Evaluation & Life Extension *of Cable Stayed Bridges*

Southeast Bridge Preservation Partnership – April 28, 2010

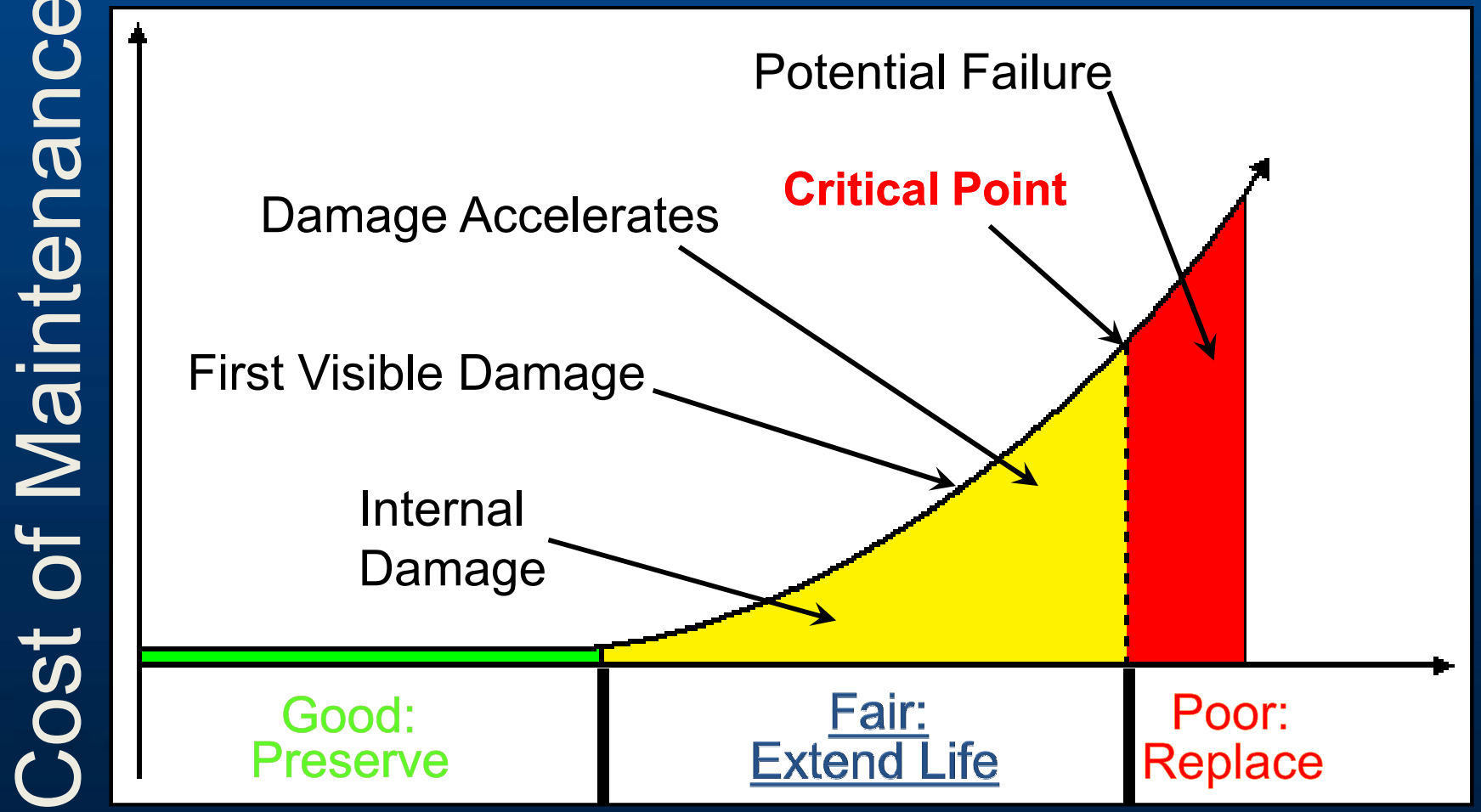
Siva – Principal Engineer
Siva@SivaCorrosion.com
SCS Inc. (610) 692-6551
www.SivaCorrosion.com

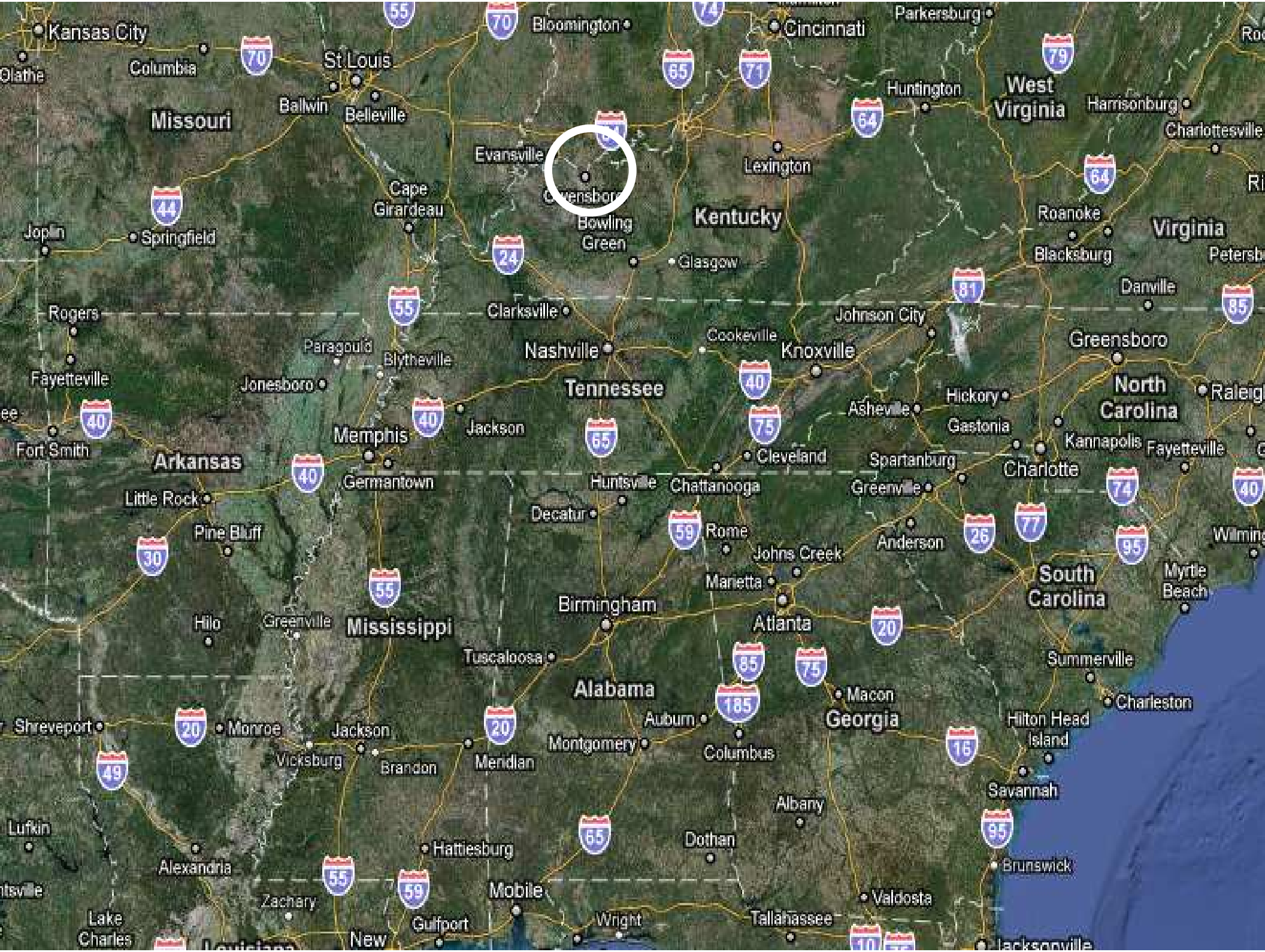
In This Presentation

We will discuss:

- *Quantifying Unseen Corrosion Using Appropriate NDT Methods*
- *Making Decisions Based On Hard Data - Not Guess Work*
- *Extending Service Lives*
- *Partnering with Clients to Solve Problems Cost-Effectively*

CORROSION COST PROGRESSION

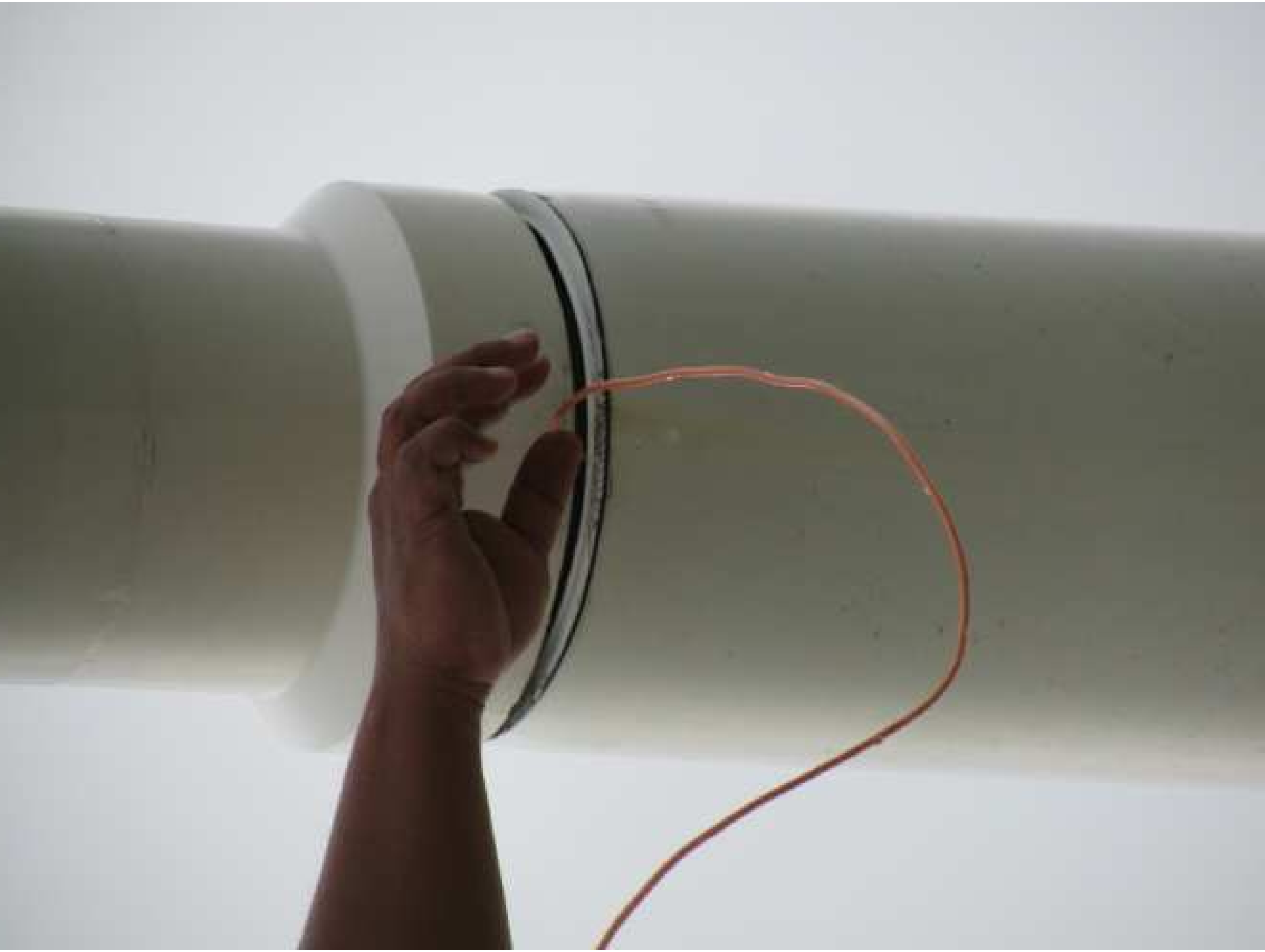



Kansas City
Olathe
Columbia
St Louis
Ballwin
Belleville
Missouri
Bloomington
Cincinnati
Parkersburg
Huntington
West Virginia
Harrisonburg
Charlottesville
Evansville
Owensboro
Lexington
Cape Girardeau
Bowling Green
Kentucky
Roanoke
Blacksburg
Virginia
Joplin
Springfield
Glasgow
Danville
Rogers
Clarksville
Johnson City
Cookeville
Nashville
Knoxville
Greensboro
Paragould
Blytheville
Fayetteville
Jonesboro
Tennessee
Hickory
North Carolina
Asheville
Gastonia
Fort Smith
Memphis
Jackson
Arkansas
Cleveland
Kannapolis
Fayetteville
Spartanburg
Charlotte
Germantown
Huntsville
Chattanooga
Greenville
Little Rock
Decatur
Pine Bluff
Rome
Anderson
Johns Creek
Marietta
South Carolina
Myrtle Beach
Hilo
Greenville
Mississippi
Birmingham
Atlanta
Tuscaloosa
Summerville
Alabama
Macon
Charleston
Georgia
Shreveport
Monroe
Jackson
Auburn
Hilton Head Island
Vicksburg
Brandon
Meridian
Montgomery
Columbus
Savannah
Albany
Lufkin
Hattiesburg
Dothan
Alexandria
Brunswick
Zachary
Mobile
Valdosta
Lake Charles
Gulfport
Wright
Tallahassee
New
Jacksonville

CABLE STAYED BRIDGE – KENTUCKY / INDIANA

<u>Strands:</u> - Greased, sheathed grouted inside HDPE duct

Total of 96 cables



PROBLEMS

- Voids in grout
- Varying grout quality
- Cracking of HDPE ducts
- Failed welds on ducts
- Water leaking through cracks in ducts
- Strands are exposed to water in the ducts

TOP OF TOWER (VIDEO)

OUR PAST EXPERIENCE

- Voids indicate problems but not all voids are problematic
- Strands corrode when grout quality is non-uniform or bad
- Corrosion has occurred when cable is completely filled with grout
- Strands that are greased, sheathed, and encased inside a plastic duct have corroded and failed within seven years

TARGETED INSPECTION

- Electrical continuity of strands
- Void locations using GPR and thermography
- Grout quality and protective properties using corrosion rate tests and specific laboratory tests
- Determine wire/strand break using Magnetic Flux Leakage – then visual confirmation at select locations

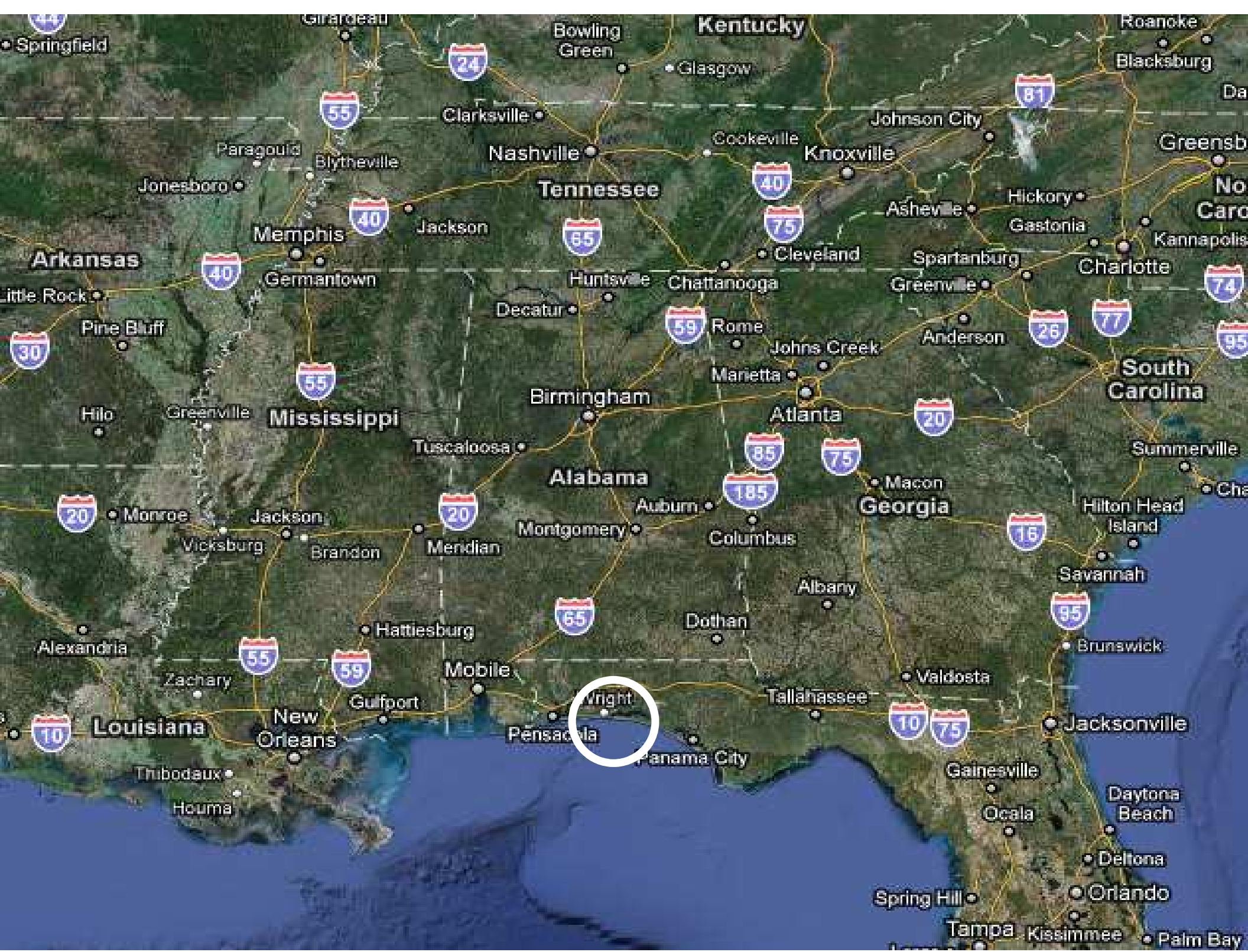
TARGETED INSPECTION

- Define time-to-criticality - measure the rate of corrosion of strands in in-situ conditions
- Quantify present and future damage
- We have successfully used our methodology to quantify corrosion in pre-stressed and post-tensioned structures


Identify small and
large voids with GPR

BENEFITS OF SCS EFFORTS

- Areas of voids in the cable duct
- Any existing wire or strand break within the duct
- Extent of corrosion of strands in areas where water was found inside the cables
- Rate of corrosion of strands exposed to rain infiltration
- Proper rehabilitation typically costs only 20% - 25% compared to replacement


Springfield
Bowling Green
Kentucky
Glasgow
Roanoke
Blacksburg
Clarksville
Johnson City
Cookeville
Nashville
Knoxville
Paragould
Blytheville
Jonesboro
Tennessee
Hickory
Asheville
Gastonia
Memphis
Jackson
Cleveland
Charlotte
Arkansas
Spartanburg
Germantown
Huntsville
Chattanooga
Greenville
Little Rock
Decatur
Rome
Pine Bluff
Anderson
Johns Creek
Marietta
South Carolina
Hilo
Greenville
Mississippi
Birmingham
Atlanta
Tuscaloosa
Summerville
Alabama
Macon
Auburn
Georgia
Hilton Head Island
Monroe
Jackson
Montgomery
Columbus
Vicksburg
Brandon
Meridian
Savannah
Albany
Dothan
Hattiesburg
Brunswick
Alexandria
Zachary
Mobile
Valdosta
Gulfport
Tallahassee
Louisiana
New Orleans
Pensacola
Panama City
Jacksonville
Thibodaux
Houma
Gainesville
Daytona Beach
Ocala
Deltona
Spring Hill
Orlando
Tampa
Kissimmee
Palm Bay

MID-BAY BRIDGE – FLORIDA

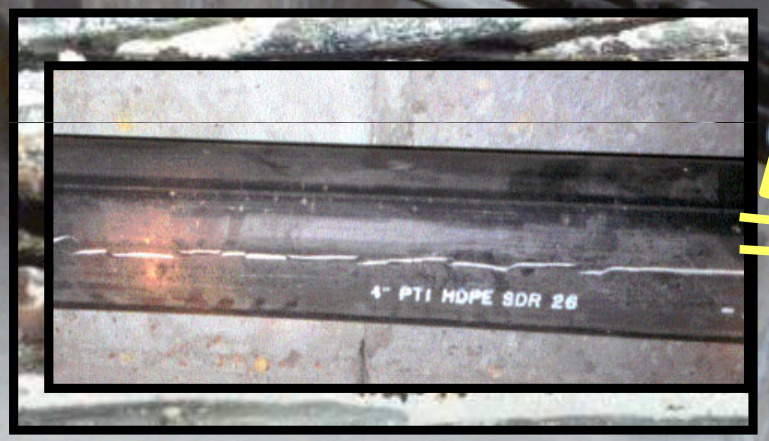
3.6 miles long

Segmental precast concrete box girders

<u>11 Tendons replaced in eight years</u>

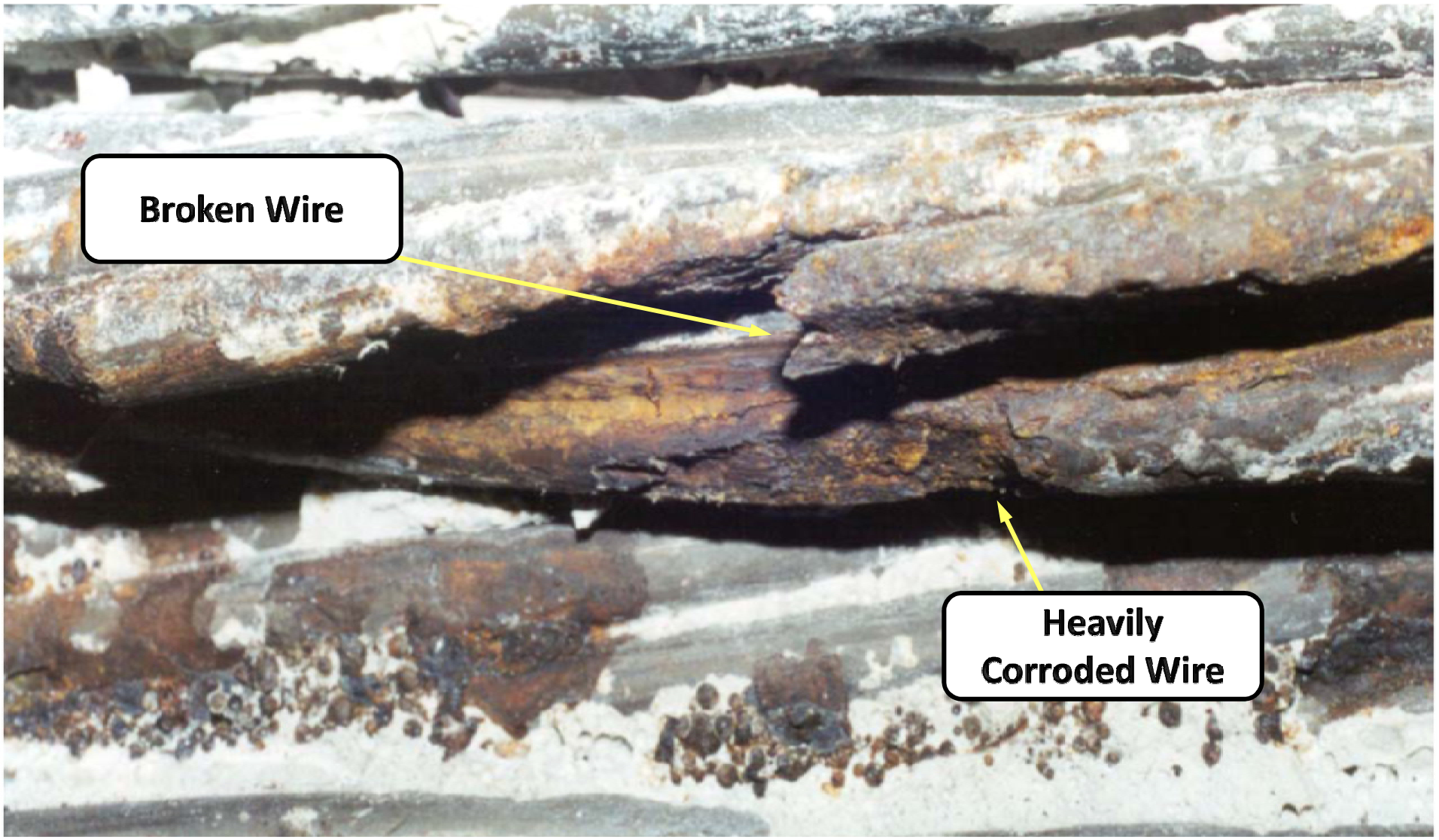
PROBLEM

- 11 Tendons replaced in eight years
- Cracking of PE duct
- What factors contributed to tendon corrosion?
- What corrosion related repairs were necessary?

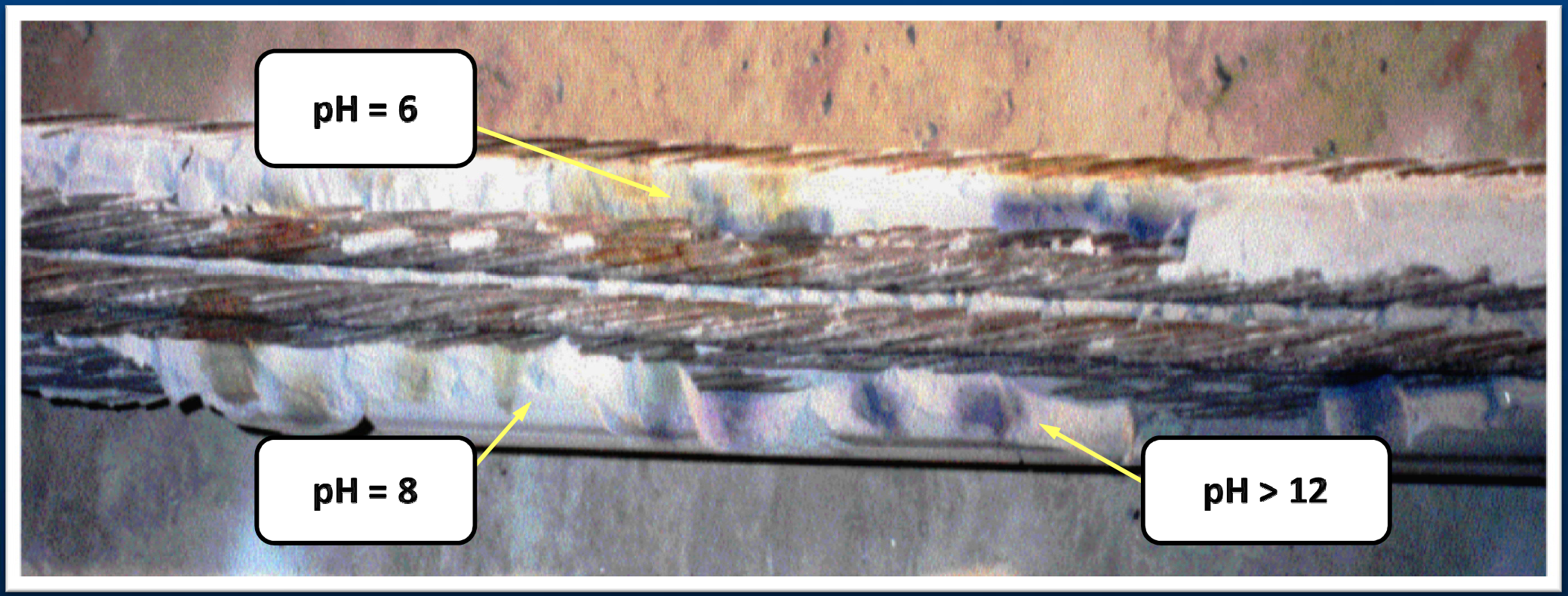


- Fully grouted tendons
- Half Cell Potential: 90% probability of no corrosion
- Chloride Content of Grout: Well below corrosion threshold

FULLY GROUTED TENDON



GROUT PH VARIATION



TYPICAL ANCHORAGE ASSEMBLY

SOLUTION

- We identified factors causing corrosion problems
- The Department replaced problem tendons
- Problems – limited to one section of the bridge
- Full replacement of the bridge was not necessary

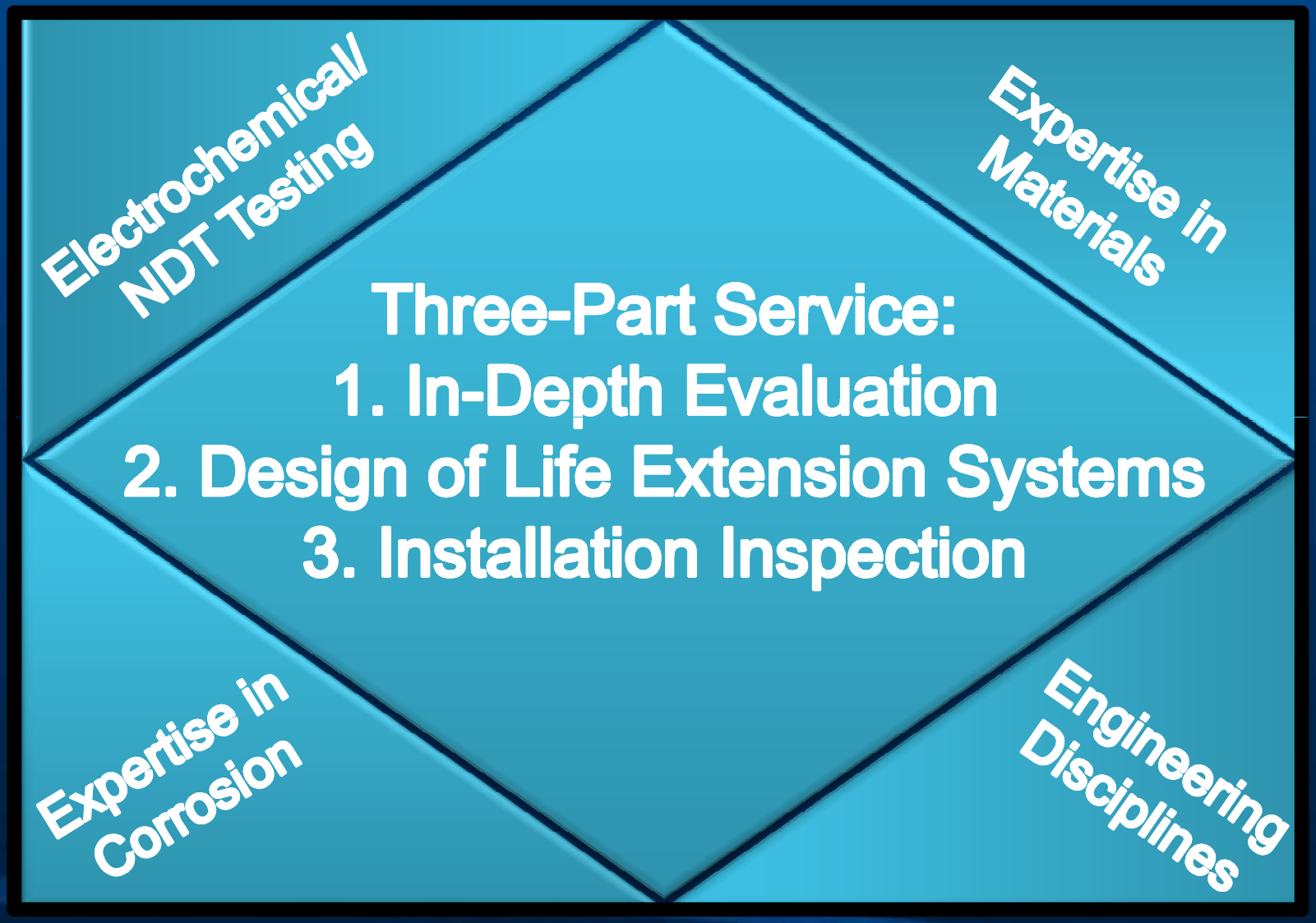
BENEFIT

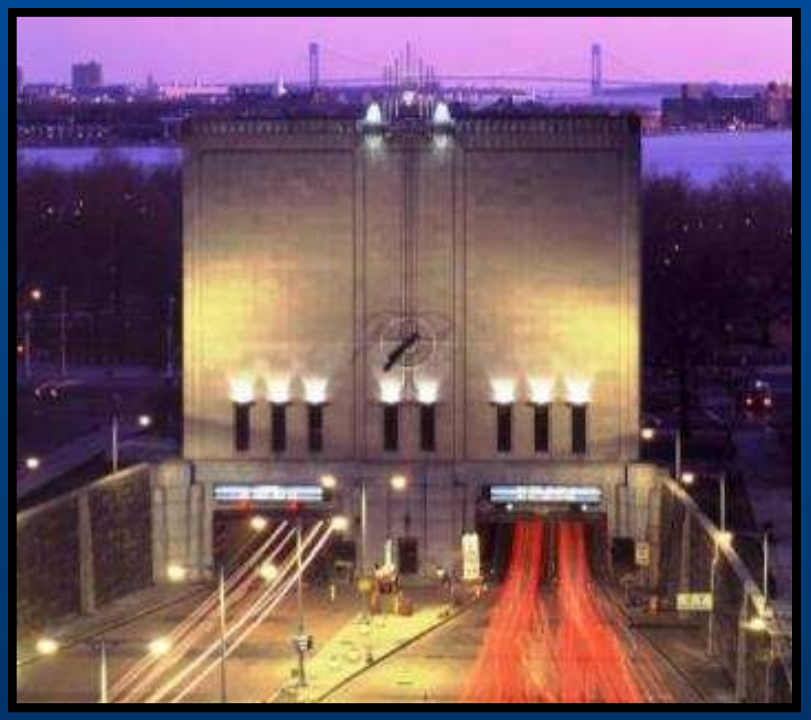
- The Department repaired the bridge while keeping it open to traffic
- Eight years later, no more tendon failures
- New specifications adopted by Florida DOT, AASHTO, ASBI

CONCLUSION

- Not all grout voids cause problems; low alkaline grout/varying grout quality increase corrosion rate
- Corrosion can occur even when tendons are filled with grout
- Significant corrosion has occurred when potential and chloride data showed otherwise
- Important to measure all factors that may be corroding the strands/cables

SCS Approach



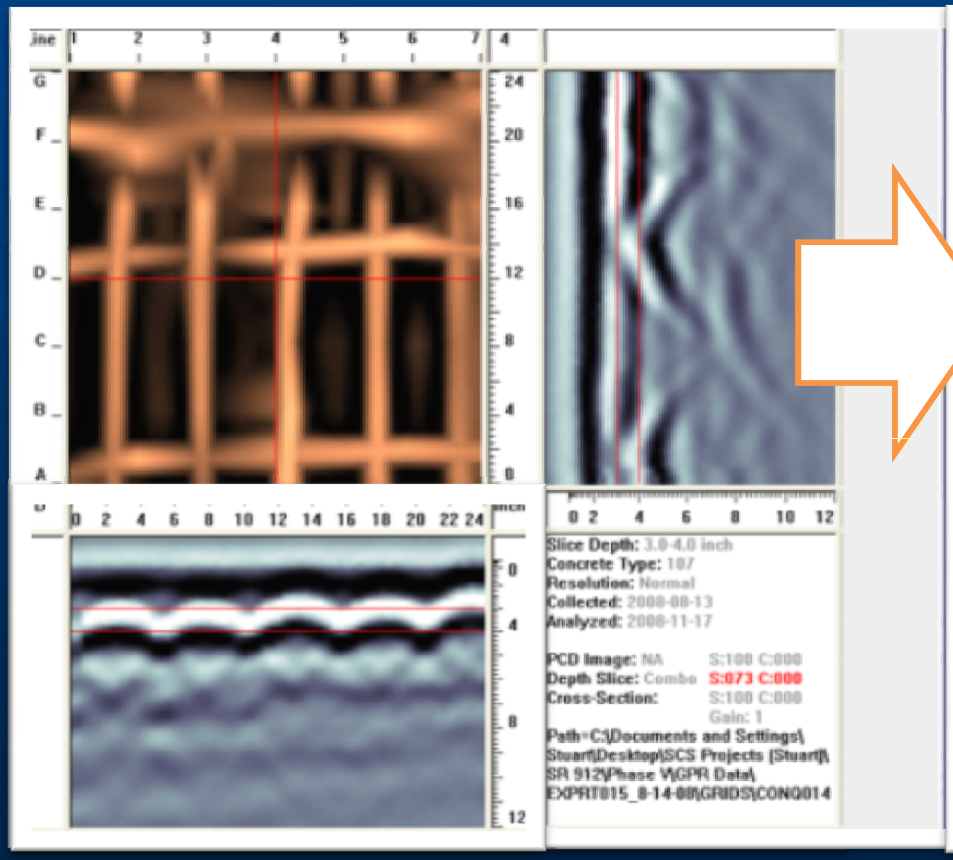


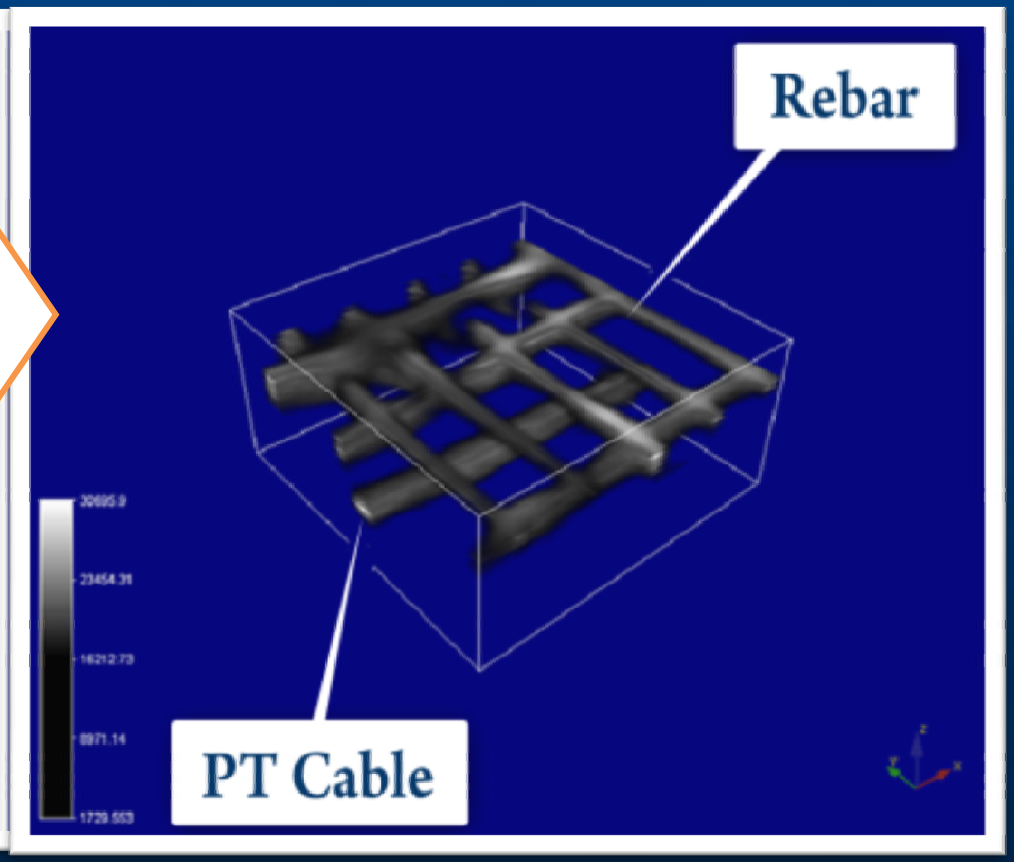
Questions?

Siva – Principal Engineer
Siva@SivaCorrosion.com
SCS Inc. (610) 692-6551
www.SivaCorrosion.com

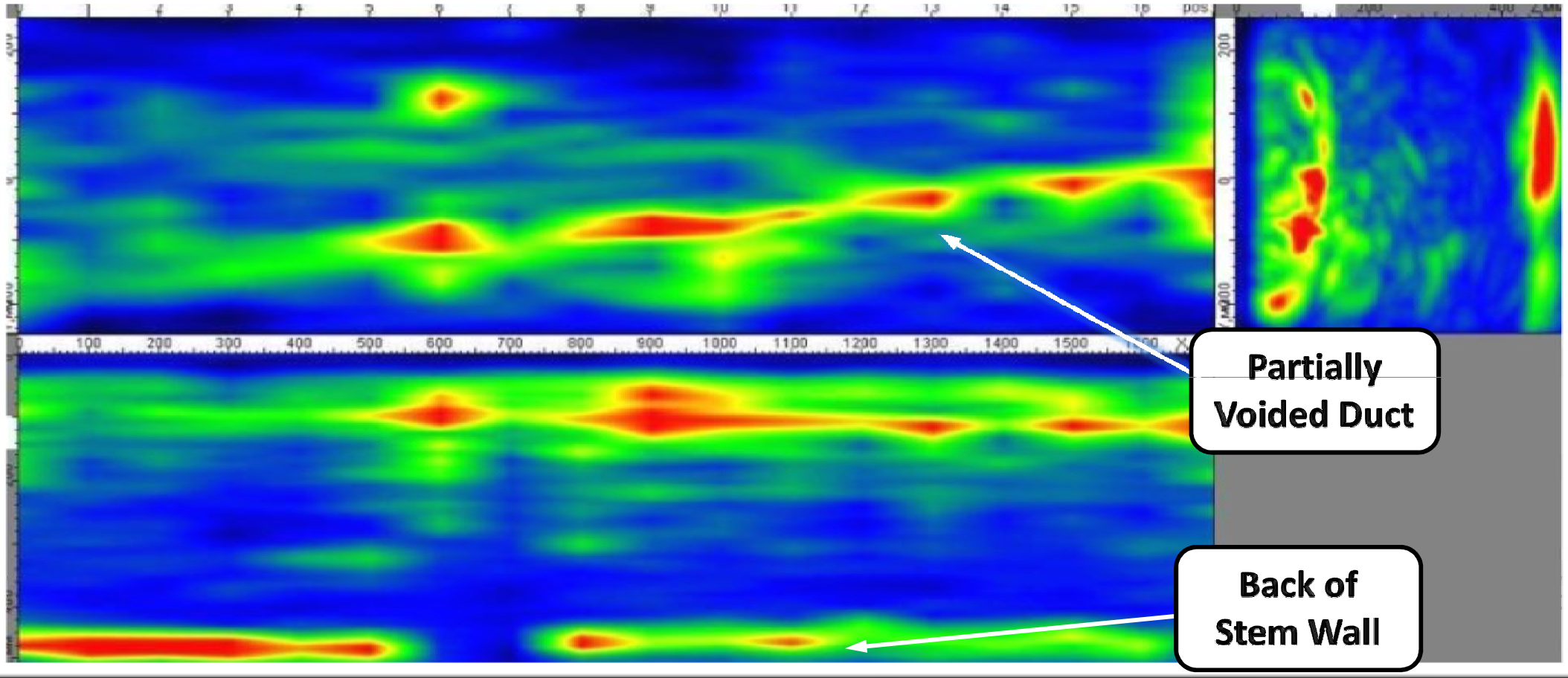
EXAMPLES OF NDT

GROUND PENETRATING RADAR (GPR)

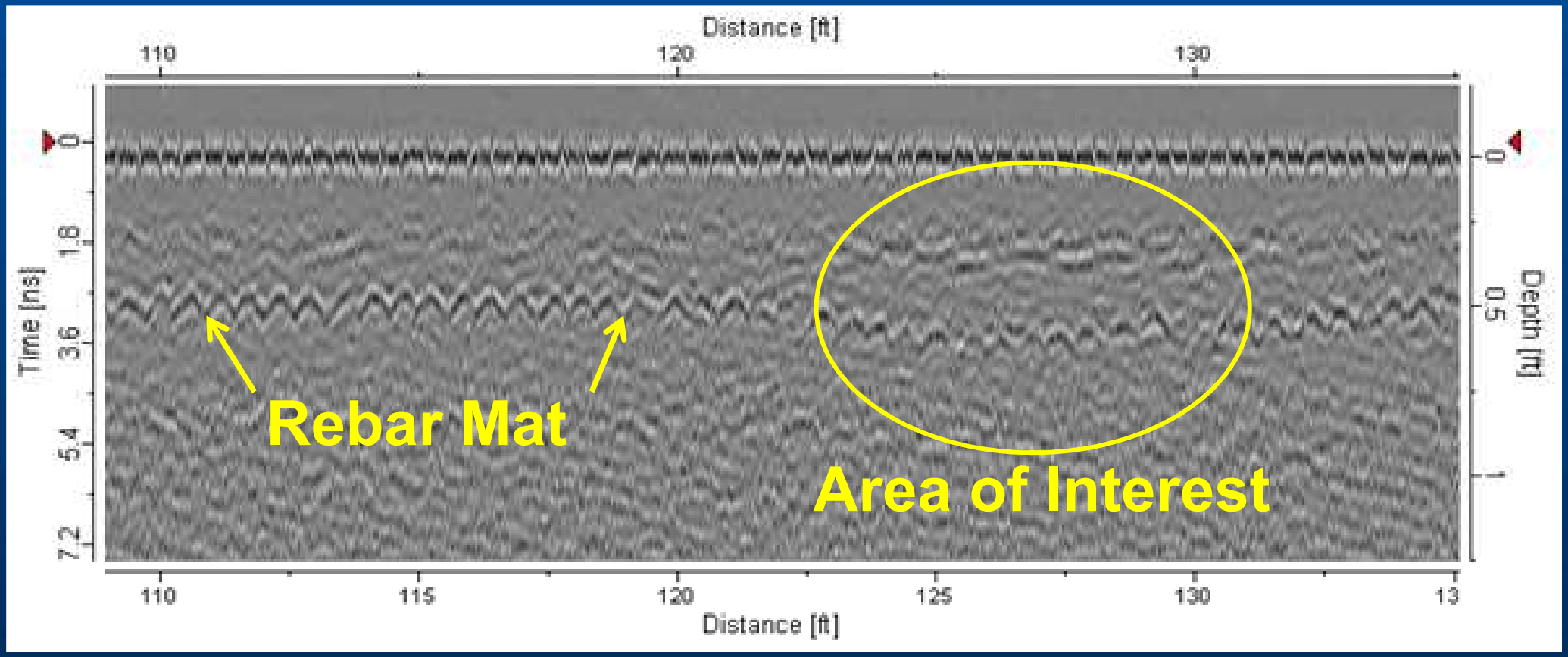




ULTRASONIC TOMOGRAPHY



ELECTROCHEMICAL TESTS


Distance [ft]
110
120
130
Time [ns]
0
1.8
3.6
5.4
7.2
Depth [ft]
0
0.5
1
Rebar Mat
Area of Interest
110
115
120
125
130
13
Distance [ft]