

USING INFRARED THERMOGRAPHY FOR NON- DESTRUCTIVE EVALUATION OF BRIDGES

SHRP2 R06A Peer Exchange

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NDDOT Bridge Division



Impact Echo Apparatus

- Impact Echo
- Ultrasonic Pulse Echo
- Ultrasonic Surface Waves
- Impulse Response
- Ground Penetrating Radar (GPR)
- Half-Cell Potential
- Galvanostatic Pulse Measurement
- Electrical Resistivity
- IR Thermography
- Chain Dragging (Sounding)

Most require specialized equipment and/or training to use and interpret

NON-DESTRUCTIVE EVALUATION (NDE) METHODS FOR BRIDGE DECKS

CHAIN DRAGGING

Advantages:

- **Accurate - Most commonly used method for determining delamination**
- **Simple to use**
- **Delamination is indicated by hollow sound as compared to a clear ringing in sound concrete**

Limitations:

- **Can be difficult to hear in noisy surroundings**
- **Dependent on inspector's hearing and experience**
- **Fairly time-consuming – chain has to touch every part of the deck**

Are there other NDE methods we can use to assist with Bridge Deck assessment?

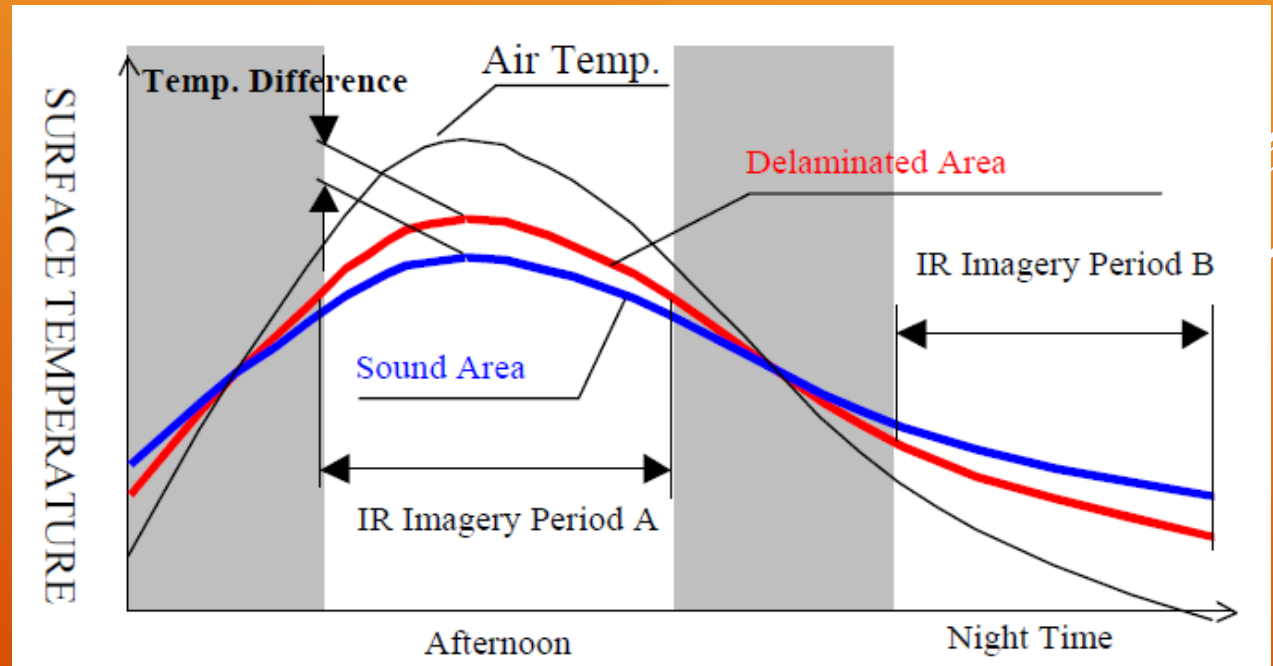
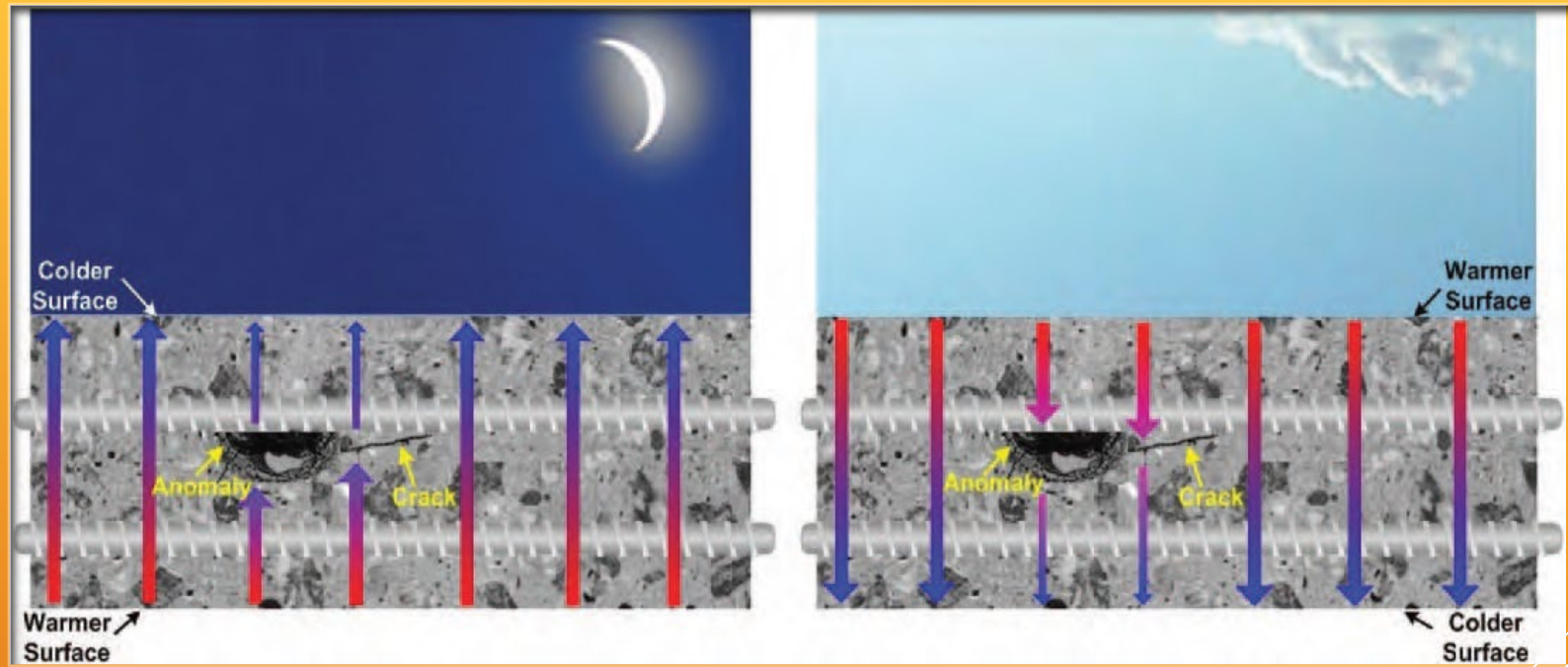


NDDOT AWARDED SHRP2 R06A GRANT, SEPT. 2016



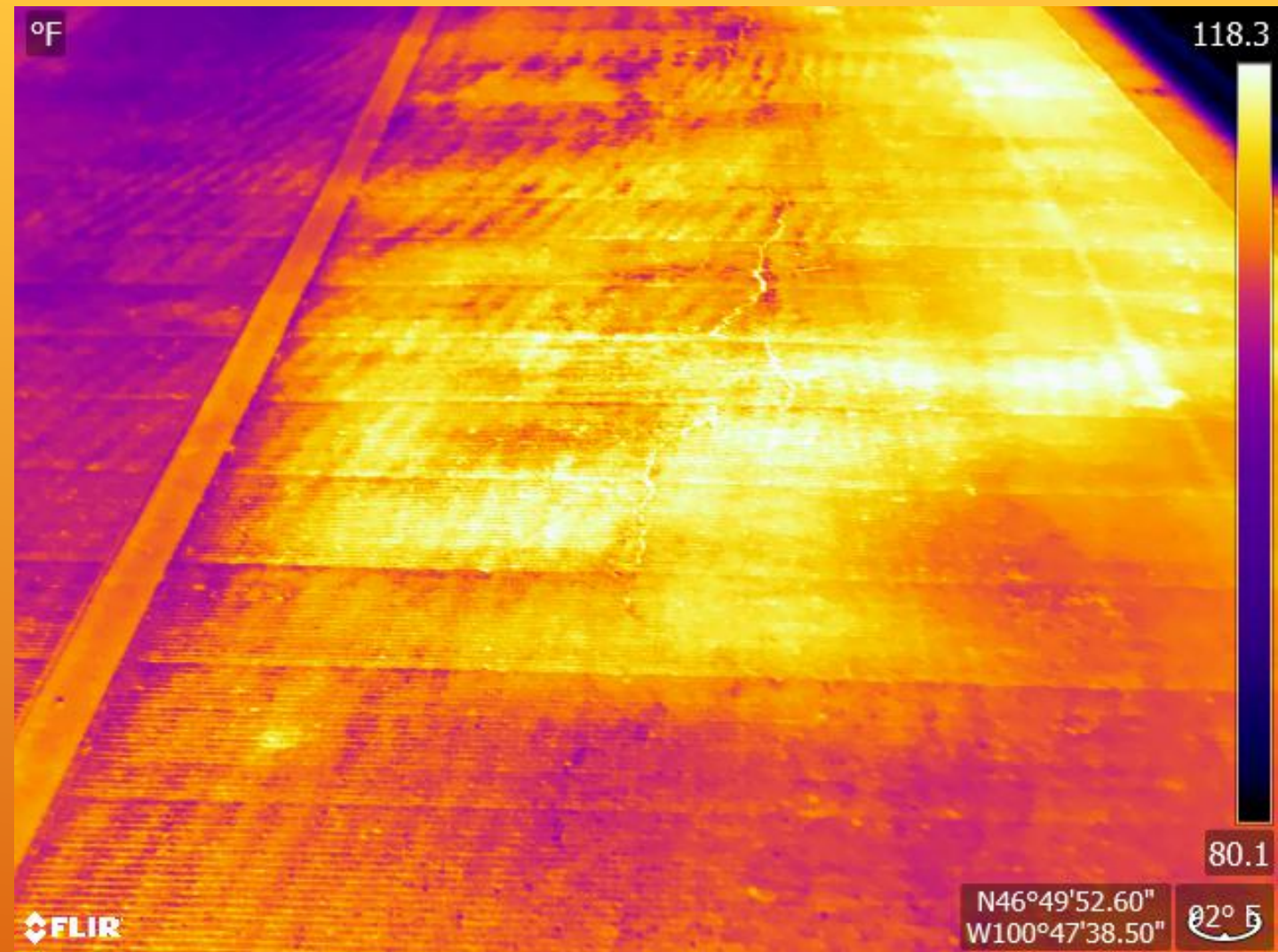
- **Purchase of Infrared camera**
 - Researched and tested several
 - Purchased FLIR T620 – March 2017
- **SME Training**
 - Provided training in Bismarck – May 2017
- **Additional training and NDE tools**
 - ITC (Infrared Training Center) Level I Certification
 - Delam Tool

- Variations in the surface temperature of the bridge deck indicate areas of discontinuity
- Uniform material of uniform depth (sound concrete) heats and cools relatively uniformly
- Uniform material of differing depths heats and cools non-uniformly

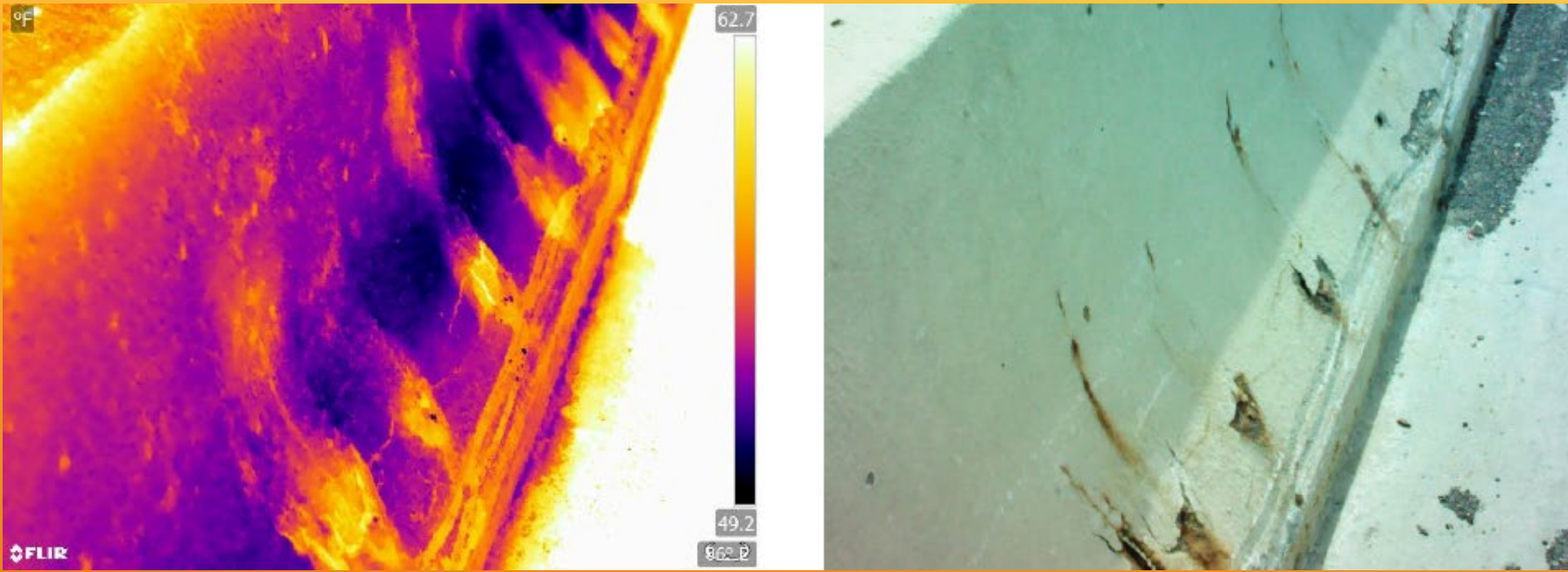


USING IR NDE FOR BRIDGE DECK ASSESSMENT

- ▶ Areas of a bridge deck with discontinuities will warm and cool more rapidly than the surrounding sound concrete.
- ▶ Using an infrared camera to observe these areas will help identify the presence of:
 - ▶ Delamination
 - ▶ Cracking
 - ▶ Voids/Anomalies



USING IR NDE FOR BRIDGE DECK ASSESSMENT

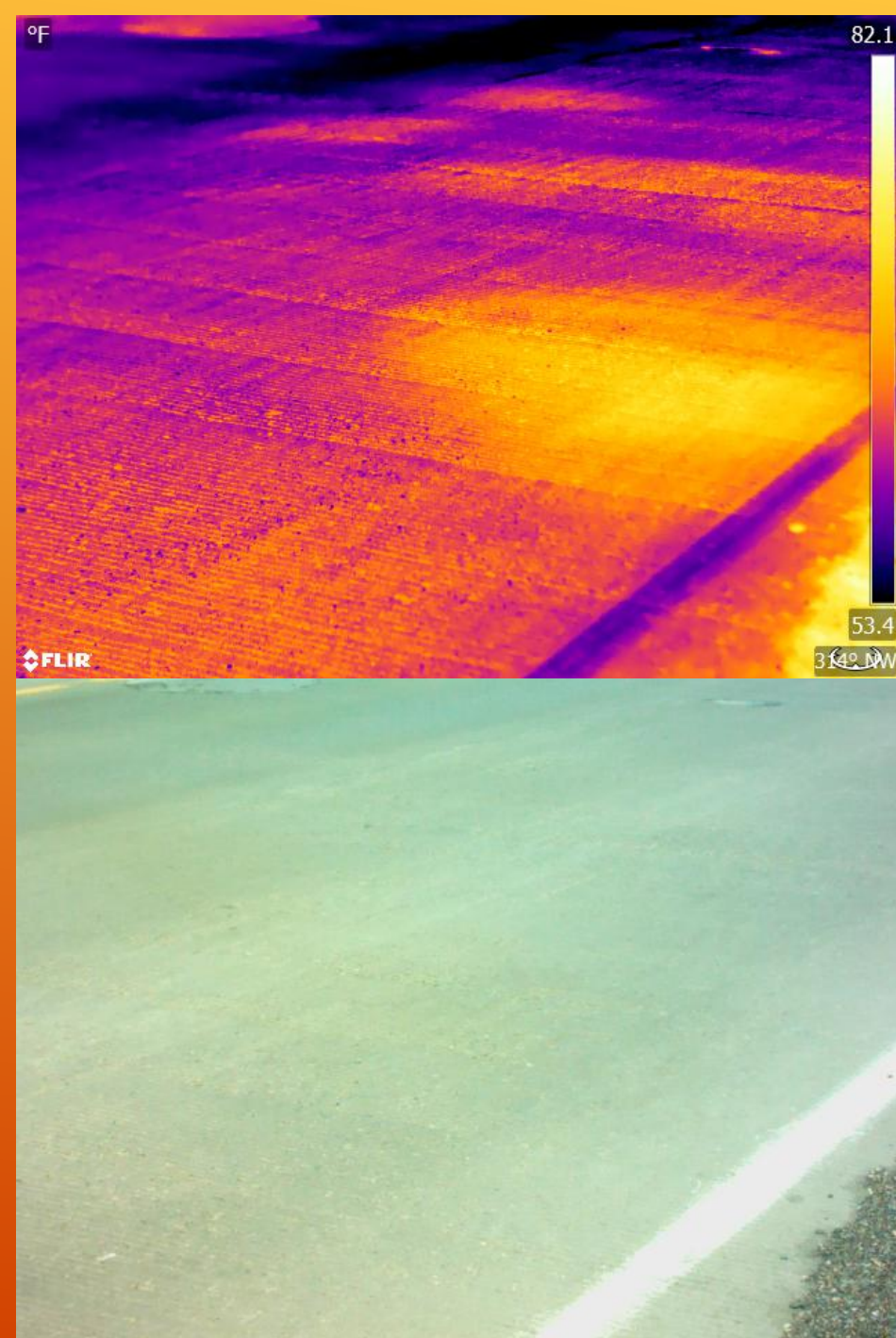


Barriers

USING IR NDE FOR
ASSESSMENT OF
OTHER BRIDGE
ELEMENTS

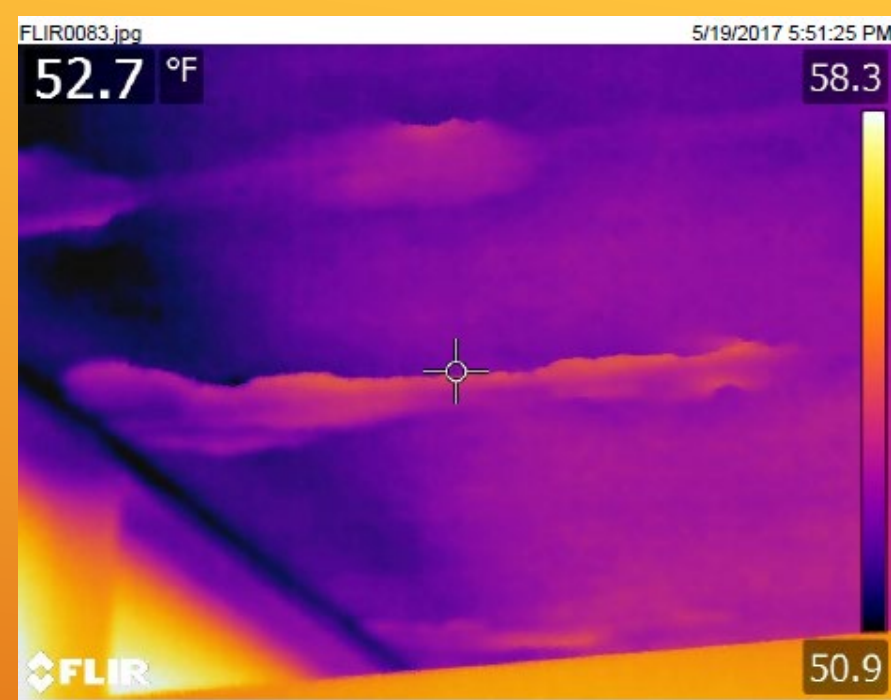


Beams



ADVANTAGES OF USING IR THERMOGRAPHY

- **Non-contact**
- **Ability to capture images from a distance minimizing traffic disruption and increasing safety**
- **Not affected by external noise**
- **Not dependent on inspector's hearing**
- **Less time consuming than chaining**
- **Physical image to review**
- **Images relatively easy to interpret**







ADVANTAGES OF USING IR THERMOGRAPHY

- Can use on vertical surfaces such as barriers, piers, abutments, etc.
- Can be used on underside of deck
- Camera is relatively easy to use

Another tool to help assess our bridge condition

Better understanding of bridge condition – better project planning

| Current Conditions | Deck Daytime | Shaded Daytime | Shaded Nighttime |
|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  |  |  |  |
| Inspection Window | 10/26/2017 12:17:00 PM to 10/26/2017 6:17:00 PM | 10/26/2017 12:17:00 PM to 10/26/2017 8:17:00 PM | 10/26/2017 7:36:00 PM to 10/27/2017 4:36:00 AM |
| Time until Inspection (hh:mm) | 02:15 | 02:15 | 05:04 |
| Time left to Inspect (hh:mm) | 03:45 | 05:45 | 09:00 |
| Temperature Increase/Decrease 6 Hr After/Before Sunrise/Sunset(Degree F) | N/A | -2.0 | -2.1 |
| Past 3hr Temperature Change (degree F/Hr) | -0.4 | -0.4 | -0.4 |
| Temperature Change Maximum (degree F) | N/A | 25 | -38 |
| 3 Hr Windspeed Average (mph) | +26.9 | N/A | N/A |

CHALLENGES OF USING IR THERMOGRAPHY



• Weather

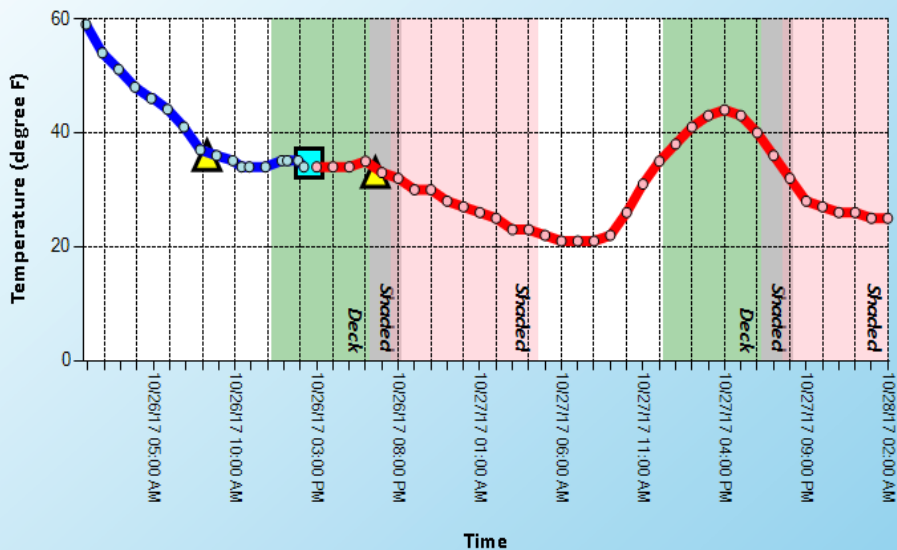
- Optimal weather – Sunshine, low humidity, calm winds, fairly large temperature changes (10° F minimum; 20° F or more is best)
- Due to thermal sensitivity of T620 can operate in less than optimal conditions

• Timing

- Typically the daytime “window of opportunity” begins about 4-6 hours after sunrise and continues for about 4-6 hours

Temperature at Bismarck, ND

Time Zone CDT (America/Chicago)

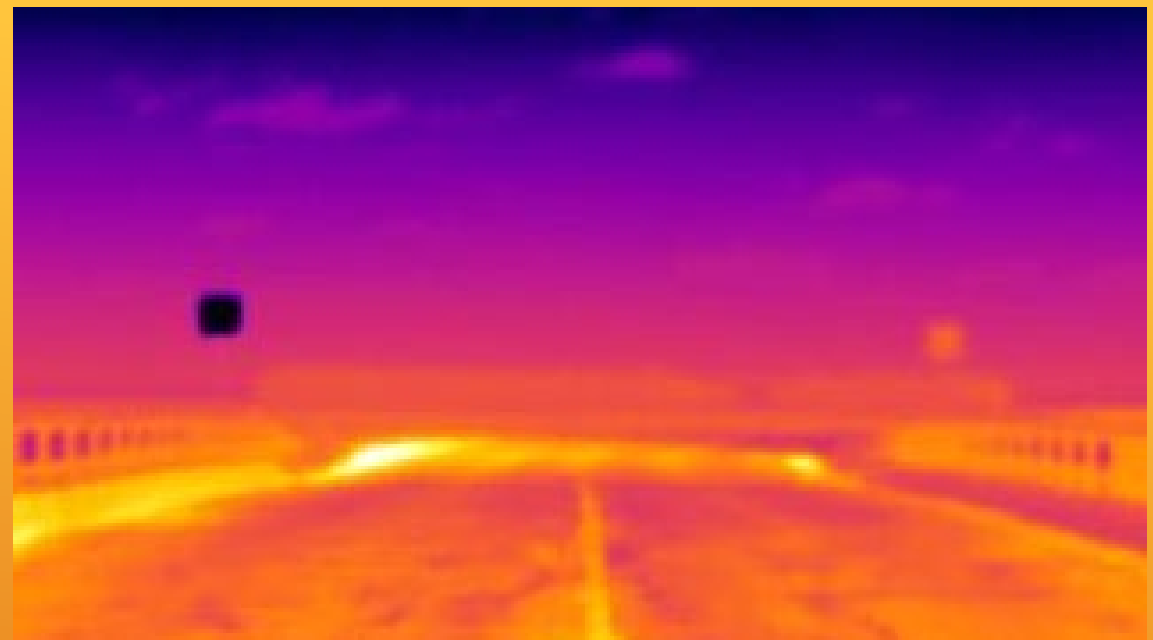


Temperature (F)

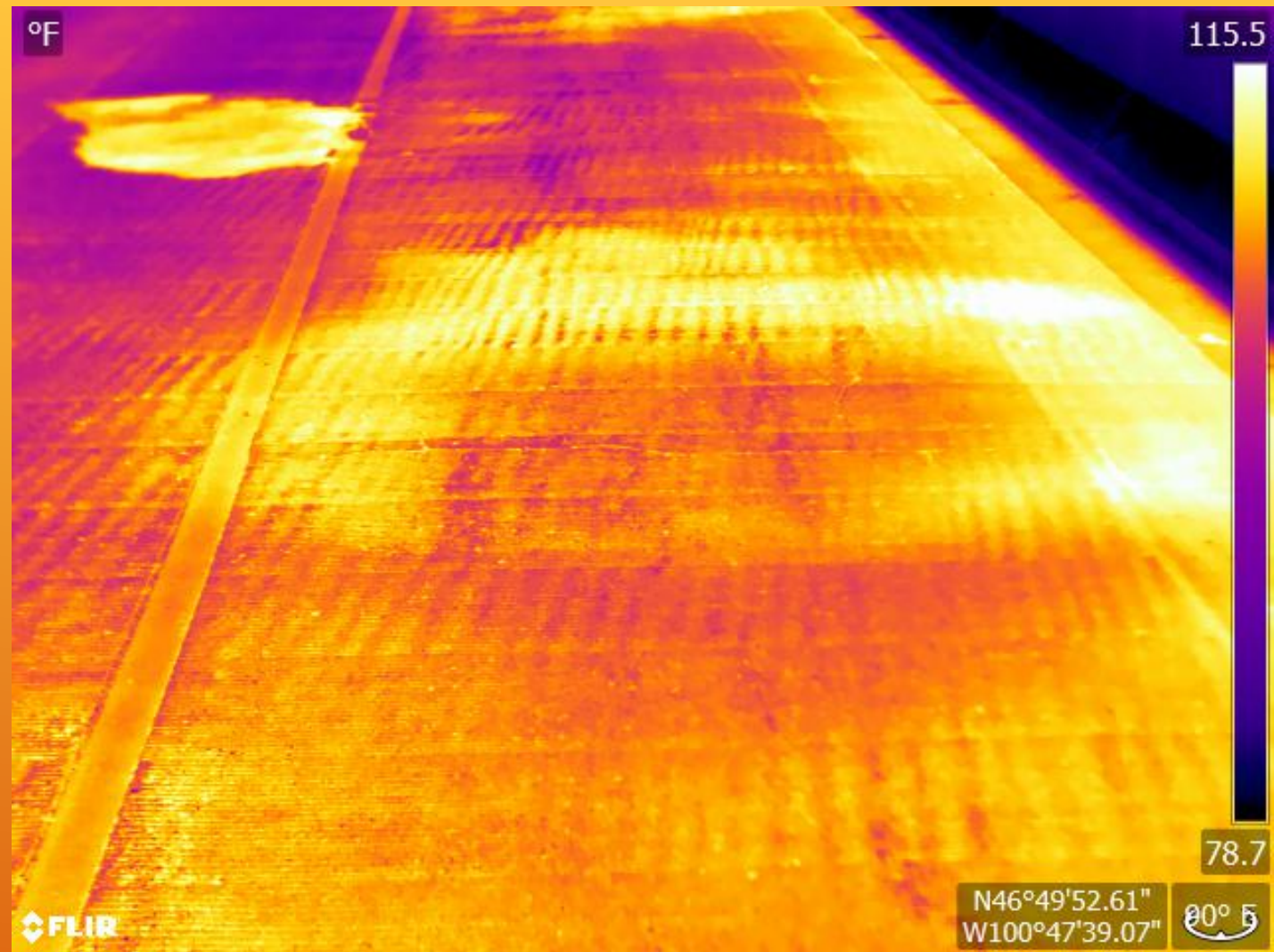
■ Current ▲ Sunrise — History ● History Pt — Forecast ● Forecast Pt
▲ Sunset

- Potential misinterpretation of image
- Different materials have different emissivities
 - Emit differing amounts of “heat”
 - Concrete has a high emissivity – typically appears close to actual temperature
 - Asphalt has a very high emissivity
 - Shiny metals typically have low emissivities – can’t trust apparent temperature
- Need to understand *what* you are seeing and *why* it appears as it does

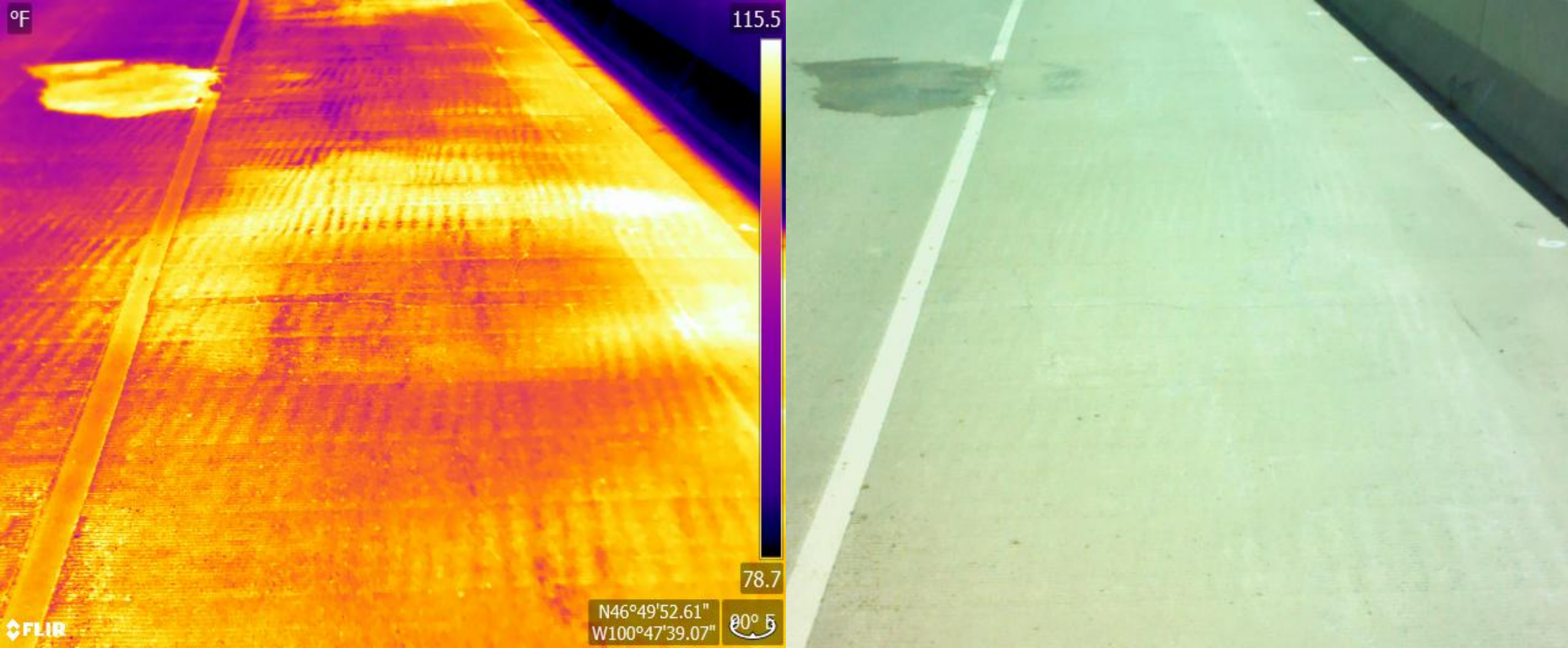
CHALLENGES OF USING IR THERMOGRAPHY



- Potential misinterpretation of image
- Other
 - Shade or shadows
 - Reflected IR radiation
 - Moisture
- Need to understand what you are seeing and why it appears as it does



CHALLENGES OF USING IR THERMOGRAPHY



CHALLENGES OF USING IR THERMOGRAPHY

Unique opportunity to test locally

- ▶ Coordinated with Materials and Research Division and Bismarck District Construction
- ▶ Measured and marked 10' grid on deck
- ▶ Used IR camera to systematically image deck
- ▶ Bismarck District chained and marked areas of delamination
- ▶ Reimaged deck with IR camera for comparison

Bernie Southam, Tyler Wollmuth, Loren Lee, Travis McCloud,
Bismarck District;

Seung Baek, and T. J. Murphy, Materials and Research

Brian Raschke, Bridge Division

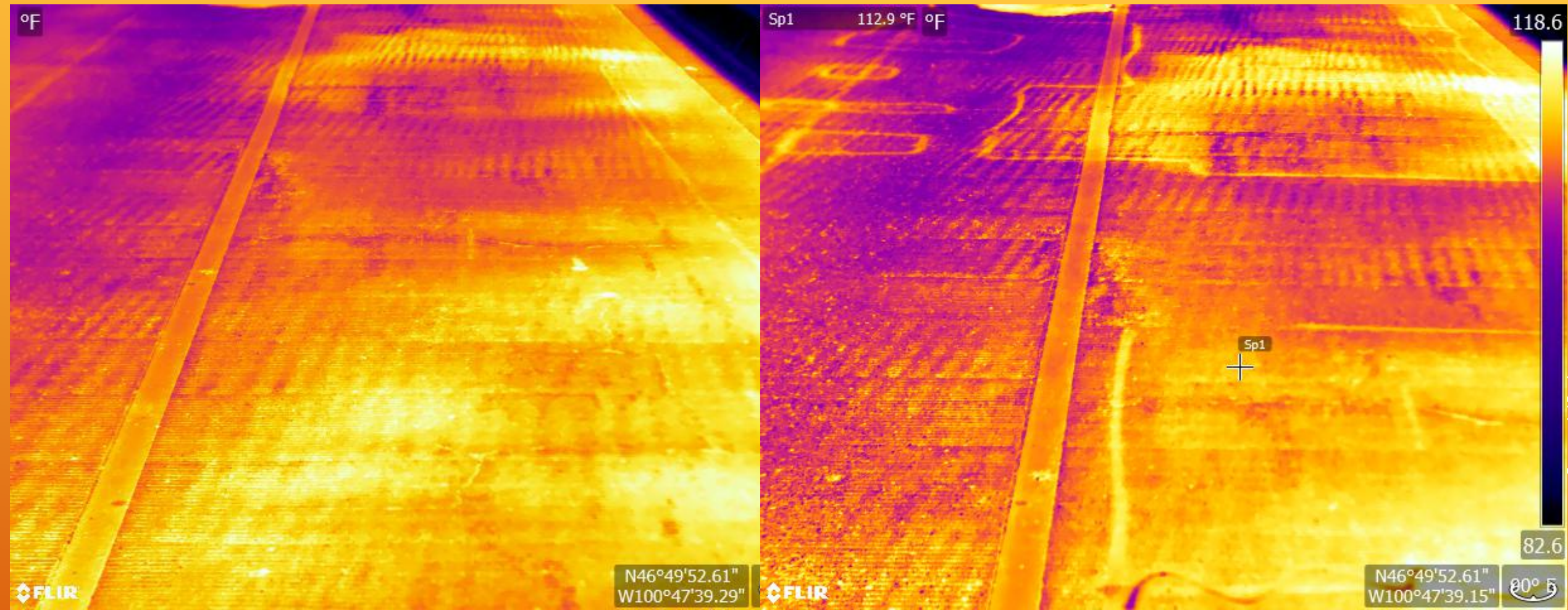


FIELD TESTING AT NDDOT 194 RECONSTRUCTION, BISMARCK

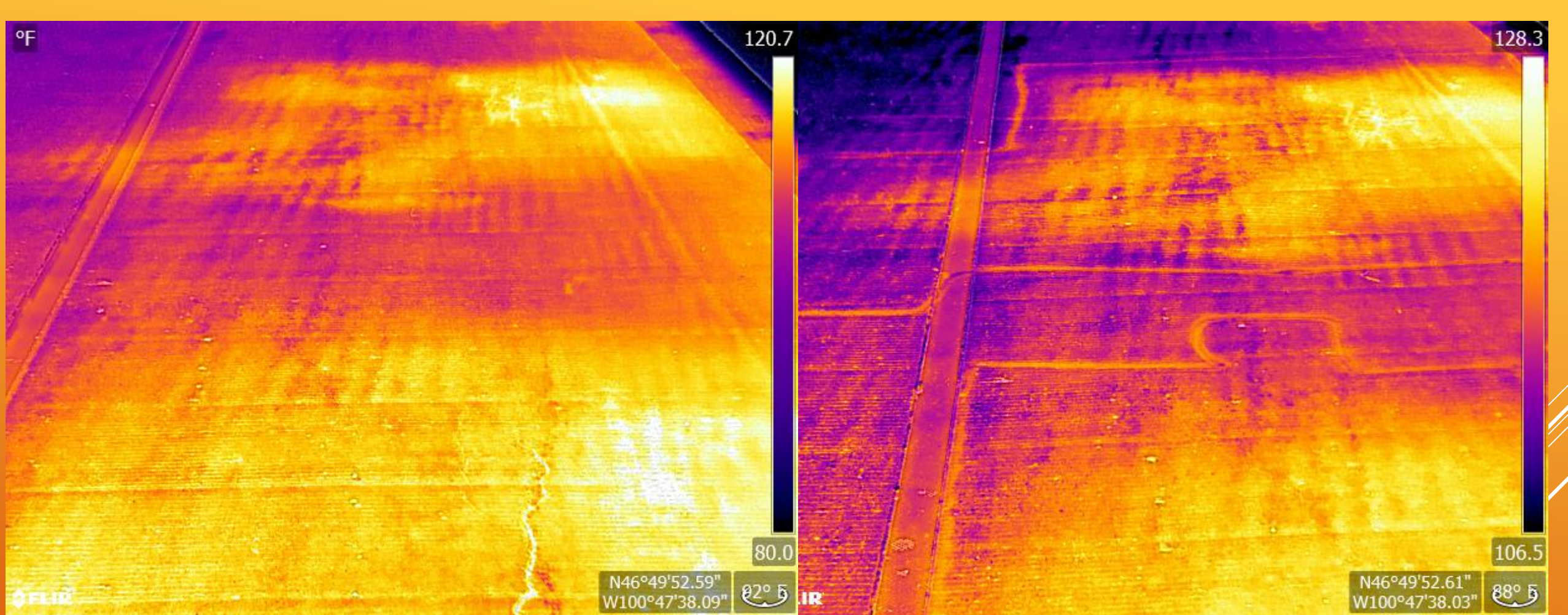
- ▶ Marking and labeling at 10' intervals along right, left, and center of bridge took about 10 minutes
- ▶ Thermal imaging of the deck took about 8 minutes (about 36 images)
 - ▶ 3 passes; 12 images per pass
- ▶ Chaining took about 45 minutes with 3 people working (2 hrs 15 minutes work time)
 - ▶ Included marking delaminated areas



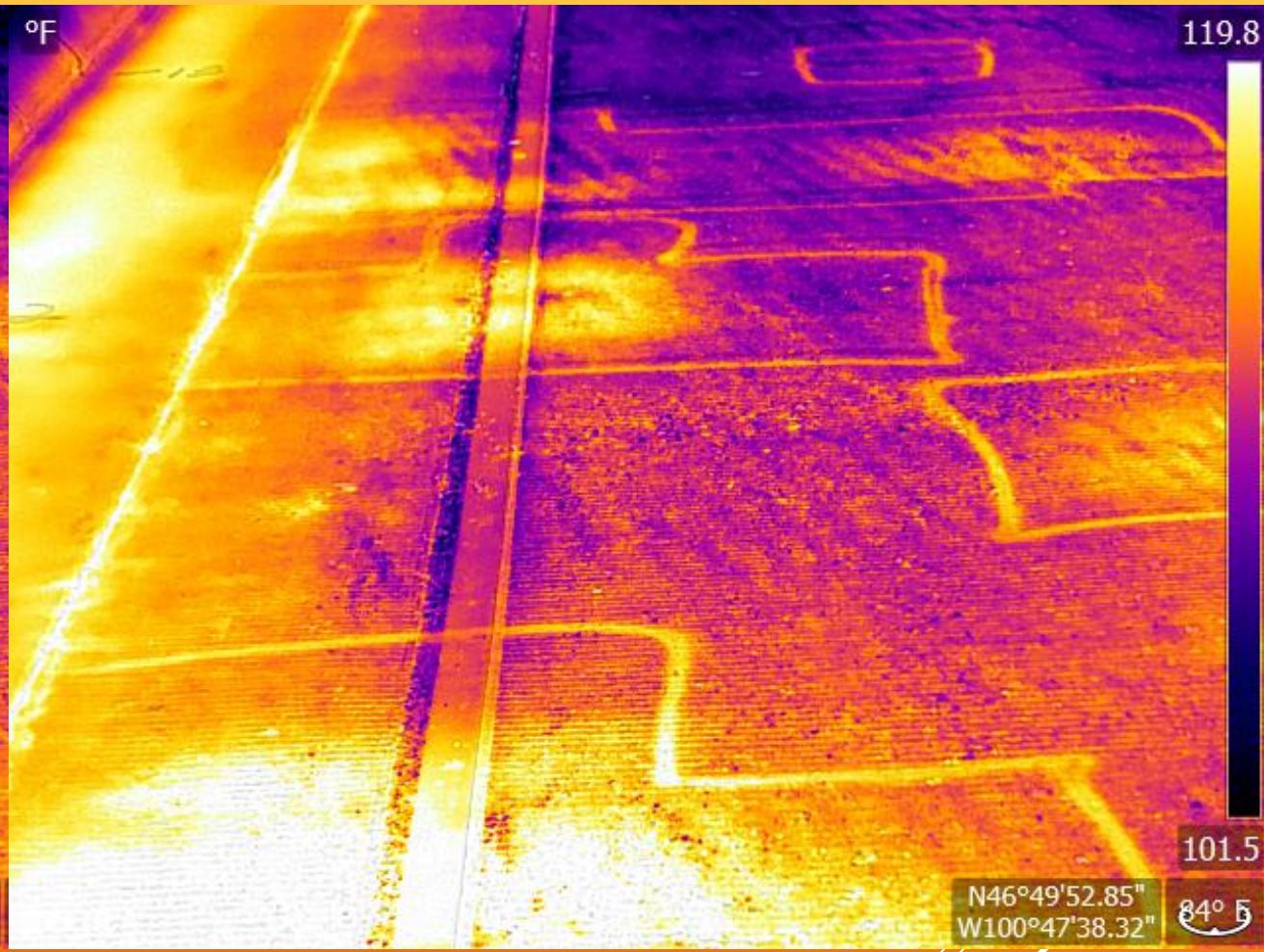
BRIDGE 94-158.425 - WASHINGTON ST



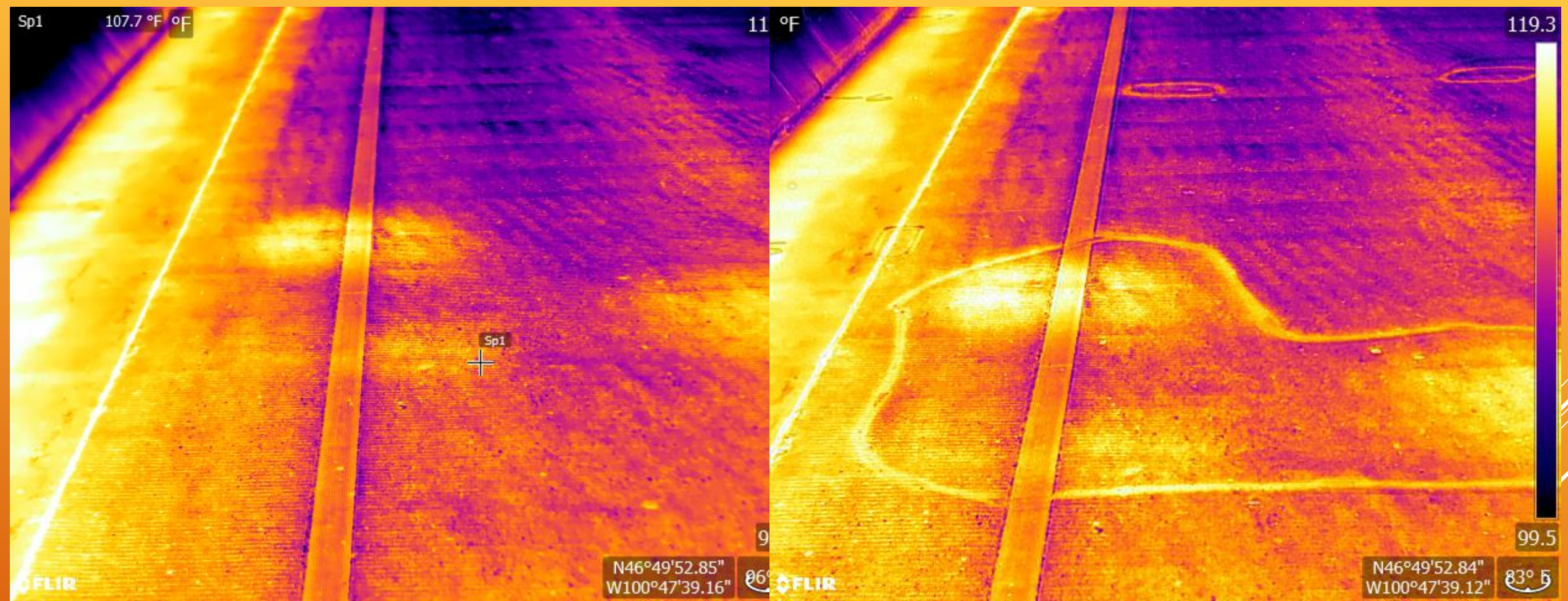
BRIDGE 94-158.425 - WASHINGTON ST



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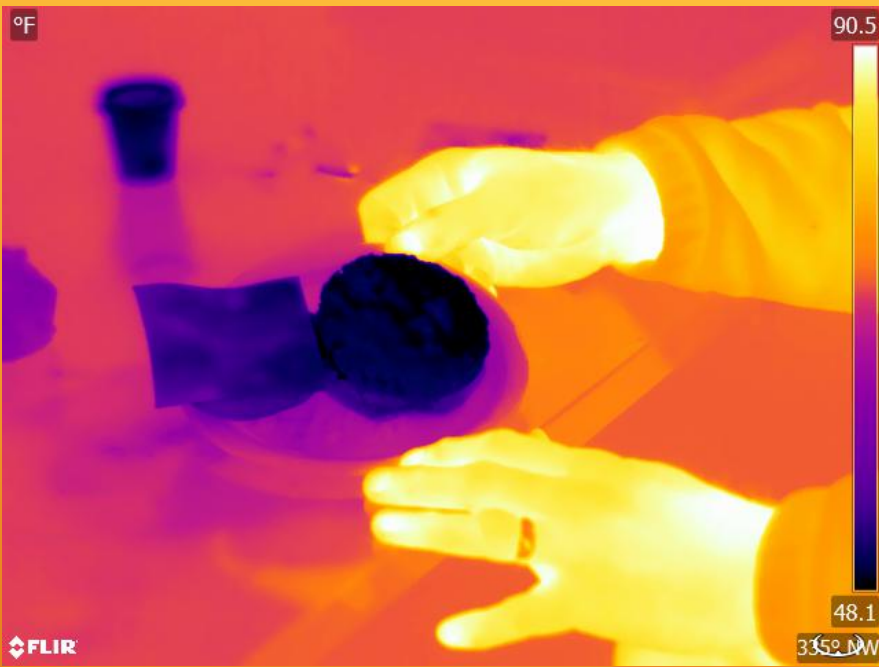


BRIDGE 94-158.425 - WASHINGTON ST

ADDITIONAL AND FUTURE USES

- **Field Reviews to determine scope of work**
 - Decks – top and bottom
 - Barriers
 - Other Bridge Elements
- **Part of Inspection Program**
 - Assist with assessment





THANK YOU!!