

Embedded Data Collectors

The Virginia Experience

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Virginia Department of Transportation
Real Solutions Web Conference
July 25, 2013



Virginia's Highway System

Interstate – 1,118

Primary – 8,111

Secondary – 48,305

Frontage – 333

Total Mileage - 57,867

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Table 1a – Total Number of Structures (Bridges and Culverts)

DISTRICT	Number of Structures (Bridges and Culverts)				
	Interstate	Primary	Secondary	Urban	Total
Bristol	216	956	2,188	83	3,443
Salem	217	807	1,943	103	3,070
Lynchburg	0	665	1,394	59	2,118
Richmond	511	801	1,146	161	2,619
Hampton Roads	458	458	515	257	1,688
Fredericksburg	79	249	474	8	810
Culpeper	122	495	1,053	23	1,693
Staunton	429	827	2,140	100	3,496
NOVA	345	446	1,181	79	2,051
Grand Total	2,377	5,704	12,034	873	20,988

VDOT's Annual Budget

\$4.19 Billion

\$1.830 Billion – Road Maintenance

\$1.605 Billion – Construction

\$449.7 Million – Support to other agencies,
administration, tolls and other
programs

\$300 Million – Debt service

VDOT's Annual Budget

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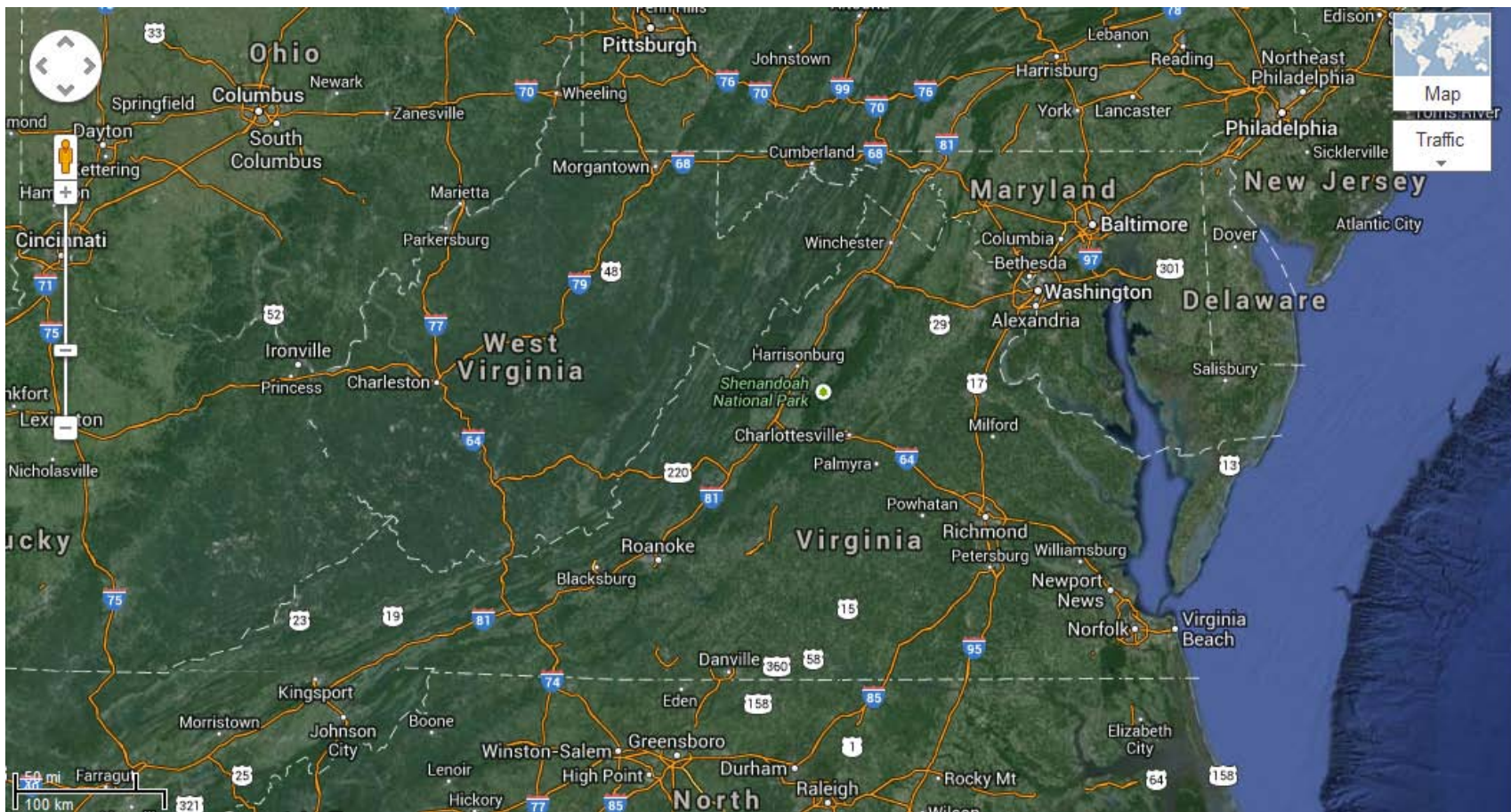
\$449.7 Million – Support to other agencies,
administration, tolls and other
programs

\$300 Million – Debt service

A new gas tax will significantly increase these numbers.

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VDOT's first project using
DYNAMIC PILE TESTING
was in the Summer 1984

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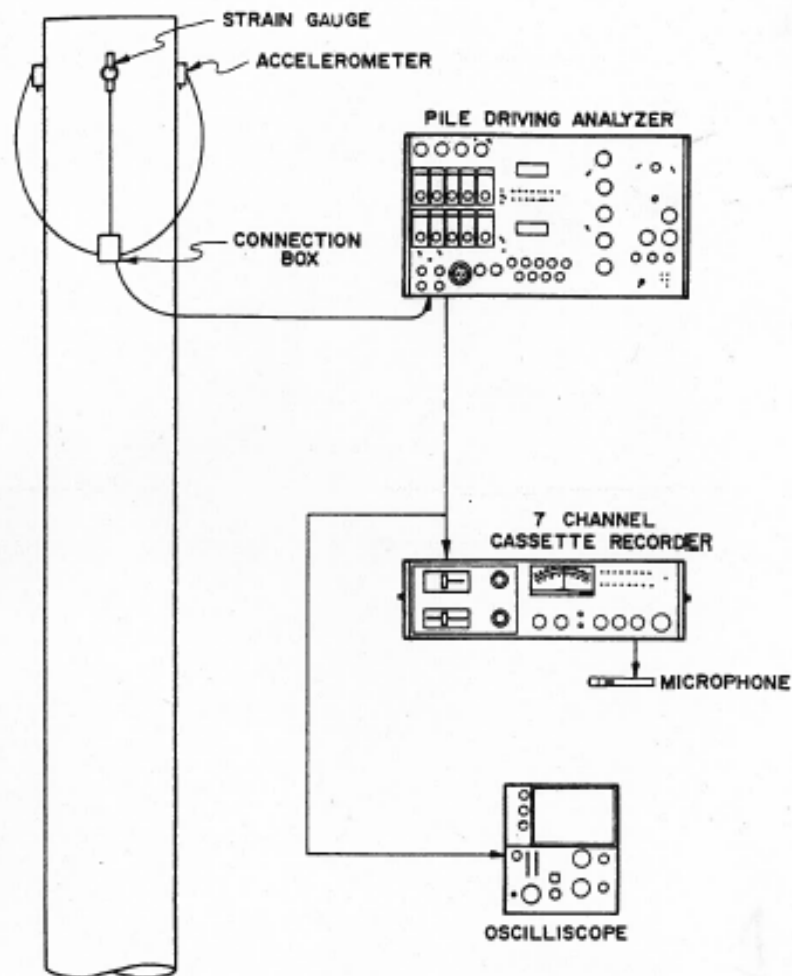


FIGURE 1. Pile Driving Analyzer Equipment Schematic

This is a sample image. Similar documentation will be posted to the TIG Embedded Data Collectors website in the near future.

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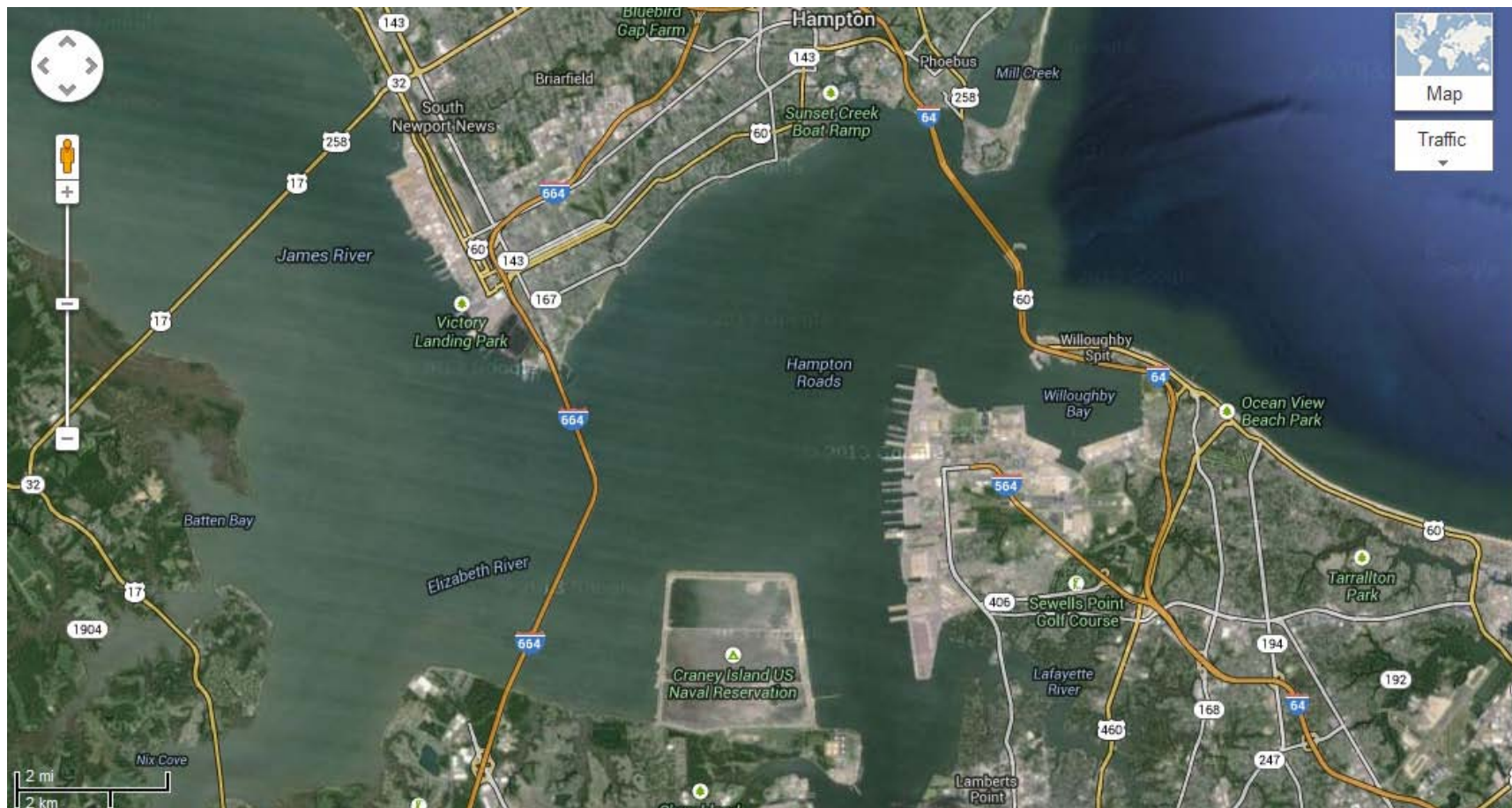
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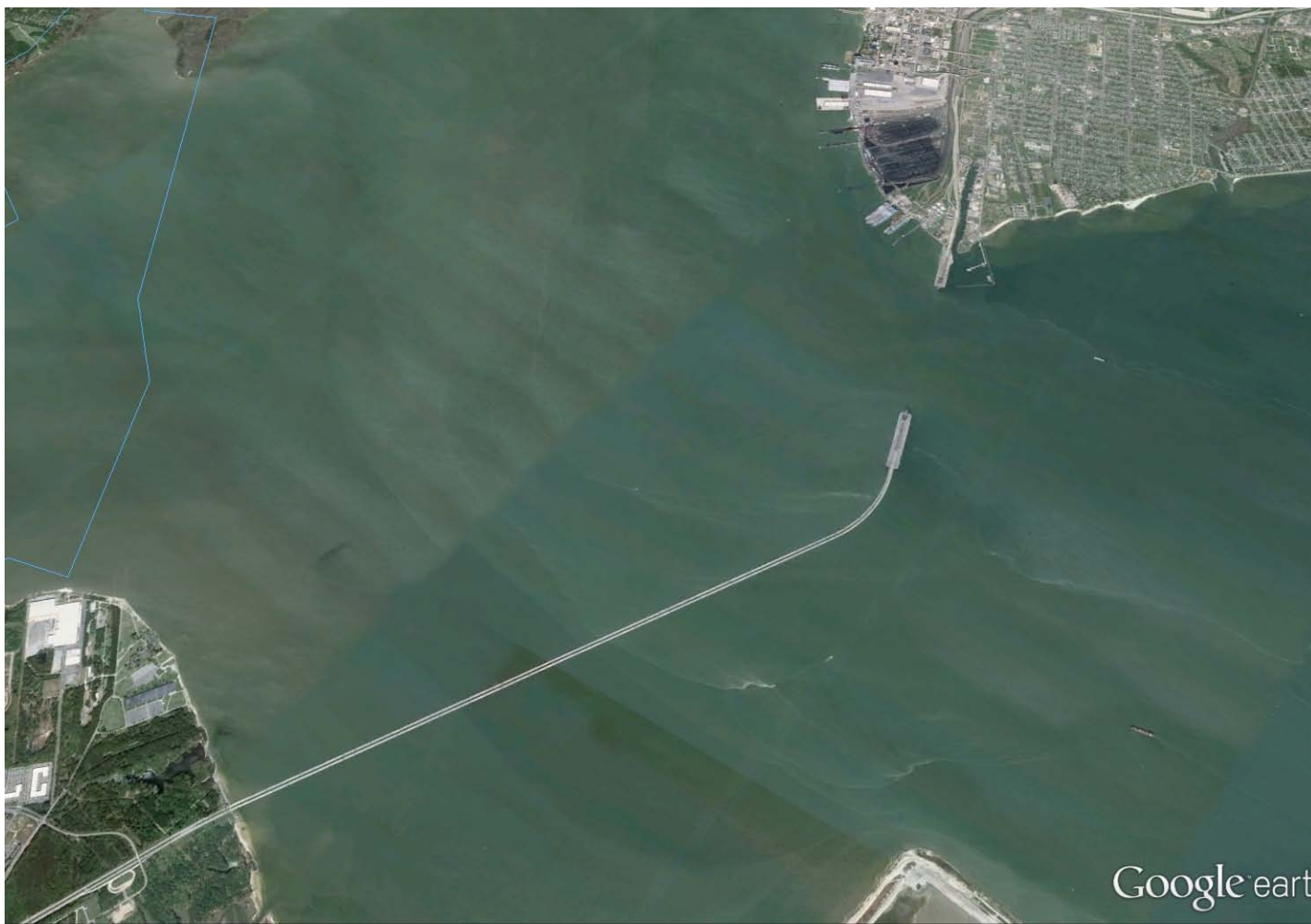
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Monitor- Merrimac Memorial Bridge

Interstate Route 664 in Newport News, Virginia

Pile Driving Program

2 Pre-Construction Pile Load Test Programs (\$333,000)

16 Construction Load Tests (\$387,000)

45 Construction Dynamic Pile Tests (\$95,000)

Monitor- Merrimac Memorial Bridge

Interstate Route 664 in Newport News, Virginia

Pile Driving Program

430,000 linear feet of pile

12" Prestressed Concrete Piles

24" Prestressed Concrete Piles

54" Prestressed Concrete Cylinder Piles

Monitor- Merrimac Memorial Bridge

Interstate Route 664 in Newport News, Virginia

Pile Testing Program Costs: \$815,000

Estimated savings in Construction Cost due to increased pile capacities: \$12 Million

Estimated savings in Construction Cost due to reduced pile lengths through Dynamic Testing: \$2 Million

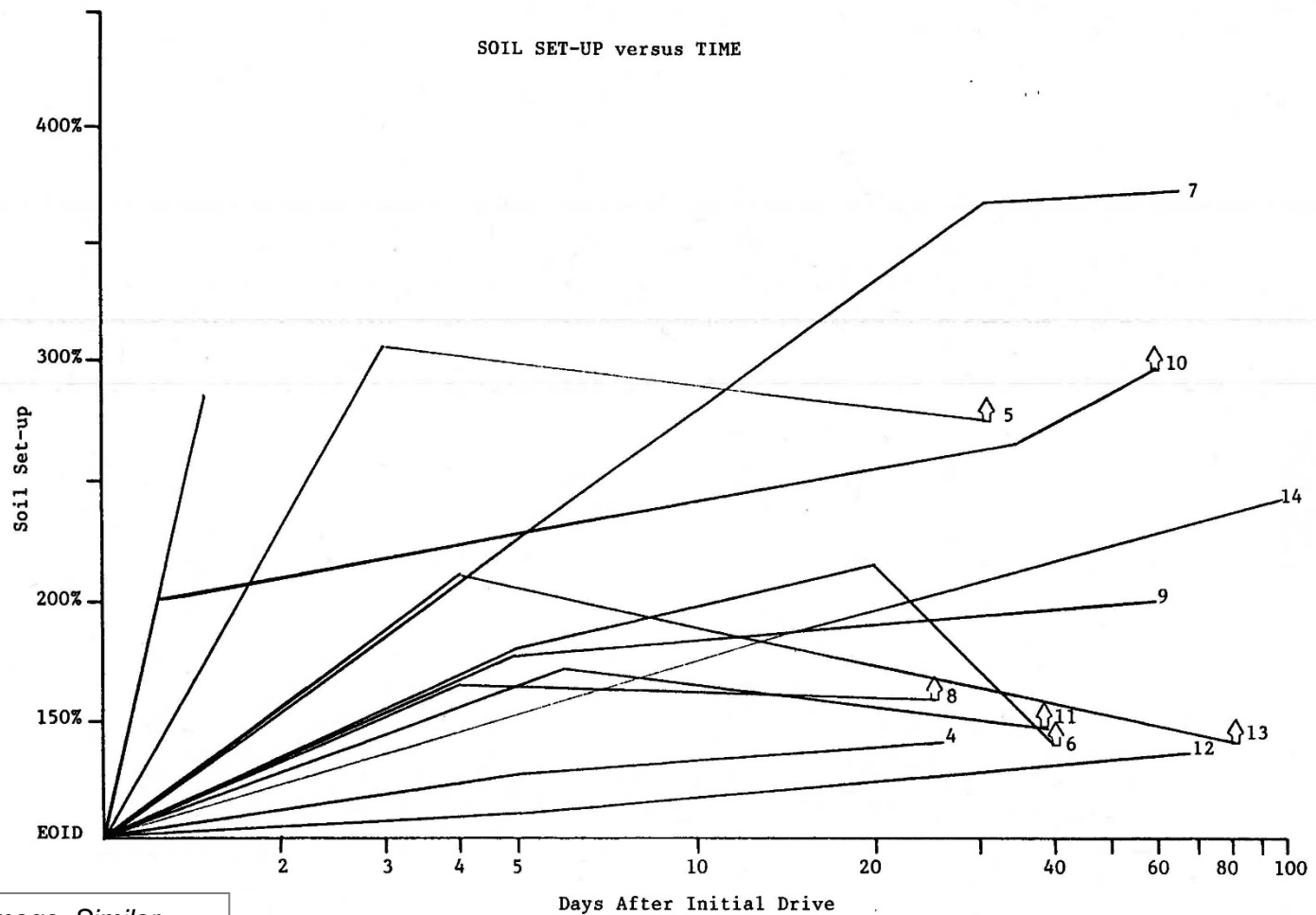
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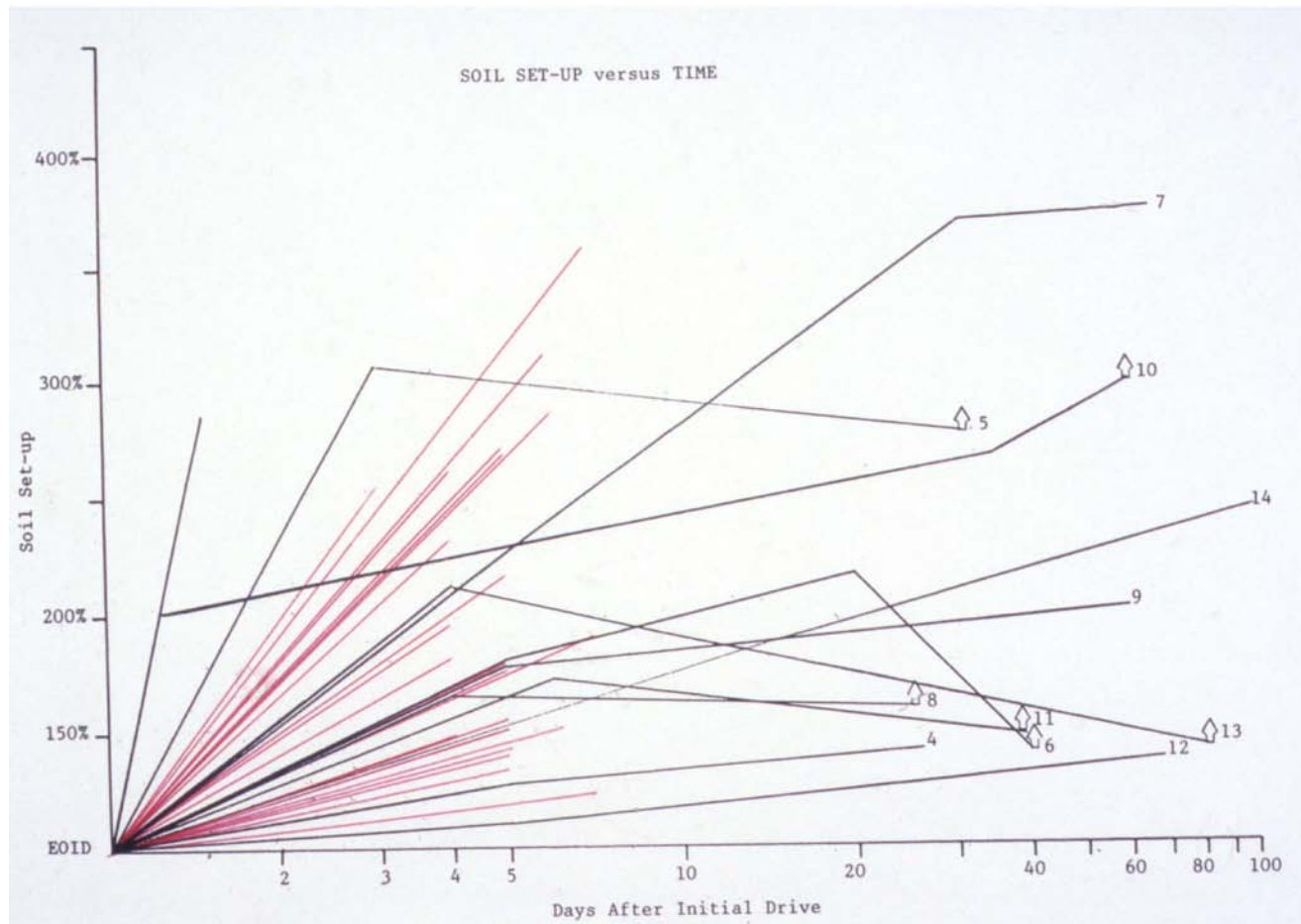
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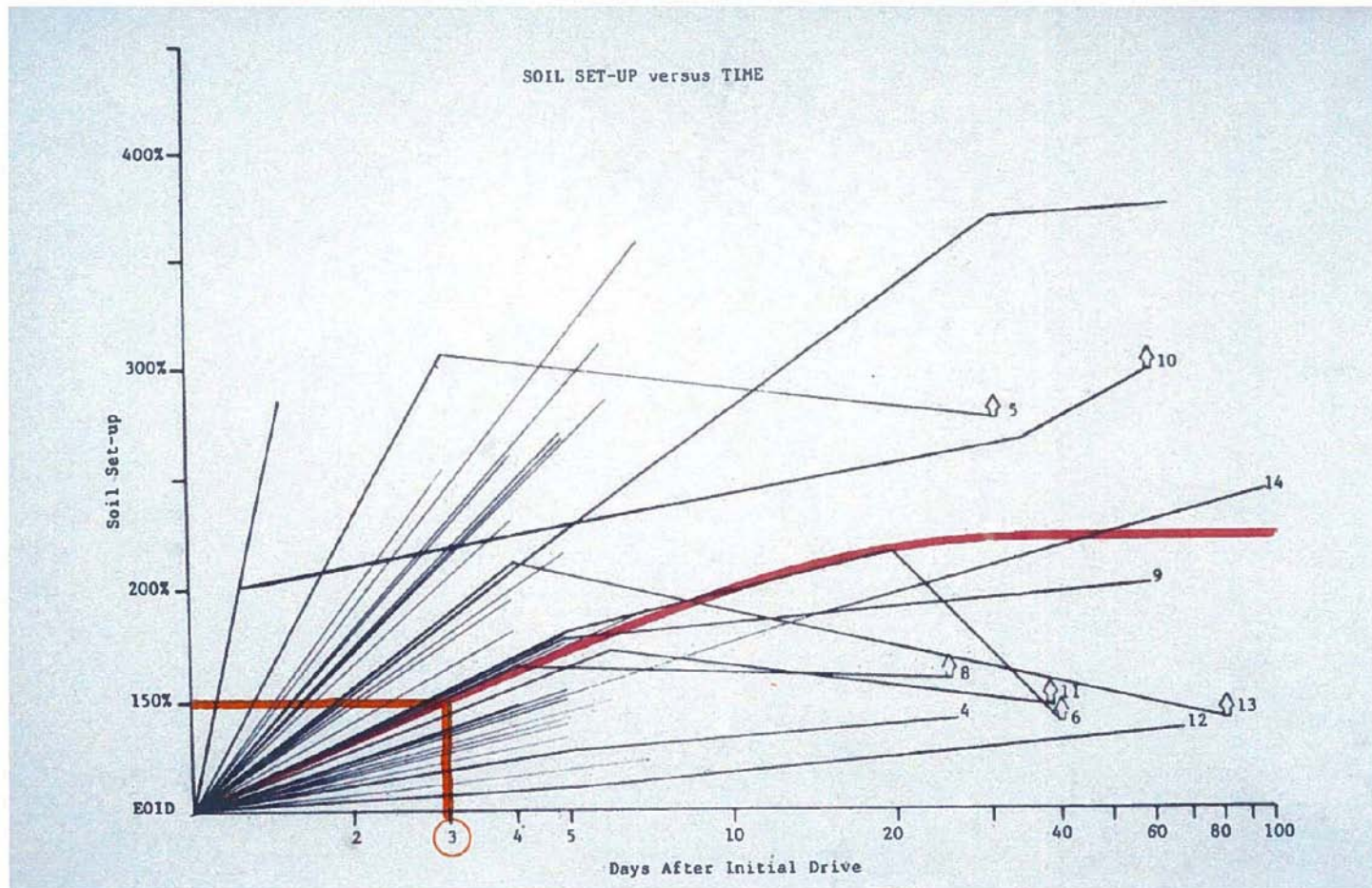
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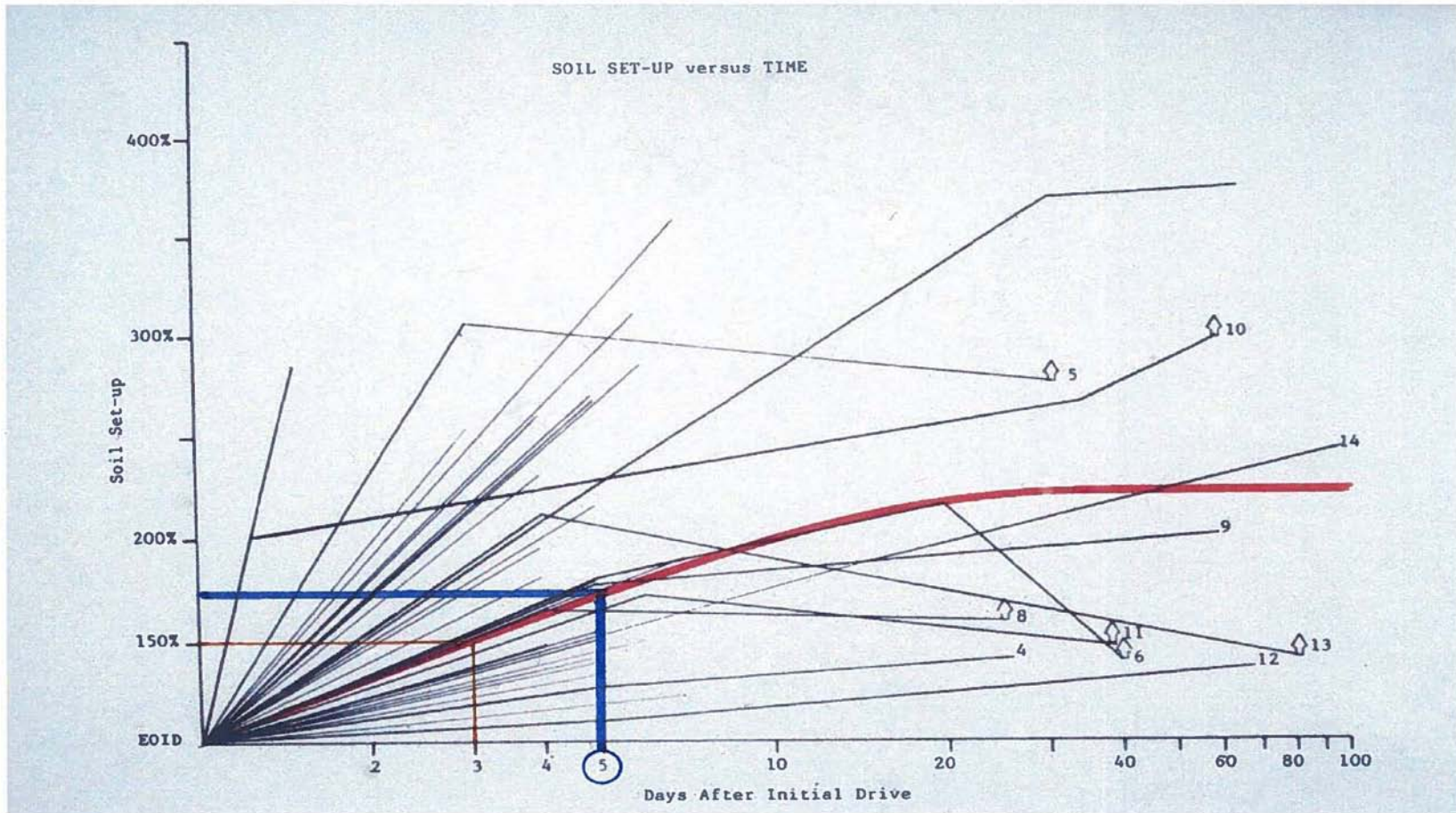
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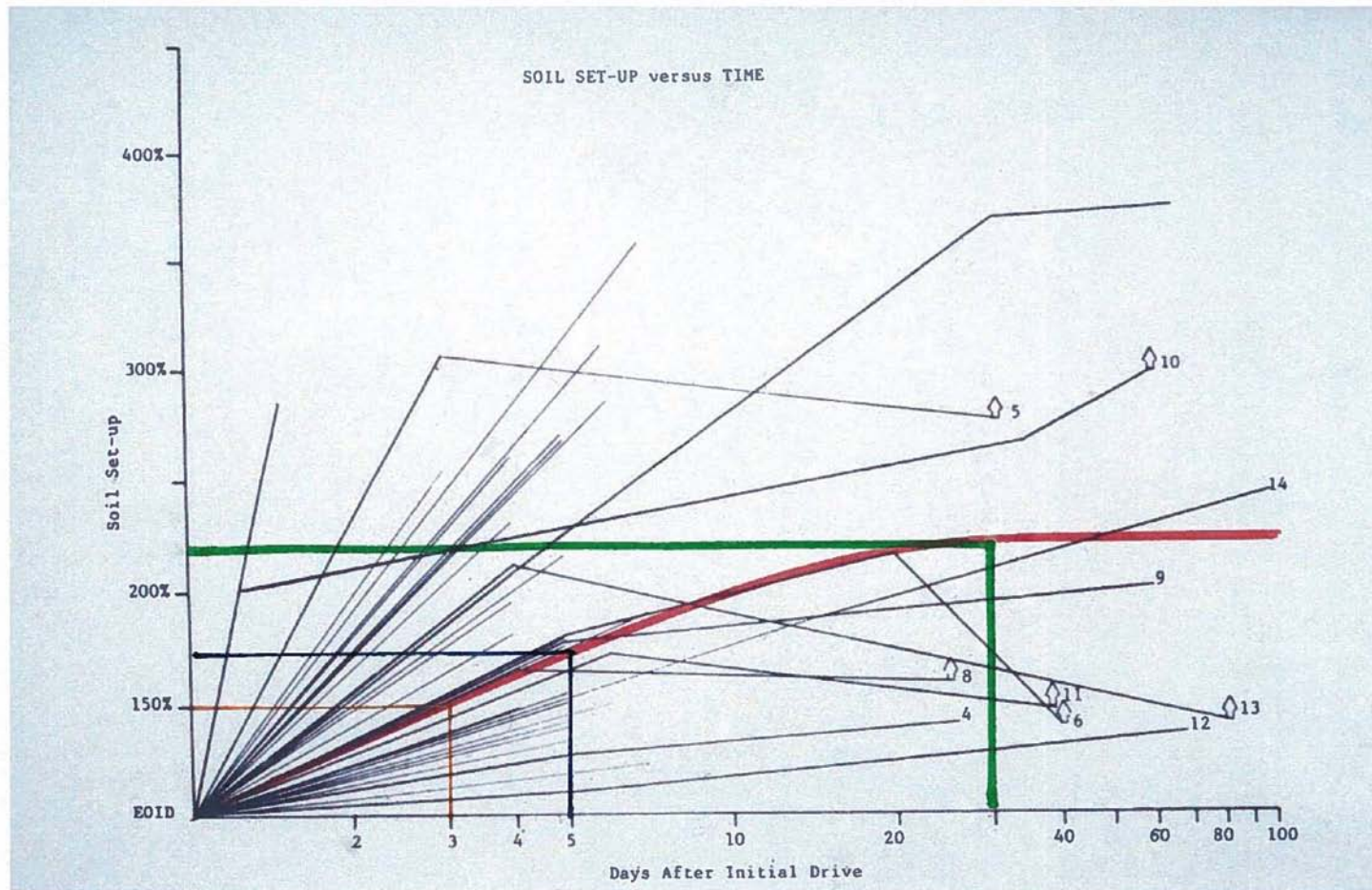
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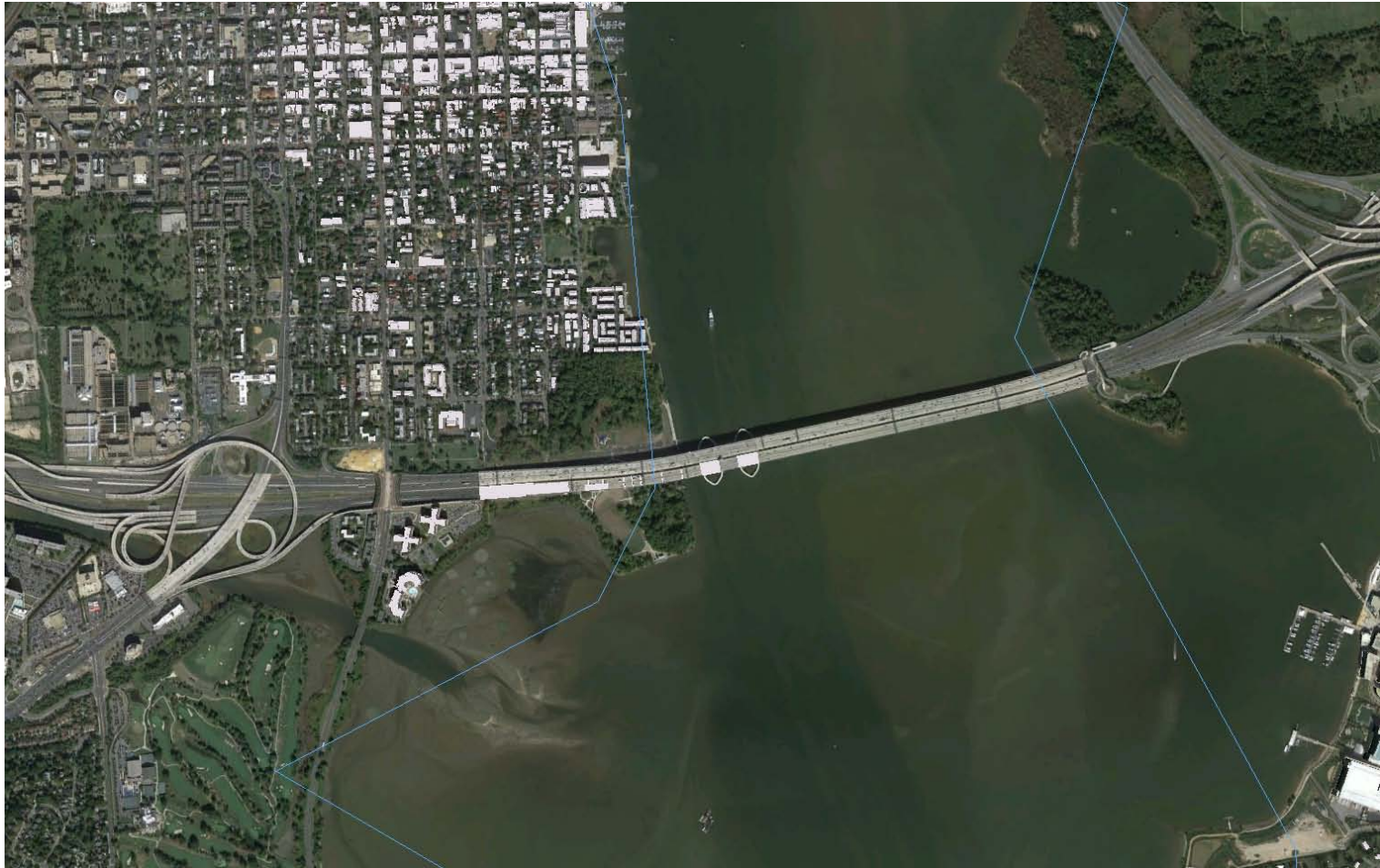
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What followed was 25 Years of productive and cost effective Pile Driving using Dynamic Testing.

Virginia first experimented with Embedded Data Collectors on the Woodrow Wilson Bridge Project in Alexandria, Virginia in 2005.

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Six 24" square prestressed concrete piles were cast with EDC's in the top and at the tip.

The piles were used as Driving Test Piles.

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The tests were only partly successful due to the failure of several of the sensors possibly due to the heat of hydration in the concrete.

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No new Virginia projects with EDC's were developed but we followed the progress of Florida DOT's EDC research.

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When the Florida research was completed and the use of EDC's was allowed in the Florida pile specification, Virginia followed suit.

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In December of 2011 VDOT organized a one day new product information transfer workshop on EDC's for our consultants and contractors.

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The first project where EDC's were chosen for use by the Contractor is the new bridge on Dominion Boulevard in Chesapeake, Virginia, advertised in 2012.

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Pile Driving Program

on Dominion Boulevard

Pile Size	Driving Tests	Linear Feet of Pile
12"	2	1,668
16"	16	15,146
24"	<u>20</u>	<u>36,657</u>
	38	53,471

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AVER TECHNOLOGIES, INC.
13104 Queensdale Dr.
Woodbridge, VA 22193
Tel: (703) 580 8907
Fax: (480) 247-4839
Email: svamy@avertechnologies.com

To: McLean Contracting Company
6700 McLean Way
Glen Burnie, MD 21060-6480
Attn: Mr. Joe Hoffman, PE

Date: 26-Mar-13
AVER Doc No.: 13-251R-VB

Subject: Dynamic Load Test and Production Pile Recommendations
RT17 over Elizabeth River, Chesapeake, VA
Test Pile at: B609 NB Pier 12

Project # (FO)6017-131-109

Dear Mr. Hoffman,

The following are summary of results from our dynamic load testing services for the above referenced test pile and our recommendations for production piles at this location. General test pile information along with results are attached to this letter in tabular and graphical form.

Dynamic Load Testing Method: EDC with Top & Tip Sensors					
Pile Information			Hammer Information		
Bridge No.: B609 NB			Name: Delmag D46-32		
Pier #: Pier 12			Total Energy: 122.435 kip-ft		
Pile No.: 18			Ram Weight: 10.14 kips		
Pile Type.: 24" PSC, SQ			Pile Cushion: Plywood		
Length: 78 Feet			Thickness: 8 inches		
Pile Cutoff: 3.5 Feet			Nom. Bearing Res.: 710 kips		
Refer. El.: 3.5 Feet					

Summary of Dynamic Load Test Results:

	EDC			PDA		
	(Performed)			(Performed)		
Test Condition:	ID	RS	Units	ID	RS	Units
Start Depth:	0	68.5	feet	0	68.5	feet
Final Depth:	68.5	68.66	feet	68.5	68.66	feet
Pile Tip El:	-65.00	-65.16	feet	-65.00	-65.16	feet
Jc: Assumed	0.5	0.5		0.5	0.5	
Required Driving Resistance:	568	710	kips	568	710	kips
Avg. Ult. Comp. Capacity (jc):	499	1085	kips	482	1014.7	kips
Avg. Ult. Comp. Capacity (UF):	455	1143	kips			kips
Avg. Ult. Tip Capacity (UF):	168	209	kips			kips
CAPWAP (total):	NA	NA	kips	450.5	1013.8	kips
CAPWAP (Tip):	NA	NA	kips	157.4	849.4	kips
CAPWAP (Skin):	NA	NA	kips	293	164.4	kips
Max Top Comp. Stress:	3.9	3.9	ksi	2.9	4.2	ksi
Max. Tip Comp. Stress:	1.2	1.0	ksi			
Max Tensile Stress:	1.9	1.9	ksi	2	0.4	ksi
Blow Count:	44	8/1 inch		44.0	8/1 inch	
Stroke:	6.9	9.3	feet	7	8.6	feet
Energy:	23.5	34.3	kip-ft	22.3	36.8	kip-ft
Average Wave Speed:	14008.5	14028.6	ft/sec			
Average Dynamic Jc:	0.3	0.4				
Maximum Loss in Prestress Top:	85.3	93.2	µ Strain			
Maximum Loss in Prestress Tip:	27.7	18.9	µ Strain			
Pile Integrity:	Good					

Notes: Ultimate Capacity, stroke, and energy indicated for initial drive are at end of drive.
Ultimate Capacity, stroke and energy indicated for restrrike are average during restrrike
All stresses reported are maximum values NA - Not Applicable

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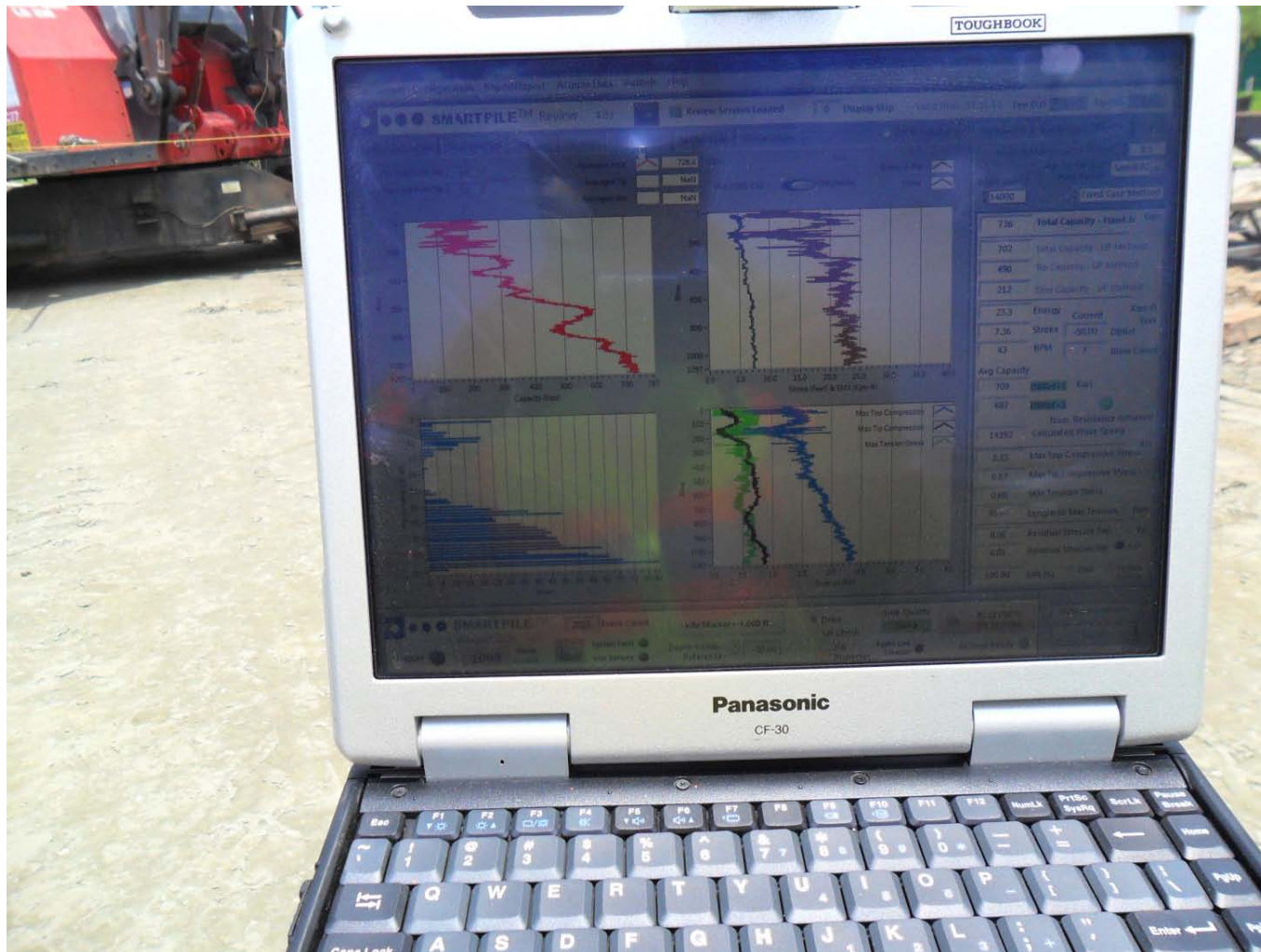


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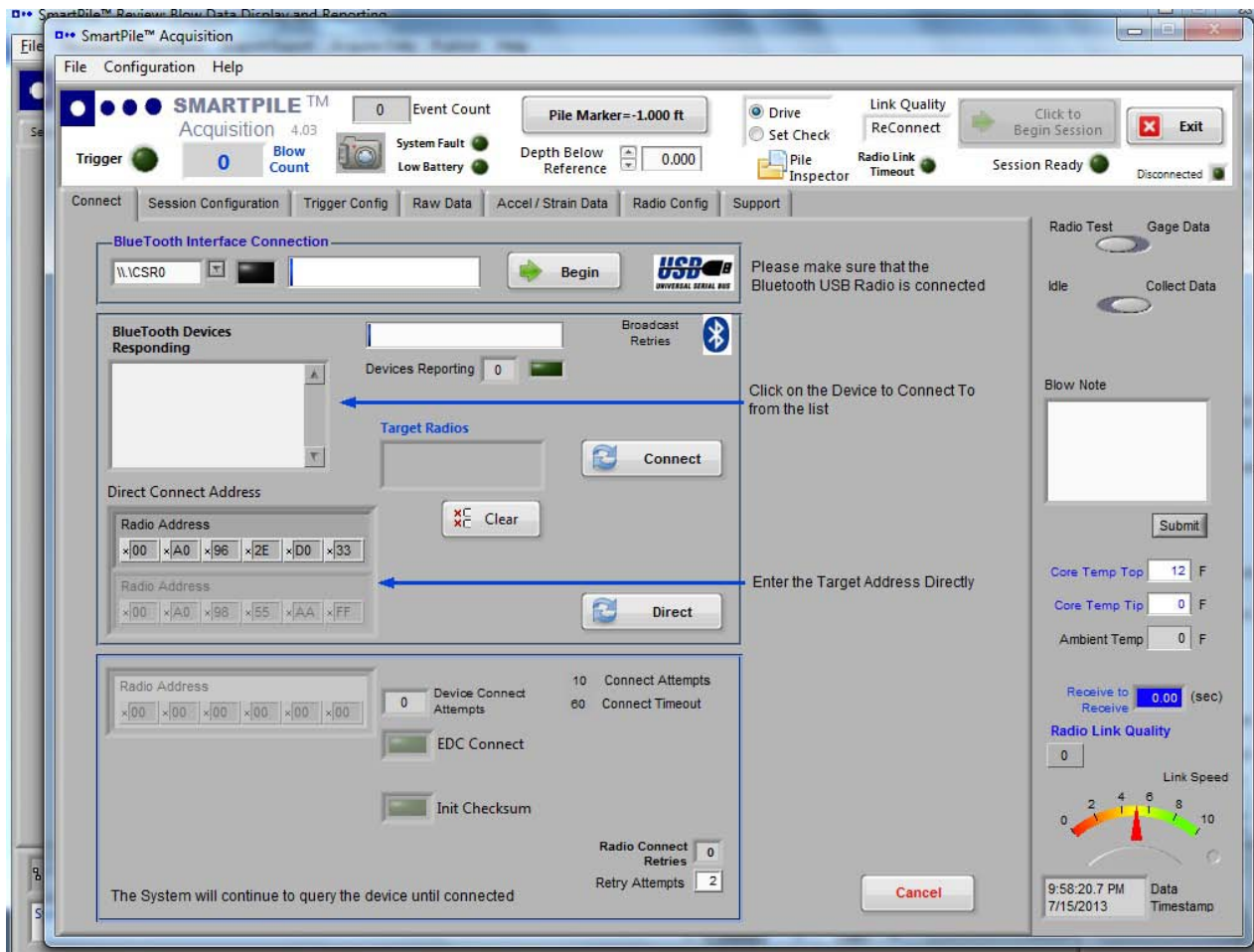


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SmartPile™ Review: Blow Data Display and Reporting

File Session Configuration Import/Export Acquire Data Publish Help

SMARTPILE™ Review 4.03 Review Session Loaded 0 Display Skip Valid Thru 07-31-13 Top PLD 6.8 Tip PLD 17.4

Session Configuration (Raw) Blow Data Top Gages Tip Gages Summary Data Session Report Session Catalog

User Project Pile Criteria Save Session

Pier 1 Pile Number 9 Test Pile

Modulus of Elasticity 6345.67 KSI

Concrete Specific Weight 0.15 KIPs/ft3

Wave Speed 14000 Ft/sec

Fixed Jc Damping Coefficient 0.5

Pile Tip UP Soil Rate Factor Sand(.92)

(Multi-Peak Top Strain) Air Hammer/Multipeak Hammer

Units English

00.A0.96.2E.CF.DE Radio 1 ID

517 Firmware Version

Radio 2 ID

Firmware Version

Pile Physical Dimensions

Pile Length 73.000 Feet

Pile Marker Increment 1.000

Set Check Marker Increment 1.000 Inches

Top Gage to Pile Top 48.000

Tip Gage to Pile Tip 24.000

d Dimension 24.000 Inches

Mid Gage to Pile Tip 1.000

Top Cross-Section Area 576.000 Inches²

Tip Cross-Section Area 576.000

Voided Pile

Void Diameter 1.000 Inches

End of Void to Top 1.000 Feet

End of Void to Tip 1.000

Last Blow Residual DBRef Displacement 0.000 Inches

Final Tip Elevation 0.000 Feet

Recalculate modulus based on wave speed Calculate

Fixed Jc Damping Coefficient 0.5

Pile Tip UP Soil Rate Factor Sand(.92)

Wave Speed 14000

Fixed Case Method

692 Total Capacity - Fixed Jc Kips

653 Total Capacity - UF Method

402 Tip Capacity - UF Method

251 Skin Capacity - UF Method

23.0 Energy Current Kips-ft

7.46 Stroke -48.00 DBRef

43 BPM 180 Blow Count

Avg Capacity

633 DBRef+1 Kips

572 DBRef+2

Nom. Resistance Achieved

14686 Calculated Wave Speed Ksi

2.23 Max Top Compressive Stress

0.83 Max Tip Compressive Stress

0.65 Max Tension Stress

59.40 Length to Max Tension feet

0.04 Residual Stresses Top Ksi

0.11 Residual Stresses Tip Sum

100.00 MPI (%) Clear Tip Data Override

C:\Users\Smartpile User\Documents\Smartpile\Projects\Dominion BlvdRte17\Route17 NB\Pier 1\Pile 9\00-A0-96-2E-CF-DE_blow-00973.bdf

Session Configuration loaded: Dominion BlvdRte17_Route17 NB_Pier 1_Pile9.ssn

Blow Number

Load 973 of 2081

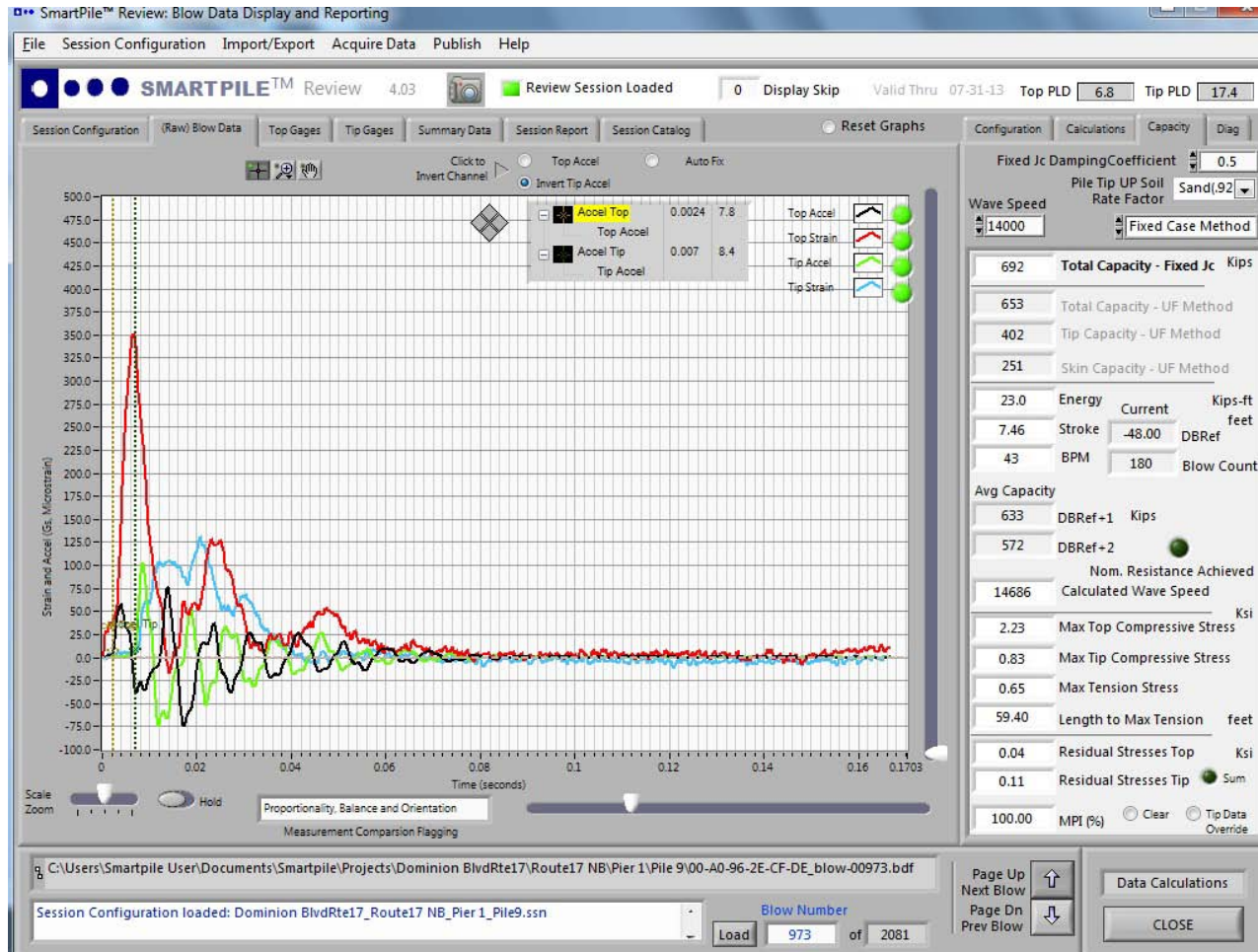
Page Up Next Blow Page Dn Prev Blow

Data Calculations CLOSE

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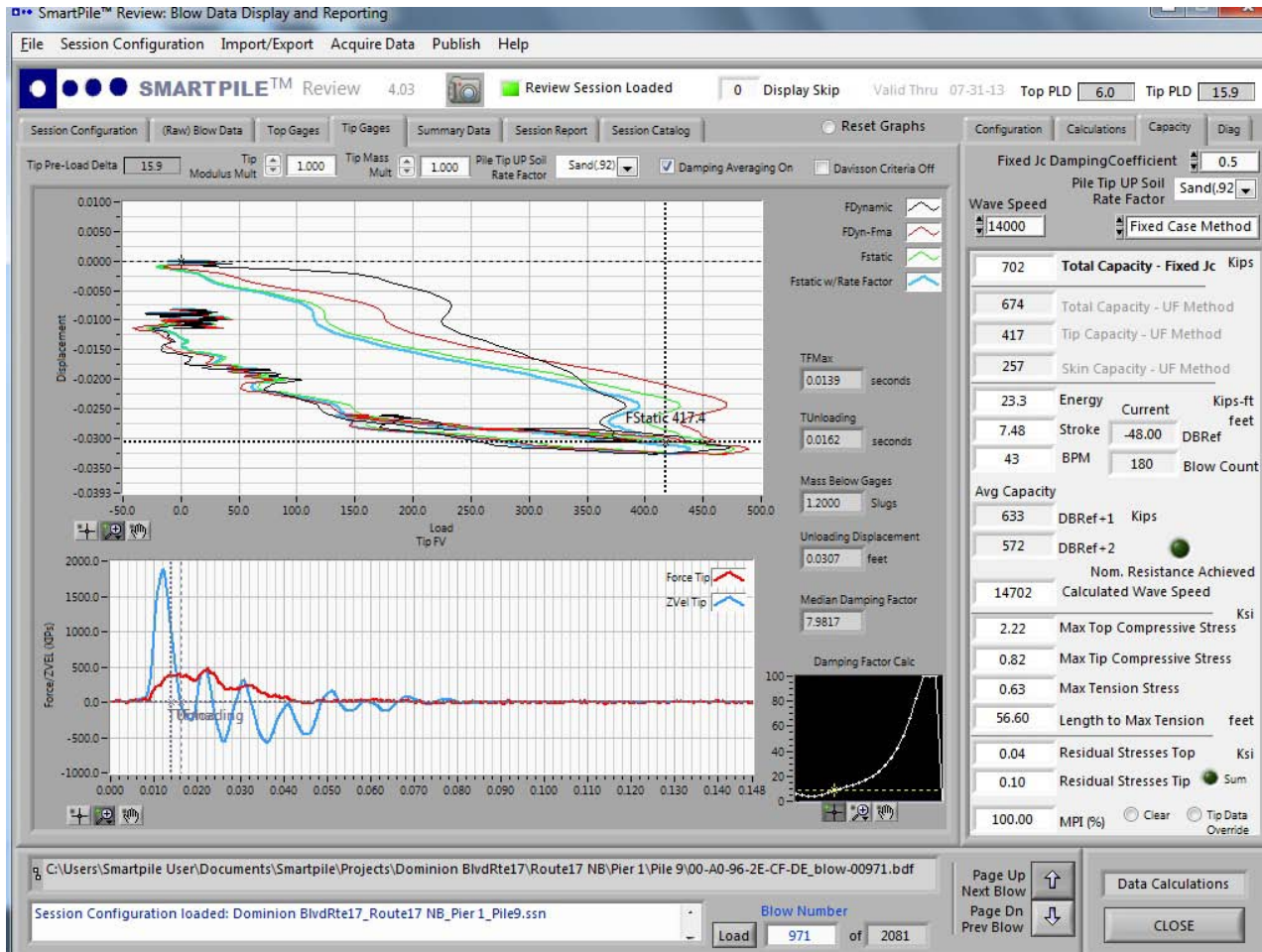
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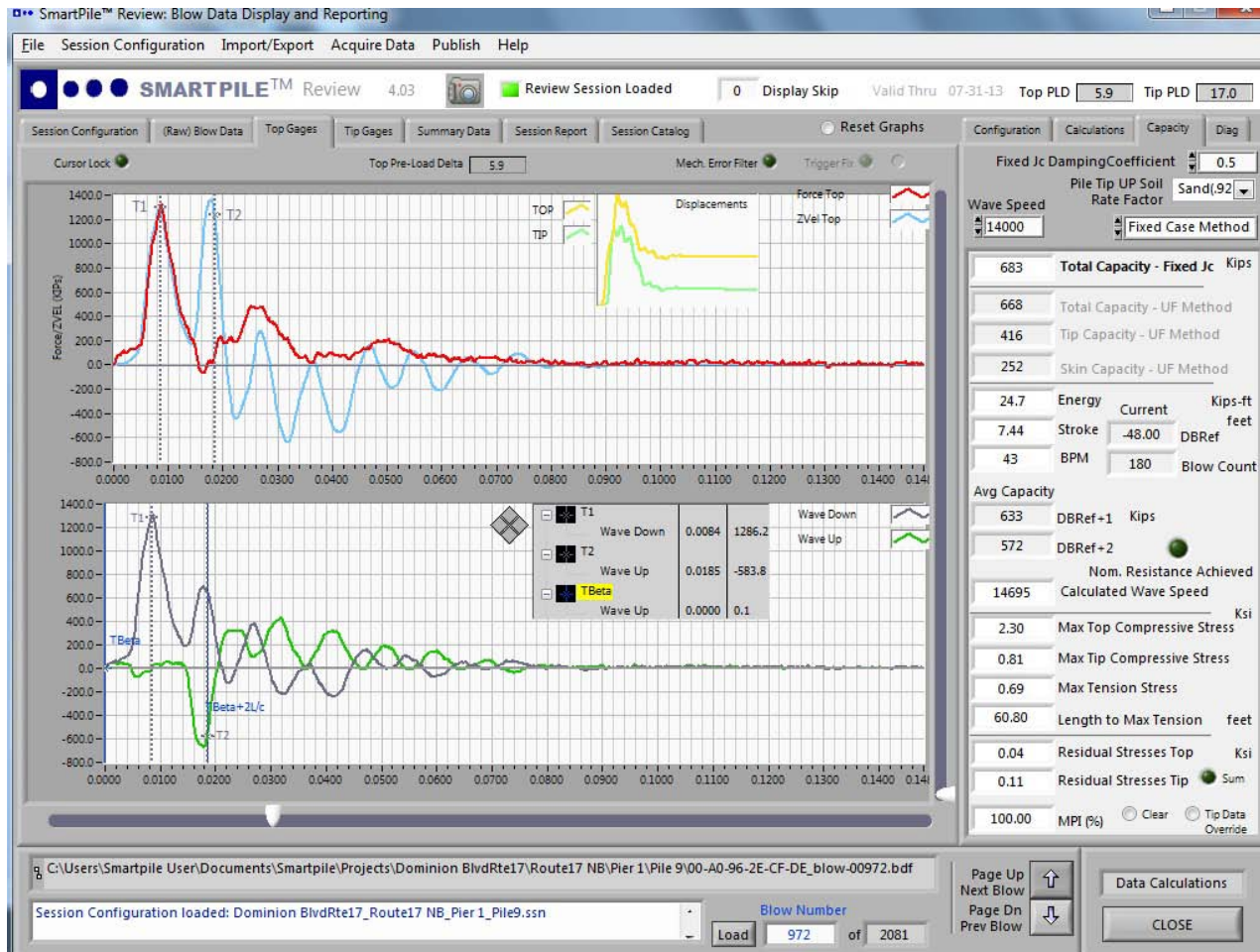
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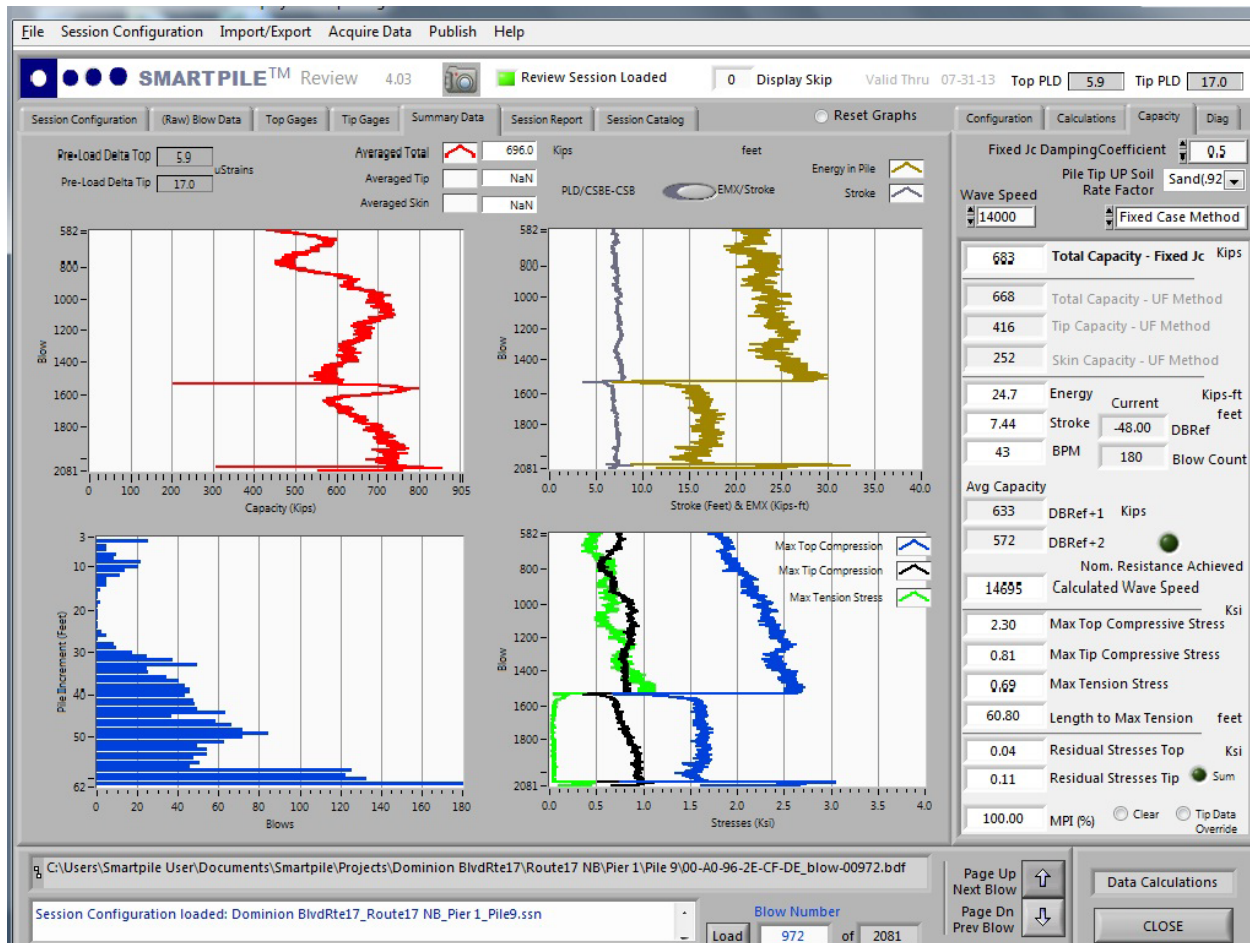
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In What Ways Does VDOT Plan To Use Embedded Data Collectors?

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The new Special Provision allows Contractors the choice to use either EDC or PDA.

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The new Special Provision allows Contractors to choice to use either EDC or PDA.

We may begin to require that the first Driving Test Pile have a top and bottom sensor.

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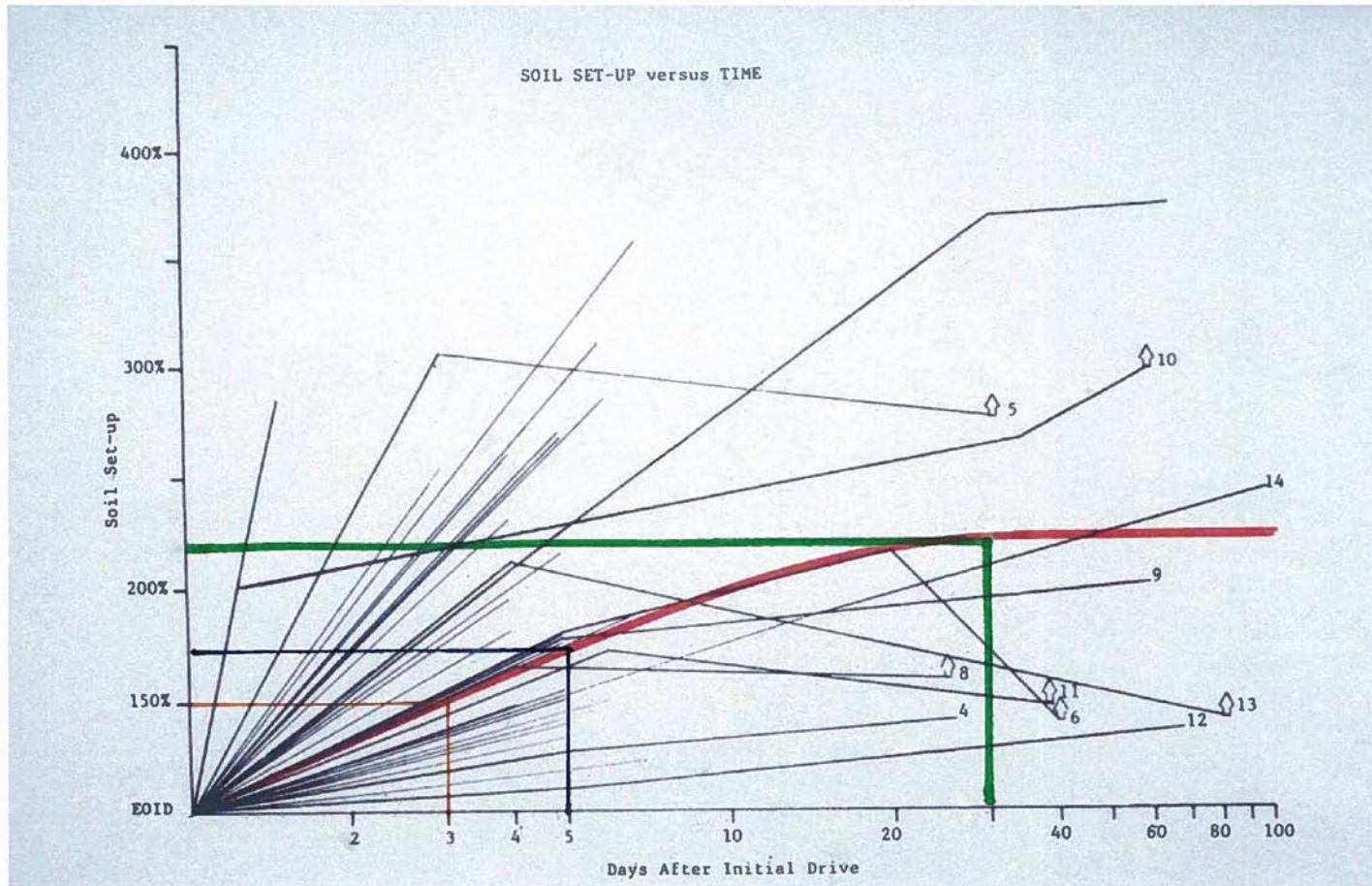
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Cost Benefits – Advanced Damage Detection (early detection saves \$\$)



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Driving Tests are usually done on a pile that will be incorporated into the bridge foundation.

EDC

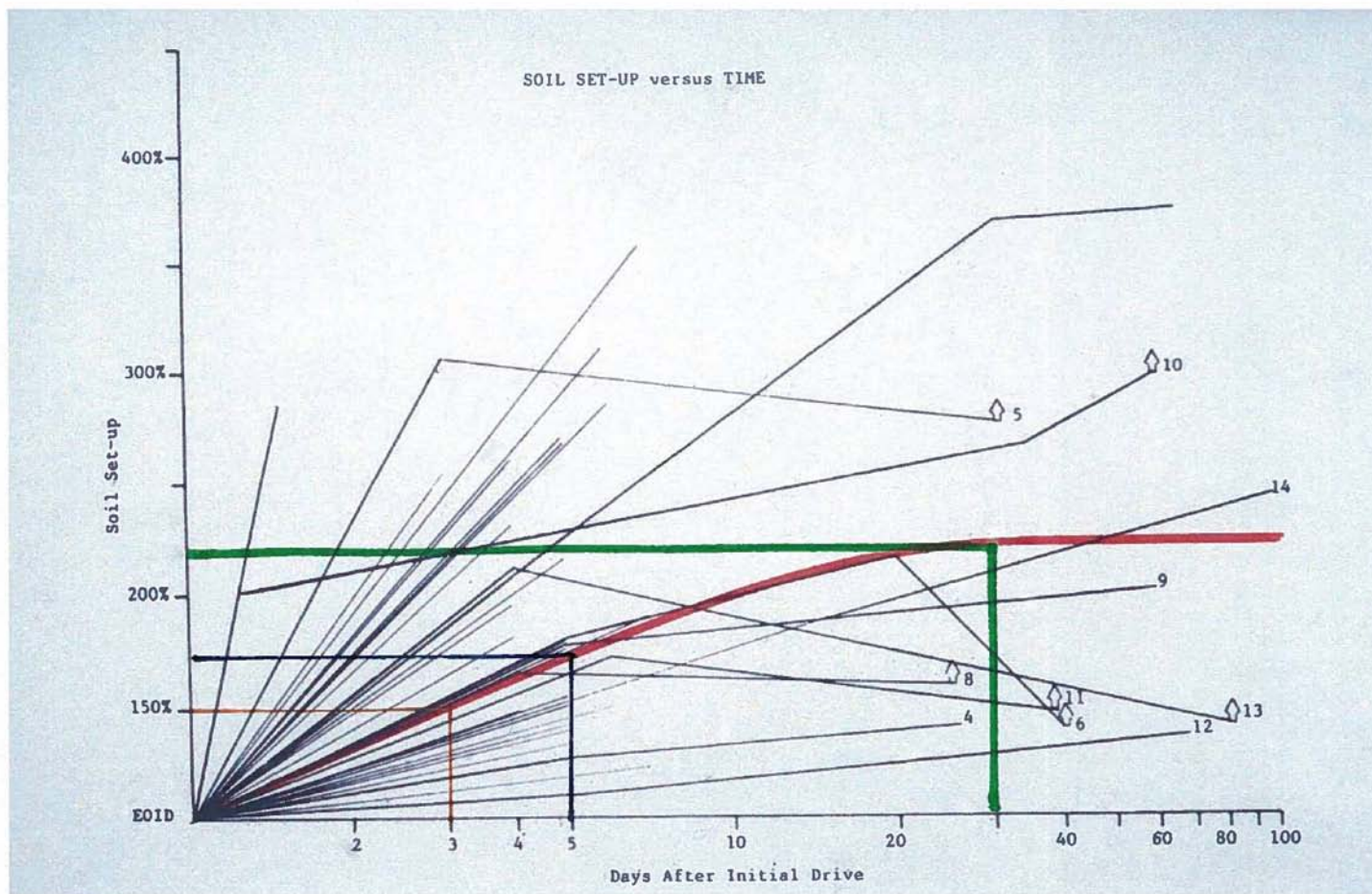
EMBEDDED DATA COLLECTORS

Driving Tests are usually done on a pile that will be incorporated into the bridge foundation.

When the Contractor remobilizes to begin production pile driving, the EDC in the Driving Test Pile can easily be reactivated and a second restrike performed, giving us soil setup weeks after initial driving.

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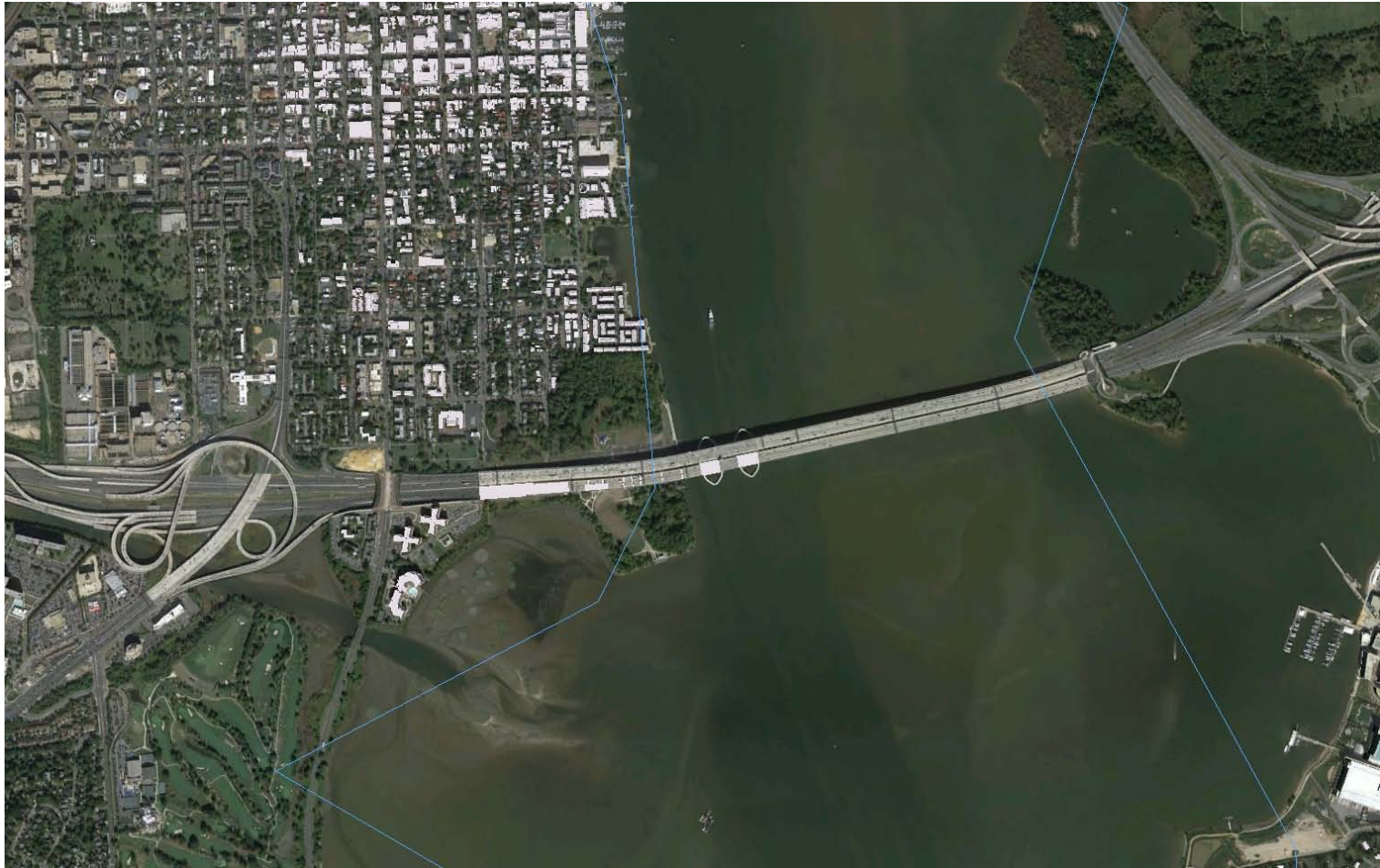
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Long Term Monitoring using Embedded Data Collectors (EDC) in Bridge Structures



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A pier cap with Embedded Data Collectors installed in it was built for FHWA's Turner-Fairbank Highway Research Center. It will provide data for ongoing studies into lifecycle monitoring and cost. The work is being done by Carl Ealy.

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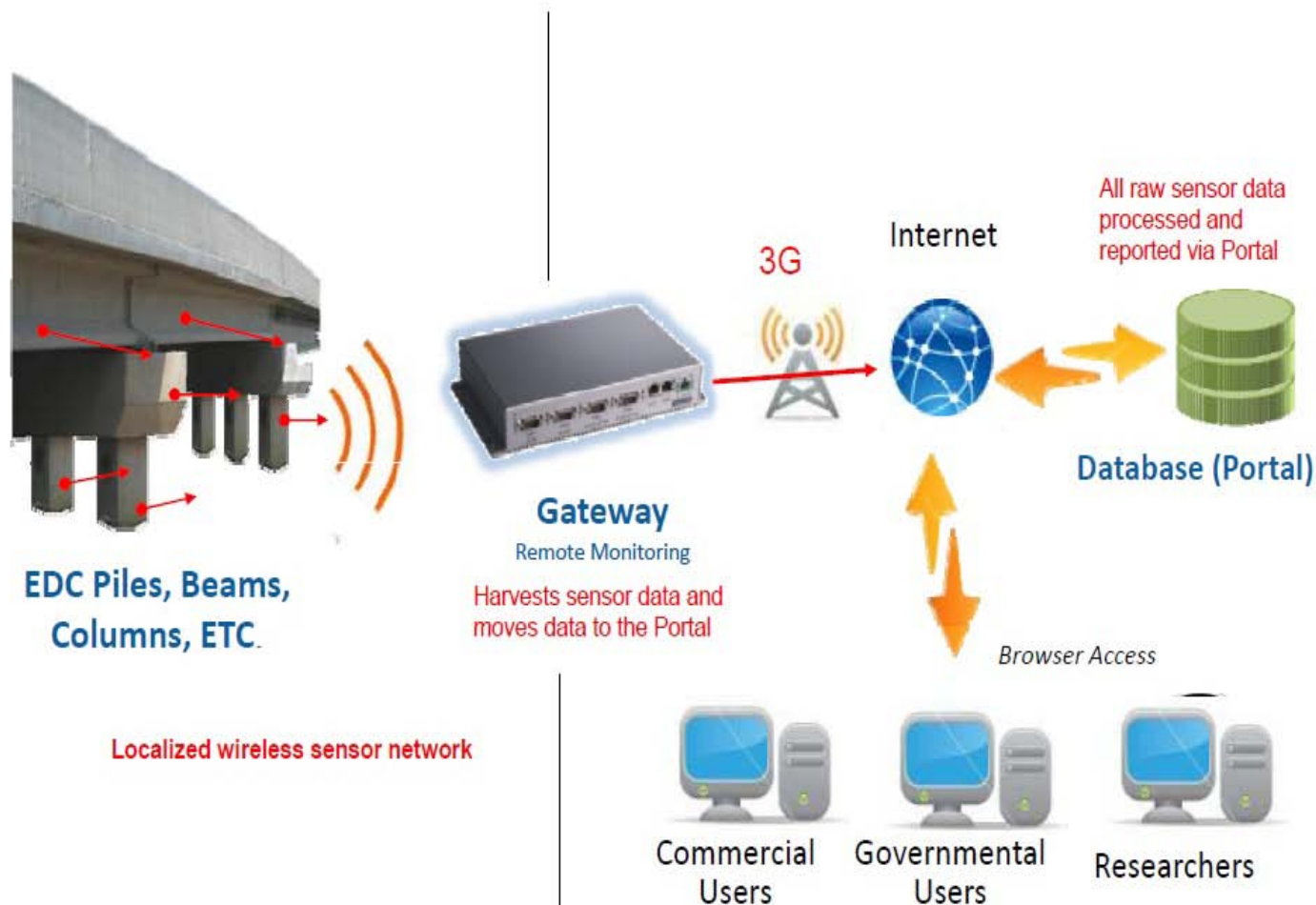


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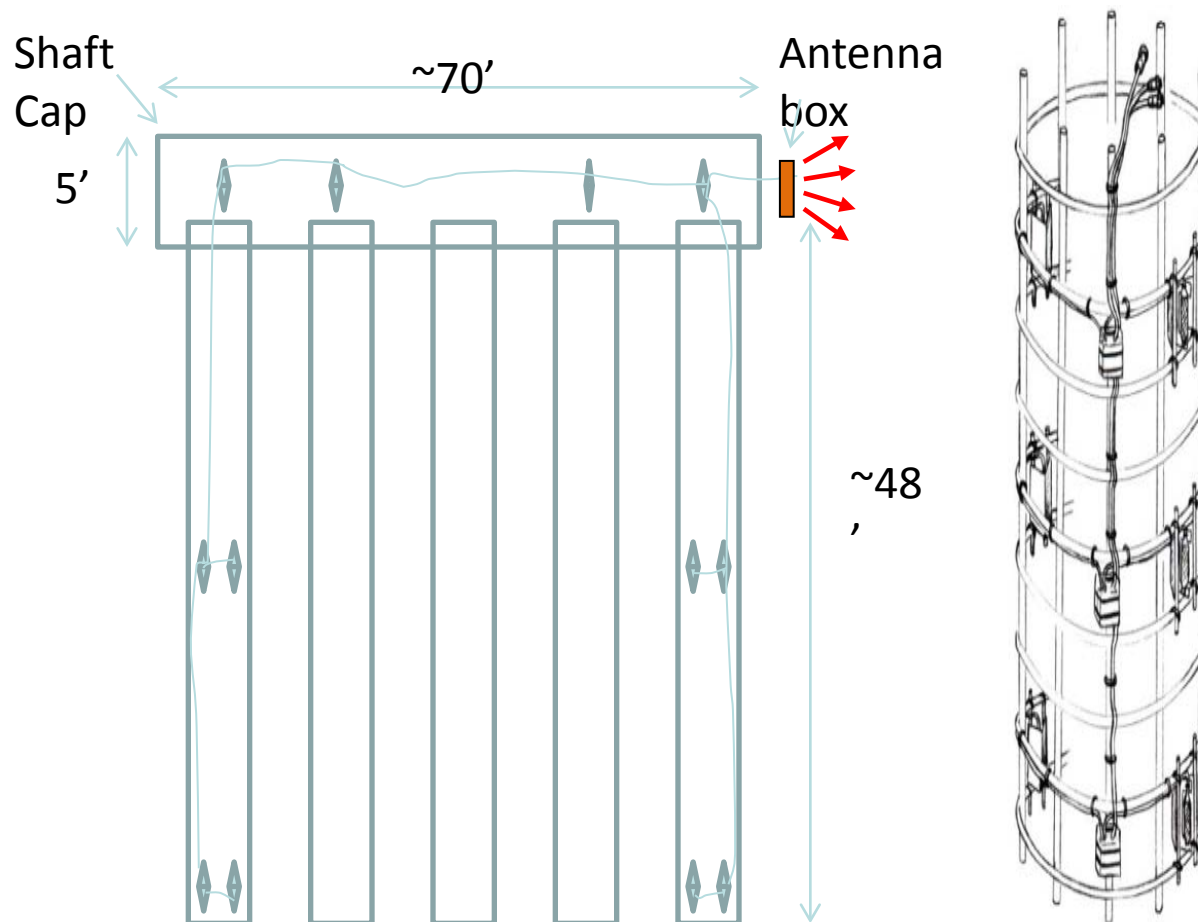
Remote Monitoring – System Elements



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EDC Drilled Shaft Instrumentation Layout – Bridge B606, I-95 Hot lanes Project, Virginia, USA



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Step 1

Strain transducers and temperature sensors are installed on drilled shaft rebar cage



Step 2

Preliminary data is collected from the dataport before and after concrete pour in drilled shafts



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Step 3

Cables are installed for cap monitoring

Step 4

Sensors are connected through cables and are connected to data port



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Step 5

Data port attached to the form work, to collect data after concrete pour

Step 6

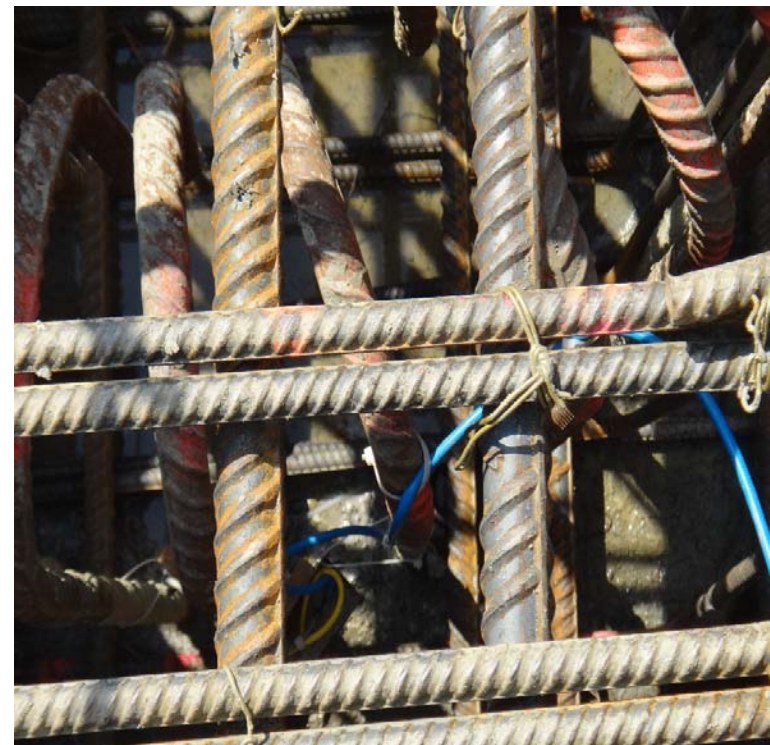
Cap instrumentation set up before concrete pour



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Concrete Pour



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Data Collection Equipment

Data port cover on the
back wall of abutment



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Purpose of using EDC Instrumentation & Monitoring in Drilled Shaft



Purpose of Using EDC Instrumentation & Monitoring in Drilled Shafts

- Static Load measurements at various locations along the shaft and shaft cap.
- Changes in shaft strain during live load, dead load and service loads.
- Temperature of concrete at various stages of the shaft and shaft cap construction and post construction.
- Determine the load transfer along the shaft.

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This information will be extremely valuable if States want to revisit and modify load and resistance factors based on their local conditions and practices.

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Embedded Data Collectors Lead States Team

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Embedded Data Collectors

Jesse Sutton
Florida Department of Transportation

NHI Real Solutions Web Conference
July 25, 2013

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