Nondestructive Testing to Better Define Repair Quantities

Brian Pailes, PhD, PE, NACE CP-4

Principal Engineer

Vector Corrosion Services

Issues Facing Owners

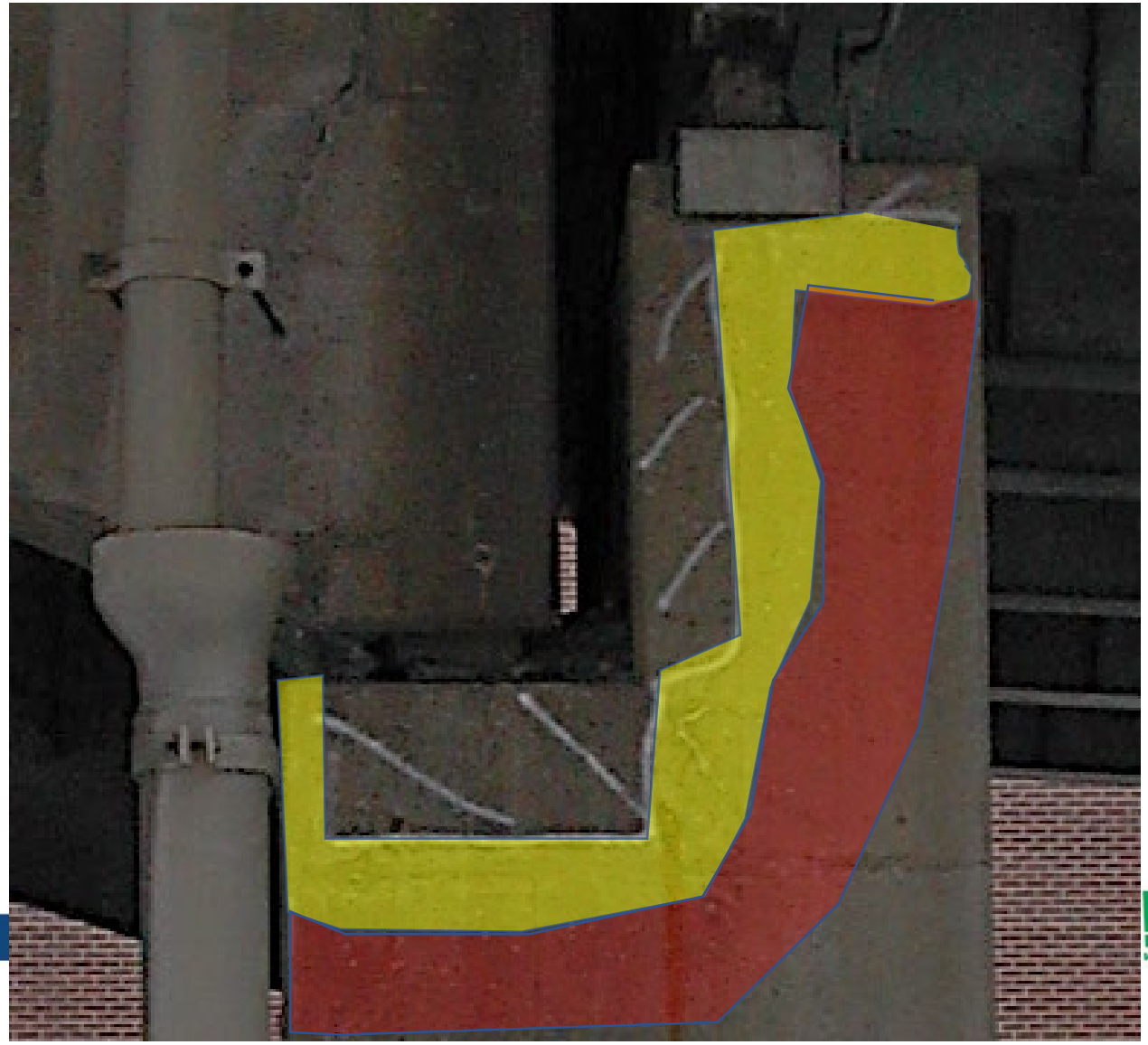
- How to properly determine repair quantities?
- Sounding and visual inspections are known to underestimate true repair area
- Impacts of underestimating repair quantities
  - Costly change orders
  - Increased project duration
- Time from inspection to construction can be long
  - Deterioration will have grown from last inspection
- **NOT JUST FOR DECKS!**

What is really happening in the concrete?

Large Near surface Delamination

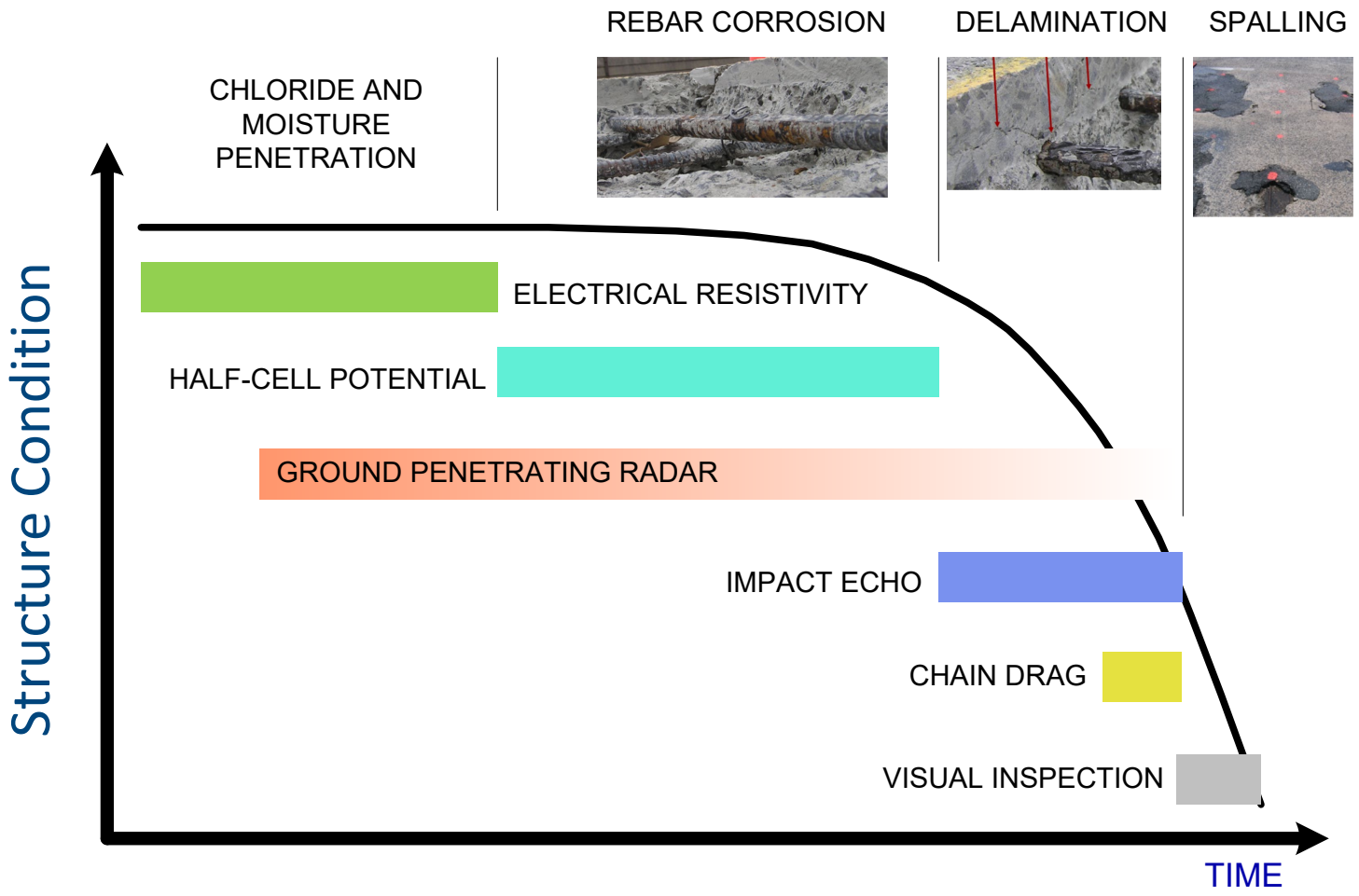
Extent of delamination beyond what sounding can pick up

Corrosion is active but has not formed enough iron oxide to create significant cracking



How can we better understand these incipient deterioration conditions?

Concrete Deterioration



Visual Inspection

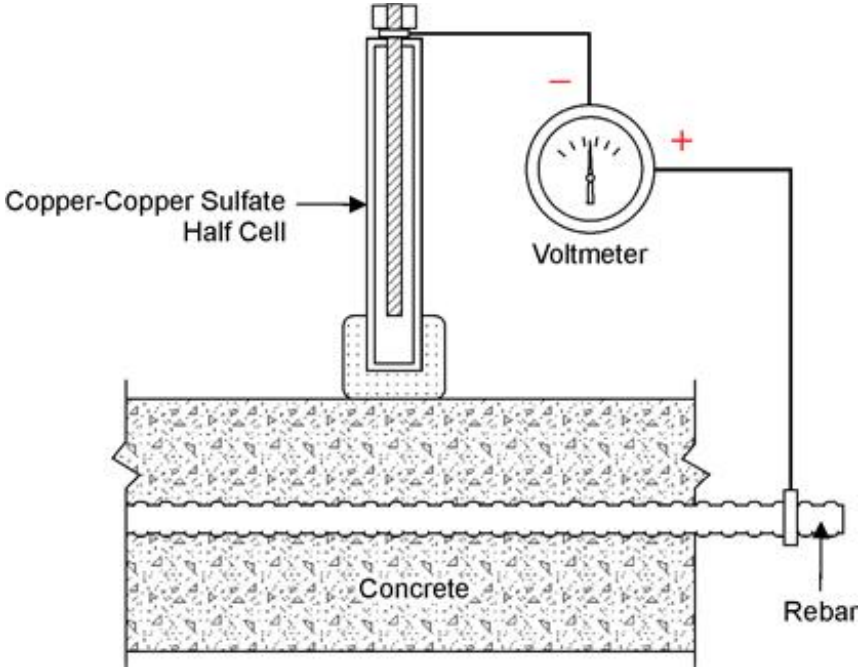
- Rust staining
- Cracking
- Spalls
- Exposed steel
- Water infiltration
- Efflorescence

Sounding Survey

- Hammer sounding or chain drag
- Locates areas of large near surface delaminations
- Incipient delaminations cannot be identified
- **False positives are rare**
- False negatives are common

Corrosion Potential Measurements

- ASTM C876 - also known as half-cell potential
- Determines probability of active corrosion



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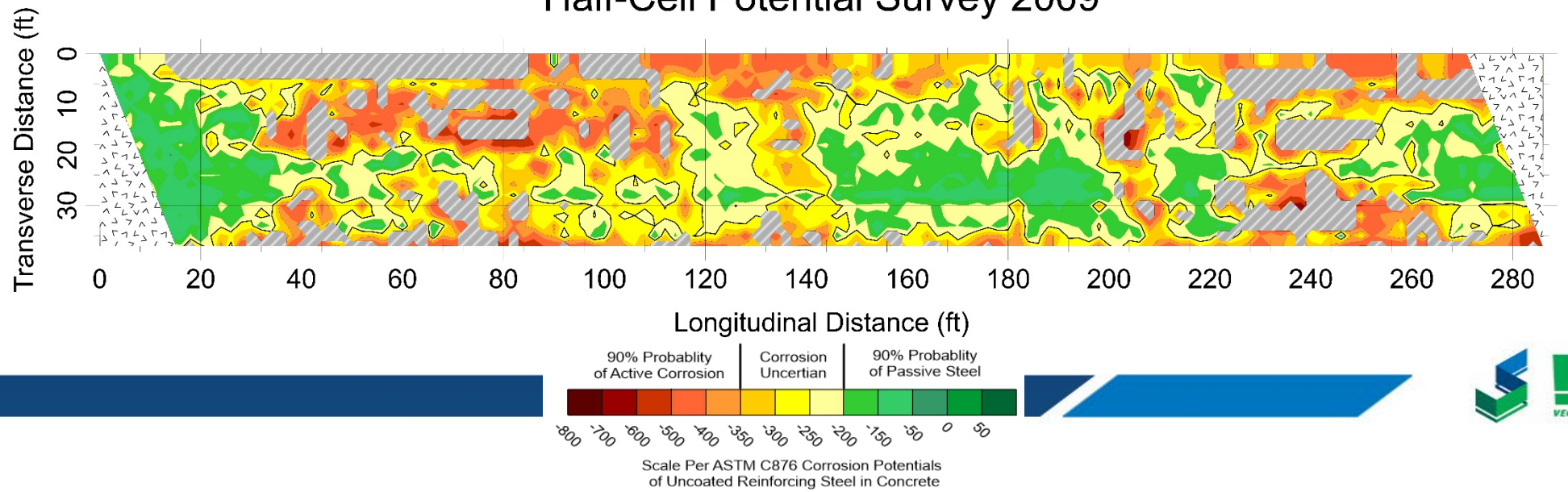
Corrosion Potential – Bridge Deck



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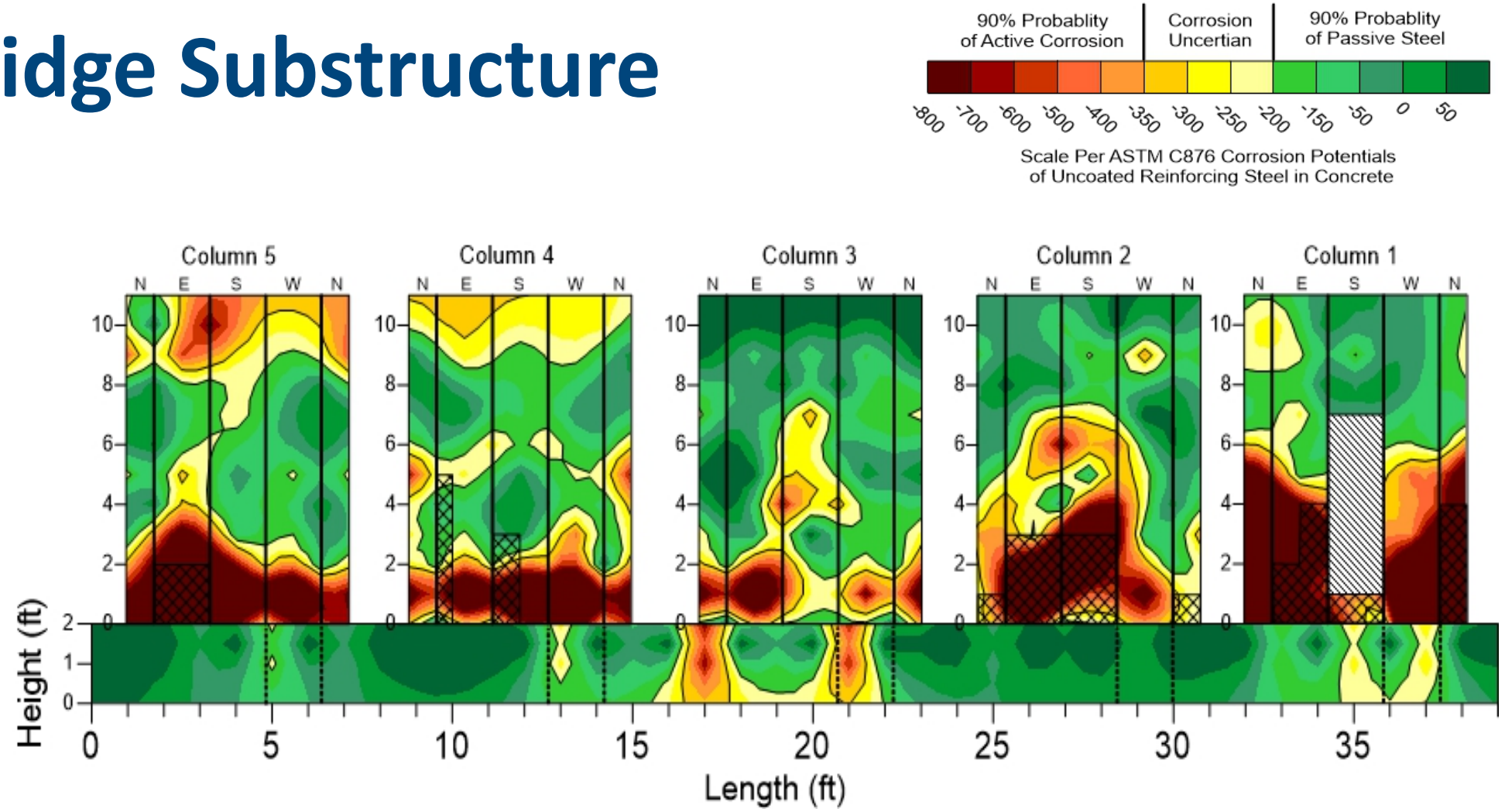
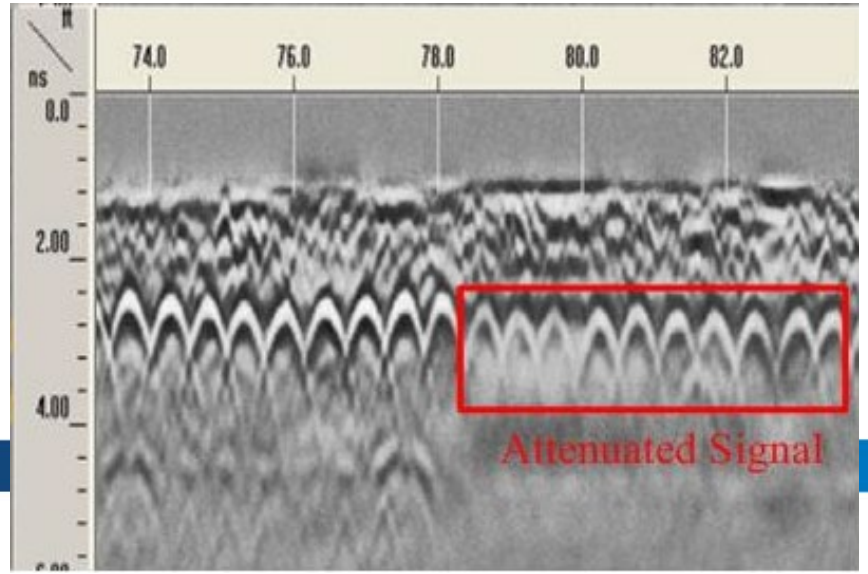
Corrosion Potential – Bridge Substructure

Corrosion Potential – Bridge Substructure



Ground Penetrating Radar

- Electromagnetic evaluation of concrete
  - Reinforcement layout
    - Location of embedded metals
  - Cover Depth
  - Qualitative condition of reinforced concrete
    - Chlorides, moisture, and concrete deterioration attenuate GPR signal



Cover Depth Survey

$$t = \left(\frac{d}{A}\right)^2$$

- Cover depth is an important factor in the service life of a structure
  - Reduced cover depths allow for chlorides and carbonation to reach steel faster

$$C_{(x,t)} = C_o\left(1 - erf\,\frac{x}{2\sqrt{D_c t}}\right)$$

$$t = \frac{1}{D_c}\left[\frac{x}{2 \times inverf\left(1 - \frac{C_{x,t}}{C_o}\right)}\right]^2$$

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GPR Cover Survey of Bridge Columns

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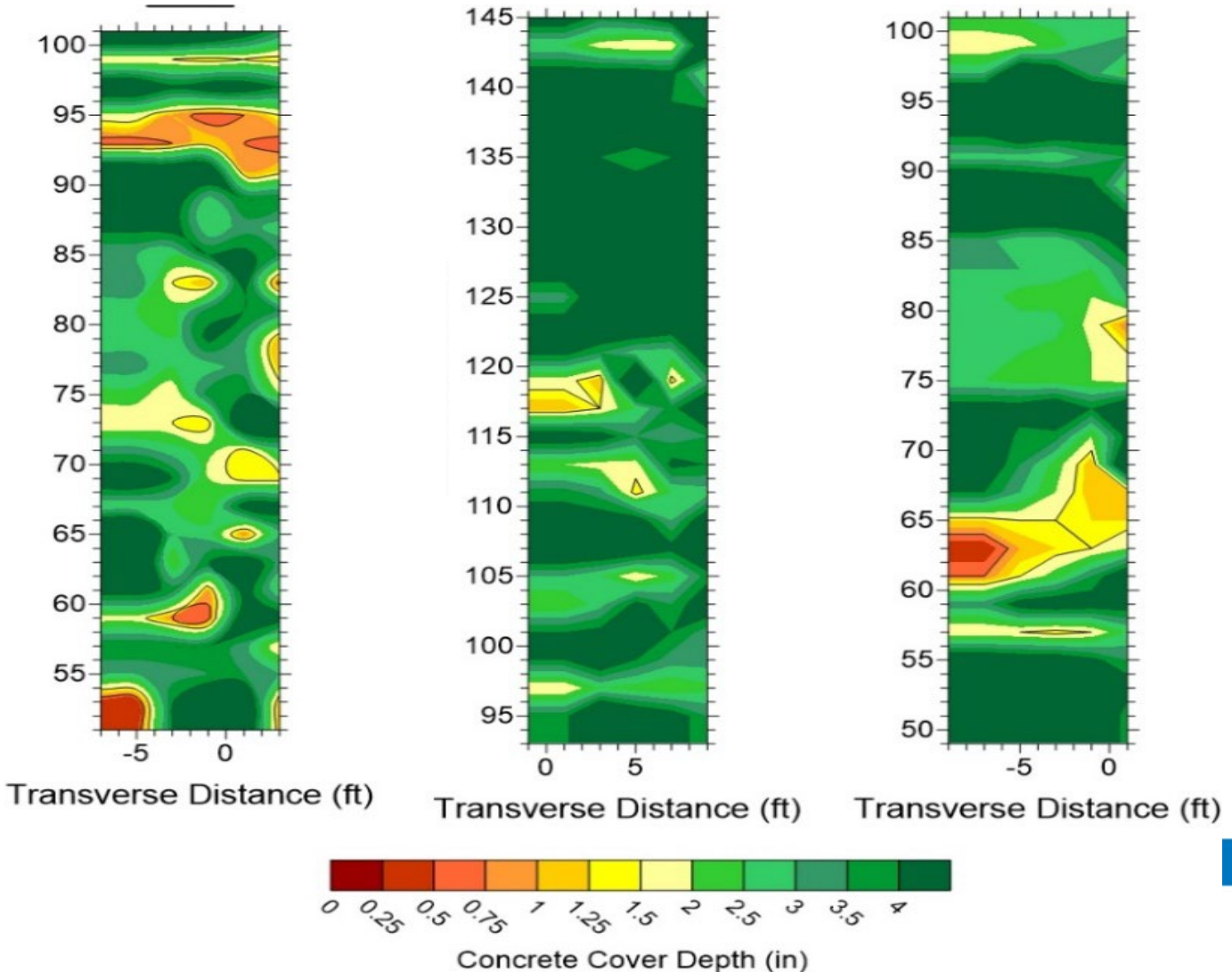
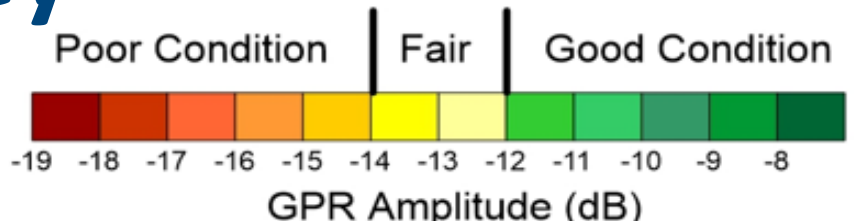
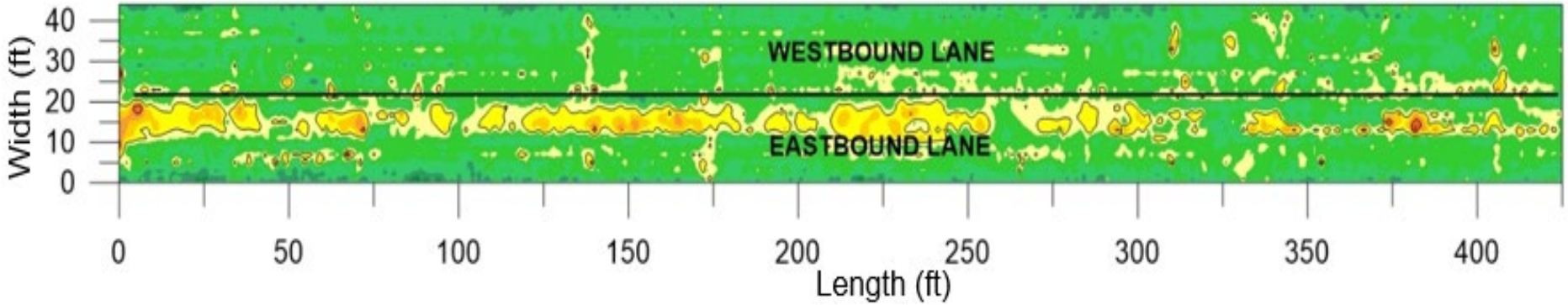
GPR Cover Survey of Bridge Columns

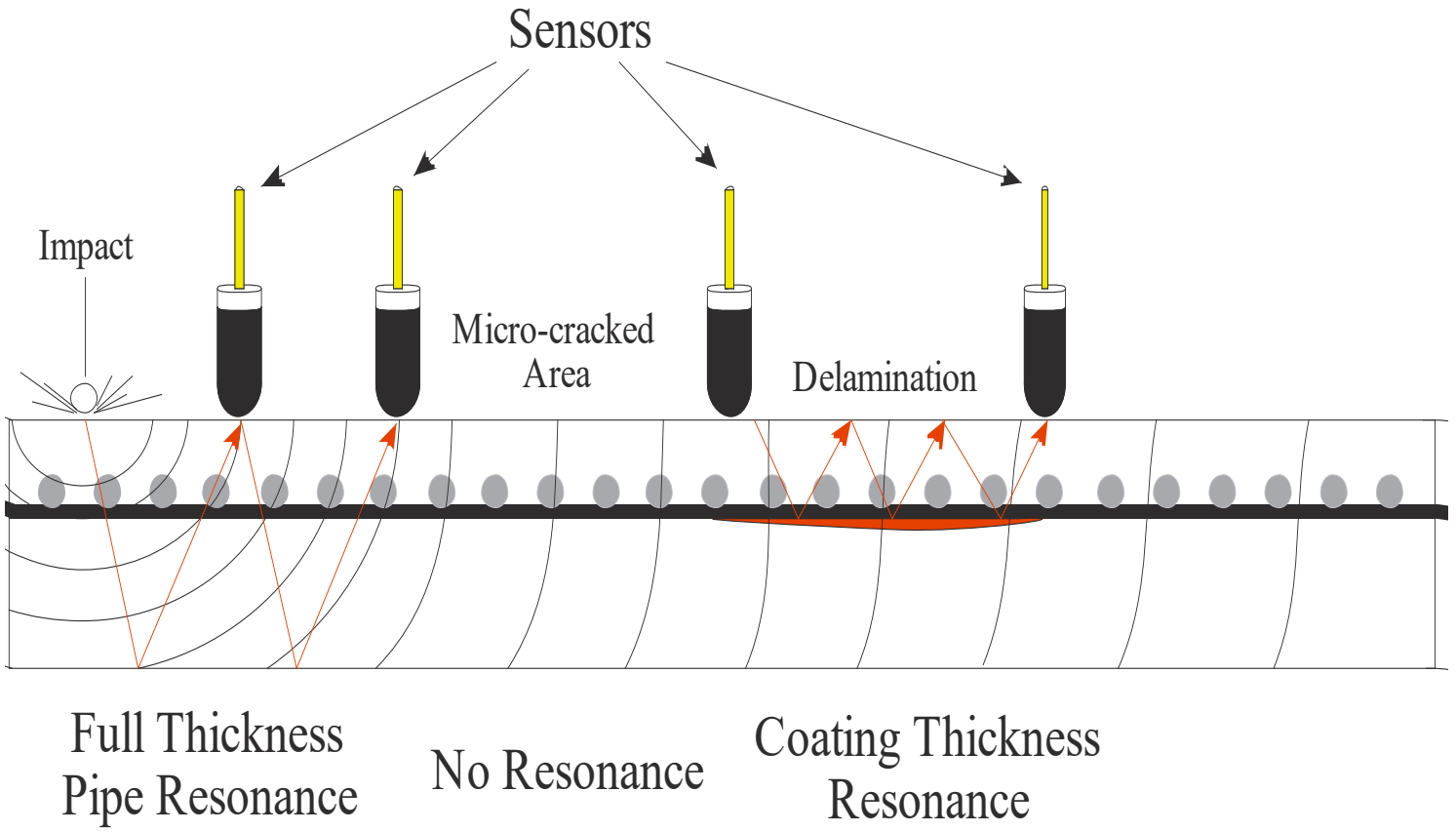


GPR Amplitude Survey
Bridge deck

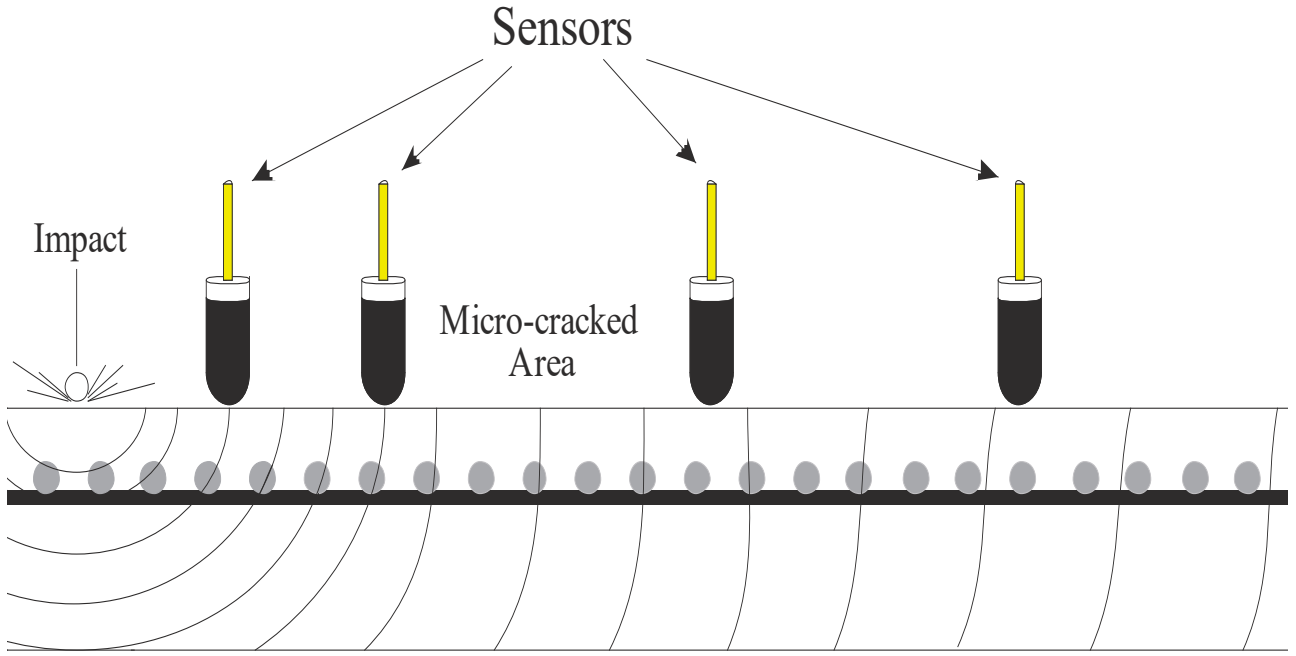




Acoustic Methods – Impact Echo



Acoustic Methods – Surface Wave Velocity

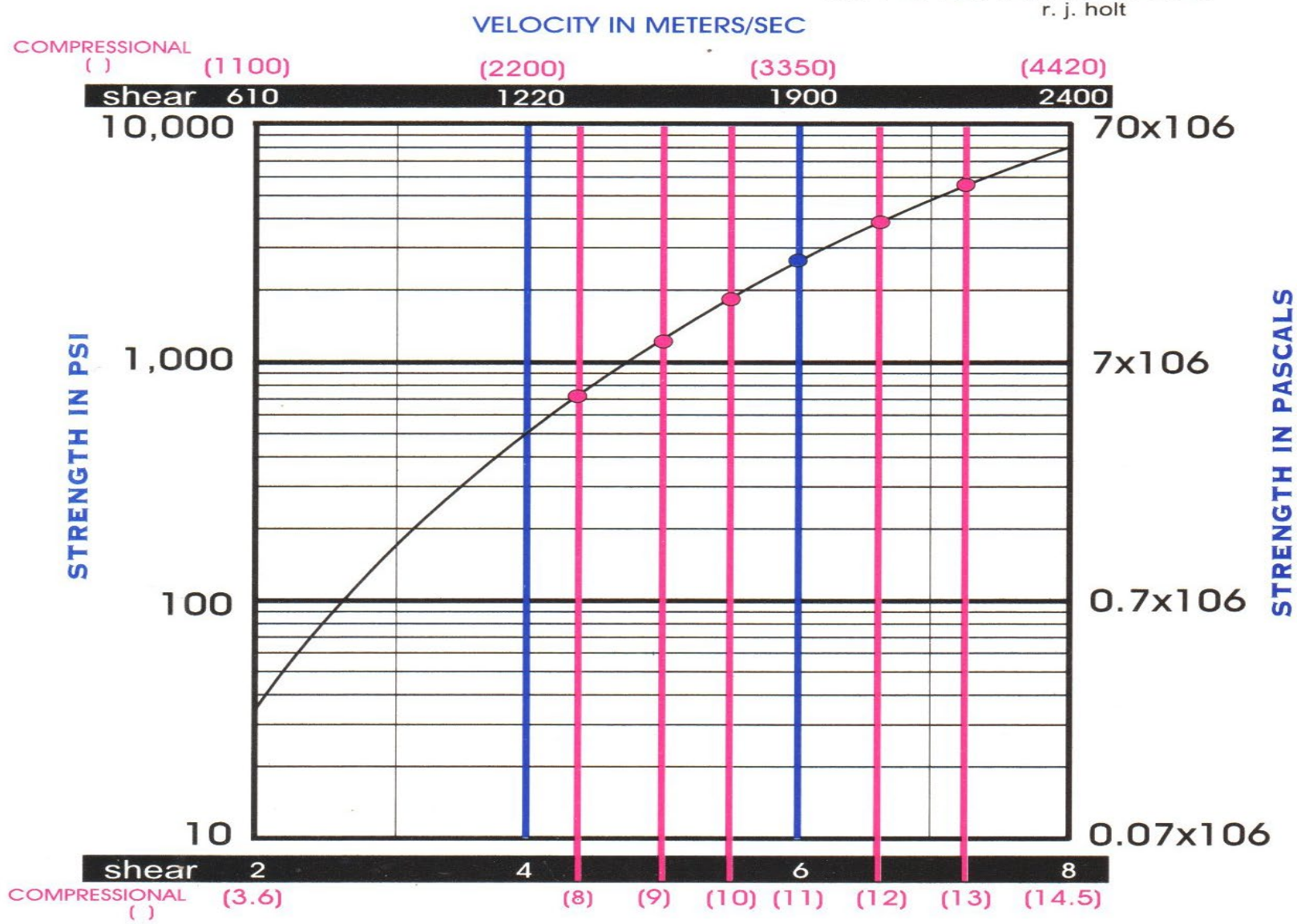


Normal Compressional and Shear Wave Velocity Values

Lower Compressional Velocity and Lower or Loss of Shear Velocity Values

STRENGTH OF CONCRETE VERSUS VELOCITY

NDT ENGINEERING, INC.
r. j. holt



CURVE IS FOR THE RATIO: $v_{SHEAR} / v_{COMPRESSIONAL} = 0.55$
WHICH IS EQUAL TO A POISSON'S RATIO OF 0.28

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Deck Testing

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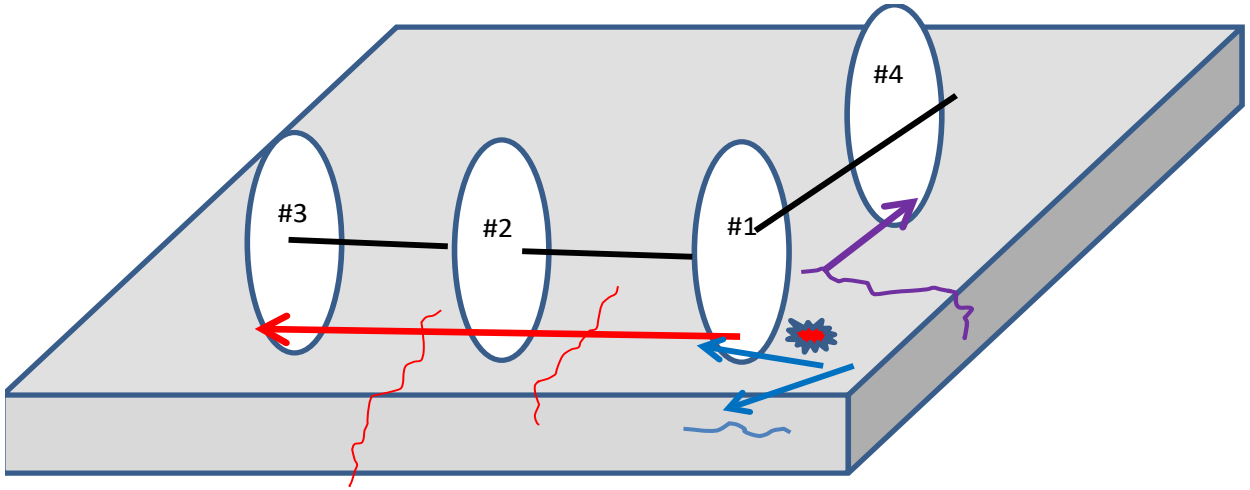
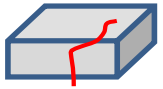
Deck Testing



1)  Deck delaminations impact echo measurements at sensor #1

2)  Longitudinal partial deck cracking measurements at sensor #2

3)  Longitudinal full deck cracking measurements at sensor #3

4)  Transverse deck cracking measurements at sensor #4

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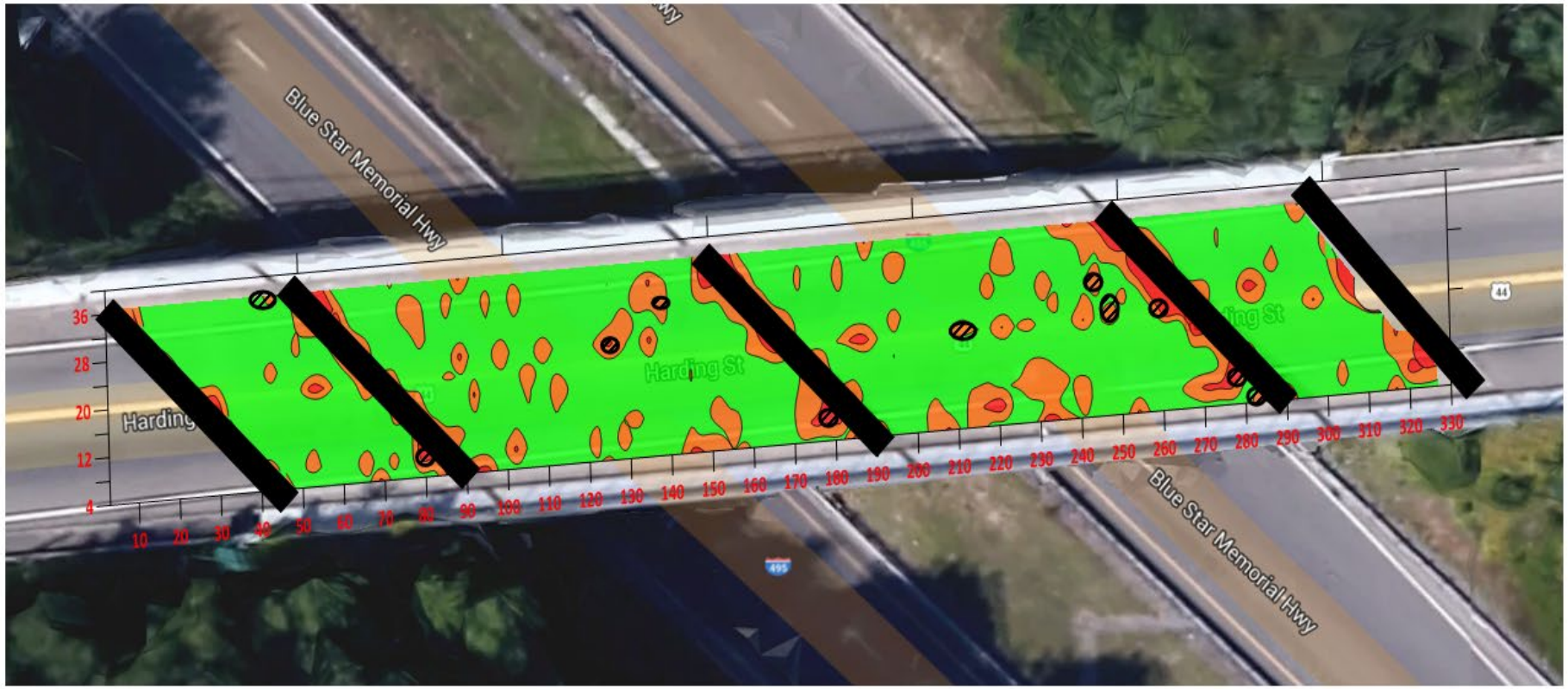
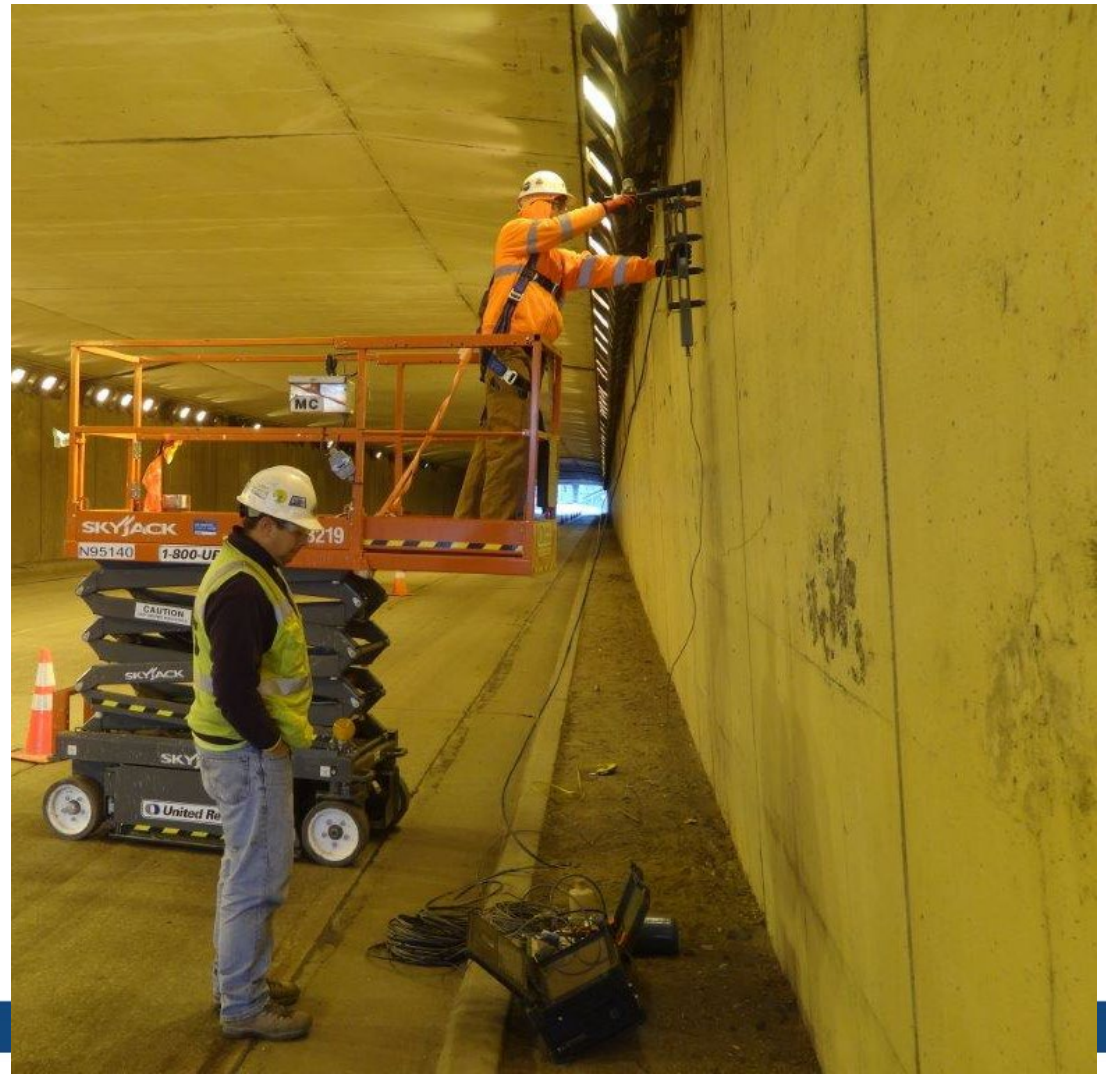
Location of Delaminations



Substructure Testing



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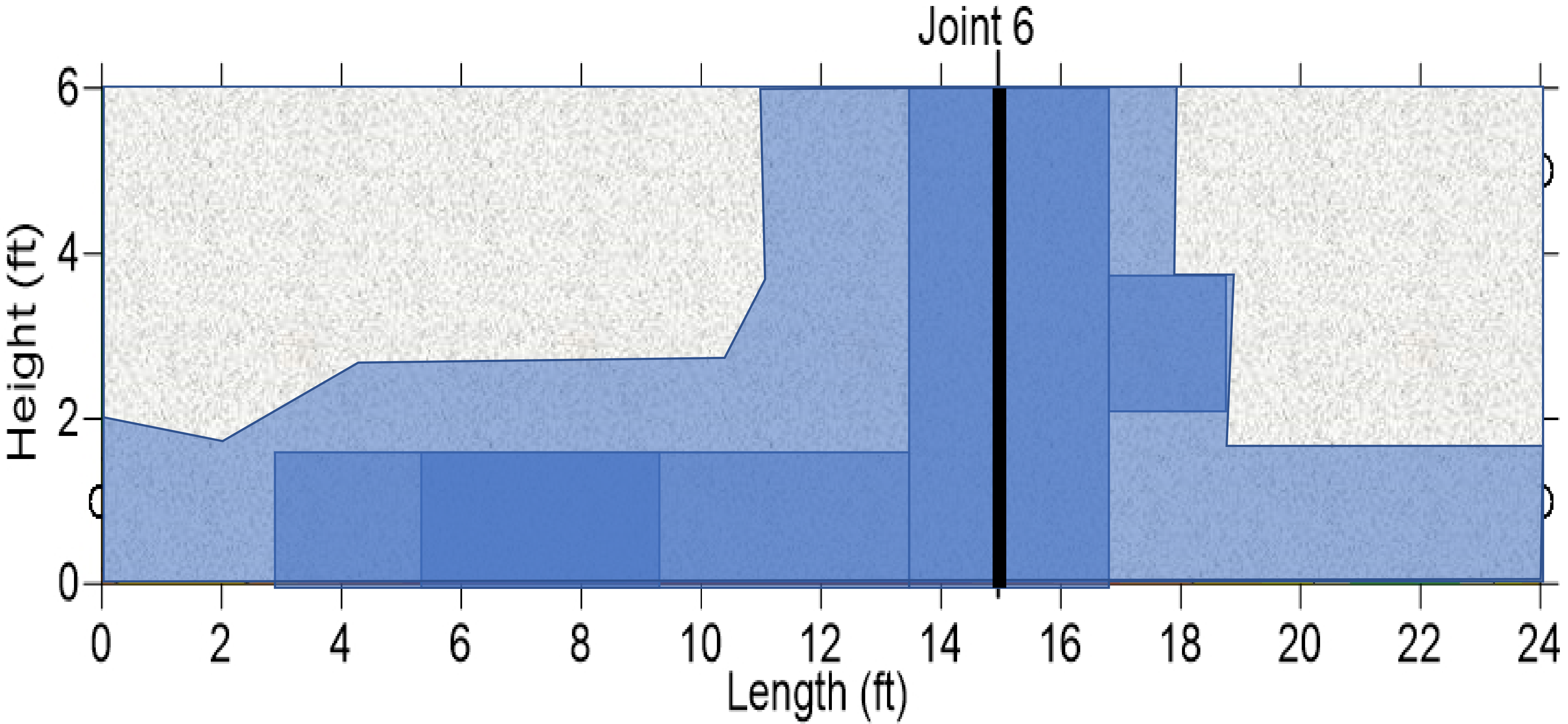
Delamination Found by Impact Sounding
In-Situ Compressive Strength
Repair Area



Thank you!

Questions?