SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

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

Hosted by:
North Carolina DOT
March22, 2017

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

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):** • Products and Application of Products o Case Studies from Demonstration Projects o 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)

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Infrared Technology (IR)

What is it and why use it?

March 22, 2017

U.S. Department of Transportation
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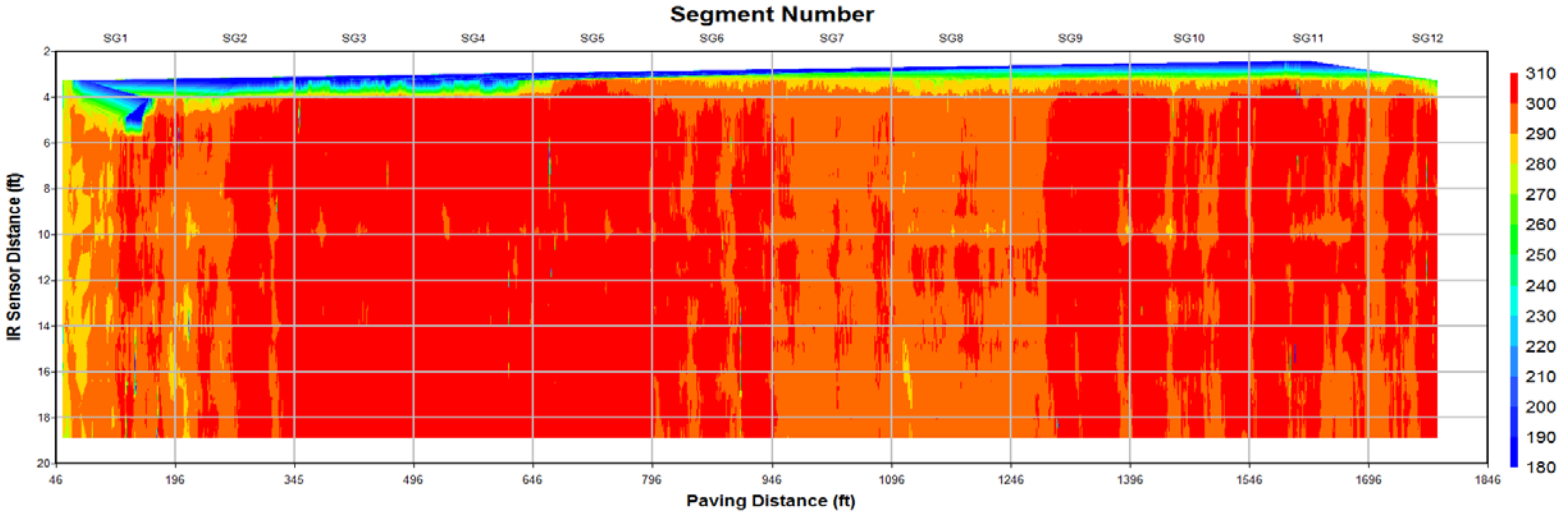
IR – What is it & why use it?

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

IR – What is it & why use it?

Infrared Thermography:

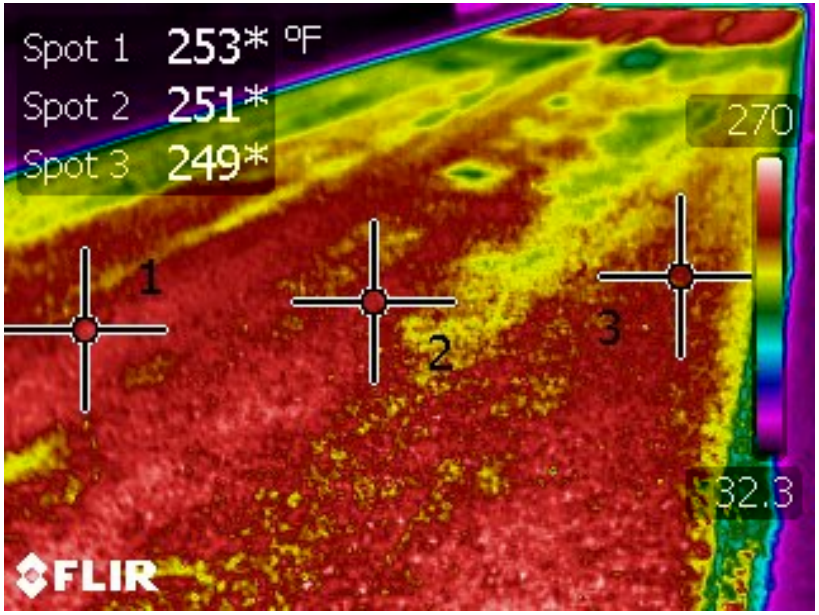
- The mapping of temperature contours (equal temperature) over the surface of a material.
- Contours are used to evaluate materials by measurement of their surface temperature and its variation.

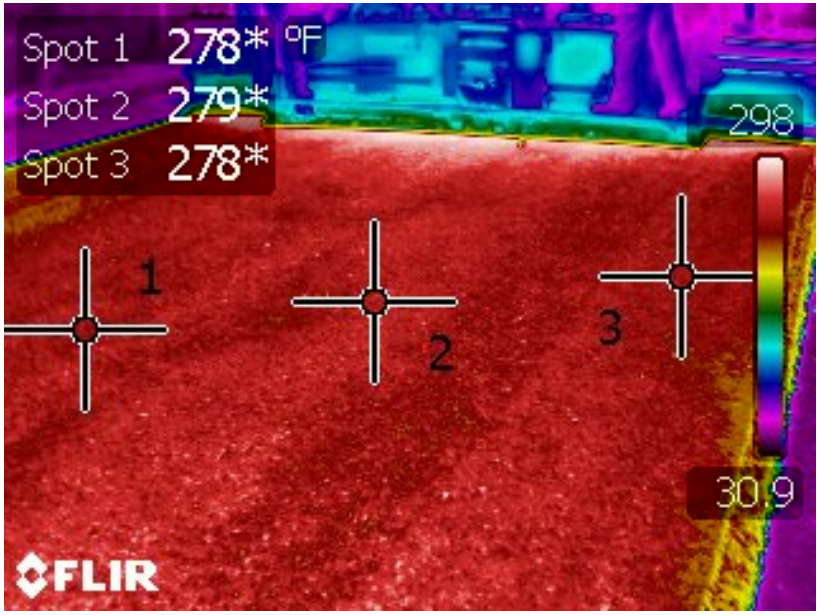


IR – What is it & why use it?

Temperature segregation (differential):

- More than 25 ºF difference in mat temperature behind screed.

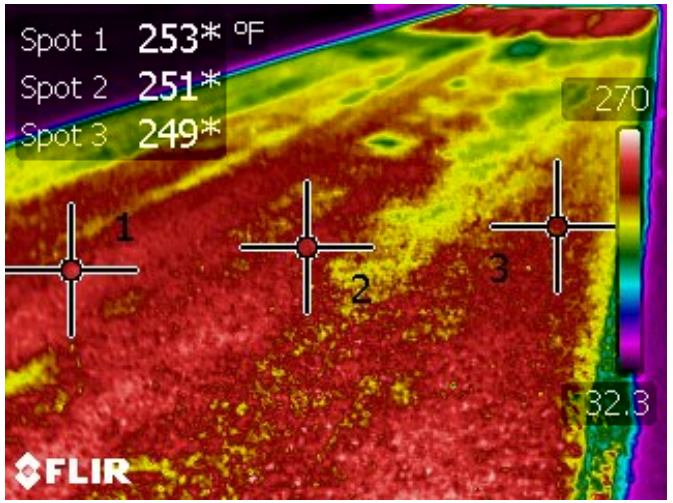


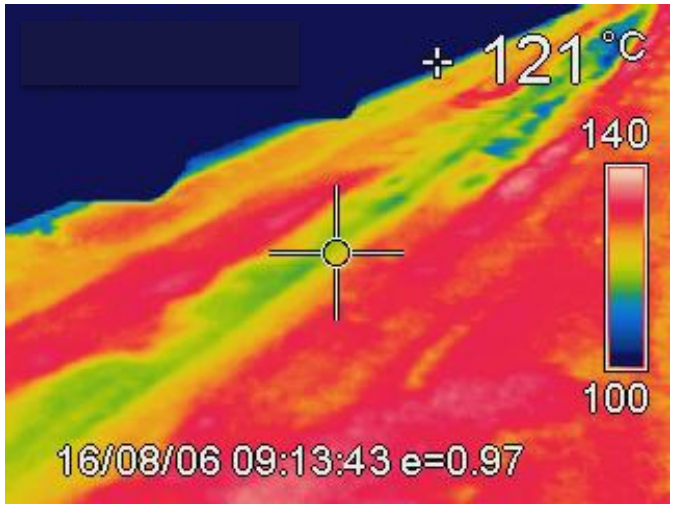


IR – What is it & why use it?

Types of Temperature Differences:

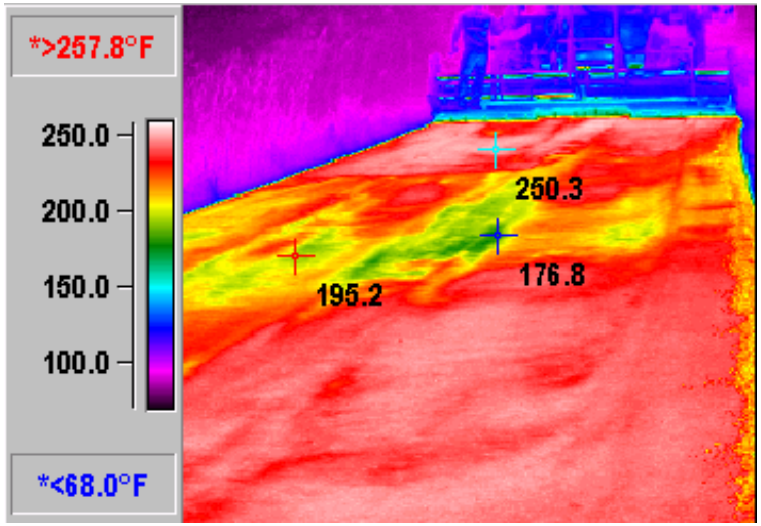
1. Cold spots
   - Truck to truck temperature differences
   - Improper loading and unloading of trucks
2. Thermal streaks
   - Longitudinal segregation
   - Inadequate or non-uniform amount of material across the mat





IR – What is it & why use it?

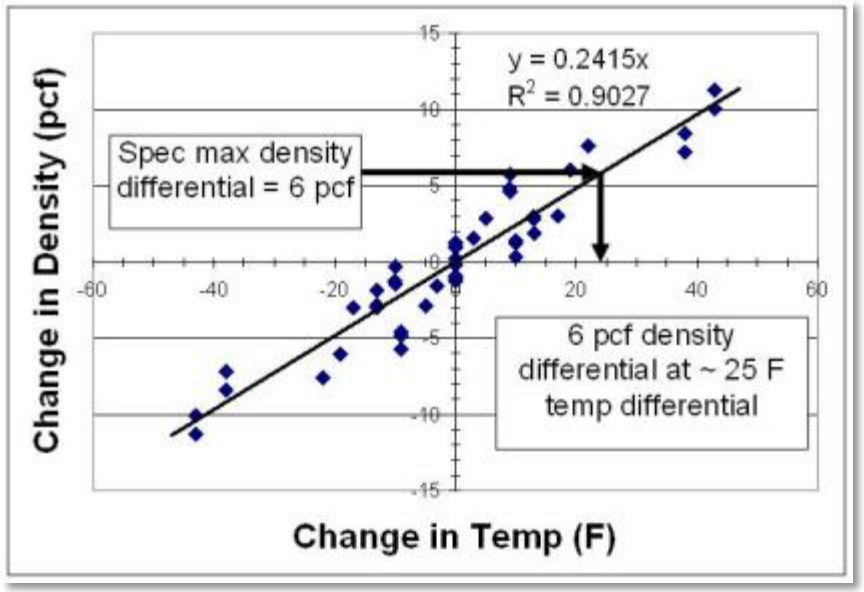
- Cold spots
  - Temperature difference of mat between truck exchanges – common.
  - Areas with higher air voids
- Focused testing have validated higher air voids
  - Coring
  - Radar (full coverage)
  - Nuclear gauge



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?

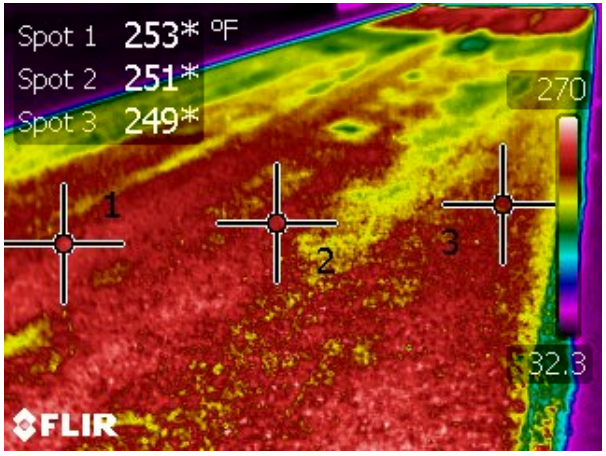
History; Mat Temperature Measurements

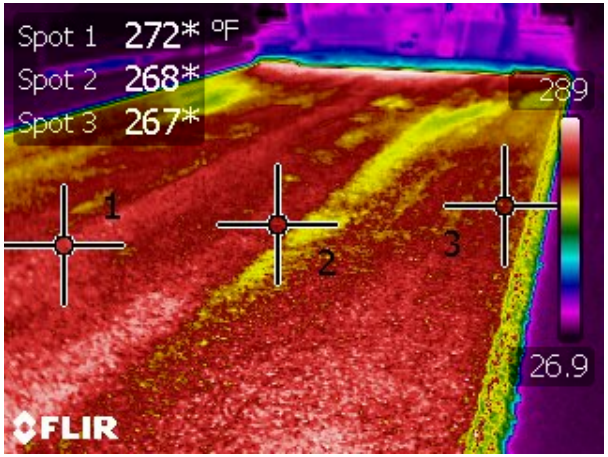
- IR sensors, IR-Bar; first device for continuous readings
- Pave-IR Scanner; second generation device for continuous readings

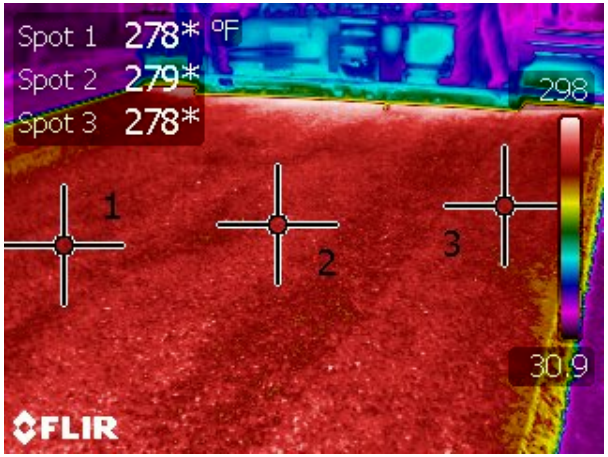
IR – What is it & why use it?

Application & use of temperature cameras

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



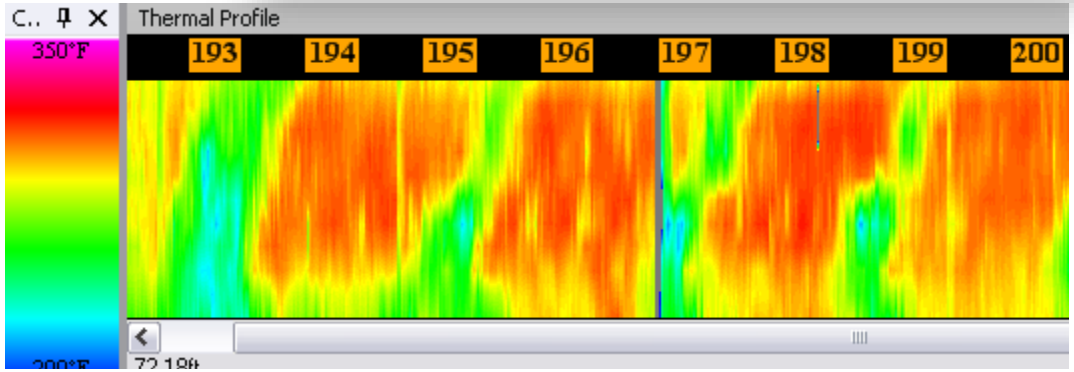




IR – What is it & why use it?

Application & use of IR-Bar and Scanner

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

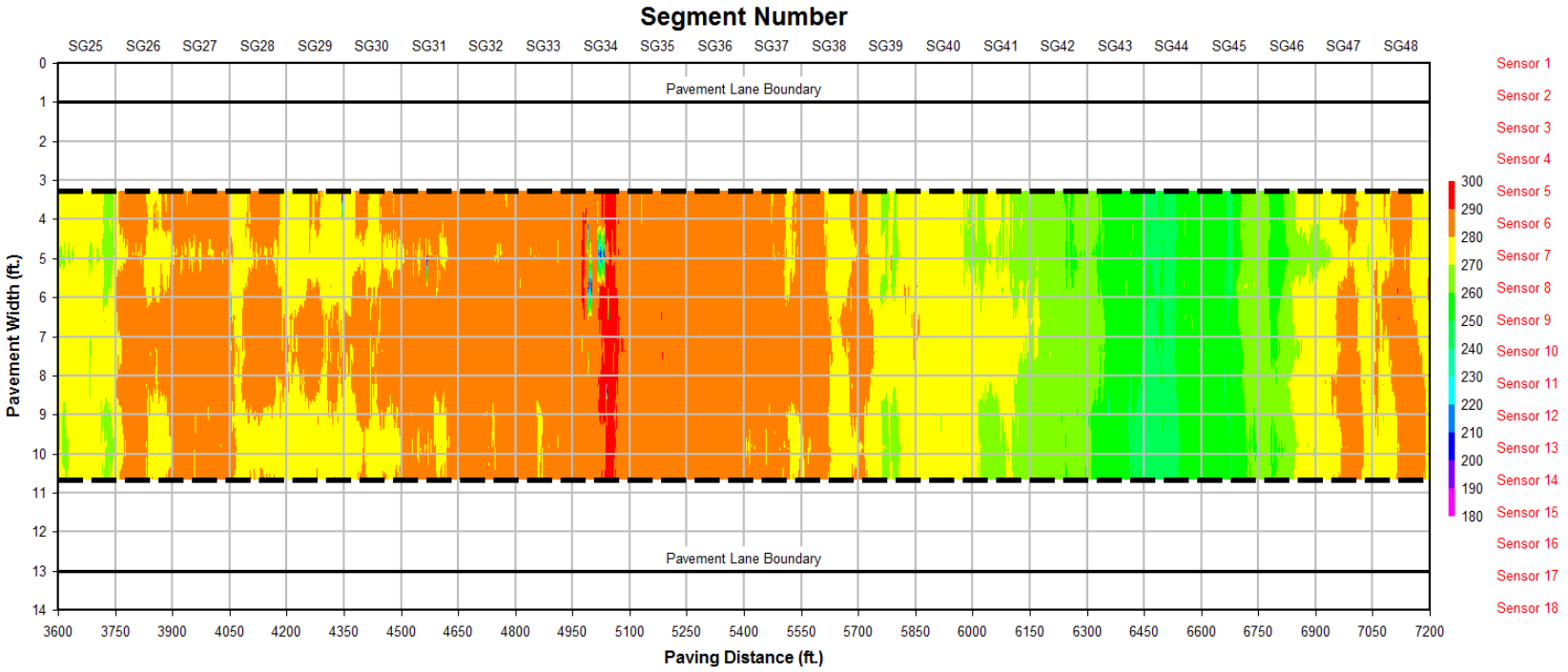


IR – What is it & why use it?

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

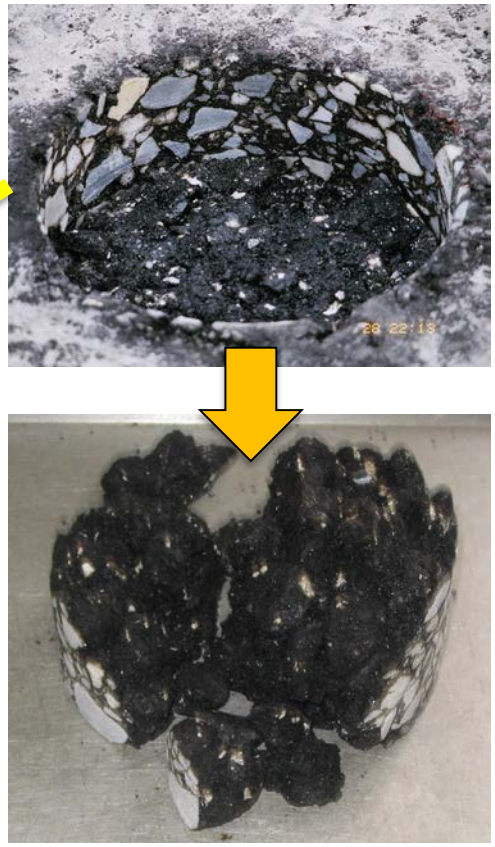
IR – What is it & why use it?

- 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?

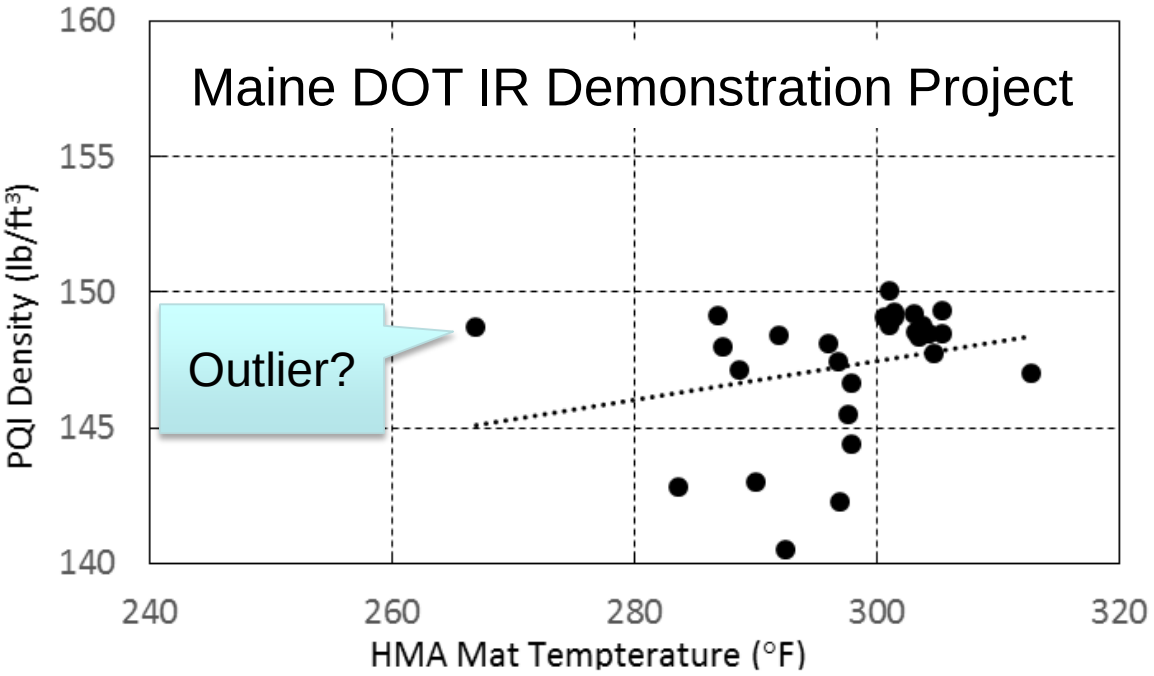
- Both sided longitudinal and centerline segregation result in thermal streaks; IR can identify these areas.

IR – What is it & why use it?

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

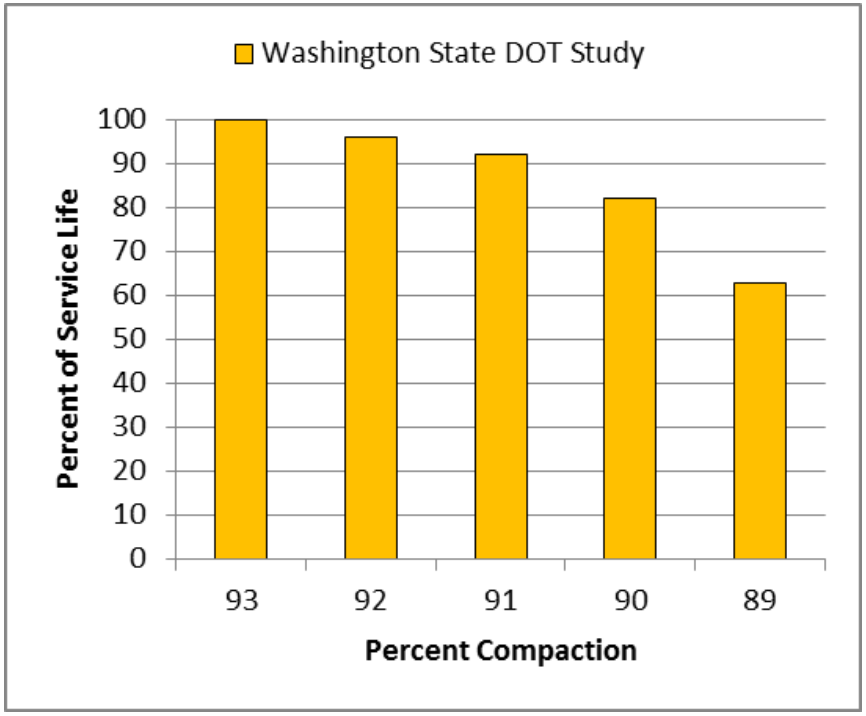
TTI Study:
Δ25 ºF ~ Δ6 pcf

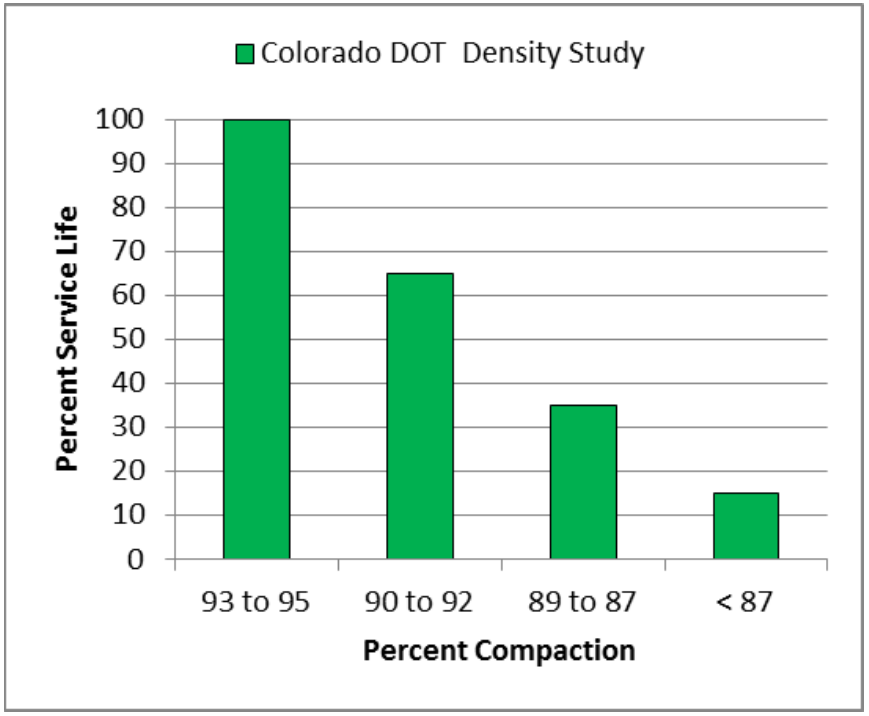
Maine DOT:
Δ20 ºF ~ Δ4 pcf



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

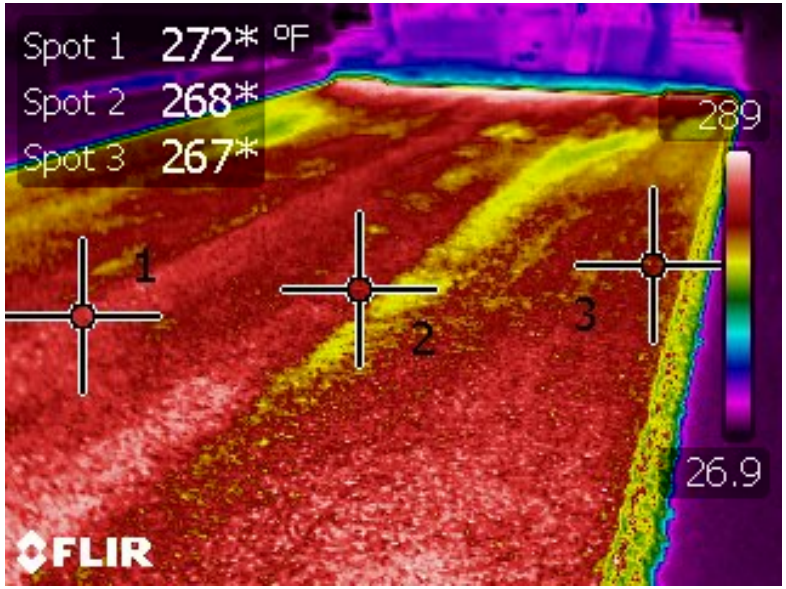
IR – What is it & why use it?

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?

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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

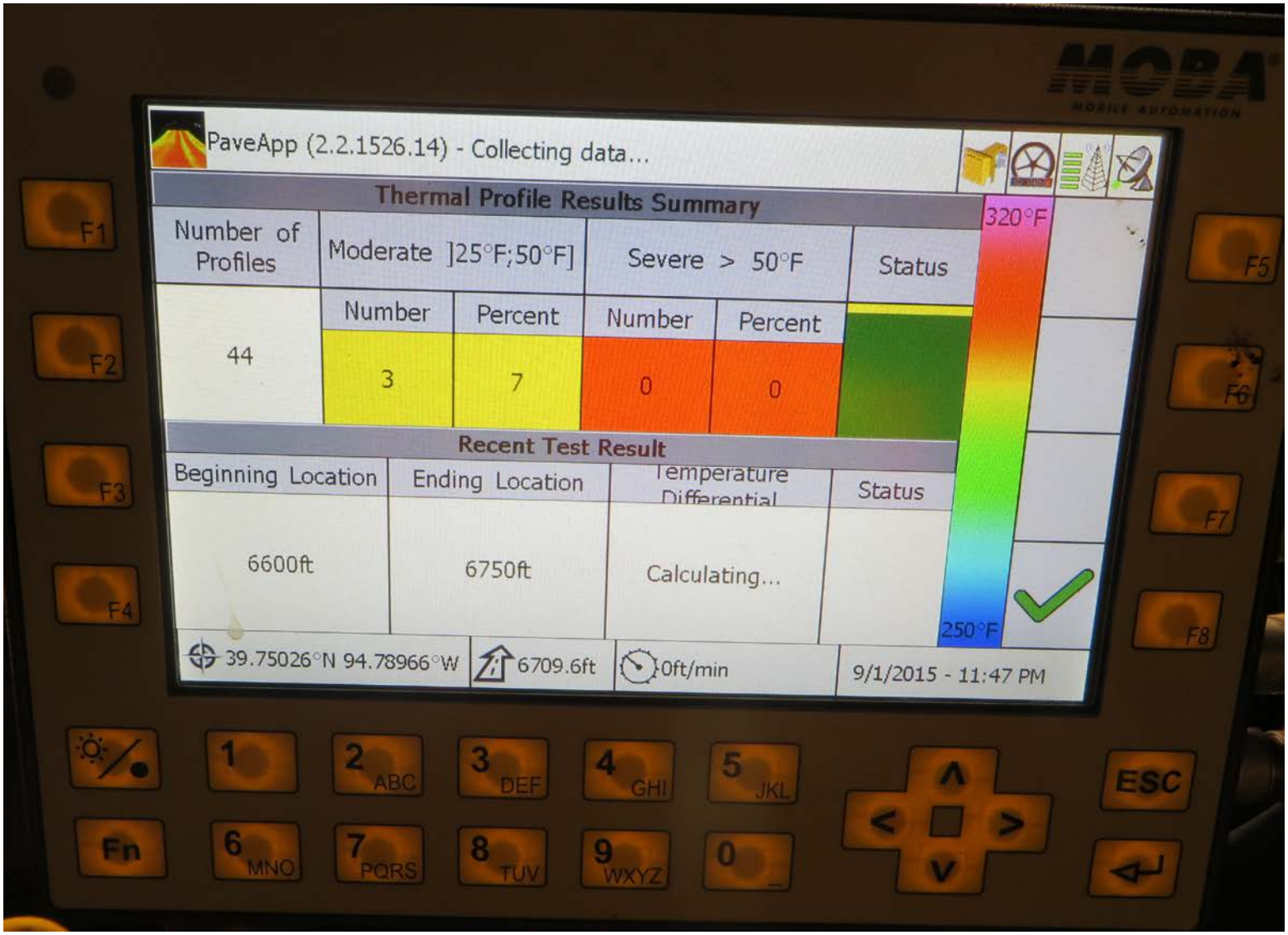
- IR Scanner attached to paver; scans mat behind screed in one direction.
- GPS attached to the mast arm.

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



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

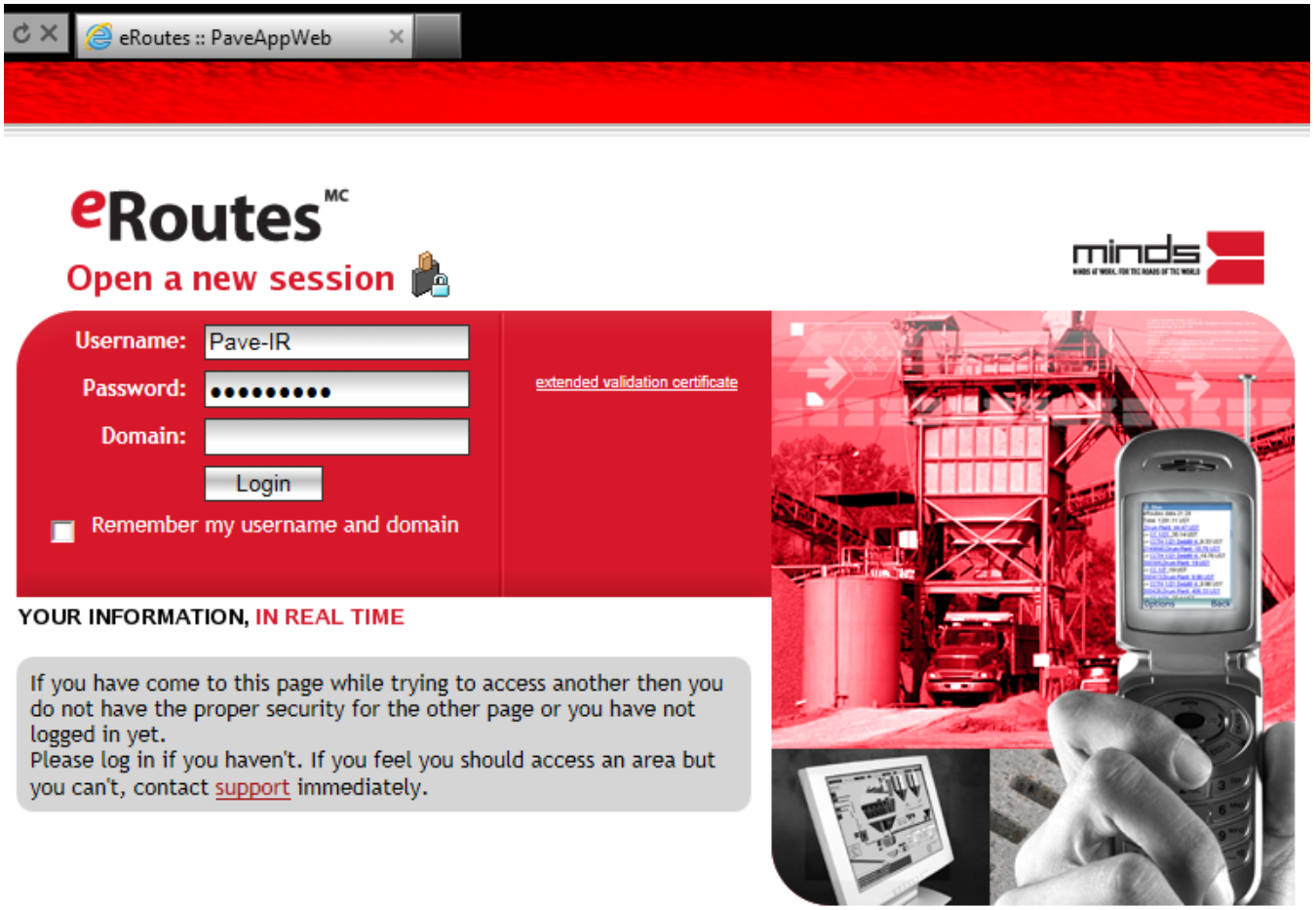
1. Equipment and Installation
2. Software and Its Features

IR Equipment and Software

Two models of data transfer and extraction

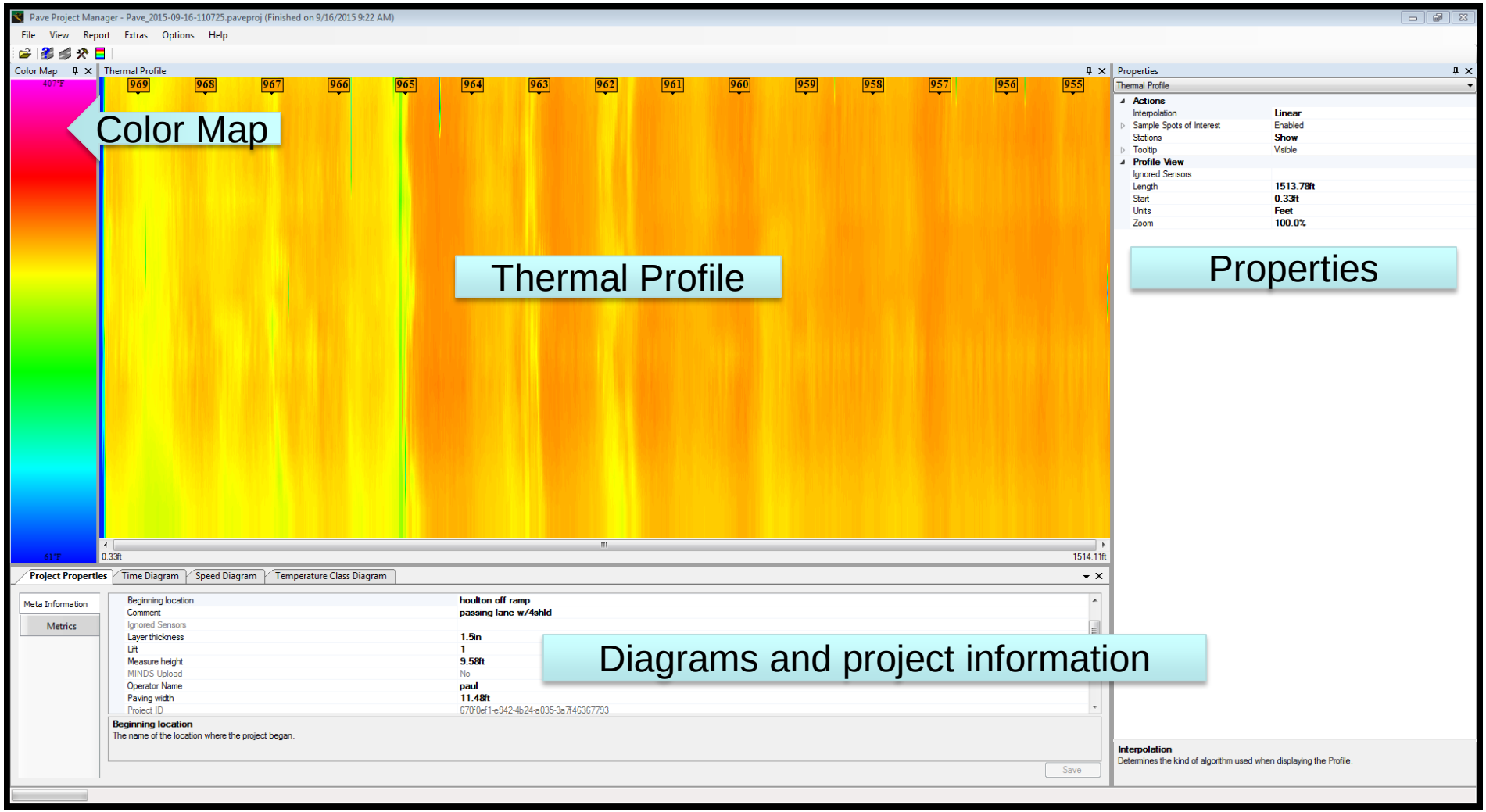
IR Equipment and Software

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



IR Equipment and Software

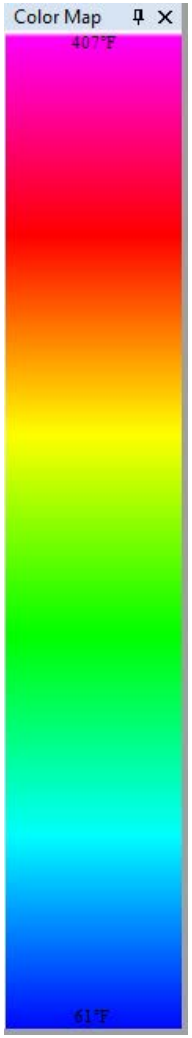
Explore Data: MOBA Pave Project Manager Main Screen



IR Equipment and Software

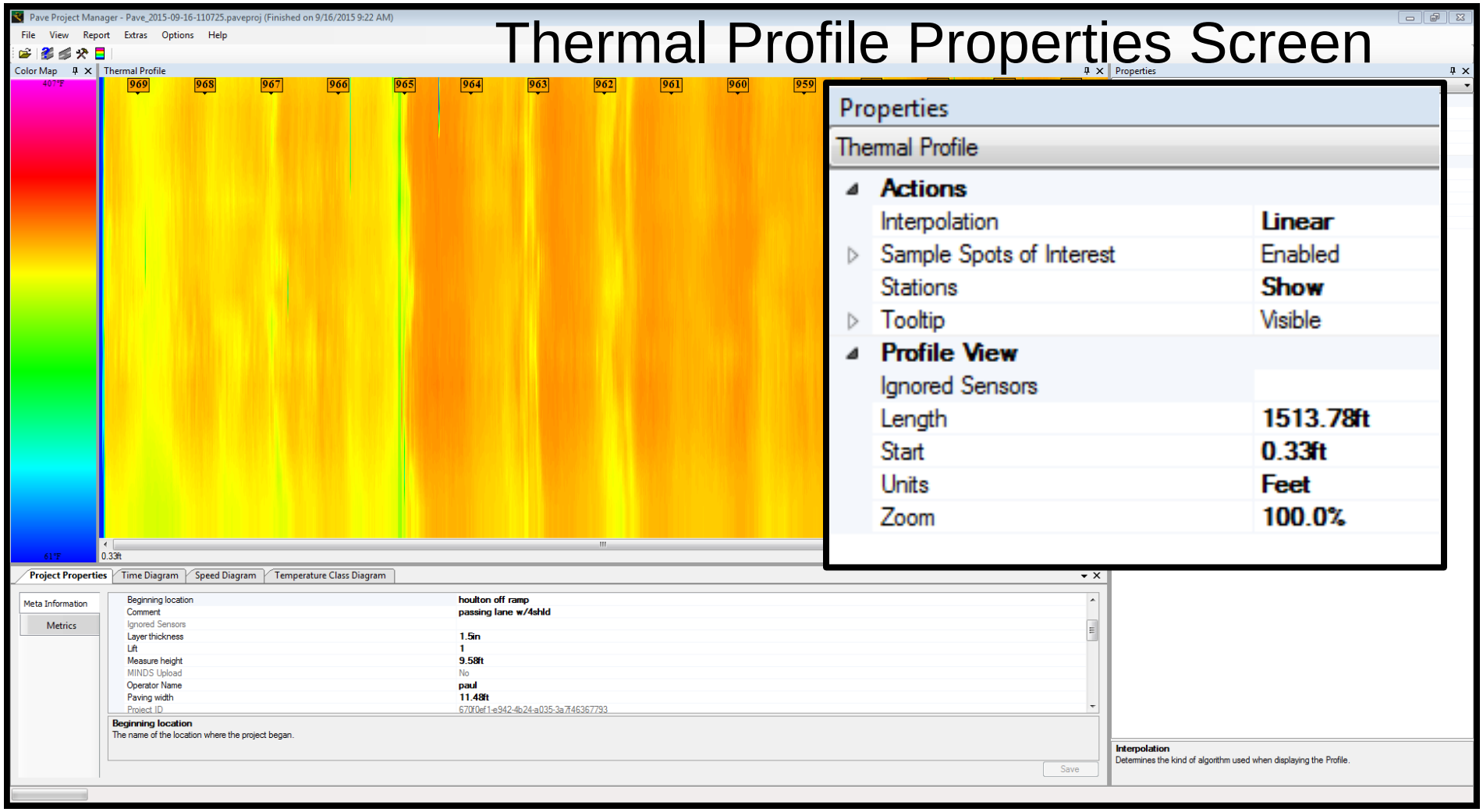
Color Map and Properties for Screen

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

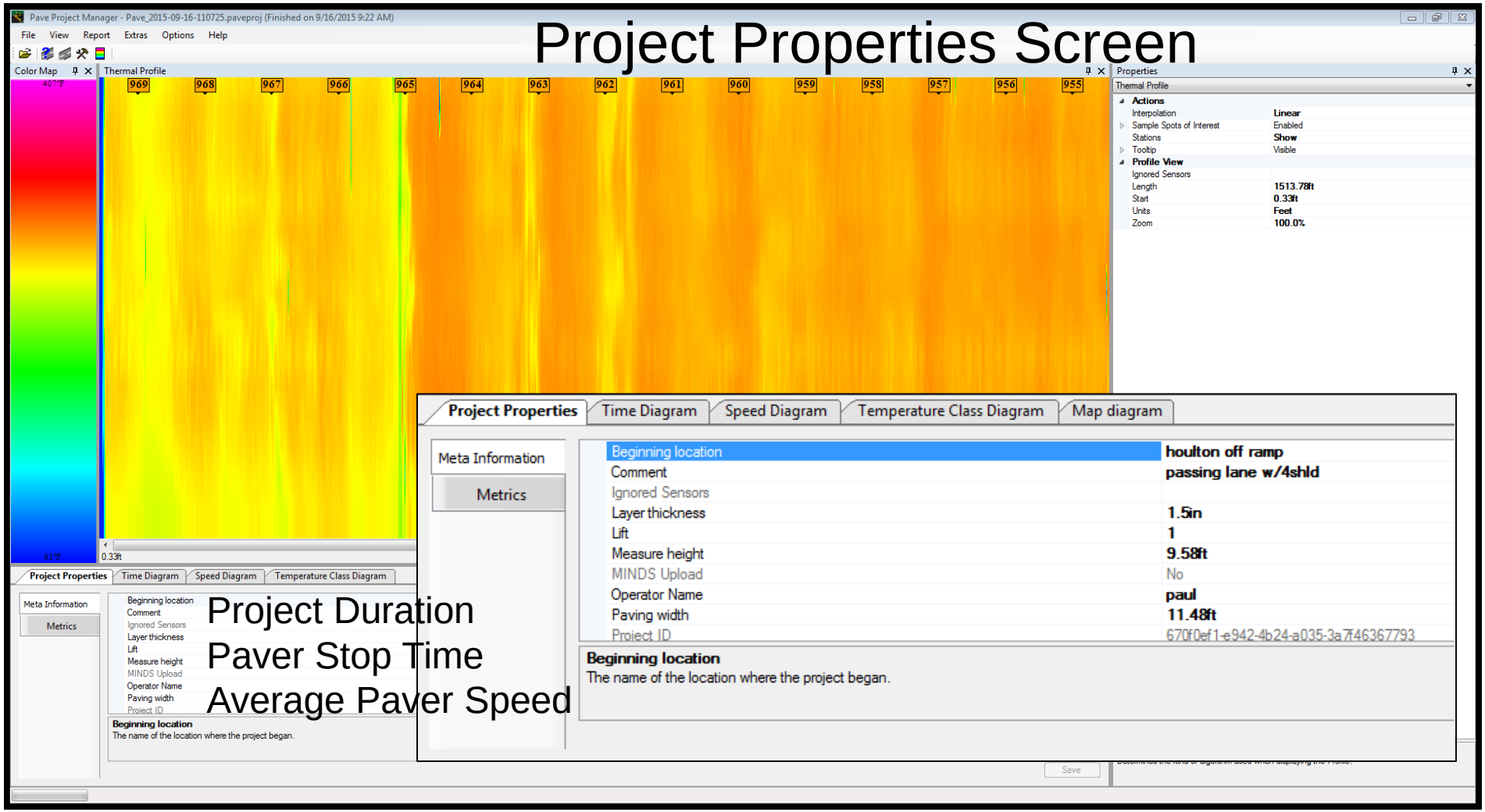


IR Equipment and Software

Thermal Profile Properties Screen

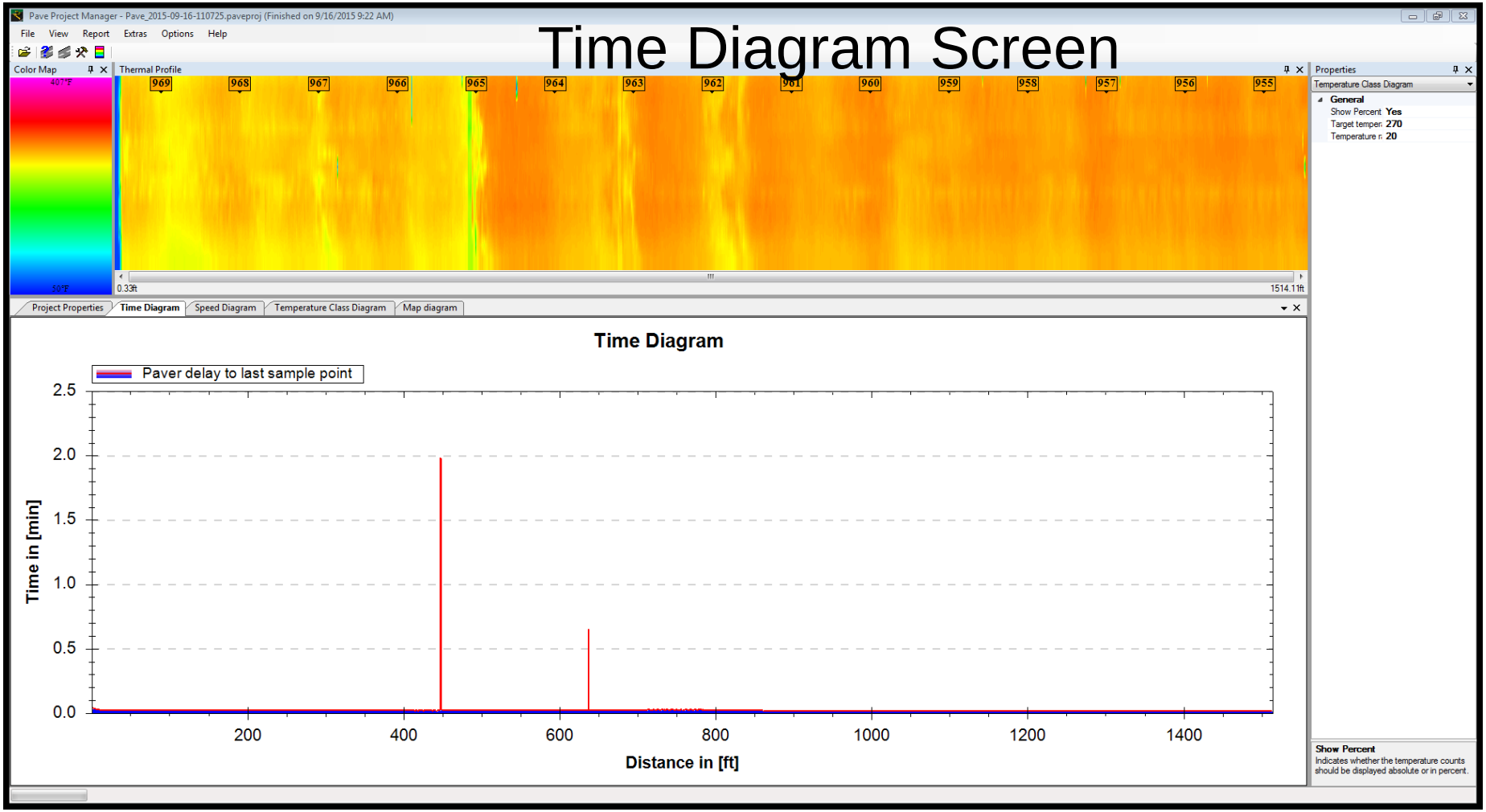


IR Equipment and Software



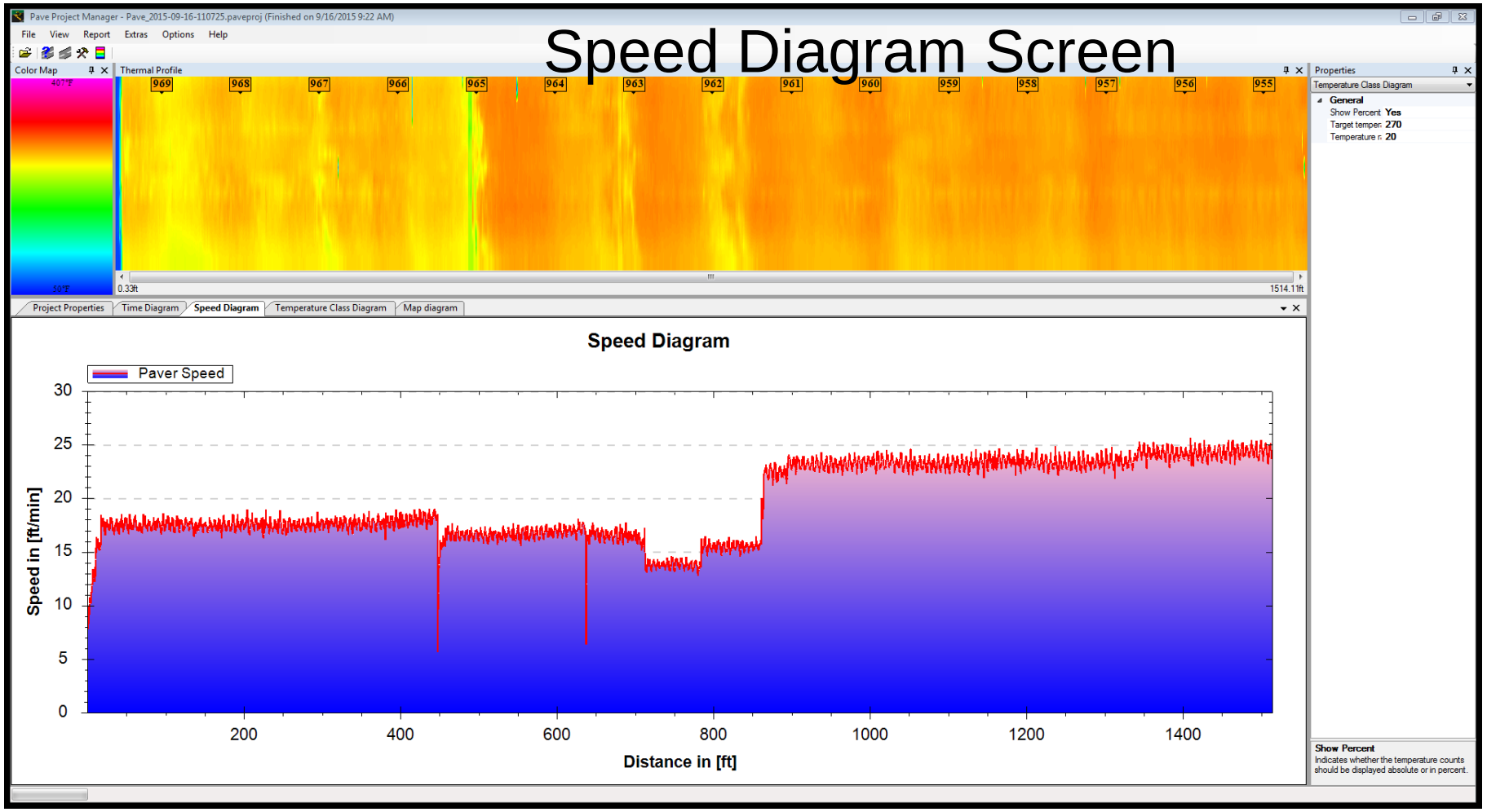
IR Equipment and Software

Time Diagram Screen



IR Equipment and Software

Speed Diagram Screen



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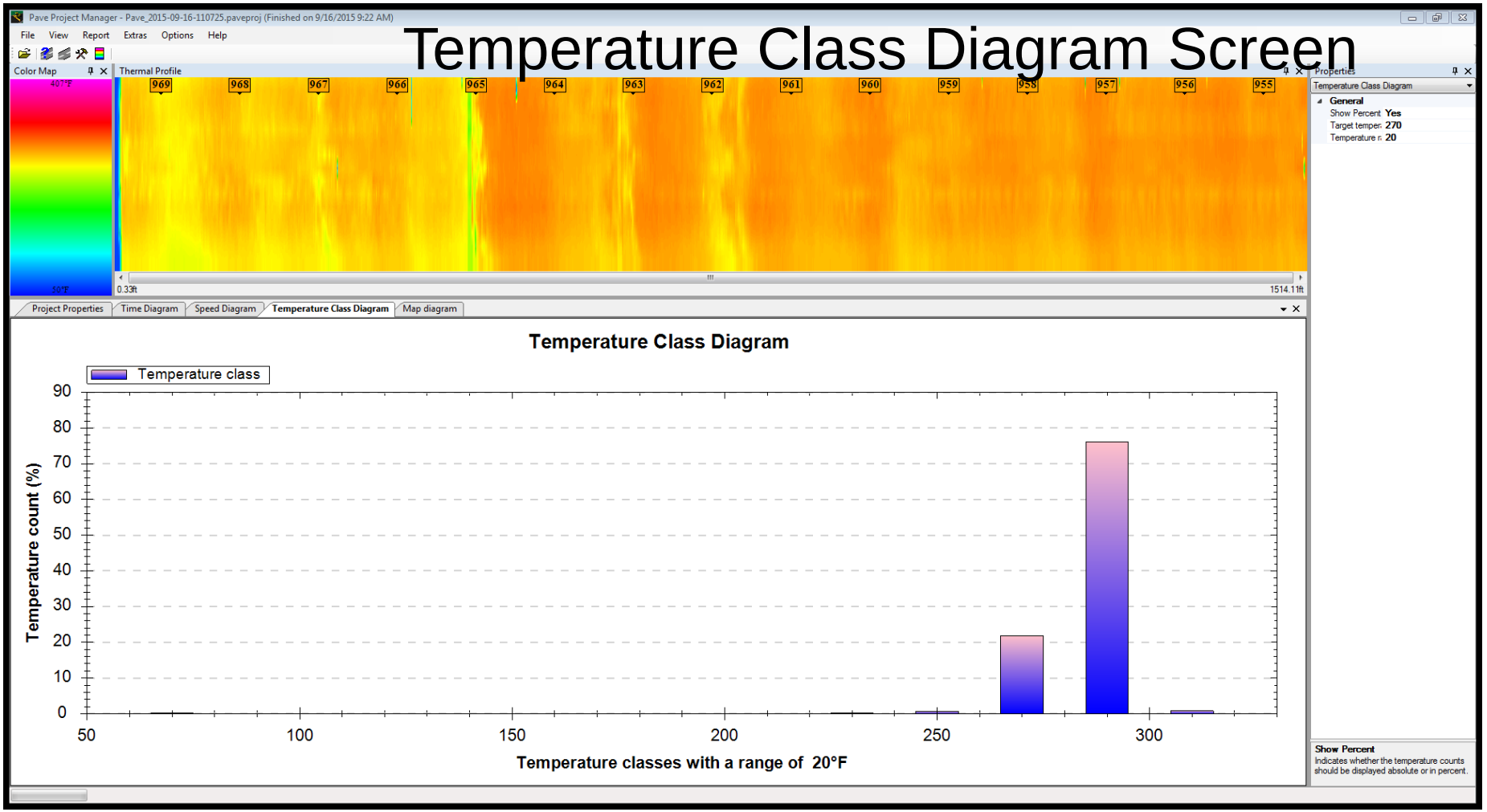

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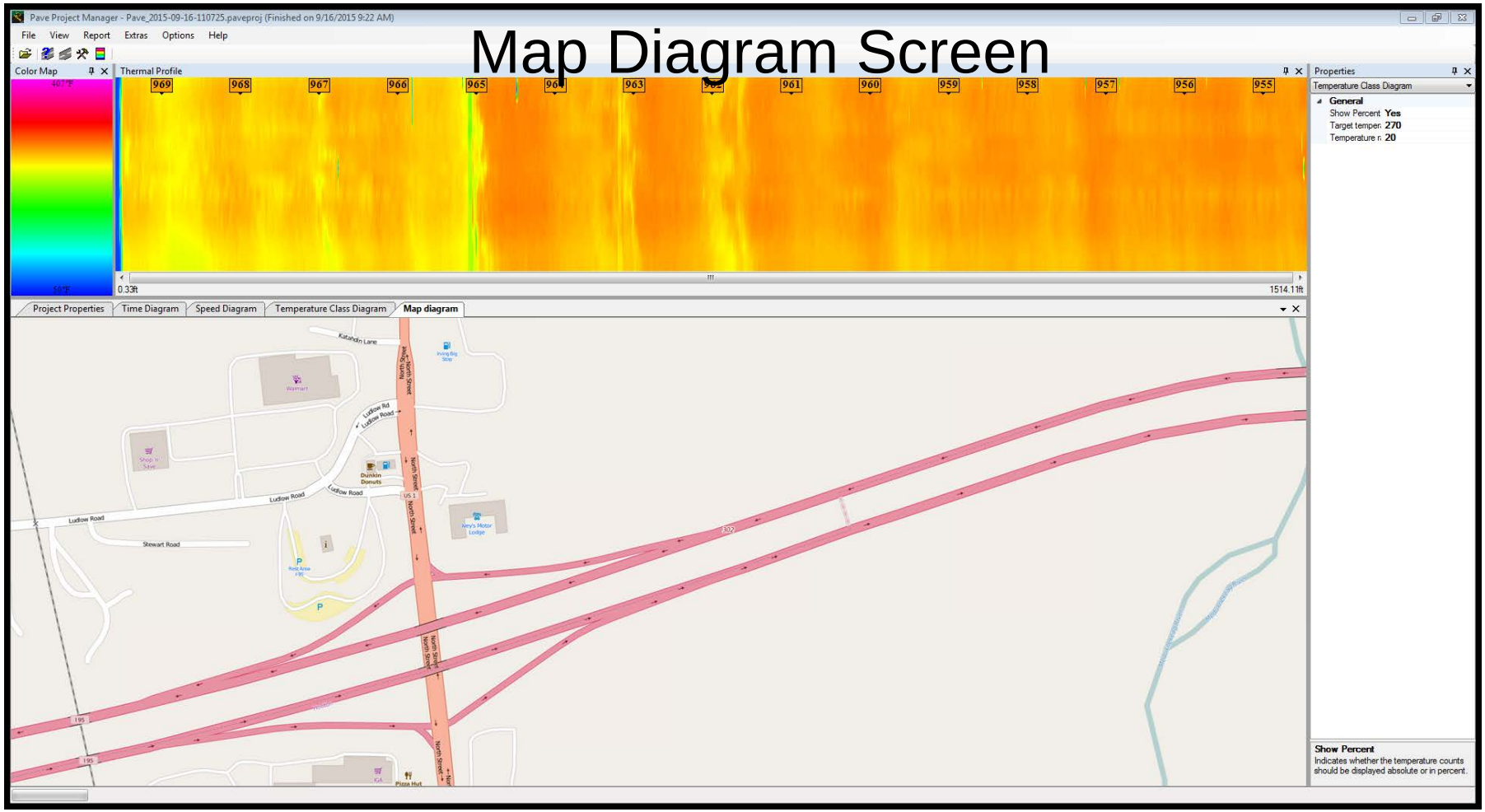

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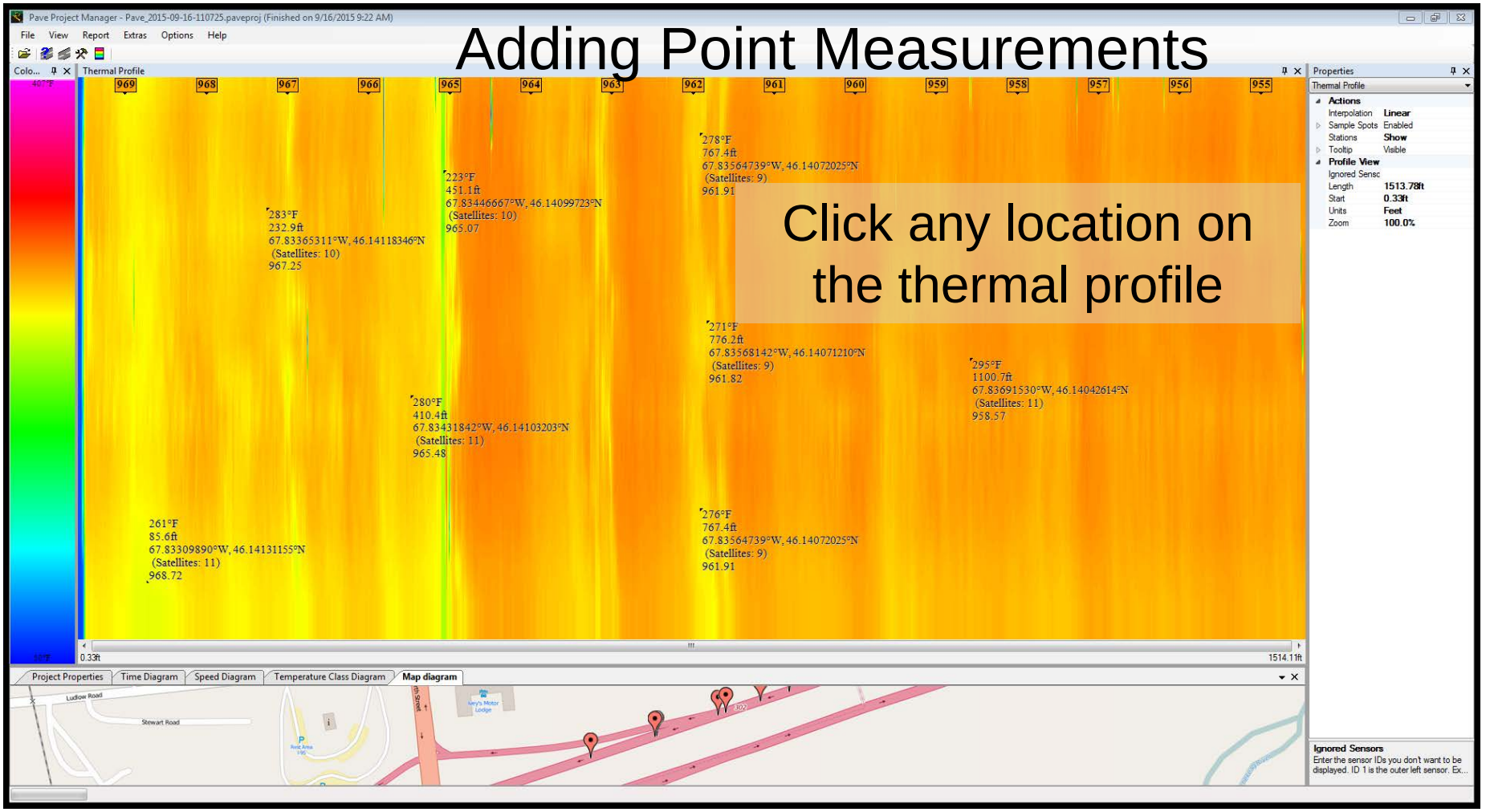
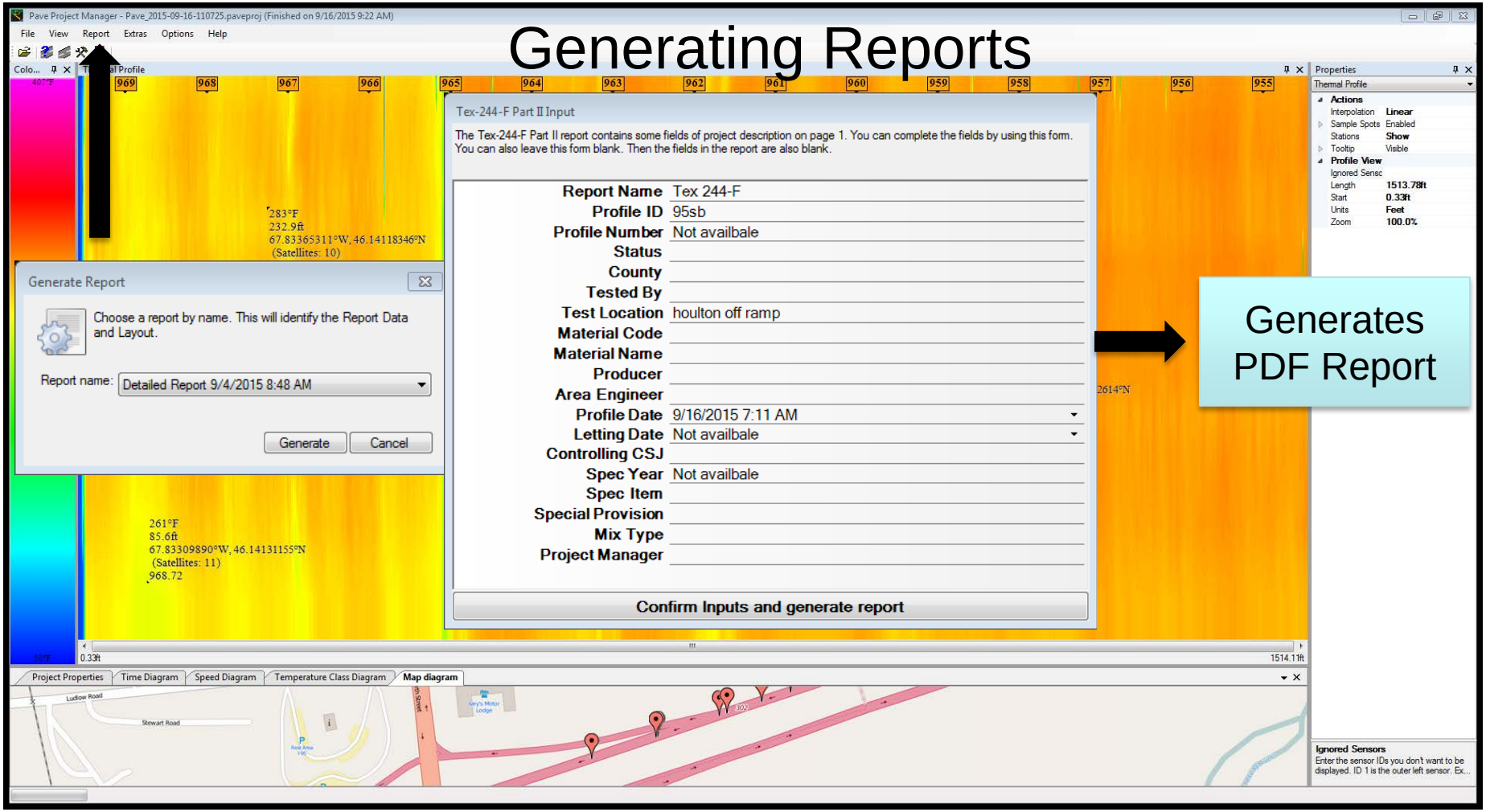


IR Equipment and Software

Generating Reports



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

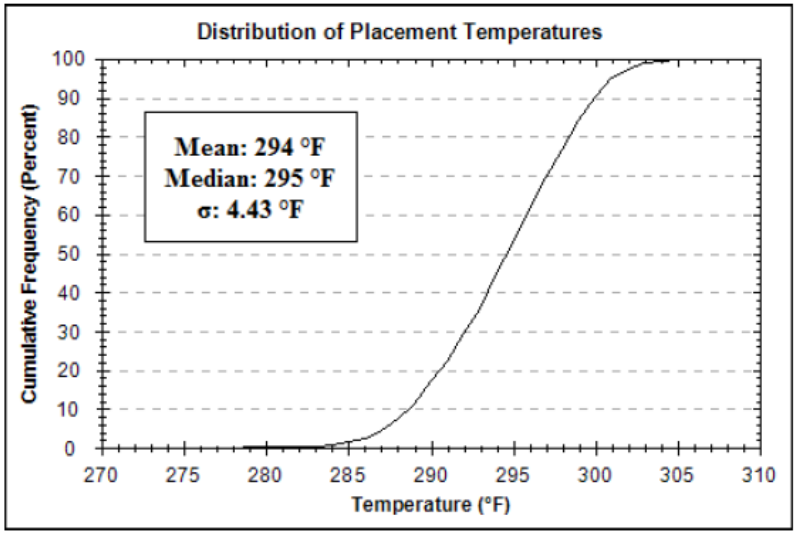
Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Station	GPS in °	Station	GPS in °			
1	194.49	68.12363437 W, 46.11892049 N	193.00	68.12419593 W, 46.11879052 N	303.4	287.8	15.7
2	192.99	68.12419985 W, 46.11878960 N	191.50	68.12476079 W, 46.11866149 N	304.9	289.6	15.3
3	191.49	68.12476285 W, 46.11866104 N	190.00	68.12532427 W, 46.11853654 N	301.1	286.3	14.8
4	189.99	68.12533012 W, 46.11853523 N	188.50	68.12589203 W, 46.11840836 N	299.3	285.8	13.5
5	188.49	68.12589363 W, 46.11840800 N	187.00	68.12645526 W, 46.11828259 N	297.7	285.4	12.2
6	186.99	68.12645906 W, 46.11828176 N	185.49	68.12702186 W, 46.11815402 N	298.9	283.5	15.5
7	185.49	68.12702379 W, 46.11815360 N	183.99	68.12758506 W, 46.11802607 N	302.2	283.8	18.4
8	183.98	68.1275889 W, 46.11802512 N	182.49	68.12815126 W, 46.11789818 N	303.1	292.6	10.4
9	182.49	68.12815319 W, 46.11789773 N	181.00	68.12871395 W, 46.11777111 N	306.1	288.1	18.0
10	180.99	68.12871621 W, 46.11777052 N	179.50	68.12928274 W, 46.11764036 N	302.2	284.4	17.8
11	179.49	68.12928577 W, 46.11763966 N	178.00	68.12985205 W, 46.11751058 N	302.9	287.6	15.3
12	177.99	68.12985387 W, 46.11751020 N	176.50	68.13042113 W, 46.11738235 N	302.0	288.0	14.0
13	176.49	68.13042482 W, 46.11738148 N	175.00	68.13099093 W, 46.11725309 N	301.8	289.2	12.6
14	174.99	68.13099275 W, 46.11725265 N	173.50	68.13155886 W, 46.11712703 N	302.2	288.0	14.2
15	173.49	68.13156263 W, 46.11712618 N	171.99	68.13212684 W, 46.11699931 N	303.6	286.3	17.3
16	171.99	68.13212971 W, 46.11699866 N	170.49	68.13269254 W, 46.11687031 N	302.9	286.5	16.4
17	170.48	68.1326963 W, 46.11686947 N	169.00	68.13325913 W, 46.11674378 N	305.8	288.9	16.9
18	168.99	68.13326314 W, 46.11674285 N	167.50	68.13382973 W, 46.11661558 N	302.0	286.0	16.0
19	167.49	68.13383168 W, 46.11661512 N	166.00	68.1343973 W, 46.11648481 N	298.6	284.2	14.4
20	165.99	68.13440119 W, 46.11648392 N	164.50	68.13497078 W, 46.11635549 N	298.4	282.9	15.5
21	164.49	68.13497271 W, 46.11635503 N	163.00	68.13554162 W, 46.11622699 N	297.5	282.4	15.1
22	162.99	68.13554551 W, 46.11622616 N	161.49	68.13611883 W, 46.11609795 N	296.1	283.6	12.4
23	161.49	68.13612069 W, 46.11609752 N	160.00	68.13668796 W, 46.11596968 N	301.6	277.2	24.5
24	159.99	68.13669173 W, 46.11596883 N	158.49	68.13725615 W, 46.11584140 N	299.7	281.1	18.5
25	158.49	68.13725879 W, 46.11584082 N	157.00	68.1378221 W, 46.11571525 N	301.6	287.4	14.2
26	156.99	68.13782589 W, 46.11571440 N	155.50	68.13839327 W, 46.11558715 N	302.2	288.5	13.7
27	155.49	68.13839721 W, 46.11558631 N	154.00	68.1389655 W, 46.11545741 N	302.2	289.8	12.4

IR Equipment and Software

Generating Reports

Summary of Locations Without Thermal Segregation

Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Station	GPS in °	Station	GPS in °			
28	153.99	68.13896866 W, 46.11545670 N	153.24	68.13925736 W, 46.11538960 N	299.1	287.2	11.9



Location of Paver Stops greater than One Minute

Location (stations)	Duration (h:min:sec)
185.89	0:2:0
172.06	0:4:22
168.59	0:4:25

IR Equipment and Software

Exporting Data

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

Questions?

NEXT:

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

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Infrared Technology (IR)

Data Analyses and Findings: I-40

March 22, 2017

U.S. Department of Transportation
Federal Highway Administration

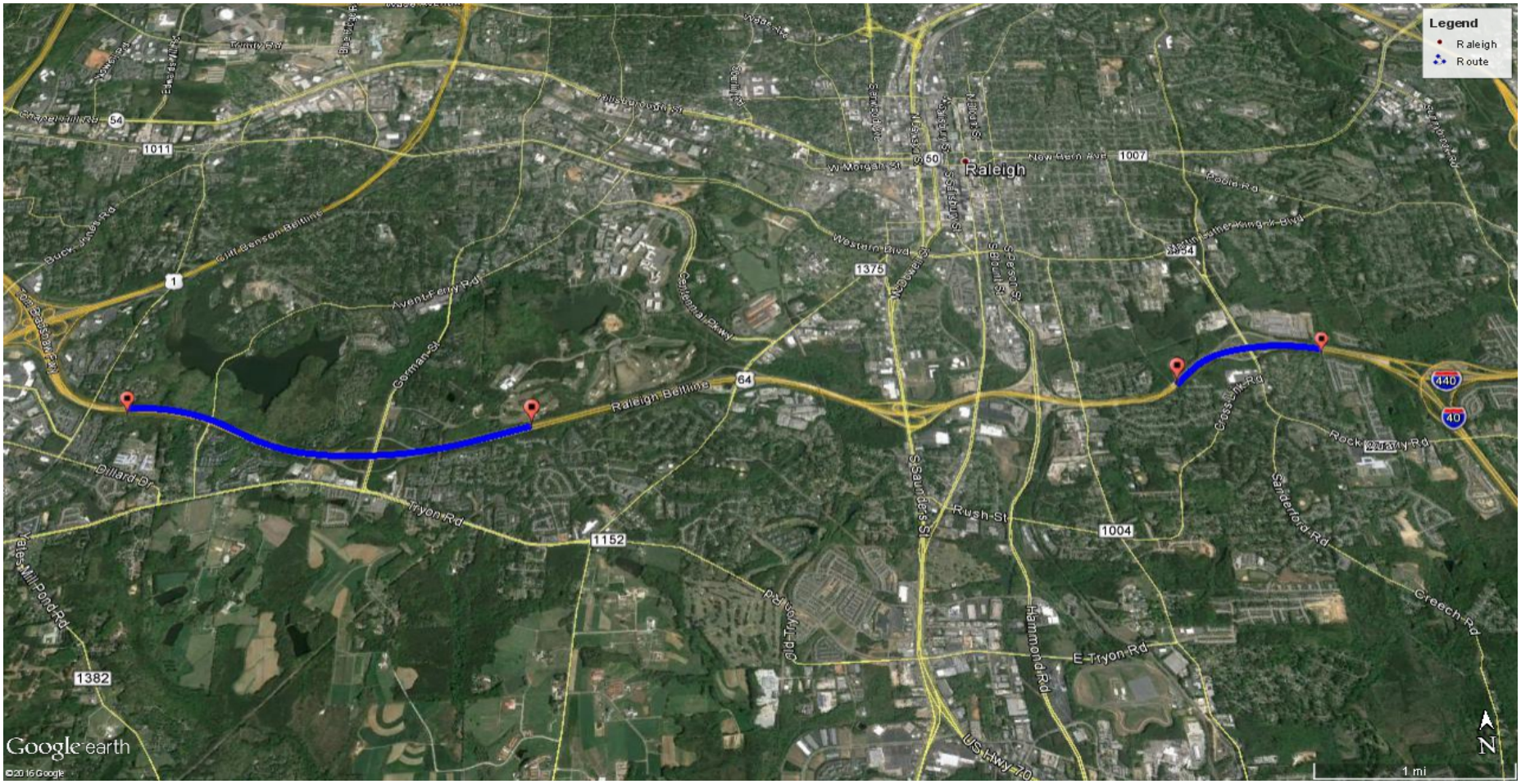
American Association of State Highway and Transportation Officials
AASHTO

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 Caterpiller 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

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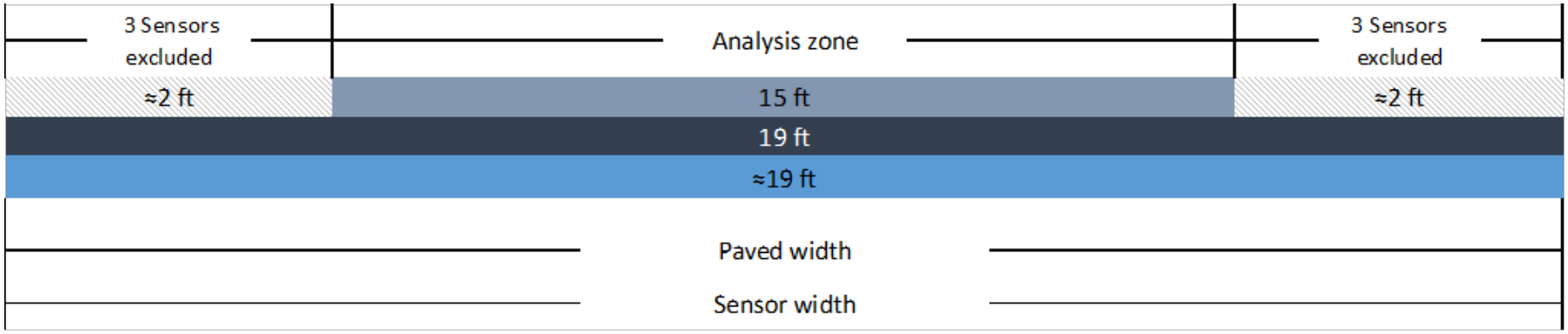
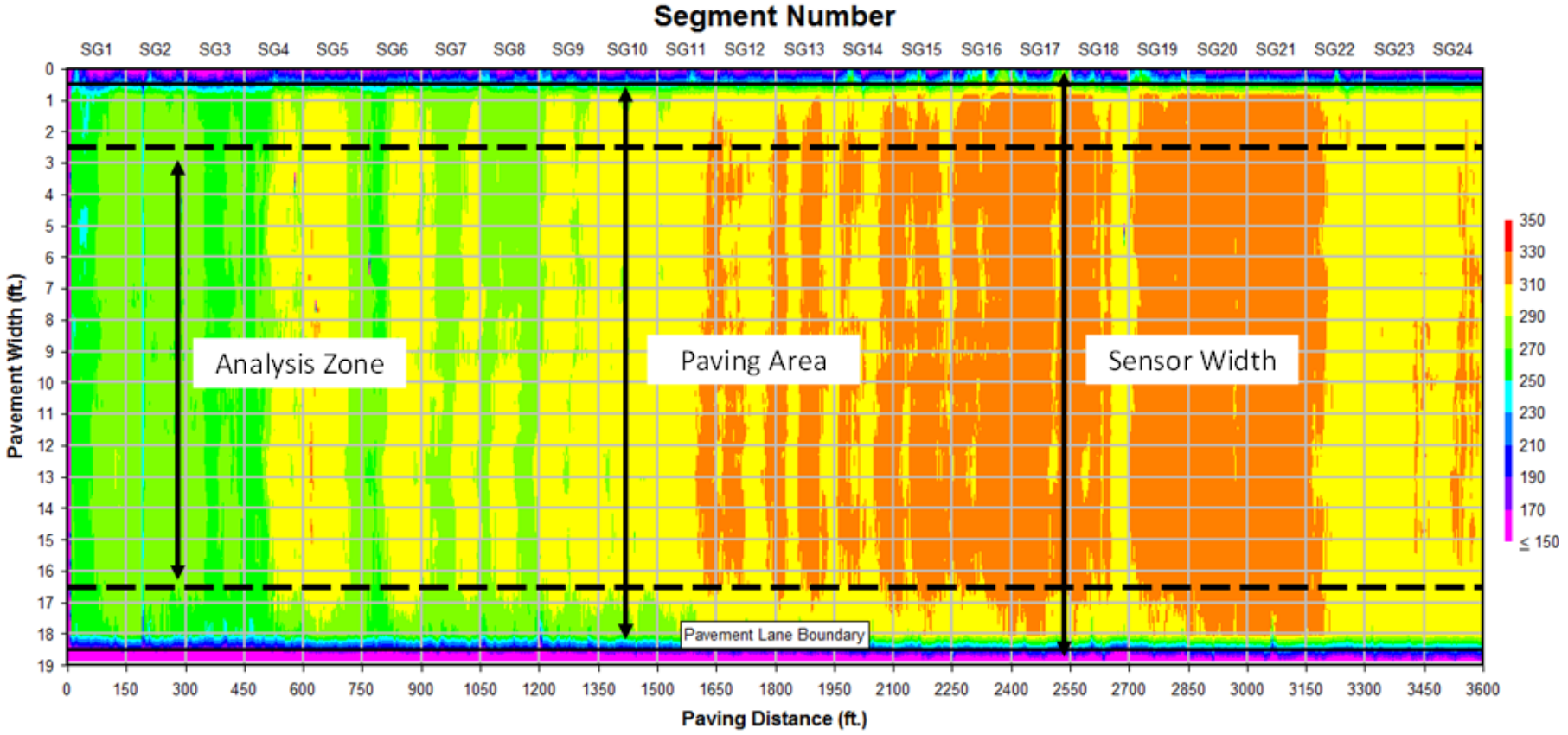
Data Analyses & Findings

Paving Width and Analysis Zones



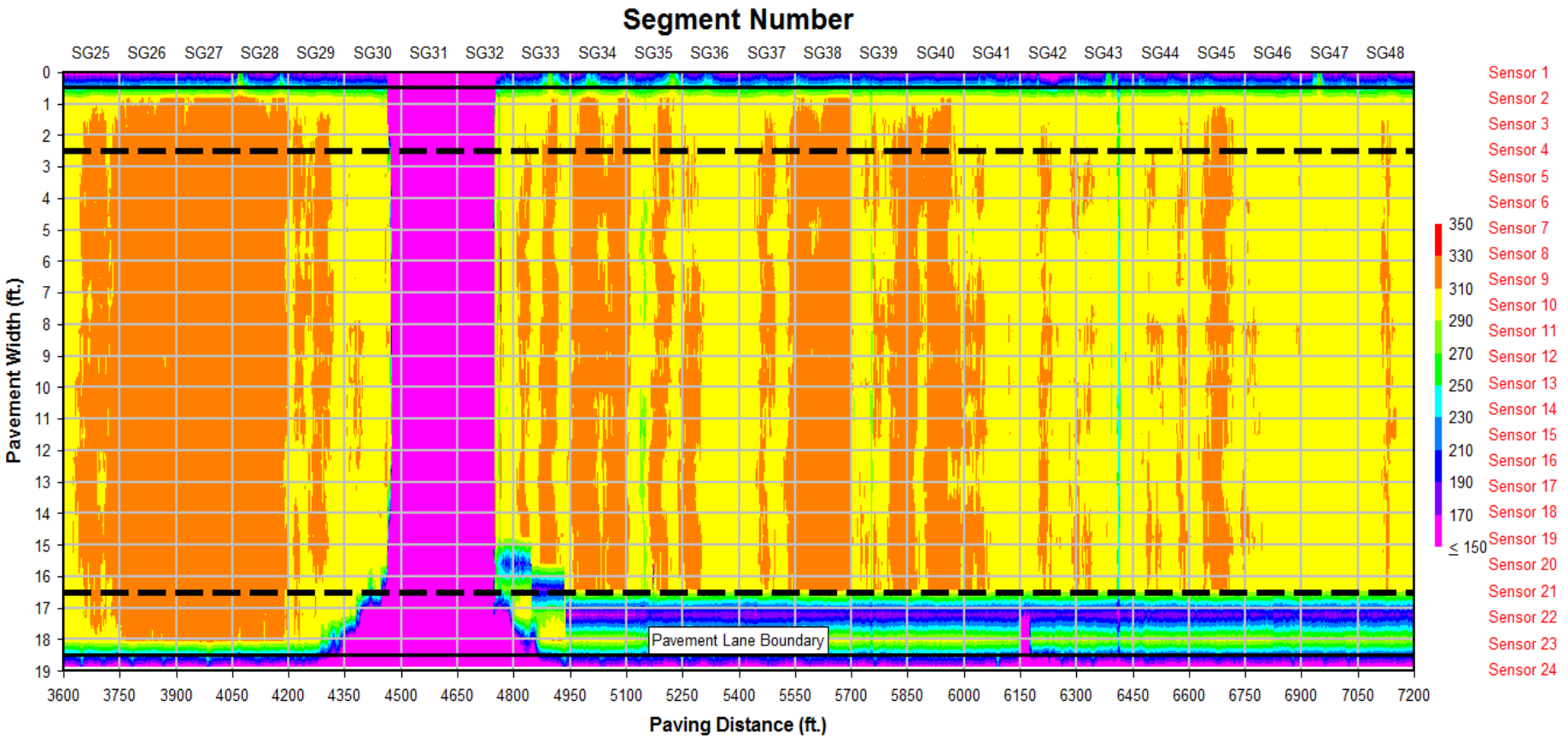
Data Analyses & Findings

Paving Width and Analysis Zones
Raw Temperature Profile Example



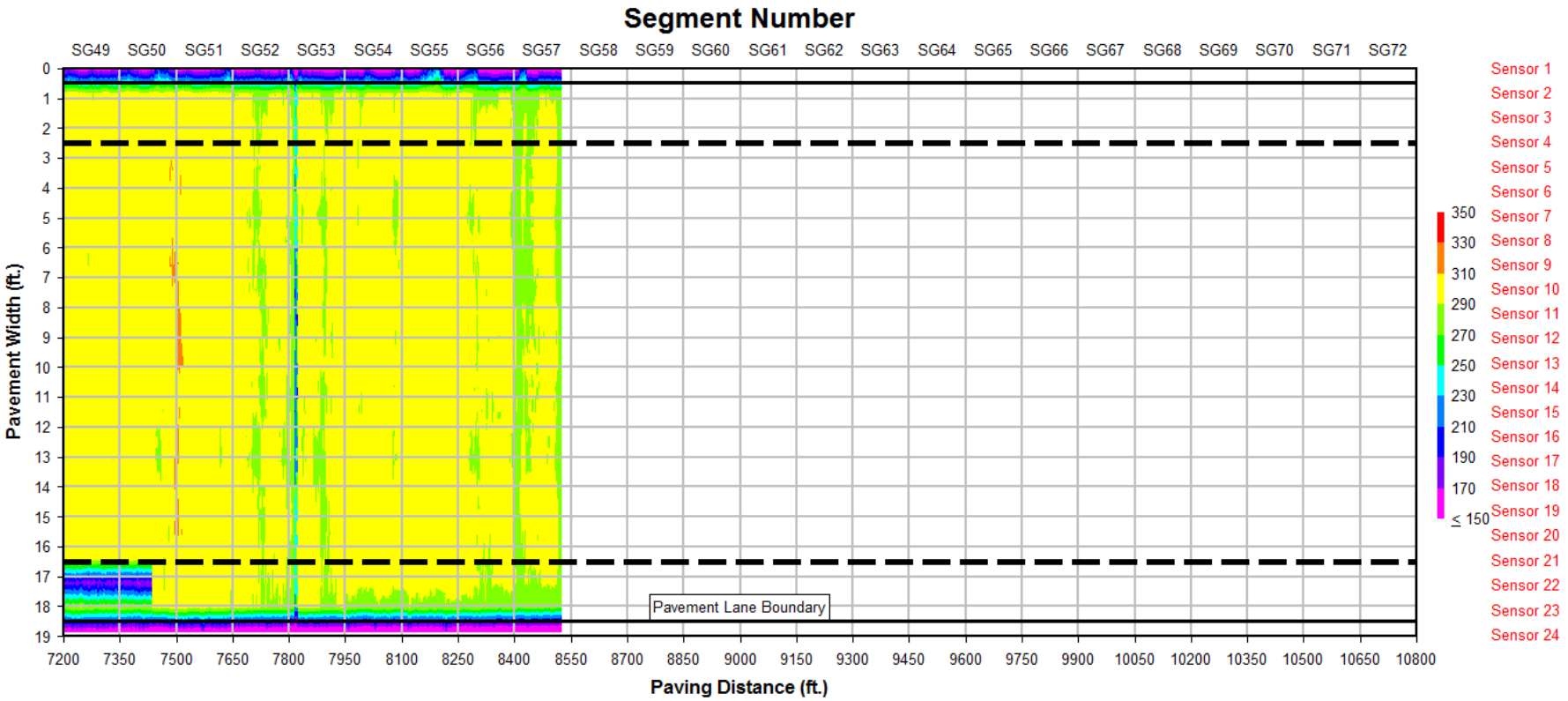
Data Analyses & Findings

Raw Temperature Profile – What's the cool spot?

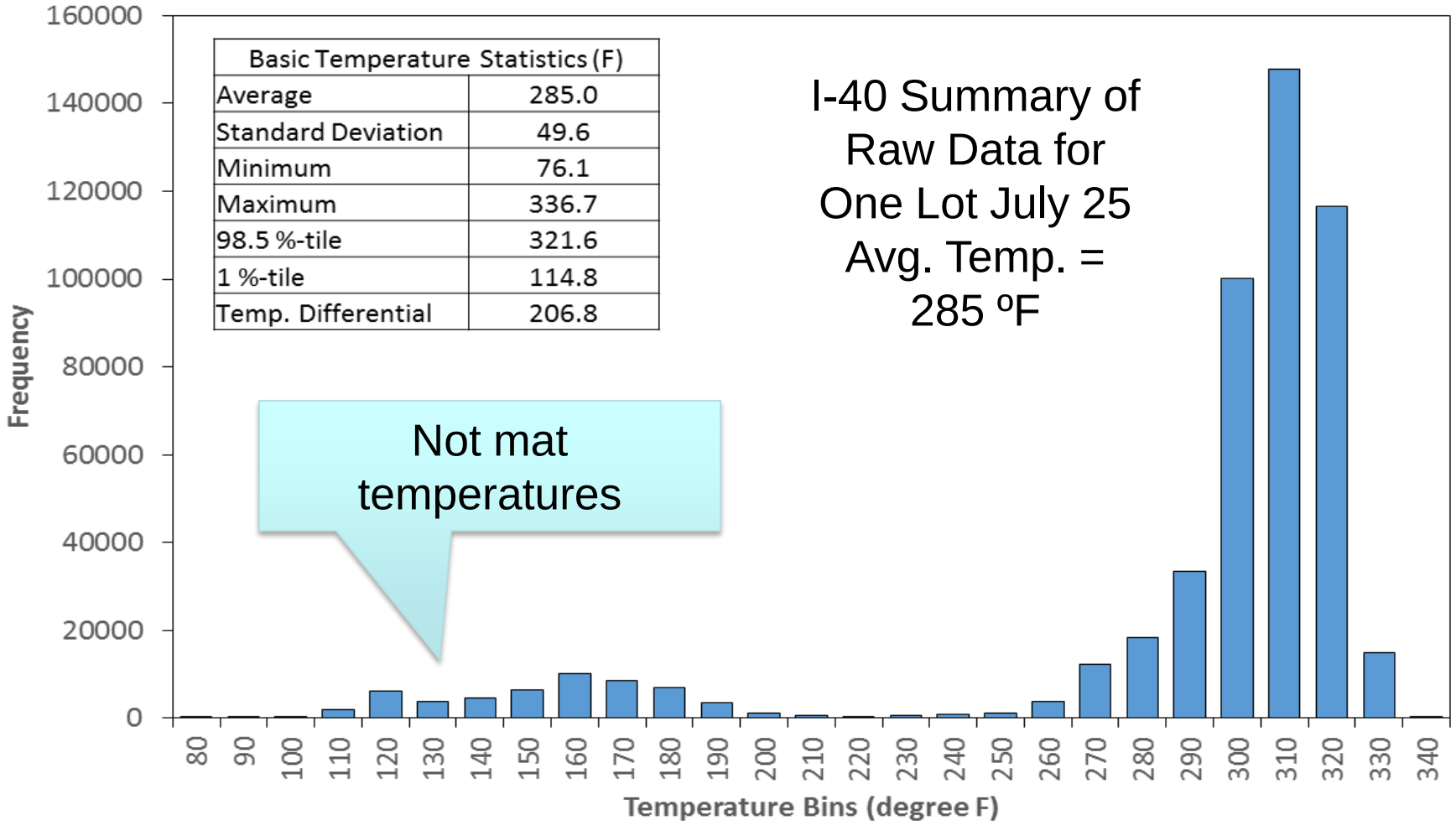


Data Analyses & Findings

Raw Temperature Profile



Data Analyses & Findings

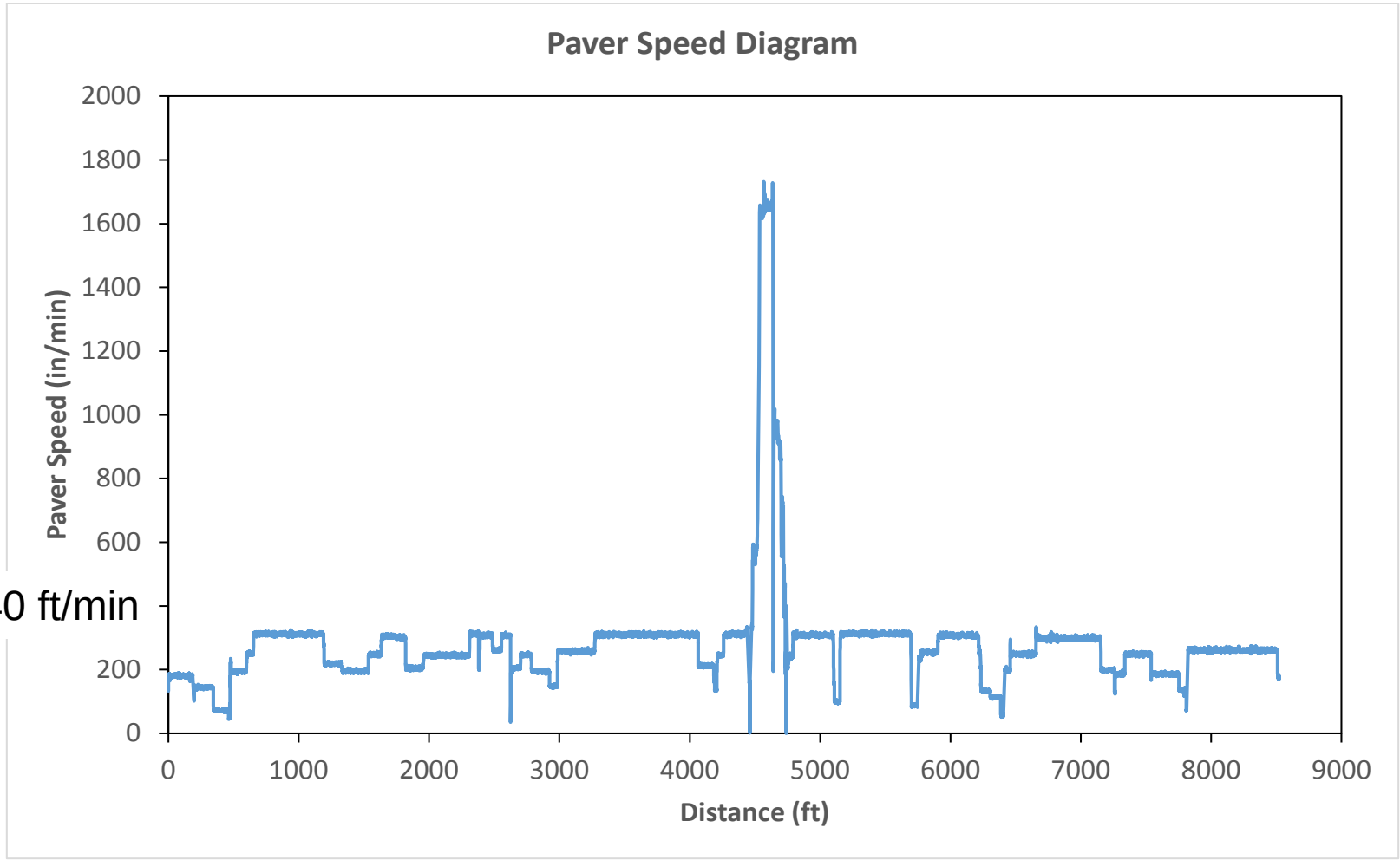


Data Analyses & Findings

Data diagrams reviewed during production:

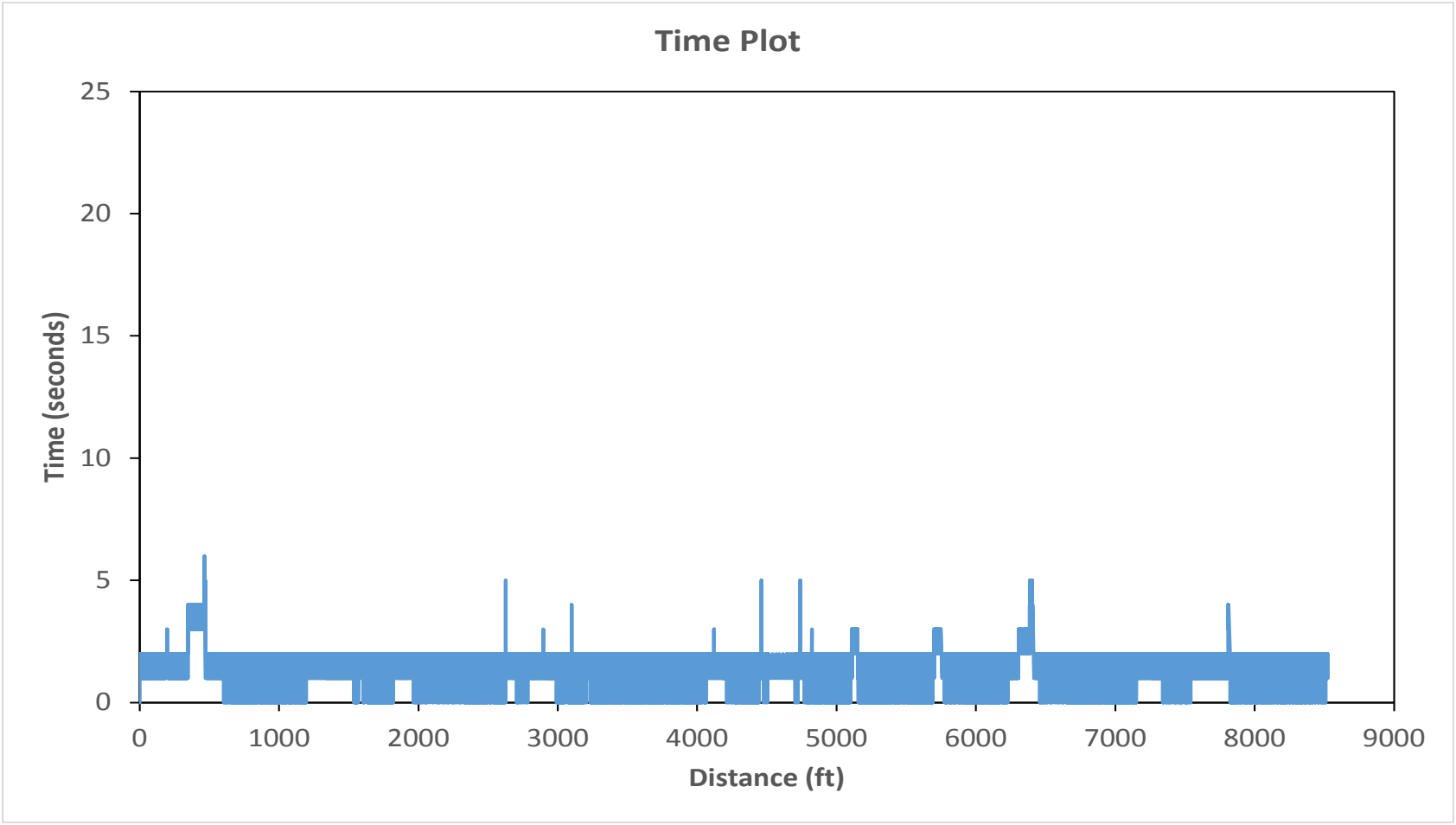
1. Paver speed diagram
2. Time plot
3. Average temperature plot

Data Analyses & Findings

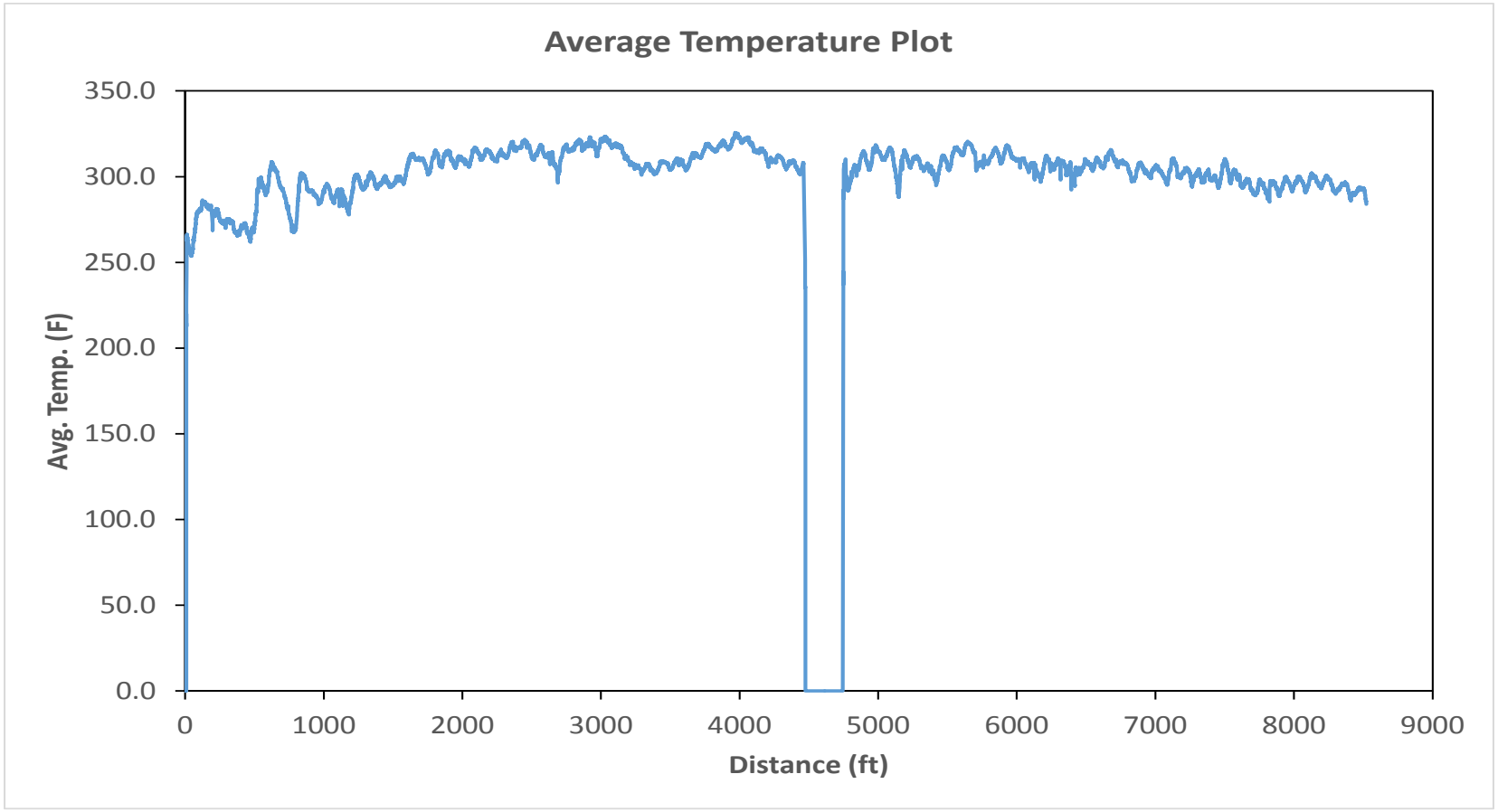


40 ft/min

Data Analyses & Findings

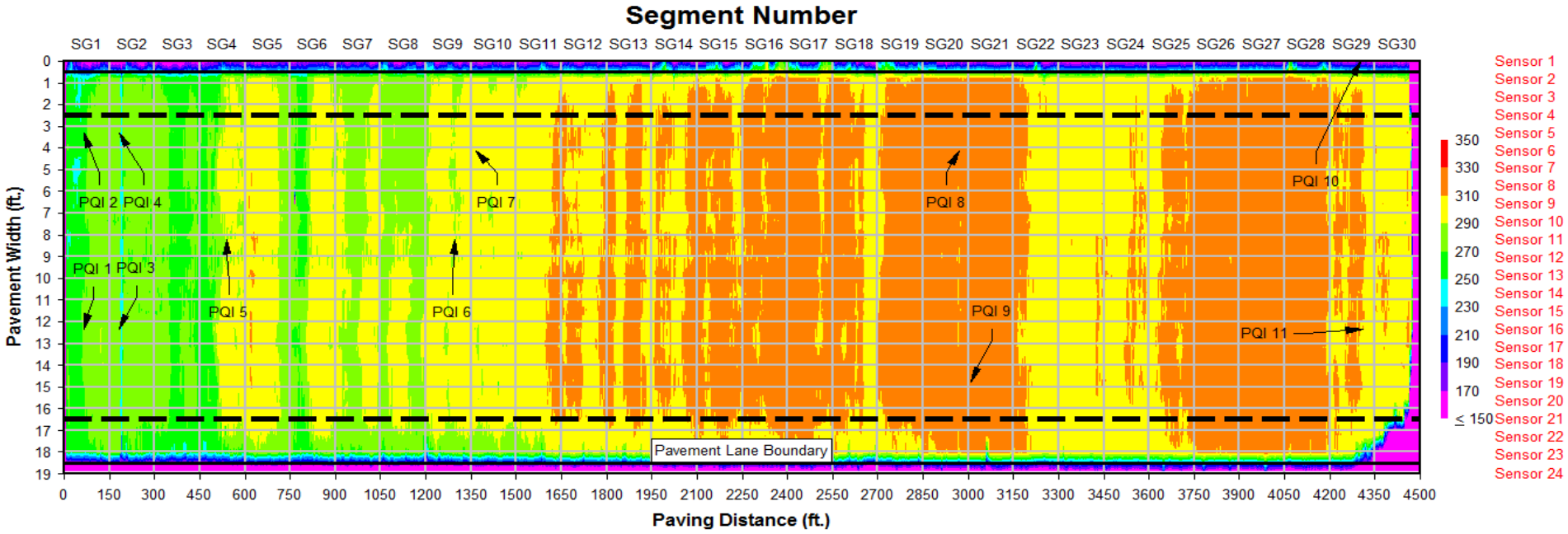


Data Analyses & Findings



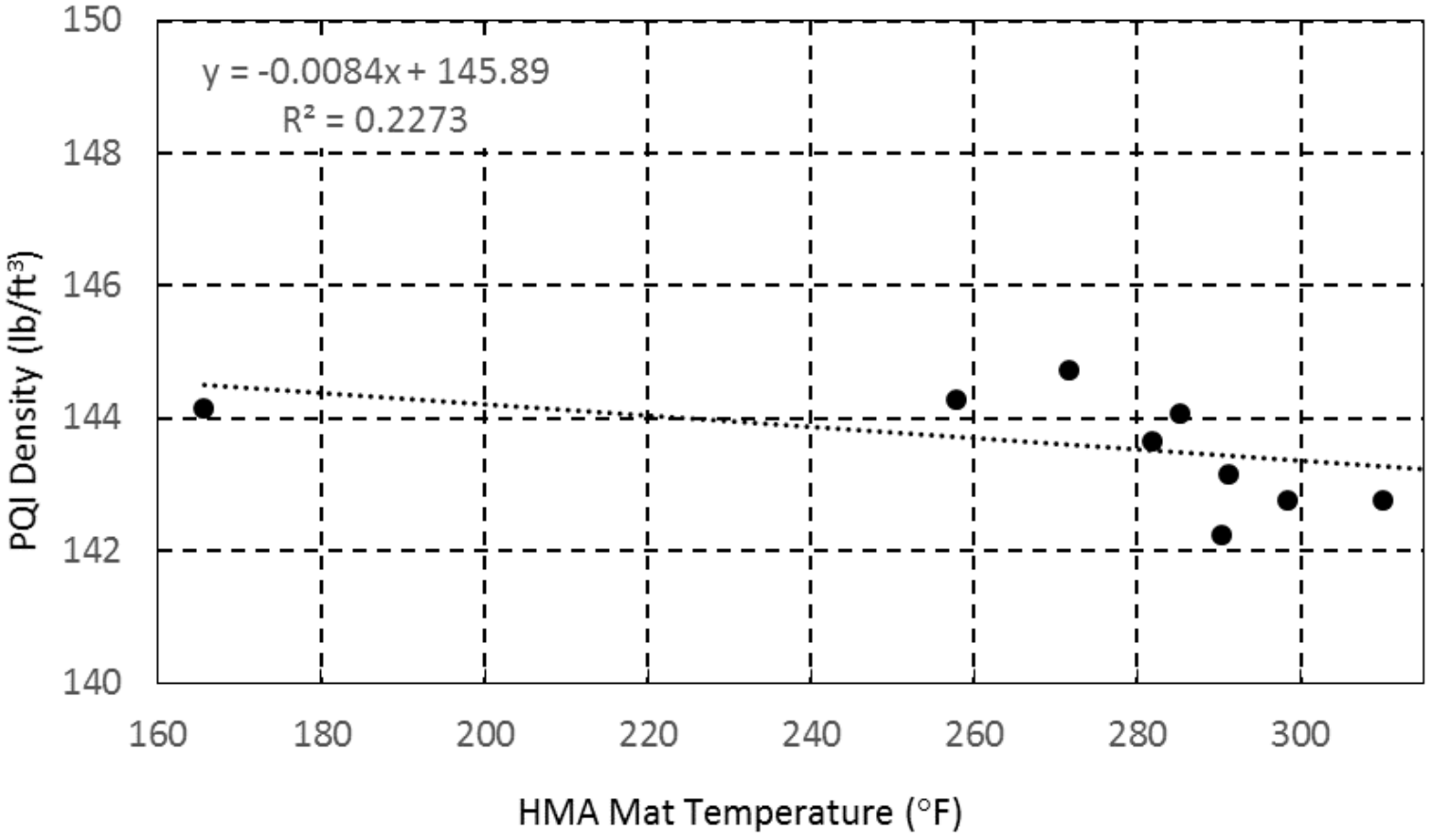
Data Analyses & Findings

Density Measurement Locations



Data Analyses & Findings

Density Measurement Locations



Data Analyses & Findings

1. Project Overview
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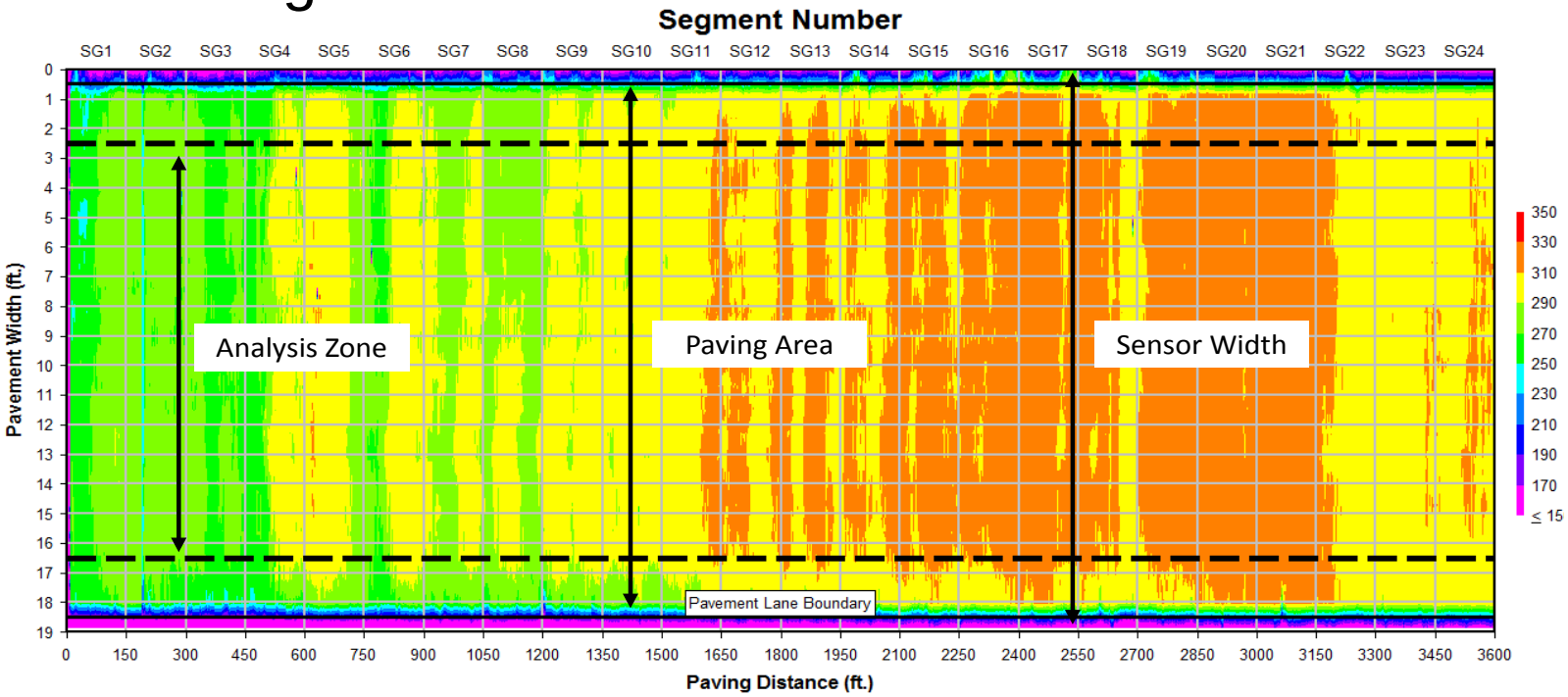
4. Data Summary

Data Analyses & Findings

Data Processing—eliminate invalid temperature measurements:

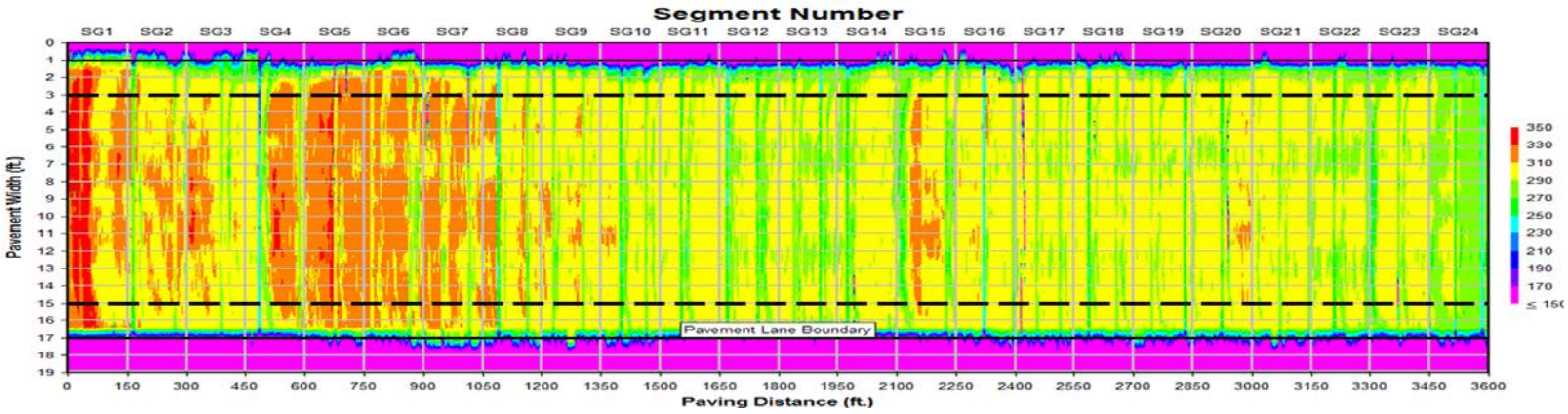
1. Eliminate measurement locations within 2 feet of the mat's edge.



Data Analyses & Findings

Data Processing—eliminate invalid temperature measurements:

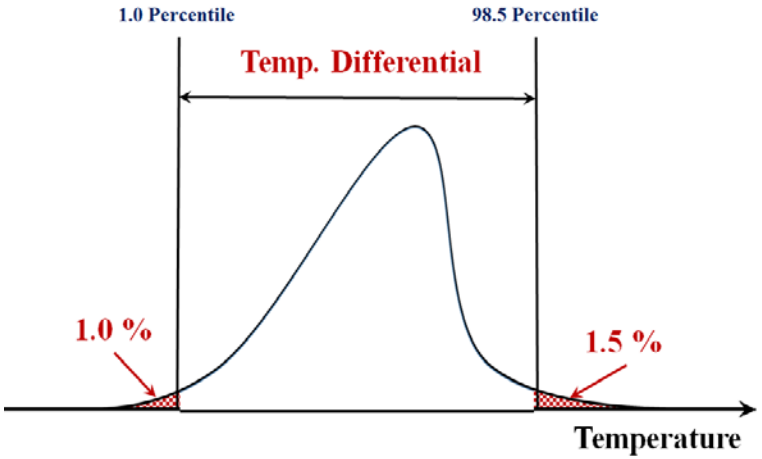
2. Eliminate data with paver stops greater than 60 seconds, between locations:
   - 2 feet behind measurement location of stop
   - 8 feet in front of measurement location of stop
3. Eliminate temperature readings < 170 ºF and > 400 ºF.



Data Analyses & Findings

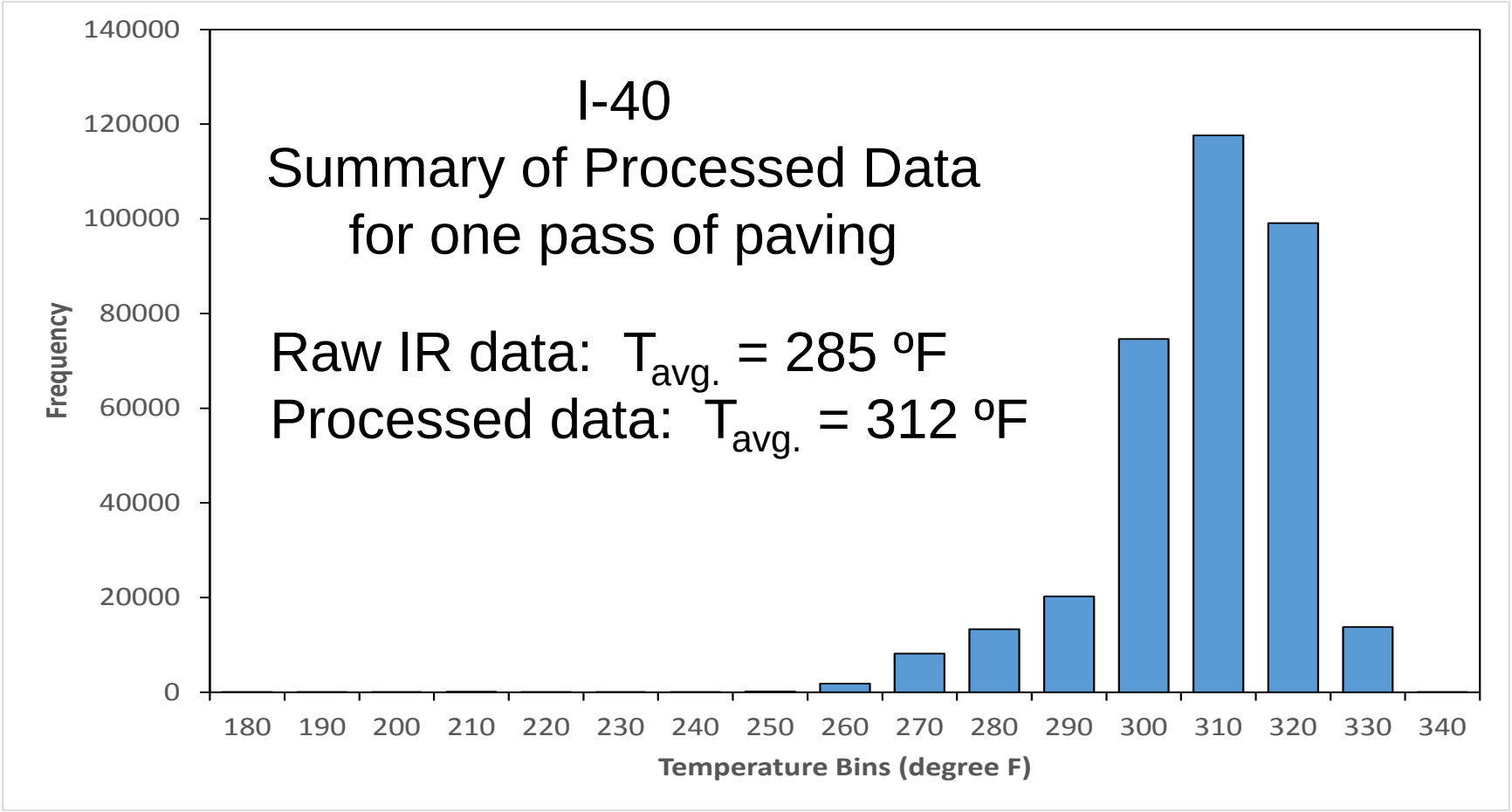
- Temperature Differential Criteria, each 150 foot segment:

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



- **$T_{diff} \leq 25$ ºF** — **No temperature difference**
- 25 ºF < $T_{diff} \leq 50$ ºF — Moderate temperature difference
- **$T_{diff} > 50$ ºF** — **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
EFL	***End Dump***	***No***	***83***	***None***
Illinois	***End Dump***	***No***	***40***	***None***
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
WV	***End Dump***	***No***	***41***	***None***
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
EFL	***End Dump***	***No***	***-$32,593***	***-$29,630***
Illinois	***End Dump***	***No***	***-$10,706***	***-$8,500***
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
WV	***End Dump***	***No***	***-$16,566***	***-$10,101***
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

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

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
AASHTO

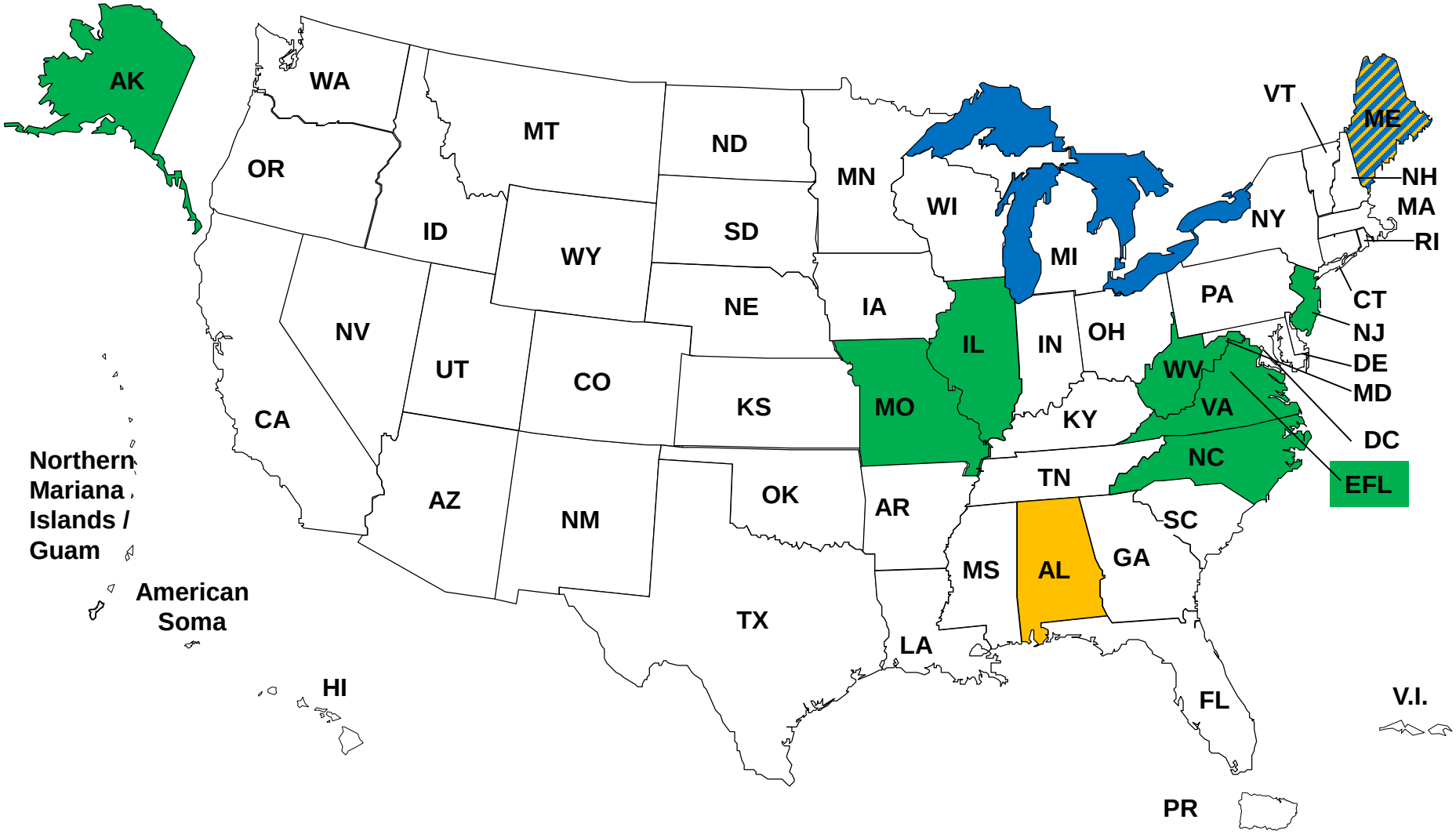
Implementation Products and Strategies

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.got.gov/goshrp2

Demonstration Projects and Products



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

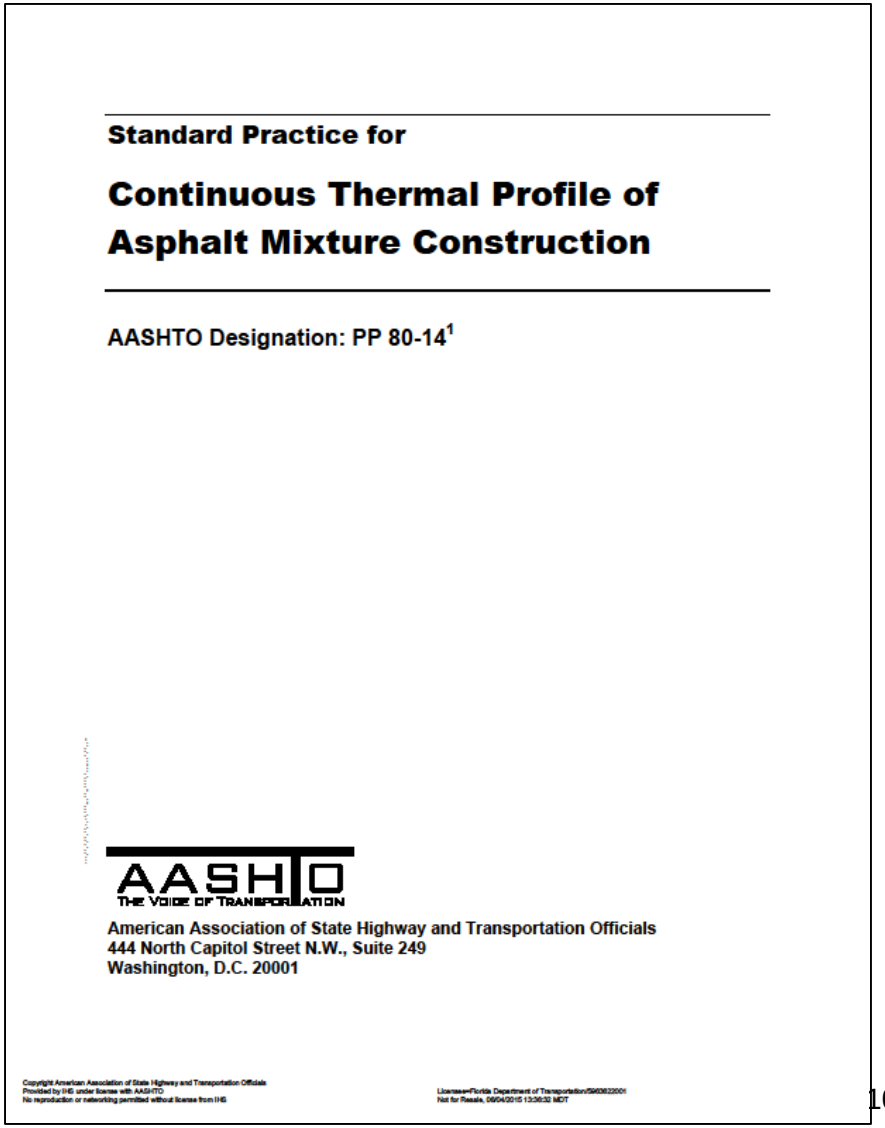
Demonstration Projects and Products

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 80-14[1]

AASHTO
THE VOICE OF TRANSPORTATION

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.

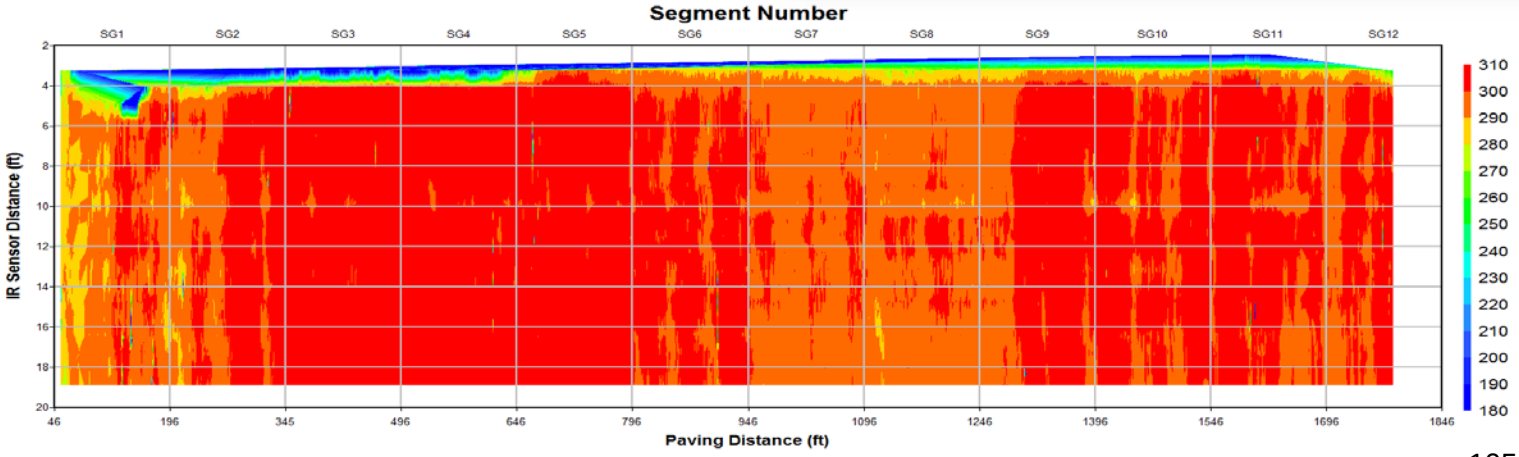
Implementation Products and Strategies

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

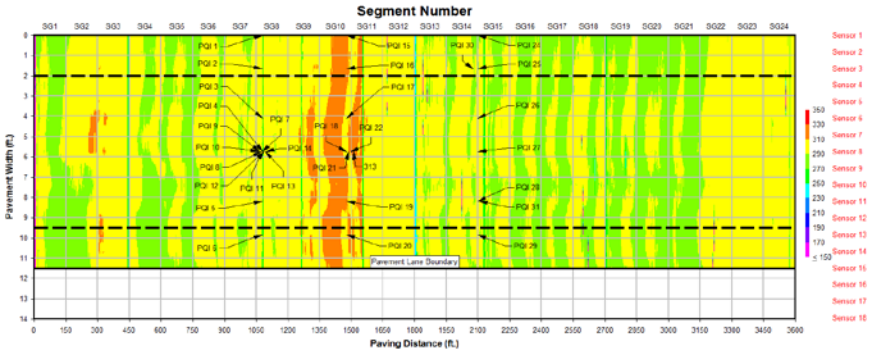
1. Missouri demonstration project
   - Use of laboratory facilities to monitor paving in real time to adjust plant on the fly

Application and Use: Examples

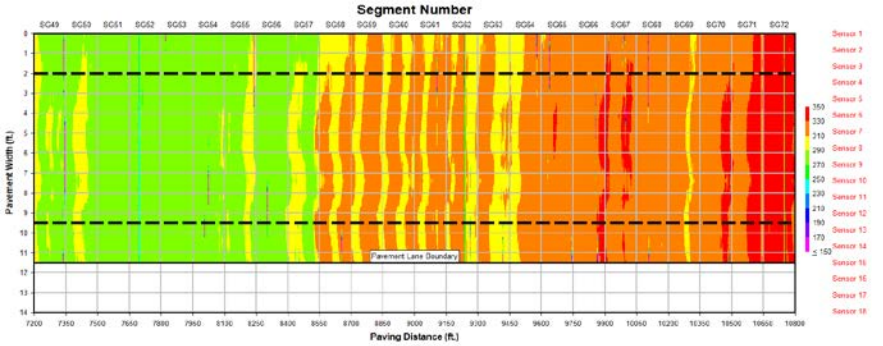
Raw Temperature Profile showing continuous improvement or more uniform mat temperatures as paving progresses.

Example from Missouri demonstration project.

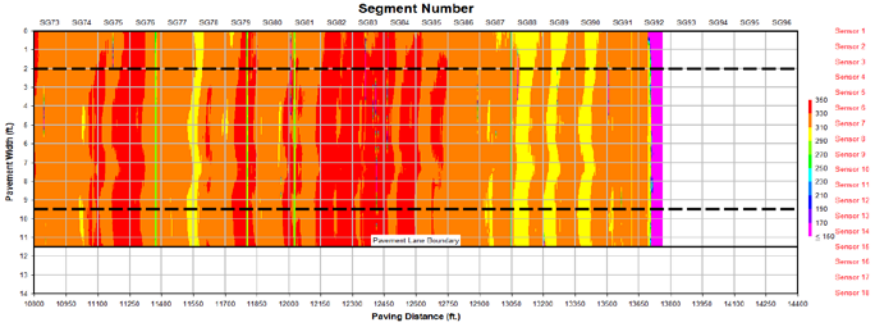
Near the beginning



Near Center of Lot



Near End of Lot

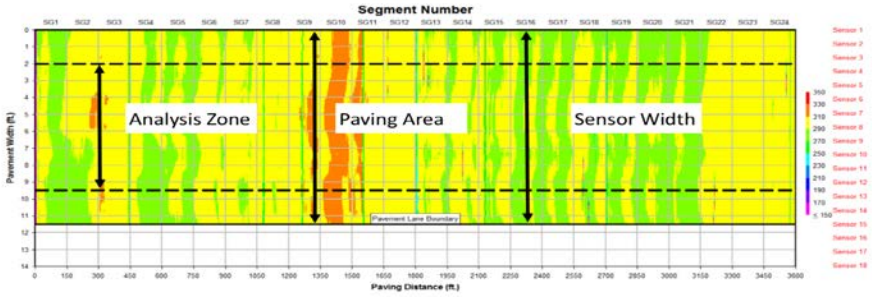


Application and Use: Examples

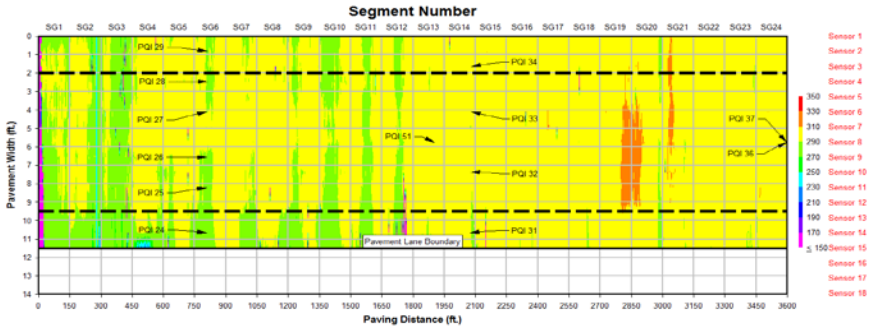
Raw Temperature Profile showing continuous improvement or more uniform mat temperatures as paving progresses.

Example from Maine demonstration project.

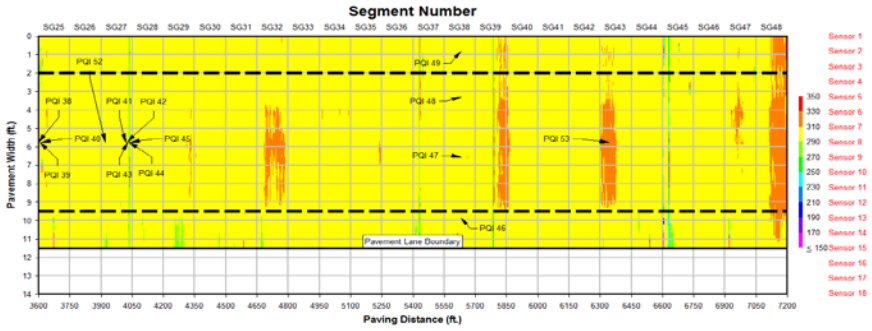
Near Start of Lot



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 ºF.
     - Avg. temperature differential after adding two trucks; about 15 ºF.

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.

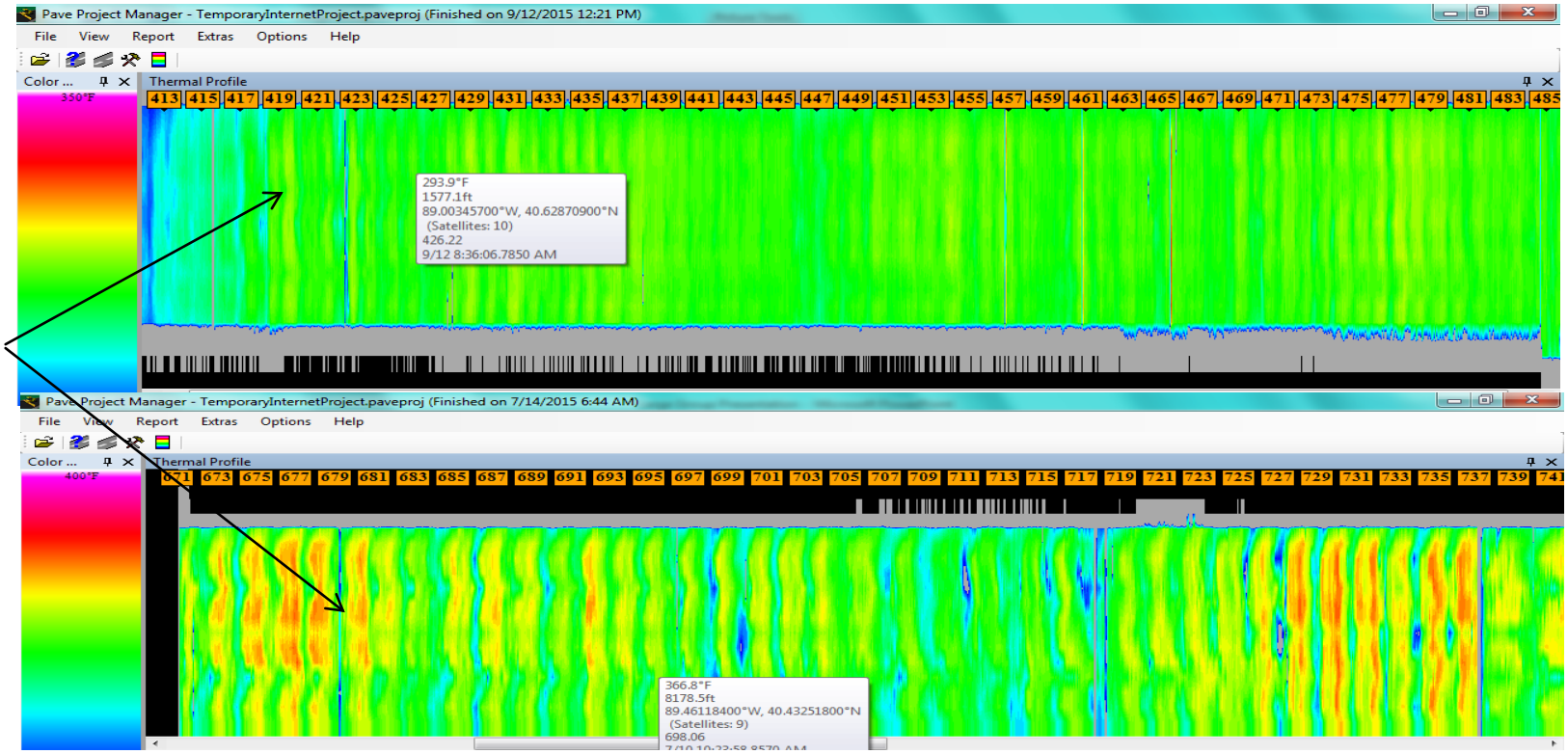
Application and Use: Examples

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

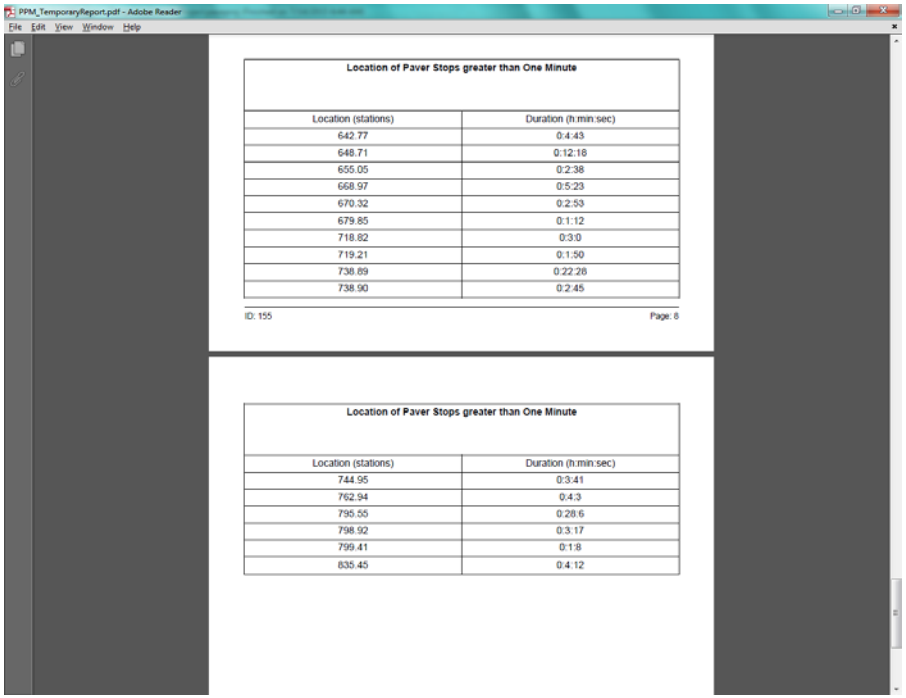
4. Illinois demonstration project

Both jobs used a MTD, so what happened?



Application and Use: Examples

4. Illinois demonstration project


PPM_TemporaryReport.pdf - Adobe Reader

File Edit View Window Help

Location of Paver Stops greater than One Minute

Location (stations)	Duration (h:min:sec)
642.77	0:4:43
648.71	0:12:18
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

ID: 155 Page: 8

Location of Paver Stops greater than One Minute

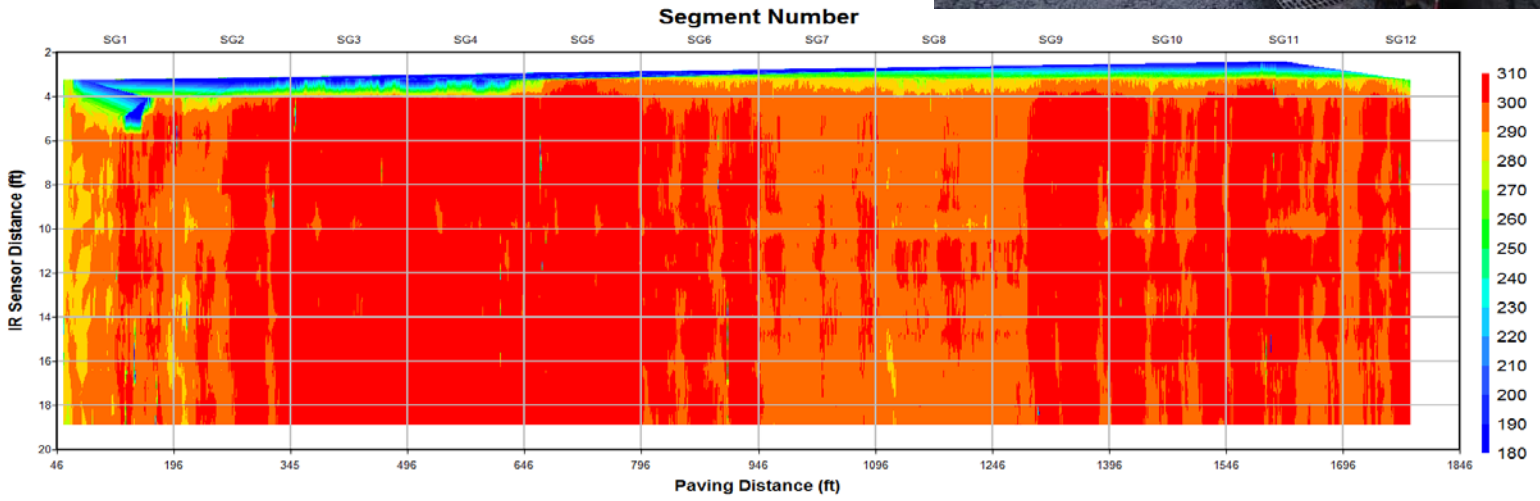
Location (stations)	Duration (h:min:sec)
744.95	0:3:41
762.94	0:4:3
795.55	0:28:6
798.92	0:3:17
799.41	0:1:8
835.45	0:4:12

- 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

Workshop Wrap-Up

Complete workshop forms

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