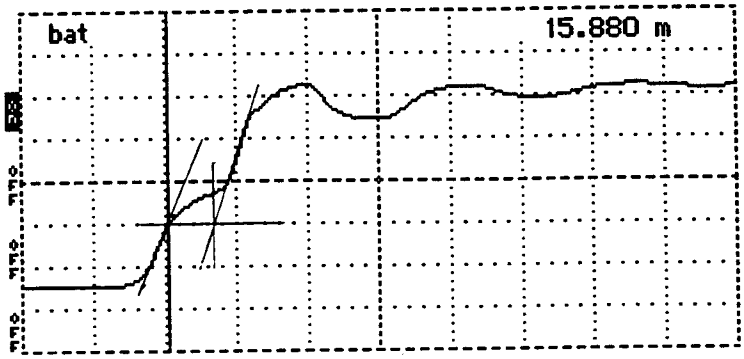
Tektronix 1502B TDR
Date 8/16/93
Cable 2
Notes Shorted @ far end

Input Trace
Stored Trace
Difference Trace

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

ce Number 3 - Probe in Air

rsor .... 15.880 m
stance/Div..... .25 m/div
rtical Scale.... 182 mρ/div
.... 0.99
ise Filter...... 1 avg
wer........... bat



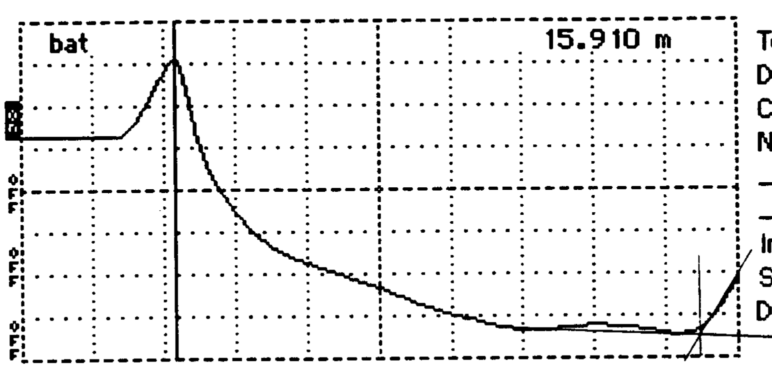
Tektronix 1502B TDR
Date 8/16/93
Cable 2
Notes in air @ 24.0°C

Input Trace
Stored Trace
Difference Trace

ace Number 4 - Probe in Alcohol

Trace Number 5 - Probe in Water

rsor .... 15.910 m
tance/Div..... .25 m/div
rtical Scale.... 74.8 mρ/div
.... 0.99
se Filter...... 1 avg
r........... bat



Tektronix 1502B TDR
Date 8/16/93
Cable 2
Notes in water @ 24.1°C

Input Trace
Stored Trace
Difference Trace

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

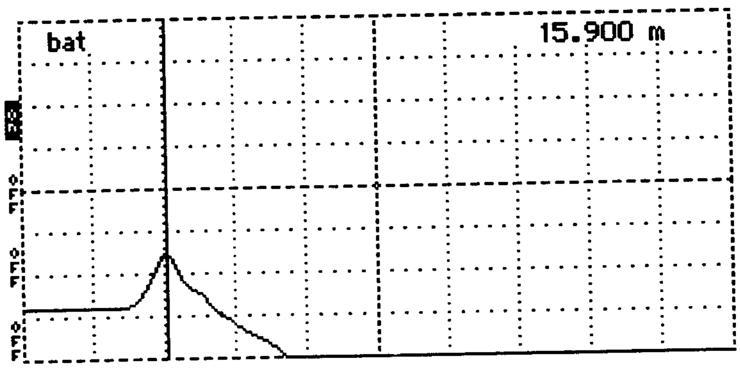
LTPP Seasonal Monitoring Study	State Code	[0 4]
TDR Probe Calibration	Test Section Number	[1 2 0 3]

ore Operation Checks
- Calibration Date 8/16/92
- Probe S/N 04 A 3

Probe Number 3

R Trace 1 - Beginning Probe Shorted

rsor .... 15.900 m
tance/Div..... .25 m/div
rtical Scale.... 177 mρ/div
 .... 0.99
ise Filter...... 1 avg
wer........... bat

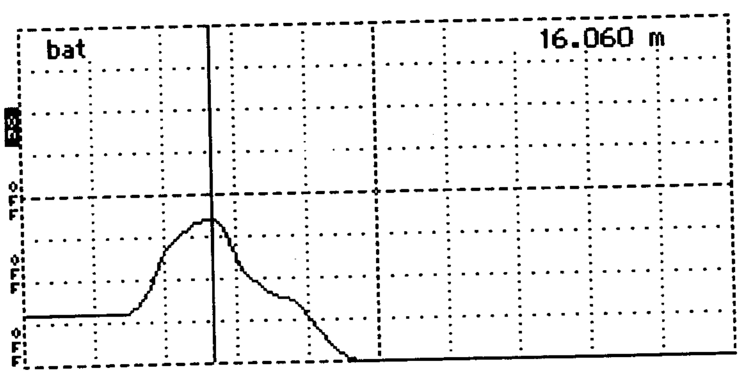


Tektronix 1502B TDR
Date 8/16/93
Cable #3
Notes Shorted @ C.B.

Input Trace
Stored Trace
Difference Trace

ace Number 2 - Ending Probe Shorted

ursor .... 16.060 m
istance/Div..... .25 m/div
ertical Scale.... 177 mρ/div
P 0.99
oise Filter...... 1 avg
ower........... bat



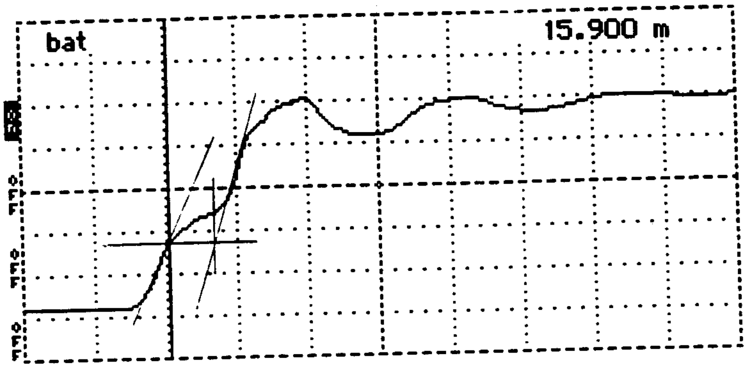
Tektronix 1502B TDR
Date 8/16/93
Cable #3
Notes Shorted @ far end

Input Trace
Stored Trace
Difference Trace

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

e Number 3 - Probe In Air

rsor .... 15.900 m
stance/Div..... .25 m/div
rtical Scale.... 177 mρ/div
 .... 0.99
ise Filter...... 1 avg
wer........... bat



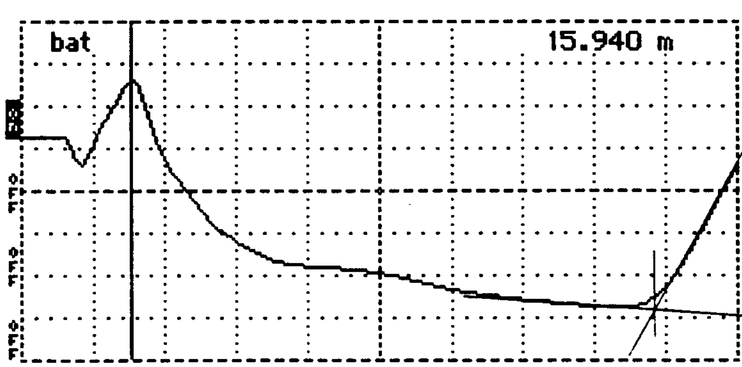
Tektronix 1502B TDR
Date 8/16/93
Cable #3
Notes in air @
24.6°C

Input Trace
Stored Trace
Difference Trace

e Number 4 - Probe In Alcohol

.e Number 5 - Probe In Water

sor .... 15.940 m
ance/Div..... .25 m/div
ical Scale.... 88.9 mρ/div
 .... 0.99
e Filter...... 1 avg
r........... bat



Tektronix 1502B TDR
Date 8/16/93
Cable #3
Notes in water @
24.0°C

Input Trace
Stored Trace
Difference Trace

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

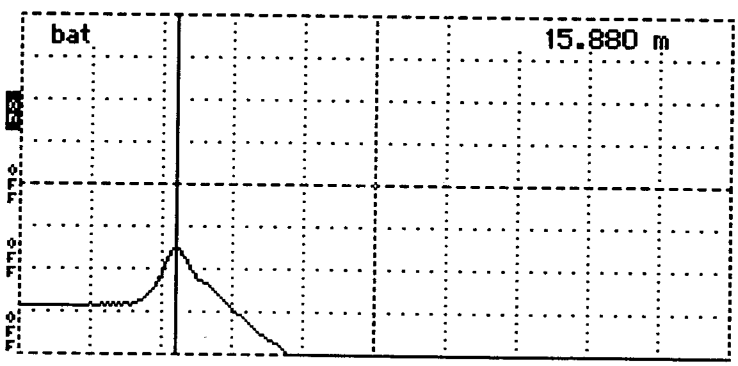
LTPP Seasonal Monitoring Study	State Code	[illegible]
TDR Probe Calibration	Test Section Number	[illegible]

ore Operation Checks
- Calibration Date 8/16/93
- Probe S/N 19A4

Probe Number 4

R Trace 1 - Beginning Probe Shorted

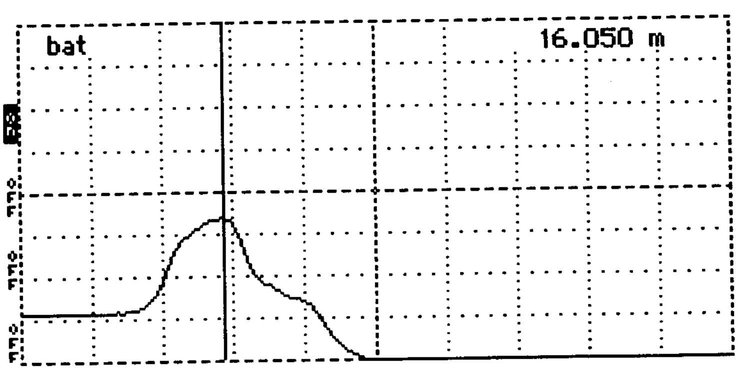
r .... 15.880 m
nce/Div..... .25 m/div
cal Scale.... 177 mρ/div
.... 0.99
Filter...... 1 avg
r........... bat



Tektronix 1502B TDR
Date 8/16/93
Cable #4
Notes Shorted @ C.B
Input Trace
Stored Trace
Difference Trace

ce Number 2 - Ending Probe Shorted

or .... 16.050 m
ance/Div..... .25 m/div
ical Scale.... 177 mρ/div
.... 0.99
e Filter...... 1 avg
er........... bat

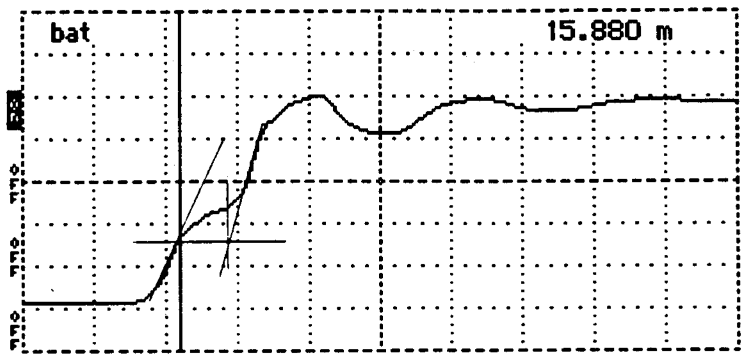


Tektronix 1502B TDR
Date 8/16/93
Cable #4
Notes Shorted at far end
Input Trace
Stored Trace
Difference Trace

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

ce Number 3 - Probe in Air

sor .... 15.880 m
tance/Div..... .25 m/div
tical Scale.... 177 mρ/div
.... 0.99
se Filter...... 1 avg
ver.......... bat



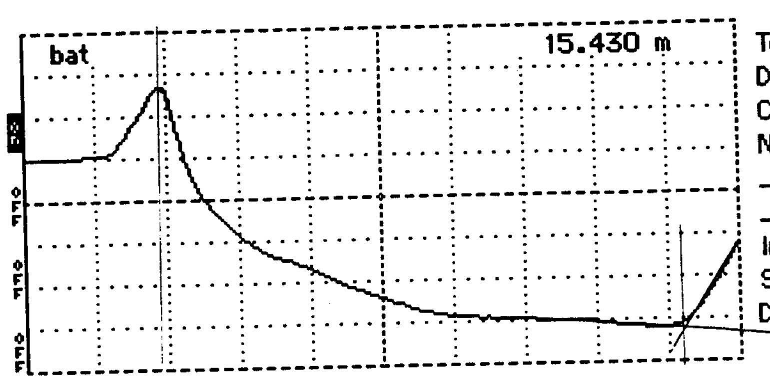
Tektronix 1502B TDR
Date 8/16/93
Cable #4
Notes in air @
24.6°C

Input Trace
Stored Trace
Difference Trace

ce Number 4 - Probe in Alcohol

ace Number 5 - Probe in Water

rsor .... 15.430 m
stance/Div..... .25 m/div
rtical Scale.... 83.9 mρ/div
.... 0.99
ise Filter...... 1 avg
r.......... bat



Tektronix 1502B TDR
Date 8/16/93
Cable #4
Notes in water @
24°C

Input Trace
Stored Trace
Difference Trace

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

LTPP Seasonal Monitoring Study	State Code	[04]
TDR Probe Calibration	Test Section Number	[1803]

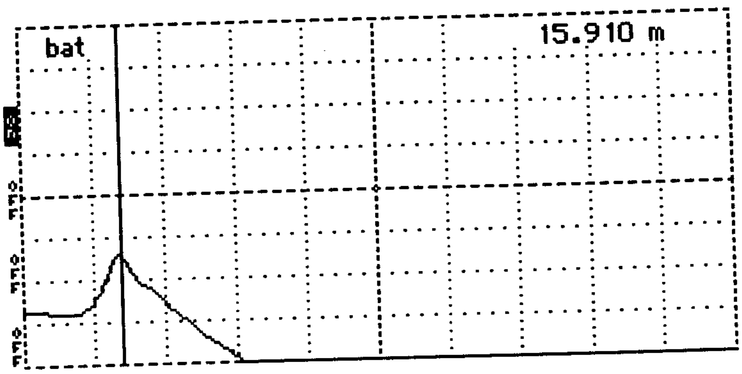
ore Operation Checks

- Calibration Date 8/16/93
- Probe S/N 09AC

Probe Number 5

R Trace 1 - Beginning Probe Shorted

sor .... 15.910 m
ance/Div ..... .25 m/div
tical Scale.... 177 mρ/div
.... 0.99
se Filter ...... 1 avg
r .... bat

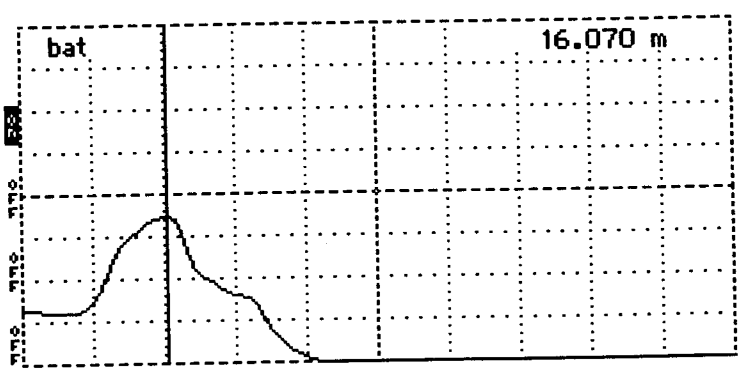


Tektronix 1502B TDR
Date 8/16/93
Cable #5
Notes Shorted @ CB

Input Trace
Stored Trace
Difference Trace

ce Number 2 - Ending Probe Shorted

rsor .... 16.070 m
stance/Div ..... .25 m/div
rtical Scale.... 177 mρ/div
.... 0.99
ise Filter ...... 1 avg
wer .... bat



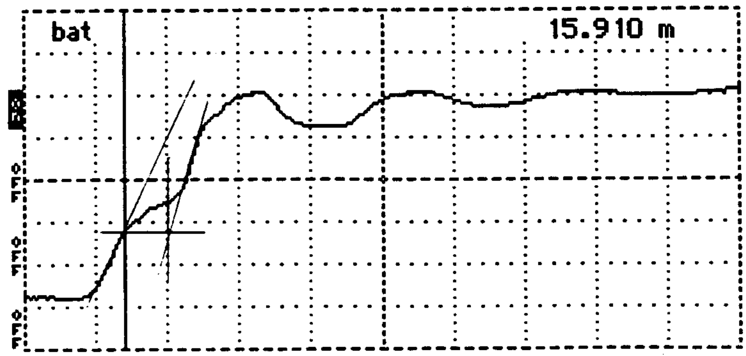
Tektronix 1502B TDR
Date 8/16/93
Cable #5
Notes Shorted @ far end

Input Trace
Stored Trace
Difference Trace

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

ace Number 3 - Probe in Air

sor .... 15.910 m
tance/Div..... .25 m/div
rtical Scale.... 177 mρ/div
.... 0.99
se Filter...... 1 avg
wer............ bat



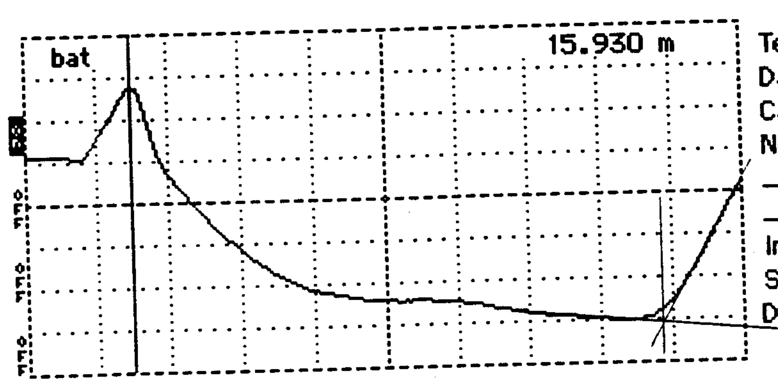
Tektronix 1502B TDR
Date 8/16/93
Cable #5
Notes in air @
24.6°C

Input Trace
Stored Trace
Difference Trace

race Number 4 - Probe in Alcohol

race Number 5 - Probe in Water

sor .... 15.930 m
ance/Div..... .25 m/div
ical Scale.... 86.4 mρ/div
.... 0.99
e Filter...... 1 avg
er............ bat



Tektronix 1502B TDR
Date 8/16/93
Cable #5
Notes in water @
24°C

Input Trace
Stored Trace
Difference Trace

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

LTPP Seasonal Monitoring Study	State Code	[2 4]
TDR Probe Calibration	Test Section Number	[1 5 2 3]

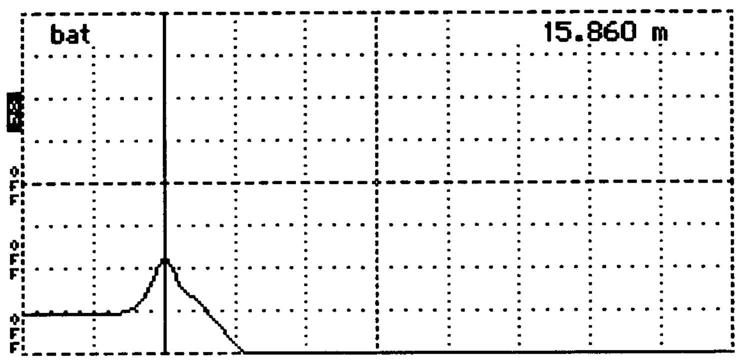
fore Operation Checks

- Calibration Date 9/4 93
- Probe S/N 06 A1

Probe Number 6

DR Trace 1 - Beginning Probe Shorted

rsor .... 15.860 m
stance/Div..... .25 m/div
rtical Scale.... 177 mρ/div
.... 0.99
ise Filter...... 1 avg
wer........... bat

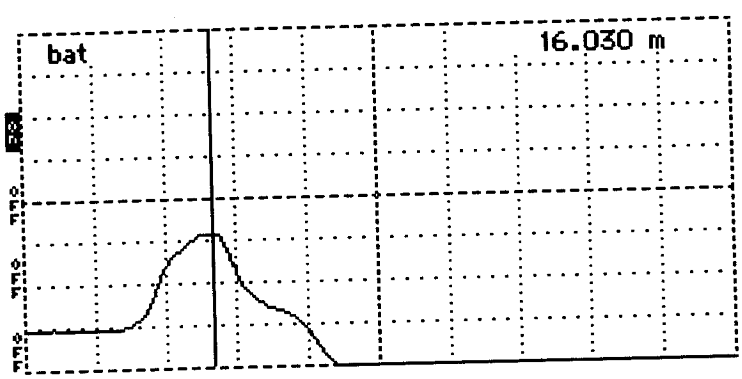


Tektronix 1502B TDR
Date 8/16/93
Cable #6
Notes Shorted @ CB

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

ace Number 2 - Ending Probe Shorted

ursor .... 16.030 m
stance/Div..... .25 m/div
ertical Scale.... 177 mρ/div
P 0.99
oise Filter...... 1 avg
ower........... bat



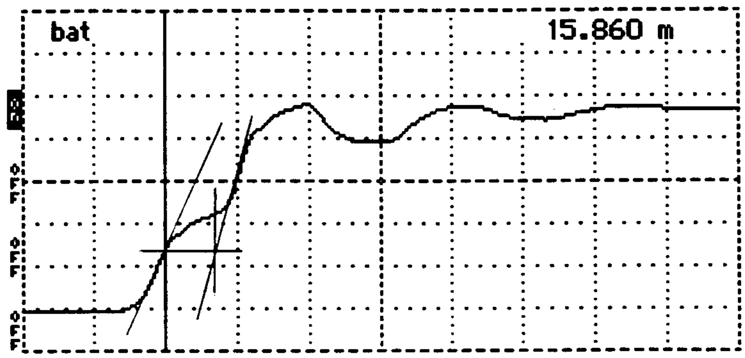
Tektronix 1502B TDR
Date 8/16/93
Cable #6
Notes Shorted @ far end

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

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

ace Number 3 - Probe in Air

ursor .... 15.860 m
stance/Div..... .25 m/div
ertical Scale.... 177 mρ/div
ρ 0.99
oise Filter...... 1 avg
ower........... bat



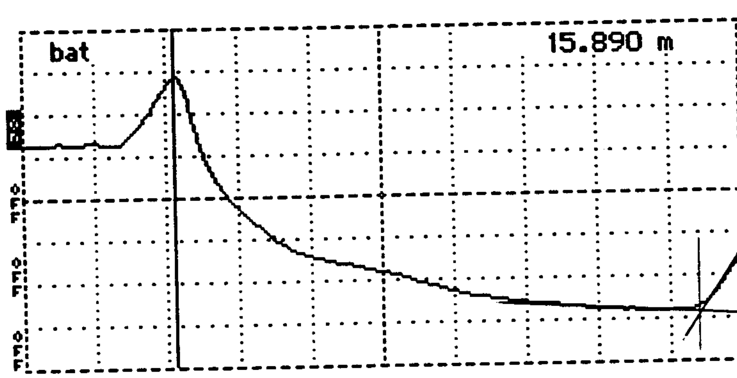
Tektronix 1502B TDR
Date 8/16/93
Cable #6
Notes in air @ 24.6°C

Input Trace
Stored Trace
Difference Trace

race Number 4 - Probe in Alcohol

race Number 5 - Probe in Water

ursor .... 15.890 m
stance/Div..... .25 m/div
ertical Scale.... 86.4 mρ/div
ρ 0.99
oise Filter...... 1 avg
ower........... bat



Tektronix 1502B TDR
Date 8/16/93
Cable #6
Notes in water @ 24°C

Input Trace
Stored Trace
Difference Trace

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

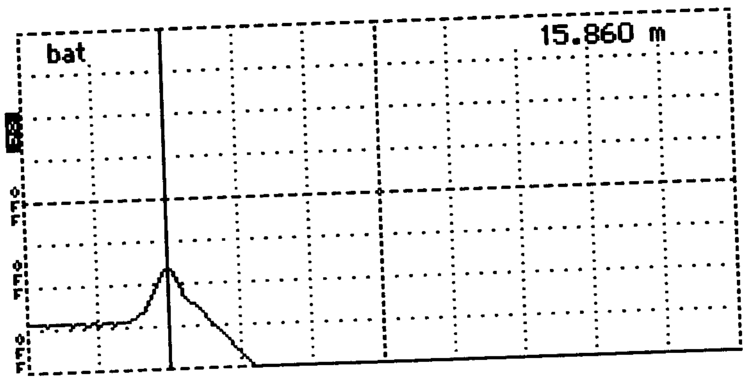
LTPP Seasonal Monitoring Study TDR Probe Calibration	State Code	[2 7]
	Test Section Number	[1 0 2 3]

ore Operation Checks - Calibration Date 8/16/93
- Probe S/N 04A7

Probe Number 7

R Trace 1 - Beginning Probe Shorted

rsor .... 15.860 m
stance/Div..... .25 m/div
rtical Scale.... 177 mρ/div
.... 0.99
ise Filter...... 1 avg
wer........... bat

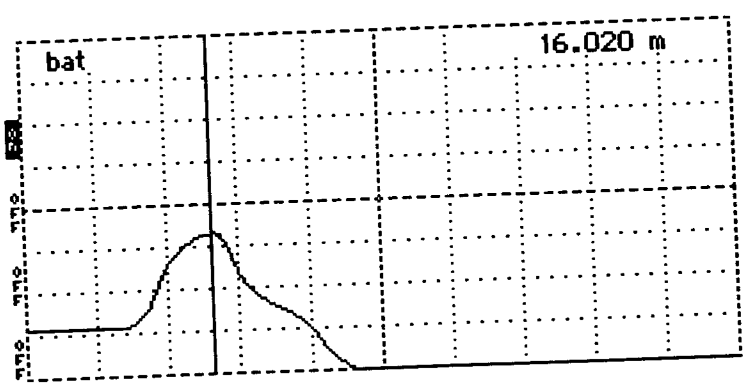


Tektronix 1502B TDR
Date 8/16/93
Cable #7
Notes Shorted @ CB

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

ace Number 2 - Ending Probe Shorted

rsor .... 16.020 m
stance/Div..... .25 m/div
rtical Scale.... 177 mρ/div
.... 0.99
ise Filter...... 1 avg
wer........... bat



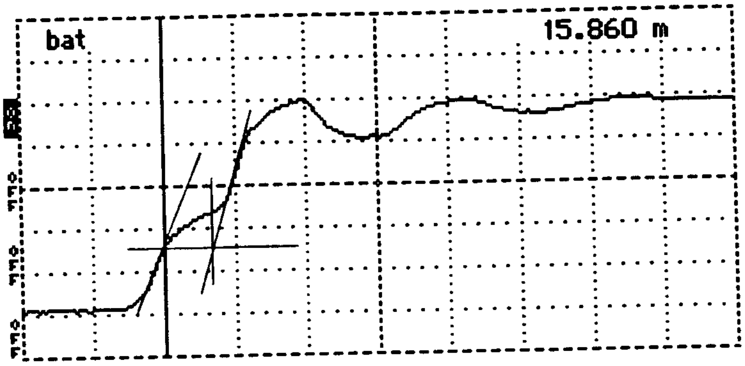
Tektronix 1502B TDR
Date 8/16/93
Cable #7
Notes Shorted @ far end

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

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

e Number 3 - Probe in Air

ursor .... 15.860 m
istance/Div ..... .25 m/div
'ertical Scale.... 177 mρ/div
'P 0.99
loise Filter ...... 1 avg
'ower .... bat



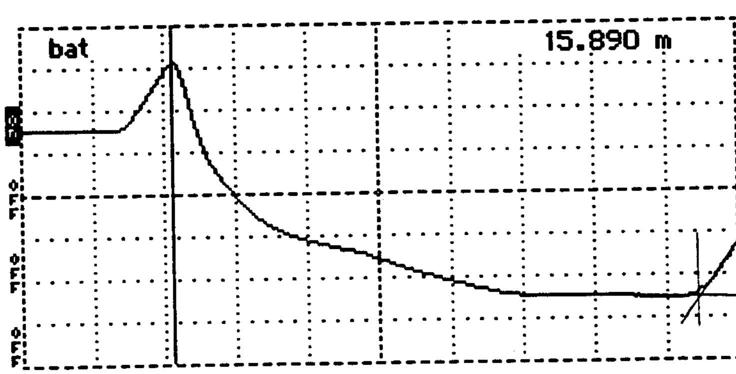
Tektronix 1502B TDR
Date 8/16/93
Cable #7
Notes in air @ 24.6°C

Input Trace
Stored Trace
Difference Trace

ce Number 4 - Probe in Alcohol

ice Number 5 - Probe in Water

rsor .... 15.890 m
stance/Div ..... .25 m/div
rtical Scale.... 86.4 mρ/div
.... 0.99
'se Filter ...... 1 avg
ver .... bat



Tektronix 1502B TDR
Date 8/16/93
Cable #7
Notes in water @ 24°C

Input Trace
Stored Trace
Difference Trace

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

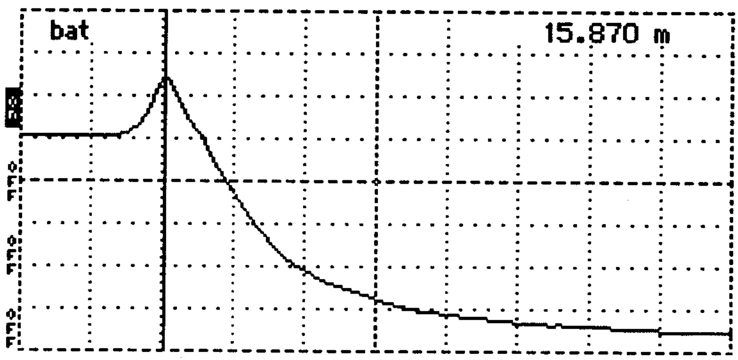
LTPP Seasonal Monitoring Study	State Code	[0 4]
TDR Probe Calibration	Test Section Number	[1 8 0 2]

ore Operation Checks
- Calibration Date 8/16/93
- Probe S/N 09A8

Probe Number 8

R Trace 1 - Beginning Probe Shorted

sor .... 15.870 m
tance/Div..... .25 m/div
tical Scale.... 177 mρ/div
.... 0.99
se Filter...... 1 avg
ver........... bat

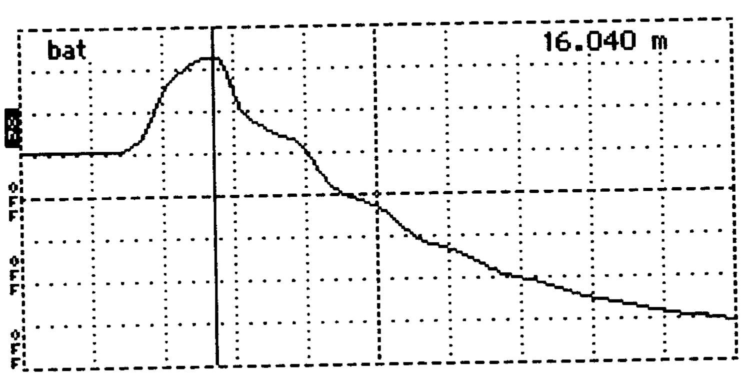


Tektronix 1502B TDR
Date 8/16/93
Cable #8
Notes Shorted @ CB

Input Trace
Stored Trace
Difference Trace

ce Number 2 - Ending Probe Shorted

ursor .... 16.040 m
istance/Div..... .25 m/div
ertical Scale.... 177 mρ/div
P 0.99
oise Filter...... 1 avg
ower........... bat



Tektronix 1502B TDR
Date 8/16/93
Cable #8
Notes Shorted @ far end

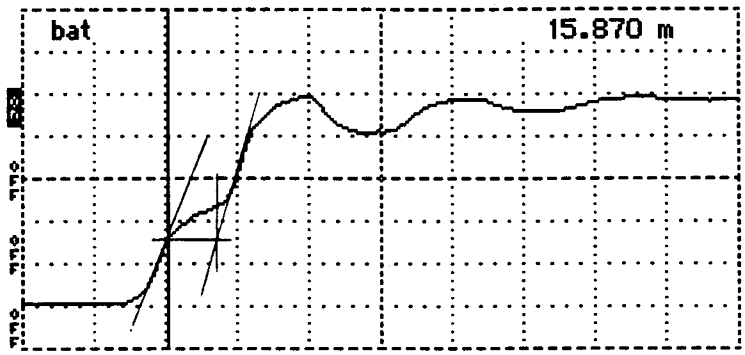
Input Trace
Stored Trace
Difference Trace

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

Probe Number 8 (cont.)

ce Number 3 - Probe in Air

ursor .... 15.870 m
istance/Div ..... .25 m/div
ertical Scale.... 177 mρ/div
P 0.99
loise Filter...... 1 avg
ower........... bat



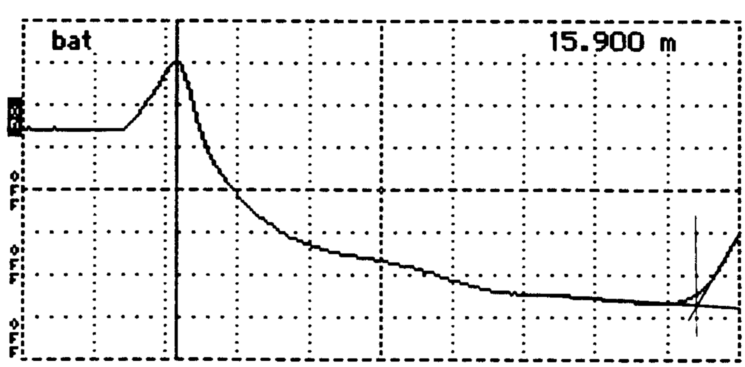
Tektronix 1502B TDR
Date 8/16/93
Cable #8
Notes in air @ 24.6°C

Input Trace
Stored Trace
Difference Trace

ce Number 4 - Probe in Alcohol

ce Number 5 - Probe in Water

rsor .... 15.900 m
tance/Div ..... .25 m/div
rtical Scale.... 86.4 mρ/div
.... 0.99
se Filter...... 1 avg
r........... bat



Tektronix 1502B TDR
Date 8/16/93
Cable #8
Notes in water @ 24°C

Input Trace
Stored Trace
Difference Trace

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

LTPP Seasonal Monitoring Study	State Code	[0 1]
TDR Probe Calibration	Test Section Number	[1 8 0 2]

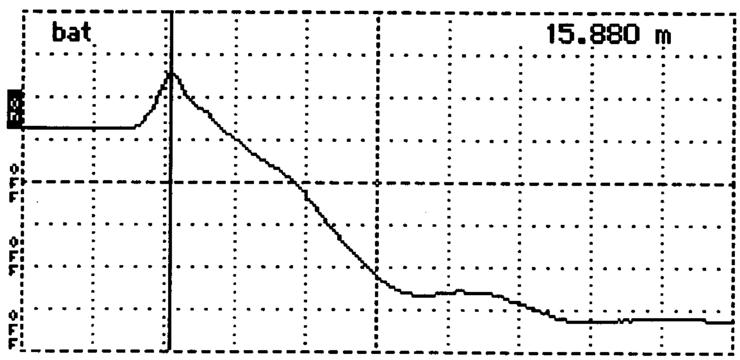
re Operation Checks

- Calibration Date 8/16/93
- Probe S/N 24A9

Probe Number 9

Trace 1 - Beginning Probe Shorted

rsor .... 15.880 m
tance/Div..... .25 m/div
tical Scale.... 177 mρ/div
.... 0.99
se Filter...... 1 avg
ver............ bat

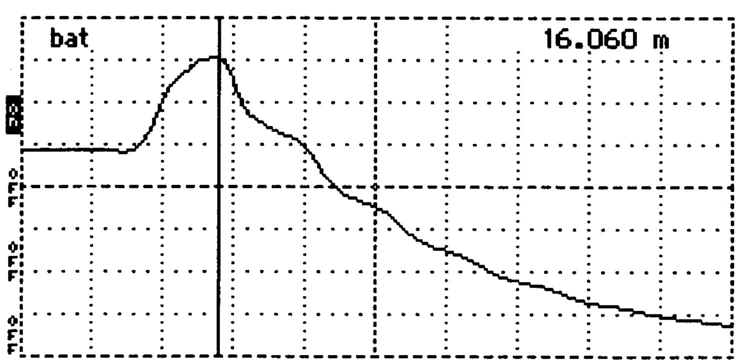


Tektronix 1502B TDR
Date 8/16/93
Cable #9
Notes Shorted @ CD

Input Trace
Stored Trace
Difference Trace

e Number 2 - Ending Probe Shorted

rsor .... 16.060 m
stance/Div..... .25 m/div
rtical Scale.... 177 mρ/div
.... 0.99
ise Filter...... 1 avg
wer............ bat



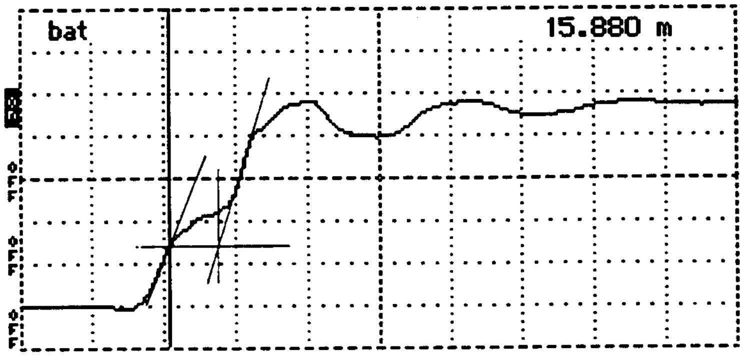
Tektronix 1502B TDR
Date 8/16/93
Cable #9
Notes Shorted @ far end

Input Trace
Stored Trace
Difference Trace

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

ce Number 3 - Probe in Air

sor .... 15.880 m
tance/Div..... .25 m/div
tical Scale.... 177 mρ/div
.... 0.99
se Filter...... 1 avg
ver........... bat



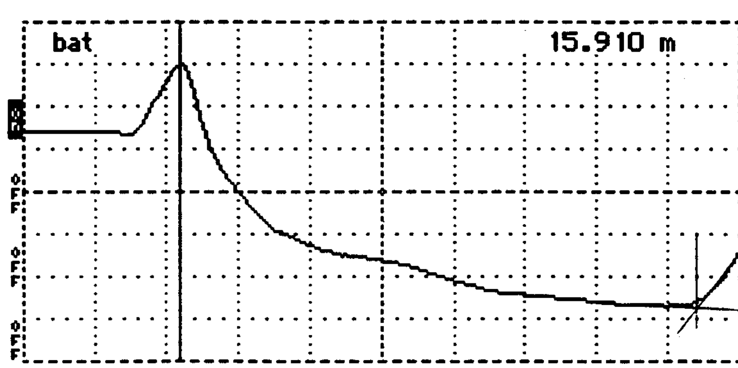
Tektronix 1502B TDR
Date 8/16/93
Cable #9
Notes in air @
24.6°C

Input Trace
Stored Trace
Difference Trace

e Number 4 - Probe in Alcohol

e Number 5 - Probe in Water

ursor .... 15.910 m
istance/Div..... .25 m/div
ertical Scale.... 86.4 mρ/div
P 0.99
oise Filter...... 1 avg
wer........... bat



Tektronix 1502B TDR
Date 8/16/93
Cable #9
Notes in water @
24°C

Input Trace
Stored Trace
Difference Trace

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

LTPP Seasonal Monitoring Study	State Code	[04]
TDR Probe Calibration	Test Section Number	[1802]

ore Operation Checks
- Calibration Date 8/13/93
- Probe S/N 09A10

Probe Number 10

Trace 1 - Beginning Probe Shorted

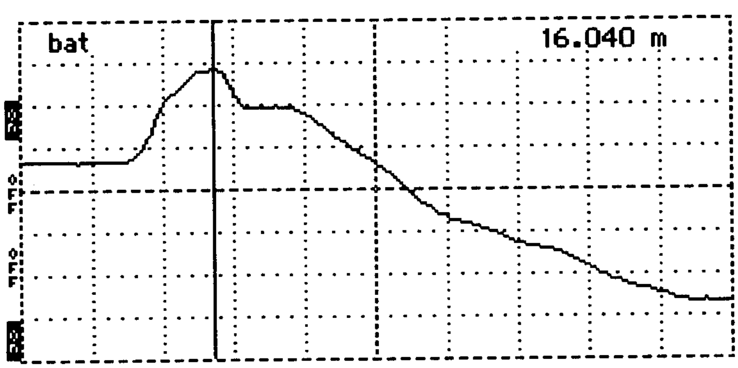
sor .... 15.880 m
ance/Div ..... .25 m/div
tical Scale.... 177 mρ/div
.... 0.99
e Filter ...... 1 avg
er .... bat

Tektronix 1502B TDR
Date 8/16/93
Cable 10
Notes Shorted @ CB

Input Trace
Stored Trace
Difference Trace

ce Number 2 - Ending Probe Shorted

sor .... 16.040 m
tance/Div ..... .25 m/div
tical Scale.... 177 mρ/div
.... 0.99
se Filter ...... 1 avg
ver .... bat



Tektronix 1502B TDR
Date 8/16/93
Cable 10
Notes Shorted @ far end

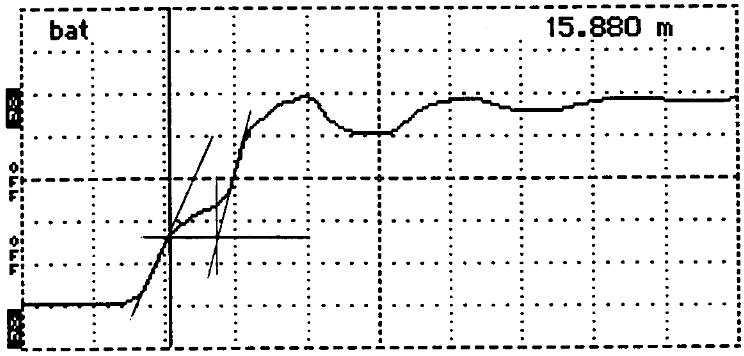
Input Trace
Stored Trace
Difference Trace

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

Probe Number 10 (cont.)

e Number 3 - Probe in Air

r .... 15.880 m
nce/Div..... .25 m/div
cal Scale.... 177 mρ/div
.... 0.99
Filter...... 1 avg
r........... bat/low



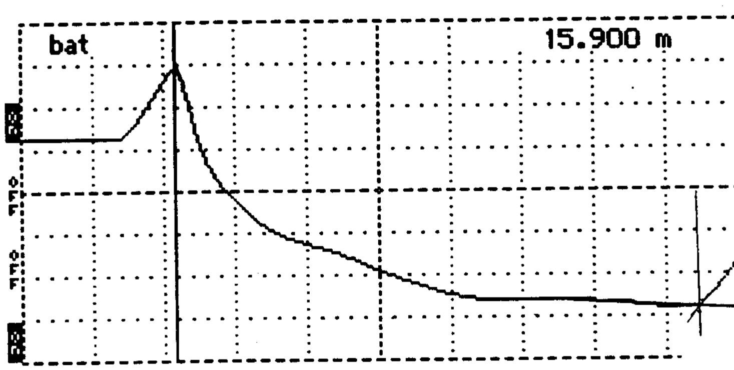
Tektronix 1502B TDR
Date 8/16/93
Cable 10
Notes in air @ 24.6°C

Input Trace
Stored Trace
Difference Trace

e Number 4 - Probe in Alcohol

ce Number 5 - Probe in Water

sor .... 15.900 m
ance/Div..... .25 m/div
tical Scale.... 86.4 mρ/div
.... 0.99
se Filter...... 1 avg
er........... bat



Tektronix 1502B TDR
Date 8/16/93
Cable 10
Notes In water @ 24°C

Input Trace
Stored Trace
Difference Trace

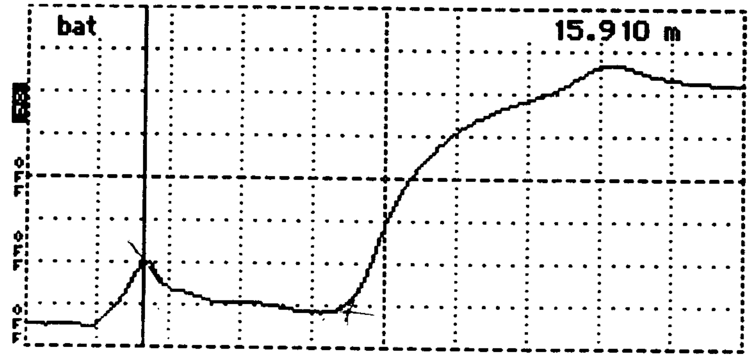
Figure B-1(cont.). TDR Traces Obtained During Calibration

APPENDIX C

Supporting Instrumentation Installation Information

Appendix C contains the following supporting information:

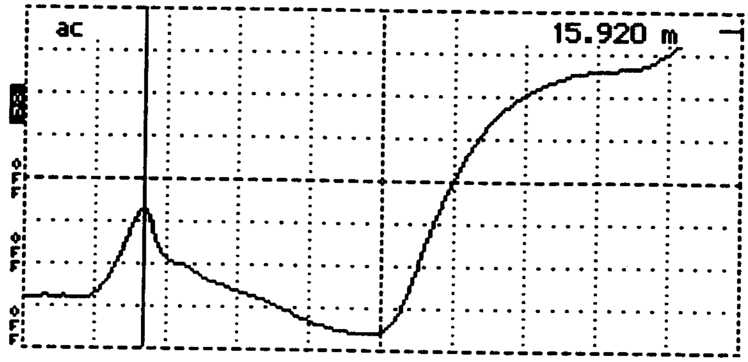
sor .... 15.910 m
ance/Div..... .25 m/div
tical Scale.... 126 mρ/div
.... 0.99
Filter...... 1 avg
er............ bat



Tektronix 1502B TDR
Date 8/18/93
Cable #1
Notes

Groton CT
Input Trace
Stored Trace
Difference Trace

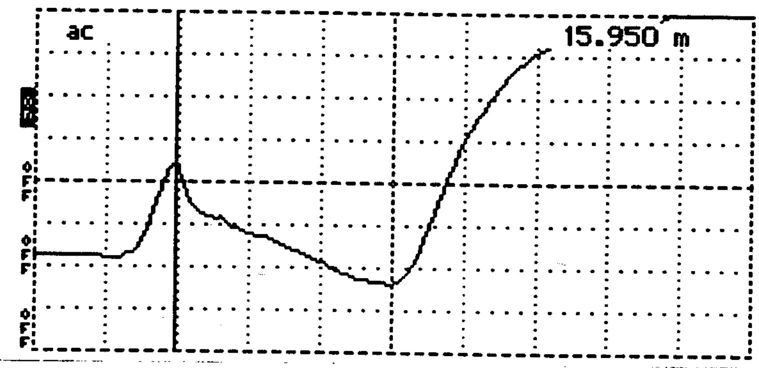
or .... 15.920 m
ance/Div..... .25 m/div
ical Scale.... 83.9 mρ/div
.... 0.99
e Filter...... 1 avg
er............ ac



Tektronix 1502B TDR
Date 8/18/93
Cable 2
Notes

Input Trace
Stored Trace
Difference Trace

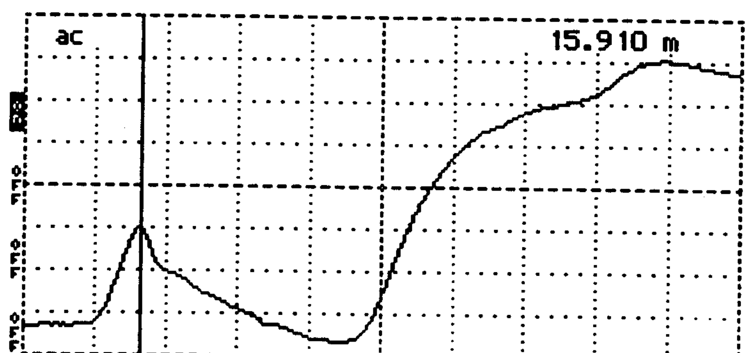
or .... 15.950 m
ance/Div..... .25 m/div
ical Scale.... 79.2 mρ/div
.... 0.99
e Filter...... 1 avg
er............ ac



Tektronix 1502B TDR
Date 8-18-93
Cable #3
Notes DARK BROWN
[illegible]

Input Trace
Stored Trace
Difference Trace

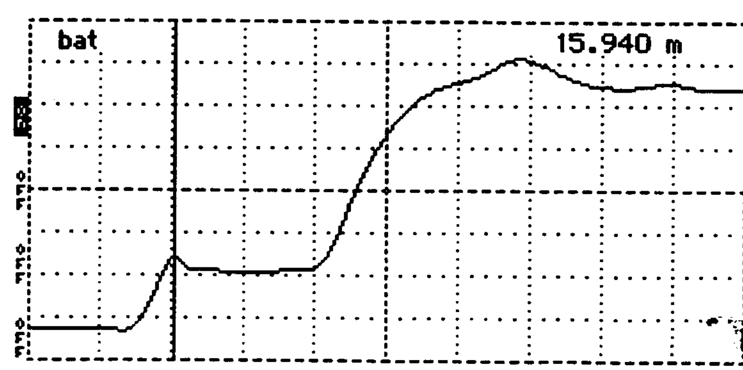
sor .... 15.910 m
ance/Div..... .25 m/div
rical Scale.... 83.9 mρ/div
.... 0.99
e Filter...... 1 avg
er............ ac



Tektronix 1502B TDR
Date 8/18/93
Cable 4
Notes

Input Trace
Stored Trace
Difference Trace

sor .... 15.940 m
ance/Div..... .25 m/div
tical Scale.... 126 mρ/div
.... 0.99
e Filter...... 1 avg
er............ bat/low

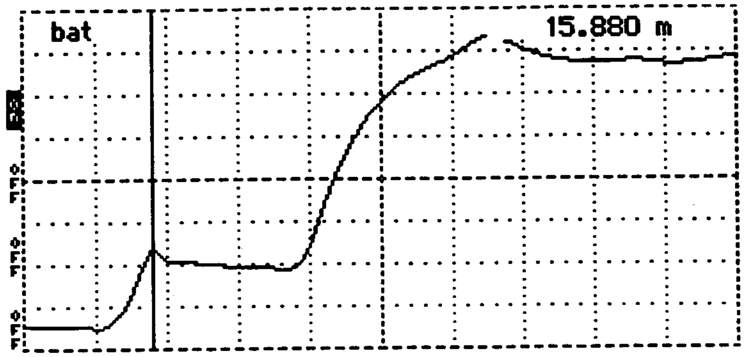


Tektronix 1502B TDR
Date 8/18/93
Cable 5
Notes Silty Sand

Input Trace
Stored Trace
Difference Trace

Figure C-1. TDR Traces Measured Manually During Installation

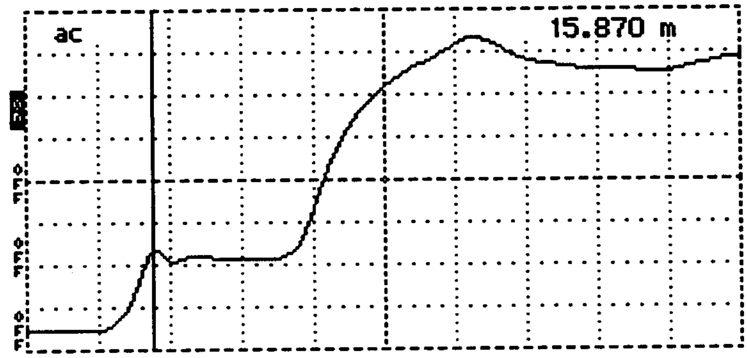
sor .... 15.880 m
tance/Div..... .25 m/div
tical Scale.... 115 mρ/div
.... 0.99
se Filter...... 1 avg
er........... bat



Tektronix 1502B TDR
Date 8/18/93
Cable 6
Notes Silty loam

Input Trace
Stored Trace
Difference Trace

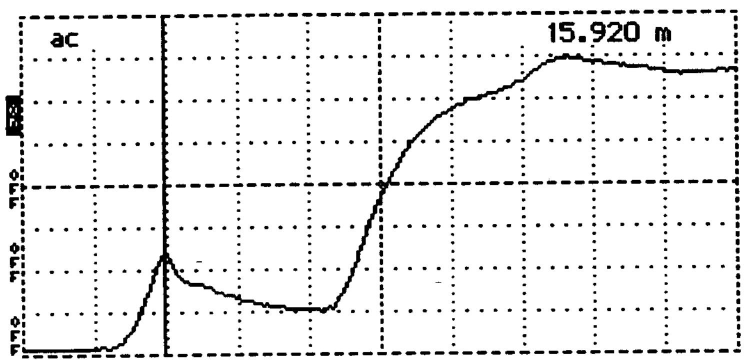
sor .... 15.870 m
tance/Div..... .25 m/div
rtical Scale.... 115 mρ/div
.... 0.99
se Filter...... 1 avg
ver........... ac



Tektronix 1502B TDR
Date 8/18/93
Cable 7
Notes silty loam

Input Trace
Stored Trace
Difference Trac

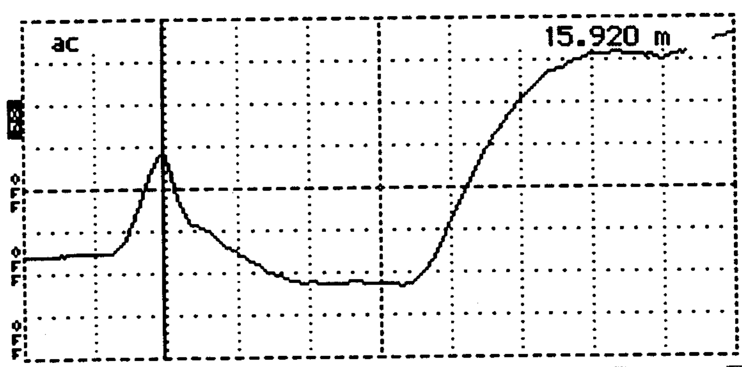
sor .... 15.920 m
tance/Div..... .25 m/div
tical Scale.... 94.1 mρ/div
.... 0.99
se Filter...... 1 avg
ver........... ac



Tektronix 1502B TDR
Date 8/18/93
Cable 8
Notes in Silty loam

Input Trace
Stored Trace
Difference Trace

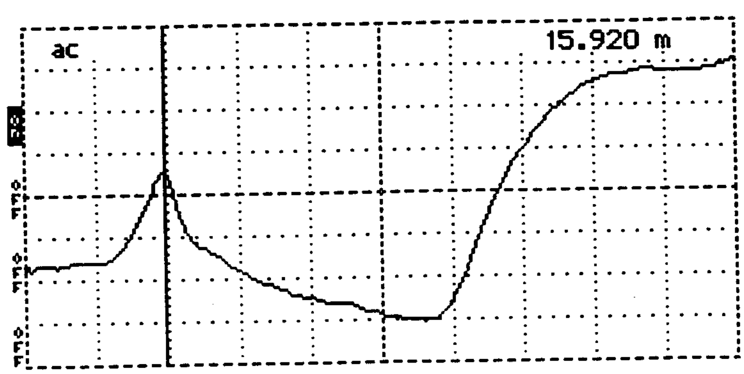
rsor .... 15.920 m
tance/Div..... .25 m/div
rtical Scale.... 79.2 mρ/div
.... 0.99
se Filter...... 1 avg
wer........... ac



Tektronix 1502B TDR
Date 8/18/93
Cable 9
Notes in black loam

Input Trace
Stored Trace
Difference Trace

sor .... 15.920 m
ance/Div..... .25 m/div
tical Scale.... 79.2 mρ/div
.... 0.99
e Filter...... 1 avg
er........... ac



Tektronix 1502B TDR
Date 8/18/93
Cable 10
Notes in light brown Silt

Input Trace
Stored Trace
Difference Trace

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

Table C-1. TDR Moisture Content During Installation

TDR No.	TDR Length (m)	Dielectric Constant	Volumetric Moisture Content (%)	In-Situ Dry Density (kg/m³)*	Gravimetric Moisture Content (%)
09A01	0.80	15.54	28.6	2264	12.63
09A02	0.90	19.67	34.3	2264	15.15
09A03	0.80	15.54	28.6	2264	12.63
09A04	0.76	14.02	26.2	2264	11.57
09A05	0.50	6.07	10.6	2264	4.68
09A06	0.55	7.34	13.4	2264	5.92
09A07	0.50	6.07	10.6	2264	4.68
09A08	0.61	9.03	17.0	2264	7.51
09A09	0.90	19.67	34.3	2264	15.15
09A10	0.97	22.84	38.1	2264	16.83

* Note: In-Situ dry density of base layer used, since no data is available for the subbase or subgrade.

Table C-2. Field Measured Moisture Content During Installation

LTPP Seasonal Monitoring Study	State Code	[09]
In-Situ Moisture Tests	Test Section Number	[1803]

Weight (gm)	Probe 1	Probe 2	Probe 3	Probe 4	Probe 5
Weight of Pan + Wet Soil		378.5		305.6	340.4
Weight of Pan + Dry Soil		352.0		281.8	324.5
Weight of Pan		120.0		120.3	120.0
Weight of Dry Soil		232.0		161.5	204.5
Weight of Wet Soil		258.5		185.3	220.4
Weight of Moisture		26.5		23.8	15.9
Wt of Moisture/Dry Wt x 100		11.4		14.7	7.8

Weight (gm)	Probe 6	Probe 7	Probe 8	Probe 9	Probe 10
Weight of Pan + Wet Soil	407.9	352.1	281.3		
Weight of Pan + Dry Soil	394.1	336.9	267.9		
Weight of Pan	119.6	120.3	119.8		
Weight of Dry Soil	274.5	216.6	148.1		
Weight of Wet Soil	288.3	231.8	161.5		
Weight of Moisture	13.8	15.2	13.4		
Wt of Moisture/Dry Wt x 100	5.0	7.0	9.0		

APPENDIX D

Initial Data Collection

Appendix D contains the following supporting information:

Table D-1. Data from the Onsite Datalogger During Initial Data Collection, August 19, 1993

```
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4,231,1422,25.11,0
5,231,1422,37.42,30.45,25.89,23.87,23.6
4,231,1423,24.86,0
5,231,1423,37.46,30.47,25.9,23.88,23.6
1,1993,231,24.91,25.14,1421,24.61,1423,0,-6999,-6999,1420,-6999,1420,37.44,30.46,25.9,23.88,23.6,23.54,23.83,24.1,24.4,24.45,24.32,23.94,23.64,23.16,22.44,21.94,21.34,20.84
2,1993,231,37.53,1423,30.49,1423,25.92,1422,23.91,1423,23.6,1422,23.55,1422,23.83,1422,24.12,1422,24.4,1422,24.45,1422,24.32,1422,23.94,1422,23.65,1422,23.16,1422,22.46,1422,
21.94,1422,21.34,1422,20.84,1422
3,1993,231,37.32,1420,30.41,1420,25.86,1420,23.86,1420,23.6,1420,23.52,1420,23.83,1420,24.09,1420,24.4,1420,24.45,1420,24.32,1420,23.94,1420,23.63,1420,23.16,1420,22.43,1420,
21.94,1420,21.34,1420,20.84,1420
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4,231,1428,24.62,0
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5,231,1429,37.84,30.59,26.02,23.94,23.63
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2050,-2050,-1984,-2016,-2031,-2039,-2044,-2045
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4,231,1435,25.69,3
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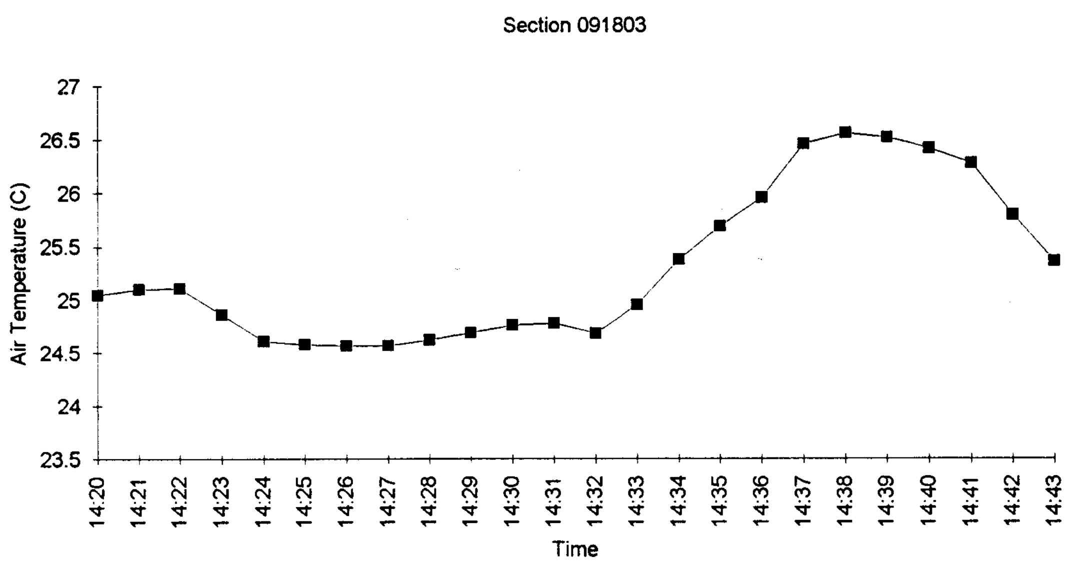


Figure D-1. Measured Air Temperature
During Initial Data Collection, August 19, 1993

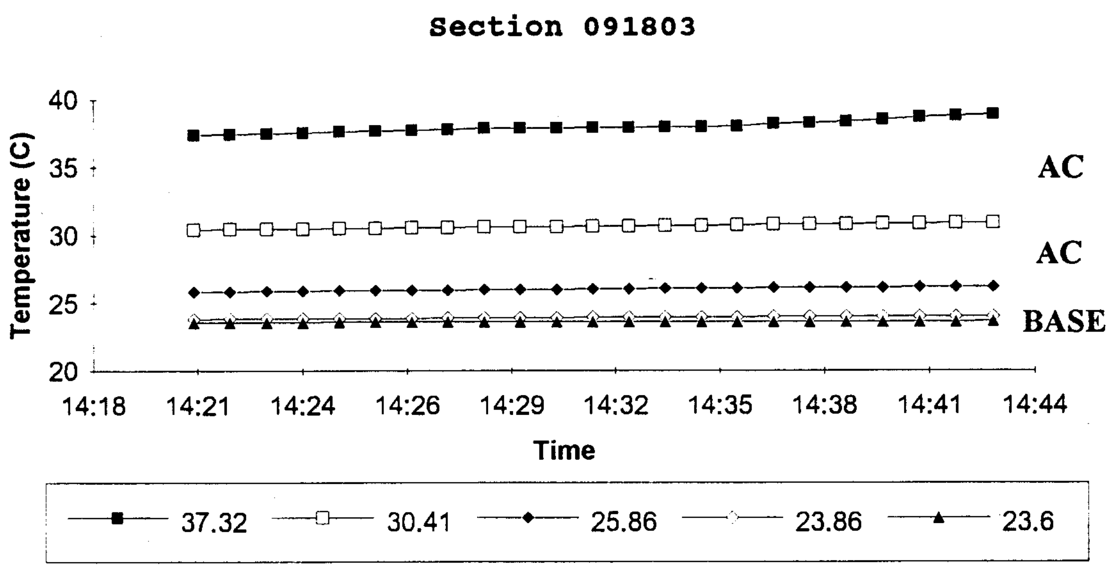


Figure D-2. Measured Subsurface Temperature for the First 5 Sensors During Initial Data Collection, August 19, 1993

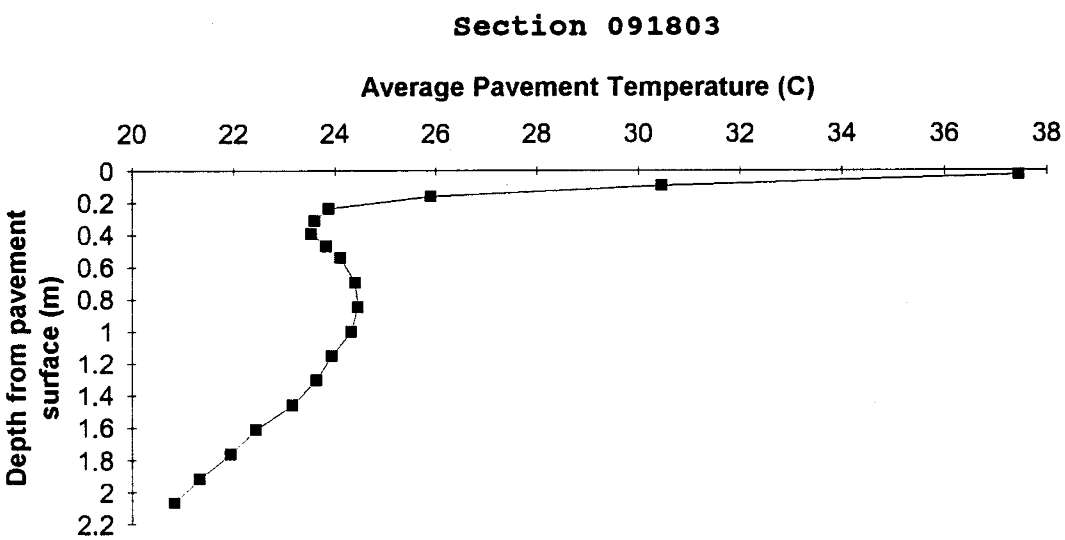


Figure D-3. Measured Subsurface Temperature for All 18 Sensors During Initial Data Collection, August 19, 1993

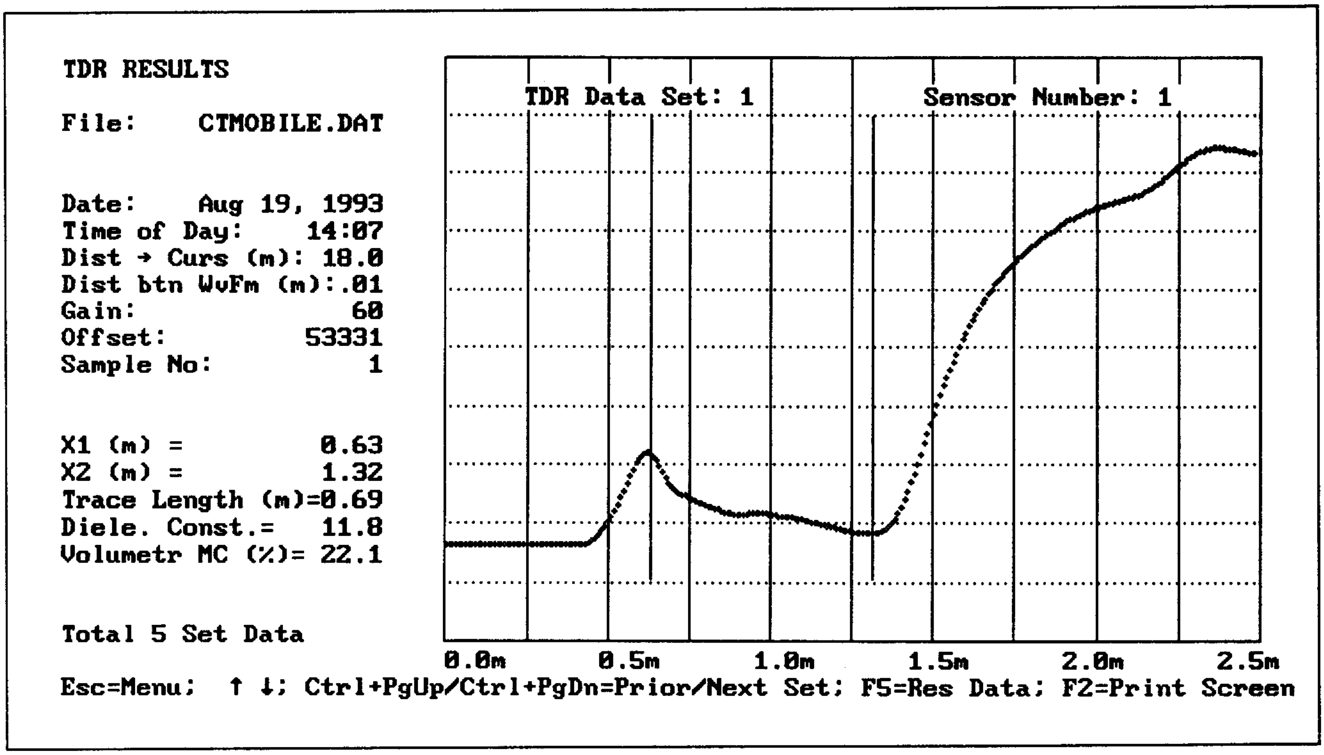


Figure D-4. Sensor Number 1 Trace of the Initial First Set of TDR Traces Measured with the Mobile Unit

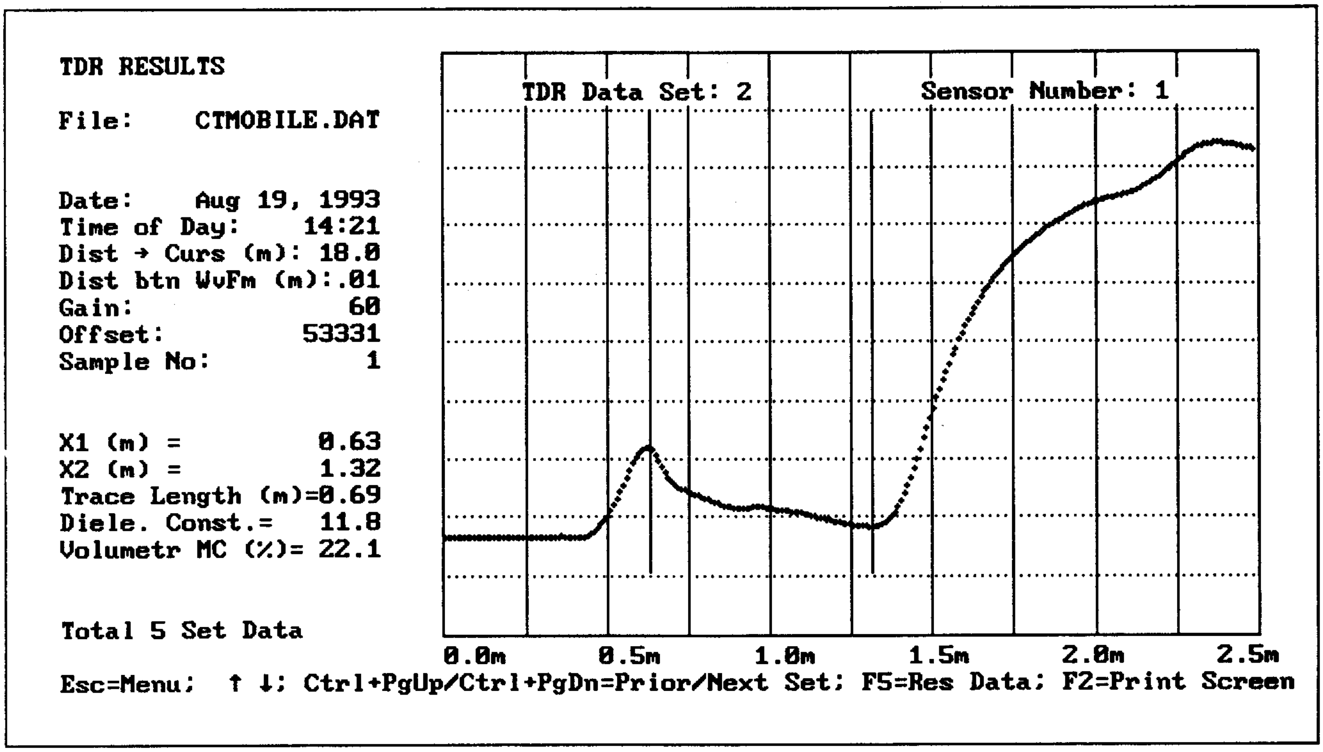


Figure D-5a. Sensor Number 1 Trace of the Initial Second Set of TDR Traces Measured with the Mobile Unit

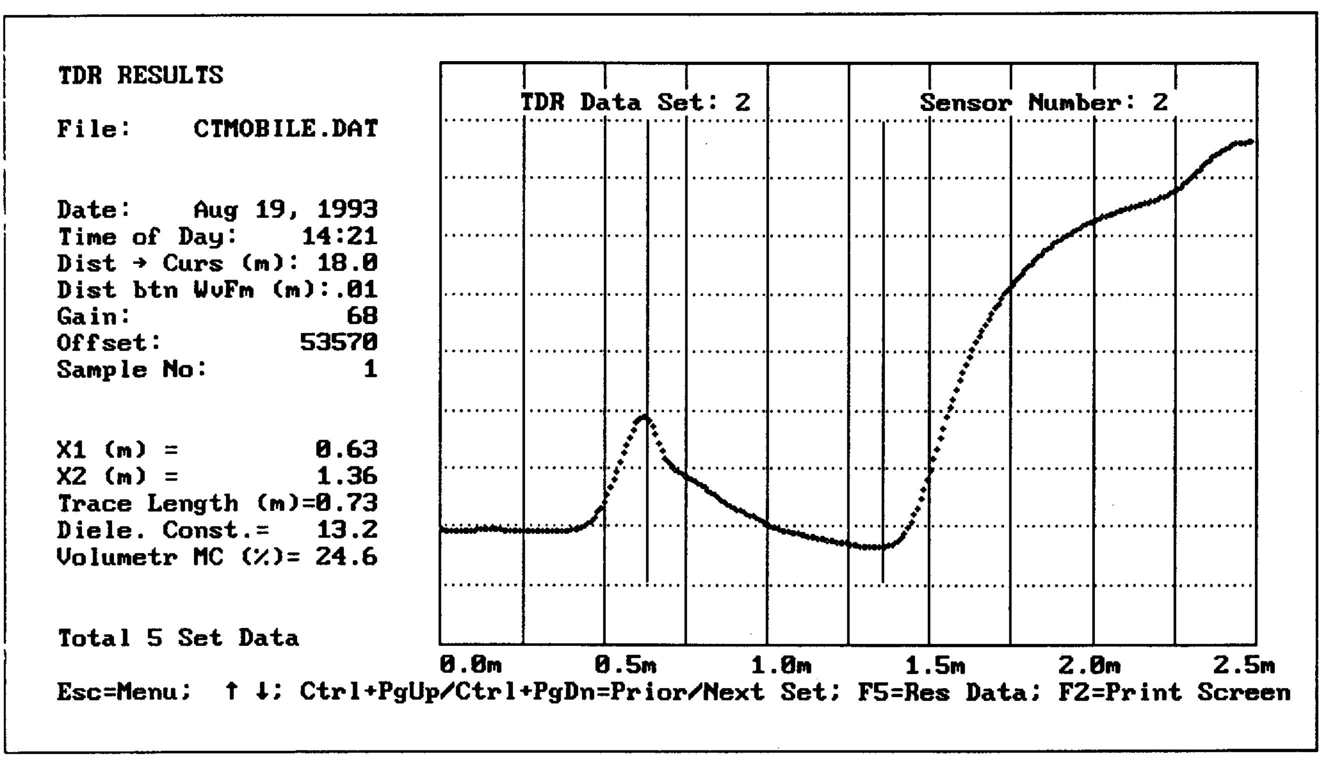


Figure D-5b. Sensor Number 2 Trace of the Initial Second Set of TDR Traces Measured with the Mobile Unit

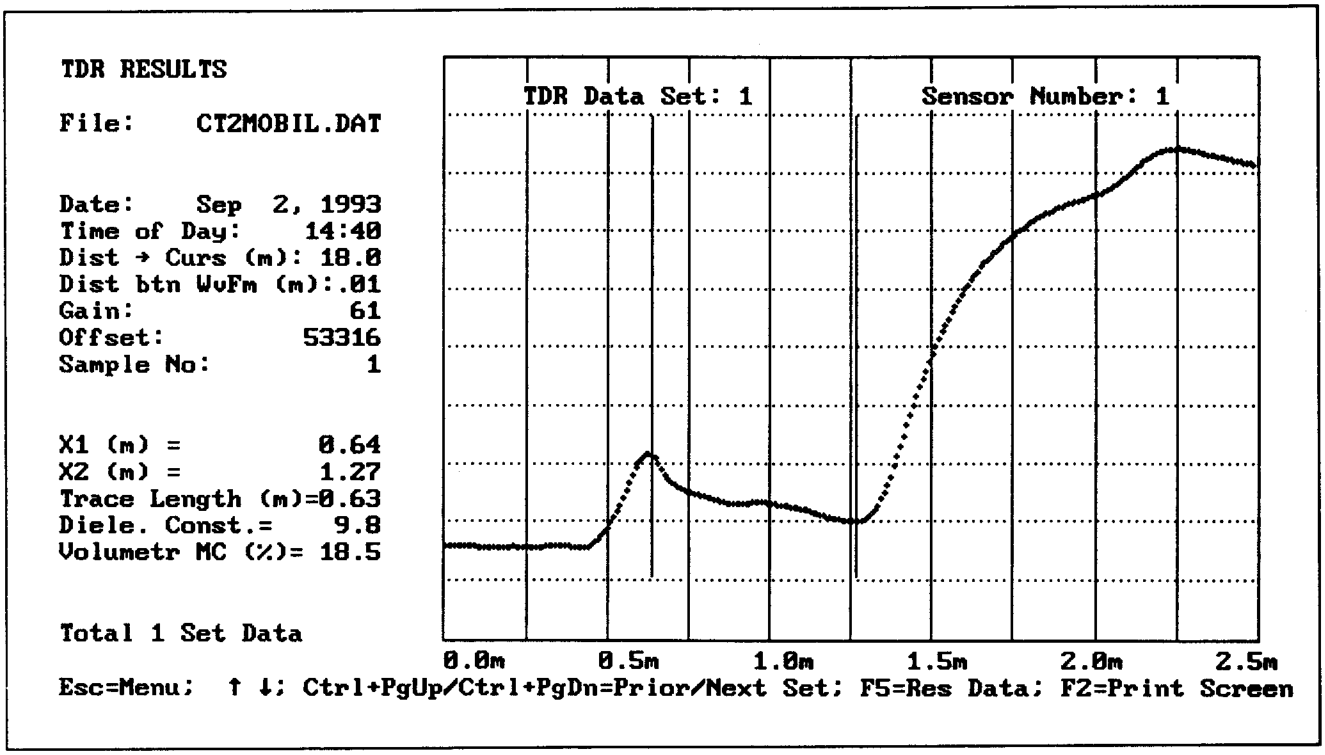


Figure D-6. Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

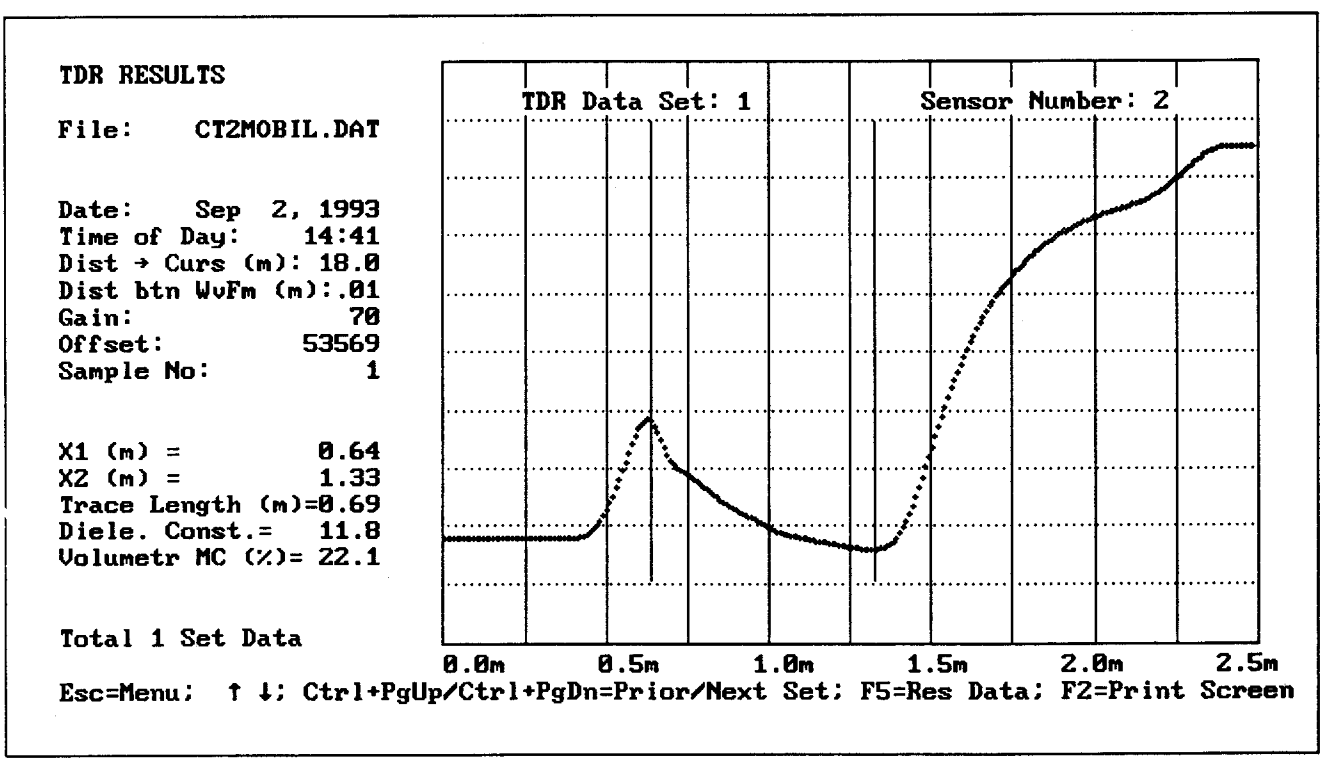


Figure D-6(cont.). Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

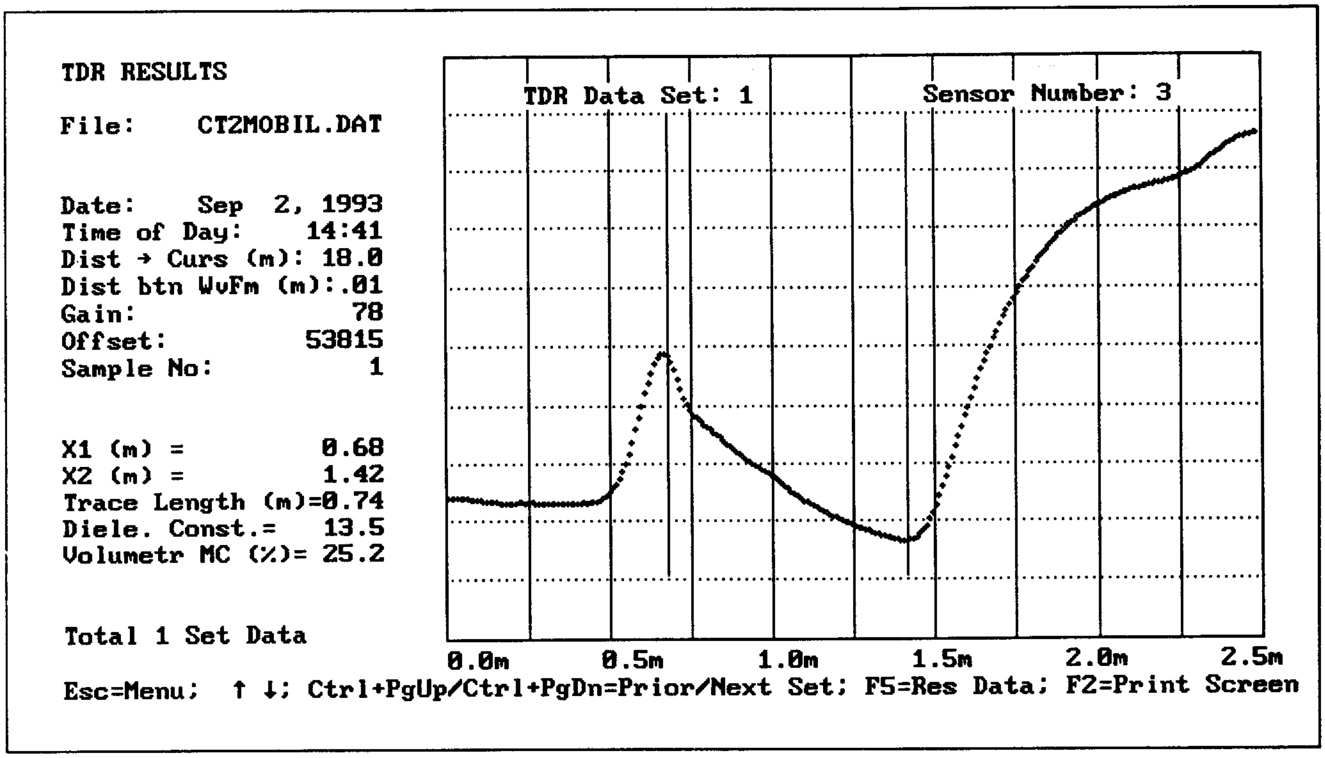


Figure D-6(cont.). Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

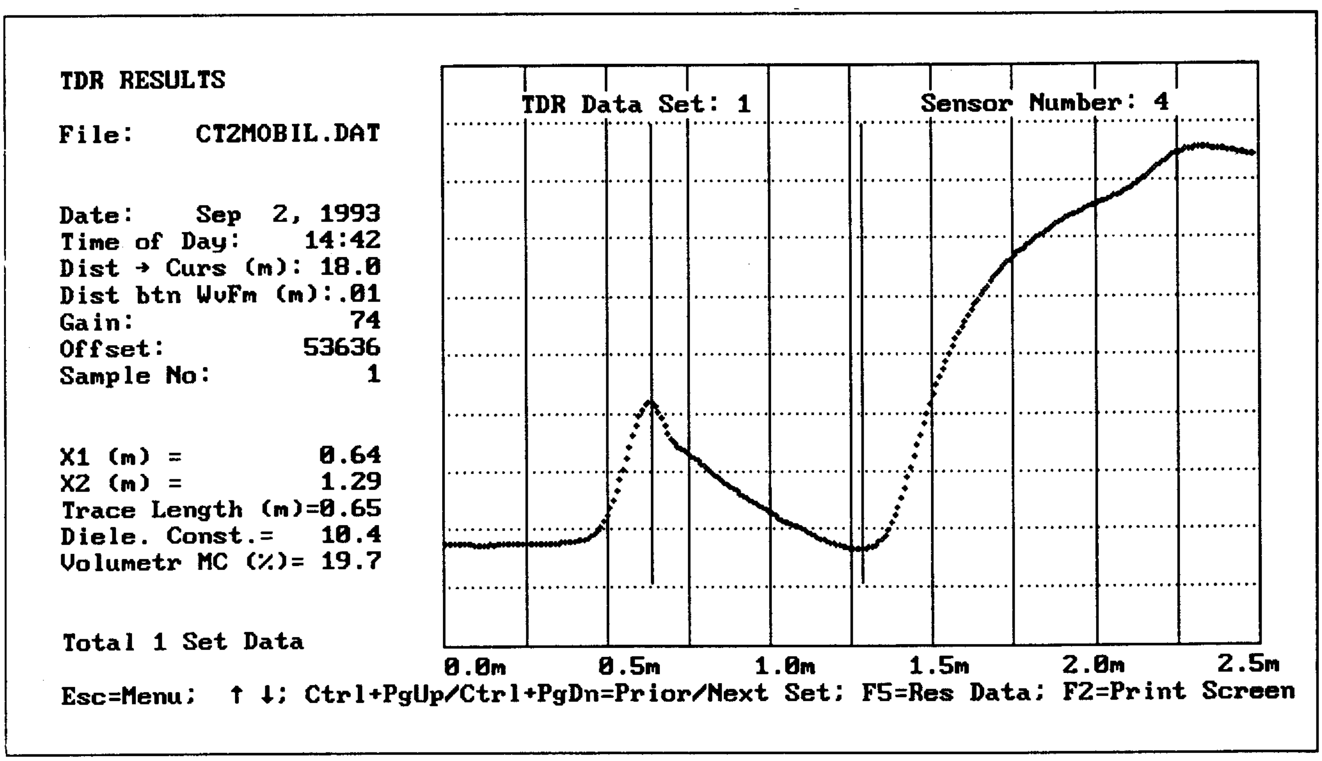


Figure D-6(cont.). Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

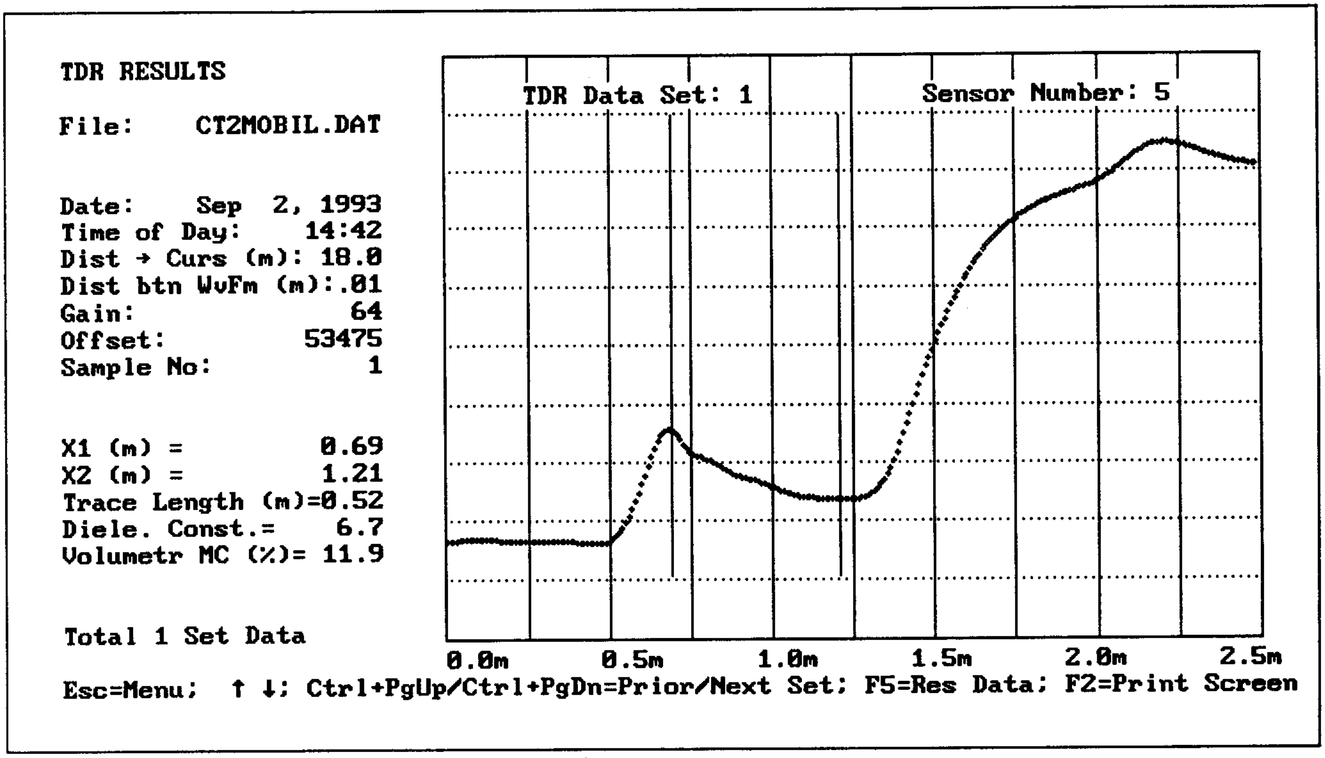


Figure D-6(cont.). Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

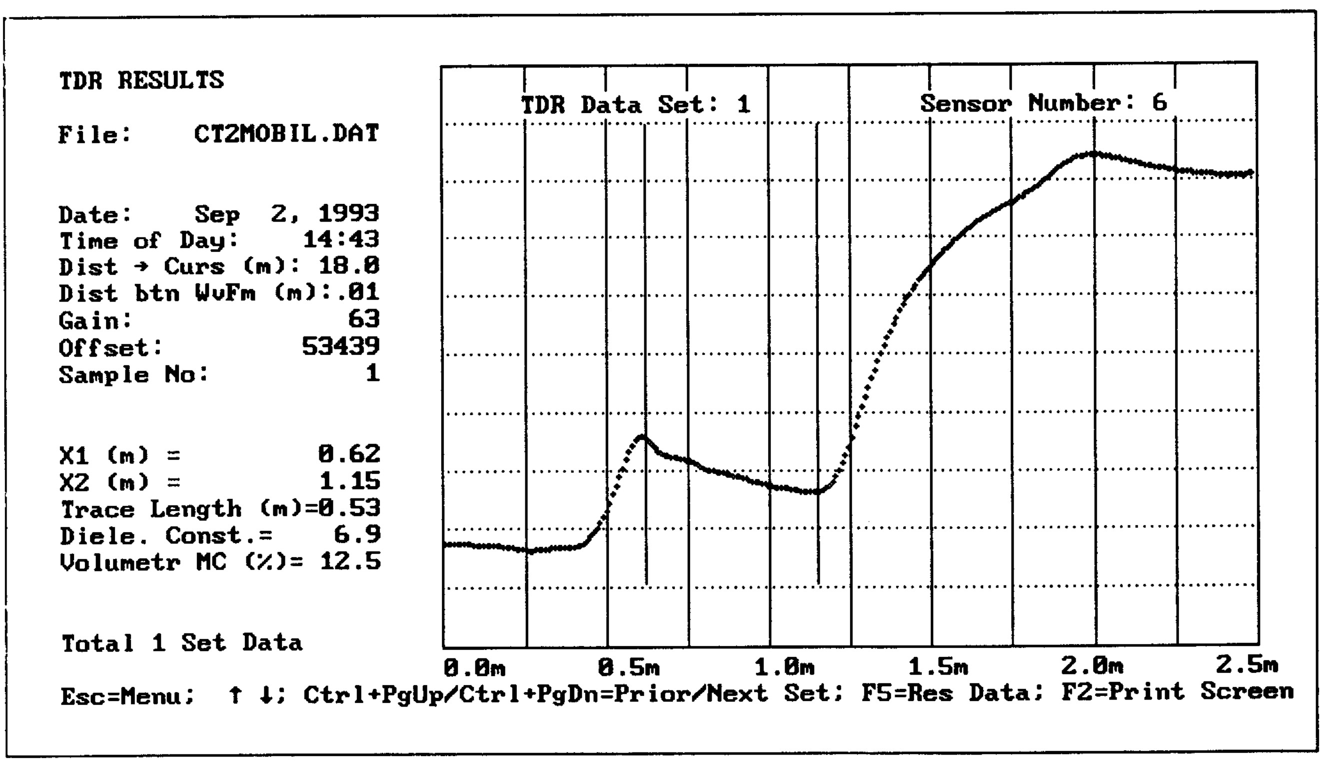


Figure D-6(cont.). Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

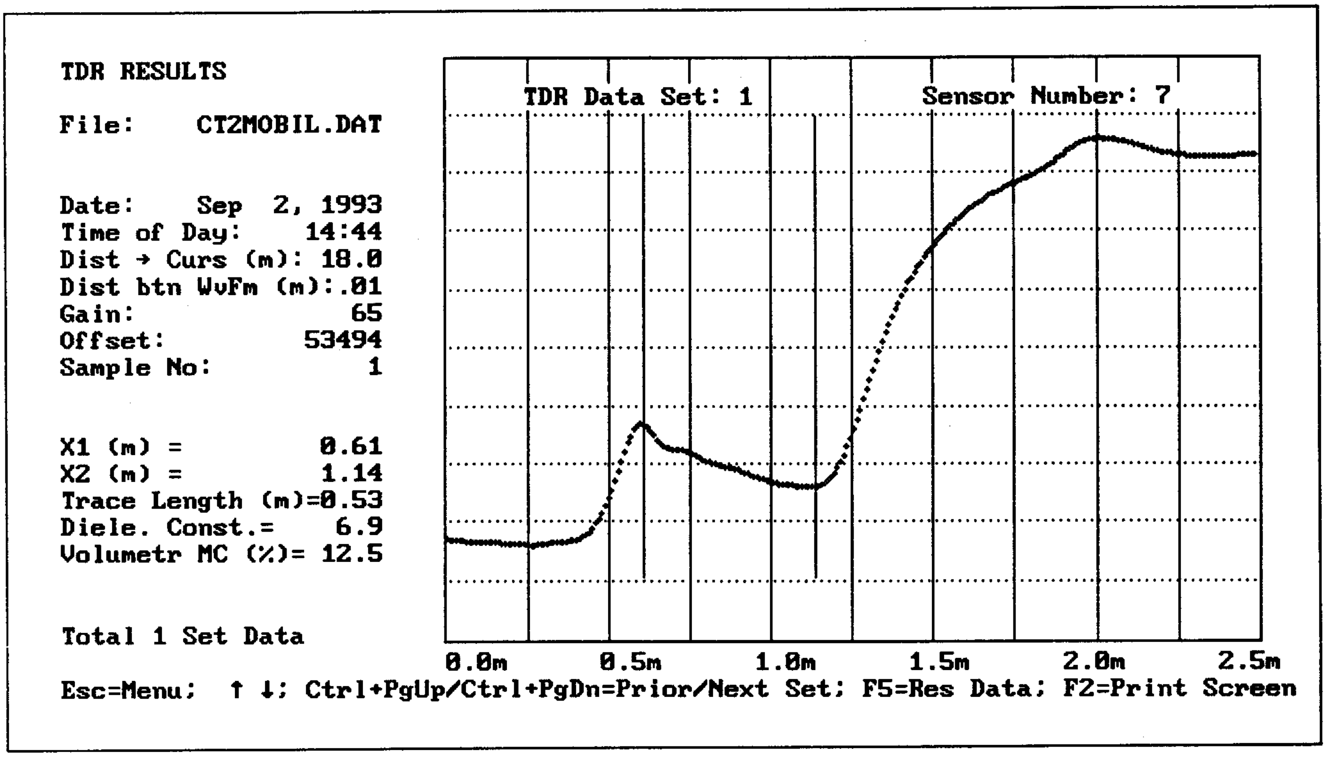


Figure D-6(cont.). Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

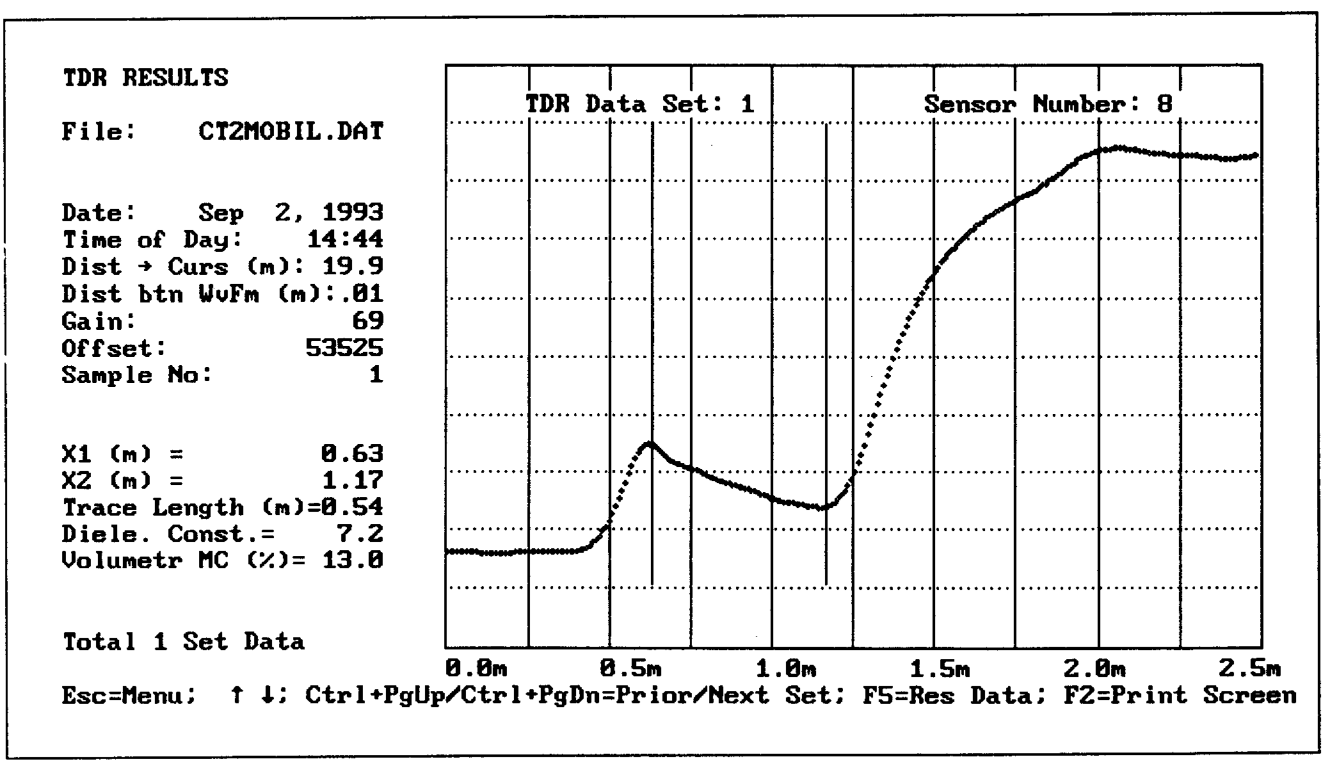


Figure D-6(cont.). Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

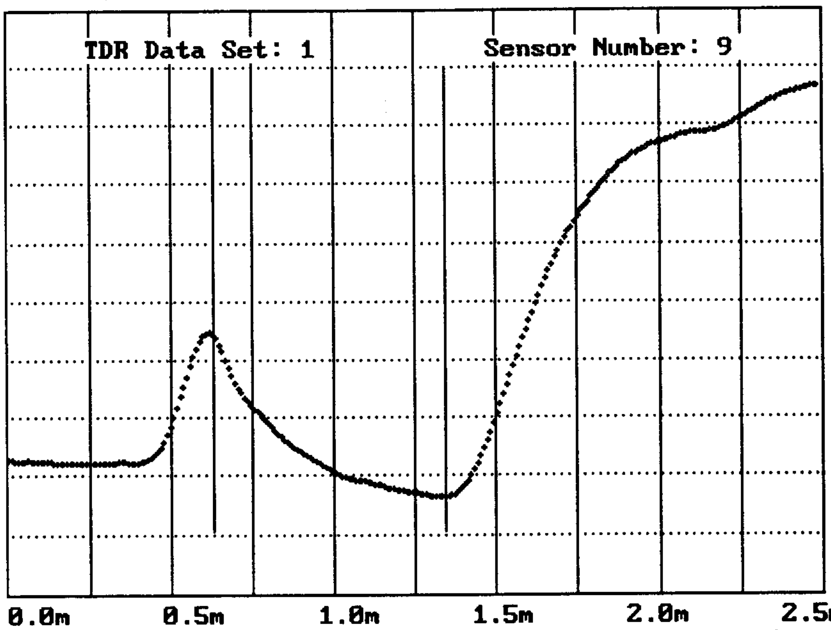
TDR RESULTS

File: CT2MOBIL.DAT

Date: Sep 2, 1993
Time of Day: 14:45
Dist → Curs (m): 19.9
Dist btn WvFm (m):.01
Gain: 79
Offset: 53804
Sample No: 1

X1 (m) = 0.63
X2 (m) = 1.35
Trace Length (m)=0.72
Diele. Const.= 12.8
Volumetr MC (%)= 24.0

Total 1 Set Data



Esc=Menu; ↑ ↓; Ctrl+PgUp/Ctrl+PgDn=Prior/Next Set; F5=Res Data; F2=Print Screen

Figure D-6(cont.). Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

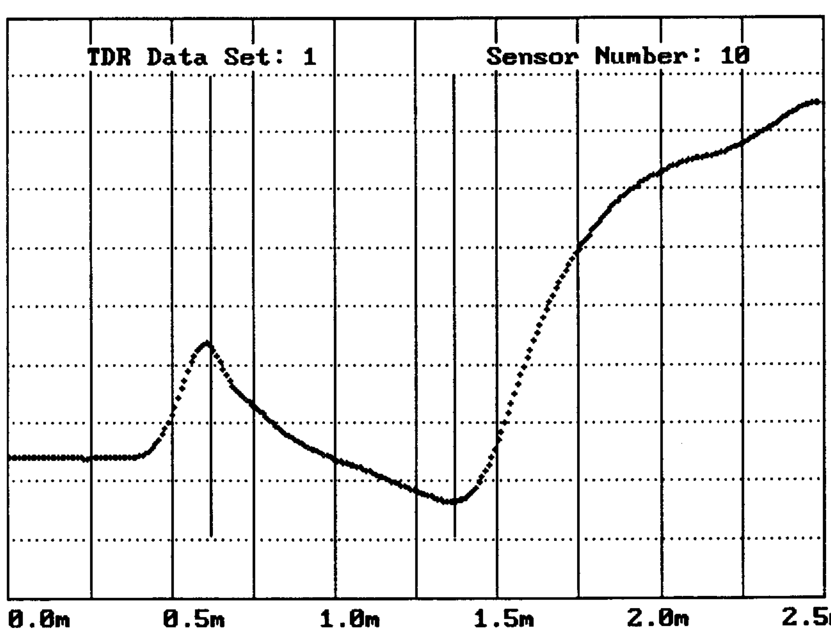
TDR RESULTS

File: CT2MOBIL.DAT

Date: Sep 2, 1993
Time of Day: 14:45
Dist → Curs (m): 19.9
Dist btn WvFm (m):.01
Gain: 74
Offset: 53734
Sample No: 1

X1 (m) = 0.62
X2 (m) = 1.37
Trace Length (m)=0.75
Diele. Const.= 13.9
Volumetr MC (%)= 25.8

Total 1 Set Data



Esc=Menu; ↑ ↓; Ctrl+PgUp/Ctrl+PgDn=Prior/Next Set; F5=Res Data; F2=Print Screen

Figure D-6(cont.). Initial Third Set of TDR Traces Measured with the Mobile Unit, Two Weeks After Installation

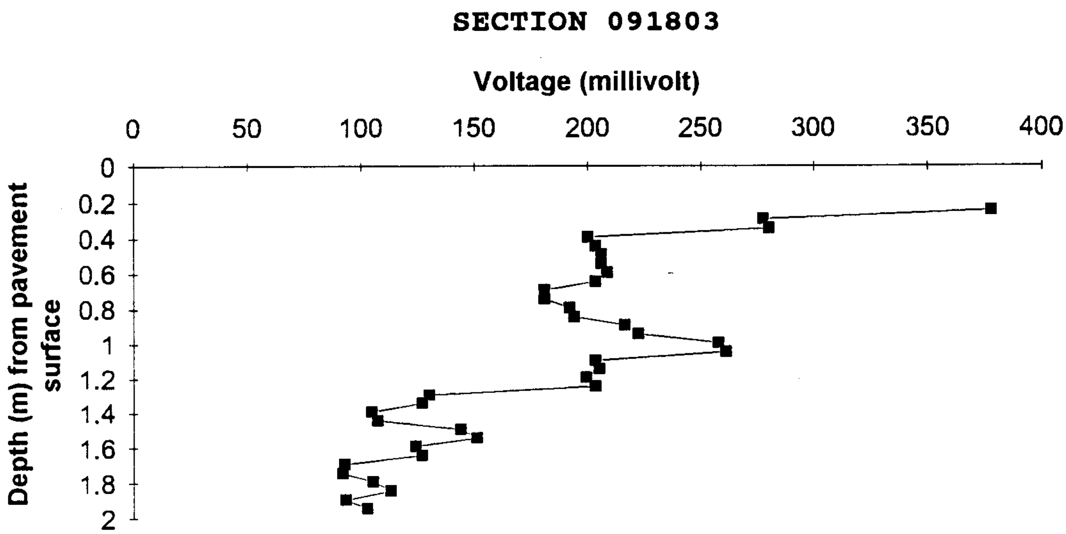


Figure D-7. Voltages Measured Using the Mobile System During Initial Data Collection, August 19, 1993

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

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 091803	Data Collection and
Date Surveyed: August 18-November 15, 1993	Processing Summary

Section Interval (ft)	Mean Deflection Values for HT 2 (mils) Corrected								Mean Temp D1 (F)
	Sensor 1	Sensor 1 std dev	Sensor 7	Sensor 7 std dev	Subg modulus (psi)	Subg modulus std dev	Effective SN	SN std dev	
300 to 450 **Aug 18** @ 1355	5.69	0.62	0.51	0.08					*
300 to 525 **Nov 15** @ 0912	6.47	0.84	0.70	0.21	43626	7226	5.54	0.31	59.8
300 to 525 **Nov 15** @ 1057	6.44	0.71	0.68	0.21	44174	7820	5.54	0.28	71.3
300 to 525 **Nov 15** @ 1240	6.52	0.75	0.65	0.21	44126	7824	5.50	0.29	75.2
300 to 525 **Nov 15** @ 1423	6.51	0.77	0.67	0.21	44842	7590	5.49	0.32	73.9

* Note: No temperature measured on August 18, 1993.

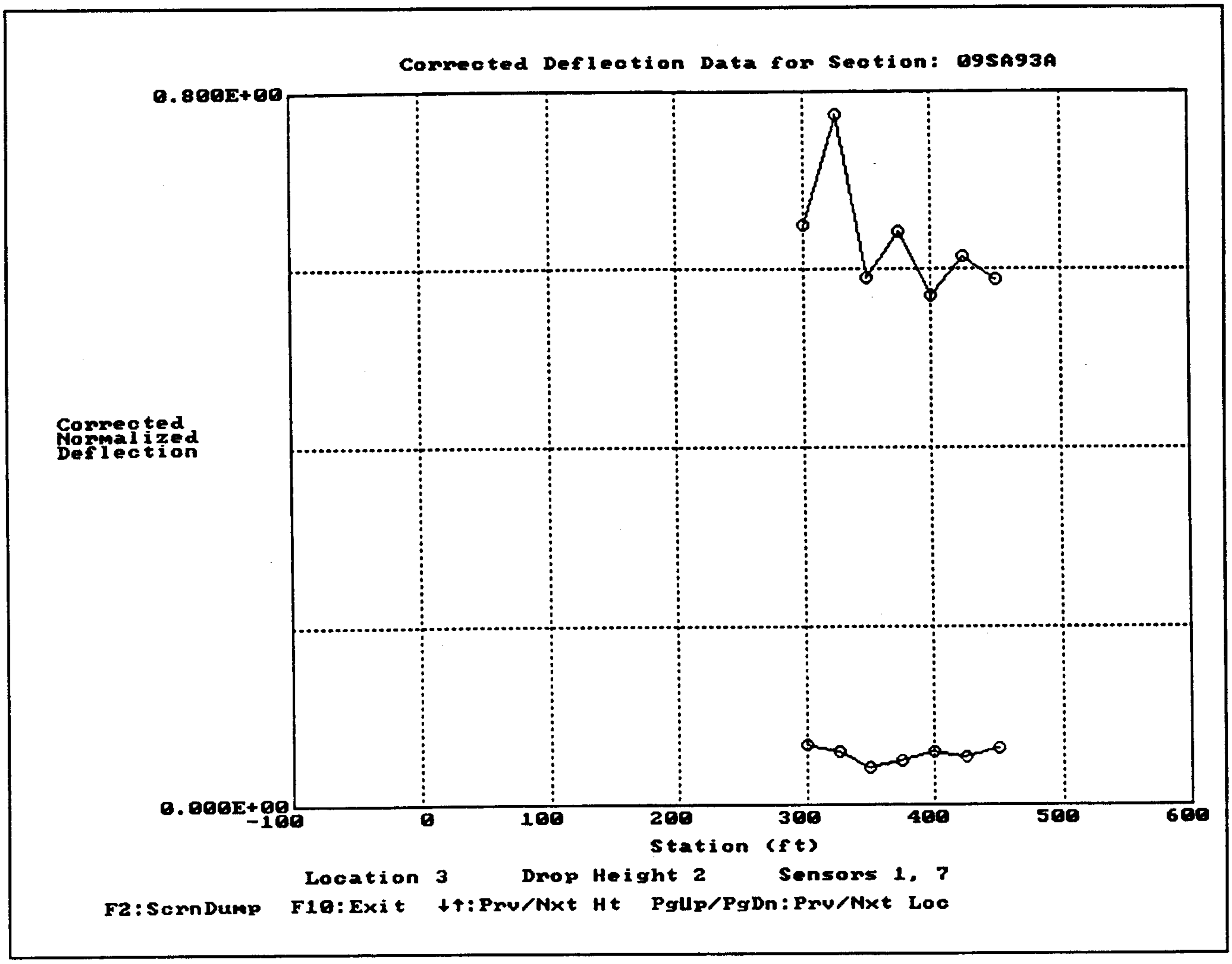


Figure D-8. Deflection Profiles from FWDCHECK
(Test Date and Time August 18, 1993 @ 1355)

Table D-3. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time August 18, 1993 @ 1355)

Flexible Pavement Thickness Statistics - 09SA93A - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	300	46816	5.60
	325	52792	5.70
	350	50501	5.75
	375	40451	5.70
	400	32164	4.85
	425	37668	5.70
	450	37337	5.65
Subsection 1	Overall Mean	40703	5.66
	Standard Deviation	6449	0.10
	Coeff. of Variation	15.84%	1.81%

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

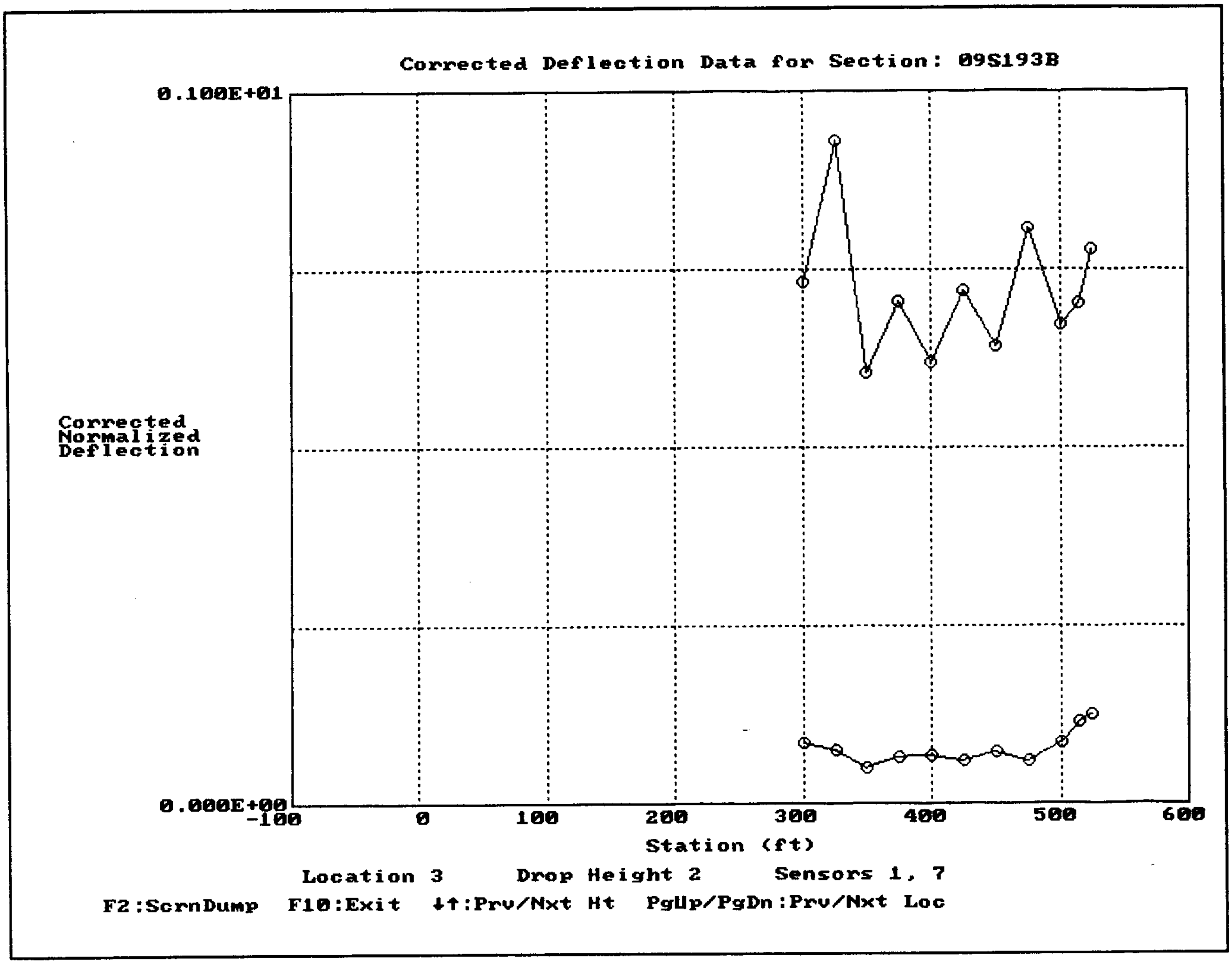


Figure D-9. Deflection Profiles from FWDCHECK
(Test Date and Time November 15, 1993 @ 0912)

Table D-4. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time November 15, 1993 @ 0912)

Flexible Pavement Thickness Statistics - 09S193B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	300	43409	5.45
	325	37160	4.95
	350	55222	5.75
	375	46949	5.45
	400	46555	5.85
	425	41594	5.55
	450	47232	5.75
	475	52873	5.00
	500	42566	5.70
	515	34503	5.85
	525	31826	5.65
Subsection 1	Overall Mean	43626	5.54
	Standard Deviation	7226	0.31
	Coeff. of Variation	16.56%	5.63%

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

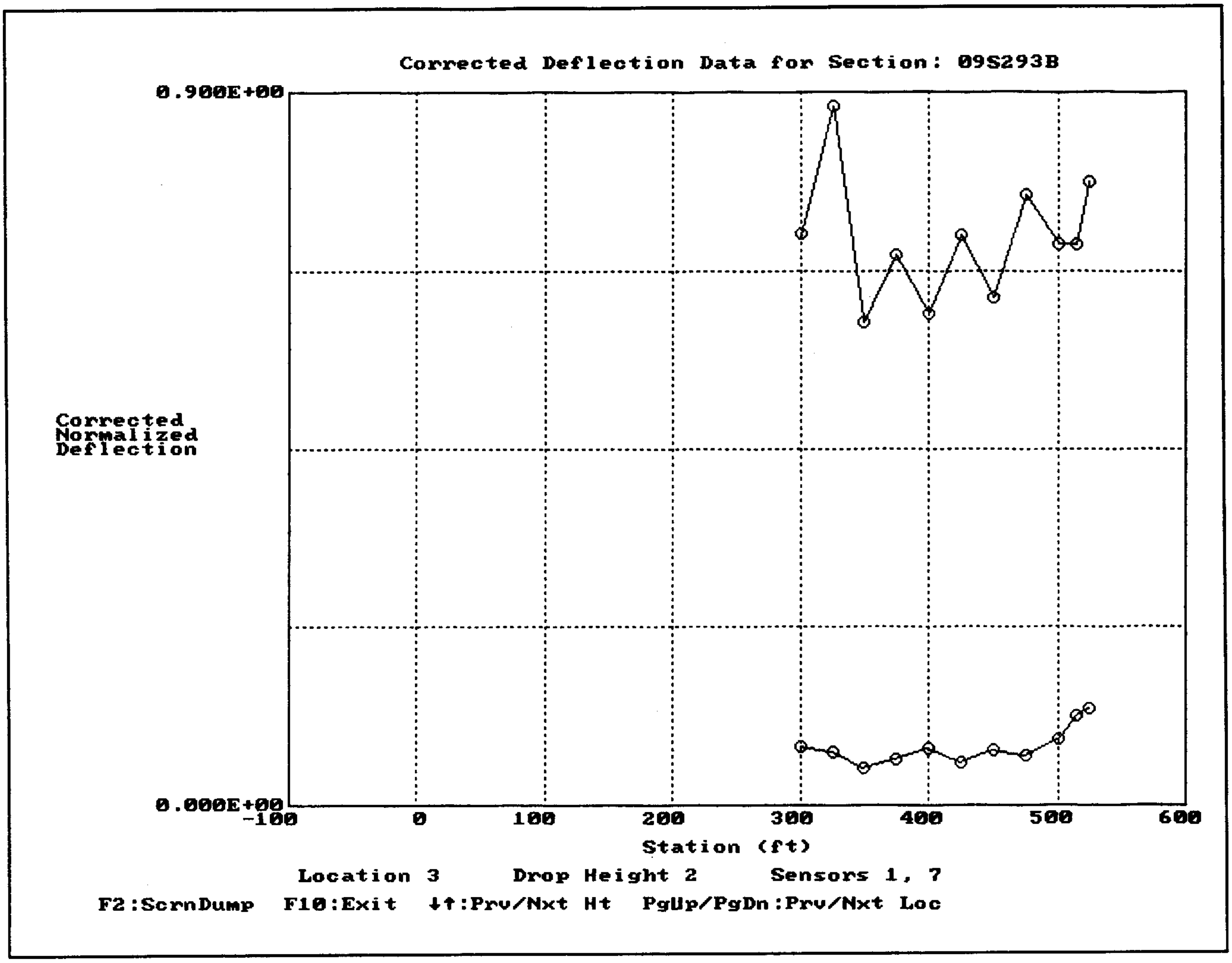


Figure D-10. Deflection Profiles from FWDCHECK
(Test Date and Time November 15, 1993 @ 1057)

Table D-5. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time November 15, 1993 @ 1057)

Flexible Pavement Thickness Statistics - 09S293B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	300	45793	5.40
	325	37544	5.05
	350	57228	5.70
	375	45791	5.55
	400	44352	5.95
	425	40281	5.60
	450	47893	5.75
	475	56141	5.05
	500	43342	5.55
	515	34956	5.80
	525	32594	5.55
Subsection 1	Overall Mean	44174	5.54
	Standard Deviation	7820	0.28
	Coeff. of Variation	17.70%	5.13%

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

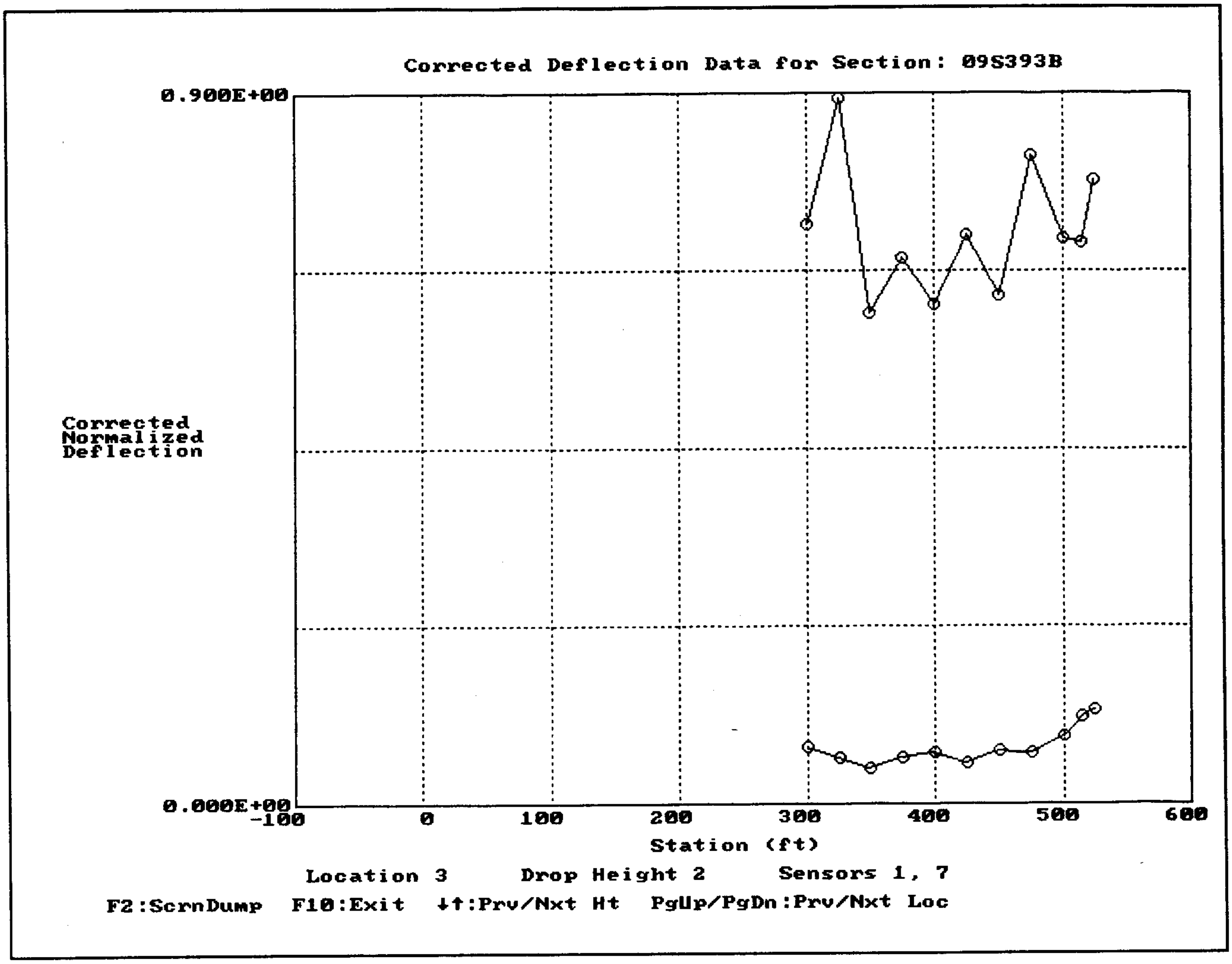


Figure D-11. Deflection Profiles from FWDCHECK
(Test Date and Time November 15, 1993 @ 1240)

Table D-6. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time November 15, 1993 @ 1240)

Flexible Pavement Thickness Statistics - 09S393B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	300	45339	5.40
	325	37167	5.05
	350	55760	5.65
	375	44948	5.55
	400	45872	5.80
	425	40046	5.60
	450	50000	5.65
	475	56242	4.90
	500	42852	5.50
	515	34302	5.85
	525	32853	5.55
Subsection 1	Overall Mean	44126	5.50
	Standard Deviation	7824	0.29
	Coeff. of Variation	17.73%	5.29%

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

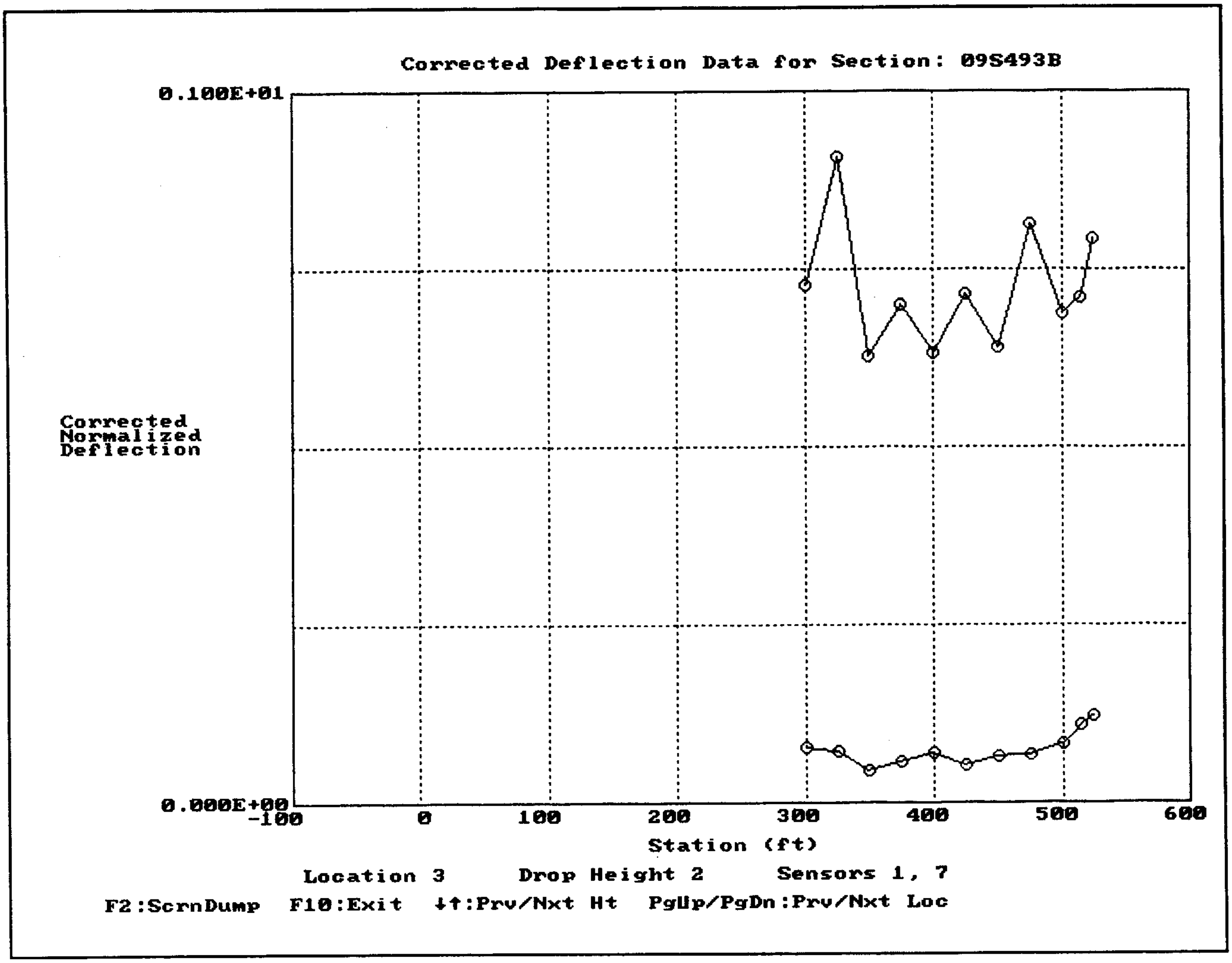


Figure D-12. Deflection Profiles from FWDCHECK
(Test Date and Time November 15, 1993 @ 1423)

Table D-7. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time November 15, 1993 @ 1423)

Flexible Pavement Thickness Statistics - 09S493B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	300	44894	5.40
	325	40860	4.90
	350	56014	5.60
	375	46223	5.50
	400	46974	5.80
	425	41168	5.55
	450	47974	5.75
	475	57494	4.90
	500	43951	5.60
	515	35171	5.80
	525	32542	5.55
Subsection 1	Overall Mean	44842	5.49
	Standard Deviation	7590	0.32
	Coeff. of Variation	16.93%	5.75%

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

Table D-8. Surface Elevation Measurements

LTPP Seasonal Monitoring Study	State Code	[09]
Surface Elevation Measurements	Test Section Number	[1803]

Survey Date	August 19, 1993
Surveyed By	AB & GC
Surface Type	A/C
Benchmark	Observation Piezometer - 1.000 meters - assumed

STATION		PE m offset 0.15m	OWP m offset 0.76m	ML m offset 1.68m	IWP m offset 2.59m	ILE m offset 3.20m
0+00	**3+00**	0.963	0.964	0.965	0.966	0.967
0+25	**3+25**	0.975	0.975	0.978	0.979	0.981
0+50	**3+50**	0.990	0.990	0.991	0.992	0.991
0+75	**3+75**	1.002	1.002	1.003	1.004	1.004
1+00	**4+00**	1.014	1.014	1.016	1.017	1.017
1+25	**4+25**	1.028	1.028	1.029	1.030	1.031
1+50	**4+50**	1.040	1.041	1.042	1.043	1.044
1+75	**4+75**	1.052	1.052	1.053	1.054	1.055
2+00	**5+00**	1.066	1.065	1.066	1.066	1.066

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

APPENDIX E

Photographs

Figure E-1. Site Overview

Figure E-2. Instrumentation Hole

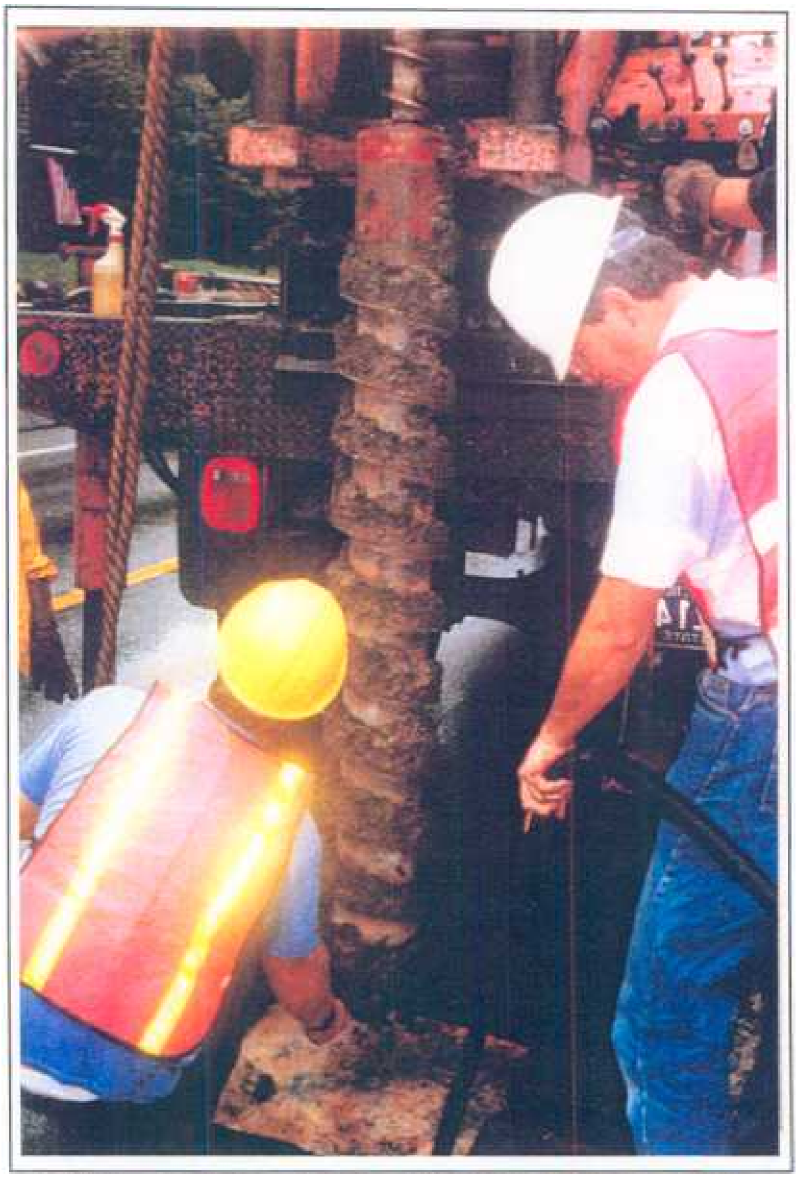


Figure E-3. Instrumentation Hole

Figure E-4. Material Sampled From Instrumentation Hole For Moisture Determination

Figure E-5. Material Sampled From Instrumentation Hole For Moisture Determination

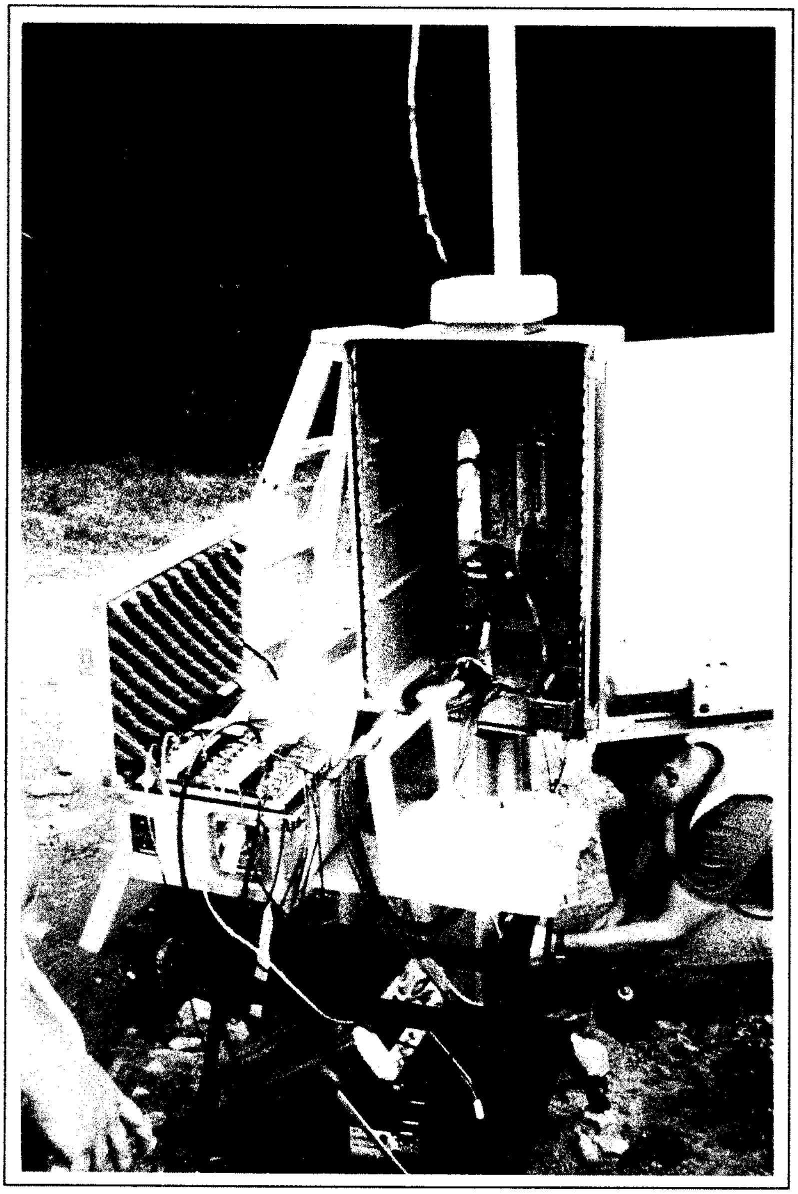


Figure E-6. Equipment Cabinet

Figure E-7. Equipment Cabinet, Air Temperature Probe, and Rain Gage

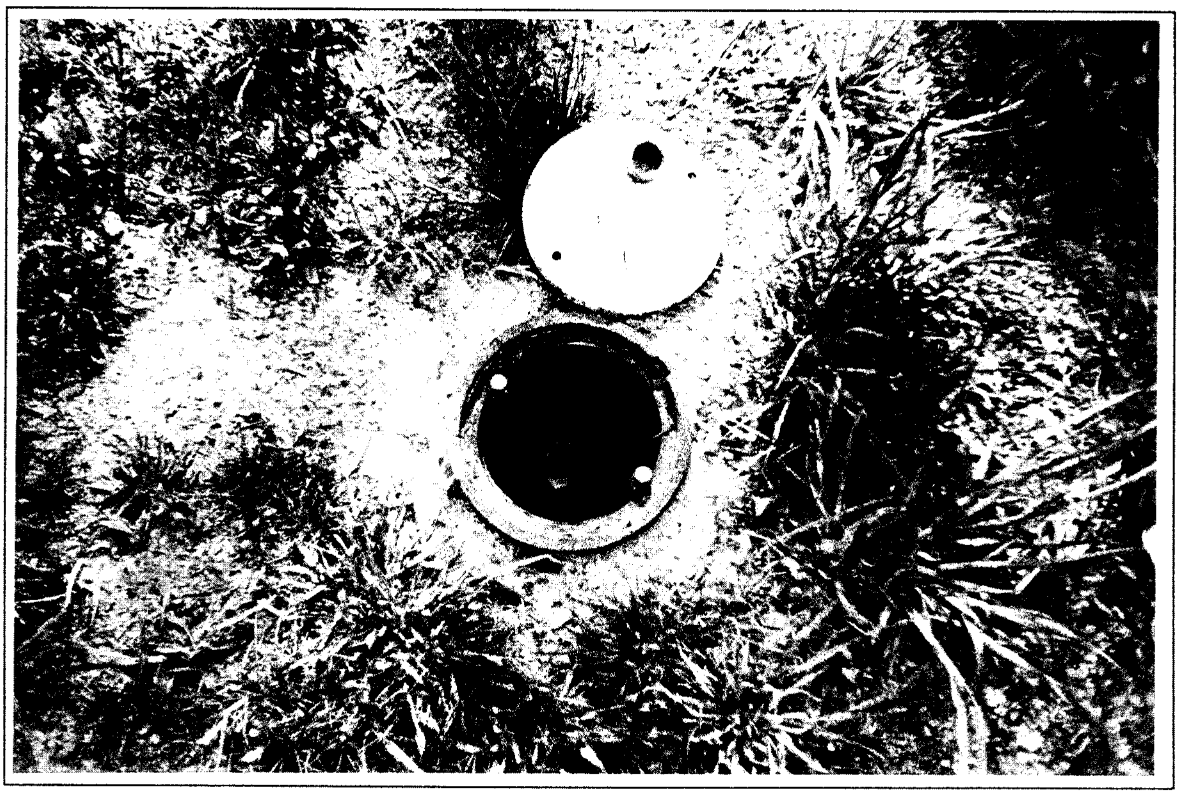


Figure E-8. Observation Well

Figure E-9. Observation Well

Figure E-10. Instrumentation Hole, a Few Months After Installation