



Rapid Technologies to Enhance Quality Control on Asphalt Pavements Infrared (IR) Scanner Workshop

Hosted by:
North Carolina DOT
March 22, 2017



U.S. Department of Transportation
Federal Highway Administration

AMERICAN ASSOCIATION
OF STATE HIGHWAY AND
TRANSPORTATION OFFICIALS



Our Focus for Today



Workshop Objective ...

1. Describe the Infrared Scanner Technology (What is it and Why it is needed?)
2. Understand how to use the IR Equipment & Software
3. Discuss the results from the North Carolina DOT and other field demonstration projects
4. Contractor's Perspective on using the IR Scanner
5. SHRP 2 Products and Lessons Learned
6. Agency's Perspective on using the IR Scanner

Infrared Scanner Workshop

AGENDA:

9:30	Doors Open / Sign In	
10:00	Call to Order	Matt Hilderbran (North Carolina DOT); Moderator
10:00 to 10:15	Welcome and Introductions	Matt Hilderbran (NCDOT) and Cooper (FHWA)
10:15 to 10:45	Introduction to Infrared Technology: What is it and Why is it Needed?	Dalbey(ARA)
10:45 to 11:00	Equipment and Software: How to use it? Getting Real Time Information for Decision Making	Dalbey (ARA)
11:00 to 11:30	Data Analyses and Findings: What was learned from the Demonstration Project; Outcome and Lessons Learned from the Field Demonstration Projects	Reiter(ARA)
11:30 to 12:00	Contractor's Perspective as a QC Tool: Contractor overview of the advantages of the technology in minimizing deficiencies and any associated pay reduction.	Maclachlan (Granite)
12:00 to 1:00	Lunch	
1:00 to 1:30	Implementation Strategies (focus on Contractor use): <ul style="list-style-type: none"> • Products and Application of Products <ul style="list-style-type: none"> ○ Case Studies from Demonstration Projects ○ Updated Specification: Improving the Mat • Trouble Shooting Guide Lead Agency Strategies/Specifications Lessons Learned 	Reiter (ARA)
1:30 to 1:45	Agency Perspective as a QA Tool: Agency overview of the technology in ensuring a higher uniformity of the mat, as well as potential implementation strategies	Matt Hilderbran (NCDOT)
1:45 to 2:15	IR Workshop Wrap-Up - Questions/Answers and Closing Comments	Matt Hilderbran (North Carolina DOT); Moderator
2:15 to 3:00	Presentation and Demonstration of Ground Penetrating Radar Equipment	Sommerfeldt (GSSI)



Infrared Technology (IR)

What is it and why use it?

March 22, 2017



U.S. Department of Transportation
Federal Highway Administration



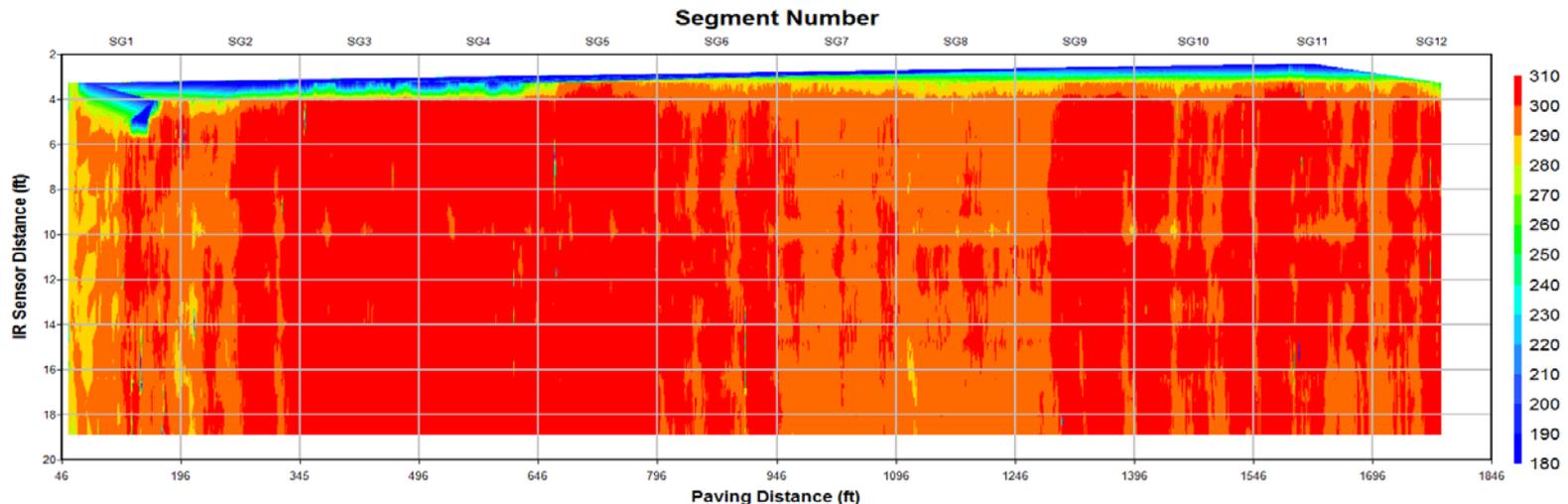
IR – What is it & why use it?

1. IR - Defined.
2. How is it measured?
3. Why is it important?

IR – What is it & why use it?

Infrared Thermography:

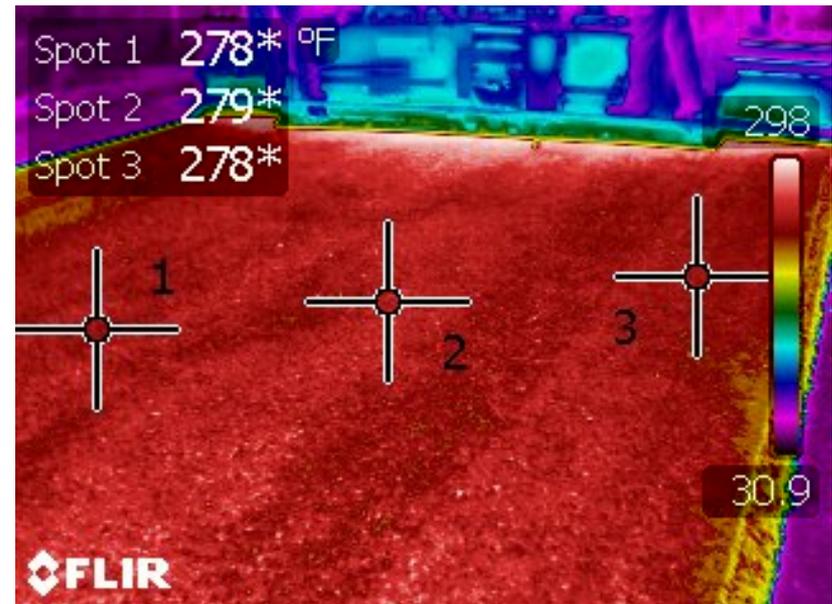
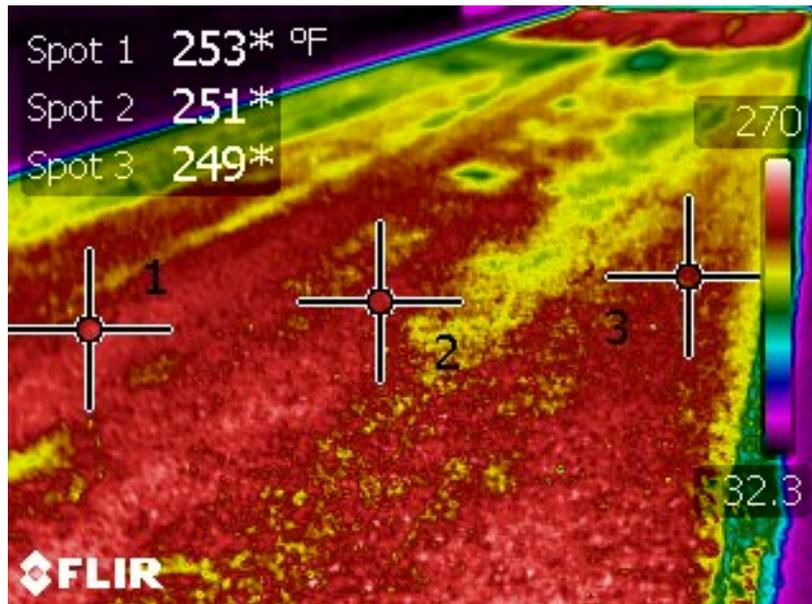
- The mapping of temperature contours (equal temperature) over the surface of a material.
- Contours are used to evaluate materials by measurement of their surface temperature and its variation.



IR – What is it & why use it?

Temperature segregation (differential):

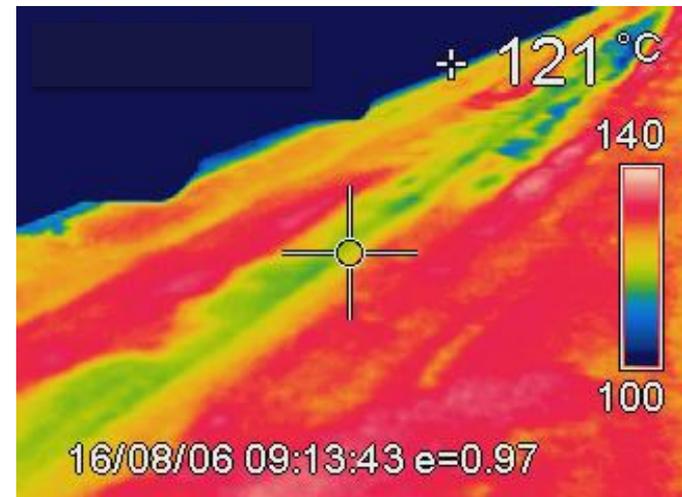
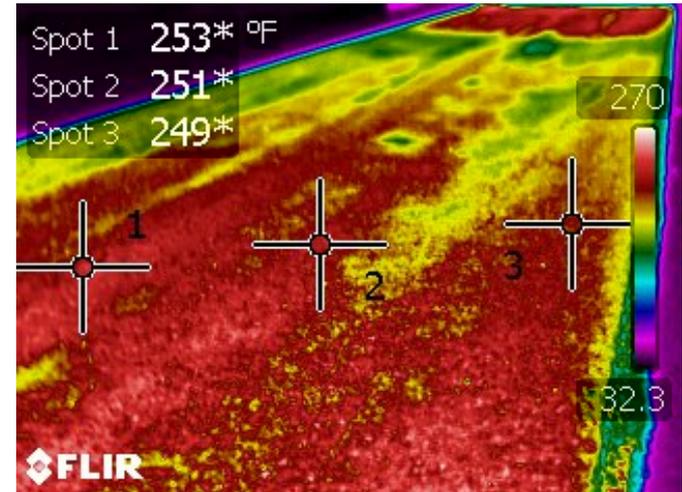
- More than 25 °F difference in mat temperature behind screed.



IR – What is it & why use it?

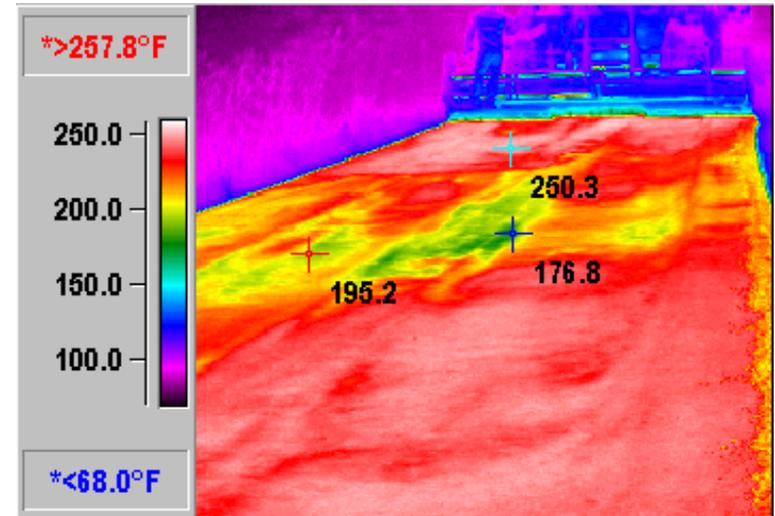
Types of Temperature Differences:

1. Cold spots
 - Truck to truck temperature differences
 - Improper loading and unloading of trucks
2. Thermal streaks
 - Longitudinal segregation
 - Inadequate or non-uniform amount of material across the mat



IR – What is it & why use it?

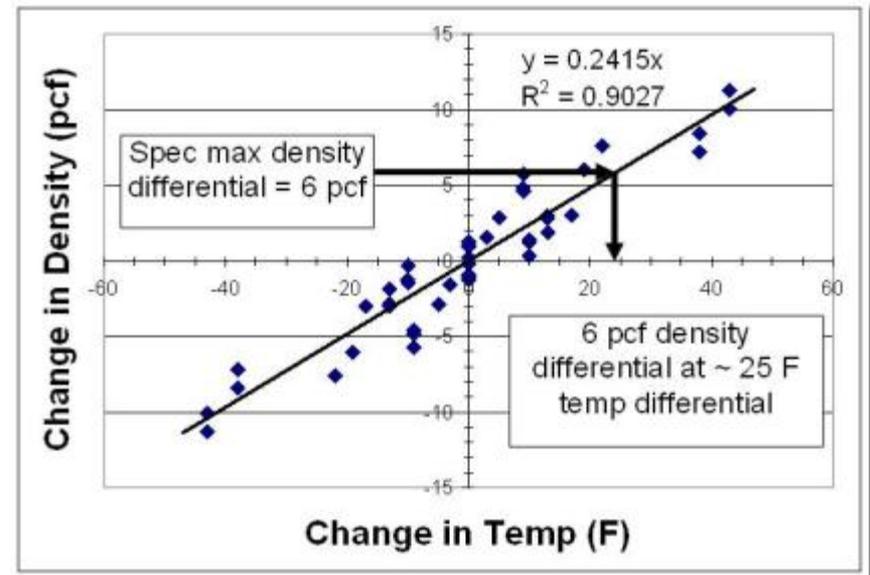
- Cold spots
 - Temperature difference of mat between truck exchanges – common.
 - Areas with higher air voids
- Focused testing have validated higher air voids
 - Coring
 - Radar (full coverage)
 - Nuclear gauge



IR – What is it & why use it?

Background

- 1996 through 2000s – field work concluded temperature differences could be accurately detected and quantified:
 - Low temperatures result in low density zones in mat
 - A few States adopt temperature uniformity specification



Temperature profile criteria based on desired density uniformity.

IR – What is it & why use it?

1. IR - Defined.
2. How is it measured?
3. Why is it important?

IR – What is it & why use it?

History; Mat Temperature Measurements

- Temperature guns
 - Point readings
- Temperature cameras
 - Time specific to identify areas with cold spots or thermal streaks



IR – What is it & why use it?

History; Mat Temperature Measurements

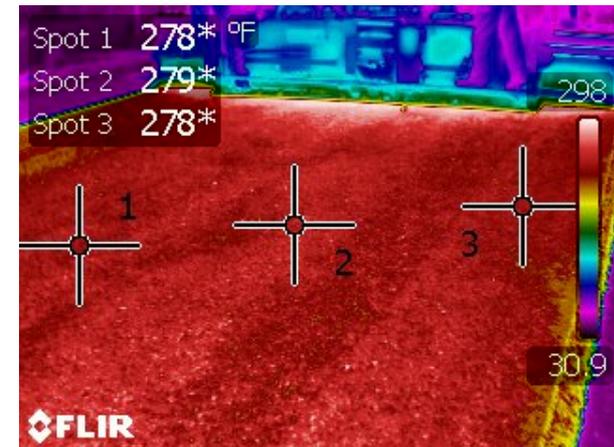
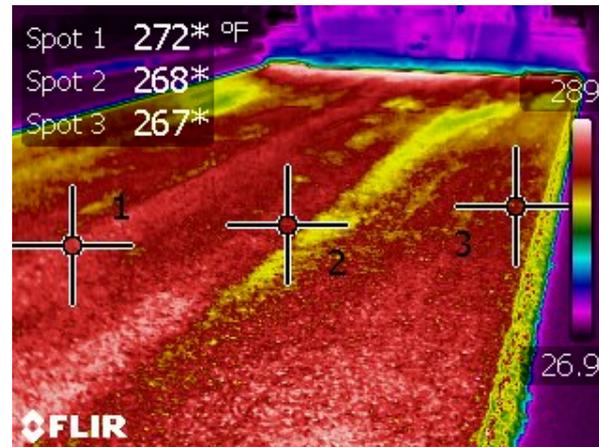
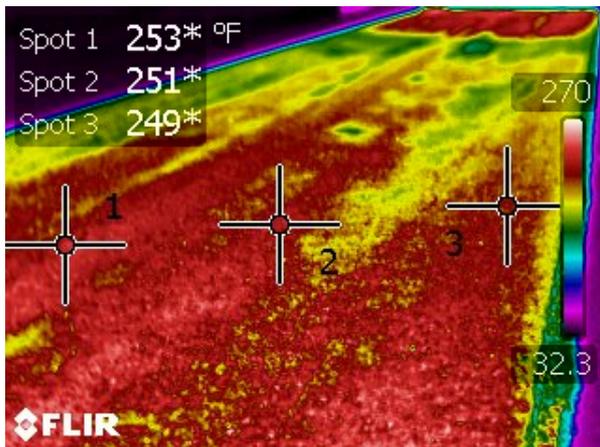
- IR sensors, IR-Bar; first device for continuous readings
- Pave-IR Scanner; second generation device for continuous readings



IR – What is it & why use it?

Application & use of temperature cameras

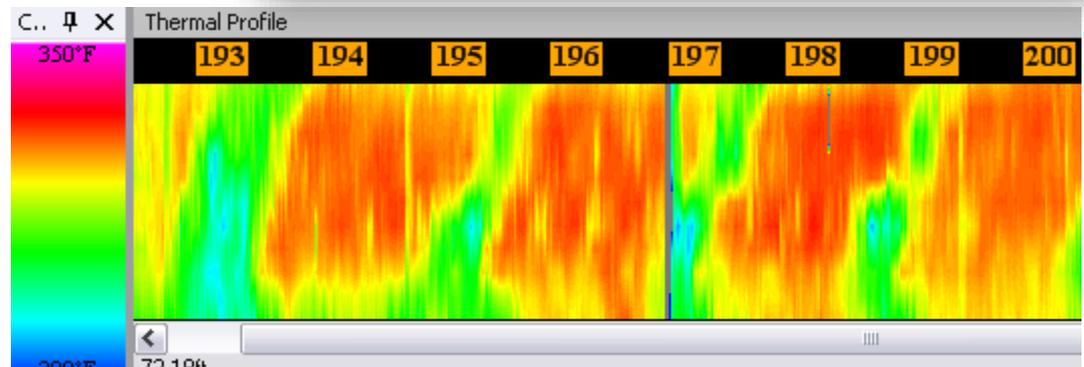
- Identify areas with cold spots for biased sampling in density specification
- Identify thermal streaks



IR – What is it & why use it?

Application & use of IR-Bar and Scanner

- Continuous readings to evaluate mat uniformity through temperature uniformity.
- Non-uniform temperatures usually mean, non-uniform densities.

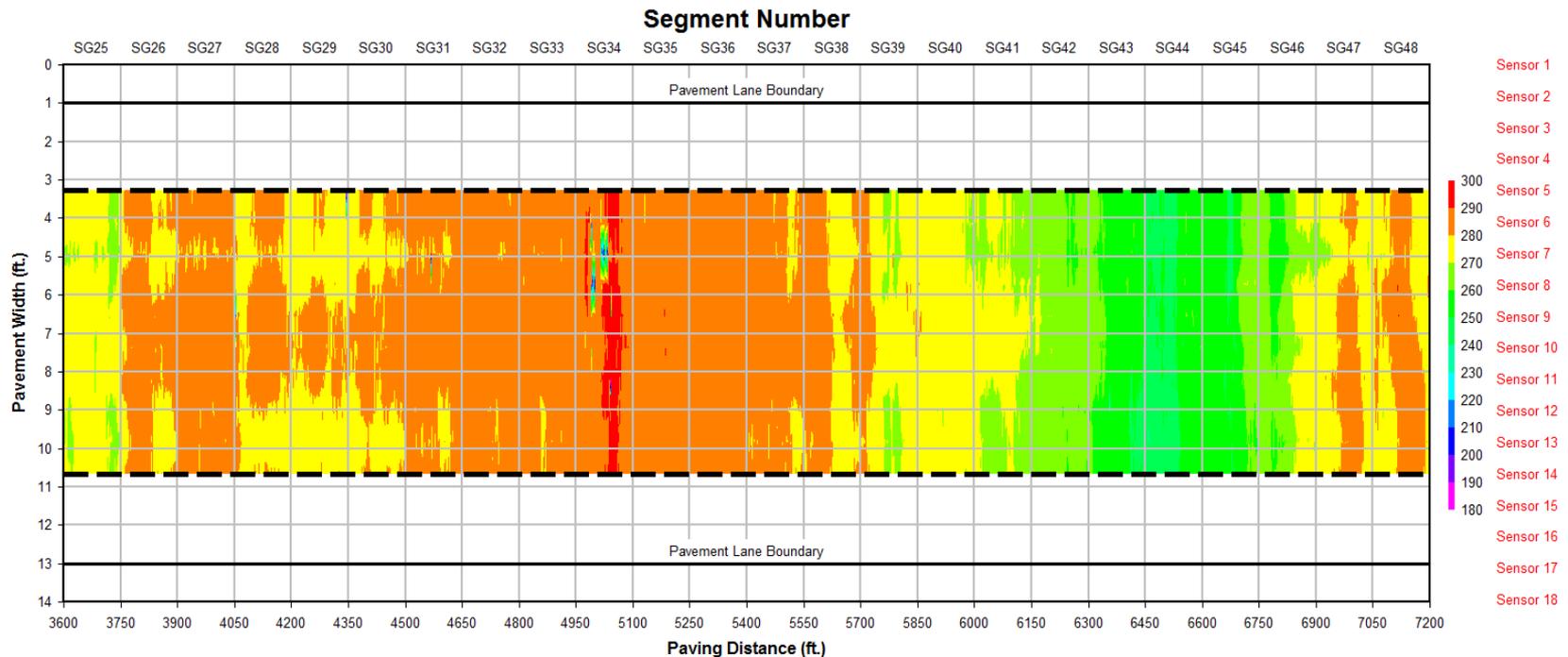


IR – What is it & why use it?

1. IR - Defined.
2. How is it measured?
3. Why is it important?

IR – What is it & why use it?

- Aggregate segregation in mat = temperature segregation
- Non-uniform temperatures usually result in non-uniform densities



IR – What is it & why use it?

Segregation – A difficult issue to resolve, when it is difficult to identify or confirm.



IR – What is it & why use it?

- *Truck to truck segregation* results in cold spots; IR can accurately identify these areas.



IR – What is it & why use it?

- Both sided longitudinal and centerline segregation result in thermal streaks; IR can identify these areas.

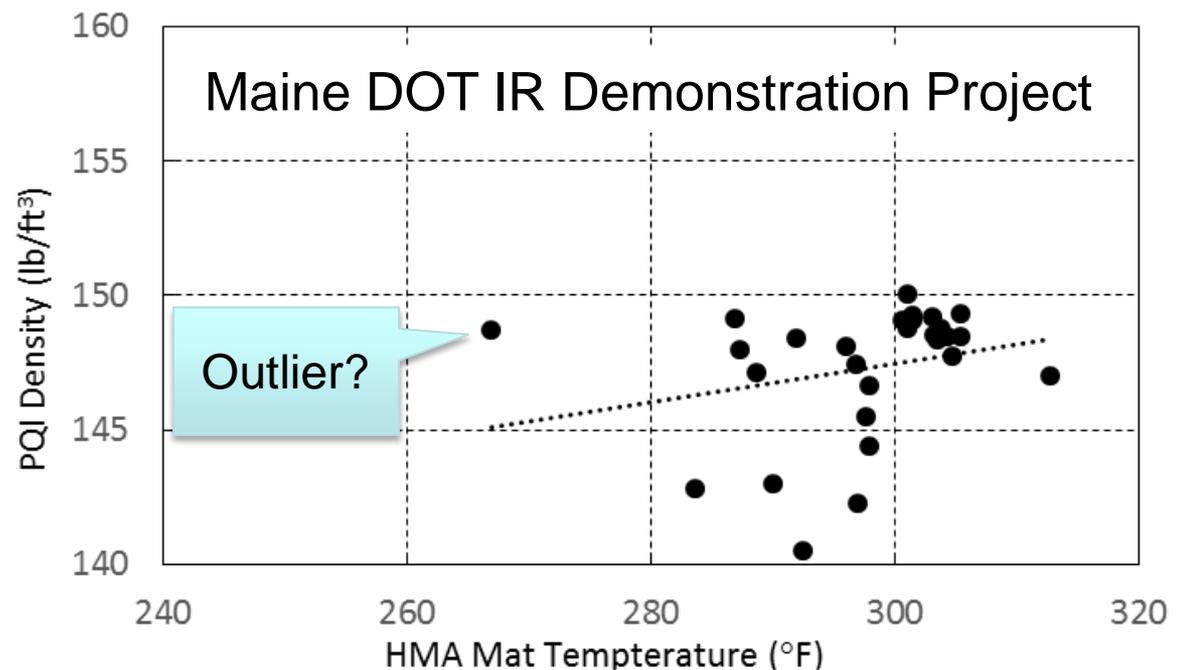


IR – What is it & why use it?

- Effect of cold spots, low mat temperatures on percent compaction; densities are:
 - Lower
 - More variable

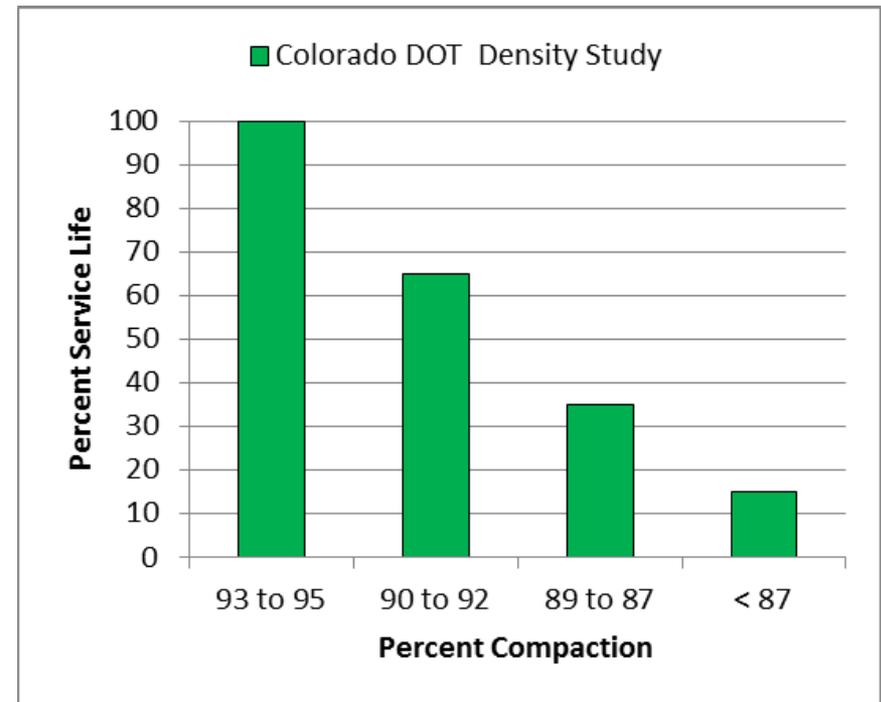
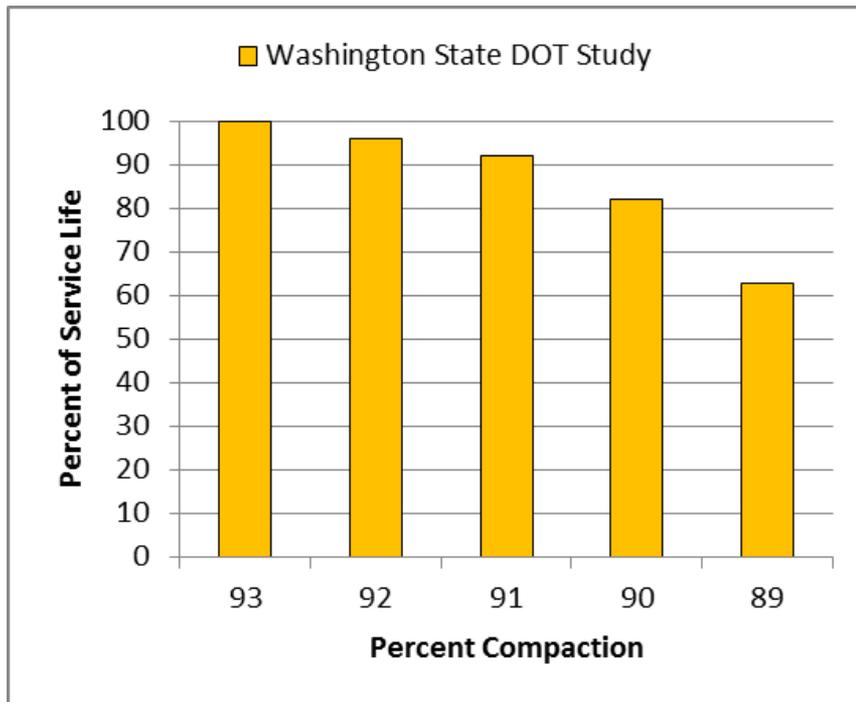
TTI Study:
 $\Delta 25\text{ }^{\circ}\text{F} \sim \Delta 6\text{ pcf}$

Maine DOT:
 $\Delta 20\text{ }^{\circ}\text{F} \sim \Delta 4\text{ pcf}$



IR – What is it & why use it?

- Effect of reduced compaction because of lower mat temperatures or inadequate rolling.



IR – What is it & why use it?

Impact of temperature differences or areas with low temperatures.



IR – What is it & why use it?

Cold spots; areas with increased potential for:

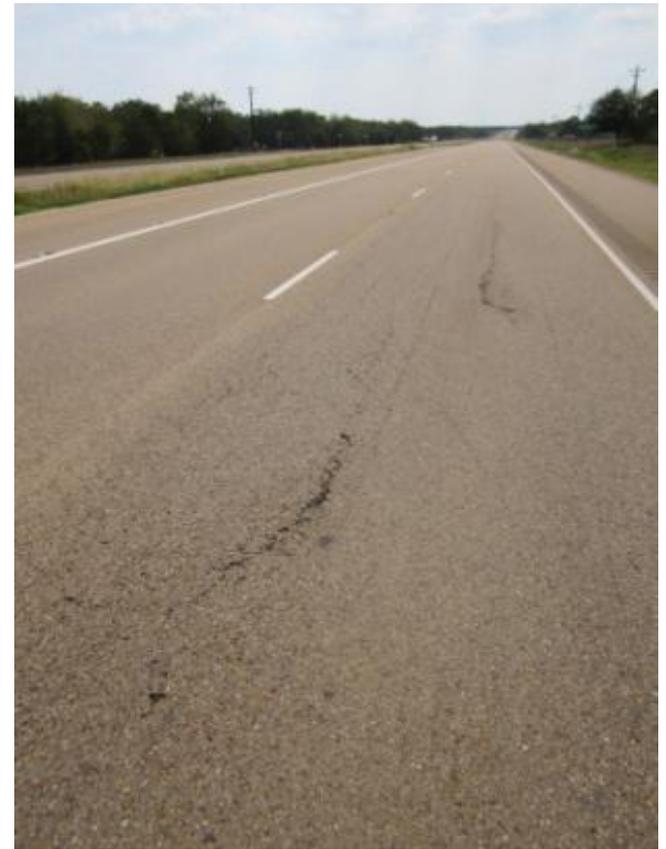
- Fatigue cracks
- Raveling
- Pot holes



IR – What is it & why use it?

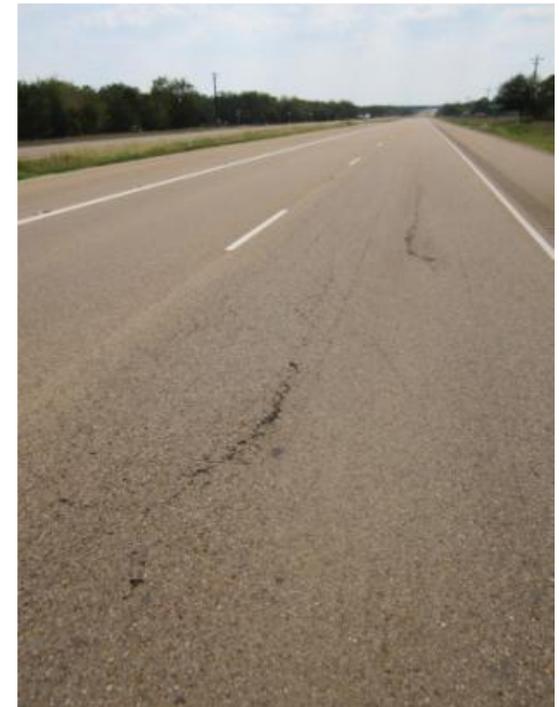
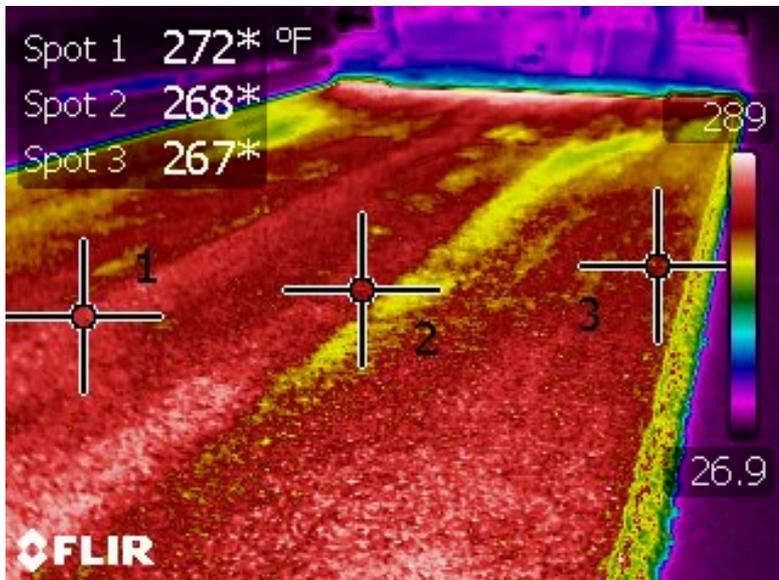
Thermal streaks; longitudinal areas with increased potential for:

- Longitudinal cracking



IR – What is it & why use it?

- Thermal streaks can be very damaging, depending on the level of density achieved in localized areas.
- Measuring the density, accurately, in a localized area is complicated.



Questions?



NEXT:

- Equipment and Software: How to use it?



Infrared Technology (IR)

IR Equipment and Software: How to Use It?

March 22, 2017



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IR Equipment and Software

1. Equipment and Installation
2. Software and Its Features

IR Equipment and Software

Equipment

- Mast Base
- Mast Extension
- Mast Arm
- IR Scanner
- DMI
- GPS Unit
- Wiring
- Connection bolts & materials



IR Equipment and Software

IR mast base and extension
attached to paver.



Mounted Directly to Screed



Mounted Directly to Work
Platform



Mounted to a Steel Plate
Attached to Work Platform

IR Equipment and Software

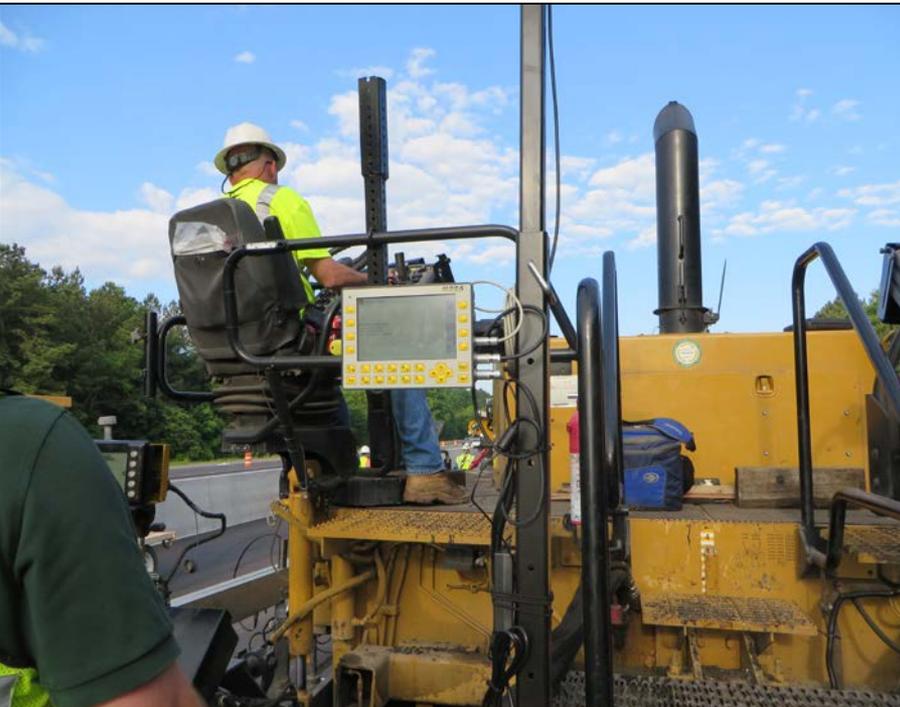


- IR Scanner attached to paver; scans mat behind screed in one direction.
- GPS attached to the mast arm.



IR Equipment and Software

IR scan screen used to see/monitor mat temperatures in real time; attached to the mast post or extension.



IR Equipment and Software



IR Equipment and Software

PaveApp (2.2.1526.14) - Collecting data...

Thermal Profile Results Summary

Number of Profiles	Moderate]25°F;50°F]		Severe > 50°F		Status
	Number	Percent	Number	Percent	
44	3	7	0	0	✓

Recent Test Result

Beginning Location	Ending Location	Temperature Differential	Status
6600ft	6750ft	Calculating...	✓

320°F

250°F

39.75026°N 94.78966°W 6709.6ft 0ft/min 9/1/2015 - 11:47 PM

IR Equipment and Software

Be careful with the temperature scale – the same data



IR Equipment and Software

DMI placed on wheel hub to measure distance during paving operation.



IR Equipment and Software

1. Equipment and Installation
2. Software and Its Features

IR Equipment and Software

Two models of data transfer and extraction



IR Equipment and Software

- Online Web App: <https://eroutes.info/paveappweb/>
- Login is user specific

eRoutes^{MC}
Open a new session

Username:

Password: [extended validation certificate](#)

Domain:

Remember my username and domain

YOUR INFORMATION, IN REAL TIME

If you have come to this page while trying to access another then you do not have the proper security for the other page or you have not logged in yet.
Please log in if you haven't. If you feel you should access an area but you can't, contact [support](#) immediately.

minds
MINDS OF WORK, FOR THE ROADS OF THE WORLD

IR Equipment and Software

Explore Data: MOBA Pave Project Manager Main Screen

The screenshot displays the MOBA Pave Project Manager software interface. The main window is titled "Pave Project Manager - Pave_2015-09-16-110725.paveproj (Finished on 9/16/2015 9:22 AM)". The interface is divided into several sections:

- Color Map:** A vertical bar on the left side of the main window, showing a color gradient from blue at the bottom to red at the top. A callout box labeled "Color Map" points to this bar.
- Thermal Profile:** A large central area displaying a heatmap of temperature data. The top of this area is labeled with station numbers from 969 to 955. A callout box labeled "Thermal Profile" is centered over this area.
- Properties:** A panel on the right side of the window, titled "Properties". It contains a "Thermal Profile" section with the following details:

Thermal Profile	
Actions	
Interpolation	Linear
Sample Spots of Interest	Enabled
Stations	Show
Tooltip	Visible
Profile View	
Ignored Sensors	
Length	1513.78ft
Start	0.33ft
Units	Feet
Zoom	100.0%

A callout box labeled "Properties" is positioned below this panel.
- Diagrams and project information:** A bottom section titled "Project Properties" with tabs for "Time Diagram", "Speed Diagram", and "Temperature Class Diagram". The "Project Properties" tab is active, showing a table of project details:

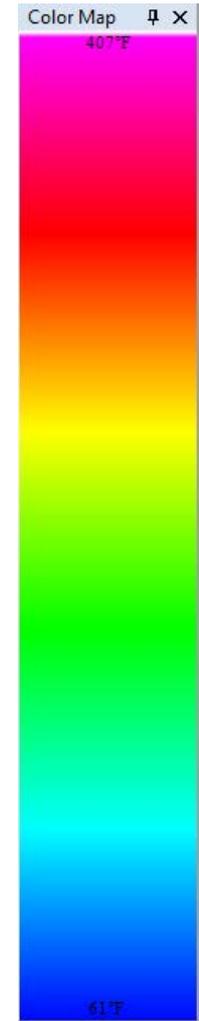
Meta Information	Value
Beginning location	houltou off ramp
Comment	passing lane w/4shld
Ignored Sensors	
Layer thickness	1.5in
Lift	1
Measure height	9.58ft
MINDS Upload	No
Operator Name	paul
Paving width	11.48ft
Project ID	6700e011e9424b24a0353a7f46367793

A callout box labeled "Diagrams and project information" is positioned over this section.

IR Equipment and Software

Color Map and Properties for Screen

Properties	
Color Map	
▲ Temperature range	
Max	407°F
Min	61°F



IR Equipment and Software

Thermal Profile Properties Screen

Thermal Profile Properties

Thermal Profile	
Actions	
Interpolation	Linear
Sample Spots of Interest	Enabled
Stations	Show
Tooltip	Visible
Profile View	
Ignored Sensors	
Length	1513.78ft
Start	0.33ft
Units	Feet
Zoom	100.0%

Meta Information	Value
Beginning location	houlton off ramp
Comment	passing lane w/4shld
Ignored Sensors	
Layer thickness	1.5in
Lift	1
Measure height	9.58ft
MINDS Upload	No
Operator Name	paul
Paving width	11.48ft
Project ID	670f0ef1e942-4b24-a035-3a7f46367793

Beginning location
The name of the location where the project began.

Interpolation
Determines the kind of algorithm used when displaying the Profile.

IR Equipment and Software

Project Properties Screen

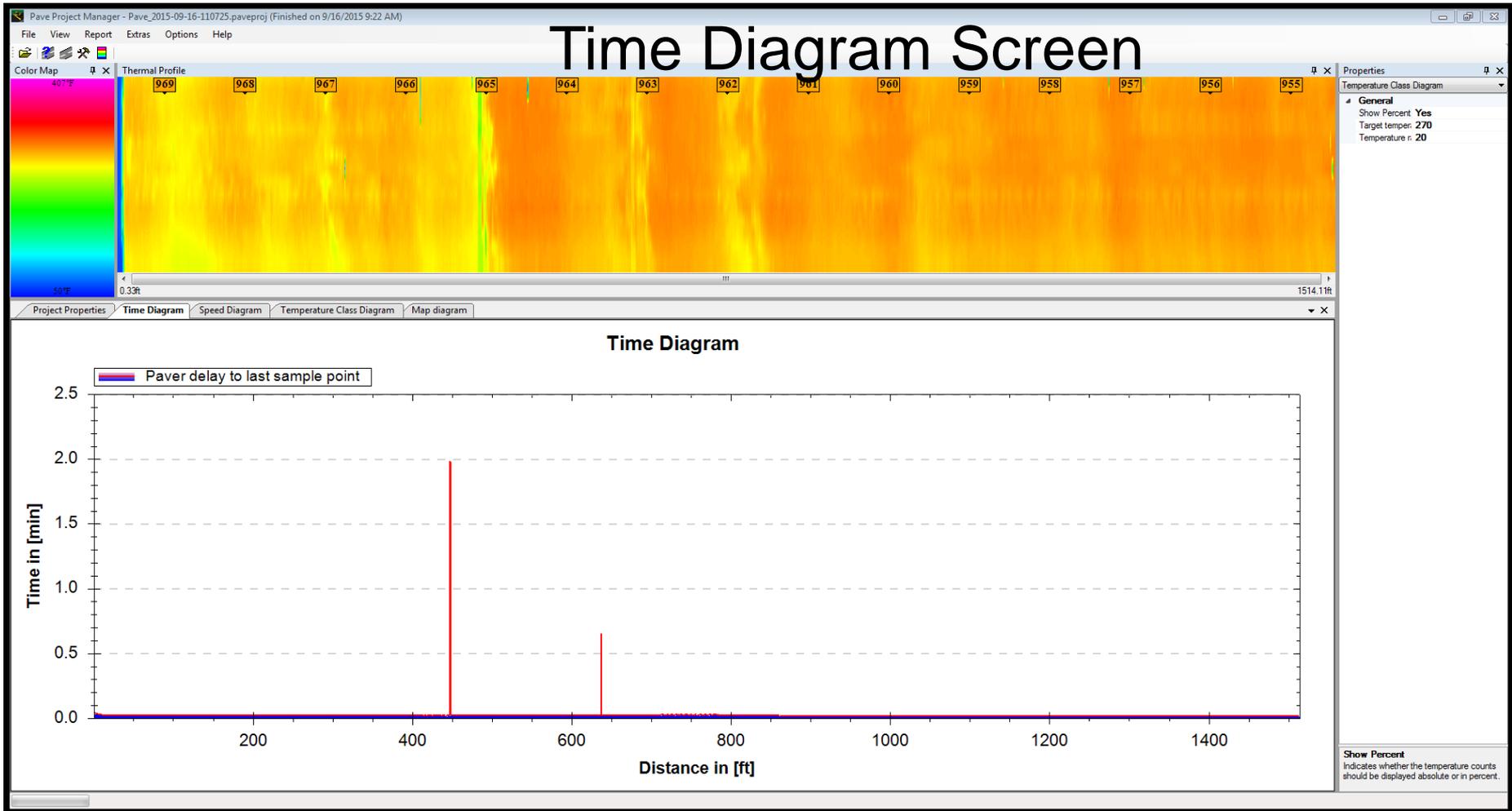
The screenshot displays the 'Project Properties' dialog box in the Pave Project Manager software. The dialog is divided into several sections:

- Meta Information:** A list of fields including Beginning location, Comment, Ignored Sensors, Layer thickness, Lift, Measure height, MINDS Upload, Operator Name, Paving width, and Project ID.
- Metrics:** A section for project performance metrics, with the following values:
 - Project Duration: 0.33h
 - Paver Stop Time: 61°F
 - Average Paver Speed: 0.33ft
- Project Details:** A table of key project parameters:

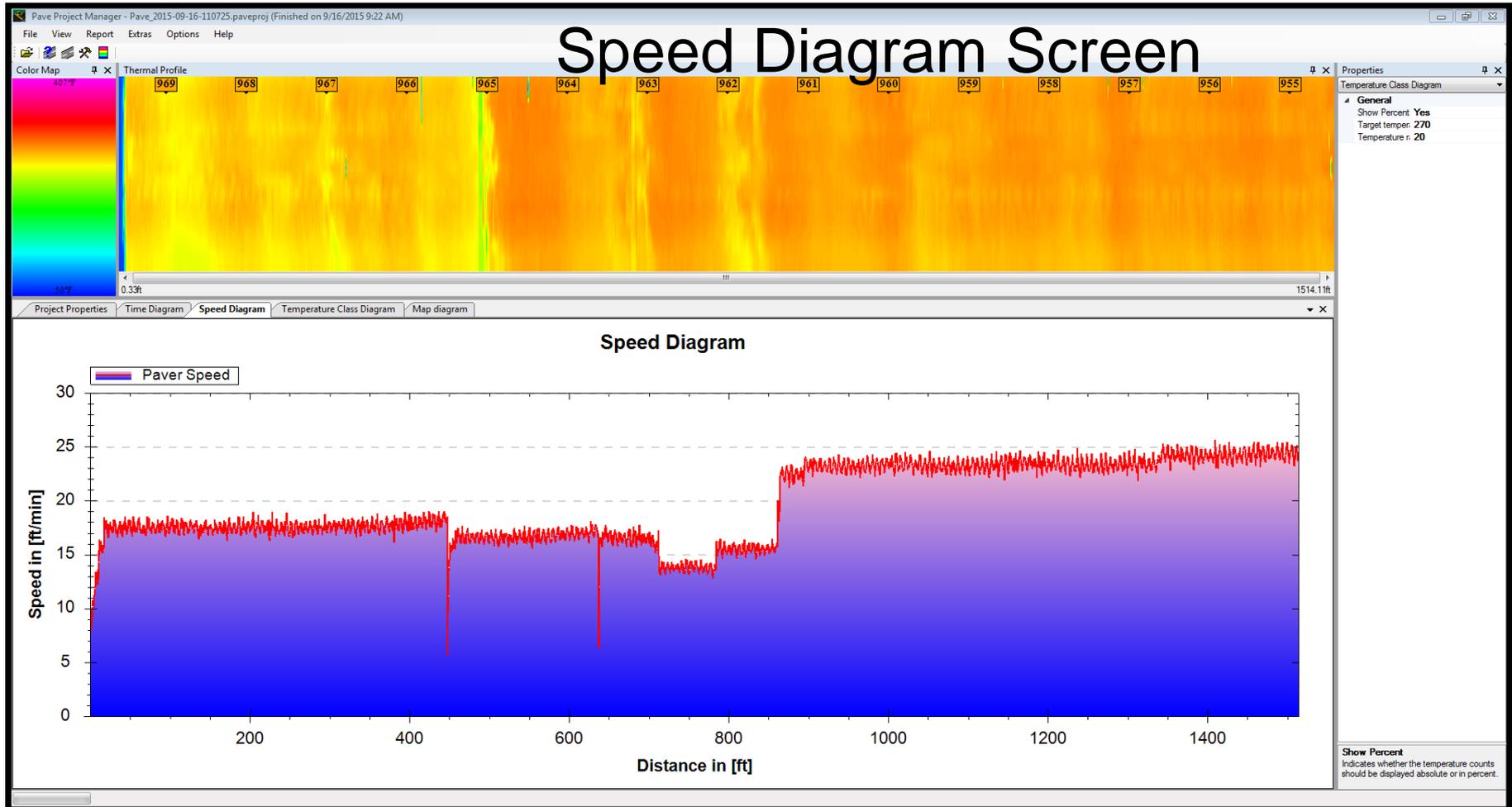
Beginning location	houlton off ramp
Comment	passing lane w/4shld
Layer thickness	1.5in
Lift	1
Measure height	9.58ft
MINDS Upload	No
Operator Name	paul
Paving width	11.48ft
Project ID	670f0ef1-e942-4b24-a035-3a746367793
- Beginning location:** A text field with the value 'houlton off ramp' and a description: 'The name of the location where the project began.'

At the bottom right of the dialog, there is a 'Save' button and a small note: 'Determined the kind of alignment used when displaying the profile.'

IR Equipment and Software

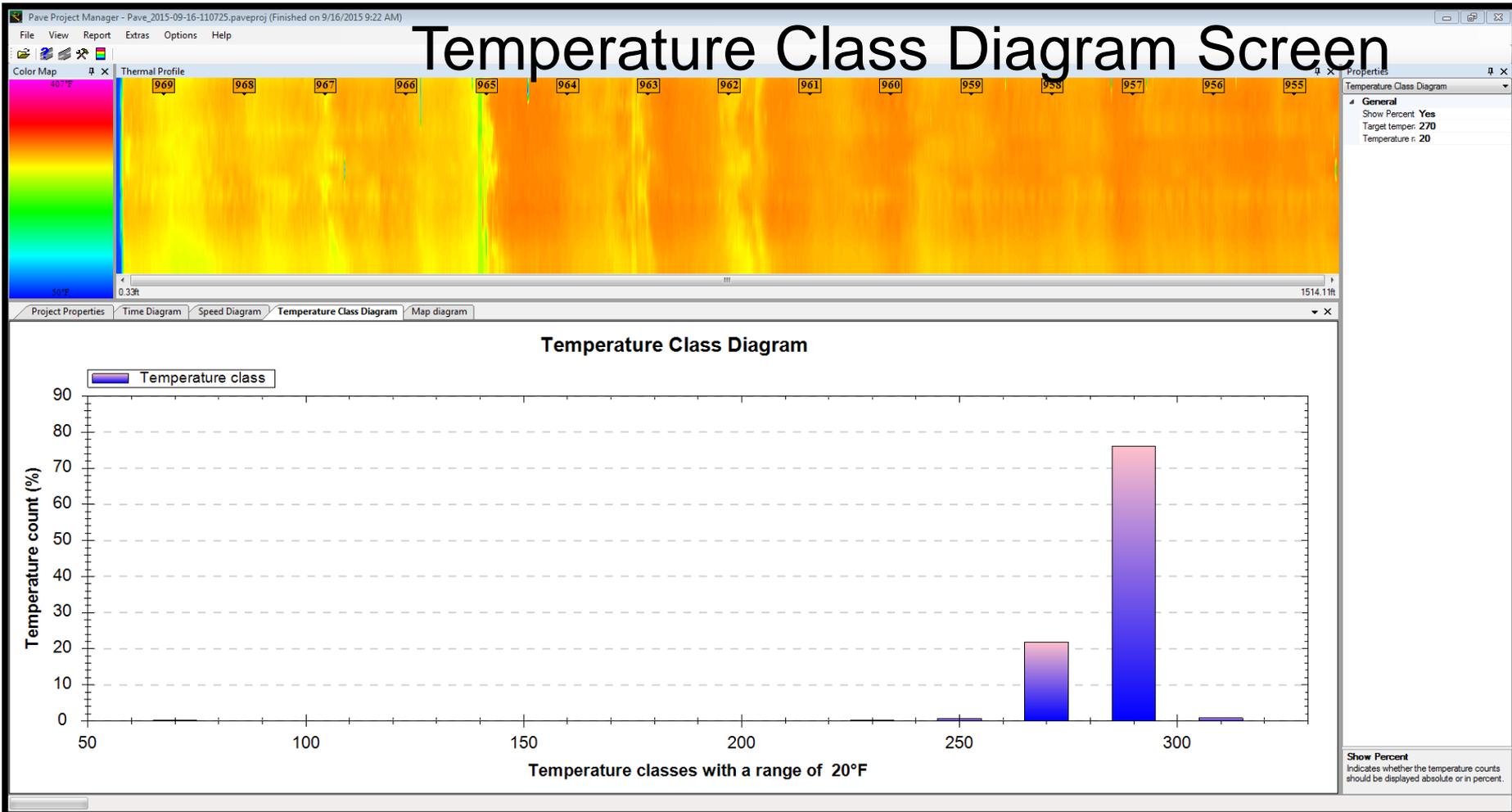


IR Equipment and Software



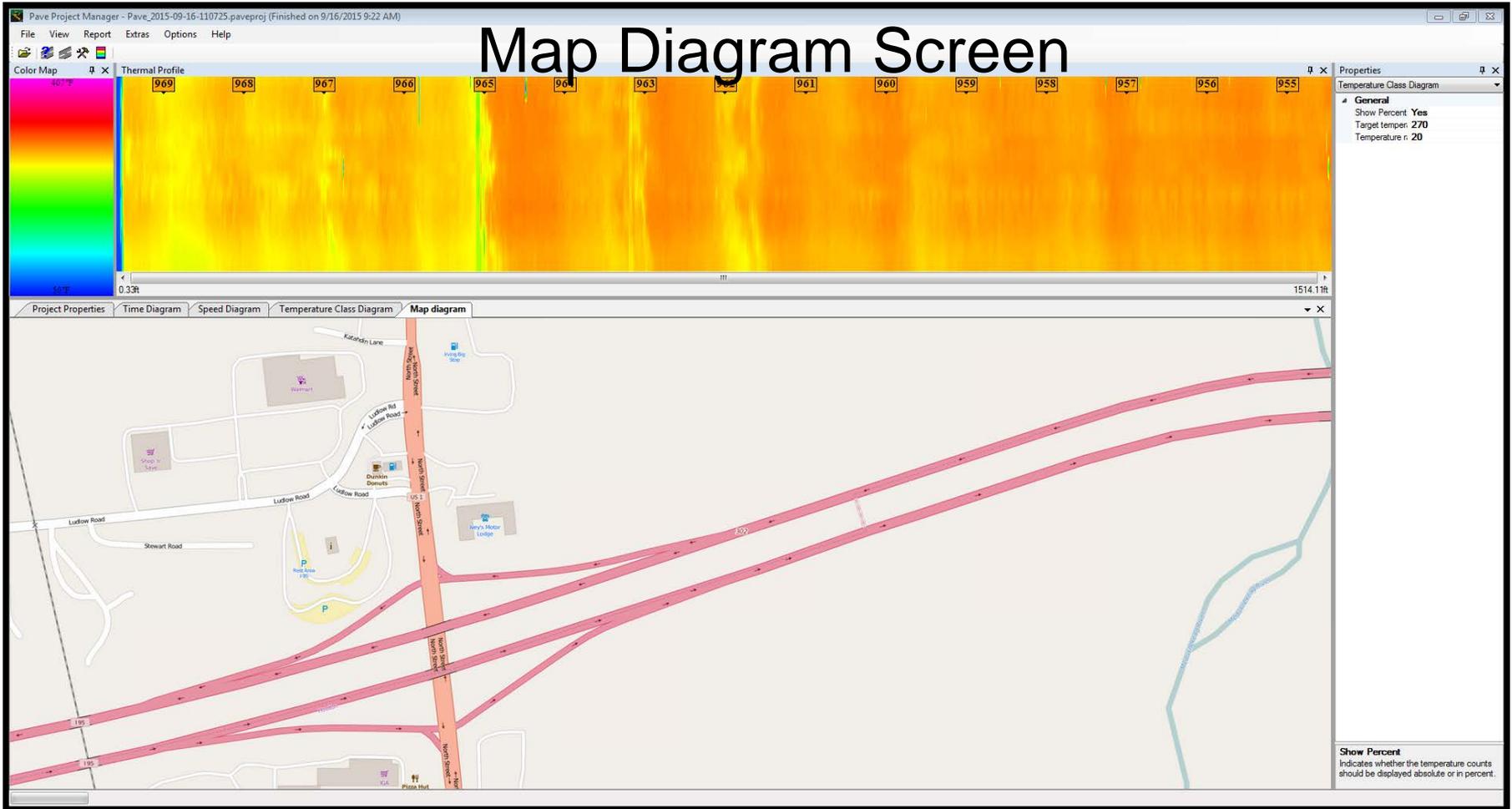
IR Equipment and Software

Temperature Class Diagram Screen



IR Equipment and Software

Map Diagram Screen



IR Equipment and Software

Adding Point Measurements

Click any location on the thermal profile

The screenshot displays the 'Pave Project Manager' software interface. The main window shows a 'Thermal Profile' with a color gradient from blue (cooler) to red (warmer). A vertical line of station markers (965-969) is visible. Several data points are overlaid on the profile, each showing temperature, elevation, and coordinates. A semi-transparent text box with the instruction 'Click any location on the thermal profile' is centered over the profile. The bottom of the window features a 'Map diagram' showing the project location on a map with red pins corresponding to the data points. A 'Properties' panel on the right shows settings for the 'Thermal Profile', including 'Interpolation: Linear', 'Sample Spots: Enabled', and 'Profile View' settings.

Station	Temperature (°F)	Elevation (ft)	Coordinates (W, N)	Satellites
969	283	232.9	67.83365311°W, 46.14118346°N	10
968	261	85.6	67.83309890°W, 46.14131155°N	11
967	228	451.1	67.83446667°W, 46.14099723°N	10
966	280	410.4	67.83431842°W, 46.14103203°N	11
965	271	776.2	67.83368142°W, 46.14071210°N	9
964	276	767.4	67.83564739°W, 46.14072025°N	9
963	278	767.4	67.83564739°W, 46.14072025°N	9
962	295	1100.7	67.83691530°W, 46.14042614°N	11
961	276	767.4	67.83564739°W, 46.14072025°N	9
960	276	767.4	67.83564739°W, 46.14072025°N	9
959	276	767.4	67.83564739°W, 46.14072025°N	9
958	276	767.4	67.83564739°W, 46.14072025°N	9
957	276	767.4	67.83564739°W, 46.14072025°N	9
956	276	767.4	67.83564739°W, 46.14072025°N	9
955	276	767.4	67.83564739°W, 46.14072025°N	9

Properties Panel:

- Interpolation: Linear
- Sample Spots: Enabled
- Stations: Show
- Tooltip: Visible
- Profile View
 - Ignored Senses: 1513.78ft
 - Start: 0.33ft
 - Units: Feet
 - Zoom: 100.0%

Map Diagram:

- Project Properties
- Time Diagram
- Speed Diagram
- Temperature Class Diagram
- Map diagram

Ignored Sensors: Enter the sensor ID(s) you don't want to be displayed. ID 1 is the outer left sensor. Ex...

IR Equipment and Software

Generating Reports

The screenshot shows the Pavement Project Manager software interface. The main window displays a color-coded profile view of a road surface. A 'Generate Report' dialog box is open, allowing the user to select a report name. The 'Report name' dropdown is set to 'Detailed Report 9/4/2015 8:48 AM'. Below the dialog, the 'Tex-244-F Part II Input' form is visible, containing various fields for report generation. A callout box with an arrow points to the form, stating 'Generates PDF Report'.

Generate Report

Choose a report by name. This will identify the Report Data and Layout.

Report name:

Tex-244-F Part II Input

The Tex-244-F Part II report contains some fields of project description on page 1. You can complete the fields by using this form. You can also leave this form blank. Then the fields in the report are also blank.

Report Name	Tex 244-F
Profile ID	95sb
Profile Number	Not availble
Status	
County	
Tested By	
Test Location	houlton off ramp
Material Code	
Material Name	
Producer	
Area Engineer	
Profile Date	9/16/2015 7:11 AM
Letting Date	Not availble
Controlling CSJ	
Spec Year	Not availble
Spec Item	
Special Provision	
Mix Type	
Project Manager	

Generates PDF Report

IR Equipment and Software

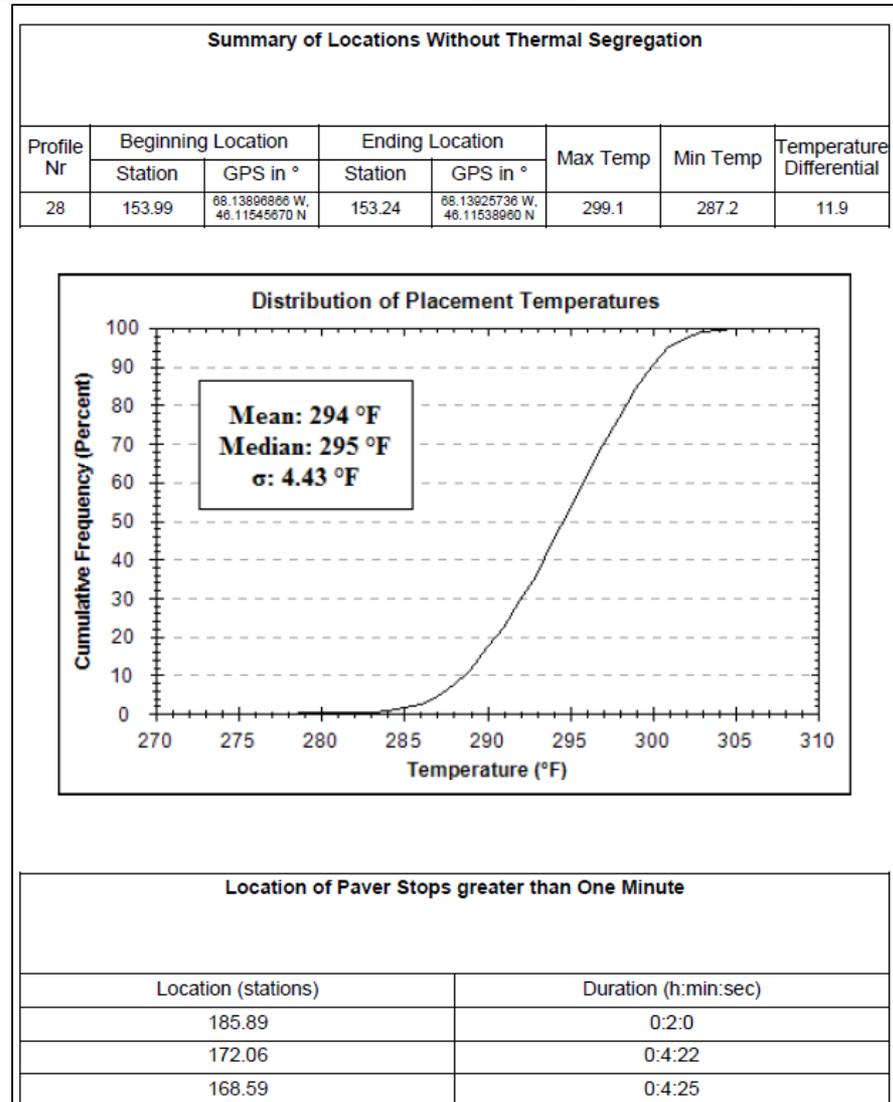
Generating Reports

Tex 244-F				
Thermal Profile Summary Report				
Profile ID:	95sb	Profile Date:	9/24/2015 9:18:13 AM	
Profile Number:		Letting Date:		
Status:		Controlling CSJ:		
County:		Spec Year:		
Tested By:		Spec Item:		
Test Location:	194	Special Provision:		
Material Code:		Mix Type:		
Material Name:				
Producer:				
Area Engineer:		Project Manager:		
Course/Lift:	3	Temperature Differential Threshold:	25.0	
Segment Length (ft):	150	Sensors Ignored:	-	
Thermal Profile Results Summary				
Number of Profiles	Moderate 25.0°F < differential <= 50.0°F		Severe differential > 50.0°F	
	Number	Percent	Number	Percent
28	0	0	0	0

Summary of Locations Without Thermal Segregation							
Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Station	GPS in °	Station	GPS in °			
1	194.49	88.12363437 W, 46.11892049 N	193.00	88.12418593 W, 46.11879052 N	303.4	287.8	15.7
2	192.99	88.12418985 W, 46.11878960 N	191.50	88.12476079 W, 46.11866149 N	304.9	289.6	15.3
3	191.49	88.12476285 W, 46.11866104 N	190.00	88.12532427 W, 46.11853654 N	301.1	286.3	14.8
4	189.99	88.12533012 W, 46.11853523 N	188.50	88.12589203 W, 46.11840836 N	299.3	285.8	13.5
5	188.49	88.12589363 W, 46.11840800 N	187.00	88.12645626 W, 46.11828259 N	297.7	285.4	12.2
6	186.99	88.12645906 W, 46.11828176 N	185.49	88.12702186 W, 46.11815402 N	298.9	283.5	15.5
7	185.49	88.12702379 W, 46.11815360 N	183.99	88.12758506 W, 46.11802607 N	302.2	283.8	18.4
8	183.98	88.1275889 W, 46.11802512 N	182.49	88.12815126 W, 46.11789918 N	303.1	292.6	10.4
9	182.49	88.12815319 W, 46.11789773 N	181.00	88.12871395 W, 46.11777111 N	306.1	288.1	18.0
10	180.99	88.12871821 W, 46.11777052 N	179.50	88.12928274 W, 46.11764030 N	302.2	284.4	17.8
11	179.49	88.12928577 W, 46.11753960 N	178.00	88.12985205 W, 46.11751058 N	302.9	287.6	15.3
12	177.99	88.12985387 W, 46.11751020 N	176.50	88.13042113 W, 46.11739235 N	302.0	288.0	14.0
13	176.49	88.13042482 W, 46.11739148 N	175.00	88.13099093 W, 46.11725309 N	301.8	289.2	12.6
14	174.99	88.13099275 W, 46.11725265 N	173.50	88.13155886 W, 46.11712703 N	302.2	288.0	14.2
15	173.49	88.13156263 W, 46.11712618 N	171.99	88.13212684 W, 46.11699931 N	303.6	286.3	17.3
16	171.99	88.13212071 W, 46.11699898 N	170.49	88.13269254 W, 46.11687031 N	302.9	286.5	16.4
17	170.48	88.1326963 W, 46.11686947 N	169.00	88.13325913 W, 46.11674378 N	305.8	288.9	16.9
18	168.99	88.13326314 W, 46.11674286 N	167.50	88.13382973 W, 46.11661558 N	302.0	286.0	16.0
19	167.49	88.13383168 W, 46.11661512 N	166.00	88.1343973 W, 46.11648481 N	298.6	284.2	14.4
20	165.99	88.13440119 W, 46.11648382 N	164.50	88.13497078 W, 46.11635549 N	298.4	282.9	15.5
21	164.49	88.13497271 W, 46.11635503 N	163.00	88.13554162 W, 46.11622699 N	297.5	282.4	15.1
22	162.99	88.13554551 W, 46.11622616 N	161.49	88.13611883 W, 46.11609795 N	296.1	283.6	12.4
23	161.49	88.13612069 W, 46.11609752 N	160.00	88.13668796 W, 46.11596968 N	301.6	277.2	24.5
24	159.99	88.13669173 W, 46.11596883 N	158.49	88.13725615 W, 46.11584140 N	299.7	281.1	18.5
25	158.49	88.13725879 W, 46.11584082 N	157.00	88.1378221 W, 46.11571525 N	301.6	287.4	14.2
26	156.99	88.13782599 W, 46.11571440 N	155.50	88.13839327 W, 46.11558715 N	302.2	288.5	13.7
27	155.49	88.13839721 W, 46.11558631 N	154.00	88.1389655 W, 46.11545741 N	302.2	289.8	12.4

IR Equipment and Software

Generating Reports



IR Equipment and Software

Exporting Data

- Export to .txt (semicolon separated)
- Save as .paveproj

Questions?



NEXT:

- Data Analyses and Findings: I-40, Raleigh, NC



Infrared Technology (IR)

Data Analyses and Findings: I-40

March 22, 2017



U.S. Department of Transportation
Federal Highway Administration

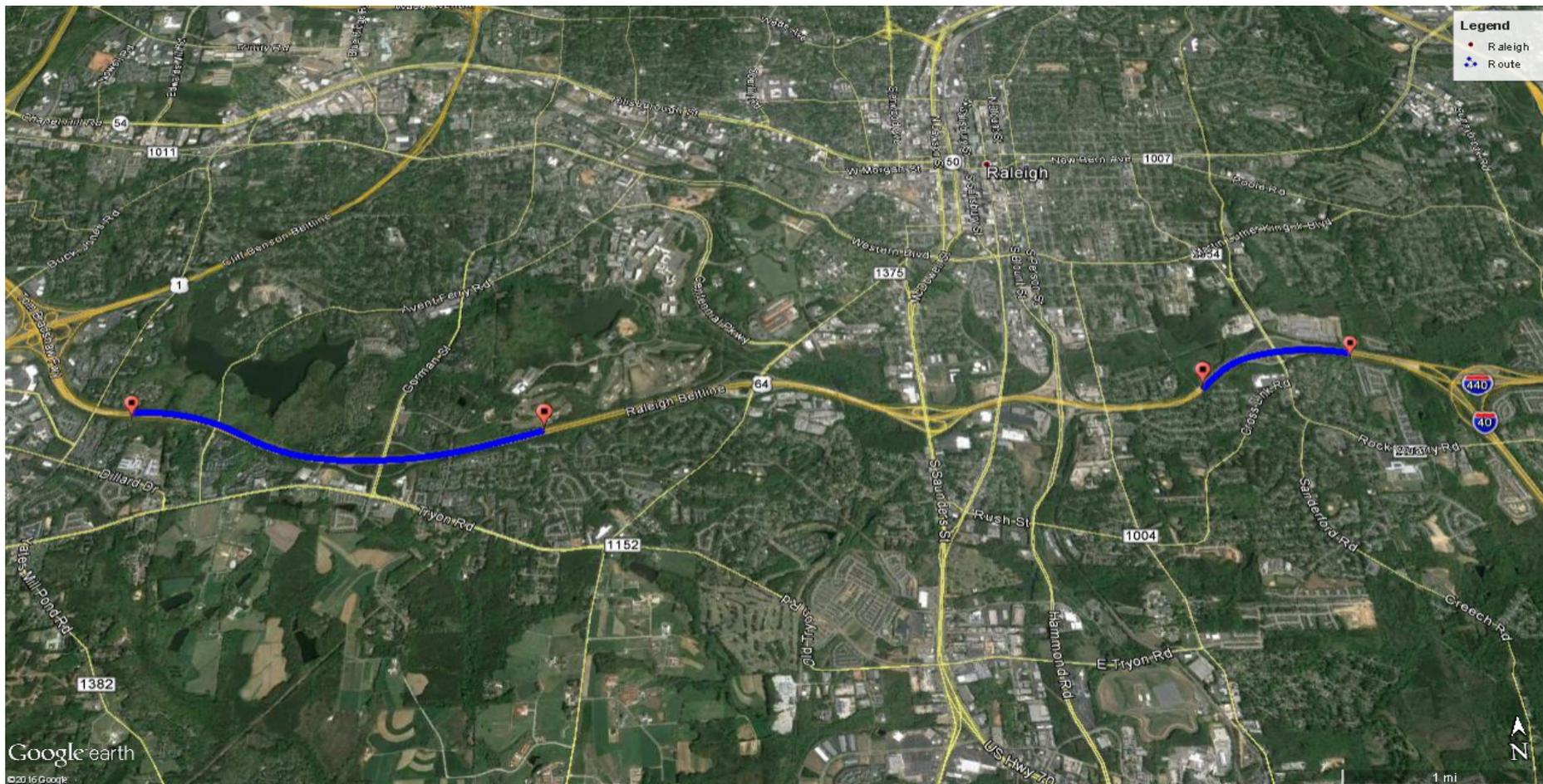


Data Analyses & Findings

1. Project Overview
2. Data Collection
3. Data Processing
4. Data Summary

Data Analyses & Findings

Two Locations along I-40



Data Analyses & Findings

- May 25 – West of US401 ARA on-site
- May 26 – West of US401 ARA on-site
- May 31 – East of US401
- June 1 – East of US401

Data Analyses & Findings



Mixtures placed with
Caterpillar Rubber
Tracked Paver

Roadtec MTD used with
hopper insert



Data Analyses & Findings



Tack coat application

Mixture delivered to site with end dump discharge trucks.



Data Analyses & Findings

Compaction Train; all steel wheel rollers



Data Analyses & Findings

Non-nuclear density gauge used to measure mat density and superimposed on temperature profiles.

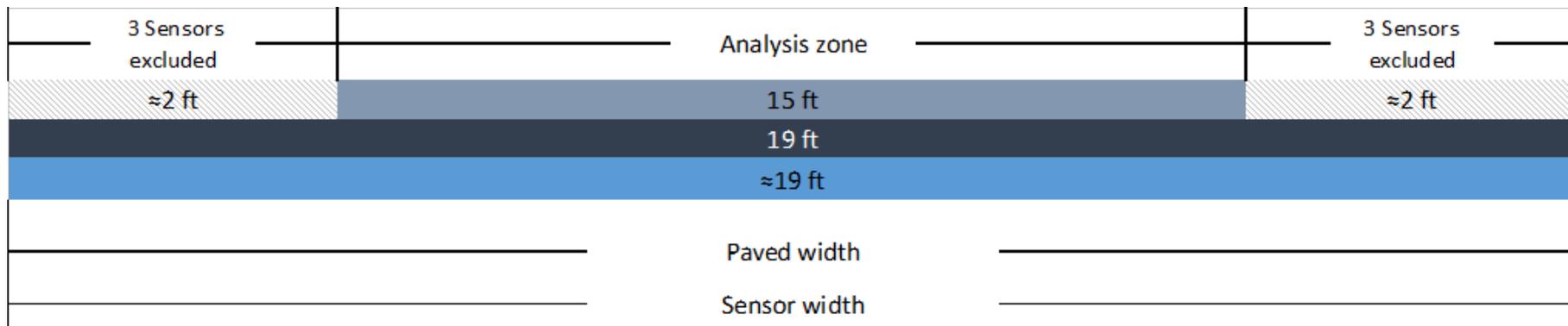


Data Analyses & Findings

1. Project Overview
2. Data Collection
3. Data Processing
4. Data Summary

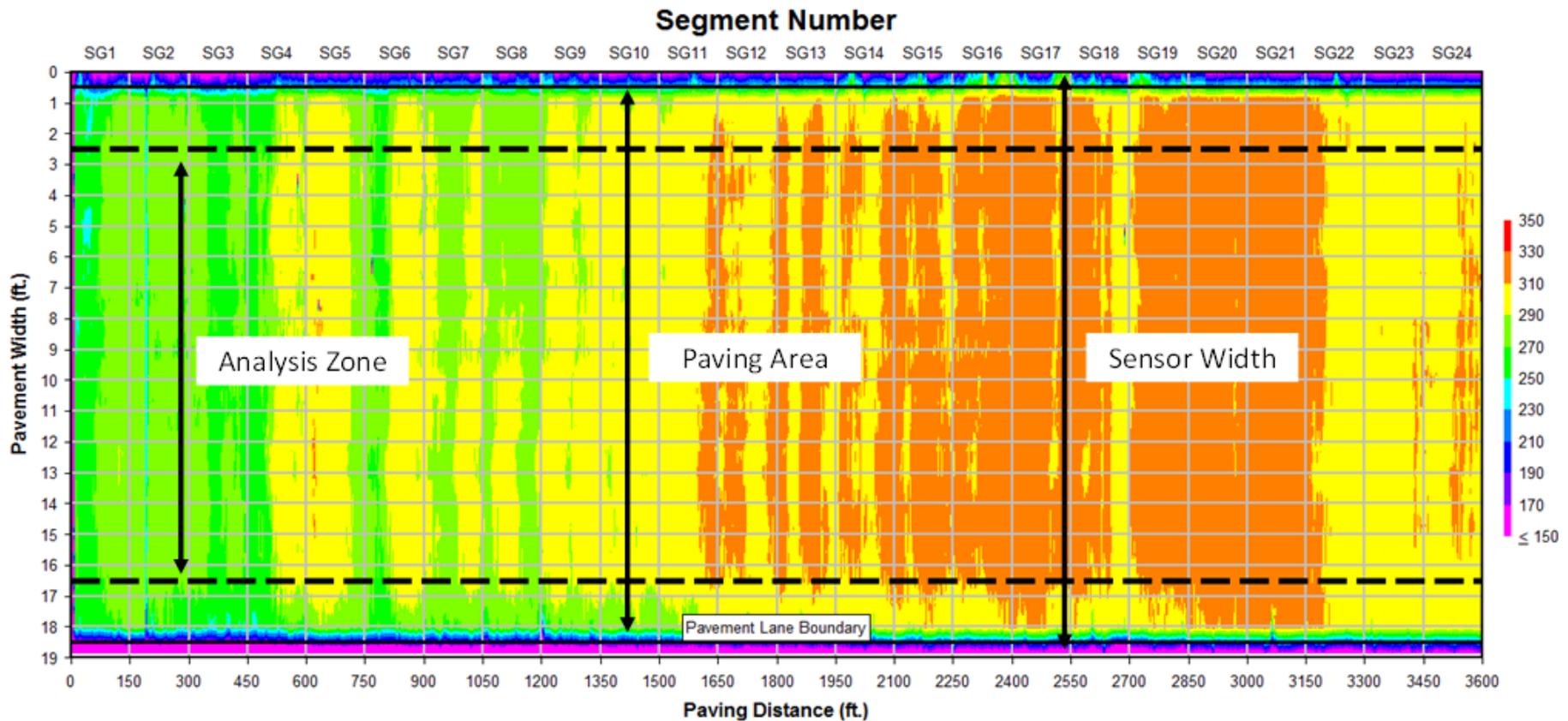
Data Analyses & Findings

Paving Width and Analysis Zones



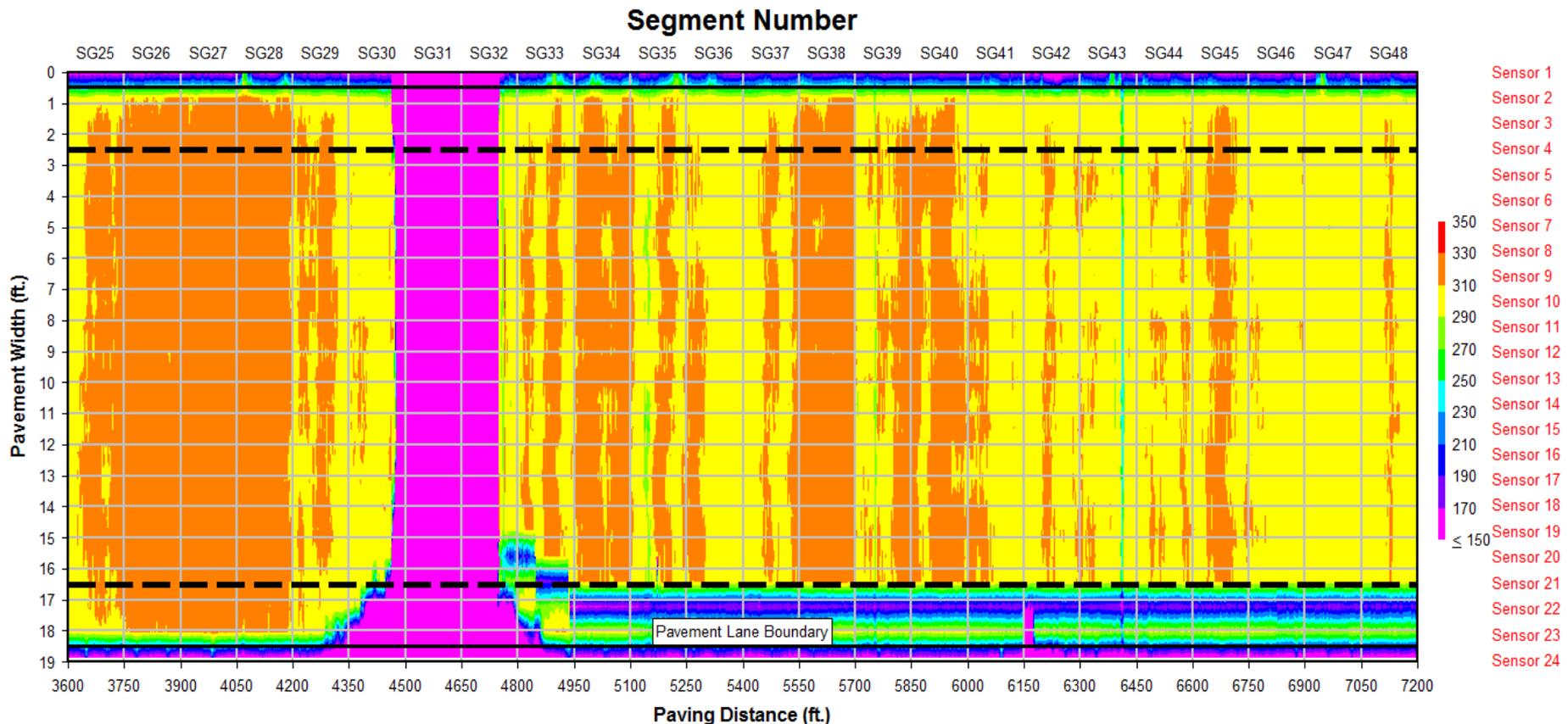
Data Analyses & Findings

Paving Width and Analysis Zones Raw Temperature Profile Example



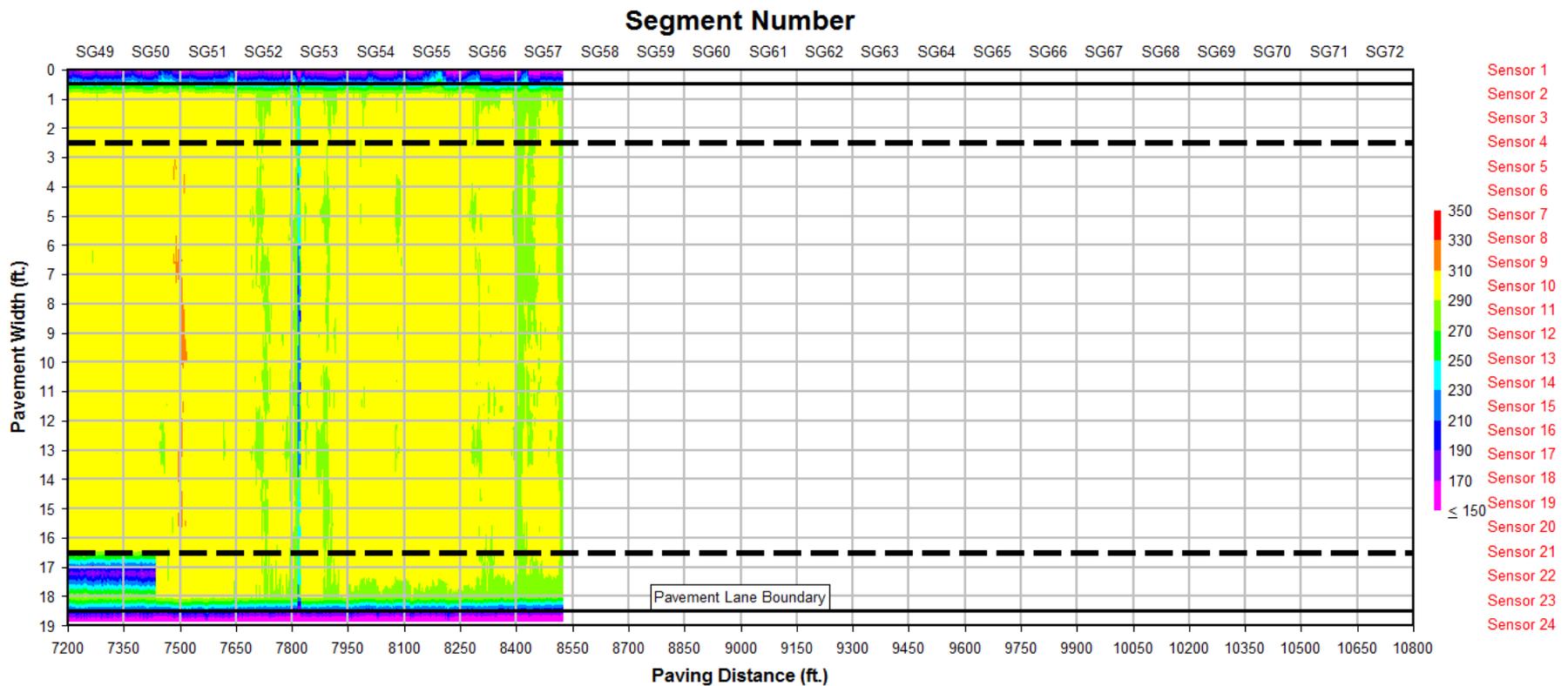
Data Analyses & Findings

Raw Temperature Profile – What's the cool spot?

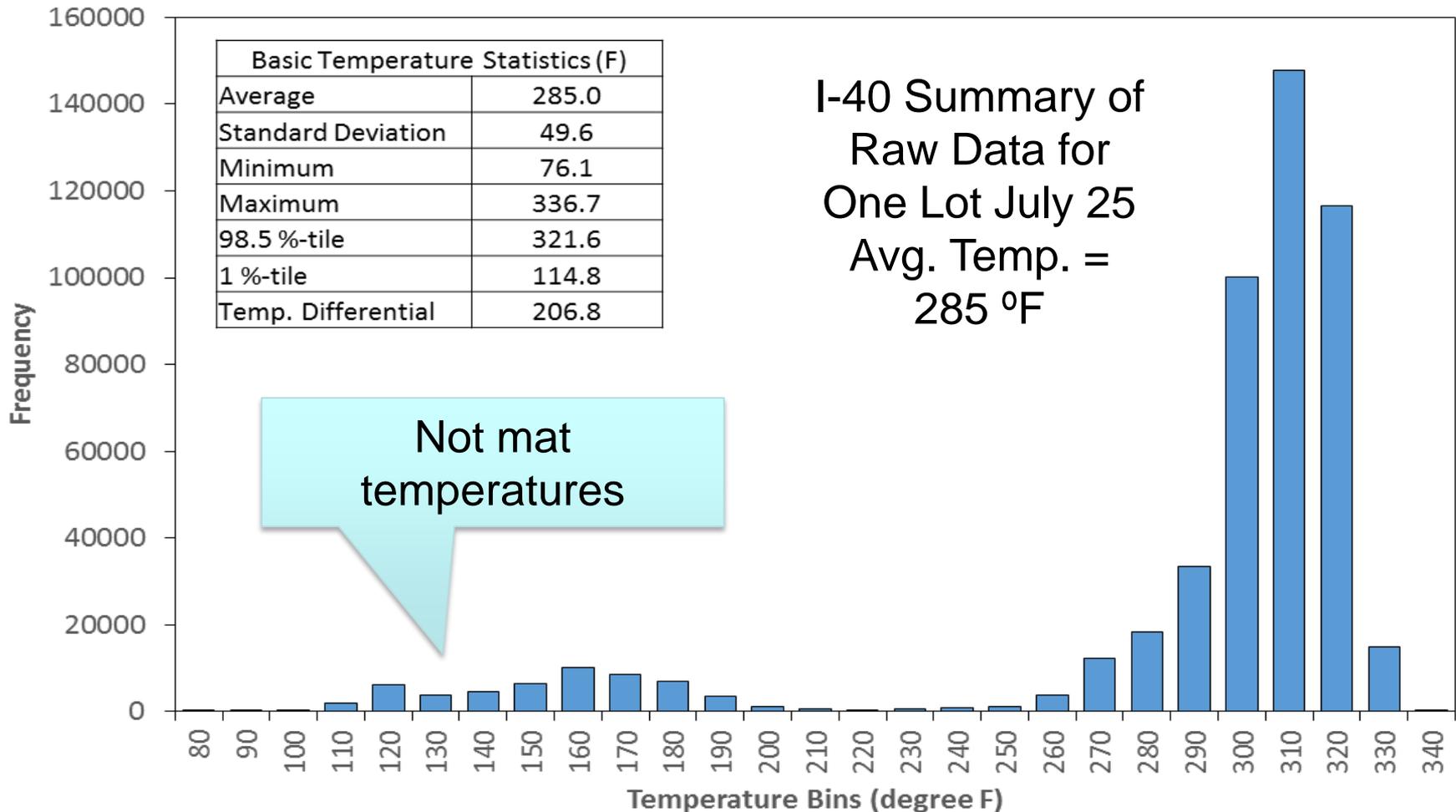


Data Analyses & Findings

Raw Temperature Profile



Data Analyses & Findings

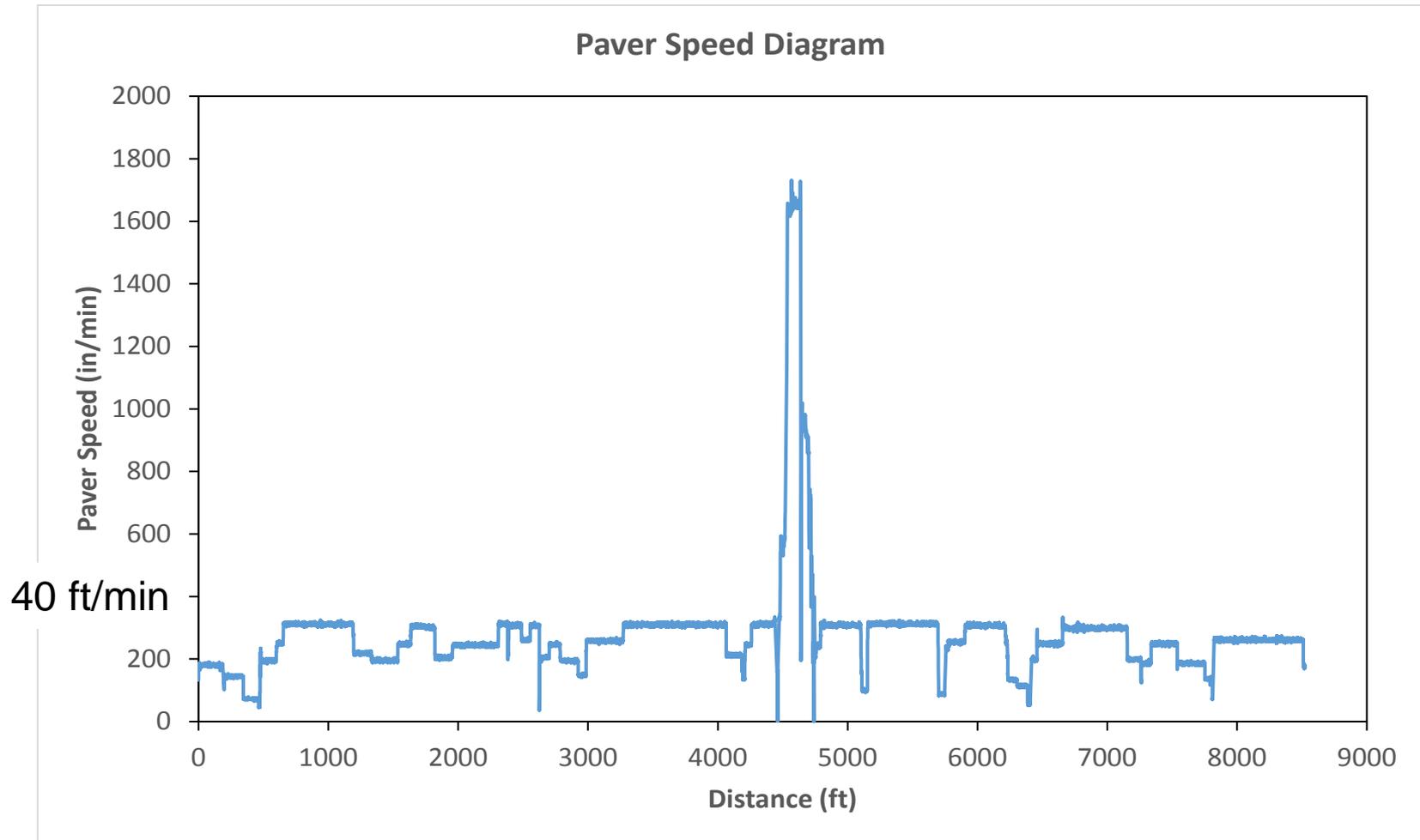


Data Analyses & Findings

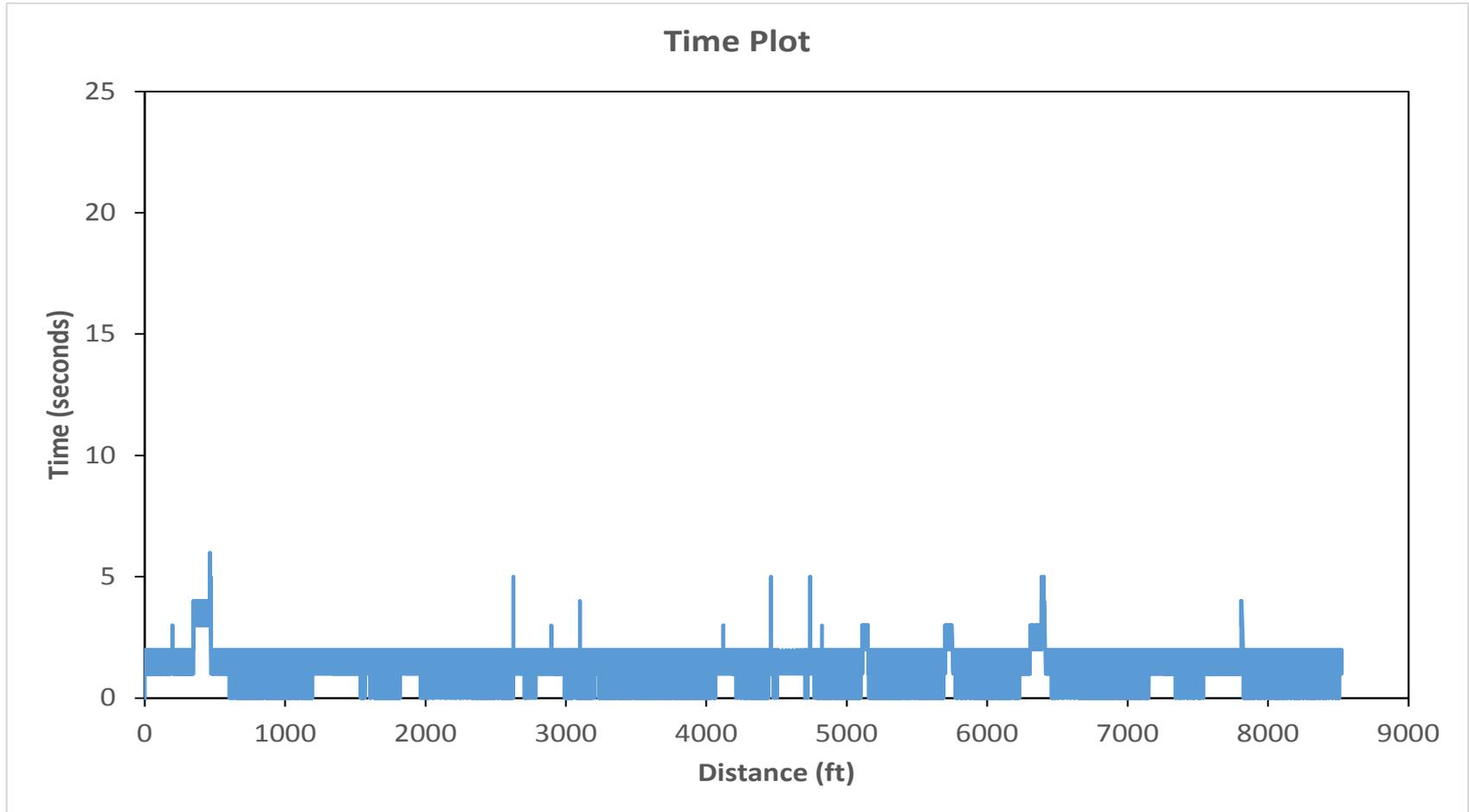
Data diagrams reviewed during production:

1. Paver speed diagram
2. Time plot
3. Average temperature plot

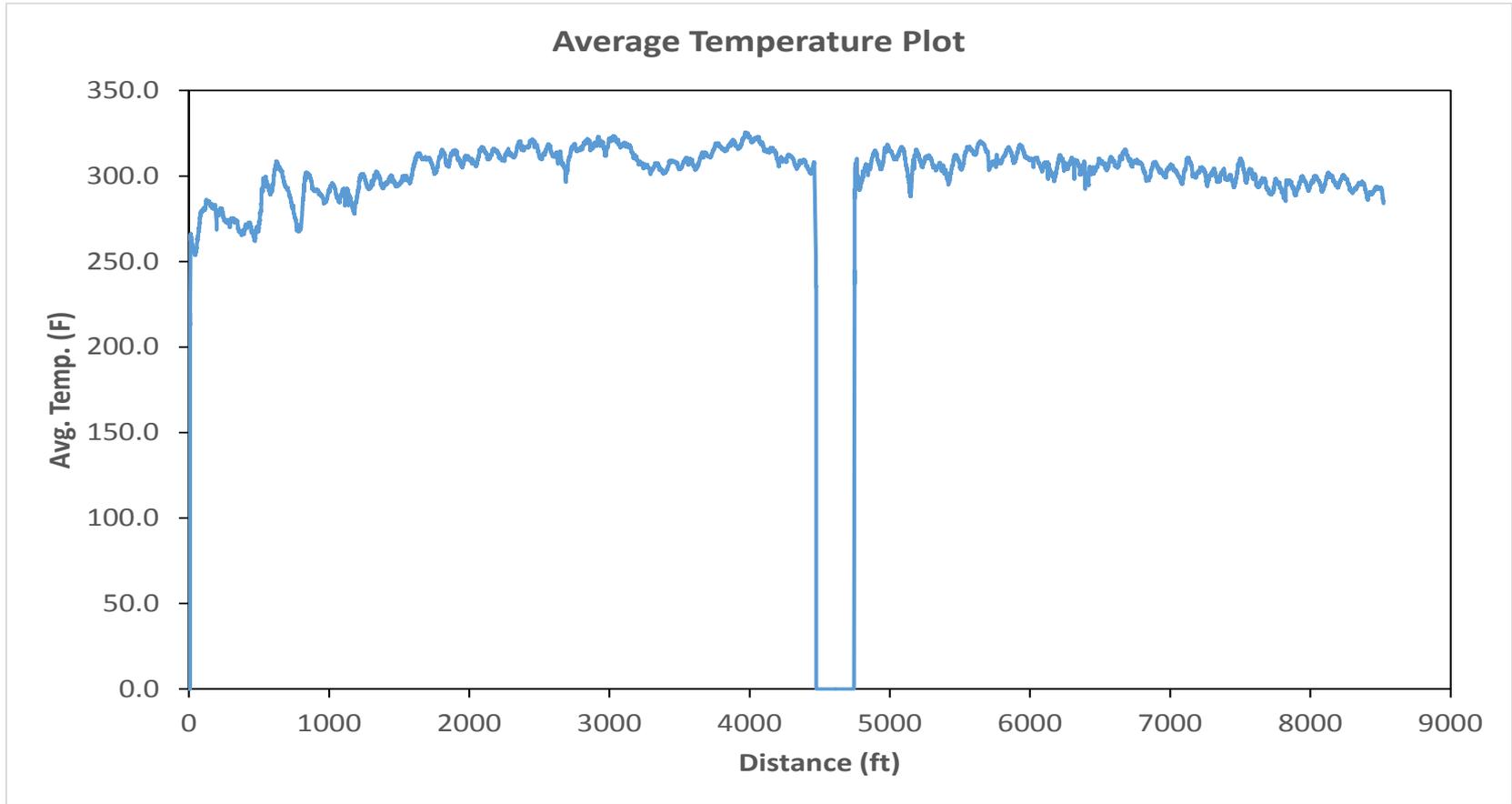
Data Analyses & Findings



Data Analyses & Findings

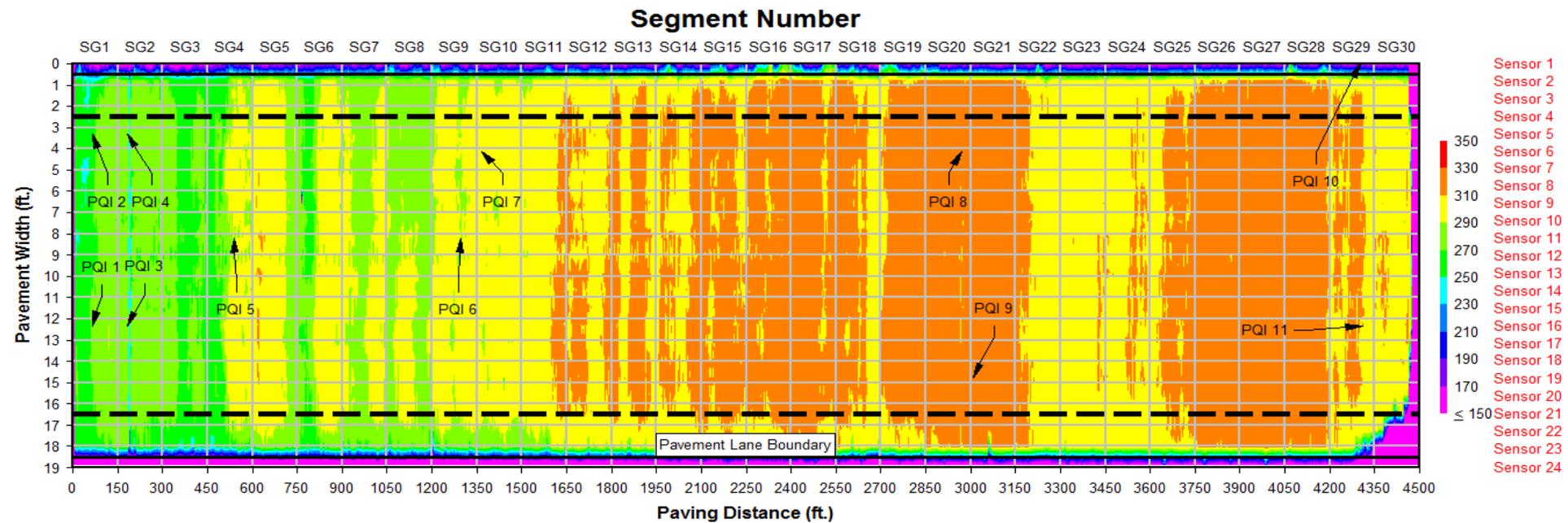


Data Analyses & Findings



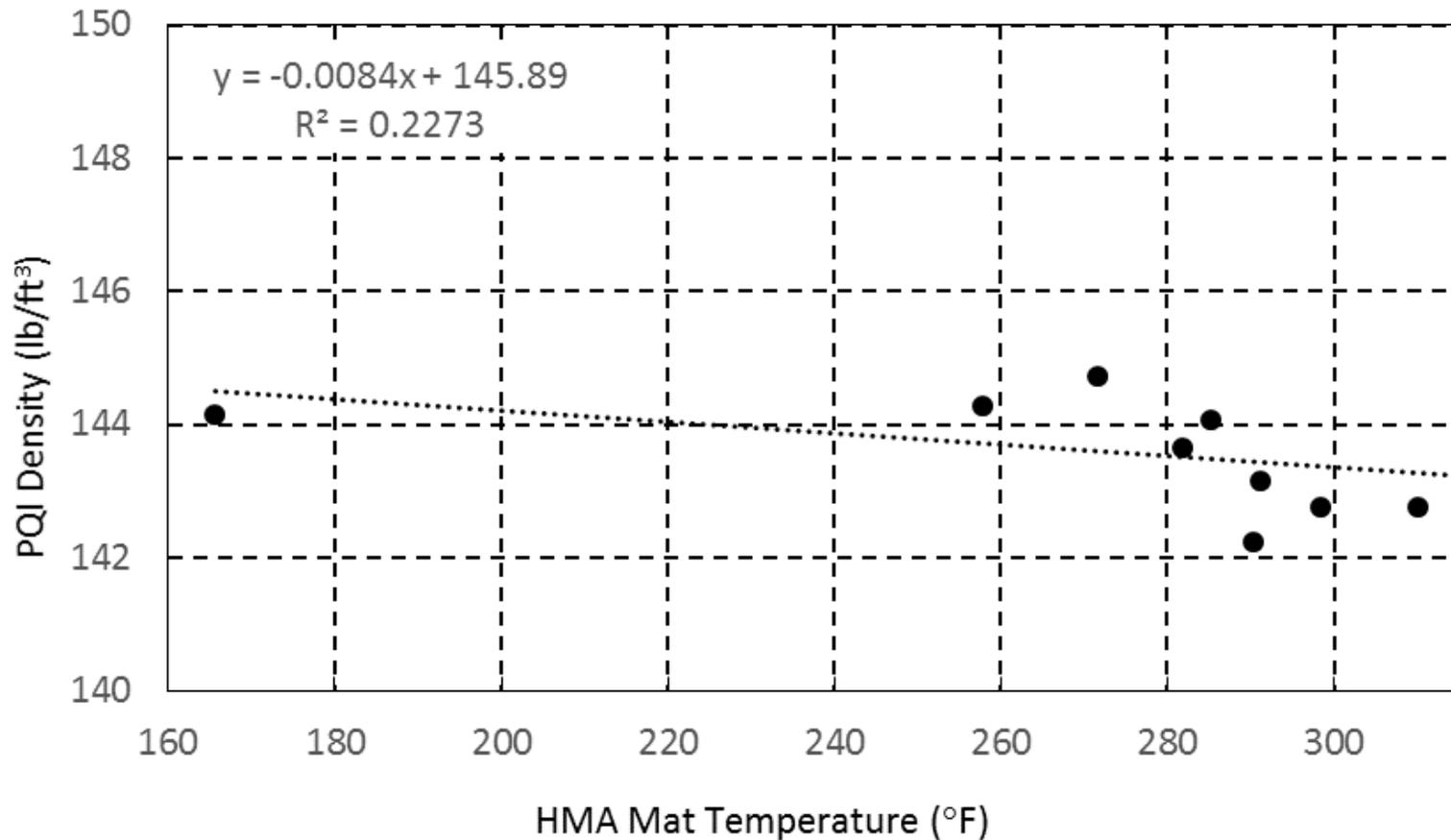
Data Analyses & Findings

Density Measurement Locations



Data Analyses & Findings

Density Measurement Locations



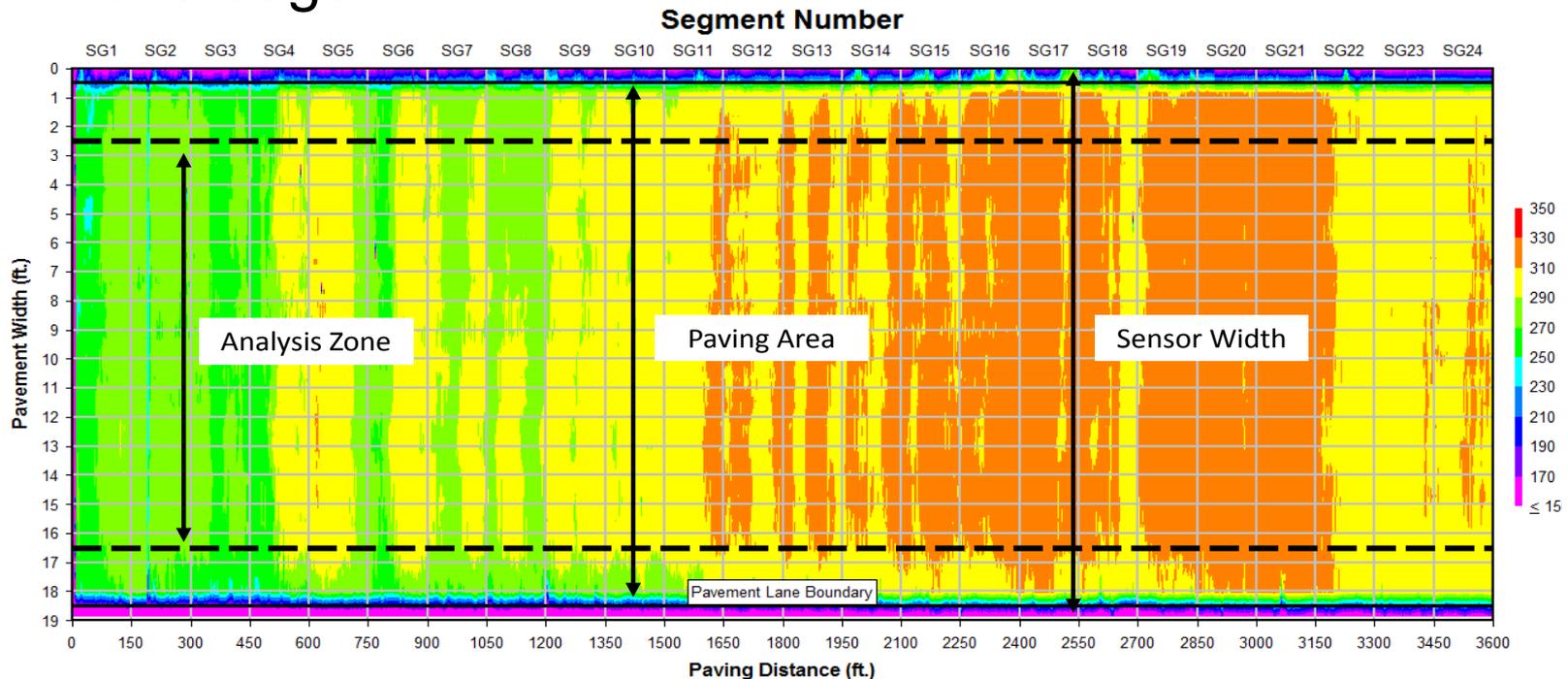
Data Analyses & Findings

1. Project Overview
2. Data Collection
3. Data Processing
4. Data Summary

Data Analyses & Findings

Data Processing—eliminate invalid temperature measurements:

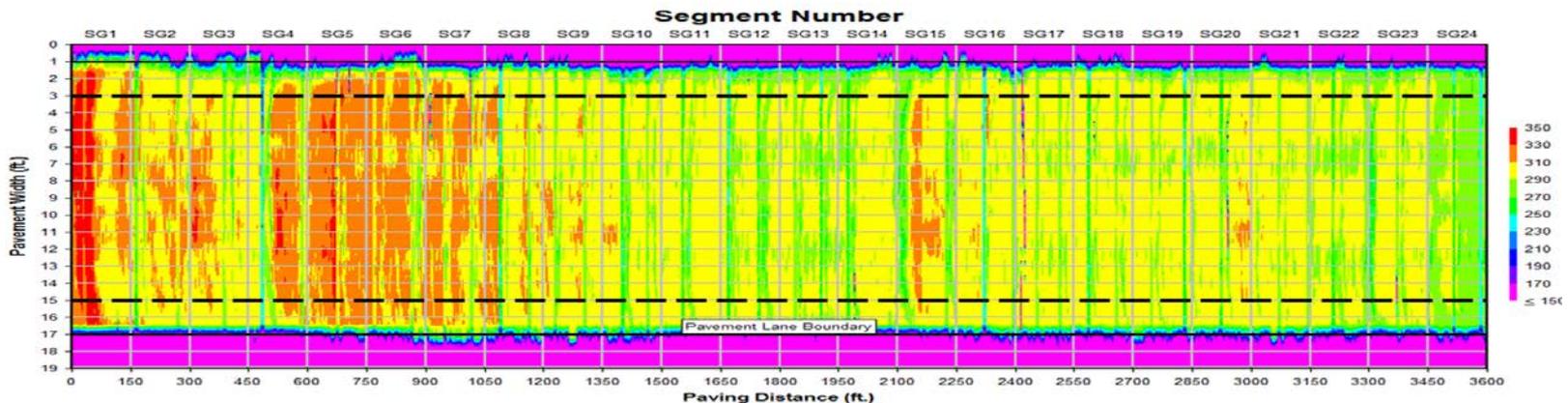
1. Eliminate measurement locations within 2 feet of the mat's edge.



Data Analyses & Findings

Data Processing—eliminate invalid temperature measurements:

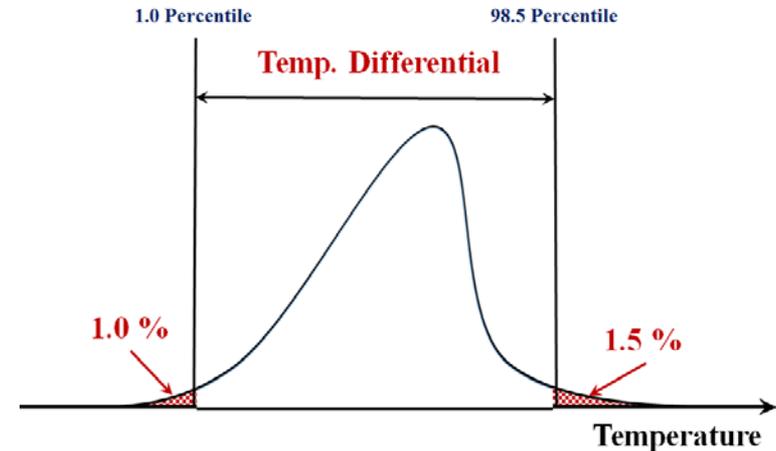
2. Eliminate data with paver stops greater than 60 seconds, between locations:
 - 2 feet behind measurement location of stop
 - 8 feet in front of measurement location of stop
3. Eliminate temperature readings < 170 °F and > 400 °F.



Data Analyses & Findings

- Temperature Differential Criteria, each 150 foot segment:

$$T_{Diff} = T_{98.5} - T_{1.0}$$



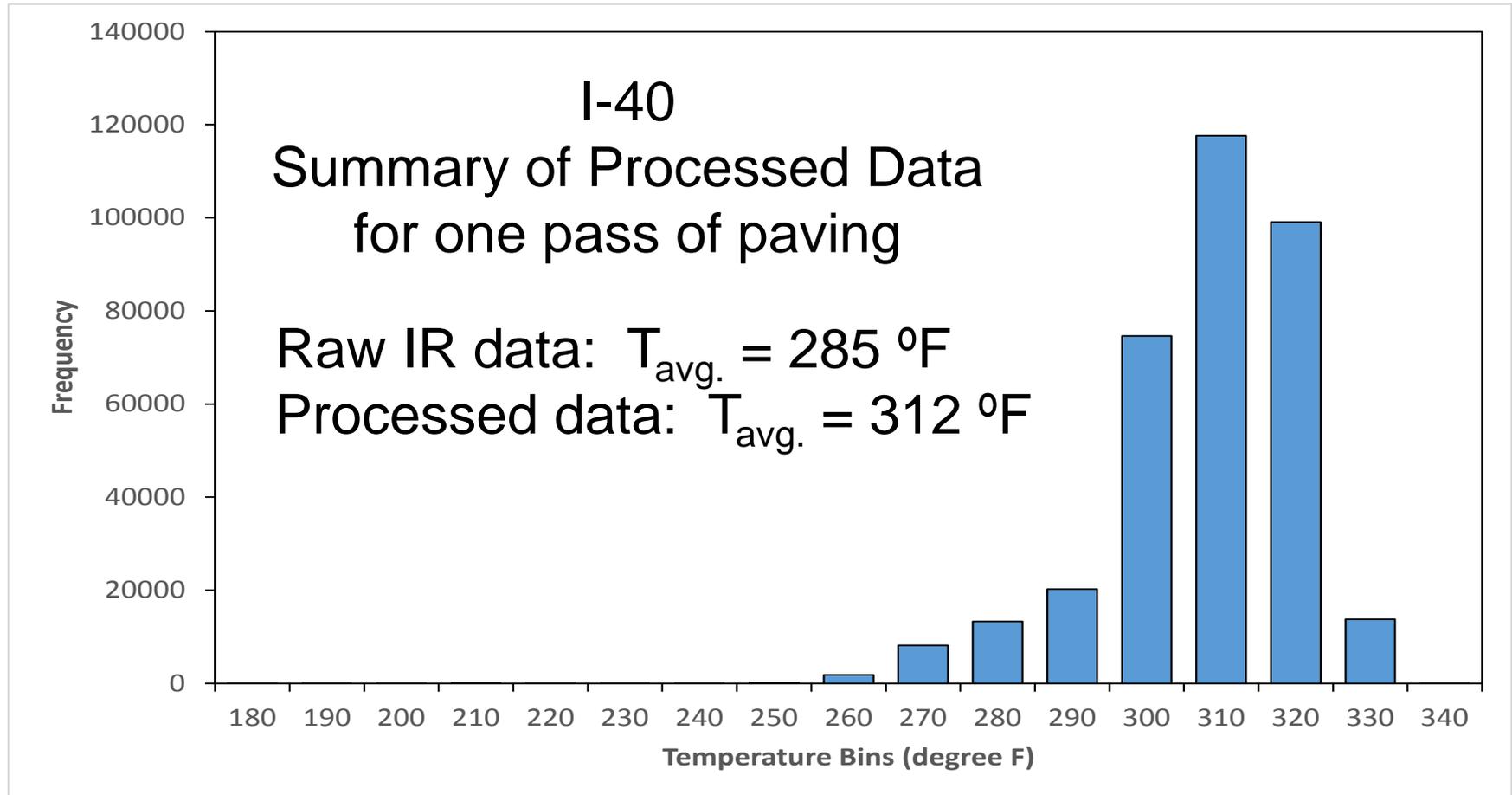
- $T_{diff} \leq 25$ °F
- 25 °F $< T_{diff} \leq 50$ °F
- $T_{diff} > 50$ °F

No temperature difference

Moderate temperature difference

Severe temperature difference

Data Analyses & Findings



Data Analyses & Findings

1. Project Overview
2. Data Collection
3. Data Processing
4. Data Summary

Data Analyses & Findings

Difference in Traffic Levels – Haul Time



IL 116



I-155

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Illinois DOT Project					
Excluded	126	95	24	7	None
Included	126	79	24	23	None

To include or exclude paver stops?
 If paver stop cause severe temperature differences:
 they should be included

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Alaska DOT Project					
Excluded	36	27	9	0	None
Included	36	22	8	6	None
Maine DOT Project					
Excluded	579	546	25	8	None
Included	579	494	56	29	None
Virginia DOT Project					
Excluded	84	72	10	2	None
Included	84	71	9	4	None

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Eastern Federal Lands					
Excluded	108	2	24	82	None
Included	108	2	16	90	None
New Jersey DOT Project					
Excluded	262	188	49	25	None
Included	262	163	43	56	None
Missouri DOT Project					
Excluded	816	648	135	33	None
Included	816	440	170	206	None

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
North Carolina DOT Project					
Excluded	126	95	24	7	None
Included	126	79	24	23	None
West Virginia DOH Project; without MTV					
Excluded	99	0	74	25	None
Included	99	0	58	41	None
West Virginia DOH Project; with an MTV					
Excluded	159	133	19	7	None
Included	159	104	47	8	None

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Illinois DOT Project					
Excluded	1,520	218	761	541	None
Included	1,502	196	708	598	None
Excluded					
Included					
Excluded					
Included					

R06C-IR Demonstration Projects

Percentage of Segments with Severe Temperature Differentials

Project	Delivery Truck Type	MTV Included	Percent Severe Temp. Differentials	Thermal Streaking
Alaska	Bottom-Dump	Windrows	17	None
<i>EFL</i>	<i>End Dump</i>	<i>No</i>	<i>83</i>	<i>None</i>
<i>Illinois</i>	<i>End Dump</i>	<i>No</i>	<i>40</i>	<i>None</i>
Maine	End Dump	Yes	5	None
Missouri	End Dump & Flow Boys	Yes	25	None
NJ	End Dump	Yes	21	None
Virginia	End Dump	Yes	5	None
NC	End Dump	Yes	18	None
<i>WV</i>	<i>End Dump</i>	<i>No</i>	<i>41</i>	<i>None</i>
WV	End Dump	Yes	5	None

Above include paver stops.

R06C-IR Demonstration Projects

Minnesota Acceptance Specification: Summary

Project	Delivery Truck Type	MTV Included	Incentive/Disincentive	
			Stops Included	Stops Excluded
Alaska	Bottom-Dump	Windrows	+\$17,778	+\$30,000
<i>EFL</i>	<i>End Dump</i>	<i>No</i>	<i>-\$32,593</i>	<i>-\$29,630</i>
<i>Illinois</i>	<i>End Dump</i>	<i>No</i>	<i>-\$10,706</i>	<i>-\$8,500</i>
Maine	End Dump	Yes	+\$32,124	+\$37,168
Missouri	End Dump & Flow Boys	Yes	+\$11,471	+\$30,147
NJ	End Dump	Yes	+\$16,336	+\$24,885
Virginia	End Dump	Yes	+\$31,905	+\$33,333
NC	End Dump	Yes	+\$17,778	+\$27,937
<i>WV</i>	<i>End Dump</i>	<i>No</i>	<i>-\$16,566</i>	<i>-\$10,101</i>
WV	End Dump	Yes	+\$24,151	+\$31,698

Based on 2,000 IR segments for each project.

Data Analyses & Findings

In summary: infrared scanner identified areas or locations with higher temperature differences.



Questions?



NEXT:

- Implementation: Contractor Perspective



Infrared Technology (IR)

Implementation Products and Strategies

March 22, 2017



U.S. Department of Transportation
Federal Highway Administration

AMERICAN ASSOCIATION
OF STATE HIGHWAY AND
TRANSPORTATION OFFICIALS

AASHIO

Implementation Products and Strategies



1. Field Demonstration Projects and Products
2. Application and Use: Examples
3. Questions and Answers

Workshop Wrap-Up



- R06C: additional information on Infrared Tech.
 - AASHTO Site: <http://shrp2.transportation.org>
 - FHWA Site: www.fhwa.gov/goshrp2

Demonstration Projects and Products



1. Case Study/Demonstration Report
2. Showcase
3. Trouble Shooting and Best Practices Guide
4. Specification Guide
5. IR Guide/Primer

Demonstration Projects and Products



1. Field Demonstration Projects and Case Study Report:
 - Purpose/Focus
 - a) Enhance the deployment and use of the IR technology.
 - b) Identify/summarize lessons learned from field trials.
 - c) Confirm Pave-IR can identify the different types of temperature differentials that affect mat density and pavement performance.
 - d) Demonstrate and discuss value added using IR technology to agency and contractor

Demonstration Projects and Products



2. Showcase:

- Purpose/Focus
 - a) Highlight IR technology, provide training & operation.
 - b) Attendance includes agencies, contractors, industry, consultants and academia.
- Missouri DOT Hosted
- June 1, 2016

Demonstration Projects and Products

3. Trouble Shooting and Best Practices Guide

- Purpose/Focus

- a) Provide guidance on:

- Setting up the equipment and getting started.
 - Interpreting the raw data for making decisions.

- b) Identify data collection and maintenance issues with the equipment and software.

Demonstration Projects and Products

4. Specification Guide; AASHTO PP 80-14

Standard Practice for
Continuous Thermal Profile of
Asphalt Mixture Construction

AASHTO Designation: PP 80-14¹



American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001

Demonstration Projects and Products



4. Specification Guide, continued

- Purpose/Focus

- a) Advance standardization of IR equipment and testing protocols through AASHTO.
- b) Agencies can customize it to their needs
- c) Revised/Enhanced AASHTO PP 80-14
- d) Agency Experience: Minnesota DOT, Texas DOT, etc.

Demonstration Projects and Products

5. IR Guide/Primer

- Purpose/Focus

- a) Introduce the Pave-IR method to transportation agencies and contractors.
- b) Increase awareness of how IR can improve paving operations and increase uniformity of mat.
- c) Demonstrate use of Pave-IR as a QC Tool.

Implementation Products and Strategies

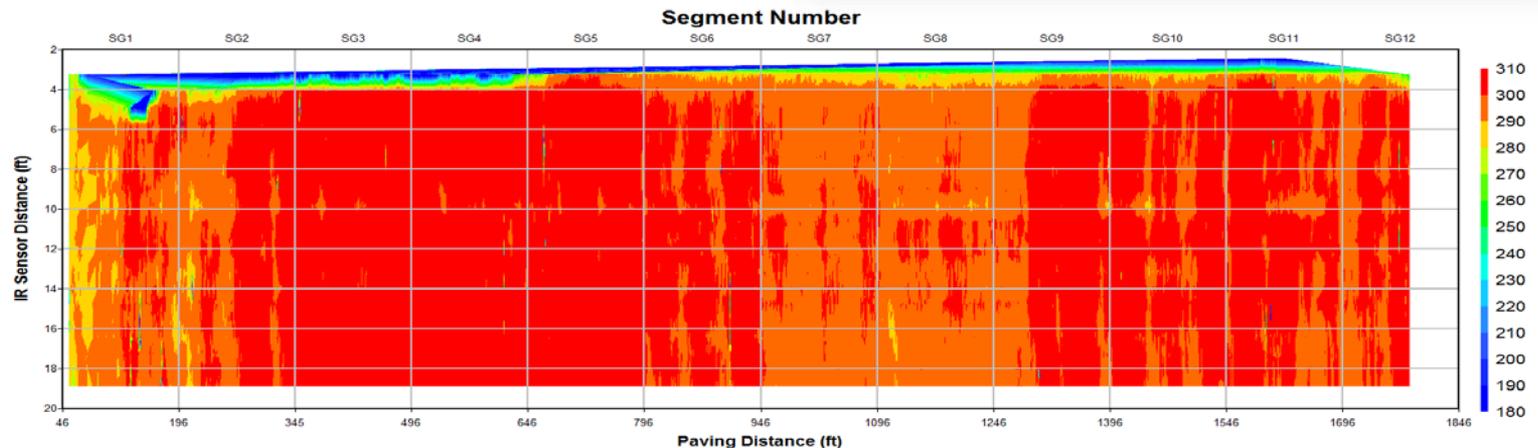


1. Field Demonstration Projects and Products
2. Application and Use: Examples
3. Questions and Answers

Application and Use: Examples

Application & Use, WHY:

- Continuous readings to evaluate mat uniformity through temperature uniformity.
- Non-uniform temperatures imply non-uniform densities, which usually mean higher maintenance.



Application and Use: Examples

Role of IR in Quality Assurance Programs

1. Quality control plan; contractor
 - Improve communication between personnel
 - Reduce risk of being penalized
 - Forensic tool to trouble shoot low or non-uniform densities
2. Acceptance plan; agency
 - Reduce future distress and maintenance costs
 - Dispute resolution

Application and Use: Examples

IR Role in Quality Control Plan; 4 examples

1. Missouri demonstration project
2. Virginia demonstration project
3. Federal Lands demonstration project
4. Illinois demonstration project

Application and Use: Examples

1. Missouri demonstration project

- Increased communication between plant and paver to minimize temperature differentials of mat.



Application and Use: Examples

1. Missouri demonstration project

- Use of laboratory facilities to monitor paving in real time to adjust plant on the fly

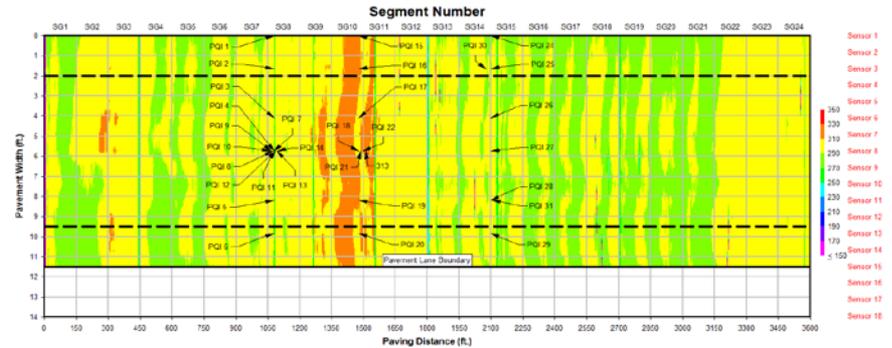


Application and Use: Examples

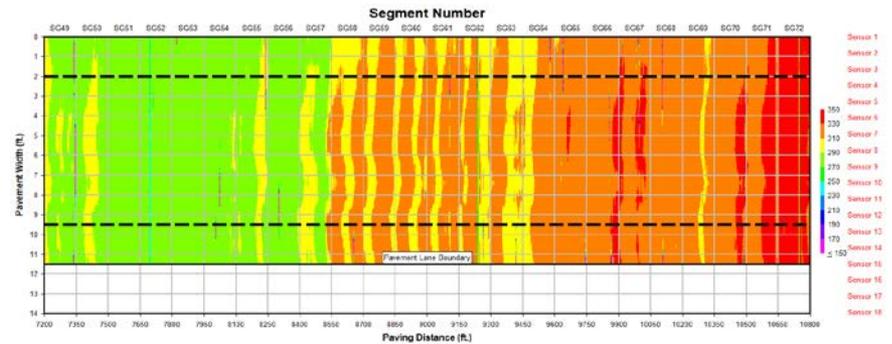
Raw Temperature Profile showing continuous improvement or more uniform mat temperatures as paving progresses.

Example from Missouri demonstration project.

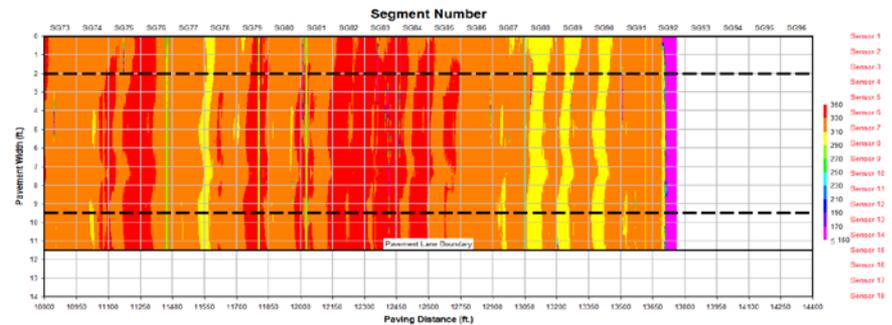
Near the beginning



Near Center of Lot



Near End of Lot

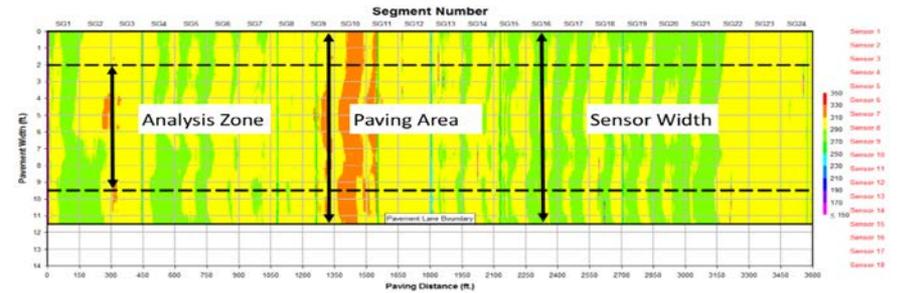


Application and Use: Examples

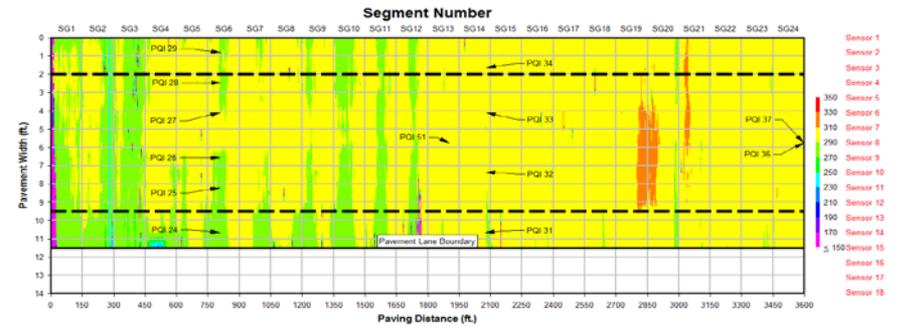
Raw Temperature Profile showing continuous improvement or more uniform mat temperatures as paving progresses.

Example from Maine demonstration project.

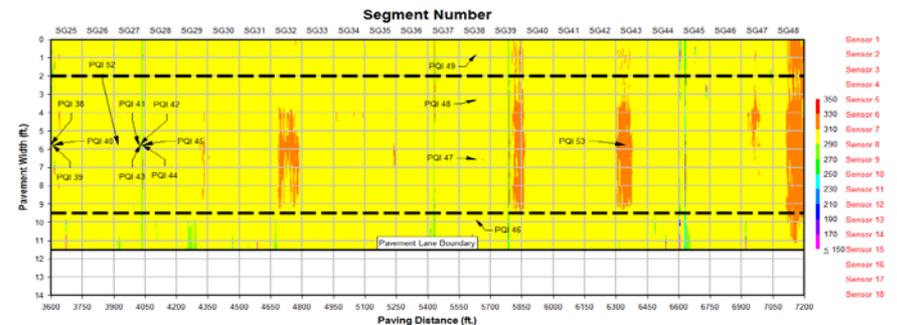
Near Start of Lot



Near Center of Lot



Near End of Lot



Application and Use: Examples

2. Virginia demonstration project

- Identify reason for severe temperature differentials and take action.
 - Avg. temperature differential at start of paving project; about 30 °F.
 - Avg. temperature differential after adding two trucks; about 15 °F.



Application and Use: Examples

3. Federal Lands demonstration project

- Identify reason for severe temperature differentials and take action; loading of trucks.
- One dump of mix in truck bed – severe temp. differential
- Two dump, no stockpile – reduced temp. differential.



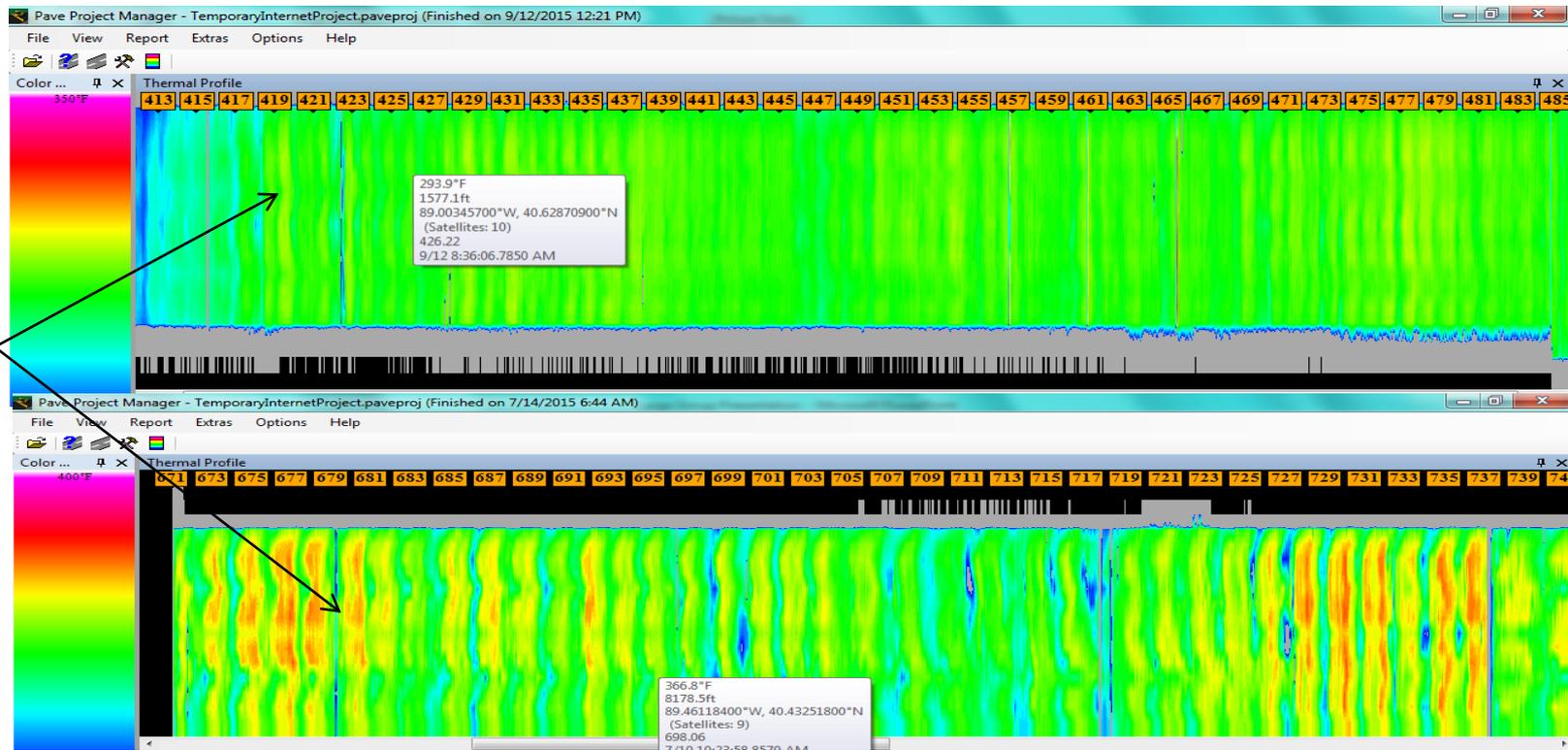
Application and Use: Examples

4. Illinois demonstration project – Contractor Comments
 - Full integration into the paving process from the paver operator to the Management level
 - How the use of an MTD can be a great tool
 - Management's decisions have consequences
 - Makes meeting PWL better to reduce penalties



Application and Use: Examples

4. Illinois demonstration project



Both jobs used a MTD, so what happened?

Application and Use: Examples

4. Illinois demonstration project

The screenshot shows a PDF document titled 'PPM_TemporaryReport.pdf - Adobe Reader'. It contains two tables, both titled 'Location of Paver Stops greater than One Minute'. The first table lists 10 locations with their respective durations. The second table lists 6 locations with their respective durations.

Location (stations)	Duration (h:min:sec)
642.77	0:4:45
648.71	0:12:16
655.05	0:2:38
668.97	0:5:23
670.32	0:2:53
679.85	0:1:12
718.82	0:3:0
719.21	0:1:50
738.89	0:22:26
738.90	0:2:45

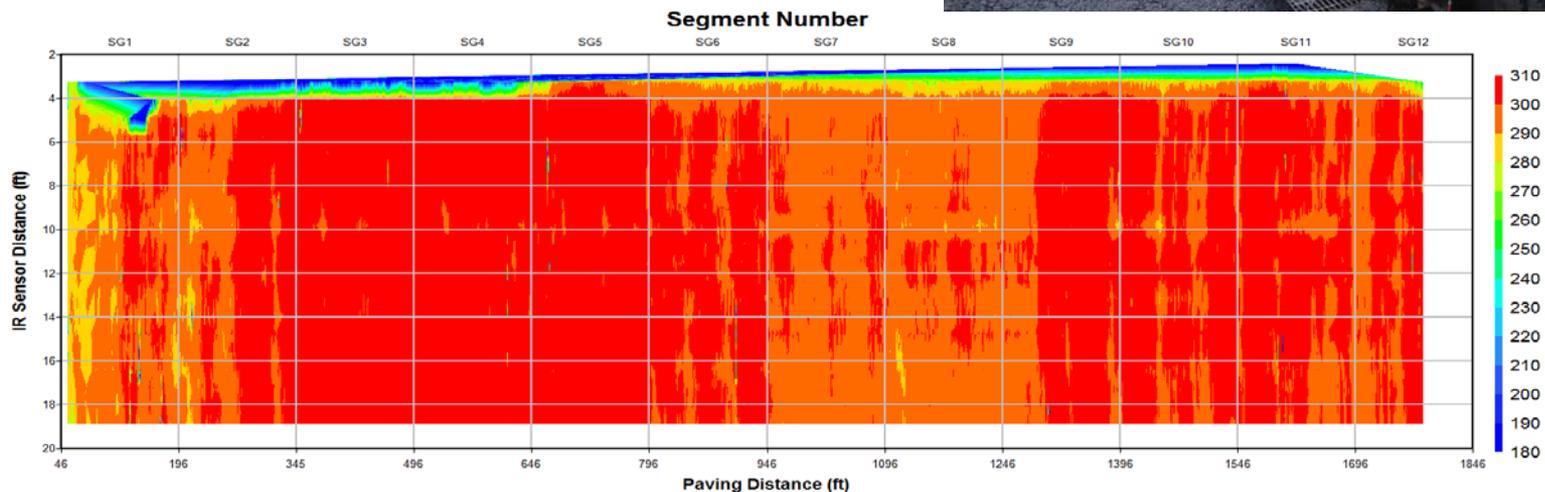
Location (stations)	Duration (h:min:sec)
744.95	0:3:41
762.94	0:4:3
795.55	0:28:6
798.92	0:3:17
799.41	0:1:8
835.45	0:4:12

- Paving time=640 min
- Total Stop time=106 min
- Effective paving time=534 min
- Distance=23,900 ft
- Average speed = 44.8'/min
- Average speed (effective) = **37.3'/min**

Application and Use: Examples

Conclusion from demonstration projects, to-date:

- Pave-IR scanner is one tool to confirm a uniform, high-quality mat.



Workshop Wrap-Up



NEXT:

- Implementation: Agency Perspective

Implementation Products and Strategies



1. Field Demonstration Projects and Products
2. Application and Use: Examples
3. Questions and Answers

Workshop Wrap-Up



NEXT:

- Implementation: Presentation of Ground Penetrating Radar Equipment

Rob Sommerfeldt

Complete workshop forms

- R06C: additional information on Infrared Tech.
 - AASHTO Site: <http://shrp2.transportation.org>
 - FHWA Site: www.fhwa.gov/goshrp2