

Florida SR-66 Sinkhole Monitoring
April 2005 Field Trip Report

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Overview

In early 2001, a sinkhole formed directly under State Road 66 near the city of Sebring in Highlands County, Florida. The Florida DOT built a land bridge over the sinkhole and the road was reopened to traffic. Since SR-66 is an important regional trucking route, it was decided that the site should be closely monitored for any future sinkhole growth. The geotechnical consulting firm GeoTDR, Inc. installed time-domain reflectometry (TDR) cables and biaxial tiltmeters at strategic locations.

The instruments and communication equipment are powered by a solar panel and deep-cycle battery. The communication link is powered on for only a brief window each day in order to save power. Since there is no telephone service at the site and cellular coverage is spotty, ITI engineers built a radio link system to connect the site to a modem on the nearest telephone pole, slightly over half a mile away.

Two events lead to the April 2005 site visit. First, in March 2005, FDOT personnel monitoring the instruments via the Civil Data Systems web site noticed that one of the TDR cables appeared to have been sheared. In addition, a site visit revealed that several washouts had formed along the sides of the land bridge. Second, later in March, communication with the site was lost. A site visit by FDOT personnel revealed that the solar panel powering the instrument box had been sawn off its pole and stolen. ITI engineers decided to travel to the site to replace the solar panel and perform other maintenance tasks.

Objectives

The objectives for the site visit were as follows:

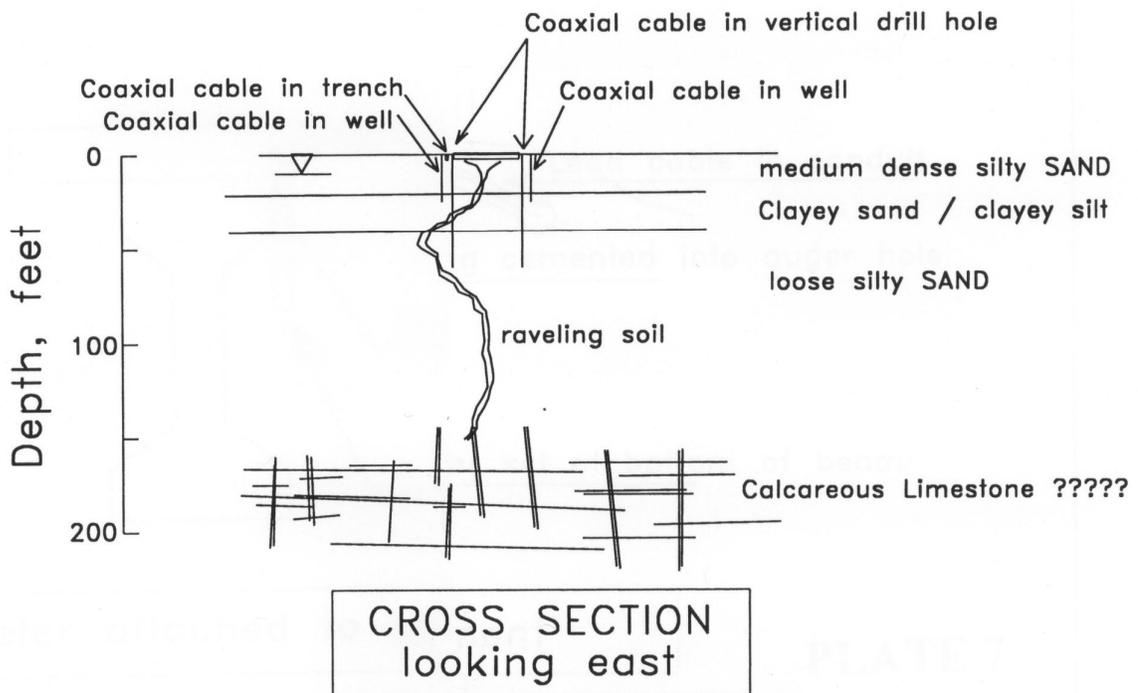
- Replace the stolen solar panel
- Install the replacement panel on a high mast to prevent further theft
- Move radio antenna to new high mast
- Install a solar-powered exhaust fan on the junction box to extend battery life by reducing temperature inside the box
- Document the extent of the washouts on the sides of the land bridge and attempt to determine where the water is flowing

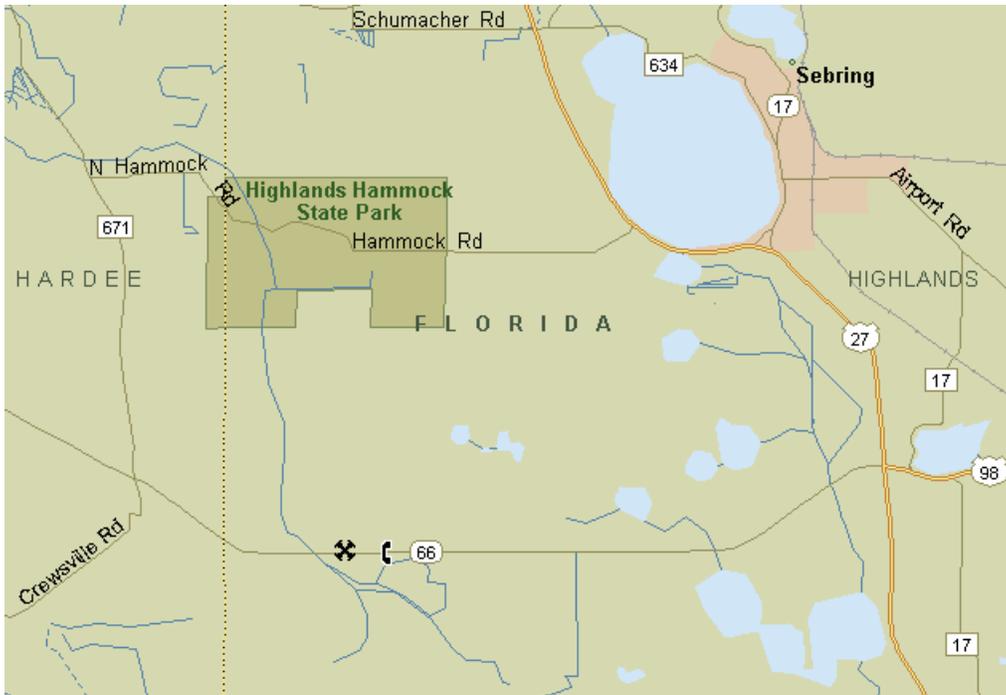
Location

The sinkhole is located at:
27.41215° N, 81.53714° W (NAD27)
7.6 miles west of US-27
Sebring, Florida

The Sebring site is in an area of central Florida where the depth to bedrock is over 200 feet. The bulk of the subsoil is poorly-graded sand and silt. These conditions are not usually conducive to sinkhole development; sinkholes typically form where bedrock is much shallower.

The prevailing belief is that the sinkhole is a deep, narrow “chimney-type” feature, as show in this drawing from the GeoTDR report.





- ✖ Sinkhole is 7.6 miles west of US-27
- ☎ Telephone box is 0.57 miles east of the sinkhole

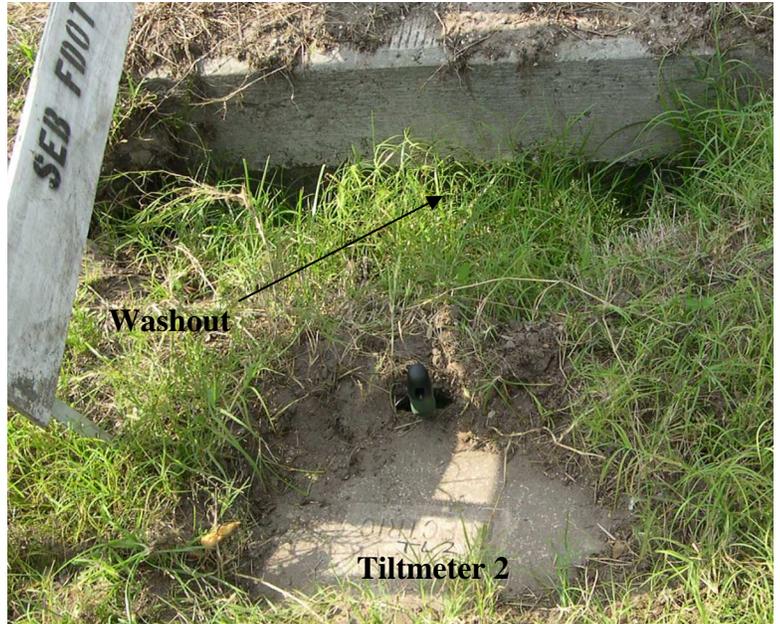


Site Conditions upon Arrival

Washouts

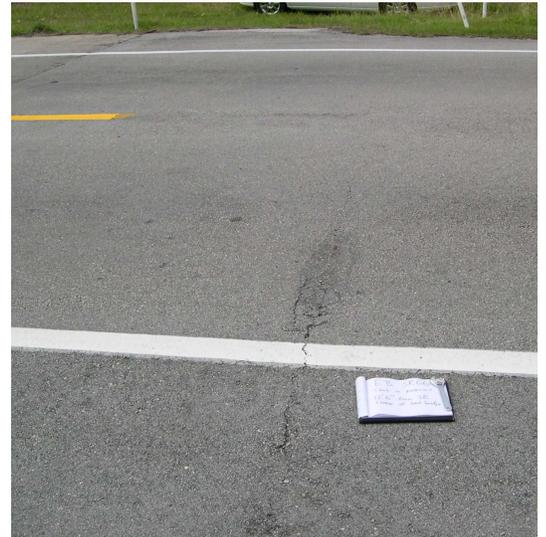
We found two washouts on the south side of the land bridge. The east washout is the larger of the two and extends at least 12” below the bottom of the land bridge girder. The west washout extends at least 4” below the bottom of the land bridge girder and lies between the land bridge girder and tiltmeter 2.

Examination of the washouts with a probe suggests that the washouts drain water from the land bridge deck down into the sinkhole. It does not appear that any kind of intermittent stream flows under the bridge through the washouts as was feared. Rather, water appears to drain straight down into the sinkhole. This is consistent with the hypothesis that the sinkhole is of a deep, narrow “chimney” type.



TDR

FDOT personnel pointed out that the road had been resurfaced recently, and that the resurfacing crew had been advised of the conduit crossing the road. However, we found a crack in the pavement suggesting that the conduit had been nicked or crushed during resurfacing. The location of the crack is consistent with the location of the kink in the TDR waveform.



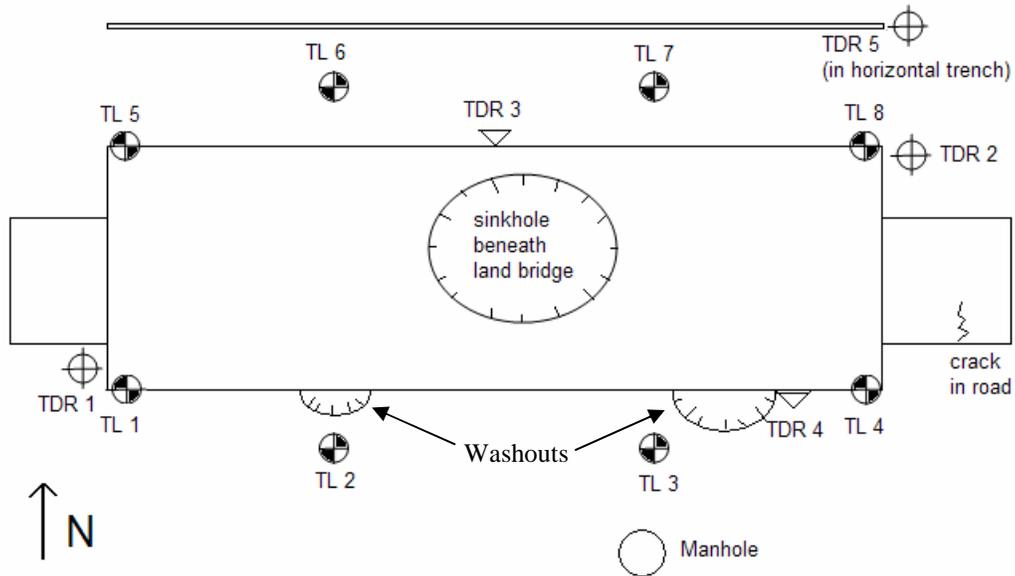
Tiltmeters

We extracted the tiltmeters that were suspected to be failed from their wells and tested them. Soil tiltmeters 2, 3, and 7 were found to be completely inoperative.

Inside the Instrumentation Box

The deep-cycle battery inside the box was completely drained and would not take a charge. We also found several broken wire connections on the TDR box.

Site Conditions, continued



Drawing not to scale. Distances are as follows:

- 32' from SW corner of land bridge to west washout
- 25' from SE corner of land bridge to east washout
- 12' 6" from SE corner of land bridge to crack in road

As noted above, several sensors appear to have been damaged. Tiltmeters classified as “completely inoperative” showed no change in reading even when we extracted them from their casings and tested them with a voltmeter on the surface.

Sensor	Status
Bridge Tilt 1	
Soil Tilt 2	Completely inoperative
Soil Tilt 3	Completely inoperative
Bridge Tilt 4	
Bridge Tilt 5	
Soil Tilt 6	Apparently OK
Soil Tilt 7	Completely inoperative
Bridge Tilt 8	
Vertical TDR 1	Damaged/kinked in conduit
Vertical TDR 2	OK
Water TDR 3	OK
Water TDR 4	OK
Horiz. TDR 5	OK

Upgrades

An FDOT crew installed a 30-foot mast on the site and secured the replacement solar panel at the top. We moved the radio antenna to the new mast as well. We also made some changes to improve battery life. We replaced the deep-cycle battery in the instrumentation box with a spiral cell car battery which promises better performance in high temperatures. Furthermore, we installed a solar-powered exhaust fan on the instrumentation box in an effort to reduce the temperature during intense sunlight.



Solar panel stolen from pole



New exhaust fan on junction box



Installation of new solar panel on 30' mast



Antenna on new mast

Recommendations

Currently, the following instruments are functional and reporting good data:

- Vertical TDR 2
- Water Table TDR 3
- Water Table TDR 4
- Horizontal TDR5 (in trench)
- Soil Tiltmeter 6
- Bridge Tiltmeter 8

If FDOT wishes to restore this site to full working order, the inoperative tiltmeters will need to be replaced. In addition, a crew will need to replace the conduit and TDR cables under the road that were damaged during repaving.

We recommend installing a second solar panel on the site. Remote monitoring of the battery voltage showed a steep decline in the five days after our visit, suggesting that the single replacement solar panel is not sufficient to charge the battery.

We highly recommend that FDOT send an engineer in the manhole to inspect under the bridge, especially given the formation of washouts on the shoulders of the land bridge.

Finally, we found that the lid on the junction box for TDR 3 is broken and needs to be replaced.

Appendices

Photographs

On-site Tiltmeter Data

Pre-Trip Remote Tiltmeter Data

“Last Known Good” Remote TDR Waveforms

Remote TDR Waveforms with Repaving Damage

SR-66 Land Bridge, looking east (construction barricades mark washouts)



Installation of new high mast for solar panel and radio antenna



Soil Tiltmeter 3 in slotted inclinometer casing



Soil Tiltmeter 3 removed from its slotted inclinometer casing



On-Site Tiltmeter Data

The following data were read with a voltmeter directly from the tiltmeter junction panel on April 21, 2005. Readings that suggest damaged or dead instruments are in **boldface**.

	TL#	X (mV)	X (° tilt)	Y (mV)	Y (° tilt)	Temp (mV)	Temp (°C)
Bridge	1	-2331	-9.7902	1841	7.7322	338	33.8
Soil	2*	222	0.9324	260	1.092	254	25.4
Soil	3	4270	17.934	1433	6.0186	260	26
Bridge	4	2435	10.227	1944	8.1648	291	29.1
Bridge	5	4410	18.522	4410	18.522	279	27.9
Soil	6	132	0.5544	113	0.4746	0	0
Soil	7	0	0	70	0.294	0	0
Bridge	8	579	2.4318	-970	-4.074	333	33.3

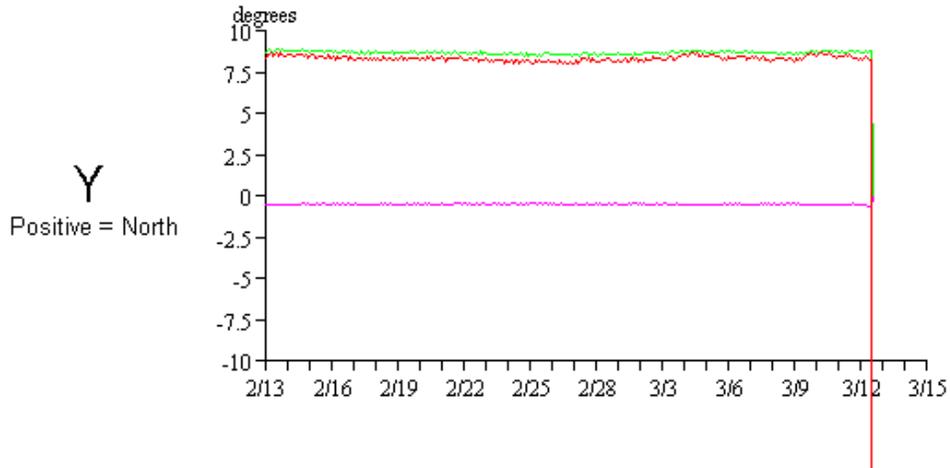
(*) We later determined that soil tiltmeter 2 was completely inoperative when we removed it from the well for more thorough testing.

Pre-Trip Remote Tiltmeter Data – Bridge Tiltmeters

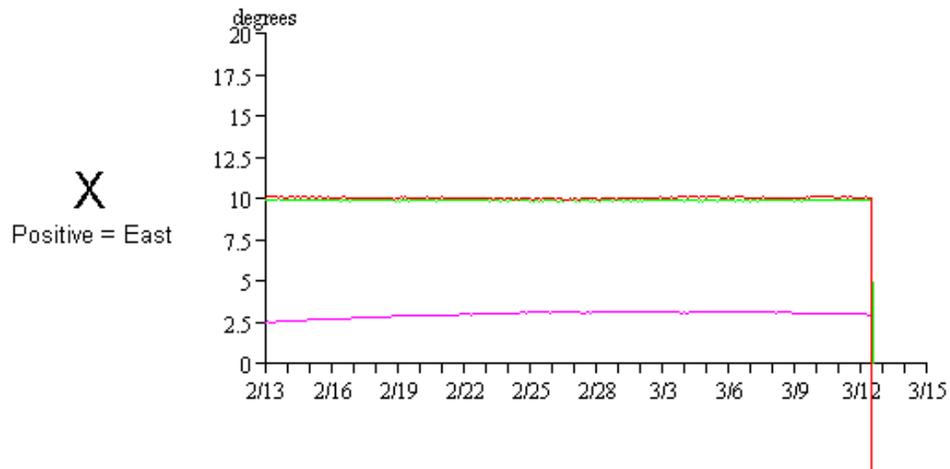
Bridge Tiltmeters

Feb 13, 2005 to Mar 15, 2005

North/South Bridge Tilt



East/West Bridge Tilt



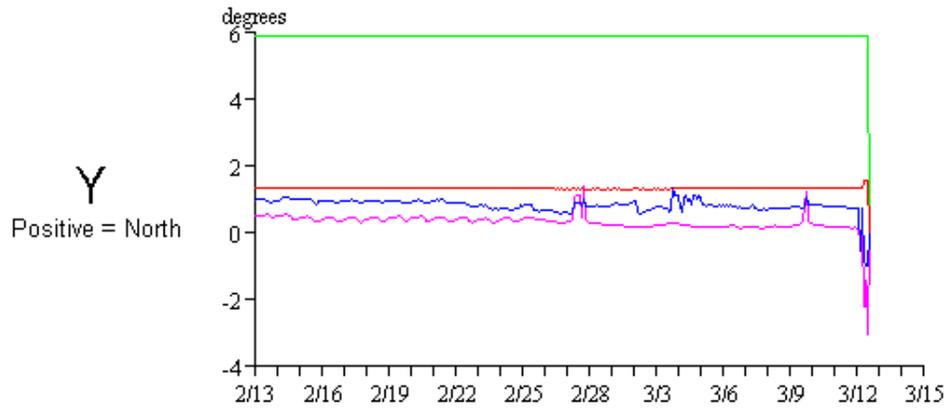
Legend	
TL-5	TL-8
TL-1	TL-4

Pre-Trip Remote Tiltmeter Data – Soil Tiltmeters

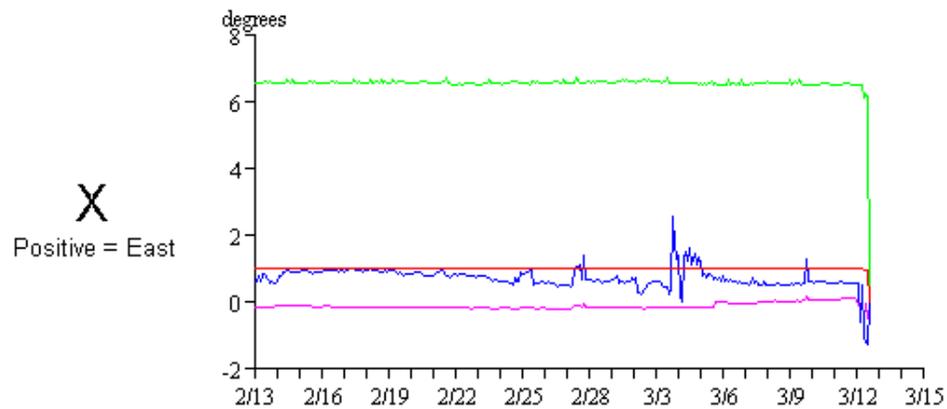
Soil Tiltmeters

Feb 13, 2005 to Mar 15, 2005

North/South Soil Tilt



East/West Soil Tilt

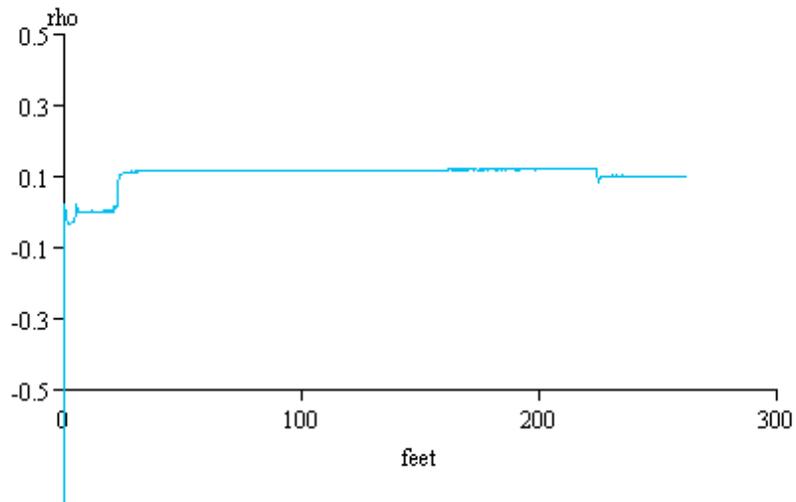


Legend	
TL-6	TL-7
TL-2	TL-3

“Last Known Good” Remote TDR Waveforms – Vertical TDR Cables

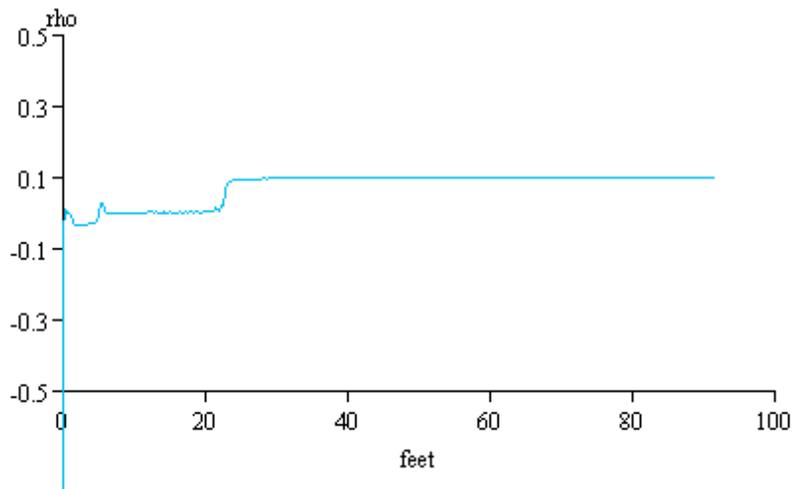
TDR 1

Aug 31, 2004 6:15



TDR 2

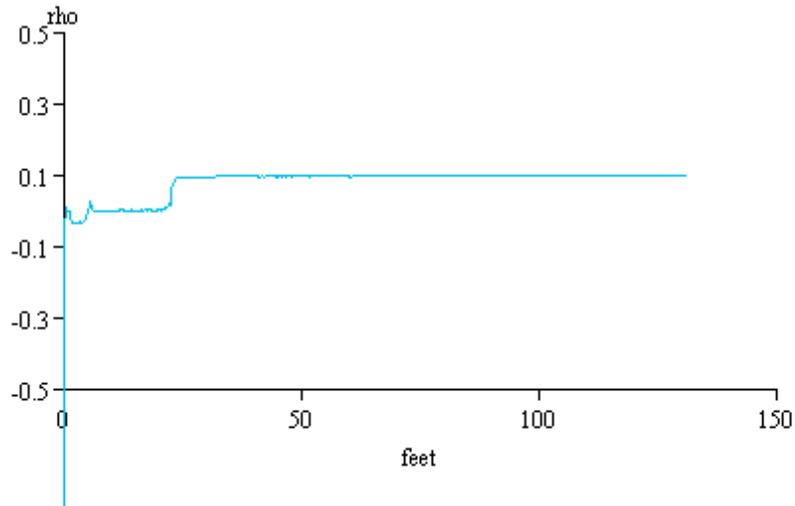
Mar 12, 2005 6:35



“Last Known Good” TDR Waveforms – Water Level TDR Cables

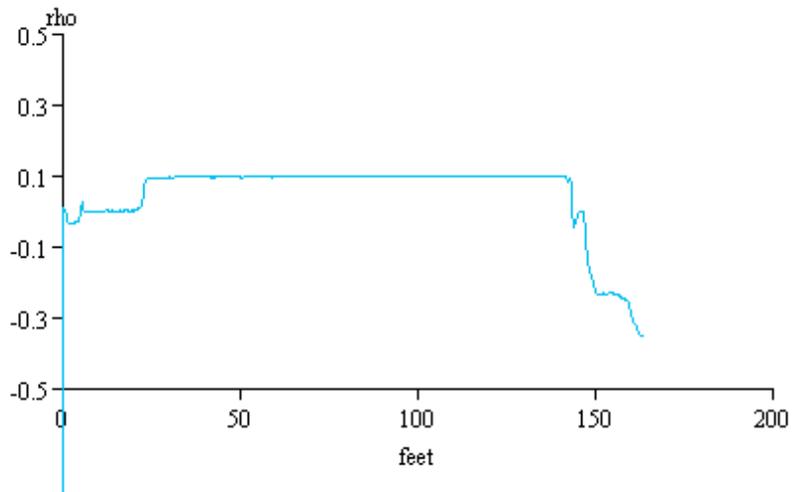
TDR 3

Mar 12, 2005 6:55



TDR 4

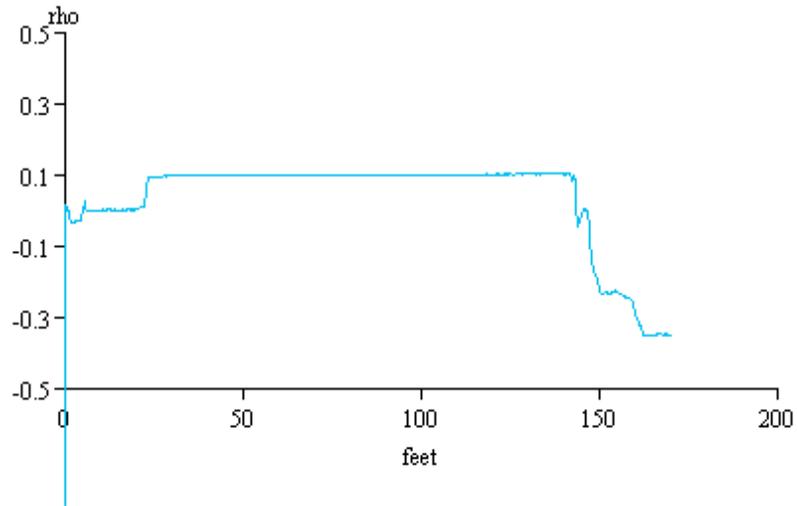
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“Last Known Good” TDR Waveforms – Horizontal TDR Cable

TDR 5

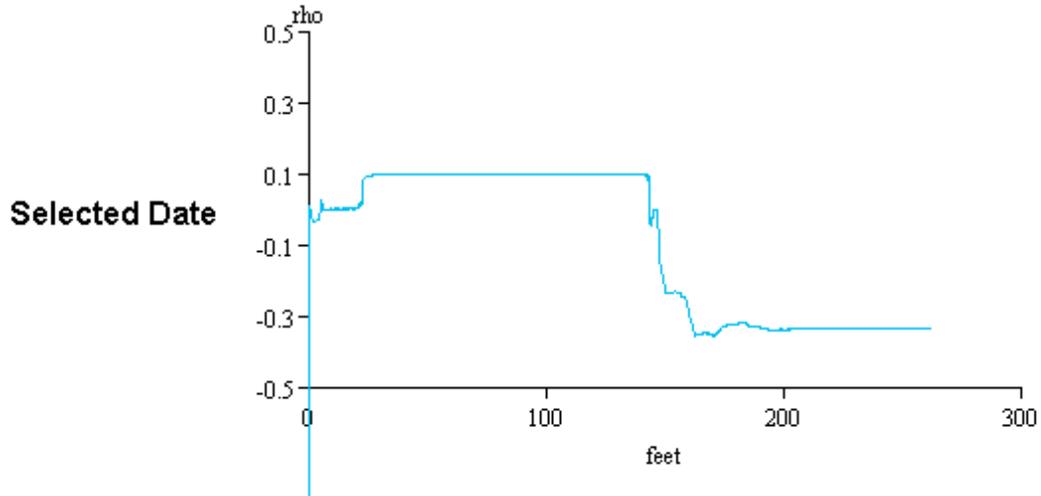
Mar 12, 2005 7:35



Remote TDR Waveforms with Repaving Damage

TDR 1

Mar 12, 2005 6:15



Nov 26, 2002 6:15

