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Success of a 4-Year Pavement Management Plan

Technical Report 0-7101-R1

Cooperative Research Program

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16. Abstract

Successful 4-year pavement management plans help provide the traveling public with a safe, comfortable, and reliable roadway network. Each maintenance section plays a role in executing an effective 4-year pavement management plan. To continue to improve the statewide system and get the most value out of fiscally constrained budgets, pavement management plan best practices are needed. Many best practices exist within Texas and are captured as part of this research project. Promoting teamwork and communication at all levels within a district ensures pavement management plans are developed and deployed effectively. Acknowledging that district seal coat projects and seal coat preparations serve as the cornerstone for long-term pavement management success is a key ingredient. For overlay and rehabilitation projects, properly scoring and prioritizing projects helps ensure plan success. Project success is required to improve plan success, and building a preliminary project scope during early project rides and connecting that scope with additional testing needs helps districts transition from plan success to project success to pavement management success.

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DISCLAIMER

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INTRODUCTION

Successful 4-year pavement management plans (PMPs) help provide the traveling public with a safe, comfortable, and reliable roadway network. The deployment of these plans at a granular level (i.e., area office [AO] and maintenance office [MO] level) ensures that local knowledge of the system's needs and appropriate repair methodologies are used. However, overall success of 4-year PMPs must feed up from each maintenance section to the district level, which feeds up to the state level. This flow ensures that the traveling public encounters a safe, comfortable, and reliable network while traveling throughout the state.

In 2001, a goal was set to have 90 percent of Texas's on-system highways in good or better condition, a goal directly affected by PMPs. In this context, good or better is defined as a roadway section having a condition score (CS) of 70 or higher. Despite a slight dip in 2017, the overall condition of Texas's pavements has been on an upward trajectory since 2013, with its current measure of 88.8 percent in good or better condition. This rise in CS has been accompanied by a general rise in pavement-related funding since 2011. Figure 1 shows that fiscal year (FY) 2020 pavement funding approached $2 billion, up approximately $750 million from a decade ago (*1*).

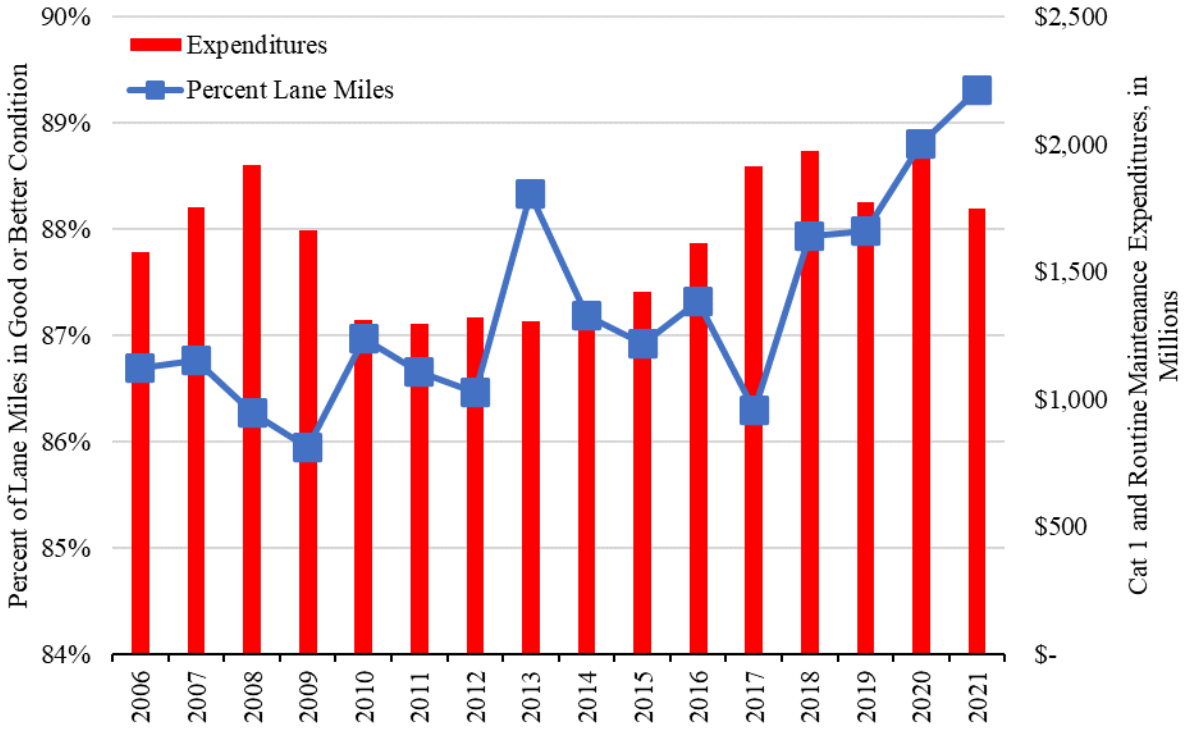

Figure 1. Statewide Pavement Condition and PMP Spending (*1*).

To continue the upward trend, this study was funded to identify 4-year PMP best practices. This synthesis project identified current practices for PMP development and execution through

literature, online surveys, and detailed follow-up questions. The synthesis used current performance metrics to identify high-performing districts. The responses from these districts were evaluated in detail to identify potential best practices. The synthesis concluded that PMP best practices occur primarily in one of three areas:

- District-level planning and decision-making.
- District seal coat needs.
- District non-seal coat needs.

The synthesis concluded that for district planning and decision-making, best practices include focusing on communication at all levels and developing a district-specific prioritization scheme. For district seal coat needs, the synthesis discovered that the long-term success of the 4-year PMP is heavily influenced by seal coat preparation. Best practices for seal coat preparation include connecting prep activities to performance metrics and helping maintenance supervisors (MSs) identify the proper solution to achieve the goals. For non-seal coat projects, the synthesis noted that having a surface selection map serves as a best practice, as does making sure all adequate underlying pavement work occurs before the new surface.

This report details each phase of the study and culminates with a summary of best practices. In addition, risks to maintaining improvement and potential mitigation strategies are discussed. The discussion of high-performing districts does not imply that other districts are developing and executing PMPs incorrectly. The high-performing districts were simply identified through performance metric evaluation and survey questions.

LITERATURE REVIEW AND PERFORMANCE REVIEW

LITERATURE REVIEW

The Texas Department of Transportation (TxDOT) maintains almost 81,000 centerline miles. Half of these centerline miles are on the aging farm- or ranch-to-market system (*1*). To effectively maintain its system, TxDOT uses multiple planning processes, including the development of a Unified Transportation Program (UTP) and 4-year PMPs. UTP serves as the statewide 10-year transportation plan organized into 12 funding categories. UTP discusses a software application that taps into TxDOT's vast array of databases to objectively compare and relatively rank projects in the areas of safety, pavement and bridge preservation, congestion mitigation, connectivity, economic development, and environmental impacts (*2*). UTP does not clearly describe how, if at all, the scoring metrics used in its development connect with the creation of district-specific, 4-year PMPs. Within UTP, Categories 1—Preventative Maintenance and Rehabilitation, 8—Safety Projects, and 11—District Discretionary align with projects in a district's 4-year PMP.

Gharaibeh et al. conducted a project in 2014 to create a methodology to support the development of 4-year PMPs (*3*). This project included an extensive literature review that found significant differences between state highway agencies (SHAs) in pavement condition indices and noted how different distresses and severities factor into those indices. A major disconnect between strategic planning and actionable maintenance and rehabilitation (M&R) plans was the singular metric used in policy goals compared with the multiple factors considered with M&R plan development. Gharaibeh et al. reviewed Illinois, Kansas, Washington, and Arizona departments of transportation (DOTs) along with the England Highway Agency and Transit New Zealand. It was discovered that Illinois, Kansas, and Washington ranked projects using current condition and an estimate of remaining life, while Arizona prioritized M&R projects using a benefit-cost ratio. Plan lengths varied, with Kansas having the shortest M&R plans, spanning 3 years, compared with Illinois' 6-year planning horizon. Both the England Highway Agency and Transit New Zealand used incremental costs to prioritize M&R projects.

During Gharaibeh et al.'s project, TxDOT districts were surveyed to understand the current data and methodology used to develop 4-year PMPs. At that time, districts overwhelmingly indicated the use of Pavement Management Information System (PMIS) data and visual inspections to help create PMPs. The researchers arrived at the general process shown in the flowchart in Figure 2 (*3*). TxDOT's Maintenance Division provided guidance in 2018 that follows a similar process, summarized in Figure 3 (*4*).

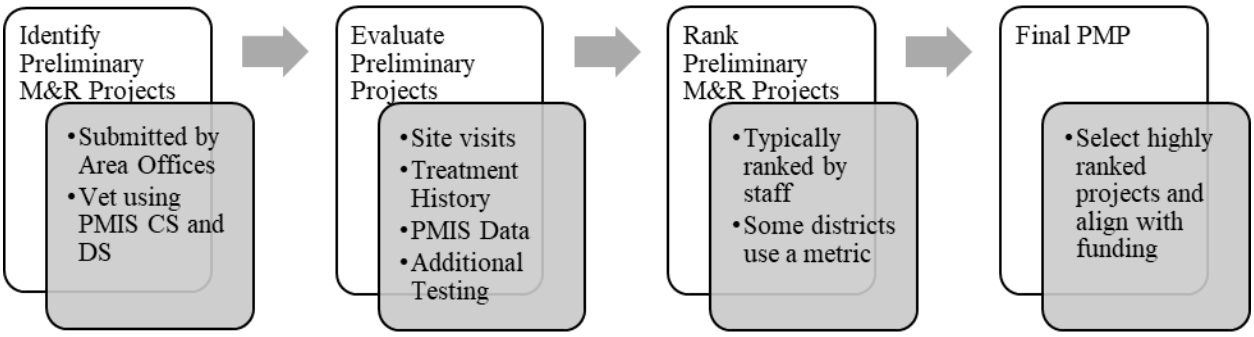

Figure 2. Gharaibeh et al. General Process for 4-Year PMP Development.

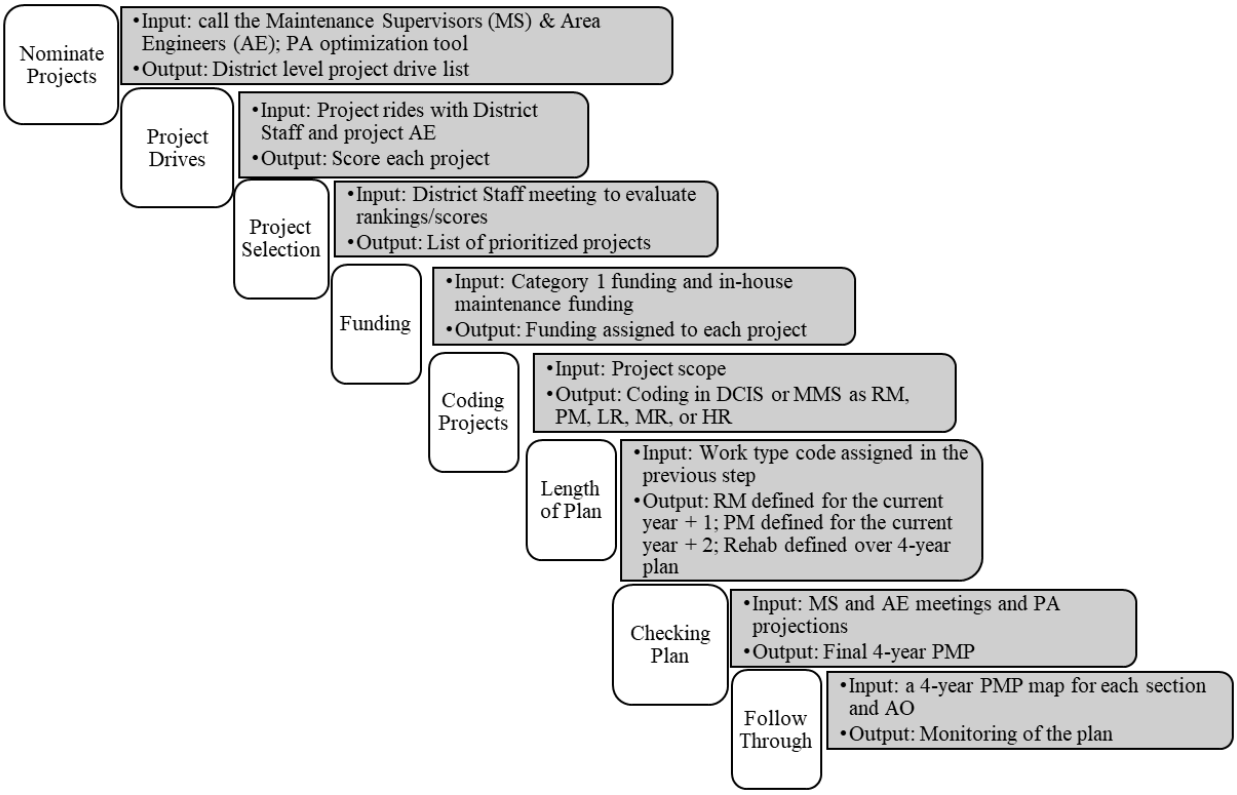

Figure 3. TxDOT Maintenance Division 4-Year PMP Development Guidance.

During the literature review process, researchers asked districts for any district-specific procedures used for the development of 4-year PMPs. The Odessa and Atlanta Districts responded with the statewide guidance described above. Only the Waco District provided a district-specific document, which was updated in September 2021. Waco's document defines the responsibilities of the district engineer (DE), director of construction (DOC), director of operations (DOO), director of transportation planning and development (TP&D), and area engineer (AE). According to Waco's document, the goal of the PMP is to keep the roadway condition above the target of 90 while balancing spending across safety and bridge maintenance

using a data-driven process. The process requires AO maintenance engineers to prepare and present candidate projects to the district staff. The procedure includes a detailed timeline with submittal dates. The year-over-year aspect of the PMP is fed by the TP&D providing a preliminary 4-year PMP using years 2–4 from the previous year's PMP. Using this preliminary plan, AOs review the candidate projects against PMIS (i.e., pavement analyst [PA]) metrics. Projects are further reviewed by members of the district staff to identify bridge work within the projects, additional testing needs, and other scope requirements. After these reviews, district staff visually inspect each project to better inform the project ranking. The process culminates with each district staff member ranking each project 1–X to develop a candidate list (*5*).

Shortly after World War II, the United States embarked on a rapid build-out of the highway network. The network was constructed using 30- to 40-year designs. As the roadway networks began to approach the end of their design life in the 1980s, the industry shifted toward a pavement preservation and management approach (*6*). The shift away from capital projects to M&R projects led to SHAs expending more funds on data collection. Most SHAs have robust and varied datasets with condition data on a myriad of assets. Unfortunately, these datasets are often underutilized when determining the effectiveness of treatment techniques. The underutilization does not stem from the lack of analytical methods or models; rather, the underutilization occurs because of the poor or unknown quality of the input data (*7*). Several studies have noted the noisiness of pavement management data, particularly the irregular patterns created due to poor documentation of in-house maintenance work (*3, 7*). North Carolina DOT found that a reliable construction records database tied to a pavement management database to evaluate treatment effectiveness was integral to improving decision-making. Unfortunately, if these databases exist, they are often not connected because different business units with the SHA populate and maintain them (*7*).

The Federal Highway Administration funded a study to create a pavement preservation research roadmap in response to the shift to a preservation mentality, the existence of robust datasets, and barriers to effectively using the available data for M&R decision-making. The first three synthesis projects proposed within this roadmap sit at the intersection of M&R treatment effectiveness and pavement management. These projects are:

- Including Pavement Preservation Treatments in Pavement Management Systems (PSs).
- Agency Selection of Preservation Treatments, Timing, and Triggers.
- Agency Design Methods for Chip Seals, Micro Surfacing, and Slurry Seals (*8*).

The discussion in the preceding paragraphs implies that the next frontier of pavement management research exists in more effectively combining construction record datasets with pavement management datasets to understand treatment appropriateness and effectiveness. Many studies have evaluated PMS data collection and data quality. Similarly, many studies have evaluated M&R treatment effectiveness. However, the literature lacks significant studies that

combine pavement management data with treatment effectiveness to improve M&R decision-making and ultimately improve an agency's pavement management processes. For example, a National Cooperative Highway Research Program study found that the most common treatments for flexible pavements within 42 U.S. SHAs and 7 Canadian agencies are chip seals, hot mix asphalt (HMA) patches, and thin overlays. Across the same agencies, the most common rigid pavement treatments are diamond grinding, joint sealing, and load-transfer restoration. To determine the effectiveness of each treatment, the study used service life extension (SLE). Unfortunately, the ranges of SLE for different treatment types were wide. For example, while the SLE range for a chip seal was 7 to 12 years, the SLE for a thin overlay was 3 to 23 years. For rigid pavements, the SLE range for a dowel-bar retrofit was 2 to 16 years. While this study did not provide justification for these large SLE ranges, it did note that agencies use different criteria for treatment selection and timing. These criteria can include in-house guidelines, engineering judgment, and decision trees (*9*).

The integration of data collected as part of an agency's pavement condition data collection plan with treatment selection is unknown. Furthermore, the use of these data to identify treatment effectiveness appears nonexistent. No methodology exists to connect the various data sources and objectively quantify the benefits of different types of treatments (*10*). While the next frontier of pavement management research includes integrating traditional pavement condition datasets with construction datasets to better understand treatment effectiveness, limitations continue to exist with traditional pavement management practices. Baladi et al.'s study included an extensive literature review that noted surveyor subjectivity continues to plague pavement condition data. The influence of this limitation should decrease as automated classification algorithms improve (*11*).

However, even as this problem diminishes, pavement condition data are often aggregated to provide a qualitative descriptor (i.e., good, fair, poor) with a composite index. These qualitative descriptors or composite index thresholds often correspond to a work description within a PMS. Work descriptions are often generic in nature while implying a level of work effort required to improve a pavement section (*11*). For example, a roadway in good condition might require preventative maintenance as opposed to a pavement in poor condition that requires a rehabilitation. TxDOT uses qualitative categories for its distress score (DS), ride score (RS), and overall composite CS. Table 1 shows the qualitative descriptors for the tree performance metrics.

Table 1. TxDOT Qualitative Condition Descriptions.

Qualitative Descriptor	Distress Score	Ride Score	Condition Score
Very Good	90–100	4.0–5.0	90–100
Good	80–89	3.0–3.9	70–89
Fair	70–79	2.0–2.9	50–69
Poor	60–69	1.0–1.9	35–49
Very Poor	1–59	0.1–0.9	1–34

A pavement section can have a CS of less than 100 through several combinations of distresses or roughness severity (*12*). While these composite indices are used to make policy decisions, a disconnect remains with treatment selection. Composite indices and qualitative descriptors can mask different distress types that require different treatments to solve the problem. Furthermore, the changes in composite scores and descriptors do not account for the expected life of a particular treatment. For example, a roadway with structural issues might need a 6-inch overlay but only receive a 2-inch overlay. In terms of distress disappearance, these treatments have the same impact in the short term but have different long-term performances (*11, 12*).

The literature reviewed above shows that much work has been done on PMSs and more recent work has occurred on M&R treatment performance. However, the literature shows that work remains on connecting different datasets (i.e., pavement condition data and construction history) to better inform M&R decision makers on treatment selection and expected life from those treatments. This gap in the research work justifies the reliance of agencies on institutional knowledge and visual site visits when making M&R decisions.

OTHER DOT PMP PRACTICES

New Mexico DOT

New Mexico indicates that its PMS should identify preservation, rehabilitation, and reconstruction projects that optimize funding at the project level. To create project-level decisions, New Mexico's PMS considers 2-mile sections. Within each 2-mile section, the system evaluates the prevalent distress and uses decision trees, performance curves, and cost-benefit analyses to recommend a treatment. These recommendations are often supplemented with field testing. Work has occurred to calibrate distress models and connect with the materials and traffic databases. New Mexico moved to fully automatic data collection in 2013. New Mexico uses the Pavement Condition Rating (PCR) as its composite index and then disaggregates the PCR into a structural index, environmental index, safety index, and roughness index for programming into the decision trees. In 2018, New Mexico used a consultant to reconfigure performance curves using construction and maintenance history. While New Mexico states that the decision trees within the PMS provide project-level recommendations, the recommendations remain generic and are:

- Monitor.
- Preventative.
- Patch.
- Preservation (Minor).
- Preservation (Major).
- Rehabilitation (Minor).
- Rehabilitation (Major).
- Reconstruction (*13*).

Oklahoma DOT

A 2014 study found that Oklahoma spends at least $600,000 annually on pavement condition data collection to cover the entirety of the network every 2 years. This study built an unrealistic number of 630 pavement deterioration curves after developing methodology to create homogenous and continuous pavement sections with the same construction year, treatment history, and structural layers (*14*). The creation of 630 curves for Oklahoma's network shows the challenges with trying to account for the number of possibilities when making project-specific decisions.

Oklahoma uses an ArcGIS platform open to the public to visualize pavement condition data. The Oklahoma Department of Transportation (ODOT) uses a composite index called the Pavement Quality Index (PQI), and depending upon the PQI, generic treatment recommendations are triggered. Oklahoma considers roadways with a PQI of 91 to 100 good, from 75 to 90 fair, and below 75 poor. Table 2 shows the qualitative descriptors based on PQI values and the threshold values to trigger an M&R action.

Table 2. ODOT Composite Index and Treatment Recommendations.

PQI Score	M&R Action
94-100	No Treatment
89-93	Preventative Maintenance
84-88	Minor Rehabilitation
73-83	Major Rehabilitation
0-72	Reconstruction

The online platform will project a do-nothing PQI over 8 and 4 years. These data help inform two lists of projects within ODOT. The ODOT Project Management Division produces an Asset Preservation Plan that includes maintenance projects within a 4-year planning horizon. This same division also produces a Construction Work Plan that includes construction projects within an 8-year plan (*15*).

Arkansas DOT

Arkansas' publicly available data reside within its transportation asset management plan (TAMP). The Arkansas Department of Transportation (ARDOT) uses the Pavement Condition Index (PCI) to evaluate the condition of its pavements. The PCI uses environmental cracking, structural cracking, roughness, and rutting to generate a composite ranking. ARDOT deploys a life-cycle strategy that includes treatment triggers, treatment resets, and subsequent treatments. Treatment triggers exist over a PQI range or a condition indices range where a treatment is deemed feasible. Depending upon the treatment selected, the condition indices either reset, extend the pavement life, or remain unchanged. Subsequent treatments are treatments that follow a previous treatment (*16*). While the logic within the ARDOT TAMP makes sense, little detail

was provided on different M&R treatment types and how the effectiveness of an M&R treatment within a PMP impacts additional PMP iterations.

Louisiana DOT

The Louisiana Department of Transportation and Development (LADOTD) uses a preservation approach to pavement management. While the preservation approach is routinely cited as the industry norm, little information is provided on how SHAs address severely deteriorated roadways that require extensive M&R work. Like Texas, LADOTD has definitions for M&R work actions. These definitions include:

- Routine Maintenance—repair work typically performed by department forces and that is planned and carried out on a scheduled basis to maintain the pavement in serviceable condition (e.g., pothole patching).
- Preventative Maintenance—a planned strategy of cost-effective, non-structural treatments to existing pavements that preserve the current condition and retard future deteriorations (e.g., micro surface, thin [<1.5 in.] overlay, or chip seal).
- Light Minor Rehabilitation—non-structural improvements or repairs made to existing pavement sections to address pavement distresses (e.g., Portland cement concrete patching or asphalt pavement patching).
- Minor Rehabilitation—single lift overlays (<2 in.), with cold planed and/or patching pavement preparation, that do not qualify as structural overlays.
- Major Rehabilitation—structural enhancements that improve the load carrying capacity and extend the service life of the existing pavement. These pavements would generally be designed for a minimum of 10–15 years design life within the existing crown.
- Replacement—replacement of the entire existing pavement structure by the placement of an equivalent or increased pavement structure generally within the existing crown. These pavements would typically be designed for a 20-year life (*17*).

While LADOTD's TAMP clearly defines these M&R actions, little is known about their performance, how the performance informs the PMS, and how this changes future M&R decisions with the development of project scopes.

Arizona DOT

The Arizona Department of Transportation (ADOT) uses a commercial off-the-shelf pavement management software called dTIMS CT developed by Deighton Associates Limited. The system allows ADOT to evaluate alternative funding scenarios and to analyze pavement segments to determine the optimum preservation, rehabilitation, and reconstruction treatments. Treatment recommendations are based on a life-cycle cost analysis. ADOT has an Overall Condition Index that is evenly based upon the international roughness index, cracking, rutting (faulting for

concrete), and risk for the pavement. The level of risk is based upon the likelihood and consequence of asset loss of service failure.

ADOT loads pavement design data and pavement construction data into its PMS to help produce custom reports, though it is unclear how much these data impact maintenance recommendations. ADOT has developed 58 pavement families using pavement type, climate, traffic loading, and foundation strength to assist with PMS decision-making.

The ADOT PMS analysis process includes the following steps:

1. Generate analysis segments.
2. Review prediction models.
3. Review treatments.
4. Review economic parameters.
5. Review budgets.
6. Generate strategies.
7. Execute optimization.
8. Execute MAP-21 analysis after budget finalization.
9. Review MAP-21 results.
10. Report results.

ADOT uses a decision treatment within its PMS to identify the treatment to apply. Each treatment has a reset value for roughness, rutting/faulting, and cracking. Each treatment also has a life reset value (*18*).

California DOT

The California Department of Transportation bought PaveM as a commercial off-the-shelf product. Per state legislation, California develops a 10-year plan (TYP). The plan follows eight steps:

1. Document current network conditions.
2. Set the performance goals by end the TYP.
3. Forecast future conditions and identify needs to reach goals.
4. Identify contribution of all current projects in the project delivery pipeline.
5. Identify performance gaps and determine lane miles to treat and investment needed.
6. Document year-by-year project list and investment needed as they TYP.
7. Monitor the delivery progress on a quarterly basis.
8. Repeat the same process every 2 years to ensure continuous planning and continuous adjustment (*19*).

EVALUATION OF CURRENT DISTRICT PERFORMANCE

To develop district-specific questions, researchers evaluated district DS, RS, and CS from FY 2013 through FY 2021. Researchers also analyzed each district's DS to understand how a district's distress compared to the statewide average and moved from year to year. Appendix A: District Scores Summary includes performance charts for each district showing the performance metric trends. These charts helped researchers develop district-specific survey questions. The CS, DS, and RS figures in Appendix A: District Scores Summary have the same layout as Figure 4. Figure 4 shows the slight upward trend for the state in the percent of sections in good or better condition since 2017. This upward trend probably dates to 2015 because the dip in 2017 relates to the transition to automated distress collection. This dip was noted in several district figures.

The distress analysis for each district allowed researchers to identify high-performing districts and evaluate their survey responses to identify best practices. Some districts were considered highly performing because of their current ranking, while others were considered highly performing because of their consistency or recently improved ranking. The remainder of this section briefly summarizes the performance of each district and should be read while referencing the district's performance charts in Appendix A: District Scores Summary.

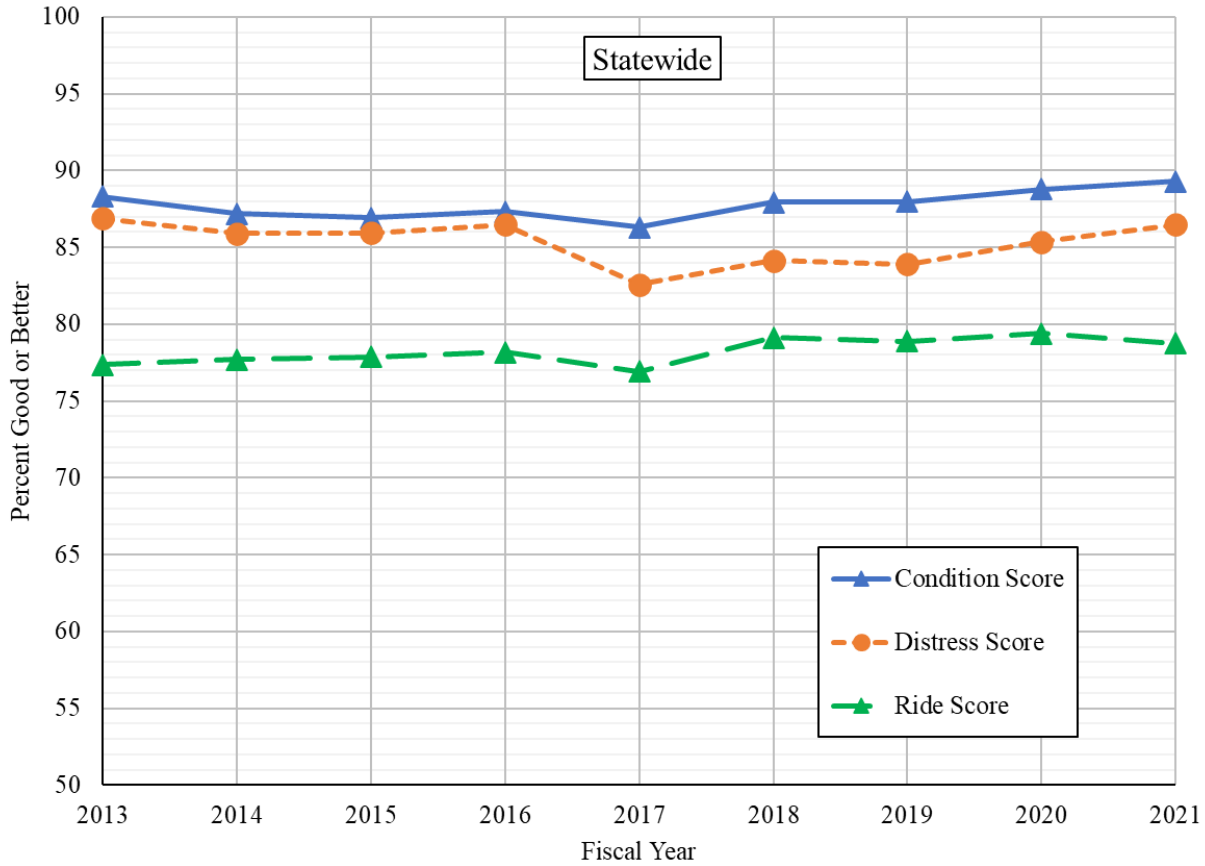

Figure 4. Statewide Summary of Performance Metrics.

Abilene (District Number 08) Performance Summary

Throwing out 2017, the Abilene District has been on a slight upward trend in overall condition over the past 9 years, exceeding 90 percent of roadways in good or better condition in 2020. In 2017, Abilene saw a CS score dip over 5 points and a DS dip over 10 points, potentially related to the automated data collection shift.

The Abilene District's overall improvement has been driven by upward movement in the DS. However, the RS has been on a steady decline since 2017 and has fallen to just over 65 percent of roadways with an RS of good or better.

In addition to the evaluation of CS, DS, and RS, a comparison of each district's DS statewide rank and movement from year to year was also performed. Appendix A: District Scores Summary contains the related figures. Figure 5 shows these trends for Abilene. In Figure 5, the green line corresponds to the primary vertical axis and represents the statewide rank for a district's DS. Abilene's DS ranked 6th best in the state in 2021. There are 26 available ranks, 25 for each district and one for the statewide summary. The blue line represents the statewide summary and is identical in each district's figure. In 2021, the statewide summary ranked 13th, indicating that 12 districts were performing better than the statewide DS average and 13 districts were performing worse. The bar charts in Figure 5 represent the rank movement of DS from year to year and correspond to the secondary vertical axis. For example, from 2020 to 2021, the Abilene District moved up one in DS rank from 7 to 6, while the statewide average moved up three from 16 to 13. The Abilene District has seen large swings in its statewide DS ranking from its large downward movement in 2017, when Abilene had a DS rank of 24 out of 26 (i.e., the 23rd worst district). This movement potentially indicates that Abilene was the most impacted by the shift to automated distress collection. Abilene then moved up 11 spots from 2019 to 2020 and was beating the statewide DS rank for the first time since 2015. Abilene has beaten the statewide DS rank the last 2 years but had only done so one other time (i.e., 2015) in the 9-year analysis period.

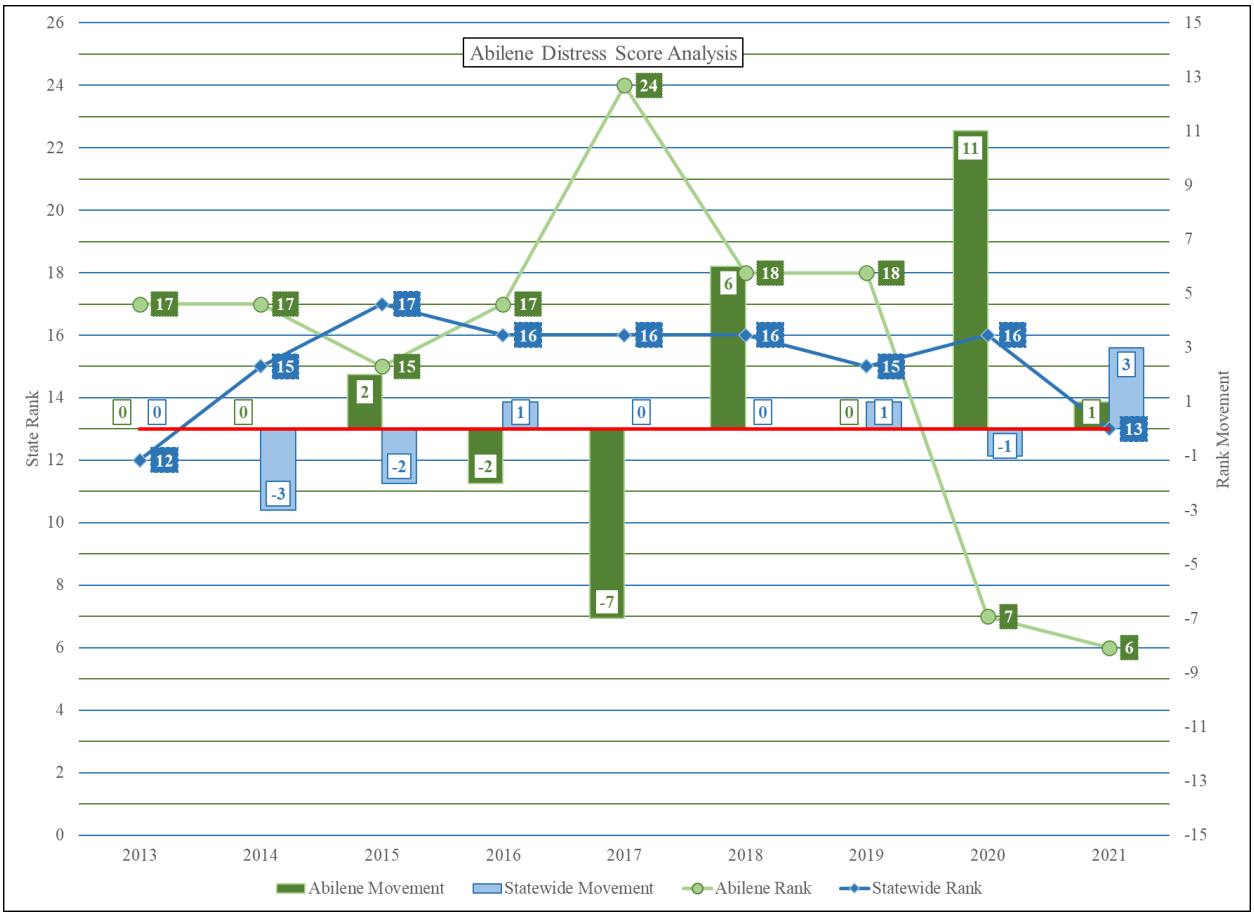

Figure 5. Abilene (08) Distress Score Comparison to Statewide.

Amarillo (04) Performance Summary

Amarillo has been on a consistent upward trend in overall CS since 2016. It was one of the few districts that had a higher RS percent of roadways in good or better condition than DS until 2018 when the RS saw a dip. Overall, the RS is down almost 5 percentage points in the last 9 years. If the Amarillo District was affected by the shift to automated distress collection, it was not noticeable in the data.

The upward trend in CS has been good because the distress analysis revealed that from 2013 to 2016, the Amarillo District was ranked last for percent of sections in good or better condition for distress. Amarillo is currently ranked 19th (i.e., 18th worst district), though its recent improvement might be a promising sign.

Atlanta (19) Performance Summary

The Atlanta District is one of only five districts to maintain 90 percent of its network in good or better condition from 2013 through 2021. The Atlanta District has maintained parity between its DS and RS, with each metric often following the same trend. Unlike the statewide trend, the Atlanta District saw an increase in the RS percentage from 2020 to 2021, continuing an upward

trend in RS, while DS has remained stable since 2019. Similar to Amarillo, if the Atlanta District was impacted by the shift to automated distress collection, it was not obvious in the data beyond a slight 1-point dip in DS in 2017.

In the DS analysis, it was discovered that the Atlanta District has outperformed the statewide rank since 2014. In 2021, its DS rank was 7th, down from 4th in 2020. A rank of 7th is the Atlanta District's lowest rank since 2015, when it was outside of the top 10. This seems to indicate that the rest of the state has made up some ground on the Atlanta District with respect to DS, a positive trend because of Atlanta's superior performance over the last 9 years.

Austin (14) Performance Summary

Austin has maintained a consistent upward trend in overall CS during the past 9 years. Over the last 9 years, only 2014 had less than 90 percent of sections in good or better condition. In 2021, the Austin District had 94.04 percent of sections in good or better condition, approaching its high of 94.15 percent in 2018. Similar to Atlanta, Austin maintains parity between its RS and DS. These metrics have followed the same trends since 2013. Any shift to automated distress collection was not noticeable in Austin's data.

The Austin District outranked the statewide DS rank beginning in 2014, entered the top 10 in 2016, and has continued to perform exceptionally well. Austin's current statewide DS rank sits at 4th. Interestingly, Austin saw a large jump in rank from 10th to 4th in 2017, the same year Abilene tumbled. While not explored within the scope of this project, it might be of interest to identify why some districts fared better than others in the switch to automated distress collection.

Beaumont (20) Performance Summary

Beaumont was on a downward trend in CS and DS from 2013 to 2017. The deeper dip in 2017 might have been attributable to the shift to automated distress collection but continued to follow the previous years' downward trajectory. The trajectory stabilized in 2018, and since that time, Beaumont has had a CS percentage above 90 percent good or better.

In the DS score analysis, it was discovered that Beaumont ranked in the top 10 from 2013 through 2021, including having the best DS score in 2015 and 2016. Beaumont currently ranks 3rd in the state for the highest percentage of sections with a DS in the good or better range. This is up six spots from its 2020 ranking of 9th.

Brownwood (23) Performance Summary

The Brownwood District has the most consistent CS over the 9-year analysis period. Like the Atlanta District, Brownwood is one of only five districts to maintain 90 percent of its sections with a CS of good or better since 2013, with a low of 91.72 percent in 2019. While the Brownwood District has been very consistent, it has started to see a downward trend in both DS

and RS. The RS trend has been steeper, falling from 75.75 percent of sections with good or better ride in 2018 to 68 percent in 2021. These downward trends might simply be a result of the challenge with consistently maintaining good pavements in good condition.

The consistency of the Brownwood District was reflected in the DS analysis, where it was discovered that Brownwood outperformed the statewide rank each year until 2021. Brownwood currently ranks 17th in the statewide DS rankings, down 11 spots from 2020. While the Brownwood District has been able to perform consistently over the years, the current ranking implies years of preventative maintenance (PM) work might need to give way to rehabilitations to avoid more distress growth.

Bryan (17) Performance Summary

The Bryan District has been on a gradual upward trend since 2013. The CS percent good or better increased from 86.46 percent in 2013 to 91.40 percent in 2021. Both the DS and RS have been trending upward, with DS percentage closely following the CS percentage.

The Bryan District's upward trend is reflected in its current statewide DS rank of 9th, only its second time in the top 10. Bryan's DS rank was volatile from 2019 through 2021. In 2019, Bryan ranked 5th, before falling 14 spots in 2020 to 19 and then rebounding to 9th in 2021.

Childress (25) Performance Summary

The Childress District is one of five districts to maintain its network CS at 90 percent good or better over the 9-year analysis period. Childress has also maintained an upward trend in CS; however, while its DS is trending upward, its RS has been trending downward for the past 5 years. The current difference between the DS and RS percent in good or better condition is the largest it has been (i.e., DS = 95.65 percent; RS = 77.2 percent).

The upward trend in Childress is reflected by its current DS ranking of 1st in 2021, its third consecutive year having the largest percentage of sections with a DS in good or better condition. Childress has been in the top 10 for 8 of the 9 analysis years, with 2017 being the only exception. Between 2016 and 2017, Childress fell eight spots from 9th to 17th, potentially due to the shift to automated distress collection. The magnitude of this fall exceeds the seven-spot drop experienced by its neighboring district, Abilene. This was not explored in further detail within this study, but the Childress and Abilene Districts might have similar characteristics that were adversely affected by the data collection change.

Corpus Christi (16) Performance Summary

The Corpus Christi District has been on the steepest upward trend for CS of any district over the past 6 years. This is likely a response to repairing roadways heavily damaged during the Eagle

Ford Shale exploration. The steepness of this upward trend has occurred because both DS and RS have improved.

The DS analysis showed that Corpus Christi was near the bottom for distress ranking from 2013 through 2016. In 2017, the district rose 13 spots to the 12th position and currently ranks 5th for DS.

Dallas (18) Performance Summary

The figures in Appendix A: District Scores Summary typically chart the CS as the highest of the three metrics. For some districts, CS and DS plot close to each other. Dallas plots with DS several percentage points higher than CS. The CS plots lower because of the poor RS within the Dallas District. For example, the current DS percentage of good or better pavements is 83.27 percent. For CS, the amount is 79.54 percent, and for RS it is 72.21 percent. Fortunately, the RS percentage has been on an upward trend, rising from 66.7 percent in 2013 to 72.21 percent in 2021.

While RS impacts the overall CS in the Dallas District more than most other districts, the distress analysis also showed that Dallas faces distress issues. Dallas currently ranks 23rd (i.e., 22nd worst district) for percent of sections in good or better condition for distress. Since 2013, Dallas has only beaten the statewide average rank once. That occurred in 2015, when Dallas ranked 16th and the statewide average was 17th, indicating that while Dallas beat the statewide average, it was still in the lower half of districts for distress ranking.

El Paso (24) Performance Summary

The El Paso District has been on a consistent downward trend in CS, DS, and RS since 2013. In 2013, 93.78 percent of sections had a CS in good or better condition, but in 2021, it was down to 88.39 percent. El Paso also saw a dip in 2017 that looked similar to the dip in Abilene and Childress, potentially associated with automated distress collection.

While El Paso has been on a downward trend, it continues to outrank the statewide average and has done so every year since 2013. However, in 2013, it ranked 3rd in most sections with a DS good or better and now ranks 10th.

Fort Worth (02) Performance Summary

The Fort Worth District has experienced a gradual decline in CS since 2013. In 2013, the percentage of sections with CS in good or better condition was 90.29 percent, but in 2021, the amount was 85.88 percent. Fortunately, the CS chart bottomed out in 2018 at 82.39 percent and has gradually risen since then.

The distress analysis illustrated the same deteriorating trend from 2013 to 2018. Beginning in 2013, Fort Worth ranked 7th for the highest number of sections with a DS in the good or better range. In 2018, it had fallen to 24th (i.e., the 23rd worst district) and remained at 20th in 2021.

Houston (12) Performance Summary

The percentage of the Houston network in good or better condition has remained stable over the past 9 years. In 2013, the percent of sections with a CS of good or better was 83.84 percent, and in 2021, it was 83.71 percent. Like Dallas, the DS charts higher than the CS, but the difference between DS and RS is not the same magnitude as with the Dallas District. In fact, in 2021, the percent of sections in the good or better category for each metric was:

- CS = 83.71 percent.
- DS = 85.28 percent.
- RS = 83.58 percent.

This parity likely comes from the minimal seal coat placed in the Houston District. Many other districts noted that seal coat preparation does not always improve ride quality, so the RS plots lower than the DS. The data suggest that construction activities in Houston have an equal influence on DS and RS.

The distress analysis showed that Houston began beating the statewide DS percentage in 2017 and did so in improving fashion until 2020, when it peaked at a rank of 10th for percent sections with a DS of good or better. Between 2020 and 2021, the district fell six places and is currently below the statewide average.

Laredo (22) Performance Summary

The Laredo District had an upward trend in CS from 2013 to 2017 but has recently seen a leveling off. The upward trend saw improvement in both DS and RS at approximately the same slope. The recent leveling off has coincided with a downward trend in DS, while the RS has remained upward or stable.

The distress analysis showed that the downward trend in DS reduced Laredo's DS rank to 24th (i.e., 23rd worst district) for percent of sections in good or better distress condition. The ranking has been falling since 2017 when it peaked at 13th, the only year Laredo was higher than the statewide average.

Lubbock (05) Performance Summary

The Lubbock District was on a slight downward trend from 2016 to 2018 but has since been trending upward. Lubbock's current network has 90.73 percent of sections in good or better condition. The upward trend has been driven by a rising DS, but the RS has been trending

downward since 2019. Lubbock experienced a significant drop in DS in 2017, similar to Abilene, Childress, and El Paso, but unlike those districts, Lubbock did not experience the same rebound in 2018. As noted with those other districts, the drop coincides with the shift to automated distress collection.

The distress analysis showed that the downward trend led to a distress ranking of 23rd (i.e., 22nd worst district) in 2018. Since that time, Lubbock's ranking has risen to 15th but still trails the statewide average. However, the rapidly improving rank implies that if Lubbock continues to do what it has done over the past 3 years, it could surpass the statewide average.

Lufkin (11) Performance Summary

Lufkin has been one of only five districts to maintain a network with 90 percent or more of its sections in good or better condition every year for the past 9 years. Even with this high level of performance, Lufkin has managed to maintain upward trends in CS, DS, and RS. Lufkin currently has 95.83 percent of its sections in good or better condition.

From a distress perspective, Lufkin outranked the statewide average for percent of sections in good or better condition from 2013 through 2021. Since 2016, Lufkin has been in the top three each year, currently on a 3-year streak ranked 2nd.

Odessa (06) Performance Summary

The Odessa District was on a steep downward trend in CS from 2013 to 2017. The DS downward trend continued through 2019. Fortunately, the DS has begun trending upward, which also helped push the CS back upward from 2020 to 2021.

The distress analysis showed that Odessa went from the highest-ranking district in percent of sections in good or better condition in 2013 and 2014 to the lowest-ranking district in 2019. Odessa still ranks last in distress. Much of the distress was a result of the rapid energy-sector development and the impact to the roadway system.

Paris (01) Performance Summary

Paris has been on a slight upward trend in CS. This trend has coincided with the upward trajectory of DS. RS has been up and down since 2017, and the difference between RS and DS is high. For example, the DS percent of sections in good or better condition in 2021 was 83.33 percent, while the RS was 70.52 percent.

The distress analysis showed this upward trend in DS, with the Paris District's DS rank rising from 24th (i.e., 23rd worst district) in 2019 to 22nd (i.e., 21st worst district) in 2021. The Paris District never outranked the statewide average during the analysis period. The closest it came was in 2015 when Paris ranked 20th and the statewide average ranked 17th.

Pharr (21) Performance Summary

The Pharr District has been on a slight downward trend in CS and DS since 2017. The RS has followed a similar trend since 2019. During the downward trend in DS, the percent of sections with an RS in good or better condition surpassed the percent of DS in good or better condition. It is odd for a district to exhibit this behavior and indicates the Pharr District has smooth pavements.

The distress analysis showed that the Pharr District outranked the statewide average in each of the 9 years. It peaked in distress rank at 1st in 2017 and fell each year thereafter to 14th in 2020. In 2020 to 2021, Pharr saw its first distress improvement since 2016 to 2017. Pharr's 2021 distress rank was 12th, and it was the last district that ranked above the statewide average rank.

San Angelo (07) Performance Summary

Throwing out 2017 data, every other year San Angelo had a CS percentage above 90 percent. The DS dipped significantly in 2017 while the RS went up, leading to a CS percentage of 87.11 percent. This dip followed the same trend as Childress, Abilene, El Paso, and Lubbock and might coincide with a switch to automated distress collection. From this analysis, it appears the western districts have some characteristics that impacted scores from the automated distress collection more than eastern districts. For San Angelo, since 2018, the DS has remained stable, while the RS has fallen over 6 percentage points.

The distress analysis for San Angelo showed that while the DS has remained stable since 2018, its lack of improvement has led to a reduction in ranking. In 2018, San Angelo ranked in front of the statewide distress average; however, in 2021, it fell to 14th, one spot below the statewide average.

San Antonio (15) Performance Summary

The San Antonio District has been on a gradual upward trend in CS since 2015. This trend was initially driven by an upward trajectory of RS as DS fell to a low in 2019. Since 2019, RS has dropped slightly while DS has risen, helping to continue the gradual upward trend.

While San Antonio has seen a gradual upward trend of DS, its trend has not been enough to move up in the distress rankings. In fact, San Antonio fell to 25th (i.e., 24th worst district) in 2021 in the distress analysis rankings. San Antonio has never outranked the statewide average from a distress perspective. The closest it has come to the statewide average is a difference of six in 2013, 2017, and 2020. There are currently 12 districts between San Antonio and the statewide distress average.

Tyler (10) Performance Summary

Tyler has seen a gradual downward trend in percent of sections in good or better condition, from 94.32 percent in 2013 to 90.11 percent in 2021. This decline has primarily been driven by a downward trajectory in DS as RS has risen from 2017 to 2021. Tyler experienced a significant dip in 2017 that looked similar to some West Texas districts. If not already known, it might be worth exploring what these districts have in common that led to the dip.

Tyler's downward trend has coincided with a reduced ranking in DS. In 2013, Tyler ranked 4th in the state for percent of sections in good or better distress condition. In 2020 and 2021, it ranked 21st (20th worst district). Tyler has been ranked below the statewide average in each of the last 3 years.

Waco (09) Performance Summary

Waco has seen a gradual upward trend, from 88.1 percent of sections in overall good or better condition in 2013 to 93.31 percent in 2021. This trend has been accompanied by improvement in both DS and RS.

While as a district Waco has been gradually improving, its rate of improvement has led to a chaotic distress ranking. The improvement in DS from 2015 to 2016 led to Waco ranking in the top 10 for highest number of sections with DS in good or better condition. The ranking of 8th held for 2016 and 2017 before dropping to 17th in 2018 and 2019 and then returning to 8th in 2020. Waco currently ranks 18th (i.e., 17th worst district) for percent of sections with DS in good or better condition.

Wichita Falls (03) Performance Summary

Wichita Falls has been one of five districts to maintain at least 90 percent of its network in an overall condition of good or better for the past 9 years. While the trends between DS and RS parallel each other, the gap between the two is large. For example, in 2021, the DS percentage was 89.76 percent and the RS percentage was 77.56 percent, a difference of over 10 percent. With such a high DS, the Wichita Falls District might have to focus on improving RS to see significant changes in overall CS.

The distress analysis showed that Wichita Falls currently ranks 8th for percent of sections in good or better condition for distress. Wichita Falls has beaten the statewide average in each of the last 9 years, hovering close to a ranking of 10th. It peaked at 3rd in 2020 before dropping back to 8th in 2021.

Yoakum (13) Performance Summary

The Yoakum District has been on one of the steepest upward trends for CS since 2013. This trend is a result of upward trajectories in both DS and RS.

The distress analysis in Yoakum showed that from 2013 through 2016, Yoakum ranked much lower than the statewide average in distress. In 2017, Yoakum moved up 15 spots to 7th, and while it dropped back to 11th in 2018, it has remained stable since. Yoakum currently ranks 11th, one district ahead of the statewide average.

SUMMARY OF DISTRICT PERFORMANCE EVALUATION

Additional analysis was performed on high performing districts. During the analysis, the following district trends were reviewed:

- Abilene: Has been trending upward and is currently highly ranked for DS after being below the statewide average for years.
- Atlanta: Is historically a consistent and high-performing district, thought it has trended downward recently.
- Austin: Is very consistent and highly ranked for DS over the past 5 years.
- Beaumont: Is highly ranked but exhibits inconsistency.
- Bryan: Showed significant improvement from 2016 to 2017 and while chaotic since, currently ranks in the top 10 for DS.
- Childress: Is consistent and highly ranked, currently on a 3-year number one ranking for DS.
- Corpus Christi: Has shown major improvement from 2016 and currently ranks 5th for DS.
- Lufkin: Is consistent, highly ranked, and continues to trend upward.
- Wichita Falls: Is consistently better than the statewide average for DS.
- Yoakum: Has shown major improvement from 2016 and has remained consistent since then.

Several western districts (i.e., Abilene, El Paso, Lubbock, and Childress) experienced large drops in the percent of sections in good or better condition in 2017. The Tyler District experienced a similar magnitude in drop. Some of the districts rebounded in 2018. This drop might coincide with TxDOT's transition to automated distress collection. If TxDOT remains concerned about the 2017 data or has concerns with data collection moving forward, additional work should investigate the characteristics of these districts that might have led to the drop.

SURVEY RESULTS

To understand the current state of practice for 4-year PMP development and help identify best practices, researchers sent an online survey to TxDOT districts. The survey was initially distributed to district DOOs and district DOMs. DOOs and DOMs were asked to forward to AEs. Responses from MSs were also solicited. In total, 69 responses were received from all 25 districts. However, the completeness of these responses varied, particularly in relation to district-specific survey questions. A review of district-specific survey questions is provided in a later section.

The following list details the TxDOT position for each of the 69 respondents:

- 25 district staff members (i.e., DE, DDE, TP&D, DOM, DOO, DOC).
- 2 district pavement engineers.
- 10 district MO staff.
- 26 AEs.
- 6 MSs.

Table 3 summarizes the number of responses received from each district.

Table 3. Number of District Survey Responses.

District	Responses	District	Responses	District	Responses
Abilene (08)	3	Dallas (18)	4	Paris (01)	1
Amarillo (04)	1	El Paso (24)	3	Pharr (21)	5
Atlanta (19)	5	Fort Worth (02)	7	San Angelo (07)	1
Austin (14)	5	Houston (12)	3	San Antonio (15)	2
Beaumont (20)	1	Laredo (22)	1	Tyler (10)	3
Brownwood (23)	1	Lubbock (05)	1	Waco (09)	1
Bryan (17)	1	Lufkin (11)	5	Wichita Falls (03)	3
Childress (25)	2	Odessa (06)	5	Yoakum (13)	3
Corpus Christi (16)	2				

SUMMARY OF GENERAL SURVEY QUESTIONS

The online survey contained several general questions to help understand the state of practice for 4-year PMP development. Appendix B: Summary of Responses to General Survey Questions provides detailed figures summarizing the responses for each question.

The survey primarily used the matrix question in Figure 6 to identify the current state of practice within TxDOT on the importance of different variables.

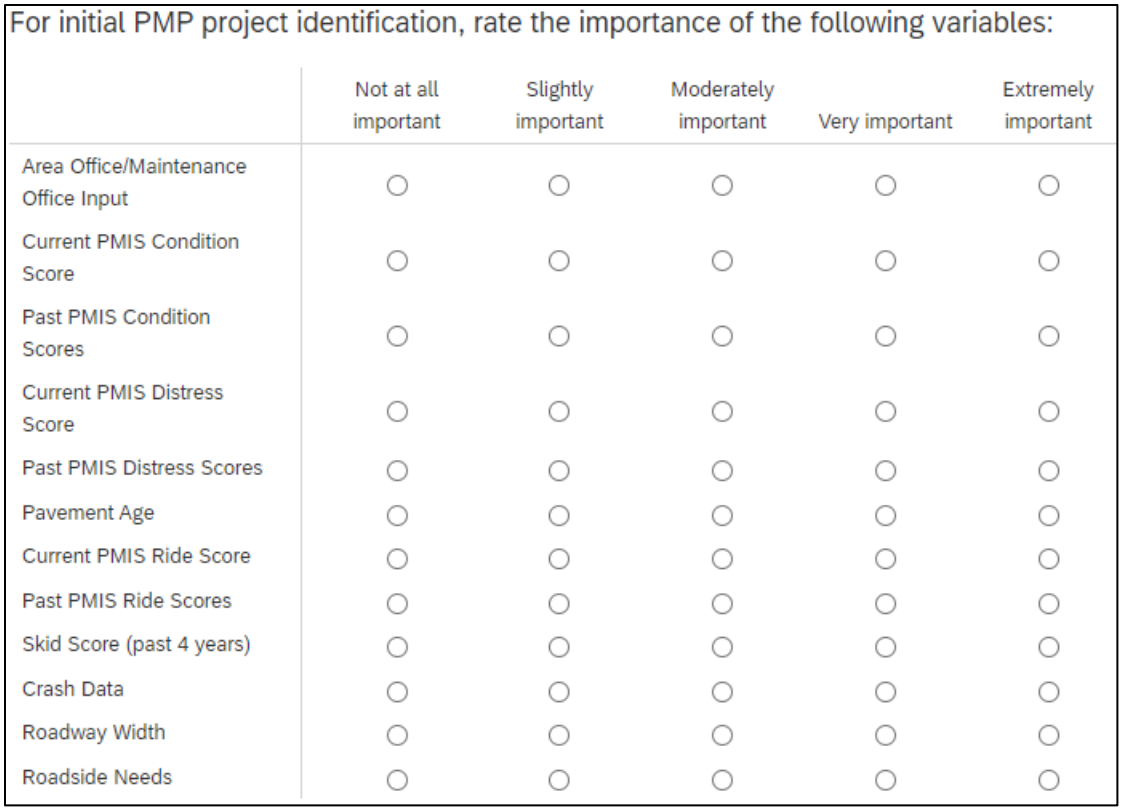

Figure 6. PMP Variable Importance Level.

The importance scale in Figure 6 was converted to the following numerical scale for additional analysis:

- Not at all important = 1.
- Slightly important = 2.
- Moderately important = 3.
- Very important = 4.
- Extremely important = 5.

Figure 7 summarizes the variable importance results from all respondents by plotting the average of all responses. Figure 7 indicates that AO and MO input is the most important variable considered in PMP development. This follows the previously identified PMP practices shown in Figure 2 and Figure 3. Five of the 12 variables received an average importance rating above 4.0. These five variables capture local knowledge (i.e., AO/MO input), current roadway condition (i.e., CS and DS), and safety (i.e., skid and crash data). Figure 7 implies that districts are less concerned with past performance. In fact, only two other variables received importance levels above 3.5—current RS and roadway width. These two variables also help describe current condition and safety and ignore past performance.

Figure 8 shows the variability associated with each general survey question response. The results in Figure 8 reinforce that the current state of practice with TxDOT is to focus on current distress and safety conditions when developing the 4-year PMP. In summary, AO/MO input, current CS, current DS, skid, and crash data have the highest average influence and the least variability within PMP development.

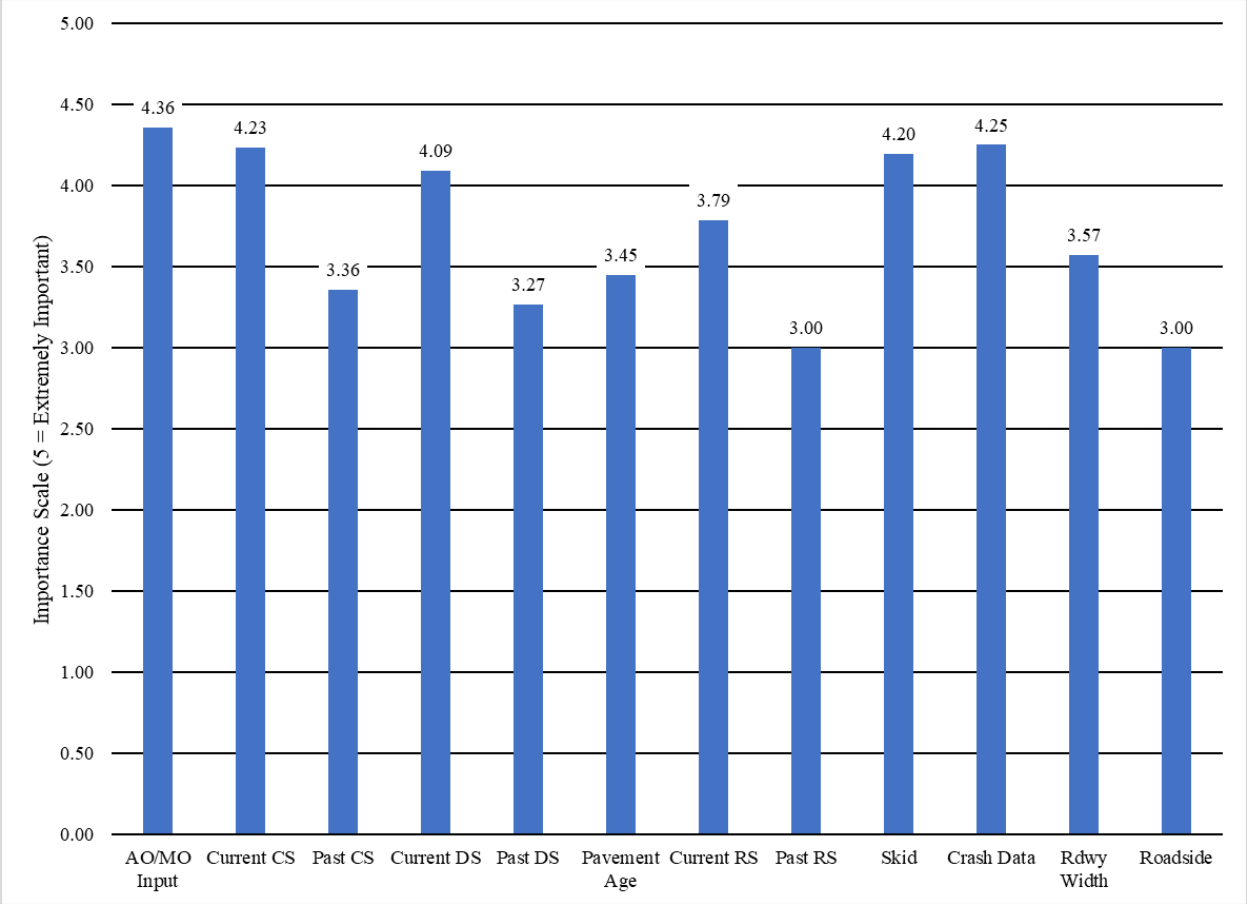

Figure 7. PMP Variable Importance Summary.

Figure 8 shows the variability associated with each general survey question response. The results in Figure 8 reinforce that the current state of practice with TxDOT is to focus on current distress and safety conditions when developing the 4-year PMP. In summary, AO/MO input, current CS, current DS, skid, and crash data have the highest average influence and the least variability within PMP development.

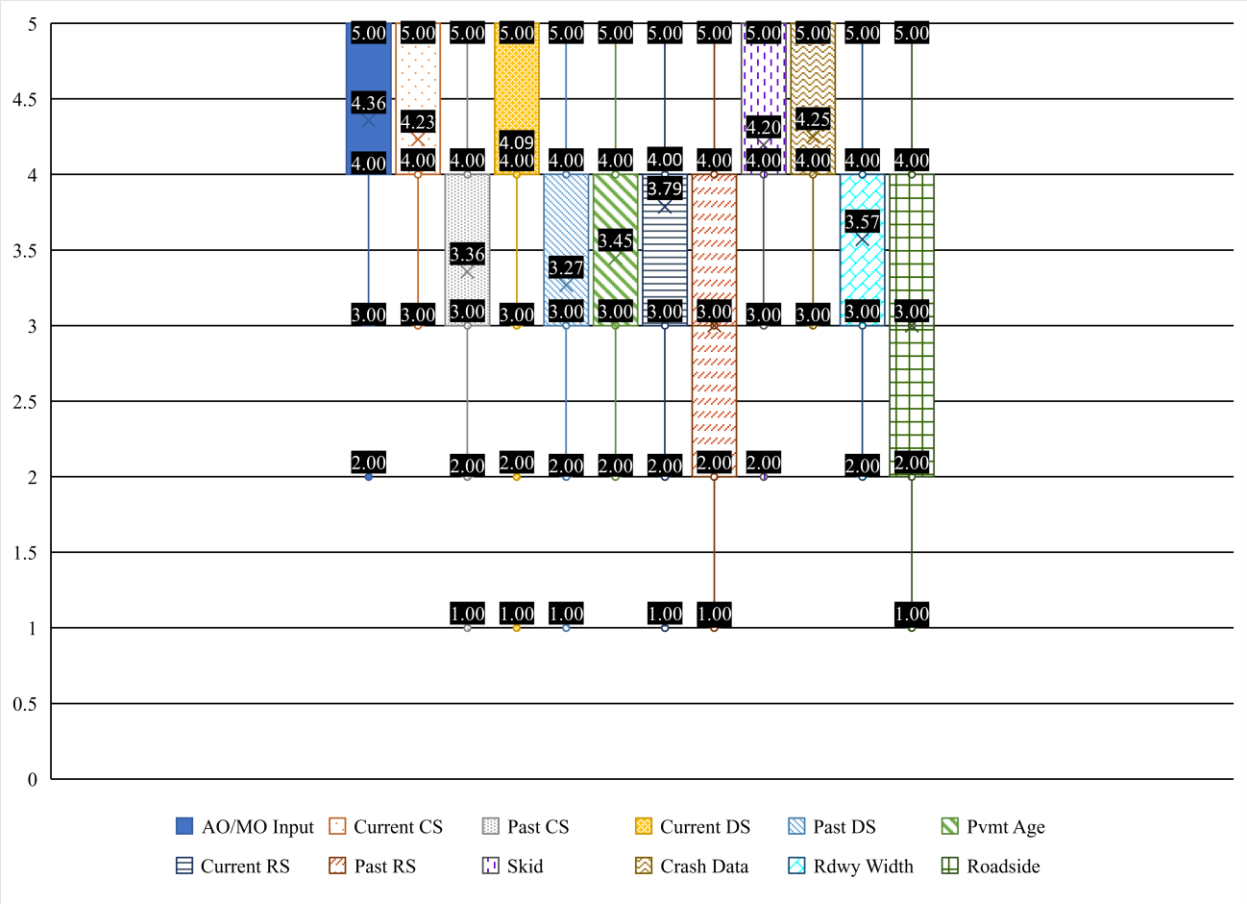

Figure 8. General Survey Question Response Variability.

The importance of local knowledge within a PMP was expected. From the literature review, researchers knew that the current TxDOT guidance recommends beginning the PMP process with AO and MO input. All but one respondent concurred that their district started the process in this way. The respondent that answered no was from the Austin District and referenced the use of their internal ranking tool as the starting place. There were four other responses from the Austin District indicating the process started with AO or MO input.

With the knowledge that local and current conditions are valuable to the PMP process, the survey sought to understand how the project selection process began. The survey asked respondents if project selection was informed by project rides by district decision makers. For this question, 62 of 67 respondents said yes. Only two respondents said no, while the other three left the question blank. One of the respondents that said no was from the Childress District, one of the highest-performing districts. This respondent elaborated and indicated that the current methodology involves the district maintenance manager and MS riding their roads first. After this ride, the needs are placed in an in-house bin or future construction project bin and submitted to the AE. The AE then submits these potential projects to the district, where they are prioritized with other projects by district staff. This prioritization accounts for types of repairs, distresses, and funding.

Because of its rural nature and limited funding, proper pavement preservation project selection is integral to Childress' success.

To further analyze the current state of practice, three additional questions were asked to determine what data might help inform the PMP process. The three questions were:

- How much do you use PA data?
- How much do you use previous PMPs?
- How much of a role does your seal coat program play in the PMP process?

Respondents could respond using the following descriptors that were converted to the associated numerical value for analysis:

- Not at all = 1.
- A little = 2.
- A moderate amount = 3.
- A lot = 4.
- A great deal = 5.

On average, respondents indicated PA data were used a lot (i.e., average = 4.0), while previous PMPS were used between a moderate amount and a lot (i.e., average = 3.82). On the other hand, a district's seal coat program was used between a lot and a great deal (i.e., average = 4.54) for PMP development. When removing Houston's three responses, the use of a district's seal coat program in PMP development rose to 4.70. This indicates that the success of TxDOT's PMPs relies heavily on a district's seal coat program. This success encompasses seal coat preparation, quality of seal, number of seal coats, and other variables that can impact the success of the pavement. TxDOT Project 0-7109, Synthesis for Best Practices for Preventative Maintenance Preparatory Work, provides additional discussion on seal coat preparation best practices.

The importance of district seal was anticipated prior to soliciting survey responses, so researchers asked a follow-up question to determine the adequacy of seal coat preparation work. Figure 9 summarizes the responses to this question and shows that most respondents felt that seal coat preparation is adequate.

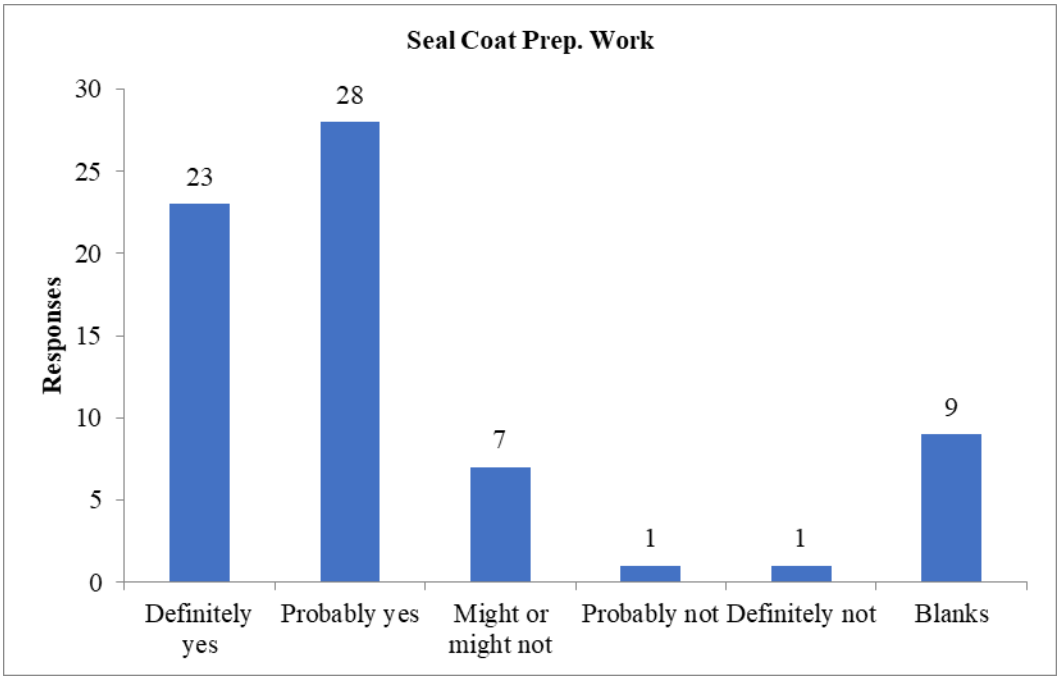

Figure 9. Summary of Adequacy of Seal Coat Prep Work.

CONCLUSIONS FROM GENERAL SURVEY QUESTIONS

Responses to the general survey questions led to the following conclusions:

- Local knowledge is vital to PMP development.
- Because of the importance of local knowledge, districts start the process by asking AOs/MOs for potential projects. This follows the previously developed PMP process shown in Figure 2 and Figure 3.
- Project rides are used to prioritize projects. Who attends those rides varies across districts.
- Current condition data play an important role in PMP development.
- Prior condition data play a much lower role in PMP development.
- Distress data are given more consideration than ride data, a fact that seems to be reflected in current performance metric trends.
- District seal coat programs play a large role in PMP development.
- PMP success depends upon the success of a district's seal coat program, with the likely exception of the Houston District.

To move from a statewide analysis of macro-level best practices, researchers developed district-specific questions to identify micro-level best practices that could potentially help with the success of PMPs if adopted throughout the state.

SUMMARY OF DISTRICT-SPECIFIC SURVEY QUESTIONS

Using the analysis of the performance metrics described in the Evaluation of Current District Performance section, researchers prepared district-specific questions. These questions and the responses provided by district personnel are shown below. These responses represent complete survey responses. There were 48 complete responses from 24 of TxDOT's 25 districts. Only Paris failed to provide district-specific responses, though the Paris respondent did answer most of the general survey questions.

Abilene (08) Specific Questions

- Question (Q). Abilene saw its network exceed 90 percent good or better in FY 2020. What are your thoughts on how Abilene was able to get to that point?
    - Answer (A). Use PM to focus on fair and good pavements to keep them good or better.
    - A. County maintenance base repair.
    - A. Teamwork, 4-year plan, good communication from the top to the maintenance sections.
- Q. Generally speaking, the Abilene District has seen a slight upward trend in overall condition over the past nine years. What are your thoughts on how Abilene has sustained that overall upward trend?
    - A. Good selection of PM for roads that need it. Using PA as a tool to identify areas for improvement.
    - A. Great seal coat program.
    - A. 4-year plan combines seal coat, preventative maintenance, all the way to full rehab. Teamwork and planning.
- Q. While the Abilene District sees an upward trend in Distress Score, the Ride Score has trended downward since 2017. What do you see as your challenges with improving ride quality?
    - A. Focus on blade patches for areas where ride quality improvements are needed in maintenance activities prior to seal coat. Use PA to identify corridors or sections of roads with ride quality issues.
    - A. More experience in field operations.
    - A. Takes hot mix or grinding to reestablish ride. Very expensive. Not enough money or resources to do so. We rented a laydown machine a couple of summers ago and laid hot mix inhouse with special jobs, it helped some but didn't put a dent in ride.

Amarillo (04) Specific Questions

- Q. Amarillo seems to be on a consistent upward trend in the percent of its network in good or better condition. What are your thoughts on how Amarillo has been able to create this upward trajectory?

    - A. We are focusing on better prep work for seal coat and allocating additional funds compared to previous years. We are also focusing on having the right scope for a project.
- Q. What is Amarillo's biggest challenge with maintaining this upward trend?
    - A. Ensuring that our seal coat roads are properly prepped. This has been a district wide issue.

Atlanta (19) Specific Questions

- Q. What are the key elements in the PMP that allow the Atlanta District to be one of only five districts to maintain a network with 90 percent or more of its sections in good or better condition in every year over the past nine years?
    - A. Good planning and project selection. Successful pavement designs and projects.
    - A. I believe that we have had good leadership in what needs to be done to preserve our pavements and in what needs to be done when rehabilitating them. Choosing the correct application and applying that at the right time.
    - A. 1 year maintenance plan and 4-year plan. District seal coat and in house seal coat.
    - A. Selection of mill and inlay, and seal coat projects.
- Q. Even with a high percent of sections in good or better condition, the Atlanta District has been able to maintain an upward trend What are your thoughts on how the district has done this?
    - A. Efficient use of money allotted to us. Thinking about how to use all categories of construction funding and maintenance funding together.
    - A. Our maintenance crews have done an awesome job as well as the new construction locations being at very good quality.
    - A. Everyone works together.
    - A. Selection of good projects.
- Q. The Atlanta District's Distress Scores and Ride Scores are almost identical over the past nine years. How has the Atlanta District maintained the parity between Distress Score and Ride Score?
    - A. Good planning and project selection. Successful pavement designs and projects.
    - A. I am not sure on this one.
    - A. Knowing what is needed.
    - A. Good prep work for seal coat roads.

Austin (14) Specific Questions

- Q. What are the key elements in the PMP that have allowed the Austin District to create the consistent upward trajectory of percent of sections in good or better condition?
    - A. Focusing on critical needs and moving to a needs-based budget. Using all available data to help prioritize and filter our needs. Final project selection

determination is still up to the DOO but this helps to review all needs over our 11 counties. In house seal coat program is also essential for our district. Our staff takes tremendous pride in the roadway prep work and the final sealcoat.
    - A. Sound evaluation and critical needs with good design principles which allow the district to distribute funds and leverage more improvements out of the allocation. Good sound decisions districtwide using proven techniques are working!
    - A. Keeping good pavement in good condition.
- Q. How does traffic volume impact the treatment selection within the Austin District?
    - A. Our district pavement design standard operating procedures has identified roadway treatment types based on ADT and future growth patterns. This is predetermined and updated each year. Many of our historical seal coat roads are now changing to TOM roadways as the surface type.
    - A. Traffic volume is directly related to the treatment, final surface, and scoped work to be performed. Our district's surface selection map directly reflects this correlation.
    - A. It impacts the surface mix.
- Q. The Austin District's Distress Scores and Ride Scores are almost identical over the past nine years. How has the Austin District maintained the parity between Distress Score and Ride Score?
    - A. Same as above, focusing on the areas that need the most attention. Also being extremely selective with the approach to the planned work and material selection for the roadway. Starting with an accurate pavement design is also critical to success.
    - A. Building a good foundation in the beginning, pro-active maintenance.
    - A. Not sure.
- Q. Please rank the following elements as to their impact to Austin's high level of pavement quality: good materials, good planning, good design, good soils, etc.

Beaumont (20) Specific Questions

- Q. What's the one thing you could do to create a steep and consistent upward movement in your condition score?
    - A. Use a well-crafted combination of Cat1 and RMC dollars to target roadways and roadway segments (half-mile) with the lowest condition scores and abandon the idea that an even distribution of funds is needed across all the district's maintenance sections.

Brownwood (23) Specific Questions

- Q. The Brownwood District has the most consistent pavement condition scores from year to year. Please rank the elements on why you think this is the case: low traffic volume, good soils, crew expertise, good seal coat prep, quality materials, …

- Q. The Brownwood District has seen a consistent downward trend in Ride Score since 2018. What do you think has been the cause of this downward trend?
    - A. I believe there are several items contributing to this trend:
        1. Loss of expertise in maintenance sections maintainer operators.
        2. In my opinion we are starting to reach a critical juncture in a large portion of our pavement sections due to the systematic 7-year cycle of sealcoat operations. This system has served us well for decades; however, many of our roads now have 2.5–3 in. of sealcoats on the surface. We are seeing increases rutting and "shoving" due to the lack of lateral stability in these stacked sealcoats.
        3. Maintenance culture. We now have a group of maintenance supervisors that were new TxDOT crew members when TxDOT made the huge shift to "pennies to the pavement" and "you can't fix every ride issue." Our current supervisors don't remember the level of preparation for sealcoat prior to the change. We are having to spend a lot of time with them changing their expectations to our current situation.

Bryan (17) Specific Questions

- Q. Bryan seems to be on a consistent upward trend in the percent of its network in good or better condition. What are your thoughts on how Bryan has been able to create this upward trajectory?
    - A. Focus on proper prep. In-house work is critical to our success. 5-mile sections are a large contributor.
- Q. With more than 90 percent of the pavement sections in the Bryan District in good or better condition, what is the key to maintaining the network at or above that level?
    - A. Fix what needs to be fixed (fiscally bound). Continue our success with 5-mile sections.
- Q. What has the Bryan District done to create an upward trend in Ride Score since 2017?
    - A. Ride is considered when scoring in the initial project ride. DOM/DDE/DE emphasize improving ride quality to our maintenance forces. District award to section with best ride improvement.

Childress (25) Specific Questions

- Q. What are the key elements in the PMP that allow the Childress District to be one of only five districts to maintain a network with 90 percent or more of its sections in good or better condition in every year over the past nine years?
    - A. Being a rural district, we don't see the traffic volumes that other parts of the state witness. That is a blessing in disguise though. Our category 1, operation, and contract maintenance funds are the smallest in the state. With that, we make the money go as far as it can with in-house operations and pavement preservation.

- Q. Even with a high percent of sections in good or better condition, the Childress District has been able to maintain an upward trend. What are your thoughts on how the district has done this?
    - A. In-house seal coat program, by far. This program has been active in our district for years and it's vital to our program.
- Q. While the Childress District has been able to maintain an upward trend in Distress Score of the past five years, it has seen a downward trend in Ride Score. What do you think is leading to this downward trend in Ride Score?
    - A. Funding. If we had more category 1 funding, we could address more ride score issues within our district. A seal coat or blade patch will only go so far with improving ride.

Corpus Christi (16) Specific Questions

- Q. The Corpus Christi District has been on the steepest upward trend of any district with regard to percent of sections in good or better condition over the past six years. What are the key elements of the PMP that have helped with this trend?
    - A. Support from the top down. People buying into what we are trying to do and the maintenance crews executing the plan.
- Q. What needs to be included in the PMP to continue this trend and maintain high scores in the future?
    - A. Seeing a relation of dollars spent on a segment to ensure condition scores are increasing in these sections.
- Q. The Corpus Christi District has created an upward trend in both Distress Score and Ride Score. What elements of the PMP have led to this tandem movement in these performance metrics?
    - A. Having access to the data and able to use it to our advantage. It helps the data is accessible in one program now instead of the way it used to be stored.

Dallas (18) Specific Questions

- Q. How or why do you think the Dallas District continually outperforms the pavement condition prediction model?
    - A. Good planning and adequate funding.

El Paso (24) Specific Questions

- Q. In your opinion, why has El Paso seen a consistent downward trend in its percent of pavements in good or better condition within the last nine years?
    - A. Mismanagement of the maintenance plan. Diversion of funds to construction projects.
    - A. The previous district PM strategy was an isolated approach, which neglected a large portion of the pavement network. During recent years, the district changed the strategy to a districtwide network approach. The current approach includes all

relevant district offices, project data review and project drives. We expect pavement score to improve as the plan cycles and takes effect.

Fort Worth (02) Specific Questions

- Q. After a downward trend from FY 2013 to FY 2018, the Fort Worth District has seen and upward trend. What do you believe is the catalyst for this upward trend?
    - A. The district's acknowledgement of and focus on improving our PMIS scores.
    - A. We are not getting the years out of the asphalts like we did back when and a lot more people moving into the area and our roads cannot handle the load.
- Q. What is necessary to maintain or steepen this upward trend?
    - A. Continued focus on PMIS scores and implementation of surface treatments that are appropriate to address the factors affecting the condition.
    - A. More rehabs on roadway.

Houston (12) Specific Questions

- Q. How much consideration do you give to the condition predictions?
    - A. Some consideration should be given.
    - A. I never used it before, but I recently took the Pavement Analyst class and it seems like a great tool to help decide the type of pavement treatment.
- Q. The Houston District's Distress Scores and Ride Scores have paralleled each other closely over the past nine years. How has the Houston District maintained the parity between Distress Score and Ride Score?
    - A. We give more consideration to distress score over ride score.
    - A. These are both considered during project selection, but distress scores should be look at closely and addressed.

Laredo (22) Specific Questions

- Q. After seeing an upward trend in percent good or better from FY 2013 to FY 2019, the performance seems to have leveled off from FY 2019 through FY 2021. What needs to be done to recreate the upward trajectory?
    - A. [The] district need[s] additional funds to address the locations needing heavy rehabilitation. The energy sector impacted many districts' pavement conditions, but additional funding was not allocated sufficiently to recover from those impacts. Our current Cat 1 allocation allows for about one heavy rehab project per fiscal year and the remainder of the allocation is committed to preventive maintenance and light rehabs. This is resulting is very slow progress toward repairing the heavily impacted energy sector roadways.

Lubbock (05) Specific Questions

- Q. What has the Lubbock District done to create the upward trend in sections in good or better condition since FY 2018?
    - A. Better planning and more overlays.
- Q. The Lubbock District saw a sharp downward trend in Distress Score and Ride Score from FY 2016 to FY 2017. What do you think led to this downward trend?
    - A. Automated PMIS data collection.

Lufkin (11) Specific Questions

- Q. What are the key elements in the PMP that allow the Lufkin District to be one of only five districts to maintain a network with 90 percent or more of its sections in good or better condition in every year over the past nine years?
    - A. We have a strong maintenance culture and urgency to address issues quickly. Additionally, our sections work well together, and we do in house rehabs and maint. seals.
    - A. We have a very good process in place that involves all the stakeholders in the process. We work as a team across design, construction, and maintenance for the benefit of the district as a whole. We have a spreadsheet for each maintenance section that has each roadway in the section and broken down into the sections that we have projects on. It displays both construction and maintenance projects, and shows the past year, current year, and the 4 years in the 4-yr plan. This allows us to make sure we are planning the prep work for construction seal coats, to make sure we aren't overlapping construction and maintenance work, and also not putting maintenance money into a roadway that will be getting rehabbed in the near future. This spreadsheet also has a budget portion that is tied to the work so that we can ensure that the plan is fiscally reasonable.
    - A. We seek as much of the unspent statewide maintenance money at the end of FY as they will give us.
- Q. Even with a high percent of sections in good or better condition, the Lufkin District has been able to maintain an upward trend. What are your thoughts on how the district has done this?
    - A. I believe PA is a great tool that helps us select the right projects including RM and PM work.
    - A. We are a very competitive district. From the director of operations to the maintenance section supervisors, we are always striving to do better within the district and the state. Also, we know that with higher scores, you get less money. With that in mind, we do our best to complete our planned projects early in the summer so that we are able to take advantage of any extra money the maintenance division has available.

Odessa (06) Specific Questions

- Q. In your opinion, why has Odessa seen a consistent downward trend in its percent of pavements in good or better condition within the last nine years?
    - A. Significant increase in energy sector activity along with the heavy traffic loading paired with a reduced PM and seal coat prior to energy sector uptick.
    - A. Steady increase of heavy oilfield traffic. We have data that supports this. Scores have improved over the past 2 years as more construction projects are completed with heavy full rehab and robust pavement designs to meet the ESALs generated by heavy truck traffic. In the past 9 years, old FM roads that had light traffic for decades all of a sudden get heavy oilfield traffic from a newly developing oil field.
    - A. I think it is a function of our environment. We have a lot of damage on our roadways due to the percent truck traffic and ADT. These roadways were not designed for the loading they are experiencing.
    - A. The fluctuation of traffic from the energy sector has been difficult to adapt to and meet the resource needs of.
- Q. The Ride Score in the Odessa District has been more stable than the Distress Score. How has the Odessa District been able to maintain more consistency in it Ride Score than in its Distress Score?
    - A. Fairly stable soils and bases.
    - A. Distress is usually caused by cracking in this district. Maintenance does a good job of patching up the roughest and worst areas and we utilize seal coat effectively to hold over bad roads until we can rehab them.
    - A. We have been fortunate to have the funding needed to help address some of our roadway issues.
    - A. The Odessa District does not have expansive soils.

Paris (01) Specific Questions

- Q. What are the key elements in the PMP to helping the Paris District continue its slight upward trend in percent of sections in good or better condition?
- Q. In the Paris District the difference between Distress Score and Ride Score is high. What can be done to improve the Ride Score so that it more closely aligns with the Distress Score?

Pharr (21) Specific Questions

- Q. The Pharr District overall percent good or better seems to be on a slight downward trend since peaking in FY 2017. Do you have any thoughts on why this is occurring?
    - A. I don’t know.
    - A. We have put seal coat after seal coat for many years and now it’s time to either overlay or rehab. With the limited budget, we can only overlay so many roadways.

    - A. The percent of sealable roadways continue to decrease over time due to traffic increase/urban sprawl coupled with a reduced and limited budget since the peak of 2017 supports the downward trend.
    - A. Increased traffic volumes in urban setting. More than half the centerline miles in urban area and thus require additional funding.
    - A. Most of that trend was single year drop. Since then, scores have been on steady incline and are now over 90 percent.
- Q. The Pharr District is one of the few districts with a Ride Score higher than the Distress Score. What does the Pharr District do to maintain a high Ride Score?
    - A. Upper management is constantly reminding us of the importance of getting a high distress score. I believe we have the expertise (Director of Construction used to be lab supervisor...DE used to be Director of Maintenance, etc.) AND we understand the sense of urgency...Pharr District takes it very seriously. That's my opinion.
    - A. We try our best to maintain our good roads by adding a thin level up on roadways that are not in the 4-year PMP.
    - A. A healthy PM program from our maintenance sections via in-house level-ups (cold-mix with blade) and contract mill and inlay.
    - A. Prep roads prior to SC.
    - A. Provide adequate material budgets for our maintenance sections to address ride concern areas.

San Angelo (07) Specific Questions

- Q. The San Angelo District saw a decline in the percent of its network in good or better condition from over 95 percent in FY 2013 to near 87 percent in FY 2017. Since 2017, the district has seen a consistent percent good or better increase back above 93 percent. What do you think led to the decline from FY 2013 to FY 2017? Specifically, the sharp decline from FY 2016 to FY 2017?
    - A. I do not know. I was not here during those years.
- Q. What do you think has led to the gradual increase from FY 2017 to current?
    - A. I do not know.
- Q. The Ride Score seems to have started another downward trend beginning in 2017. What can be done to stop this downward trend in Ride Score?
    - A. Use better material, use the correct material for that correct operations, and hold contractors more accountable during construction projects, work on base failures more completely.

San Antonio (15) Specific Questions

- Q. What is the key to San Antonio's upward trend since FY 2018 in the percent of sections in good or better condition?
    - A. Increased our SC program funding and trying to get to a seven-year cycle on SC for the majority of roadways. We have also invested in some base repair

contracts to help the maintenance section with problematic roadways. A lot of major construction projects have been completed in Bexar County increasing the PMIS scores.
    - A. Maintain the roadways already in good or better condition and address as many as practical that are not. Maintain an aggressive seal coat and overlay program.

Tyler (10) Specific Questions

- Q. The Tyler District has seen its percent of sections in good or better condition go from 94.32 percent in FY 2013 to 90.11 percent in FY 2021. Do you have any thoughts on what has led to this decline?
    - A. PMIS went from visual rating to automated.
    - A. Rainfall and increase in traffic counts. We are also putting more focus on bridge infrastructure. Construction and maintenance costs have also risen, which limits the amount of repair that can be funded.
    - A. Some of the cause is the increase [in] number of travelers and people coming to the area compared to what the roadways were originally built for. Additionally, the material we are primarily using on a lot of roadways (HMA) has been a quality issue and the district has been working diligently to solve the issue. Another issue is the PFC that is being used to help with safety conditions and wet weather items is looking at having a 10 to 12 yr. life. We have a lot of these roadways that are coming to the end of that life cycle.
- Q. What do you think led to the sharp decline in Distress Score from FY 2016 to FY 2017?
    - A. PMIS went from visual rating to automated.
    - A. Rainfall.
    - A. Switching from a visual rating setup to a digital rating setup with lasers. Lasers show more minute items that are not visible as closely to the human eye.
- Q. What is the key to the Tyler District's gradual upward trend in Ride Score over the past nine years?
    - A. Hot mix is readily available in the Tyler District and it is a tool that is utilized. The benefit to hot mix is the improvement of the ride scores.
    - A. Not sure.
    - A. The district has used contract laydown to supplement the laydown machine that is used on in house work. We have also had a good amount of very good blade operators throughout the district that can blade overlay patches with a very smooth finish.

Waco (09) Specific Questions

- Q. What has been the key to the Waco District's success on its gradual upward trend from 88.1 percent of sections in good or better condition in FY 2013 to 91.31 percent in FY 2021?
    - A. Identifying projects based on needs, not an even distribution of projects across the district.
- Q. What is needed to continue this upward trend?
    - A. Identify and anticipate the reduction of pavement condition early so that we can have the plan to address the issue promptly.

Wichita Falls (03) Specific Questions

- Q. What are the key elements in the PMP that allow the Wichita Falls District to be one of only five districts to maintain a network with 90 percent or more of its sections in good or better condition in every year over the past nine years?
    - A. Much of our district focus is, and has historically been, on pavement management. Involvement in the selection process from all levels of the district including the sections, areas, and district personnel. Using the PMIS Data as a tool to determine needs, but also getting out to look at the roads at multiple levels to determine the right project is performed at the right location. Following up on what worked and what didn't, then repeating processes that work well.
    - A. Employees that put a lot of thought and effort into our PMP and do a good job of addressing not only roadways that currently have issues, but also roadways that could develop issues in the near future (proactive vs. reactive).
- Q. Do you think the Wichita Falls District could do anything to improve the Ride Score across the district?
    - A. On higher volume roadways we have been using higher grade mixes (SMA, PFC, etc.) to attempt to improve both distress and ride quality. On many of our lower volume roads we could improve ride, but it becomes cost prohibitive to implement the higher grade mixes, we try to implement spot leveling and repair to address these areas in a more cost efficient manner.
    - A. Put more emphasis on concrete pavement that is consistently lowering our overall scores in the district, specifically in Wichita County.

Yoakum (13) Specific Questions

- Q. The Yoakum District has been on one of the steepest upward trends with respect to percent of sections in good or better condition since FY 2013. What has led to this upward trend?
    - A. I would like to say good leadership but in reality, I attribute it to the work done in the maintenance sections. The prep work that happens before a seal coat makes all the difference in the performance of the road. MSs understand how the

program works and what they need to do to bring scores up. We are also trying to better utilize our contracts to help section get roads ready for a seal.
    - A. Great seal coat program. Cycling seals. Great prep work by maintenance sections. Good 4-year plans. Close communication between district and area office.
- Q. What do you need to continue this upward trend?
    - A. Continued funding is critical. We use the vast majority of our material funds for level up in preparation for seal coat. If funding is reduced, we will not be able to continue prepping roads to the same extent. Competition for maintenance dollars. There are a number of competing interests for maintenance dollars that could reduce funding for seal coat prep. Material and trucking—currently material availability along with truck is limiting our production.
    - A. Keep doing the things we're doing.
- Q. This upward trend has included both Distress Score and Ride Score. What has been the primary driver of the upward trend in Distress Score?
    - A. Addressing base failure, soft spots and not just covering up problem areas with spot seals or level up. Goes back to properly prepping a road for seal coat. Lessons learned—improved rehab projects where we learned from our mistakes in the energy sector.
    - A. Good prep work. Most maintenance sections are able to perform rehabilitations in house.
- Q. What has been the primary driver of the upward trend in Ride Score?
    - A. Quality and quantity of level up. It is our top maintenance function. District encourages full width level up on existing seal coat road as part of their prep work. Overlay of jointed concrete pavement. JCP is good structurally but show up on ride scores.
    - A. Blade on hot mix by maintenance sections.

SUMMARY OF FOLLOW-UP INTERVIEWS

Using the online survey results, researchers sent out additional follow-up, email-based interview questions. These follow-up interview emails were sent to Atlanta, Lubbock, Brownwood, Bryan, Lufkin, Odessa, Pharr, San Antonio, Waco, Wichita Falls, and Yoakum employees. While many of the questions were similar, questions varied slightly based on the responses received in the general surveys. Each of the practitioners included in the follow-up surveys indicated their willingness to do so in the online survey.

The online surveys clearly showed that the annual seal coat program and its preparation have the highest influence on the long-term success of the PMP. Therefore, many practitioners were consulted on who decides what seal coat preparation to perform. When this question was asked, all responded that this responsibility falls to the MS. Most qualified this answer with the fact that the MS's plan is vetted and approved by either the AE or district staff. Also, most districts have a culture of preparation techniques that have been successful in the past.

Understanding maintenance techniques that work within a district and communicating that throughout the sections is important for prolonged success. For example, the Yoakum District has a Gradeall in every section because the MSs like its versatility and it allows sections to dig and repair base failures quickly. Other districts might have only one or two Gradealls in the entire district. While that might meet that district's needs, having an understanding of the repairs that work and ensuring the district has the equipment available is important to the success of the PMP.

The follow-up interviews also showed that the 1-year plan essentially captures seal coat preparation. The connection between the 1-year plan and the 4-year plan hinges on the preparation of seal coat roadways. However, the 1-year plan also must account for perennial contracts such as mowing, litter pick-up, tree trimming, etc. While these contracts are necessary, they have fiscal impacts on seal coat preparation, especially for rural, low-volume districts with small Category 1 and routine maintenance contract (RMC) funds. Understanding that the 1-year plan's highest priority must be seal coat preparation creates a mindset that helps break the reactive cycle. When seal coat preparation starts going right, maintenance sections stay ahead, allowing them to finish early and take advantage of unused funds.

Using the knowledge that the seal coat program serves as the most important variable in plan success, researchers asked a follow-up question on whether formal overlay programs existed within a district. Yoakum indicated that it did, but most other respondents indicated they did not. The San Antonio respondent indicated that an overlay program was being discussed for high-volume roadways, and the Lubbock respondent indicated they would love to have this type of programming but have no funding to transition to one. Researchers assumed that practitioners would be open to a formal overlay program and subsequently asked if the district had a surface selection map similar to Austin. No other districts responded that they had a surface selection map.

A nugget gleaned from the follow-up interview came from the Bryan District's 5-mile section development. This process involves selecting five centerline miles each year for a maintenance section to repair in addition to seal coat preparation. These sections must have a CS below 70 or the MS must have a reason to believe the CS will drop below 70 in the upcoming year. This allows the district to repair fair, poor, or very poor sections without waiting for a construction project.

Another best practice from the follow-up interviews came from the Wichita Falls District, where the respondent elaborated on the district's proactive philosophy. The district allows flexibility, both budget and schedule, in its 1-year and 4-year plans to pivot and address issues in real time. The MSs are responsible for identifying problem locations, and then the AE and district maintenance staff work with the MS to develop a solution.

FOUR-YEAR PMP BEST PRACTICES

Researchers took a tiered approach to summarize 4-year PMP best practices. First, researchers used the high-performing districts identified in the Summary of District Performance Evaluation section and analyzed their responses for similarities. Second, researchers used common responses to the survey questions to generate typical best practices. Finally, researchers identified potential risks to successful PMPs through survey responses and performance metrics to suggest new or improved best practices for PMPs.

DISTRICT BEST PRACTICES

Many, potentially most, districts follow similar practices as the high-performing districts highlighted in this section. Nonetheless, researchers further evaluated a handful of districts to identify processes that were uniform among high performers in hopes that these processes could be used at the statewide level. The sections below highlight best practices identified in the Abilene, Atlanta, Austin, Beaumont, Bryan, Childress, Corpus Christi, Lufkin, Wichita Falls, and Yoakum Districts.

Abilene (08) Best Practices

Abilene was chosen as a best practices district because of its upward trend in CS, with 91.88 percent of its network in good or better condition. In addition to this, Abilene has seen its DS ranking rise to 6th in the state. Three personnel from the Abilene District responded to the survey. All three personnel were district-level staff members.

The Abilene process includes scoring projects on a 1 to 10 scale during project rides. Projects are then prioritized by including other variables, such as average daily traffic (ADT), PA scores, truck traffic, etc. These project rides help establish the initial scope of the project.

Abilene is pursuing moving to a 7-year seal coat cycle. They have not yet achieved this goal, but it appears that district personnel understand this goal and pursue it aggressively. This understanding across the district highlights the common themes of teamwork and communication noted by the respondents.

Acquiring the necessary funding to continue to maintain an upward trend is the biggest risk to Abilene. This might be evident with the deterioration of RS despite the improvement in DS and CS. Stretching dollars to repair lane miles often comes at the expense of work actions that improve ride.

Atlanta (19) Best Practices

Atlanta was chosen as a best practices district because of its consistency over the past 9 years and its current 93.51 percent of sections in good or better overall condition. Atlanta also ranks in

the top 10 for percent of sections in good or better condition for DS. This has been the case since 2016. Five individuals responded from the Atlanta District: a district staff member, the district pavement and materials engineer, and three MSs.

The PMP process includes projects rides where personnel use a 1 to 10 scoring system to score each project. The district planning committee then prioritizes projects. The project rides help establish the initial scope of the project, but the district also utilizes testing when necessary to identify what needs to be done. The district leadership supports the mentality to acquire the necessary information to select the proper treatment.

Respondents also noted that the district has a culture of teamwork that has helped lead to its success.

Austin (14) Best Practices

Austin was chosen as a best practices district because of its upward trend and consistency. It currently has 94.04 percent of its network in good or better condition and ranks 4th in Texas for percent of sections in good or better condition for DS. Five Austin District personnel responded to the survey. These personnel included a district staff member, three AEs, and one district MO staff member.

Austin performs project rides but does not score or rank projects during the rides because of its thorough district tool. The tool prioritizes the projects across the district. The project rides help establish the initial project scope.

The district has a detailed pavement design standard operating procedure and a district surface selection map. This selection map has helped shift toward the use of thin overlay mixes (TOMs) on roadways that are no longer sealed because of high traffic volumes.

Beaumont (14) Best Practices

Beaumont was chosen as a best practices district because while it has been on a slight downward trend, it has had 90 percent or more of its network in good or better condition 8 out of the last 9 years and currently has 91.63 percent of its network in good or better condition. Also, Beaumont currently has the 3rd largest percent of sections with a DS in good or better condition and has ranked in the top 10 in each of the last 9 years.

The survey received a single response from a district staff member.

Beaumont performs project rides and scores each project using a 1 to 10 rating scale. Beaumont does not attempt to evenly allocate funds across sections; rather, it allocates funds based on needs.

Bryan (17) Best Practices

Bryan was chosen as a best practices district because of its upward trend, and it has 91.4 percent of its network in good or better condition. Bryan's network currently has the 9th largest percent of sections in good or better condition from a DS perspective. This is up 10 places from 2020. The survey received one response from a district staff member in Bryan.

The Bryan District performs project rides and uses a 1 to 10 rating scale. These rides help establish initial project scope.

In an attempt to improve RS, which has been trending upward, the district gives an annual award to the section with the best ride improvement.

Childress (25) Best Practices

Childress was chosen as a best practices district because of its consistency with having 90 percent or more of its sections in good or better condition. Currently, 96.59 percent of its network is in good or better condition, and Childress has ranked 1st in largest percent of sections with a DS in good or better condition each of the last 3 years.

The survey received one response from a district staff member. Childress starts the process by having the MS nominate projects to the AE. These nominations usually occur after the MS and district maintenance manager have ridden the projects. Prioritization of projects occurs at the district level. This prioritization is usually informed by the deep distress maps and previous maintenance expenditures.

In-house work, both rehabilitation and seal coat, is vital to the success of the pavement management programs. The in-house expertise and talent help ensure the system is maintained with the smallest Category 1 and RMC budgets in the state.

With RS trending downward, the only way to see improvement is to do something other than seal coat, and funds do not currently allow this to take place.

Corpus Christi (16) Best Practices

Corpus Christi was chosen as a best practices district because of its steep upward trend, rising from 76.72 percent of its network in good or better condition in 2017 to 89.97 percent in 2021. This rise has occurred because of both DS and RS, though its DS has risen to the 5th best in the state.

Two AEs responded to the survey. Corpus Christi uses project rides in the process and uses a numerical scale to rank the projects. These project rides help establish the initial project scope.

One of the key reasons for success has been top-down district support and good communication among all partners. The district has been using data to help create the upward trajectory in DS and RS.

Lufkin (11) Best Practices

Lufkin was chosen as a high-performing district because of its consistency and its continued upward trend even with high scores. The Lufkin District network currently has 95.83 percent of its sections in good or better condition. Lufkin is also on a 3-year streak of being ranked 2nd with the highest percentage of sections with a good or better DS. Lufkin has been in the top three for this metric since 2016.

There were five responses from the Lufkin District: a district staff member, a district MO employee, and three AEs.

The Lufkin District strives for a 7-year seal coat cycle on major roadways and uses a needs-based approach to address other roadways. Lufkin has a seal coat specialist to assist with seal coat preparation. Seal coat roadway selection has its own project ride with the AEs, DOO, and seal coat specialist. This allows AEs to understand the needs across the state.

Rehabilitation and overlay projects are prioritized by district staff and the DE by reviewing condition maps, ADT, safety, and wet crashes. MSs are consulted on additional needs within the project and on what maintenance work has been performed in the past.

Respondents from Lufkin noted that the success of the district is due to the following reasons:

- In-house rehabilitation projects.
- Teamwork, communication, and plan buy-in from the top down.
- Emphasis on bringing up scores using an internal formula.
- Friendly competition among district sections.
- Finishing of seal coat preparation early to take advantage of unused funds.

The respondents noted that the biggest risk to maintaining PMP success is attrition (i.e., knowledge loss).

Wichita Falls (08) Best Practices

Wichita Falls was chosen as a high performer because its DS has ranked above the statewide average in each of the last 9 years. Its DS has ranked in the top 10 since 2017 and currently ranks 8th. Wichita Falls has also been consistent over the past 9 years, having 93.2 percent of its network in good or better condition in 2013 and 93.52 percent in 2021. Three Wichita Falls personnel responded to the survey, a district staff member and two AEs.

Project rides start at the section level, and 1 to 5 scoring scales are used to score projects. District staff ride the projects after initial identification at the section level. The entire district has a focus on pavement management.

Improving the ride quality within the district has been a priority, and high-volume roadways have had projects with overlays. However, addressing ride on low-volume roadways would require a different surface than seal coat, and this is currently cost prohibitive.

Yoakum (13) Best Practices

Yoakum was chosen as a high performer because of its consistent upward trend in CS, DS, and RS since 2014. The district currently has 92.8 percent of its network in good or better condition and ranks 11th in DS. Yoakum saw its DS rank rise 15 spots from 2016 to 2017 and has been ranked in front of the statewide average since. Three district personnel responded to the survey, including a district staff member and two AEs.

The Yoakum District performs project rides but does not use a scoring scale. Instead of scoring each project, a priority list is developed. For district seal, the district is pursuing a 7-year cycle. Yoakum recently began using RMCs to supplement maintenance sections with seal coat preparation. The district feels that it has strong maintenance sections with MSs that understand and buy in to the program. Most sections can perform their own in-house rehab but are careful to do so to ensure they do not fall behind on seal coat preparation.

For non-seal coat projects, the district works with the AO to perform the necessary testing to develop the proper scope.

HIGH-PERFORMING DISTRICTS BEST PRACTICES SUMMARY

Most of the high-performing districts stressed good communication and buy-in at all levels. Personnel within these districts understand the goals and the approach required to achieve those goals.

The use of project rides was commonplace, as was the use of a scoring system while riding. In addition to a scoring system, these districts have a project prioritization scheme. Each district should consider developing its own prioritization scheme that helps deliver projects to meet its short-term and long-term goals.

District seal coat programs play a vital role in PMP success, and seal coat preparation must be a maintenance section’s highest priority. Finishing seal coat preparation early should be each section’s goal. Developing maintenance sections with in-house expertise to perform rehab-type work seems to be a best practice, specifically for more rural districts.

Finally, Austin's surface selection map appears to be a best practice, especially for urban and metro locations.

BEST PRACTICES SUMMARY

Using knowledge gained from the high-performing districts and information gleaned from other districts through the surveys, researchers developed a summary of best practices. These best practices are divided into four sections:

- District-Wide Practices: Strategic practices that are occurring in some districts that should be considered by all districts.
- The Role of District Seal Coat: Seal coat practices that should be considered by all districts that view the seal coat program as integral to PMP success.
- Non-Seal Coat Projects: Practices that should be considered when developing overlay and rehabilitation plans in the PMP.
- Risks Identified during the Synthesis: Practices that should be considered for implementation to address PMP risks identified during the synthesis.

District-Wide Practices

Communication and teamwork are strategic district-wide best practices. From the synthesis, researchers found that having a clear understanding of the pavement management goals within the district facilitates successful 4-year PMPs. These goals need to be clear and well understood from the DE level to the maintenance crew level. For example, if a district wants to improve RS over a 4-year period, this needs to be articulated at each level and the plan on how to get there needs to be well understood. For instance, the Lufkin District has a spreadsheet for each maintenance section that shows each roadway segment with a construction or maintenance project. The spreadsheet shows the current year and the 4 years in the PMP so that everyone understands where and why work is occurring.

Ensuring MSs are consulted and involved in the PMP process helps create more effective PMPs. MS input helps identify the extent of the distresses and what techniques have been working or not working, and it helps designers understand other features that should be addressed during a project.

Performing project rides is a necessity. From the synthesis, it appears that ranking projects using a numerical scale during the rides serves as a best practice. This practice is a recommendation by the TxDOT Maintenance Division during plan development and is shown in Figure 3. Moving beyond project rides, a prioritization process functions as a best practice. The Austin District has the most thorough prioritization process, but many other districts have less formal processes that consider multiple variables. Having each district develop a district-specific prioritization process or, at a minimum, list other variables of interest could serve as a best practice.

MSs clearly impact the success of PMPs as much or more than any other employee. An AE in Odessa noted that he hired an AO maintenance engineer to assist with maintenance operations. This seems like a best practice, though most districts do not have the full-time employees or budget to sustain this practice. However, it might be valuable for TxDOT to consider how the maintenance rotation works in the engineering assistant rotation program to determine if the maintenance rotation is better served at the AO/MO level with interaction with district maintenance. Having an employee in this role helps understand maintenance practices, identify successes and failures, and potentially improve operations through improvements in material or workmanship quality.

The Role of District Seal Coat

For most districts (i.e., all but Houston), the role of the district seal coat program and its success plays a vital role in the success of the 4-year PMP. Seal coat preparation should be the highest priority for most maintenance sections. Trying to stay a minimum of 6 months ahead of district seal coat operations with the goal of being a full year ahead ensures that roadways are adequately prepared and serves as a best practice. Furthermore, finishing preparation work early positions districts to take advantage of unused statewide funds to help meet other needs.

Seal coat preparation should have a purpose connected to district goals. As previously noted, communication at all levels leads to a successful 4-year PMP. Districts should tie their seal coat preparation to pavement management goals to ensure plan success.

Due to the importance of seal coat preparation, supplementing internal forces with an RMC for preparation work might be appropriate. This is particularly true for districts that feel they need to get back on track, address a particular distress, supplement loss of expertise, or try to get one year ahead of district seal.

Targeting a seal coat cycle serves as a best practice. Achieving a seal coat cycle might not be attainable, but understanding what it would take to achieve a 7-year or 8-year cycle is valuable. This understanding helps scale the annual seal coat preparation required by each maintenance section. When it is not feasible to put every roadway on a cycle, the district might want to consider deliberately placing some roadways on a cycle while letting others float.

In-house seal coat plays a vital role in the success of the 4-year PMP. Many districts have roadways that are ineligible for Category 1 funding and must be maintained at the local level. Each district should formalize its in-house seal coat plan and ensure it follows the same cycle and goals as the district seal coat program.

Non-Seal Coat Projects

As traffic volumes have risen across the state, many districts are facing the dilemma of what to do with heavily trafficked roadways that have historically been sealed. The Austin District has

addressed this issue by developing a surface selection map. A potential best practice would be for each district to develop a surface selection map or surface selection criteria. The challenge for other districts is that while the Austin District has the funds to transition to using TOMs, other districts do not. Figure 10 is a partial view of the Austin District's surface selection map. The legend is included to show that the district uses ADT and posted speed limit to inform the surface selection.

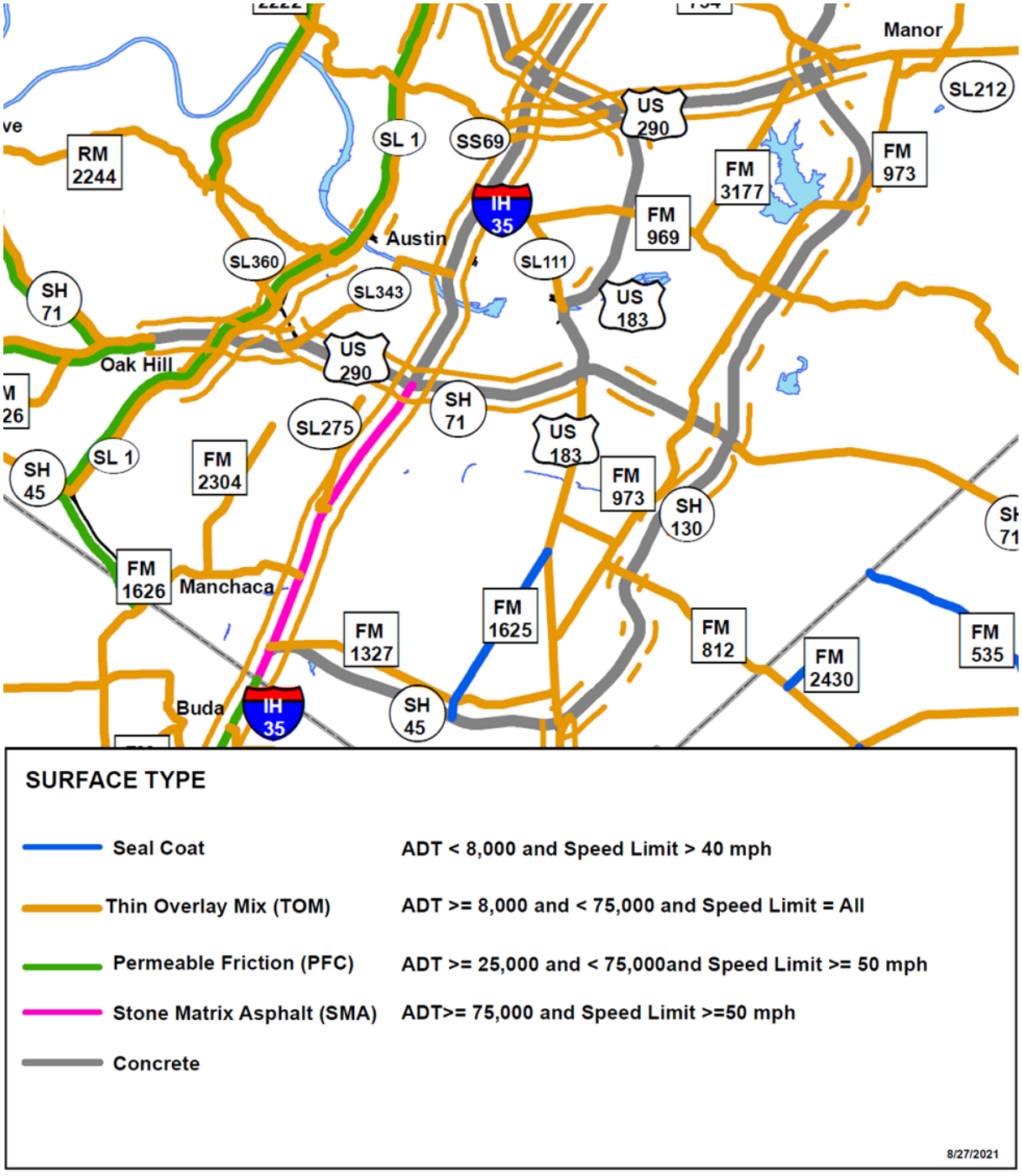

Figure 10. Austin District Surface Selection Map.

Most successful districts noted that the initial project rides help establish a project's preliminary scope. Developing a document that helps formalize the initial project scope during project rides might be beneficial and could serve as a best practice. Furthermore, most successful districts have well-developed pavement design processes. Connecting these pavement design processes to the initial project scope can help ensure adequate pavement projects are initially scoped. This helps mitigate scope changes later in design. Also, many successful districts have well-developed testing protocols to collect the necessary data to properly design a new project. Districts should formally connect these pieces to help improve the 4-year PMP.

Successful districts, from a performance metric perspective, have in-house forces capable of performing rehabilitation work. Developing this talent and identifying the necessary equipment serves as a best practice. However, personnel from successful districts noted that this can be a double-edged sword. While having these skills can allow for rehabilitations in-house, the work takes much longer and can put a section behind on seal coat preparation. Districts need to formalize how they approach in-house rehab with the understanding that seal coat preparation must be a section's highest priority.

Risks Identified during the Synthesis

The biggest risk noted by practitioners was the loss of institutional knowledge and experience. TxDOT faces the same attrition issues as many corporations and must find ways to mitigate the impact. TxDOT should find ways to educate and train future personnel with a primary focus on sustaining best practices for seal coat preparation and in-house rehabilitation work.

Understanding the link between seal coat preparation and performance metrics helps understand the magnitude and limitations of preparation work. Without additional funds, many districts are confined to using limestone rock asphalt or cold lay to blade-on patches. While this material is more forgiving than HMA because it can be reworked, it typically does not provide the same level of ride improvement. This might not be as important if the district has a specific focus on addressing distresses, but everyone associated with the 4-year PMP should understand that ride quality might not improve significantly or at all. It seems that TxDOT is currently facing this at the statewide level as DS continues an upward trend while RS is moving downward. A strategic or tiered approach to improving ride quality might serve as a best practice and help the state better tell its pavement management story.

While the seal coat program might be the most influential activity for the overall success of TxDOT's pavement management, its positive aspects might have a limit. The number of allowable seals remains a question and part of active research. Many practitioners believe that some roadways have reached the limit. Unfortunately, the alternative means applying a more costly surface treatment (i.e., TOM or HMA). The Austin District has successfully made this shift. A decision epoch might have arrived where TxDOT needs to consider if funds should be reallocated over a planning horizon to reestablish roadway surfaces for future seals. This will

take years to accomplish and should be accompanied by proper pavement designs. It will have the effect of improving RS across Texas. For some roadways, it could help reestablish a surface that could be sealed for the next 25 to 35 years. Current projects evaluating the maximum number of seal coats should be watched closely to help inform this decision.

Another risk noted by researchers through the performance metric evaluation was the rapid deteriorating impact of heavy traffic. For example, the Corpus Christi District has experienced significant improvement since 2016, partly in response to the drastic deterioration caused by the Eagle Ford Shale exploration. Most likely, the steep upward trend would not have occurred if energy-sector traffic had not rapidly deteriorated many roadways. Odessa faces similar situations, and its respondents indicated that scores should improve throughout 2022 and 2023 because many energy-sector projects are finishing. Staying ahead of these events remains a challenge for TxDOT.

The survey clearly indicated that practitioners primarily concern themselves with current conditions and safety when developing the PMP. The survey went on to ask how often inadequate underlying pavement work was performed prior to placing a new surface. Figure 11 summarizes the 60 responses and shows that inadequate underlying work is a concern of many practitioners. Thirteen districts were part of the group that indicated inadequate underlying pavement work was performed at least half of the time, including Atlanta and Lufkin, two of the highest-performing districts in the state. Inadequate work could occur for a variety of reasons, but one reason might be the minimal use of a historical perspective when developing the PMP. TxDOT has made strides to mitigate this by creating the bad-good-bad report to show sections that rapidly increase and then rapidly decrease. A potential future best practice might come in using current condition data and finding a way to capitalize on previous condition data to help inform the PMP. Understanding historical condition data helps reinforce if maintenance sections have been holding a section together while waiting for a project. Another option would be ensuring that the PMP process captures the maintenance money spent on a section over the previous 3 years.

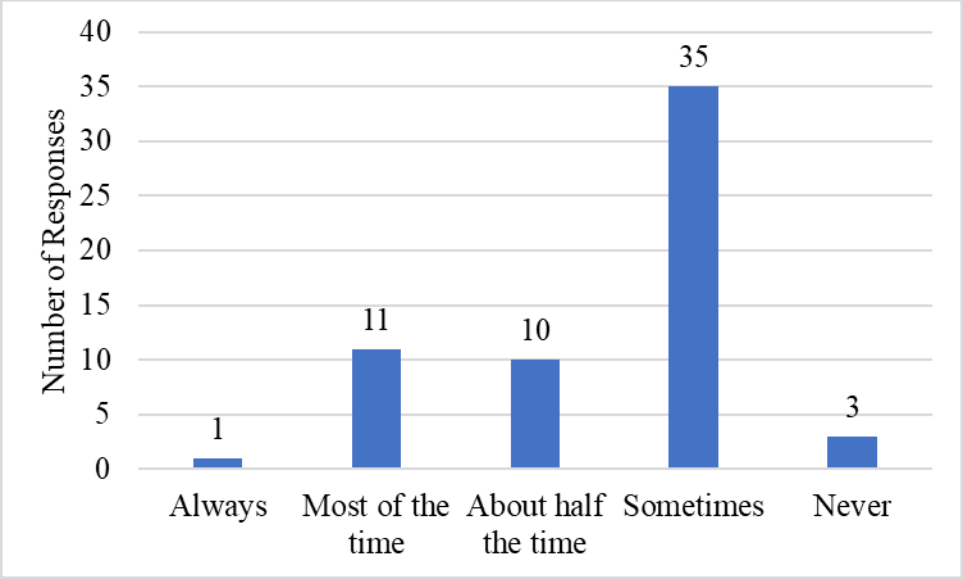

Figure 11. Frequency of Inadequate Underlying Pavement Work.

CONCLUSIONS AND RESEARCH NEEDS

SYNTHESIS CONCLUSIONS

Through this synthesis project, researchers discovered that the development of 4-year PMPs follows the timeline in Figure 12. PMP development typically follows the layout shown in Figure 2 and Figure 3, where AOs and MOs submit projects for consideration. These projects are ridden, scored, and prioritized. Projects are then selected by the district staff and the 4-year PMP is populated. Nuances exist in each district with various levels of refinement and sophistication at each phase of PMP development.

While developing a PMP was of interest, the primary goal of the synthesis was to identify PMP best practices. To accomplish this, researchers analyzed performance metrics and built surveys to solicit responses that would illuminate the practices of high-performing districts. Figure 13 generalizes the concepts identified as best practices. These concepts are discussed in more detail in the following sections.

Metric

What metrics will a district consider during the PMP development process? Identified best practices were the use of a scoring system during project rides and a prioritization method during project selection. Has the district attached its metrics of interest to the scoring system and prioritization scheme? While most districts will probably use similar metrics (i.e., CS, DS, crashes), a one-size-fits-all approach does not work. Ensuring districts understand the metrics they are evaluating and how metrics tie to actual roadwork must occur for successful PMPs.

Goal

Has the district developed specific goals associated with the metrics? During the synthesis, researchers found that districts perform differently and sometimes paradoxically. For example, as several districts continue to improve their DS, their RS trends downward. Do some of these districts want to try to reverse the RS trend? Is reversing the RS trend possible within the existing funding environment? While the state has a singular goal of having 90 percent of sections in overall good or better condition, each district's contribution to that goal will vary. Also, districts will have additional metrics beyond pavement performance goals. A district might place an emphasis on wet-weather crash reduction or run-off-the-road reduction in addition to pavement performance metrics. It must also be understood that infrastructure goals take time to achieve. Developing a PMP goal sheet might help a district stay focused and serve as a PMP best practice.

Communicate

High-performing districts identified in the synthesis always noted that teamwork, communication, and buy-in at all levels help lead to their success. Understanding the metrics and developing goals helps set the stage for effective communication. Work plans and execution improve when all parties understand the why with what is happening. District leaders should strive to communicate to the entire district what needs to be accomplished, why it needs to be done, and how the district plans to get there. Having a district plan on the what, why, and how might serve as a best practice for PMP communication.

Plan

With everyone on the same page, developing the how-to-get-there plan falls to practitioners and experts within the districts. Long-term PMP success relies heavily on the district seal coat programs. The preparation of seal coat roadways drives the success of the district seal coat program. MSs primarily dictate seal coat preparation. Ensuring MSs have the necessary support, equipment, materials, and knowledge to effectively prepare roadways must be the highest priority within a district. After accomplishing this, districts can focus on testing, project scoping, and surface selection for other projects. Planning tools exist or can be built to help a district in this process. For example, the Austin District has a surface selection map that might prove helpful for urban and metro sections. Many districts understand the cost to move to a seal coat cycle and have made decisions to place some roadways on cycles while leaving others off. Supplementing contracts with in-house rehabs can improve pavement performance but should only occur if it does not detrimentally impact seal coat preparation.

For non-seal coat projects, the synthesis revealed that defining a preliminary project scope during project rides occurs. Formalizing this process helps ensure districts perform the necessary testing, address all project issues, and engage the MS to identify what has been done and what has been successful.

Execute

Everything builds up to the execution point. Projects through in-house forces, RMCs, or construction should occur that move the district toward its goals. Because of effective communication, anyone within the district that drives through a pavement project should understand the why behind the work. With everything in place to this point, the execution becomes the easy part.

Following this generalized cycle will ultimately lead to score improvement or score stabilization. Districts will begin to see network improvement in pursuit of their goals. If after a couple of cycles this is not being achieved, districts can reevaluate the metric and goals portion and identify areas of change.

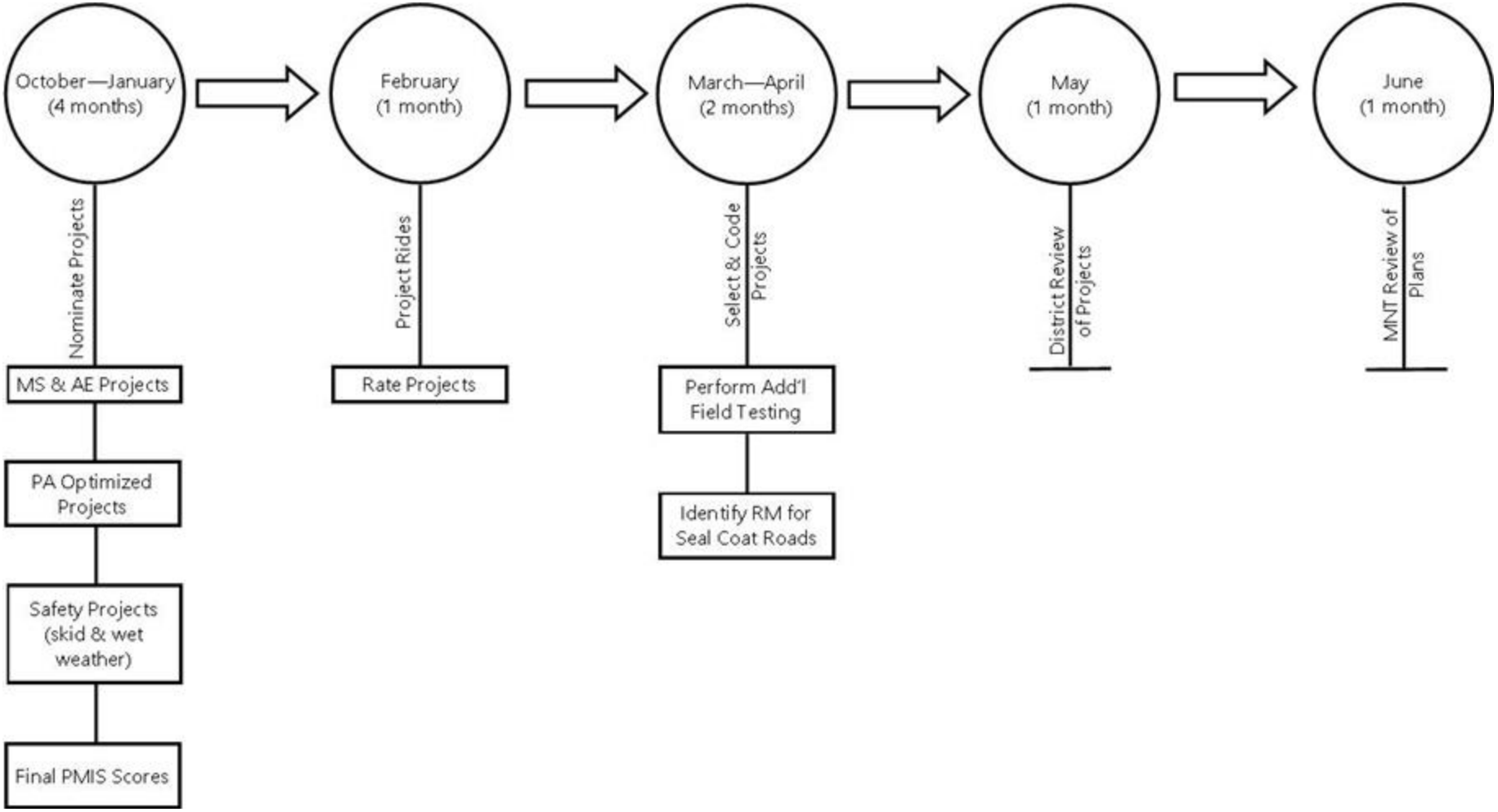

Figure 12. 4-Year PMP Timeline.

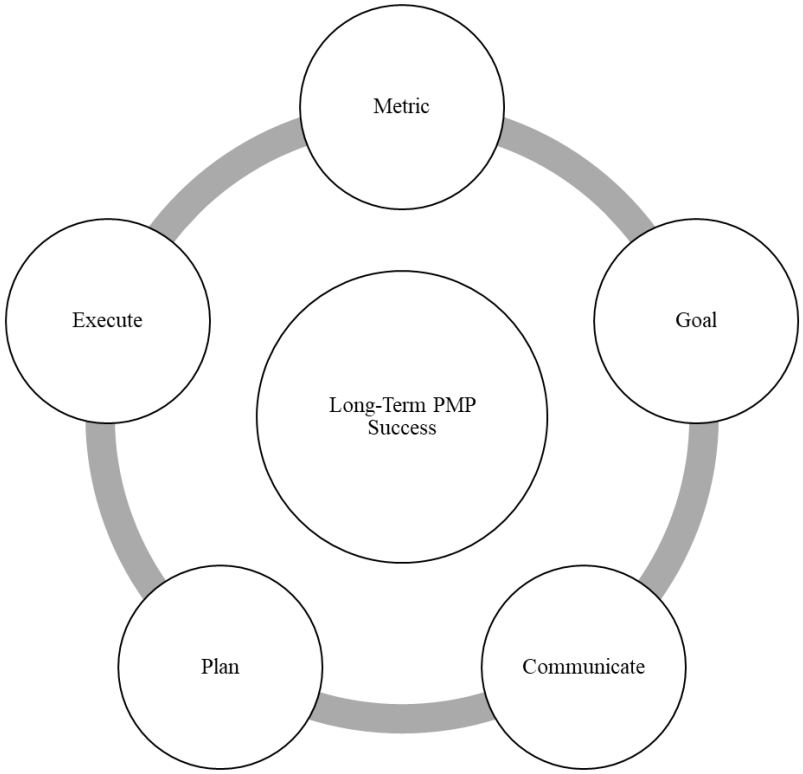

Figure 13. Generalized Flowchart of PMP Best Practice.

AREAS OF FUTURE RESEARCH

This project gathered input from across the state. Through the synthesis, researchers were able to identify areas where some districts could use additional support. The following list provides opportunities for future research or support activities, primarily focused on helping districts better achieve the process generalized in Figure 13:

- Develop district-specific prioritization schemes that coincide with district goals.
- Develop an evaluation process to determine the underlying cause of the poor ride or distresses to assist in determining the best pavement repair strategy.
- Investigate the development of overlay programs similar to district seal programs.
    - What impact would this have on statewide RS?
    - What are the cost impacts?
    - What standard operating procedures are required to ensure long-term overlay success?
    - Would a district surface selection map help with the implementation?
- Develop a knowledge management system to help capture current best practices for attrition planning.
    - Focus on seal coat preparation and quality within construction projects.
    - Potentially include videos of construction activities that provide visual aids.

    - Connect to the long-term success cycle in Figure 13.
- Develop a project scoping document for PMP project rides.

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APPENDIX A: DISTRICT SCORES SUMMARY

Appendix A includes figures showing 9-year trends for each district. These figures helped identify which districts were performing well for not only overall CS but also DS and RS. Furthermore, these figures helped to identify if districts were trending up in one metric and down in another. Using this type of information, researchers developed district-specific questions.

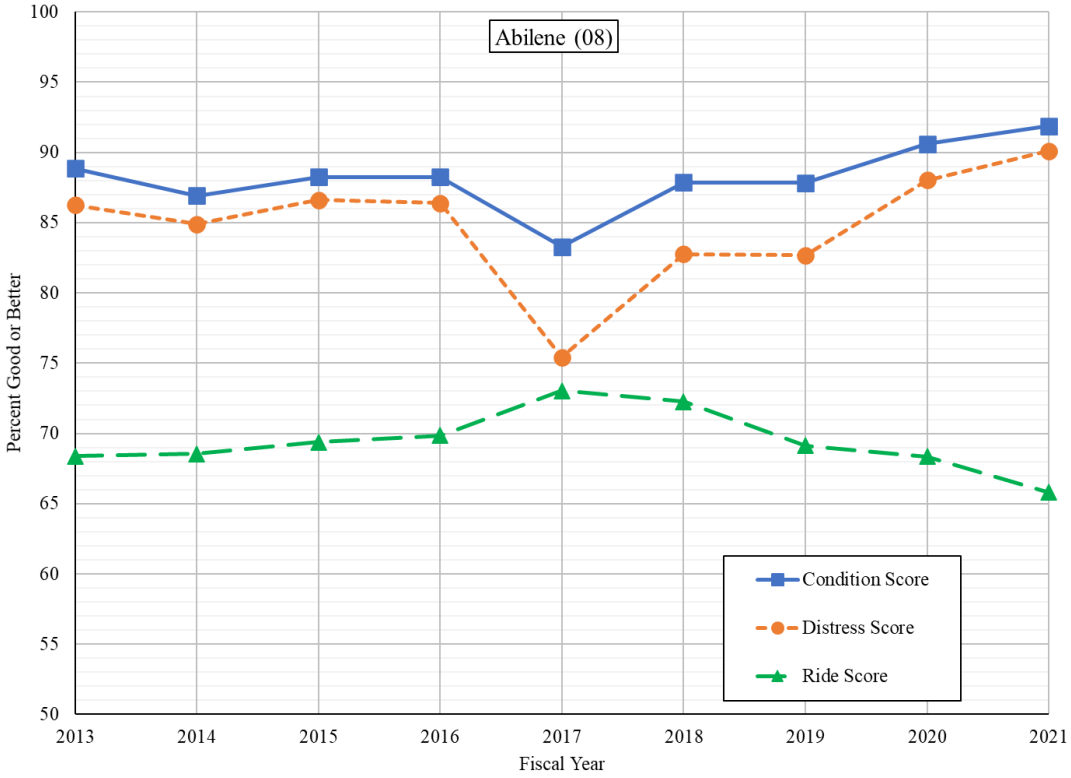

Figure A-1. Abilene District (08) Pavement Performance Metrics.

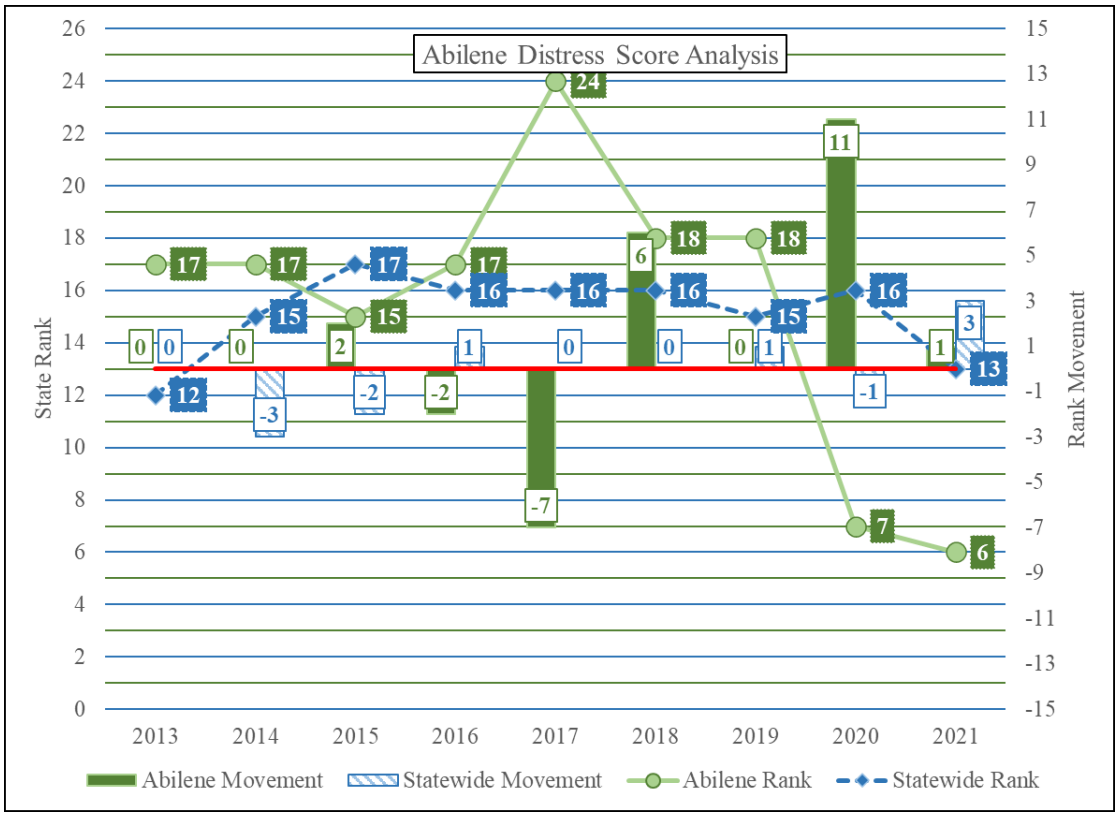

Figure A-2. Abilene District (08) Distress Score Comparison to Statewide.

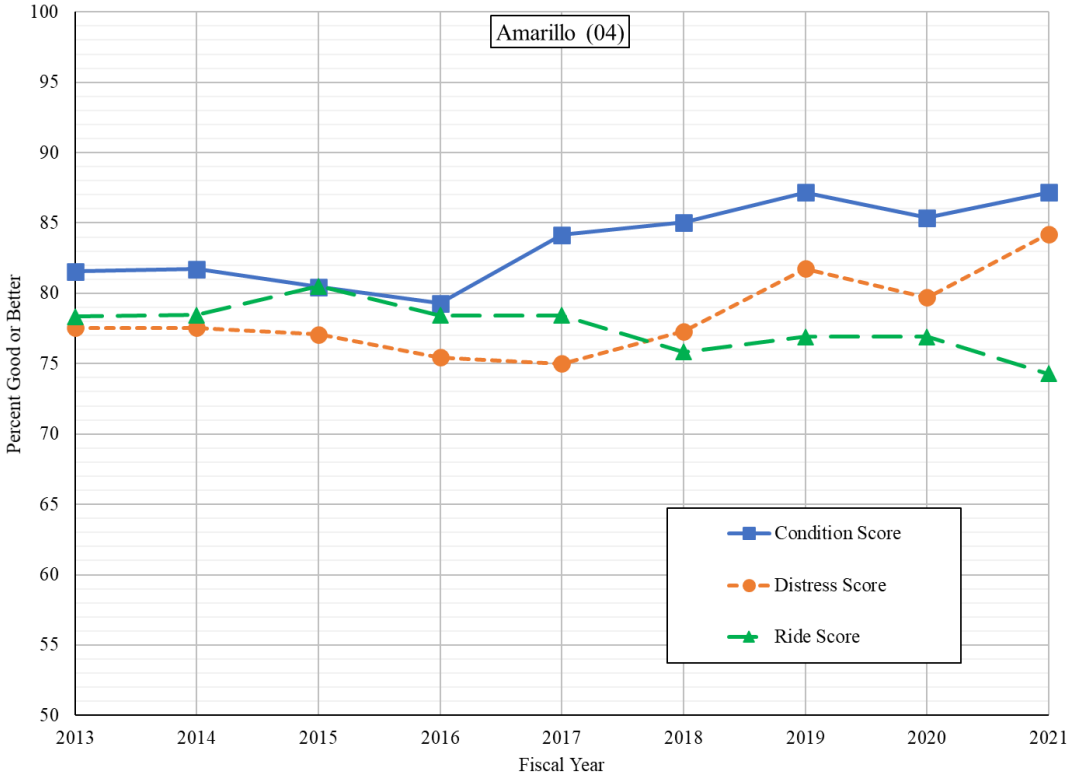

Figure A-3. Amarillo District (04) Pavement Performance Metrics.

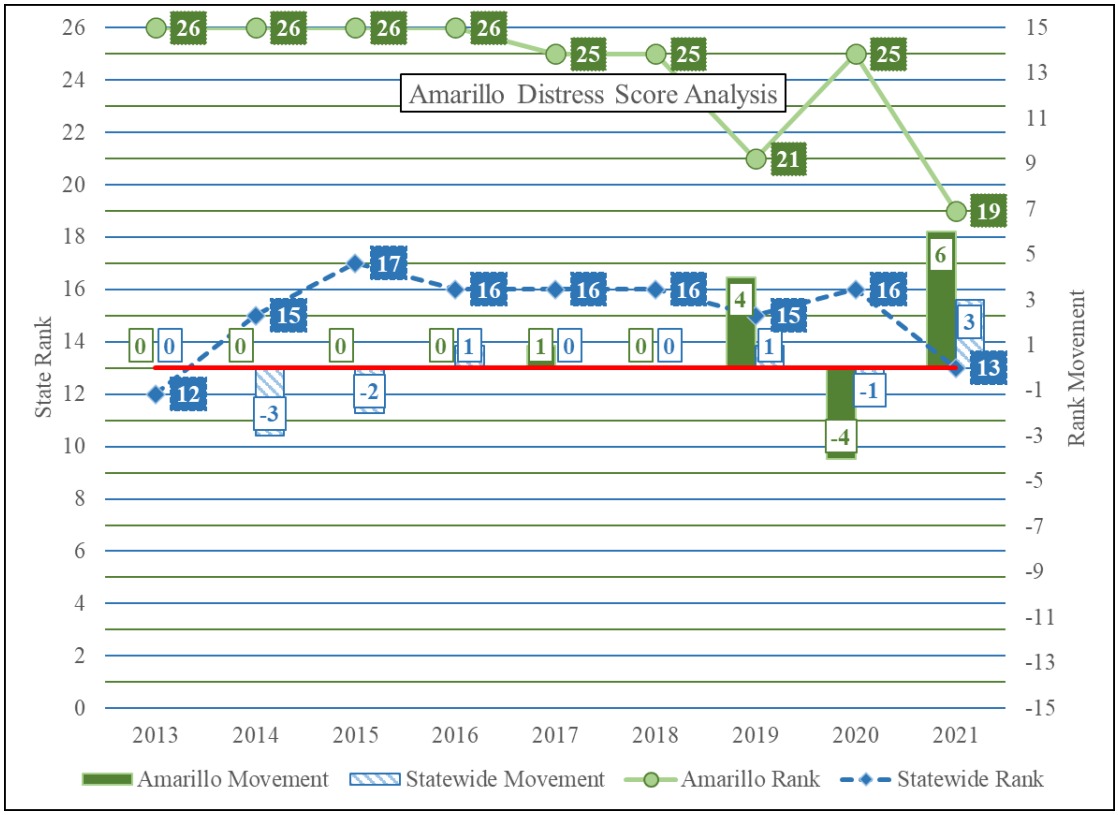

Figure A-4. Amarillo District (04) Distress Score Comparison to Statewide.

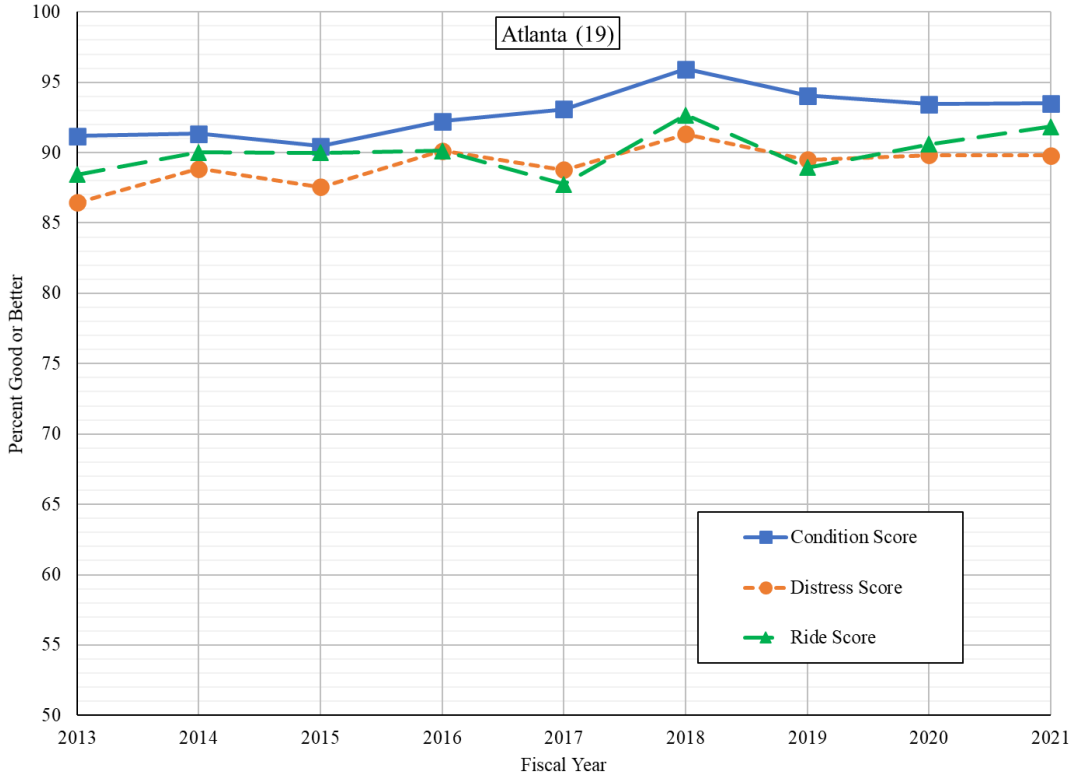

Figure A-5. Atlanta District (19) Pavement Performance Metrics.

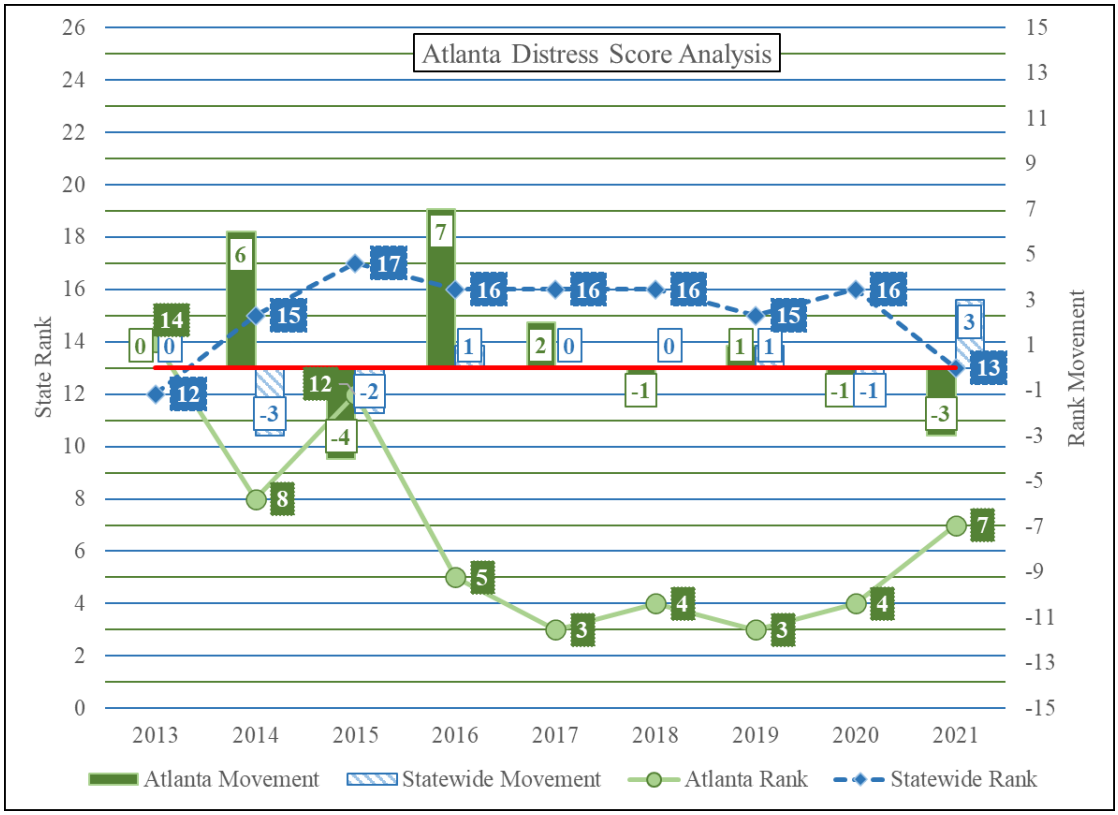

Figure A-6. Atlanta District (19) Distress Score Comparison to Statewide.

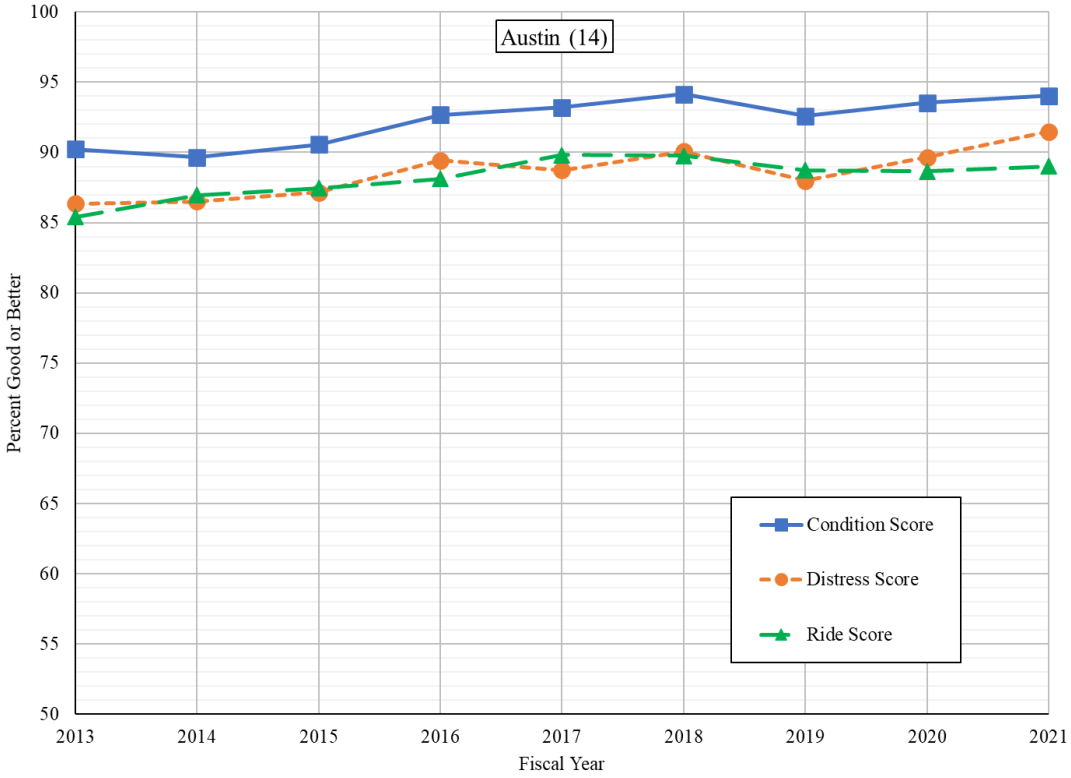

Figure A-7. Austin District (14) Pavement Performance Metrics.

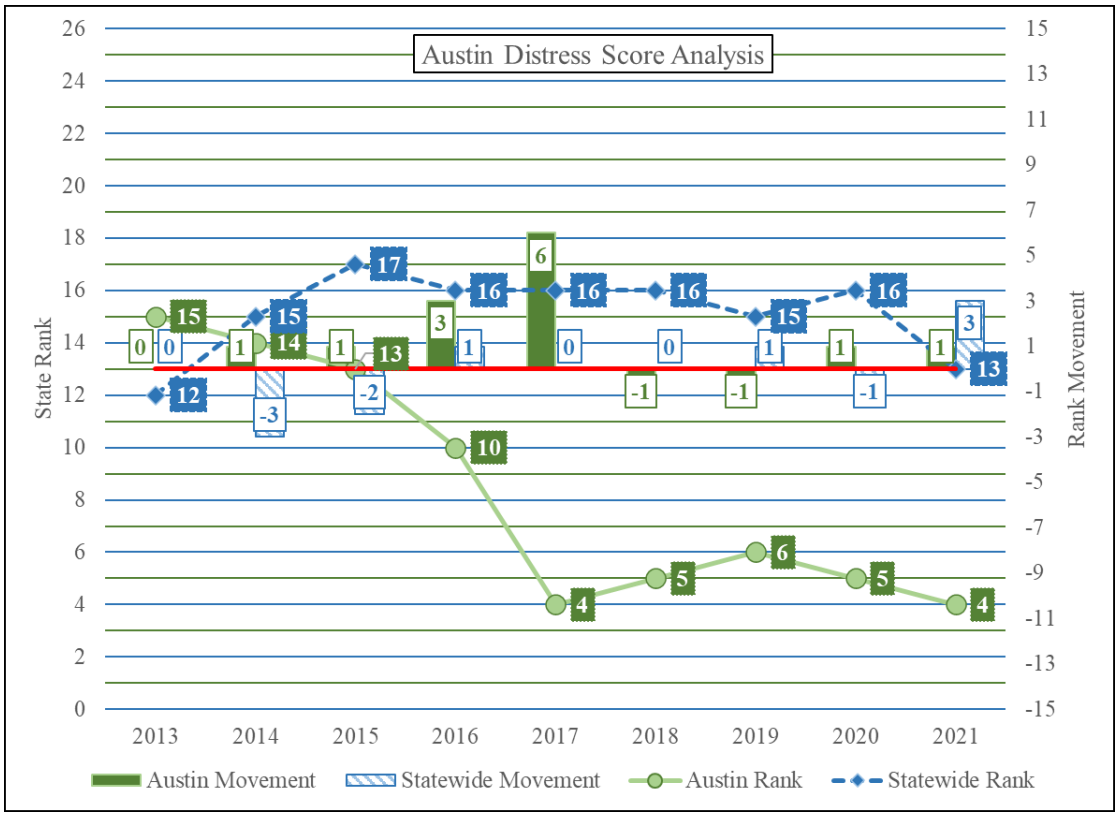

Figure A-8. Austin District (14) Distress Score Comparison to Statewide.

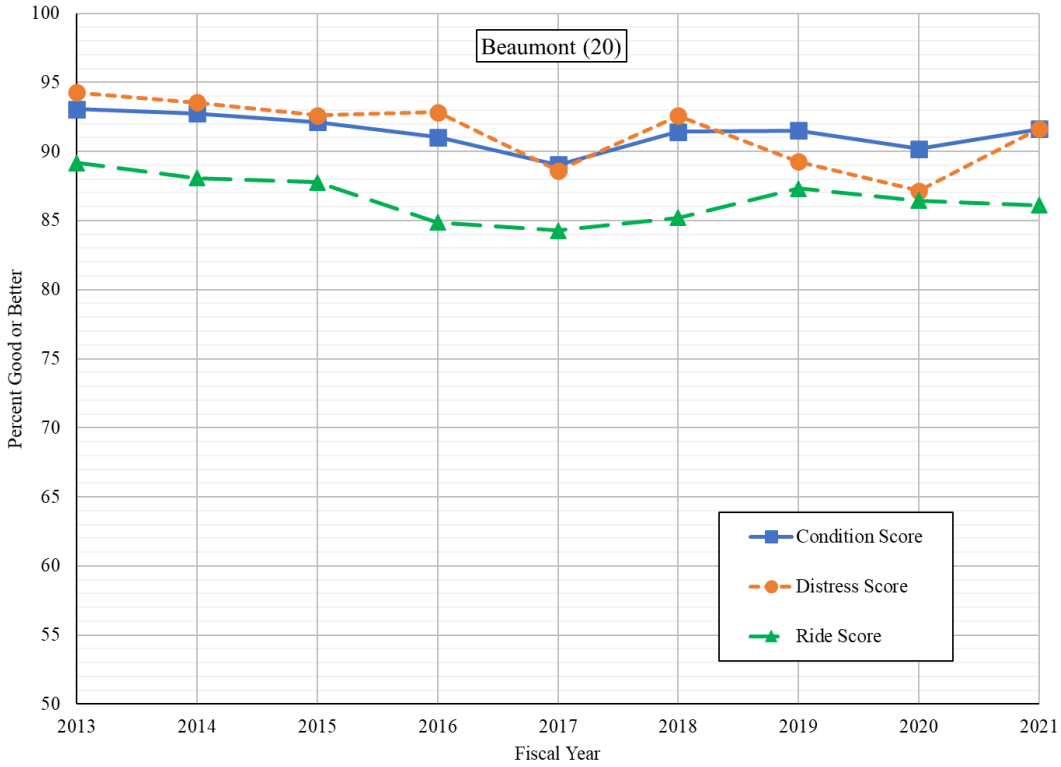

Figure A-9. Beaumont District (20) Pavement Performance Metrics.

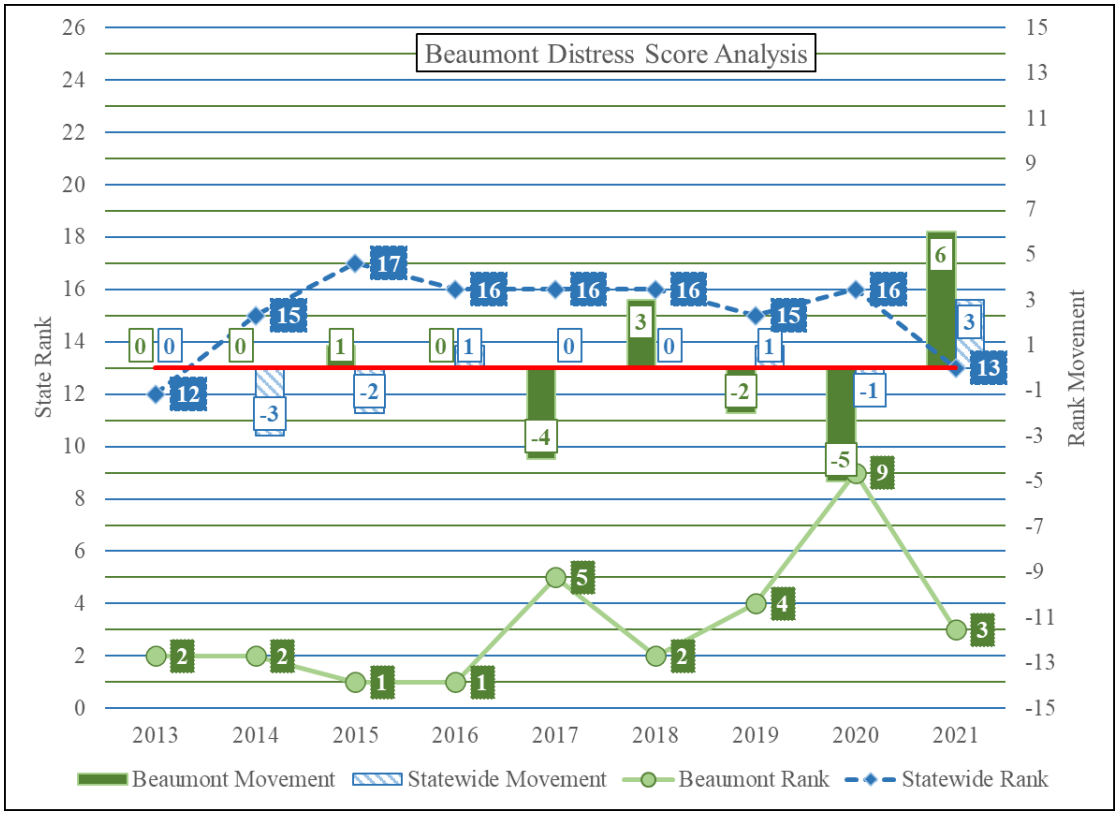

Figure A-10. Beaumont District (20) Distress Score Comparison to Statewide.

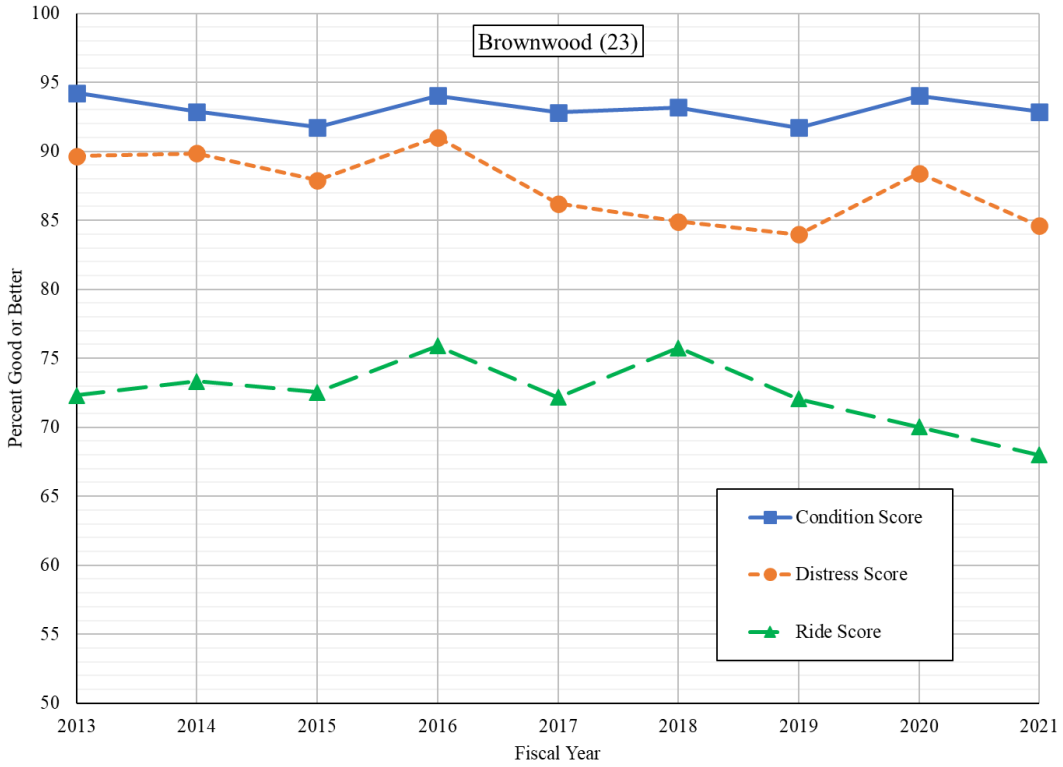

Figure A-11. Brownwood District (23) Pavement Performance Metrics.

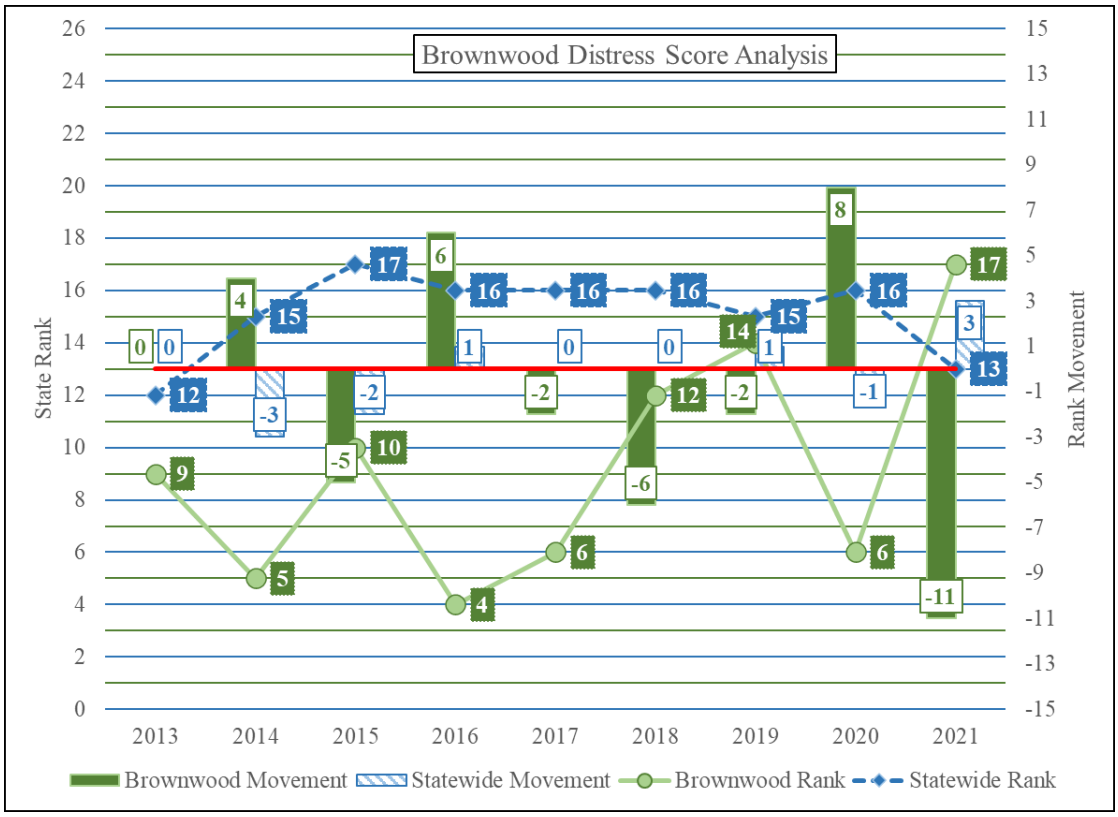

Figure A-12. Brownwood District (23) Distress Score Comparison to Statewide.

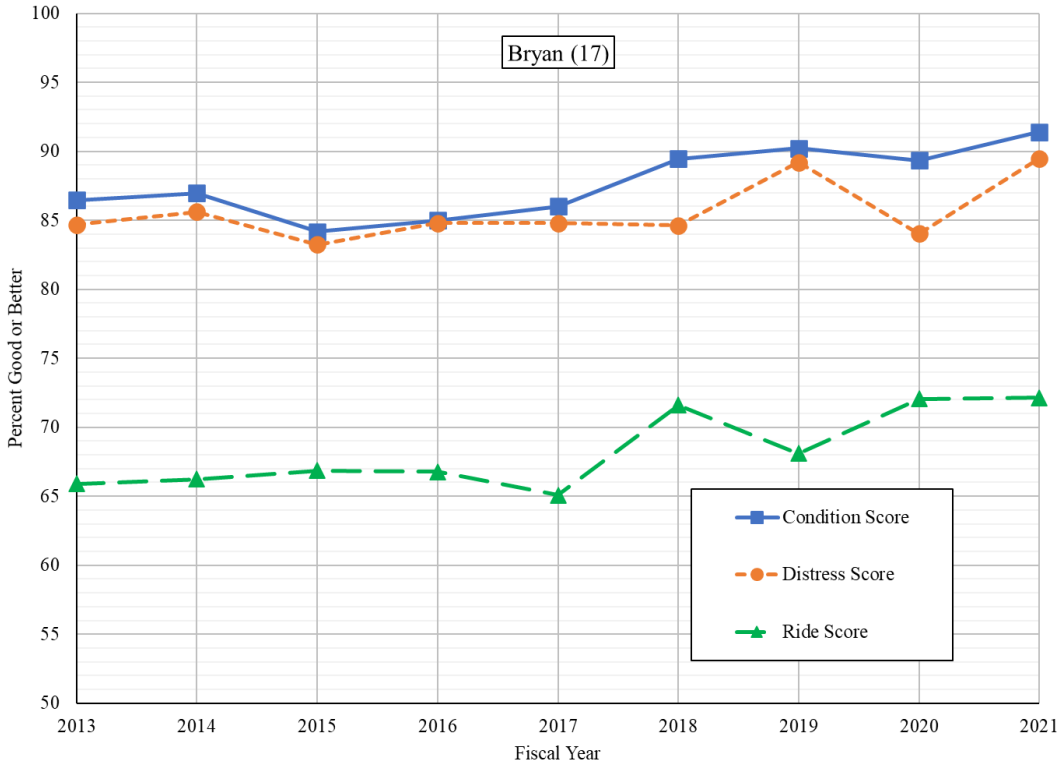

Figure A-13. Bryan District (17) Pavement Performance Metrics.

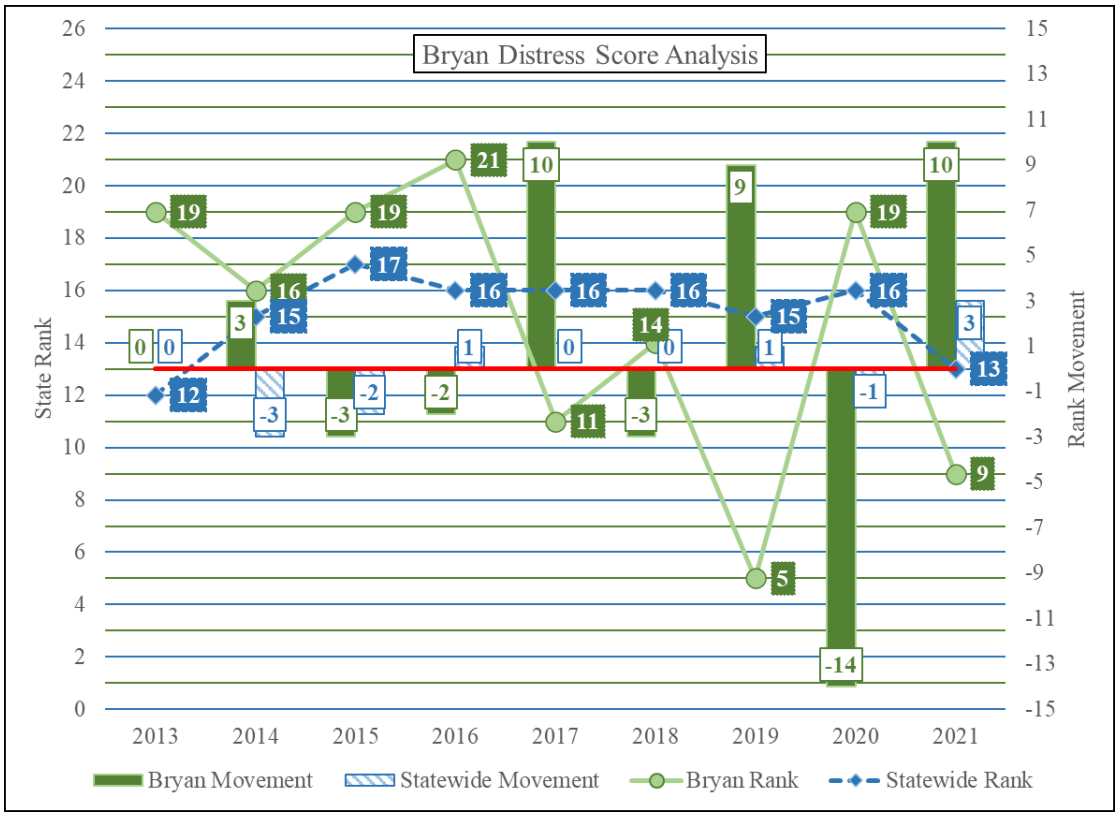

Figure A-14. Bryan District (17) Distress Score Comparison to Statewide.

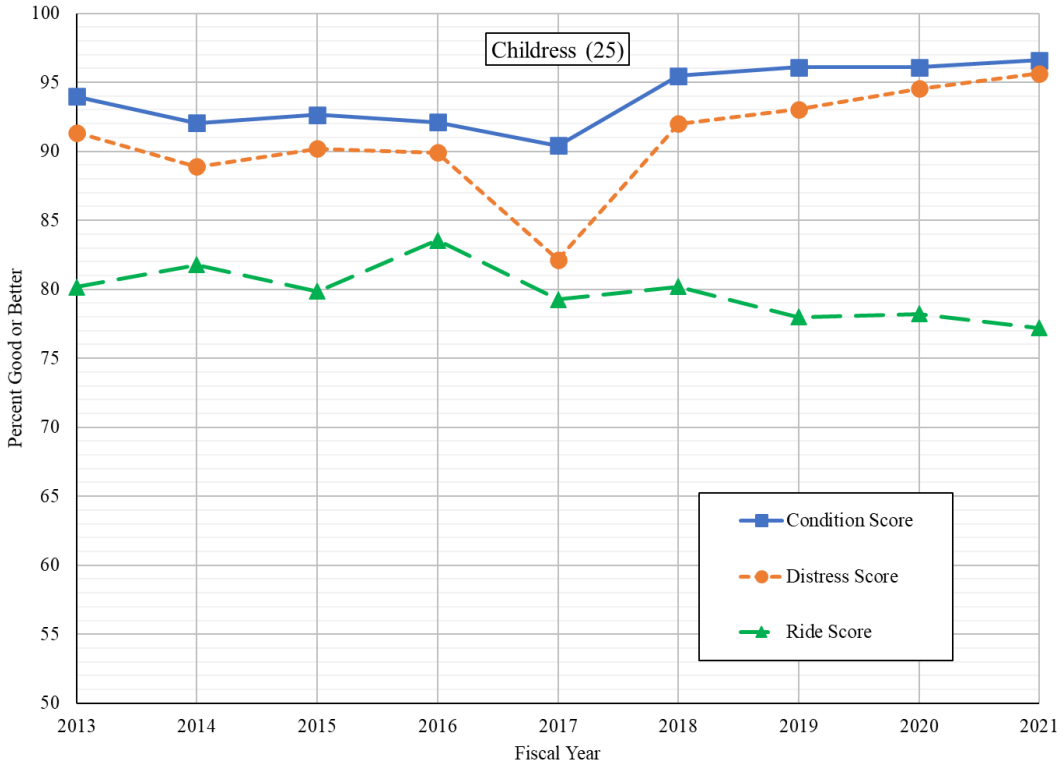

Figure A-15. Childress District (25) Pavement Performance Metrics.

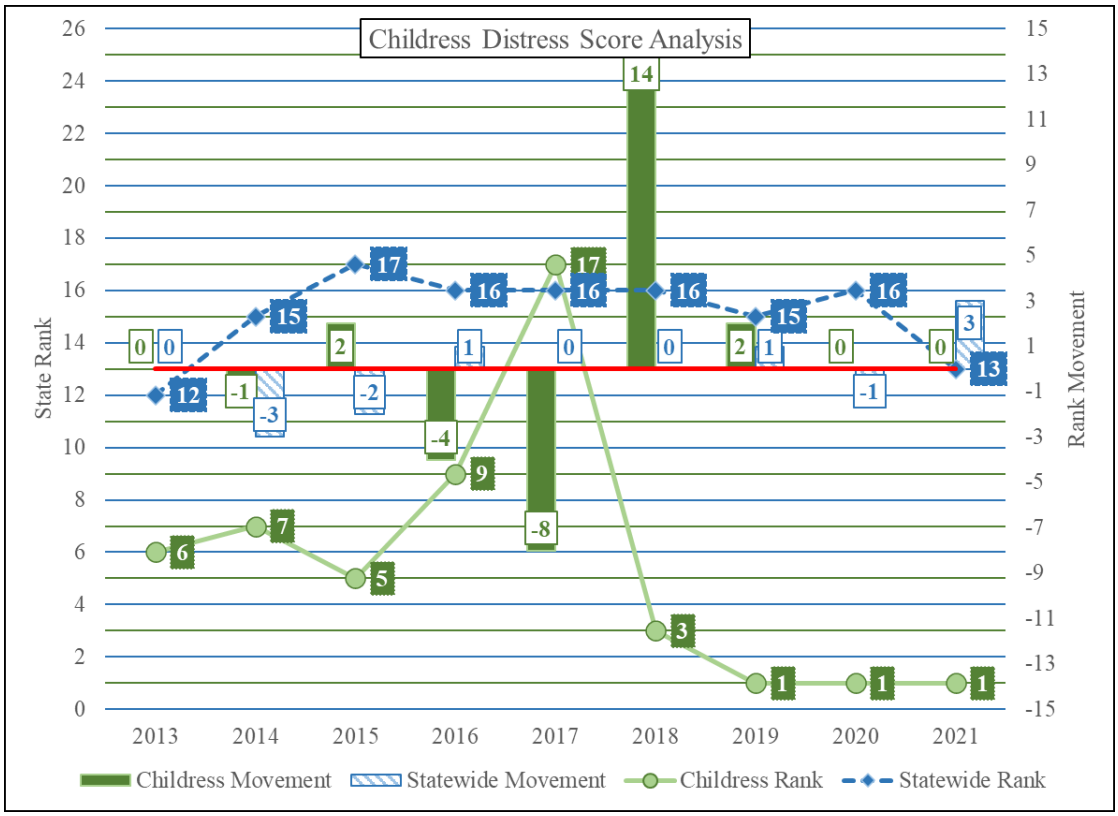

Figure A-16. Childress District (25) Distress Score Comparison to Statewide.

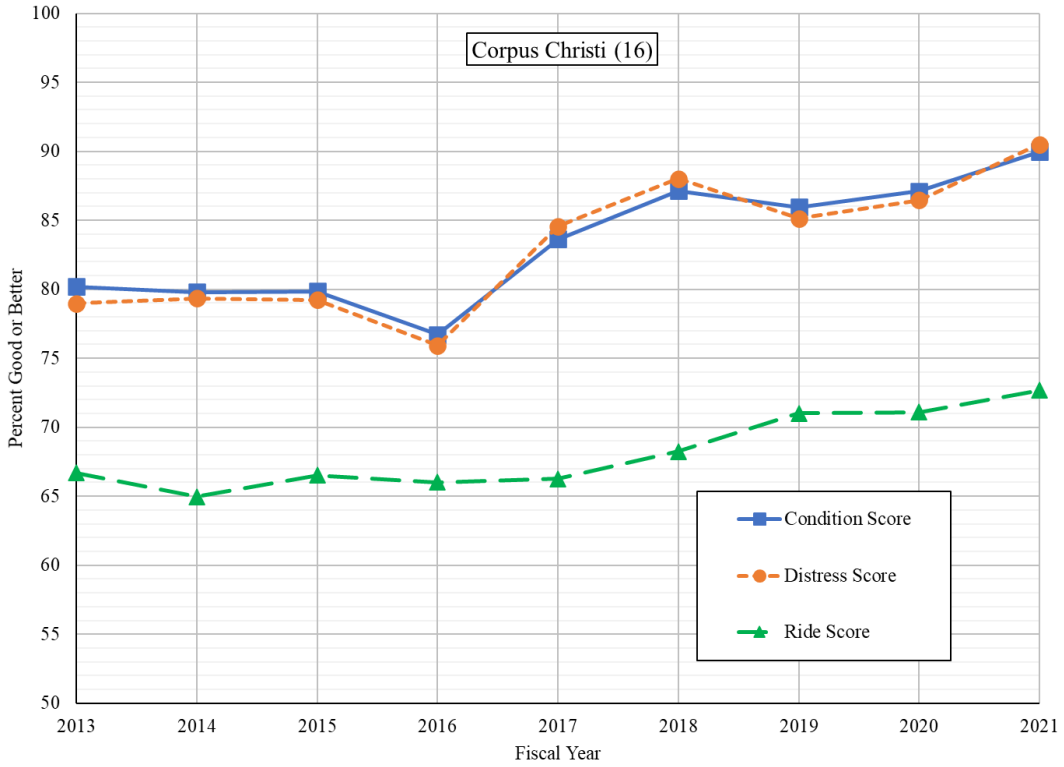

Figure A-17. Corpus Christi District (16) Pavement Performance Metrics.

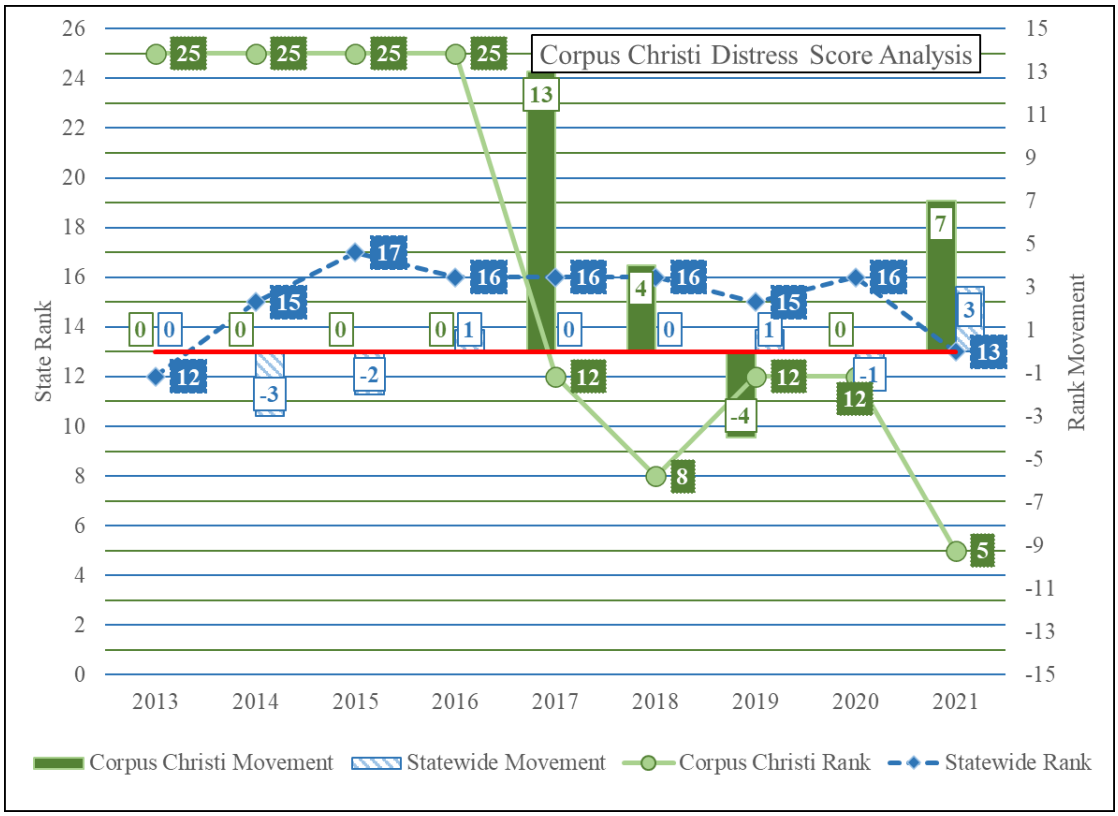

Figure A-18. Corpus Christi District (16) Distress Score Comparison to Statewide.

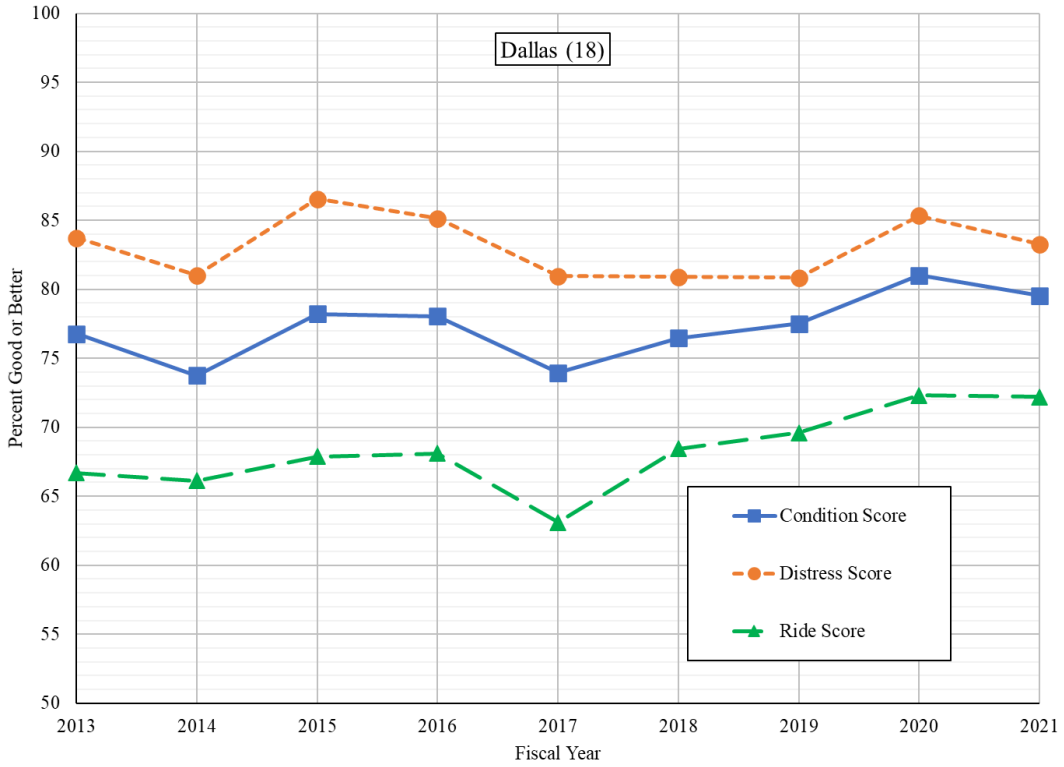

Figure A-19. Dallas District (18) Pavement Performance Metrics.

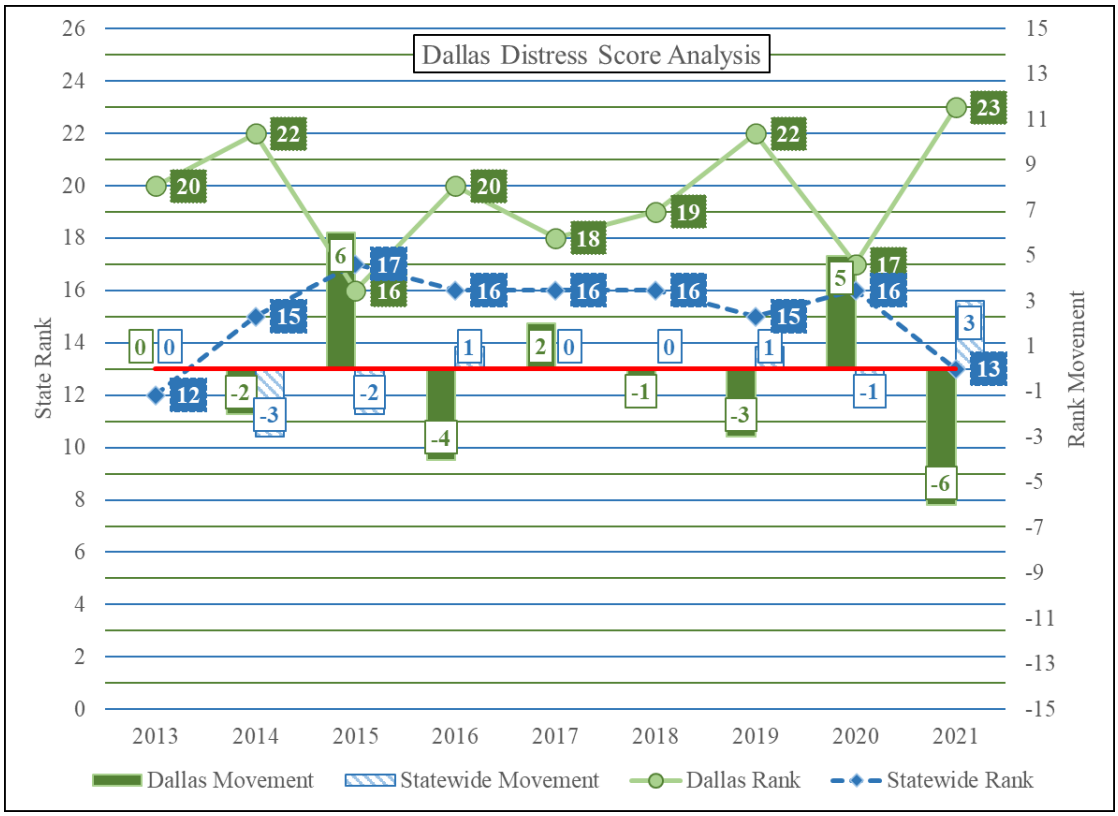

Figure A-20. Dallas District (18) Distress Score Comparison to Statewide.

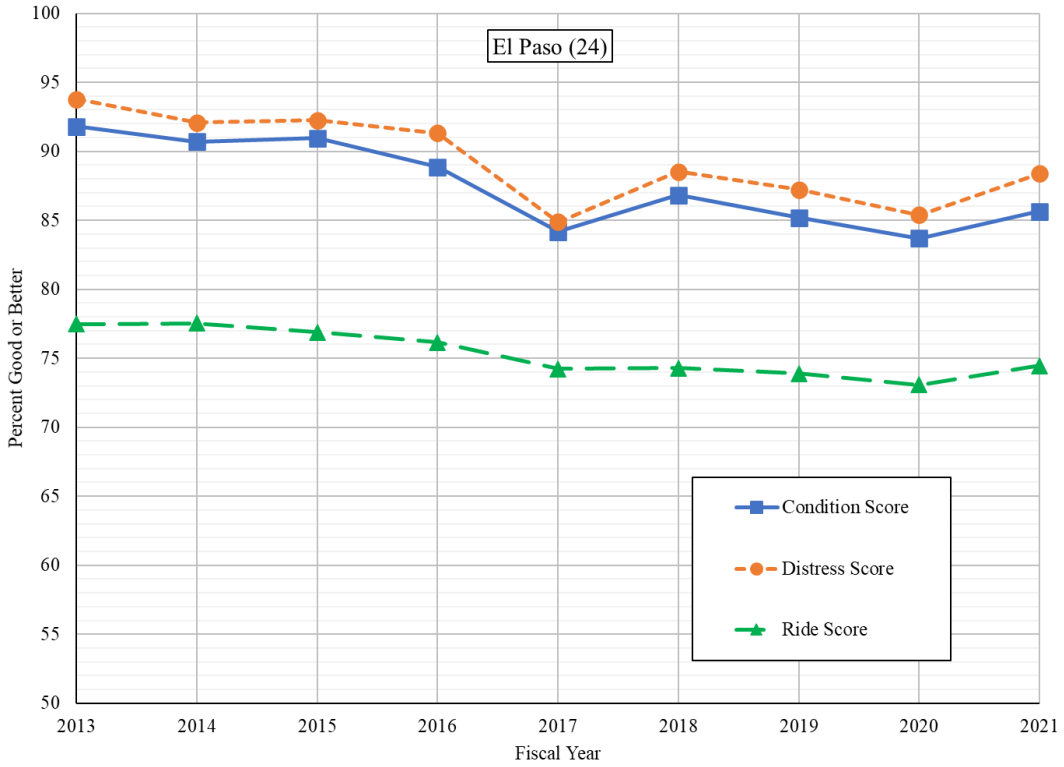

Figure A-21. El Paso District (24) Pavement Performance Metrics.

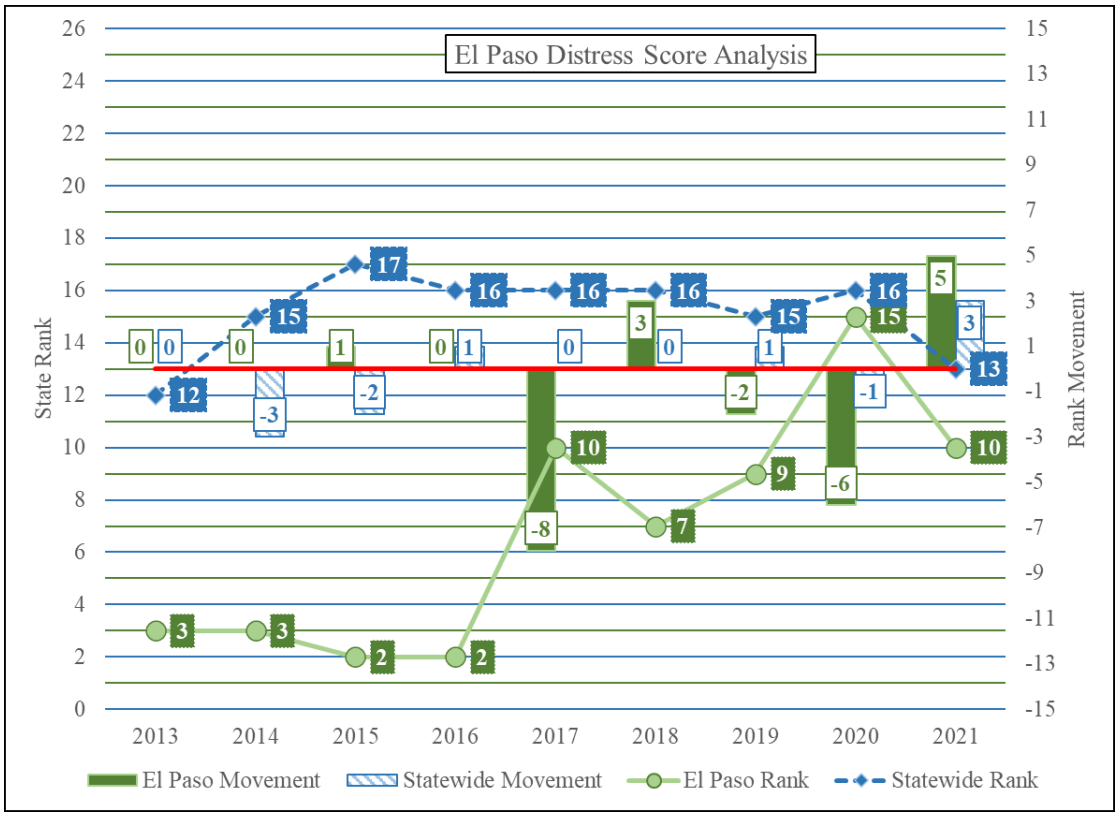

Figure A-22. El Paso District (24) Distress Score Comparison to Statewide.

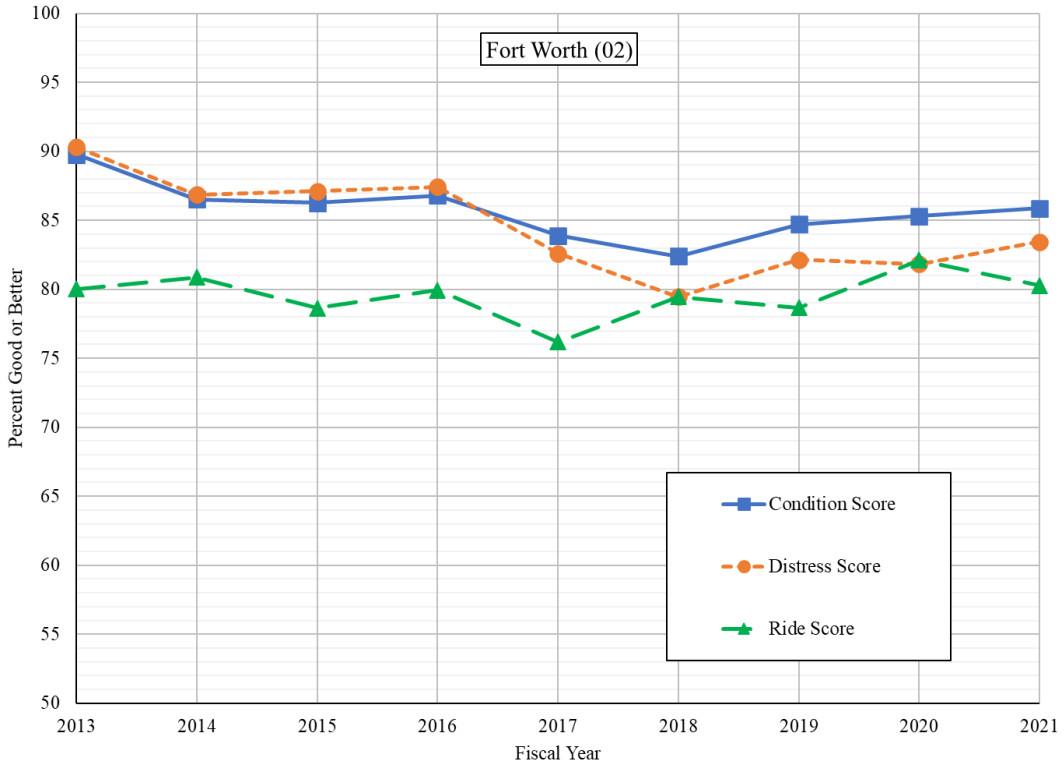

Figure A-23. Fort Worth District (02) Pavement Performance Metrics.

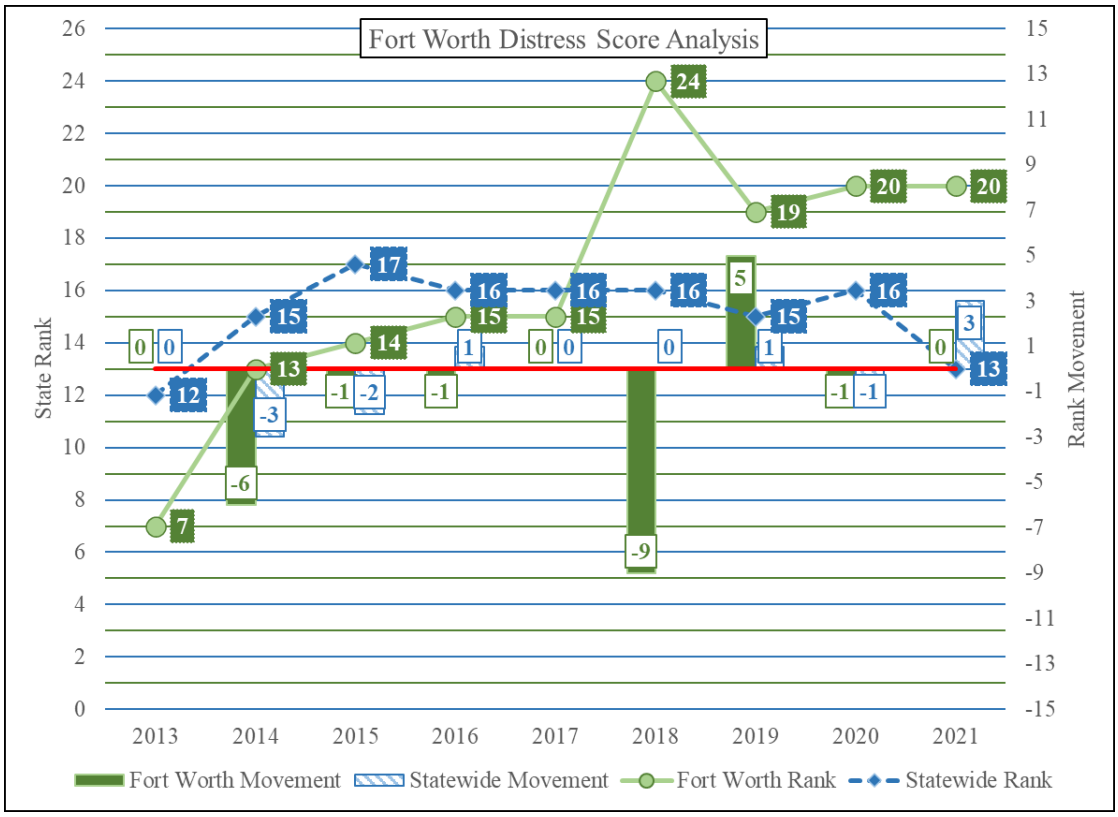

Figure A-24. Fort Worth District (02) Distress Score Comparison to Statewide.

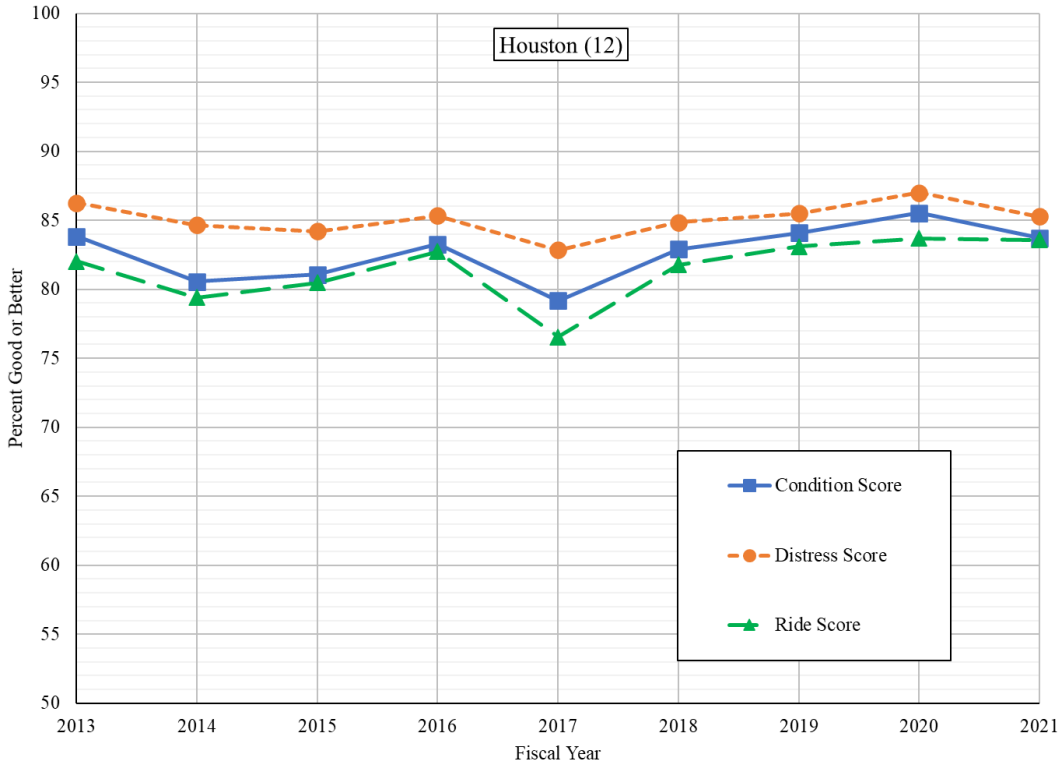

Figure A-25. Houston District (12) Pavement Performance Metrics.

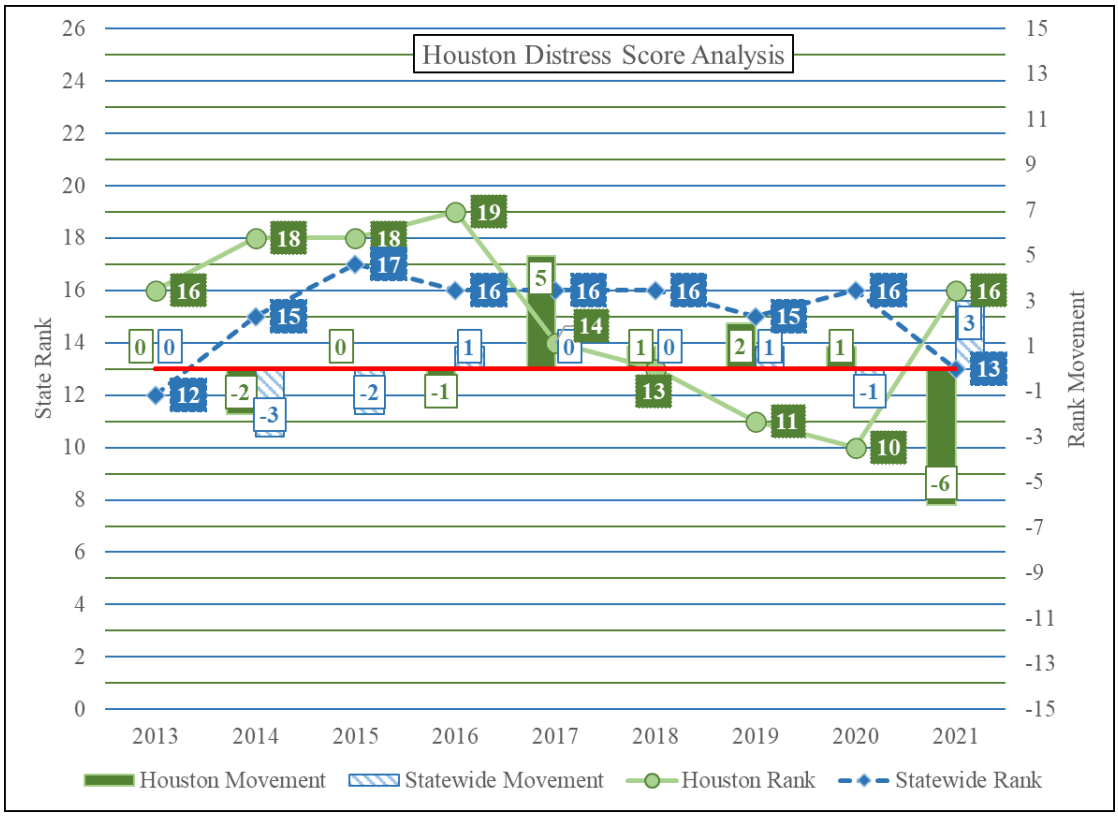

Figure A-26. Houston District (12) Distress Score Comparison to Statewide.

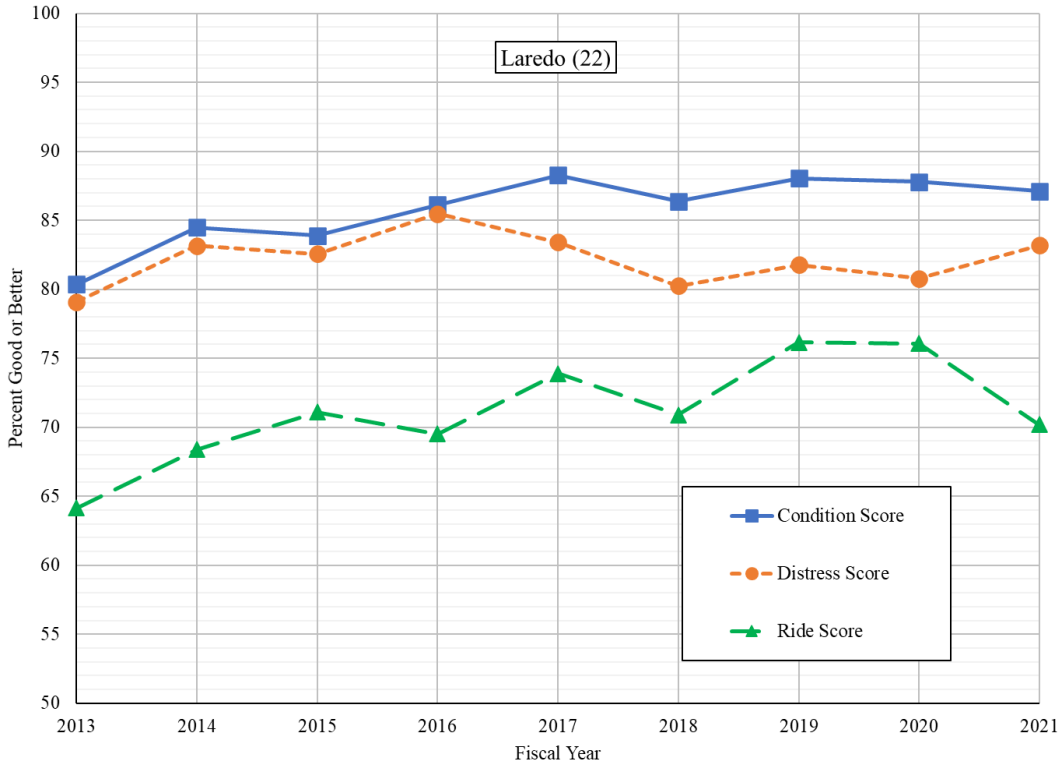

Figure A-27. Laredo District (22) Pavement Performance Metrics.

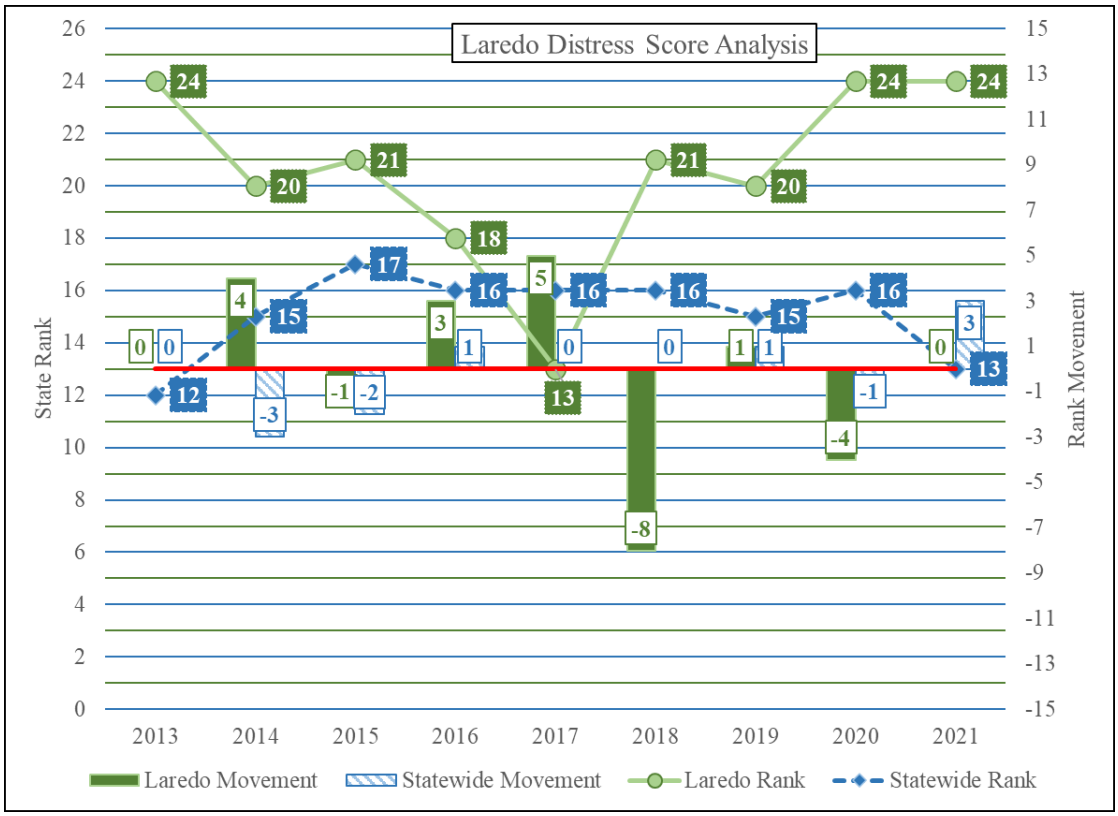

Figure A-28. Laredo District (22) Distress Score Comparison to Statewide.

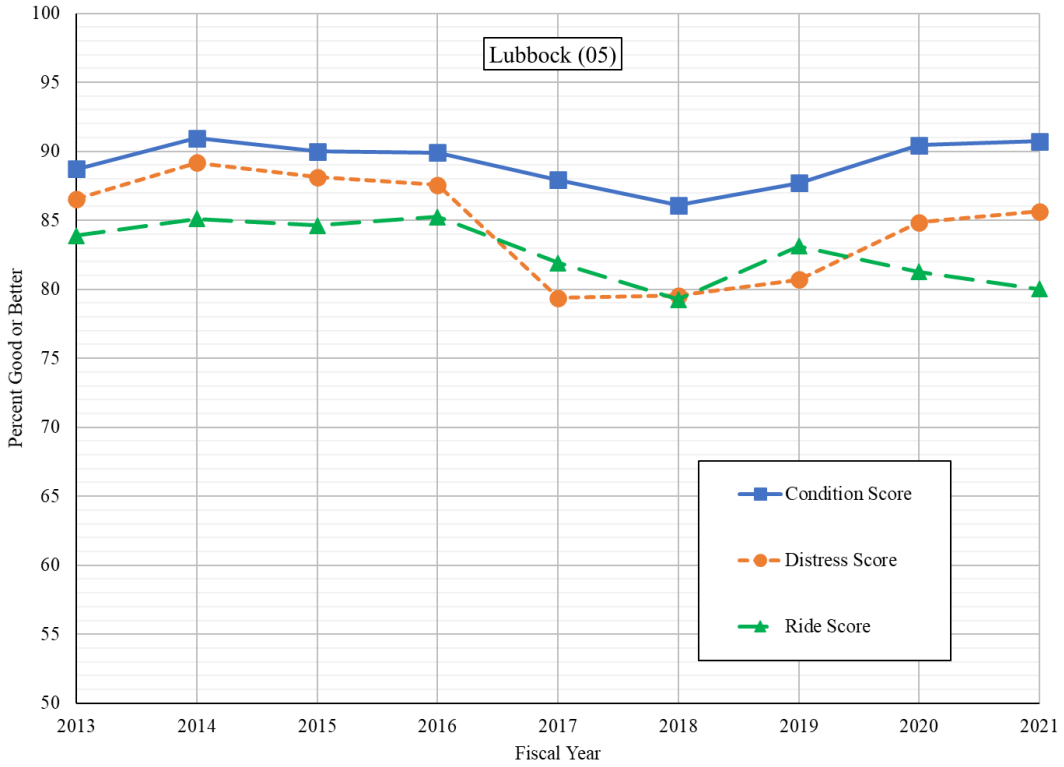

Figure A-29. Lubbock District (05) Pavement Performance Metrics.

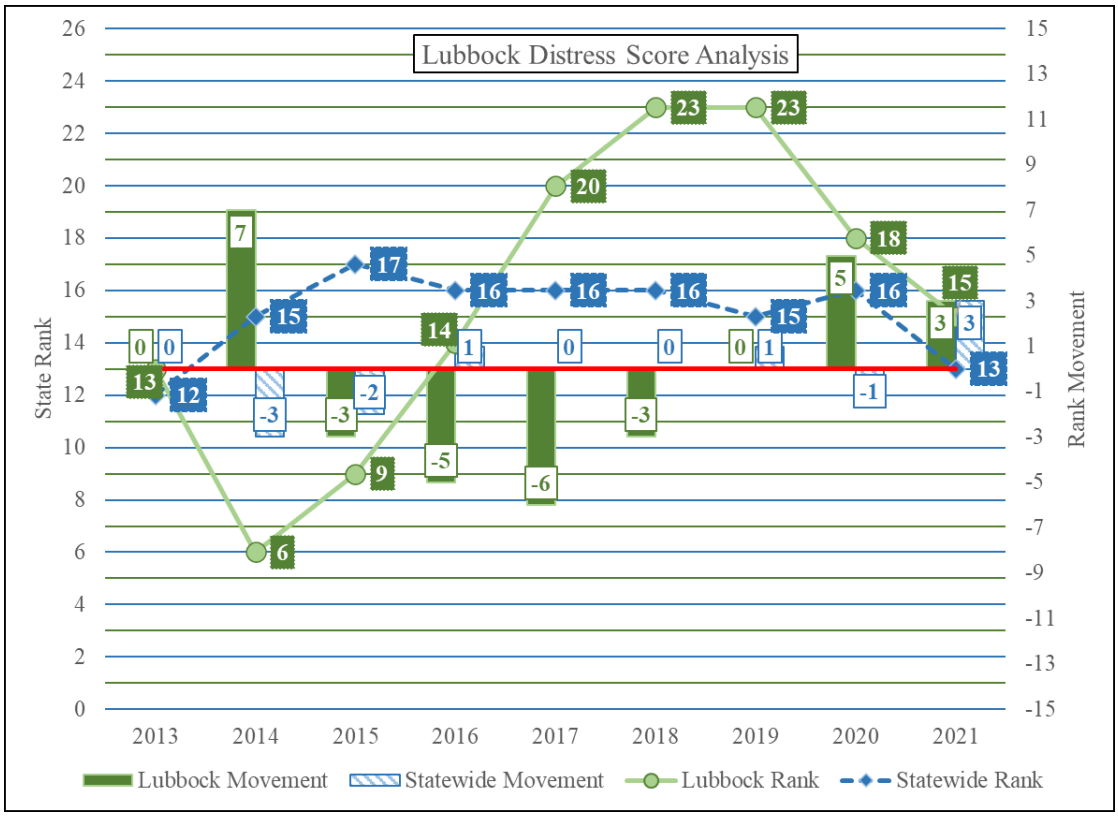

Figure A-30. Lubbock District (05) Distress Score Comparison to Statewide.

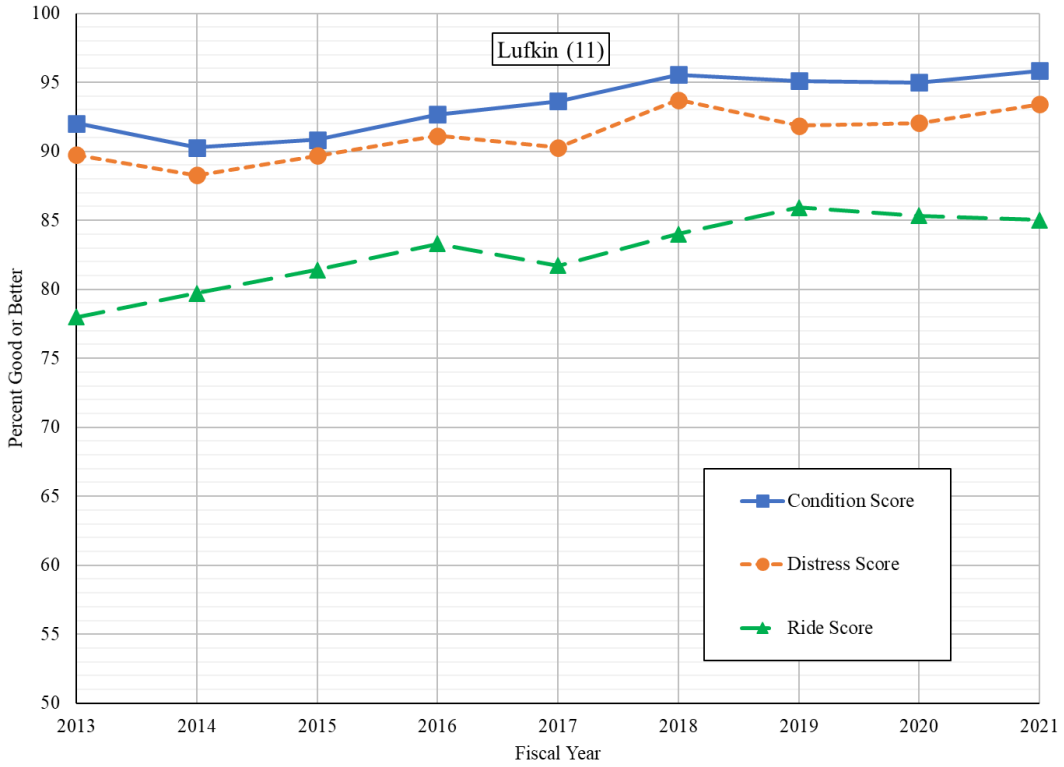

Figure A-31. Lufkin District (11) Pavement Performance Metrics.

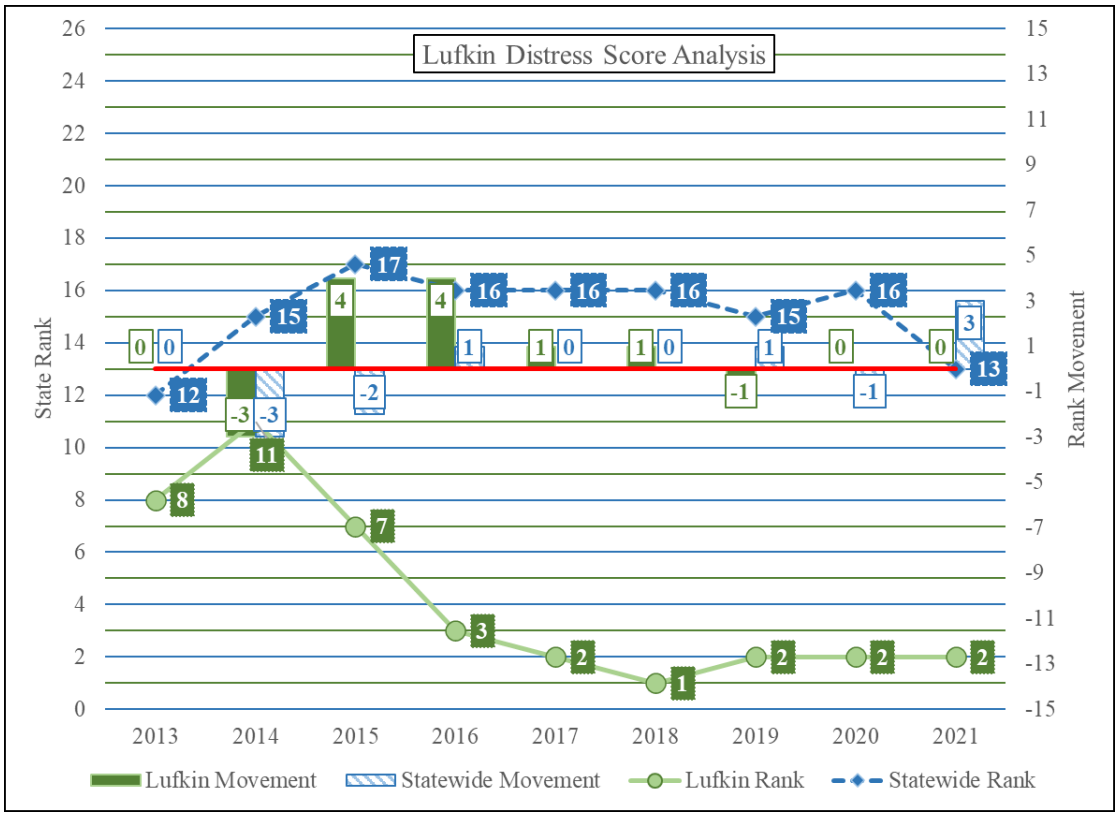

Figure A-32. Lufkin District (11) Distress Score Comparison to Statewide.

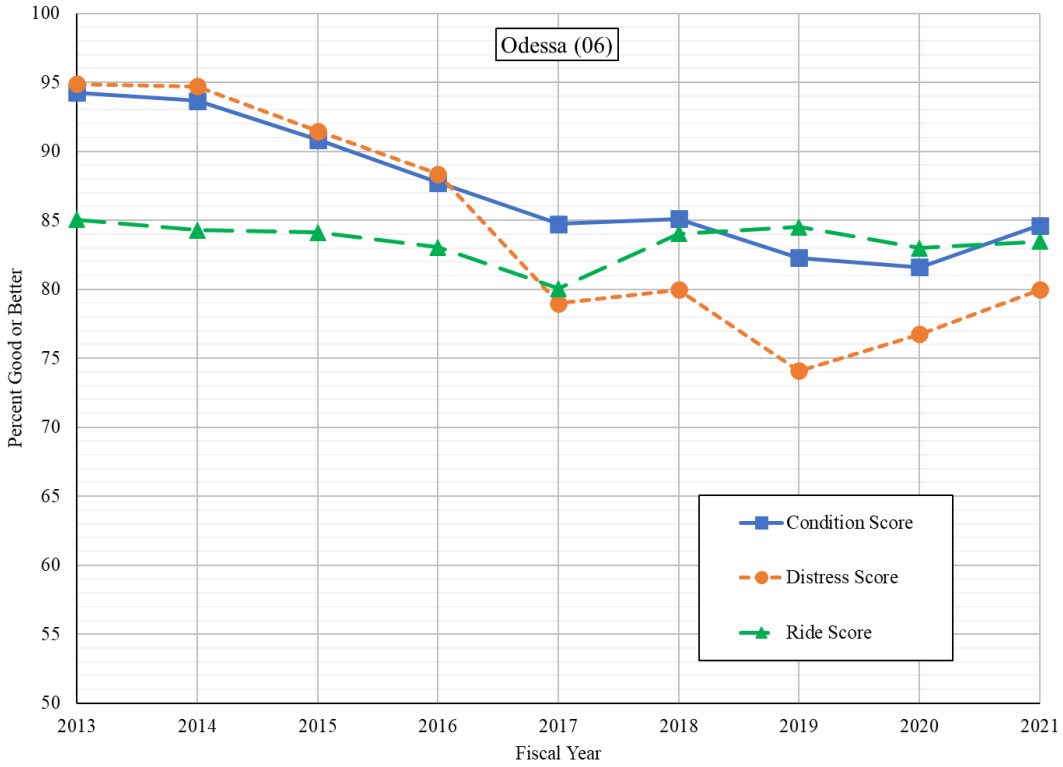

Figure A-33. Odessa District (06) Pavement Performance Metrics.

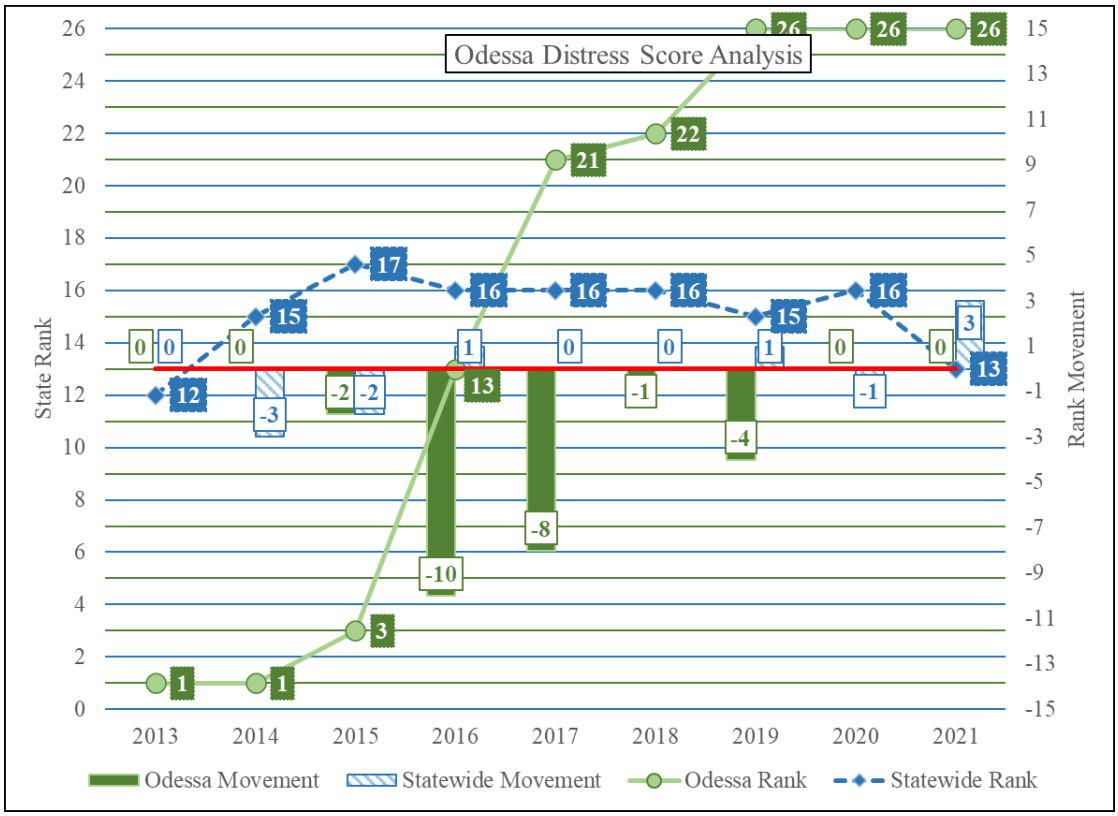

Figure A-34. Odessa District (06) Distress Score Comparison to Statewide.

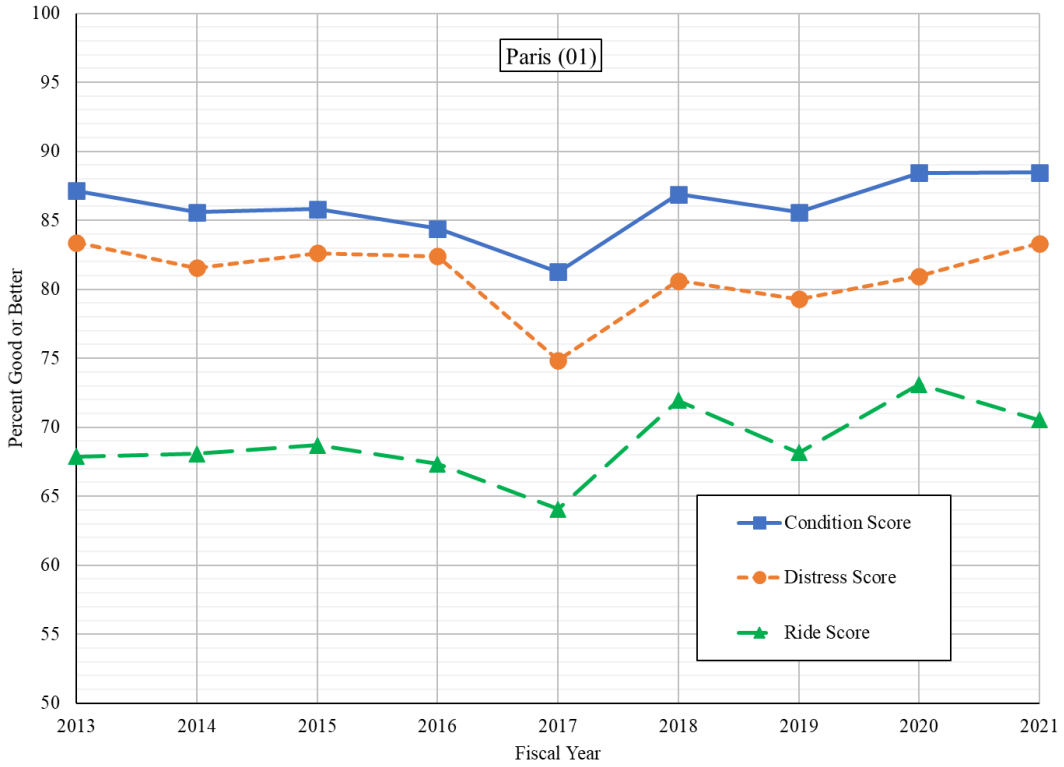

Figure A-35. Paris District (01) Pavement Performance Metrics.

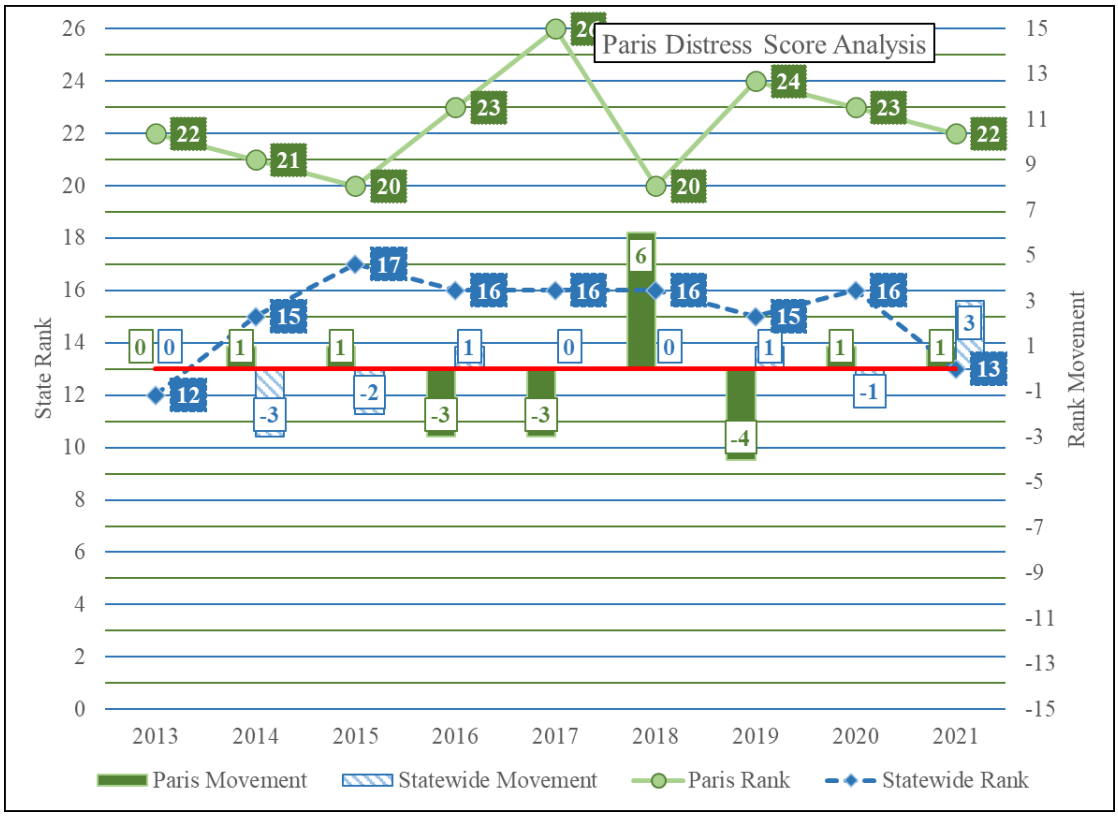

Figure A-36. Paris District (01) Distress Score Comparison to Statewide.

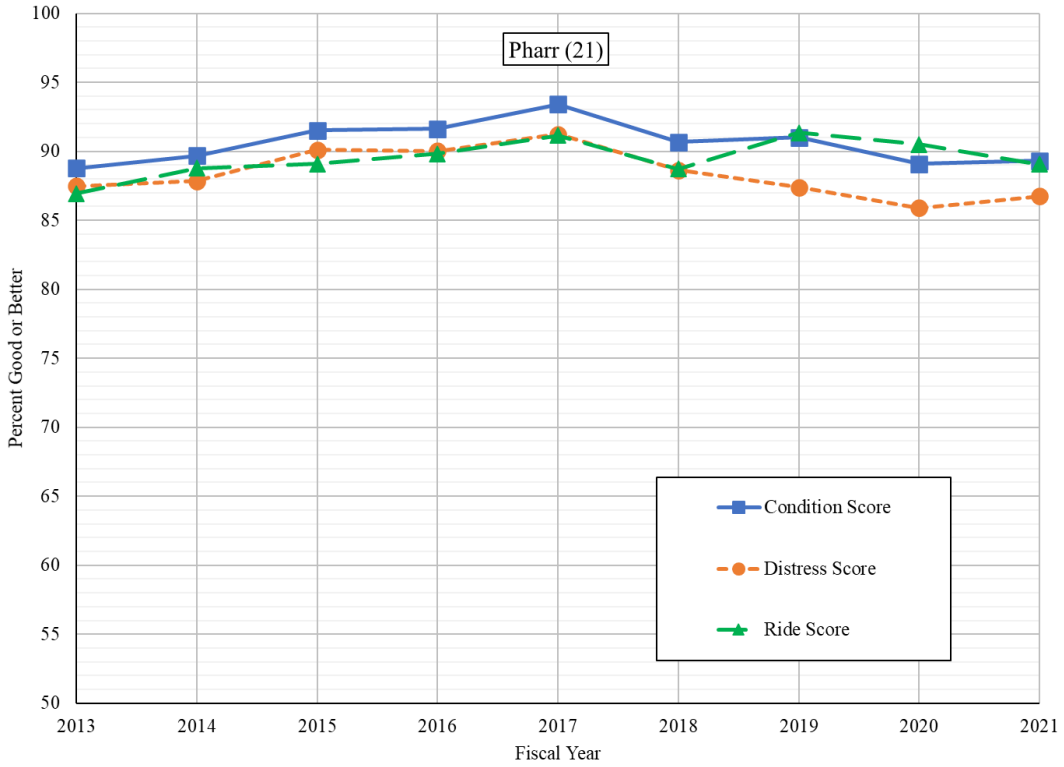

Figure A-37. Pharr District (21) Pavement Performance Metrics.

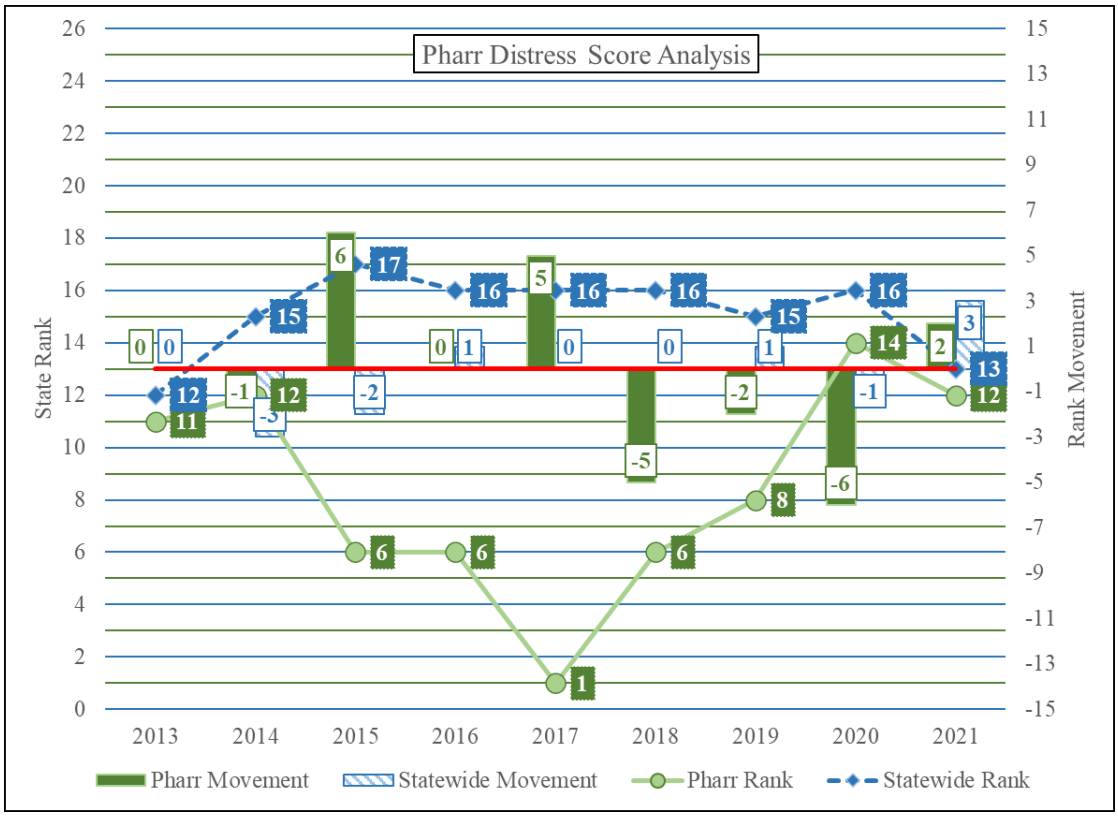

Figure A-38. Pharr District (21) Distress Score Comparison to Statewide.

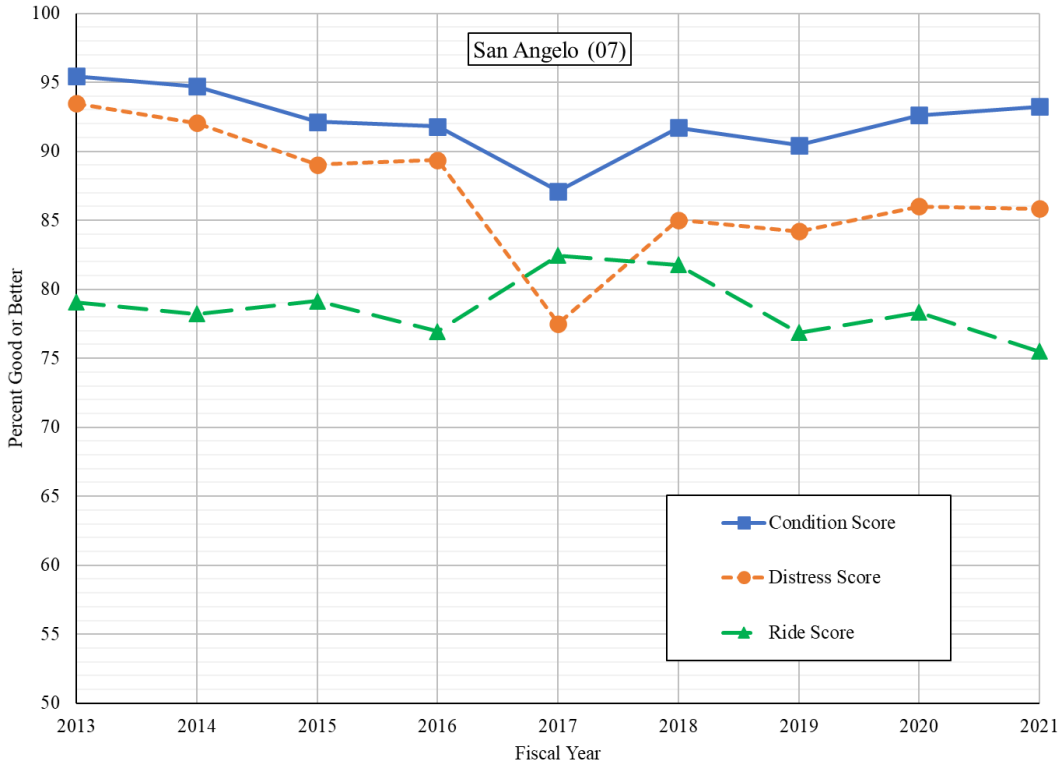

Figure A-39. San Angelo District (07) Pavement Performance Metrics.

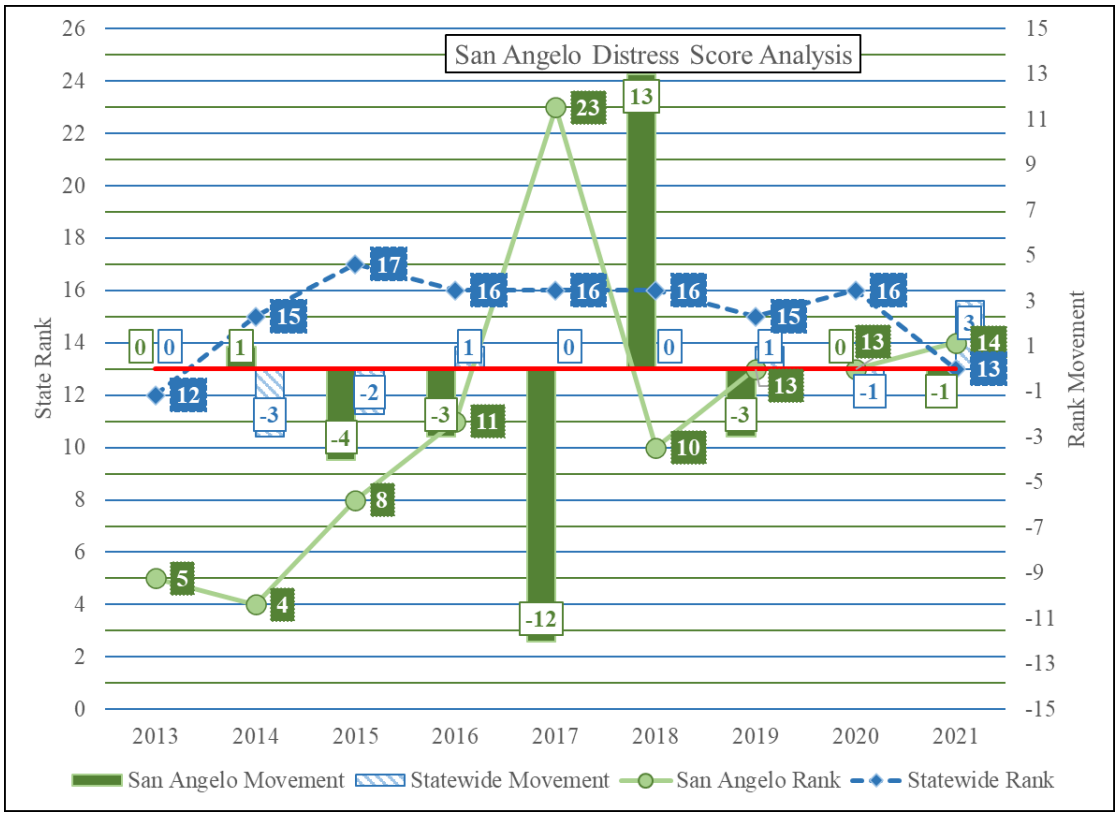

Figure A-40. San Angelo District (07) Distress Score Comparison to Statewide.

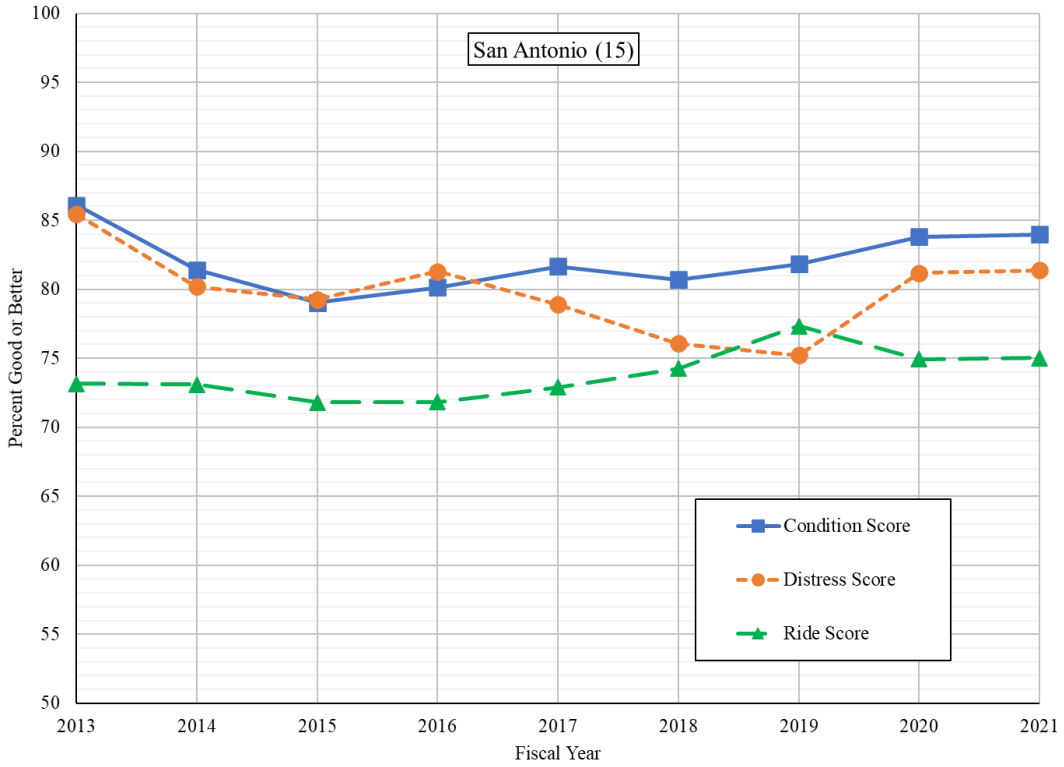

Figure A-41. San Antonio District (15) Pavement Performance Metrics.

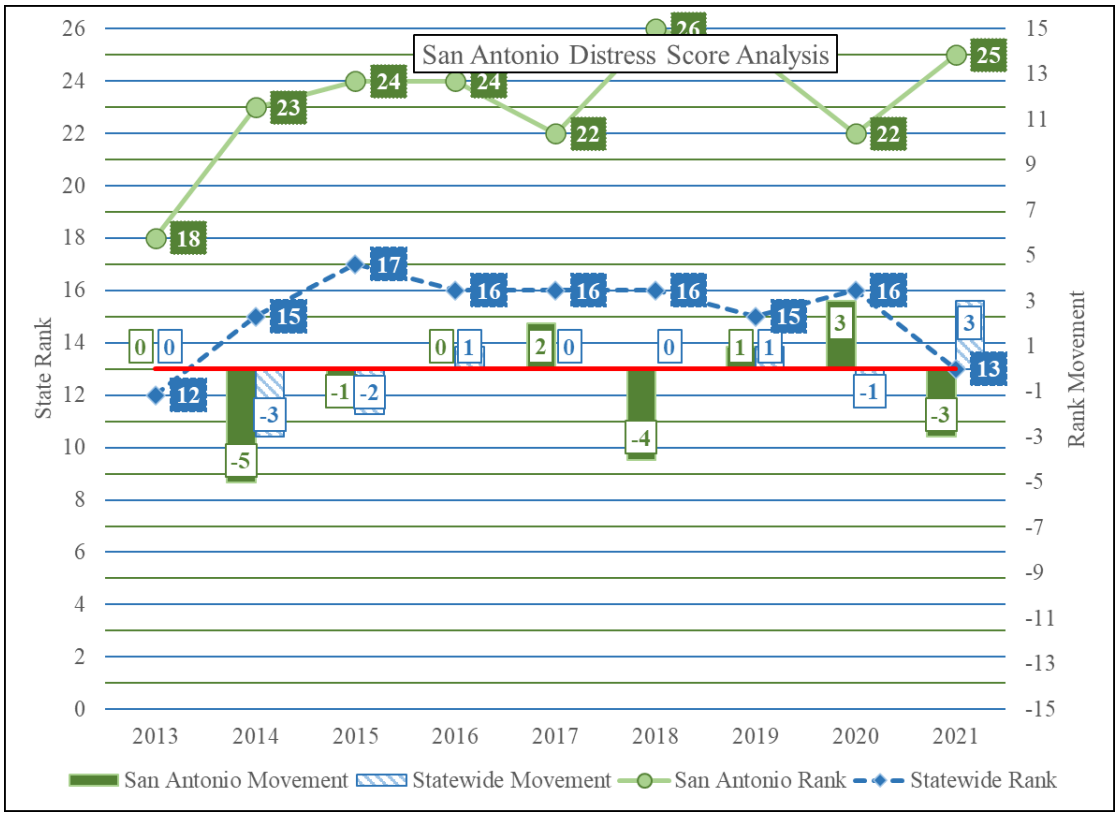

Figure A-42. San Antonio District (15) Distress Score Comparison to Statewide.

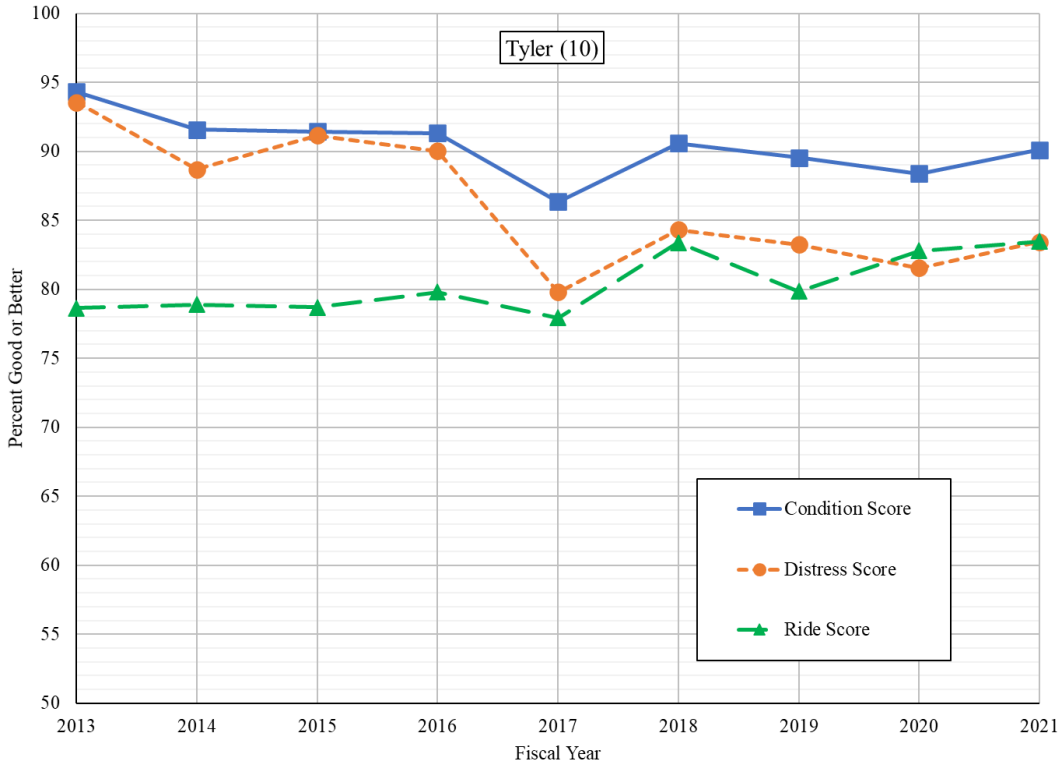

Figure A-43. Tyler District (10) Pavement Performance Metrics.

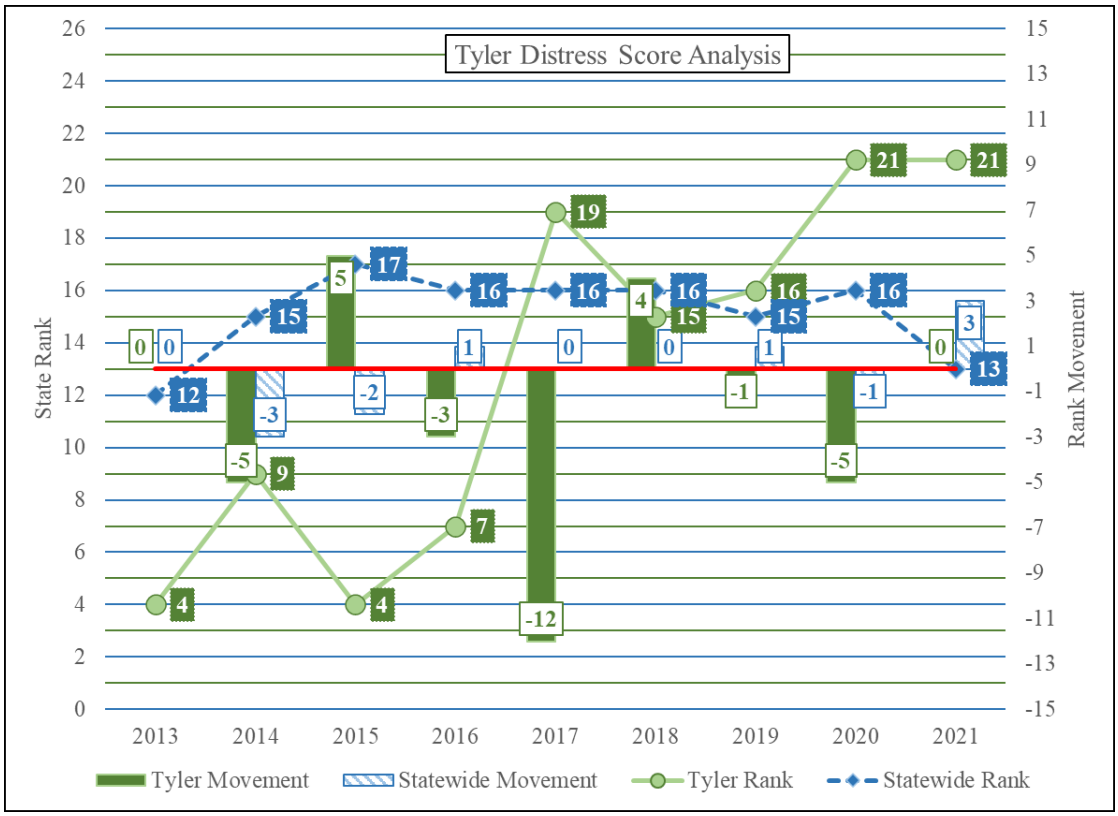

Figure A-44. Tyler District (10) Distress Score Comparison to Statewide.

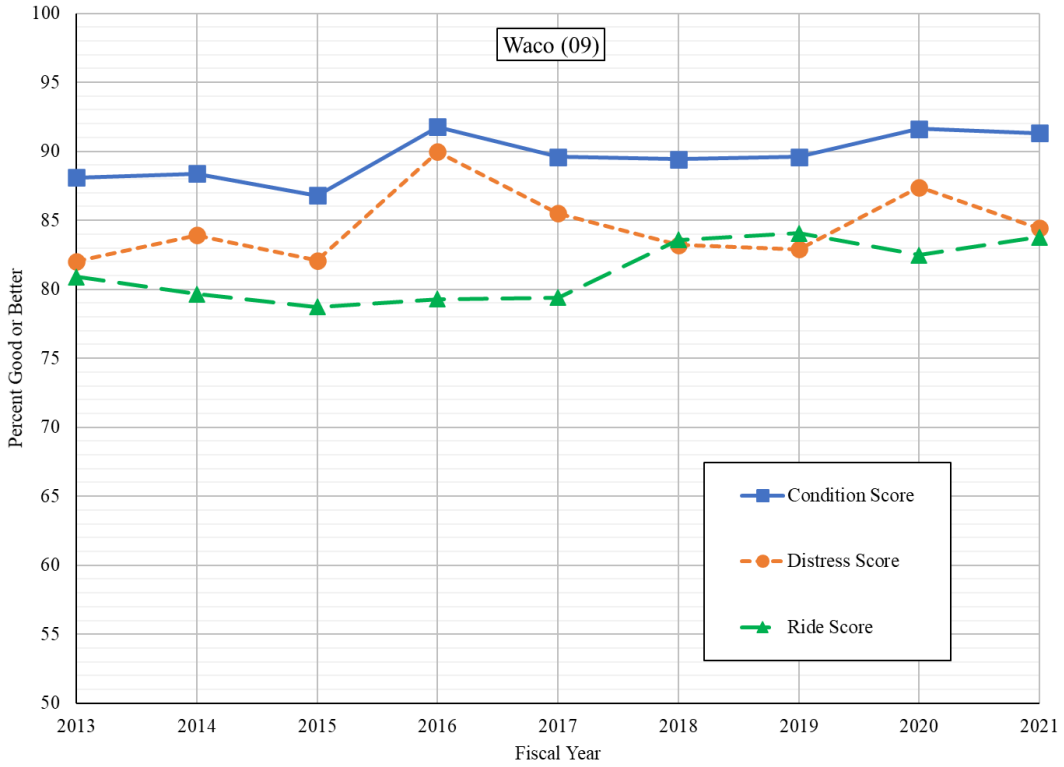

Figure A-45. Waco District (09) Pavement Performance Metrics.

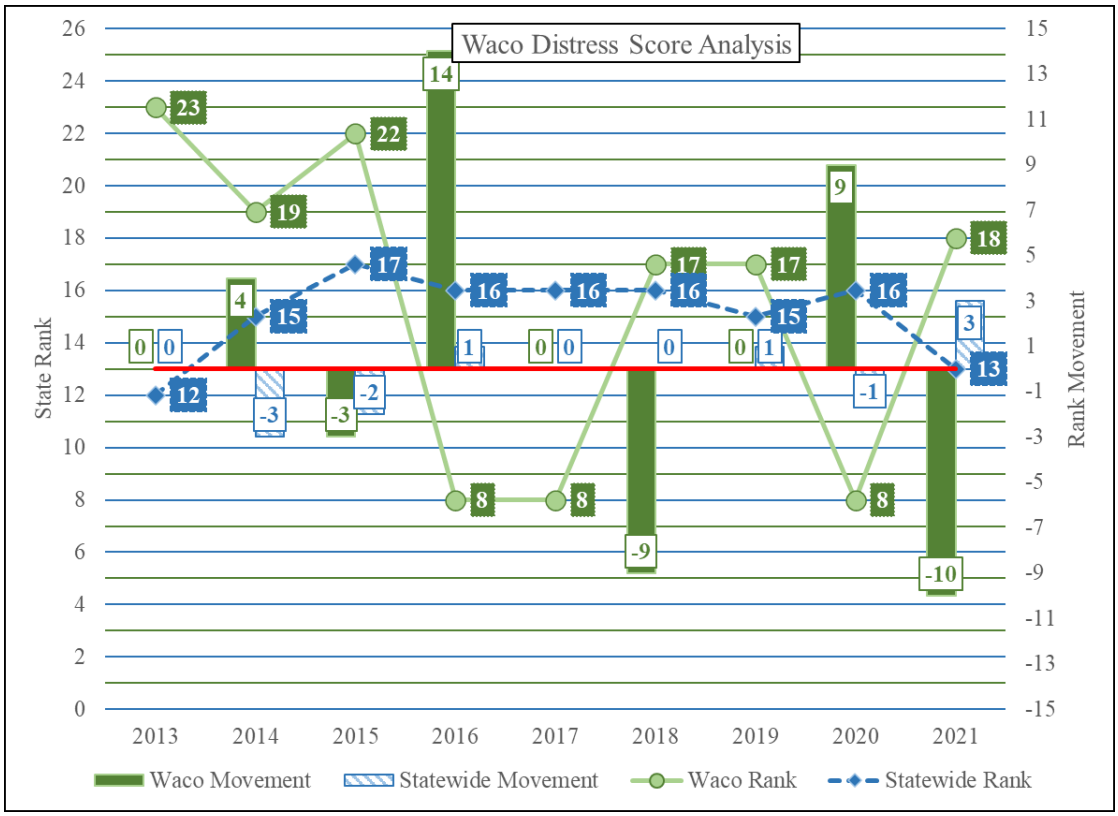

Figure A-46. Waco District (09) Distress Score Comparison to Statewide.

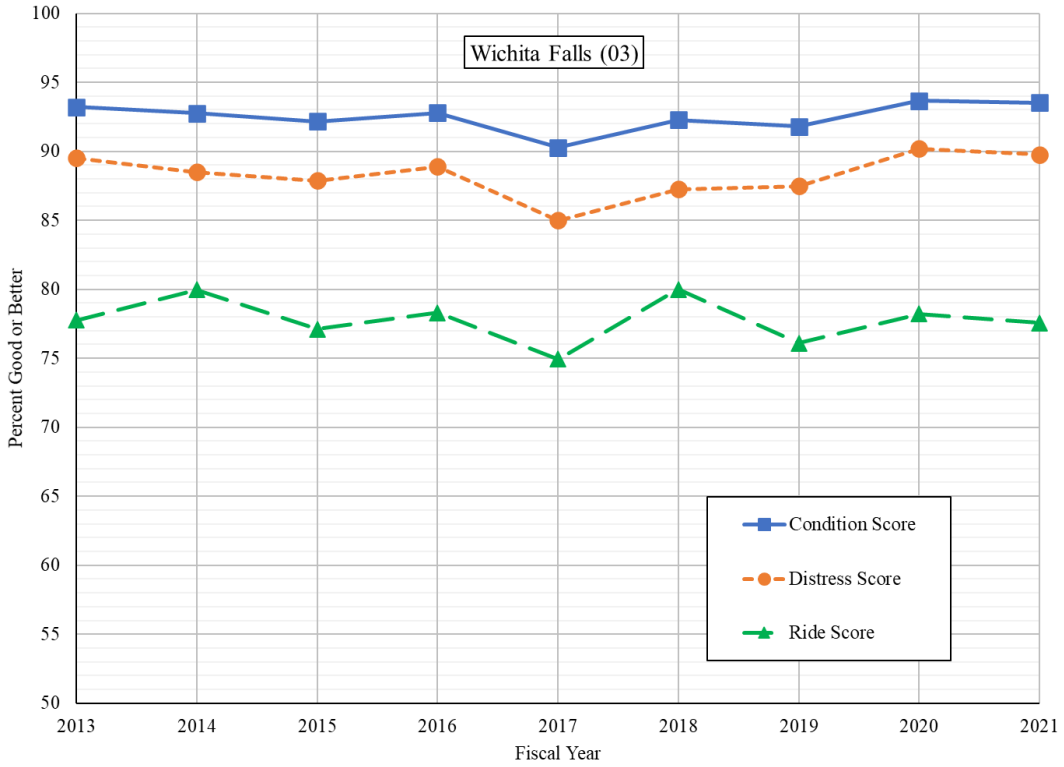

Figure A-47. Wichita Falls District (03) Pavement Performance Metrics.

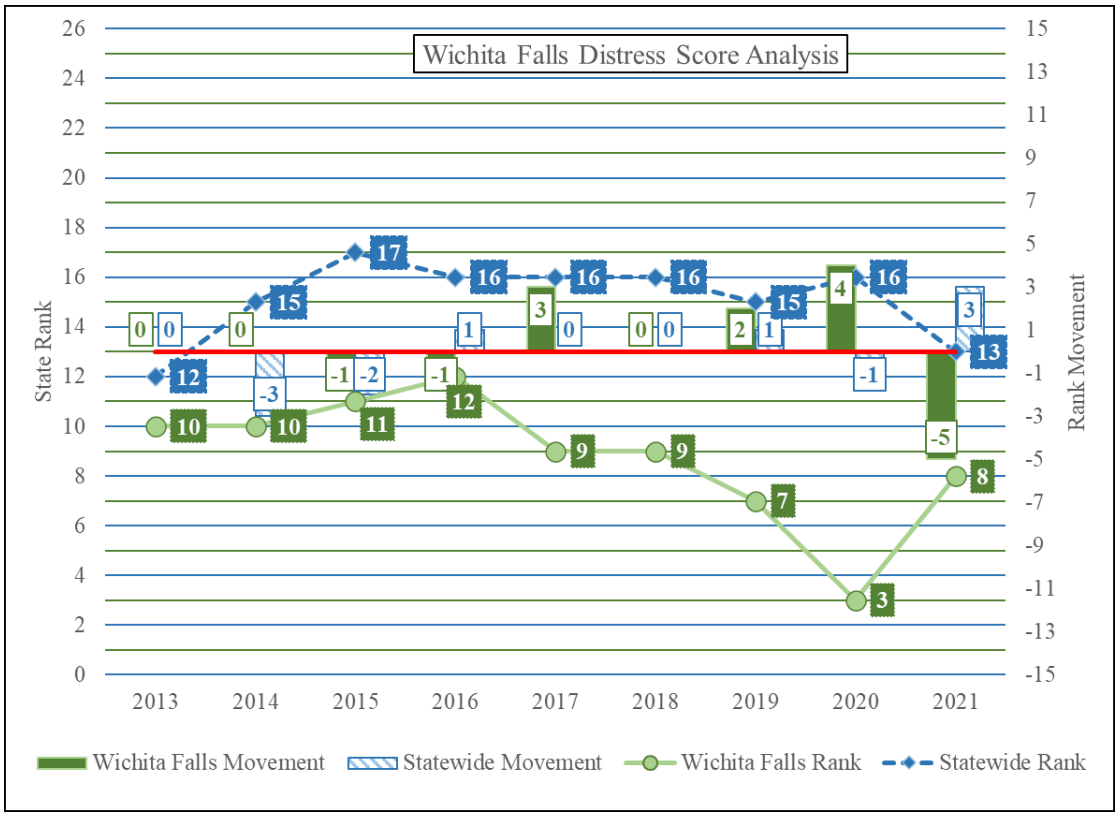

Figure A-48. Wichita Falls District (03) Distress Score Comparison to Statewide.

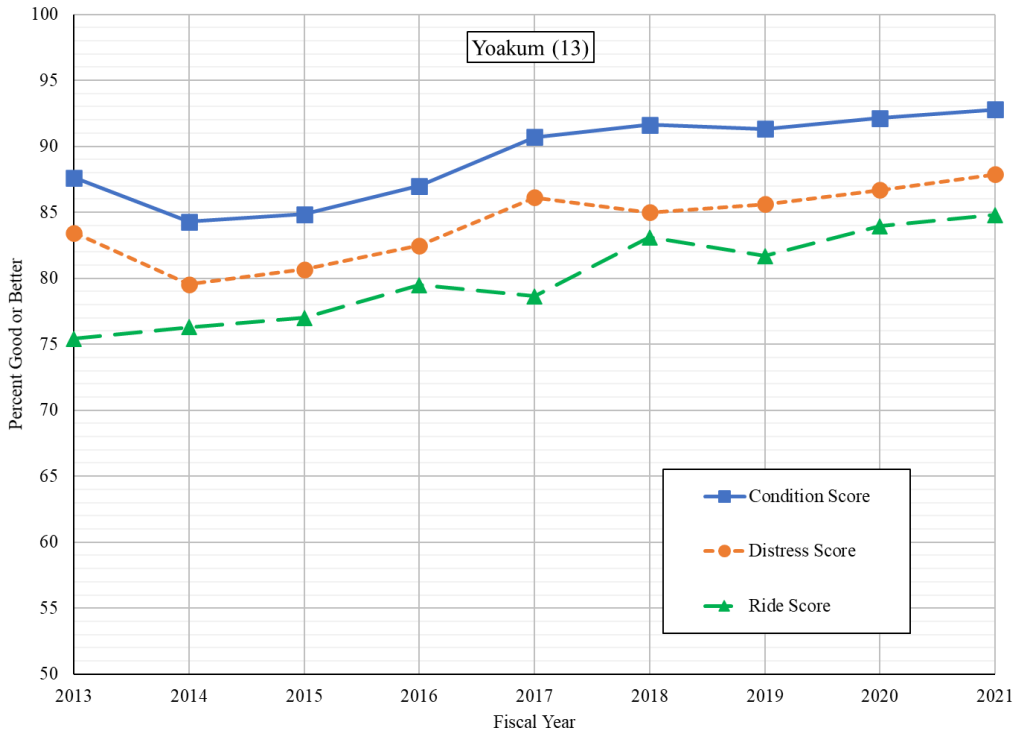

Figure A-49. Yoakum District (13) Pavement Performance Metrics.

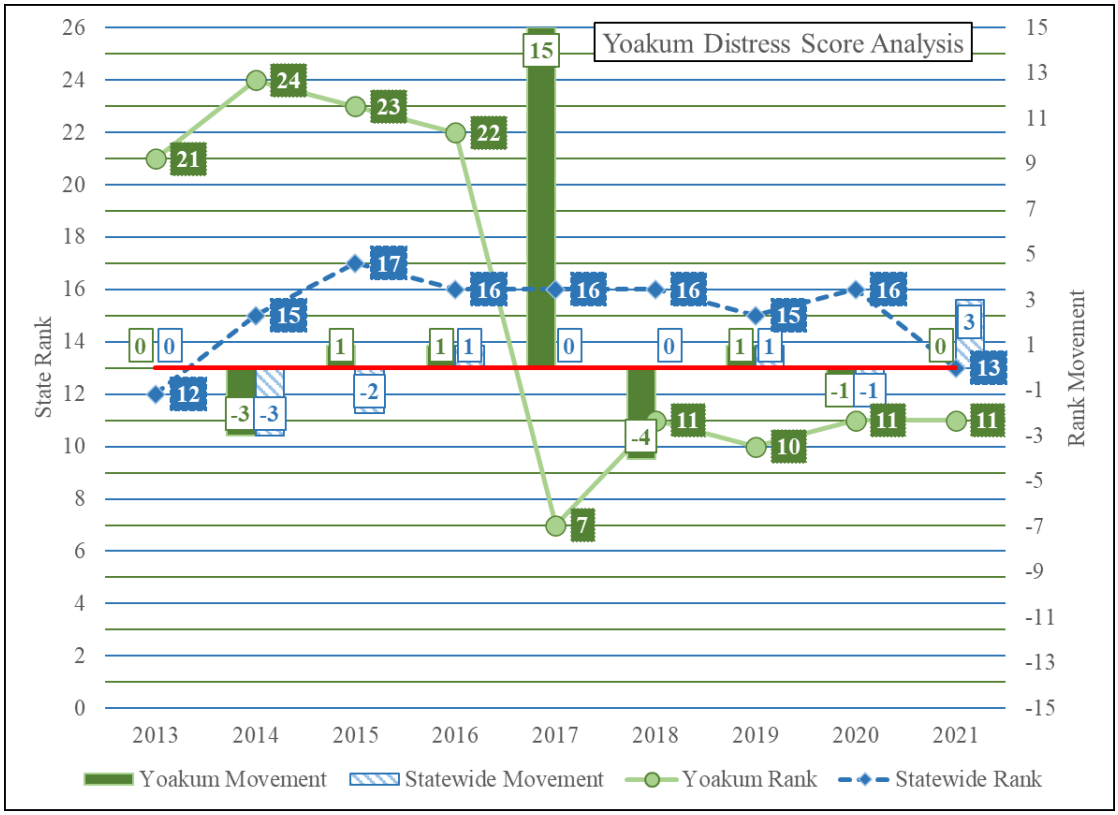

Figure A-50. Yoakum District (13) Distress Score Comparison to Statewide.

APPENDIX B: SUMMARY OF RESPONSES TO GENERAL SURVEY QUESTIONS

Appendix B includes summary figures for the general questions presented to each respondent in the online platform. These responses were used to identify typical practices in 4-year PMP development.

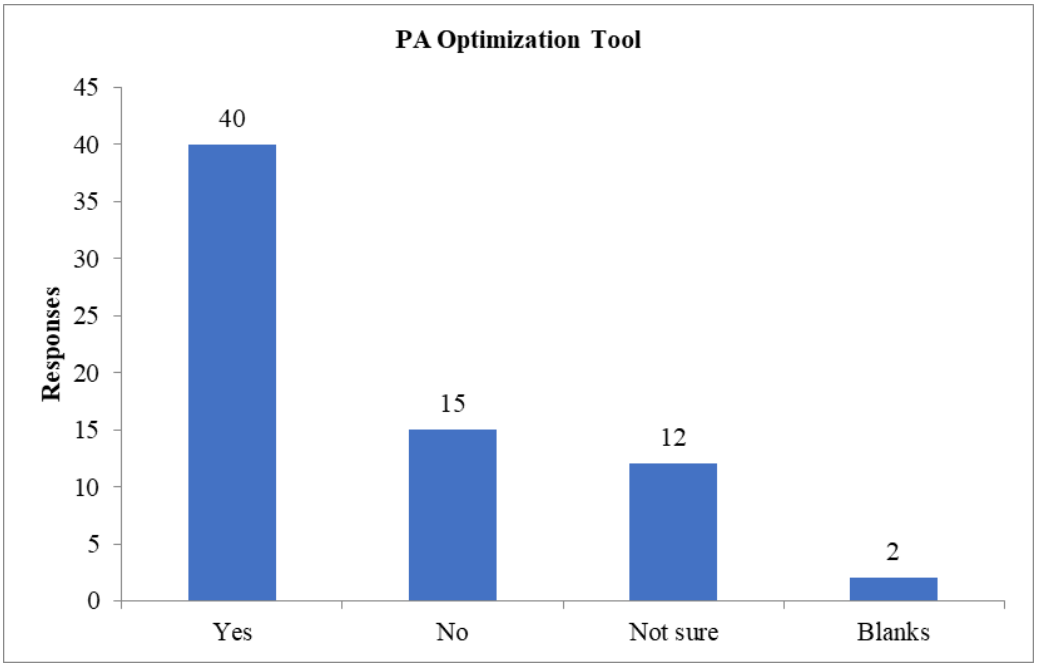

Figure B-1. Summary of the Use of the Pavement Analyst Optimization Tool.

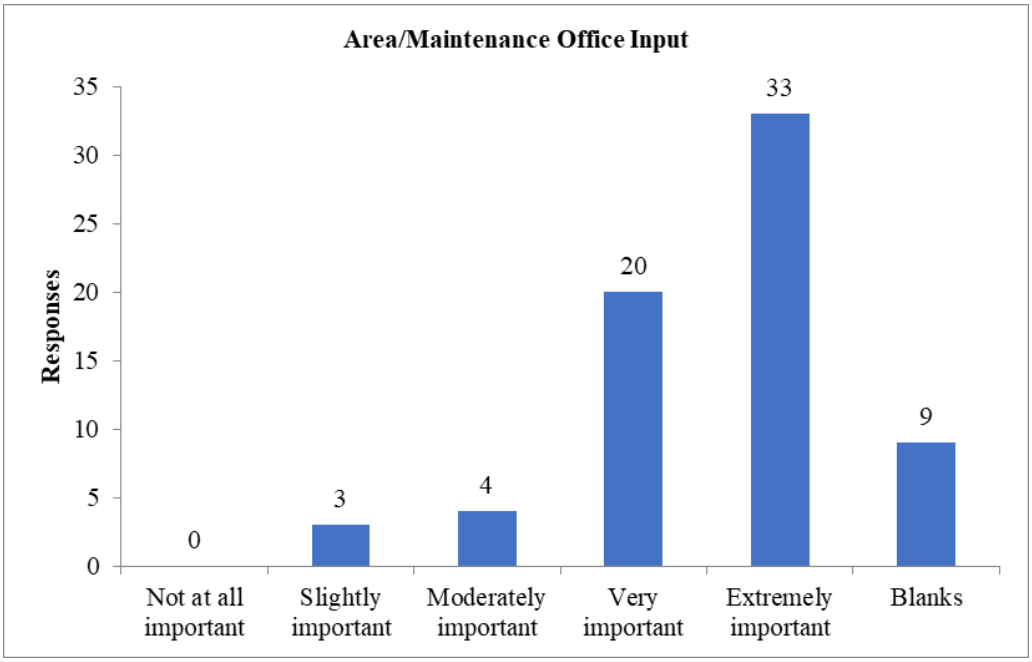

Figure B-2. Summary of the Importance of AO/MO Input.

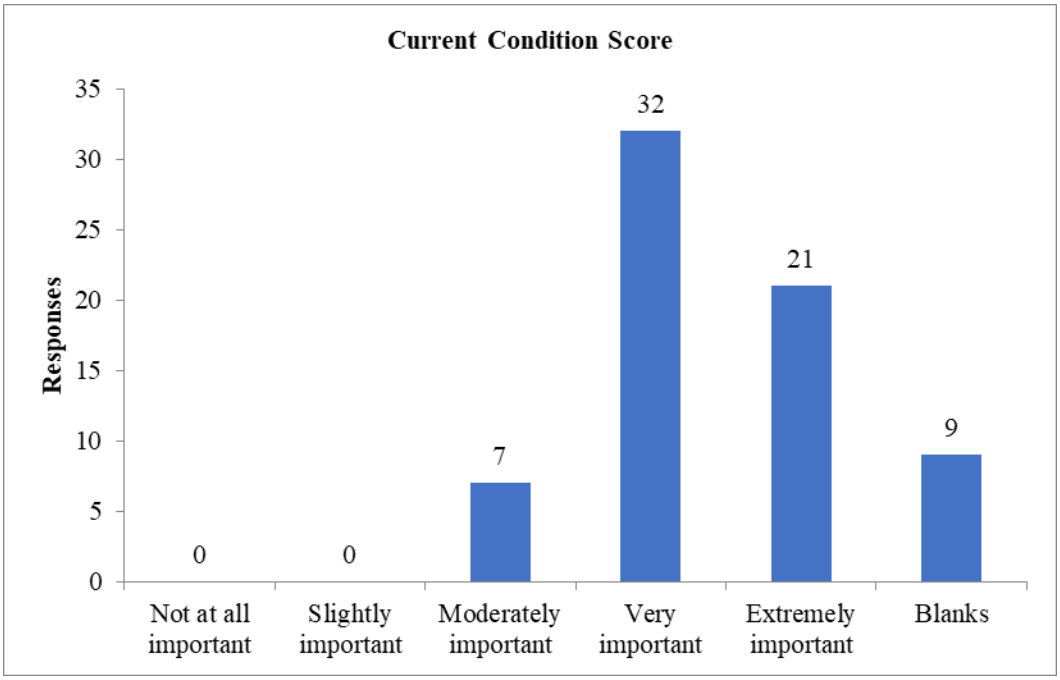

Figure B-3. Summary of the Importance of Current Condition Score.

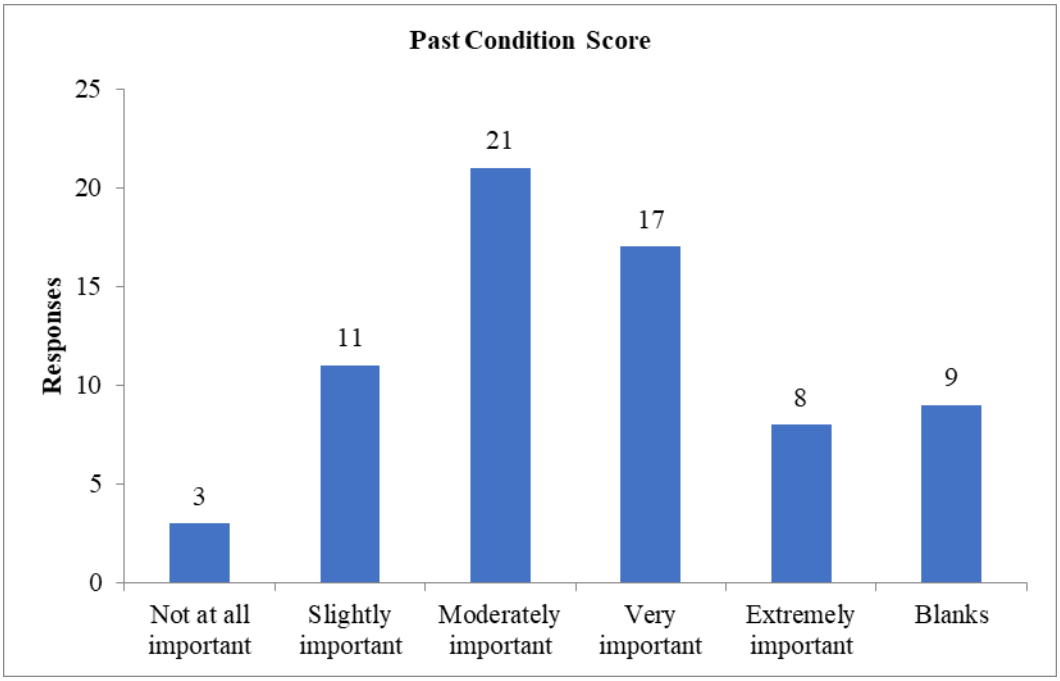

Figure B-4. Summary of the Importance of Past Condition Score.

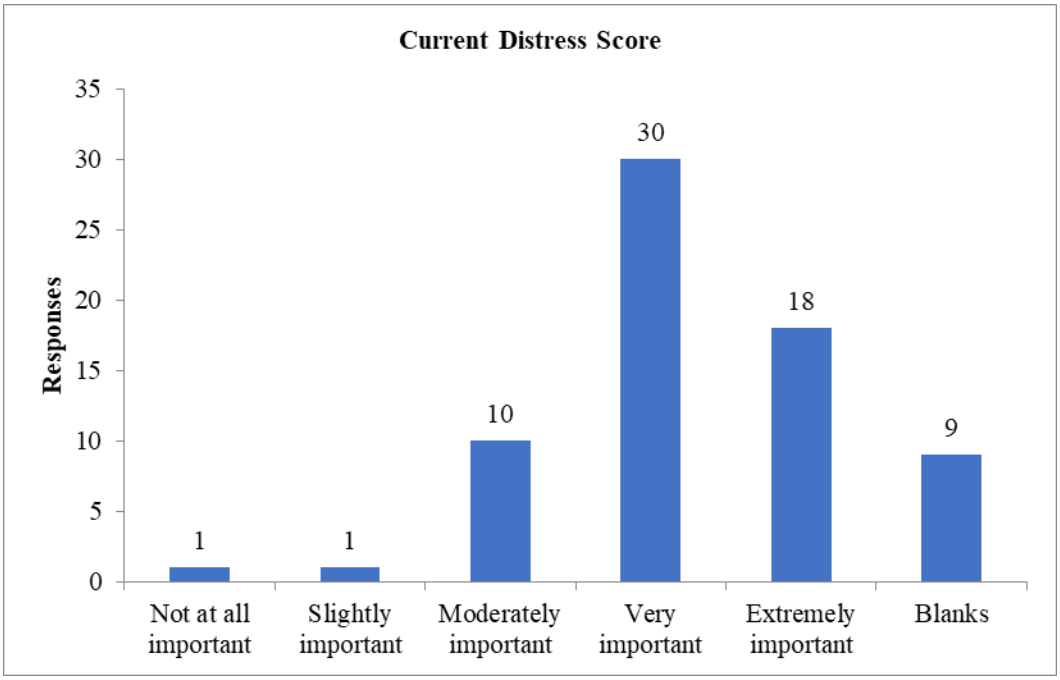

Figure B-5. Summary of the Importance of Current Distress Score.

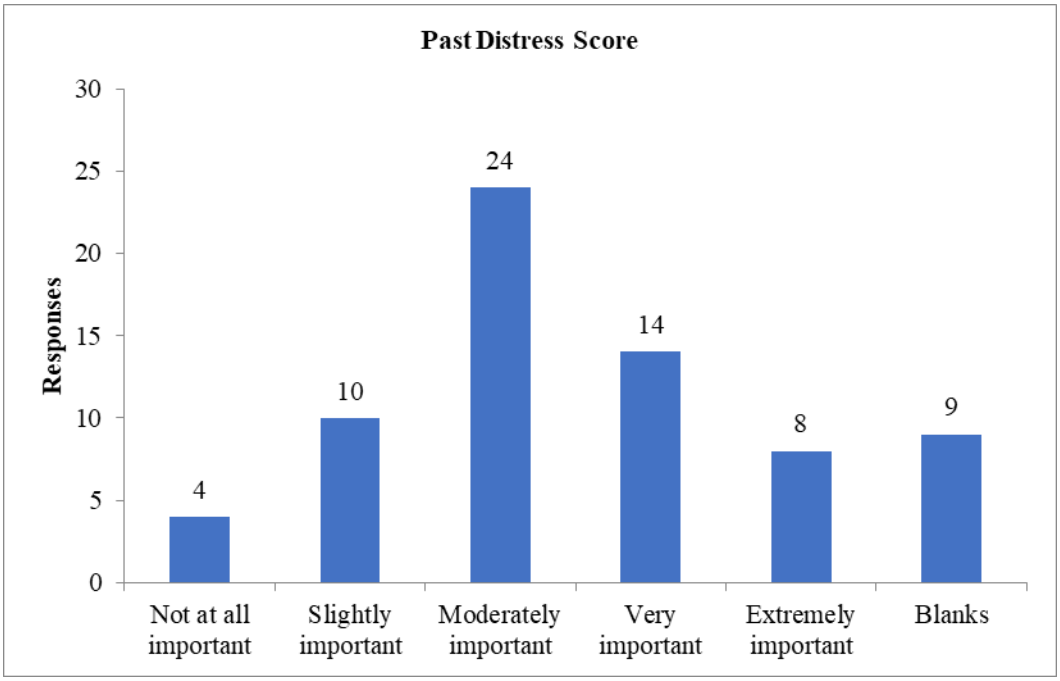

Figure B-6. Summary of the Importance of Past Distress Score.

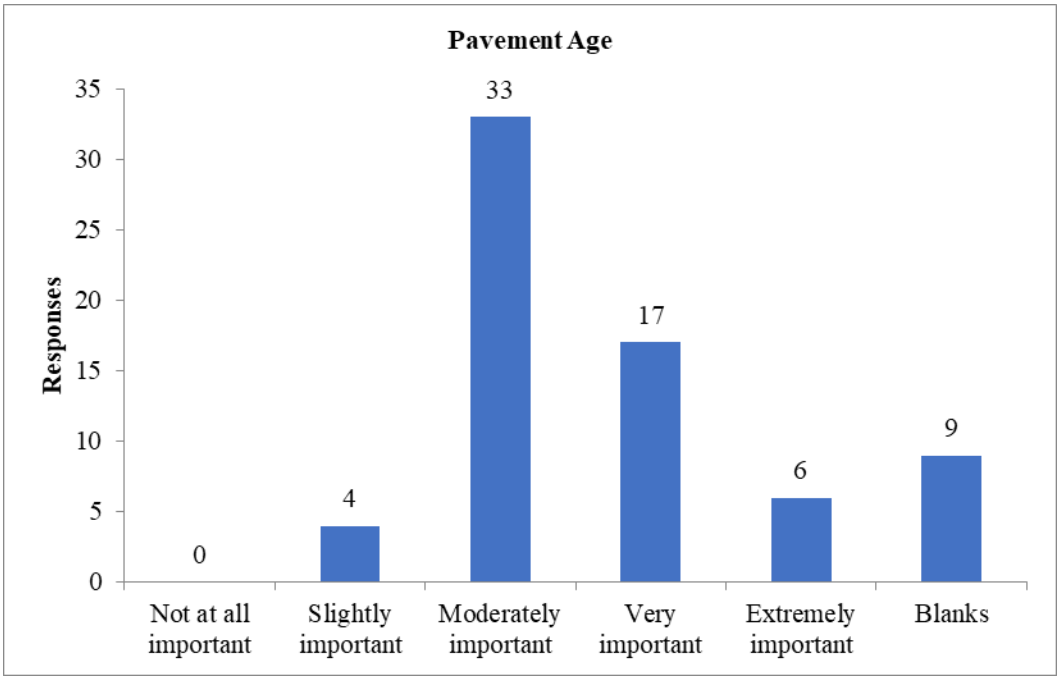

Figure B-7. Summary of the Importance of Pavement Age.

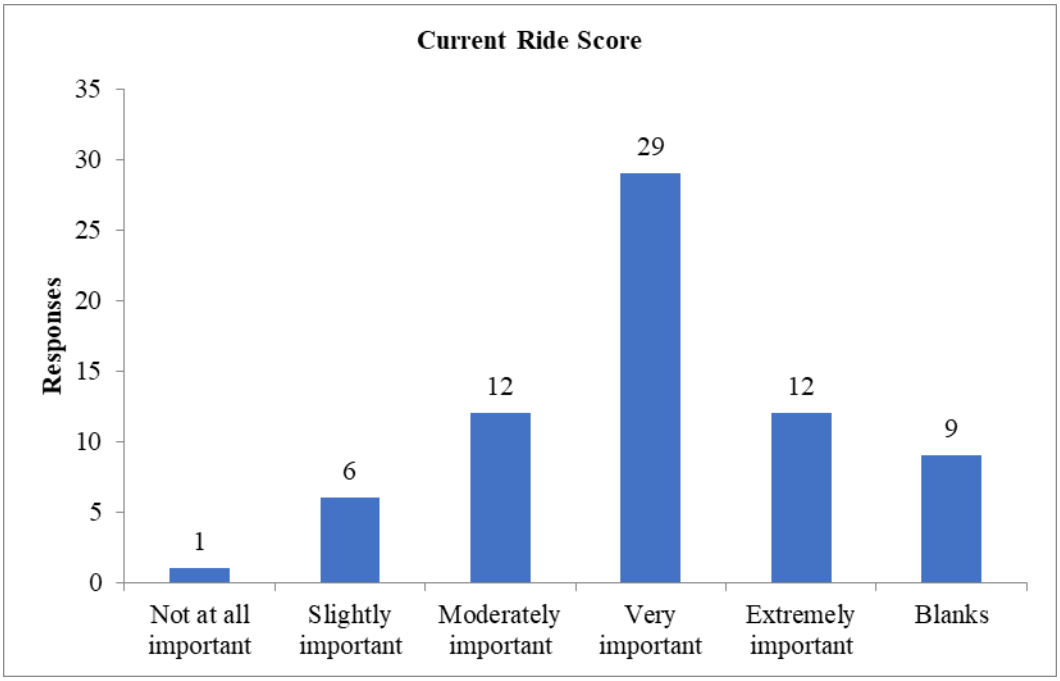

Figure B-8. Summary of the Importance of Current Ride Score.

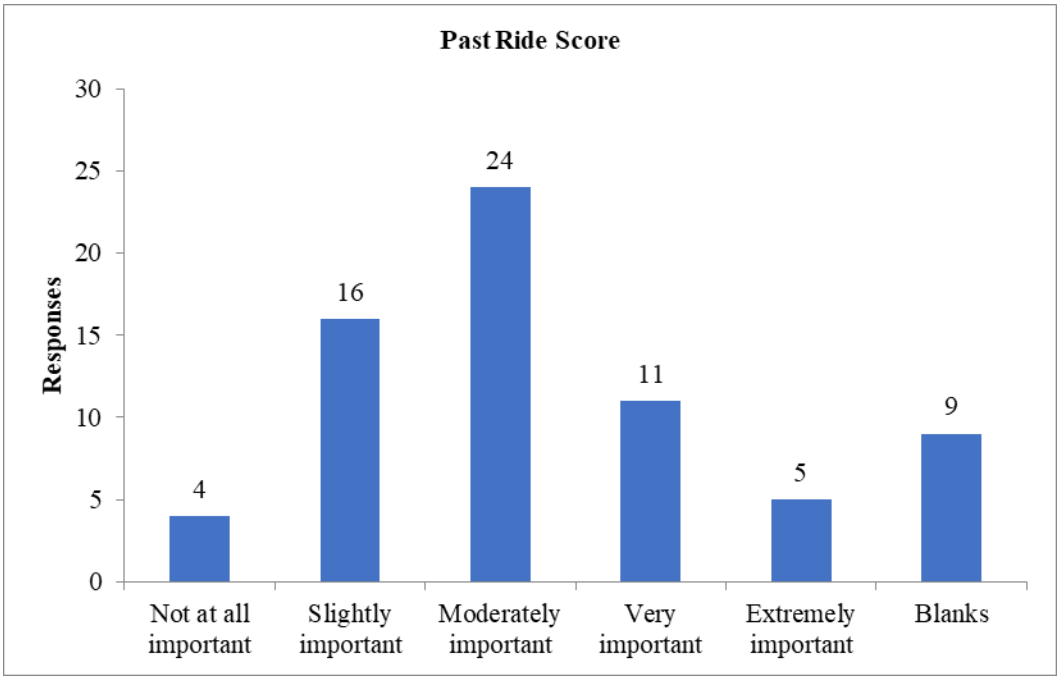

Figure B-9. Summary of the Importance of Past Ride Score.

Figure B-10. Summary of the Importance of Skid Score.

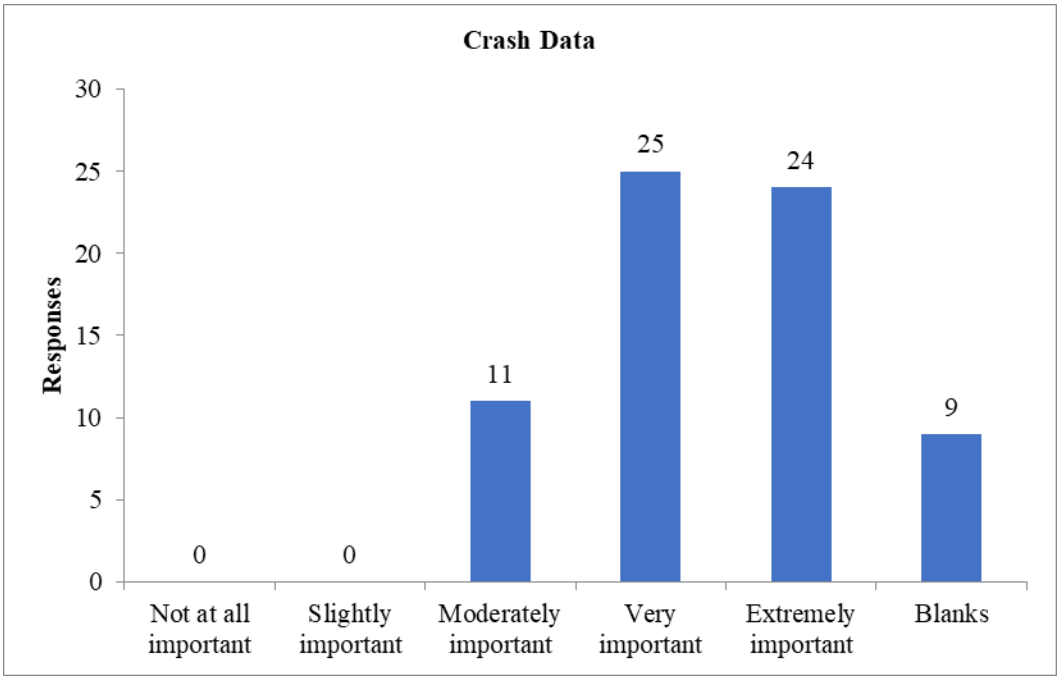

Figure B-11. Summary of the Importance of Crash Data.

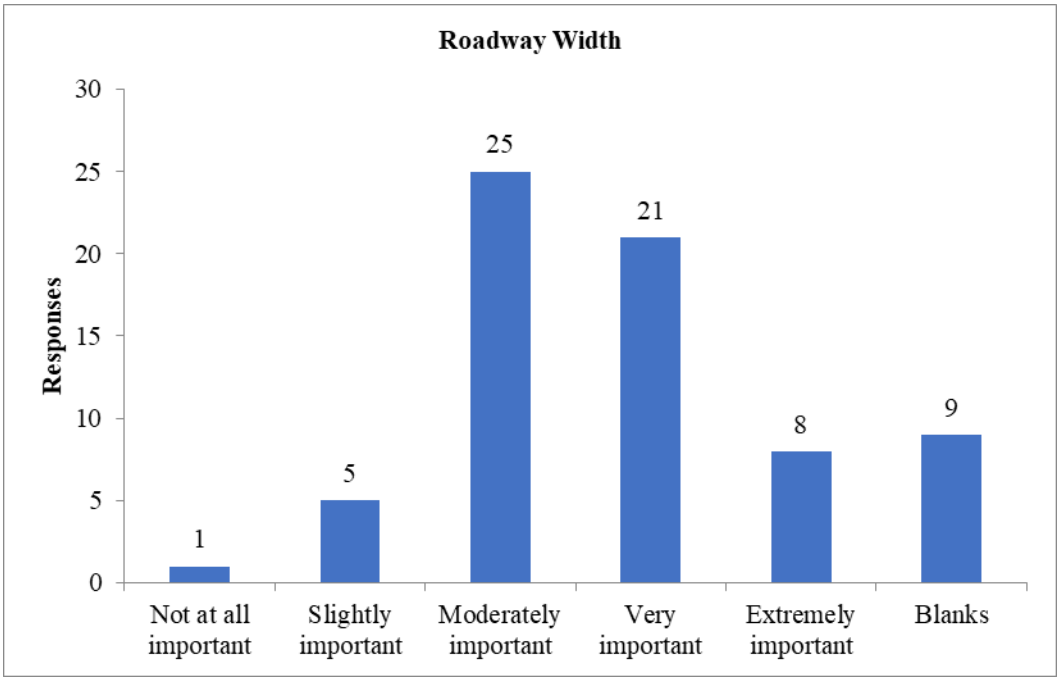

Figure B-12. Summary of the Importance of Roadway Width.

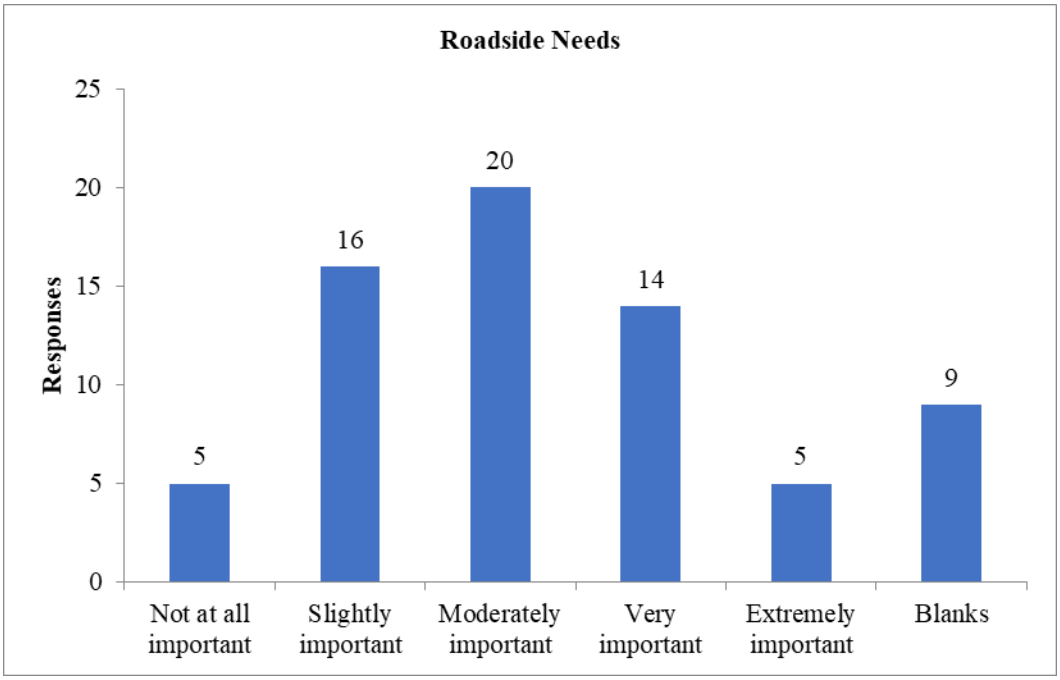

Figure B-13. Summary of the Importance of Roadside Needs.

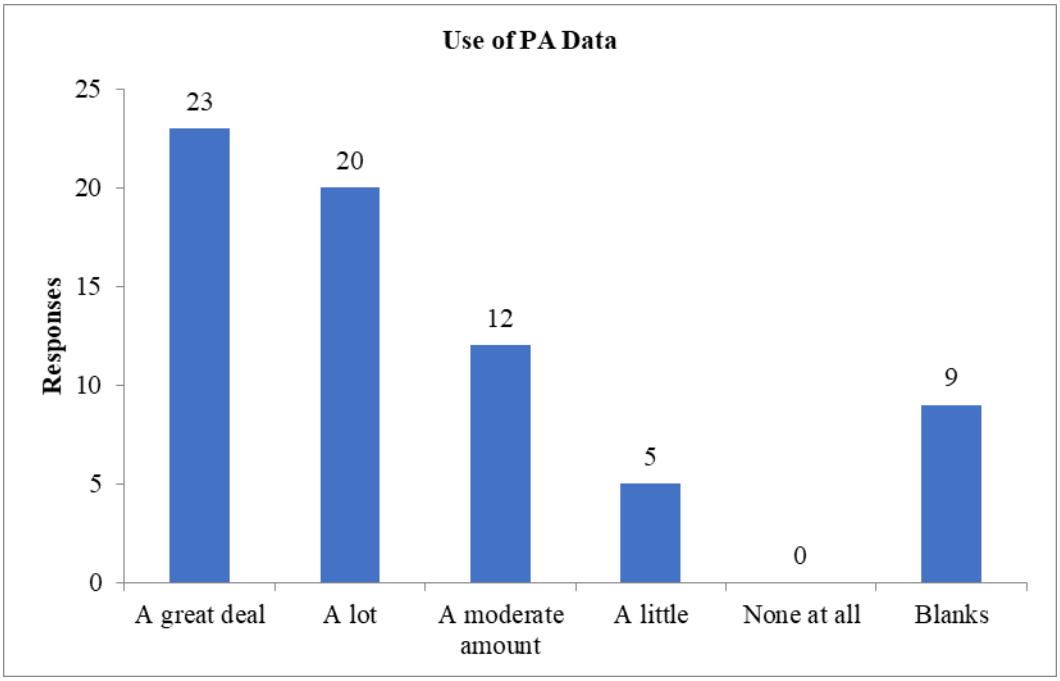

Figure B-14. Summary of the Use of Pavement Analyst Data.

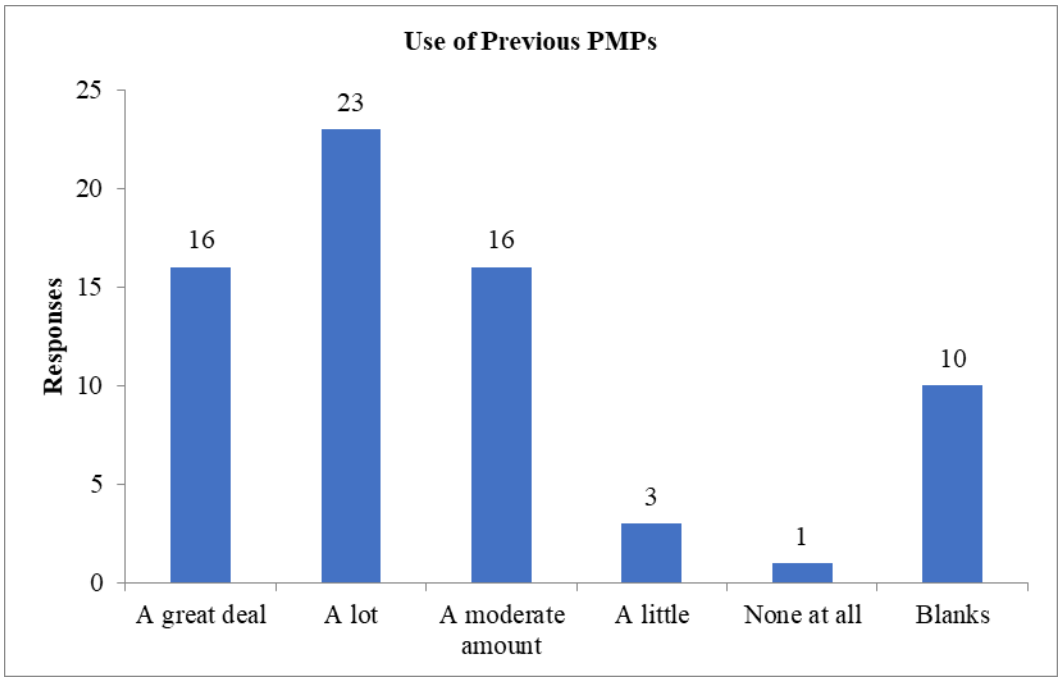

Figure B-15. Summary of the Use of Previous PMPs.

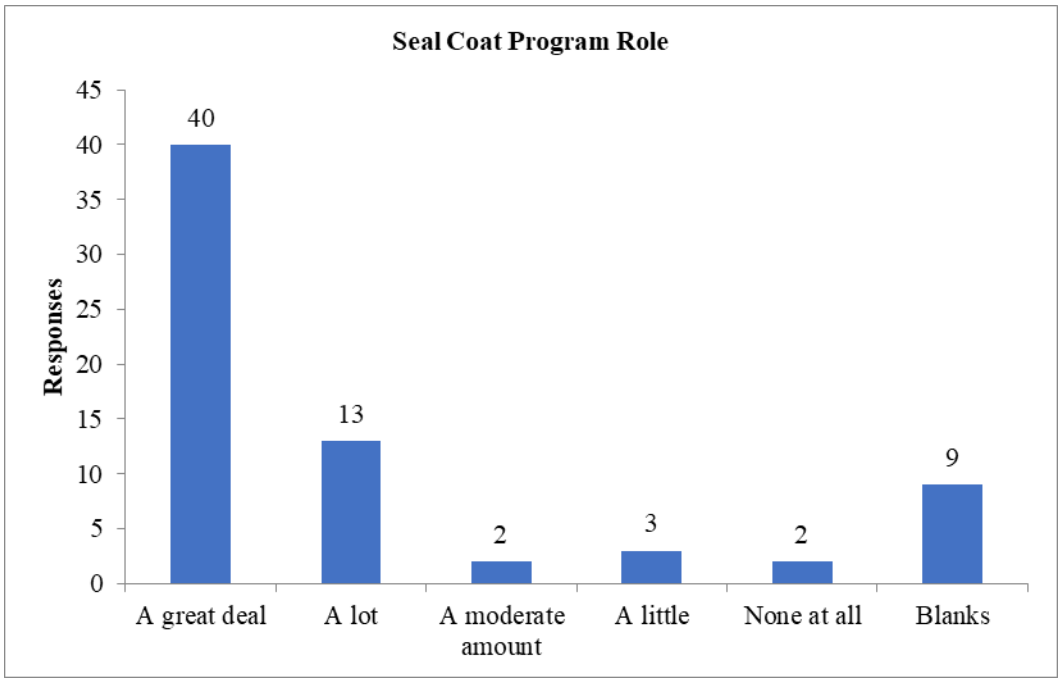

Figure B-16. Summary of the Influence of the Seal Coat Program on the PMP.

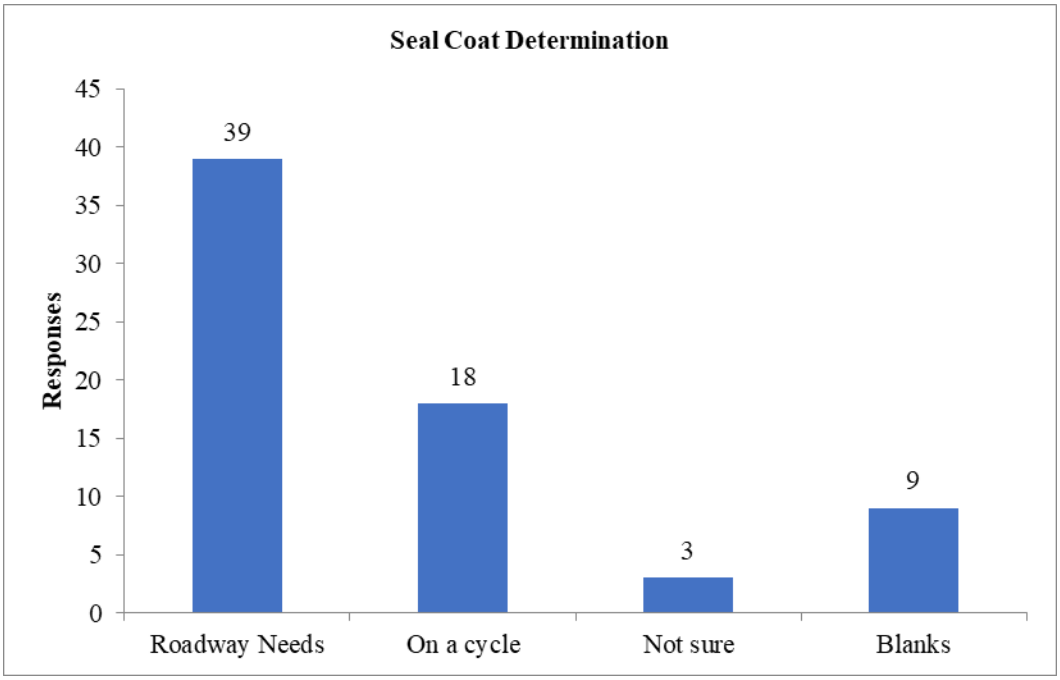

Figure B-17. Summary of How District Seal Coat Roads Are Selected.

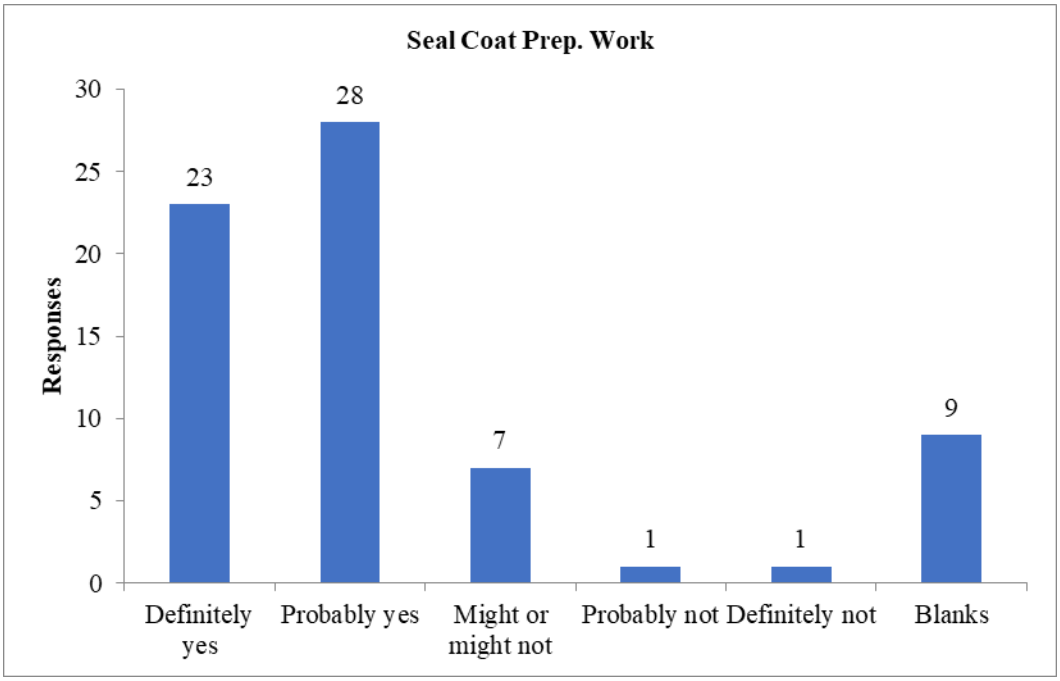

Figure B-18. Summary of Adequacy of Seal Coat Prep Work.

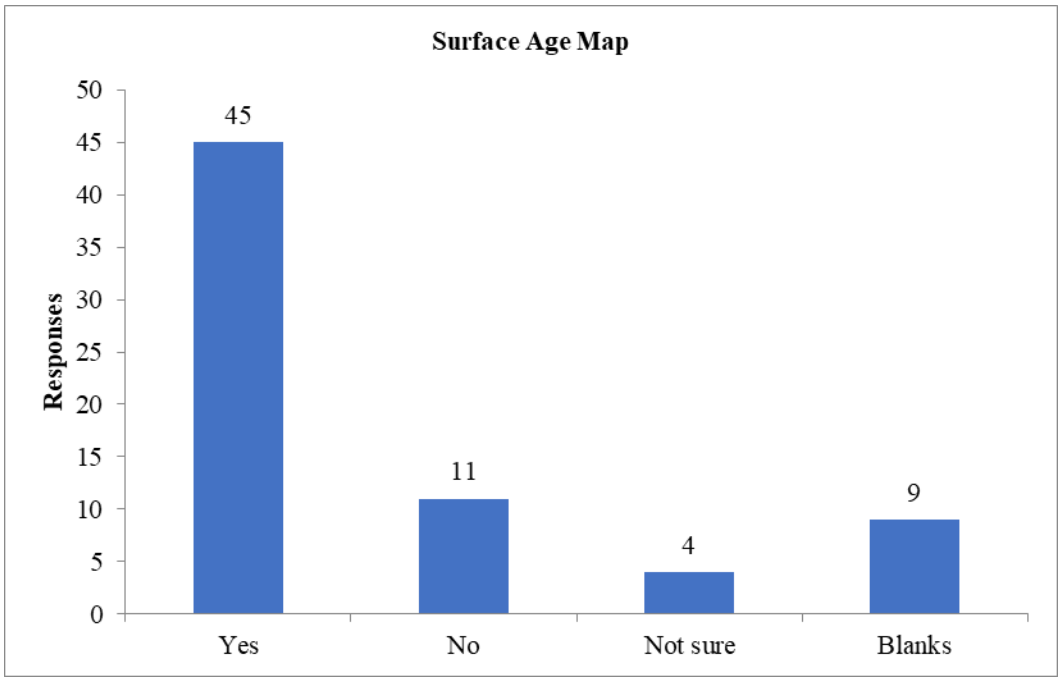

Figure B-19. Summary of Districts with a Surface Age Map.