# LTPP Seasonal Monitoring Program

## Site Installation and Initial Data Collection
## Section 351112, Hobbs, New Mexico

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16. Abstract

This report contains a description of the instrumentation installation activities and initial data collection for test section 351112, which is a part of the LTPP Core Seasonal Monitoring Program. This asphalt concrete surfaced pavement test section, which is located on US-62/180 in the eastbound lanes, approximately 14.1 km west of SH-207 in Hobbs, New Mexico, was instrumented on April 5-6, 1994. The instrumentation installed included time domain reflectometry probes for moisture content, thermistor probes for temperature, tipping-bucket rain gauge, an observation well to monitor the ground water table, and an on-site data logger. Initial data collection was performed on April 6, 1994, which consisted of deflection measurements with a Falling Weight Deflectometer (FWD), elevation measurements, temperature measurements and TDR measurements. The report contains a description of the test site and its location, the instruments installed at the site and their locations, characteristics of the installed instruments and probes, problems encountered during installation, specific site circumstances and deviations from the standard guidelines, and a summary of the initial data collection.

17. Key Words

Pavement, Highway, Instrumentation, Monitoring, Time Domain Reflectometry, Thermistor, Observation Well, Test Equipment, Field Tests.

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# Table of Contents

# List of Tables

# SEASONAL INSTRUMENTATION STUDY
# INSTRUMENTATION INSTALLATION
# NEW MEXICO SECTION 351112/35SA

## I. Introduction

The seasonal instrumentation installation of Section 351112 was performed on April 5-6, 1994, and was the ninth one completed in the Southern Region.

The GPS-1 test section resides in Seasonal Cell 13 and is located in a dry-no freeze zone. The site (see Figure A-1) is in the eastbound lanes on US-62/180, approximately 14.1 km west of SH-207 in Hobbs, New Mexico. The divided highway consists of two 3.7 m wide travel lanes in each direction. The outside shoulder is 3.0 m wide.

The average maximum daily temperature for the months of June through August is 33°C and the average minimum daily temperature for the months of December through February is 9°C. The average annual precipitation is 427 mm.

The pavement is a flexible structure consisting of approximately 160 mm of asphalt concrete over 152.4 mm of granular aggregate base. The subgrade is classified as a poorly graded sand. The typical soil profile under the pavement is illustrated in Figure A-2. This information was obtained from bore holes drilled during the GPS material sampling and testing. The dry densities of the unbound layers are given in Table 1.

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

| Material | Layer Thickness (mm) | In Situ Dry Density (kg/m$^3$) |
|---|---|---|
| Asphalt Concrete | 160.0 | - - - |
| Base | 152.4 | 1721 |
| Subgrade | - - - | 1646 |

The annual average daily traffic (AADT) in the GPS lane is almost 810, of which 21% is truck traffic. The estimated annual ESALs on the GPS lane were 26,000. This information is based on historical traffic estimates provided by the New Mexico State Highway and Transportation Department (New Mexico SHTD) for 1988.

Installation of the instrumentation was completed through the cooperative efforts of the New Mexico SHTD and the Federal Highway Administration (FHWA) Southern Region Coordination Office (SRCO) staff from Brent Rauhut Engineering Inc. (BRE). The following is a list of the personnel who participated in the installation:

| | | | |
|---|---|---|---|
| Larry Peirce | SRCO, BRE | Robin Belt | SRCO, BRE |
| Jon Peacock | SRCO, BRE | Keun-Wook Yi | New Mexico SHTD |
| Steve Davis | SRCO, BRE | Jim Yarbrough | New Mexico SHTD |

# II. Instrumentation Installation

## Pre-Installation Activities

A pre-installation meeting was held at the New Mexico SHTD offices on February 14, 1994. The meeting agenda appears in Appendix B. At the planning meeting, roles and responsibilities for all the various tasks to be performed during installation were assigned. A slide presentation was given, highlighting the order of operations for the installations in Delta, Colorado and Grand Rapids, Minnesota.

A site inspection and a manual distress survey were performed on March 27, 1991 by Mark Gardner (SRCO). Deflection testing was conducted on July 5, 1989. The 0+00 end of the test section was selected for instrumentation, based on the amount of distress present and uniformity of the deflection profile. Both the deflection plots and distress survey data can be found in Appendix A.

## Equipment Installed

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

**Table 2. Equipment Installed**

| Equipment | Quantity | Serial Nº. |
|---|---|---|
| Instrument Hole | | |
| MRC Thermistor Probe | 1 | 182 (35 AT) |
| TDR Sensors | 10 | 35A01-35A10 |
| Equipment Cabinet | | |
| CR10 Data Logger | 1 | 16521 |
| Battery Package | 1 | 5674 |
| Weather Station | | |
| Tipping-Bucket Rain Gauge | 1 | 12032-693 |
| Air Temperature Probe | 1 | 3042 |
| Observation Well | 1 | None |

## Equipment Check/Calibration

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

In addition to the above tests, the distances between sensors in the thermistor probe were measured and are presented in Table 3.

Table 3. Sensor Spacing in MRC Thermistor Probe

| Unit | Channel №. | Distance from Top of Unit (mm) | Remarks |
|---|---|---|---|
| 1 | 1 | Not Measured | This unit was installed in the AC layer. |
|  | 2 | Not Measured |  |
|  | 3 | Not Measured |  |
| 2 | 4 | 23 | This unit was installed in the base and subgrade. |
|  | 5 | 96 |  |
|  | 6 | 174 |  |
|  | 7 | 250 |  |
|  | 8 | 325 |  |
|  | 9 | 480 |  |
|  | 10 | 631 |  |
|  | 11 | 783 |  |
|  | 12 | 937 |  |
|  | 13 | 1087 |  |
|  | 14 | 1239 |  |
|  | 15 | 1392 |  |
|  | 16 | 1547 |  |
|  | 17 | 1698 |  |
|  | 18 | 1847 |  |

## Location of Instrumentation

The instrumentation was installed at Station 0-20 of the test section. Approximately 762 mm from the lane edge, in the outside wheel path, a 457 mm square was removed from the pavement and a 254 mm diameter hole, 2.1 m deep, was drilled to install the thermistor probe and TDR sensors. Cables from the instrumentation were placed in a 51 mm diameter flexible conduit and buried in a 102 mm wide trench leading to the equipment cabinet located approximately 8.3 m from the lane edge.

The observation well was installed at Station 1+00 of the test section approximately 4.3 m from the lane edge. The top of the observation well was also used as the permanent benchmark.

## Installation

Installation of the monitoring equipment was completed on April 5-6, 1994. Verification that the instrumentation was working was made the following day. The New Mexico SHTD provided the traffic control, augering, pavement sawing, pavement repair materials, observation well and a permanent benchmark. The monitoring equipment and cabinet installation was performed by the SRCO staff.

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

To ensure functioning of the TDR sensors during installation, the 1502B cable tester was connected to each sensor as backfilling of the instrumentation hole was performed. If a reasonable trace was displayed, it was assumed the sensor was functioning properly. The trace was printed for each TDR and the moisture content was determined using Topp's equation. The field moisture content was also measured by drying the soil on a propane stove. The TDR moisture contents, position of the TDR sensors and field moisture contents appear in Table 4. The field printed traces appear in Appendix C. Table 5 shows the distance from the top of the pavement to each individual thermistor sensor.

When backfilling of the instrumentation hole was completed, the concrete surface was patched using cold-mix asphalt. The overcuts from the pavement sawing operation (including the groove for the temperature probe) were also sealed with Dow-Corning 888 crack sealant.

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

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

## Table 4. Location of TDR Sensors and Measured Moisture Contents

| Sensor | Sensor Depth | TDR Moisture Content | Measured Moisture Content |
|---|---|---|---|
| 35A01 | 254 | 5.2 | 4.4 |
| 35A02 | 406 | 0.4 | 1.6 |
| 35A03 | 559 | 0.6 | 1.4 |
| 35A04 | 724 | 0.8 | 3.4 |
| 35A05 | 864 | 1.6 | 5.1 |
| 35A06 | 1016 | 2.1 | 2.0 |
| 35A07 | 1168 | 6.7 | 7.7 |
| 35A08 | 1321 | 14.9 | 10.0 |
| 35A09 | 1626 | 27.5 | 11.1 |
| 35A10 | 1905 | 31.2 | 13.9 |

## Table 5. Thermistor Sensor Locations

| Unit | Channel № | Depth from Pavement Surface (mm) | Remarks |
|---|---|---|---|
| 1 | 1 | 25 | This unit was installed in the AC layer. |
|  | 2 | 80 |  |
|  | 3 | 135 |  |
| 2 | 4 | 186 | This unit was installed in the base and subgrade. |
|  | 5 | 259 |  |
|  | 6 | 337 |  |
|  | 7 | 413 |  |
|  | 8 | 488 |  |
|  | 9 | 643 |  |
|  | 10 | 794 |  |
|  | 11 | 946 |  |
|  | 12 | 1100 |  |
|  | 13 | 1250 |  |
|  | 14 | 1402 |  |
|  | 15 | 1555 |  |
|  | 16 | 1710 |  |
|  | 17 | 1861 |  |
|  | 18 | 2010 |  |

# III. Initial Data Collection

## Onsite Data Logger

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

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

Figure D-1 shows the average hourly ambient air temperatures which were collected the night of April 5, 1994. Figure D-2 shows hourly average subsurface temperatures for the first five sensors for the same data collection period. Figure D-3 shows the measured average subsurface temperatures for all 18 sensors during the initial data collection.

## Moisture Content Measurement by TDR Sensors

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

To begin data collection using the mobile system the TDR cable leads and 1502B cable reader were connected to the proper channels and the MOBILE program was downloaded from the notebook computer to the CR10 Data Logger. After approximately five minutes, the cable reader was triggered by the MOBILE program and the TDR traces were displayed. The data collection process was completed in approximately five minutes and was automatically repeated four hours later. The data was then uploaded to the notebook computer. Traces displayed on the cable reader indicated that the sensors were working properly. Figures D-4 through D-13 show the plots of the TDR traces obtained approximately 24 hours after installation.

## Deflection Measurements

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

## Elevation Surveys

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

## IV. Summary

The instrumentation installation on Section 351112 was completed on April 5, 1994 and initial data collection was completed on April 6, 1994. Instrumentation and equipment currently at the site includes time domain reflectometry probes for moisture content measurements; a thermistor probe for monitoring temperature gradient changes in the pavement, base and subgrade layers; a tipping-bucket rain gauge; an air temperature probe; an observation well to monitor ground water table movement; a permanent swell and frost-free benchmark; and an on-site data logger and battery pack.

At the time of this report, all of the equipment installed on-site appears to be functioning properly. After the initial installation, the alkaline battery pack was replaced with a gel-cell sealed battery.

# APPENDIX A

## Test Section Background Information

Appendix A contains the following information:

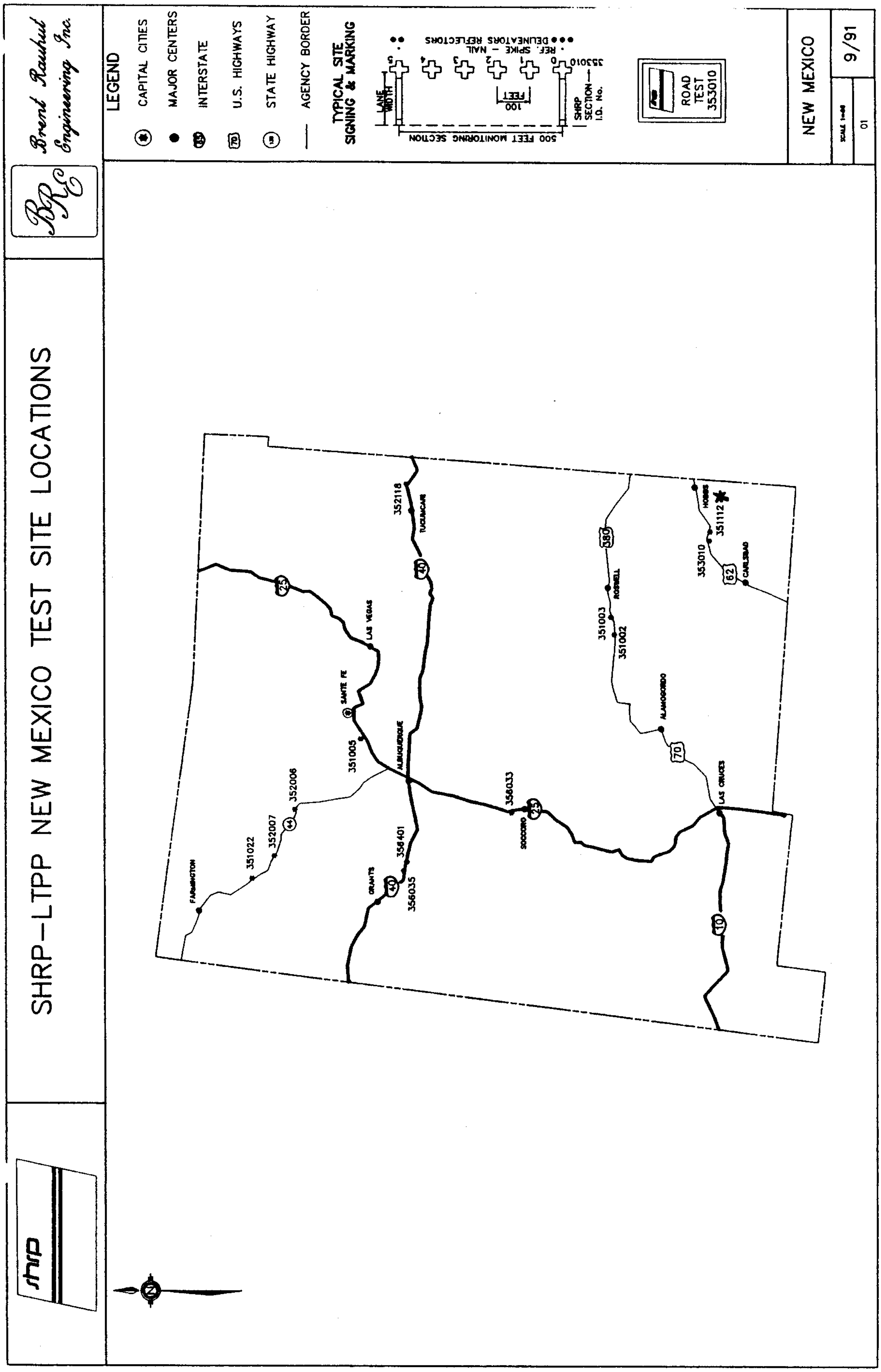


Figure A-1. Location of Test Site, GPS Test Section 351112

# APPROXIMATE
# SUMMARY OF FIELD LOGS
# GPS TEST SECTIONS

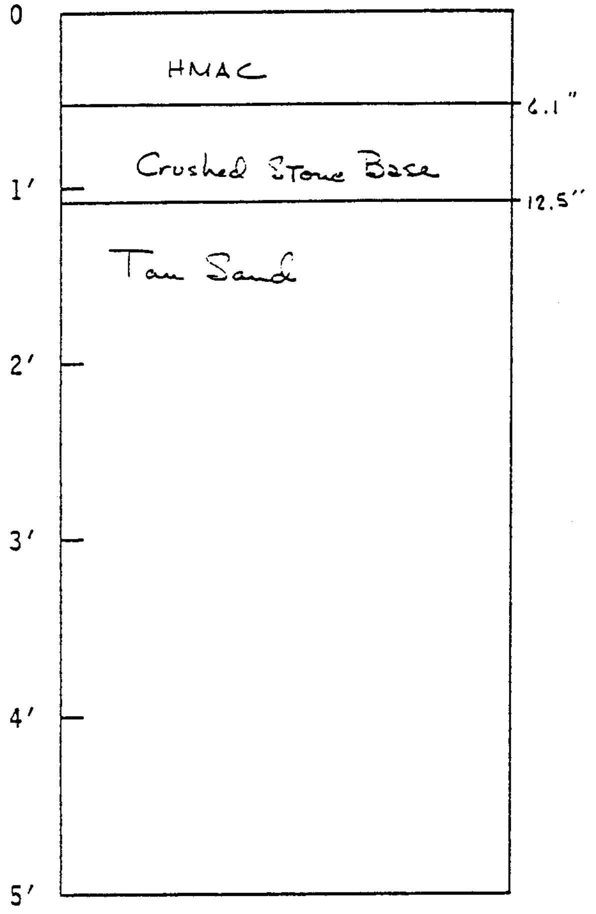
TEST SECTION I.D. No. 351112

STATE New Mexico

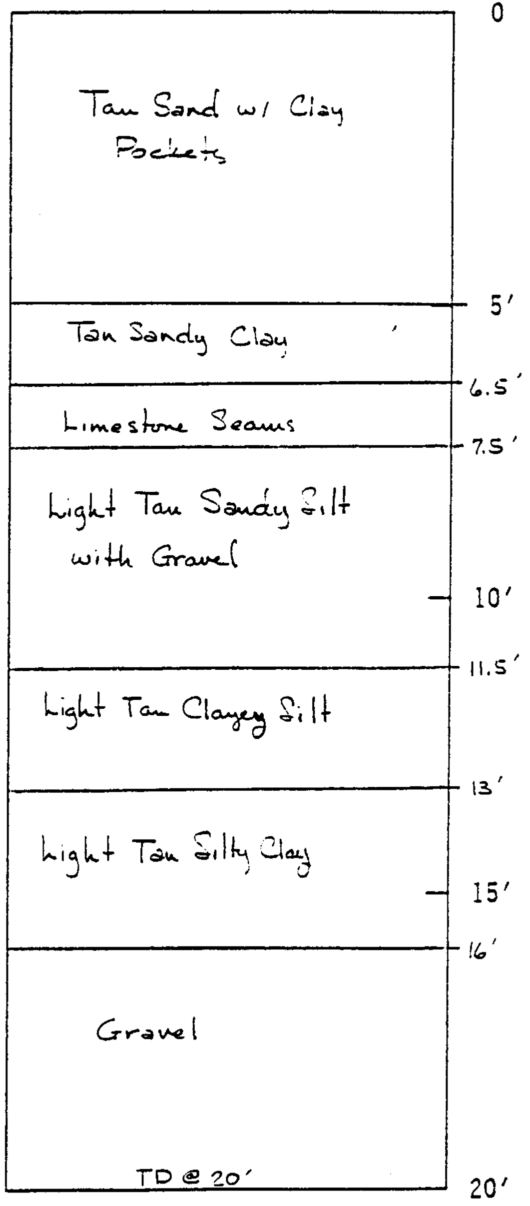
EXPERIMENT No. GPS-1

DATE SAMPLED 7-5-89

**PAVEMENT LOG**



**SHOULDER PROBE LOG**



Instuctions for Pavement Log:

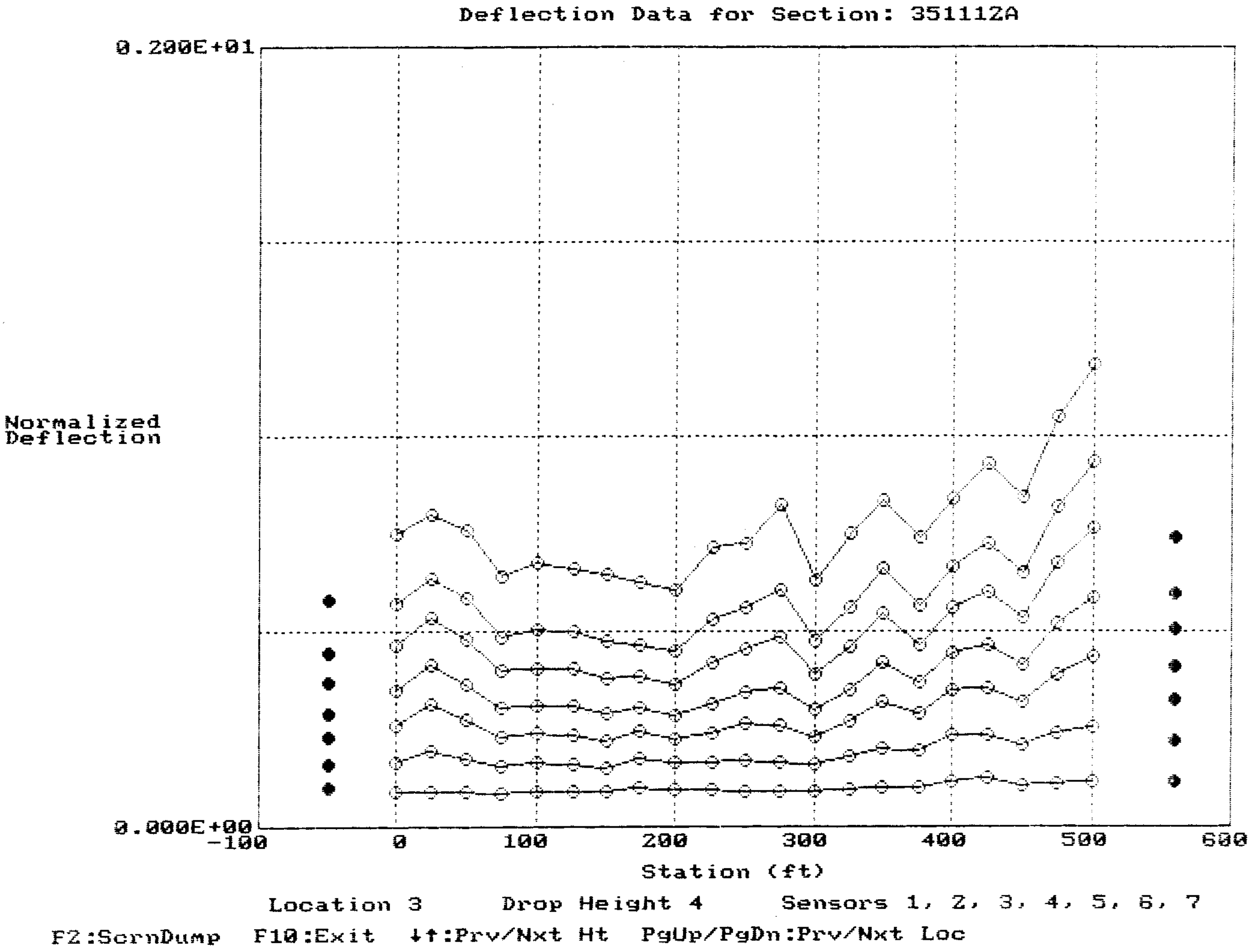
1. Review logs of bore holes, cores, and test pit to establish approximate depths of layer changes.
2. Draw lines across log above to indicate approximate average layer depths and label to identify the materials.

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

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

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

Figure A-2. Profile of Test Section Layers



Location 3 Drop Height 4 Sensors 1, 2, 3, 4, 5, 6, 7

Figure A-3. Deflection Profiles from FWDCHECK

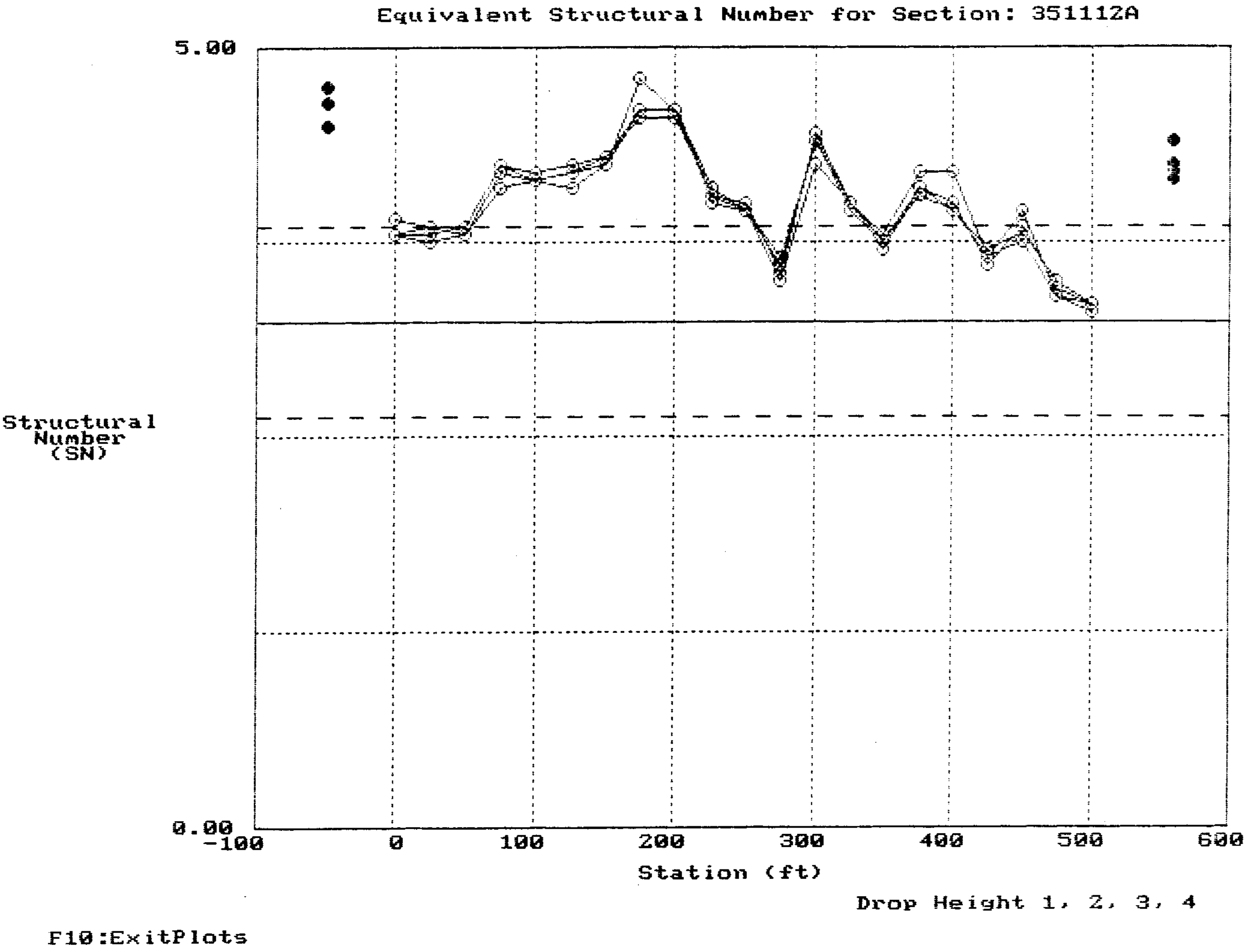


Figure A-4. Structural Number Profiles from FWDCHECK

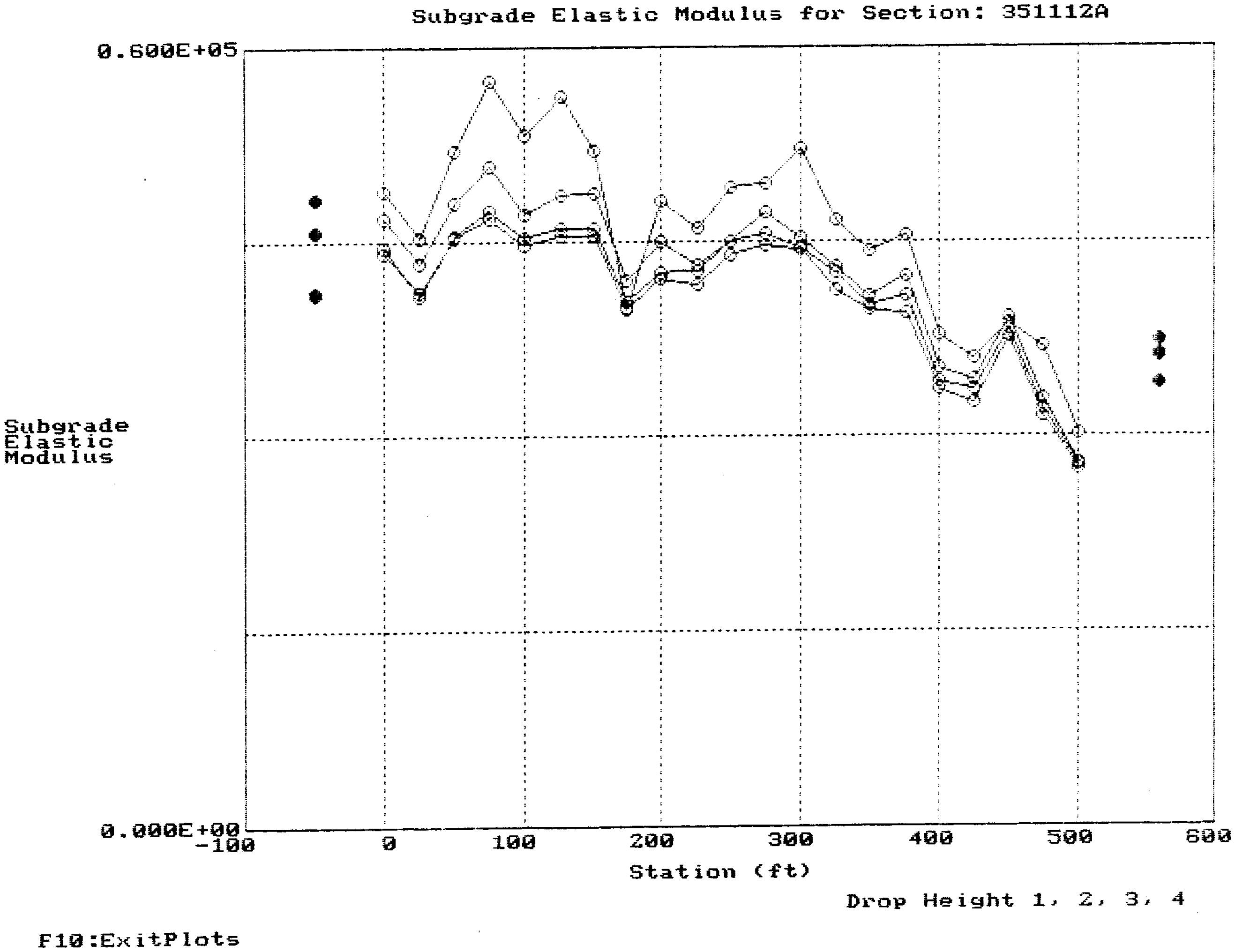


Figure A-5. Subgrade Modulus Profiles from FWDCHECK

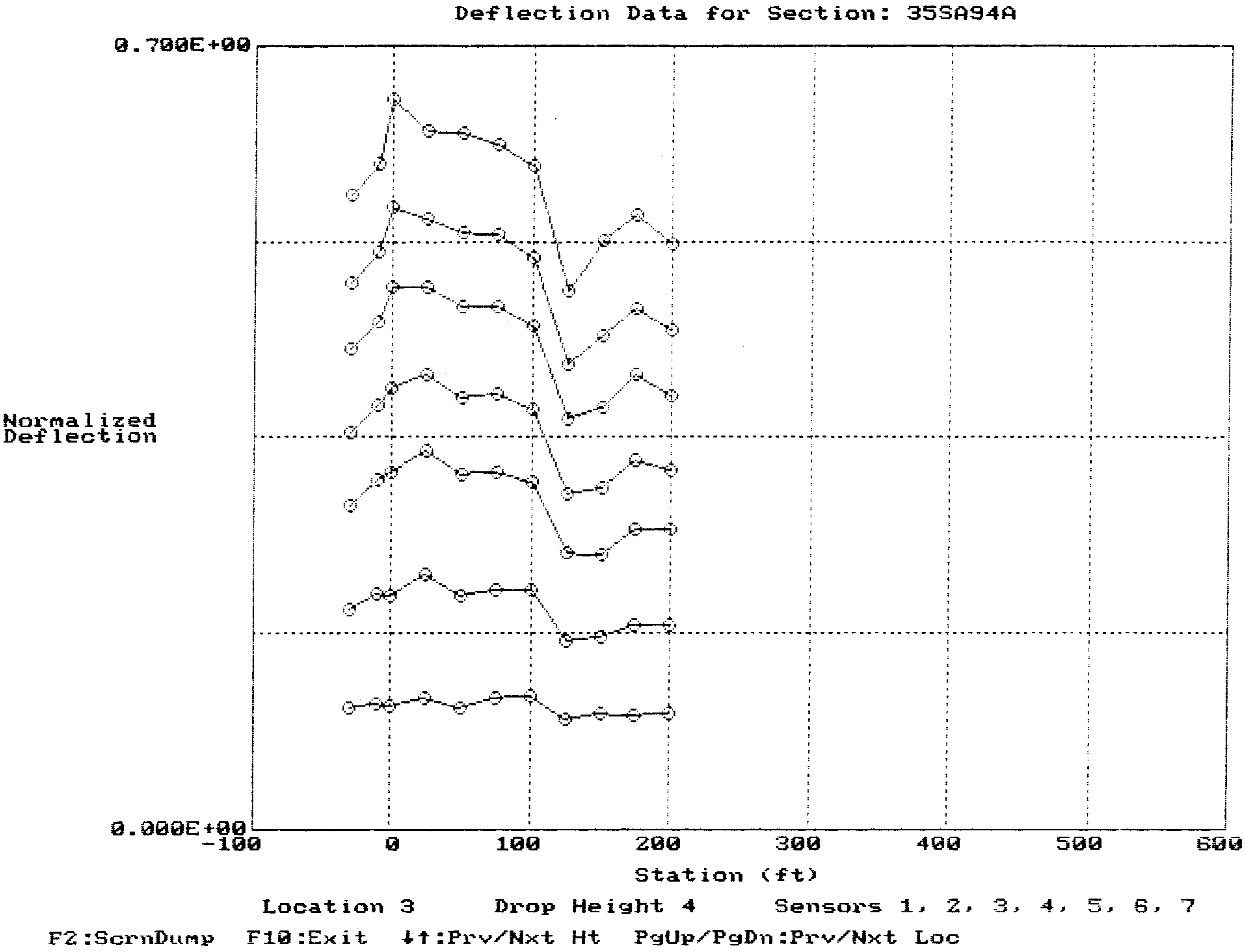


Figure A-6. Deflection Profiles from FWDCHECK on Installation Day

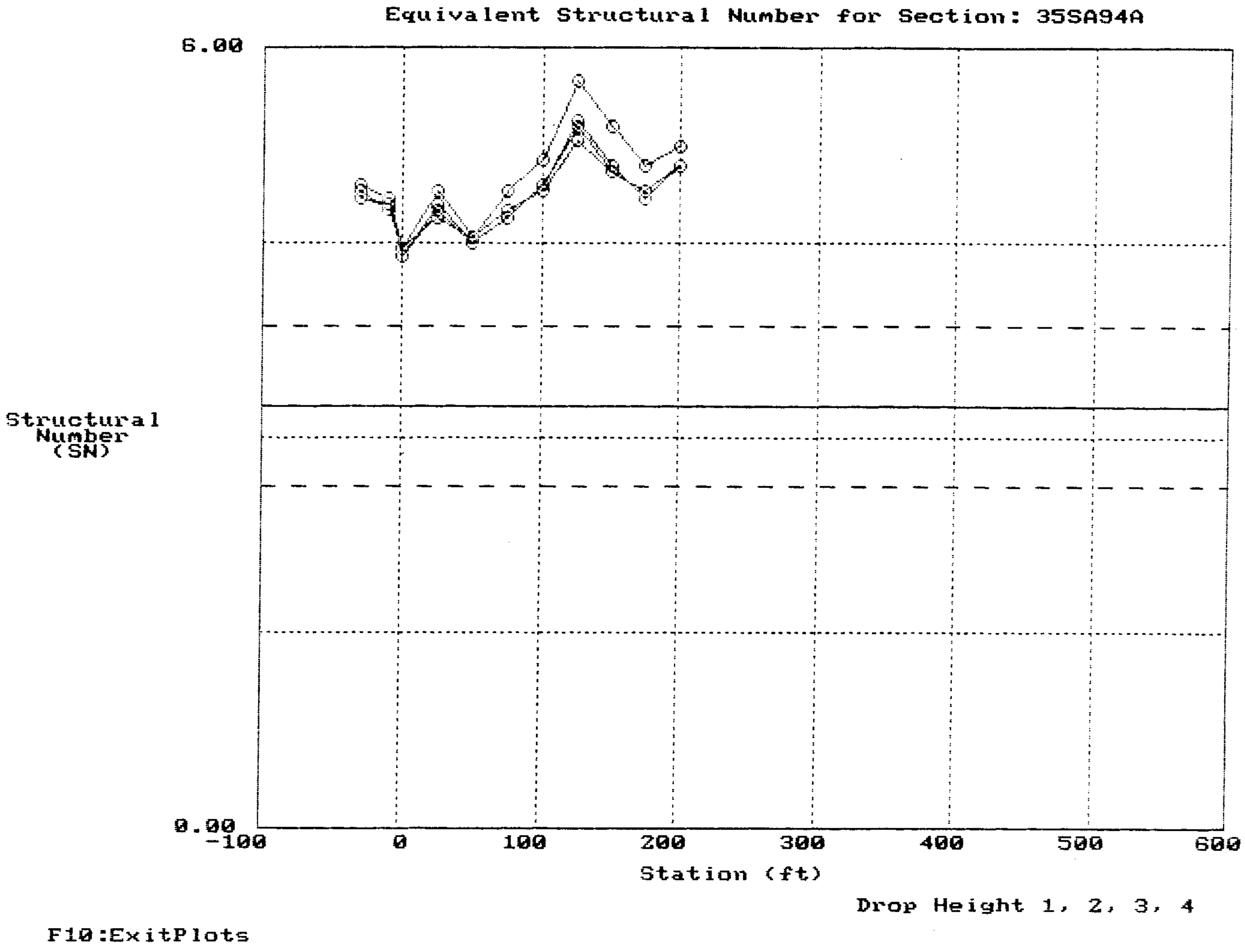


Figure A-7. Structural Number Profiles from FWDCHECK on Installation Day

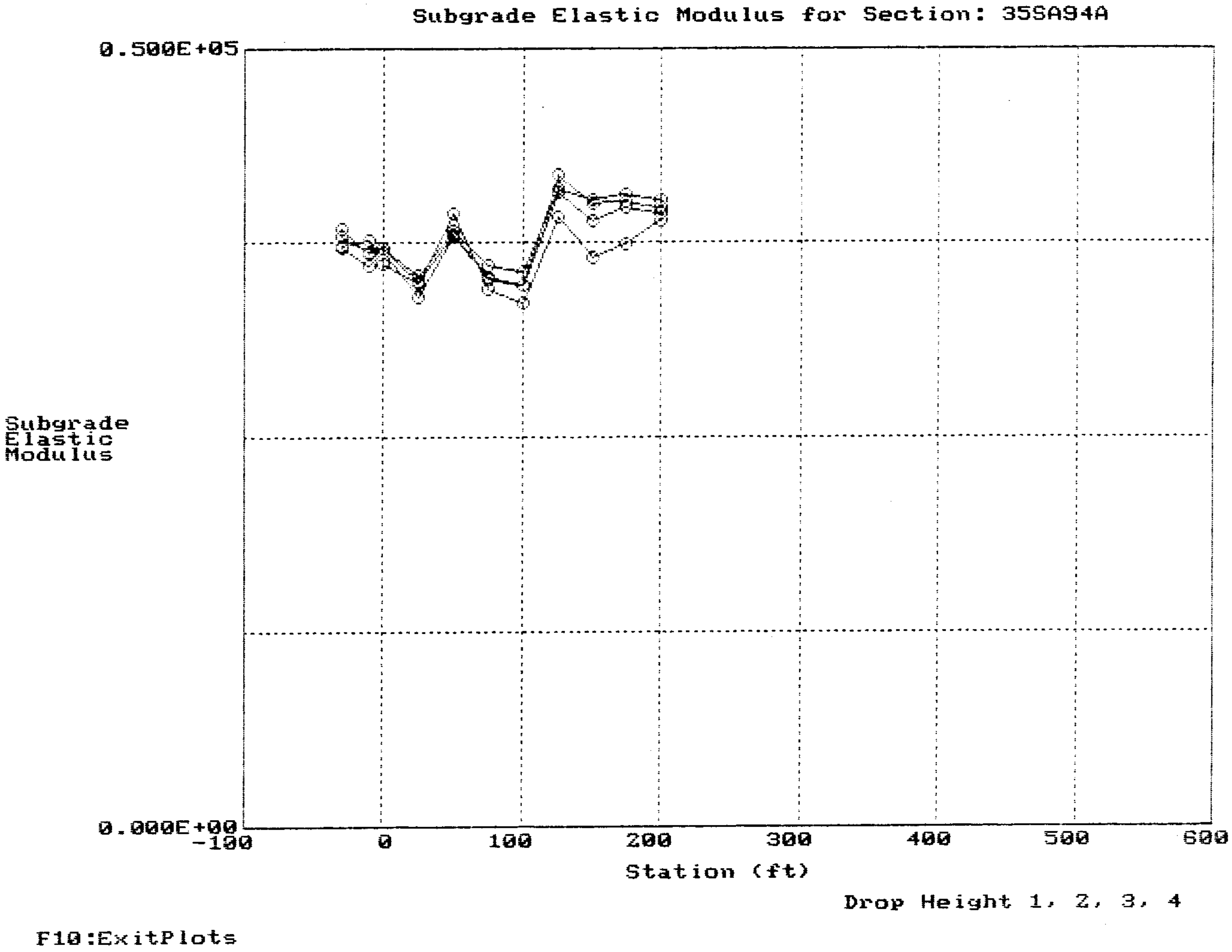


Figure A-8. Subgrade Modulus Profiles from FWDCHECK on Installation Day

Revised December 1, 1992

SHEET 1

DISTRESS SURVEY

LTPP PROGRAM

STATE ASSIGNED ID _ _ _ _

STATE CODE 35

SHRP SECTION ID 1 1 1 2

## DISTRESS SURVEY FOR PAVEMENTS WITH ASPHALT CONCRETE SURFACES

DATE OF DISTRESS SURVEY (MONTH/DAY/YEAR) 03/27/91

SURVEYORS: MPG, _ _ _ PHOTOS, VIDEO, OR BOTH WITH SURVEY (P, V, B) _
PAVEMENT SURFACE TEMP - BEFORE _ _ _ _°C; AFTER _ _ _ _°C

02/14/94

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

NO DISTRESS NOTED

PER SPREAD SHEET NO DISTRESS SURVEY FOUND.

Figure A-9. Distress Survey Data

# APPENDIX B

## Pre-installation Activities

Appendix B contains the following information:

# SEASONAL MONITORING INSTRUMENTATION PRELIMINARY PLANNING MEETING

## *DISCUSSION TOPICS*

**Introduction**

- Objectives of Seasonal Monitoring Program
- Overview of Activities

**Site**

- Section Location
- Instrumentation Layout
- Planned Rehabilitation and Maintenance
- Underground Utilities

**Installation Procedures, Materials and Equipment (Assisted with Slide Presentation)**

- Instrumentation: Sensors and Procedures
  - TDR Probes
  - Resistivity Instrumentation
  - Thermistor Probe
  - Air Temperature and Rain Gauge
  - Equipment Cabinet and On-site Instrumentation
  - Observation Piezometer
- Materials and Equipment
  - Drill Rig
  - Pavement Saw
  - Tools
  - Pavement Repair Materials
  - Piezometer Materials
    - Sand
    - Bentonite
    - Access Cover
  - Others

**Schedule**

- Pre-installation Meeting
- Traffic Control
- Installation Schedule

**Installation Team and Responsibilities**

- Participating Highway Agency Staff
  - Drill Crew
  - Traffic Control
  - Project Contacts
- RCOC Staff
- FHWA Staff
- Others

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 1)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 1 1 2] |

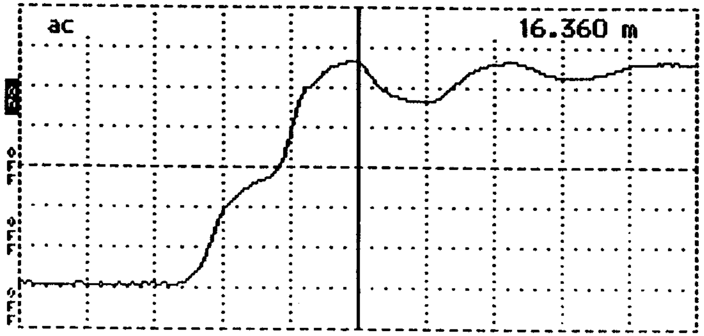
Cursor .......... 15.860 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
VP .............. 0.99
Noise Filter ...... 1 avg
Power .......... ac

Tektronix 1502B TDR
Date 2/21/94
Cable 35A01
Notes Shorted

Input Trace J.P.
Stored Trace ..........
Difference Trace ..........

| TDR Trace | Apparent Length, (m) | Dielectric Constant |
|---|---|---|
| "Shorted at Start" | _ . _ _ | _ _ . _ _ |

Cursor .......... 16.360 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
VP .............. 0.99
Noise Filter ...... 1 avg
Power .......... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A01
Notes Air

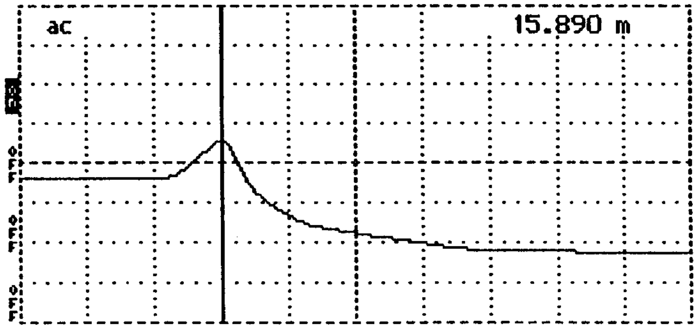
Input Trace J.P.
Stored Trace ..........
Difference Trace ..........

| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Air" | 0.24 | 1.43 |

Figure B-1. TDR Traces Obtained During Calibration

| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 2)<br>TDR Probe Check | Agency Code [4 8]<br>LTPP Section ID [1 1 1 2] |
|---|---|

Cursor .......... 15.890 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp ............... 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A01
Notes WATER
68°F

Input Trace JR
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m)[1] | Dielectric Constant[2] |
|---|---|---|
| "In Water" | _ . _ _ | _ _ . _ _ |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

Note: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: 35A01 Measured Length of Coax Cable: _ _ . _ m

Comments: Cursor not far enough left to calculate dielectric constant.

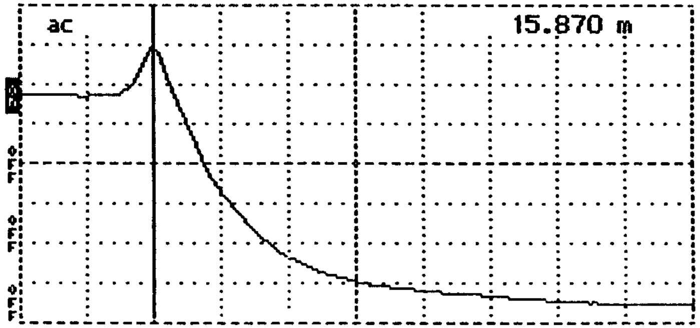
Prepared by: Matt Cole Employer: BRE

Date (dd/mm/yy): 01 / 09 / 94

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 1)<br>TDR Probe Check | Agency Code [4 8]<br>LTPP Section ID [1 1 1 2] |

Cursor .......... 15.870 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
VP ............. 0.99
Noise Filter...... 1 avg
Power........... ac

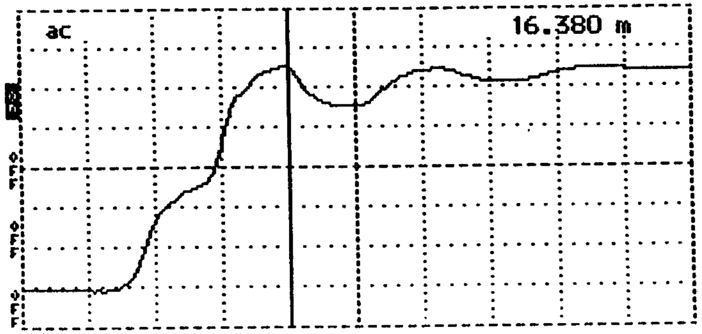


Tektronix 1502B TDR
Date 2/21/94
Cable 35A02
Notes SHORTED

Input Trace JA
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant |
|---|---|---|
| "Shorted at Start" | _ . _ _ | _ _ . _ _ |

Cursor .......... 16.380 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
VP ............. 0.99
Noise Filter...... 1 avg
Power........... ac



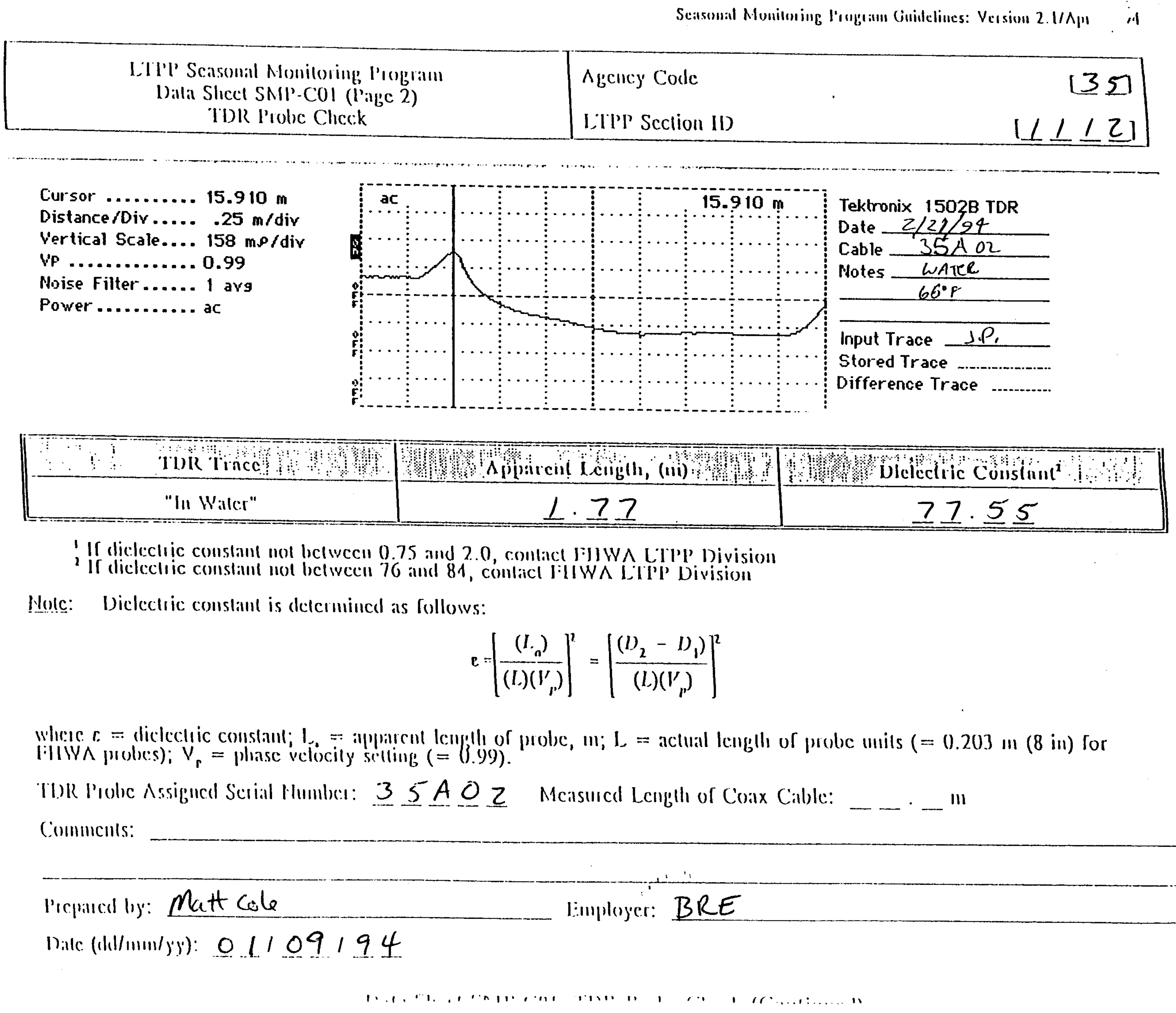
Tektronix 1502B TDR
Date 2/21/94
Cable 35A02
Notes AIR

Input Trace JP
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Air" | 0.24 | 1.43 |

Data Sheet SMP-C . TDR Probe Check

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



Seasonal Monitoring Program Guidelines: Version 2.1/Apr 4

LTPP Seasonal Monitoring Program
Data Sheet SMP-C01 (Page 2)
TDR Probe Check

Agency Code [3 5]

LTPP Section ID [1 1 1 2]

Cursor .......... 15.910 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp ............... 0.99
Noise Filter ...... 1 avg
Power ........... ac

Tektronix 1502B TDR
Date 2/21/94
Cable 35A 02
Notes WATER
66°F
Input Trace JP
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant² |
|---|---|---|
| "In Water" | 1.77 | 77.55 |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

Note: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: 3 5 A 0 2 Measured Length of Coax Cable: __ __ . __ m

Comments:

Prepared by: Matt Cole Employer: BRE

Date (dd/mm/yy): 01/09/94

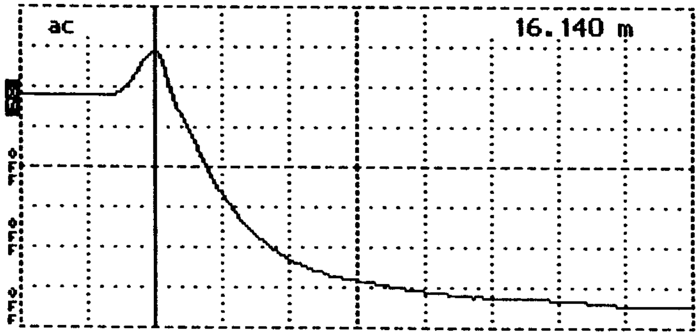
[illegible]

A-3

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 1)<br>TDR Probe Check | Agency Code [4 8]<br>LTPP Section ID [1 1 1 2] |

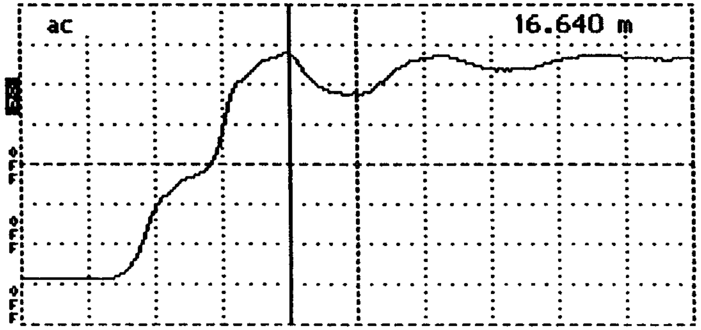
Cursor .......... 16.140 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
VP ............... 0.99
Noise Filter...... 1 avg
Power............ ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A03
Notes SHORTED
Input Trace JP
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant |
|---|---|---|
| "Shorted at Start" | _ . _ _ | _ _ . _ _ |

Cursor .......... 16.640 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
VP ............... 0.99
Noise Filter...... 1 avg
Power............ ac

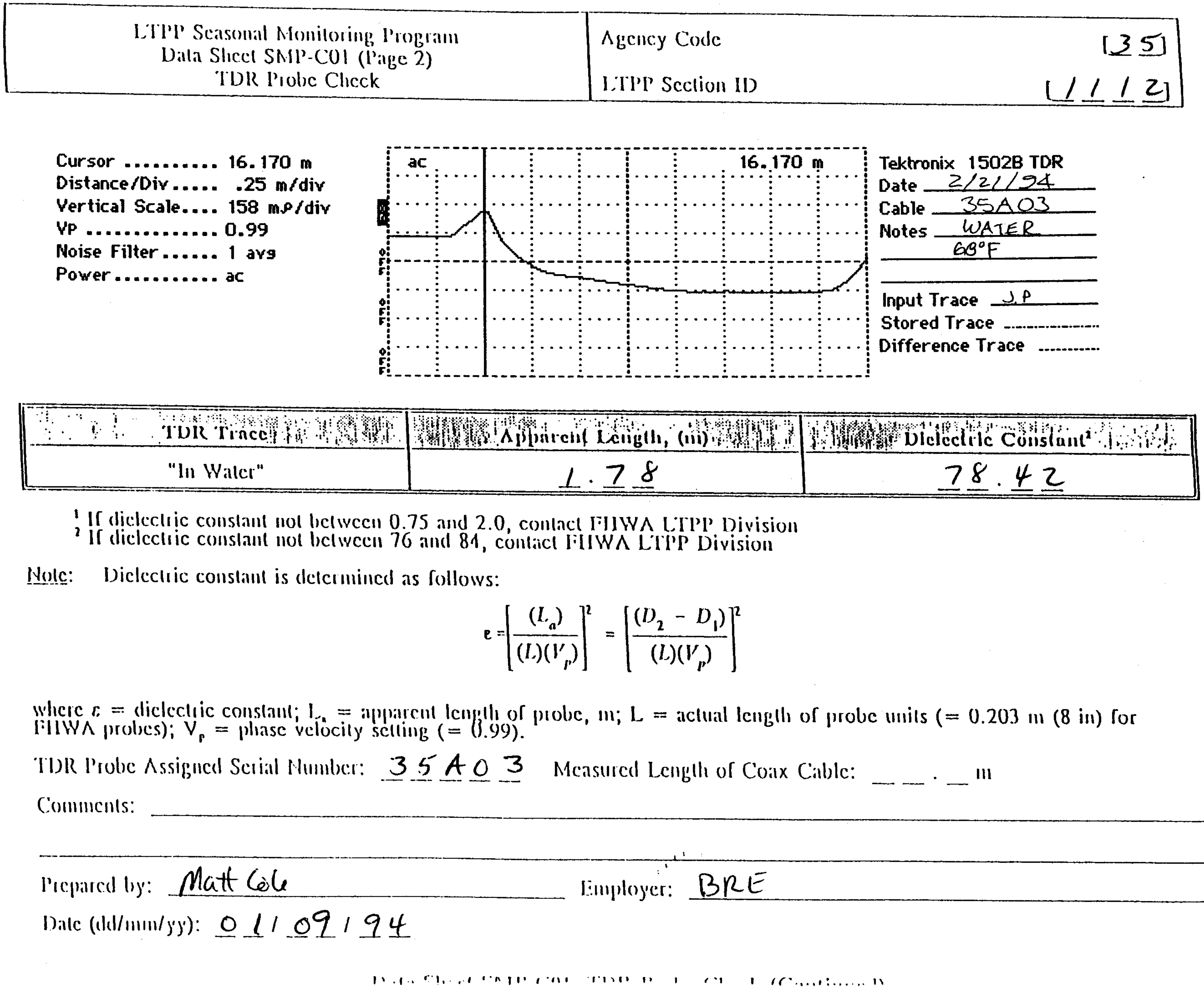


Tektronix 1502B TDR
Date 2/21/94
Cable 35A03
Notes ~~SHORTED~~ JP
AIR
Input Trace JP
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Air" | 0. 24 | 1 . 43 |

Data Sheet SMP-C . TDR Probe Check

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



LTPP Seasonal Monitoring Program
Data Sheet SMP-C01 (Page 2)
TDR Probe Check

Agency Code [35]

LTPP Section ID [1112]

Cursor .......... 16.170 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
VP ............. 0.99
Noise Filter ...... 1 avg
Power .......... ac

Tektronix 1502B TDR
Date 2/21/94
Cable 35A03
Notes WATER
68°F

Input Trace J.P
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m)[1] | Dielectric Constant[2] |
|---|---|---|
| "In Water" | 1.78 | 78.42 |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

Note: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: 35A03 Measured Length of Coax Cable: __ __ . __ m

Comments:

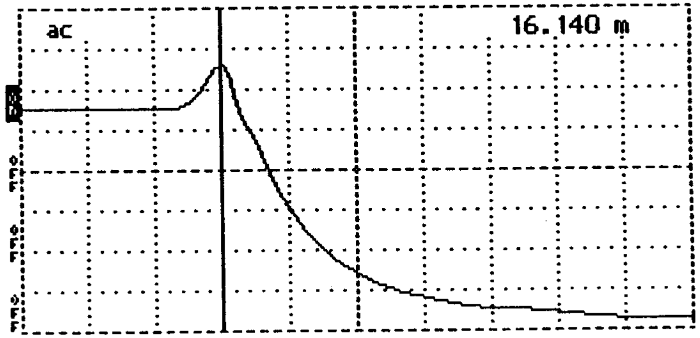
Prepared by: Matt Cole Employer: BRE

Date (dd/mm/yy): 01/09/94

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 1)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 1 1 2] |

Cursor .......... 16.140 m
Distance/Div..... .25 m/div
Vertic l Scale.... 158 mρ/div
VP .............. 0.99
Noise Filter...... 1 avg
Power........... ac

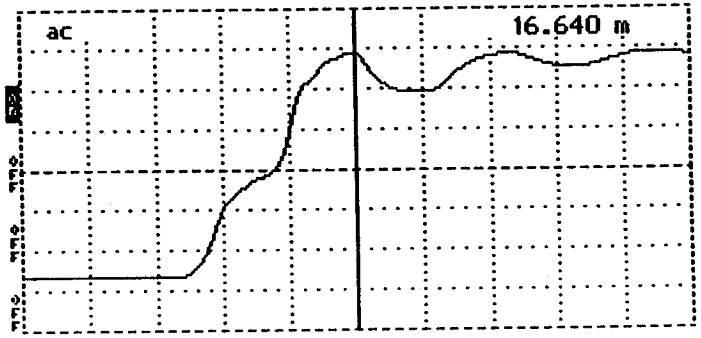


Tektronix 1502B TDR
Date 2/21/94
Cable 35A04
Notes
SHORTED

Input Trace J.P
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant |
|---|---|---|
| "Shorted at Start" | __ . __ __ | __ __ . __ __ |

Cursor .......... 16.640 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
VP .............. 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A04
Notes AIR

Input Trace J.R
Stored Trace
Difference Trace

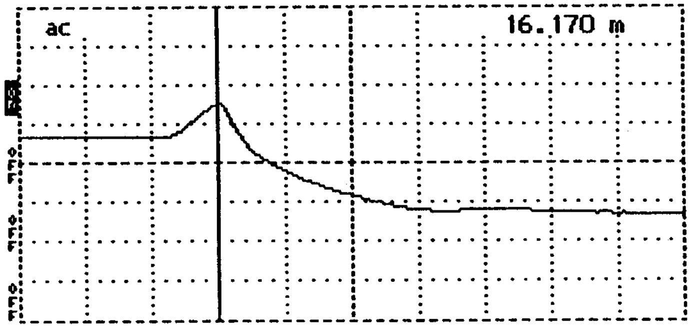
| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Air" | 0.24 | 1.43 |

Data Sheet SMP-C . TDR Probe Check

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 2)<br>TDR Probe Check | Agency Code [35]<br>LTPP Section ID [1112] |

```
Cursor .......... 16.170 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp .............. 0.99
Noise Filter...... 1 avg
Power........... ac
```



Tektronix 1502B TDR
Date 2/21/94
Cable 35A04
Notes WATER
68°F

Input Trace JP
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m)[1] | Dielectric Constant[2] |
|---|---|---|
| "In Water" | _ . _ _ | _ _ . _ _ |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

<u>Note</u>: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: _ _ _ _ _ _     Measured Length of Coax Cable: _ _ . _ m

Comments: Cursor not far enough left to calculate dielectric constant.

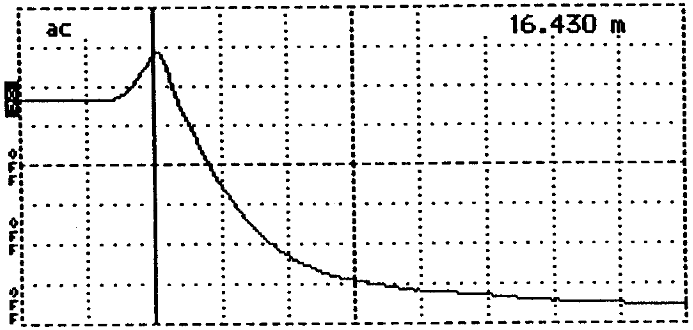
Prepared by: Matt Cole     Employer: BRE

Date (dd/mm/yy): 01/09/94

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 1)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 1 1 2] |

Cursor .......... 16.430 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp .............. 0.99
Noise Filter ...... 1 avg
Power ........... ac

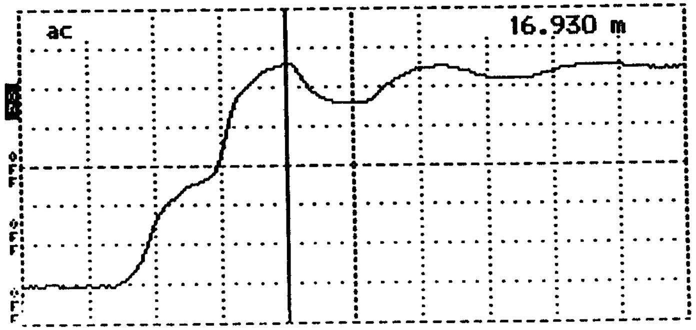


Tektronix 1502B TDR
Date 2/21/94
Cable 35A 05
Notes SHORTED

Input Trace J.P
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant |
|---|---|---|
| "Shorted at Start" | _ . _ _ | _ _ . _ _ |

Cursor .......... 16.930 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp .............. 0.99
Noise Filter ...... 1 avg
Power ........... ac



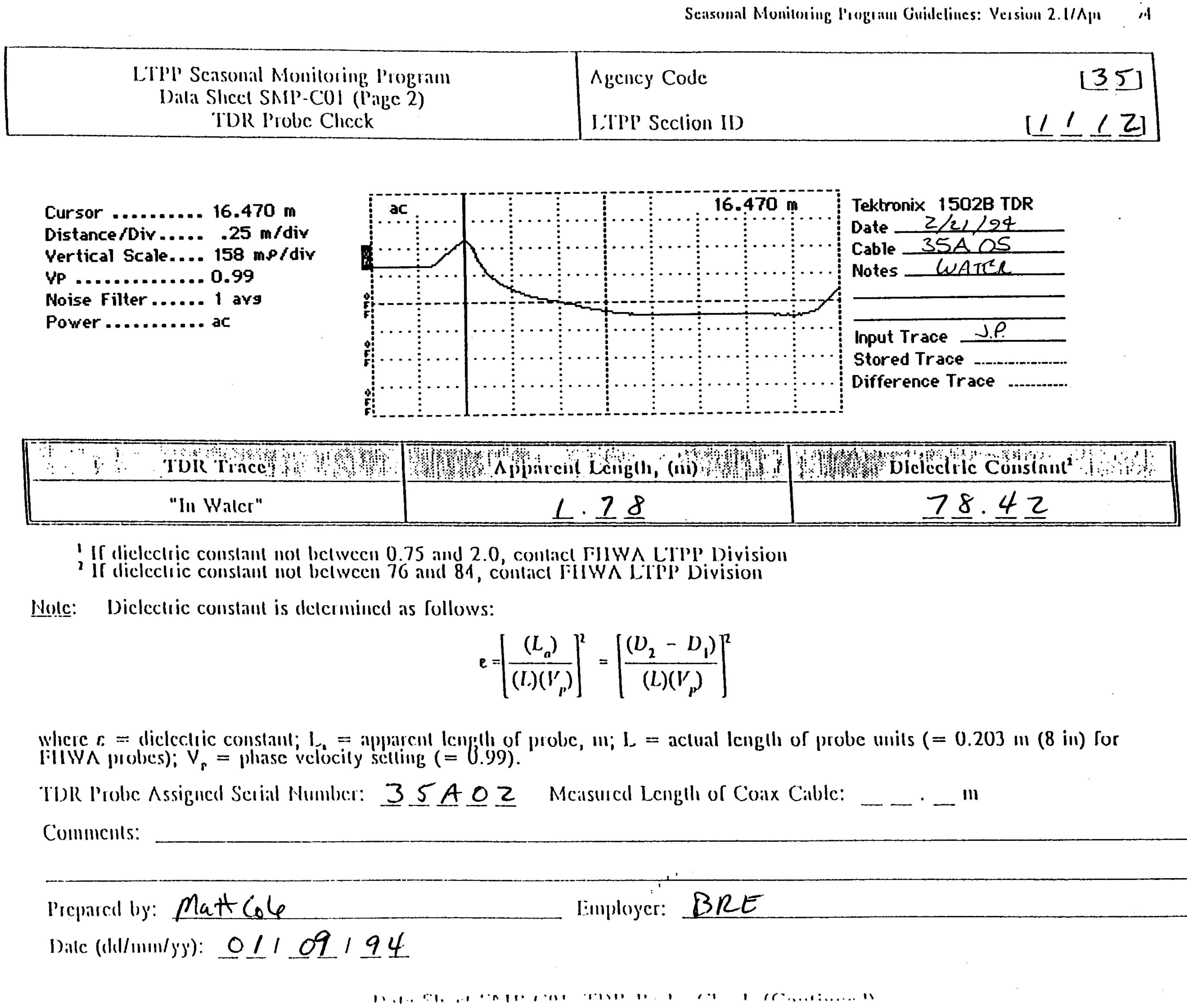
Tektronix 1502B TDR
Date 2/21/94
Cable 35A05
Notes AIR

Input Trace J.P.
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Air" | 0.25 | 1.55 |

Data Sheet SMP-C . TDR Probe Check

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



LTPP Seasonal Monitoring Program
Data Sheet SMP-C01 (Page 2)
TDR Probe Check

Agency Code [3 5]

LTPP Section ID [1 1 1 2]

Cursor .......... 16.470 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
VP ............. 0.99
Noise Filter ...... 1 avg
Power .......... ac

Tektronix 1502B TDR
Date 2/21/94
Cable 35A05
Notes WATER

Input Trace J.P.
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant[2] |
|---|---|---|
| "In Water" | 1.78 | 78.42 |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

Note: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: 35A02 Measured Length of Coax Cable: __ __ . __ m

Comments: _________________________________________________________________________________________________

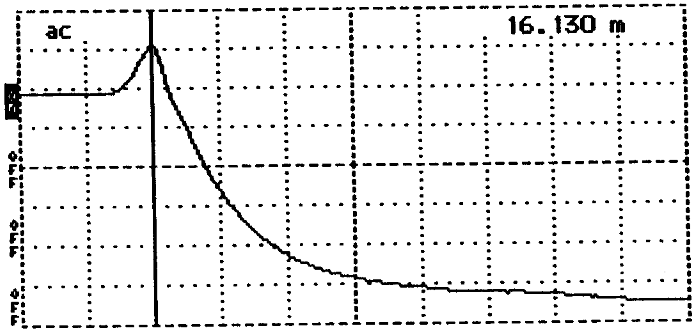
Prepared by: Matt Cole Employer: BRE

Date (dd/mm/yy): 01/09/94

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 1)<br>TDR Probe Check | Agency Code [35]<br>LTPP Section ID [1 1 1 2] |

Cursor .......... 16.130 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp .............. 0.99
Noise Filter...... 1 avg
Power........... ac

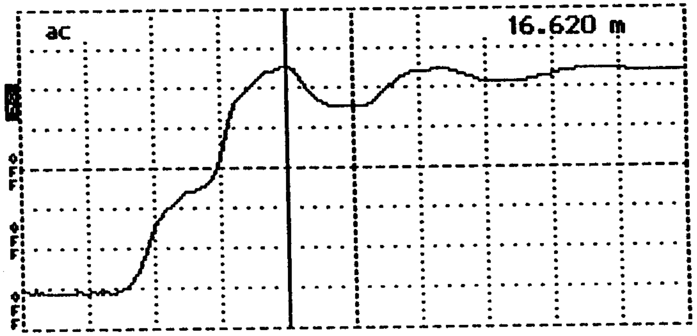


Tektronix 1502B TDR
Date 2/21/94
Cable 35A06
Notes SHORTED

Input Trace J.P
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant |
|---|---|---|
| "Shorted at Start" | _ . _ _ | _ _ . _ _ |

Cursor .......... 16.620 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp .............. 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A06
Notes AIR.

Input Trace JP.
Stored Trace
Difference Trace

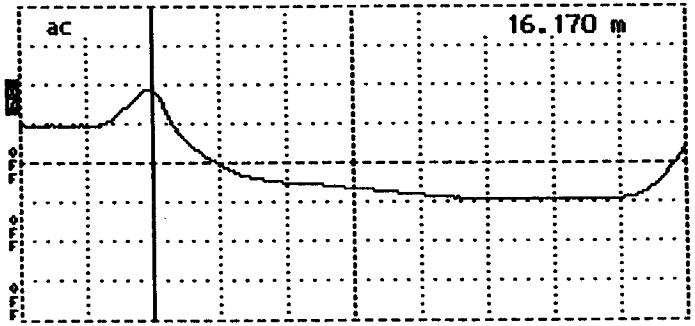
| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Air" | 0.25 | _1.55 |

Data Sheet SMP-C . TDR Probe Check

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 2)<br>TDR Probe Check | Agency Code [35]<br>LTPP Section ID [1112] |

Cursor .......... 16.170 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
VP .............. 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A06
Notes
WATER
68°F
Input Trace SP
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Water" | 1.77 | 77.55 |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

Note: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: 35A06 Measured Length of Coax Cable: __ __ . __ m

Comments:

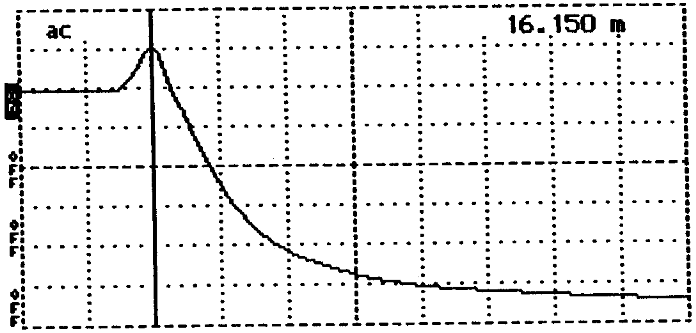
Prepared by: Matt Cole Employer: BRE

Date (dd/mm/yy): 01/09/94

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 1)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 1 1 2] |

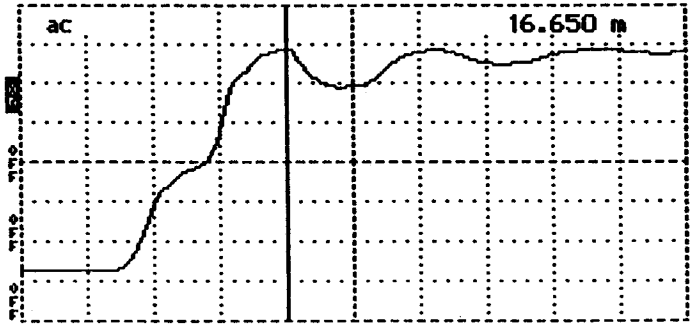
Cursor .......... 16.150 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp ............... 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A07
Notes SHORTED
Input Trace J.P.
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant |
|---|---|---|
| "Shorted at Start" | __ . __ __ | __ __ . __ __ |

Cursor .......... 16.650 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp ............... 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A07
Notes AIR
Input Trace JP
Stored Trace
Difference Trace

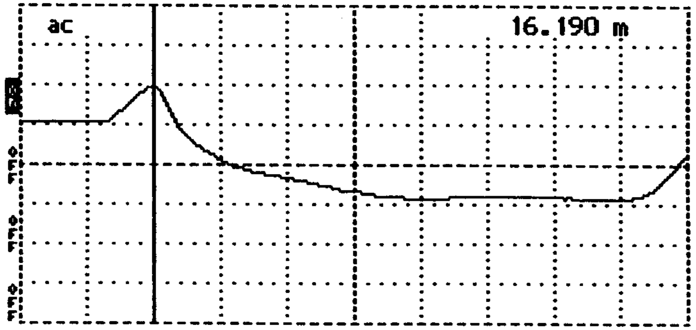
| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Air" | 0.24 | 1.43 |

Data Sheet SMP-C . TDR Probe Check

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 2)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 1 1 2] |

Cursor .......... 16.190 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
VP ............. 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A07
Notes WATER

Input Trace J.P.
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m)[1] | Dielectric Constant[2] |
|---|---|---|
| "In Water" | 1.78 | 78.42 |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

Note: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: 35A07 Measured Length of Coax Cable: __ __ . __ m

Comments:

Prepared by: Matt 66 Employer: BRE

Date (dd/mm/yy): 01/09/94

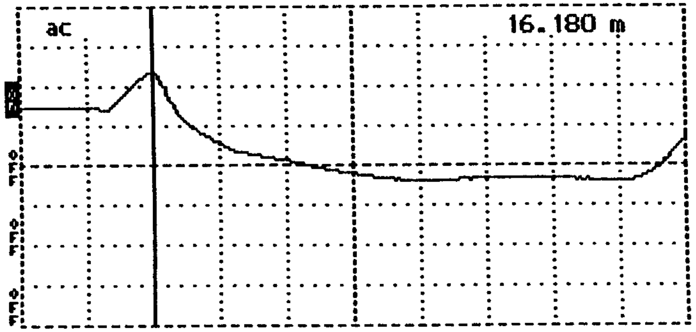
Data Sheet SMP-C01 TDR Probe Check (Continued)

A-3

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 2)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 1 1 2] |

Cursor .......... 16.180 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp .............. 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A08
Notes WATER
68°F

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

| TDR Trace | Apparent Length, (m) | Dielectric Constant[2] |
|---|---|---|
| "In Water" | 1.78 | 78.42 |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

Note: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: 35A08 Measured Length of Coax Cable: _ _ . _ m

Comments:

Prepared by: Matt Cole Employer: BRE

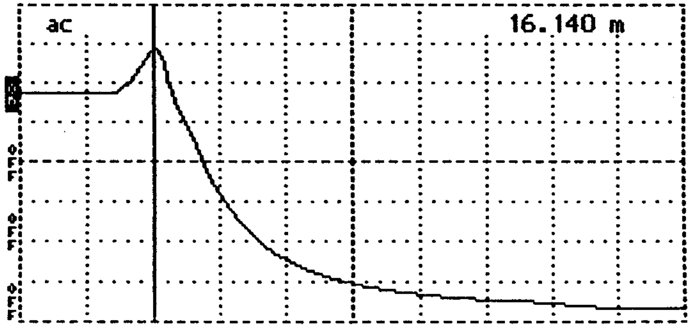
Date (dd/mm/yy): 01/09/94

A-3

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

| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 1)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 / 1 / 1 2] |
|---|---|

Cursor .......... 16.140 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
VP ............. 0.99
Noise Filter...... 1 avg
Power.......... ac

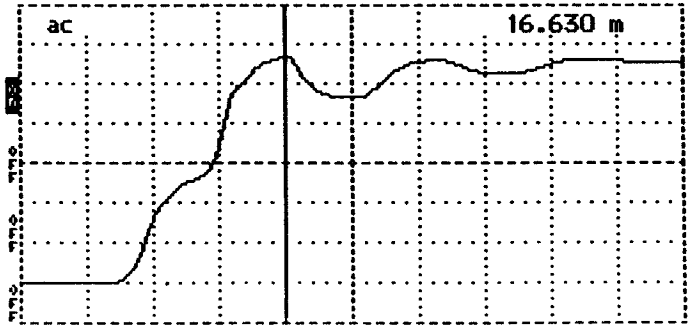


Tektronix 1502B TDR
Date 2/21/94
Cable 35A09
Notes Shorted

Input Trace SP
Stored Trace ............
Difference Trace ..........

| TDR Trace | Apparent Length, (m) | Dielectric Constant |
|---|---|---|
| "Shorted at Start" | _ . _ _ | _ _ . _ _ |

Cursor .......... 16.630 m
Distance/Div..... .25 m/div
Vertical Scale.... 158 mρ/div
VP ............. 0.99
Noise Filter...... 1 avg
Power.......... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A09
Notes AIR

Input Trace SP
Stored Trace ............
Difference Trace ..........

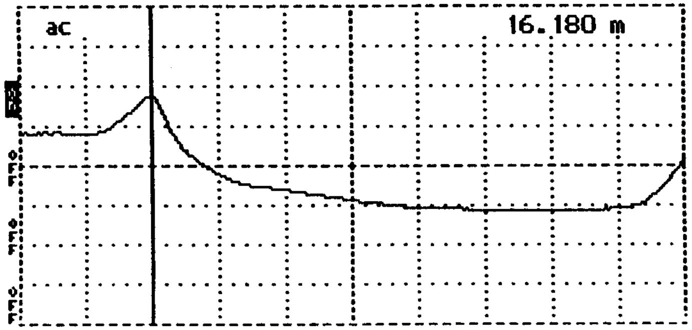
| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Air" | 0.25 | 1.55 |

Data Sheet SMP-C . TDR Probe Check

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 2)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 1 1 2] |

Cursor .......... 16.180 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
VP .............. 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A09
Notes WATER

Input Trace JP
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant[2] |
|---|---|---|
| "In Water" | 1.77 | 77.55 |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

Note: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: 35A09 Measured Length of Coax Cable: __ __ . __ m

Comments:

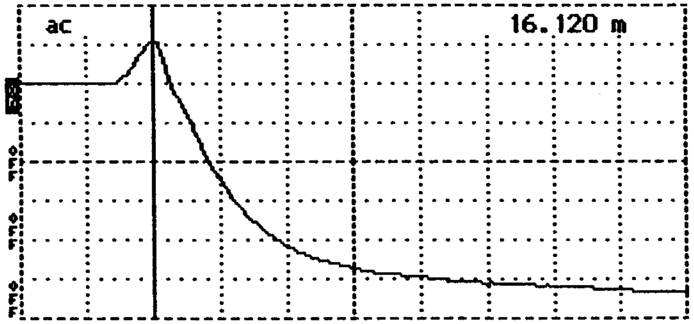
Prepared by: Matt Cole Employer: BRE

Date (dd/mm/yy): 01/09/94

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 1)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 1 1 2] |

Cursor .......... 16.120 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp ............. 0.99
Noise Filter ...... 1 avg
Power .......... ac

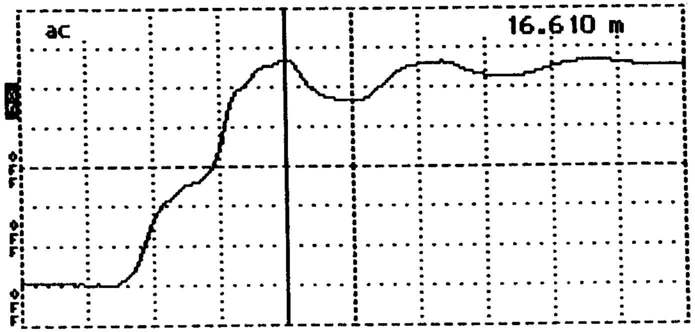


Tektronix 1502B TDR
Date 2/21/94
Cable 35A1D
Notes SHORTED

Input Trace J.P.
Stored Trace ..........
Difference Trace ..........

| TDR Trace | Apparent Length, (m) | Dielectric Constant |
|---|---|---|
| "Shorted at Start" | __ . __ __ | __ __ . __ __ |

Cursor .......... 16.610 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp ............. 0.99
Noise Filter ...... 1 avg
Power .......... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A1D
Notes AIR

Input Trace J.P.
Stored Trace ..........
Difference Trace ..........

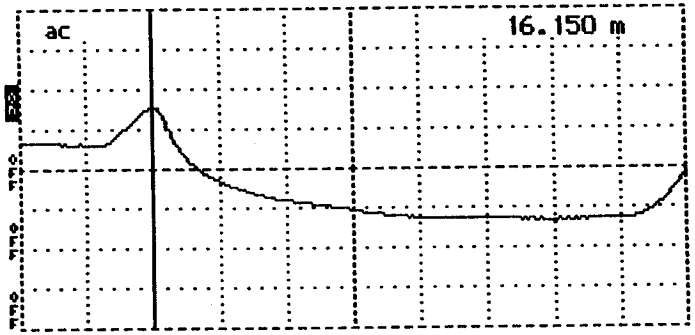
| TDR Trace | Apparent Length, (m) | Dielectric Constant[1] |
|---|---|---|
| "In Air" | 0.25 | 1.55 |

Data Sheet SMP-C . TDR Probe Check

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

| | |
|---|---|
| LTPP Seasonal Monitoring Program<br>Data Sheet SMP-C01 (Page 2)<br>TDR Probe Check | Agency Code [3 5]<br>LTPP Section ID [1 1 1 2] |

Cursor .......... 16.150 m
Distance/Div ..... .25 m/div
Vertical Scale.... 158 mρ/div
Vp ............. 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 2/21/94
Cable 35A10
Notes WATER
60°F

Input Trace
Stored Trace
Difference Trace

| TDR Trace | Apparent Length, (m) | Dielectric Constant² |
|---|---|---|
| "In Water" | 1.78 | 78.42 |

[1] If dielectric constant not between 0.75 and 2.0, contact FHWA LTPP Division
[2] If dielectric constant not between 76 and 84, contact FHWA LTPP Division

Note: Dielectric constant is determined as follows:

$$\varepsilon = \left[\frac{(L_a)}{(L)(V_p)}\right]^2 = \left[\frac{(D_2 - D_1)}{(L)(V_p)}\right]^2$$

where $\varepsilon$ = dielectric constant; $L_a$ = apparent length of probe, m; L = actual length of probe units (= 0.203 m (8 in) for FHWA probes); $V_p$ = phase velocity setting (= 0.99).

TDR Probe Assigned Serial Number: 35A10 Measured Length of Coax Cable: __ __ . __ m

Comments:

Prepared by: Matt Cole Employer: BRE

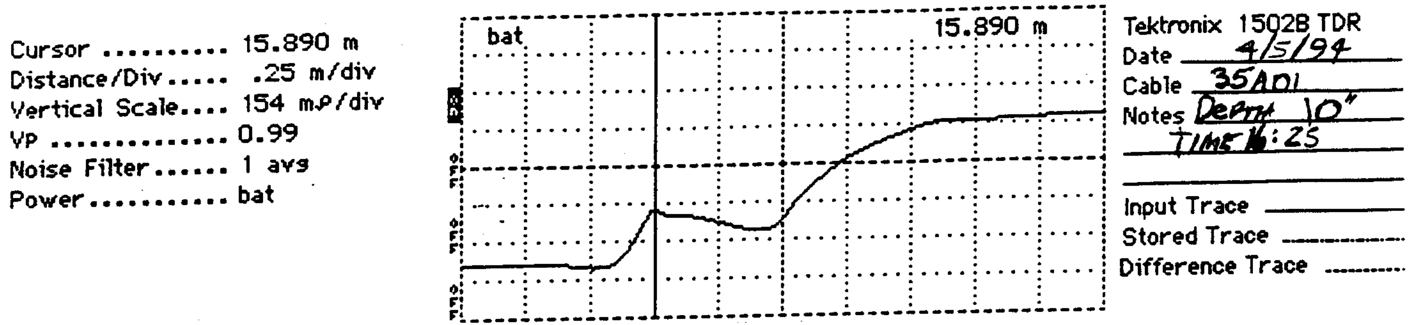
Date (dd/mm/yy): 01/09/94

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

# APPENDIX C

## Instrumentation Installation Information

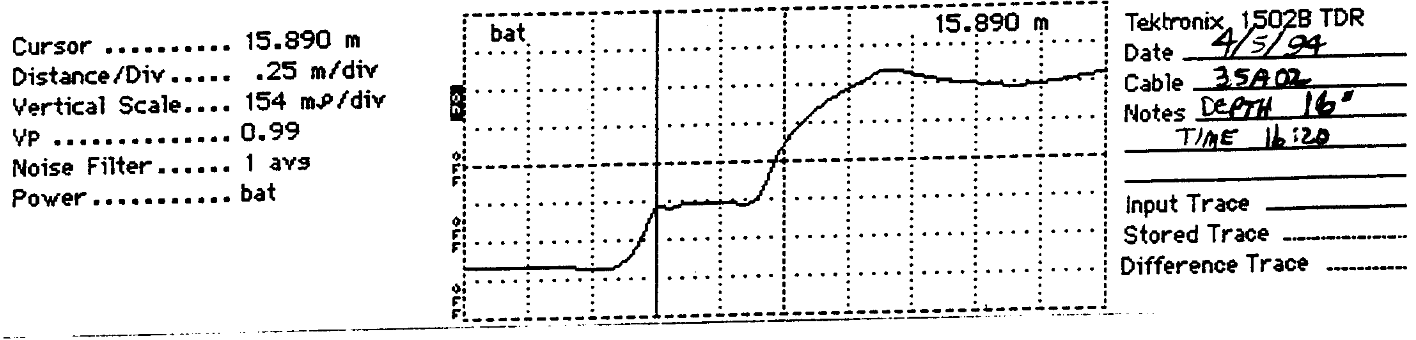
Appendix C contains the following information:



Cursor .......... 15.890 m
Distance/Div..... .25 m/div
Vertical Scale.... 154 mρ/div
Vp ............. 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A01
Notes DEPTH 10"
TIME 16:25

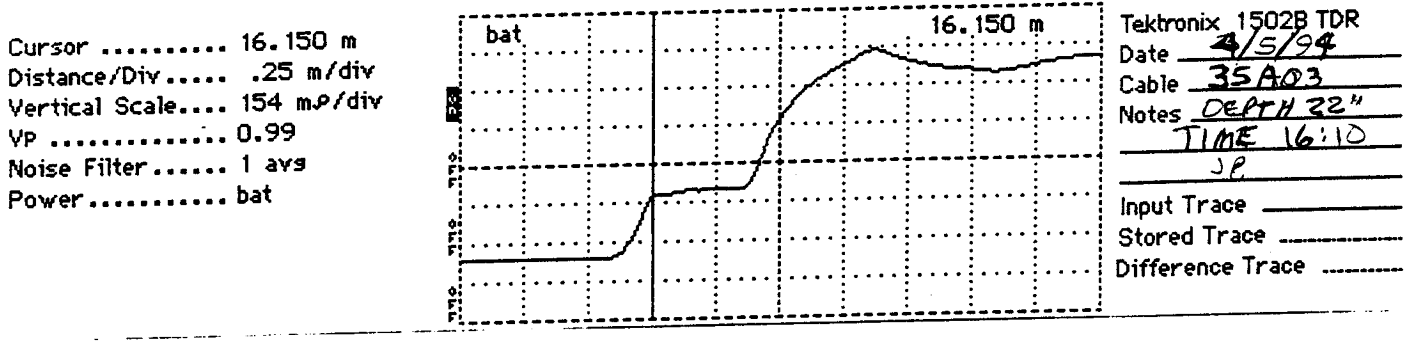
Input Trace
Stored Trace
Difference Trace



Cursor .......... 15.890 m
Distance/Div..... .25 m/div
Vertical Scale.... 154 mρ/div
Vp ............. 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A02
Notes DEPTH 16"
TIME 16:20

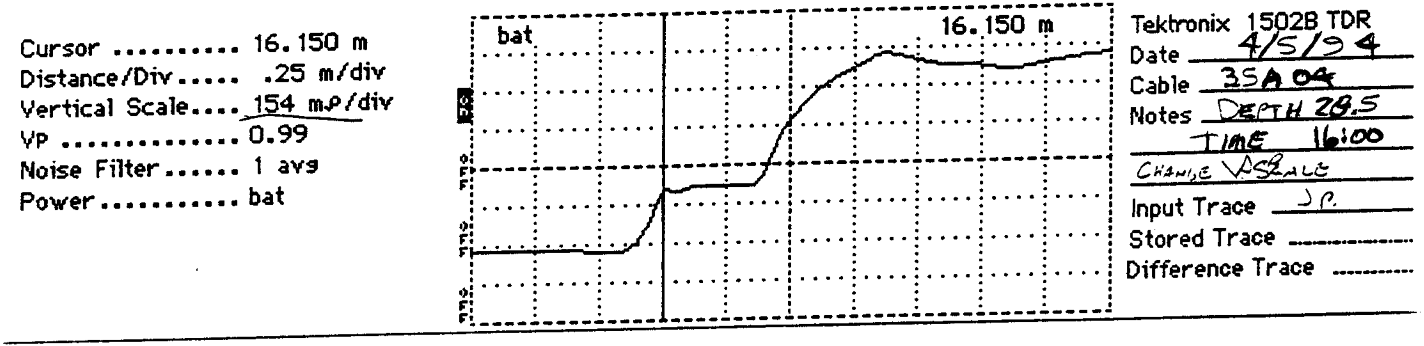
Input Trace
Stored Trace
Difference Trace



Cursor .......... 16.150 m
Distance/Div..... .25 m/div
Vertical Scale.... 154 mρ/div
Vp ............. 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A03
Notes DEPTH 22"
TIME 16:10
JP

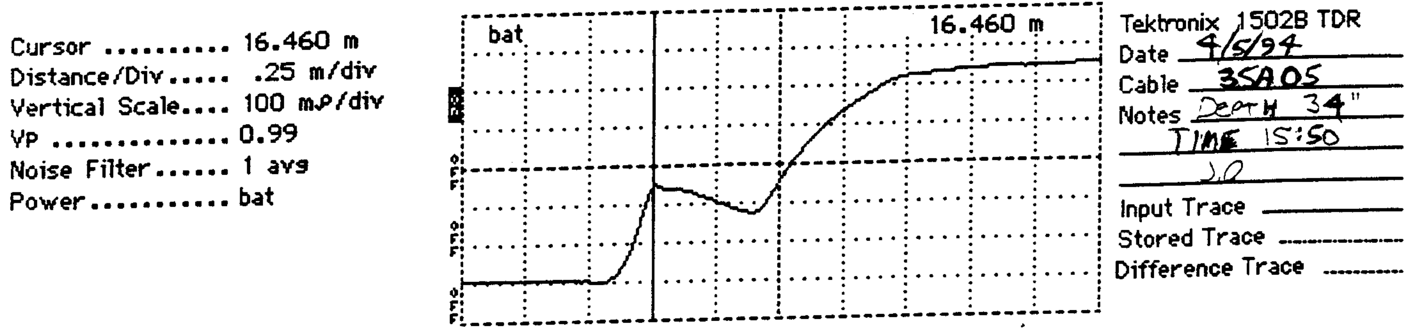
Input Trace
Stored Trace
Difference Trace



Cursor .......... 16.150 m
Distance/Div..... .25 m/div
Vertical Scale.... 154 mρ/div
Vp ............. 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A04
Notes DEPTH 28.5
TIME 16:00
CHANGE VSCALE

Input Trace JP.
Stored Trace
Difference Trace

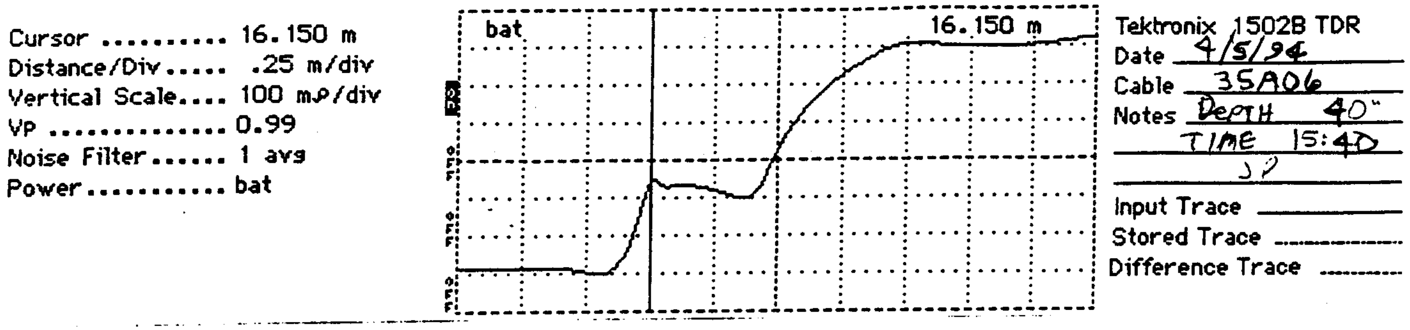


Cursor .......... 16.460 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp ............. 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A05
Notes DEPTH 34"
TIME 15:50
JP

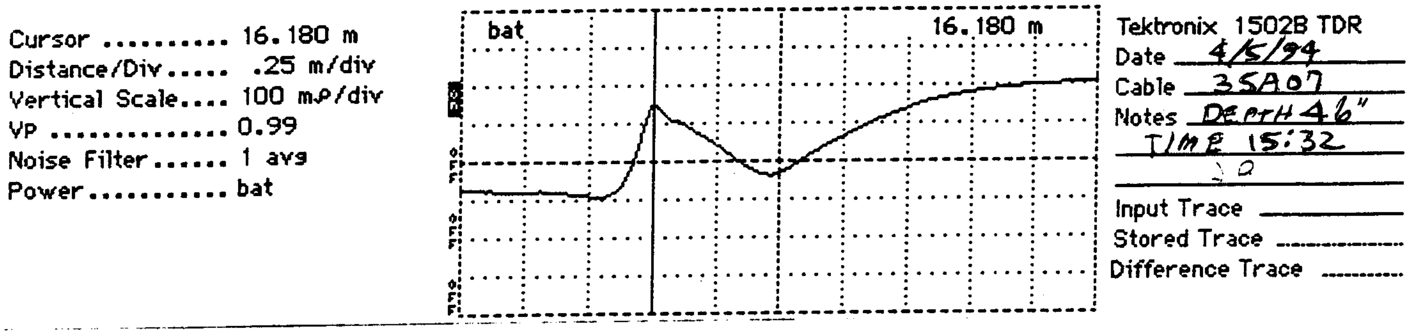
Input Trace
Stored Trace
Difference Trace

Figure C-1. TDR Traces During Installation



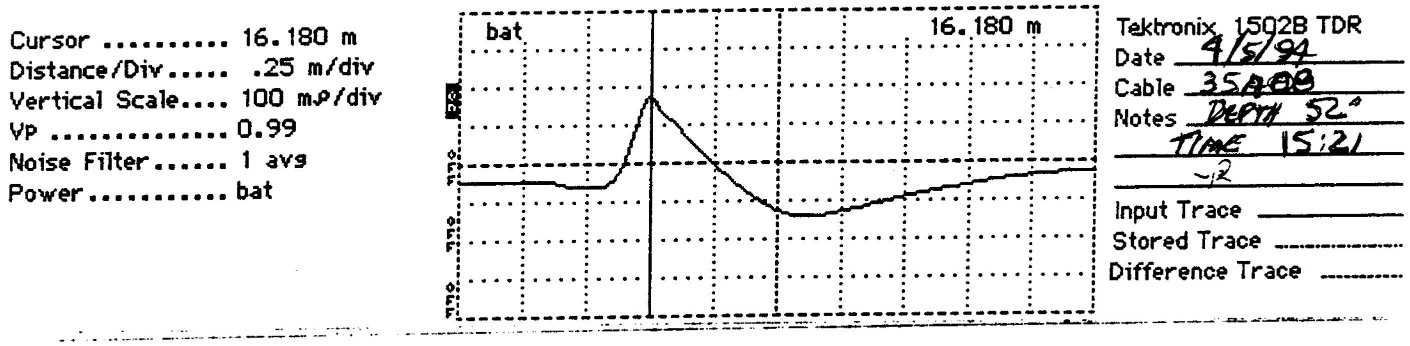
Cursor .......... 16.150 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp ............... 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A06
Notes DEPTH 40"
TIME 15:40
JP
Input Trace
Stored Trace
Difference Trace



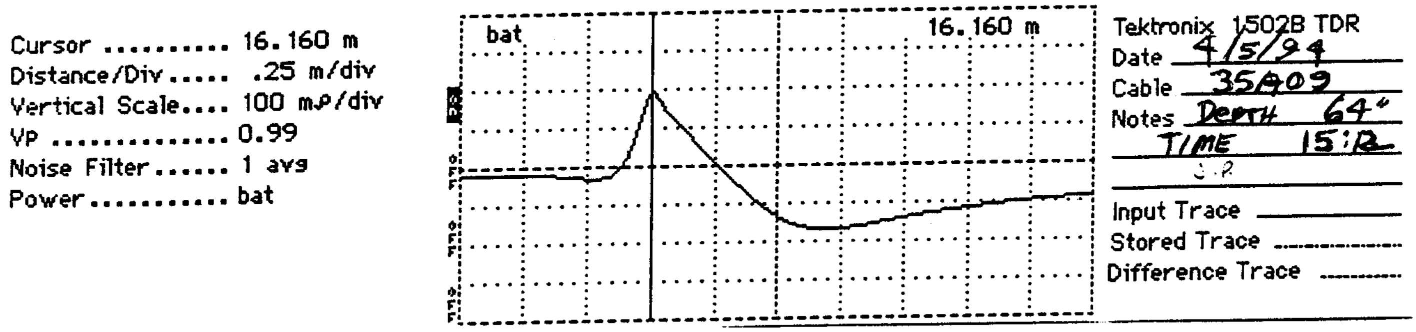
Cursor .......... 16.180 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp ............... 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A07
Notes DEPTH 46"
TIME 15:32
JP
Input Trace
Stored Trace
Difference Trace



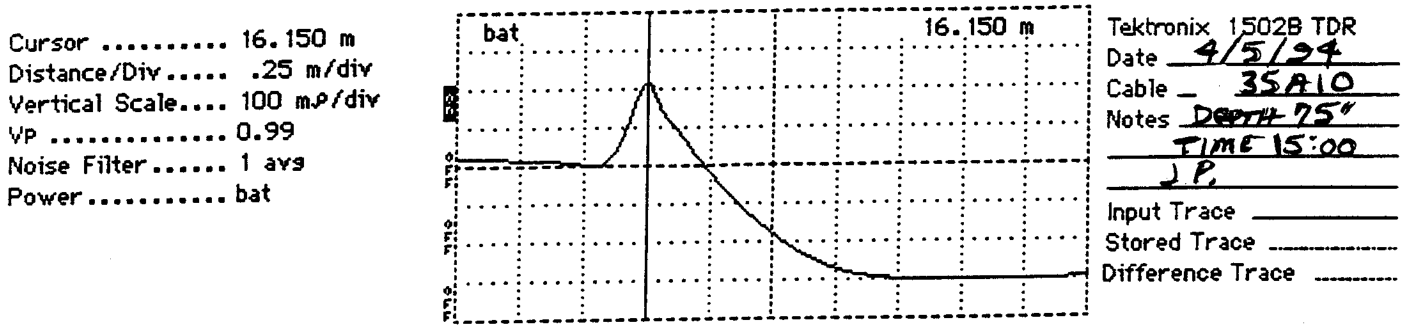
Cursor .......... 16.180 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp ............... 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A08
Notes DEPTH 52"
TIME 15:21
JP
Input Trace
Stored Trace
Difference Trace



Cursor .......... 16.160 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp ............... 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A09
Notes DEPTH 64"
TIME 15:12
JP
Input Trace
Stored Trace
Difference Trace



Cursor .......... 16.150 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp ............... 0.99
Noise Filter...... 1 avg
Power........... bat

Tektronix 1502B TDR
Date 4/5/94
Cable 35A10
Notes DEPTH 75"
TIME 15:00
JP.
Input Trace
Stored Trace
Difference Trace

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

## Table C-1. Field Measured Moisture Contents

SITE NO. 351112 4/5/94

### MOISTURE CONTENTS FOR TDR

| TDR # | WT. OF PAN(g) | (WET) PAN & SOIL(g) | (DRY) PAN & SOIL(g) | M.C. (%) |
|---|---|---|---|---|
| 35A10 | 149 | 305 | 286 | 13.9% |
| 35A09 | 152 | 292 | 278 | 11.1% |
| 35A08 | 152 | 273 | 262 | 10.0% |
| 35A07 | 172 | 298 | 289 | 7.7% |
| 35A06 | 149 | 299 | 296 | 2.0% |
| 35A05 | 172 | 296 | 290 | 5.1% |
| 35A04 | 172 | 293 | 289 | 3.4% |
| 35A03 | 149 | 289 | 287 | 1.4% |
| 35A02 | 152 | 280 | 278 | 1.6% |
| 35A01 | 152 | 293 | 287 | 4.4% |

# APPENDIX D

## Initial Data Collection

Appendix D contains the following support information:

## Table D-1. Raw Data from the On-Site Datalogger During Initial Data Collection

```
5,1994,126,100,12.82,18.43,0
6,1994,126,100,21.33,22.83,23.32,21.86,20.89
5,1994,126,200,12.81,17.83,0
6,1994,126,200,20.39,21.91,22.61,21.68,20.88
5,1994,126,300,12.81,17.79,0
6,1994,126,300,19.66,21.14,21.97,21.48,20.81
5,1994,126,400,12.81,18.21,0
6,1994,126,400,19.17,20.52,21.41,21.26,20.72
5,1994,126,500,12.81,17.86,0
6,1994,126,500,18.78,20.05,20.93,21.02,20.6
5,1994,126,600,12.81,17.61,0
6,1994,126,600,18.42,19.63,20.52,20.8,20.46
5,1994,126,700,12.81,17.1,0
6,1994,126,700,18.13,19.28,20.17,20.58,20.32
5,1994,126,800,12.81,18.37,0
6,1994,126,800,18.31,19.05,19.86,20.37,20.18
5,1994,126,900,12.81,20.72,0
6,1994,126,900,20.54,19.51,19.72,20.17,20.03
5,1994,126,1000,12.81,22.61,0
6,1994,126,1000,24.43,21.3,20.1,20.01,19.89
5,1994,126,1100,12.82,22.89,0
6,1994,126,1100,26.62,23.1,20.98,19.96,19.79
5,1994,126,1200,12.83,24.55,0
6,1994,126,1200,30.68,25.23,21.99,20.06,19.76
5,1994,126,1300,12.83,26.6,0
6,1994,126,1300,35.07,28.01,23.35,20.27,19.81
5,1994,126,1400,12.84,27.67,0
6,1994,126,1400,38.38,30.79,25,20.62,19.94
5,1994,126,1500,12.84,28.02,0
6,1994,126,1500,38.33,32.57,26.6,21.13,20.21
5,1994,126,1600,12.84,28.77,0
6,1994,126,1600,37.84,32.77,27.66,21.7,20.53
5,1994,126,1700,12.84,29.38,0
6,1994,126,1700,39.8,33.91,28.4,22.28,20.93
5,1994,126,1800,12.84,28.82,0
6,1994,126,1800,38.81,34.56,29.23,22.81,21.34
5,1994,126,1900,12.84,28.46,0
6,1994,126,1900,36.74,33.92,29.67,23.32,21.73
5,1994,126,2000,12.84,21.81,0
6,1994,126,2000,33.11,32.62,29.6,23.77,22.13
5,1994,126,2100,12.83,20.78,0
6,1994,126,2100,29.41,30.42,28.96,24.11,22.49
5,1994,126,2200,12.82,19.75,0
6,1994,126,2200,27.18,28.51,27.98,24.28,22.77
5,1994,126,2300,12.81,18.29,0
6,1994,126,2300,25.32,26.93,26.99,24.3,22.95
1,1994,126,2400,12.82,12.85,1705,12.8,2349,22.05,29.74,1606,15.41,0,0,4067
2,1994,126,2400,27.51,26.01,24.29,21.75,20.92,20.15,19.45,18.88,18.06,17.51,17.09,18.37,16.76,16.6,16.53,16.39,16.2,16.07
```

# Site 351112

## June 21, 1994

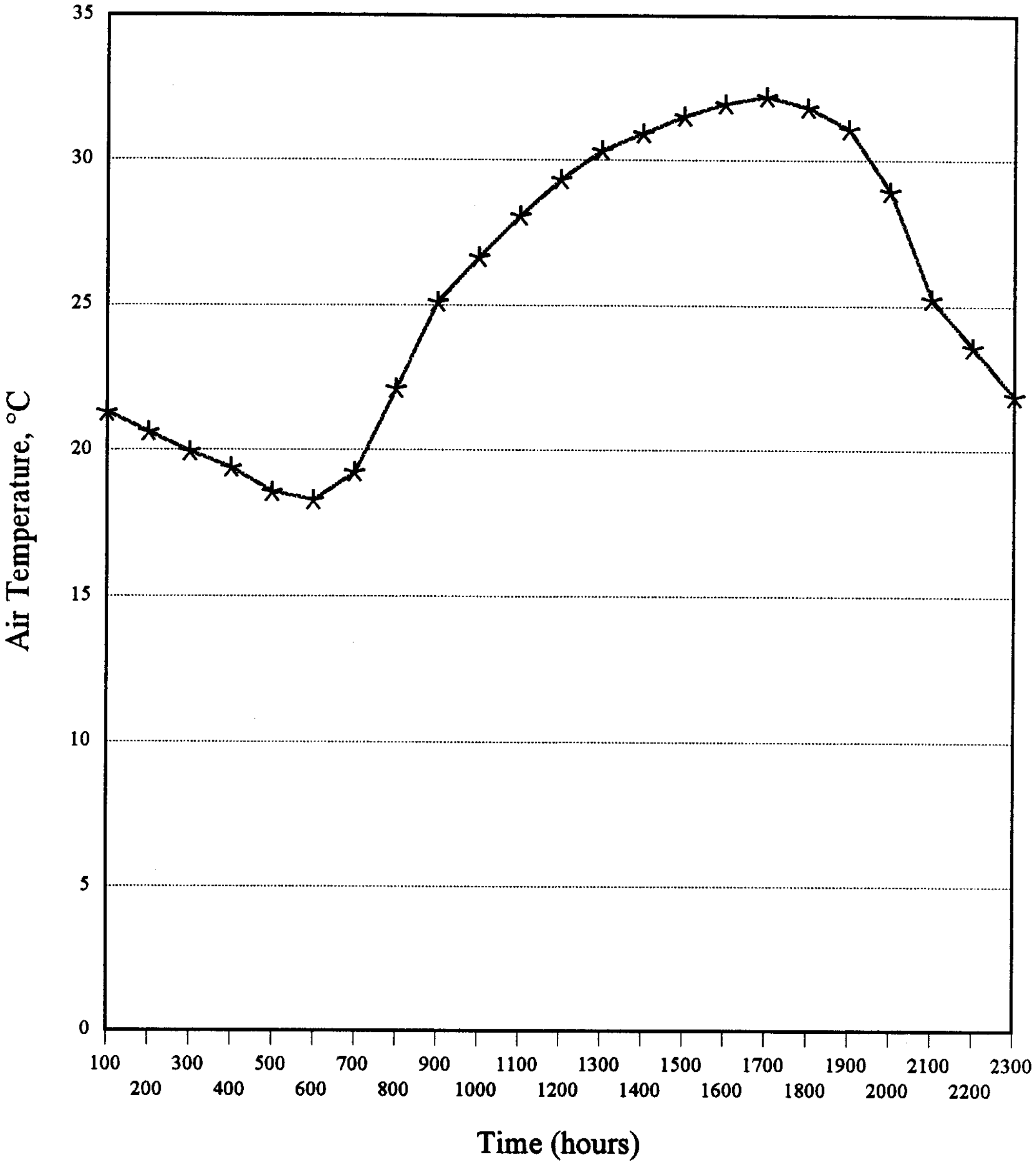


**Figure D-1. Measured Air Temperature During June Data Collection.**

# Site 351112

## June 21, 1994

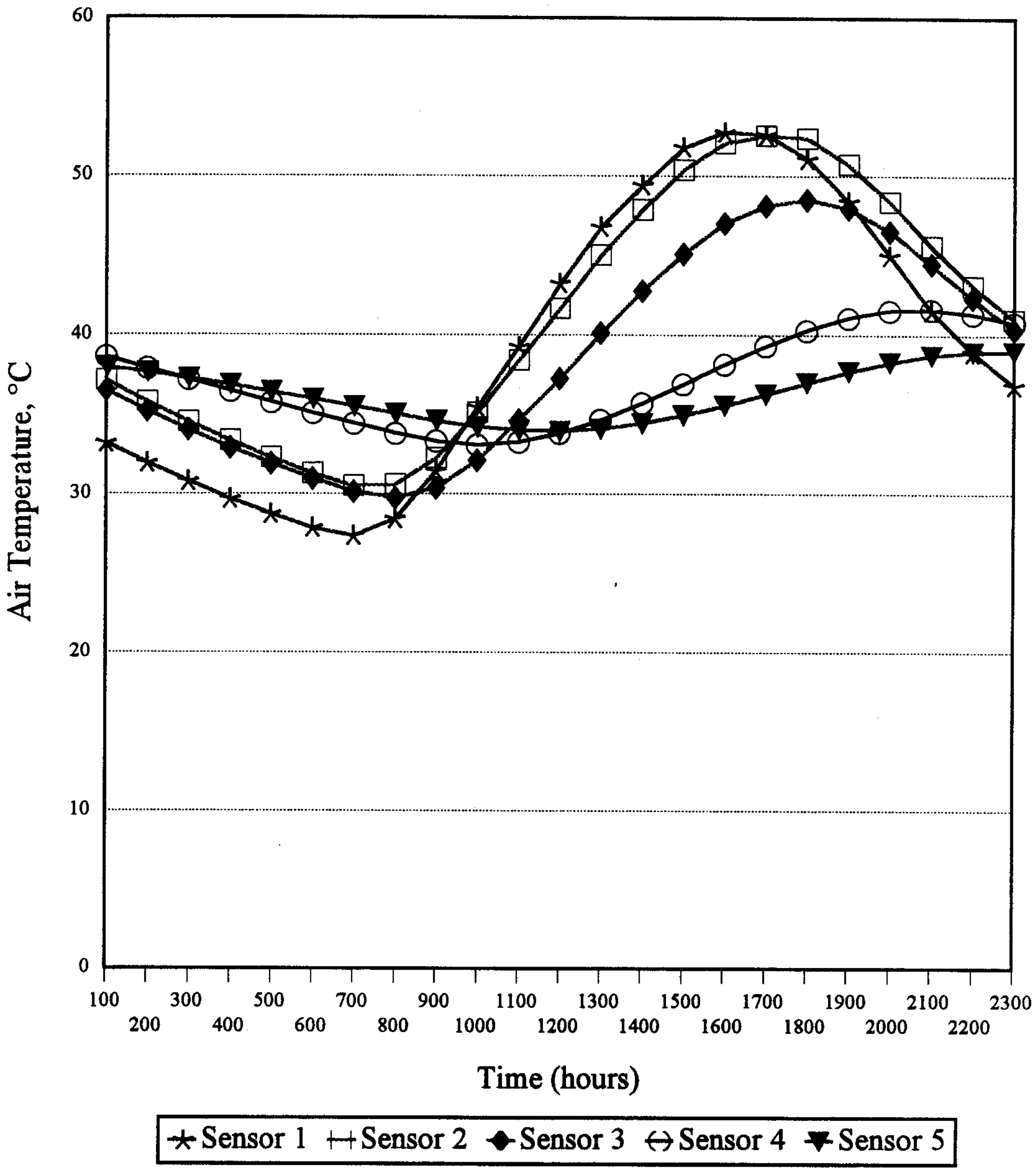


**Figure D-2. Measured Average Subsurface Temperature for the First 5 Sensors During June Data Collection.**

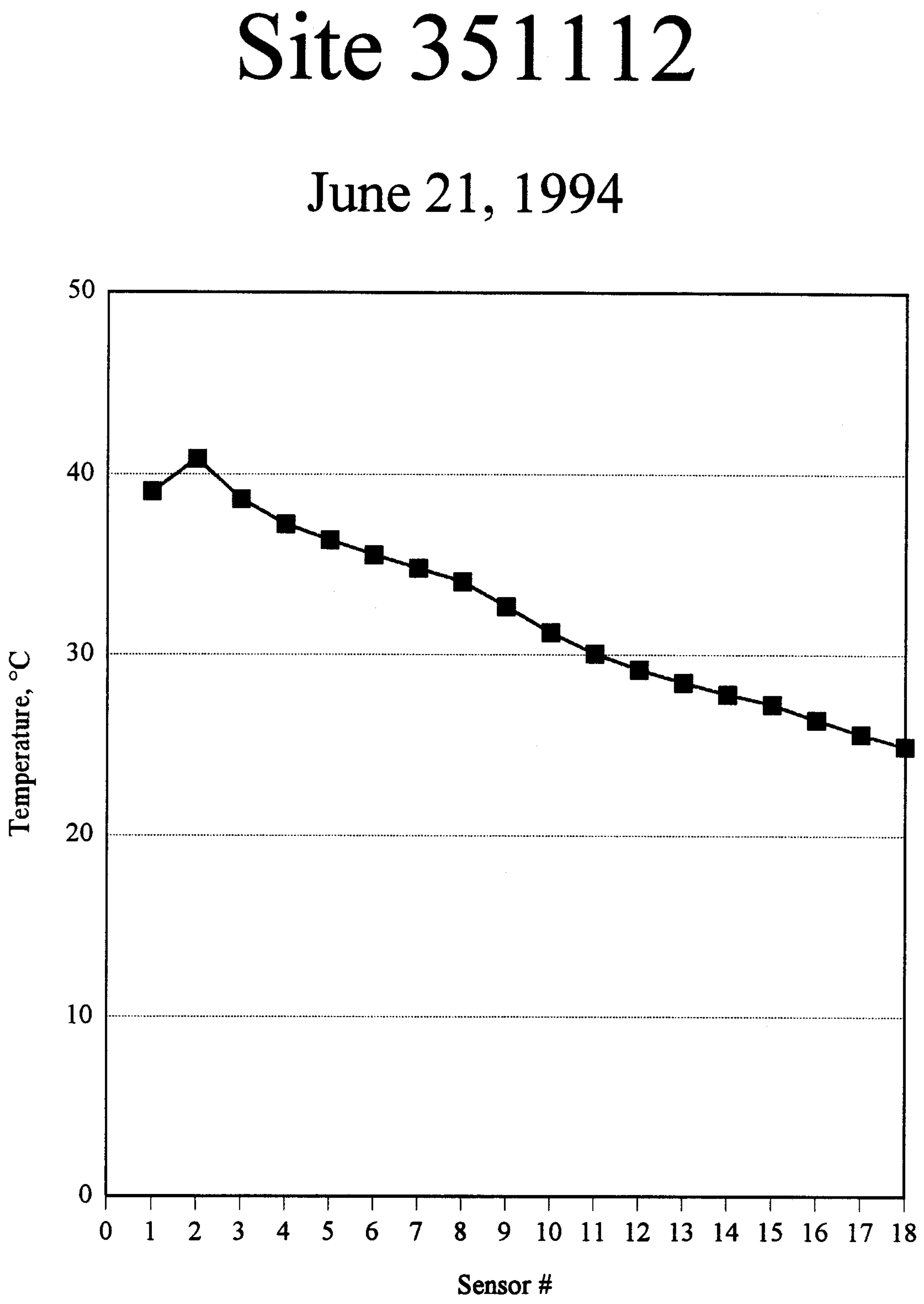
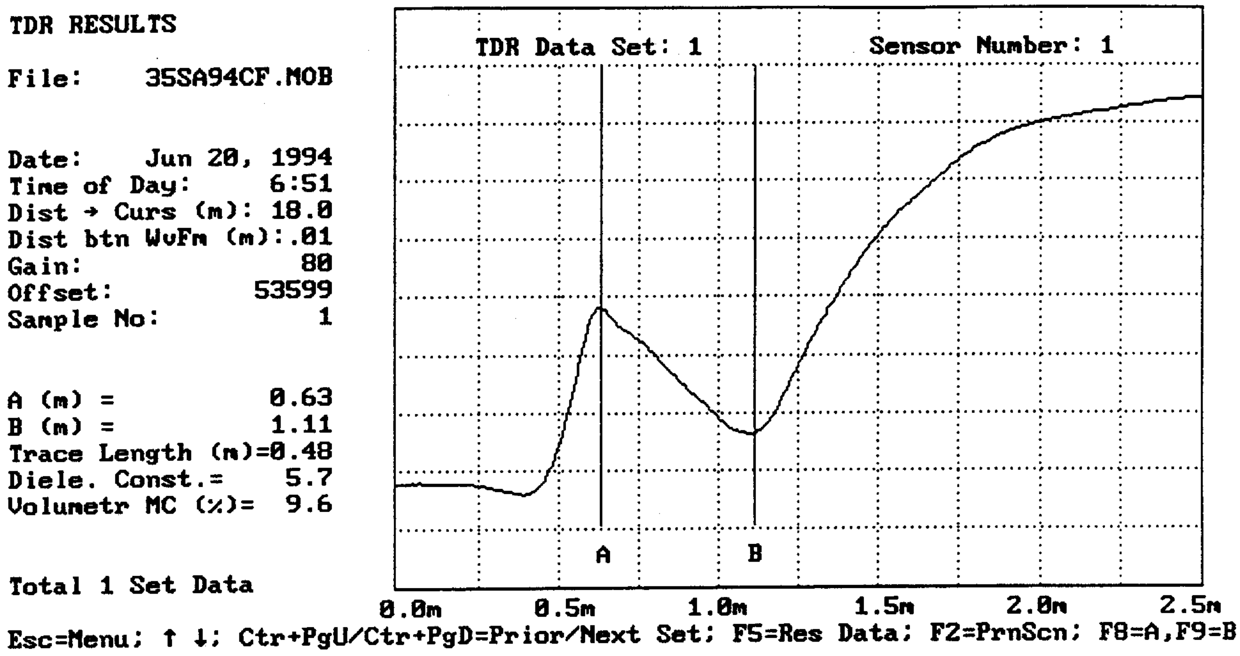
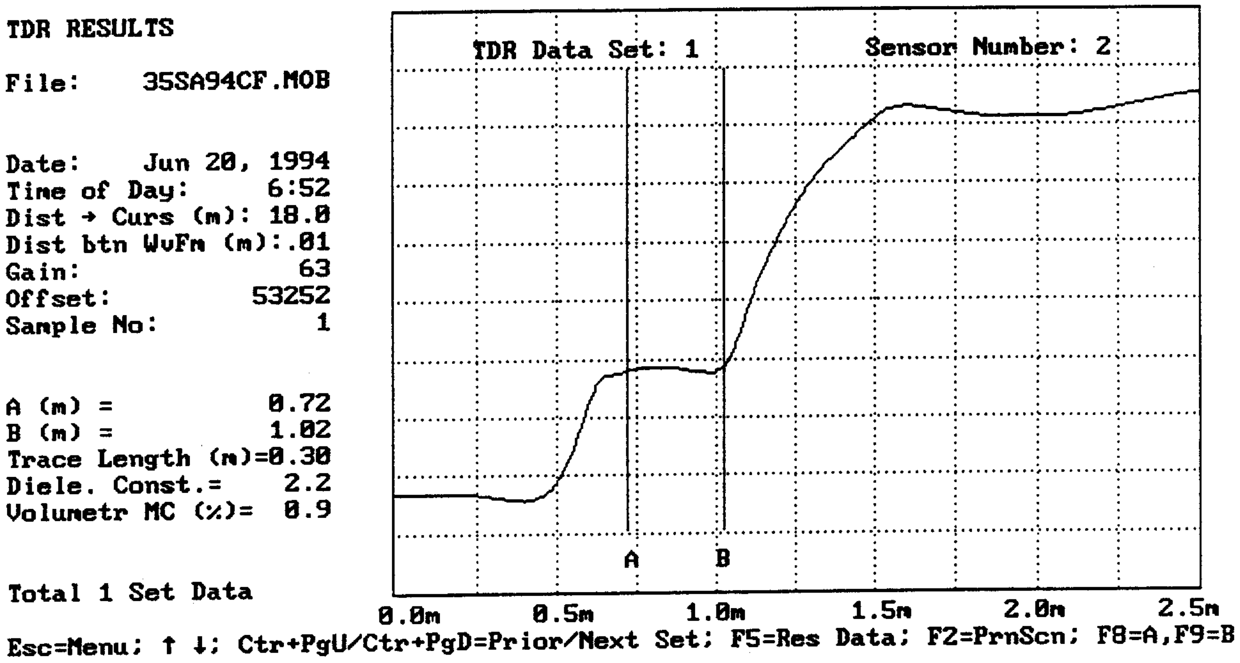


**Figure D-3. Measured Average Subsurface Temperature for all 18 Sensors During June Data Collection.**



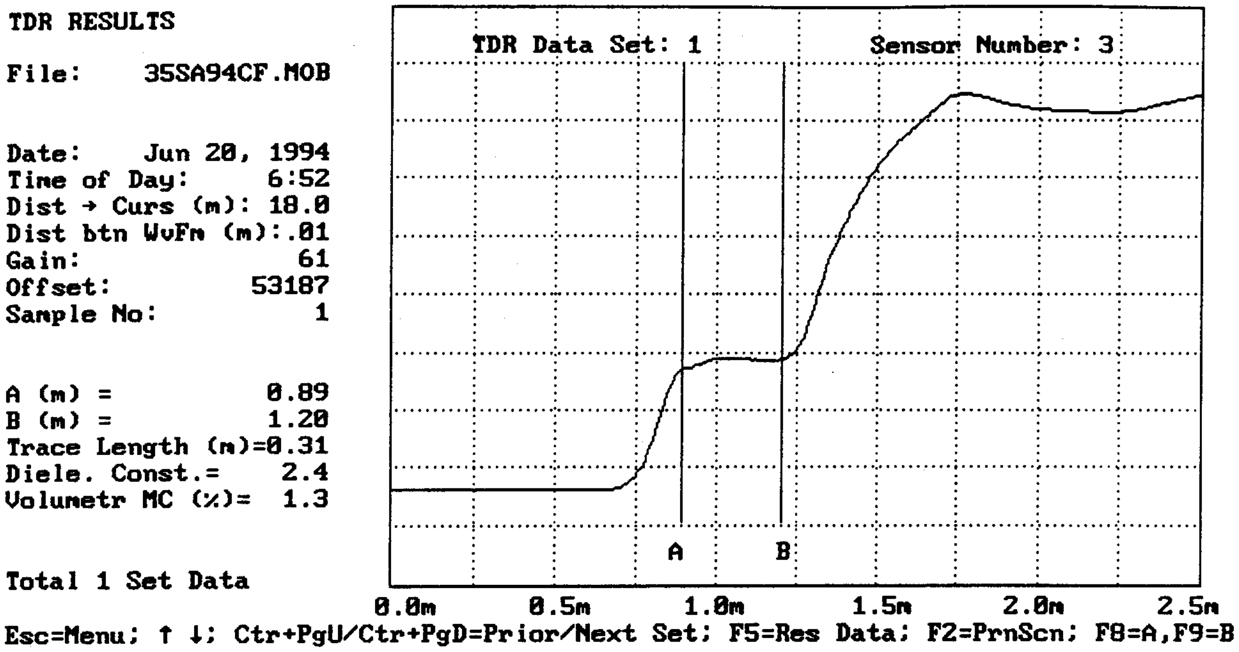
```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:51
Dist → Curs (m): 18.0
Dist btn WvFm (m):.01
Gain:               80
Offset:          53599
Sample No:           1

A (m) =           0.63
B (m) =           1.11
Trace Length (m)=0.48
Diele. Const.=     5.7
Volumetr MC (%)=   9.6

Total 1 Set Data
Esc=Menu; ↑ ↓; Ctr+PgU/Ctr+PgD=Prior/Next Set; F5=Res Data; F2=PrnScn; F8=A,F9=B
```

Figure D-4. Trace from TDR Sensor 1



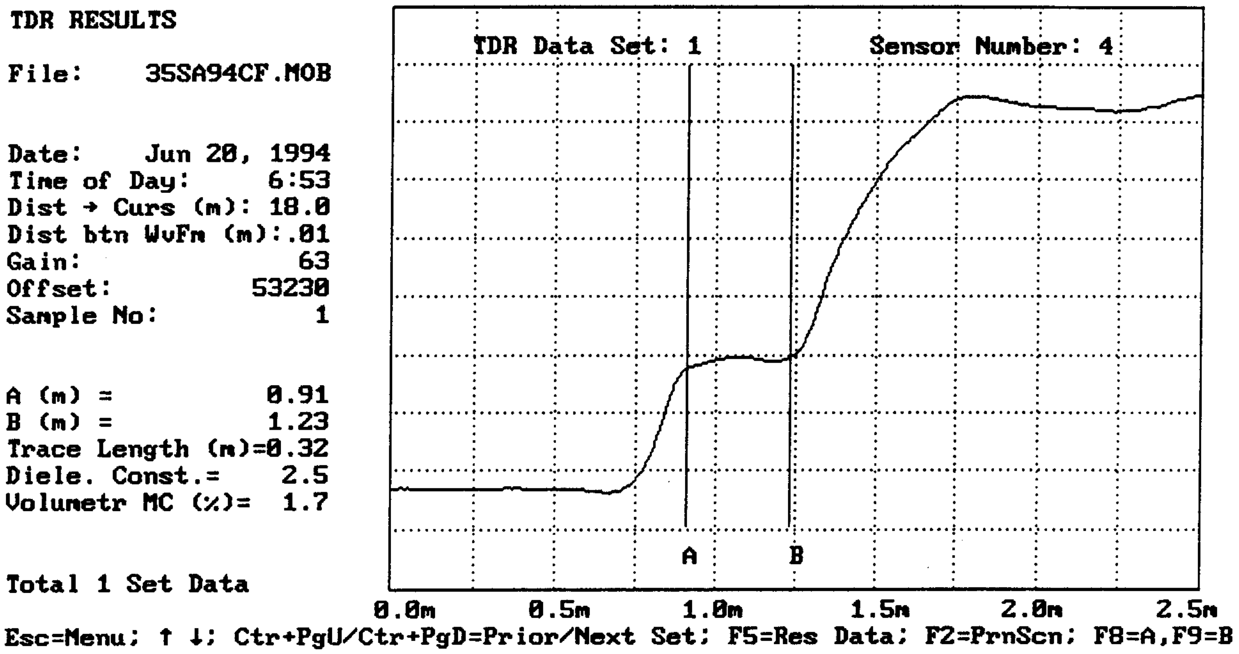
```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:52
Dist → Curs (m): 18.0
Dist btn WvFm (m):.01
Gain:               63
Offset:          53252
Sample No:           1

A (m) =           0.72
B (m) =           1.02
Trace Length (m)=0.30
Diele. Const.=     2.2
Volumetr MC (%)=   0.9

Total 1 Set Data
Esc=Menu; ↑ ↓; Ctr+PgU/Ctr+PgD=Prior/Next Set; F5=Res Data; F2=PrnScn; F8=A,F9=B
```

Figure D-5. Trace from TDR Sensor 2



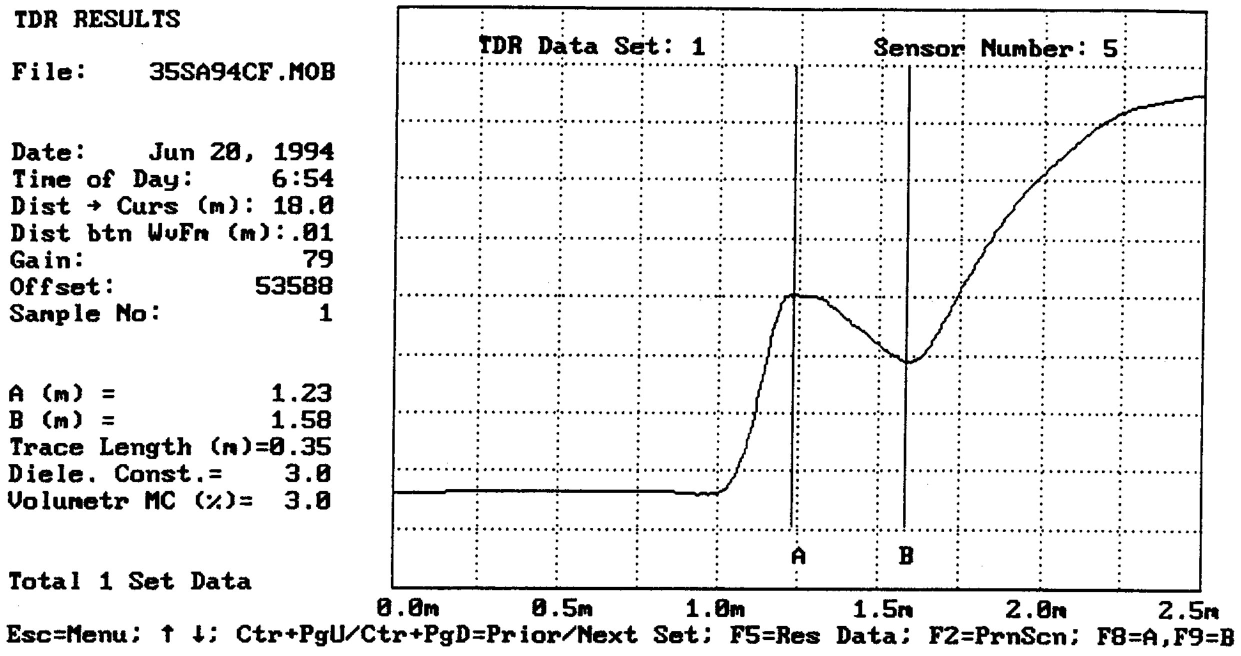
```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:52
Dist → Curs (m): 18.0
Dist btn WvFm (m):.01
Gain:               61
Offset:          53187
Sample No:           1


A (m) =           0.89
B (m) =           1.20
Trace Length (m)=0.31
Diele. Const.=     2.4
Volumetr MC (%)=   1.3


Total 1 Set Data
Esc=Menu; ↑ ↓; Ctr+PgU/Ctr+PgD=Prior/Next Set; F5=Res Data; F2=PrnScn; F8=A,F9=B
```

Figure D-6. Trace from TDR Sensor 3



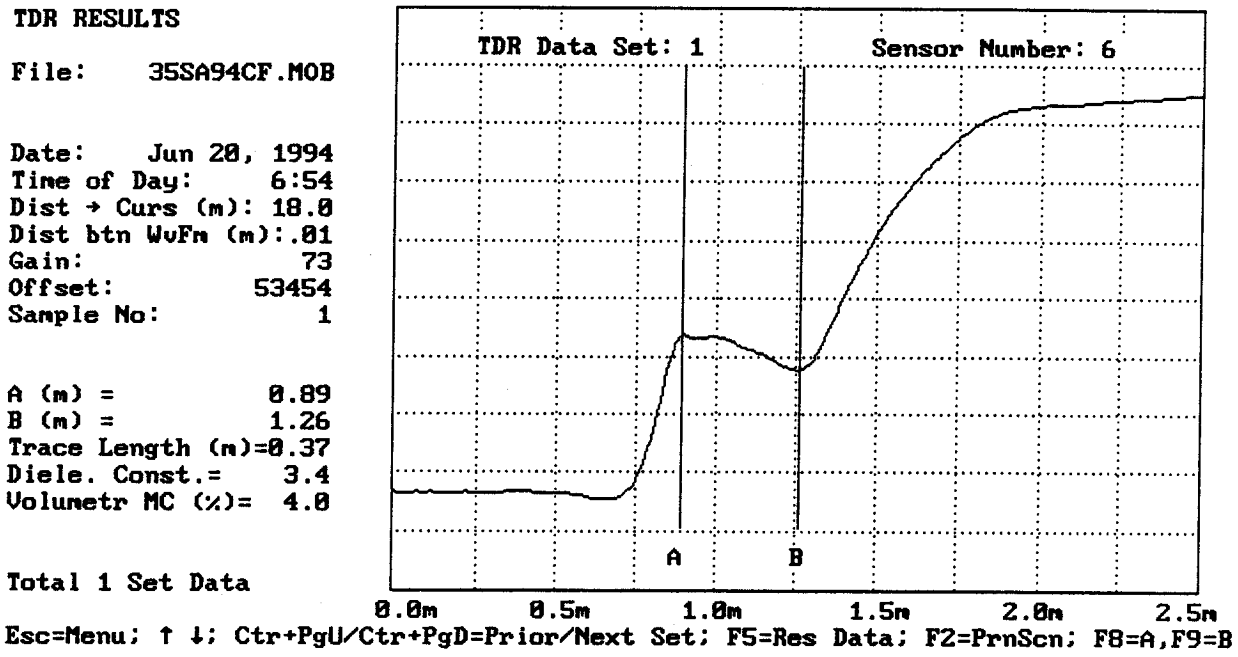
```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:53
Dist → Curs (m): 18.0
Dist btn WvFm (m):.01
Gain:               63
Offset:          53230
Sample No:           1


A (m) =           0.91
B (m) =           1.23
Trace Length (m)=0.32
Diele. Const.=     2.5
Volumetr MC (%)=   1.7


Total 1 Set Data
Esc=Menu; ↑ ↓; Ctr+PgU/Ctr+PgD=Prior/Next Set; F5=Res Data; F2=PrnScn; F8=A,F9=B
```

Figure D-7. Trace from TDR Sensor 4



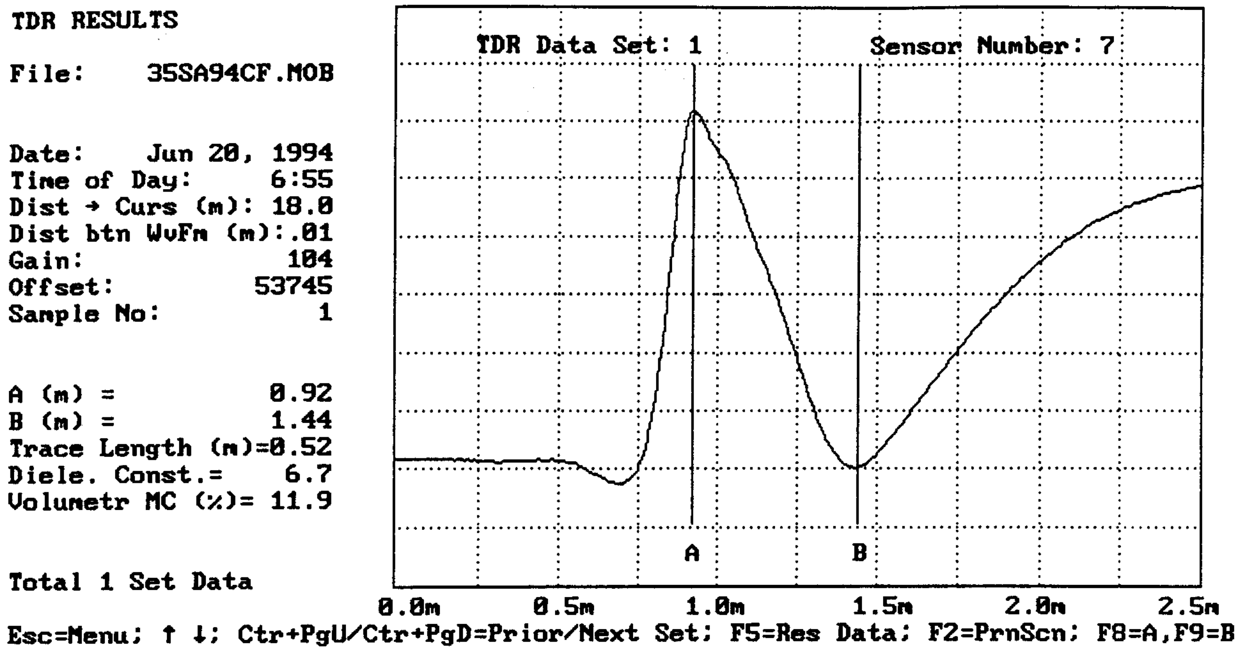
```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:54
Dist → Curs (m): 18.0
Dist btn WvFm (m):.01
Gain:               79
Offset:          53588
Sample No:           1

A (m) =           1.23
B (m) =           1.58
Trace Length (m)=0.35
Diele. Const.=     3.0
Volumetr MC (%)=  3.0

Total 1 Set Data
```

Figure D-8. Trace from TDR Sensor 5



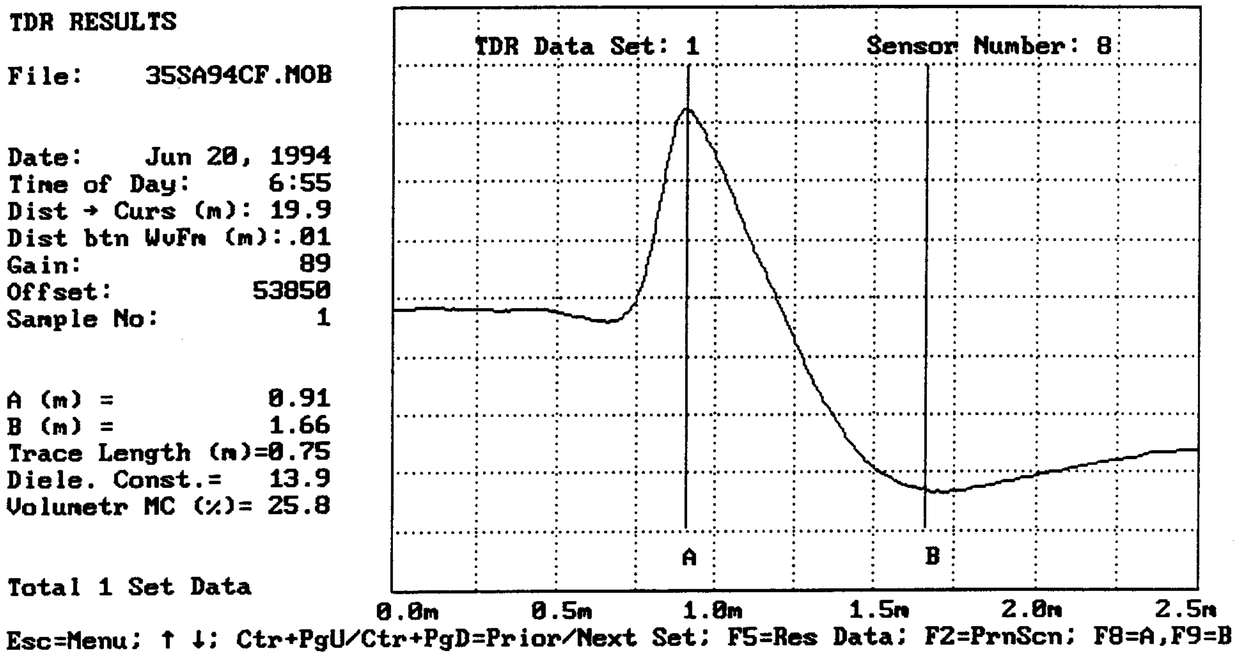
```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:54
Dist → Curs (m): 18.0
Dist btn WvFm (m):.01
Gain:               73
Offset:          53454
Sample No:           1

A (m) =           0.89
B (m) =           1.26
Trace Length (m)=0.37
Diele. Const.=     3.4
Volumetr MC (%)=  4.0

Total 1 Set Data
```

Figure D-9. Trace from TDR Sensor 6



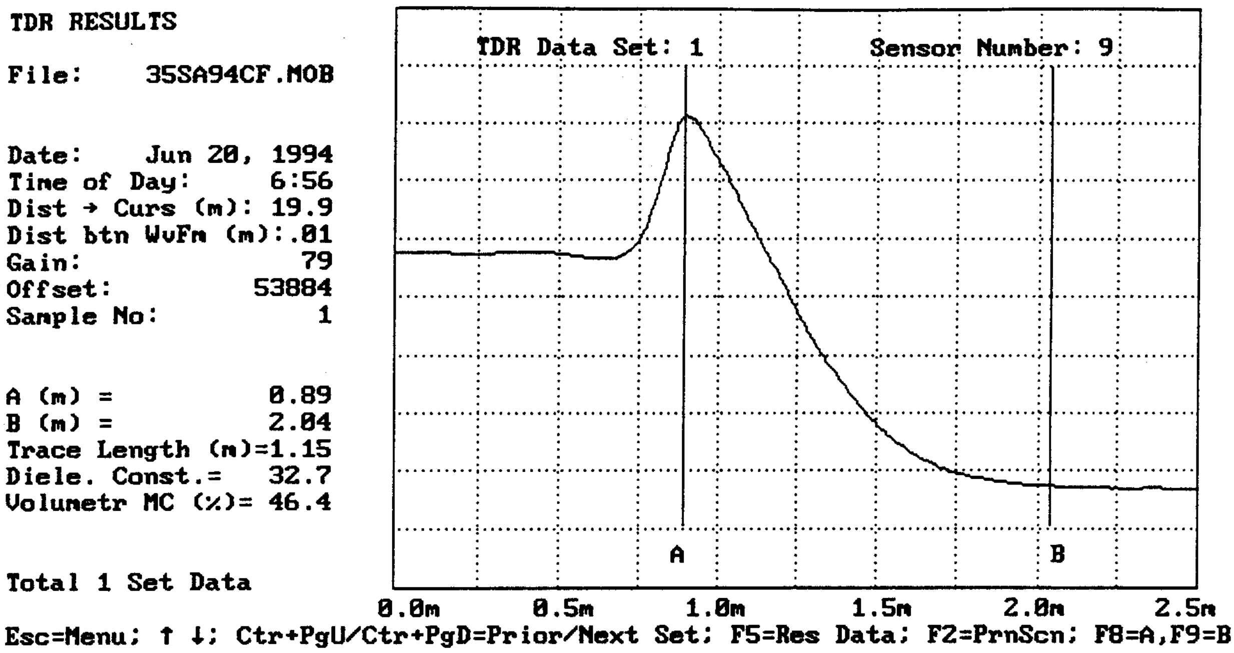
```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:55
Dist → Curs (m): 18.0
Dist btn WvFm (m):.01
Gain:              104
Offset:          53745
Sample No:           1

A (m) =           0.92
B (m) =           1.44
Trace Length (m)=0.52
Diele. Const.=    6.7
Volumetr MC (%)= 11.9

Total 1 Set Data
Esc=Menu; ↑ ↓; Ctr+PgU/Ctr+PgD=Prior/Next Set; F5=Res Data; F2=PrnScn; F8=A,F9=B
```

Figure D-10. Trace from TDR Sensor 7



```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:55
Dist → Curs (m): 19.9
Dist btn WvFm (m):.01
Gain:               89
Offset:          53850
Sample No:           1

A (m) =           0.91
B (m) =           1.66
Trace Length (m)=0.75
Diele. Const.=   13.9
Volumetr MC (%)= 25.8

Total 1 Set Data
Esc=Menu; ↑ ↓; Ctr+PgU/Ctr+PgD=Prior/Next Set; F5=Res Data; F2=PrnScn; F8=A,F9=B
```

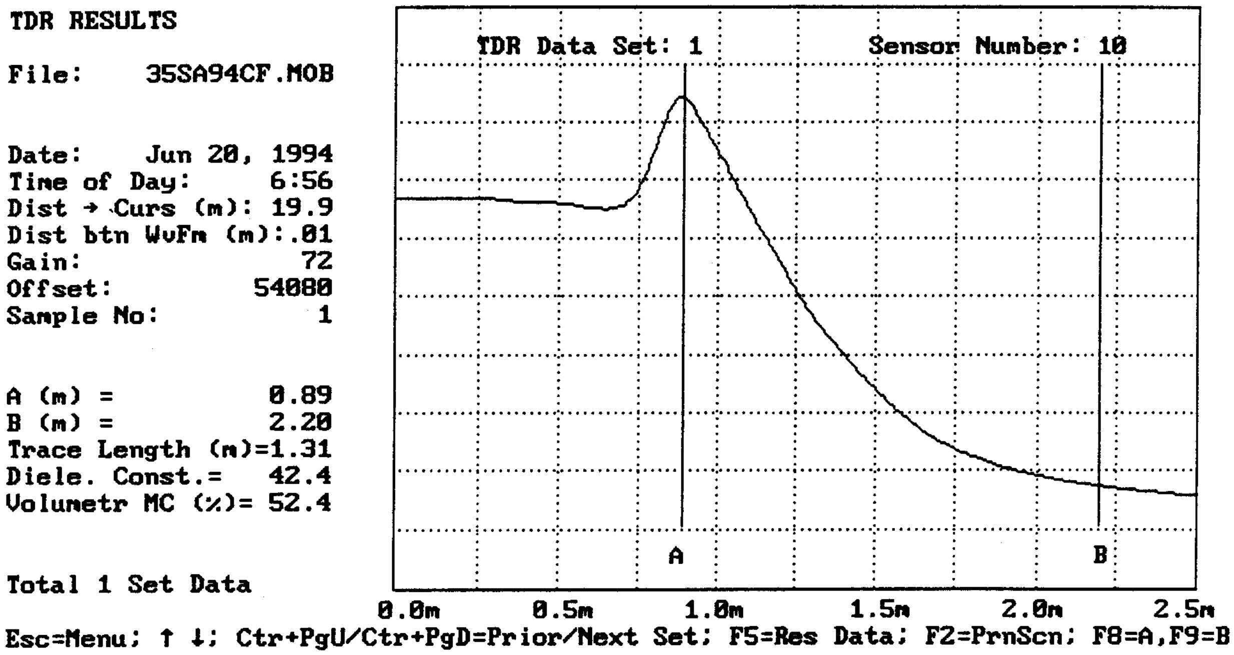
Figure D-11. Trace from TDR Sensor 8



```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:56
Dist → Curs (m): 19.9
Dist btn WvFm (m):.01
Gain:               79
Offset:          53884
Sample No:           1

A (m) =           0.89
B (m) =           2.04
Trace Length (m)=1.15
Diele. Const.=    32.7
Volumetr MC (%)= 46.4

Total 1 Set Data
```

```
Esc=Menu; ↑ ↓; Ctr+PgU/Ctr+PgD=Prior/Next Set; F5=Res Data; F2=PrnScn; F8=A,F9=B
```

Figure D-12. Trace from TDR Sensor 9



```
TDR RESULTS

File:     35SA94CF.MOB

Date:     Jun 20, 1994
Time of Day:      6:56
Dist → Curs (m): 19.9
Dist btn WvFm (m):.01
Gain:               72
Offset:          54080
Sample No:           1

A (m) =           0.89
B (m) =           2.20
Trace Length (m)=1.31
Diele. Const.=    42.4
Volumetr MC (%)= 52.4

Total 1 Set Data
```

```
Esc=Menu; ↑ ↓; Ctr+PgU/Ctr+PgD=Prior/Next Set; F5=Res Data; F2=PrnScn; F8=A,F9=B
```

Figure D-13. Trace from TDR Sensor 10

## Table D-2. Elevation Measurements from Installation

35SA9

## SEASONAL MONITORING
### "FLEX" TRANSVERSE ELEVATION MEASUREMENTS[1]

| Station | Outside Edge | | OWP | | ML | | IWP | | Inside Edge | |
|---|---|---|---|---|---|---|---|---|---|---|
| | O/S | Elev. | O/S | Elev. | O/S | Elev. | O/S | Elev. | O/S | Elev. |
| | | | | | | | | | | |
| 0-30 | | | .80 | 100.096 | | | | | | |
| 0-20 | | | | | 1.90 | 100.143 | | | | |
| 0-10 | | | .80 | 100.140 | 1.90 | 100.164 | | | | |
| 0+00 | .15 | 100.158 | .80 | 100.163 | 1.90 | 100.189 | 2.80 | 100.198 | 365 | 100.209 |
| 0+25 | " | 100.218 | " | 100.223 | " | 100.251 | " | 100.259 | " | 100.268 |
| 0+50 | " | 100.284 | " | 100.293 | " | 100.319 | " | 100.329 | " | 100.345 |
| 0+75 | " | 100.345 | " | 100.353 | " | 100.379 | " | 100.389 | " | 100.403 |
| 1+00 | " | 100.397 | " | 100.405 | " | 100.432 | " | 100.440 | " | 100.453 |
| 1+25 | " | 100.457 | " | 100.463 | " | 100.489 | " | 100.497 | " | 100.508 |
| 1+50 | " | 100.511 | " | 100.523 | " | 100.550 | " | 100.559 | " | 100.573 |
| 1+75 | " | 100.572 | " | 100.584 | " | 100.611 | " | 100.620 | " | 100.636 |
| 2+00 | " | 100.636 | " | 100.647 | " | 100.673 | " | 100.688 | " | 100.698 |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

3.

**Bench Mark** : TOP OF 1" PIPE MONITOR WELL STA 1+00, RT. 14', ASSUMED ELEV. 100.00 METERS. T.B.M. + ON EAST END OF BOX INLET @ MEDIAN, STA. -0+12, ELEV. 99.302
INST @ 0-32 SHOULDER BREAK (10' RT) TELU✓

**Comments:** P.K. NAILS SET @ OUTSIDE SHOULDER STRIPE + P.K.'S SET @ 3.75 METERS LT (℄)

COOL, CLEAR

**Test Section No.** 351112
**Time** 10:10
**Recorded By** JON K., ROBIN B

**Date** 4/6/94
**Device Used** LASER PLANE LEVEL
**Employer** BRE

---

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

10/29/93

# APPENDIX E

## Photographs

Appendix E contains the following photographs:

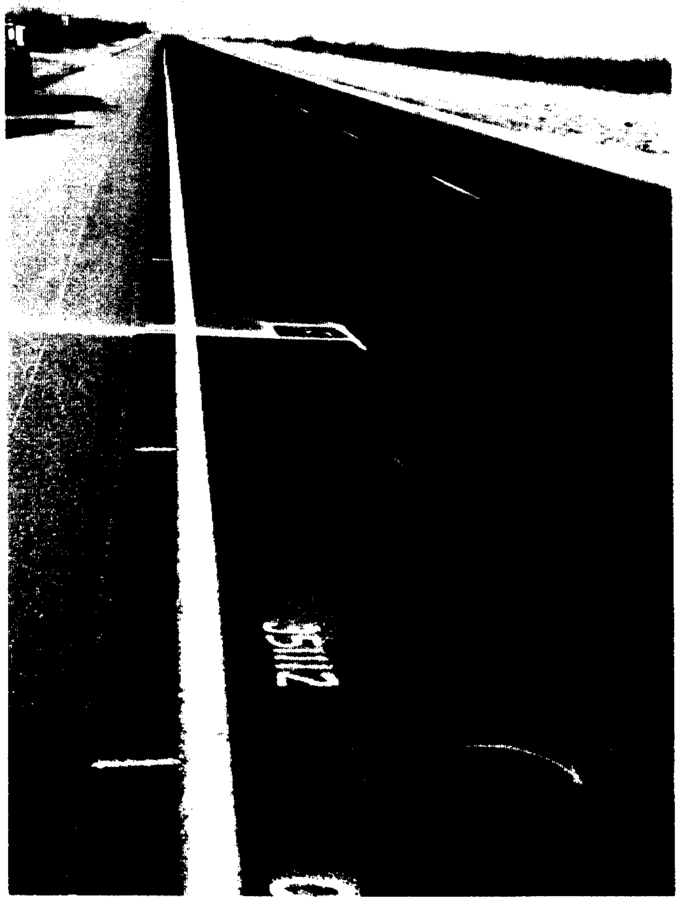


Photo E-1. Location of Instrumentation Area

Photo E-2. Preparing for Instrumentation Installation

Photo E-3. Placement of Instrumentation Probes

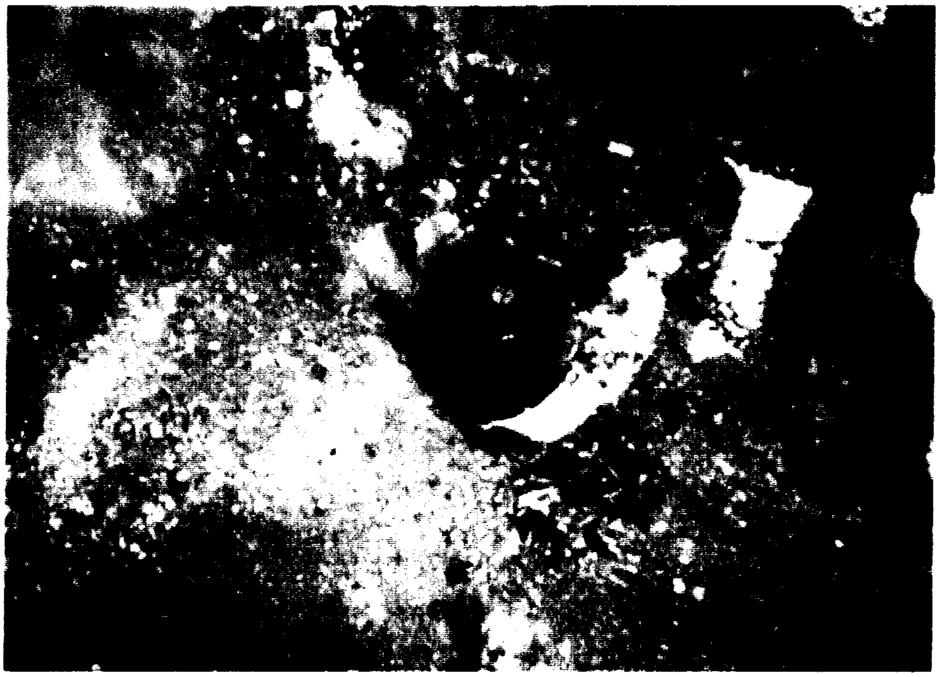


Photo E-4. Setting Observation Well

Photo E-5. Preparing Weather Station for Installation

Photo E-6. Monitoring and Data Collection After Installation

Photo E-7. Location of Benchmark

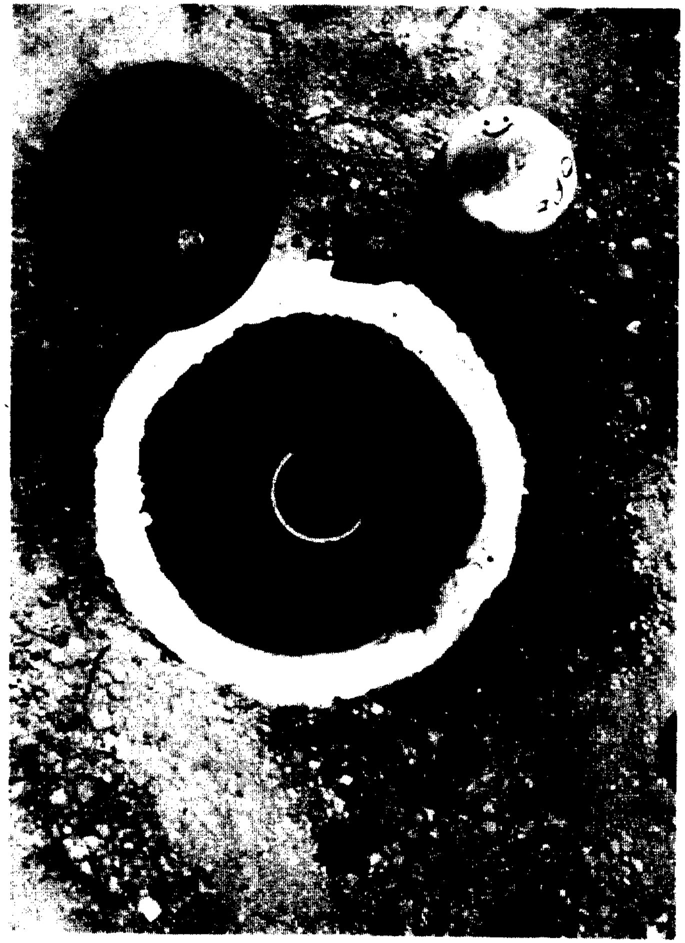


Photo E-8. Observation Well