U.S. Department of Transportation

Federal Highway Administration

LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection

Section 493011 Nephi Utah

Report No. FHWA-49-3011

February 1994

Notice

LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection
Section 493011, Nephi Utah

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16. Abstract

This report contains a description of the instrumentation installation activities and initial data collection for test section 493011 which is a part of the LTPP Core Seasonal Monitoring program. This portland cement concrete surfaced pavement test section, which is located on Interstate 15 (I-15) just south of Nephi Utah, was instrumented on August 3-4, 1993. The instrumentation installed included time domain reflectometery probes for moisture content, electrical resistivity probes for frost location, thermistor probes for temperature, tipping bucket rain gage, piezometer to monitor the ground water table, and an on-site data logger. Initial data collection was performed on August 4, 1993 which consisted of deflection measurements with a Falling Weight Deflectometer, elevation measurements, temperature measurements, TDR measurements, and electrical resistance and resistivity measurements. The report contains a description of the test site and its location, the instruments installed at the site and their locations, characteristics of the installed instruments and probes, problems encountered during installation, specific site circumstances and deviations from the standard guidelines, and a summary of the initial data collection.

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I. Introduction

The installation of instrumentation on test section 493011 near Nephi Utah was performed on August 3 - 4, 1993.

The site is located on northbound of Interstate 15 (I-15), approximately one mile south of the city of Nephi in Central Utah (Figure A-1 in Appendix A). The test section is located on a divided highway consisting two 3.7m wide travel lanes in each direction. The outside shoulder is 3m wide. The test section is classified as a GPS-3 project.

The pavement structure consists of 254mm of plain portland cement concrete (PCC) with undoweled, skewed joints and a sequenced joint spacing of 5.49, 3.96, 3.66, and 5.18m. The base layer consists of a 99mm thick cement treated base (CTB). The subbase consists of large size gravel and cobbles with an average thickness of approximately 81mm. The subbase layer appears to be relatively uniform throughout the test section. The subgrade is primarily a sandy clay. Pavement structure information from the GPS material drilling log is presented in Figure A-2. Properties determined from the laboratory material tests are presented in Table 1.

Deflection profile and analysis results from the FWDCHECK program are presented in Appendix A.

The climate at this site is classified as a dry-freeze zone (SMP cell #19). No climatic information exists in the LTPP demonstration program for this test section. The site is estimated to have the following climatic characteristics which were based on information in the SHRP report "Strategic Highway Research Program, Operational Memorandum No. SHRP-LTPP-OM-027, February, 1992":

The highest monthly average maximum daily temperature:	32°C to 38°C
The annual lowest temperature:	-23°C to -29°C
The annual precipitation:	Less than 432mm

The estimated annual average daily traffic (AADT) in 1989 was 4920 (two-way) of which 36% was truck traffic. The GPS lane carried about 40% of the total AADT. The truck AADT on the GPS lane was 917. The estimated annual ESALs on the GPS lane were approximately 51,700.

Installation of the instrumentation was a cooperative effort between Utah Department of Transportation (UDOT), Nichols Consulting Engineers (NCE) LTPP Western Region Coordination Office staff, staff from PCS/Law Engineering, and staff from Braun Intertec.

The following personnel participated in the instrumentation installation:

Gary E. Elkins	Nichols Consulting Engineers
Mark Potter	Nichols Consulting Engineers
Jason Dietz	Nichols Consulting Engineers
Haiping Zhou	Nichols Consulting Engineers
Gonzalo R. Rada	PCS/Law Engineering (TAC)
Robert VanSambeek	Braun Intertec/NCRCO
Dale Stapley	Utah Department of Transportation
Darrell Geannonatti	Utah Department of Transportation

Table 1. Material properties.

Description	Surface Layer	Base Layer	Subbase Layer	Subgrade
Material	PCC	CTB	Granular Aggregate	Fine Soil
Thickness (mm)	254	99	81	∞
Lab Max Dry Density (kg/m^3)	---	---	2243 @5% MC	2002 @10.5% MC
Liquid Limit	---	---	NP	21
Plastic Limit	---	---	NP	14
Plastic Index	---	---	NP	7
% Passing #200	---	---	13.8	35.8

MC - Moisture content
NP - Non Plastic

II. Instrumentation Installation

Meeting with Highway Agency and site visits

A planning meeting was held with Utah Department of Transportation (UDOT) on July 13, 1993. Attending the meeting were Messrs Darrell Geannonatti and Deloy Dye of UDOT and Gary Elkins of Nichols Consulting Engineers, Chtd. The plans for both seasonal monitoring sections (sites 491001 and 493011) in Utah were discussed. After discussing installation requirement, UDOT decided that it would be best to contract out the pavement coring, sawing and drilling on the two seasonal monitoring sites. UDOT would provide traffic control and pavement patching materials.

Test section 493011 was inspected by Gary Elkins on July 13, 1993. The test section appeared in excellent condition, although a cold construction joint was noted to be present in the last 61m of the test section. Although the leave end of the test section had a more uniform deflection profile, the approach end was selected for instrumentation primarily because the materials drilling logs showed that some of the boreholes on the leave end of the section hit refusal at about 0.61m due to the presence of large cobbles. All of the bore holes on the approach end were able to penetrate the layer with cobbles and reached 1.8m below the pavement surface. The cold construction joint on the leave end of the test section also influenced this decision.

Equipment Installed

The equipment installed at the test site included instrumentation for measuring air and subsurface temperature, subsurface moisture content, frost depth, rainfall, joint opening, bench mark and depth to water table. An equipment cabinet was installed to house cable leads from the instrumentation, the datalogger, and battery pack. The equipment installed are shown in Table 2.

Equipment Check/Calibration

Prior to field installation, all equipment were checked or calibrated. The air temperature probe, thermistor probe, and the tipping bucket rain gauge were connected to the CR10 datalogger for calibration and function checks. The tipping bucket rain gage was calibrated using 473ml of water placed in a plastic container with a tiny hole in the bottom. The hole size was adjusted so that 45 minutes were required to drain all of the water out of the container. For the 473ml of water, the tipping bucket was found to be within the range of 100 tips $\pm$ 3 tips. The air temperature and thermistor probes were checked for proper functioning by placing them in an ice bath and in direct sun light and comparing the measured temperatures. The results indicated that the air temperature and thermistor probes were functioning properly. The spacings between the thermistor sensors in the plastic tube were measured and recorded. These measurements are shown in Table 3.

Table 2. Equipment installed.

Equipment	Quantity	Serial Number
Instrument Hole		
MRC Thermistor Probe	1	200 (49AT)
ABF Resistivity Probe	1	49AR
TDR Sensors	10	49A01-49A10
Equipment Cabinet		
Campbell Scientific CR10 Datalogger	1	16529
Battery Package	1	5664
Weather Station		
TE525 MM Rain Gauge	1	12061
Air Temperature Probe (Model 107)	1	421316
Radiation Shield	1	41301
Observation Well/Bench Mark	1	None

The wiring of the resistivity probe was checked by performing continuity measurements between the each electrode and to the pins in the connector. The distance between the electrodes were measured and recorded. These spacing are shown in Table 4. Electrical resistance and resistivity measurements were performed with the probe immersed in a water bath. The results of these measurements are shown in Appendix B. The checks on the resistivity probe indicated that the probe was correctly wired and functioning properly.

The functioning of the TDR sensors were checked by performing measurements in air, with the prongs shorted at beginning of the sensor and not shorted, and in water. The TDR measurements indicated that all sensors produced the expected traces and appeared to be functioning properly. Results of these TDR measurements are presented in Appendix B.

Equipment Installation

A pre-installation meeting was held with UDOT on July 30, 1993 to finalize all details and responsibilities. Installation of the measurement equipment was started on August 2, 1993. UDOT provided traffic control and pavement repair. Pavement sawing and auguring of the instrumentation hole and bench mark/observation well were performed by a local contractor. The NCE, PCS/Law Engineering, and Braun Intertec staff installed all in-pavement instrumentation, observation well, calliper ring for joint opening measurements, support for climatic measurements and equipment cabinet.

Installation of the instrumentation was completed in two days. The first day activities consisted of set-up of traffic control, site layout and marking, installation of calliper rings,

Table 3. Description of MRC thermistor probe and sensor spacing.

Unit	Channel Number	Distance from Top of Unit (cm)	Remarks
1	1	1.3	This unit was installed in the surface layer.
	2	15.2	
	3	29.2	
2	4	2.0	This unit was installed in the subbase and subgrade.
	5	9.6	
	6	17.3	
	7	25.0	
	8	32.4	
	9	47.7	
	10	63.3	
	11	78.4	
	12	93.4	
	13	109.3	
	14	124.1	
	15	139.9	
	16	155.0	
	17	170.2	
	18	184.8	

preparation of instrumentation for installation, digging of the equipment cabinet hole and access trench in the shoulder, and site clean up. No instrumentation was placed the first day because the drill crew did not show up at the site. The instrumentation hole was placed at test section station 0-20. It was placed at the mid-point of a 5.18m long slab that was adjacent to the start of the test section. A 254mm diameter core was cut through the PCC surface layer and CTB for the instrumentation hole. A concrete saw was used to cut the access trench through the pavement and shoulder. Due to the thickness of the pavement and equipment used, the trench removal required nearly three hours to complete. The removal time was increased since the blade on the concrete saw got stuck several times and had to be manually removed. Since the auger crew did not show up the first day, placement of the instrumentation was delayed to the

Table 4. Resistivity probe and sensor spacing

Connector Pin Number	Electrode Number	Continuity ✓	Measurement	Spacing (cm)			Dist. from top (cm)
				Line 1	Line 2	Avg	
36	1	✓	Top-1	2.9	3.1	3.00	3.0
35	2	✓	1-2	4.9	4.9	4.90	7.9
34	3	✓	2-3	4.9	4.9	4.90	12.8
33	4	✓	3-4	5.1	5.1	5.10	17.9
32	5	✓	4-5	5.3	5.1	5.20	23.1
31	6	✓	5-6	4.9	5.1	5.00	28.1
30	7	✓	6-7	5.3	5.0	5.15	33.3
29	8	✓	7-8	4.9	5.2	5.05	38.3
28	9	✓	8-9	5.1	5.0	5.05	43.4
27	10	✓	9-10	5.2	5.1	5.15	48.5
26	11	✓	10-11	5.0	5.1	5.05	53.6
25	12	✓	11-12	5.0	5.1	5.05	58.6
24	13	✓	12-13	5.1	4.9	5.00	63.6
23	14	✓	13-14	5.0	5.1	5.05	68.7
22	15	✓	14-15	5.0	5.1	5.05	73.7
21	16	✓	15-16	5.3	5.1	5.20	78.9
20	17	✓	16-17	4.9	5.0	4.95	83.9
19	18	✓	17-18	5.2	5.2	5.20	89.1
18	19	✓	18-19	4.9	5.0	4.95	94.0
17	20	✓	19-20	5.3	5.1	5.20	99.2
16	21	✓	20-21	5.0	5.1	5.05	104.3
15	22	✓	21-22	5.0	5.0	5.00	109.3
14	23	✓	22-23	5.1	5.1	5.10	114.4
13	24	✓	23-24	5.1	5.1	5.10	119.5
12	25	✓	24-25	5.1	5.1	5.10	124.6
11	26	✓	25-26	5.3	5.1	5.20	129.8
10	27	✓	26-27	5.1	5.1	5.10	134.9
9	28	✓	27-28	5.0	5.0	5.00	139.9
8	29	✓	28-29	5.1	5.1	5.10	145.0
7	30	✓	29-30	5.2	5.0	5.10	150.1
6	31	✓	30-31	5.0	5.1	5.05	155.1
5	32	✓	31-32	5.1	5.0	5.05	160.2
4	33	✓	32-33	5.0	5.2	5.10	165.3
3	34	✓	33-34	5.0	4.8	4.90	170.2
2	35	✓	34-35	5.0	5.3	5.15	175.3
1	36	✓	35-36	5.0	5.0	5.00	180.3
			36-End	2.7	2.5	2.60	182.9

second day. The core and excavated trench material were replaced loosely in the holes overnight to allow traffic movement.

The snap rings to monitor joint movements were installed using an installation jig developed by Bob VanSambeek of Braun Intertec. The jig controls alignment and depths of the holes drilled into the concrete surface. The snap rings were secured into the hole with epoxy.

On the second day the in-pavement instrumentation, piezometer/bench mark, equipment cabinet, and climatic sensor support were placed. The installation followed the procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines".

No significant damage occurred to the instrumentation hole overnight which had the core loosely placed in the hole. The instrumentation hole was augured to a depth of 2.26m with a worn 229mm nominal diameter hollow-stem, small-flight auger, which created a 216mm diameter hole. The thermistor probe and electrical resistivity probe were position on opposite sides of the hole with the thermistor probe placed adjacent to the leave edge of the trench. The TDR probes were placed in a fan pattern with 10° offsets in orientation between adjacent probes. The TDR lead wires were positioned parallel to each other and were run up the side of the hole adjacent to the trench in a flat plane.

The steel thermistor probe for pavement surface layer measurements was placed in a groove cut perpendicular to the direction of traffic which extended from the core towards the center of the lane. This groove was cut in line with the saw cut on the leading edge of the trench. This was done to minimize potential damage caused by cutting both sides of the core hole since the diameter of the hole was less than the diameter of the saw blade required to cut the surface layer full depth. The surface layer thermistor probe was placed in the surface PCC layer and did not extend into the CTB.

The piezometer/bench mark was at the edge of the shoulder placed at test section station 0+24. This location is at the approximate midpoint of the 5 pavement panels within the test section being monitored.

Tables 5 presents the installed depths of the TDR probes, Table 6 the thermistor sensors, and Table 7 the electrodes on the electrical resistivity probe. Table 8 presents a comparison of moisture content estimated from TDR measurements and those from the on-site gravimetric measurements on moisture samples taken during installation of the TDR probes. TDR traces obtained during installation are presented in Appendix C.

Upon completion of the installation, all wiring to the cabinet were carefully examined. The Version 1.0 of the ONSITE computer program was downloaded from the notebook computer to the onsite CR10 datalogger mounted in the cabinet. The datalogger was left to collect data overnight so that the results could be evaluated the next day.

Table 5. Installed depths of TDR sensors.

Sensor #	Depth from Pavement Surface (m)	Layer
49A01	0.394	Subbase
49A02	0.546	Subgrade
49A03	0.699	
49A04	0.851	
49A05	1.003	
49A06	1.156	
49A07	1.308	
49A08	1.461	
49A09	1.765	
49A10	2.070	

Pavement Repair

A quick setting portland cement patching concrete was used to repair the core hole and conduit trench. This material was placed full depth through the PCC layer and CTB. The pavement temperature probe was fixed in place using a fine sand portland cement concrete grout material that was mixed with the rapid setting cement patch material and trowelled into place.

The next morning the patch was inspected and some loss of the material in the core hole was noted. It appeared that traffic may have been applied to the site prior to setting of the repair material.

Table 6. Installed location of MRC thermistor sensors

Unit	Channel Number	Depth from Pavement Surface (m)	Remarks
1	1	.013	This unit was installed in the PCC layer.
	2	.127	
	3	.241	
2	4	.461	This unit was installed in the subbase and subgrade.
	5	.537	
	6	.614	
	7	.691	
	8	.765	
	9	.918	
	10	1.074	
	11	1.225	
	12	1.375	
	13	1.534	
	14	1.682	
	15	1.840	
	16	1.991	
	17	2.143	
	18	2.289	

Table 7. Location of electrodes of the resistivity probe.

Connector Pin Number	Electrode Number	Depth from Pavement Surface (m)
36	1	0.441
35	2	0.490
34	3	0.539
33	4	0.590
32	5	0.642
31	6	0.692
30	7	0.744
29	8	0.794
28	9	0.845
27	10	0.896
26	11	0.947
25	12	0.997
24	13	1.047
23	14	1.098
22	15	1.148
21	16	1.200
20	17	1.250
19	18	1.302
18	19	1.351
17	20	1.403
16	21	1.454
15	22	1.504
14	23	1.555
13	24	1.606
12	25	1.657
11	26	1.709
10	27	1.760
9	28	1.810
8	29	1.861
7	30	1.912
6	31	1.962
5	32	2.013
4	33	2.064
3	34	2.113
2	35	2.164
1	36	2.214

Table 8. Field measured moisture content during installation.

Sensor Number	Sensor Depth (m)	Layer	TDR Moisture Content (by wt)	Measured Moisture[3] Content (by wt)
49A01	0.394	Subbase[1]	6.6%	9.00%
49A02	0.546	Subgrade[2]	6.5%	7.29%
49A03	0.699		11.7%	10.19%
49A04	0.851		9.6%	7.77%
49A05	1.003		8.3%	8.31%
49A06	1.156		8.0%	8.26%
49A07	1.308		13.8%	12.46%
49A08	1.461		11.1%	14.09%
49A09	1.765		9.6%	10.26%
49A10	2.070		8.3%	14.88%

[1] Conversion factor = 2.24, determined from laboratory maximum dry density.
[2] Conversion factor = 2.00, determined from laboratory maximum dry density.
[3] Raw data are given in Appendix C

III. Initial Data Collection

A reduced data collection effort was performed the second day since the instrumentation could not be completely installed the first day. Data collected on the second day included deflection measurements, elevation surveys, electrical resistance and resistivity measurements, TDR measurements and measurement of slab joint opening.

Air Temperature, Subsurface Temperature, Rain-fall Data

After the completion of instrumentation installation, the functioning of the Onsite data logger was checked in the monitoring mode. All instrumentation connected to the Onsite data logger appeared to be operating correctly in the monitoring mode. The Onsite data logger was left running overnight and was checked the next morning prior to travelling to the next seasonal monitoring site installation in southeastern Utah. The measurements collected and stored overnight by the Onsite data logger were uploaded the next morning. Inspection of the data file and battery voltage indicated that the equipment was operating properly and producing numbers within the appropriate logical ranges. This data file is presented in Appendix D. Note that in this data file, the automated electrical resistance measurement function was active, although it was not connected to the resistivity probe, and produced a series of large negative numbers. This is data type 6, identified by the first number on a line.

Figure D-1 shows a plot of the air temperature data collected from 6:00 p.m. (August 3) through 7:00 a.m. (August 4). Figure D-2 the hourly average subsurface temperature for the first 5 sensors over the same period is plotted. The plot of average subsurface temperature for all 18 sensors is shown in Figure D-3.

TDR Measurement Data

TDR data were collected using the Mobile data acquisition system. The mobile system contains a CR10 datalogger, a 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 traces for each sensor.

Figures D-4 to D-13 show the TDR wave form traces collected with the MOBILE data acquisition system for all 10 sensors. These figures indicate that the multiplexers of the mobile systems and TDR sensors were working.

Resistance Measurement Data

Resistance data were collected in the automated and manual mode. The Mobile data acquisition system automatically performs two point contact resistance measurements and stores the results as measured millivolts between adjacent electrodes. The contact resistance measurements with the Mobile system appeared to be functioning properly in the field, since the numbers changed and were within the logical range of correct values. However after subsequent inspection and investigation of the Mobile unit in the office, it was found that the multiplexer board had been improperly wired and the measurements erroneous.

Manual contact resistance and resistivity measurements were performed using a Simpson Model 420D function generator, two Beckman HD-110 digital multi-meters and a manual switch board. The measured contact resistance data are plotted in Figure D-14. In Figure D-15 the 4-point electrical resistivity profile computed from 4-point measurements are plotted. The raw measurement data are given in Appendix D.

Deflection Measurement Data

Deflection measurements followed procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines." Due to the installation of instrumentation on the second day, only 2 FWD measurements passes were performed. One pass was made prior to the installation of monitoring equipment and the other after. The last pass was completed at approximately 1800 hours.

Elevation Surveys

One surface elevation survey was performed following the guidelines. The elevation of the well top was assigned 1.000 meters. The survey results are presented in Appendix D.

Joint Opening Measurement

The joint opening measurement was performed following the procedures described in the Guidelines. However, only one set of data was obtained because the delay of the instrumentation installation. The measurement data are shown in Appendix D.

IV. Summary

The instrumentation installation on test section 493011 was completed on August 3 - 4, 1993 with initial data collection performed on August 4 and upload from the Onsite data logger early on the morning of August 5, 1993. The instrumentation installed included time domain reflectometery probes to monitor for moisture content, electrical resistivity probes for frost location, thermistor probes for temperature, tipping bucket rain gage, piezometer to monitor the ground water table, and an on-site datalogger.

The test section is located on northbound of Interstate 15 (I-15) just south of Nephi, Utah. The pavement structure consists of 254mm of plain portland cement concrete (PCC) with undoweled, skewed joints and a sequenced joint spacing of 5.49, 3.96, 3.66, and 5.18m. The base layer consists of a 99mm thick cement treated base (CTB). The subbase consists of large size gravel and cobbles with an average thickness of approximately 81mm. The subbase layer appears to be relatively uniform throughout the test section. The subgrade is primarily a sandy clay.

The instrumentation installation schedule was disrupted since the drilling crew did not show up at this site on the first day. As many activities were performed on the first day as possible, including FWD measurements prior to cutting the pavement, coring the instrumentation hole and cutting the access trench, placement of the snap rings for measurement of joint opening, and preparation of the instrumentation for installation. The instrumentation was placed and all of the initial data collection activities were performed the second day. Due to the delay in installation, a reduce number of FWD measurement passes were performed on the second day.

The instrumentation installation generally followed the procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines".

- The monitoring well was located at test section station 0+24 since this was the approximate mid-point of the 5 consecutive slabs being monitored. Station 1+00 is beyond the range of the slabs being monitored. This decision was made with the concurrence of Dr. Gonzalo Rada. It is recommended that the guidelines be changed to specify this position for the monitoring well on SMP rigid pavement test sections.

- Load transfer tests with the FWD were performed on the leave side joint of the last slab being monitored. These tests were performed at this location since it was reasoned that the approach side of this joint was part of the last slab being monitored. The guidelines at the time did not indicated that load transfer tests should be performed at this location.

- Since the auger did not create a hole large enough for placement of the TDR probes, a metal bar was used to enlarge the sides of the hole. With the sandy soil this procedure worked well and resulted in a "tight" placement of the ends of the TDR sensors into notches carved in the side of the hole.

The procedure and placement jig developed by Mr. Bob VanSambeek for installation of the snap rings worked very well. It is recommended that this equipment and procedure be used for all other SMP rigid pavement test sections.

All equipment and instrumentation installed appeared to be functioning properly. As noted in the report, the automated resistance data acquisition system did not function properly, although this was difficult to determine in the field. The malfunction was subsequently traced to a faulty wiring connection. In the future, all data acquisition systems should be thoroughly tested in the office prior to field use. In addition, a program which plots the data collected by the datalogger is also needed as a field quality control check.

APPENDIX A

Test Section Background Information

Appendix A Includes the Following Supporting Information:

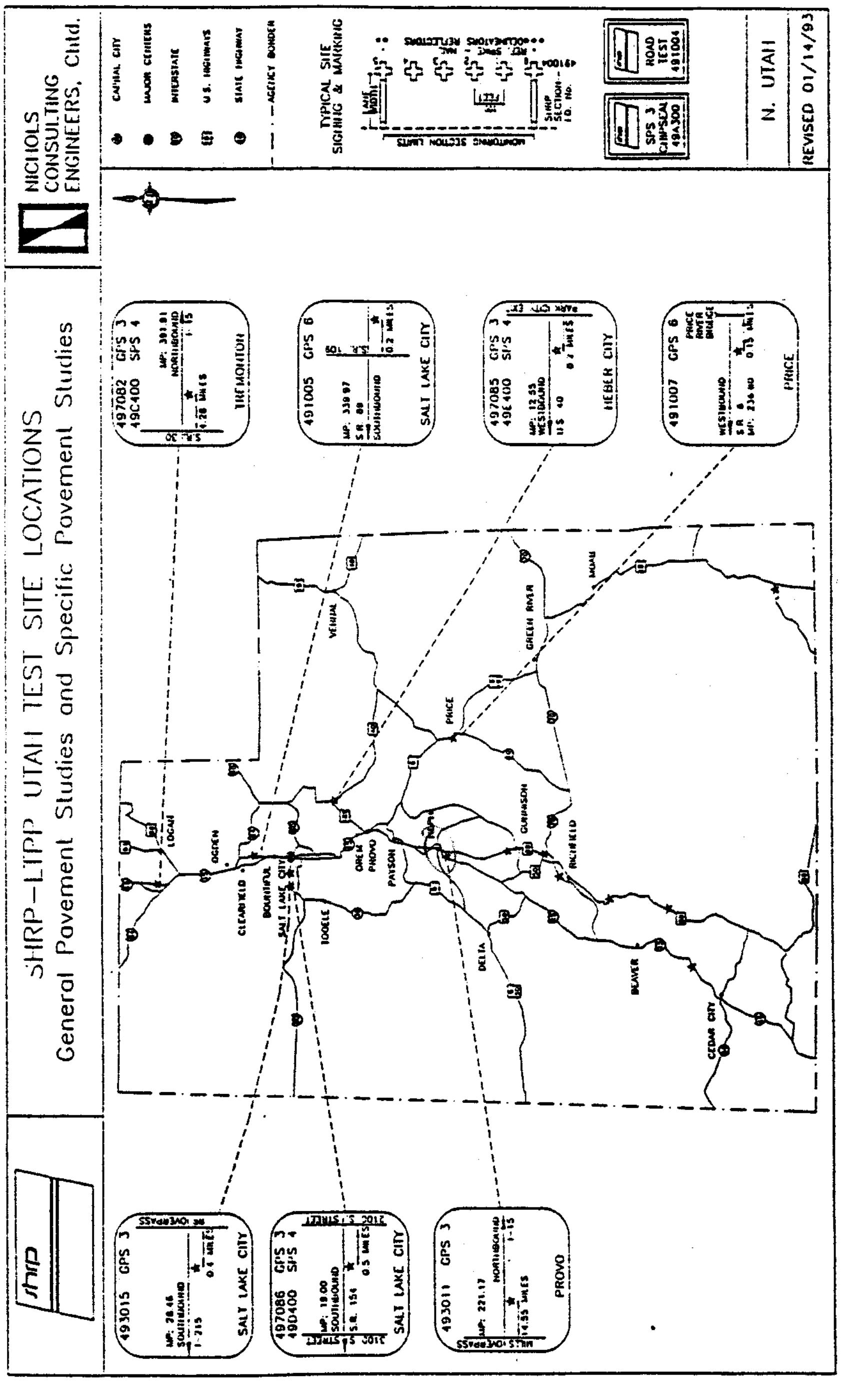


Figure A-1. Location of test site, GPS test section 493011.

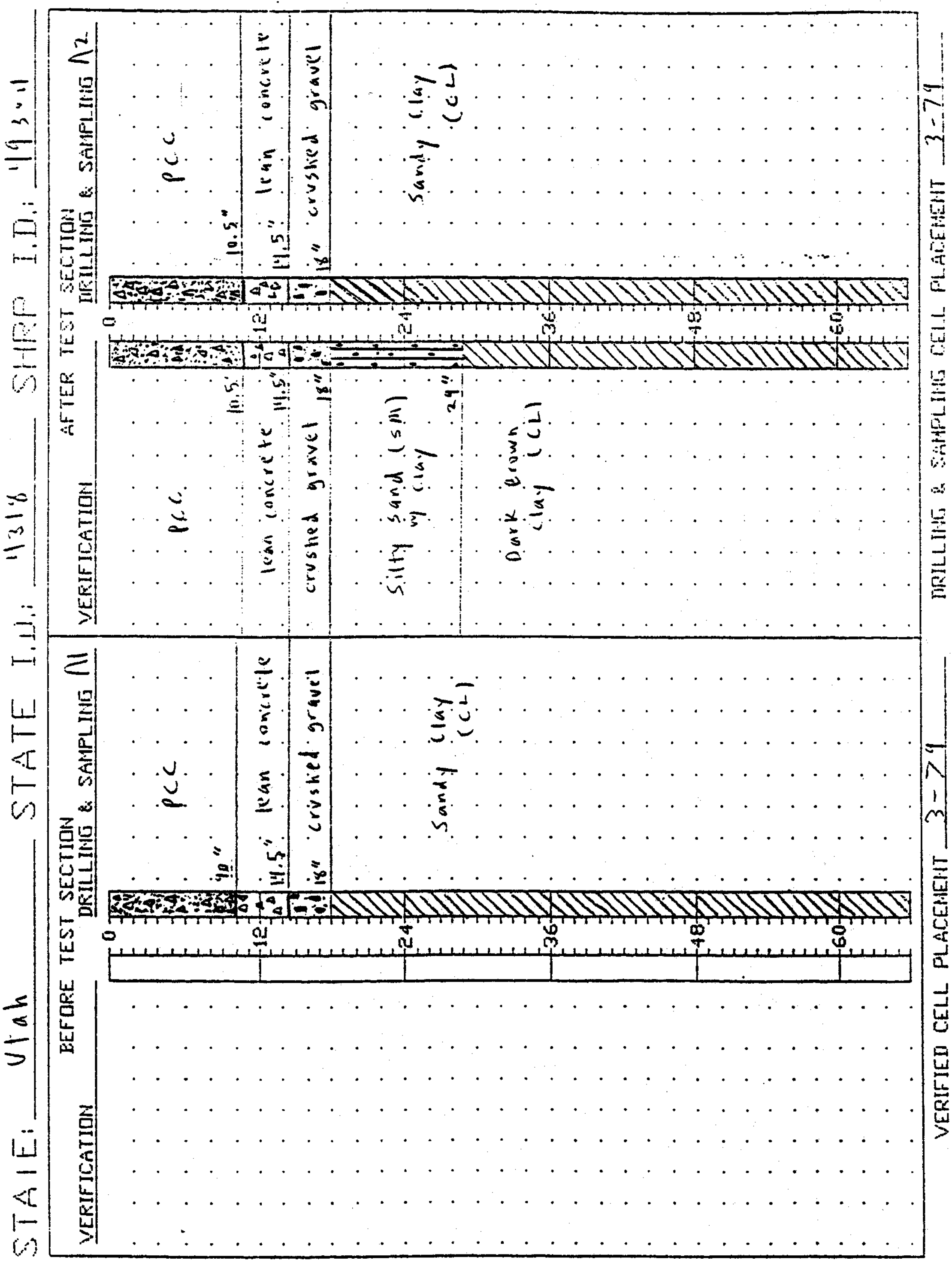


Figure A-2. Profile of test section.

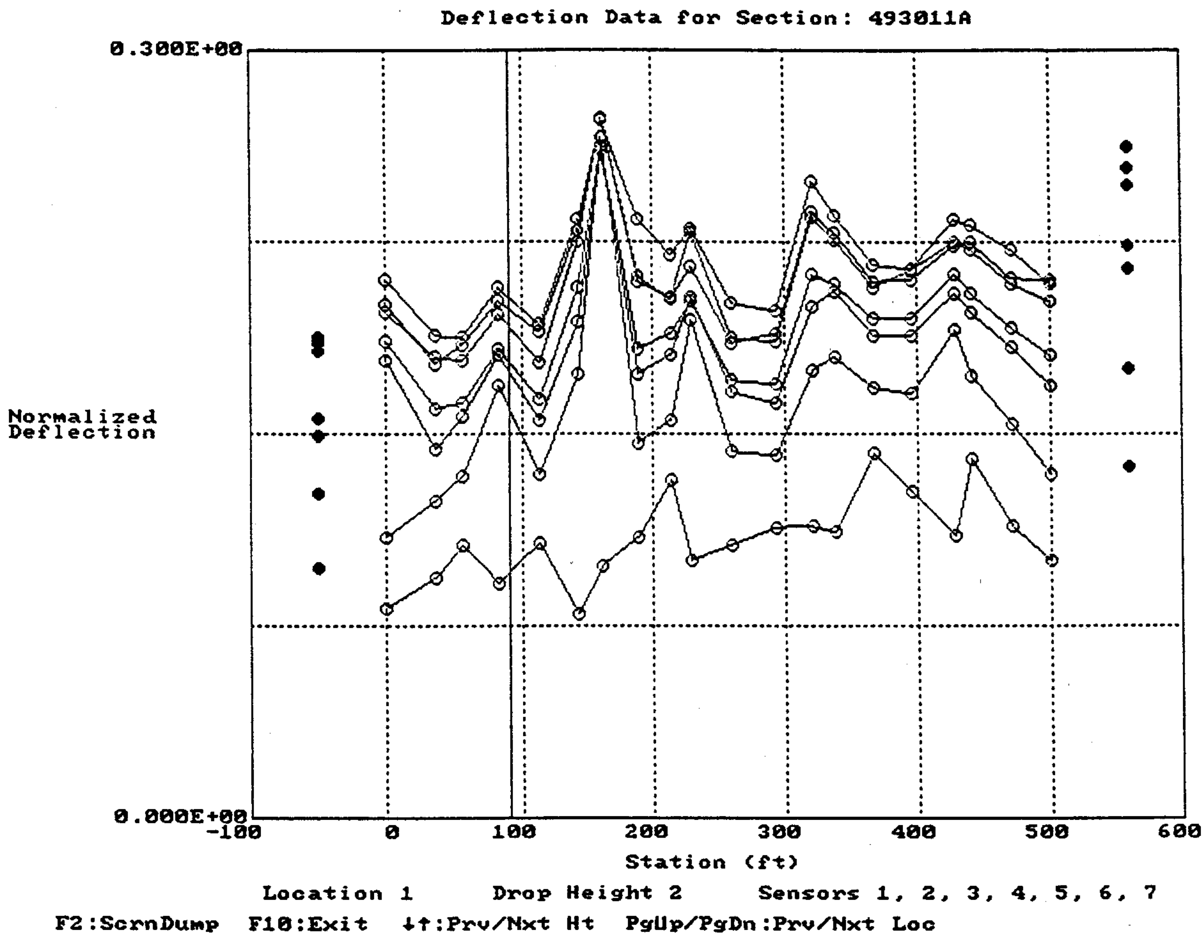


Figure A-3. Normalized deflection profile from FWDCHECK (test date 4/20/89).

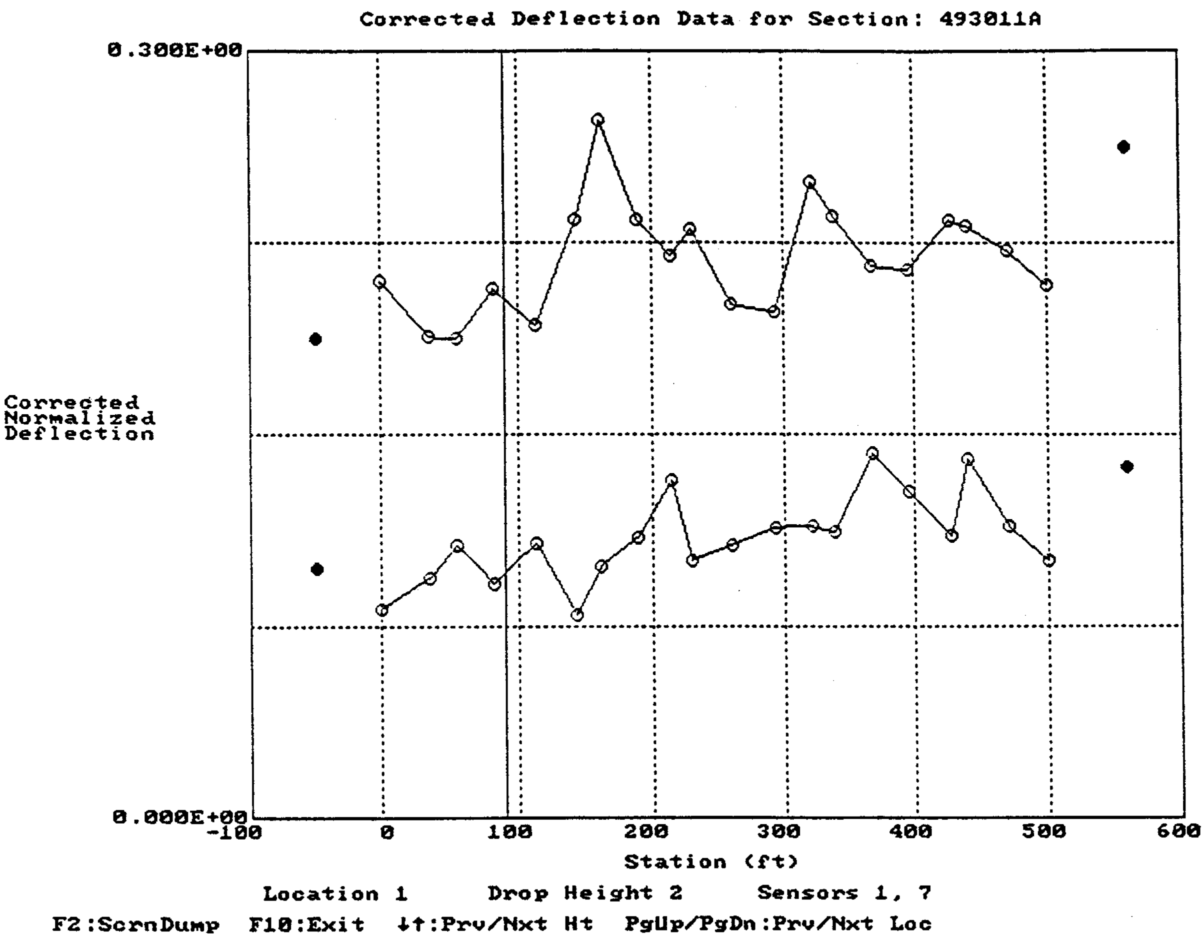


Figure A-4. Corrected normalized deflection profile from FWDCHECK.

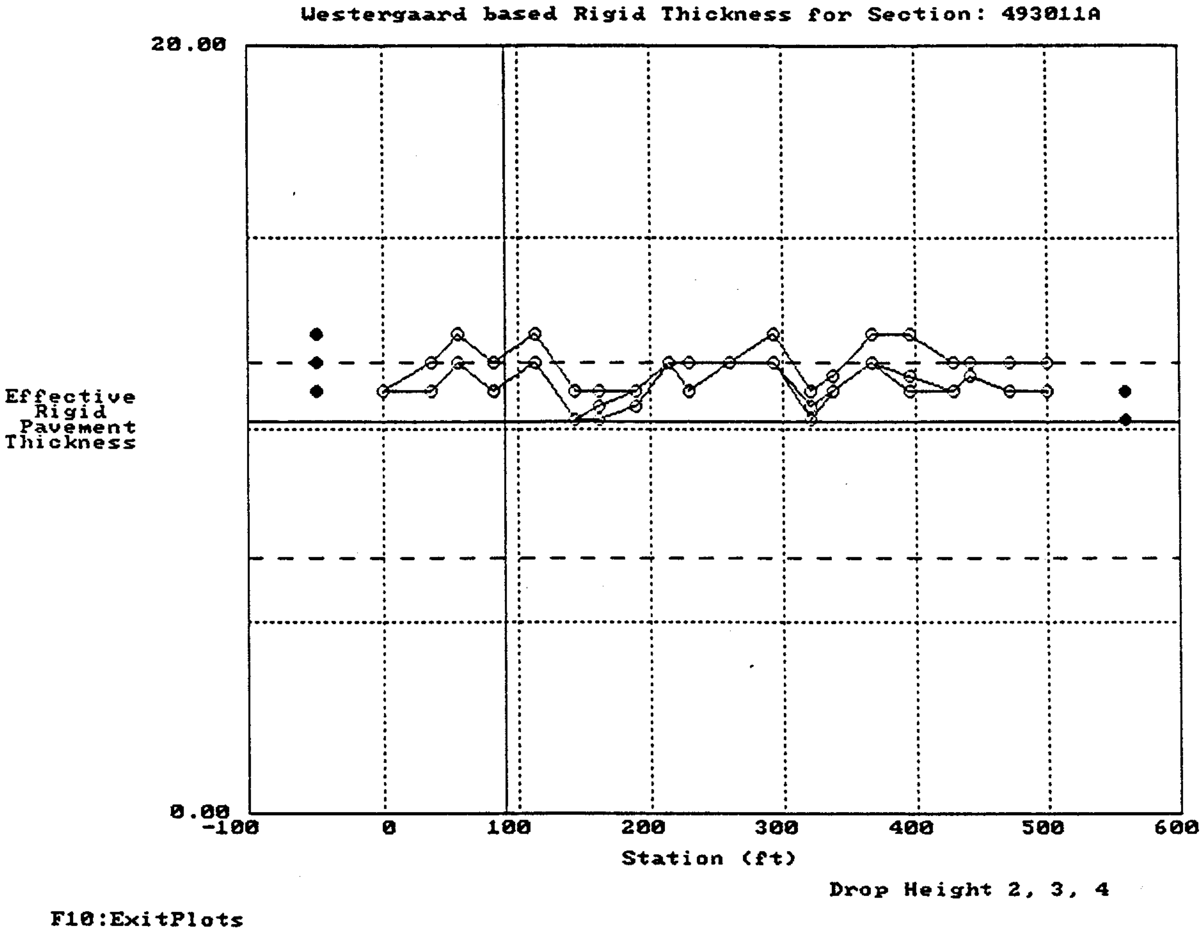


Figure A-5. Effective rigid pavement thickness profiles from FWDCHECK.

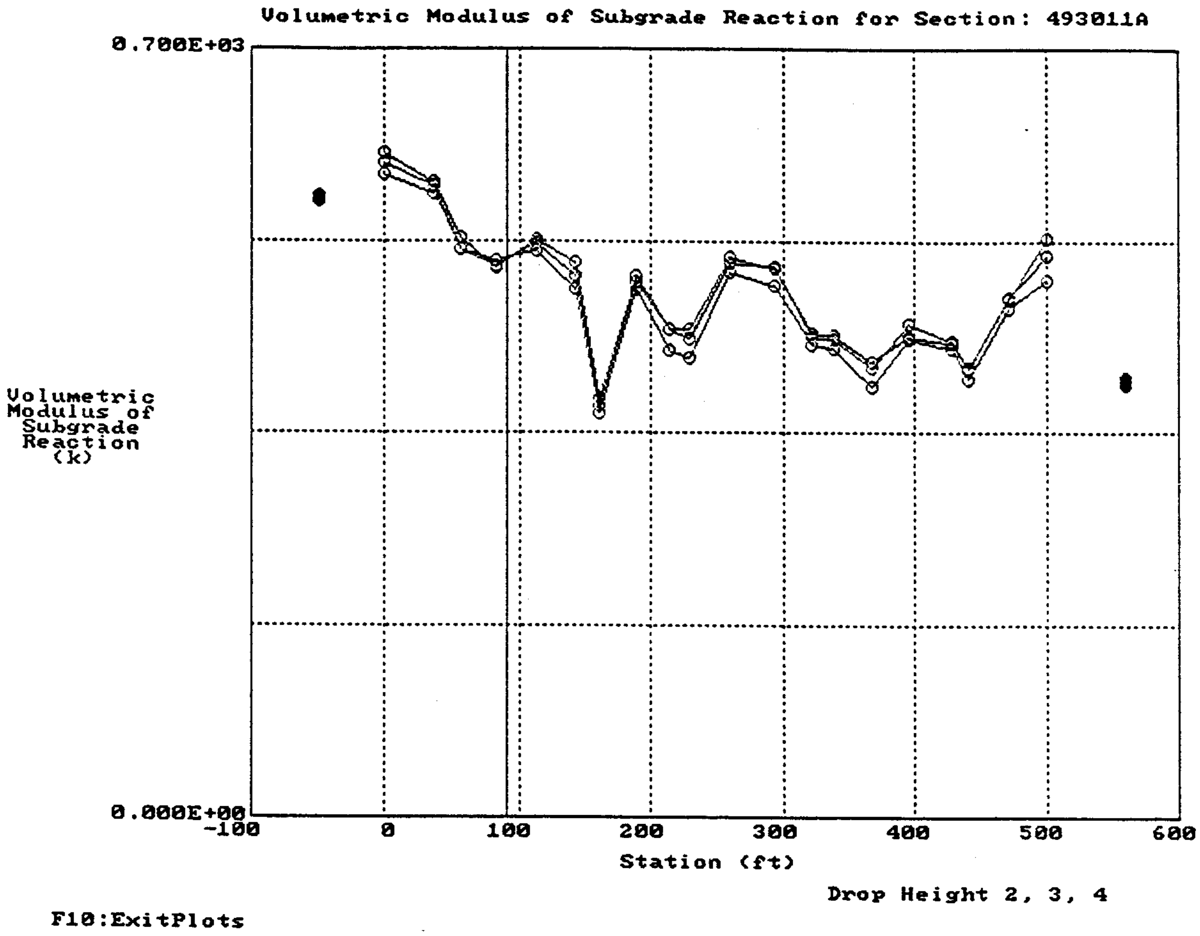


Figure A-6. Volumetric modulus of subgrade reaction (k) from FWDCHECK.

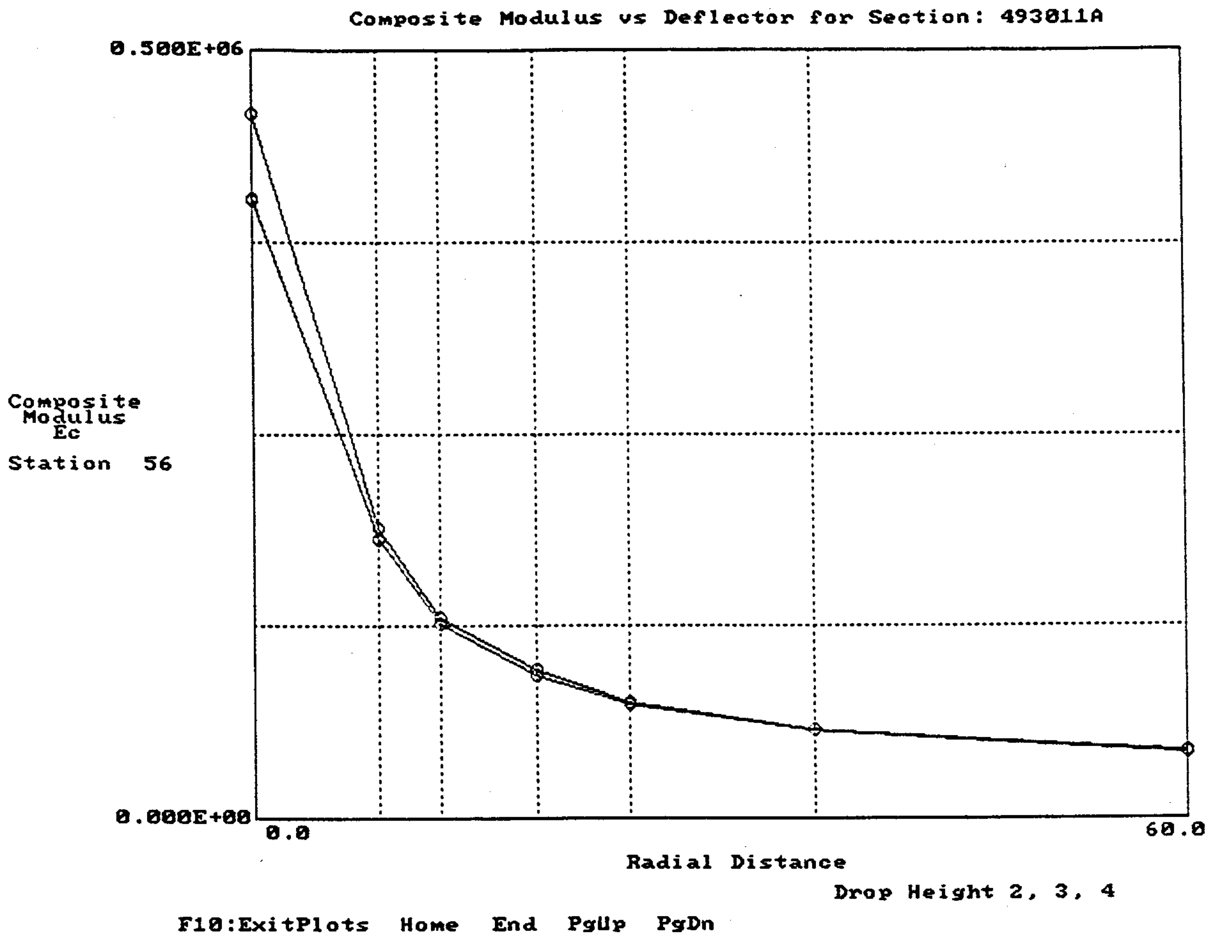


Figure A-7. Composite modulus Ec at station 56 from FWDCHECK.

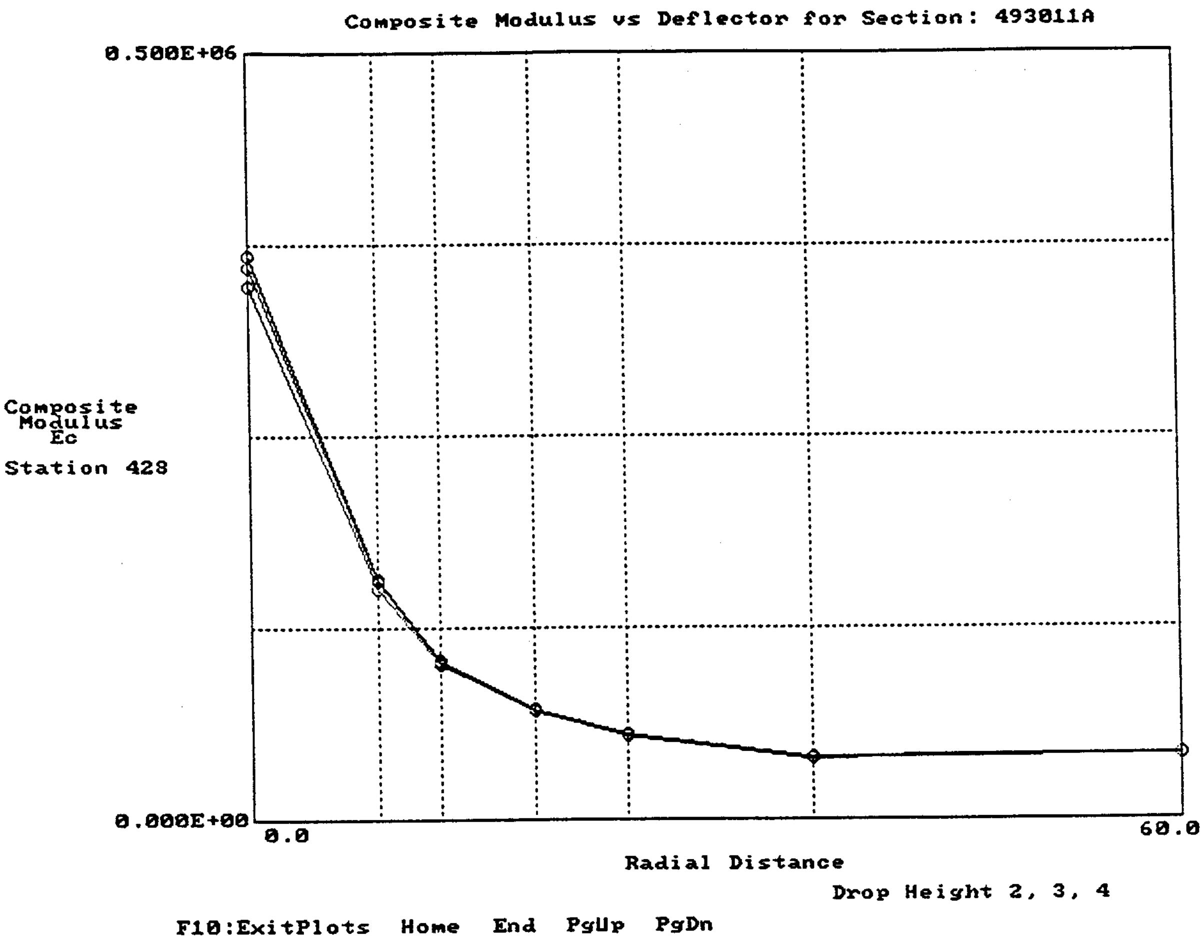


Figure A-8. Composite modulus Ec at station 428 from FWDCHECK.

APPENDIX B

Installed Instrument Information

Appendix B Includes the Following Supporting Information:

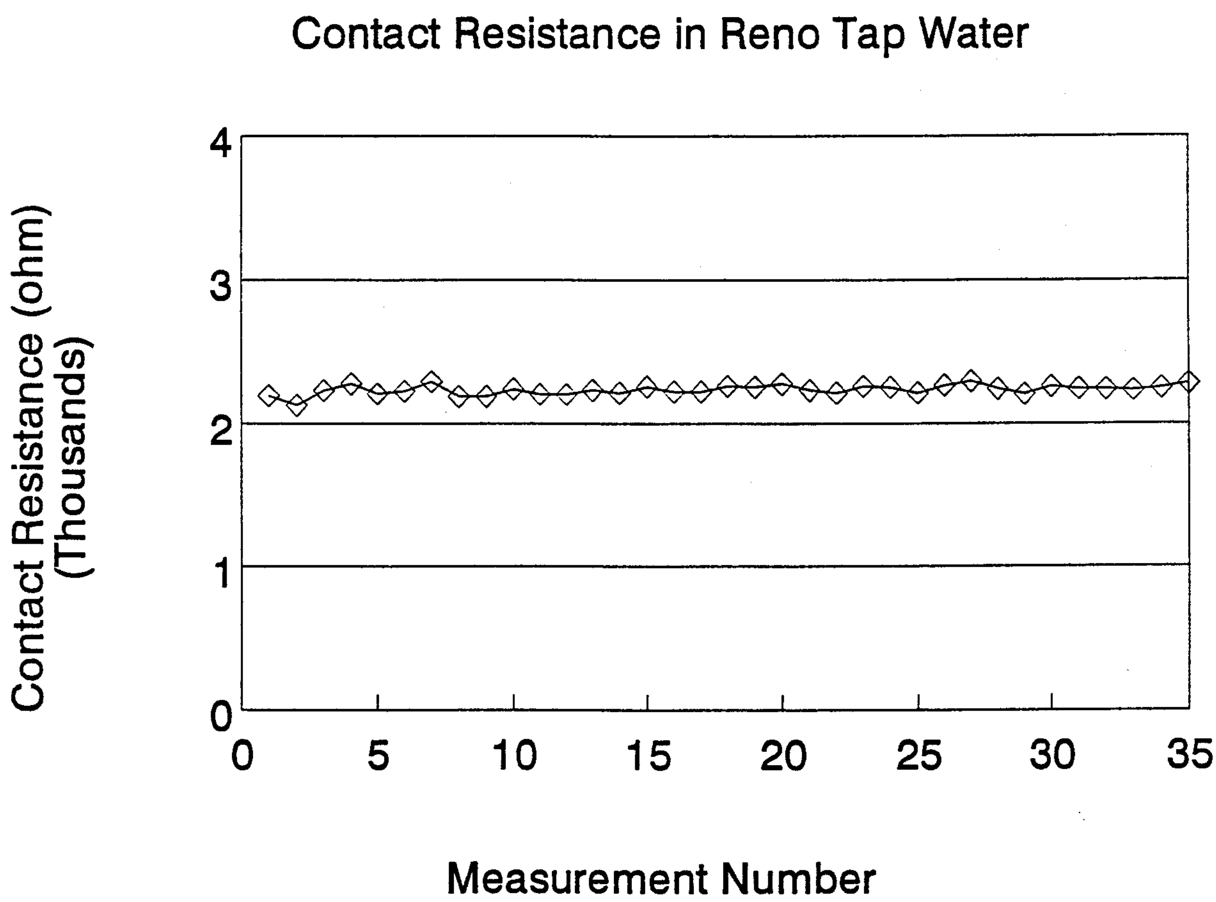


Figure B-1. Contact resistance measured in Reno tap water.

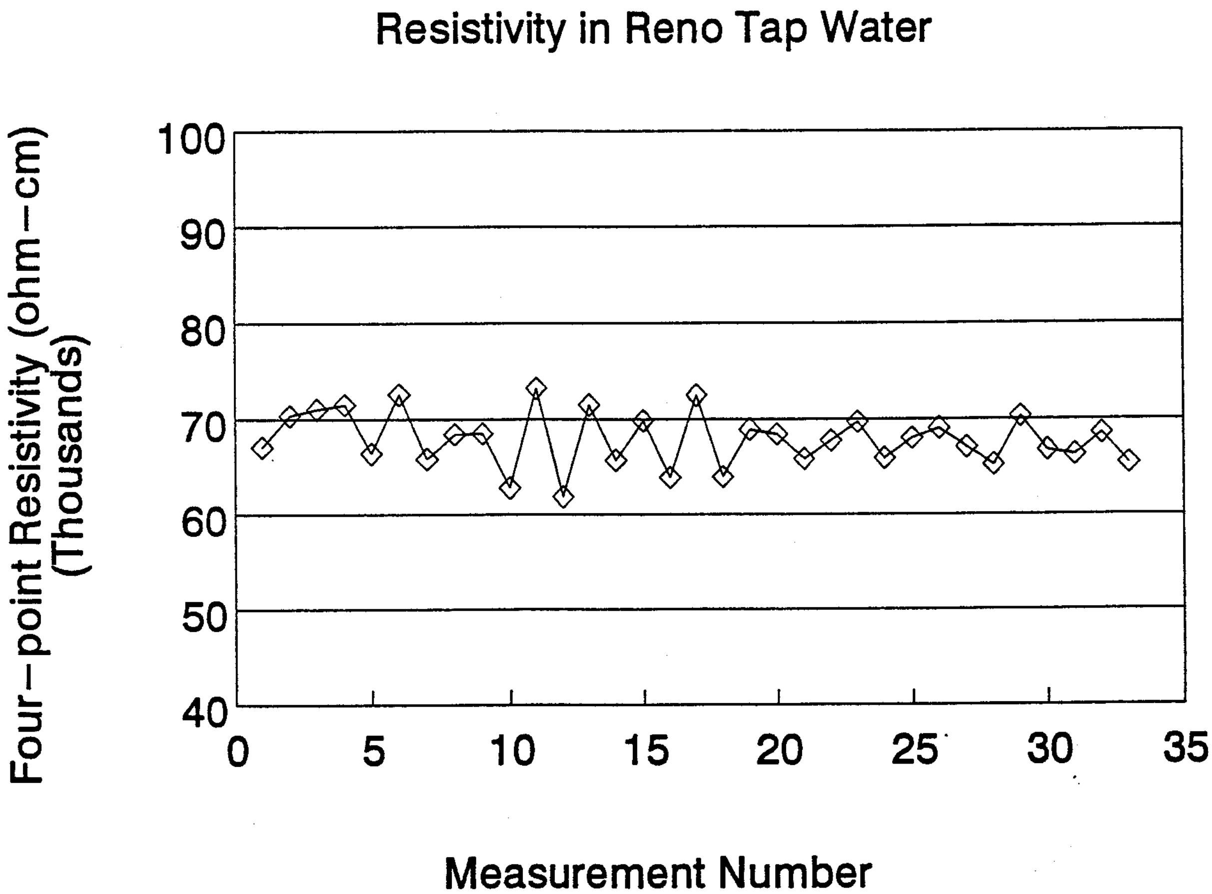
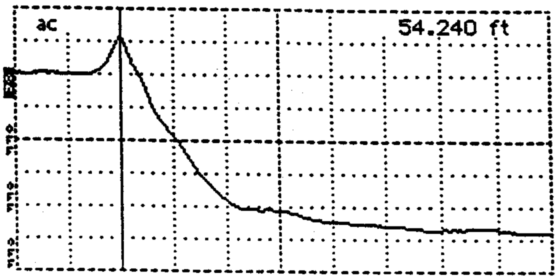


Figure B-2. Four-Point resistivity measured in distilled water.

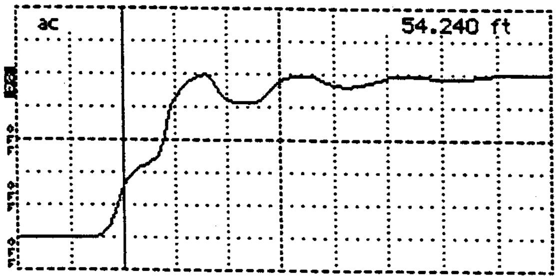
Cursor .... 54.240 ft
Distance/Div...... 1 ft/div
Vertical Scale.... 177 mρ/div
.... 0.99
Noise Filter...... 1 avg
Power............ ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49AC1
Notes 74° F
Shorted

Input Trace
Stored Trace
Difference Trace

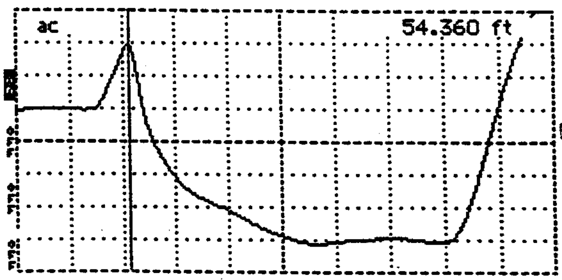
Cursor .... 54.240 ft
Distance/Div...... 1 ft/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power............ ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49AC1
Notes 74 °F
In Air

Input Trace
Stored Trace
Difference Trace

Cursor .... 54.360 ft
tance/Div...... 1 ft/div
Vertical Scale.... 72.7 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power............ ac

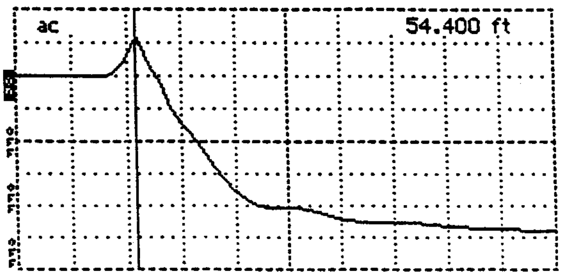


Tektronix 1502B TDR
Date 7/20/93
Cable 49A01
Notes In Distilled
Water 71°F

Input Trace
Stored Trace
Difference Trace

Figure B-3. TDR traces obtained during calibration.

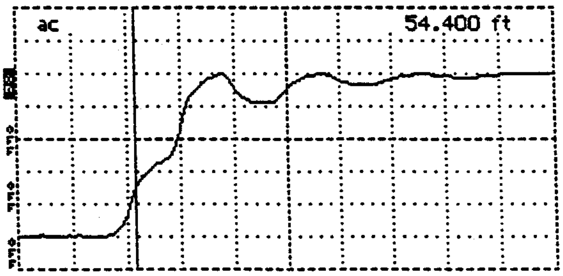
Cursor .... 54.400 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp............. 0.99
[illegible] Filter...... 1 avg
Power.......... ac



Tektronix 1502B TDR
Date ________
Cable ________
Notes ________

Input Trace ________
Stored Trace ________
Difference Trace ________

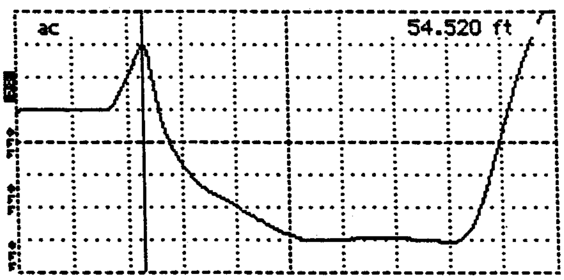
Cursor .... 54.400 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power.......... ac



Tektronix 1502B TDR
Date ________
Cable ________
Notes 74°F
In Air

Input Trace ________
Stored Trace ________
Difference Trace ________

Cursor .... 54.520 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
[illegible] 0.99
[illegible]se Filter...... 1 avg
Power.......... ac

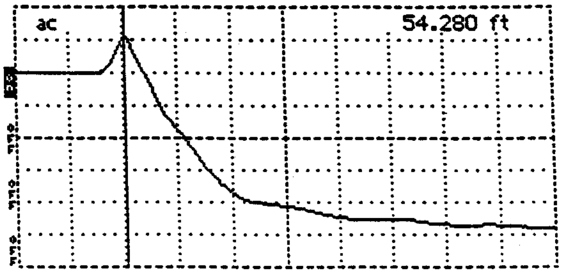


Tektronix 1502B TDR
Date 7/20/93
Cable 49A02
Notes In Distilled
Water 71°F

Input Trace ________
Stored Trace ________
Difference Trace ________

Figure B-3. TDR traces obtained during calibration (cont.).

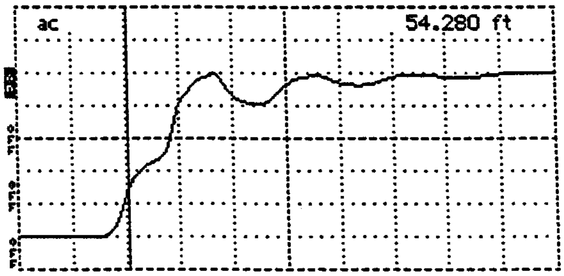
Cursor .... 54.280 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power............ ac



Tektronix 1502B TDR
Date ____
Cable ____
Notes ____

Input Trace ____
Stored Trace ____
Difference Trace ____

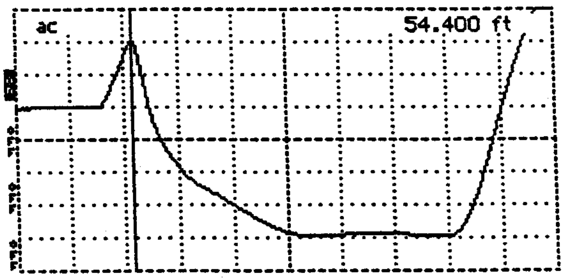
Cursor .... 54.280 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power............ ac



Tektronix 1502B TDR
Date 7/20/93
Cable ____
Notes ____

Input Trace ____
Stored Trace ____
Difference Trace ____

Cursor .... 54.400 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power............ ac

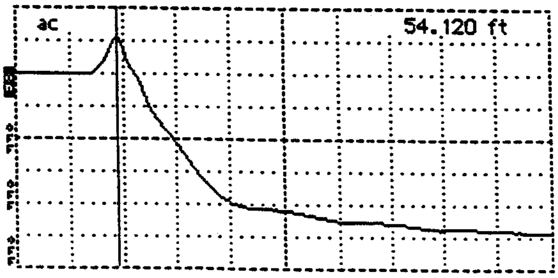


Tektronix 1502B TDR
Date 7/20/93
Cable 49A03
Notes ____
Water 71°F

Input Trace ____
Stored Trace ____
Difference Trace ____

Figure B-3. TDR traces obtained during calibration (cont.).

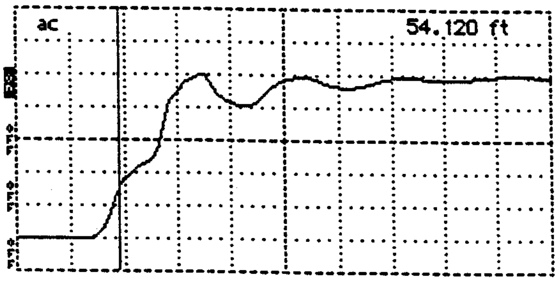
Cursor .... 54.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp 0.99
N . Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49404
Notes

Input Trace
Stored Trace
Difference Trace

Cursor .... 54.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49404
Notes 74°F
In Air

Input Trace
Stored Trace
Difference Trace

Cursor .... 54.200 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
Vp 0.99
F : Filter...... 1 avg
Power........... ac

Tektronix 1502B TDR
Date 7/20/93
Cable 49404
Notes In Distilled
Water 71°F

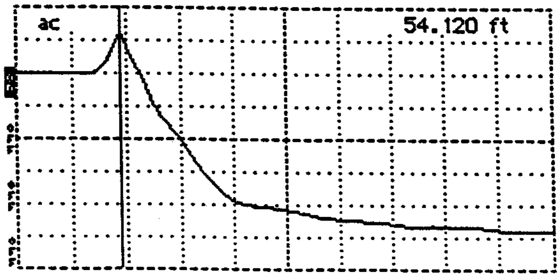
Input Trace
Stored Trace
Difference Trace

Probe has one skinny metal rod

Insulated on bottom

Figure B-3. TDR traces obtained during calibration (cont.).

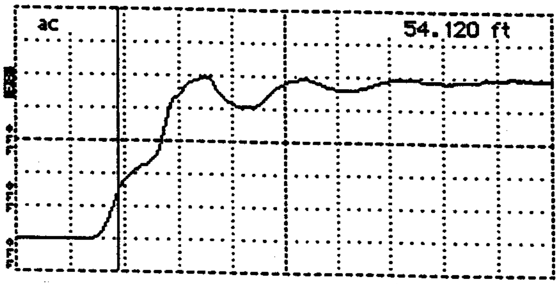
Cursor .... 54.120 ft
Distance/Div..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp............... 0.99
Noise Filter...... 1 avg
Power............ ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A0S
Notes 74° F
Shorted

Input Trace
Stored Trace
Difference Trace

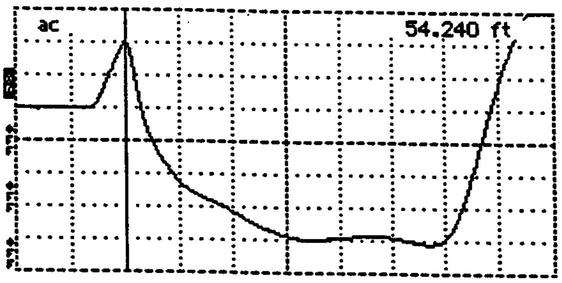
Cursor .... 54.120 ft
Distance/Div..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp............... 0.99
Noise Filter...... 1 avg
Power............ ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A0S
Notes 74° F
In Air

Input Trace
Stored Trace
Difference Trace

Cursor .... 54.240 ft
Distance/Div..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
Vp............... 0.99
Noise Filter...... 1 avg
Power............ ac

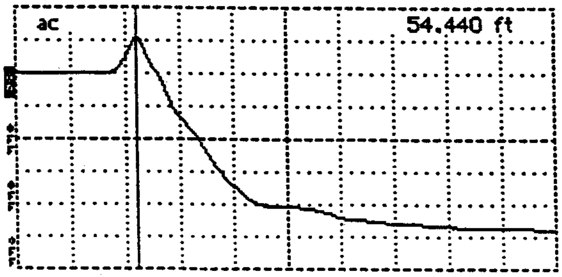


Tektronix 1502B TDR
Date 7/20/93
Cable 49A0S
Notes In Distilled Water 71° F

Input Trace
Stored Trace
Difference Trace

Figure B-3. TDR traces obtained during calibration (cont.).

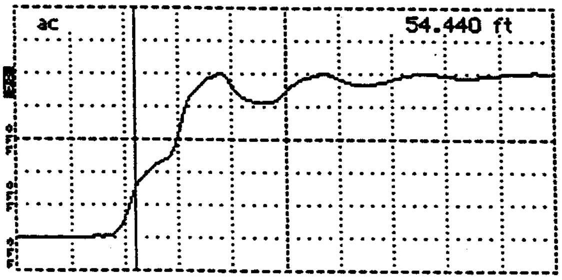
Cursor .... 54.440 ft
Distance/Div..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power.......... ac



Tektronix 1502B TDR
Date 4/20/93
Cable 49A06
Notes 74°F
Shorted

Input Trace
Stored Trace
Difference Trace

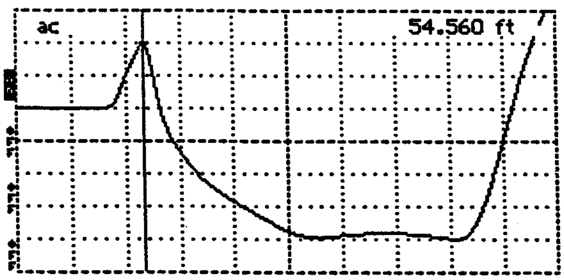
Cursor .... 54.440 ft
Distance/Div..... 1 ft/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power.......... ac



Tektronix 1502B TDR
Date 4/20/93
Cable 49A06
Notes 74°F
In Air

Input Trace
Stored Trace
Difference Trace

Cursor .... 54.560 ft
Distance/Div..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power.......... ac



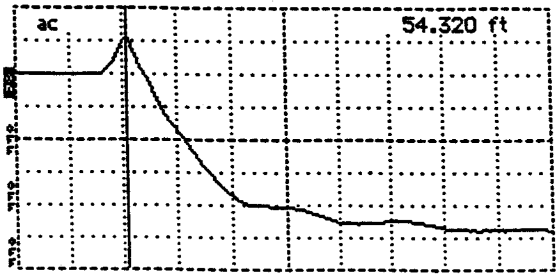
Tektronix 1502B TDR
Date 4/20/93
Cable 49A06
Notes In Distilled Water 71°F

Input Trace
Stored Trace
Difference Trace

Probe has 3 skinny metal rods

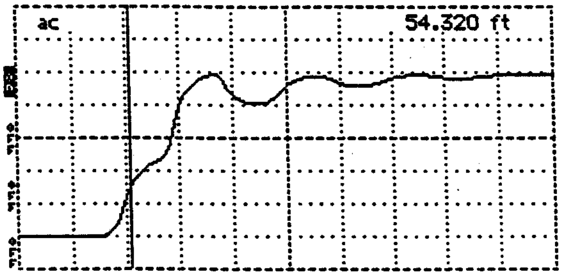
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 54.320 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp............... 0.99
N[illegible] Filter...... 1 avg
Power........... ac



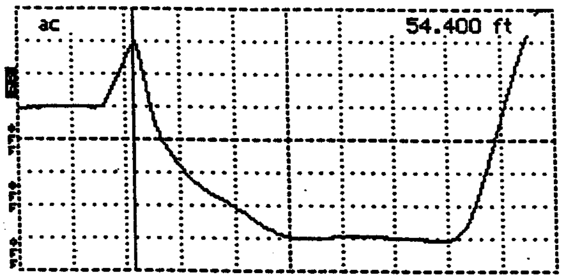
Tektronix 1502B TDR
Date 7/20/93
Cable 49A07
Notes 74°F
Shorted
Input Trace
Stored Trace
Difference Trace

Cursor .... 54.320 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power............ ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A07
Notes 74°F
In Air OC
Input Trace
Stored Trace
Difference Trace

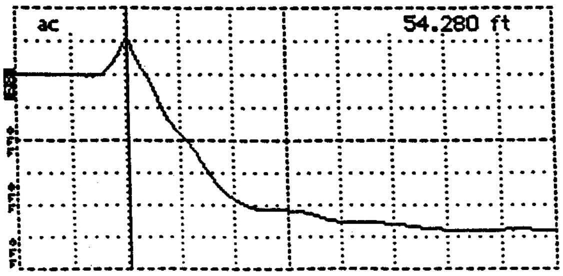
Cursor .... 54.400 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
Vp 0.99
[illegible]e Filter...... 1 avg
P[illegible]wer............ ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A07
Notes In Distilled
Water 71°F
Input Trace
Stored Trace
Difference Trace

Figure B-3. TDR traces obtained during calibration (cont.).

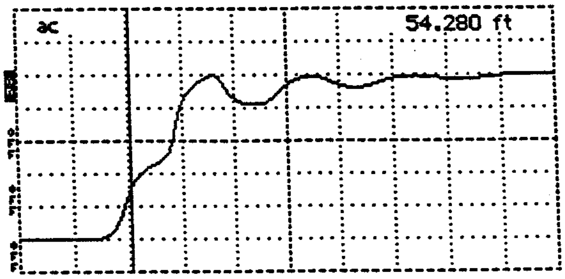
Cursor .... 54.280 ft
Distance/Div ..... 1 ft/div
Vertical Scale .... 177 mρ/div
V............. 0.99
N e Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A08
Notes 74°F
Shorted

Input Trace
Stored Trace
Difference Trace

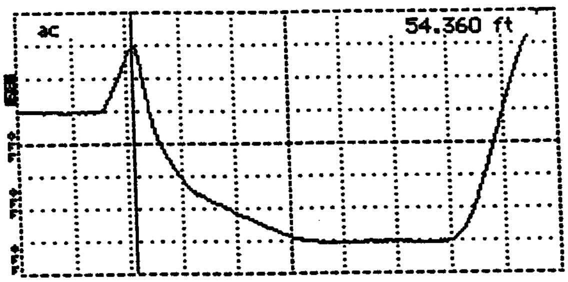
Cursor .... 54.280 ft
Distance/Div ..... 1 ft/div
Vertical Scale .... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A08
Notes 74°F
In Air

Input Trace
Stored Trace
Difference Trace

Cursor .... 54.360 ft
Distance/Div ..... 1 ft/div
Vertical Scale .... 72.7 mρ/div
.... 0.99
se Filter ...... 1 avg
Power .... ac

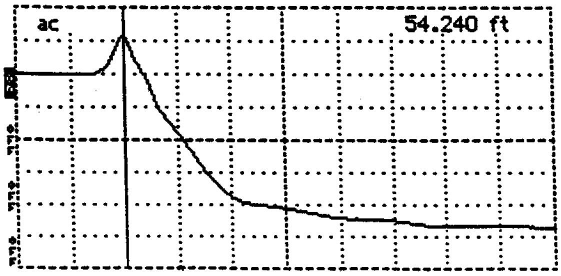


Tektronix 1502B TDR
Date 7/20/93
Cable 49A08
Notes In Distilled
Water 71°F

Input Trace
Stored Trace
Difference Trace

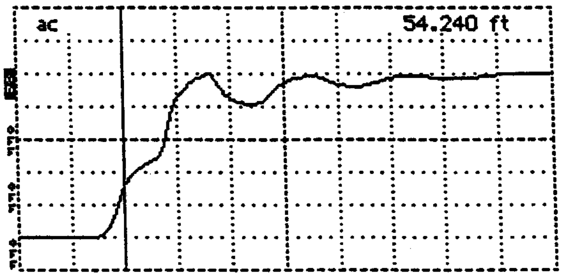
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 54.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



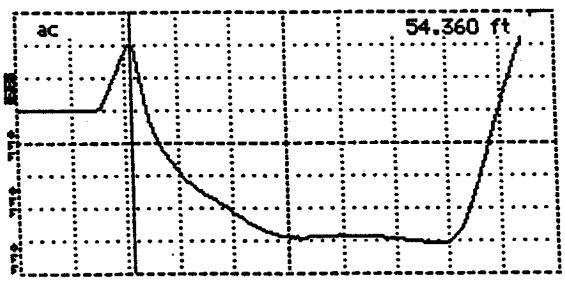
Tektronix 1502B TDR
Date 7/20/93
Cable 49A09
Notes 74°F
Shortened
OD
Input Trace
Stored Trace
Difference Trace

Cursor .... 54.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A09
Notes 74°F
In Air OD
Input Trace
Stored Trace
Difference Trace

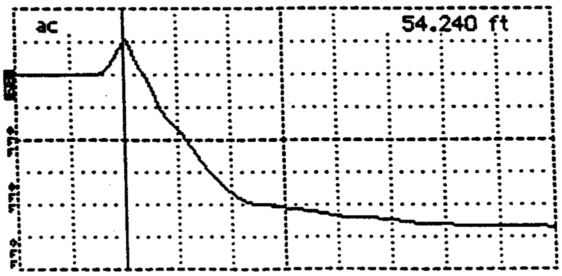
Cursor .... 54.360 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A09
Notes In Distilled
Water 71°F
OD
Input Trace
Stored Trace
Difference Trace

Figure B-3. TDR traces obtained during calibration (cont.).

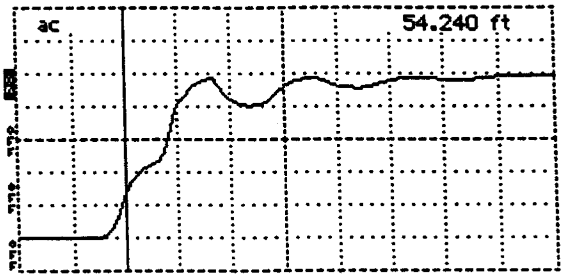
Cursor .... 54.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avs
Power .... ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A10
Notes 74°F
Shorted [illegible]

Input Trace
Stored Trace
Difference Trace

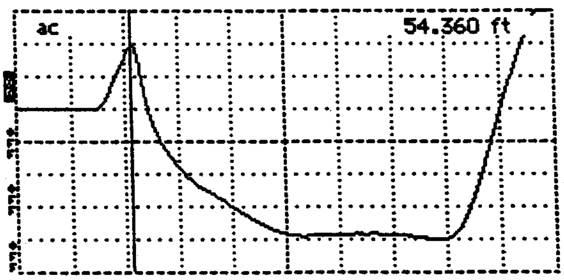
Cursor .... 54.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avs
Power .... ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A10
Notes 74°F
In Air [illegible]

Input Trace
Stored Trace
Difference Trace

Cursor .... 54.360 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
Vp 0.99
Noise Filter ...... 1 avs
Power .... ac



Tektronix 1502B TDR
Date 7/20/93
Cable 49A10
Notes In Distilled
Water, 71°F [illegible]

Input Trace
Stored Trace
Difference Trace

Probe has one skinny metal rod

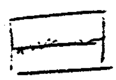


Figure B-3. TDR traces obtained during calibration (cont.).

APPENDIX C

Supporting Instrumentation Installation Information

Appendix C Includes the Following Supporting Information:

Figure C-1 TDR Traces Measured During Installation

Figure C-2 Field Measured Moisture Content

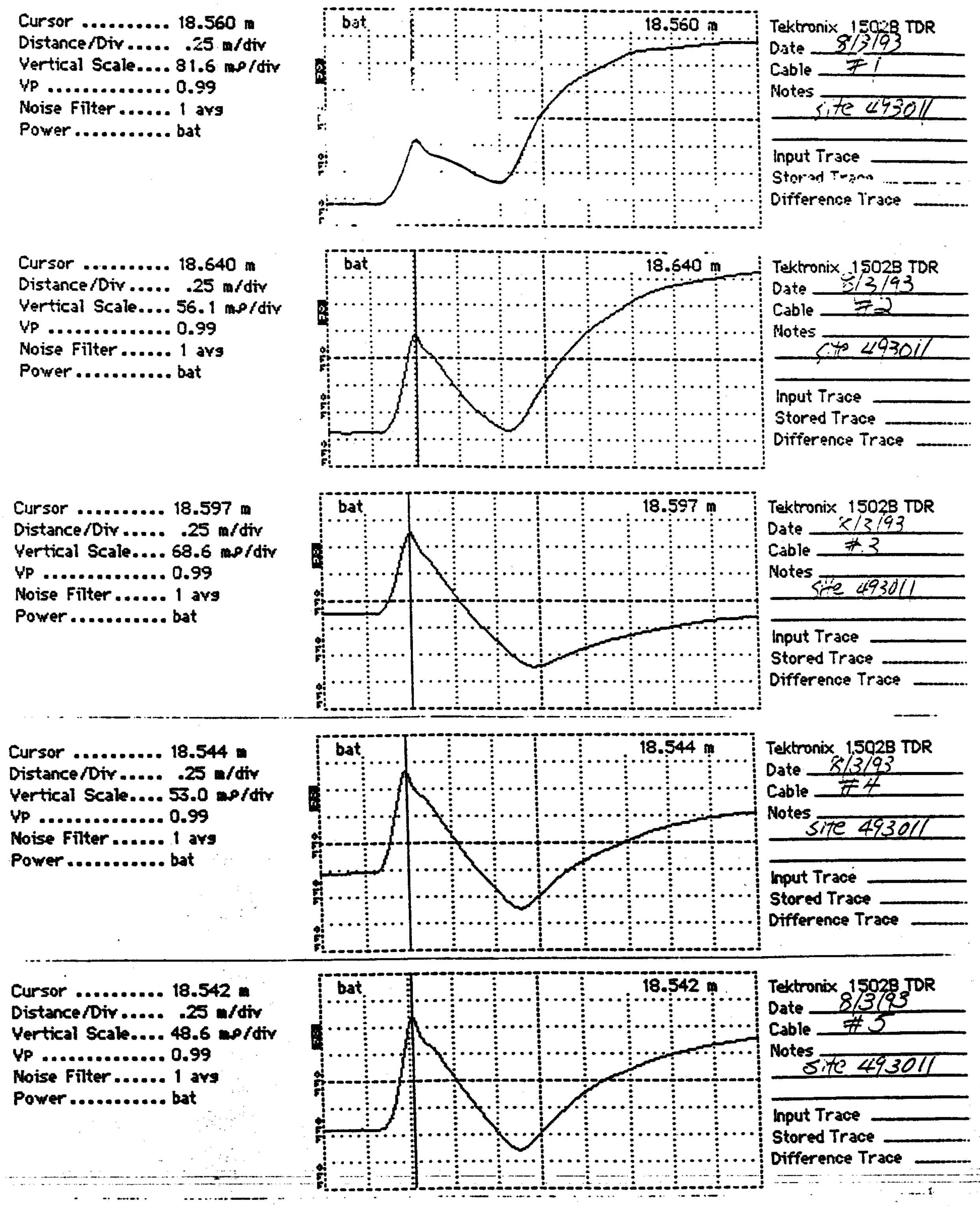
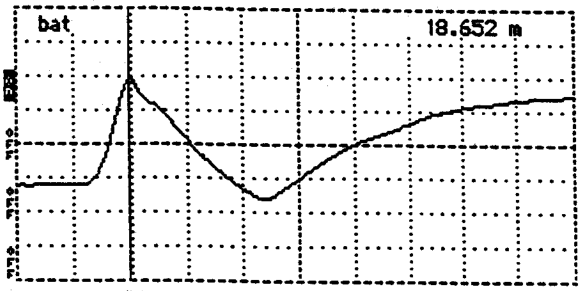


Figure C-1. TDR traces measured during installation.

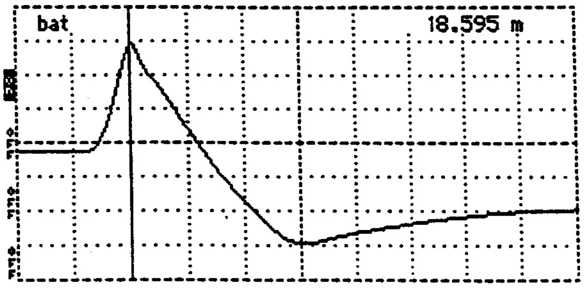
Cursor .... 18.652 m
Distance/Div ..... .25 m/div
Vertical Scale.... 62.9 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... bat



Tektronix 1502B TDR
Date 8/3/93
Cable #6
Notes Site 493011

Input Trace
Stored Trace
Difference Trace

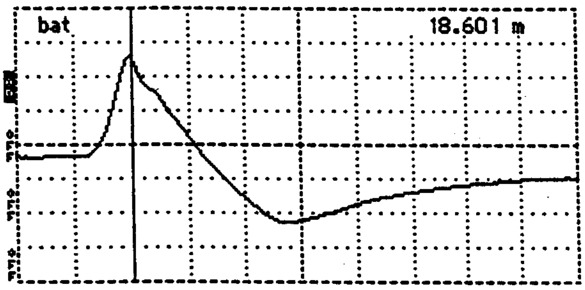
Cursor .... 18.595 m
Distance/Div ..... .25 m/div
Vertical Scale.... 61.2 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... bat



Tektronix 1502B TDR
Date 8/3/93
Cable #7
Notes Site 493011

Input Trace
Stored Trace
Difference Trace

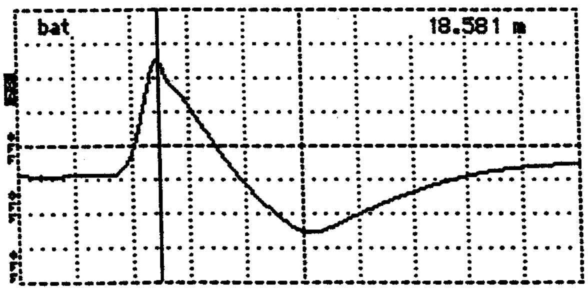
Cursor .... 18.601 m
Distance/Div ..... .25 m/div
Vertical Scale.... 68.6 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... bat



Tektronix 1502B TDR
Date 8/3/93
Cable #8
Notes Site 493011

Input Trace
Stored Trace
Difference Trace

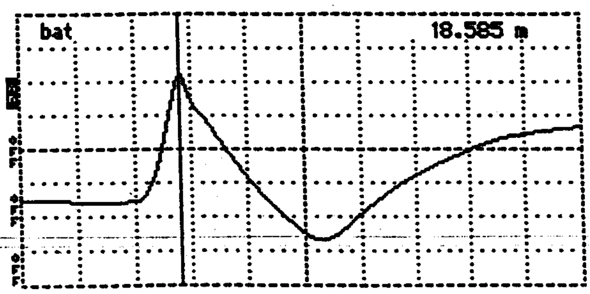
Cursor .... 18.581 m
Distance/Div ..... .25 m/div
Vertical Scale.... 61.2 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... bat



Tektronix 1502B TDR
Date 8/3/93
Cable #9
Notes Site 493011

Input Trace
Stored Trace
Difference Trace

Cursor .... 18.585 m
Distance/Div ..... .25 m/div
Vertical Scale.... 53.0 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... bat



Tektronix 1502B TDR
Date 8/3/93
Cable #10
Notes Site 493011

Input Trace
Stored Trace
Difference Trace

Figure C-1. TDR traces measured during installation (cont.).

LTPP Seasonal Monitoring Study Moisture Contents (%)	* State Code [49] * Test Section Number [3011]

Personnel : Jason M. Dietz
Date : 8/3/93
Start Time : 12:30 PM
Finish Time : 2:00 PM
Surface Type : Portland Cement Concrete
Weather Conditions : Clear 32.2°C
Unusual Conditions : None

TDR Probe #	Moisture Content (%)
10	14.88
9	10.26
8	14.09
7	12.46
6	8.26
5	8.31
4	7.77
3	10.19
2	7.29
1	9.00

Figure C-2. Field measured moisture content.

APPENDIX D

Initial Data Collection

Appendix D Includes the Following Supporting Information:

Table D-1	Raw data from the onsite datalogger during initial data collection
Figure D-1	Measured air temperature during initial data collection
Figure D-2	Measured hourly average subsurface temperature for the first 5 sensors during initial data collection
Figure D-3	Measured average subsurface temperature for all 18 sensors during initial data collection
Fig. D-4 - 13	TDR traces measured with the mobile system during initial data collection
Figure D-14	Manually collected contact resistance
Figure D-15	Manually collected 4-point resistivity
Table D-2	Contact resistance measurement data sheet
Table D-3	Four-point resistivity measurement data sheet
Table D-4	Surface elevation measurement data sheet
Table D-5	Joint opening measurement data sheet

Table D-1 Data from the onsite datalogger during initial data collection, August 3 - August 4, 1993

```
4,215,1800,30.87,0
5,215,1800,33.68,31.8,30.53,27.69,27.31
6,215,1801,216.7,-184.3,-572.1,-947,-1310,-1634,-1864,-2000,-2071,-2107,-2125,-2133,-2138,-2140,-2142,-2144,-2144,-2144,-2144,-2143,-2143,-2142,-2142,-2142,-2143,-2144,-2144,-2143,-2142,-2143,-2144,-2143,-2143,-2142,-2142
4,215,1900,29.37,0
5,215,1900,31.79,31.51,30.72,27.84,27.44
4,215,2000,25.25,0
5,215,2000,29.61,30.5,30.97,28.03,27.55
4,215,2100,24,0
5,215,2100,28.1,29.46,30.94,28.34,27.72
4,215,2200,23.87,0
5,215,2200,27.18,28.67,30.44,28.59,27.89
4,215,2300,20.61,0
5,215,2300,26.24,27.99,29.91,28.71,28.03
1,1993,215,25.18,31.63,1745,20.16,2300,0,-6999,-6999,1715,-6999,1715,28.89,29.61,30.42,28.28,27.72,27.45,27.32,27.27,27.17,26.94,26.57,26.04,25.54,25.06,24.5,24.03,23.58,23.21
2,1993,215,34.02,1715,31.85,1745,31.08,2015,28.76,2330,28.15,2345,27.72,2345,27.43,0,27.47,1715,27.49,1715,27.31,1715,26.96,1715,26.39,1715,25.96,1715,25.6,1715,25.01,1715,24.47,1715,23.98,1715,23.59,1715
3,1993,215,25.54,0,27.18,0,29.27,0,27.59,1715,27.26,1715,27.23,1730,27.24,1945,27.19,2130,27,0,26.72,0,26.33,0,25.8,0,25.31,0,24.77,0,24.25,0,23:79,0,23.35,0,22.96,0
4,216,0,22.31,0
5,216,0,25.65,27.36,29.44,28.75,28.13
6,216,1,-239.4,-745,-1238,-1709,-2064,-2263,-2359,-2400,-2417,-2422,-2425,-2425,-2425,-2425,-2425,-2425,-2424,-2424,-2423,-2423,-2422,-2423,-2422,-2422,-2421,-2421,-2422,-2422,-2421,-2421,-2421,-2419,-2420,-2419,-2420
4,216,100,23.26,0
5,216,100,25.36,26.95,29.01,28.76,28.18
4,216,200,21.45,0
5,216,200,24.73,26.51,28.64,28.75,28.22
4,216,300,20.51,0
5,216,300,24.34,26.08,28.32,28.71,28.22
4,216,400,20.71,0
5,216,400,24.15,25.8,28.04,28.68,28.22
4,216,500,19.84,0
5,216,500,23.87,25.56,27.8,28.63,28.23
4,216,600,19.93,0
5,216,600,23.75,25.34,27.57,28.55,28.18
6,216,601,-271.2,-785,-1284,-1758,-2102,-2291,-2380,-2420,-2438,-2444,-2446,-2446,-2446,-2446,-2446,-2446,-2446,-2446,-2446,-2444,-2444,-2444,-2444,-2444,-2443,-2443,-2443,-2442,-2443,-2444,-2444,-2444,-2444,-2443,-2443
4,216,700,20.71,0
5,216,700,23.88,25.24,27.35,28.45,28.14
```

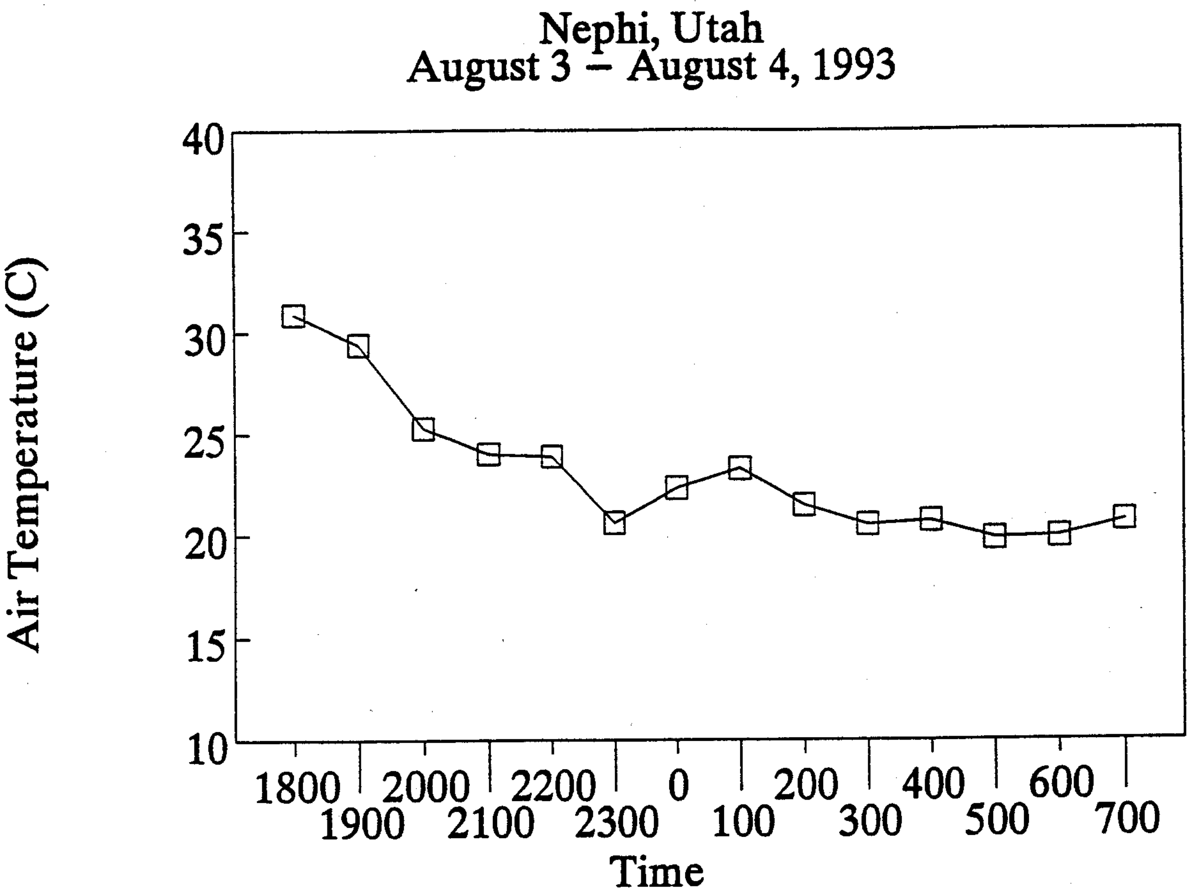


Figure D-1. Measured air temperature during initial data collection.

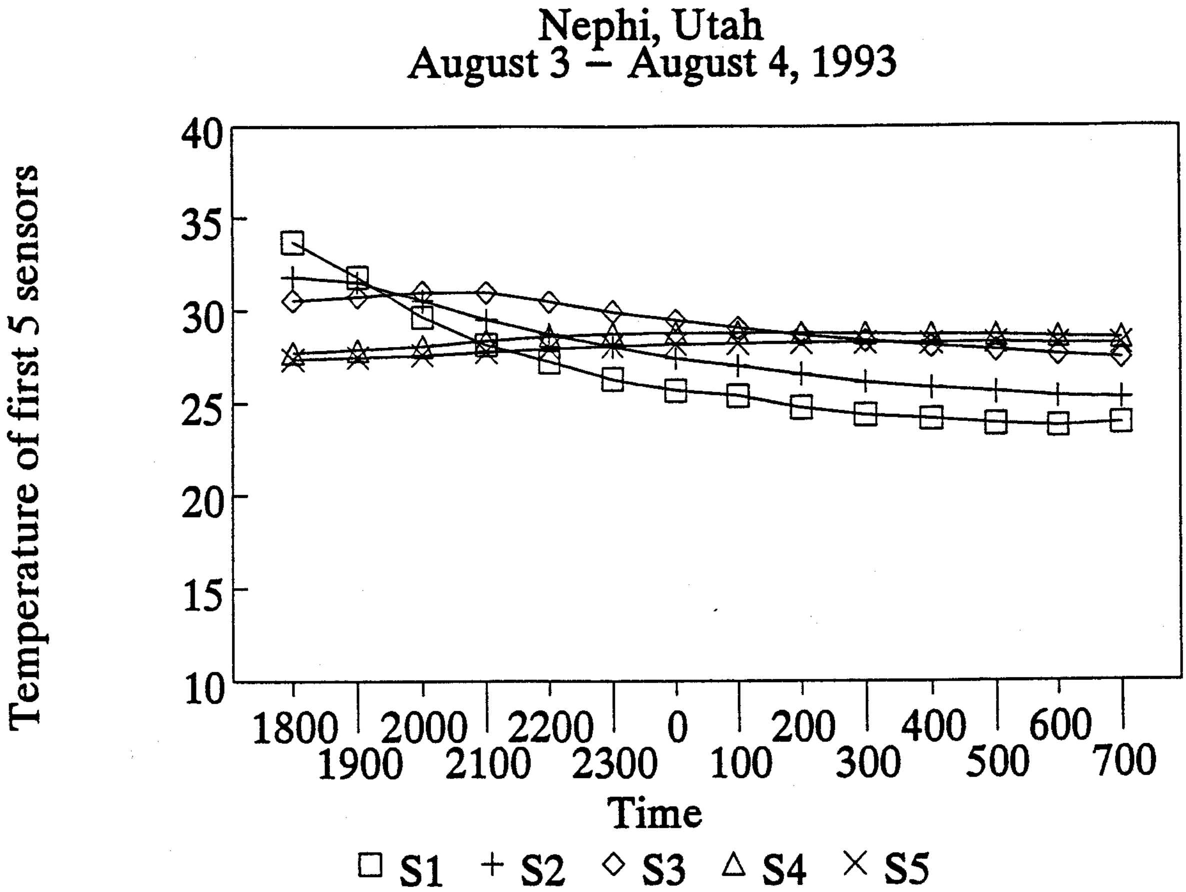


Figure D-2. Measured hourly average subsurface temperature for the first 5 sensors during initial data collection.

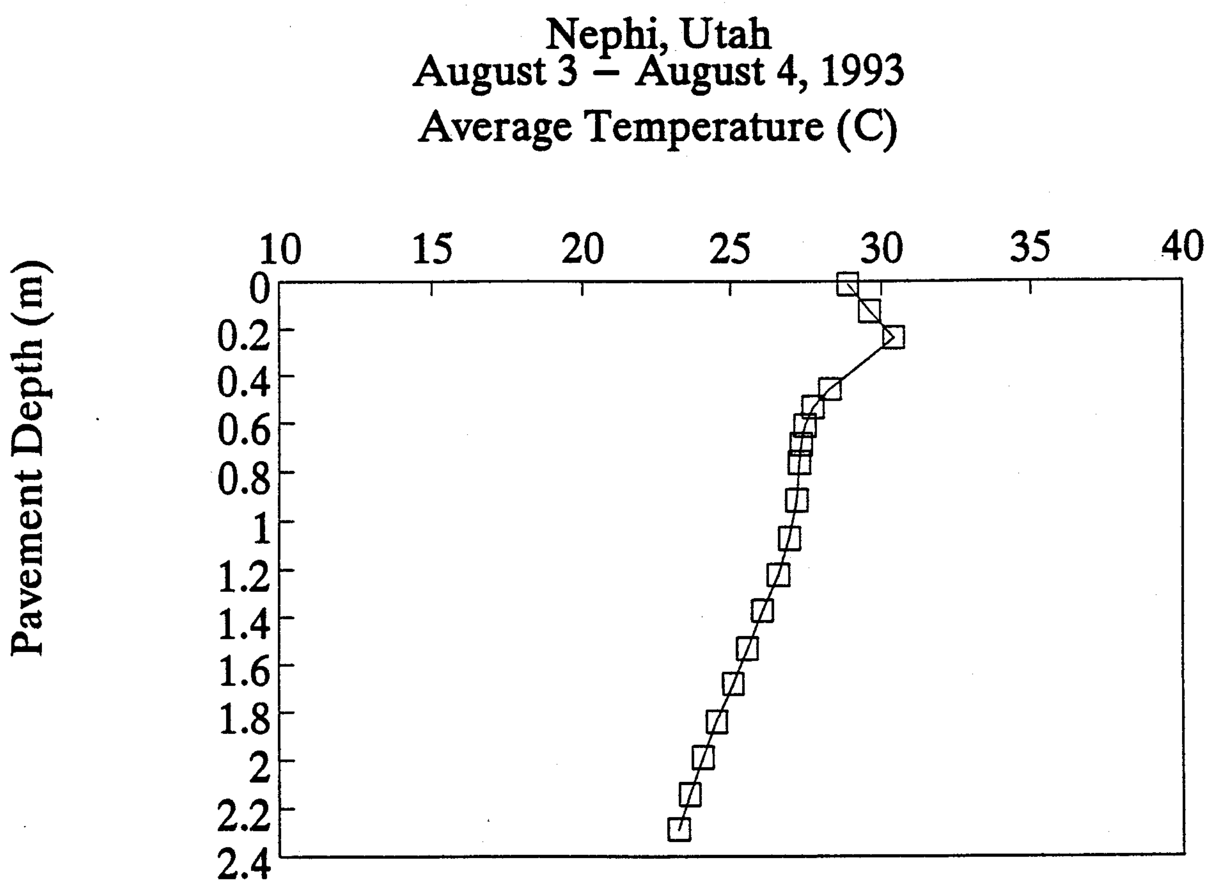


Figure D-3. Measured average subsurface temperature for all 18 sensors during initial data collection.

Nephi, UT

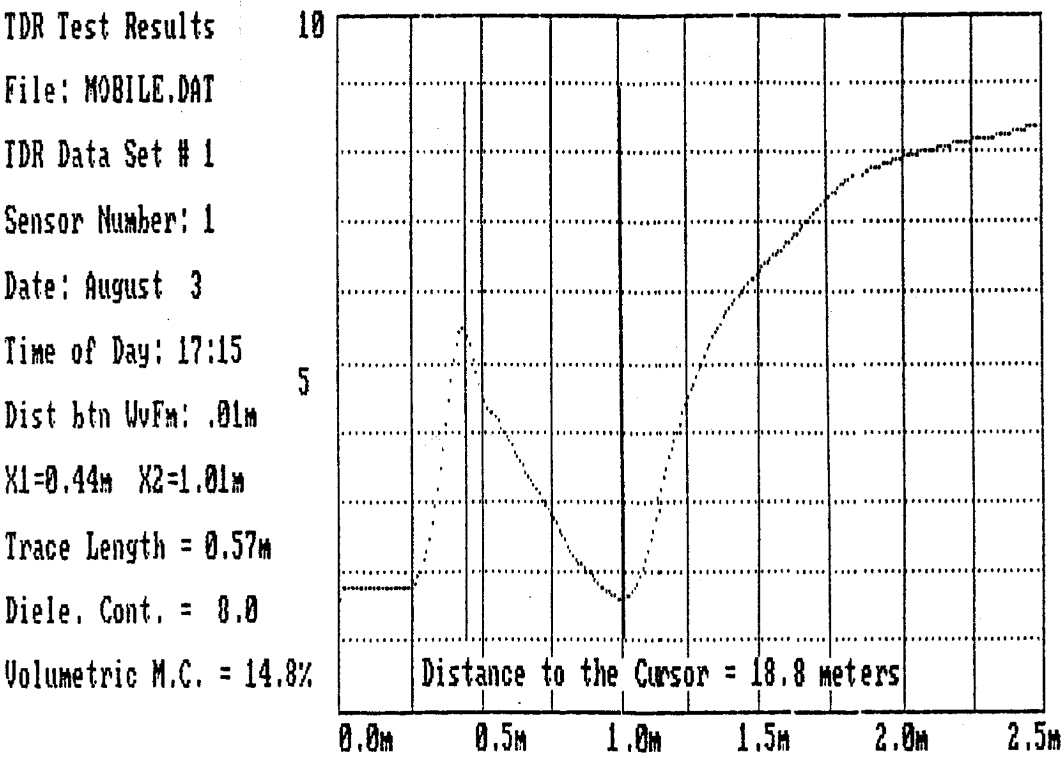


Figure D-4. Trace from TDR sensor 1.

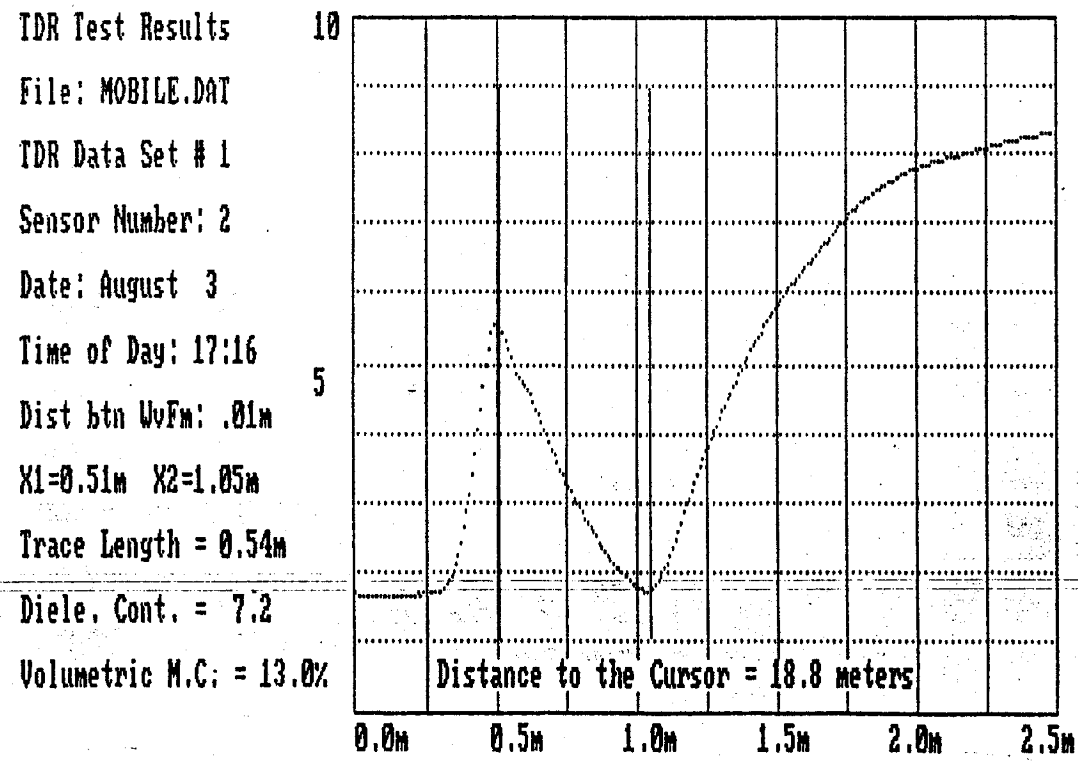


Figure D-5. Trace from TDR sensor 2.

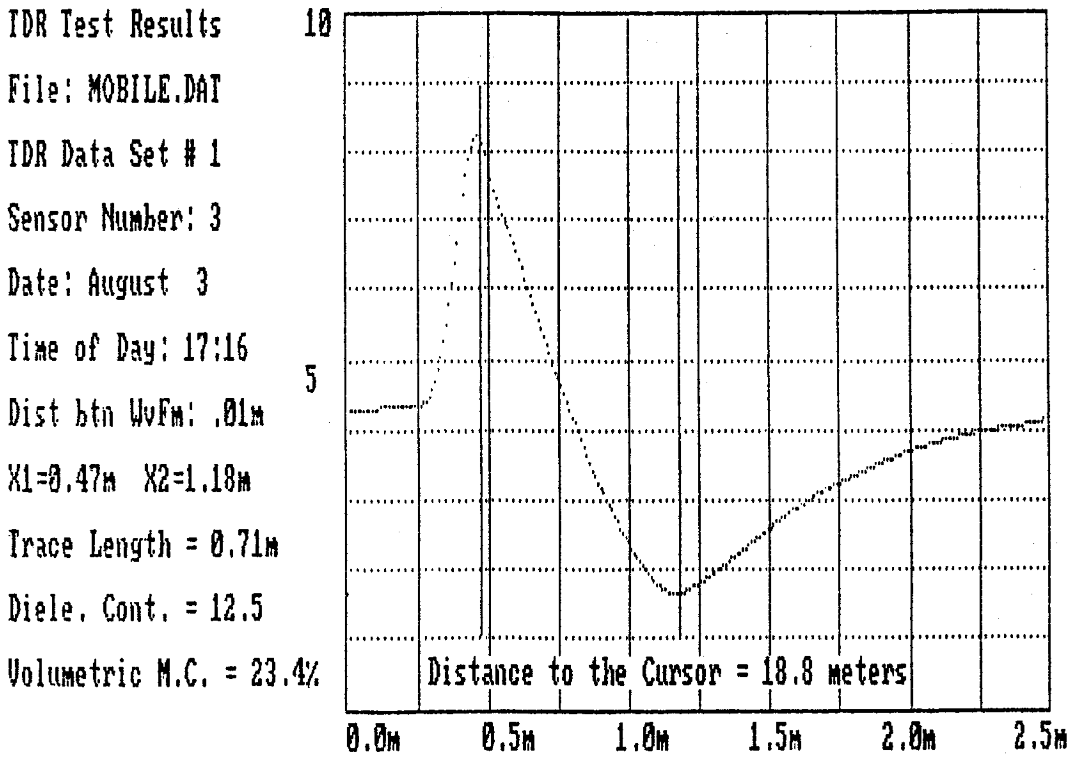


Figure D-6. Trace from TDR sensor 3.

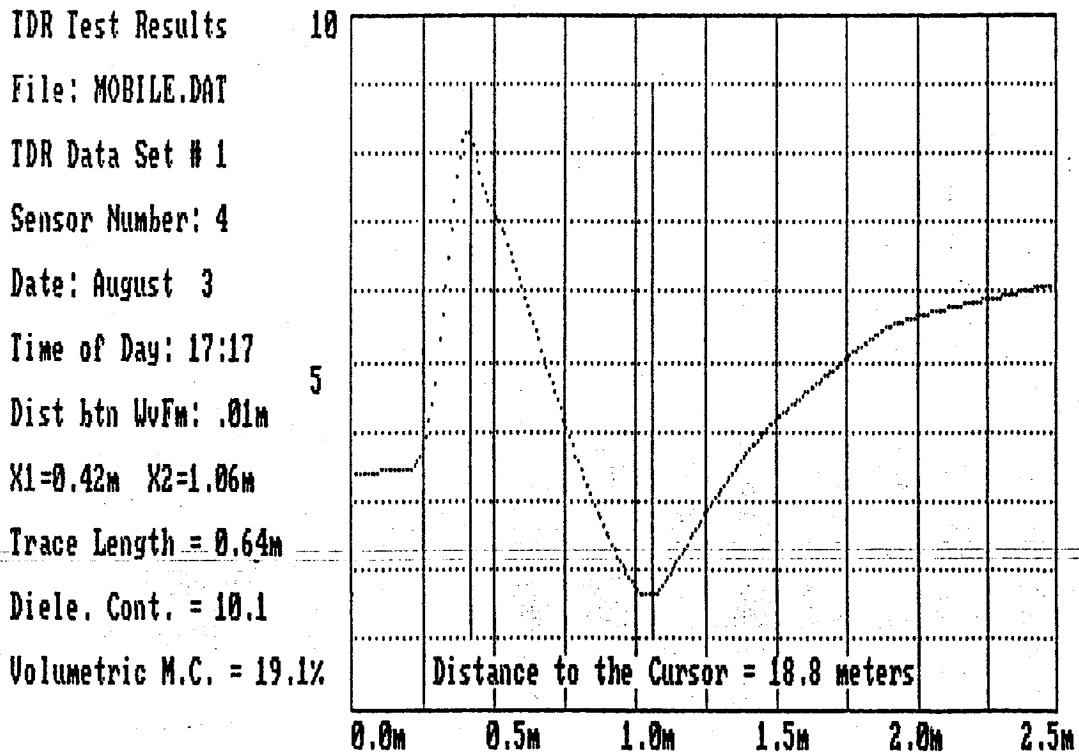


Figure D-7. Trace from TDR sensor 4.

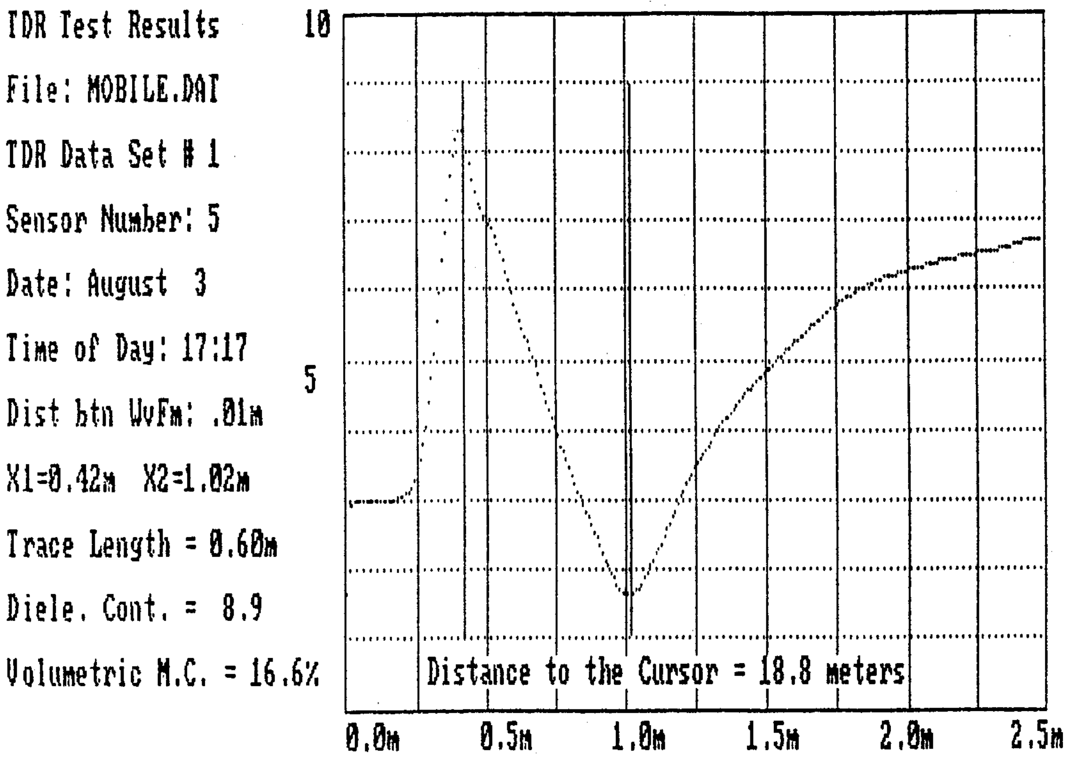


Figure D-8. Trace from TDR sensor 5.

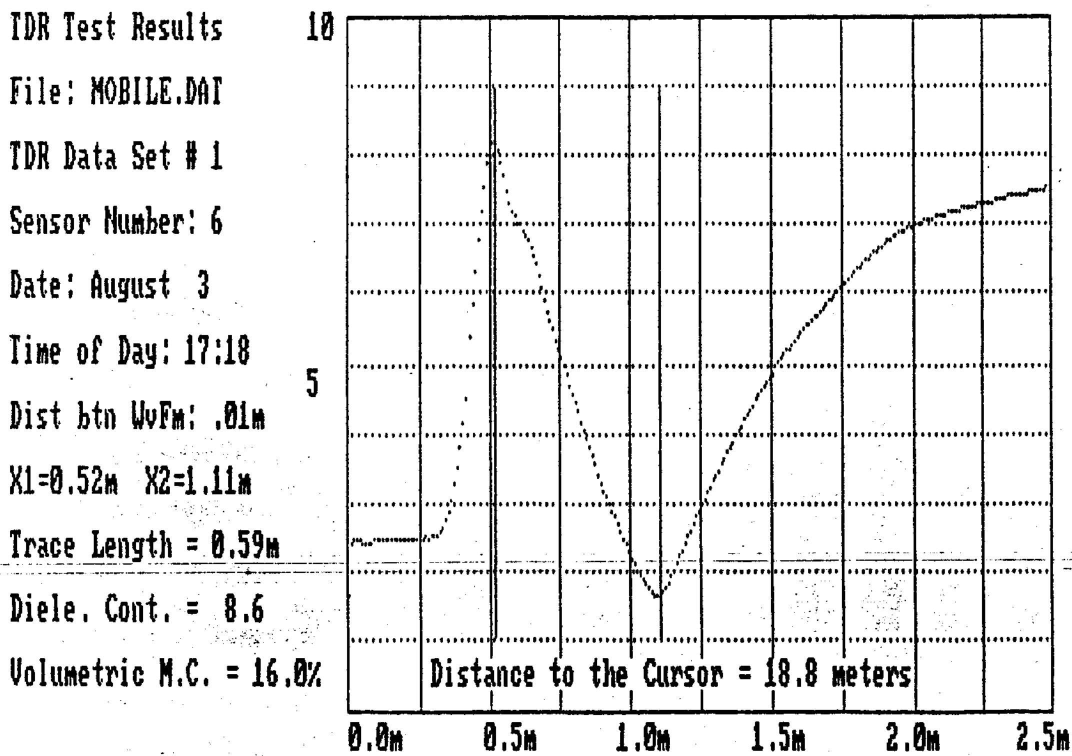


Figure D-9. Trace from TDR sensor 6.

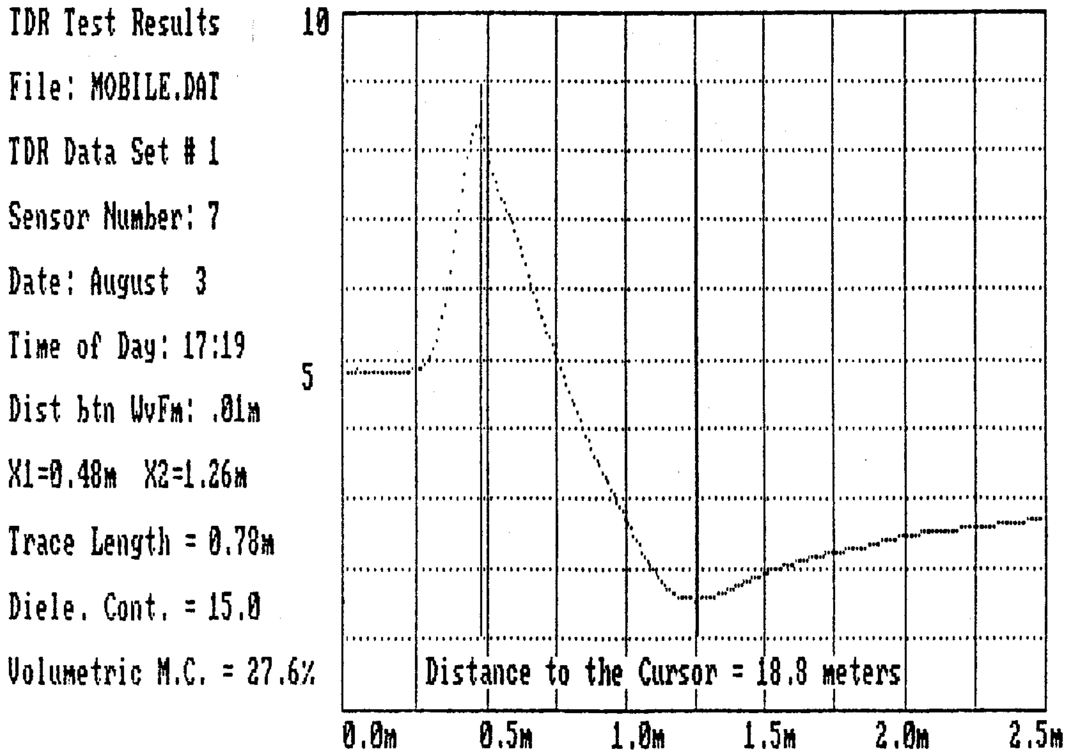


Figure D-10. Trace from TDR sensor 7.

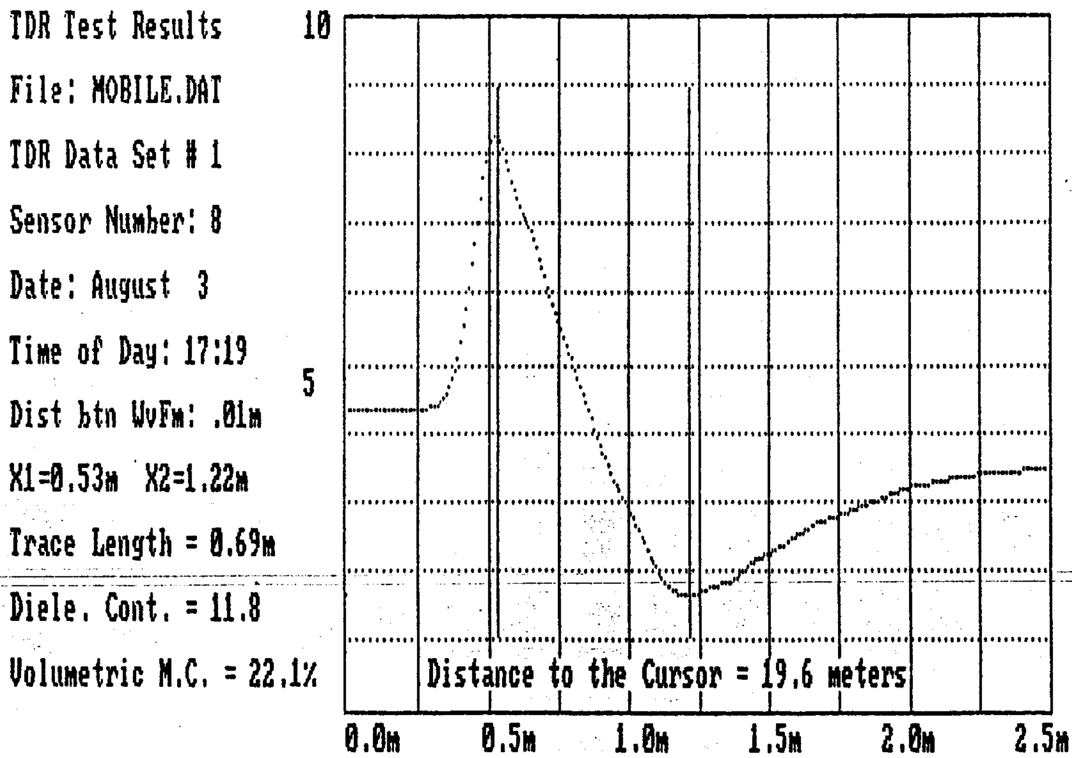


Figure D-11. Trace from TDR sensor 8.

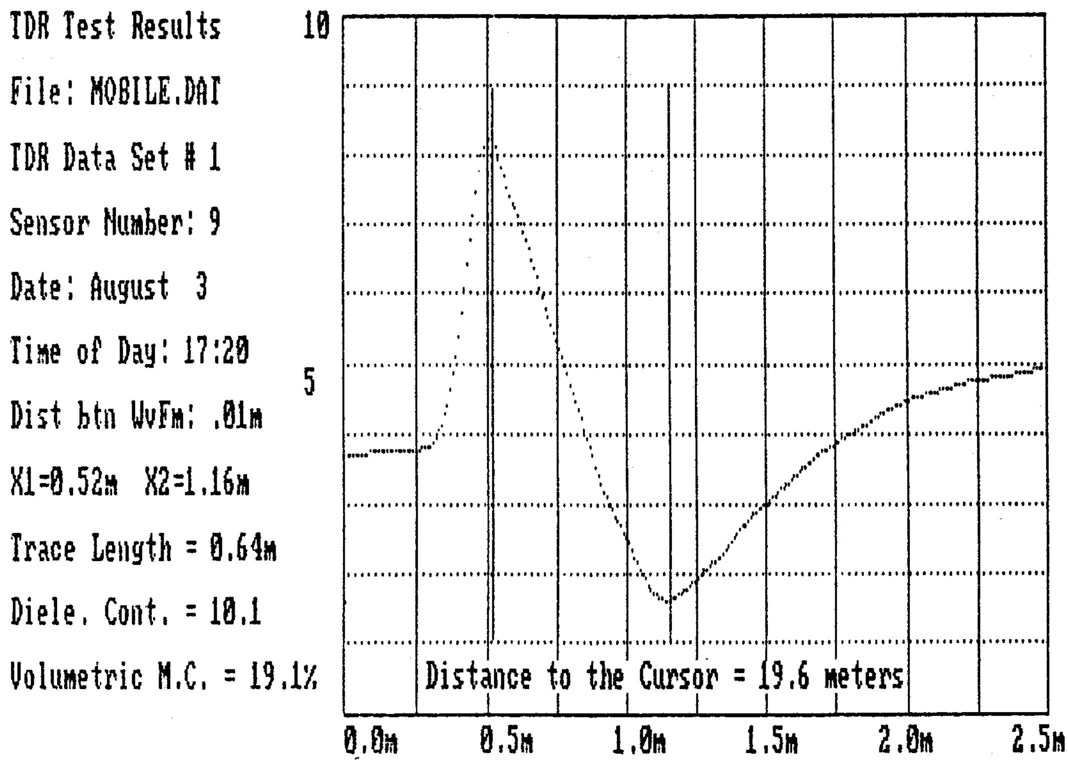


Figure D-12. Trace from TDR sensor 9.

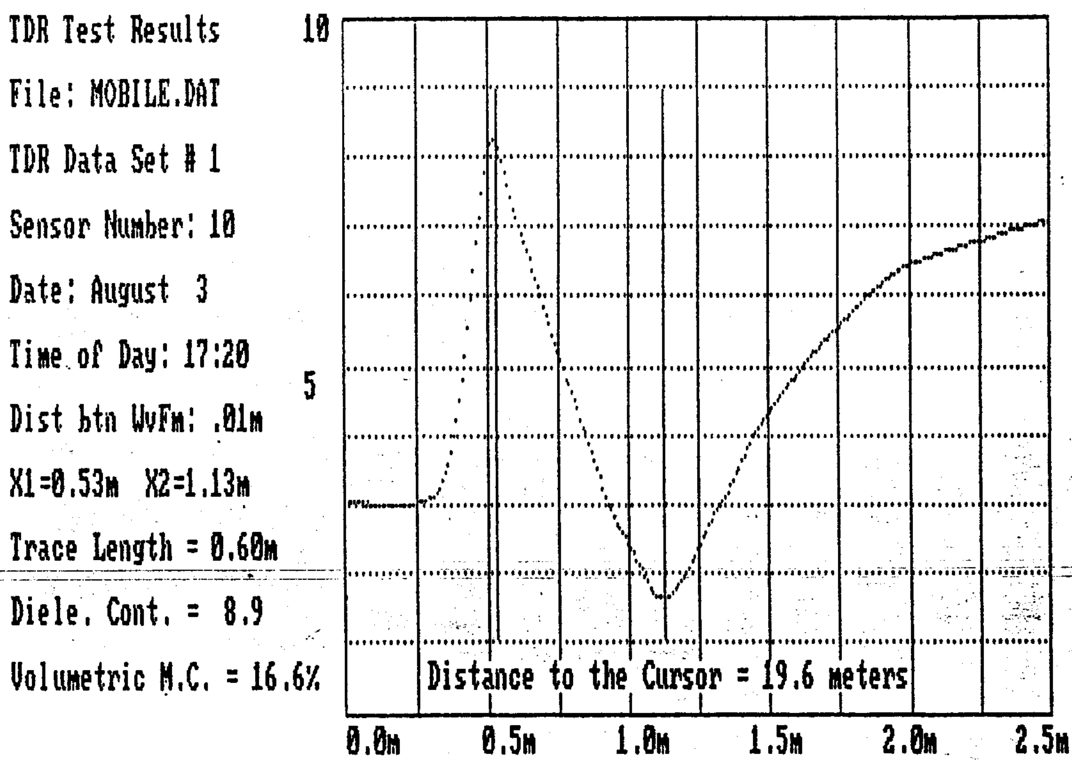


Figure D-13. Trace from TDR sensor 10.

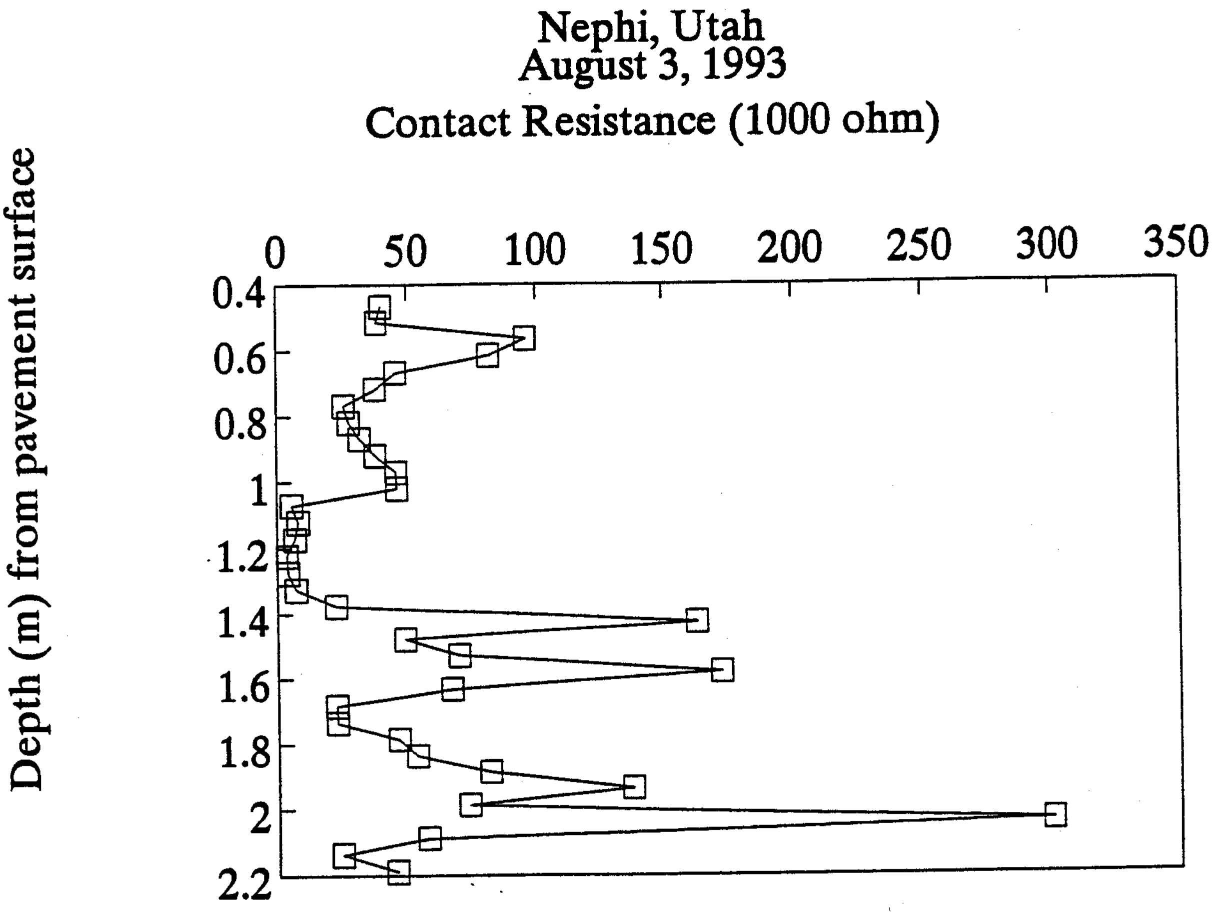


Figure D-14. Manually collected contact resistance.

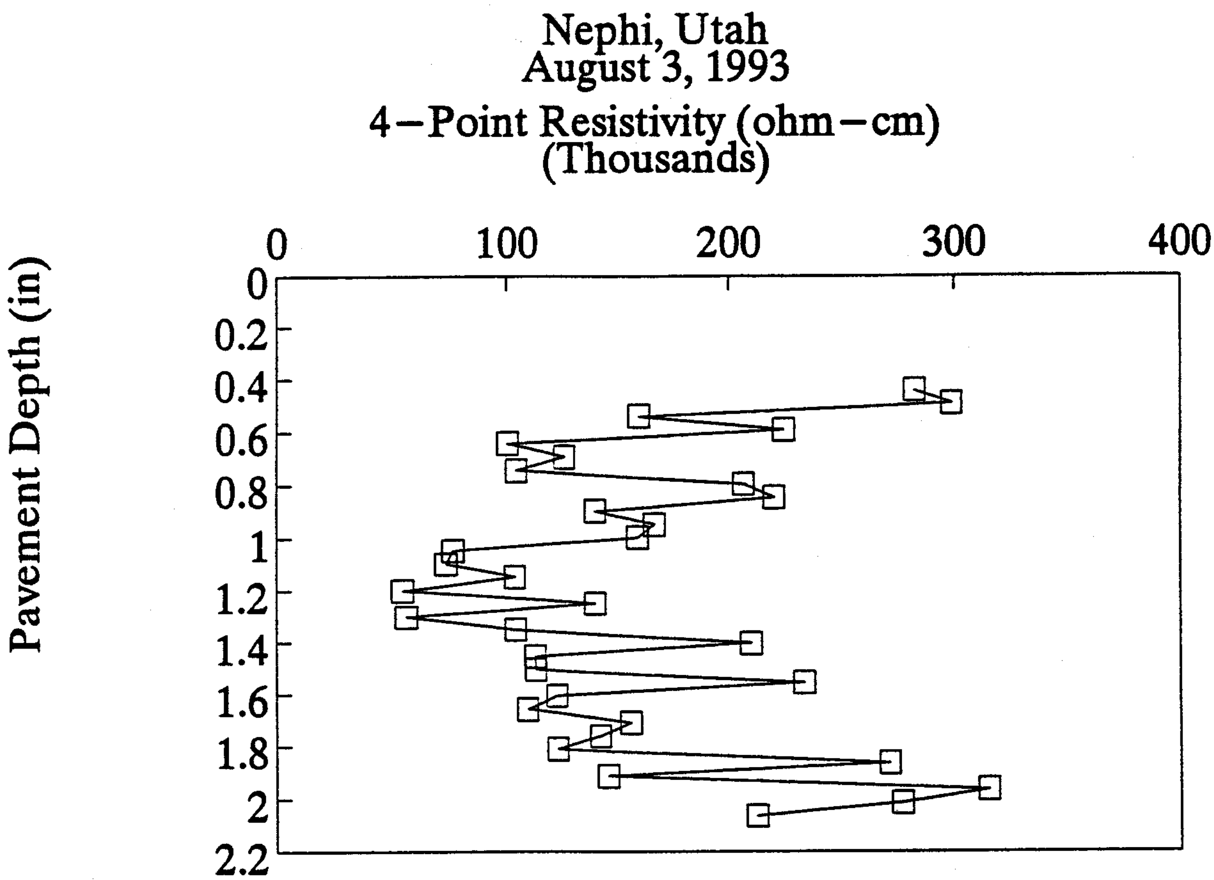


Figure D-15. Manually collected 4-point resistivity.

Table D-2. Contact resistance measurement data sheet.

SEASONAL INSTRUMENTATION DATA COLLECTION SHEET

Resistant Measurements

Site No: 493011 Sheet 1 of ___

Collected by: HZ Time Collected: 1725-1738 Date: 8/3/93

Weather Conditions: clear FWD Run? yes

NO GENDER CHANGER USED – USE OUTLINE NUMBERS

Connections	Voltage		Current		Comments
I_1, V_1	Range Setting	Reading	Range Setting	Reading	
1, 2	20 V	7.04	200 µA	176.0	
2, 3	20 V	7.03	200 µA	183.7	
3, 4	20 V	7.95	200 µA	82.8	
4, 5	20 V	7.94	200 µA	97.2	
5, 6	20 V	5.56	200 µA	122.0	
6, 7	20 V	5.54	200 µA	147.1	
7, 8	20 V	4.59	200 µA	180.3	
8, 9	20 V	4.60	200 µA	167.4	
9, 10	20 V	5.21	200 µA	165.0	
10, 11	20 V	5.23	200 µA	138.9	
11, 12	20 V	6.18	200 µA	135.3	
12, 13	20 V	6.18	200 µA	135.0	
13, 14	20 V	3.62	2 mA	0.637	
14, 15	20 V	3.66	2 mA	0.457	
15, 16	20 V	2.78	2 mA	0.403	
16, 17	20 V	2.75	2 mA	0.723	
17, 18	20 V	3.17	2 mA	0.768	
18, 19	20 V	3.22	2 mA	0.444	
19, 20	20 V	7.17	2 mA	0.324	
20, 21	20 V	7.16	200 µA	44.0	
21, 22	20 V	4.39	200 µA	90.0	
22, 23	20 V	4.41	200 µA	63.5	
23, 24	20 V	6.32	200 µA	36.7	
24, 25	20 V	6.27	200 µA	94.0	
25, 26	20 V	3.60	200 µA	162.0	
26, 27	20 V	3.61	200 µA	161.3	
27, 28	20 V	5.87	200 µA	127.2	
28, 29	20 V	5.88	200 µA	110.8	
29, 30	20 V	7.35	200 µA	90.3	
30, 31	20 V	7.36	200 µA	53.5	
31, 32	20 V	7.14	200 µA	97.5	
32, 33	20 V	7.10	200 µA	23.6	
33, 34	20 V	4.27	200 µA	74.7	
34, 35	20 V	4.20	200 µA	174.8	
35, 36	20 V	5.10	200 µA	112.8	
1000 kΩ	20 V	10.45	200 µA	15.3	NC
1 kΩ	20 V	6.45	20 mA	6.47	NC
1 Ω	200 mV	17.9	20 mA	16.43	HOT

Table D-3. Four point resistivity measurement data sheet.

SEASONAL INSTRUMENTATION DATA COLLECTION SHEET

Resistivity Measurements

Site No: 493011 Sheet 1 of ____

Collected by: HZ / RV Time Collected: 1740 - 1758 Date: 8/3/93

Weather Conditions: Sunny to Partly Cloudy and Warm FWD Run? YES

NO GENDER CHANGER - AND USING OUTLINE NUMBERS ON WHITE BOARD

Read No.	Connections				Voltage		Current		Comments
	I_1	V_1	V_2	I_2	Range Set	Reading	Range Set	Reading	
1	1	2	3	4	200mV	97.4	200µA	21.9	
2	2	3	4	5		192.8		40.7	
3	3	4	5	6		108.9		42.5	
4	4	5	6	7		127.2		37.8	
5	5	6	7	8		90.2		55.3	
6	6	7	8	9		122.1		63.4	
7	7	8	9	10		116.2		70.2	
8	8	9	10	11		144.8		44.9	
9	9	10	11	12		177.0		50.8	
10	10	11	12	13		143.5		65.1	
11	11	12	13	14		141.3		53.9	
12	12	13	14	15		128.0		49.9	
13	13	14	15	16		106.3		90.2	
14	14	15	16	17		103.0		86.5	
15	15	16	17	18		116.8		75.0	
16	16*	17/15	18/2	19/1		74.6		82.3	
17	17	18	19	20		89.1		42.7	
18	18	19	20	21		42.7		46.5	
19	19	20	21	22		104.8		64.4	
20	20	21	22	23		51.2		15.8	
21	21	22	23	24		51.9		29.0	
22	22	23	24	25		104.5		59.0	
23	23	24	25	26		111.5		31.1	
24	24	25	26	27		95.6		49.3	
25	25	26	27	28		74.3		43.4	
26	26	27	28	29		124.2		51.3	
27	27	28	29	30		97.3		43.0	
28	28	29	30	31		70.5		36.1	
29	29	30	31	32		~~[illegible]~~ 128.4		30.7	
30	30	31	32	33		22.7		9.8	
31	31	32	33	34	2V	0.231		45.6	
32	32	33	34	35	200mV	133.1		31.5	
33	33	34	35	36		64.4		18.6	
100kΩ					20V	10.28	200µA	15.1	
1kΩ					20V	6.30	20mA	6.34	
1Ω					200mV	17.6	20mA	16.12	

* ~~Alternate reading configuration for Idaho section (163023).~~

Table D-4. Surface elevation measurement data sheet.

LTPP Seasonal Monitoring Study Surface Elevation Measurements	* State Code [49] * Test Section Number [3011]

Surveyed : Jason M. Dietz
Date : 8/3/93
Start Time : 2:30 PM
Finish Time : 4:00 PM
Surface Type : Portland Cement Concrete
Weather Conditions : Clear 32.2°C
Unusual Conditions : None

Beginning Elevation of Frost Free Bench Mark : 1.000 meters
Ending Elevation of Frost Free Bench Mark : 1.000 meters

STATION	OWP 0.305 m	ML 1.829 m	IWP 3.353 m
End of Slab 0	1.206	1.235	1.265
Beginning of Slab 1	1.202	1.231	1.265
End of Slab 1	1.185	1.212	1.249
Beginning of Slab 2	1.183	1.207	1.242
End of Slab 2	1.159	1.188	1.222
Beginning of Slab 3	1.156	1.187	1.219
End of Slab 3	1.134	1.163	1.193
Beginning of Slab 4	1.132	1.160	1.190
End of Slab 4	1.106	1.133	1.164
Beginning of Slab 5	1.102	1.132	1.160

OWP : Outer Wheel Path
ML : Mid Lane
IWP : Inner Wheel Path

→ Eastbound Direction. I 15 South of Nephi, UT

0+00 1+00 5+00

(Bench Mark)
Observation Well

Table D-5. Joint opening measurement data sheet.

SEASONAL JOINT WIDTH MEASUREMENTS

DATE: 3/3/93

473011

SHRP #: 495193

	TIME	#1	#2	#3
STATION #1	5:50pm	4595	460	4585
STATION #2	5:57pm	4595	458	460
STATION #3	6:00pm	459	458	457
STATION #4	6:06pm	460	460	463
STATION #5	6:10	459	459	460
STATION #6				
STATION #7				

COMMENTS:

OPERATOR:

APPENDIX E

Photographs

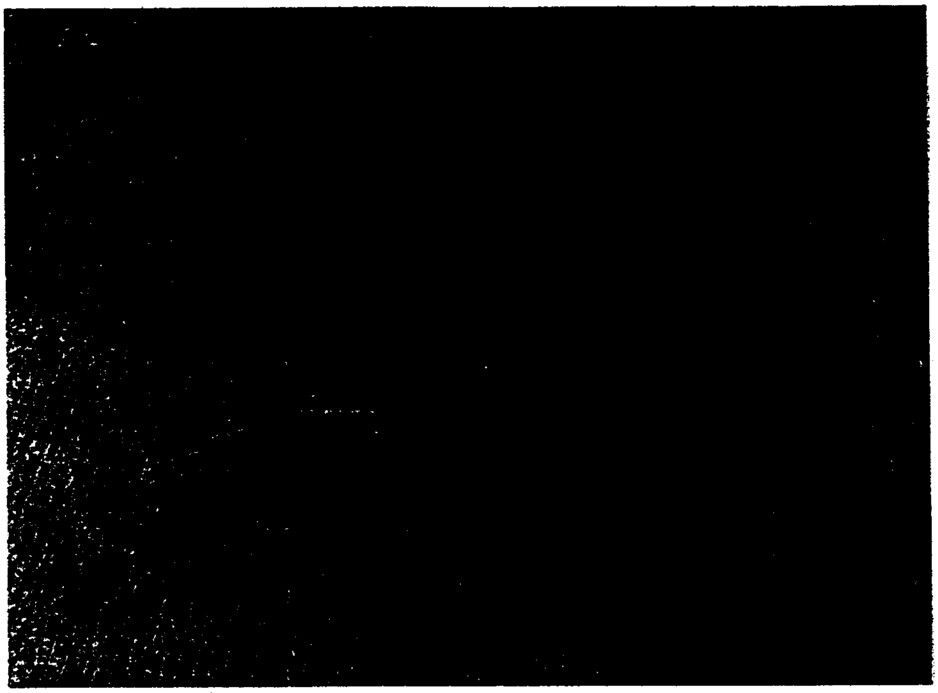


Figure E-1. Snap ring installation jig designed by Bob VanSambeek.

Figure E-2. Positioning of in-pavement instrumentation

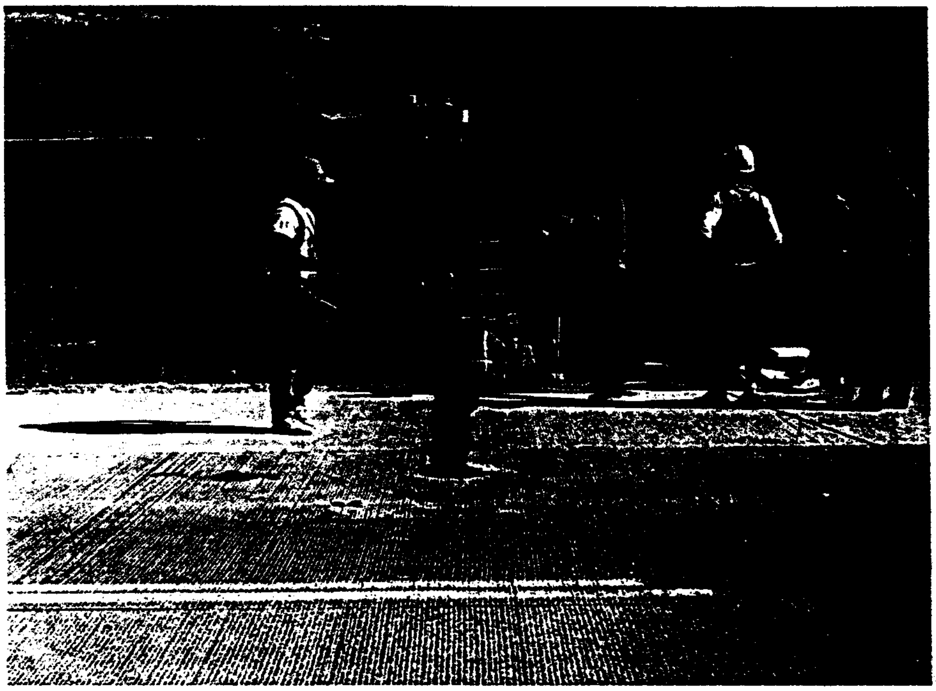


Figure E-3. Completed instrumentation hole and cabinet at the end of day 2.

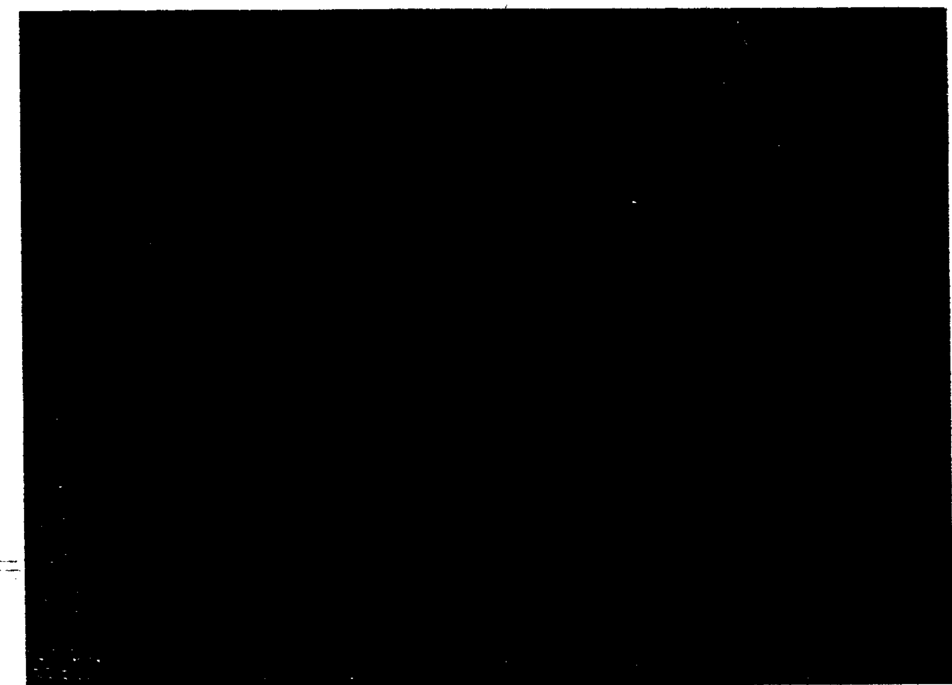


Figure E-4. Condition of pavement repair the next day.