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16. Abstract

An implementation project was performed to expand use of transversely varied asphalt rate (TVAR) seal coat practices in all districts. The project included nine regional workshops, continued field texture testing of test sites, provided one set of sand patch test equipment to each TxDOT district, and published 500 copies of the TVAR Field Guide for broad TxDOT distribution.

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. This report is not intended for construction, bidding, or permitting purposes. The engineer in charge of the project was Paul E. Krugler, P.E. #43317. The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report.

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This project was conducted in cooperation with TxDOT and FHWA. The authors thank Tammy Sims of the Maintenance Division, TxDOT's Project Director for this implementation project, for her continued guidance and assistance throughout this project. Appreciation is also extended to the many individuals in the districts who provided traffic control for the numerous pavement test locations and who were essential to the planning and hosting of the regional workshops held throughout the state. Special thanks are extended to Randy King, John Baker, Darlene Goehl, Ernest Teague, and Jimmy Parham for their assistance in presenting their districts' experiences using TVAR at regional workshops.

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CHAPTER 1: INTRODUCTION

A survey performed during Research Project 0-5833, "Synthesis Study on Variable Asphalt Shot Rates for Seal Coats," determined that only about half of the Texas Department of Transportation (TxDOT) districts were routinely using transverse variable asphalt rates (TVAR) in seal coat operations. While this disparity in usage was found, the survey also found strong indication among those districts using it that TVAR reduced likelihood of reoccurrence of wheel path flushing. This implementation report documents activities undertaken to attain statewide implementation of TVAR in Texas.

ORGANIZATION OF THE REPORT

There were three primary aspects of the planned implementation effort. After this introductory chapter, a chapter of this report is dedicated to each of these primary activity areas. Chapter 2 documents the series of TVAR regional workshops held over a two-year period. Chapter 3 describes provision of sand patch test kits and TVAR Field Guides throughout the state. Chapter 4 presents follow-up texture test data obtained from pavements seal coated during Research Project 0-5833. A comparison of performance is made between pavements selected for TVAR seal coats and those not selected. Chapter 5 includes conclusions and recommendations based on all implementation project activities.

CHAPTER 2: TVAR REGIONAL WORKSHOPS

Nine regional TVAR workshops were held across the state to teach TVAR concepts. Table 1 indicates the dates and locations of these workshops. The workshops included both classroom and roadside training modules. Appendix A includes an example regional workshop agenda. TxDOT personnel experienced in using TVAR methods greatly assisted in the success of these workshops by sharing personal experiences with attendees from other districts. TxDOT personnel assisting in workshop instruction included Darlene Goehl of the Bryan District, Randy King of the Brownwood District, Ernest Teague of the Paris District, John Baker of the Atlanta District, and Jimmy Parham of the Lufkin District.

Table 1. TVAR Regional Workshop Dates and Locations.

Date	Location
March 25, 2009	Odessa District Office
April 16, 2009	Wichita Falls District Office
April 23, 2009	Tyler District Office
April 27, 2009	Corpus Christi District Office
April 30, 2009	200 Riverside Building, Austin, TX
February 23, 2010	Bexar Metro Office, San Antonio, TX
March 1, 2010 - morning	Bryan District Office
March 1, 2010 - afternoon	Bryan District Office
March 4, 2010	Lubbock District Office

The regional workshops were planned and coordinated in conjunction with the Training Section of TxDOT's Human Resources Division. The Training Section assigned course number IPR007 to the course, and TxDOT personnel records of those attending the workshop were documented to show the training received.

The roadside training module included demonstration of the sand patch test followed by a practical exercise in which each participant was invited to perform the test for comparison with results from other attendees. Figure 1 shows the practical exercise in progress.

Figure 1. Roadside Practical Exercise.

A total of 225 TxDOT personnel attended these workshops. District and division participation breakdown is shown in Table 2.

Table 2. Workshop Attendance by District and Division.

District/Division	2009 TVAR Regional Workshops					2010 TVAR Regional Workshops				Total Attendance
	Odessa	Wichita Falls	Tyler	Corpus Christi	Austin	San Antonio	Bryan (AM)	Bryan (PM)	Lubbock	
1		1	3							4
2			3							3
3		12								12
4		2								2
5									16	16
6	5									5
7	5									5
8	4									4
9			10					4		14
10			6					4		10
11			5							5
12							2	2		4
13					1	3				4
14					9					9
15				4	3	13				20
16				15		8				23
17					5		27	8		40
18										0
19			3							3
20			3					6		9
21				4						4
22				8		3				11
23	1				1					2
24	9									9
25										0
CST					2	1		4		7
Totals	24	15	33	31	21	28	29	28	16	225

Both the classroom and roadside training modules of the workshop held in Austin on April 30, 2009, were videotaped by TxDOT's Pavement Preservation Center, thereby making TVAR training available on an on-going basis as the need may arise. An instructor's guide and the PowerPoint® presentation used for the workshops were also provided to TxDOT for possible later use.

CHAPTER 3: SAND PATCH TEST KITS AND TVAR FIELD GUIDES

SAND PATCH TEST KITS

The sand patch test has been a TxDOT test method for many years, used primarily in earlier years to determine adequacy of concrete bridge deck texturing. The procedure and equipment is prescribed in Texas Test Method Tex-436-A. A number of districts no longer possessed a sand patch test kit because of declining test applications. For this reason this implementation project included providing a sand patch test kit for each of TxDOT's 25 district offices.

Figure 2 shows a sand patch test kit as provided to each district. The test kits were distributed to most districts during the regional workshops. Remaining test kits were delivered to the TxDOT Maintenance Division for appropriate distribution.

Figure 2. Sand Patch Test Kit.

TVAR FIELD GUIDES

A TVAR Field Guide was developed as a product of Research Project 0-5833. This implementation project included publication and distribution of the field guide. Field guide content remained unchanged from the version accepted as a product of Research Project 0-5833. Five-hundred copies of the field guide were provided to TxDOT. Each participant in the TVAR regional workshops was provided a copy, and remaining copies were delivered to the TxDOT Maintenance Division for later distribution at conferences and other opportunities. Figure 3 shows the field guide cover, and Figure 4 lists field guide content.

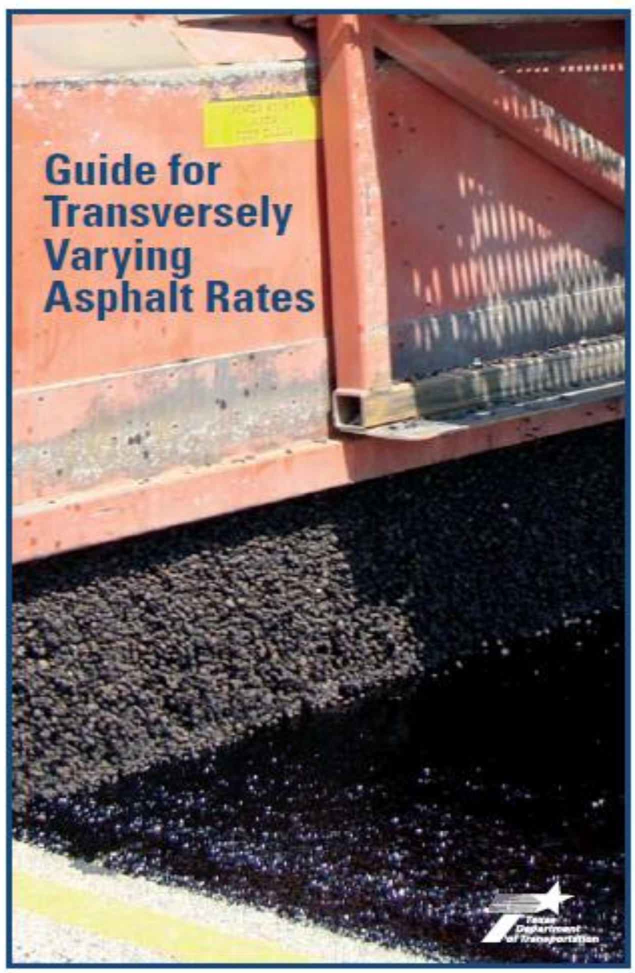


Figure 3. TVAR Field Guide Cover.

Guide Organization

Guide for Traversely Varying Asphalt Rates v

Figure 4. TVAR Field Guide Table of Contents.

CHAPTER 4: FOLLOW-UP TEXTURE TESTING OF PAVEMENT LOCATIONS ORIGINALLY TESTED DURING THE RESEARCH PROJECT

The implementation project included revisiting at one-year intervals, for two years, the seal coats observed during the original research project. Of the 30 seal coats included in the original study, five were no longer available for testing due to pavement reconstruction or later placement of microsurfacing. Documentation obtained during the original research project allowed researchers to again perform the sand patch texture depth test on the exact locations as the pre-seal coat tests had been performed.

TEXTURE TESTING PROCEDURES

As done during the research project, three texture tests were performed in accordance with Texas Test Method Tex-436-A, "Measuring Texture Depth by the Sand Patch Method," and the results were averaged to determine a representative texture depth for the pavement location's wheel path condition. Another three tests were performed and averaged to represent the pavement location's between wheel path condition. Figure 5 shows the standard test layout used for all sand patch testing.

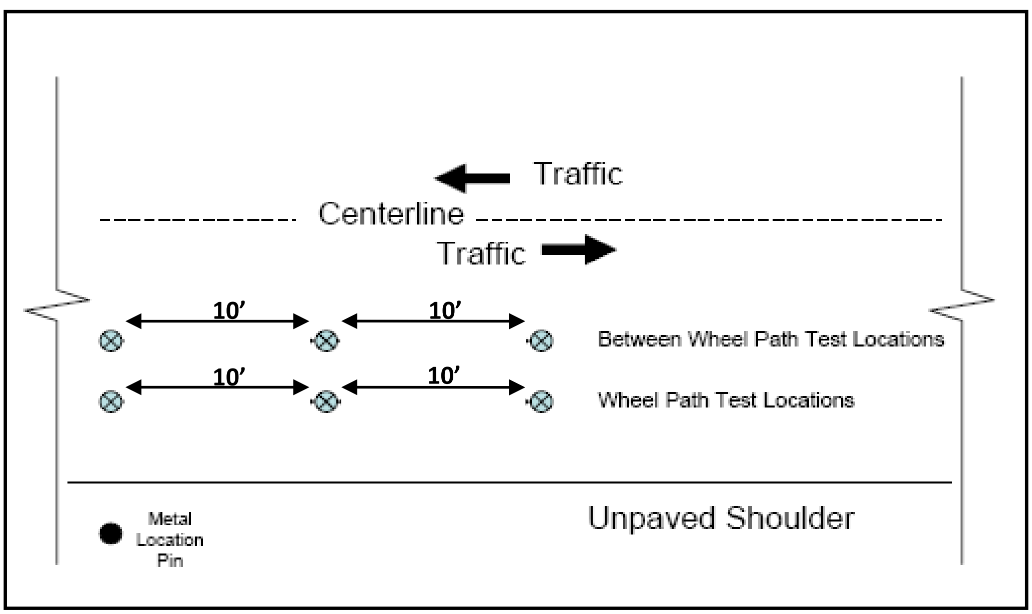


Figure 5. Standard Pavement Texture Test Location Layout.

To reduce inaccuracy due to test procedure repeatability limitations, the same operator who performed all sand patch testing for the original research project also performed all sand patch testing during this implementation project.

Locations where texture tests were performed prior to seal coat construction had been documented during the research project based on GPS coordinates of a metal pin placed in the pavement shoulder and measurement of the transverse distance from that pin to the texture test wheel path and between wheel path locations. Figure 6 shows the procedure for relocating an original test location prior to post-seal coat testing in 2009 and 2010. Once the first wheel path and between wheel path locations were identified, the four additional test locations were determined by measuring in 10-ft intervals as indicated in Figure 5.

Figure 6. Identifying Texture Test Locations.

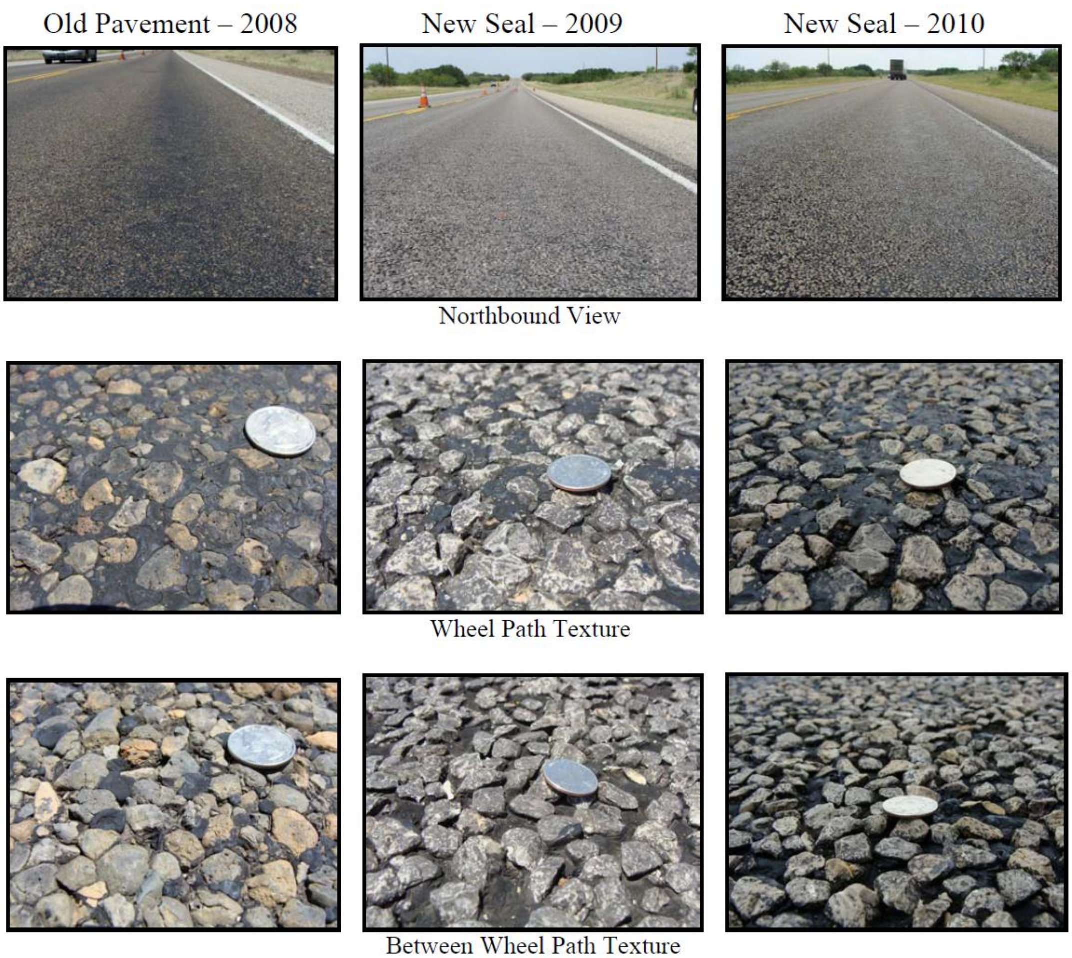
In 2009 and again in 2010, photographs of each location were taken similarly to the photography taken prior to placement of the seal coats in 2008. Photography included close-ups of pavement textures both in the outside wheel path and between the wheel paths. Figures 7 and 8 are a pair of close-up photographs of the seal coat textures on US 283 in the Brownwood District after two years of traffic. Note the welling up of asphalt between the aggregates in the wheel path photograph.

Figure 7. Wheel Path Texture Close-up on US 283 Two Years after Seal Coat Placement.

Figure 8. Between Wheel Path Texture Close-up on US 283 Two Years after Seal Coat Placement.

The sand patch test results over a two-year period and the photography provide an opportunity for early analysis of success in mitigating return of wheel path flushing using TVAR. A summary sheet showing texture depth test results and corresponding photography obtained between 2008 and 2010 for each pavement location is found in Appendix B. Appendix C displays all texture depth data in a single table. An example of the Appendix B summary sheets is displayed in Figure 9.

US 283 (Location 2) – Coleman County
Grade 3 Aggregate with Straight AC-20XP at 0.47 gal/SY



Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.04	2.16	1.94
Between WP	1.91	3.51	3.19
Difference	0.87	1.35	1.25

Figure 9. Example of Appendix B Texture Depth and Photography Summary Pages.

ANALYSIS OF TEXTURE TEST RESULTS

A primary purpose of revisiting the seal coated pavements to monitor performance was to verify the original project's recommendations pertaining to when TVAR was appropriate. The research team utilized multiple approaches to analyze the gathered information, including:

- ❖ Tabular display listing all studied pavement locations indicating which locations met field guide TVAR use criteria, based on pre-seal coat sand patch test results, versus which locations actually received TVAR seal coats.
- ❖ Graphical display of differences in wheel path texture depth across the lane obtained over the two-year time period for all seal coated pavements included in the study.
- ❖ Graphical display of wheel path texture depth information obtained over the two-year time period for all seal coated pavements included in the study.
- ❖ Graphical displays of wheel path texture depth information obtained over time, separately, for pavements where the TVAR method was used and where the TVAR method was not used.
- ❖ Graphical displays of wheel path texture depth information obtained over time, separately, for pavements where Grade 3 seal coats were placed and where Grade 4 seal coats were placed.
- ❖ Tabular display of wheel path texture depths over time, showing degree of texture retention, for all seal coats and for Grade 3 and Grade 4 seal coats separately.
- ❖ Performance comparisons of location pairs with either differing apparent need for TVAR but that received the same asphalt application or near identical need for TVAR with one receiving TVAR asphalt application and the other not receiving it.
- ❖ Side-by-side photography comparisons (Appendix B) showing changes in seal coat texture appearance over the two-year time period of the study.

The above analyses provide a variety of observations. Discussions which follow first consider global views of the test results, and then findings from comparisons of location pairs are presented.

Sand patch test criteria guidance in the field guide for warranting TVAR use is shown in Table 3. Table 4 lists all pavement test locations and indicates whether or not the field guide criteria were met and whether or not the TVAR method was used.

Table 3. TVAR Field Guide Recommendations for Interpreting Sand Patch Test Results.

Difference in Sand Patch Average Diameters, mm	TVAR Rate Increase Outside of Wheel Paths
Less than 20	None
21 to 50	15%
Greater than 50	30%

Table 4. All Pavement Locations and TVAR Selections.

Highway - Location	Meets Field Guide TVAR Criteria	District TVAR Decision	Seal Coat Aggregate Grade	Actual Asphalt Application Rate, Gal/SY	
				Wheel Path	Outside Wheel Path
US 190 – 1	No	No	3	0.45	0.45
US 190 – 2	No	No	3	0.48	0.48
US 190 – 3	No	No	3	0.50	0.50
SH 153	Yes, 15%	No	3	0.49	0.49
FM 3425	Yes, 15%	No	3	0.42	0.42
US 283 – 1	Yes, 15%	No	3	0.47	0.47
US 283 – 2	Yes, 15%	No	3	0.47	0.47
FM 2134 – 1	Yes, 15%	No	3	0.52	0.52
FM 2134 – 2	No	No	3	0.52	0.52
SH 6	Yes, 15%	No	3	0.45	0.45
FM 2689 – 1	Yes, 15%	Yes, 27%	3	0.30	0.38
FM 2689 – 2	No	Yes, 27%	3	0.30	0.38
FM 696 – 1	No	No	4	0.36	0.36
FM 696 – 2	Yes, 30%	No	4	0.36	0.36
FM 908 – 1	Yes, 30%	Yes, 19%	4	0.32	0.38
FM 908 – 2	Yes, 15%	Yes, 19%	4	0.32	0.38
FM 908 – 3	NA	Yes, 15%	4	0.39	0.45
FM 2027 – 1	NA	No	4	0.38	0.38
FM 2027 – 2	NA	No	4	0.38	0.38
FM 819 – 1	Yes, 15%	NA	4	NA	NA
FM 819 – 2	Yes, 15%	NA	4	NA	NA
SH 147 – 1	Yes, 15%	Yes, 19%	4	0.32	0.38
SH 147 – 2	No	No	4	0.33	0.33
SH 147 – 3	Yes, 30%	No	4	0.34	0.34
SH 147 – 4	No	No	4	0.38	0.38
SH 103 – 1	Yes, 30%	Yes, 28%	4	0.25	0.32
SH 103 – 2	Yes, 15%	No	4	0.35	0.35
SH 103 – 3	Yes, 15%	Yes, 27%	4	0.30	0.38
FM 2457 – 1	Yes, 30%	Yes, 38%	4	0.24	0.33
FM 2457 – 2	Yes, 30%	Yes, 31%	4	0.26	0.34

In summary of Table 4, the field guide criteria for a full measure of TVAR use was met at six pavement locations. TVAR was actually used at four of these pavement locations. The criteria for TVAR use at a lesser percentage were met at an additional 13 pavement locations, with the districts using TVAR at four of these locations. Criteria for TVAR use was not met or was not determined at the remaining 11 pavement locations. TVAR was known to be used at one of these 11 locations.

Lack of congruence between field guide TVAR warrants for given locations as shown in Table 4 and field TVAR-use decisions by the districts was expected due to the nature of the selection of a number of the test locations. To better show effect of TVAR use and capture performance comparisons during the research project, several pairs of pavement locations with distinctly different textures and TVAR needs were purposely selected in close proximity on the same lane so that relative performances could be compared resulting from the identical asphalt application occurring on both.

Another important factor to be considered when analyzing wheel path texture depth test results is that rapid loss of wheel path texture at pavement locations where TVAR was used cannot, in itself, be conclusively considered a failure of the TVAR method to prevent or mitigate return of wheel path flushing. Improper or less than optimal selection of the design asphalt application rate, which by definition is the asphalt rate to be applied in the wheel paths, is very likely a more significant contributor to less than desirable wheel path texture than the decision to use TVAR or not at that location. This is true because proper use of the TVAR method requires the seal coat designer to select the design asphalt rate based solely on needs for asphalt to hold the wheel path aggregate. The minimum asphalt rate which avoids loss of wheel path aggregate is the desired design amount for flushed wheel paths. Then, the seal coat designer determines if additional asphalt will be needed outside of the wheel paths to prevent aggregate loss in those locations. If so, a TVAR percentage is selected to *increase* the asphalt rate for application outside of the wheel paths.

Figure 10 displays differences in texture depth test results across the lane over the two-year period of the study for all pavements included in the post-seal coat texture test study. The pavements are sequenced from left to right on the chart from least to greatest pre-seal coat texture depth difference across the lane. In other words, pavements with the most uniform textures across the lane are displayed on the left portion of the chart. These more uniform textures in some cases resulted from the pavement being uniformly low in texture across the lane and in others cases from the texture being more uniformly deep across the lane. In either scenario resulting in a relatively high degree of texture uniformity across the lane, the TVAR Field Guide recommends use of a transversely uniform asphalt application rate instead of TVAR. Shading is used on the figure to show which pavements fell into the two categories for recommended use of TVAR seal coats as determined by the pre-seal coat texture depth differences across the lane. The double-frame text boxes indicate which pavement locations actually received a TVAR treatment and the percentage difference in the asphalt application rate.

Several observations may be made from Figure 10. District decisions to use TVAR are in general agreement with field guide recommendations. There is, however, an indication that the three districts involved in this study tend to use TVAR less often than indicated by the current field guide recommendations. Another observation is that when a district did choose to use TVAR, and a higher TVAR percentage was selected for use, these pavements were among the group of pavements meeting field guide criteria for higher percentage TVAR applications. The single location where field guide criteria recommended uniform asphalt application and the district instead used TVAR was on FM 2689 location 2. While location 2 had a relatively uniform texture location, it was not believed to be the most common texture situation found throughout the FM 2689 pavement length to be sealed. The texture difference found at FM 2689 location 1 was considerably greater and in all likelihood better represents the condition of the entire pavement length to be sealed. Pavement locations 1 and 2 were within 600 ft of each other. A final observation is the uniquely high textures found in 2009 and 2010 on FM 2134 at location 2. This location is on a short dead-end length of pavement just past a park entrance. There are only two or three residences past the park entrance on FM 2134, and it was uncertain if these homes were inhabited. So traffic level on this pavement location is extremely low.

Similarly, Figure 11 displays the wheel path texture depths found in the outside wheel paths over the two-year period of the study. Observing the change in wheel path texture alone is another method of studying degree of success in mitigating return of wheel path flushing when TVAR is used during seal coat construction. The pavements are sequenced in the same manner as in Figure 10, facilitating comparison of displayed information.

Observations to be made from Figure 11 include that wheel path textures varied widely among pavement locations selected for study. It is evident on the left portion of the chart that pavements with relatively uniform textures across the lane in some cases were uniformly low textured and in some cases were uniformly well textured. Within two years, wheel path textures were less than the textures existing prior to seal coat construction at four pavement locations. However, three of these four had rather good wheel path textures prior to receiving the new seal coat and the resulting wheel path textures are still considered satisfactory.

Figure 12 displays wheel path texture depth test results for only the pavement locations where TVAR methods were used. On this chart the test results are sequenced from lowest to highest pre-seal coat wheel path texture depth. Conversely, Figure 13 displays results for only the pavement locations where TVAR methods were not used.

Figure 12 shows that after two years of traffic two of the pavement locations were found to have wheel path textures less than respective wheel path textures prior to the TVAR seal coat placement. These two TVAR locations were the lowest percentage TVARs included in the study, both at 19 percent. Similarly to one of the observations made on Figure 10, the districts frequently chose high TVAR percentages at locations where wheel path texture depths were the lowest. These pavements are those displayed on the left portion of the chart. Also note there are no 2010 texture data displayed for SH 103 locations. SH 103 was microsurfaced earlier in 2010. The district determined that microsurfacing was necessary to ensure long lasting adequacy of pavement textures. This pavement had been the worst flushing condition included in the original research project.

Figure 13 displays wheel path texture depth test results for the pavement locations where TVAR methods were not used when the seal coat was constructed. Only two of the 16 locations were found to have wheel path texture depths lower after two years of traffic than those existing prior to seal coat placement. Besides these two exceptions, wheel path texture depths two years later were usually considerably higher than pre-existing texture depths.

One district participating in this project used only Grade 3 seal coat aggregate, one used only Grade 4 seal coat aggregate, and the third used both Grade 3 and Grade 4 seal coat aggregates. As Grade 3 aggregate seal coat inherently creates more texture depth because of the larger aggregate size, Figures 14 and 15 were prepared to observe TVAR performance of just Grade 3 aggregates and just Grade 4 aggregates, respectively.

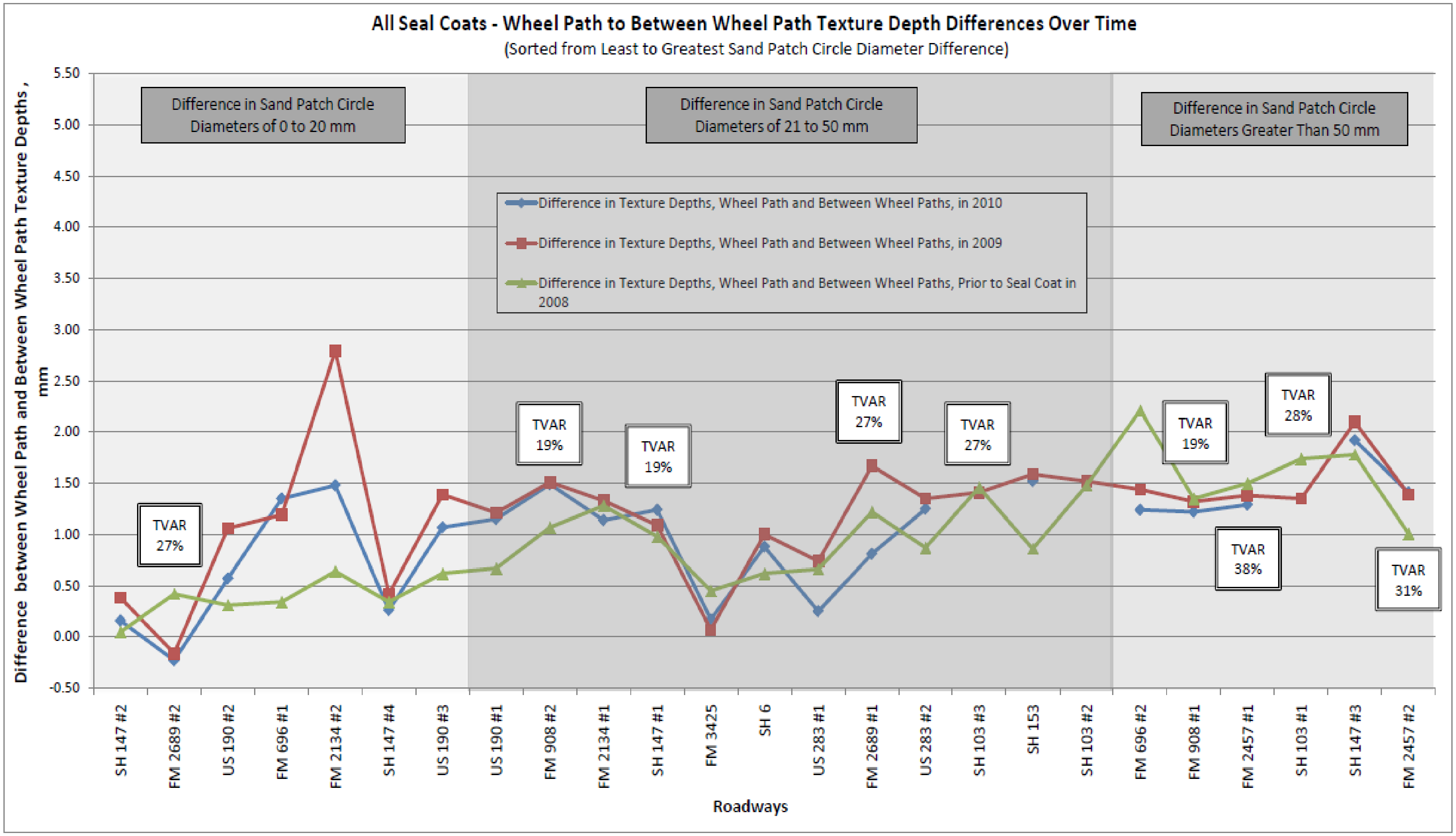


Figure 10. Transverse Difference in Texture Depth over Time Sorted by Difference in Sand Patch Test Circle Diameters.

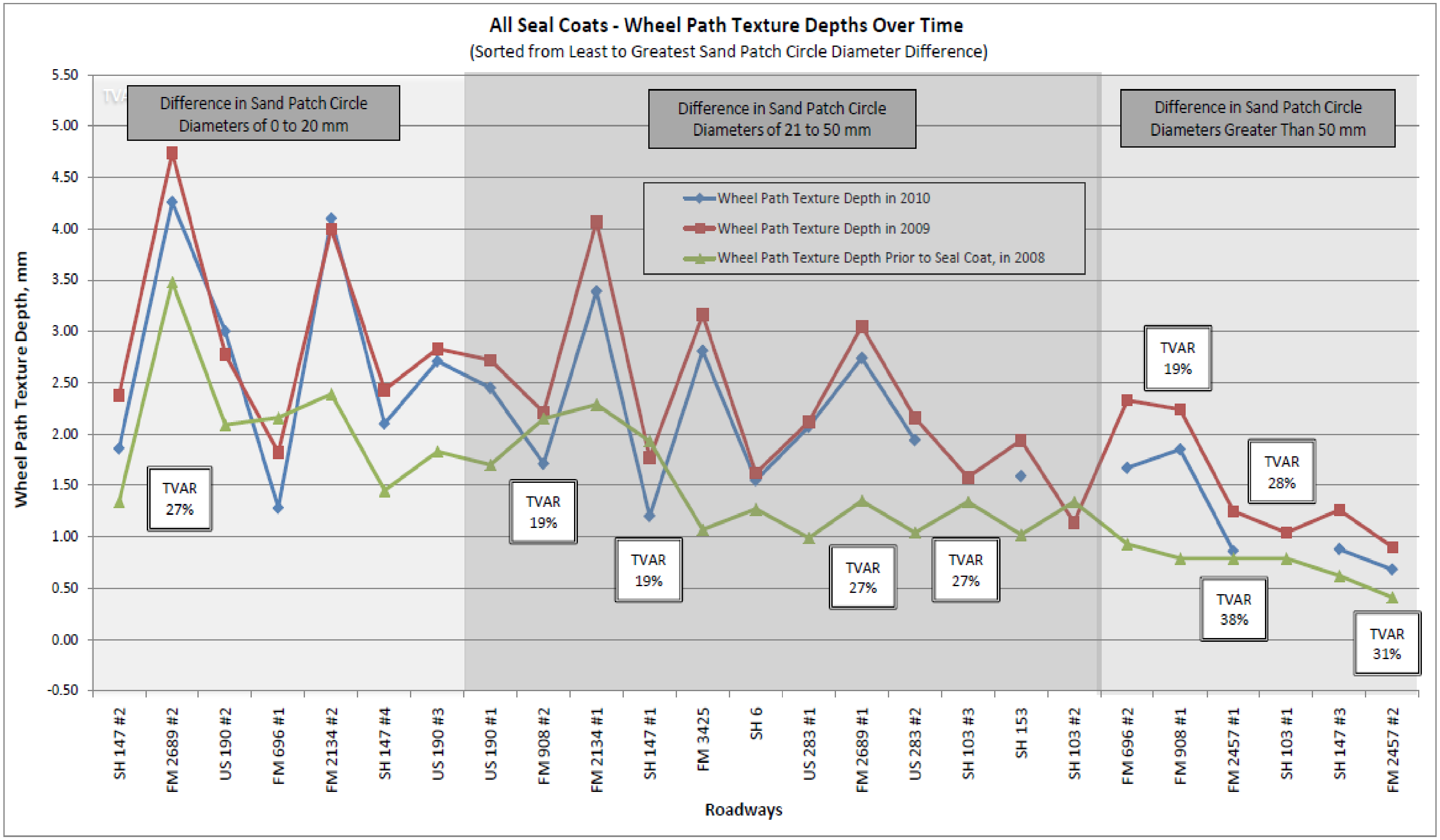


Figure 11. Wheel Path Texture Depth over Time Sorted by Difference in Sand Patch Test Circle Diameters.

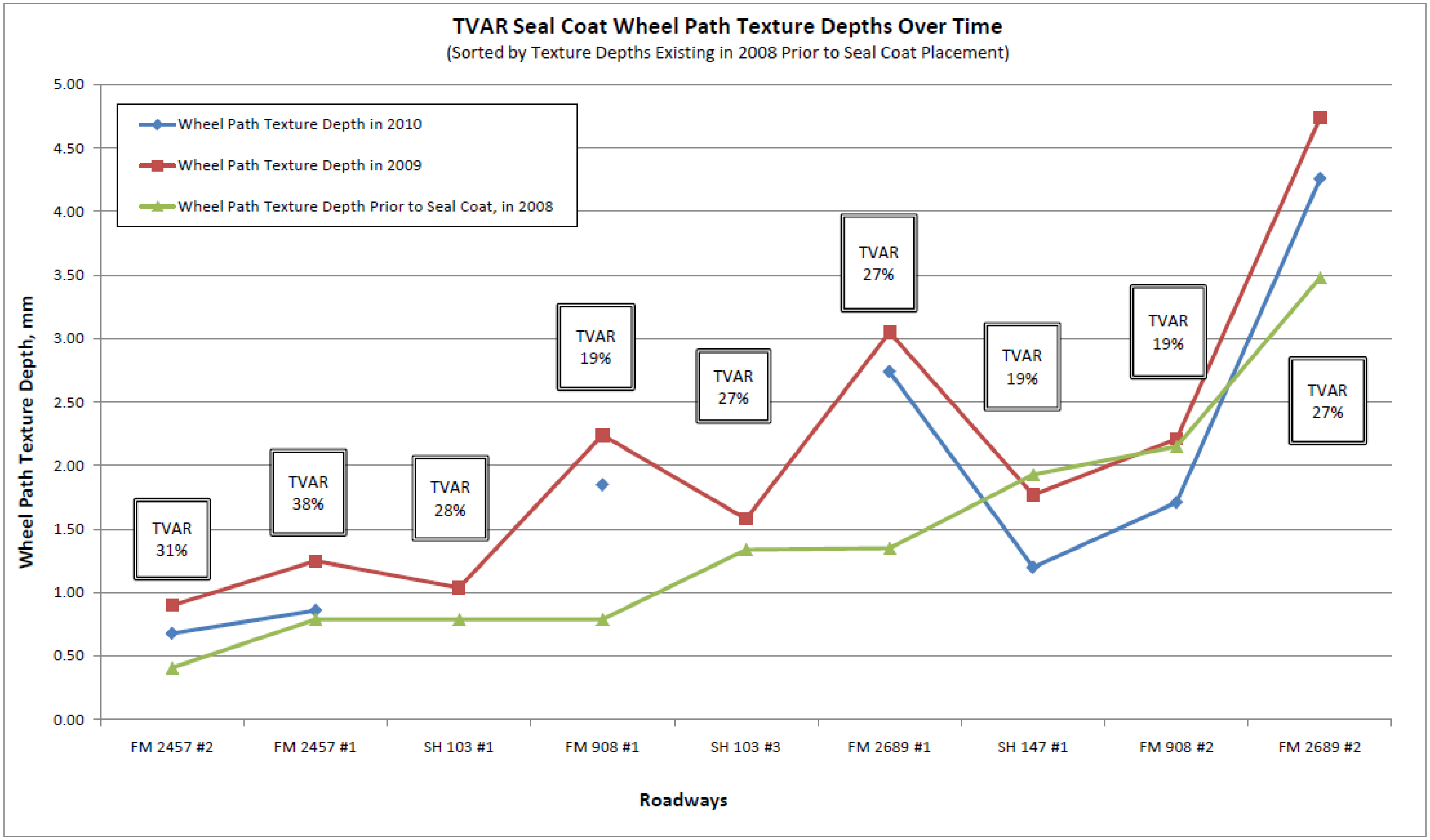


Figure 12. Wheel Path Texture Depth over Time for Pavements Using TVAR Asphalt Application Rates.

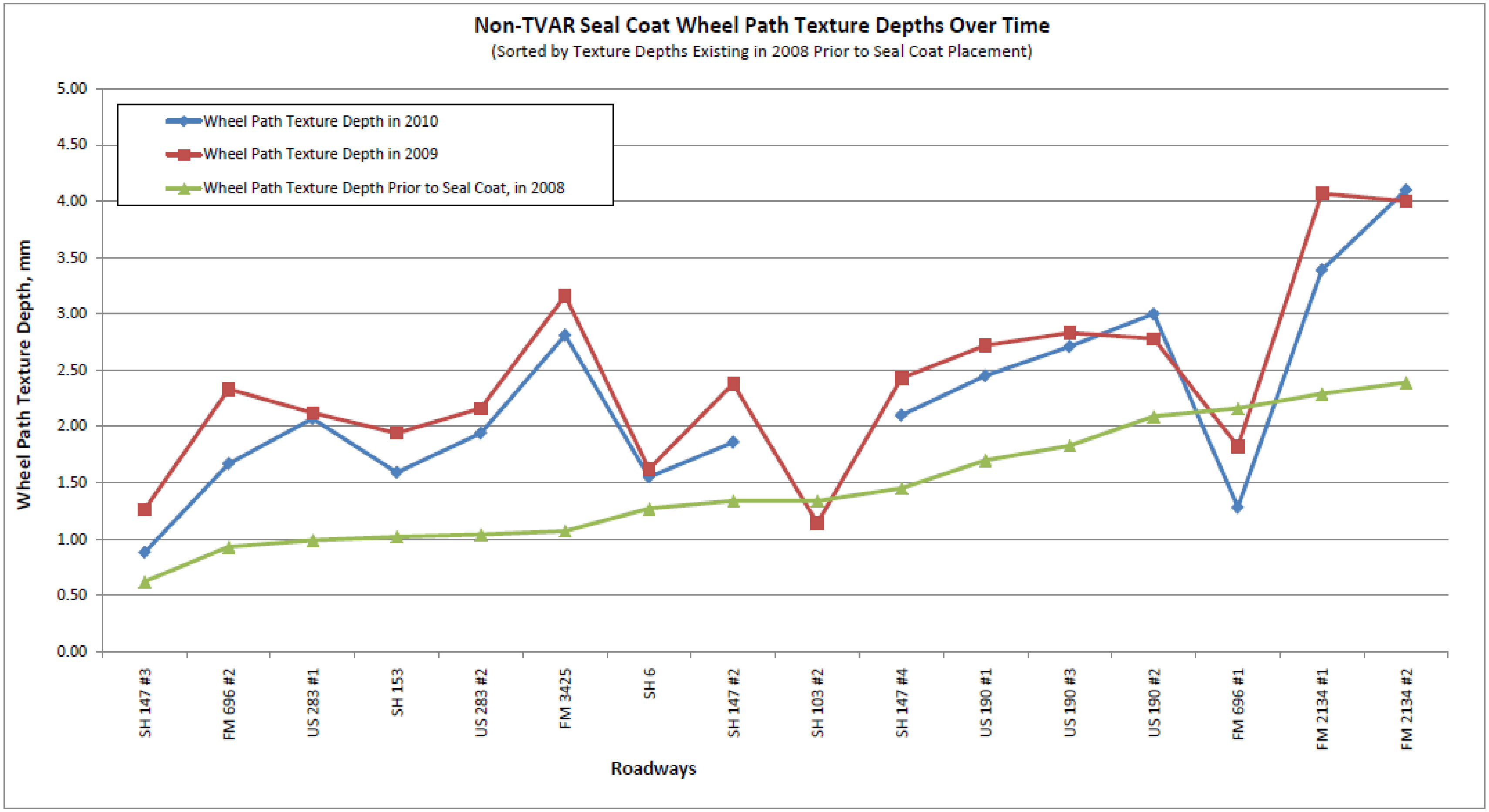


Figure 13. Wheel Path Texture Depth over Time for Pavements Using Uniform Asphalt Application Rates.

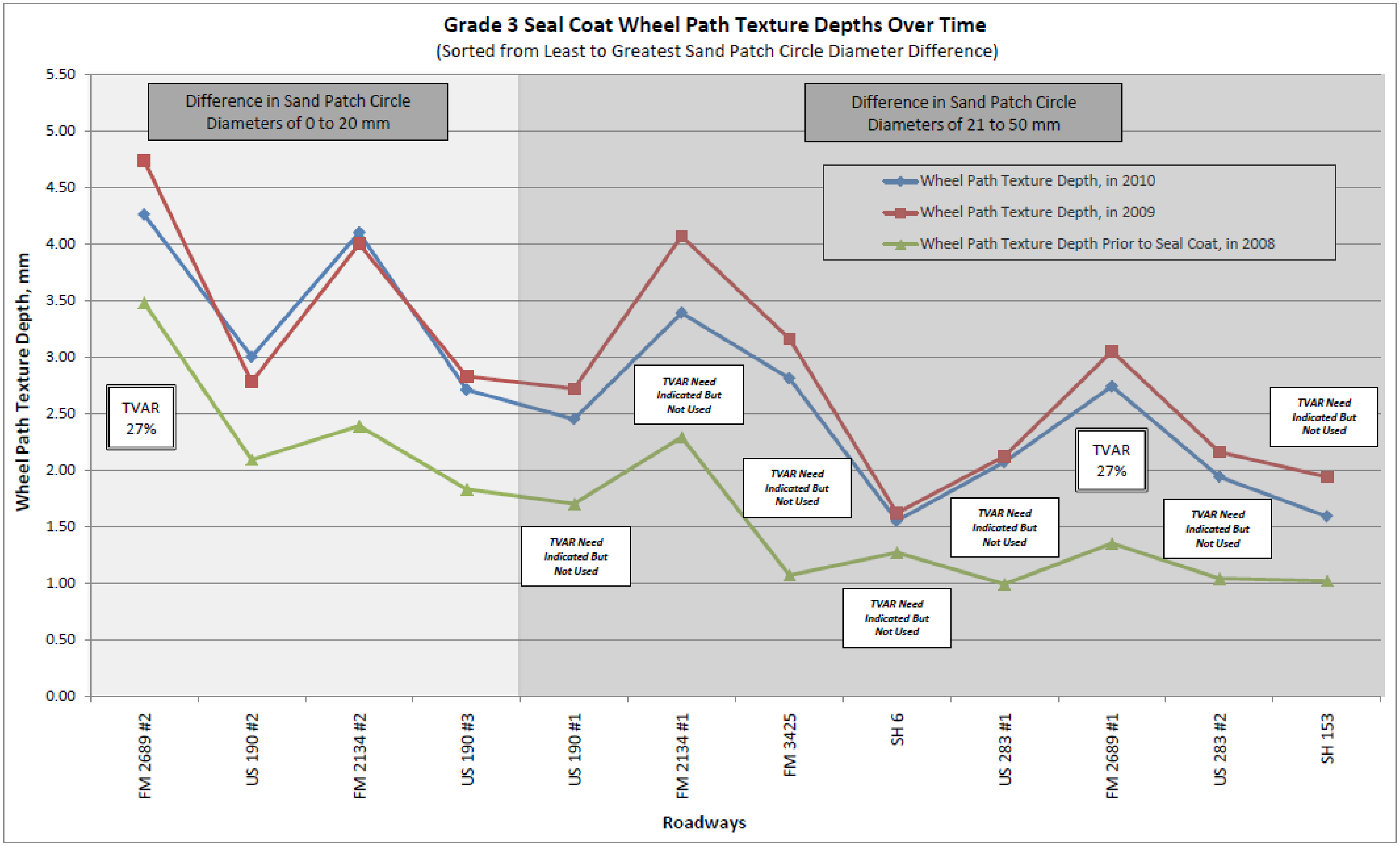


Figure 14. Grade 3 Seal Coat Wheel Path Texture Depth over Time.

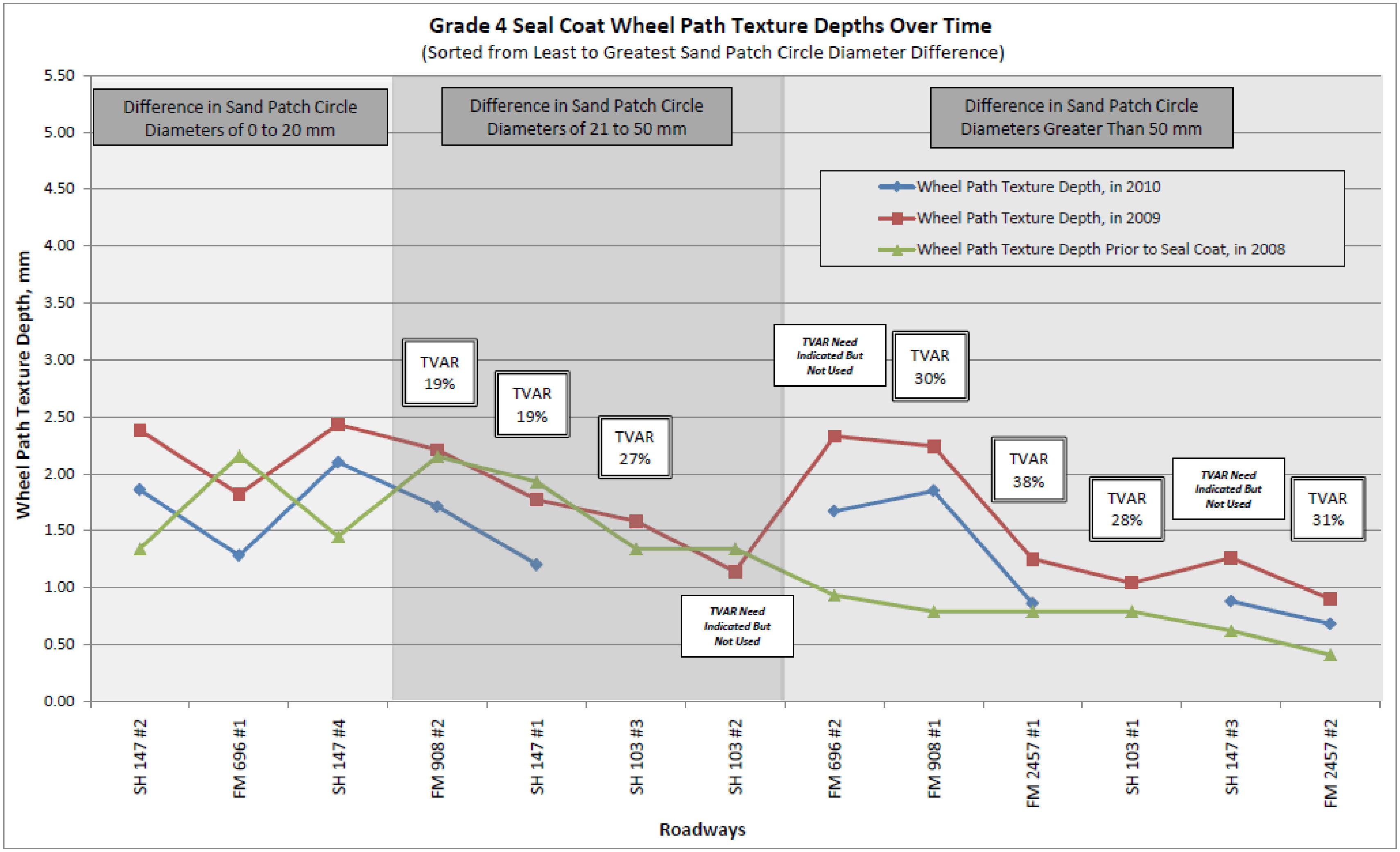


Figure 15. Grade 4 Seal Coat Wheel Path Texture Depth over Time.

A comparison of Figures 14 and 15 clearly indicates, as expected, the greater texture depths resulting when Grade 3 aggregate seal coats were placed. What was somewhat of a surprise was the extent to which the Grade 3 seal coats outperformed the Grade 4 seal coats, even those using TVAR methods, in retaining wheel path texture depth improvements over the two year period of observation. Based on the limited information displayed in these two figures, it may be that use of Grade 3 seal coat aggregate is just as effective as and possibly more effective in mitigating return of flushed wheel paths than use of Grade 4 aggregate in conjunction with TVAR asphalt application methods. Additional data points and study would be required to confidently compare relative performance of Grade 3 and Grade 4 aggregate seal coats, with and without use of the TVAR method.

An additional global view of texture test results is afforded in Tables 5 and 6, showing wheel path texture depths over time for pavement locations where the TVAR method was used and where it was not used, respectively. These tables include all pavement locations, whether a Grade 3 or a Grade 4 aggregate seal coat was placed.

There are several interesting observations to be made comparing the information in these two tables. Texture depth improvements of approximately 50% and 70% were found to remain after one year of traffic, on average, for all TVAR seal coats and all non-TVAR seal coats, respectively. The texture depth improvements remaining after two years of traffic averaged approximately 22% and 50% for TVAR and non-TVAR locations, respectively.

It is noted that where TVAR was used, texture depths fell off over time more rapidly than where TVAR methods were not used. This may be due to the fact that pavement locations where TVAR was used usually had an over abundance of asphalt near the surface, and the degree to which this occurred was beyond the capability of the TVAR method to correct with a single seal coat. A second possible cause is that current seal coat design methods overestimate the need for asphalt in wheel paths where texture is minimal due to asphalt welling up around the aggregate. A third possibility is that district seal coat designers are hesitant to shoot a low enough asphalt rate in the wheel paths to address the existing flushed condition for fear of possibly losing wheel path aggregate, which would result in a far worse pavement condition than existed prior to seal coat construction. It is the opinion of the researchers that each of these are contributing factors, but the relative involvement of each cannot be determined based on the data gathered during this study.

Table 5. All TVAR Method Wheel Path Texture Depths over Time

Highway and Site #	Texture Depth in Wheel Path, mm		
	2008	2009	2010
FM 2457 #2	0.41	0.90	0.68
FM 2457 #1	0.79	1.25	0.86
FM 908 #1	0.79	2.24	1.85
FM 2689 #1	1.35	3.05	2.74
SH 147 #1	1.93	1.77	1.20
FM 908 #2	2.15	2.21	1.71
FM 2689 #2	3.48	4.74	4.26
Average	1.56	2.31	1.90
Texture Improvement Remaining, mm		0.75	0.34
Percent Increase Over Pre-Existing Texture Depth	-	48.3	22.0

Table 6. All Non-TVAR Method Wheel Path Texture Depths over Time

Highway and Site #	Texture Depth in Wheel Path, mm		
	2008	2009	2010
SH 147 #3	0.62	1.26	0.88
FM 696 #2	0.93	2.33	1.67
US 283 #1	0.99	2.12	2.07
SH 153	1.02	1.94	1.59
US 283 #2	1.04	2.16	1.94
FM 3425	1.07	3.16	2.81
SH 6	1.27	1.62	1.55
SH 147 #2	1.34	2.38	1.86
SH 147 #4	1.45	2.43	2.10
US 190 #1	1.70	2.72	2.45
US 190 #3	1.83	2.83	2.71
US 190 #2	2.09	2.78	3.00
FM 696 #1	2.16	1.82	1.28
FM 2134 #1	2.29	4.07	3.39
FM 2134 #2	2.39	4.00	4.10
Average	1.48	2.51	2.23
Texture Improvement Remaining, mm		1.03	0.75
Percent Increase Over Pre-Existing Texture Depth	-	69.5	50.5

Tables 7, 8, 9 and 10 break out the texture depths shown in Tables 5 and 6 by grade of aggregate of the seal coat, i.e., Grade 3 and Grade 4. While data was limited to only one pavement and two locations for Grade 3 TVAR seal coats, both locations had excellent texture depth retention at both one year and two years after placement. The non-TVAR Grade 3 seal coats show a consistency in both significantly improving wheel path texture depths and in retaining these improvements between year one and year two.

Table 7. Grade 3 TVAR Method Wheel Path Texture Depths over Time

Highway and Site #	Texture Depth in Wheel Path, mm		
	2008	2009	2010
FM 2689 #1	1.35	3.05	2.74
FM 2689 #2	3.48	4.74	4.26
Average	2.42	3.90	3.50
Texture Improvement Remaining, mm		1.48	1.09
Percent Increase Over Pre-Existing Texture Depth	-	61.3	44.9

Table 8. Grade 3 Non-TVAR Method Wheel Path Texture Depths over Time

Highway and Site #	Texture Depth in Wheel Path, mm		
	2008	2009	2010
US 283 #1	0.99	2.12	2.07
SH 153	1.02	1.94	1.59
US 283 #2	1.04	2.16	1.94
FM 3425	1.07	3.16	2.81
SH 6	1.27	1.62	1.55
US 190 #1	1.70	2.72	2.45
US 190 #3	1.83	2.83	2.71
US 190 #2	2.09	2.78	3.00
FM 2134 #1	2.29	4.07	3.39
FM 2134 #2	2.39	4.00	4.10
Average	1.57	2.74	2.56
Texture Improvement Remaining, mm		1.17	0.99
Percent Increase Over Pre-Existing Texture Depth	-	74.6	63.2

The degree of increase in wheel path texture depth, and retention of that increase in texture depth, is notably less for Grade 4 aggregate seal coats than for Grade 3 aggregate seal coats, both when TVAR methods were used and when TVAR methods were not used. While lesser texture is expected when smaller Grade 4 aggregates are used, the much more rapid loss of the texture improvements that were obtained is a concern. Of the five pavement locations receiving a Grade 4 TVAR seal coat, the average wheel path texture depth after two years of traffic averaged only 0.05 mm better than the average pre-existing wheel path texture depth. For the Grade 4 non-TVAR seal coats, the average wheel path texture depth was only 0.26 mm better than the pre-existing average texture depth. Based on the limited number of pavements and pavement locations tested in this study, Grade 4 aggregate seal coats are significantly more likely to rapidly lose wheel path texture than Grade 3 aggregate seal coats, whether or not TVAR methods of applying the asphalt are used.

Table 9. Grade 4 TVAR Method Wheel Path Texture Depths over Time

Highway and Site #	Texture Depth in Wheel Path, mm		
	2008	2009	2010
FM 2457 #2	0.41	0.90	0.68
FM 2457 #1	0.79	1.25	0.86
FM 908 #1	0.79	2.24	1.85
SH 147 #1	1.93	1.77	1.20
FM 908 #2	2.15	2.21	1.71
Average	1.21	1.67	1.26
Texture Improvement Remaining, mm		0.46	0.05
Percent Increase Over Pre-Existing Texture Depth	-	37.9	3.8

Table 10. Grade 4 Non-TVAR Method Wheel Path Texture Depths over Time

Highway and Site #	Texture Depth in Wheel Path, mm		
	2008	2009	2010
SH 147 #3	0.62	1.26	0.88
FM 696 #2	0.93	2.33	1.67
SH 147 #2	1.34	2.38	1.86
SH 147 #4	1.45	2.43	2.10
FM 696 #1	2.16	1.82	1.28
Average	1.30	2.04	1.56
Texture Improvement Remaining, mm		0.74	0.26
Percent Increase Over Pre-Existing Texture Depth	-	57.2	19.8

COMPARISON OF PAVEMENT LOCATION PAIRS

Several pairs of pavements merit individual comparison. The first is a pair of pavement locations in Burleson County. FM 696 and FM 908 are parallel north-south roads which carry similar traffic. FM 696 location 1 and FM 908 location 2 had both been sealed by maintenance the prior year with a fine Grade 4 seal coat. These maintenance seals were short in length, leaving the majority of these pavement surfaces to be sealed in 2008 in an aged condition. The appearance and texture depth test results in 2008 for these two test locations were virtually identical, as seen in Table 11 and Figure 16. However, since the textures of these two pavements otherwise differed, FM 908 location 2 received a TVAR seal coat, with asphalt rates at 0.32 and

0.38 gal/SY, and FM 696 location 1 received a uniform asphalt application of 0.36 gal/SY. As seen in Table 11, the TVAR seal coat wheel path has retained a significantly better texture than the non-TVAR seal coat wheel path.

The second pair of pavement locations was on FM 2689 in Eastland County. They were located in the same lane, within approximately 600 ft of each other, and may be seen in Figure 17. Yet, location 1 had limited pre-existing wheel path texture depth, 1.35 mm, compared to the pre-existing wheel path texture depth of 3.48 mm at location 2. These wheel path texture depths and those found after one year and two years of traffic are shown in Table 12. Both locations received a TVAR seal coat, at asphalt application rates of 0.30 and 0.38 gal/SY, as the bulk of the pavement length called for a TVAR seal coat. Both locations have retained excellent textures over the two-year period of the study. Location 2, which did not require a TVAR method seal coat, has not lost aggregate from the wheel path even though a relatively low asphalt rate was applied.

The third pair of locations is on SH 147 in San Augustine County. Location 1 is in the northbound lane and location 3 is in the southbound lane, approximately three miles apart. Because of predominantly differing texture conditions around these test locations, location 1 with reasonably good pre-existing wheel path textures received a TVAR seal coat at 0.32 and 0.38 gal/SY and location 3, which was a considerably flushed wheel path location, received a uniform asphalt application at 0.34 gal/SY. The visual appearances of these locations may be seen in Figure 18, and Table 13 contains pre-existing and post-seal coat wheel path texture depths. Location 3 has lost virtually all texture improvement provided by the new seal coat within two years of construction. Location 1 now has *less* wheel path texture than existed prior to seal coat construction two years prior, although the texture depth is superior to that in location 3. The appearance is that both of these locations still have an excess of asphalt at the surface and both would have benefited from a lesser asphalt application in the wheel paths provided that the lesser asphalt amount would have held the aggregate over the first winter.

Table 11. FM 696 and FM 908 Wheel Path Texture Comparison.

Location	TVAR Used	Asphalt Application Rate(s), Gal/SY	Aggregate Grade	2008 Pre-Seal Coat Wheel Path Texture Depth, mm	2009 Wheel Path Texture Depth, mm	2010 Wheel Path Texture Depth , mm
FM 696 #1	No	0.36	4	2.16	1.82	1.28
FM 908 #2	Yes	0.32 and 0.38	4	2.15	2.33	1.67

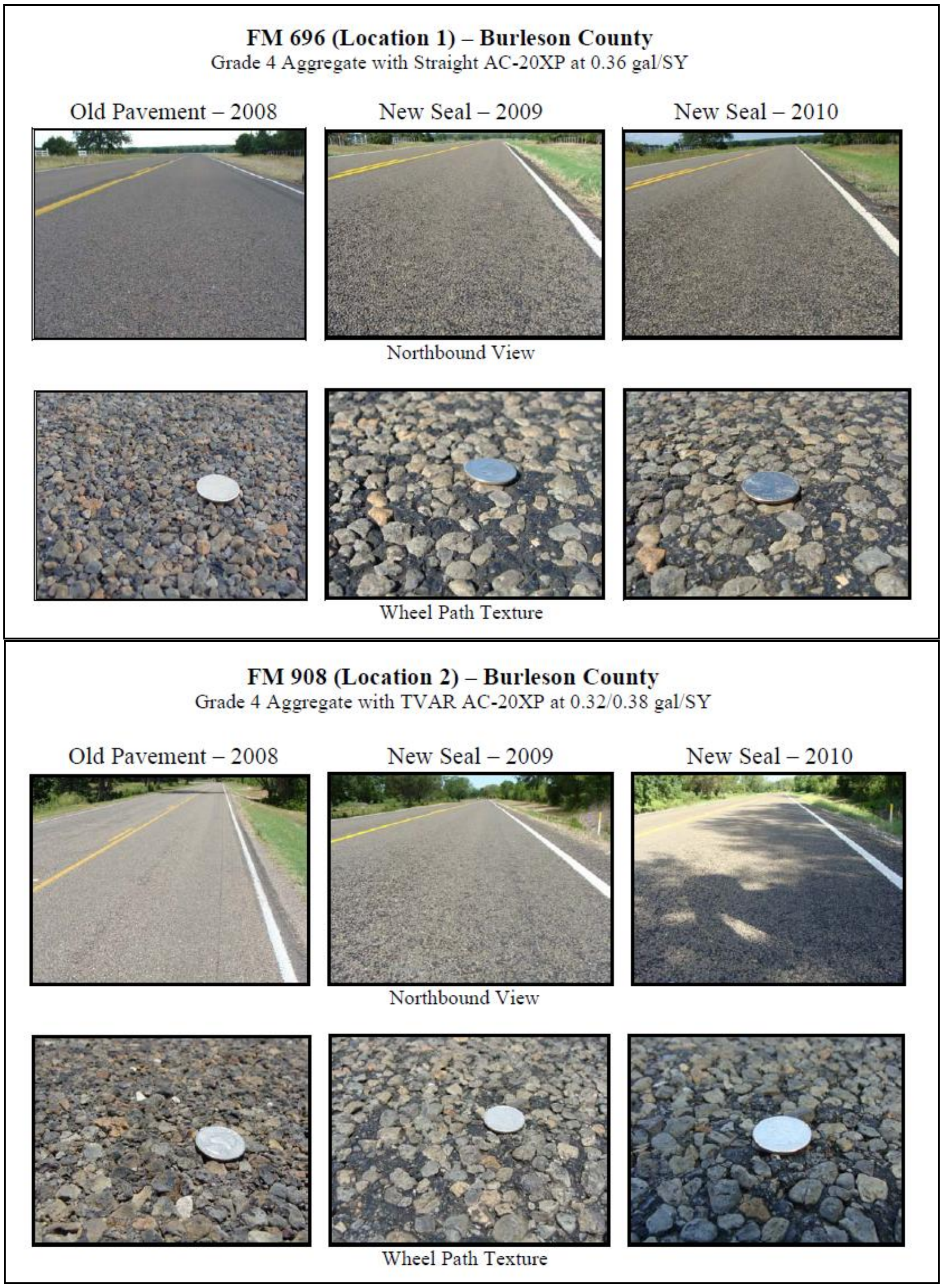


Figure 16. Photographs of FM 908 and FM 696 Textures.

Table 12. FM 2689 Location Wheel Path Texture Comparison.

Location	TVAR Used	Asphalt Application Rate(s), Gal/SY	Aggregate Grade	2008 Pre-Seal Coat Wheel Path Texture Depth, mm	2009 Wheel Path Texture Depth, mm	2010 Wheel Path Texture Depth , mm
FM 2689 # 1	Yes	0.32 and 0.38	3	1.35	3.05	2.74
FM 2689 #2	Yes	0.32 and 0.38	3	3.48	4.74	4.26

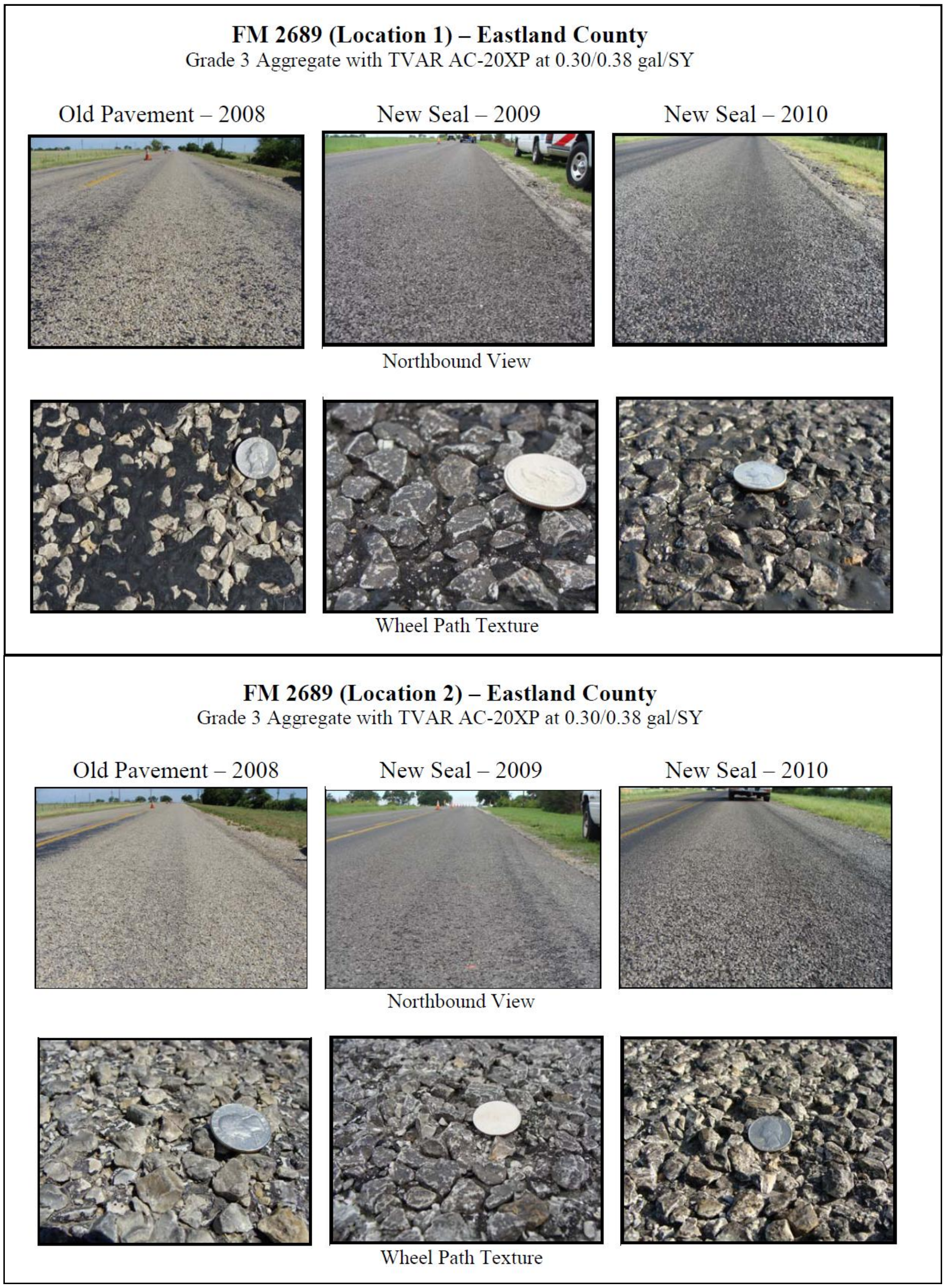


Figure 17. Photographs of FM 2689 Textures.

Table 13. SH 147 Wheel Path Texture Comparison.

Location	TVAR Used	Asphalt Application Rate(s), Gal/SY	Aggregate Grade	2008 Pre-Seal Coat Wheel Path Texture Depth, mm	2009 Wheel Path Texture Depth, mm	2010 Wheel Path Texture Depth , mm
SH 147 #1	Yes	0.32 and 0.38	4	1.93	1.77	1.20
SH 147 #3	No	0.34	4	0.62	1.26	0.88

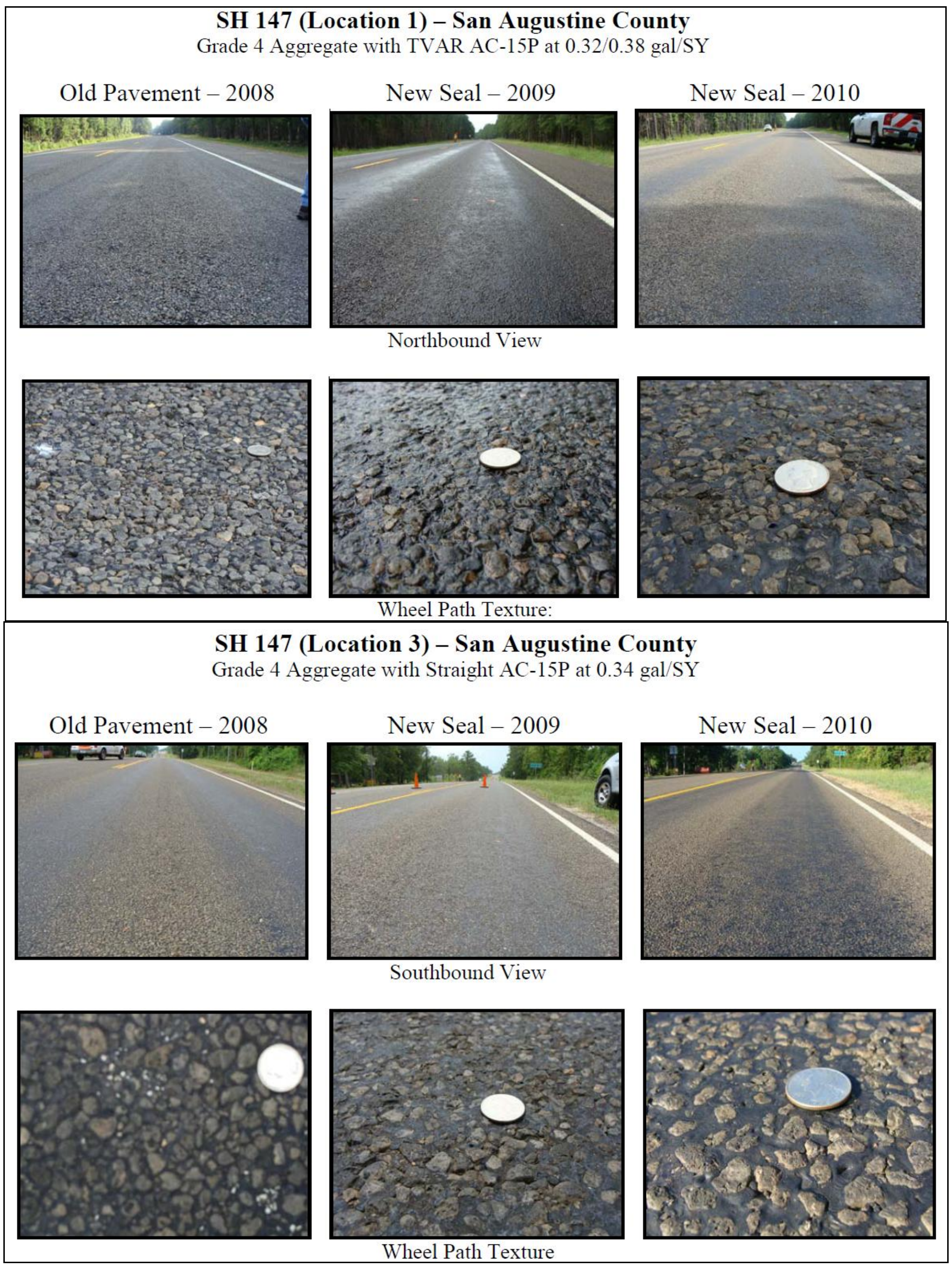


Figure 18. Photographs of SH 147 Textures.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This implementation project not only spread knowledge and trained personnel in use of TVAR methods, it also gathered extensive pavement texture data over a two-year period, thereby allowing additional learning about seal coat texture retention and how TVAR methods impact texture retention over the first two years of traffic.

1. TVAR methodology was successfully communicated across Texas as 225 TxDOT employees from 23 districts and one division received training at regional workshops.
2. Limited quantitative evidence was found indicating TVAR positively affects seal coat wheel path texture retention. Conclusive determination of quantitative benefits of TVAR use could not be made based on the pavements studied over a two-year period.
3. While general agreement was found between district decisions to use TVAR methods and the texture test criteria published in the TVAR Field Guide, the three districts participating in this study appear to employ TVAR methods less frequently than indicated by criteria in the TVAR Field Guide.
4. Whether or not TVAR methods were employed with Grade 3 aggregates, Grade 3 aggregate seal coats provided greater improvements in wheel path texture depths and retained these improvements better over the two-year period of study than Grade 4 aggregate seal coats.
5. TVAR methods employed with Grade 4 aggregate seal coats in this project showed only minimal wheel path texture improvement over the pre-existing texture after two years of traffic.
6. There is indication that design seal coat asphalt rates for flushed wheel paths may be higher than desirable from the standpoint of mitigating or eliminating return of wheel path flushing. It is unknown, however, if additional reduction in wheel path asphalt would have resulted in satisfactory retention of wheel path aggregate through the first winter.
7. A two-year study period is inadequate to conclusively and quantitatively determine the degree of value of employing TVAR methods.

RECOMMENDATIONS

The following recommendations are offered based on the findings of this study.

1. Criteria for recommending use of TVAR methods currently published in the TVAR Field Guide should not be revised at this time.
2. Districts should evaluate all pavements scheduled for seal coats for potential of obtaining improved performance with use of TVAR construction methods.
3. Districts should consider increased use of Grade 3 aggregate seal coats when the existing pavements exhibit easily visible wheel path flushing.
4. Seal coat asphalt rate determination methods for pavements with flushed wheel paths should be reviewed for possible revision to provide reduced asphalt application rates in these situations. Construction of carefully controlled test sections is recommended to determine if adjustments in design procedures are required and magnitudes of those adjustments.
5. The potential for using TVAR percentages well above 30 percent should be investigated for pavements with severely flushed wheel paths. Construction of carefully controlled test sections is recommended to determine the limits of TVAR percentage effectiveness for severely flushed pavement wheel paths.
6. Additional Grade 3 TVAR seal coats should be constructed and texture tested over time to better determine value of Grade 3 TVAR methods in mitigating or eliminating return of wheel path flushing conditions.
7. Consideration should be given to again visiting and texture testing the pavement locations included in this study at four years and six years of age, thereby determining performance of these pavements over the majority of their service lives.

APPENDIX A – EXAMPLE WORKSHOP AGENDA

March 26, 2009

Schedule

Odessa Regional Workshop

Transversely Varying Asphalt Rates (TVAR)

(HRD Training Course # IPR007)

Administrative:

Don't forget to sign the training course roster to get credit for attending.
Each district will take home one Sand Patch Test Kit at the end of the workshop.

District Training Room Session – 1:00 to 2:00

Workshop Introduction – Tammy Sims, Maintenance Division

Defining TVAR and Its Value – Cindy Estakhri, TTI

Specification for TVAR – Cindy Estakhri, TTI

Where to Use TVAR – Paul Krugler, TTI

Selecting TVAR Rates – Paul Krugler, TTI

Inspection and Adjusting Shot Rates – Paul Krugler, TTI, and Randy King, Brownwood District

Drive to Road Location – 2:00 to 2:15

Map attached. Bring hard hats and vests.

Roadside Session – 2:15 to 4:00 (Thanks to Jesse Gutierrez and his Maintenance Section for traffic control!)

Sand Patch Testing Demonstration – Estakhri and Krugler, TTI

Practical Exercise – All

Brownwood Insights on Selecting TVAR Rates – Randy King, Brownwood District

Questions and Adjourn

Have a safe trip home! You may leave for home from the roadside session.

APPENDIX B – PHOTO AND TEXTURE DATA SUMMARIES

US 190 (Location 1) – McCullough County

Grade 3 Aggregate with Straight AC-20XP at 0.45 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Eastbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.70	2.72	2.45
Between WP	2.37	3.93	3.60
Difference	0.67	1.21	1.15

US 190 (Location 2) – McCullough County

Grade 3 Aggregate with Straight AC-20XP at 0.48 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Westbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	2.09	2.78	3.00
Between WP	2.40	3.83	3.57
Difference	0.31	1.06	0.57

US 190 (Location 3) – McCullough County

Grade 3 Aggregate with Straight AC-20XP at 0.50 gal/SY

Old Pavement – 2008 New Seal – 2009 New Seal – 2010

Westbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.83	2.83	2.71
Between WP	2.45	4.22	3.78
Difference	0.62	1.39	1.07

SH 153 – Coleman County

Grade 3 Aggregate with Straight AC-20XP at 0.49 gal/SY

Old Pavement – 2008	New Seal – 2009	New Seal – 2010



Eastbound View



Wheel Path Texture



Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.02	1.94	1.59
Between WP	1.88	3.53	3.11
Difference	0.86	1.59	1.52

FM 3425 – Coleman County

Grade 3 Aggregate with Straight AC-20XP at 0.42 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Southbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.07	3.16	2.81
Between WP	1.52	3.23	2.98
Difference	0.45	0.07	0.17

US 283 (Location 1) – Coleman County

Grade 3 Aggregate with Straight AC-20XP at 0.47 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Southbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	0.99	2.12	2.07
Between WP	1.65	2.86	2.32
Difference	0.66	0.74	0.25

US 283 (Location 2) – Coleman County

Grade 3 Aggregate with Straight AC-20XP at 0.47 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010



Northbound View



Wheel Path Texture



Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.04	2.16	1.94
Between WP	1.91	3.51	3.19
Difference	0.87	1.35	1.25

FM 2134 (Location 1) – Coleman County

Grade 3 Aggregate with Straight AC-20XP at 0.52 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Westbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	2.29	4.07	3.39
Between WP	3.57	5.40	4.53
Difference	1.28	1.33	1.14

FM 2134 (Location 2) – Coleman County

Grade 3 Aggregate with Straight AC-20XP at 0.52 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Eastbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	2.39	4.00	4.10
Between WP	3.03	6.79	5.58
Difference	0.64	2.79	1.48

SH 6 – Eastland County

Grade 3 Aggregate with Straight AC-20XP at 0.45 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010



Southbound View



Wheel Path Texture



Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.27	1.62	1.55
Between WP	1.89	2.61	2.43
Difference	0.62	1.00	0.88

FM 2689 (Location 1) – Eastland County

Grade 3 Aggregate with TVAR AC-20XP at 0.30/0.38 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Northbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.35	3.05	2.74
Between WP	2.57	4.72	3.55
Difference	1.22	1.67	0.81

FM 2689 (Location 2) – Eastland County

Grade 3 Aggregate with TVAR AC-20XP at 0.30/0.38 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Northbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	3.48	4.74	4.26
Between WP	3.90	4.58	4.04
Difference	0.42	-0.16	-0.22

FM 696 (Location 1) – Burleson County

Grade 4 Aggregate with Straight AC-20XP at 0.36 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Northbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	2.16	1.82	1.28
Between WP	2.50	3.02	2.62
Difference	0.34	1.19	1.34

FM 696 (Location 2) – Burleson County

Grade 4 Aggregate with Straight AC-20XP at 0.36 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Northbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	0.93	2.33	1.67
Between WP	2.14	3.78	2.92
Difference	1.21	1.44	1.25

FM 908 (Location 1) – Burleson County

Grade 4 Aggregate with TVAR AC-20XP at 0.32/0.38 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Northbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	0.79	2.24	1.85
Between WP	2.14	3.55	3.07
Difference	1.35	1.32	1.22

FM 908 (Location 2) – Burleson County

Grade 4 Aggregate with TVAR AC-20XP at 0.32/0.38 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010



Northbound View



Wheel Path Texture



Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	2.15	2.21	1.71
Between WP	3.22	3.72	3.21
Difference	1.07	1.51	1.50

FM 908 (Location 3) – Burleson County

Grade 4 Aggregate with TVAR AC-20XP at 0.39/0.45 gal/SY

Old Pavement – 2008	New Seal – 2009	New Seal – 2010



Northbound View



Wheel Path Texture



Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	Photographic documentation only at this location.		
Between WP			
Difference			

FM 2027 (Location 1) – Milam County

Grade 4 Aggregate with Straight AC-20-5TR at 0.38 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Southbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	Photographic documentation only at this location.		
Between WP			
Difference			

FM 2027 (Location 2) – Milam County

Grade 4 Aggregate with Straight AC-20-5TR at 0.38 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010



Northbound View



Wheel Path Texture



Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	Photographic documentation only at this location.		
Between WP			
Difference			

FM 819 (SB) – Angelina County

Grade 4 Aggregate with AC-20-5TR

Old Pavement – 2008	New Seal – 2009	New Seal – 2010
	Photo Unavailable Due to Repaving	Photo Unavailable Due to Repaving

Southbound View

Old Pavement – 2008	New Seal – 2009	New Seal – 2010
	Photo Unavailable Due to Repaving	Photo Unavailable Due to Repaving

Wheel Path Texture

Old Pavement – 2008	New Seal – 2009	New Seal – 2010
	Photo Unavailable Due to Repaving	Photo Unavailable Due to Repaving

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.19	Data Unavailable Due to Repaving	
Between WP	1.97		
Difference	0.78		

FM 819 (NB) – Angelina County

Grade 4 aggregate with AC-20-5TR asphalt

Old Pavement – 2008	New Seal – 2009	New Seal – 2010
	Photo Unavailable Due to Repaving	Photo Unavailable Due to Repaving

Northbound View

	Photo Unavailable Due to Repaving	Photo Unavailable Due to Repaving

Wheel Path Texture

	Photo Unavailable Due to Repaving	Photo Unavailable Due to Repaving

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.49	Data Unavailable due to Repaving	
Between WP	2.51		
Difference	1.02		

SH 147 (Location 1) – San Augustine County

Grade 4 Aggregate with TVAR AC-15P at 0.32/0.38 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010



Northbound View



Wheel Path Texture:



Between Wheel Path Texture:

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.93	1.77	1.20
Between WP	2.91	2.86	2.44
Difference	0.98	1.09	1.24

SH 147 (Location 2) – San Augustine County

Grade 4 Aggregate with Straight AC-15P at 0.33 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010



Northbound View



Wheel Path Texture:



Between Wheel Path Texture:

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.34	2.38	1.86
Between WP	1.39	2.76	2.02
Difference	0.05	0.38	0.16

SH 147 (Location 3) – San Augustine County

Grade 4 Aggregate with Straight AC-15P at 0.34 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Southbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	0.62	1.26	0.88
Between WP	2.40	3.36	2.80
Difference	1.78	2.10	1.92

SH 147 (Location 4) – San Augustine County

Grade 4 Aggregate with Straight AC-15P at 0.38 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Southbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.45	2.43	2.10
Between WP	1.79	2.86	2.36
Difference	0.34	0.42	0.26

SH 103 (Location 1) – San Augustine County

Grade 4 Aggregate with TVAR AC-15P at 0.25/0.32 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Photo Unavailable
Due to Repaving

Westbound View

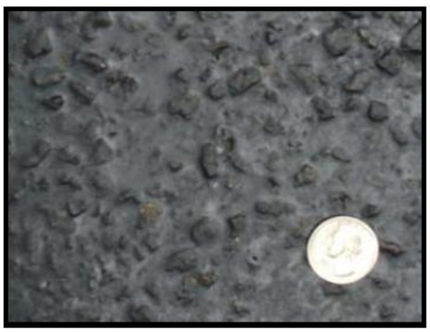


Photo Unavailable
Due to Repaving

Wheel Path Texture

Photo Unavailable
Due to Repaving

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	0.79	1.04	N/A
Between WP	2.53	2.39	N/A
Difference	1.74	1.35	N/A

SH 103 (Location 2) – San Augustine County

Grade 4 Aggregate with Straight AC-15P at 0.35 gal/SY

Old Pavement – 2008

New Seal – 2009

New Seal – 2010

Photo Unavailable
Due to Repaving

Westbound View

Photo Unavailable
Due to Repaving

Wheel Path Texture

Photo Unavailable
Due to Repaving

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.34	1.14	N/A
Between WP	2.82	2.67	N/A
Difference	1.48	1.52	N/A

SH 103 (Location 3) – San Augustine County

Grade 4 Aggregate with TVAR AC-15P at 0.30/0.38 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Photo Unavailable
Due to Repaving

Southbound View

Photo Unavailable
Due to Repaving

Wheel Path Texture

Photo Unavailable
Due to Repaving

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	1.34	1.58	N/A
Between WP	2.80	2.99	N/A
Difference	1.46	1.41	N/A

FM 2457 (Location 1) – Polk County

Grade 4 Aggregate with TVAR AC-20-5TR at 0.24/0.33 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Westbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	0.79	1.25	0.86
Between WP	2.29	2.63	2.15
Difference	1.50	1.38	1.29

FM 2457 (Location 2) – Polk County

Grade 4 Aggregate with TVAR AC-20-5TR at 0.26/0.34 gal/SY

Old Pavement – 2008 | New Seal – 2009 | New Seal – 2010

Eastbound View

Wheel Path Texture

Between Wheel Path Texture

Sand Patch Mean Texture Depth, mm			
	Old Pavement in 2008	New Seal in 2009	New Seal in 2010
Wheel Path	0.41	0.90	0.68
Between WP	1.42	2.29	2.09
Difference	1.01	1.39	1.47

APPENDIX C – SAND PATCH TEXTURE DEPTH TEST RESULT SUMMARY TABLE

Highway and Site #	County	Texture Depth in Wheel Paths, mm			Texture Depth Between Wheel Paths, mm			Difference in Texture Depth, mm		
		2008 - before seal	2009 - one year	2010 - two years	2008	2009	2010	2008	2009	2010
US 190 #1	McCullough	1.70	2.72	2.45	2.37	3.93	3.60	0.67	1.21	1.15
US 190 #2	McCullough	2.09	2.78	3.00	2.40	3.83	3.57	0.31	1.06	0.57
US 190 #3	McCullough	1.83	2.83	2.71	2.45	4.22	3.78	0.62	1.39	1.07
US 283 #1	Coleman	0.99	2.12	2.07	1.65	2.86	2.32	0.66	0.74	0.25
US 283 #2	Coleman	1.04	2.16	1.94	1.91	3.51	3.19	0.87	1.35	1.25
FM 2134 #1	Coleman	2.29	4.07	3.39	3.57	5.40	4.53	1.28	1.33	1.14
FM 2134 #2	Coleman	2.39	4.00	4.10	3.03	6.79	5.58	0.64	2.79	1.48
SH 153	Coleman	1.02	1.94	1.59	1.88	3.53	3.11	0.86	1.59	1.52
FM 3425	Coleman	1.07	3.16	2.81	1.52	3.23	2.98	0.45	0.07	0.17
SH 6	Eastland	1.27	1.62	1.55	1.89	2.61	2.43	0.62	1.00	0.88
FM 2689 #1	Eastland	1.35	3.05	2.74	2.57	4.72	3.55	1.22	1.67	0.81
FM 2689 #2	Eastland	3.48	4.74	4.26	3.90	4.58	4.04	0.42	-0.16	-0.22
SH 147 #1	San Augustine	1.93	1.77	1.20	2.91	2.86	2.44	0.98	1.09	1.24
SH 147 #2	San Augustine	1.34	2.38	1.86	1.39	2.76	2.02	0.05	0.38	0.16
SH 147 #3	San Augustine	0.62	1.26	0.88	2.40	3.36	2.80	1.78	2.10	1.92
SH 147 #4	San Augustine	1.45	2.43	2.10	1.79	2.86	2.36	0.34	0.42	0.26
FM 2457 #1	Polk	0.79	1.25	0.86	2.29	2.63	2.15	1.50	1.38	1.29
FM 2457 #2	Polk	0.41	0.90	0.68	1.42	2.29	2.09	1.01	1.39	1.41
SH 103 #1	Polk	0.79	1.04	N/A	2.53	2.39	N/A	1.74	1.35	N/A
SH 103 #2	Polk	1.34	1.14	N/A	2.82	2.67	N/A	1.48	1.52	N/A
SH 103 #3	Polk	1.34	1.58	N/A	2.80	2.99	N/A	1.46	1.41	N/A
FM 908 #1	Burleson	0.79	2.24	1.85	2.14	3.55	3.07	1.35	1.32	1.22
FM 908 #2	Burleson	2.15	2.21	1.71	3.22	3.72	3.21	1.07	1.51	1.50
FM 696 #1	Burleson	2.16	1.82	1.28	2.50	3.02	2.62	0.34	1.19	1.34
FM 696 #2	Burleson	0.93	2.33	1.67	2.14	3.78	2.92	1.21	1.44	1.25