Consultant Support for IC-PMTPS Projects

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Final Report

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16. Abstract

Due to the success of the MoDOT 2017 Intelligent Compaction (IC) and Infrared Scanning (IR) projects that demonstrated QC improvements on 13 field projects, MoDOT established a plan that included further IC and Paver-mounted Thermal Profile Systems (PMTPS) projects in 2018-2019 with a goal of full implementation in 2021. To ensure the continued success of the MoDOT IC-PMTPS projects in 2018 and beyond, MoDOT procured Consulting Support for the selected IC-PMTPS projects in 2018-2019 (i.e., Phase II). This document details the results from the 2019 IC-PMTPS Projects and an average of overall results from 2017 to 2019. There was a significant improvement in IC and PMTPS data management and analysis efforts by contractors from 2017 to 2019. The thermal segregation continually improved from 2017 to 2019 according to AASHTO PP80 definitions of thermal segregation. There was a significant improvement in IC coverage from 2018 to 2019. Based on the 2017-2019 projects and lessons learned, recommendations for future implementation are included in the study.

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Disclaimer

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

Acronyms and Symbols

CCV: Compaction Control Value, a type of ICMV manufactured by Sakai

CMV: Compaction Meter Value, a type of ICMV manufactured by German's Vogele, used by Caterpillar, Trimble, Dynapac, and Volvo

DMI: Distance Measurement Instrument

EDV: Estimated Density Value, a type of ICMV manufactured by Volvo

GNSS: Global Navigation Satellite System

GPS: Global Positioning System

HCQ: HAMM Compaction Quality system

IC: Intelligent Compaction

ICMV: Intelligent Compaction Measurement Values, a generic term for various solutions from the industry

IR: Infrared Scanning

NDG: Nuclear Density Gauge

OEM : Original Engineering Manufacturer

PMTPS: Paver-Mounted Thermal Profile Systems

PPM: PaveProj Program, MOBA's software program for the PAVE-IR thermal profile system

QA: Quality Assurance

QC: Quality Control

RE: Resident Engineer

Chapter 1 - Introduction

Project Scope

Due to the success of the MoDOT 2017 Intelligent Compaction (IC) and Infrared Scanning (IR) projects that demonstrated QC improvements on 13 field projects, MoDOT established a plan to include additional IC and IR, now known as Paver-mounted Thermal Profile Systems (PMTPS), projects between 2018 and 2019 with a goal of full implementation in 2021. To ensure the continuous success of the MoDOT IC-PMTPS projects in 2018 and beyond, MoDOT procured Consulting Support for the selected IC-PMTPS projects in 2018-2019 (Phase II).

This report is a summary of results for the 2019 IC-PMTPS projects and a summary of the progress made from 2017 to 2019. This report includes recommendations for achieving full implementation by 2021. A summary of the 2018 IC-PMTPS projects were reported separately in the "2018 Final Report" dated December 2018.

Structure of this Report

This report includes the following chapters:

1. Introduction (this Chapter)
2. Work Plan and Activities
3. Pilot Innovation Technology Case Study
4. Field Project Data Analysis and Results
5. Feedback Meeting Discussions, Summary and Recommendations

Chapter 2 – Work Plan and Activities

This chapter details the work plan and project team for the consulting support from the 2019 IC-PMTPS Projects completed under this project.

The work plan for the remainder of this project (Phase II) included four (4) main tasks (Tasks 2, 3, 4, and 5) to be performed from January 1st, 2019 to December 31, 2019, for 12 months. Note that the contract end date is on January 31, 2020, to allow room for report reviews and edits. A summary of the tasks includes:

- Task 1 – Kick Off Meeting (completed in July 2018)
- Task 2 – IC-PMTPS Training Courses
- Task 3 – IC-PMTPS Project Supports
- Task 4 – Final Report
- Task 5 – IC-PMTPS Feedback Meetings

The timeline for each task according to the work plan is illustrated in the following table.

Table 1: Summary of the Timeline of the Tasks

	2018						2019											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Months from NTP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Task 1: Kick Off Meeting																		
Task 2: Training Courses																		
Task 3: IC-IR Project Support																		
Task 4: IC-IR Fial Report																		
Task 5: IC-IR Feedback Meetings						X												X
Quarterly Reports			X			X			X			X			X			X

Training, projects and schedule will be determined by MoDOT.

The project team included: Dr. George K. Chang, P.E., serving as the Principle Investigator (PI). Ms. Amanda Gilliland, P.E., serving as the Pavement Engineer (PE). Mr. Victor (Lee) Gallivan, P.E., serving as the Subcontractor (SCNT).

The following sections detail how each task was completed during the project.

Task 1 – Kick Off Meeting

The task was completed in July 2018.

Task 2 – IC-PMTPS Training Courses

Task 2-1 - Update IC-PMTPS Protocol and Training Materials

The protocols and training materials were updated in July 2018. Contractor forms and a summary sheet were updated in the spring of 2019. The Excel summary sheet with macros was developed to include all project data and IC and PMTPS results and calculate price incentive and disincentive as shown in Figure 1 through Figure 7.

Job No. J1I1234
Route: US NN
IC System: My IC Retrofit
IR System: PAVE-IR
GNSS Ref: UTM 15N
Total Days: 10

Use the two buttons below to add/delete a row - one per day.
It would make changes to all tables in this workbook.
Do not manually change each table.

Add Row | Delete Row

Total Length (mi.): 16.44 **Total AC (tons):** 14,287

No.	*Dates*	*Location*	*Start MP*	*Stop MP*	*Length (ft)*	*Lift*	*Width (ft)*	*Thickness (in)*	*AC (tons)*	*Notes*
1	10/11/2018	SBPL	0+00	24+32	2,432	1	12	1.75	450	First day
2	10/13/2018	SBPL	24+32	99+68	7,536	1	12	1.75	1,327	
3	10/15/2018	SBPL	99+68	199+28	9,960	1	12	1.75	1,759	
4	10/16/2018	SBDL	0+00	141+01	14,101	1	12	1.75	2,054	
5	10/17/2018	SBDL	199+28	263+46	6,418	1	12	1.75	1,127	
6	10/18/2018	SBPL	263+46	391+75	12,829	1	12	1.75	2,275	
7	10/19/2018	SBDL	141+04	288+44	14,770	1	12	1.75	2,294	
8	10/20/2018	SBDL	288+44	395+32	10,688	1	12	1.75	1,668	
9	10/22/2018	SBDL	395+32	434+00	3,868	1	12	1.75	626	
10	10/26/2018	SBPL	391+75	434+00	4,225	1	12	1.75	707	

Figure 1: Excel Project Summary Sheet: Paving Tab

Job No. J1I1234
Route: US NN
C System: My IC Retrofit
R System: MOBA PAVE-IR
GNSS Ref: UTM 15N

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	10/11/2018	99	Passed	70		180	
2	10/13/2018	83	Moderate	80		200	
3	10/15/2018	0	Failed	65	flagged	220	
4	10/16/2018	60	Failed	90		190	
5	10/17/2018	76	Moderate	80		170	Deficient
6	10/18/2018	86	Moderate	50	flagged	190	
7	10/19/2018	59	Failed	70		180	
8	10/20/2018	64	Failed	80		210	
9	10/22/2018	63	Failed	90		220	
10	10/26/2018	48	Failed	60	flagged	200	

Figure 2: Excel Project Summary Sheet: IC Tab (Table)

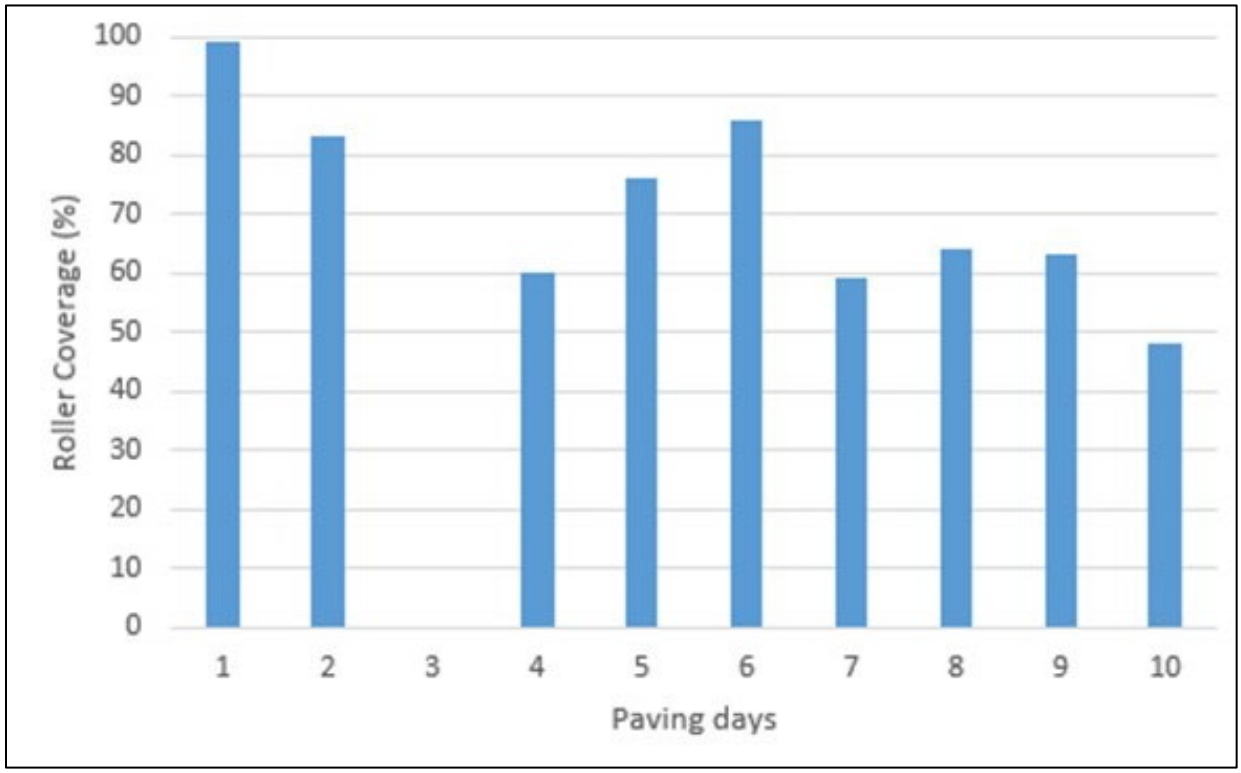

Figure 3: Excel Project Summary Sheet: IC Tab (plot)

Job No. J1I1234
Route: US NN
IC System: My IC Retrofit
IR System: MOBA PAVE-IR

No.	*Dates*	*Data QA*	*Low Temp Seg (LTS) #*	*LTS %*	*Moderate Temp Seg (MTS) #*	*MTS %*	*Severe Temp Seg (STS) #*	*STS%*
1	10/11/2018	Pass	5	*31*	9	*56*	2	*13*
2	10/13/2018	Pass	26	*51*	18	*35*	7	*14*
3	10/15/2018	Pass	47	*72*	14	*22*	4	*6*
4	10/16/2018	Pass	69	*74*	23	*25*	1	*1*
5	10/17/2018	Pass	7	*44*	7	*44*	2	*13*
6	10/18/2018	Pass	66	*78*	19	*22*	0	*0*
7	10/19/2018	Pass	50	*51*	40	*41*	8	*8*
8	10/20/2018	Pass	32	*45*	33	*46*	6	*8*
9	10/22/2018	Pass	12	*46*	13	*50*	1	*4*
10	10/26/2018	Pass	8	*40*	9	*45*	3	*15*

Figure 4: Excel Project Summary Sheet: PMTPS Tab (Table)

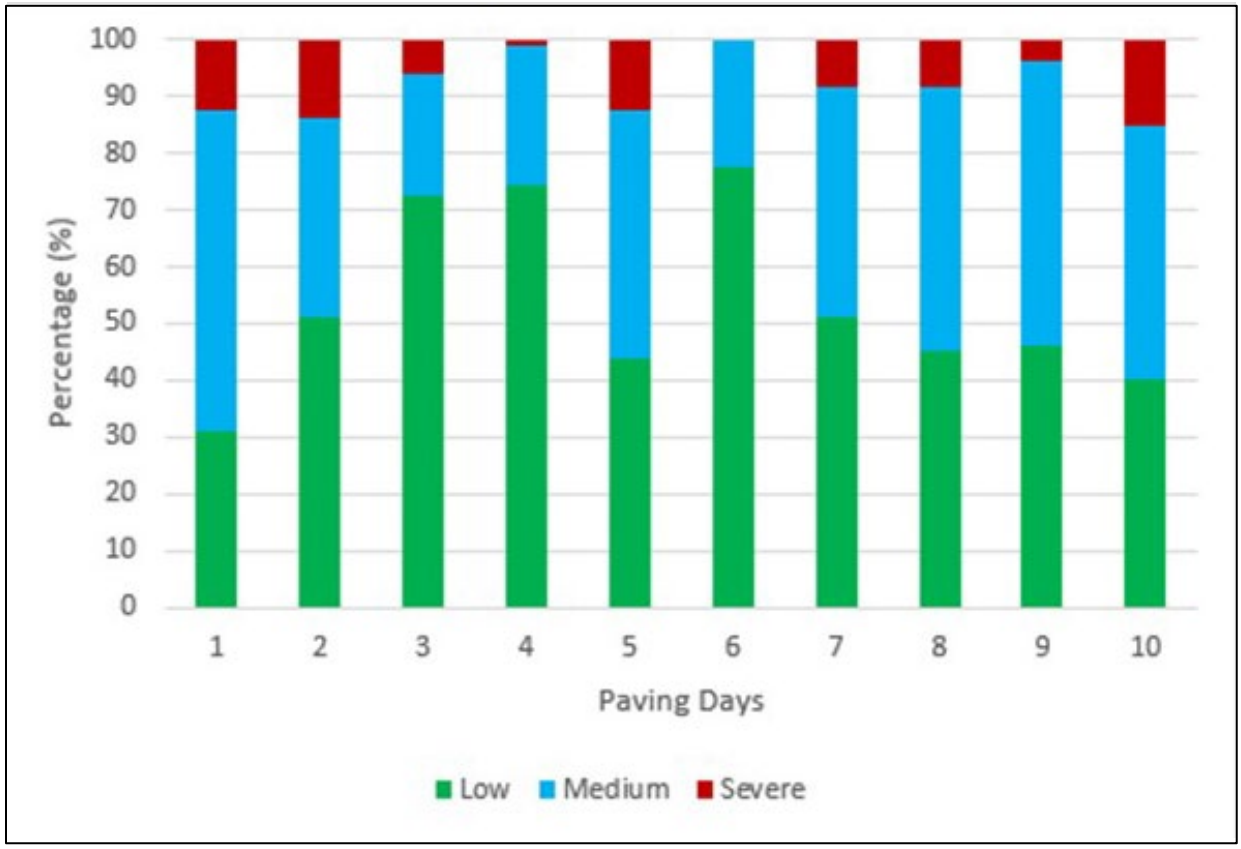

Figure 5: Excel Project Summary Sheet: PMTPS Tab (Plot)

Job No. J1I1234
Route: US NN
IC Pay Item

									Total	$ (4,138.50)
No.	Dates	Location	Start Milepost	Stop Milepost	Distance (ft)	No. 1000' sections	Rounded Coverage (%)	Bonus-Deduct ($)	Estimate #	Estimated total ($)
1	10/11/2018	SBPL	0+00	24+32	2432	2.43	99	$ 182.40	6	$ 182.40
2	10/13/2018	SBPL	24+32	99+68	7536	7.54	83	$ -	6	$ 182.40
3	10/15/2018	SBPL	99+68	199+28	9960	9.96	0	$ (747.00)	6	$ (564.60)
4	10/16/2018	SBDL	0+00	141+01	14101	14.10	60	$ (1,057.58)	6	$ (1,622.18)
5	10/17/2018	SBDL	199+28	263+46	6418	6.42	76	$ -	6	$ (1,622.18)
6	10/18/2018	SBPL	263+46	391+75	12829	12.83	86	$ -	6	$ (1,622.18)
7	10/19/2018	SBDL	141+04	288+44	14770	14.77	59	$ (1,107.75)	6	$ (2,729.93)
8	10/20/2018	SBDL	288+44	395+32	10688	10.69	64	$ (801.60)	6	$ (3,531.53)
9	10/22/2018	SBDL	395+32	434+00	3868	3.87	63	$ (290.10)	6	$ (3,821.63)
10	10/26/2018	SBPL	391+75	434+00	4225	4.23	48	$ (316.88)	6	$ (4,138.50)

Figure 6: Excel Project Summary Sheet: IC Payment Tab

Job No. J1I1234
Route: US NN
PMTP Pay Item

												Total	$ 1,440.00
No.	Dates	Location	Start Milepost	Stop Milepost	Distance (ft)	No. 150' sections	# Segements (No Segregation)	# Segements (Moderate Segregation)	# Segements (Severe Segregation)	Bonus-Deduct ($)	Estimate #	Estimated total ($)	
1	10/11/2018	SBPL	0+00	24+32	2432	2.43	5	9	2	$ 15.00	6	$ 15.00	
2	10/13/2018	SBPL	24+32	99+68	7536	7.54	26	18	7	$ 95.00	6	$ 110.00	
3	10/15/2018	SBPL	99+68	199+28	9960	9.96	47	14	4	$ 215.00	6	$ 325.00	
4	10/16/2018	SBDL	0+00	141+01	14101	14.10	69	23	1	$ 340.00	6	$ 665.00	
5	10/17/2018	SBDL	199+28	263+46	6418	6.42	7	7	2	$ 25.00	6	$ 690.00	
6	10/18/2018	SBPL	263+46	391+75	12829	12.83	66	19	0	$ 330.00	6	$ 1,020.00	
7	10/19/2018	SBDL	141+04	288+44	14770	14.77	50	40	8	$ 210.00	6	$ 1,230.00	
8	10/20/2018	SBDL	288+44	395+32	10688	10.69	32	33	6	$ 130.00	6	$ 1,360.00	
9	10/22/2018	SBDL	395+32	434+00	3868	3.87	12	13	1	$ 55.00	6	$ 1,415.00	
10	10/26/2018	SBPL	391+75	434+00	4225	4.23	8	9	3	$ 25.00	6	$ 1,440.00	

Figure 7: Excel Project Summary Sheet: IC Payment Tab

Task 2-2 - Conduct IC-PMTPS Training Workshops

The workshops were conducted on September 7, 2018 at the MoDOT Chillicothe Project Office and February 26, 2019 at the MoDOT Jefferson City office. Key personnel including paving contractors, QC managers, MoDOT Resident Engineers (RE), and inspectors were in attendance.

Task 3 – IC-PMTPS Project Supports

Various levels of technical support were provided to the selected IC-PMTPS projects as described in this section.

Task 3-1 - On-site Technical Support

In 2019, the research team provided full on-site field technical support for the following projects designated by MoDOT:

Table 2: The Projects that Received On-site Field Technical Support

Job Number	Route	District	Contractor	Resident Engineer
J6I3189	I-44	SL	NB West	Virgil T Reed
J7I3084	I-44	SW	APAC-Central, Inc.	Marvin Morris
J7P3139	249	SW	Blevins Asphalt Construction Company	Marvin Morris

These jobs were selected based on the contractors having no prior experience with IC and PMTPS projects. Each field support included 2 to 3 days of on-site support and 2 days of travels for the consultant. The purpose of the on-site support was to ensure proper IC-PMTPS operations and data reviews for the first days of paving. In addition, consultation was provided to MoDOT project management which covered the checklist of MoDOT IC-PMTPS project management protocol, IC PMTPS systems and operation, and Veta analysis.

Concurrent to the field visits mentioned above, the research team made visits to the following projects to provide ad hoc on-site training and support to MoDOT or contractor personnel:

Table 3: The Projects that Received Ad Hoc On-site Training and Support

Job Number	Route	District	Contractor	Resident Engineer
J5P3212	21,32	CD	Pace Construction Company	Chris Brownell
J7S3116	LP49	SW	Blevins Asphalt Construction Company	Marvin Morris

Task 3-2 - Pilot Innovation Technologies

Vogele RoadScan and HAMM Compaction Quality (HCQ) Intelligent Compaction equipment were demonstrated as Pilot Innovation technologies during the Highway 61/24 Project in Palmyra, MO. The contractor was Emery Sapp Chester Bross. More information regarding the Pilot Innovation Technology is in Chapter 3.

Task 3-3 -IC-PMTPS Data Management and Analysis

In 2019, the research team provided data management and analysis for projects on an as-needed basis. Contractor data was analyzed at the start of each project and support was given if there were any problems with naming convention, data submission, analysis, or reporting.

IC-PMTPS data were analyzed for data QA and assistance was given to contractors to conduct their own data analysis. The analysis included data observations, statistical analysis, and correlation analysis to identify IC-PMTPS equipment or system issues and to evaluate the quality levels of contractors' field operations.

Task 3-4 - Concise IC-PMTPS QA Reports

In 2019, the research team provided concise IC-PMTPS QA reports for the following projects:

Table 4: The Projects that Includes Concise QA Reports

Job Number	Route	District	Contractor
J6I3189	I-44	SL	NB West
J6I3165	I-70	SL	Pace Construction
J1I3019	I-29	NW	Herzog
J5P3212	21,32	CD	Pace Construction Company
J2P3135	54	NE	Magruder Paving, LLC
J5P3114	US-63	CD	Capital Paving & Construction LLC
J5P3233	US-63	CD	Capital Paving & Construction LLC
J7I3084	I-44	SW	APAC-Central, Inc.
J9S3282	US-61	SE	Pace Construction Company

These notes were provided to REs and contractor personnel as needed to assist with data management and analysis. The concise notes can be found in the designated project folder on the MoDOT SharePoint site. A summary of lessons learned were discussed at the Feedback Meetings and are further discussed in Chapter 5 of this report.

Task 4 – IC-PMTPS Final Report

Task 4-1 - Part I of the Final Report (2018)

Part I of the final report includes the IC-PMTPS projects completed in 2018.

Task 4-2 - Part II of the Final Report (2019)

Part II of the final report includes those projects completed in 2019. This document is Part II of the final report.

Task 5 – IC-PMTPS Feedback Meetings

The feedback meetings for 2018 were skipped due to scheduling conflicts.

The feedback meetings for 2019 took place December 18-19 in the MoDOT Jefferson City offices. The outcomes of these meetings are further summarized in Chapter 5.

The purpose was to present lessons learned from the projects completed in the 2018 and 2019 construction seasons and to discuss items for improvement and issues to be resolved for the next construction seasons.

Chapter 3 – Pilot Innovative Technologies

The selected innovation technologies piloted during Phase II of the project included the Vogele RoadScan Thermal Imaging System and HAMM HCQ Intelligent Compaction System.

Vogele RoadScan Thermal Imaging System

The Veta team implemented the import feature for Vogele RoadScan data in Veta 5.2. This equipment allows for high precision GPS. A brief description of this innovative technology is as follows.

The RoadScan system is an infrared camera which scans the asphalt pavement behind the screed over the entire area. The VÖGELE system captures grids of 25 x 25cm-sized tiles at a measuring width of 10m. Each of these tiles contains up to 16 single measuring points which are then used to calculate a mean value. That allows the system to capture the newly paved surface with no gaps, and so no theoretical or computed values need to be added. The measurable temperature range of RoadScan lies between 0°C and 250°C with a tolerance of only ±2°C.

The purpose of RoadScan's other components is to capture the base temperature before paving (pyrometer), record precise positional data (high-precision GPS receiver) and document the wind strength and direction, ambient temperature, air pressure and humidity (weather station available as an option).

The RoadScan system is controlled from the paver operator’s ErgoPlus 3 console. The user views the temperatures currently being recorded on the color display in real time. The paver operator can program the color scale to allow any deviation from the required temperature of the freshly paved asphalt to be quickly identified.

The measurement data obtained using RoadScan is stored in the paver operator's ErgoPlus 3 console. After paving, this data can be read off via an external data storage device which transfers the data in encrypted form. The data is then analyzed in the office using the RoadScan Analysis web application, or Veta.

VÖGELE RoadScan can also be integrated into WITOS Paving. This innovative IT-based tool for the process optimization of asphalt job sites helps companies to plan more transparently and respond flexibly to interruptions in ongoing operations, significantly increasing overall cost efficiency.

Currently, the Vogele RoadScan system can be mounted only on certain models of Vogele asphalt pavers. Images of the equipment are shown in Figure 8 and Figure 9.

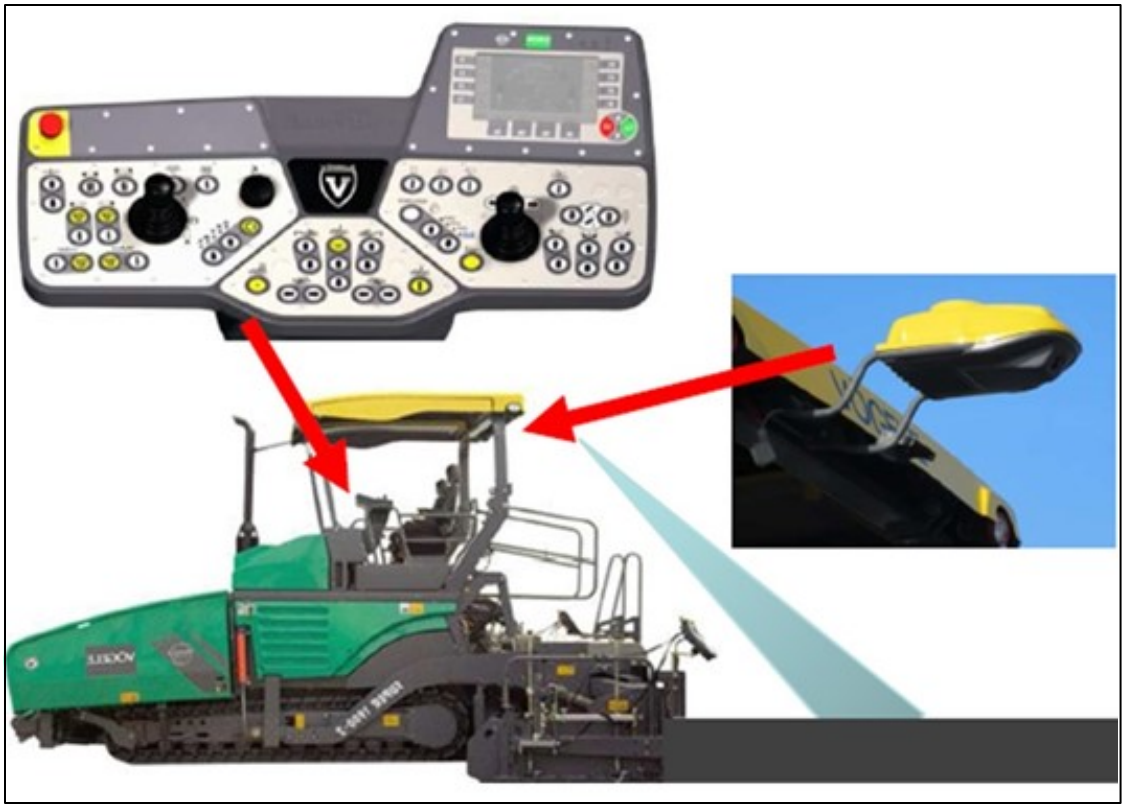

Figure 8: Vogele RoadScan Thermal Imaging System

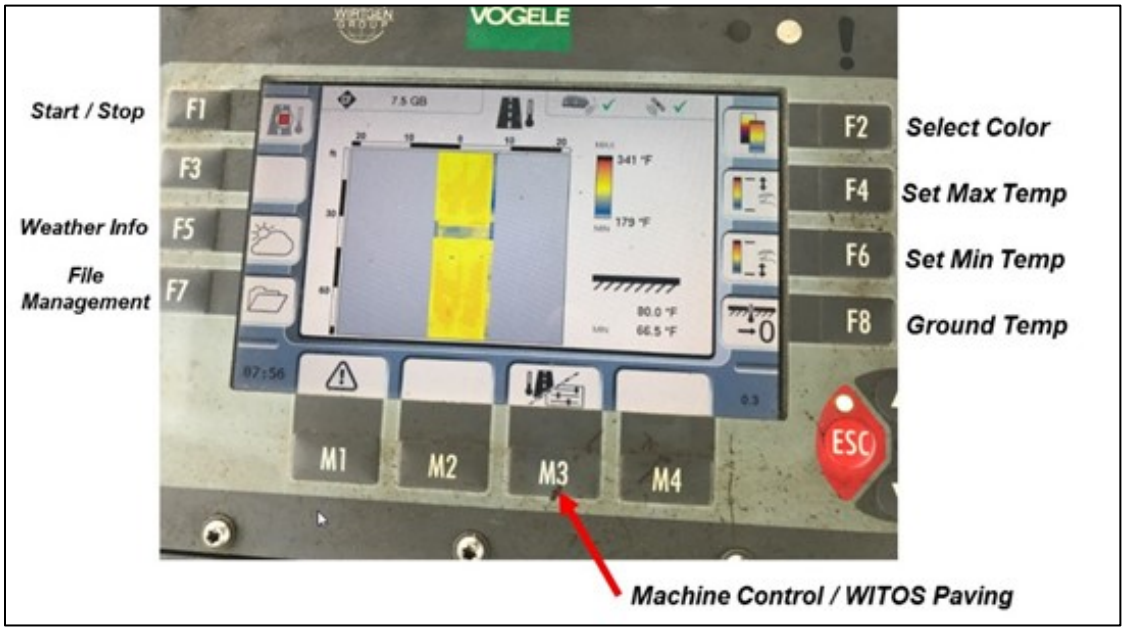

Figure 9: Vogele RoadScan Thermal Imaging System: Control Panel

HAMM Compaction Quality (HCQ) System

HCQ stands for “HAMM Compaction Quality“. It bundles together all the HAMM solutions for compaction measurement and documentation. The modular system offers suitable components for all roller types as well as for the most diverse applications and is available for all current tandem rollers, compactors and pneumatic tire rollers. The various HCQ modules contribute to greater transparency in the compaction process with a corresponding increase in quality.

In asphalt compaction, the aim is to minimize the void content in the asphalt. In order to be able to compact the asphalt, it must have a material-dependent minimum temperature. Various HCQ modules are available to monitor the asphalt compaction. To measure and display the rigidity or the temperature at the asphalt surface, the HAMM Compaction Meter (HCM) or the HAMM Temperature Meter (HTM), respectively, can be used. The HCQ Navigator displays the number of passes and the asphalt temperature on a monitor in the roller while compacting.

The HAMM Compaction Meter (HCM) shows the ICMV value of the compacted materials. This enables weak points to be identified already during compaction. If the HCM is calibrated before starting to compact, it is possible to determine the actual load bearing capacity in earth work, or degree of compaction. This optimizes the number of passes and avoids over and under-compaction.

The HAMM Temperature Meter shows the current asphalt surface temperature. It enables the roller driver to decide where and how the asphalt needs to be compacted, thus making optimum use of the working time window and avoiding damage. The HAMM system is shown in Figure 10 and Figure 11.

Figure 10: HAMM HCQ Intelligent Compaction System

Figure 11: HAMM HCQ Intelligent Compaction System in Echelon Mode with Wi-Fi Connection

The HCQ Navigator software offers many options for evaluating the data on the panel PC and on office PCs. For example, various filters enable the depiction of specific compaction types, such as when and where the rollers used static or dynamic compaction.

One highlight is the analysis of individual points or areas. Here, the compaction history with the number of passes, the compaction achieved and the temperature at the time of compaction can be displayed for each location, even years later. Another feature of the system is the replay function. It shows the compaction process in expedited speed.

Evaluations with the HCQ Navigator can also identify weaknesses in the roadbed that are invisible to the eye. During proof rolling, the roller is driven over the prepared roadbed before beginning the asphalt work, and the pass is recorded with the HCQ Navigator. An evaluation of the data can reveal any weak areas of the roadbed in question. This simple detection of inadequately compacted areas can prevent expensive damage that generally only becomes apparent years later.

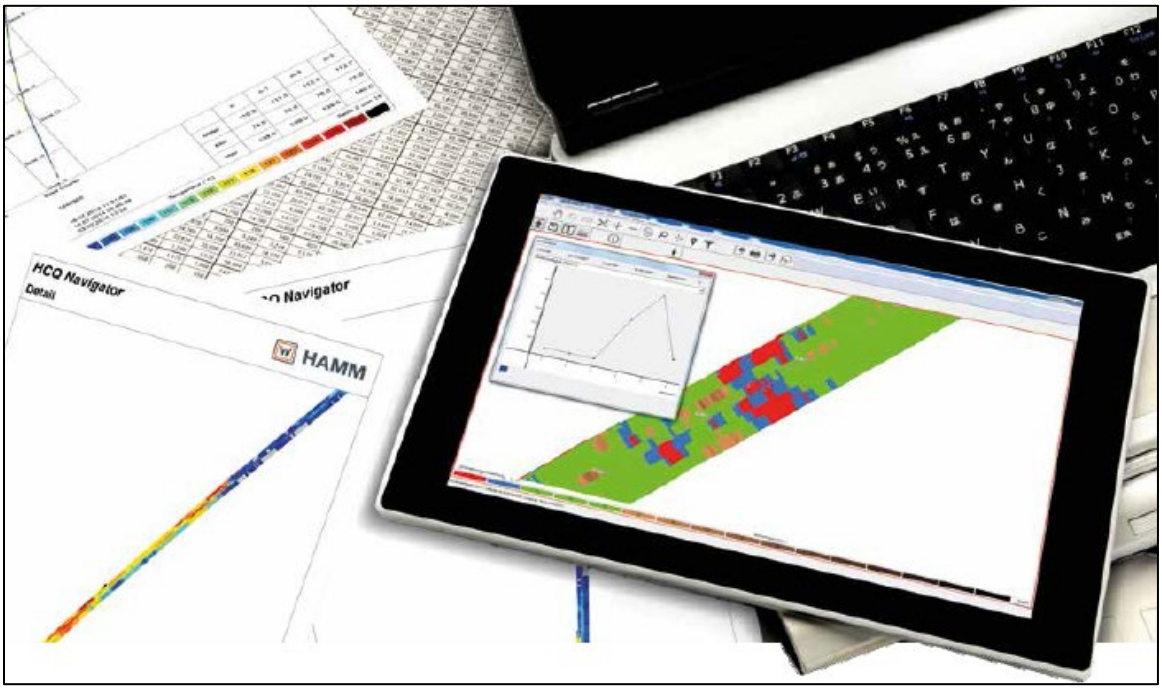

Figure 12: HAMM HCQ Navigator Software

HAMM is an innovator in Intelligent Compaction technologies. During BAUMA 2019, HAMM announced their planned future integration with Construction Site 4.0 and Building Information Modeling (BIM) for pavements.

Demonstration at the HWY 61/24 Project in Palmyra, MO

The demonstration of the Vogele RoadScan PMTPS and HAMM HCQ IC system took place at the HWY 61/24 project in Palmyra, MO, on August 29, 2019. MoDOT representatives were on-site to observe the field demonstration and participate in the vendor's presentation, with the latter hosted by the Roland Machinery.

A Roadtec material transfer vehicle (MTV) was used at the project (Figure 13). Figure 14 shows Vogele RoadScan PMTPS mounted on a Vogele Paver. Figure 15 shows the RoadScan PMTPS data in Veta. HAMM HCQ equipment is shown in Figure 16.

The demonstration was a success. There was a briefing on the RoadScan system, the HCQ system, and the WITOS Paving System for the MoDOT representatives.

Figure 13: Roadtec Material Transfer Vehicle (MTV) On-Site (HWY 61/24 Project)

Figure 14: Vogele RoadScan PMTPS Mounted on a Vogele Paver On-site (HWY 61/24 Project)

Figure 15: RoadScan PMTPS Data in Veta (HWY 61/24 Project)

Figure 16: HAMM HCQ Intelligent Compaction System On-site (HWY 61/24 Project)

Chapter 4 – Field Project Data Analysis and Results

Project Descriptions

The basic project information for the 2019 IC-PMTPS projects and the contractor codes are described in Table 5 and Table 6. The locations of each project are mapped in Figure 17. Note that there are three projects listed that did not have any IC or PMTPS data uploaded to the SharePoint site (listed in Table 7).

Table 5: 2019 IC-PMTPS Project Information

2019 Project No.	Job No.	District	County	Route	Contractor Code
1	J1I3169	NW	Harrison	I-35	7
2	J5P3212	CD	Washington	21, 32	8
3	J5P3114	CD	Phelps	63	1
4	J6I3189	SL	Franklin	I-44	9
5	J6I3165	SL	St. Louis	I-70	8
6	J2P3133	NE	Pike	54	5
7	J9S3271	SE	Scott	62	8
8	J9S3282	SE	Scott	61	8
9	J1I3017	NW	Harrison	I-35	3
10	J4I3122	KC	Platte	I-435	2
11	J5P3233	CD	Osage	63	1
12	J6P3184	SL	Jefferson	141	9
13	J1I3019	NW	Holt	I-29	7
14	J2P3135	NE	Audrain	54	5
15	J4I3119	KC	Jackson	470	2
16	J7I3084	SW	Newton	I-44	4
17	J7P3139	SW	Jasper	249	6
18	J7S3116	SW	Jasper	LP49	6
19	J7S3117	SW	Newton	LP49	6

Table 6: 2019 IC-PMTPS Contractor Code (this table is intentionally left blank)

Contractors	Code

1. I-35, Harrison (from 2018)
2. MO 21 & 32, Washington
3. US 63, Phelps
4. I-44, Franklin
5. I-70, St. Louis
6. US 54, Pike
7. US 62, Scott
8. US 61, Scott
9. I-35, Harrison (no data collected)
10. I-435, Platte (no data collected)
11. US 63, Osage
12. MO 141, Jefferson
13. I-29, Holt
14. US 54, Audrain
15. US 470, Jackson (no data collected)
16. I-44, Newton
17. MO 249, Jasper
18. LP 49, Jasper
19. LP 49, Newton

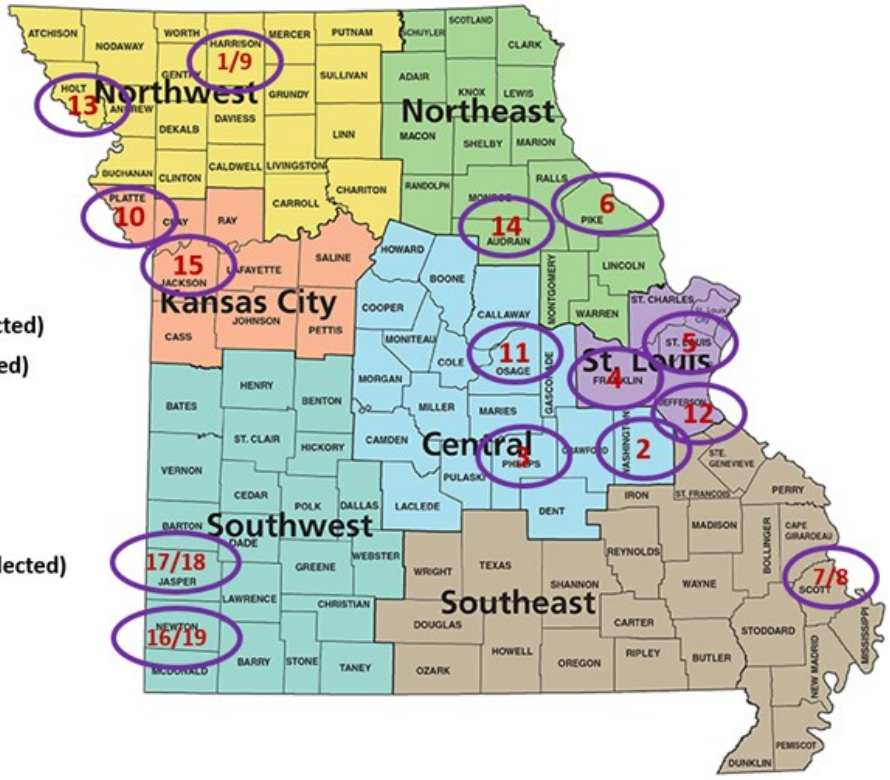

Figure 17: Mapped Project Locations

The schedule for the MoDOT IC-PMTPS field projects is listed in Table 7. The PMTPS and IC systems used for each of the projects are listed in Table 8.

Table 7: MoDOT IC-PMTPS Project Schedule

No.	Job No.	District	County	Route	Start Date	End Date	Paving Days
1	J1I3169	NW	Harrison	I-35	10/11/2018	5/22/2019	18
2	J5P3212	CD	Washington	21, 32	4/29/2019	5/30/2019	14
3	J5P3114	CD	Phelps	63	4/22/2019	5/23/2019	13
4	J6I3189	SL	Franklin	I-44	4/29/2019	9/17/2019	56
5	J6I3165	SL	St. Louis	I-70	5/23/2019	8/2/2019	35
6	J2P3133	NE	Pike	54	5/30/2019	8/15/2019	18
7	J9S3271	SE	Scott	62	7/8/2019	7/18/2019	4
8	J9S3282	SE	Scott	61	6/27/2019	7/8/2019	7
9	J1I3017	NW	Harrison	I-35	NO DATA	NO DATA	NO DATA
10	J4I3122	KC	Platte	I-435	NO DATA	NO DATA	NO DATA
11	J5P3233	CD	Osage	63	9/26/2019	10/16/2019	12
12	J6P3184	SL	Jefferson	141	10/14/2019	10/23/2019	8
13	J1I3019	NW	Holt	I-29	7/17/2019	9/5/2019	27
14	J2P3135	NE	Audrain	54	6/13/2019	7/25/2019	29
15	J4I3119	KC	Jackson	470	NO DATA	NO DATA	NO DATA
16	J7I3084	SW	Newton	I-44	7/31/2019	9/17/2019	32
17	J7P3139	SW	Jasper	249	8/28/2019	9/10/2019	7
18	J7S3116	SW	Jasper	LP49	10/13/2019	10/27/2019	9
19	J7S3117	SW	Newton	LP49	9/16/2019	9/19/2019	4

Table 8: MoDOT IC-PMTPS Project Systems Used

No.	Job No.	District	County	Route	PMTPS System	IC System
1	J1I3169	NW	Harrison	I-35	MOBA PAVE-IR	Trimble
2	J5P3212	CD	Washington	21, 32	MOBA PAVE-IR	Trimble
3	J5P3114	CD	Phelps	63	MOBA PAVE-IR	TOPCON
4	J6I3189	SL	Franklin	I-44	MOBA PAVE-IR	Volvo
5	J6I3165	SL	St. Louis	I-70	MOBA PAVE-IR	Volvo
6	J2P3133	NE	Pike	54	MOBA PAVE-IR	Caterpillar/Trimble
7	J9S3271	SE	Scott	62	MOBA PAVE-IR	Caterpillar/Trimble
8	J9S3282	SE	Scott	61	MOBA PAVE-IR	Caterpillar/Trimble
9	J1I3017	NW	Harrison	I-35	NO DATA	NO DATA
10	J4I3122	KC	Platte	I-435	NO DATA	NO DATA
11	J5P3233	CD	Osage	63	MOBA PAVE-IR	TOPCON
12	J6P3184	SL	Jefferson	141	MOBA PAVE-IR	Volvo
13	J1I3019	NW	Holt	I-29	MOBA PAVE-IR	Trimble
14	J2P3135	NE	Audrain	54	MOBA PAVE-IR	Caterpillar/Trimble
15	J4I3119	KC	Jackson	470	NO DATA	NO DATA
16	J7I3084	SW	Newton	I-44	MOBA PAVE-IR	TOPCON
17	J7P3139	SW	Jasper	249	MOBA PAVE-IR	Trimble
18	J7S3116	SW	Jasper	LP49	MOBA PAVE-IR	Trimble
19	J7S3117	SW	Newton	LP49	MOBA PAVE-IR	Trimble

Data Analysis and Results

The following section describes how the data was analyzed and reported for each project. The analysis and reporting was the responsibility of the contractor.

PMTPS Data Analysis

The PMTPS data were analyzed using the Veta (version 5.2) analysis reports. Veta uses the AASHTO PP 80-17 method to compute the "Range" values by taking the differences between the 98.5-percentile value and 1-percentile value of thermal profile data with a given 150 ft. sublot. The areas of any paver stop, 2 ft. before and 8 ft. after, were excluded from temperature differential computation per AASHTO PP 80-17 specification (Figure 18).

The remaining data are used to calculate the range value, 98.5th percentile – 1st percentile (Figure 19). The classification of temperature segregation is based on the Range value as follows: Low (Range ≤ 25.0 °F); Moderate (25.0 °F < Range ≤ 50.0 °F); and Severe (Range > 50.0 °F), as shown in Figure 20.

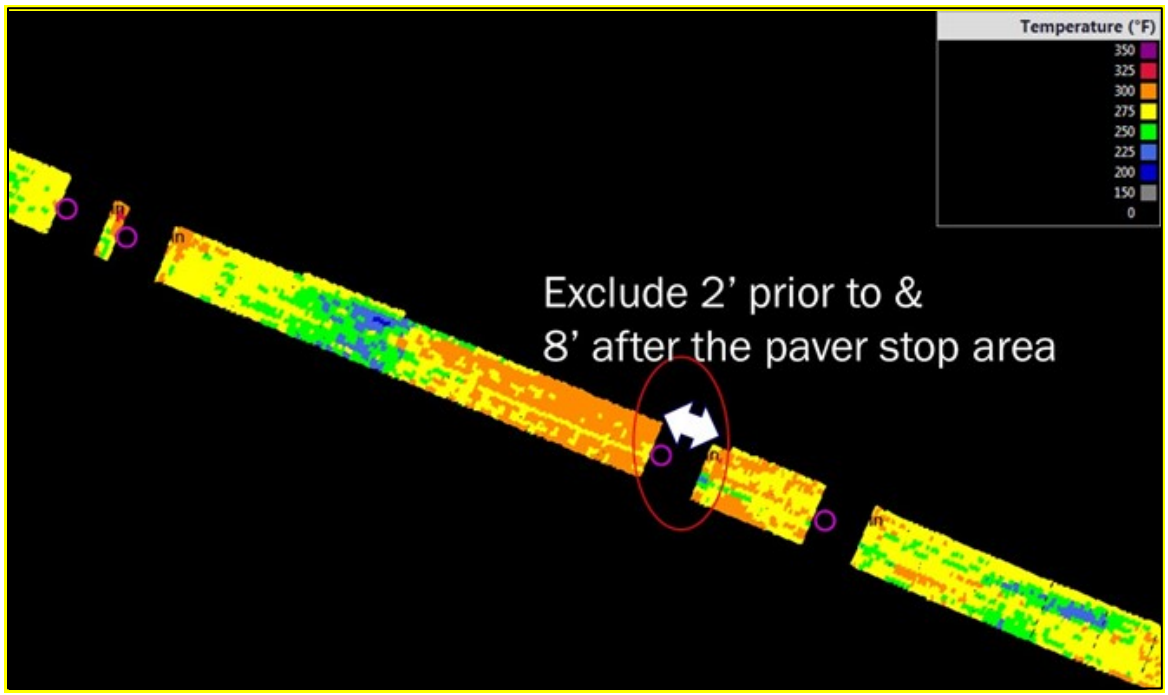

Figure 18: AASHTO PP80 IR Analysis Method: 10' Exclusion Around a Paver Stop Location

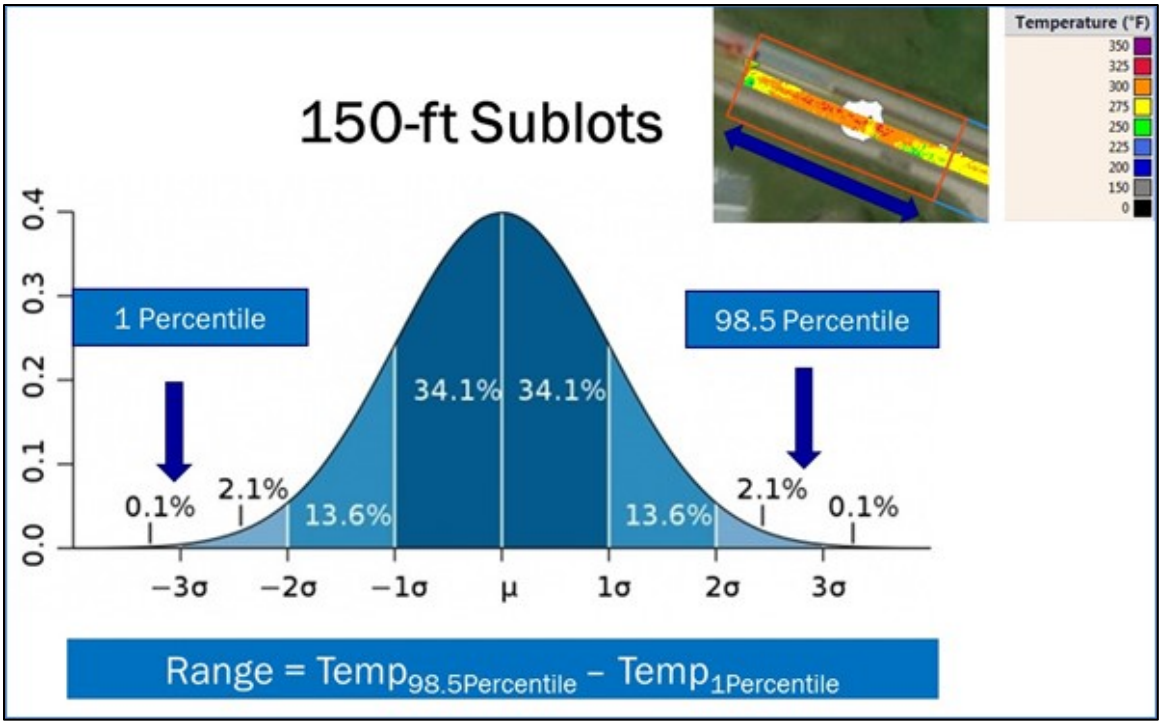

Figure 19: AASHTO PP80 IR Analysis Method: Computation of "Range" Value

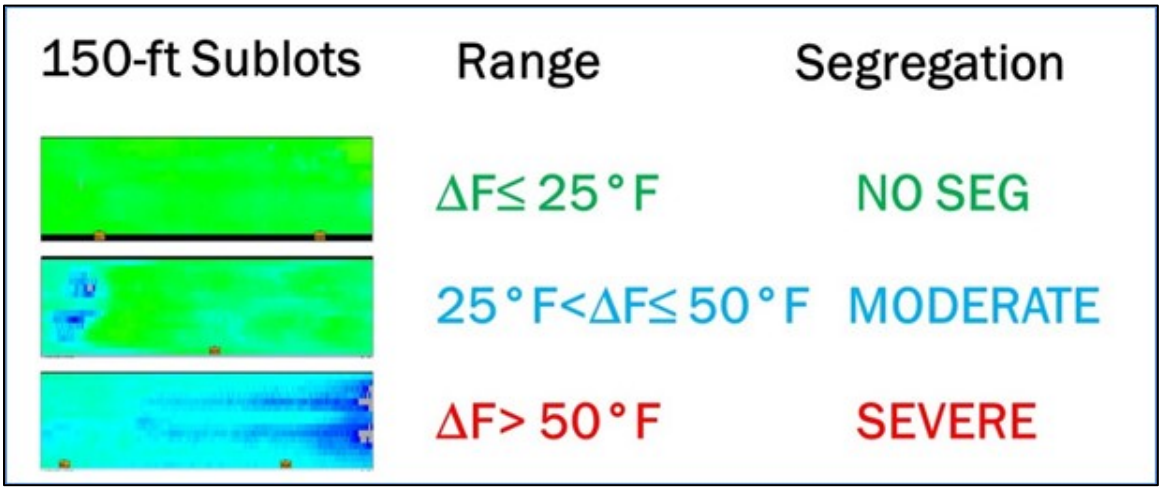

Figure 20: AASHTO PP80 IR Analysis Method: Segregation Categories

PMTPS Analysis Examples

An example of PMTPS data analysis from October 22, 2018 from project J5S3207 RT 54 is shown below. The MOBA PAVE-IR data were downloaded from the Cloud, and the corresponding import results are shown in Figure 21.

The MOBA PAVE-IR data is imported to Veta 5.2 and saved as J5S3207-20181022-IR.vetaproj.

There are minor data points with invalid coordinates. A few invalid coordinates are typical and not of concern. The “raw” thermal profile data shows the cold edges of adjacent existing asphalt (Figure 22).

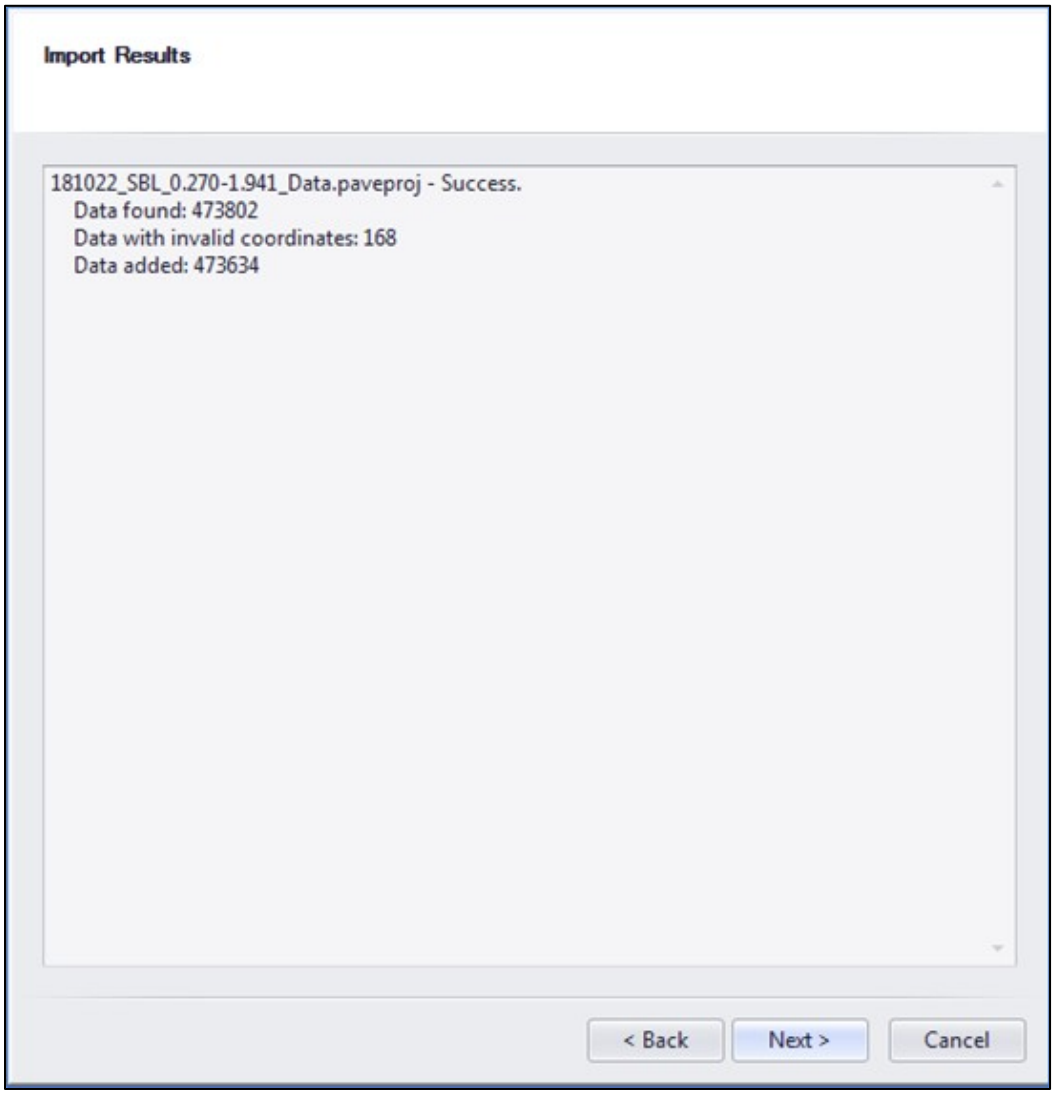

Figure 21: Screenshot of Data Import Results

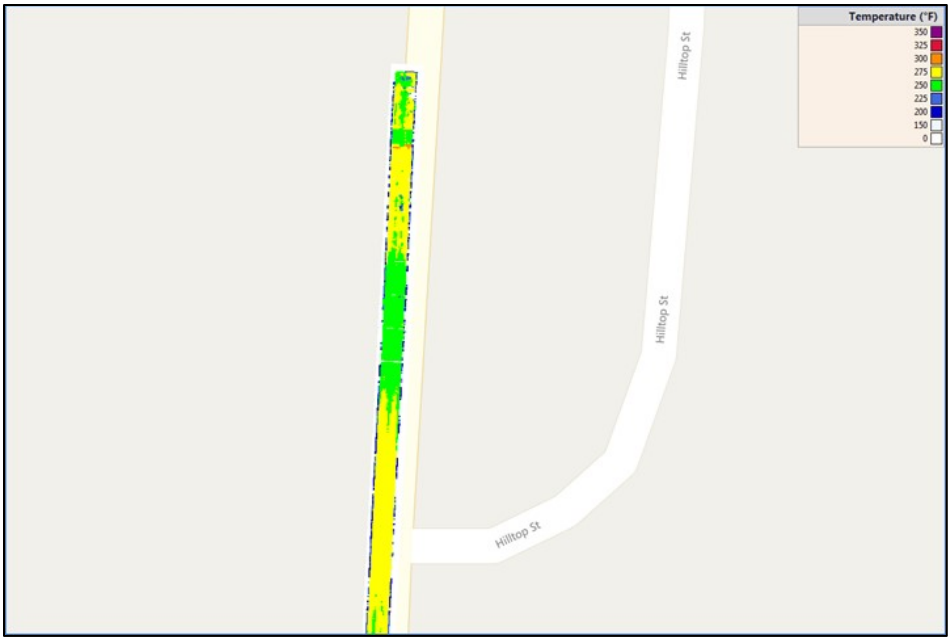

Figure 22: Veta View Screen for PMTPS Data Analysis

These edges are removed by setup of a filter group, J5S3207-20181022-IR, as shown in Figure 23. A data filter is created to exclude temperatures less than 180F. An operation filter is created that excludes cold edges (and hot bracket). Figure 24 shows the new profile after the filter group has been applied and the cold edges have been filtered out. Sublots with 150 feet of length are created per AASHTO PP 80-17 as shown in Figure 25.

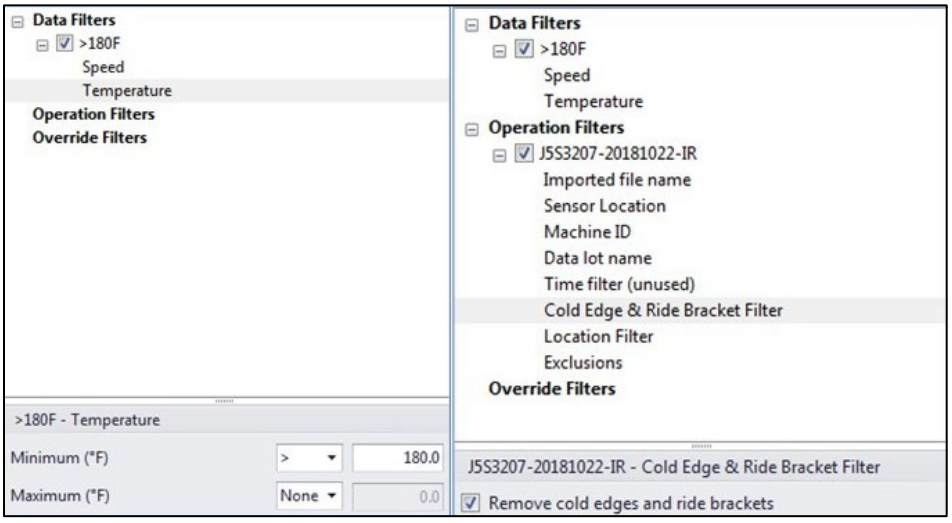

Figure 23: Veta Filter Group Screen of PMTPS Data Analysis

Figure 24: Veta Filter Group Screen of PMTPS Data Analysis: After Filtering

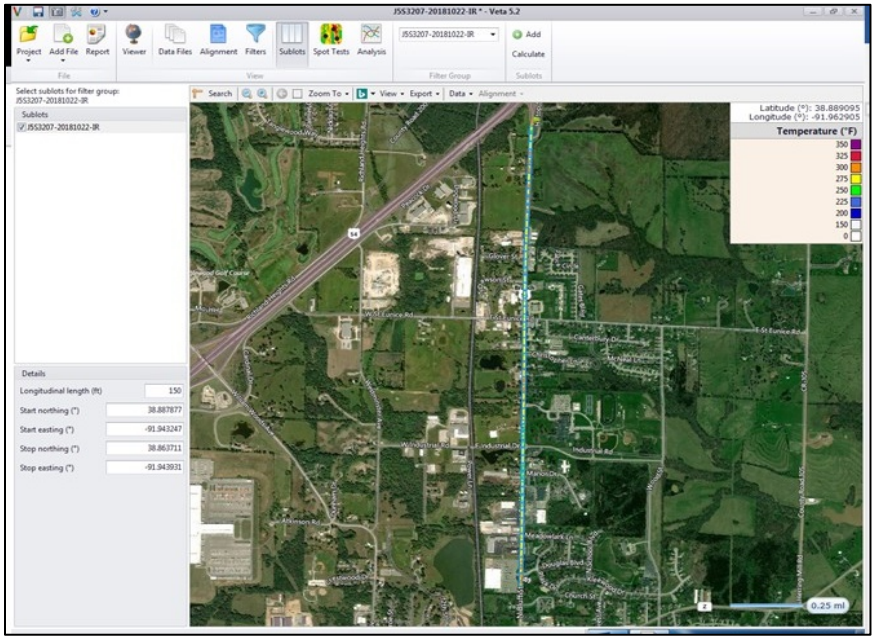

Figure 25: Veta Sublot Screen of PMTPS Data Analysis

The analysis is configured as shown in Figure 26 and Figure 27. Figure 28 shows the Veta coverage report screen with the actual area and length paved.

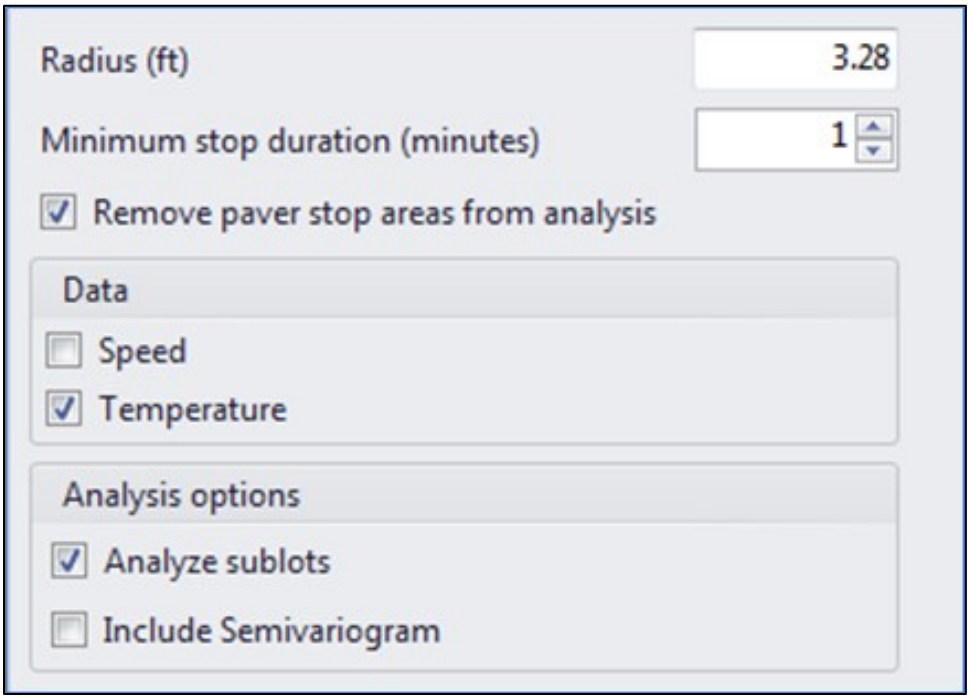

Figure 26: Veta Analysis Setup Screen of PMTPS Data Analysis: Main Setup

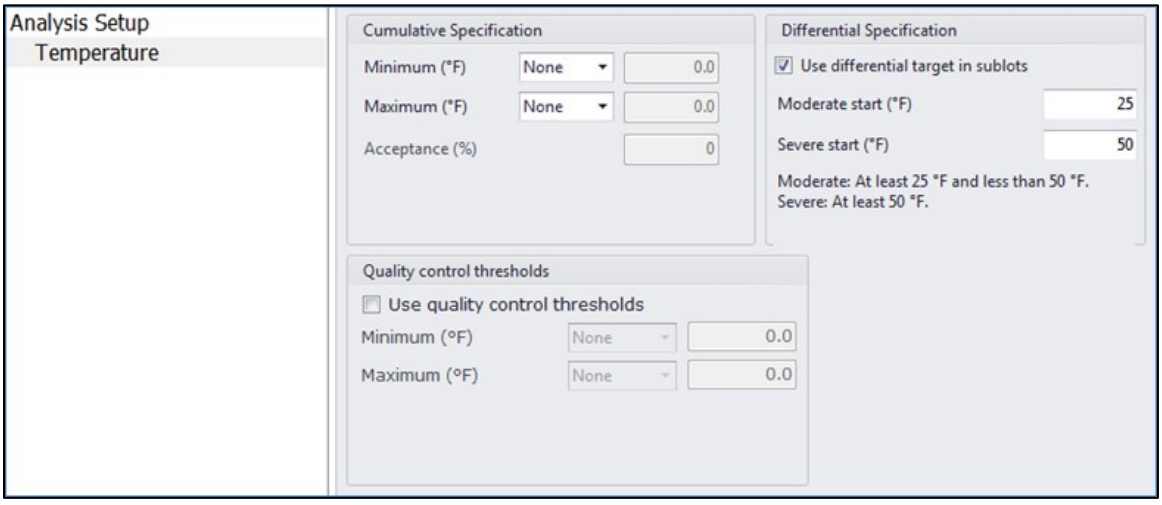

Figure 27: Veta Analysis Setup Screen of PMTPS Data Analysis: Temperature Criteria

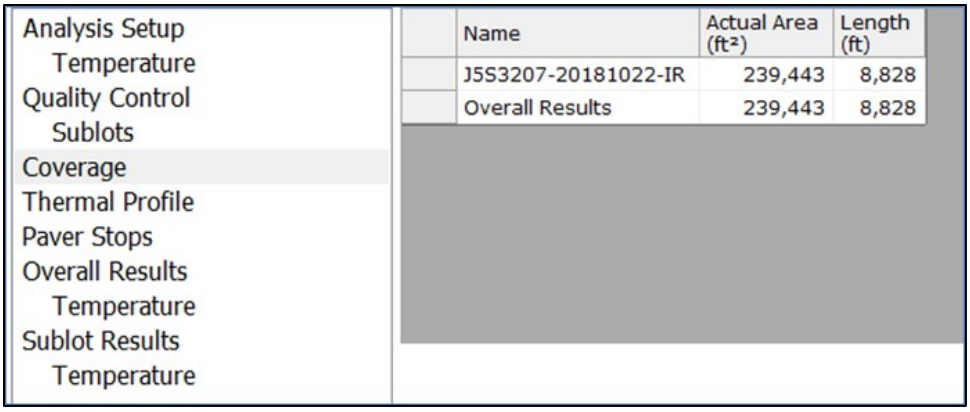

Figure 28: Veta Coverage Report Screen of PMTPS Data Analysis

The thermal profile, paver stops, and speed plots can be viewed in Veta as shown in Figure 29. Note that the thermal profile width changes at 5,550ft. It is recommended to verify this change of paving width with the contractor.

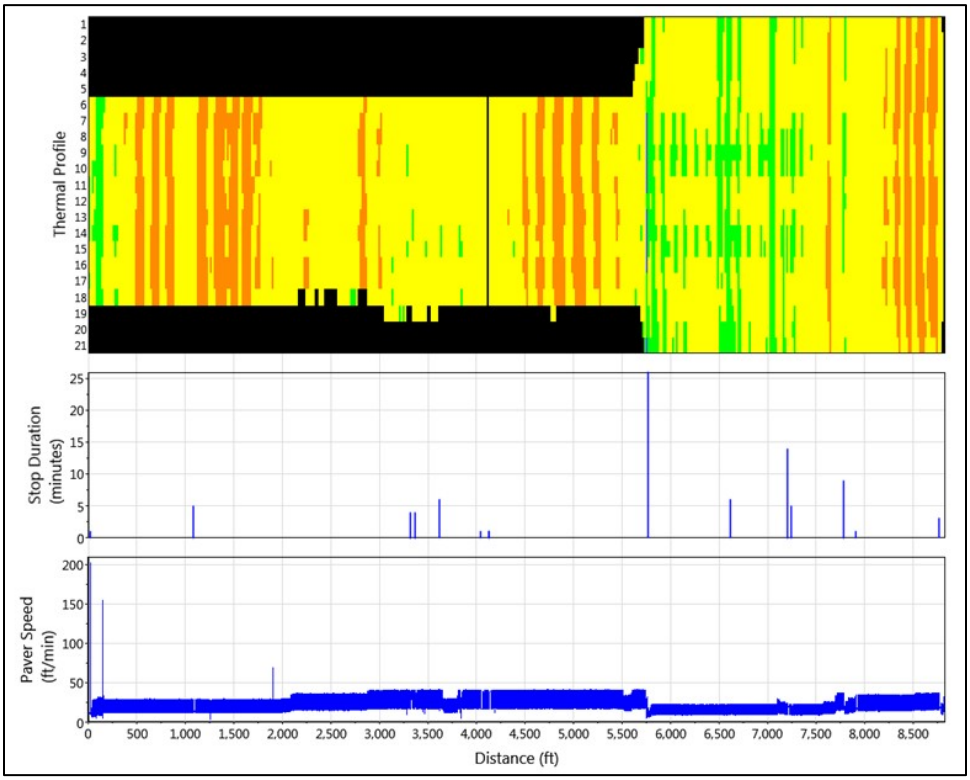

Figure 29: Veta Thermal Profile/Paver Stops/Paver Speed Screen of PMTPS Data Analysis

The paver stop maps can be seen in the "Paver Stops" results. The stop location and duration is displayed as shown in Figure 30. The count and percent of temperature differentials analyzed according to AASHTO PP80 are displayed in Veta as shown in Figure 31. One example of a sublot with severe temperature segregation coincides with a paver stop as shown in Figure 32.

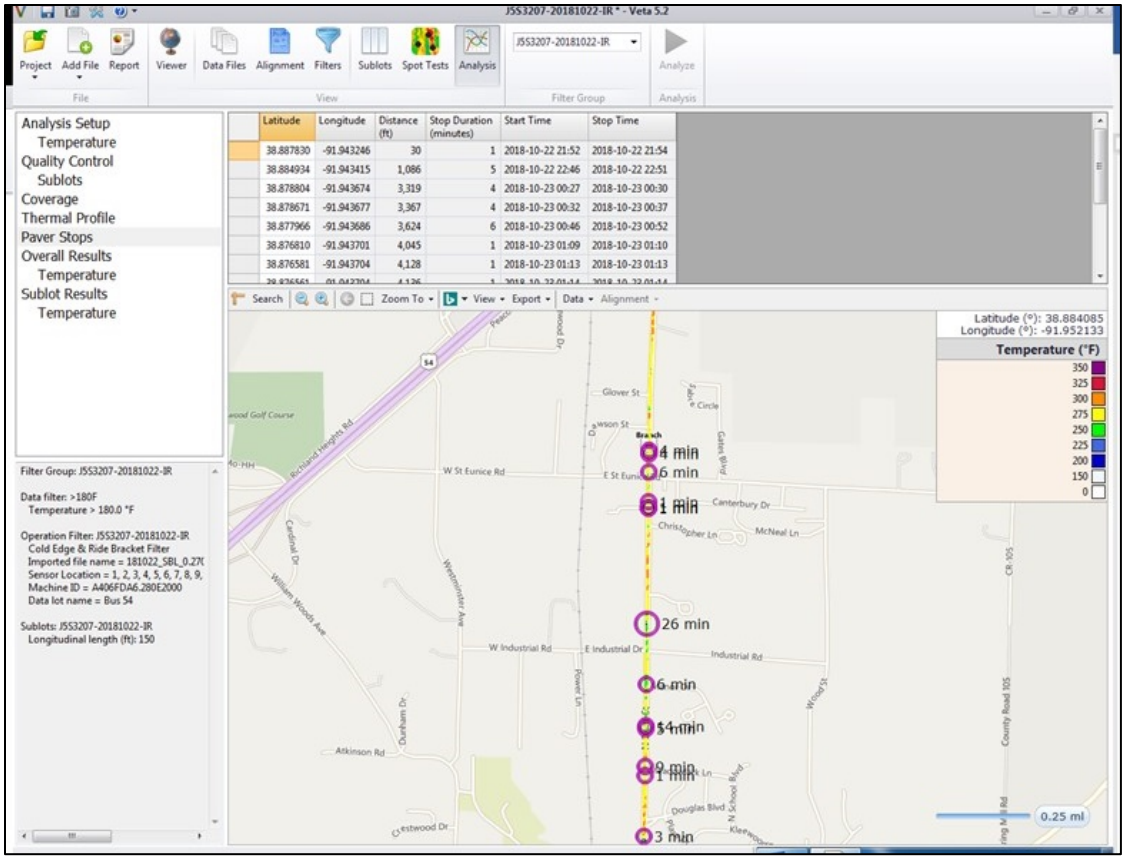

Figure 30: Veta Stop Map Screen of PMTPS Data Analysis

Distribution | Mean | Differentia

Category	Count	Percent (%)
Low	17	29
Moderate	39	66
Severe	3	5

Figure 31: Veta Temperature Differential Report Screen of PMTPS Data Analysis

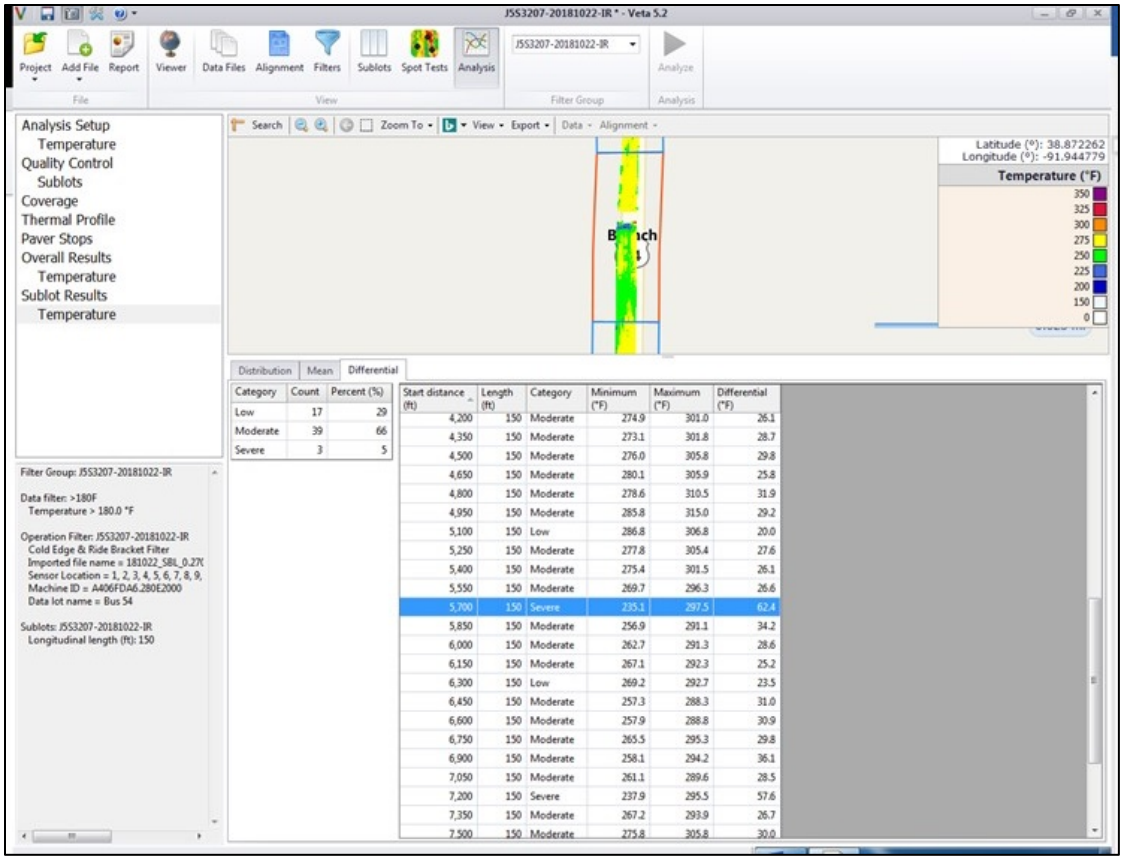

Figure 32: Veta Temperature Differential Report Screen of PMTPS Data Analysis: Detailed Sublot Analysis

IC Data Analysis

The IC coverage analysis is based on the optimum pass count determined by the trial section. Optimum pass count may consist of vibratory passes, static passes, or a combination of both. The "Roller Coverage" for each day of paving was classified according to the percentage of paved area which met or exceeded the optimum number of rolling passes based on the MoDOT specification shown in Table 9.

Table 9: MoDOT IC Coverage Classification

Classification	% Coverage
Passing	>90
Moderate	70 < < 90
Deficient	< 70

The target ICMV can be determined based on the correlation between the ICMV data and acceptance spot tests from the trial section (Figure 33). The requirements for the acceptable correlation between ICMV and acceptance spot tests is $R < 0.7$ or $R^2 < 0.5$, based on most of the international IC specifications.

Figure 33: Target ICMV Determined by Correlation Between ICMV and Acceptance Spot Tests from Trial Section Data

Note that ICMV and acceptance spot tests are often fundamentally different mechanisms and not all ICMV methods are equal. The FHWA ICMV Tech Brief provides additional details on this issue (FHWA-HIF-17-046). Since ICMV is measured only with vibratory passes, the projects that use only static passes or mix of vibratory/static passes did not have sufficient or valid ICMV data for further analysis. When vibratory passes are used, but there are no companion spot tests, the target ICMV and optimal passes can be determined based on the ICMV compaction curve where the increment of ICMV with each subsequent pass is less than 5% (Figure 34).

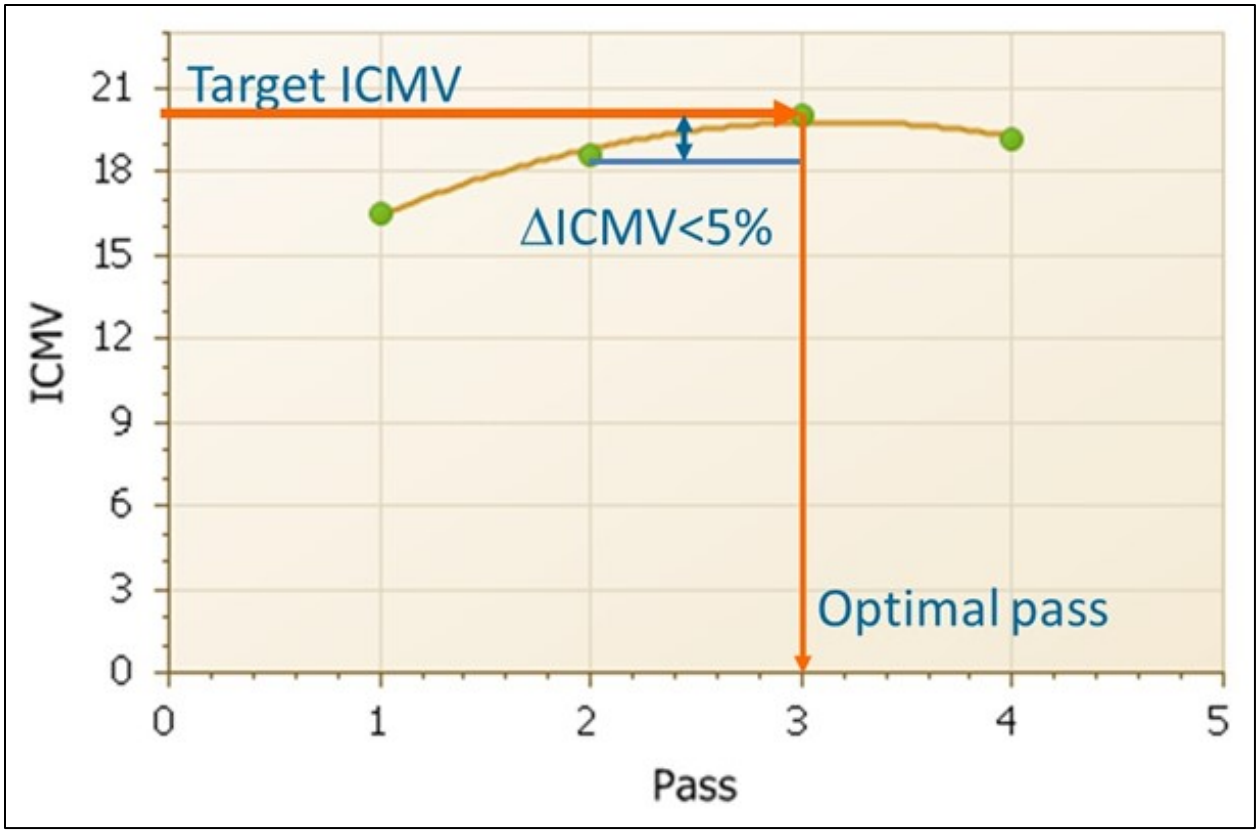

Figure 34: Target ICMV Determined by an ICMV Compaction Curve when Spot Tests from Trial Section Data are Not Available

The target ICMV coverage classification is based on MoDOT IC specification, as shown in Table 10.

Table 10: MoDOT Target ICMV Coverage Classification

Classification	% > Target ICMV
Not Flagged	≥ 70
Flagged	< 70

Based on MoDOT NJSP-18-08 (Figure 35) all segments with a mean temperature of less than 180˚F at the optimum pass shall be considered deficient. Note that this was a new requirement in 2019.

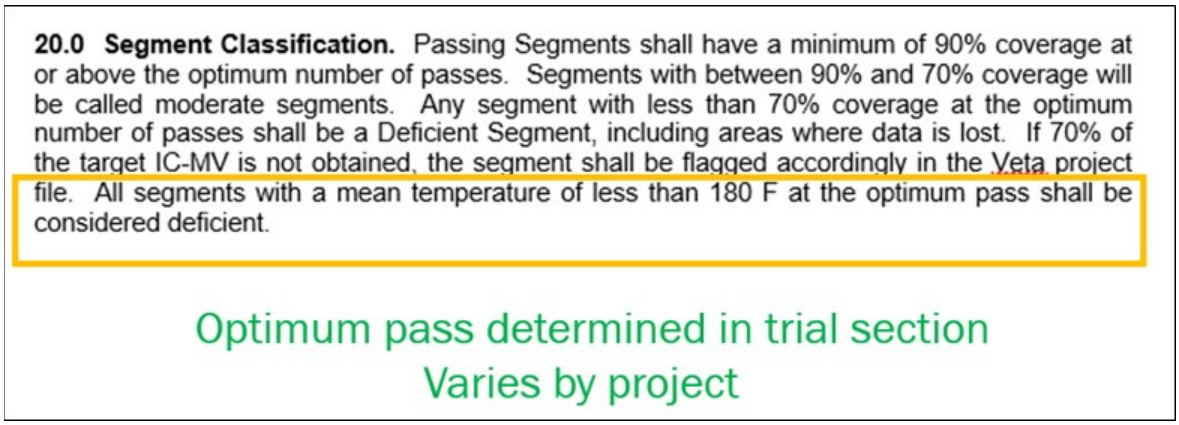

Figure 35: MoDOT Requirement for Mat Temperatures During Compaction

The Veta analysis for the temperature requirement includes analyzing individual passes and looking at the mean temperature value at the optimum pass. Figure 36 shows an example of the mean temperature results at the optimum pass after analyzing in Veta.

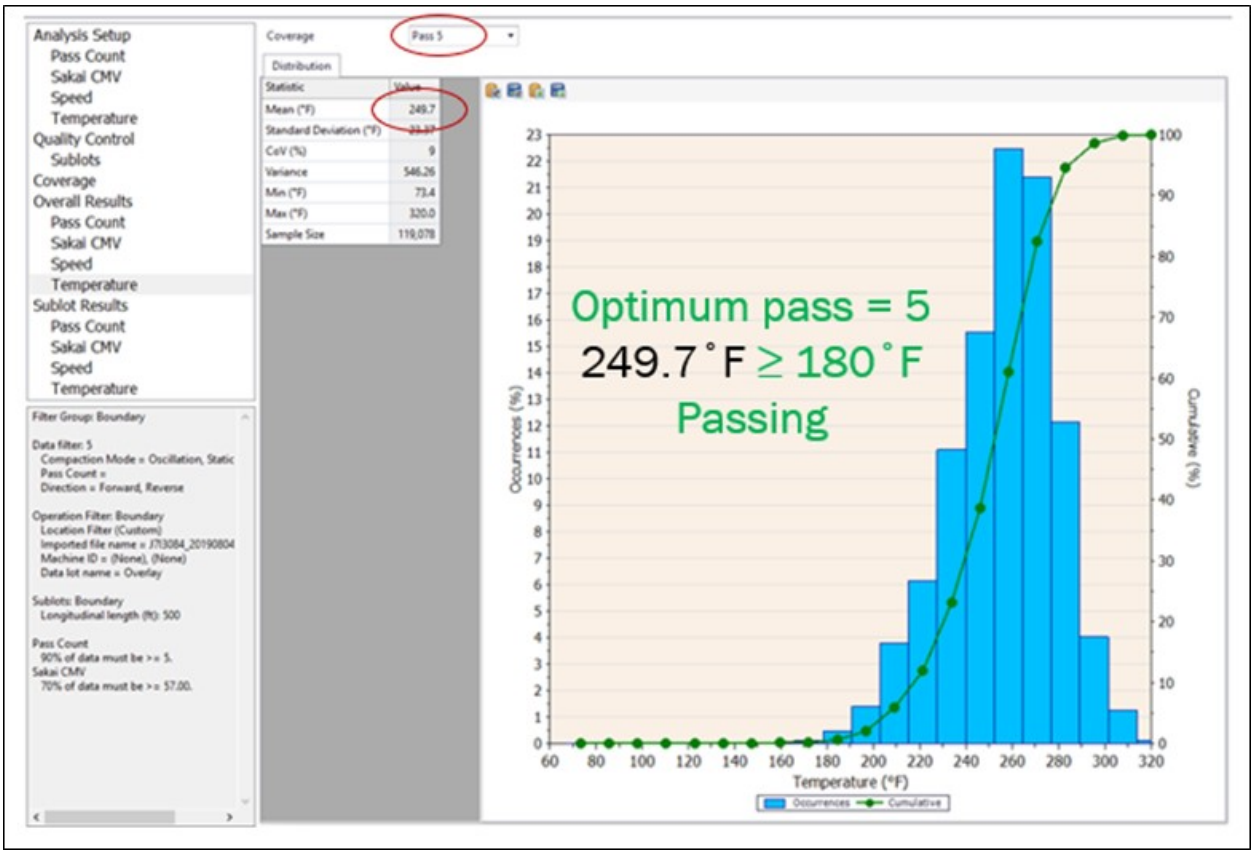

Figure 36: Mean Temperature at Optimum Pass Meets the Requirements of Greater than 180˚F

IC Analysis Example

An example of a complete IC analysis is presented below for the J6I3189 I-44 project using data from June 24, 2019. The Volvo all-passes data (.csv) files from the two IC rollers are imported to Veta 5.2 and saved as J6I3189-20190624-IC.vetaproj.

Based on the Trial Section NDG compaction curve and information provided by the contractor, the target is five vibratory passes. The compaction curve was recorded starting at pass two, so pass one is actually pass two as shown in Figure 37. The color palette for pass count map is adjusted as shown in Figure 38. This simplifies the coverage maps created during the analysis and reporting.

A filter group is created and named J6I3189-20190624-IC. An operation filter J6I3189-20190624-IC is added. A location filter is added, and the paving boundary is defined using the contractor provided GPS boundary file as shown in Figure 39. The data prior to filtering is shown in Figure 40 and the data after filtering is shown in Figure 41.

1000 foot sublots can be created and used to analyze smaller sections of the paved area as shown in Figure 42. 1000 foot sublots are industry standard. Note that sublots are not required per the MoDOT specifications as an IC segment is considered one day's production. However, analyzing the data using sublots can identify potential localized coverage and temperature problems.

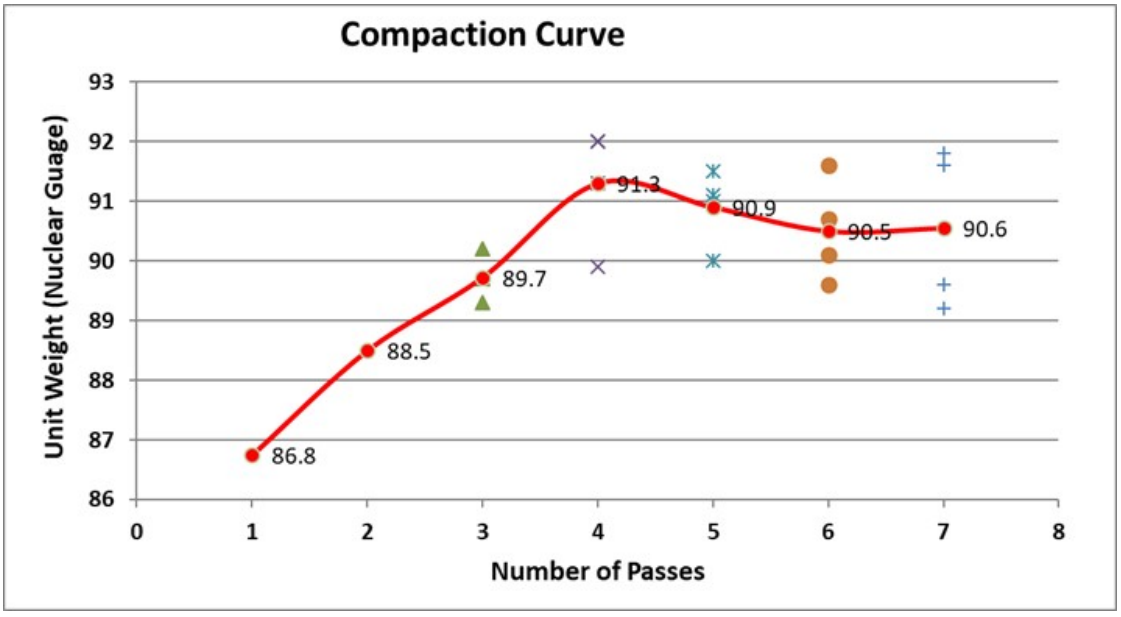

Figure 37: Density Compaction Curve based on the Trial Section Data J6I3189, I-44

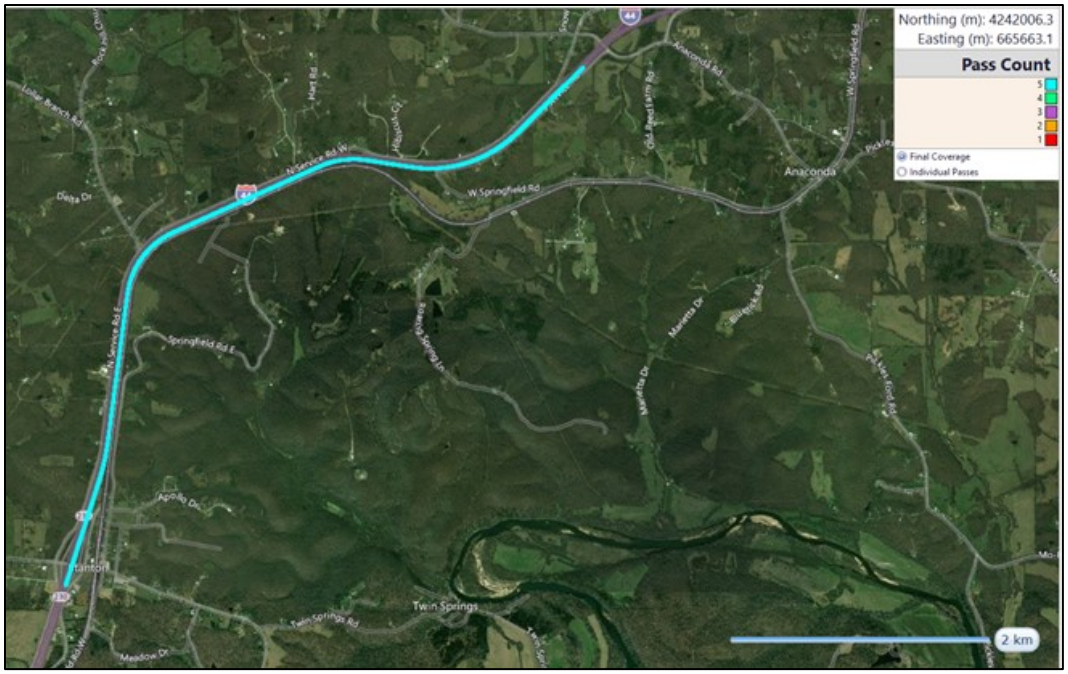

Figure 38: Veta Pass Count Screen of IC Data Analysis J6I3189, I-44

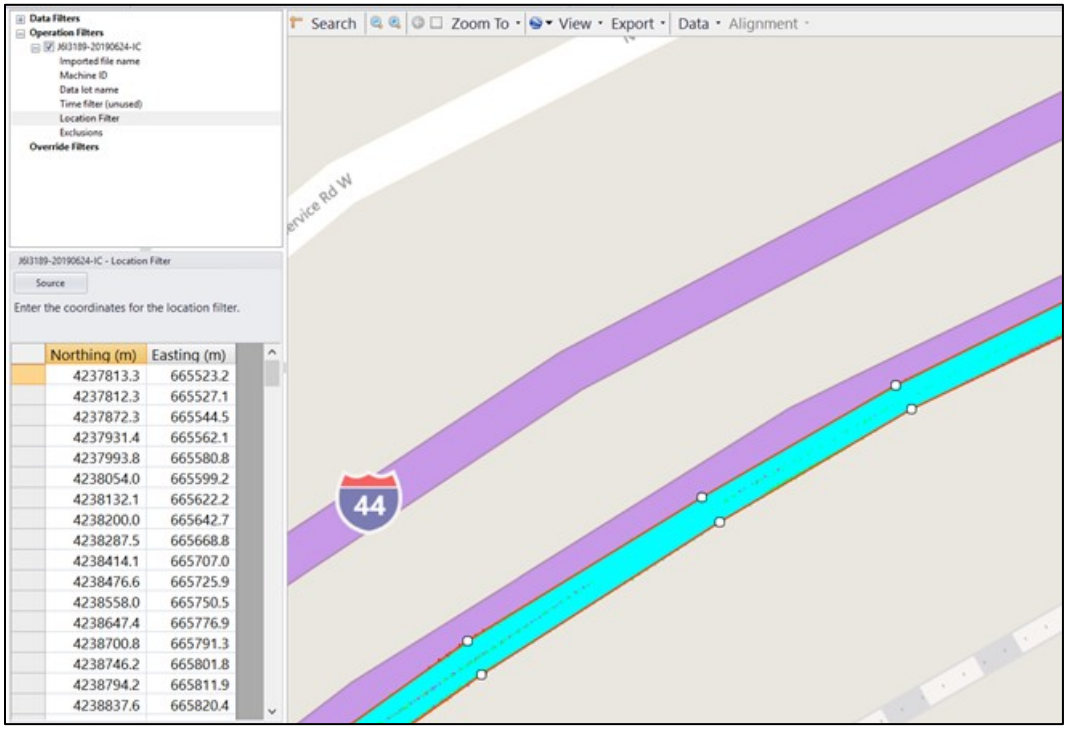

Figure 39: Veta Filter Group Screen with Boundary Coordinates During IC Data Analysis J6I3189, I-44

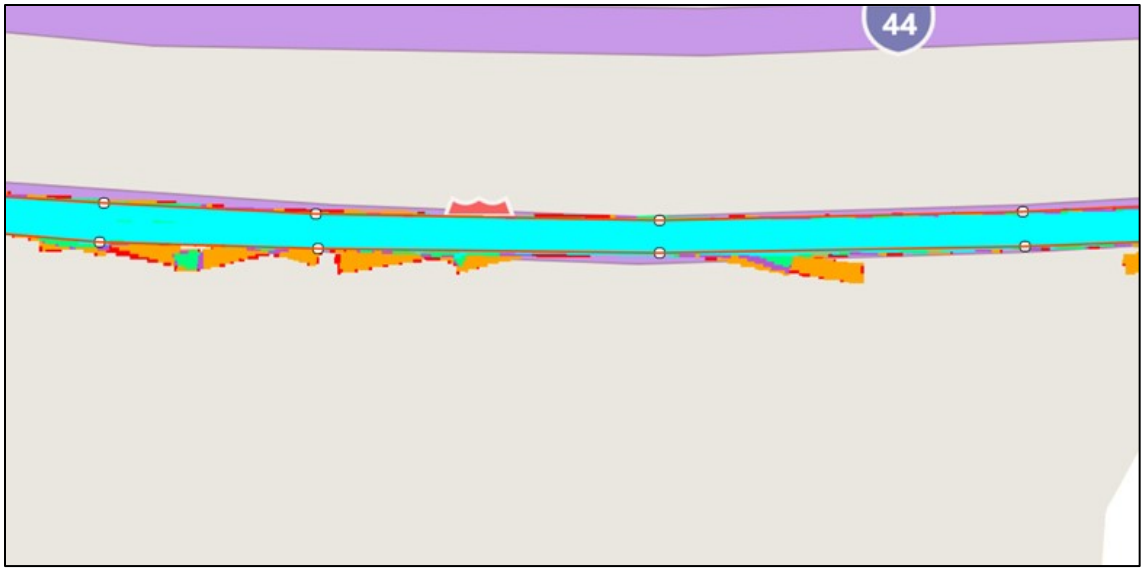

Figure 40: Veta Filter Group Screen of IC Data Analysis: Before Filtering J6I3189, I-44

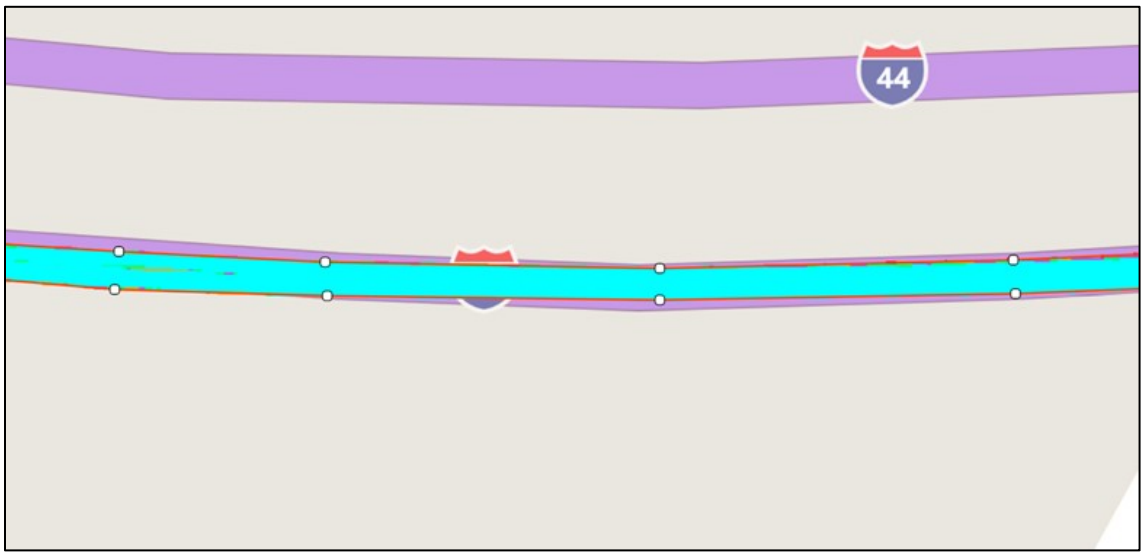

Figure 41: Veta Filter Group Screen of IC Data Analysis: After Filtering J6I3189, I-44

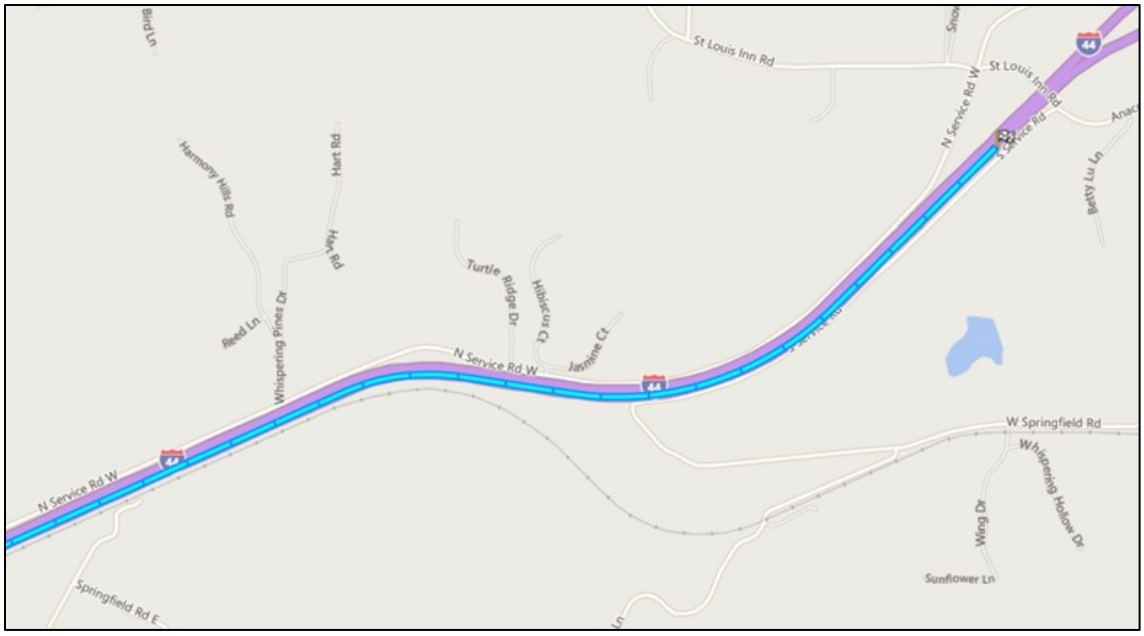

Figure 42: Veta Sublot Screen of IC Data Analysis J6I3189, I-44

The all-passes CCV compaction curve is generated in Veta during analysis. CCV plateaus around five passes as shown in the compaction curve in Figure 43. This mirrors the compaction curve created using the NDG during the trial section. Based on this curve the optimum ICMV is set at 43.

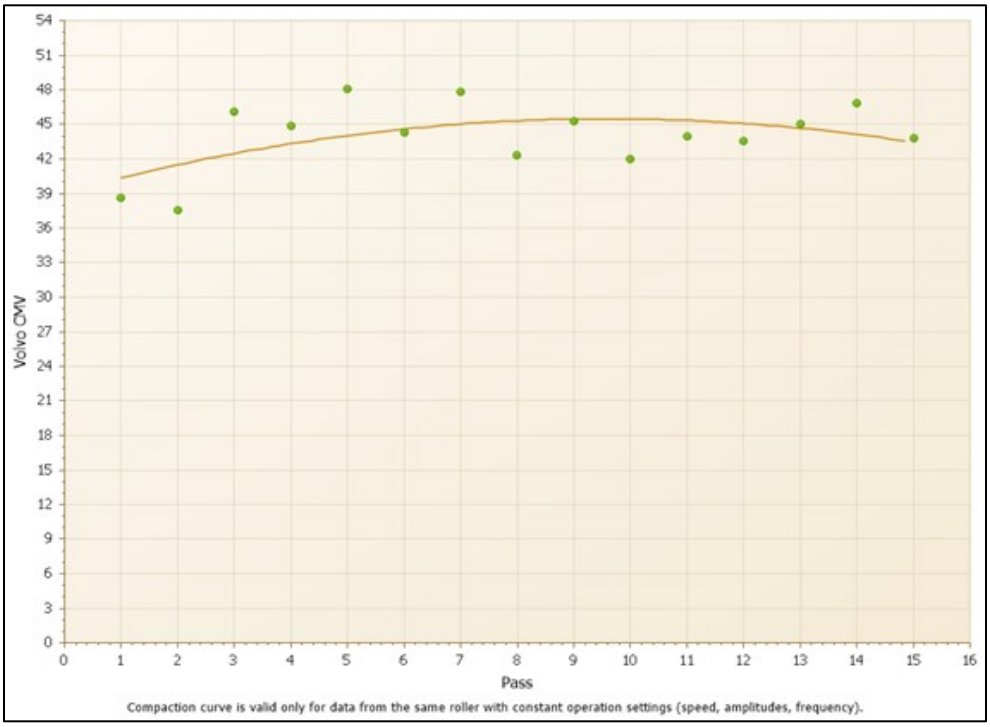

Figure 43: Veta Compaction Curve Screen of IC Data Analysis J6I3189, I-44

The data can be analyzed using specification requirements. The target CCV and target pass count can be setup as shown in Figure 44 and Figure 45.

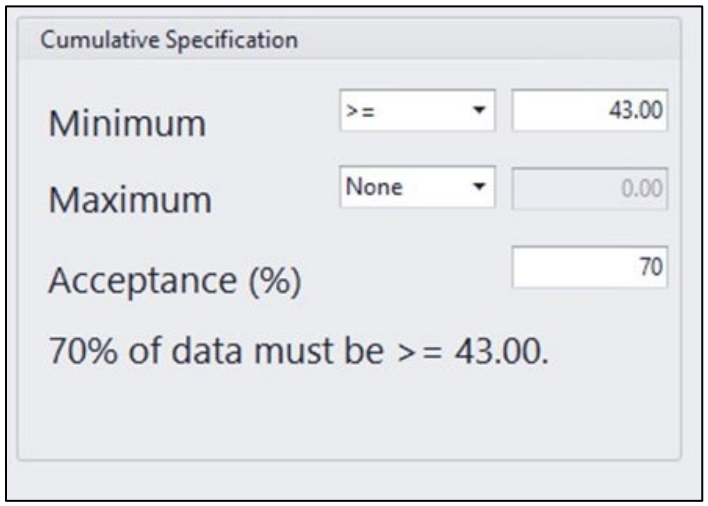

Figure 44: ICMV Target of 43 J6I3189, I-44

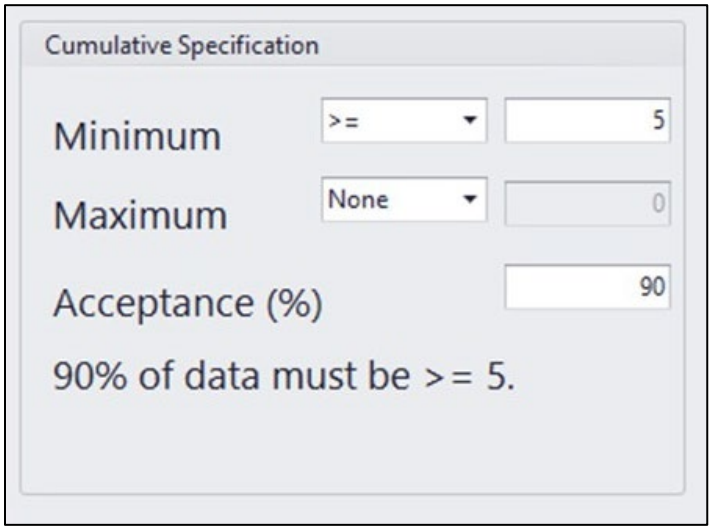

Figure 45: Pass Count Target of 5 J6I3189, I-44

After analysis the results can be viewed. The overall pass count coverage is 90.3% (Figure 46) meeting the target passes (passing 90%) requirement for price incentive.

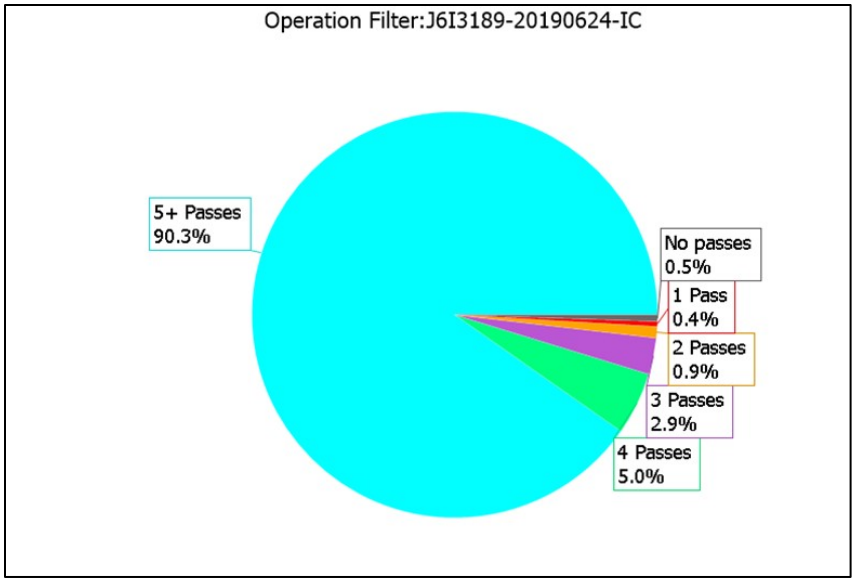

Figure 46: Veta Pass Count Coverage Screen of IC Data Analysis J6I3189, I-44

The target ICMV coverage is 45.18% (Figure 47) which is less than the 70% requirement. However, due to the poor correlation between the level 1 CMV and core density, minimum requirements for ICMV are not recommended.

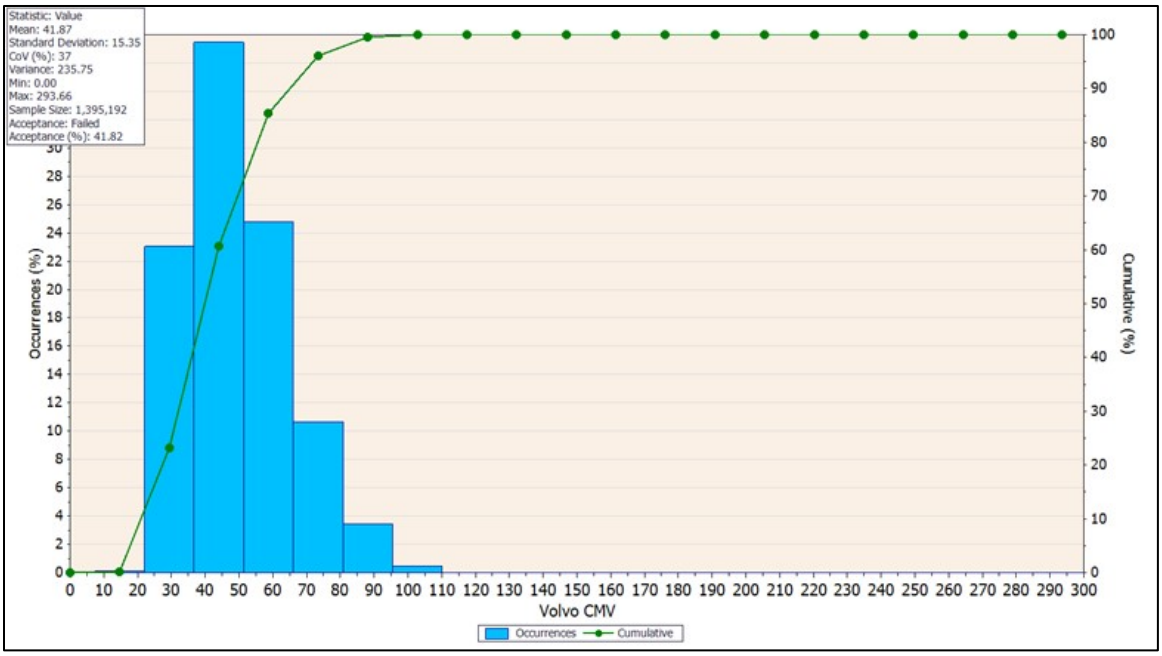

Figure 47: Veta CMV Statistics of IC Data Analysis J6I3189, I-44

The mean temperature at pass 5 is 212 degrees Fahrenheit. This meets the specification requirement of greater than 180 degrees at optimum pass.

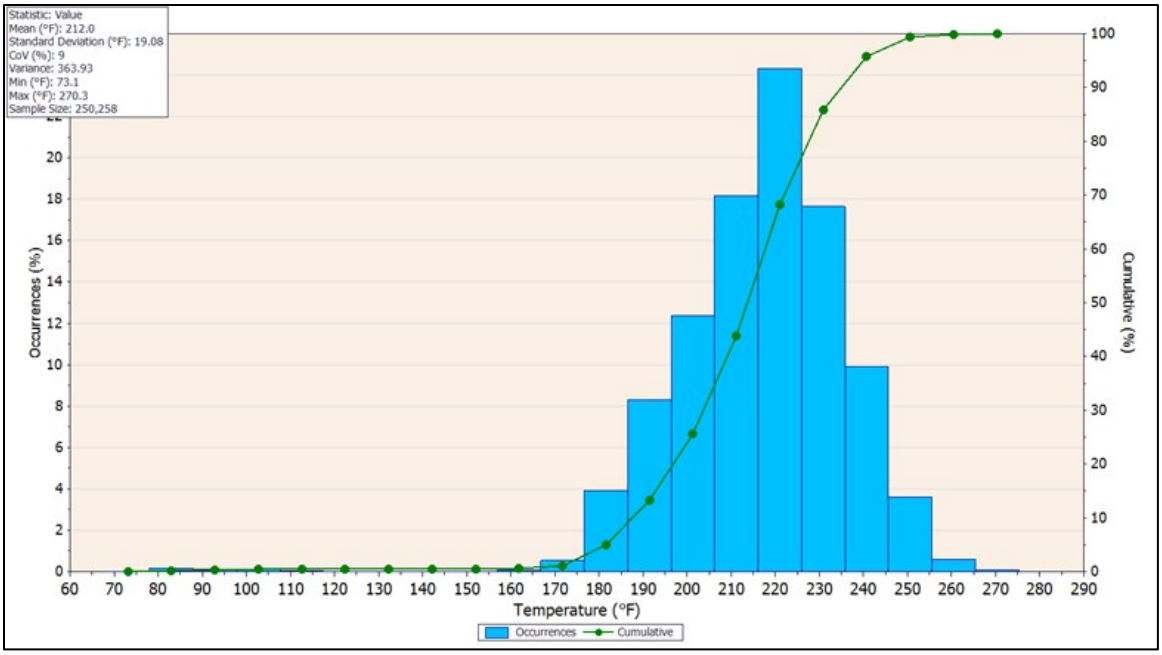

Figure 48: Veta Temperature Statistics Screen of IC Data Analysis J6I3189, I-44

The 1000-ft sublot results for pass count coverage are as shown in Figure 49 and Figure 50.

Distribution | Mean | Acceptance

Location (m)	Length (m)	Acceptance	Acceptance (%)	Min	Mean	Max	Standard Deviation	Variance	CoV (%)	Sample Size
0	152	Passed	90.6	1	6	14	2	4.48	34	6,191
152	152	Failed	80.9	1	5	13	2	3.67	35	6,756
305	152	Failed	86.8	1	6	13	2	3.85	35	6,523
457	152	Failed	88.2	1	6	14	2	4.07	35	6,088
610	152	Passed	94.5	1	6	13	2	2.79	29	6,094
762	152	Failed	85.3	1	5	13	2	2.76	31	6,305
914	152	Failed	87.2	1	5	13	1	1.58	24	6,524
1,067	152	Passed	91.2	1	6	13	2	2.31	27	6,330
1,219	152	Failed	51.9	1	5	11	2	3.68	42	6,655
1,372	152	Failed	88.5	1	5	15	2	2.98	32	6,640
1,524	152	Passed	92.6	1	6	11	1	1.64	23	6,525
1,676	152	Failed	88.5	1	5	11	1	1.88	25	6,616
1,829	152	Passed	98.2	3	7	14	2	3.58	25	6,020
1,981	152	Passed	97.3	3	6	13	2	2.80	26	6,131
2,134	152	Passed	91.7	1	6	11	1	1.58	23	6,611
2,286	152	Passed	95.1	2	6	11	1	1.67	22	6,329

Figure 49: Veta Sublot Statistics Report Screen of IC Data Analysis J6I3189, I-44

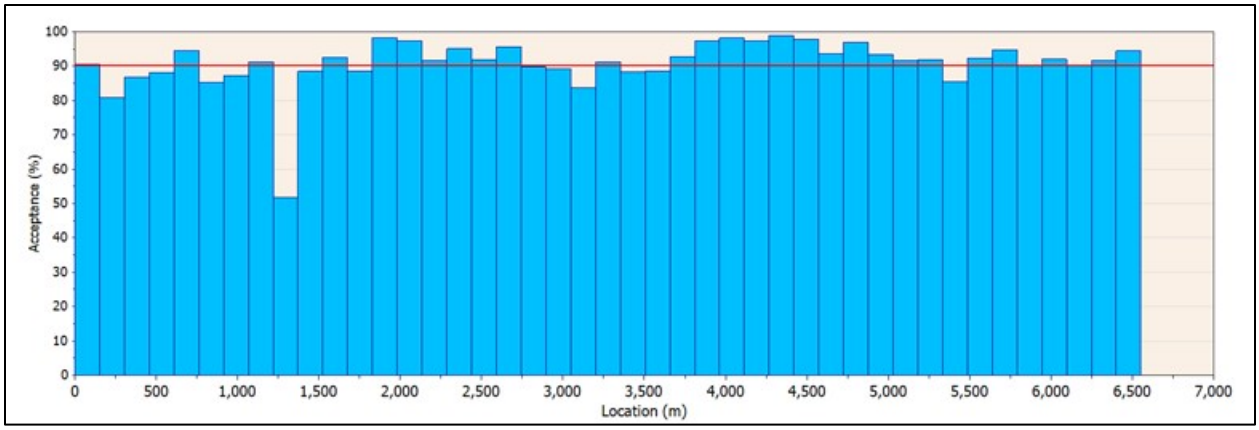

Figure 50: Veta Sublot Statistics Report Plot Screen of IC Data Analysis J6I3189, I-44

Summary of Individual Project Results

The following section includes a summary of results for each of the 16 projects that had IC and PMTPS data submitted to the SharePoint site. Note that there were three projects that did not receive data submission. Many contractors did not complete the analysis for percent of data meeting the target ICMV. This was for informational purposes only and did not affect price incentives or disincentives.

Project No. 1 J1I3169, I-35

Trial Section (10/11/2018)

The established rolling pattern is 8 passes as shown in Figure 51. This was used as optimum pass count for the pass count coverage and mean temperature specification requirements.

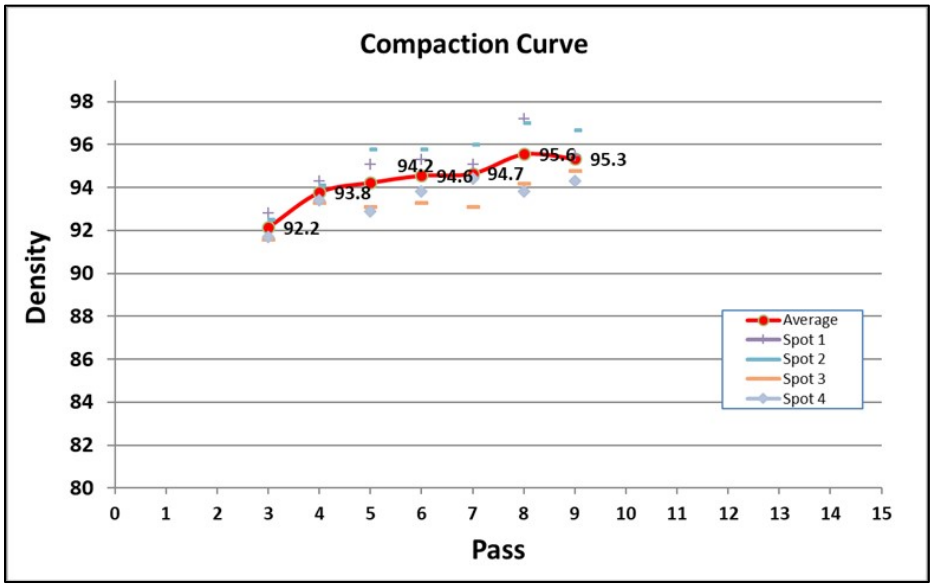

Figure 51: Trial Section Compaction Curve J1I3169, I-35

A summary of the PMTPS and IC results are shown in the remainder of this section. Note that there is no PMTPS data for 10/31/2018. There were many days that the contractor did not meet the minimum temperature requirements at optimum pass count.

Table 11: Summary of PMTPS Results for J1I3169, I-35

No.	Dates	Data QA	Low Temp Seg (LTS) #2	LTS %2	Moderate Temp Seg (MTS) #2	MTS %2	Severe Temp Seg (STS) #2	STS%2
1	10/11/2018	Pass	5	31	9	56	2	13
2	10/13/2018	Pass	26	51	18	35	7	14
3	10/15/2018	Pass	47	72	14	22	4	6
4	10/16/2018	Pass	69	74	23	25	1	1
5	10/17/2018	Pass	7	44	7	44	2	13
6	10/18/2018	Pass	66	78	19	22	0	0
7	10/19/2018	Pass	50	51	40	41	8	8
8	10/20/2018	Pass	32	45	33	46	6	8
9	10/22/2018	Pass	12	46	13	50	1	4
10	10/26/2018	Pass	8	40	9	45	3	15
11	10/31/2018	Pass						
12	11/1/2018	Pass	61	73	19	23	3	4
13	11/2/2018	Pass	49	65	23	31	3	4
14	11/6/2018	Pass	22	27	56	68	4	5
15	5/16/2019	Pass	77	86	13	14	0	0
16	5/17/2019	Pass	28	67	11	26	3	7
17	5/20/2019	Pass	34	47	36	50	2	3

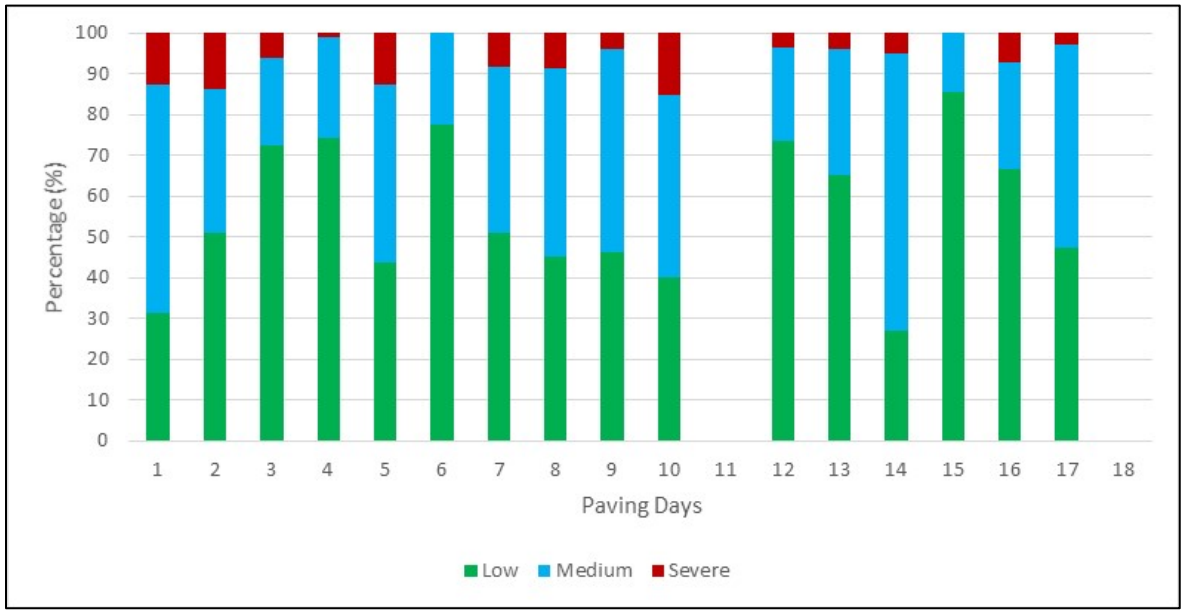

Figure 52: Summary of Veta Temperature Segregation Report for J1I3169, I-35

Table 12: Summary of IC Results for J1I3169, I-35

No.	Dates	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	10/11/2018	99	Passed	70		159.1	Deficient
2	10/13/2018	83	Moderate	70		149.2	Deficient
3	10/15/2018	31	Failed	70		178.9	Deficient
4	10/16/2018	60	Failed	70		168.2	Deficient
5	10/17/2018	76	Moderate	70		172.1	Deficient
6	10/18/2018	86	Moderate	70		184.8	
7	10/19/2018	59	Failed	70		171.1	Deficient
8	10/20/2018	64	Failed	70		178.4	Deficient
9	10/22/2018	63	Failed	70		185.4	
10	10/26/2018	48	Failed	70		163.5	Deficient
11	10/31/2018	86	Moderate	70		178.6	Deficient
12	11/1/2018	86	Moderate	70		165.9	Deficient
13	11/2/2018	62	Failed	70		170.7	Deficient
14	11/6/2018	63	Failed	70		155.7	Deficient
15	5/16/2019	82	Moderate	70		135.7	Deficient
16	5/17/2019	76	Moderate	70		143.2	Deficient
17	5/20/2019	62	Failed	70		175.1	Deficient
18	5/22/2019	63	Failed	70		173.3	Deficient

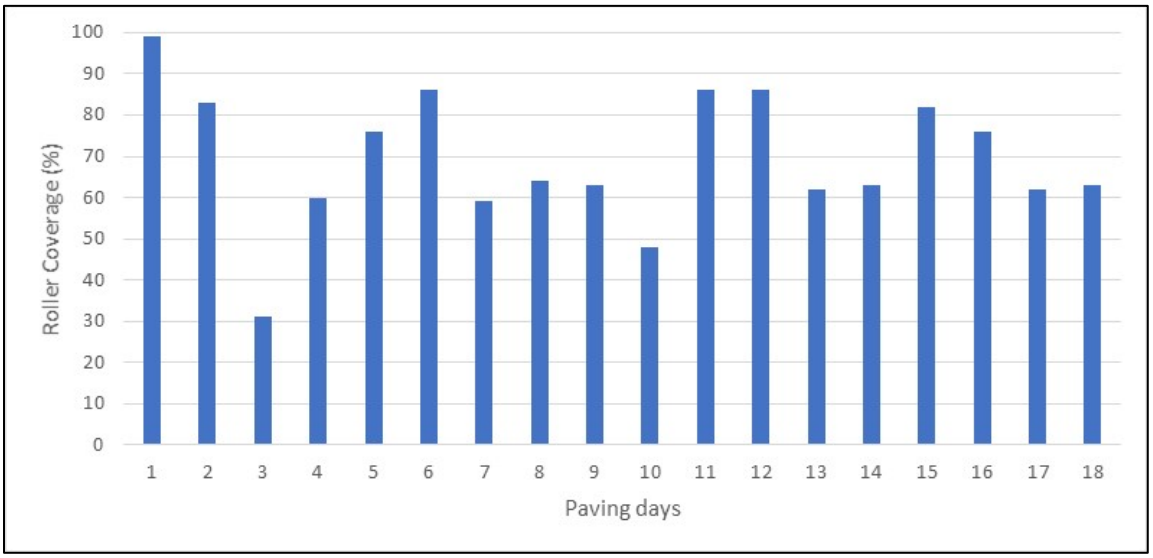

Figure 53: Summary of Roller Coverage Report for J1I3169, I-35

Project No. 2 J5P3212, Rte. 21,32

Trial Section (4/29/2019)

The established rolling pattern is 2 passes. This is based on information from the RE as no compaction curve was uploaded to SharePoint. This was used as optimum pass count for the pass count coverage and mean temperature specification requirements.

A summary of PMTPS and IC results are shown in the remainder of this section. No data QA results were reported from the contractor or RE. Note that there was an increase of low temperature segregation and decrease of severe temperature segregation as the project progressed.

Table 13: Summary of PMTPS Results for J5P3212, Rte. 21,32

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	4/29/2019							
2	5/6/2019		0	0	53	65	28	35
3	5/8/2019		2	3	59	77	16	21
4	5/10/2019		0	0	10	59	7	41
5	5/13/2019		1	1	57	61	36	38
6	5/14/2019		1	2	33	58	23	40
7	5/15/2019		2	3	71	91	5	6
8	5/16/2019		3	3	85	82	16	15
9	5/17/2019		0	0	70	95	4	5
10	5/20/2019		5	8	44	73	11	18
11	5/21/2019		3	5	55	85	7	11
12	5/22/2019		9	10	78	87	3	3
13	5/28/2019		26	23	74	66	12	11
14	5/30/2019		15	13	77	68	21	19

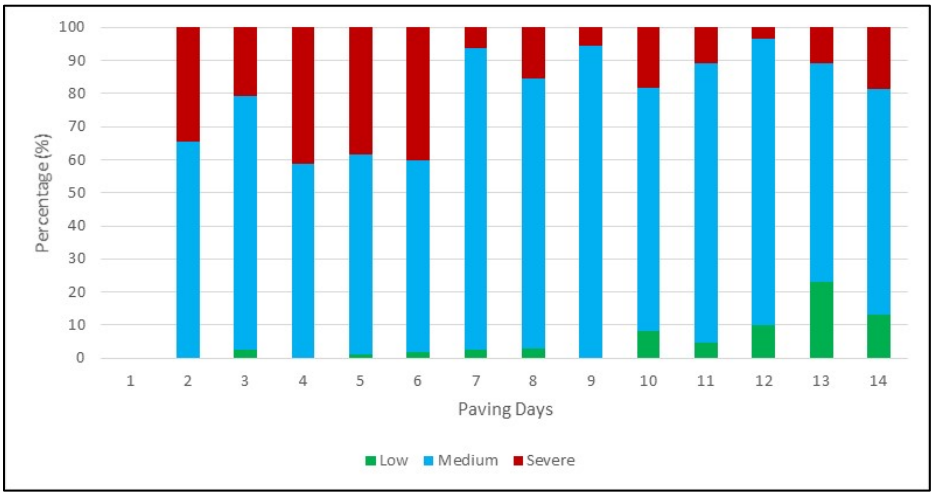

Figure 54: Summary of Veta Temperature Segregation Report for J5P3212, Rte. 21,32

Table 14: Summary of IC Results for J5P3212, Rte. 21,32

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	4/29/2019						
2	5/6/2019	98	Passed	71.23		234.4	
3	5/8/2019	98	Passed	11.13	flagged	243.1	
4	5/10/2019	99	Passed	0	flagged	245.8	
5	5/13/2019	99	Passed	0	flagged	246.5	
6	5/14/2019	98	Passed	0	flagged	244.3	
7	5/15/2019	99	Passed	0	flagged	251.8	
8	5/16/2019	99	Passed	0	flagged	235.6	
9	5/17/2019	99	Passed	0	flagged	254.9	
10	5/20/2019	99	Passed	0	flagged	245.2	
11	5/21/2019	100	Passed	0	flagged	236.4	
12	5/22/2019	100	Passed	0	flagged	239.7	
13	5/28/2019	99	Passed	0	flagged	255.6	
14	5/30/2019	99	Passed	0	flagged	249.5	

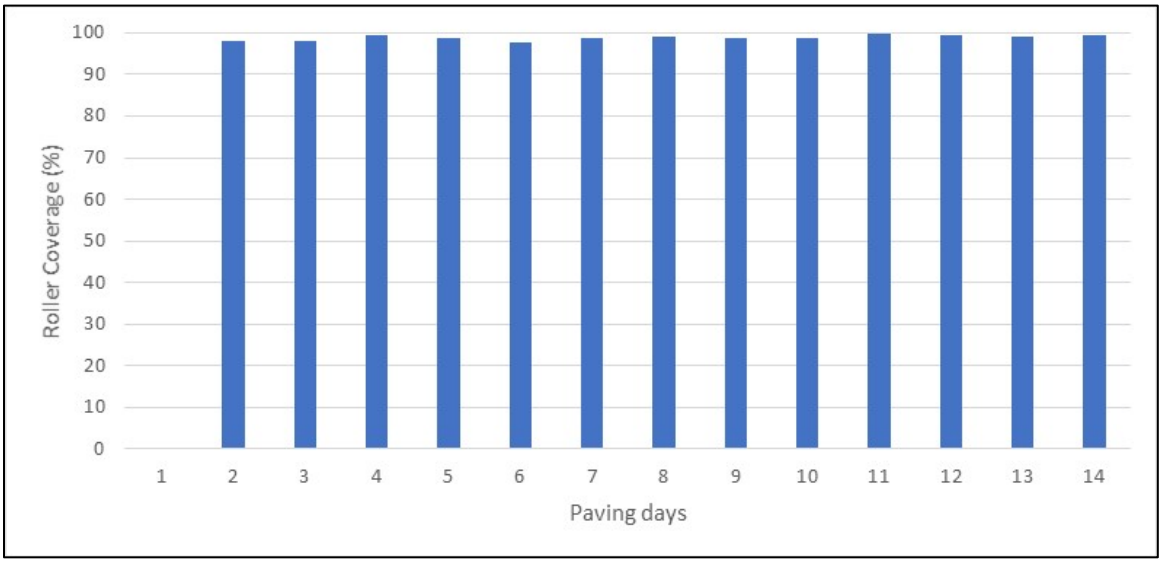

Figure 55: Summary of Roller Coverage Report for J5P3212, Rte. 21,32

Project No. 3 J5P3114, Rte. 63

Trial Section (5/10/2019)

The established rolling pattern is 7 passes as shown in the compaction curve in Figure 56. This was used as optimum pass count for the pass count coverage and mean temperature specification requirements.

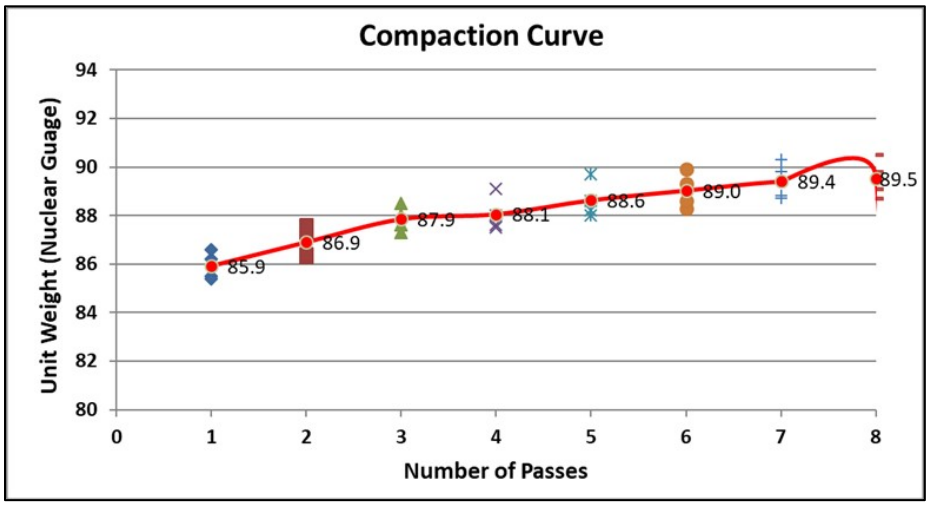

Figure 56: Trial Section Compaction Curve for J5P3114, Rte. 63

A summary of PMTPS and IC results are shown in the remainder of this section.

Table 15: Summary of PMTPS Results for J5P3114, Rte. 63

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	4/22/2019	Pass	57	71	22	28	1	1
2	4/26/2019	Pass	44	64	23	33	2	3
3	5/10/2019	Pass	73	88	10	12	0	0
4	5/13/2019	Pass	85	88	12	12	0	0
5	5/14/2019	Pass	84	89	10	11	0	0
6	5/15/2019	Pass	74	85	12	14	1	1
7	5/16/2019	Pass	95	88	11	10	2	2
8	5/17/2019	Pass	88	87	12	12	1	1
9	5/20/2019	Pass	76	87	7	8	4	5
10	5/22/2019	Pass	24	65	12	32	1	3
11	5/22/2019	Pass	24	75	7	22	1	3
12	5/23/2019	Pass	23	64	12	33	1	3
13	5/23/2019	Pass	28	82	5	15	1	3

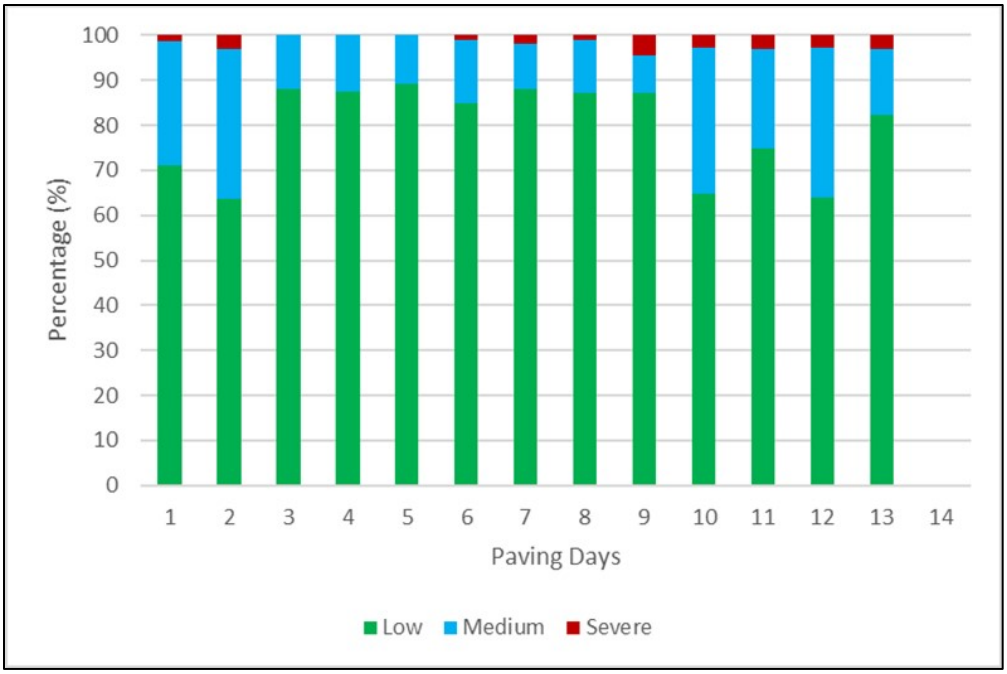

Figure 57: Summary of Veta Temperature Segregation Report for J5P3114, Rte. 63

Table 16: Summary of IC Results for J5P3114, Rte. 63

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	4/22/2019	88	Moderate	57.14	flagged	NA	NA
2	4/26/2019	97	Passed	96.52		NA	NA
3	5/10/2019	76	Moderate	86.83		203.1	
4	5/13/2019	69	Failed	98.16		177.6	Deficient
5	5/14/2019	63	Failed	99.54		202.8	
6	5/15/2019	69	Failed	97.52		215	
7	5/16/2019	78	Moderate	99.39		198.2	
8	5/17/2019	83	Moderate	99.23		202.9	
9	5/20/2019	89	Moderate	98.41		184.6	
10	5/22/2019	71	Moderate	82.63		172.7	Deficient
11	5/22/2019	72	Moderate	74.33		176.3	Deficient
12	5/23/2019	90	Passed	71.15		189	
13	5/23/2019	84	Moderate	86.06		203.9	

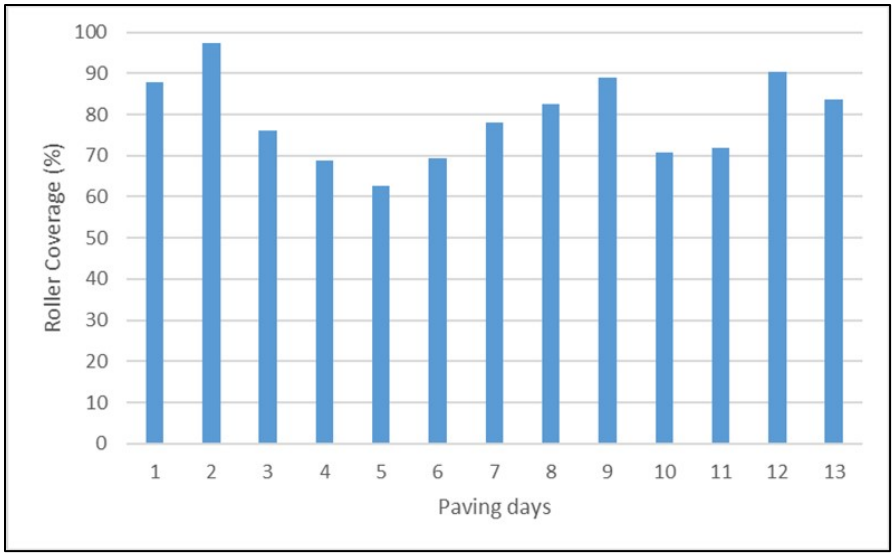

Figure 58: Summary of Roller Coverage Report for J5P3114, Rte. 63

Project No. 4 J6I3189, I-44

Trial Section (4/29/2019)

The established rolling pattern is 5 passes as shown in the compaction curve in Figure 59. Note that the number of passes begins at pass 2 per contractor's notes. This was used as optimum pass count for the pass count coverage and mean temperature specification requirements.

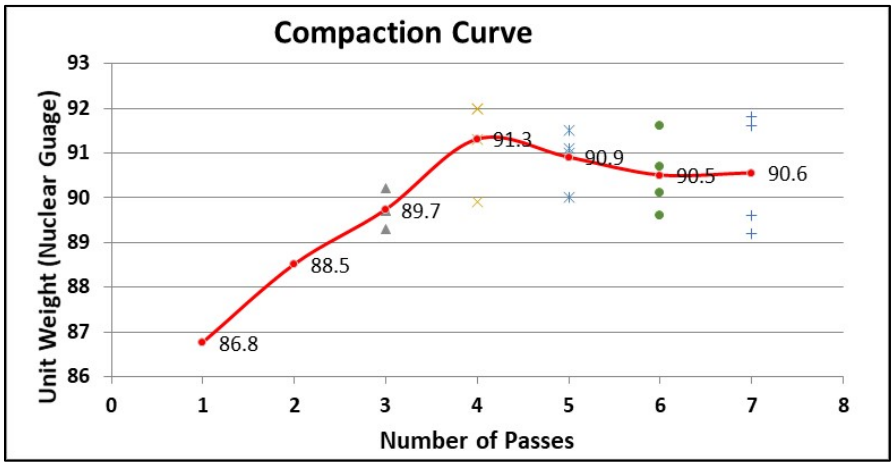

Figure 59: Trial Section Compaction Curve for J6I3189, I-44

A summary of PMTPS and IC results are shown in the remainder of this section. Note that there were several days when there were GPS issues on one of the four rollers. This caused a lower than typical coverage for those days. The contractor used MOBA analysis and reports for the PMTPS data as allowed in their specification from 2018.

Table 17: Summary of PMTPS Results for J6I3189, I-44

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	4/29/2019	Pass	17	52	11	33	5	15
2	5/7/2019	Pass	34	76	5	11	6	13
3	5/9/2019	Pass	76	92	7	8	0	0
4	5/10/2019	Pass	60	86	8	11	2	3
5	5/13/2019	Pass	45	90	5	10	0	0
6	5/15/2019	Pass	47	77	14	23	0	0
7	5/16/2019	Pass	66	78	17	20	2	2
8	5/17/2019	Pass	56	65	25	29	5	6
9	5/28/2019	Pass	59	83	9	13	3	4
10	5/30/2019	Pass	56	85	8	12	2	3
11	5/31/2019	Pass	41	58	22	31	8	11
12	6/3/2019	Pass	8	62	5	38	0	0
13	6/7/2019	Pass	57	79	13	18	2	3
14	6/11/2019	Pass	5	29	12	71	0	0
15	6/13/2019	Pass	81	85	13	14	1	1
16	6/18/2019	Pass	76	88	4	5	6	7
17	6/19/2019	Pass	98	92	6	6	2	2
18	6/20/2019	Pass	108	93	7	6	1	1
19	6/24/2019	Pass	136	94	9	6	0	0
20	6/25/2019	Pass	141	90	12	8	3	2
21	7/1/2019	Pass	45	69	18	28	2	3
22	7/2/2019	Pass	57	76	16	21	2	3
23	7/8/2019	Pass	46	73	16	25	1	2
24	7/9/2019	Pass	38	83	8	17	0	0
25	7/10/2019	Pass	33	85	5	13	1	3
26	7/10/2019	Pass	24	59	17	41	0	0
27	7/16/2019	Pass	101	81	21	17	2	2
28	7/18/2019	Pass	130	90	14	10	1	1
29	7/19/2019	Pass	28	61	15	33	3	7
30	7/19/2019	Pass	11	26	26	62	5	12
31	7/29/2019	Pass	41	75	12	22	2	4
32	7/30/2019	Pass	39	65	18	30	3	5
33	7/31/2019	Pass	14	52	12	44	1	4
34	8/1/2019	Pass	43	66	20	31	2	3
35	8/2/2019	Pass	28	67	11	26	3	7
36	8/5/2019	Pass	22	56	12	31	5	13
37	8/6/2019	Pass	35	45	33	42	10	13
38	8/7/2019	Pass	61	54	38	34	14	12
39	8/12/2019	Pass	46	75	12	20	3	5
40	8/13/2019	Pass	53	73	19	26	1	1
41	8/14/2019	Pass	48	68	22	31	1	1
42	8/15/2019	Pass	46	85	7	13	1	2
43	8/16/2019	Pass	71	91	7	9	0	0
44	8/19/2019	Pass	60	78	15	19	2	3
45	8/20/2019	Pass	54	69	19	24	5	6
46	8/28/2019	Pass	7	41	8	47	2	12
47	8/29/2019	Pass	56	86	9	14	0	0
48	9/3/2019	Pass	59	86	10	14	0	0
49	9/4/2019	Pass	90	83	18	17	0	0
50	9/5/2019	Pass	127	91	12	9	0	0
51	9/6/2019	Pass	73	67	35	32	1	1
52	9/9/2019	Pass	63	66	30	31	3	3
53	9/10/2019	Pass	97	75	33	25	0	0
54	9/11/2019	Pass	130	82	15	9	14	9
55	9/16/2019	Pass	158	92	13	8	1	1
56	9/17/2019	Pass	131	97	4	3	0	0

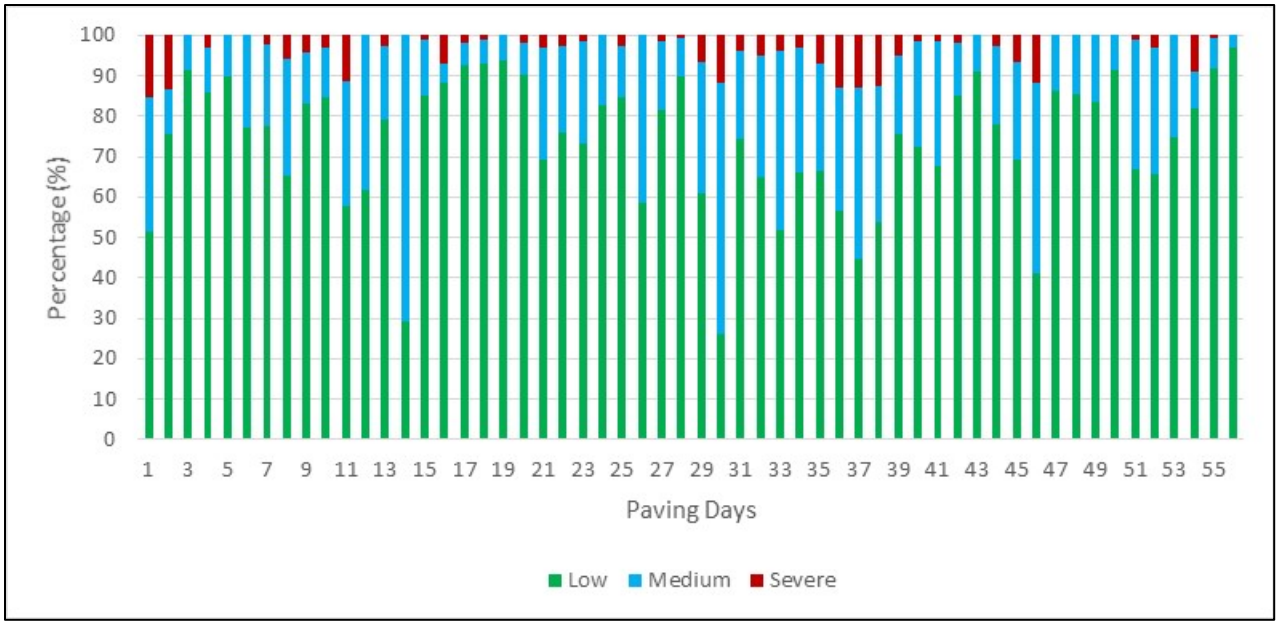

Figure 60: Summary of Veta Temperature Segregation Report for J6I3189, I-44

Table 18: Summary of IC Results for J6I3189, I-44

No.	Dates	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass -MTOP (F)	MTOP Classification
1	4/29/2019	91	Passed	70		216.2	
2	5/7/2019	45	Failed	66.53	flagged	204.1	
3	5/9/2019	95	Passed	70		211.9	
4	5/10/2019	94	Passed		flagged	212.8	
5	5/13/2019	94	Passed		flagged	207.5	
6	5/15/2019	93	Passed		flagged	210.9	
7	5/16/2019	94	Passed		flagged	201.6	
8	5/17/2019	90	Passed		flagged	208.5	
9	5/28/2019	91	Passed		flagged	208.9	
10	5/30/2019	93	Passed		flagged	192.7	
11	5/31/2019	92	Passed		flagged	212.6	
12	6/3/2019	93	Passed		flagged	206.8	
13	6/7/2019	94	Passed		flagged	224.3	
14	6/11/2019	97	Passed		flagged	221.4	
15	6/13/2019	96	Passed		flagged	221.8	
16	6/18/2019	83	Moderate		flagged	211	
17	6/19/2019	91	Passed		flagged	214.3	
18	6/20/2019	93	Passed		flagged	195.6	
19	6/24/2019	91	Passed		flagged	222	
20	6/25/2019	95	Passed		flagged	199.4	
21	7/1/2019	94	Passed		flagged	232.2	
22	7/2/2019	97	Passed		flagged	246.2	
23	7/8/2019	93	Passed		flagged	232.2	
24	7/9/2019	70	Moderate		flagged	225.6	Roller GPS was malfunctioning on 1 of the 4 rollers
25	7/10/2019	95	Passed		flagged	218.4	
26	7/10/2019	95	Passed		flagged	218.4	
27	7/16/2019	67	Failed		flagged	212.5	Roller GPS was malfunctioning on 1 of the 4 rollers
28	7/18/2019	71	Moderate		flagged	180.3	Roller GPS was malfunctioning on 1 of the 4 rollers
29	7/19/2019	72	Moderate		flagged	195.1	Roller GPS was malfunctioning on 1 of the 4 rollers
30	7/19/2019	84	Moderate		flagged	191.7	Roller GPS was malfunctioning on 1 of the 4 rollers
31	7/29/2019	91	Passed		flagged	207	
32	7/30/2019	94	Passed		flagged	210.3	
33	7/31/2019	95	Passed		flagged	221.7	
34	8/1/2019	95	Passed		flagged	215.8	
35	8/2/2019	94	Passed		flagged	195.8	
36	8/5/2019	94	Passed		flagged	219.7	
37	8/6/2019	96	Passed		flagged	201.1	
38	8/7/2019	97	Passed		flagged	157.8	
39	8/12/2019	94	Passed		flagged	219.1	
40	8/13/2019	96	Passed		flagged	229.9	
41	8/14/2019	94	Passed		flagged	215.2	
42	8/15/2019	96	Passed		flagged	212.5	
43	8/16/2019	94	Passed		flagged	138.7	Deficient
44	8/19/2019	77	Moderate		flagged	224.7	Roller GPS was malfunctioning on 1 of the 4 rollers
45	8/20/2019	93	Passed		flagged	224.8	
46	8/28/2019	92	Passed		flagged	220.5	
47	8/29/2019	94	Passed		flagged	226.1	
48	9/3/2019	96	Passed		flagged	183.6	
49	9/4/2019	76	Moderate		flagged	197.3	Roller GPS was malfunctioning on 1 of the 4 rollers
50	9/5/2019	73	Moderate		flagged	195.5	Roller GPS was malfunctioning on 1 of the 4 rollers
51	9/6/2019	72	Moderate		flagged	170.6	Roller GPS was malfunctioning on 1 of the 4 rollers
52	9/9/2019	93	Passed		flagged	174.1	Deficient
53	9/10/2019	73	Moderate		flagged	196.8	Roller GPS was malfunctioning on 1 of the 4 rollers
54	9/11/2019	94	Passed		flagged	167.2	Deficient
55	9/16/2019	94	Passed		flagged	190.7	
56	9/17/2019	97	Passed		flagged	204.9	

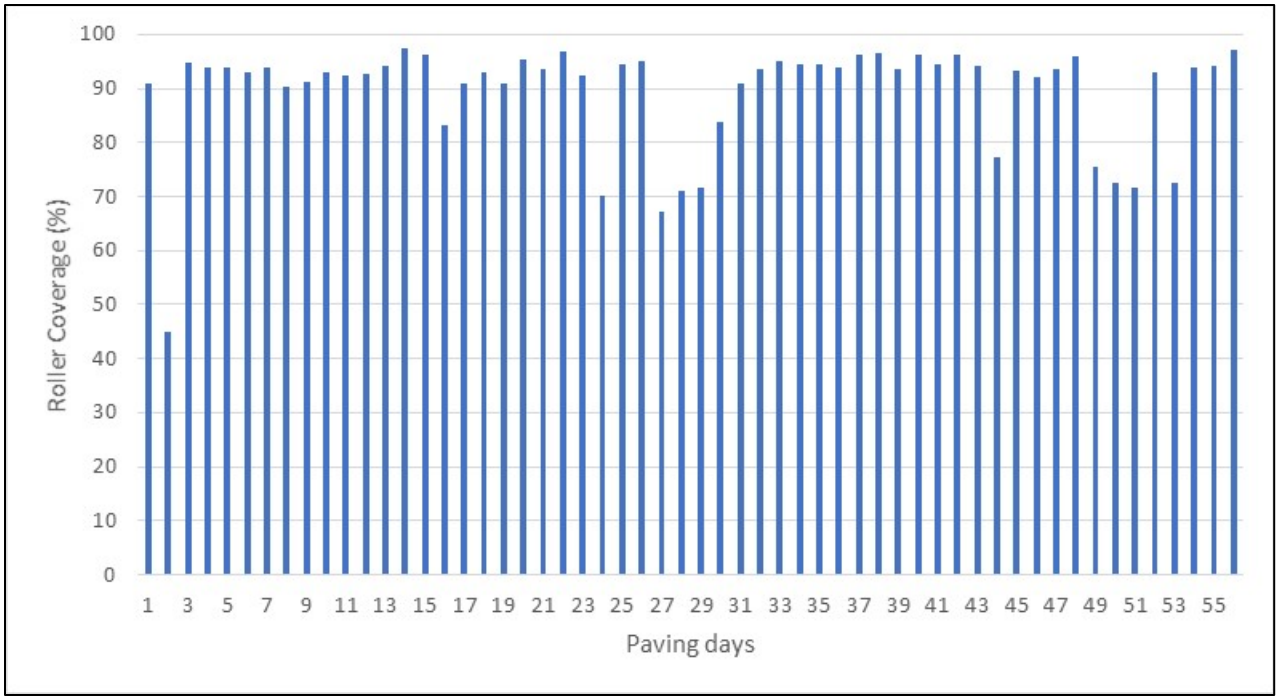

Figure 61: Summary of Roller Coverage Report for J6I3189, I-44

Project No. 5 J6I3165, I-70

Trial Section (5/23/2019)

The established rolling pattern is 7 passes as shown in the compaction curve in Figure 62. This was used as optimum pass count for the pass count coverage and mean temperature specification requirements. Note that this is the second trial section for this project. The first trial section established optimum pass count at 4 passes, however there was a discrepancy between core data and NDG data. The core densities on the first trial section failed.

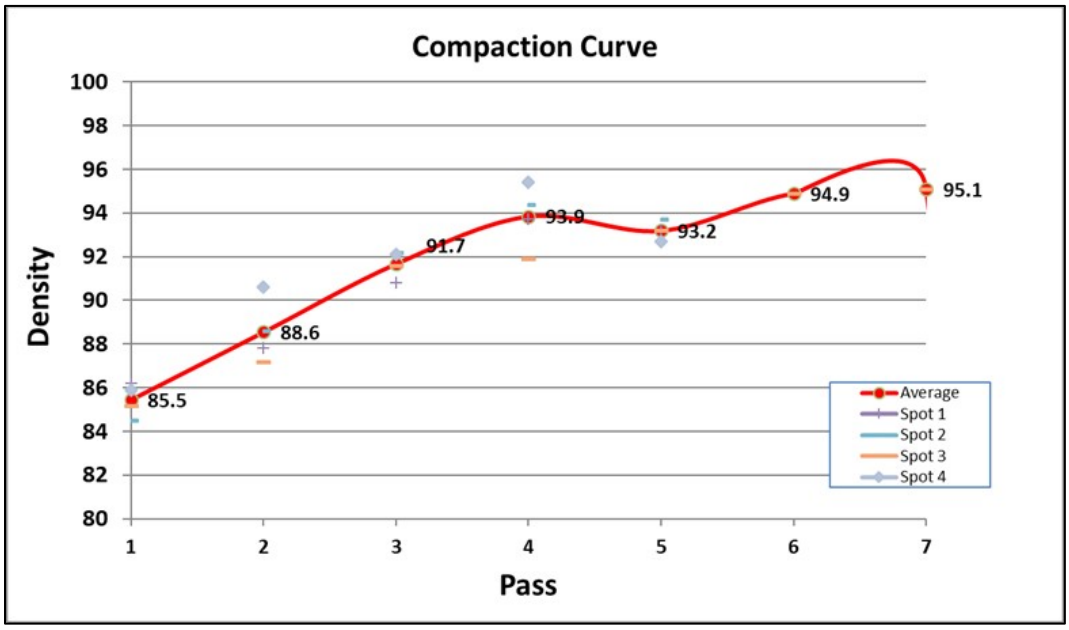

Figure 62: Trial Section Compaction Curve for J6I3165, I-70

A summary of PMTPS and IC results are shown in the remainder of this section. Note that the contractor began production targeting the original (failed) optimum pass count of 4. The RE was notified that the optimum pass count should be updated to reflect the new passing trial section. The results below were updated accordingly.

Table 19: Summary of PMTPS Results for J6I3165, I-70

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	5/23/2019	Pass	2	18	9	82	0	0
2	5/28/2019	Pass	7	32	10	45	5	23
3	5/30/2019	Pass	3	14	13	59	6	27
4	5/31/2019	Pass	9	27	18	55	6	18
5	6/3/2019	Pass	1	14	3	43	3	43
6	6/6/2019	Pass	6	18	22	67	5	15
7	6/7/2019	Pass	10	32	14	45	7	23
8	6/8/2019	Pass	6	27	9	41	7	32
9	6/10/2019	Pass	7	24	17	59	5	17
10	6/11/2019	Pass	11	46	11	46	2	8
11	6/13/2019	Pass	1	7	6	43	7	50
12	6/18/2019	Pass	8	31	14	54	4	15
13	6/19/2019	Pass	6	26	12	52	5	22
14	6/20/2019	Pass	26	60	16	37	1	2
15	6/24/2019	Pass	15	38	20	50	5	13
16	6/25/2019	Pass	2	29	5	71	0	0
17	6/26/2019	Pass	19	50	17	45	2	5
18	6/27/2019	Pass	11	33	21	64	1	3
19	6/29/2019	Pass	23	51	19	42	3	7
20	7/1/2019	Pass	10	31	19	59	3	9
21	7/2/2019	Pass	19	48	15	38	6	15
22	7/8/2019	Pass	13	42	16	52	2	6
23	7/9/2019	Pass	17	65	6	23	3	12
24	7/11/2019	Pass	12	39	18	58	1	3
25	7/12/2019	Pass	12	40	12	40	6	20
26	7/16/2019	Pass	7	29	14	58	3	13
27	7/18/2019	Pass	27	47	27	47	3	5
28	7/19/2019	Pass	33	47	33	47	4	6
29	7/20/2019	Pass	40	74	13	24	1	2
30	7/22/2019	Pass	23	46	23	46	4	8
31	7/23/2019	Pass	53	66	24	30	3	4
32	7/24/2019	Pass	63	70	23	26	4	4
33	7/25/2019	Pass	46	58	33	41	1	1
34	7/26/2019	Pass	61	51	52	43	7	6
35	8/2/2019	Pass	33	43	38	49	6	8

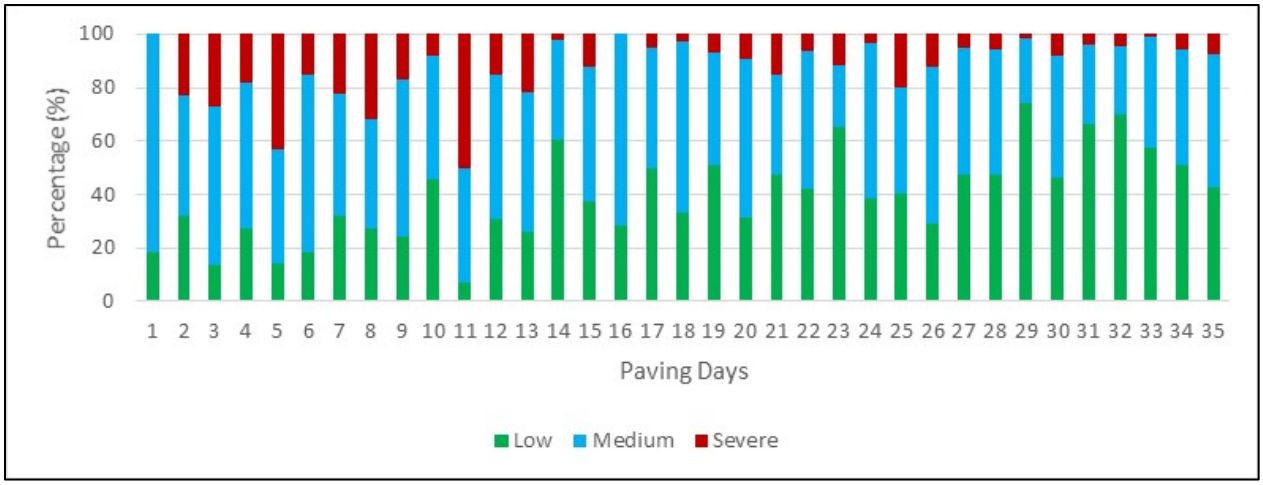

Figure 63: Summary of Veta Temperature Segregation Report for J6I3165, I-70

Table 20: Summary of IC Results for J6I3165, I-70

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	5/23/2019	86.0	Moderate		flagged	246.5	
2	5/28/2019	85.9	Moderate		flagged	233.5	
3	5/30/2019	88.0	Moderate		flagged	230.4	
4	5/31/2019	89.0	Moderate		flagged	237.8	
5	6/3/2019	89.9	Passed		flagged	222.2	
6	6/6/2019	86.3	Moderate		flagged	240.0	
7	6/7/2019	80.8	Moderate		flagged	237.4	
8	6/8/2019	72.5	Moderate		flagged	237.2	
9	6/10/2019	84.0	Moderate		flagged	232.1	
10	6/11/2019	81.6	Moderate		flagged	228.6	
11	6/13/2019	81.8	Moderate		flagged	225.8	
12	6/18/2019	76.4	Moderate		flagged	240.4	
13	6/19/2019	81.7	Moderate		flagged	230.4	
14	6/20/2019	85.3	Moderate		flagged	230.4	
15	6/24/2019	77.9	Moderate		flagged	230.4	
16	6/25/2019	89.7	Passed		flagged	230.4	
17	6/26/2019	75.5	Moderate		flagged	230.4	
18	6/27/2019	70.2	Moderate		flagged	230.4	
19	6/29/2019	80.4	Moderate		flagged	230.4	
20	7/1/2019	80.6	Moderate		flagged	230.4	
21	7/2/2019	74.8	Moderate		flagged	230.4	
22	7/8/2019	77.0	Moderate		flagged	230.4	
23	7/9/2019	75.3	Moderate		flagged	230.4	
24	7/11/2019	79.2	Moderate		flagged	230.4	
25	7/12/2019	81.6	Moderate		flagged	230.4	
26	7/16/2019	92.6	Passed		flagged	185.1	
27	7/18/2019	94.8	Passed		flagged	188.3	
28	7/19/2019	79.2	Moderate		flagged	202.1	
29	7/20/2019	77.8	Moderate		flagged	195.2	
30	7/22/2019	76.5	Moderate		flagged	193.0	
31	7/23/2019	84.5	Moderate		flagged	182.2	
32	7/24/2019	85.0	Moderate		flagged	186.3	
33	7/25/2019	84.1	Moderate		flagged	175.5	Deficient
34	7/26/2019	83.7	Moderate		flagged	178.4	Deficient
35	8/2/2019	81.4	Moderate		flagged	164.8	Deficient

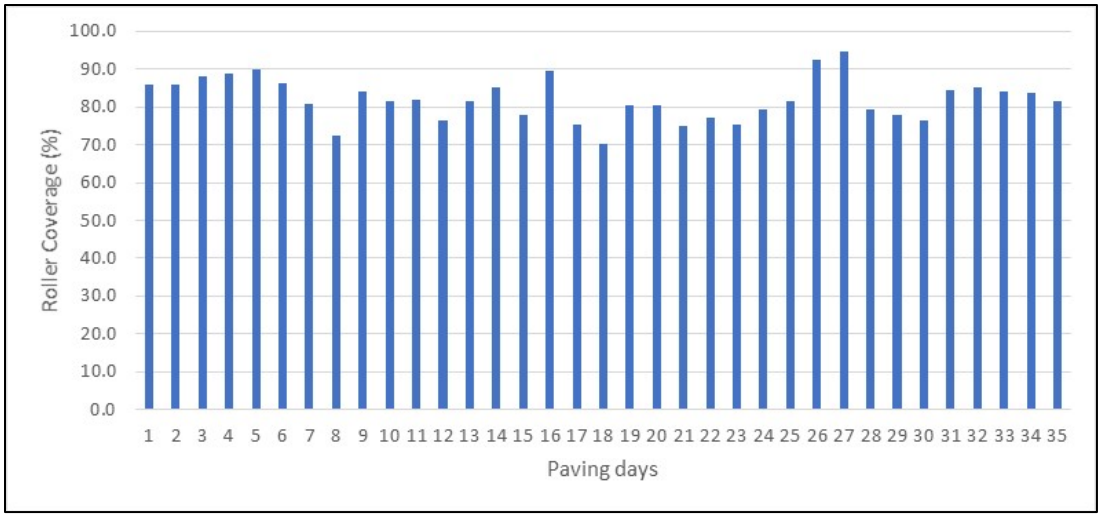

Figure 64: Summary of Roller Coverage Report for J6I3165, I-70

Project No. 6 J2P3133, Rte. 54

Trial Section (5/30/2019)

The established rolling pattern is 8 passes as shown in the compaction curve in Figure 65. Note that a combination of static and vibratory passes was used in the rolling pattern. This makes the ICMV curve invalid.

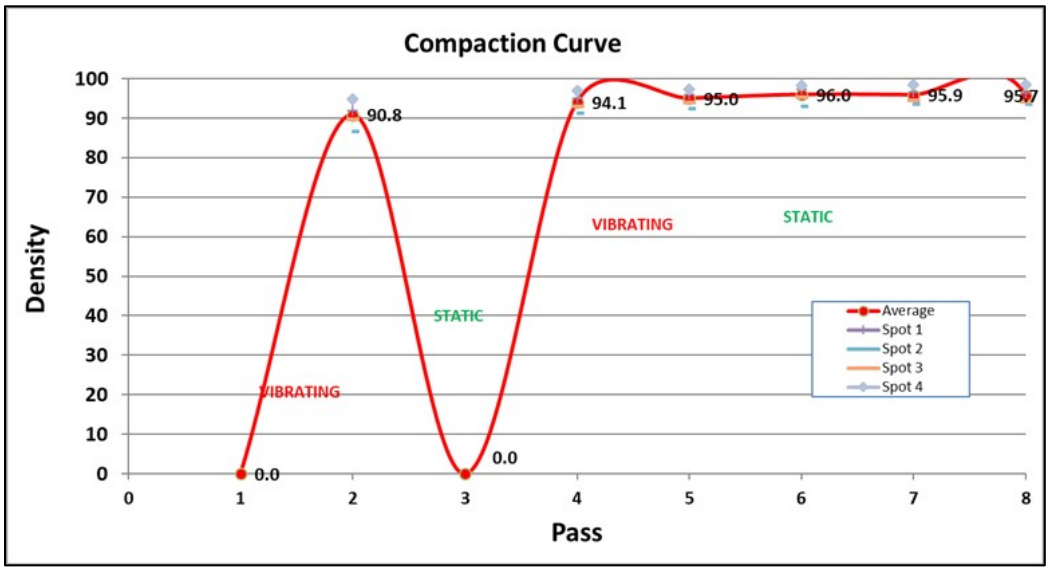

Figure 65: Trial Section Compaction Curve for J2P3133, Rte. 54

A summary of PMTPS and IC results are shown in the remainder of this section.

Table 21: Summary of PMTPS Results for J2P3133, Rte. 54

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	5/30/2019	Pass						
2	5/31/2019	Pass	92	73	30	24	4	3
3	6/1/2019	Pass	101	83	21	17	0	0
4	6/3/2019	Pass	105	83	22	17	0	0
5	6/4/2019	Pass	91	77	25	21	2	2
6	6/5/2019	Pass	73	70	31	30	0	0
7	6/6/2019	Pass	86	79	22	20	1	1
8	6/7/2019	Pass	86	80	19	18	3	3
9	6/10/2019	Pass	95	82	20	17	1	1
10	6/11/2019	Pass	123	86	17	12	3	2
40	8/6/2019	Pass	120	86	20	14	0	0
41	8/7/2019	Pass	141	87	21	13	0	0
42	8/8/2019	Pass	138	89	14	9	3	2
43	8/9/2019	Pass	142	91	14	9	0	0
44	8/12/2019	Pass	58	72	20	25	3	4
45	8/13/2019	Pass	124	84	13	9	10	7
46	8/14/2019	Pass	130	90	12	8	2	1
47	8/15/2019	Pass	42	74	10	18	5	9

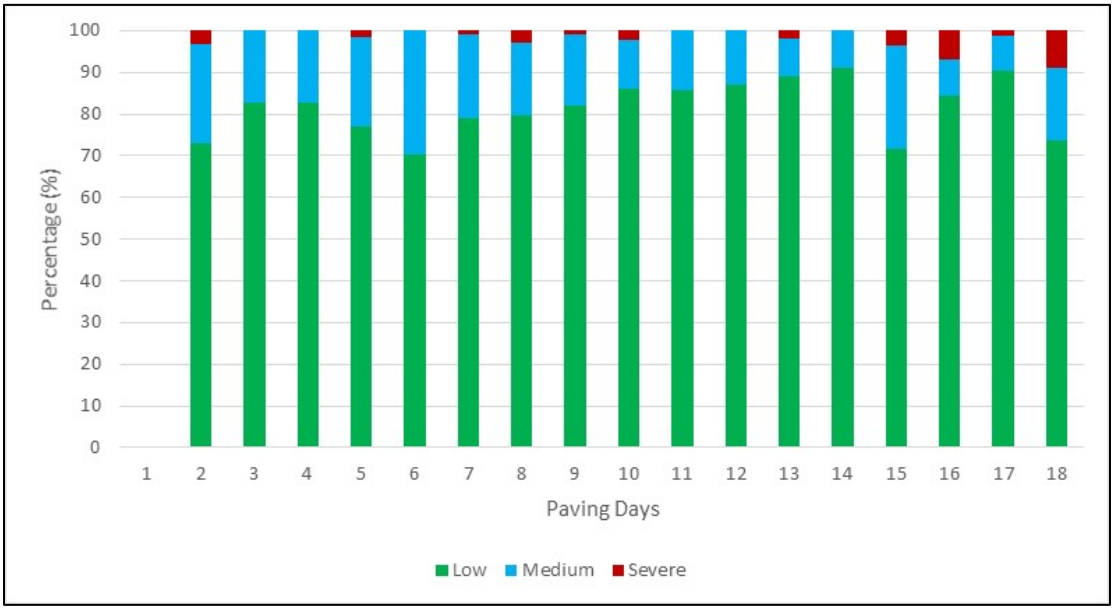

Figure 66: Summary of Veta Temperature Segregation Report for J2P3133, Rte. 54

Table 22: Summary of IC Results for J2P3133, Rte. 54

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	5/30/2019						
2	5/31/2019	83	Moderate	83.52		206.7	
3	6/1/2019	95	Passed	94.03		214.8	
4	6/3/2019	81	Moderate	92.7		206.3	
5	6/4/2019	97	Passed	88.9		207.8	
6	6/5/2019	95	Passed	81.68		211.5	
7	6/6/2019	96	Passed	77.26		218.1	
8	6/7/2019	82	Moderate	61.34	flagged	204.9	
9	6/10/2019	88	Moderate	84.24		208.7	
10	6/11/2019	93	Passed	89.86		223.7	
11	8/6/2019	86	Moderate	89.45		211.9	
12	8/7/2019	88	Moderate	90.76		205.2	
13	8/8/2019	86	Moderate	75.29		206.8	
14	8/9/2019	90	Passed	86.77		208	
15	8/12/2019	84	Moderate	87.72		207.7	
16	8/13/2019	84	Moderate	68.76	flagged	202.1	
17	8/14/2019	87	Moderate			206.1	
18	8/15/2019	87	Moderate			205.2	

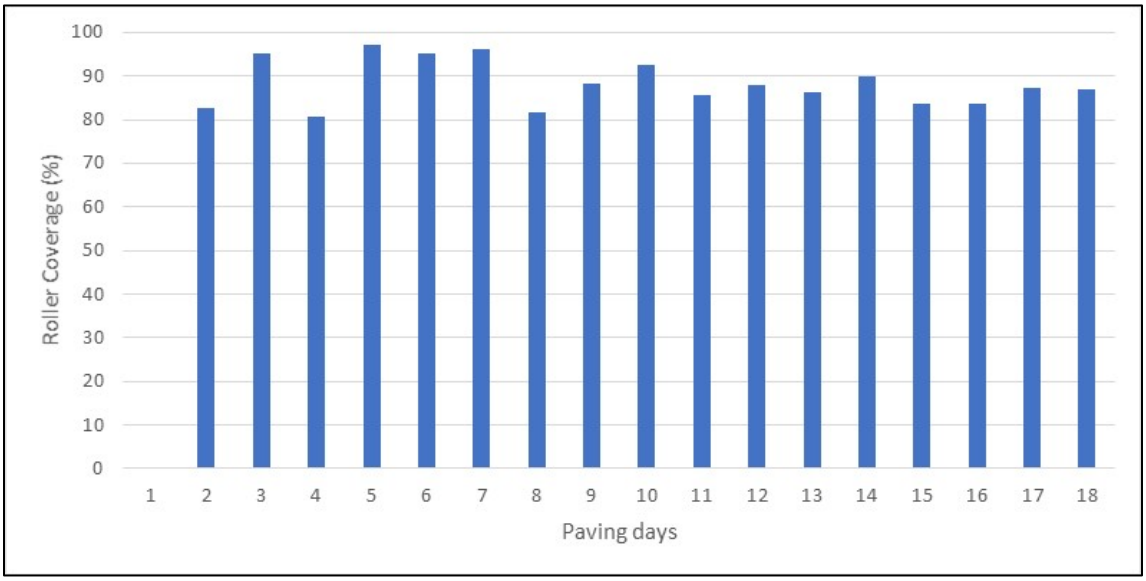

Figure 67: Summary of Roller Coverage Report for J2P3133, Rte. 54

Project No. 7 J9S3271, Rte. 62

Trial Section (6/27/2019)

The established rolling pattern is 3 passes as shown in the compaction curve in Figure 68.

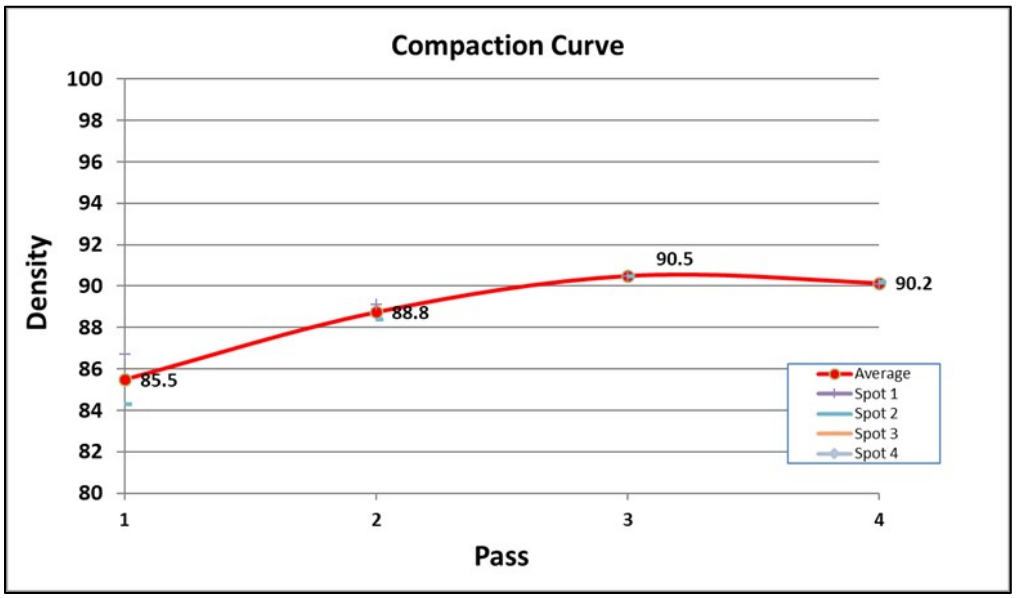

Figure 68: Trial Section Compaction Curve for J9S3271, Rte. 62

A summary of PMTPS and IC results are shown in the remainder of this section.

Table 23: Summary of PMTPS Results for J9S3271, Rte. 62

No.	*Dates*	*Data QA*	*Low Temp Seg (LTS) #*	*LTS %*	*Moderate Temp Seg (MTS) #*	*MTS %*	*Severe Temp Seg (STS) #*	*STS%*
1	7/8/2019	Pass	29	*81*	7	*19*	0	*0*
2	7/9/2019	Pass	43	*81*	8	*15*	2	*4*
3	7/9/2019	Pass	2	*25*	1	*13*	5	*63*
4	7/11/2019	Pass	0	*0*	57	*74*	20	*26*
5	7/11/2019	Pass	0	*0*	69	*80*	17	*20*
6	7/18/2019	Pass	0	*0*	69	*78*	19	*22*

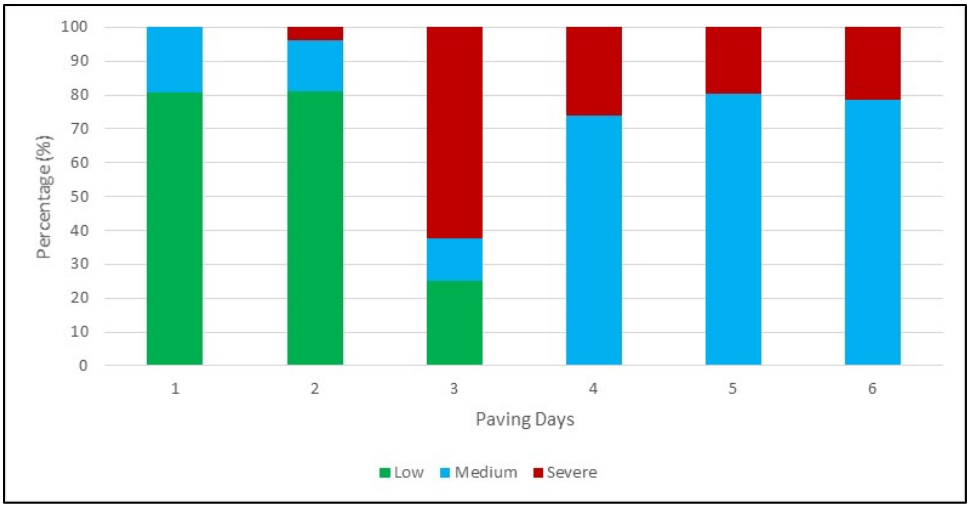

Figure 69: Summary of Veta Temperature Segregation Report for J9S3271, Rte. 62

Table 24: Summary of IC Results for J9S3271, Rte. 62

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	7/8/2019	95.8	Passed	70		230.6	
2	7/9/2019	98.5	Passed	70		227.4	
3	7/9/2019	98.0	Passed	70		238.7	
4	7/11/2019	97.2	Passed	70		247	
5	7/11/2019	98.9	Passed	70		247.6	
6	7/18/2019	98.8	Passed	70		240.3	

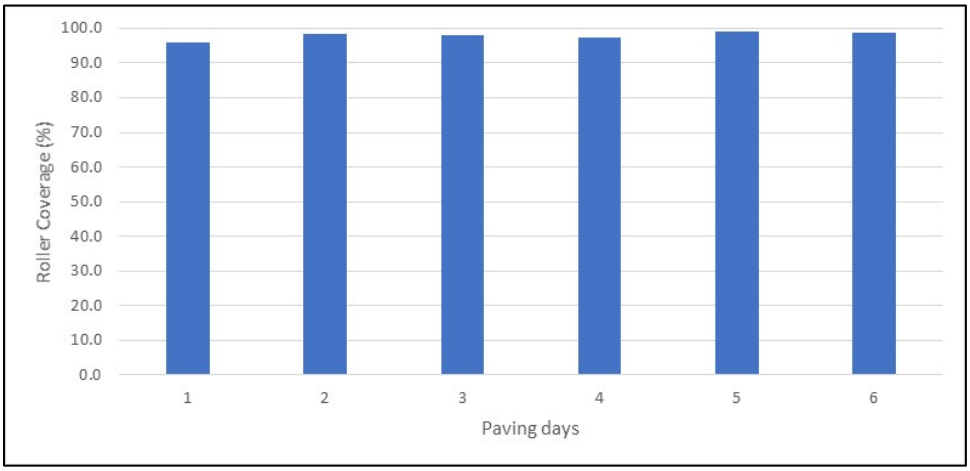

Figure 70: Summary of Roller Coverage Report for J9S3271, Rte. 62

Project No. 8 J9S3282, Rte. 61

Trial Section (6/27/2019)

The established rolling pattern is 3 passes as shown in the compaction curve in Figure 71. Note that this is the same trial section used for J9S3271, Rte. 62. This was a nearby project completed by the same contractor using the same asphalt mix and equipment.

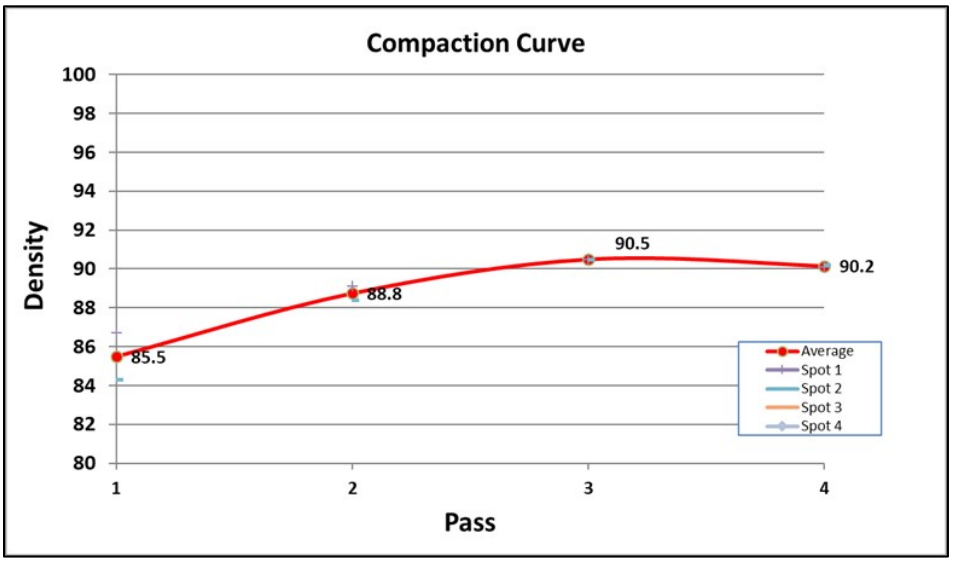

Figure 71: Trial Section Compaction Curve for J9S3282, Rte. 61

A summary of PMTPS and IC results are shown in the remainder of this section.

Table 25: Summary of PMTPS Results for J9S3282, Rte. 61

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	6/27/2019	Pass	48	74	15	23	2	3
2	6/28/2019	Pass	39	85	6	13	1	2
3	6/28/2019	Pass	13	54	8	33	3	13
4	6/29/2019	Pass	48	81	8	14	3	5
5	7/1/2019	Pass	17	63	10	37	0	0
6	7/1/2019	Pass	21	31	35	51	12	18
7	7/2/2019	Pass	107	92	8	7	1	1
8	7/6/2019	Pass	62	85	9	12	2	3
9	7/6/2019	Pass	36	84	6	14	1	2
10	7/8/2019	Pass	38	88	5	12	0	0

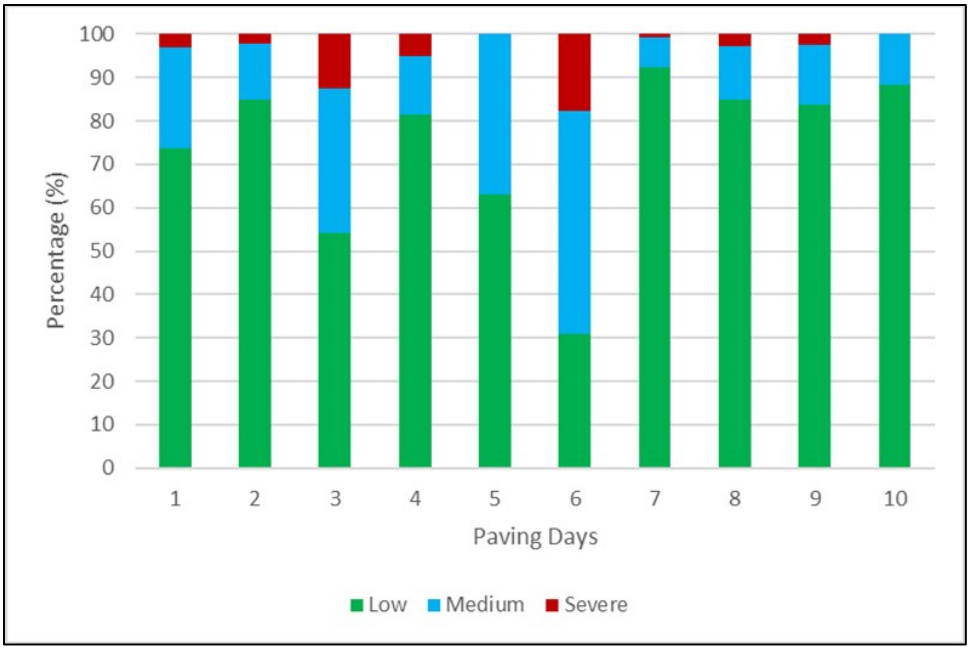

Figure 72: Summary of Veta Temperature Segregation Report for J9S3282, Rte. 61

Table 26: Summary of IC Results for J9S3282, Rte. 61

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	6/27/2019	97.3	Passed	70		246.3	
2	6/28/2019	98.3	Passed	70		241.1	
3	6/28/2019	93.2	Passed	70		226.5	
4	6/29/2019	96.8	Passed	70		222.8	
5	7/1/2019	99.6	Passed	70		235	
6	7/1/2019	94.6	Passed	70		223.5	
7	7/2/2019	98.6	Passed	70		242.4	
8	7/6/2019	98.6	Passed	70		241.9	
9	7/6/2019	96.2	Passed	70		210.6	
10	7/8/2019	99.0	Passed	70		243.1	

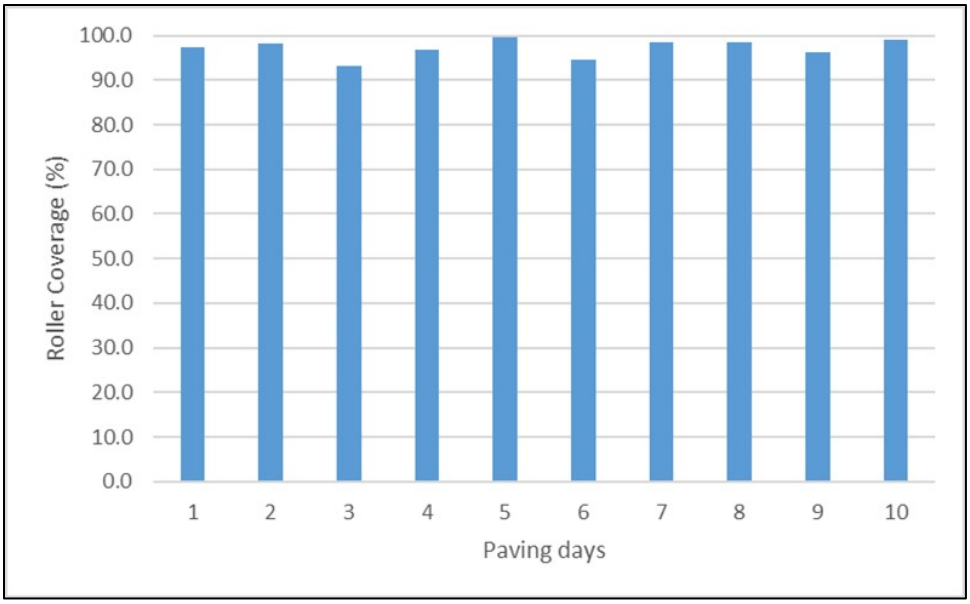

Figure 73: Summary of Roller Coverage Report for J9S3282, Rte. 61

Project No. 11 J5P3233, Rte. 63

Trial Section (10/8/2019)

The established rolling pattern is 12 passes as shown in the compaction curve in Figure 74.

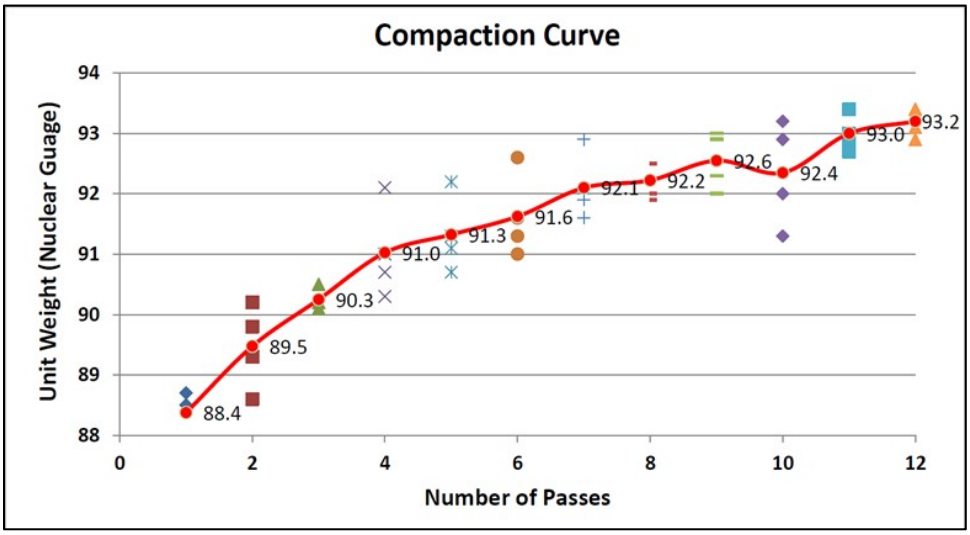

Figure 74: Trial Section Compaction Curve for J5P3233, Rte. 63

A summary of PMTPS and IC results are shown in the remainder of this section. Note that the IC data and analysis is not complete. There were several issues with erroneously high roller temperatures in this project. Therefore temperature analysis is not completely accurate.

Table 27: Summary of PMTPS Results for J5P3233, Rte. 63

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	9/26/2019	Pass	26	34	47	62	3	4
2	9/27/2019	Pass	36	54	30	45	1	1
3	9/30/2019	Pass	64	59	42	39	3	3
4	10/1/2019	Pass	41	44	52	55	1	1
5	10/2/2019	Pass	55	59	32	34	6	6
6	10/3/2019	Pass	42	45	47	50	5	5
7	10/8/2019	Pass	39	34	74	64	3	3
8	10/9/2019	Pass	29	45	34	52	2	3

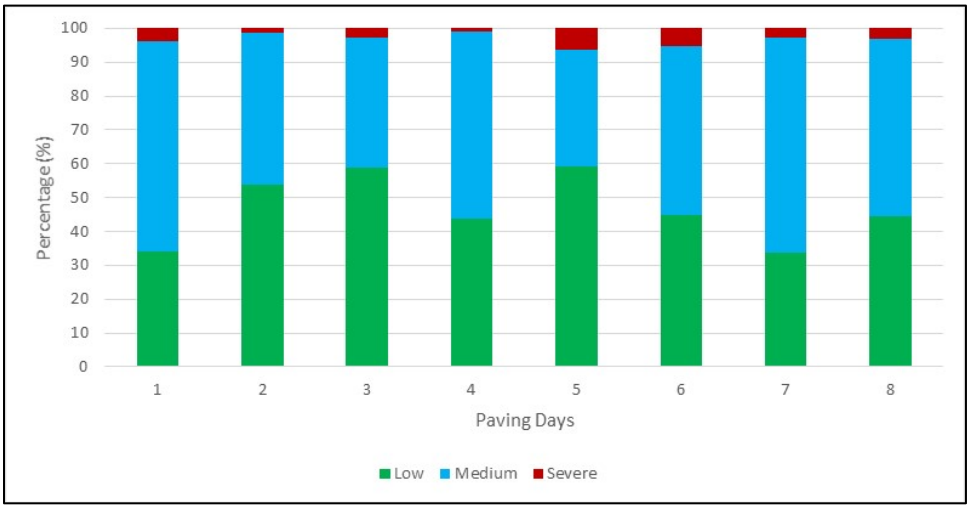

Figure 75: Summary of Veta Temperature Segregation Report for J5P3233, Rte. 63

Table 28: Summary of IC Results for J5P3233, Rte. 63

No.	Dates	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	9/26/2019	66	Failed	45	flagged	204	
2	9/27/2019	45	Failed	78.9		189.4	
3	9/30/2019	25	Failed	65	flagged	116.4	Deficient
4	10/1/2019	47	Failed	82.4		190.1	
5	10/2/2019	20	Failed	60.11	flagged	106.5	Deficient
6	10/3/2019	66	Failed	77.89		171.9	Deficient
7	10/8/2019		Failed		flagged		Deficient
8	10/9/2019		Failed		flagged		Deficient

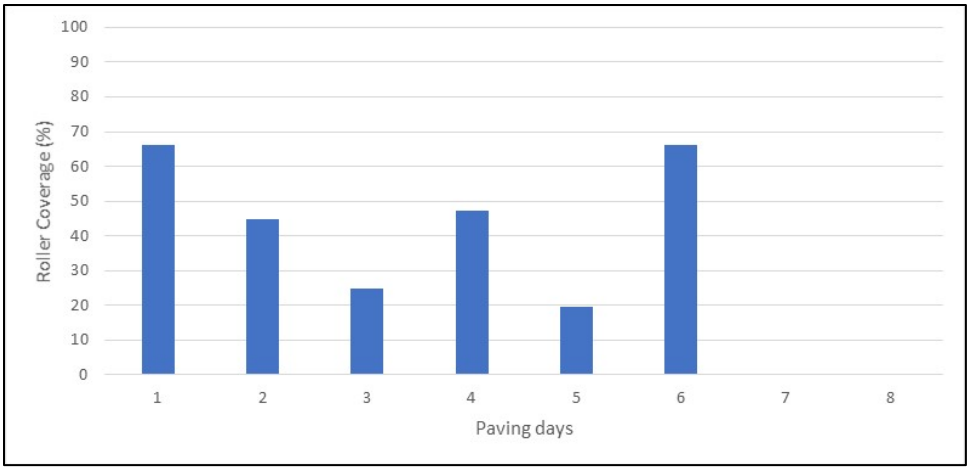

Figure 76: Summary of Roller Coverage Report for J5P3233, Rte. 63

Project No. 12 J6P3184, Rte. 141

Trial Section (10/14/2019)

The established rolling pattern is 5 passes as shown in the compaction curve in Figure 77.

Note that the pass count starts at three passes per the contractor's notes. The compaction curve is relatively flat and an optimum density of 5 passes is acceptable based on the specifications.

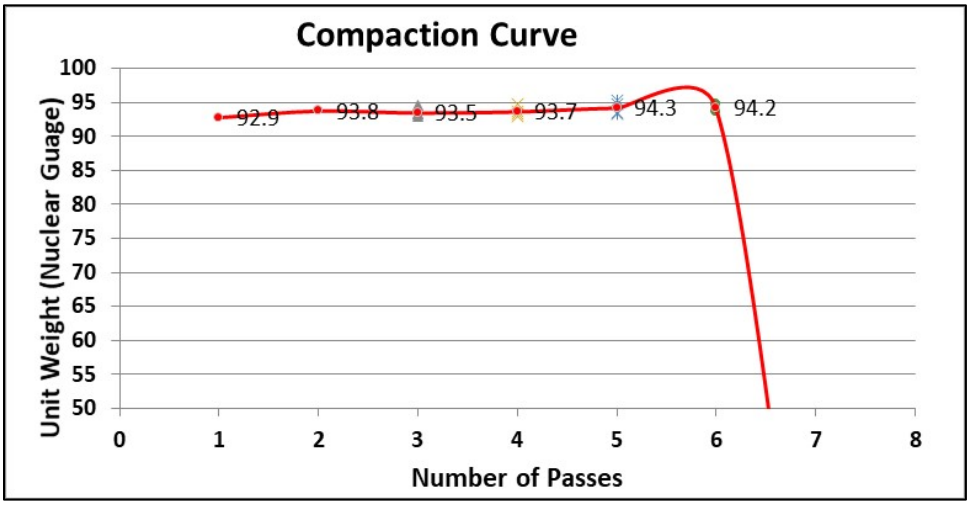

Figure 77: Trial Section Compaction Curve for J6P3184, Rte. 141

A summary of PMTPS and IC results are shown in the remainder of this section.

Table 29: Summary of PMTPS Results for J6P3184, Rte. 141

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	10/14/2019	Pass	36	72	11	22	3	6
2	10/15/2019	Pass	31	74	10	24	1	2
3	10/16/2019	Pass	40	71	14	25	2	4
4	10/17/2019	Pass	41	69	14	24	4	7
5	10/18/2019	Pass	31	54	22	39	4	7
6	10/21/2019	Pass	28	47	27	46	4	7
7	10/22/2019	Pass	33	56	22	37	4	7
8	10/23/2019	Pass	43	74	13	22	2	3

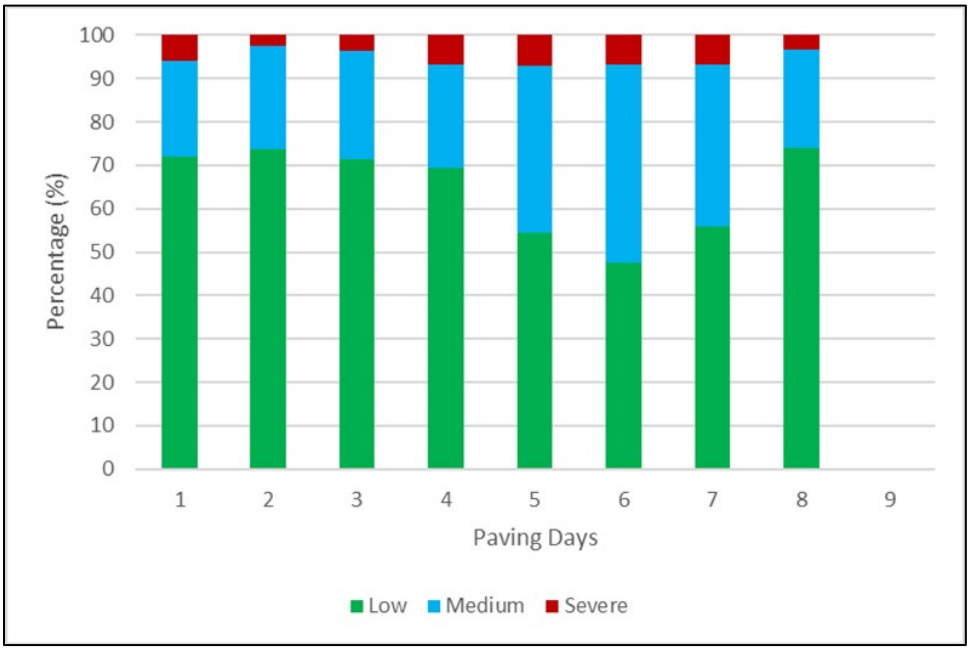

Figure 78: Summary of Veta Temperature Segregation Report for J6P3184, Rte. 141

Table 30: Summary of IC Results for J6P3184, Rte. 141

No.	Dates	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	10/14/2019	97	Passed	70		204.6	
2	10/15/2019	90	Moderate	70		210.9	
3	10/16/2019	98	Passed	70		224.8	
4	10/17/2019	90	Passed	70		217.5	
5	10/18/2019	87	Moderate	70		223.4	
6	10/21/2019	96	Passed	70		215.7	
7	10/22/2019	97	Passed	70		218.6	
8	10/23/2019	98	Passed	70		206.9	

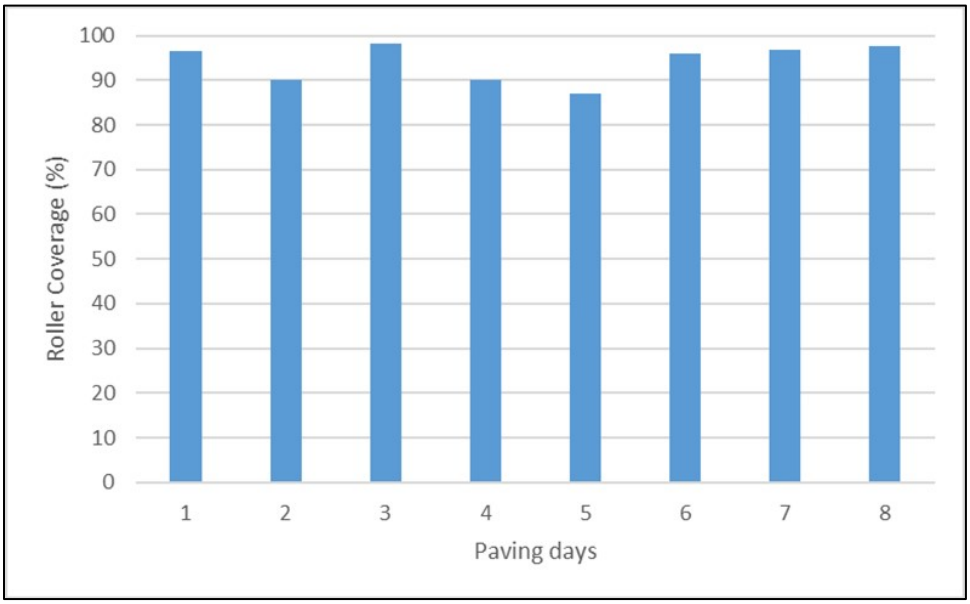

Figure 79: Summary of Roller Coverage Report for J6P3184, Rte. 141

Project No. 13 J1I3019, I-29

Trial Section (07/17/2019)

The established rolling pattern is 7 passes as shown in the compaction curve in Figure 80.

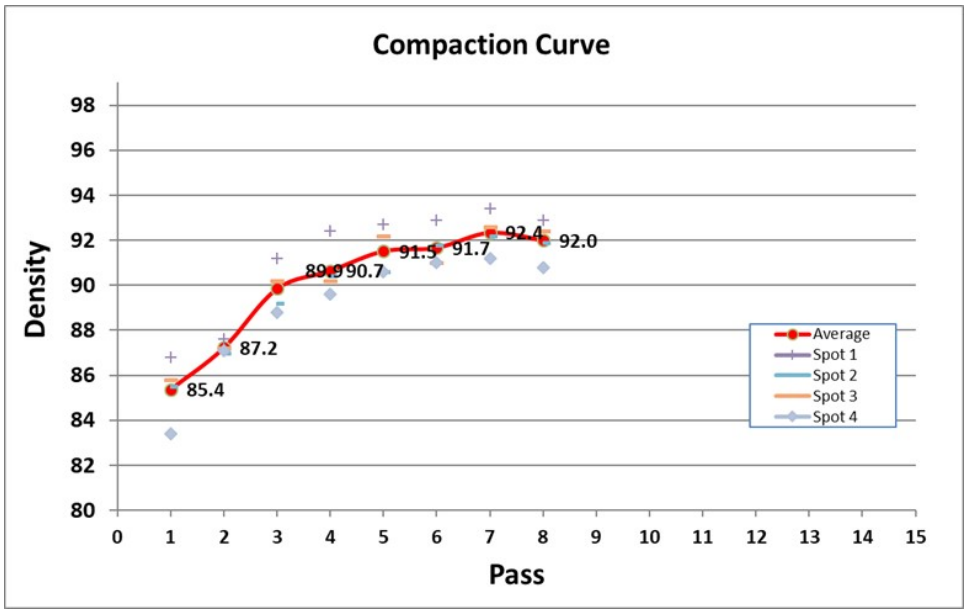

Figure 80: Trial Section Compaction Curve for J1I3019, I-29

A summary of PMTPS and IC results are shown in the remainder of this section.

Table 31: Summary of PMTPS Results for J1I3019, I-29

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	7/17/2019	Fail	56	81	12	17	1	1
2	7/18/2019	Pass	67	75	22	25	0	0
3	7/19/2019	Pass	13	62	7	33	1	5
4	7/25/2019	Pass	46	68	21	31	1	1
5	7/26/2019	Pass	83	77	25	23	0	0
6	7/27/2019	Pass	24	59	16	39	1	2
7	7/29/2019	Pass	77	70	30	27	3	3
8	7/30/2019	Pass	68	72	27	28	0	0
9	7/31/2019	Pass	30	64	14	30	3	6
10	8/1/2019	Pass	21	72	8	28	0	0
11	8/2/2019	Pass	75	66	37	33	1	1
12	8/3/2019	Pass	37	64	20	34	1	2
13	8/5/2019	Pass	65	66	31	32	2	2
14	8/6/2019	Pass	36	63	20	35	1	2
15	8/6/2019	Pass	29	69	12	29	1	2
16	8/12/2019	Pass	66	79	17	20	1	1
17	8/13/2019	Pass	97	84	19	16	0	0
18	8/14/2019	Pass	80	73	29	26	1	1
19	8/15/2019	Pass	36	47	27	36	13	17
20	8/16/2019	Pass	11	26	22	52	9	21
21	8/19/2019	Pass	26	46	26	46	5	9
22	8/27/2019	Pass	75	75	22	22	3	3
23	8/28/2019	Pass	52	66	22	28	5	6
24	8/29/2019	Pass	48	56	32	38	5	6
25	9/3/2019	Pass	67	59	44	39	3	3
26	9/4/2019	Pass	63	53	46	39	9	8
27	9/5/2019	Pass	46	65	23	32	2	3

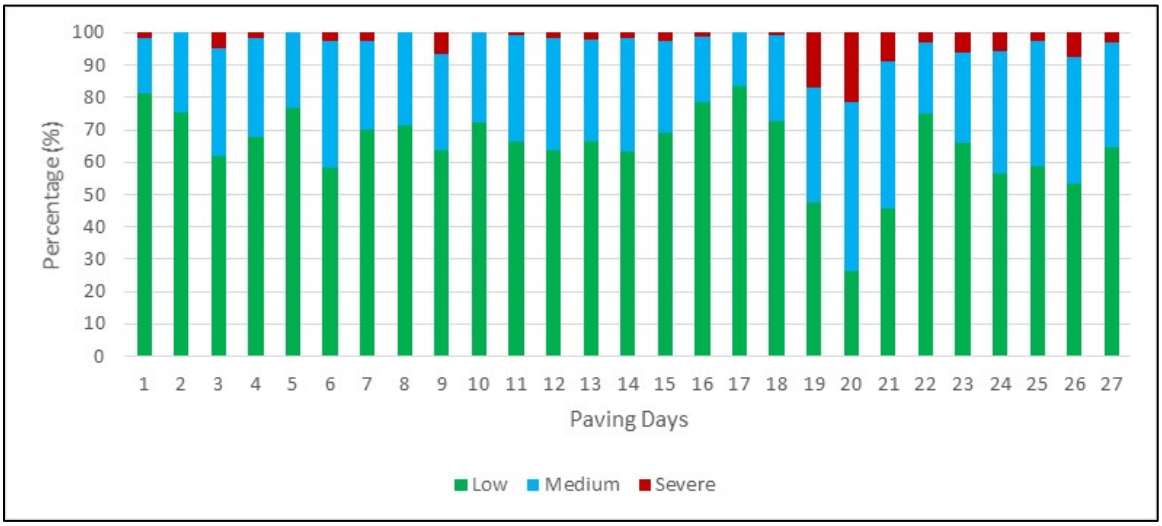

Figure 81: Summary of Veta Temperature Segregation Report for J1I3019, I-29

Table 32: Summary of IC Results for J1I3019, I-29

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	7/17/2019	100	Passed		flagged	179.4	Deficient
2	7/18/2019	99	Passed		flagged	189.2	
3	7/19/2019	96	Passed		flagged	191.5	
4	7/25/2019	97	Passed		flagged	193.6	
5	7/26/2019	99	Passed		flagged	206.9	
6	7/27/2019	98	Passed		flagged	199.9	
7	7/29/2019	98	Passed		flagged	197.9	
8	7/30/2019	92	Passed		flagged	210.4	
9	7/31/2019	97	Passed		flagged	194.3	
10	8/1/2019	99	Passed		flagged	200.5	
11	8/2/2019	97	Passed		flagged	196.8	
12	8/3/2019	98	Passed		flagged	205.5	
13	8/5/2019	98	Passed		flagged	200.4	
14	8/6/2019	81	Moderate		flagged	183.3	
15	8/6/2019	59	Failed		flagged	214.1	
16	8/12/2019	99	Passed		flagged	212	
17	8/13/2019	99	Passed		flagged	211.6	
18	8/14/2019	99	Passed		flagged	210.3	
19	8/15/2019	97	Passed		flagged	202.3	
20	8/16/2019	99	Passed		flagged	204	
21	8/19/2019	100	Passed		flagged	205.8	
22	8/27/2019	70	Moderate		flagged	192.1	
23	8/28/2019	70	Moderate		flagged	192.5	
24	8/29/2019	70	Moderate		flagged	193.7	
25	9/3/2019	70	Moderate		flagged	189.1	
26	9/4/2019	70	Moderate		flagged	184	
27	9/5/2019	70	Moderate		flagged	186.4	

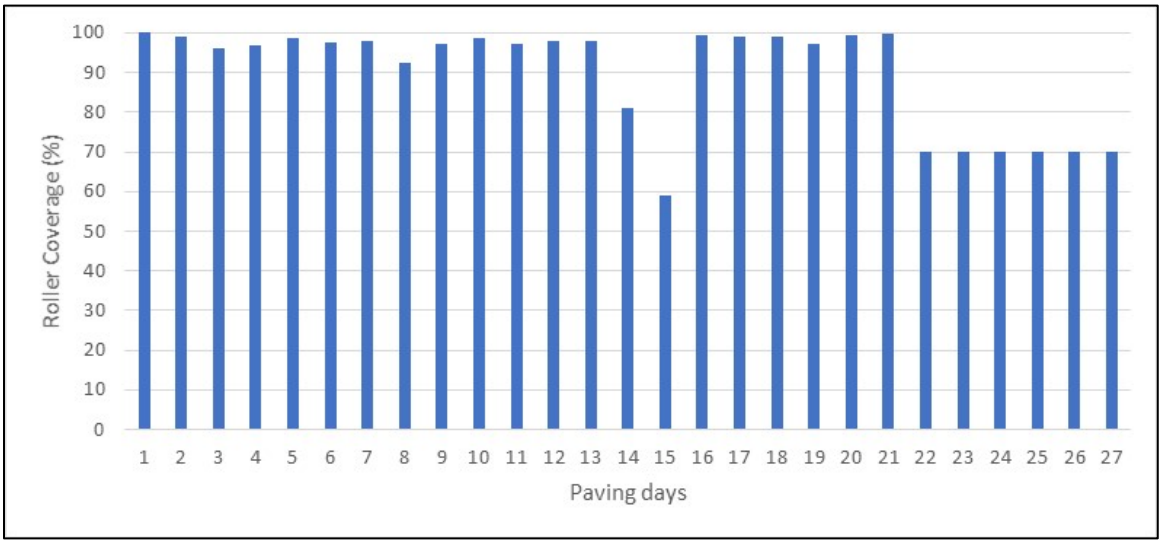

Figure 82: Summary of Roller Coverage Report for J1I3019, I-29

Project No. 14 J2P3135, Rte. 54

Trial Section (06/13/2019)

The established rolling pattern is 8 passes as shown in the compaction curve in Figure 83. Note that this is the same trial section used for J2P3133, Rte. 54. This was a nearby project completed by the same contractor using the same asphalt mix and equipment.

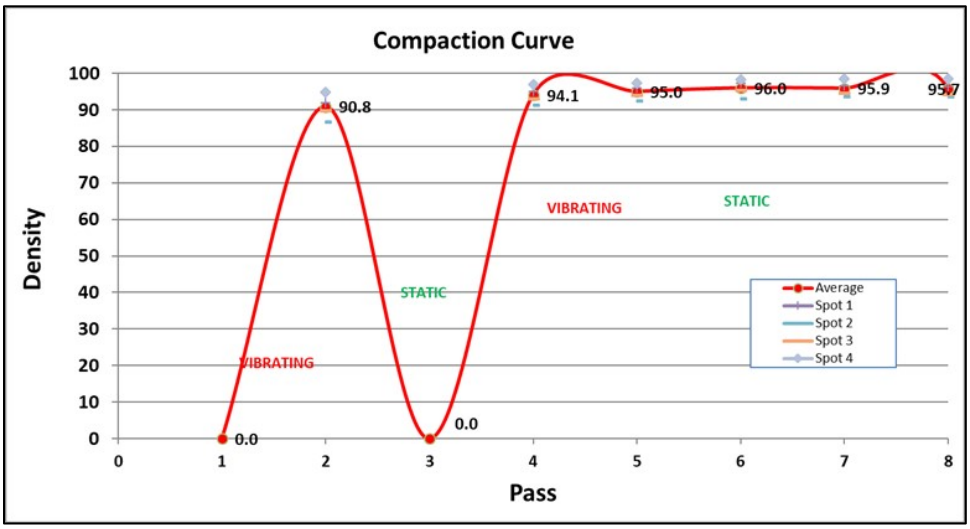

Figure 83: Trial Section Compaction Curve for J2P3135, Rte. 54

A summary of PMTPS and IC results are shown in the remainder of this section. Note that there are several days where the PMTPS data reads 100% thermal segregation. This is due to malfunctioning PMTPS equipment. It is unclear whether the price disincentive was applied during those days.

Table 33: Summary of PMTPS Results for J2P3135, Rte. 54

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	6/13/2019	Pass	63	60	34	32	8	8
2	6/14/2019	Pass	67	67	27	27	6	6
3	6/17/2019	Pass	67	74	17	19	7	8
4	6/18/2019	Pass	101	80	20	16	5	4
5	6/20/2019	Pass	133	90	13	9	2	1
6	6/21/2019	Pass	31	72	10	23	2	5
7	6/24/2019	Pass	7	6	11	10	90	83
8	6/25/2019	Pass	0	0	0	0	108	100
9	6/26/2019	Pass	0	0	0	0	126	100
10	6/27/2019	Pass	0	0	0	0	146	100
11	6/28/2019	Pass	0	0	0	0	41	100
12	6/28/2019	Pass	0	0	0	0	36	100
13	6/29/2019	Pass	0	0	0	0	60	100
14	6/29/2019	Pass	0	0	0	0	36	100
15	7/1/2019	Pass	0	0	0	0	87	100
16	7/2/2019	Pass	0	0	0	0	83	100
17	7/8/2019	Pass	69	53	59	45	3	2
18	7/9/2019	Pass	60	64	31	33	3	3
19	7/10/2019	Pass	87	60	55	38	4	3
20	7/11/2019	Pass	113	74	37	24	3	2
21	7/15/2019	Pass	71	64	30	27	10	9
22	7/16/2019	Pass	31	53	23	40	4	7
23	7/17/2019	Pass	108	83	18	14	4	3
24	7/18/2019	Pass	114	70	46	28	3	2
25	7/20/2019	Pass	107	83	17	13	5	4
26	7/22/2019	Pass	128	92	8	6	3	2
27	7/23/2019	Pass	139	93	7	5	3	2
28	7/24/2019	Pass	33	89	4	11	0	0
29	7/25/2019	Pass	45	76	14	24	0	0

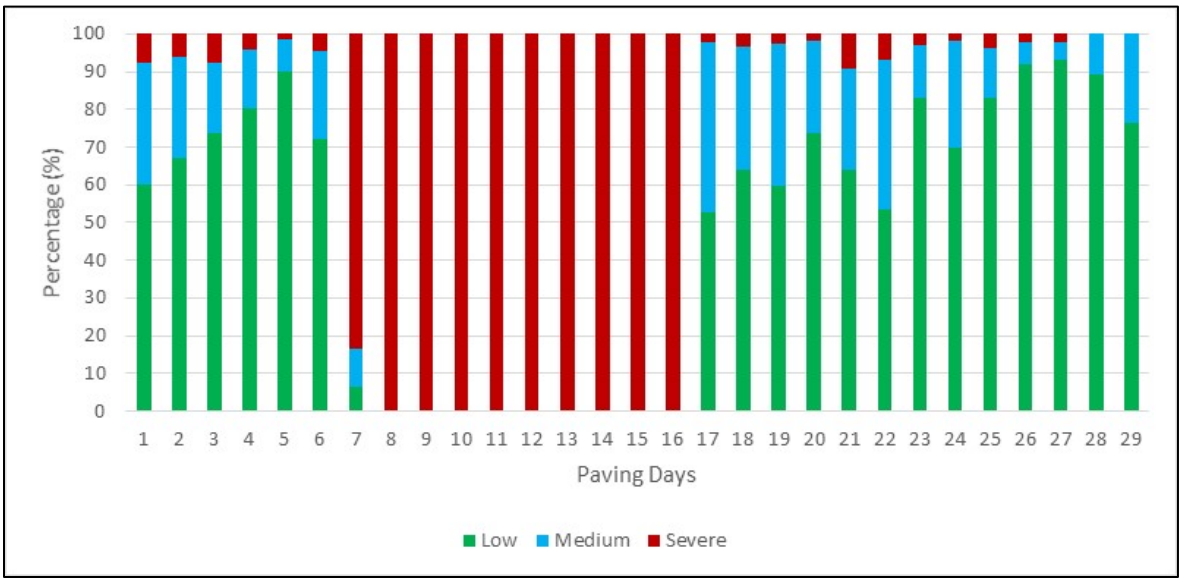

Figure 84: Summary of Veta Temperature Segregation Report for J2P3135, Rte. 54

Table 34: Summary of IC Results for J2P3135, Rte. 54

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	6/13/2019	84	Moderate	68.23	flagged	207	
2	6/14/2019	89	Moderate	62.63	flagged	208.1	
3	6/17/2019	75	Moderate	72.53		197	
4	6/18/2019	95	Passed	56.14	flagged	214.8	
5	6/20/2019	90	Passed	69.46	flagged	217	
6	6/21/2019	87	Moderate	65.97	flagged	213.6	
7	6/24/2019	91	Passed	77.37		205.4	
8	6/25/2019	56	Failed	34.89	flagged	201.5	
9	6/26/2019	96	Passed	36.85	flagged	211.5	
10	6/27/2019	93	Passed	46.44	flagged	211.6	
11	6/28/2019	89	Moderate	87.09		206.2	
12	6/28/2019	95	Passed	9.62	flagged	223.3	
13	6/29/2019	94	Passed	63.68	flagged	209.5	
14	6/29/2019	95	Passed	9.15	flagged	224.7	
15	7/1/2019	74	Moderate	16.88	flagged	208.1	
16	7/2/2019	73	Moderate	33.29	flagged	210.4	
17	7/8/2019	97	Passed	45.99	flagged	214.5	
18	7/9/2019	93	Passed	46.36	flagged	215.9	
19	7/10/2019	93	Passed	56.11	flagged	199.1	
20	7/11/2019	93	Passed	60.32	flagged	203.6	
21	7/15/2019	76	Moderate	74.92		210.9	
22	7/16/2019	92	Passed	69.18	flagged	210.4	
23	7/17/2019	85	Moderate	34.19	flagged	207.9	
24	7/18/2019	90	Passed	63.64	flagged	211.3	
25	7/20/2019	92	Passed	44.27	flagged	213.7	
26	7/22/2019	89	Moderate	68.73	flagged	206.7	
27	7/23/2019	91	Passed	58.53	flagged	207.8	
28	7/24/2019	87	Moderate	90.4		199.6	
29	7/25/2019	88	Moderate	95.9		213.7	

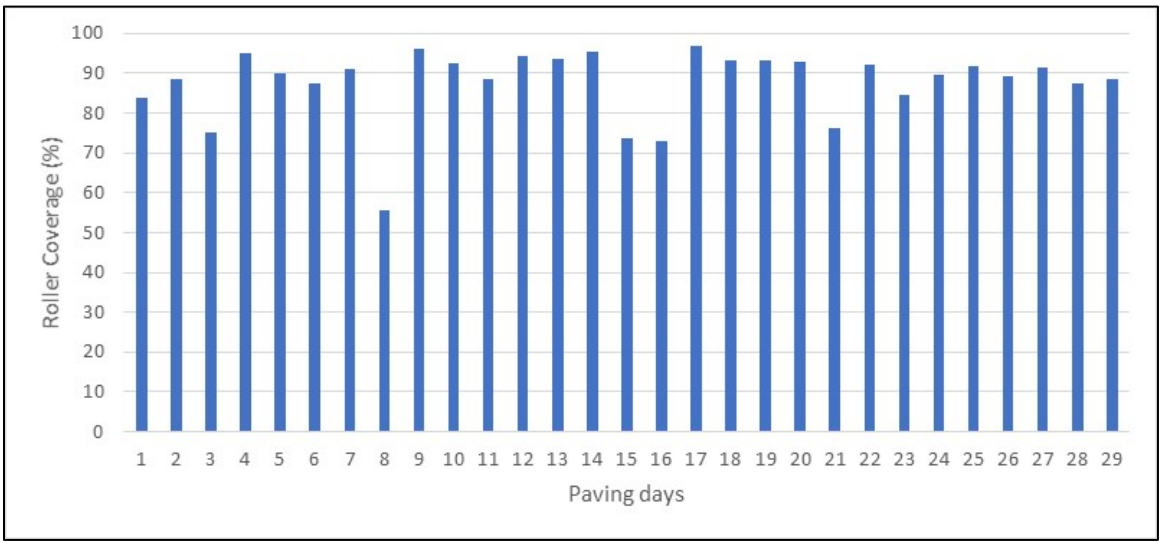

Figure 85: Summary of Roller Coverage Report for J2P3135, Rte. 54

Project No. 16 J7I3084, I-44

Trial Section (07/31/2019)

The established rolling pattern is 7 passes as shown in the compaction curve in Figure 86.

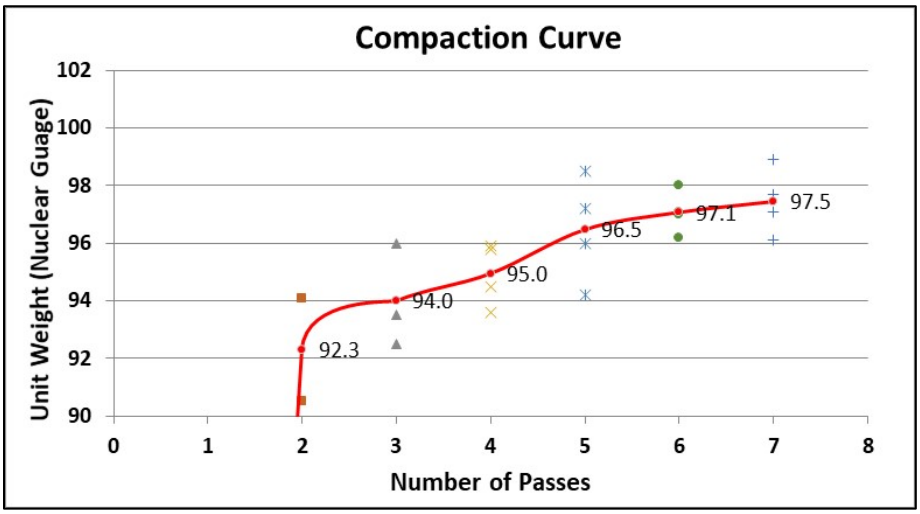

Figure 86: Trial Section Compaction Curve for J7I3084, I-44

A summary of PMTPS and IC results are shown in the remainder of this section. Note that there are a few days with missing data for both IC and PMTPS. According to the paving notes, this was due to equipment malfunction. It is unclear whether the price disincentive was applied during those days.

Table 35: Summary of PMTPS Results for J7I3084, I-44

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	7/31/2019	Pass	4	57	2	29	1	14
2	8/3/2019	Pass	2	13	10	67	3	20
3	8/4/2019	Pass	94	80	23	20	0	0
4	8/5/2019	Pass	107	88	12	10	3	2
5	8/6/2019	Pass	59	70	19	23	6	7
6	8/10/2019	Pass	0		0		0	
7	8/11/2019	Pass	87	76	21	18	6	5
8	8/12/2019	Pass	77	79	16	16	5	5
9	8/13/2019	Pass	100	77	19	15	11	8
10	8/14/2019	Pass	93	72	24	19	12	9
11	8/19/2019	Pass	79	92	5	6	2	2
12	8/19/2019	Pass	24	69	8	23	3	9
13	8/20/2019	Pass						
14	8/20/2019	Pass						
15	8/21/2019	Pass	33	73	5	11	7	16
16	8/23/2019	Pass	57	92	3	5	2	3
17	8/27/2019	Pass	54	82	11	17	1	2
18	8/28/2019	Pass	82	75	13	12	15	14
19	8/29/2019	Pass	32	76	7	17	3	7
20	9/3/2019	Pass	47	80	7	12	5	8
21	9/4/2019	Pass	49	51	34	35	14	14
22	9/5/2019	Pass	49	58	27	32	9	11
23	9/6/2019	Pass	79	78	17	17	5	5
24	9/7/2019	Pass	53	62	27	32	5	6
25	9/9/2019	Pass	65	78	15	18	3	4
26	9/9/2019	Pass	29	59	18	37	2	4
27	9/10/2019	Pass	96	75	31	24	1	1
28	9/11/2019	Pass	58	60	36	37	3	3
29	9/11/2019	Pass	12	40	18	60	0	0
30	9/15/2019	Pass	83	61	49	36	4	3
31	9/16/2019	Pass	27	56	15	31	6	13
32	9/17/2019	Pass	63	67	20	21	11	12

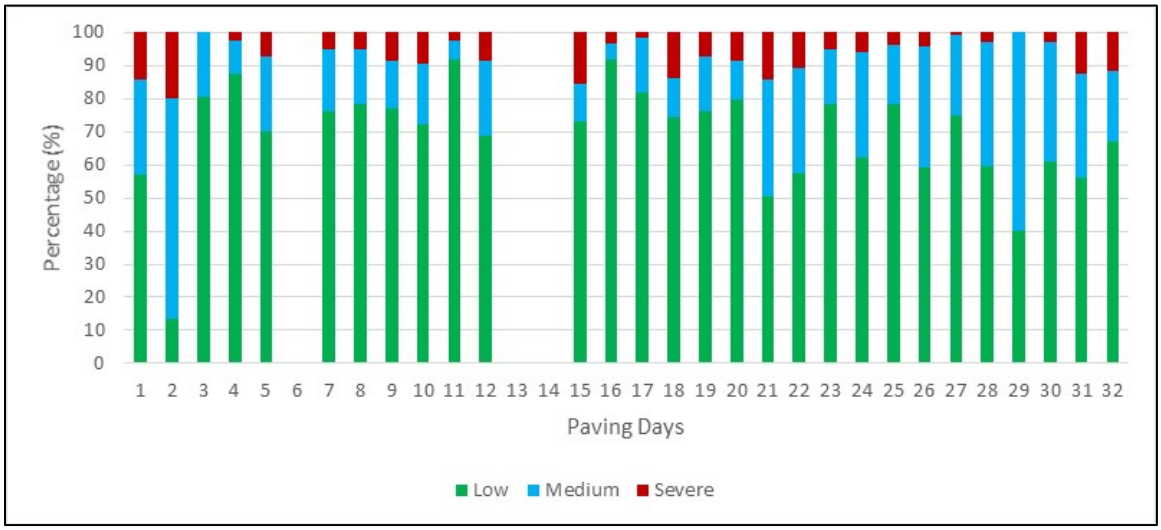

Figure 87: Summary of Veta Temperature Segregation Report for J7I3084, I-44

Table 36: Summary of IC Results for J7I3084, I-44

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	7/31/2019	98	Passed	31.9	flagged	251.4	
2	8/3/2019	82	Moderate	72.57		236.7	
3	8/4/2019	97	Passed	69.83		255.4	
4	8/5/2019	99	Passed	64.34	flagged	234	
5	8/6/2019	95	Passed	65.17	flagged	233.9	
6	8/10/2019		Failed		flagged		Deficient
7	8/11/2019	99	Passed	63.31	flagged	247.1	
8	8/12/2019	100	Passed	65.11	flagged	245.6	
9	8/13/2019	99	Passed	75.61		233.3	
10	8/14/2019	98	Passed	63.82	flagged	236.1	
11	8/19/2019	94	Passed	59.45	flagged	209.2	
12	8/19/2019	97	Passed	66.12	flagged	203.6	
13	8/20/2019		Failed		flagged		Deficient
14	8/20/2019		Failed		flagged		Deficient
15	8/21/2019	100	Passed	66.63	flagged	210.8	
16	8/23/2019	99	Passed	70.61		205.9	
17	8/27/2019	99	Passed	65.5	flagged	202.8	
18	8/28/2019	43	Failed	85.56		188.4	
19	8/29/2019	100	Passed	64.11	flagged	214.5	
20	9/3/2019	100	Passed	66.67	flagged	215.1	
21	9/4/2019	98	Passed	51.87	flagged	206.2	
22	9/5/2019	89	Moderate	56.76	flagged	217.1	
23	9/6/2019	100	Passed	65.9	flagged	206.2	
24	9/7/2019	44	Failed	65.9	flagged	229.4	
25	9/9/2019	94	Passed	53.54	flagged	403.8	
26	9/9/2019	85	Moderate	54.59	flagged	456	
27	9/10/2019	95	Passed	47.48	flagged	407.7	
28	9/11/2019	100	Passed	57.4	flagged	230.5	
29	9/11/2019	100	Passed	58.88	flagged	236.6	
30	9/15/2019	96	Passed	59.19	flagged	213.3	
31	9/16/2019	78	Moderate	58.56	flagged	227.5	
32	9/17/2019	79	Moderate	60.38	flagged	224.9	

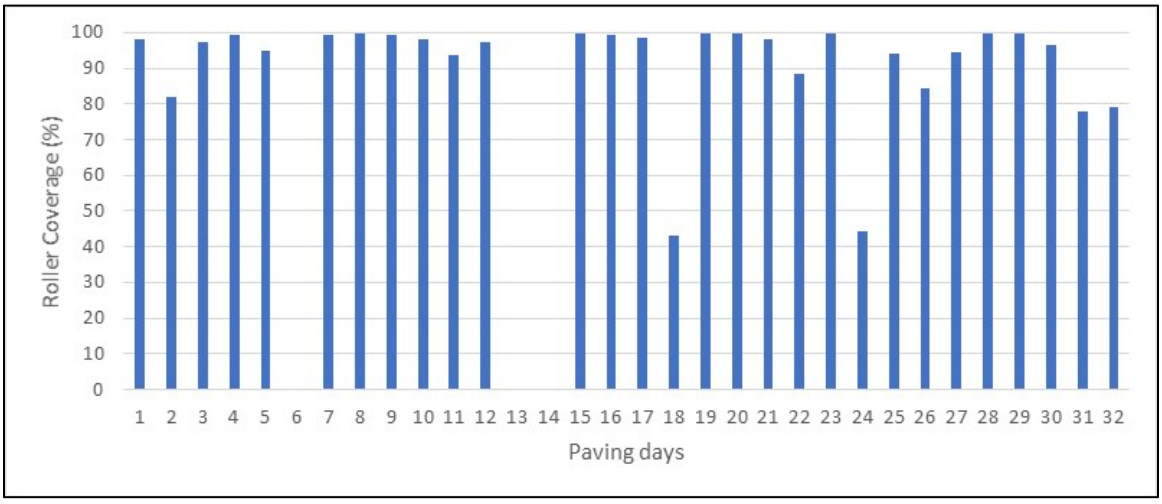

Figure 88: Summary of Roller Coverage Report for J7I3084, I-44

Project No. 17 J7P3139, Rte. 249

Trial Section (08/28/2019)

The established rolling pattern is 5 passes as shown in the compaction curve in Figure 89.

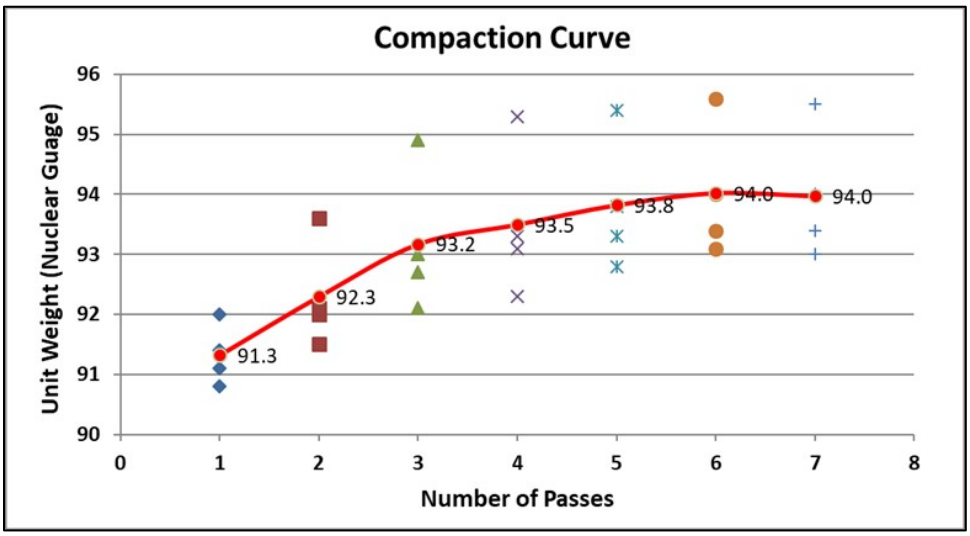

Figure 89: Trial Section Compaction Curve for J7P3139, Rte. 249

A summary of PMTPS and IC results are shown in the remainder of this section. Note that there are three days where IC data is missing. Per the contractor notes, all IC payment disincentives were waived by the RE.

Table 37: Summary of PMTPS Results for J7P3139, Rte. 249

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	8/28/2019	Pass	30	81	6	16	1	3
2	8/28/2019	Pass	28	78	8	22	0	0
3	8/29/2019	Pass	47	92	4	8	0	0
4	8/29/2019	Pass	12	86	1	7	1	7
5	9/3/2019	Pass	30	79	7	18	1	3
6	9/3/2019	Pass	33	92	2	6	1	3
7	9/4/2019	Pass	46	90	5	10	0	0
8	9/4/2019	Pass	11	79	3	21	0	0
9	9/6/2019	Pass	10	100	0	0	0	0
10	9/6/2019	Pass	8	73	3	27	0	0
11	9/6/2019	Pass	5	71	2	29	0	0
12	9/6/2019	Pass	8	80	1	10	1	10
13	9/6/2019	Pass	6	75	2	25	0	0
14	9/9/2019	Pass	30	81	6	16	1	3
15	9/9/2019	Pass	22	100	0	0	0	0
16	9/9/2019	Pass	9	82	2	18	0	0
17	9/9/2019	Pass	5	100	0	0	0	0
18	9/9/2019	Pass	3	75	0	0	1	25
19	9/9/2019	Pass	21	81	5	19	0	0
20	9/10/2019	Pass	32	86	5	14	0	0
21	9/10/2019	Pass	20	83	4	17	0	0
22	9/10/2019	Pass	10	91	1	9	0	0
23	9/10/2019	Pass	4	80	0	0	1	20
24	9/10/2019	Pass	2	50	2	50	0	0
25	9/10/2019	Pass	20	77	5	19	1	4

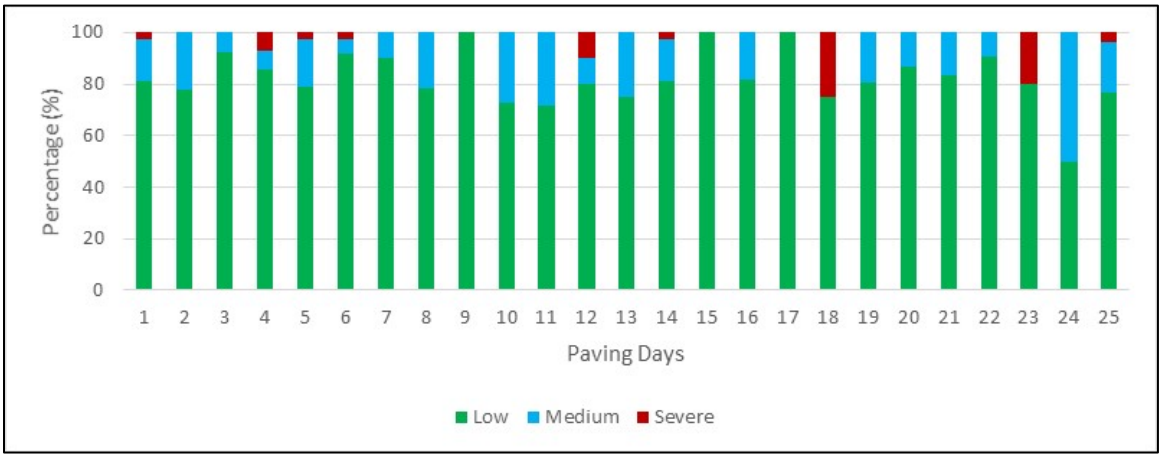

Figure 90: Summary of Veta Temperature Segregation Report for J7P3139, Rte. 249

Table 38: Summary of IC Results for J7P3139, Rte. 249

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	8/28/2019	88.9	Moderate	42.87	flagged	193.7	
2	8/28/2019	68.4	Failed	32.97	flagged	182.4	
3	8/29/2019	70.2	Moderate	93.13		188.2	
4	8/29/2019	87.6	Moderate	58.05	flagged	143.2	Deficient
5	9/3/2019	72.5	Moderate	96.64		200.1	
6	9/3/2019	71.0	Moderate	97		192.9	
7	9/4/2019	96.8	Passed	67.01	flagged	196.9	
8	9/4/2019	100.0	Passed	54.87	flagged	207.9	
9	9/6/2019	99.8	Passed	58.3	flagged	211.9	
10	9/6/2019	99.8	Passed	43.73	flagged	206.7	
11	9/6/2019	67.8	Failed	82.51		164.6	Deficient
12	9/6/2019		Failed		flagged		Deficient
13	9/6/2019		Failed		flagged		Deficient
14	9/9/2019		Failed		flagged		Deficient
15	9/9/2019		Failed		flagged		Deficient
16	9/9/2019		Failed		flagged		Deficient
17	9/9/2019		Failed		flagged		Deficient
18	9/9/2019		Failed		flagged		Deficient
19	9/9/2019		Failed		flagged		Deficient
20	9/10/2019		Failed		flagged		Deficient
21	9/10/2019		Failed		flagged		Deficient
22	9/10/2019		Failed		flagged		Deficient
23	9/10/2019		Failed		flagged		Deficient
24	9/10/2019		Failed		flagged		Deficient
25	9/10/2019		Failed		flagged		Deficient

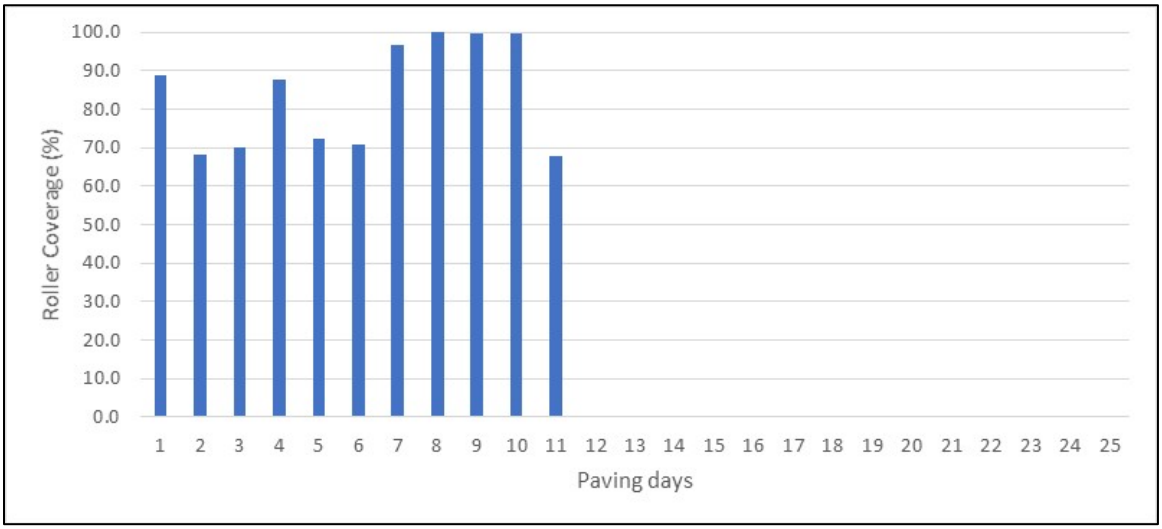

Figure 91: Summary of Roller Coverage Report for J7P3139, Rte. 249

Project No. 18 J7S3116, LP49

Trial Section (08/28/2019)

The established rolling pattern is 5 passes as shown in the compaction curve in Figure 92. Note that this is the same compaction curve from project J7P3139, Rte. 249. This was a nearby project completed by the same contractor using the same asphalt mix and equipment.

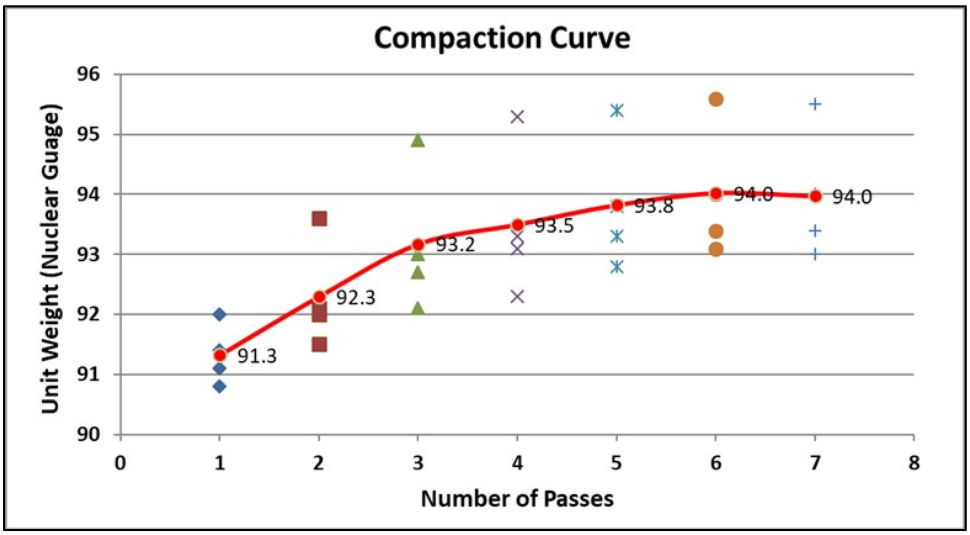

Figure 92: Trial Section Compaction Curve for J7S3116, LP49

A summary of PMTPS and IC results are shown in the remainder of this section. Note that there are three days where PMTPS data is missing. Per the RE notes, the paver with the PMTPS equipment installed on it broke down. A replacement paver was brought in. There was no PMTPS equipment installed on the new paver. The disincentives were waived while the contractor moved the PMTPS equipment to the new paver. The PMTPS equipment was mounted to the new paver; however the equipment malfunctioned after a few days of paving. The disincentives for PMTPS equipment were waived for last day when the equipment would not power on.

The IC equipment was still malfunctioning on the first two days of paving. This was the same equipment that was experiencing equipment issues on a previous job (reference project J7P3139, Rte. 249). All IC equipment was operational by the third day of paving. The disincentives for IC equipment were not waived for this project.

Table 39: Summary of PMTPS Results for J7S3116, LP49

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	10/13/2019	Pass	29	48	23	38	9	15
2	10/14/2019	Pass	44	50	40	45	4	5
3	10/15/2019	Pass	68	51	63	47	2	2
4	10/17/2019	Pass	0	0	0	0	0	0
5	10/18/2019	Pass	0	0	0	0	0	0
6	10/18/2019	Pass	0	0	0	0	0	0
7	10/21/2019	Pass	0	0	0	0	0	0
8	10/22/2019	Pass	45	45	49	49	5	5
9	10/23/2019	Pass	30	49	30	49	1	2
10	10/27/2019	Pass	0	0	0	0	0	0
11	10/27/2019	Pass	0	0	0	0	0	0
12	10/27/2019	Pass	0	0	0	0	0	0

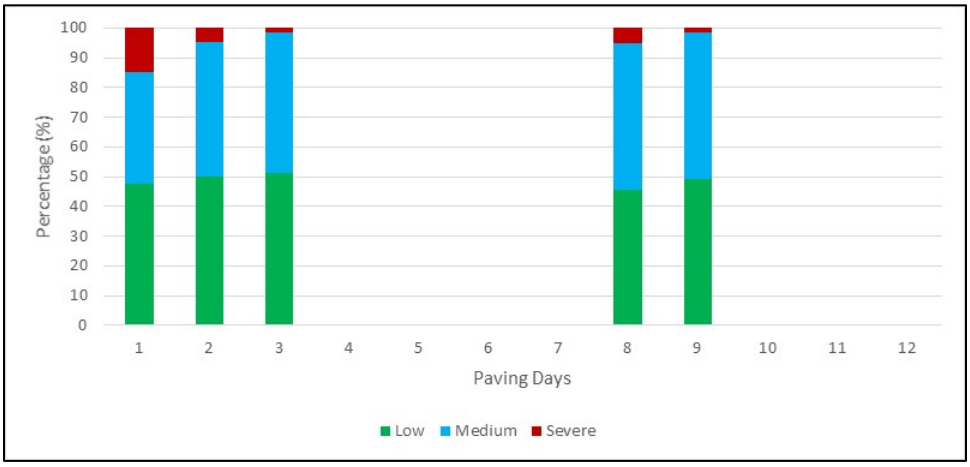

Figure 93: Summary of Veta Temperature Segregation Report for J7S3116, LP49

Table 40: Summary of IC Results for J7S3116, LP49

No.	Dates	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	10/13/2019	66.9	Failed	29.37	flagged	206.9	
2	10/14/2019	26.4	Failed	15.21	flagged	188.1	
3	10/15/2019	97.4	Passed	13.9	flagged	224.5	
4	10/17/2019	97.4	Passed	14.93	flagged	223	
5	10/18/2019	99.8	Passed	11.99	flagged	225.7	
6	10/18/2019	95.3	Passed	13.94	flagged	221.7	
7	10/21/2019	97.4	Passed	12.87	flagged	223.1	
8	10/22/2019	93.6	Passed	13.48	flagged	219.6	
9	10/23/2019	94.5	Passed	16.71	flagged	223	
10	10/27/2019	91.8	Passed	19.27	flagged	220.8	
11	10/27/2019	98.2	Passed	39.82	flagged	200.3	
12	10/27/2019	92.3	Passed	20.47	flagged	191.8	

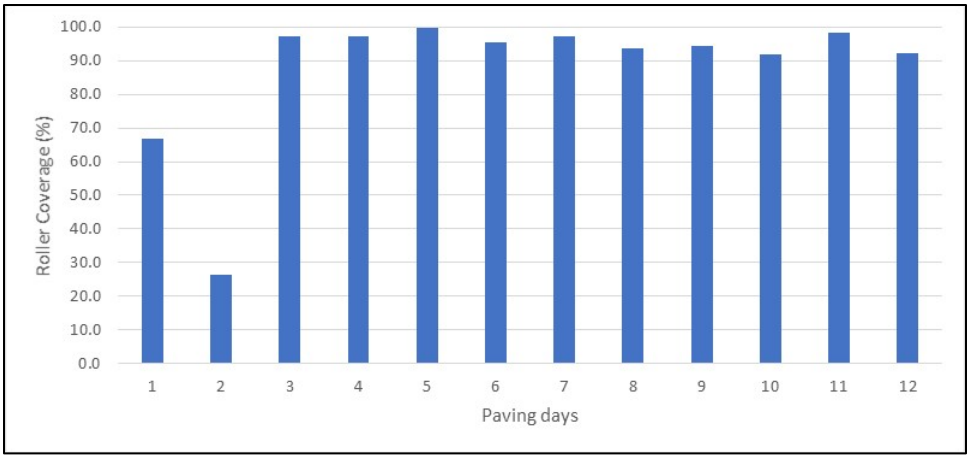

Figure 94: Summary of Roller Coverage Report for J7S3116, LP49

Project No. 19 J7S3117, LP49

Trial Section (08/28/2019)

The established rolling pattern is 5 passes as shown in the compaction curve in Figure 95. Note that this is the same compaction curve from project J7P3139, Rte. 249 and J7S3116, LP49. These were nearby projects completed by the same contractor using the same asphalt mix and equipment.

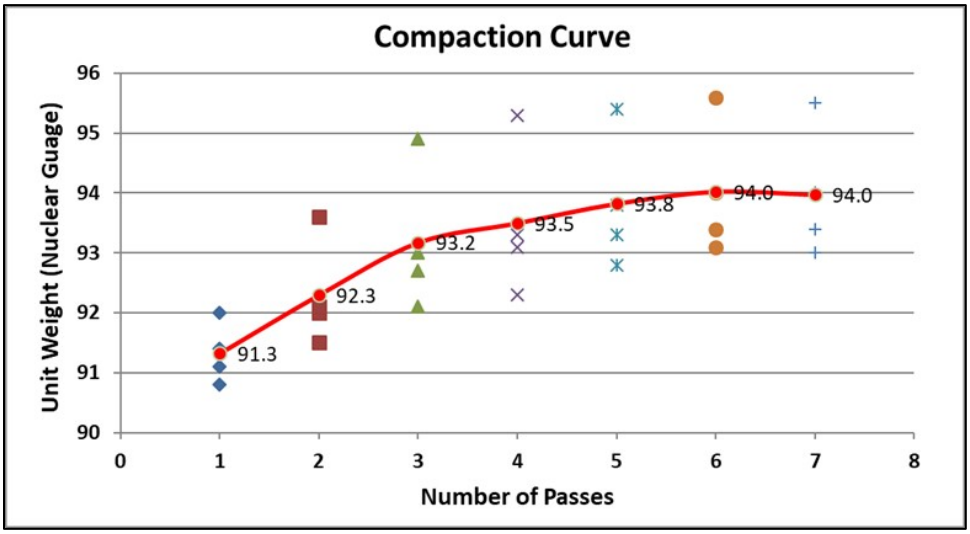

Figure 95: Trial Section Compaction Curve for J7S3117, LP49

A summary of PMTPS and IC results are shown in the remainder of this section. Note that there is one day when the PMTPS equipment was not working. The disincentives were waived for this day.

Table 41: Summary of PMTPS Results for J7S3117, LP49

No.	Dates	Data QA	Low Temp Seg (LTS) #	LTS %	Moderate Temp Seg (MTS) #	MTS %	Severe Temp Seg (STS) #	STS%
1	9/16/2019	Pass	0		0		0	
2	9/17/2019	Pass	101	77	28	21	2	2
3	9/18/2019	Pass	13	43	16	53	1	3
4	9/18/2019	Pass	32	53	24	40	4	7
5	9/19/2019	Pass	18	60	12	40	0	0
6	9/19/2019	Pass	40	69	14	24	4	7

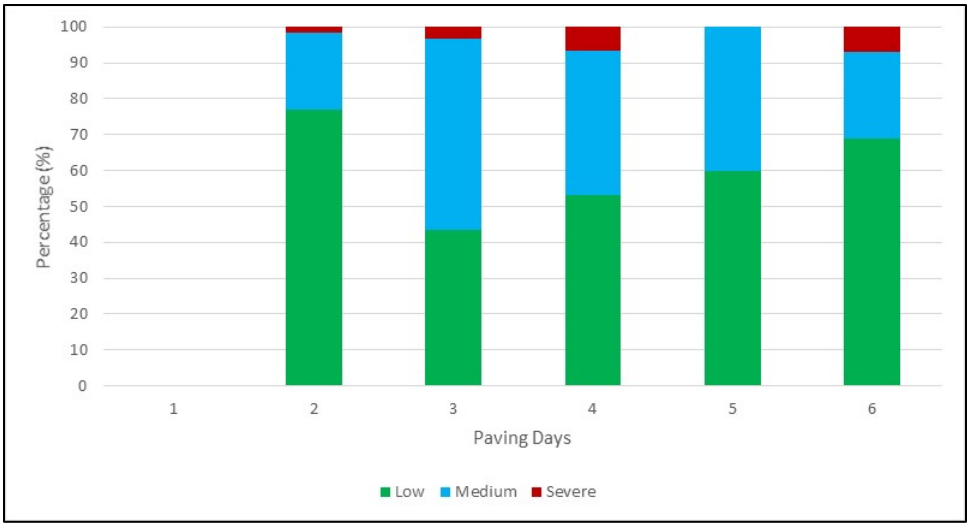

Figure 96: Summary of Veta Temperature Segregation Report for J7S3117, LP49

Table 42: Summary of IC Results for J7S3117, LP49

No.	*Dates*	Roller % Coverage	Roller % Coverage Classification	Target ICMV % Coverage	Target ICMV Classification	Mean Temp at Optimum Pass - MTOP (F)	MTOP Classification
1	9/16/2019	96.2	Passed	56.32	flagged	204.5	
2	9/17/2019	96.0	Passed	65	flagged	208.6	
3	9/18/2019	94.7	Passed	48.41	flagged	203.1	
4	9/18/2019	96.0	Passed	65	flagged	208.6	
5	9/19/2019	99.5	Passed	35.89	flagged	206.2	
6	9/19/2019	96.0	Passed	65	flagged	208.6	

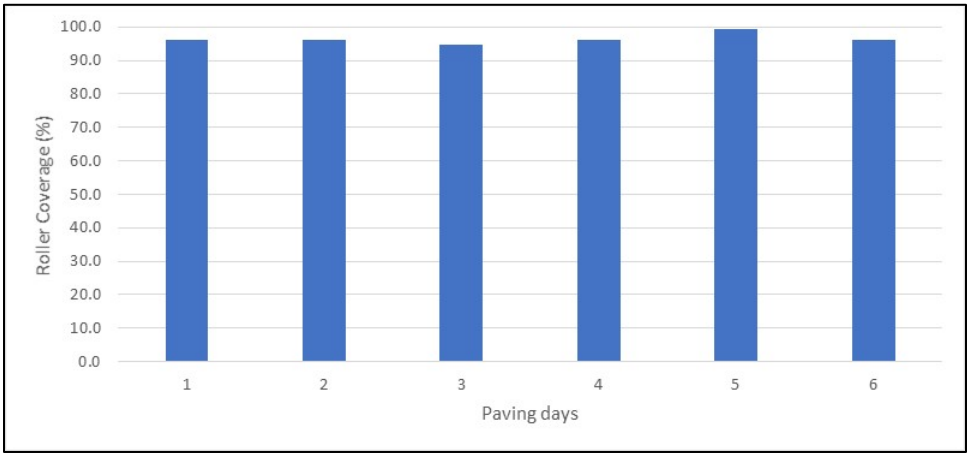

Figure 97: Summary of Roller Coverage Report for J7S3117, LP49

Overall Project Evaluation

The field projects were evaluated on various aspects including:

GPS Verification

- GPS verification and record keeping has mostly been done by contractors.

GPS and Cellular Signal Coverage

- GPS and cellular signal coverage have not been serious issues.

Functioning of IC Equipment and System

- Most IC equipment and systems were functioning except for some occasions (e.g., setting telematic for machines to collect data and transmit data). Data loss happens on those occasions. Vendor support is needed to correct these malfunctions quickly. Most projects allowed a grace period for repair of systems with no price disincentives applied. This has been officially implemented into the most recent version of specifications.

Functioning of PMTPS Equipment and System

- Similar to those in 2017 and 2018, there was only one PMTPS system used for these projects (MOBA). It is expected to have other PMTPS systems available in 2020.
- There were still issues regarding lack of technical training and support from vendors' dealers. Several system malfunctions occurred. Vendor support is needed to correct these malfunctions quickly. Most projects allowed a grace period for repair of systems with no price disincentives applied. This has been officially implemented into the most recent version of specifications.

Paving Boundary Measurements

- The paving boundary measurements were still collected using a hand-held GPS rover which is time consuming and labor intensive.

IC Data Collection and Submission

- Most IC data collection was conducted properly.
- The data submission to the MODOT SharePoint has greatly improved since 2018.

PMTPS Data Collection and Submission

- Most PMTPS data collection was conducted properly.
- The data submission to the MODOT SharePoint has greatly improved since 2018.

Other Data Collection and Submission (trial sections and core data)

- Trial section data were mostly recorded for these projects. There was only one project with IC and PMTPS data that did not upload a trial section.
- Some core locations were recorded for these projects. There is room for improvement for recording core locations and uploading them to SharePoint.

Completion of Checklist

- Contractor's checklist was mostly completed in 2019.
- RE's checklist and diary are not consistently uploaded to SharePoint, though it is not explicitly required in the specifications. It is recommended that the RE diary gets uploaded to complete the database.
- Nearly every contractor completed the contractor diary and paving records. This was greatly improved compared to 2018.

Utilization of Full Capabilities of IC and PMTPS Systems

- The roller coverage was much improved in 2019 compared to 2018, and even improved slightly from 2017. This is likely a result of contractors getting past the learning curve and making more of an effort to achieve the results required to receive price incentives.

IC-PMTPS Training Workshops

- There was one IC-PMTPS training conducted prior to the 2019 construction season.
- The refresher course was helpful to the contractors; however, there was still a large demand for remote support to remind the contractors how to analyze the data. All the contractors seemed to be more proficient with the data analysis compared to 2018.
- It is recommended to conduct refresher classes for contractors in 2020.
- It is recommended that a certification program be established to ensure each contractor has a person able to analyze and report the data.

IC-PMTPS Data Comparisons

IC-PMTPS Data Completion Summary

Most of the contractors submitted the required data to SharePoint as shown in Table 43.

Table 43: Completion of IC-IR Data Collection

Job No.	Route	Trial Section Data	IR Data	IC Data	GPS Data	Analysis Complete
J1I3169	I-35	Y	Y	Y	Y	Y
J5P3212	21, 32	Y	Y	Y	P	Y
J5P3114	63	Y	Y	Y	Y	Y
J6I3189	I-44	Y	Y	Y	P	Y
J6I3165	I-70	Y	Y	Y	Y	Y
J2P3133	54	Y	Y	Y	Y	Y
J9S3271	62	Y	Y	Y	Y	Y
J9S3282	61	Y	Y	Y	Y	Y
J1I3017	I-35	No Data				
J4I3122	I-435	No Data				
J5P3233	63	Y	Y	P	Y	N
J6P3184	141	Y	Y	Y	Y	Y
J1I3019	I-29	Y	Y	Y	Y	Y
J2P3135	54	Y	Y	Y	Y	Y
J4I3119	470	No Data				
J7I3084	I-44	Y	Y	Y	Y	Y
J7P3139	249	Y	Y	Y	Y	Y
J7S3116	LP49	Y	Y	Y	Y	Y
J7S3117	LP49	Y	Y	Y	Y	Y

Legend: Y- Yes N- No P- Partial

IC-PMTPS Checklist and Form Completion

Most REs have not submitted the checklist and diary as shown in Table 44. It is recommended that the REs submit their diary to SharePoint in order to complete the database. Most contractors have performed their analyses. This was improved from 2018.

Table 44: Completion of IC-IR Checklists and Forms

Job No.	Route	Contractor Check List	Paving Record Forms	Contractor Analysis	RE check List
J1I3169	I-35	Y	Y	Y	Y
J5P3212	21, 32	N	N	Y	N
J5P3114	63	N	Y	Y	N
J6I3189	I-44	N	Y	Y	P
J6I3165	I-70	Y	Y	Y	N
J2P3133	54	N	Y	Y	N
J9S3271	62	Y	Y	Y	N
J9S3282	61	Y	Y	Y	N
J1I3017	I-35	No Data			
J4I3122	I-435	No Data			
J5P3233	63	N	N	P	N
J6P3184	141	N	Y	Y	N
J1I3019	I-29	Y	Y	Y	N
J2P3135	54	N	Y	Y	N
J4I3119	470	No Data			
J7I3084	I-44	Y	Y	Y	Y
J7P3139	249	Y	Y	Y	Y
J7S3116	LP49	Y	Y	Y	Y
J7S3117	LP49	Y	Y	Y	Y

Comparison of IC-PMTPS Results

Overall the PMTPS data and IC coverage was significantly improved from 2018. The PMTPS segregation for each project in 2019 is shown in Figure 98. The PMTPS segregation by contractor is shown in Figure 99. The contractor code is shown previously in Table 6. The IC coverage for all projects in 2019 is shown in Figure 100. The IC coverage by contractor is shown in Figure 101.

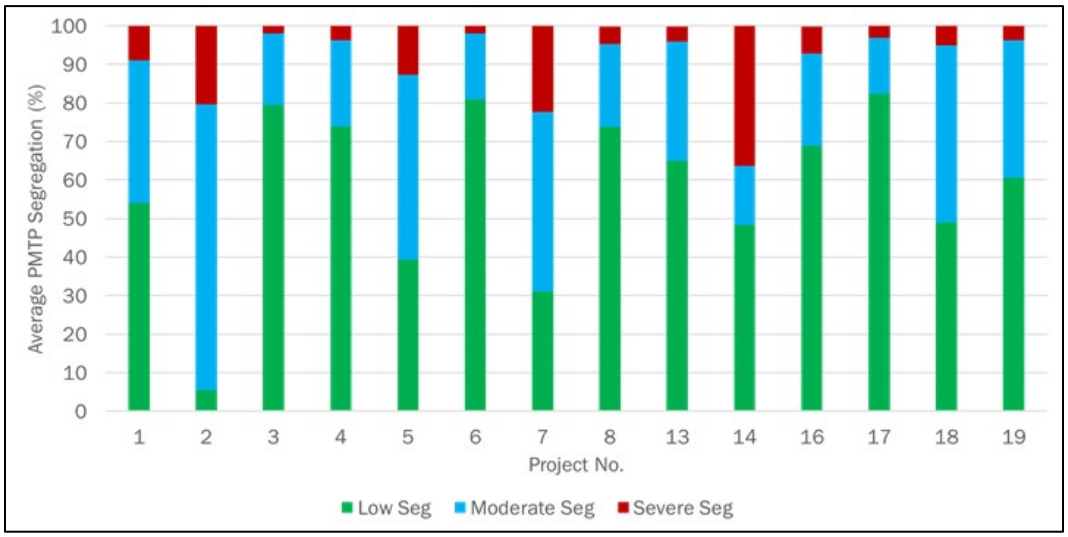

Figure 98: PMTPS Segregation for 2019 Projects

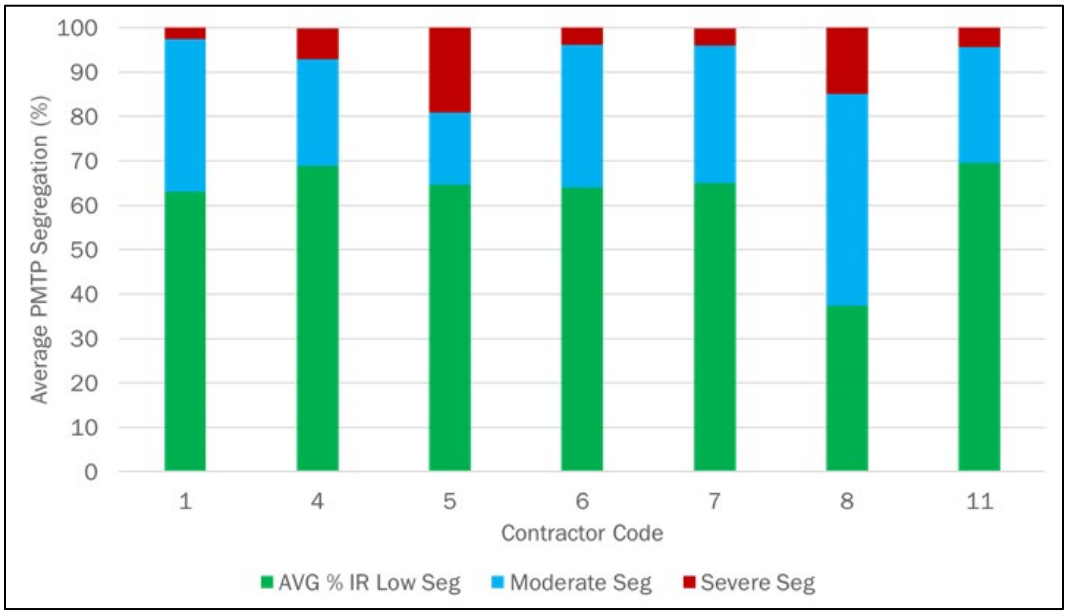

Figure 99: PMTPS Segregation by Contractor in 2019

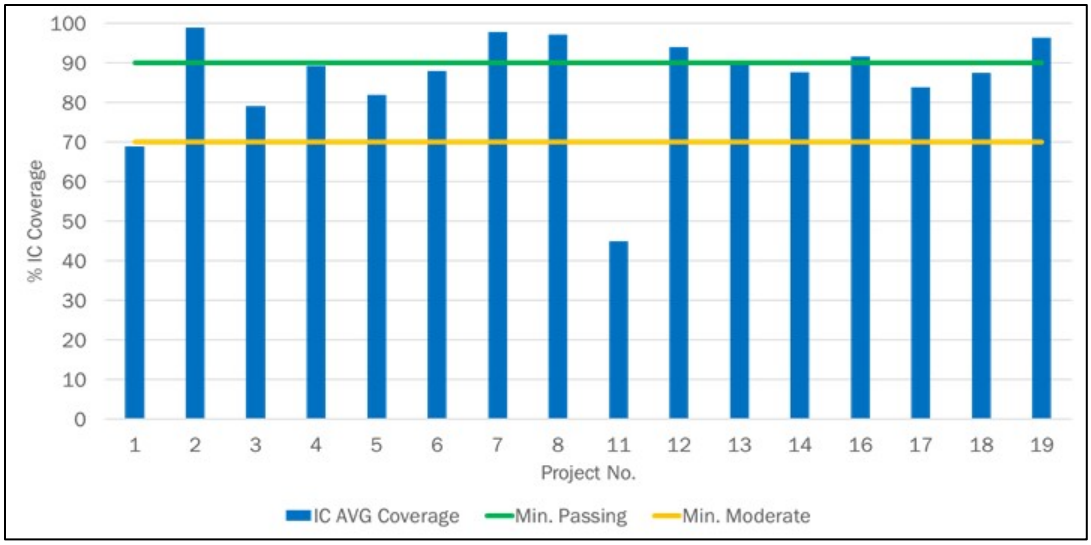

Figure 100: IC Coverage for All 2019 Projects

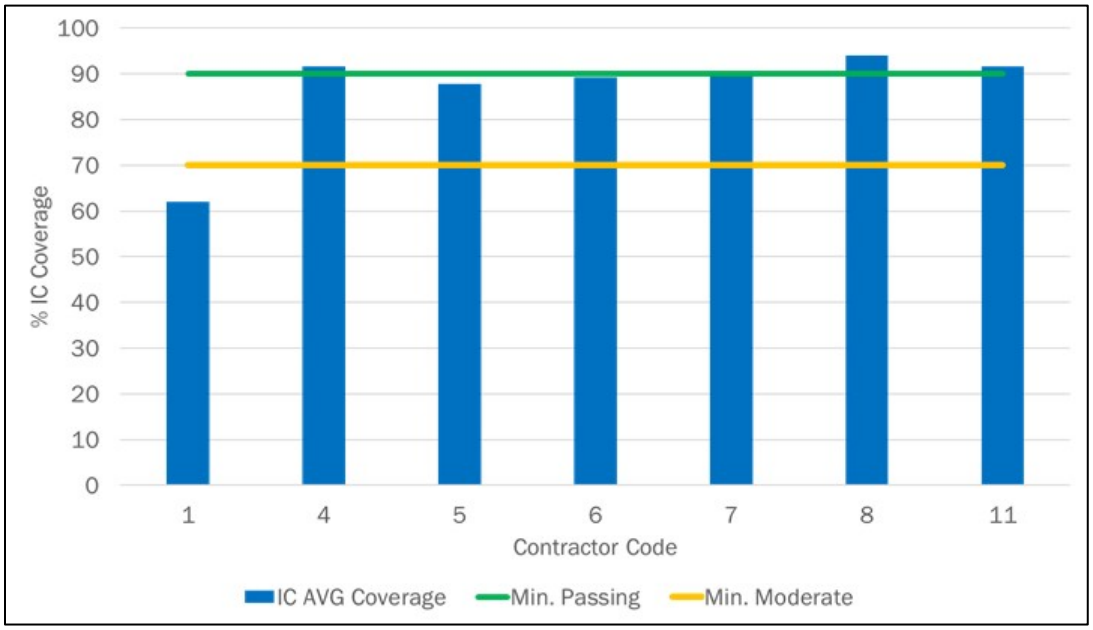

Figure 101: IC Coverage by Contractor in 2019

Comparisons of PMTPS segregation and IC coverage from 2017 to 2019 are shown in Figure 102 through Figure 104. PMTPS segregation results continue to improve each year. The low coverage in 2018 is attributed to the learning curve faced by contractors. In 2017 nearly every job had on-site support. This was greatly reduced in 2018. The efforts by the contractor were improved in 2019.

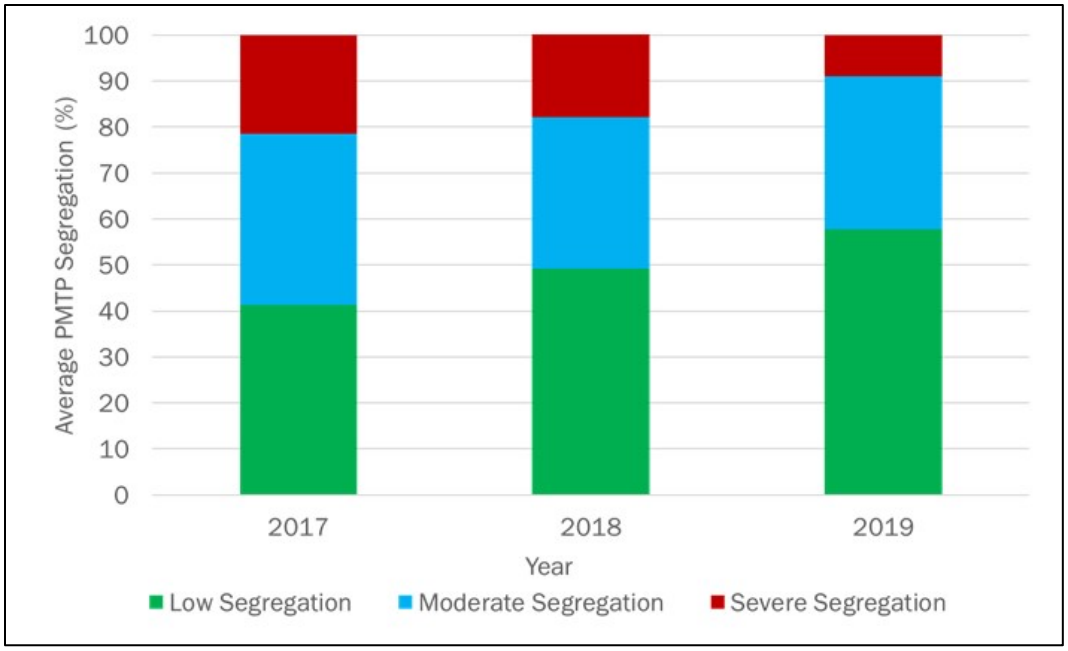

Figure 102: Average PMTPS Segregation for all Projects from 2017 to 2019

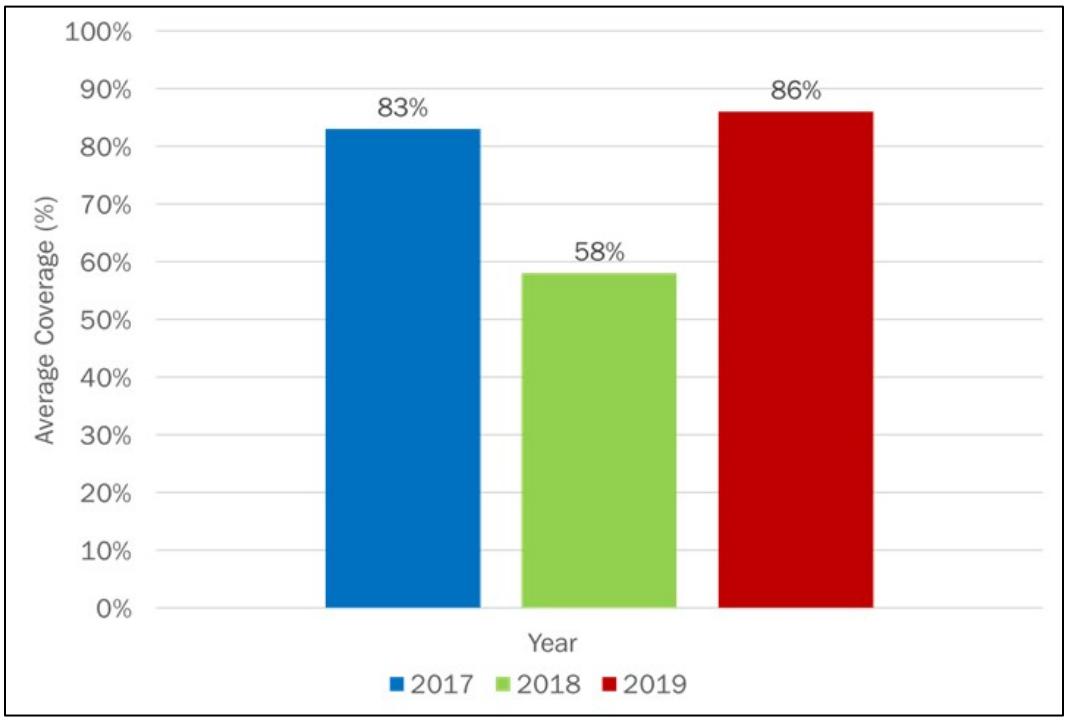

Figure 103: Average IC Coverage for all Projects from 2017- 2019

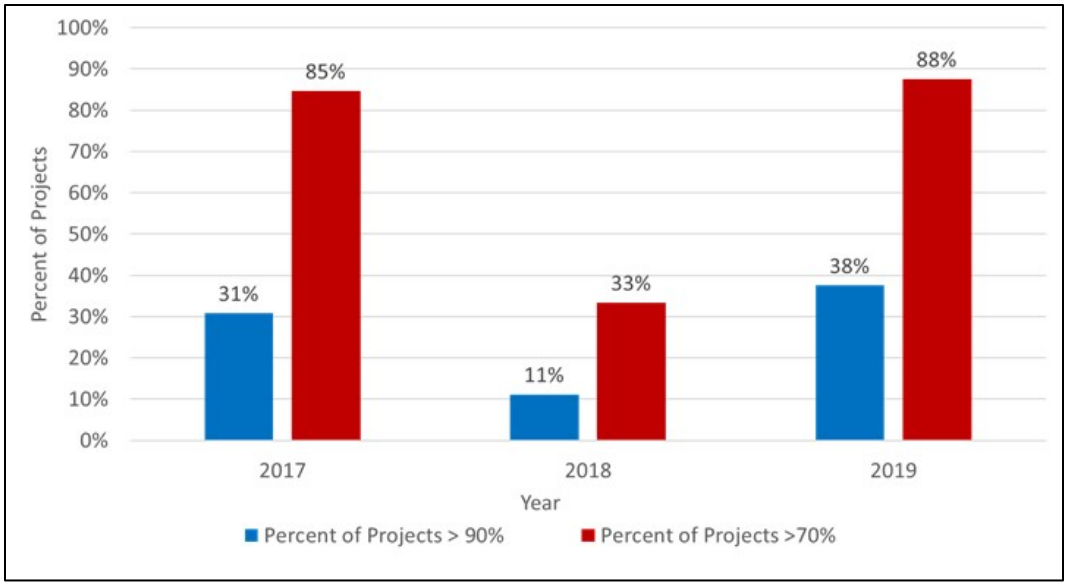

Figure 104: Percent of Projects with Coverage Greater than 90% and Greater than 70% from 2017-2019

Chapter 5 – Feedback Meetings, Summary, and Recommendations

Feedback Meeting

The feedback meetings took place at the MoDOT Central Lab in Jefferson City on December 18, 2019. The meeting was open to contractors, vendors, and MoDOT personnel. Following the meeting, a de-briefing took place with the research team and a FHWA representative. A meeting with MoDOT executives was held the following day on December 19, 2019. This meeting summarized all of the topics covered in the previous feedback meetings. A summary of the key discussions from the December 18, 2019 meeting with industry include:

- PMTPS suppliers: There will be more PMTPS suppliers available in 2020 to provide options and healthy competition for the industry. These PMTPS include Volvo, Vogele (RoadScan), and Caterpillar/Trimble. Healthy competition should encourage vendor customer support and equipment improvements.
- Correlation to density: contractors would like to see if there is a correlation between in-place asphalt density with IC/PMTPS measurements, including pass count and temperature. This will be included in future analysis efforts as performance tracking.
- GPS/temperature validation: contractors suggested reduced frequency of strict daily validation requirements. This will be taken into consideration for future specification updates.
- Clarification of how to handle equipment failures: There are still times that the equipment malfunctions and the contractors do not always have good vendor support. MoDOT has addressed this specifically in the new specifications. The new specifications include verbiage that allows the contractors to be temporarily exempt from disincentives while the equipment is repaired as long as they notify the RE immediately and make a reasonable effort to fix the equipment quickly.
- Trial sections:
    - The research team suggested flexibility for minor adjustment during production compaction, if needed (e.g. +1/-1 pass from the target pass determined from the trial section).
    - For the second or third trial sections, contractors suggested using simplified methods or using longer sections than 1000 ft. to more closely represent production paving.
    - Note that there were changes to the IC specifications that allow for more leniency with the trial sections that most contractors were not aware of and did not take advantage of. It is recommended to try and inform REs and contractors of specification changes.
- Further discussion on trial sections (contractors citing KS examples as possible solution to eliminate or reduce coring)
    - Use a 1000-foot section to establish target passes.
    - Take NDG measurements at 10 locations. Each NDG measurement takes 5 readings at 1 min. (may turn NDG 90 degrees). Then, the high and low readings are excluded. The final measurement is the average of the remaining

3 readings.
    - Take cores at the 10 locations. Then use the core density values to calibrate both contractor's and DOT's NDGs.
    - Cores are not taking routinely during production, instead the calibrated NDG results are used.
- Minimum compaction temperature: There were suggestions to adjust temperature requirements for warm mix asphalts.
- Poor compaction results with consistent passes: contractors reported observations of poor subgrade conditions and suspected such results may be due to poor or variable support conditions under the compacted asphalt layers.
- FHWA comments on acceptance:
    - It was suggested to weight density higher. 40% has been used for pay-factors in some states, with weighting for VMA being 10%.
- Contractors suggested not increasing the weighting of density for pay-factors higher, citing the following reasons:
    - Soft spots or variable support condition may be present.
    - Significant differences in the ICMV during the trial section from the production paving have been observed.

Following this meeting, the discussions at the de-briefing included:

- Certification program: There was a discussion on a certification program for IC/PMTPS technicians. This will largely include data analysis and using Veta.
- Future acceptance: The expected timeline is to begin using IC/PMTPS for acceptance by 2021. This will likely still include coring. However, the main price incentives will be for IC/PMTPS.
- Data QA: In order to implement acceptance using IC/PMTPS by 2021, it is recommended that the FHWA QA requirements should be piloted in 2020 and completed by 2021. IC/PMTPS projects may continue using state funds until the FHWA data QA requirements are met.
- Data QA data processing spreadsheet tool: Until Veta includes a solution, the research team will work on a spreadsheet to implement immediately for the pilot projects in 2020 to compare the QA and contractor data. The Veta solution is expected to be available in 2021.
- Boundary survey: Innovative solutions to establish a boundary more efficiently will be piloted in 2020.
- Trial section: All discussed that specification changes may include more leniency on the trial section, or that contractors be notified of the changes already made for the 2019 projects that were not utilized on all projects.
- Future efforts: There was discussion for further efforts by research team to provide consulting support in 2020.
- Implementing PMTPS statewide: There was recommendation that there be statewide implementation of PMTPS since all contractors already have buy-in, and it appears to be simple-to-use.

Summary

The final results of IC data and PMTPS data indicate that implementing these technologies is improving the roller coverage at the optimum density and reducing thermal segregation behind the paver. MoDOT is progressing towards its goal of full implementation of IC and PMTPS technologies by 2021. The use of these technologies provides information on 100% of the pavement, as opposed to traditional spot testing. IC coverage requirements target an optimum density, rather than minimum requirements typically specified for spot tests. In addition to the quality benefits, these technologies are arguably safer for contractors and MoDOT personnel as there will be a reduction or elimination of taking physical core samples in the future.

Based on poor IC coverage results, there appears to have been a learning curve for contractors during the 2018 construction season. This was the first year that contractors were largely responsible for all data collection and analysis with limited on-site support from the Research Team. It is also possible that contractors did not make significant efforts to implement the technologies, under the assumption that MoDOT may decide to eliminate the requirements in future years. The IC coverage in 2019 was significantly improved. The data submission, naming convention, completion of contractor analysis, and submission of reports were also significantly improved from 2018 to 2019.

Thermal segregation consistently improved year to year. There was approximately a l0% decrease in severe thermal segregation, and approximately a 10% increase in low thermal segregation based on the AASHTO definitions of low and severe.

Based on industry feedback, there are still a few challenges associated with the implementation of IC and PMTPS technology. These are addressed in the following section “Final Recommendations”.

Final Recommendations

There are a few recommendations based on lessons learned and industry feedback that should be considered. This section describes these recommendations.

Continual training and refresher courses should be offered to contractors and MoDOT personnel. There is generally high turnover of employment for IC technicians and providing continual training will ensure opportunities for contractors and MoDOT personnel to learn the relatively new technology. Remote support should be offered for experienced contractors, while novice contractors should be given on-site support for initial implementation.

A certification program for Veta technicians would be useful for tracking and training technicians to analyze and understand intelligent construction data. It is recommended that a certification program be developed and implemented to assess the skill level of participants in interpreting and analyzing data. This could be valuable for both contractor personnel and MoDOT employees who will be performing QA on the contractor submitted data. The program should be developed so that it is easily distributed by MoDOT or a third-party consultant.

Using contractor data for acceptance comes with specific QA requirements per the Code of Federal Regulations (CFR) 23 CFR 637 Subpart B. This requires methods to independently verify the data. Candidate QA equipment includes the use of infrared cameras for validating PMTPS data, and GPS asset tracking devices to validate IC coverage or pass count data. Developing QA methods for IC and PMTPS QA is critical to achieving the full implementation

goals set by MoDOT. These methods need to meet the CFR requirements and be able to be simply and safely implemented by MoDOT REs. It is recommended that QA procedures be developed as soon as possible and piloted in the 2020 season in order to expedite potentially lengthy approval processes by FHWA. Implementing QA procedures may start with basic spreadsheet tools to compare the IC and PMTPS data to the independent QA equipment, and eventually work towards a tool in Veta that can quickly do the comparison.

There are other intelligent construction technologies that may be beneficial to MoDOT's program. One technology, in particular, is the use of dielectric constant profilers (DCP). This technology, when used correctly, has the capability of determining full coverage asphalt density in almost real-time. Scanning equipment is used behind the finish roller to continuously map density. The equipment must be calibrated using cores specific to the asphalt where density is being measured. It is recommended that these technologies be piloted in future construction seasons to see what benefits they bring to the MoDOT intelligent construction program.

One of the biggest complaints among contractors is the labor-intensive boundary data collection. This requires collecting GPS coordinates along the boundary of paved roads on a daily basis in order to evaluate percent coverage. There are several emerging technologies that can do this at traffic speed. It is recommended that some of these technologies be piloted in 2020 in order to reduce the labor required by the contractors. Responding to contractor concerns and complaints is a good way to encourage their participation and successful implementation of new technologies.

Giving feedback to equipment vendors that expresses the frustration of contractors regarding equipment malfunction is recommended. It is the responsibility of the vendor to assist with troubleshooting and timely repair of equipment. Healthy competition of multiple vendors should naturally assist with this. The verbiage in the specifications that temporarily dismisses price disincentives to allow the contractors time to fix the malfunctioning equipment should remain in-place while these technologies are still advancing.

Continual active participation in the Intelligent Construction Transportation Pooled Fund (TPF) is encouraged. This is an efficient way to voice needs to the other participating State DOTs and align with national efforts. If the scope of MoDOT's needs differs from those of the existing TPF, a new TPF specific to MoDOT's needs may be considered.

There were several comments during the industry meetings regarding performance tracking of IC and PMTPS projects. Contractors generally understand that these technologies are promoting best practices. However, a direct correlation to pavement performance will strengthen the efforts and participation of contractors. It is recommended that performance tracking for some of the projects constructed from 2017-2019 and beyond be investigated and documented.

Based on the progress since 2017, it can be anticipated that MoDOT will be the second leading DOT, with MnDOT being the first, to fully implement IC and PMTPS in the near future.