KENTUCKY TRANSPORTATION CABINET

TRANSPORTATION ASSET MANAGEMENT PLAN

JUNE 2019

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CHAPTER 1:

INTRODUCTION

OVERVIEW

The Kentucky Transportation Cabinet (KYTC) is charged with providing a safe, efficient, and environmentally-sound transportation system in a fiscally-responsible manner to support the state's economic opportunities and to provide a desirable quality of life to its citizens. To keep the system operating safely and efficiently, KYTC invests billions of dollars in building, preserving, and enhancing the roads, bridges, airports, transit facilities, and other elements that comprise the state-maintained transportation system.

KYTC MISSION STATEMENT

To provide a safe, efficient, environmentally sound and fiscally responsible transportation system that delivers economic opportunity and enhances the quality of life in Kentucky.

According to the 2014 *Kentucky Long-Range Statewide Transportation Plan (LRSTP)*[1], funding for roads and bridges has not kept pace with the needs of the transportation system and the condition of pavements and bridges in the Commonwealth have been steadily declining. In 2002, KYTC reached an undesirable milestone, in which the state's highway pavements had deteriorated to the point that there were more roads in "Fair or Poor" condition than in "Good" condition.

To address this situation, the KYTC has adopted a "Fix it First" mentality, where the agency has been using available funds to invest aggressively in the maintenance and preservation of the transportation infrastructure. This approach reflects the principles behind Transportation Asset Management (TAM), which provides a strategic and systematic framework for managing infrastructure that:

- Links performance expectations to investment levels.
- Extends the service life of the transportation system very economically.
- Uses low-cost treatments early in the life of an asset to address the risks to achieving agency goals.
- Reduces agency risk or exposure.

KYTC is focused on preserving Kentucky's investment in roads, bridges, and other assets for future generations.

TAM relies on asset inventory and condition data to drive performance-based resource allocation and project selection decisions.

TAM is a crucial element for achieving the Cabinet's Mission, Vision and Goals[2]. TAM helps KYTC be accountable to its customers by:

- Minimizing the annual costs of preserving the system.
- Maximizing system performance.
- Supporting an objective, data-driven decision-making process.
- Balancing expectations with available funding.

1 Long Range Statewide Transportation Plan (2014)
http://transportation.ky.gov/YourTurn/Documents/000LRSTP%20Final%20Combined%20-103114.pdf

2 Kentucky Long-Range Statewide Transportation Plan
http://transportation.ky.gov/Planning/Documents/Ch%202%20%20Vision,%20Mission%20and%20Goals.pdf

TAMP PURPOSE AND REQUIREMENTS

Current federal legislation requires all state transportation agencies to develop a risk-based Transportation Asset Management Plan (TAMP) that describes how the state's roads and bridges *"will be managed to achieve system performance effectiveness and State DOT targets for asset condition, while managing the risks in a financially responsible manner, at a minimum practicable cost over the life cycle of its assets."* Although a TAMP is only required for the portion of the state's pavements and bridges that comprise the National Highway System (NHS), transportation agencies are encouraged to incorporate all of their state-maintained roads and bridges into their TAMP to further demonstrate that these assets are being managed in a financially-responsible manner at the lowest practical cost.

MINIMUM TAMP CONTENT TO SATISFY FEDERAL REQUIREMENTS INCLUDE:

- ☑ Asset management objectives.
- ☑ Asset management measures and state DOT targets for asset condition.
- ☑ A summary description of asset conditions.
- ☑ Performance gap identification.
- ☑ Life-cycle planning.
- ☑ Risk management analysis.
- ☑ Financial plan.
- ☑ Investment strategies.

This TAMP outlines KYTC's planned road and bridge investments and desired levels of service for the next 10 years. It documents the processes used to develop the required elements of the TAMP and is compliant with federal requirements. The Federal Highway Administration (FHWA) does not certify the TAMP itself. Instead, the processes are reviewed by the FHWA to ensure that the federal requirements are met. The TAMP does not replace any existing plans; rather, it provides critical input to existing plans, linking capital and maintenance expenditures to asset conditions.

The TAMP's Critical Role

The timing of the TAMP is especially critical to the KYTC due to Governor Bevin's initiative to develop a new system for prioritizing the investment of transportation dollars that is data-driven, objective, and transparent. Commonly referred to as the Strategic Highway Investment Formula for Tomorrow (SHIFT), the goal is to create a strategic, data-driven funding model that produces a balanced plan for identifying both statewide and regional projects. This strategy was successfully utilized for the development of the 2018-2024 6-Year Highway Plan (SYP) to prioritize more than $6 billion in unfunded transportation projects.

SHIFT supports the Cabinet's TAM efforts through its use of measurable data to assess the benefits of planned projects. It also helps to ensure that available funding is being used to address the highest agency priorities, while balancing competing demands for system expansion and system preservation. The investment strategies described in this TAMP are aligned with the SHIFT program and reflect the recommendations that were incorporated into the 2018-2024 SYP.

TAMP Requirements

The requirement to develop a TAMP first emerged under federal legislation known as the Moving Ahead for Progress in the 21st Century (MAP-21) Act. Current federal transportation legislation, known as the Fixing America's Surface Transportation (FAST) Act, further endorsed the TAMP requirements as well as other requirements for performance-based management. The FHWA established the processes that must be used to develop a TAMP, the minimum requirements that apply, the penalties for failure to develop and implement a TAMP, and the minimum standards for tools to support the TAMP development. This TAMP meets the requirements outlined in the final rules (23 CFR 515) and provides a framework that will guide KYTC's future approach to asset management investments. As specified in the TAMP requirements, KYTC's TAMP will be updated every four years.

TAMP Content

KYTC's TAMP includes the seven chapters listed below.

- **Chapter 1: Introduction** introduces the TAMP, explains its purpose, and identifies its content.
- **Chapter 2: Asset Management Objectives** summarizes KYTC's goals and objectives for TAM and documents existing processes that support these efforts.

- **Chapter 3: Asset Inventory and Performance** summarizes the pavement and bridge inventories and presents current conditions.
- **Chapter 4: Life Cycle Planning** explains how pavements and bridges are managed cost-effectively over their service life.
- **Chapter 5: Risk Management** identifies key risks and mitigation strategies that might impact KYTC's ability to achieve the objectives outlined in the TAMP.
- **Chapter 6: Financial Plan and 10-Year Investment Strategies** presents anticipated funding levels for pavement and bridge preservation over the next 10 years, expected gaps between desired and anticipated performance, and plans for how funding will be invested to achieve performance targets.
- **Chapter 7: Planned Enhancements** describes steps that KYTC will be taking to further strengthen their asset management practices. ■

CHAPTER 2: ASSET MANAGEMENT OBJECTIVES

OVERVIEW

Traditionally, KYTC has managed its transportation assets through the *SYP* that is approved by the Kentucky General Assembly and the Governor based on anticipated state and federal road funding. The *SYP* is updated on a 2-year cycle, based on needs identified by the Highway District Offices, the Area Development Districts (ADDs), and the Metropolitan Planning Organizations (MPOs). KYTC submits the recommended *SYP* to the State Legislature, which then reviews, modifies, and approves the *SYP* as part of the biennial budget process.

In 2018, the KYTC undertook an effort to update its *SYP* to reflect several significant changes from previous plans. First, the *SYP* included projects generated through the SHIFT program's prioritization process that considers safety, congestion, asset management, economic growth, and cost-benefit ratios. This new process introduced a more objective and transparent approach to balancing asset management needs with other competing priorities across the Commonwealth. Second, the SYP was linked to anticipated road funding levels, estimated at $2.6 billion over the subsequent 6-year cycle (2018-2024). Finally, the *2018-2024 Highway Plan* was aligned with the asset management objectives outlined in this TAMP, providing an increased

focus on accountability through performance monitoring and reporting.

In conjunction with the changes associated with the development of the *SYP*, the KYTC has initiated several activities to facilitate the technical, organizational, and policy issues that must be addressed to fully implement the increased focus on asset management. For instance, in 2016, an Asset Management Gap Analysis was conducted that identified several key areas that needed to be addressed to improve the agency's asset management practices. The study found that at the strategic level, asset management practices could be strengthened by placing a greater emphasis on investments that reduce the annual cost of system preservation and implementing emerging technology that improves operations and the overall performance of the transportation system[3]. Finally, in 2018 the Cabinet developed an Asset Management Roadmap outlining the steps needed to advance the agency's asset management practices and held a workshop with agency leadership to develop strategies to ensure lasting change.

GOALS AND OBJECTIVES FOR ASSET MANAGEMENT

The *2014 Kentucky LRSTP* outlines a plan for achieving the agency's mission of *"providing a safe, efficient, environmentally sound and fiscally responsible transportation system that delivers economic opportunity and enhances the quality of life in Kentucky."* KYTC's ability to fulfill its mission is greatly influenced by available funding, demands on the system, changes in Commonwealth demographics, and other factors. For that reason, the Cabinet has adopted a performance-based planning and programming process that uses data to support decisions that will help to achieve the desired outcomes. These decisions are organized around the Pyramid of Performance shown in figure 2-1[4]. Driving the decisions is the vision, which states the KYTC will provide *"transportation infrastructure and services for the 21st century that deliver new economic opportunities for all Kentuckians."* Several goals have been

3 Asset Management Gap Analysis Implementation Plan (2016) https://transportation.ky.gov/ProfessionalServices/Procurement%20Bulletins/2017-06%20(Dec.%202016)/KYTC%20TAM%20GAP%20Implementation%20Plan%20Report.pdf

4 Modeled after the Long Range Statewide Transportation Plan (2014) http://transportation.ky.gov/YourTurn/ Documents/000LRSTP%20Final%20Combined%20-103114.pdf

established to drive the identification and prioritization of projects. These goals reflect regional objectives and priorities that were developed jointly by the 12 KYTC District Offices, the 15 ADDs, and the 9 MPOs.

With respect to asset management, the 2014 *LRSTP* establishes a goal to *"ensure that the process which develops and maintains the transportation system adequately considers the efficient and flexible use of available resources to meet the transportation needs of the state."* For highways, the following goals were specified:

- Provide for the safe and secure movement of people and freight.
- Provide for the improvement and maintenance of the existing transportation infrastructure.
- Provide a dependable transportation system that effectively and efficiently moves people and freight.
- Provide reliable connectivity and access—locally, regionally, and globally—for people and freight.
- Ensure that the process which develops and maintains a transportation system adequately considers dependable access to markets, jobs, and resources.

To achieve these goals, KYTC considers asset management and the preservation of existing infrastructure to be key components. Beginning in 2007, KYTC began focusing more heavily on pavement preservation techniques that prioritize preventive maintenance treatments. The program grew gradually in subsequent years as the Cabinet developed internal expertise to effectively manage these treatments.

In 2016, the program was expanded significantly based on the proven performance and cost effectiveness that had been demonstrated. Based on this performance, the *LRSTP* established a pavement performance target of 92 percent of the network in

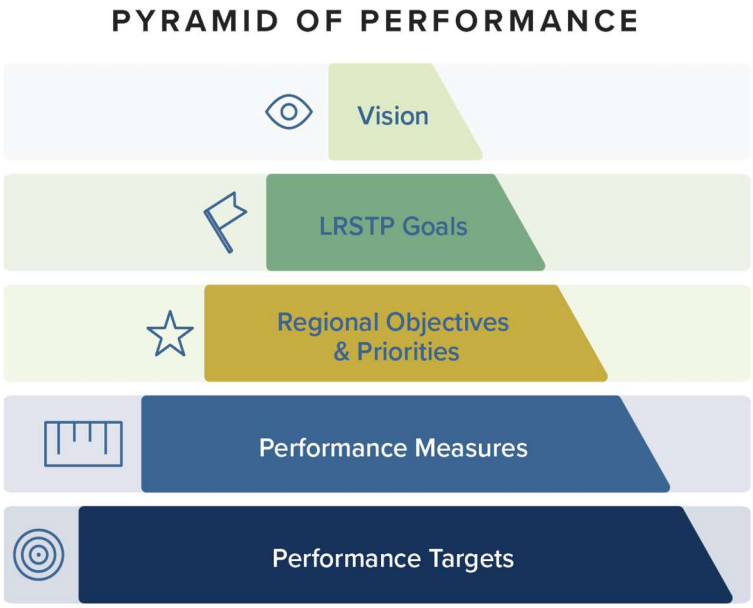


Figure 2-1. KYTC's pyramid of performance

Good or *Fair* condition by 2035.[5] Achieving that target will require additional resources for system preservation since only 81 percent of the pavement network was in *Good* or *Fair* condition at the time the *LRSTP* was published. For bridges, the objective is to continue decreasing the number of bridges in *Poor* condition and increasing the number in *Good* and *Fair* condition by being more proactive in allocating resources to preservation activities that slow the rate of deterioration. A pilot preservation program for bridges is currently underway, putting the Cabinet in a solid position to grow bridge preservation into a statewide program over the next two years. The investment strategies outlined in the TAMP will enable the KYTC to have less than 3 percent of its bridges by deck area in *Poor* condition by 2027.

In addition to these condition targets, the TAMP reflects several asset management goals to:

- Increase the use of performance measures to drive investment decisions.
- Increase the resources targeted towards preservation activities.
- Better balance expansion needs with asset management needs.
- Build the asset management culture within the Cabinet.

EXISTING BUSINESS PROCESSES SUPPORTING ASSET MANAGEMENT

There are a number of initiatives underway to enable the KYTC to achieve its performance goals for safety, mobility, and asset conditions. These initiatives are aimed at investing available funding effectively to address agency priorities, increasing the resources available for asset management to preserve system conditions, and increasing accountability and transparency in agency decisions.

5 The target established in the LRSTP used rideability as the primary performance measure. Through this TAMP, KYTC adopts 92% of pavements in Good or Fair condition as the desired state of good repair, based on KYTC's condition rating (described in detail in chapter 3) which includes rideability and other surface distresses.

The development of this TAMP supports those efforts by demonstrating the cost-effectiveness of planned pavement and bridge management programs and establishing performance targets that are linked to available funding.

The State Highway Engineer's Office in the Department of Highways is leading the implementation of asset management at the KYTC, with support from the Office of Project Development and the Office of Project Delivery and Preservation. A Core Team has been established to support the development of the TAMP and the activities associated with integrating asset management into the day-to-day operations at the Cabinet. Since asset management must be integrated at all levels of the Cabinet, the TAMP has been aligned with several other important initiatives (including the *SYP*, the Performance-Based Flexible Solutions Report, the SHIFT initiative, and the *LRSTP* illustrated in figure 2-2 and described in the following sections) to help ensure that the entire organization is working in concert to achieve its goals. The coordination between the TAMP and these other planning and programming efforts will lead to a more directed effort towards system preservation and improved transparency and accountability in the Cabinet's planning and programming processes.

Figure 2-2. Asset Management is aligned with these other KYTC initiatives

6-YEAR HIGHWAY PLAN (SYP)

Using input provided by the District Offices, the ADDs, and MPOs, the KYTC prepares a 6-year proposed highway plan and presents it to the Executive Branch Leadership in the fall of odd-numbered years. The Governor presents the Recommended *SYP* to the Kentucky General Assembly as part of the state budget process by the end of January in even-numbered years.

Only projects listed in the first 2 years of the *SYP* can be funded, while the projects in the subsequent 4 years are included for planning purposes; however, the total list of projects included in the *SYP* are not constrained by available funding.

Both chambers of the legislature must approve the *SYP* as separate legislation in each budget cycle. The most recently enacted SYP is shown in figure 2-3.

Figure 2-3. KYTC 2018-2024 Highway Plan

The *SYP* must be signed by the Governor whereby it then becomes the Cabinet's roadmap for projects and spending for the next 2 years. Traditionally, this process has challenged the asset management process, as individual projects are negotiated through the legislative budget process. As a result, the *SYP* has historically contained nearly twice as many capital construction projects as preservation projects. With the adoption of the SHIFT program (see next section), agency leadership is promoting a "Fix It First" mindset that flipped spending to prioritize managing existing infrastructure over expansion in the *FY 2018–2024 Highway Plan* and beyond. New construction will be advanced as funding allows while the primary focus of KYTC investments will be on the preservation and safety of the existing infrastructure. The *FY 2018-2024 Highway Plan* also reflects an additional $205 million annually to address aging bridges and roads highlighted under SHIFT.

Although the *SYP* has traditionally been over-programmed, federally funded projects have been fiscally constrained, as required by federal law. The federal projects included in the approved SYP are incorporated into the Statewide Transportation Improvement Plan (STIP) for submission to the FHWA every 2 years.

SHIFT

SHIFT KENTUCKY AHEAD

In June 2017, the KYTC released a data-driven list of statewide transportation priorities to guide the development of the subsequent SYP. The prioritization process,

known as SHIFT, was designed to help prioritize the investment of limited transportation dollars through an objective approach that addresses capacity and safety needs while also taking into consideration system preservation. KYTC developed the SHIFT process to allow all projects to be viewed through the same lens; considering each project's ability to meet the needs of the traveling public by improving congestion, safety, system preservation, and economic development through sound investments. Projects in the *2018-2024 Highway Plan* submitted to the State Legislature were prioritized based upon the SHIFT criteria.

Kentucky's Long-Range Statewide Transportation Plan: Planning to Make a Difference in America's Tomorrow

2014-2035

Figure 2-4. KYTC Long-Range Statewide Transportation Plan

LONG RANGE STATEWIDE TRANSPORTATION PLAN

The *2014 LRSTP* (as shown in figure 2-4) provides the basis for meeting the KYTC's vision for Kentucky's transportation system over the next 20 years by clearly identifying goals, policies, and needs. The development of the Long Range Plan consisted of a collaborative process involving several stakeholder group meetings and a well-publicized web-based survey that connected the Cabinet to Kentucky's citizens. As a 20-year visionary planning document, the *LRSTP* does not include specific projects that will be constructed. Rather, the *LRSTP* outlines the vision, goals, and performance objectives that will drive ongoing investments and policy decisions.

The measures by which the effectiveness of planned system improvements will be evaluated are outlined in the *2014 LRSTP* and listed below[6]:

- Providing a safe and secure system.
- Maintaining and improving existing infrastructure on a continual basis.
- Ensuring dependable, effective and efficient facilities.
- Improving local, regional, and global connectivity and access.

6 Long Range Statewide Transportation Plan (2014) http://transportation.ky.gov/YourTurn/Documents/000LRSTP%20Final%20Combined%20-103114.pdf

- Including all appropriate modes of transportation within a fully-integrated system.

In addition, the processes and practices that will be used to deliver improvements and maintain the system will account for[7]:

- Dependable access to markets, jobs and resources.
- Consideration of human and natural resources.
- Efficient and flexible use of available resources.
- Transparent decision-making processes.

The *LRSTP* includes a graphical representation, shown in figure 2-5, to illustrate how its process and project goals drive project selection. ■

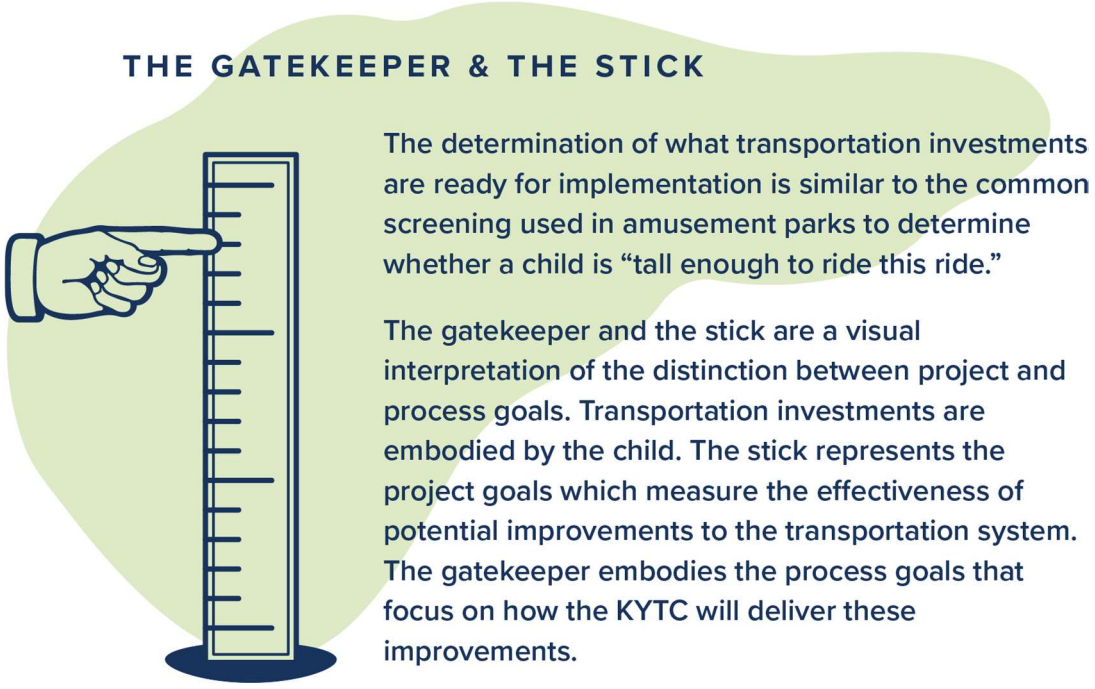


Figure 2-5. Using KYTC goals to drive project selection

7 Long Range Statewide Transportation Plan (2014) http://transportation.ky.gov/YourTurn/Documents/000LRSTP%20Final%20Combined%20-103114.pdf

CHAPTER 3:

ASSET INVENTORY AND CONDITIONS

OVERVIEW

The public roads system within the state of Kentucky (shown in figure 3-1) includes approximately 79,598 centerline miles of streets and highways. KYTC is administratively responsible for the maintenance and preservation of 27,638 centerline miles of that network. While that is only one-third of the total mileage, the state-maintained system serves nearly 90 percent of the vehicle-miles of travel within the Commonwealth of Kentucky. KYTC manages many different types of transportation assets within its highway right-of-way; however, this TAMP covers only the pavements and bridges (and bridge size culverts as defined by National Bridge Inspection Standards, NBIS) maintained by KYTC.

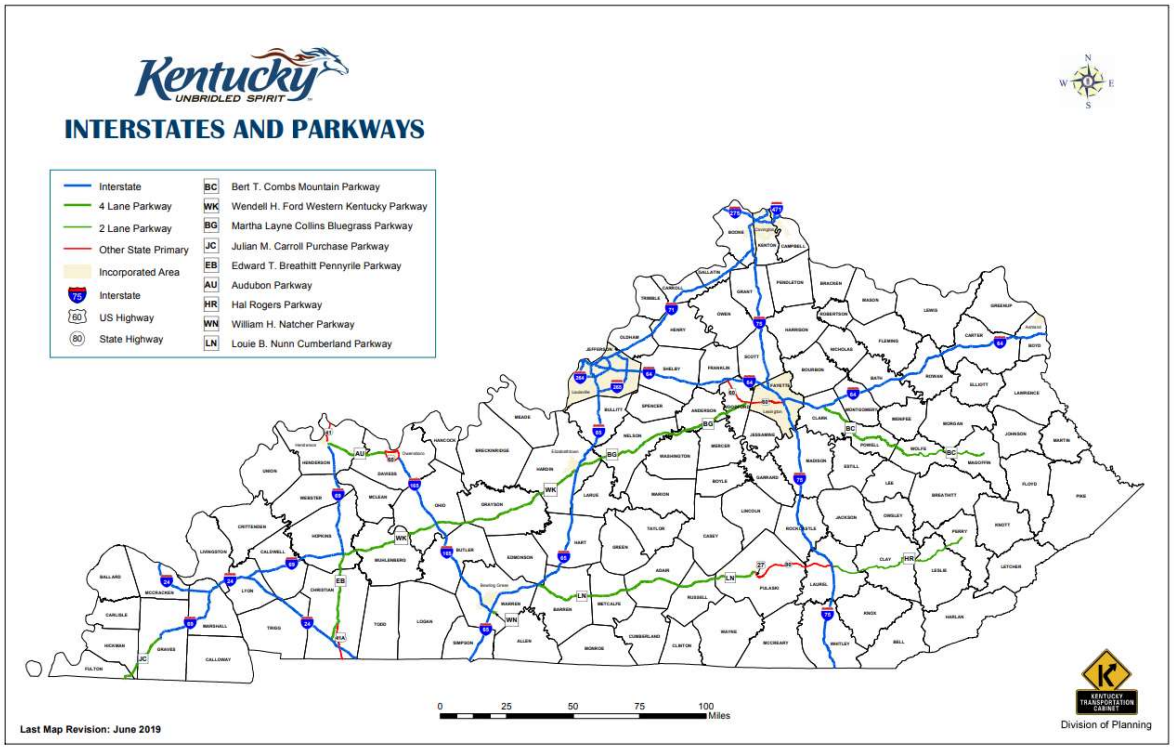


Figure 3-1. Map of Kentucky state highway system

HIGHWAY SYSTEMS

Kentucky's highway network was designed to meet various transportation needs within the state, predominantly access and connectivity. The portions of the highway system under KYTC's responsibility are primarily intended to provide connectivity. The remainder of the system, mainly those elements of the highway system primarily intended to provide access, are the administrative responsibility of local units of government, including counties, cities, and towns.

Kentucky's state-maintained highways are categorized into the systems described below based on the type of service and function they provide. These systems are used to categorize all assets within the right-of-way, and therefore apply to both pavements and bridges. These system designations are called out in the Kentucky biennial budget process, which contains specific funding for maintenance program and rural secondary routes.

1. **Interstate system:** This system consists of highways that are signed as federal interstate highways, as designated by the United States Secretary of Transportation. Kentucky's interstate system currently consists of six major and five supplementary interstate routes. Figure 3-2 shows an image of a typical interstate roadway, Interstate 64 (I-64).

Figure 3-2. Typical interstate roadway

2. **Parkway system:** This system consists of multilane limited-access expressways which are not part of the interstate system. The parkway system was originally constructed as a network of toll roads, but currently all parkways operate as freeways. Figure 3-3 shows an image of a typical parkway roadway.

Figure 3-3. Typical parkway roadway

3. **Maintenance Program (MP) system:** This system is comprised of non-interstate and parkway state primary pavement, state secondary pavement, and supplemental pavement. These routes carry vehicular and commercial traffic and are essential to the daily lives of residents. The MP system can be broken down further into the following three subsystems.

   a. **State Primary routes:** This system consists of long-distance, high-volume, intrastate routes on the MP system that are of statewide significance. These routes generally link major urban areas within the state.

   b. **State Secondary routes:** This system consists of shorter distance MP routes of regional significance with both access to land use activity and mobility as their functions. These routes generally serve smaller cities and county seats within a region.

c. **Supplemental routes:** This system consists of all other state-maintained MP routes that are not included in the higher classifications, with an Average Daily Traffic (ADT) of at least 375 vehicles. They are generally short-distance routes with main functions as frontage roads, cross roads, and local access roads, such as farm-to-market routes. Figure 3-4 shows an image of a typical MP roadway.

Figure 3-4. Typical MP roadway

4. **Rural Secondary (RS) system:** This system consists of routes of sub-regional significance that might include urban arterial streets and other collectors. Often these routes have access to land use activity such as farm-to-market routes, as their main function.

Figure 3.5 shows an image of a typical RS roadway, Kentucky route 1846 that passes through Horse Cave in Hart County.

Figure 3 5. Typical RS roadway

For pavements, KYTC does not distinguish between the MP route types for most performance reporting and programming activities. For bridges, the state primary routes are distinguished from the state secondary and supplemental routes.

INVENTORY

KYTC Pavements

KYTC maintains over 62,000 lane-miles of pavement across the four highway systems. Figures 3-6 and 3-7 summarize the distribution of pavement inventory within each state highway system. As can be seen from figure 3-7, the MP system contains 50 percent of the lane-miles and the rural secondary routes contain 40 percent of the lane-miles.

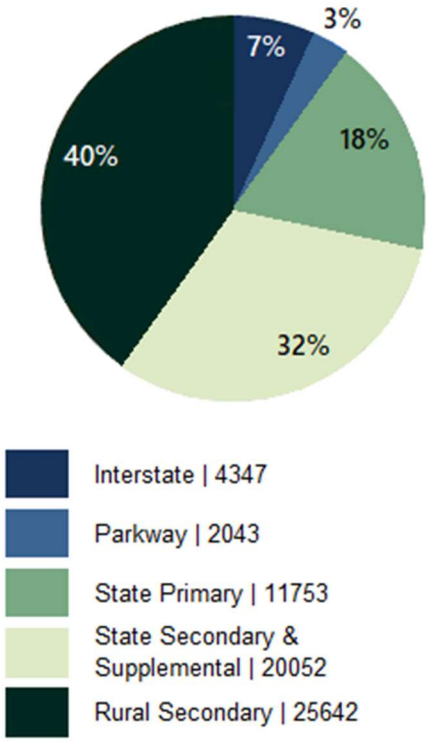


Figure 3-6. State-maintained highway system lane-miles by highway network

The vast majority of KYTC's pavements (98 percent) are constructed of asphalt concrete, as shown in figure 3-8, with the remaining 2% constructed of Portland cement concrete (PCC).

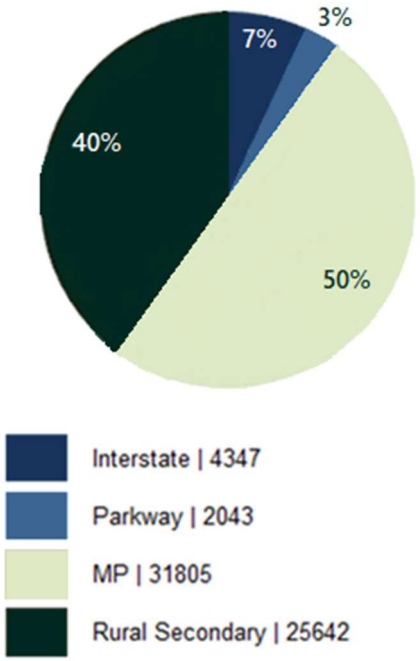


Figure 3-7. State-maintained highway system lane-miles by pavement management network

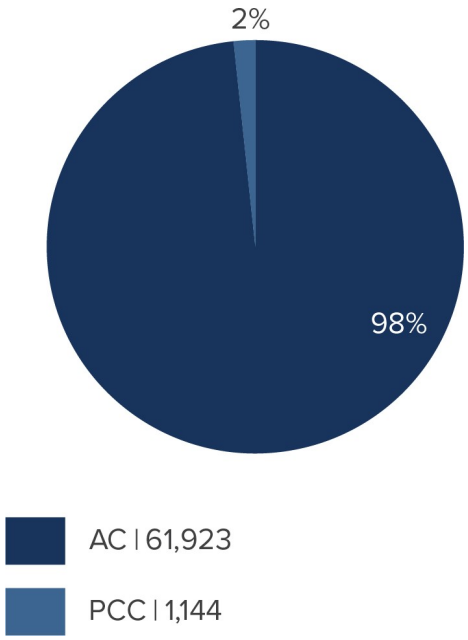


Figure 3-8. KYTC Pavement type by lane-miles

Most PCC pavement (69 percent) is on the interstate system.

KYTC Bridges

KYTC owns and maintains 9,080 bridges, which comprise more than 62 million square feet (ft^2) of bridge decks. Figures 3-9 and 3-10 summarize KYTC's bridge inventory by count and deck area, respectively[8]. The interstate system contains only 10 percent of the bridges (883) but 25 percent of the bridge deck area (15.4 million ft^2). Conversely, the rural secondary routes contain 41 percent of the bridges (3774), but only 18 percent of the deck area (11 million ft^2).

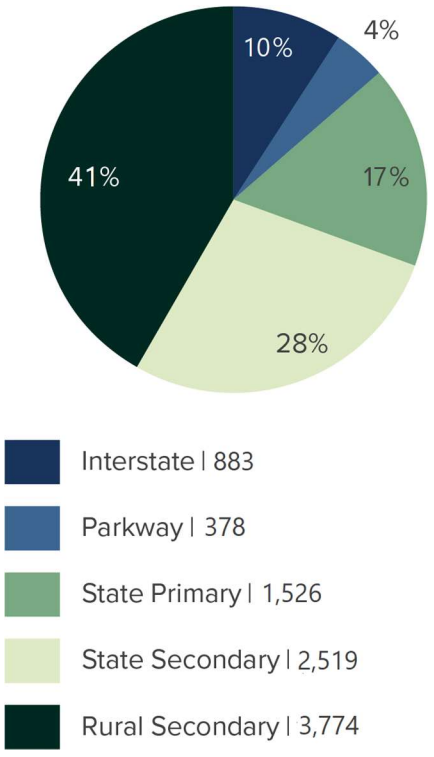
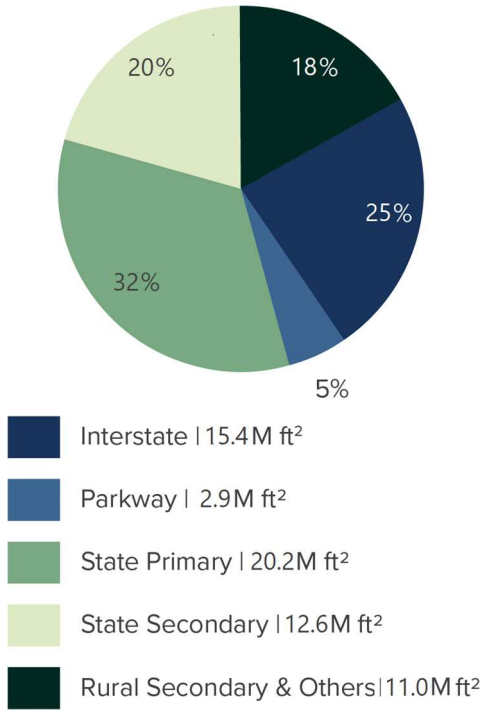


Figure 3-9. KYTC bridge inventory by count

Figure 3-10. KYTC bridge inventory by deck area



KYTC bridge inventory numbers have fluctuated over the past decade, as shown in figure 3-11. Total bridge deck area of state-owned bridges has generally increased since 2008. In 2008, the state owned a total of over 51 million ft^2 of bridge decks, and in 2018, this number has increased to over 62.4 million ft^2. The dip in 2016 is the result of the Ohio River Bridge project which was under construction at that time. Several large bridges were taken off inventory while construction was ongoing and new bridges were added back once work was complete, resulting in the sharp increase the following year.

8 State Secondary contains bridges included in the inventory with no network designation.

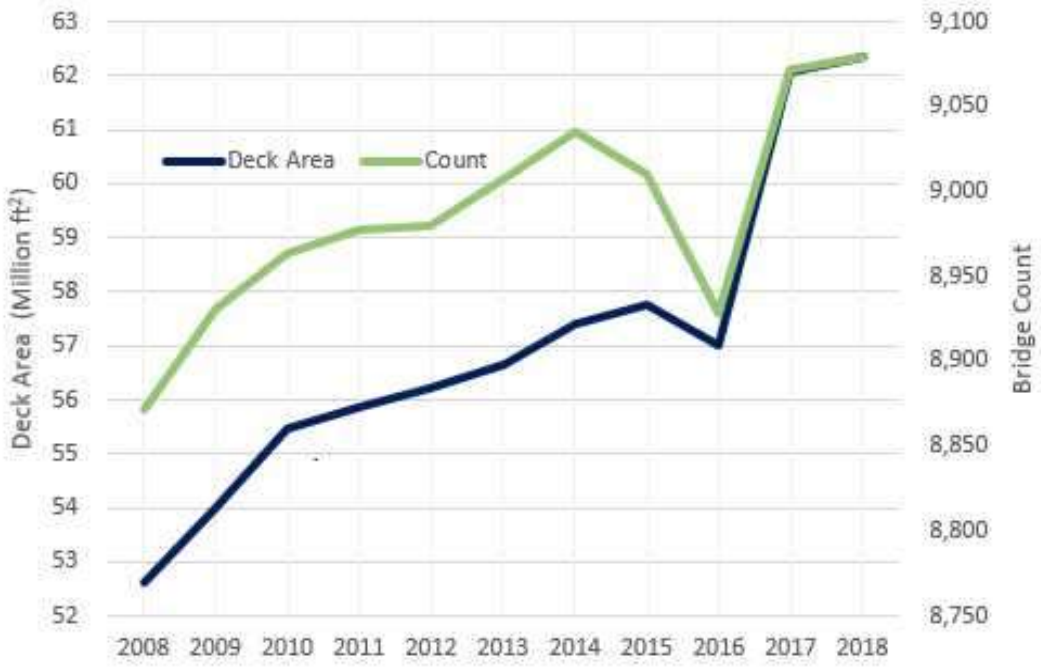


Figure 3-11. KYTC bridge inventory trends

Smaller fluctuations over time can be understood by looking at the state's capital replacement projects that primarily include replacing bridges in *Poor* condition with new bridges that may have different deck areas than the original bridges. In addition, bridges may be taken out of service or demolished, and at the same time, new bridges may be added to the system, which can affect the number of total deck area of bridges owned by the state.

FACTORS INFLUENCING PERFORMANCE

Pavement Performance Factors

All pavements decline in condition due to exposure to traffic and weather. There are several factors that can cause pavements to deteriorate at different rates, such as:

- Pavement type.
- Traffic volumes.
- Traffic weight.
- Environmental factors.
- Material properties.
- Type of underlying material.
- Maintenance frequency.
- Construction quality.

Traffic is the most influential factor in pavement performance in Kentucky, which is why KYTC currently factors traffic volume and loading into treatment selection and timing decisions.

Another significant factor in the performance of KYTC's pavements is the design of the pavement structure. All of KYTC's interstate and parkway pavements were designed following engineering standards for structural capacity and include features such as sub-surface drainage to maximize service life. Other pavement systems, such as the MP system, contain many pavements that began as trails and gravel roads, which were later paved with asphalt. Over time, these pavements have been paved over multiple times, and may have received improvements to surface drainage, but do not have full-depth, engineered pavement structures.

A key to managing pavement effectively is the ability to accurately forecast changes in condition over time. KYTC has been collecting pavement performance data since 1999 and has developed preliminary deterioration models based on this data. These models are implemented in the pavement management system and will be used to predict future conditions under different treatment and budget scenarios.

The initial deterioration models provide an average deterioration rate for asphalt pavements. Over time, as KYTC collects more performance history, further refinement of the models will be possible to account for specific factors that impact pavement performance.

Bridge Performance Factors

The average age of KYTC-owned highway bridges is 50 years, nearly 14 percent older than the national average of 43 years[9]. The advanced age of its bridges is one of the primary challenges facing KYTC today. Figure 3-12 shows the age profile for state-owned highway bridges, with approximately 52 percent of KYTC's bridges built before the early 1970s. The major spike of activity in the late 1950s through the 1960s was the inception of the interstate system construction, which also included the structural enhancement of much of the non-interstate system. This activity began to taper off in the 1970s as much of the rural interstate system was completed. Several gaps in the interstate system were completed through the mid-1980s.

9 2017 Infrastructure Report Card, American Society of Civil Engineers. **www.infrastructurereportcard.org**, Accessed on Oct 9, 2017.

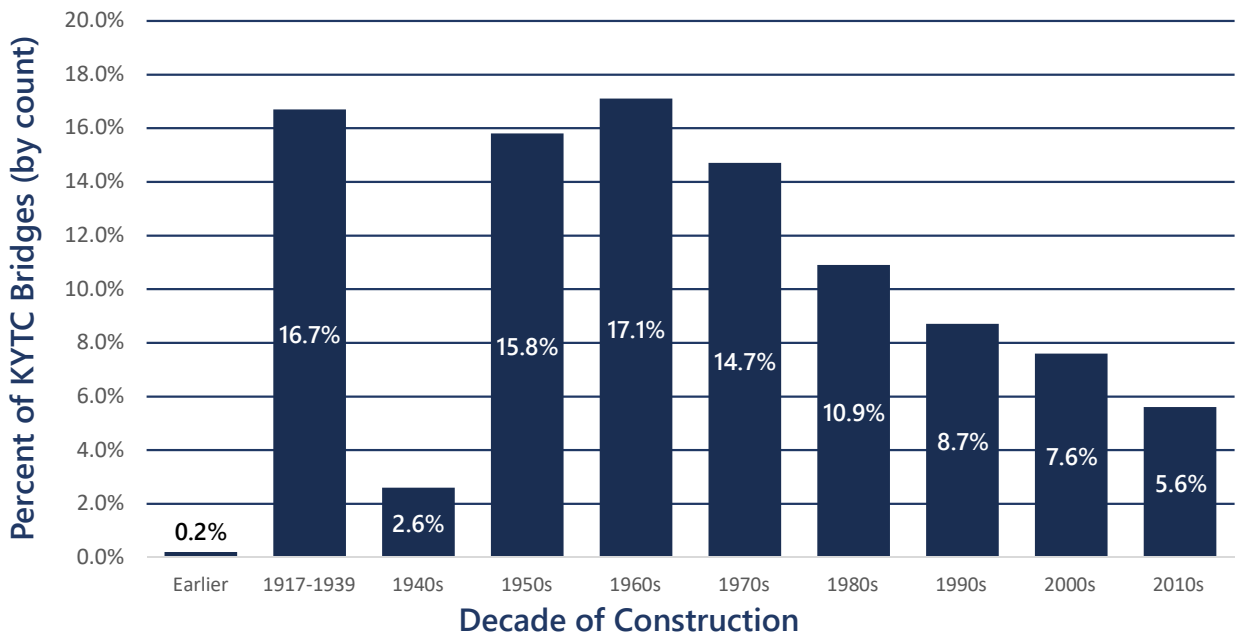


Figure 3-12. Age profile of state-owned bridge (based on KYTC highway system)

Among the highway systems, state secondary route bridges have the highest average age of 57 years, and the state primary route bridges have the lowest average age of 41 years.

As bridges age and their conditions deteriorate, the cost of maintaining bridges in a desired state of good repair increases considerably. As such, it is important to collect quality inventory and condition data, accurately assess the condition of bridges, forecast this condition for decision-making purposes (such as capital investment planning and prioritization, and to monitor the performance trends which inform analytical predictive models and investment plans. When forecasting the condition of bridges, it is important to recognize the factors influencing a bridge's performance over its effective life cycle.

Among these factors, age, type and quality of construction, climate conditions (including both normal and severe climatic conditions), and traffic demand on the bridge have the highest effects. Other factors influencing the condition of bridges included in the TAMP are provided below:

- Bridge type.
- Type and amount of deicing chemicals used during winter operations.
- Proximity of bodies of water.
- Traffic volumes and weight.
- Environmental factors.
- Material properties.
- Maintenance practice (e.g. preventive maintenance vs. corrective maintenance).

MEASURING CONDITIONS

Measuring Pavement Condition

KYTC currently uses the data collected by the Operations and Pavement Management Branch to assess pavement condition, using four performance measures: an overall condition rating, average Remaining Service Interval (RSI), Asset Sustainability Ratio (ASR), and the International Roughness Index (IRI). The data is collected at highway speeds, using automated equipment.

KYTC collects pavement condition data on 35,000 lane-miles of pavement each year, using high-speed automated equipment, shown in figure 3-13. Pavement condition data is collected annually on all interstates, non-interstate NHS (including all parkways), and non-NHS MP pavements with traffic levels of 375 vehicles per day or higher. Condition data has not been collected on non-NHS RS pavements since 2016.

Data collection is performed by technicians in the Operations and Pavement Management Branch using collection vehicles equipped with mapping grade GPS, an inertial measurement unit, three forward facing digital cameras, a Laser Crack Measurement System (LCMS), and a Road Surface Profiler Mark IV. This data collection equipment provides automated pavement distress, rutting, cross slope, roughness (IRI), joint and crack faulting, roadway geometry (curve & grade), GPS data, and roadway images.

Figure 3-13. KYTC's automated pavement data collection equipment

KYTC summarizes the distress data into the four performance measures described below. These measures are used by KYTC to report on pavement performance and make pavement management decisions.

Remaining Service Interval (RSI)

RSI estimates the number of years before a treatment is required for any given pavement section. RSI is calculated as the difference between the recommended year of treatment and the current year, or year of analysis.

International Roughness Index (IRI)

IRI is a measure of ride quality as experienced by the traveling public using the pavement. It is calculated from longitudinal pavement profiles captured using the road surface profilers in the automated data collection equipment. The IRI is commonly used for reporting pavement condition.

Condition Rating

KYTC's condition rating system is a subjective analysis of smoothness, traffic levels, cracking, and other pavement distresses identified by engineers within the Transportation Cabinet's Division of Maintenance. Using the condition rating system, highway sections are categorized as being in either *Good*, *Fair*, or *Poor* condition. For example, a *Good* pavement is smooth with a few defects, while a rough ride and moderate to severe distresses characterize a *Poor* condition pavement.

Since the ultimate purpose of Kentucky's highways is to serve the public, KYTC places a higher emphasis on maintaining pavements with higher traffic volumes. KYTC utilizes a sliding scale that holds high-traffic highways to a higher standard of performance, rating the highways as *Good*, *Fair*, or *Poor* depending upon the overall level of distress and the total traffic volume.

The condition rating is based on two factors:

1. The time remaining before the pavement requires corrective work to be performed, and

2. An assessment of ride quality using IRI.

These two factors are combined into an easily understood description of overall conditions. For instance, pavements that have been determined to need resurfacing (for asphalt pavements) or diamond grinding (for concrete pavements) within 1 year are rated in *Poor* condition. Pavements determined to need a similar level of treatment within 2 to 5 years are rated in *Fair* condition. All other pavements are rated in *Good* condition.

The second step of the condition analysis requires that each pavement is rated according to traffic volume and roughness as defined in table 3-1. This step may result in a decline of assessed condition for pavements previously rated in step 1. However, this step cannot result in a condition assessment that is better than what was defined based on RSI. Where visual assessments are not available, the condition is determined solely by evaluation of the most recent IRI and traffic volume data. For rural secondary routes, pavement condition rating is based on IRI and traffic volume, according to table 3-1. However, automated data collection on rural secondary routes was stopped after the 2016 collection year because the information was not being used to manage investment decisions.

Table 3-1. Condition assessments based on IRI and traffic volume

ADT	POOR CONDITION	FAIR CONDITION	GOOD CONDITION
Above 12000	130 or higher	98-129	97 or lower
10001-12000	136 or higher	102-135	103 or lower
8001-10000	143 or higher	111-142	110 or lower
6001-8000	149 or higher	117-148	116 or lower
4001-6000	155 or higher	124-154	123 or lower
2001-4000	162 or higher	130-161	129 or lower
1501-2000	168 or higher	136-167	135 or lower
1001-1500	175 or higher	143-174	142 or lower
801-1000	181 or higher	149-180	148 or lower
601-800	188 or higher	156-187	155 or lower
401-600	194 or higher	162-193	161 or lower
201-400	200 or higher	168-199	167 or lower
1-200	207 or higher	175-206	174 or lower

Asset Sustainability Ratio

The ASR measures how well KYTC pavement preservation and rehabilitation treatments keep up with pavement wear. It explains how much life was put back into the pavement system during the year to restore the service consumed. An asset sustainability ratio of 1.0 indicates that the pavement treatments delivered in a year offset the level of pavement deterioration in that year.

Measuring Bridge Condition

KYTC is responsible for federally-mandated inspections on all bridges in Kentucky. Bridge inspections are currently conducted based on the new "element level" data collection methodology in support of its bridge management system (AASHTOWare BrM).

KYTC currently uses BrM to manage bridge element-level data but intends to utilize the BrM decision-support tools in the future for

bridge management decision-making, such as forecasting of bridge conditions and capital investment prioritization. Element-level data collection requirements went into effect in 2015. KYTC switched to American Association of State Highway and Transportation Officials (AASHTO) Commonly Recognized Structural Elements (CoRe elements) data collection in 2006, and then to the new AASHTO elements in 2015. Since then, KYTC's bridge inspections have been conducted according to these guidelines and in compliance with the federal requirements.

Component-level data (deck, superstructure, substructure) is reported to FHWA on an annual basis for all bridges in the state, including state-owned and local bridges based on the federal National Bridge Inventory (NBI) "component level" data collection requirements, which include reporting of over 100 data items for each bridge.

At KYTC, the bridge inspection process is done at the district level and coordinated through the central office. KYTC also utilizes consultants for bridge inspections to supplement their in-house crews. KYTC has 50 bridge inspectors in-house, with some districts having 2 and others having 4 to 5 bridge inspection crews. Each inspection crew consists of one team leader and inspection technicians. To be a team leader, the staff have to meet certain minimum qualifications (for example, possessing a Professional Engineer license (PE) and having passed the training). Bridge inspection technicians work under the supervision of the team leaders, and may be promoted to a team leader after gaining certain minimum experience and meeting the qualification requirements.

Bridge inspectors are required to train through National Highway Institute (NHI) courses on bridge inspections, including scour and safety. KYTC also organizes an annual bridge workshop to share the best practices in bridge inspection.

The KYTC central office conducts quality assurance checks on bridge inspections each year. Bridges are selected randomly and then a full review of the inspection is performed. The central office also offers hands-on training in the field to ensure consistency between bridge inspections across the districts. This includes fracture-critical bridges with rope techniques. KYTC has 20 bridge inspectors certified for this technique.

For bridges that need more accurate assessments, KYTC performs nondestructive testing (NDT), including magnetic particle testing and ultrasound tests using in-house expertise or by hiring external consultants. KYTC uses different software packages for load rating of their bridges, including LARS and ComplexTruss, both developed by a consultant for the state. For major or specialty analysis, KYTC may hire external consultants to perform the work.

Summary of Pavement Performance

Table 3-2 provides a summary of KYTC's pavement inventory and conditions using data collected in 2018. While the largest portion of KYTC's pavement network is rated *Good* (40 percent), almost a one third of all pavement segments (30 percent) are rated *Poor*. This deficiency can be attributed primarily to underinvestment in pavement maintenance, such as thin overlays. In recent years, KYTC has been unable to increase maintenance expenditures or move additional projects into the state's legislative highway program due to funding constraints.

Figures 3-14, 3-15, 3-16, and 3-17 provide historic summaries of the pavement condition of each of the four system tiers.

Table 3-2. Pavement condition summary

	Lane-Miles Good	%	Lane-Miles Fair	%	Lane-Miles Poor	%	Lane-Miles Untested	%
Interstate	1,532	35%	1,372	32%	1,409	32%	34	1%
Parkway	832	41%	338	17%	824	40%	49	2%
MP System	11,629	37%	9,094	28%	8,486	27%	2596	8%
Dept. of Highways Subtotal	13,993	37%	10,804	28%	10,719	28%	2,679	7%
Rural Secondary	n/a		n/a		n/a		25,642	100%

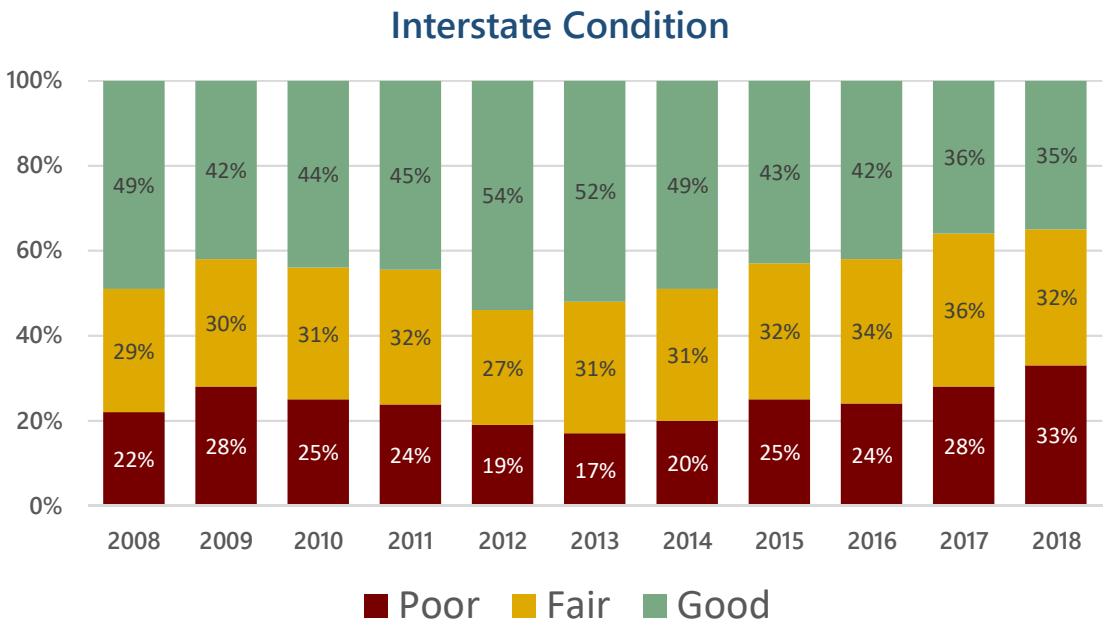


Figure 3-14. Interstate pavement conditions

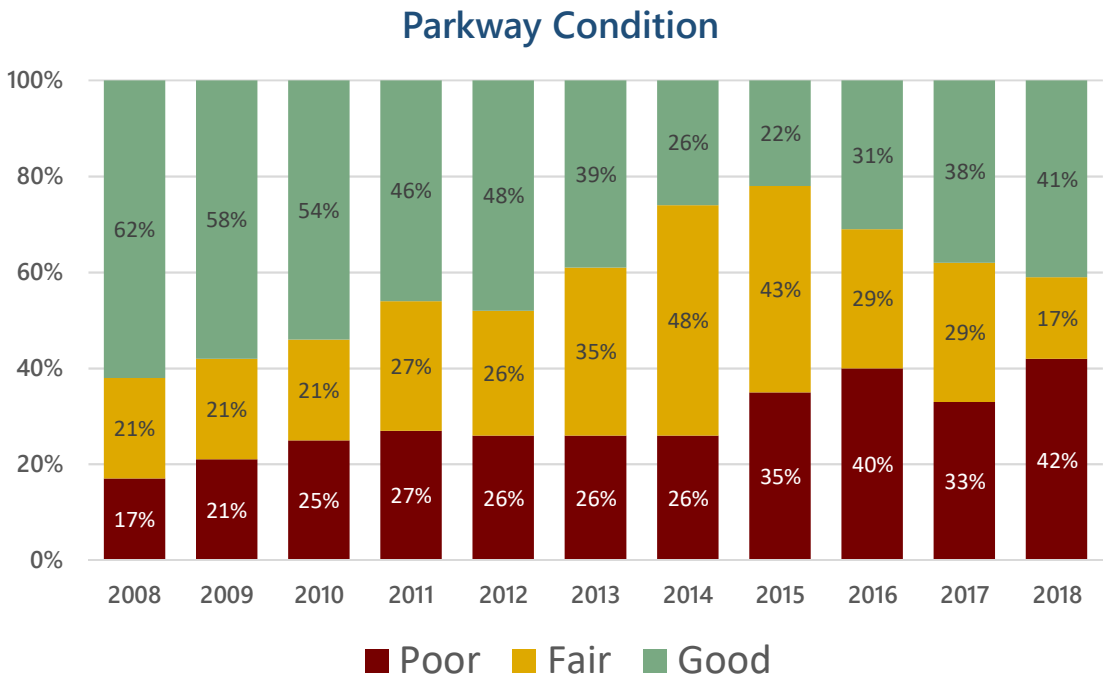


Figure 3-15. Parkway pavement conditions

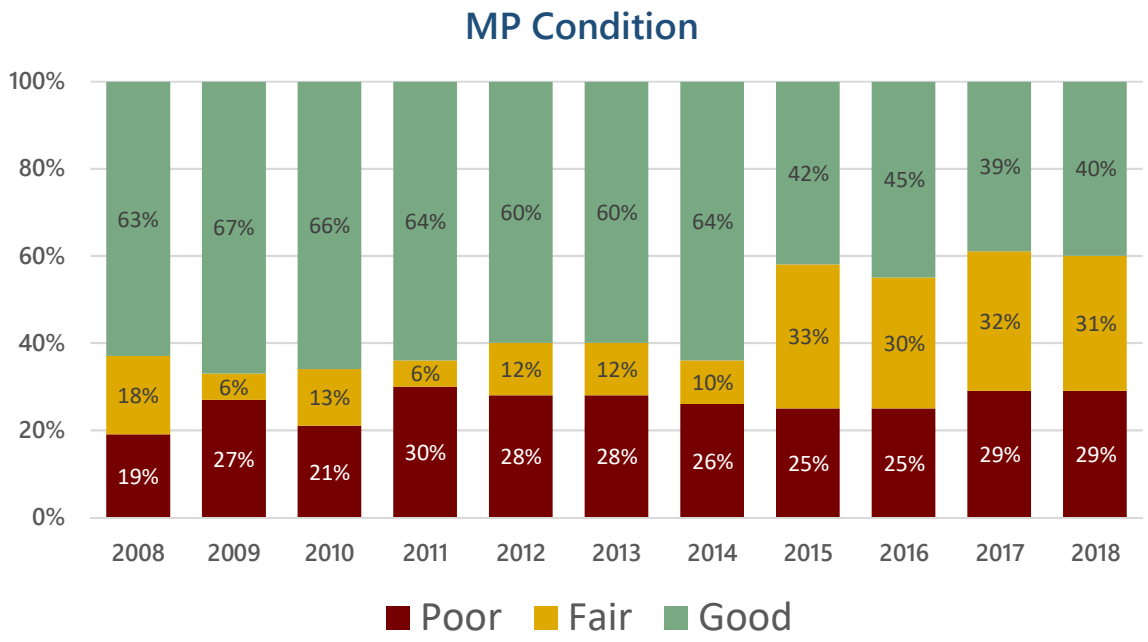


Figure 3-16. MP pavement conditions

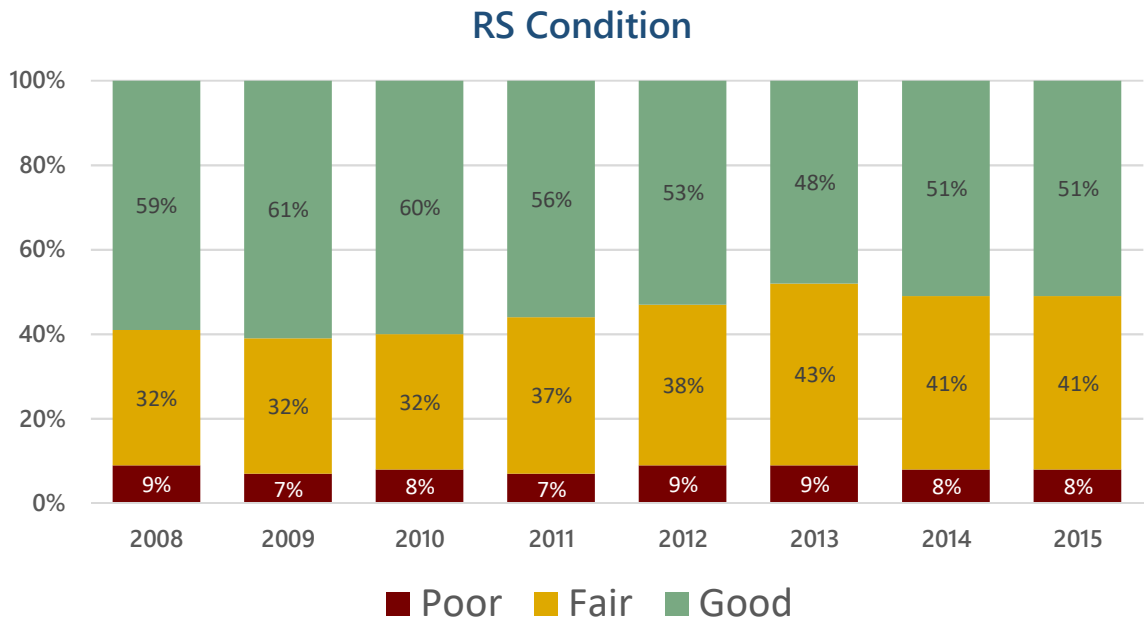


Figure 3-17. Rural secondary pavement conditions

On average, since 2008, the percent of pavements that are in *Good* condition has decreased, while the percent of pavements in *Fair* and *Poor* condition has increased. This is true for each highway system, as well as the network as a whole. In 2015, the Pavement Management Branch implemented a methodology to more accurately assess the break between *Fair* and *Good* pavements based on improved data sources. As a result, the percentage of *Fair* pavements has increased, beginning in 2015. Furthermore, the investments in preventive maintenance made in 2013 and 2014 created a slight improvement in pavement conditions across the network in 2014. However, there is also a considerable increase in the percentage of *Poor* pavements in 2017. However, the increase in *Poor* pavements was likely due to the high influx of recommended thin overlays coming in from the parkway system.

Summary of Bridge Performance

Table 3-3 summarizes condition statistics for KYTC's bridges. On average, 6.2 percent of KYTC's bridges by count and 4.8 percent by deck area are in *Poor* condition. In this context, a bridge rated as *Poor* is a bridge with any of its main components (deck, superstructure, substructure) rated 4 or below based on NBI condition rating guidelines. Federal regulations require states to report the condition of bridges based on the deck area, rather than by count. However, in this TAMP, bridge inventory and condition are presented using both units. Among KYTC's highway systems, interstate and state primary route bridges have the highest and the lowest deck area percentage in *Poor* condition at 6.9 percent and 2.5 percent of the total deck area in those categories, respectively.

Table 3-3. Summary of KYTC bridge inventory and condition by highway systems

Highway System	Good			Fair			Poor		
	Count	Deck Area (sq. ft.)	% Deck Area	Count	Deck Area (sq. ft.)	% Deck Area	Count	Deck Area (sq. ft.)	% Deck Area
Interstate	236	3,901,675	25.2%	621	10,501,301	67.9%	26	1,074,184	6.9%
Parkway	109	860,124	29.0%	268	2,102,668	70.9%	1	1,015	0.0%
State Primary	669	8,766,858	43.3%	819	10,989,702	54.2%	38	509,103	2.5%
State Secondary	756	6,154,831	40.7%	1,600	6,915,432	54.6%	163	594,562	4.7%
Rural Secondary*	1,143	3,428,363	31.2%	2,299	6,776,214	61.6%	332	796,298	7.2%
Total	**2,913**	**23,111,851**	**35.5%**	**5,607**	**37,285,317**	**59.8%**	**560**	**2,975,162**	**4.8%**

*** Includes bridges in the inventory without network designation.**

Figure 3-18 and figure 3-19 illustrate the historic trend of the state-owned bridges, by both count and deck area. Even though these numbers have fluctuated, the general trend has been toward improving the condition of bridges. In 2008, 6.7 percent of bridges by count were in *Poor* condition, whereas in 2018 this number dropped to 6.2 percent. For bridge deck area in *Poor* condition, this number was at 7.4 percent in 2008 and dropped to 4.8 percent in 2018. Since 2014, the general trend for this measure has been increasing. This trend can be explained by the fact that bridges continue to deteriorate so each year bridges fall into the *Poor* condition category. Although KYTC has been aggressively addressing bridges in *Poor* condition, the ongoing deterioration is outpacing the bridge condition improvements.

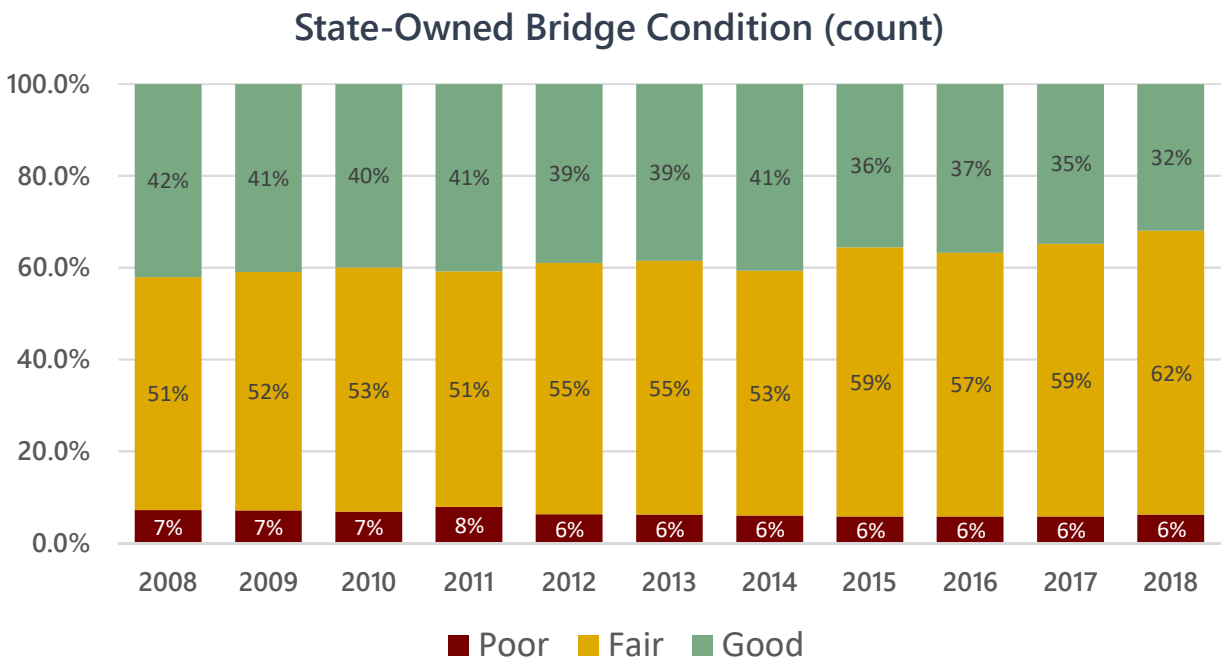


Figure 3-18. Historic inventory and condition trend for state-owned bridges (count)

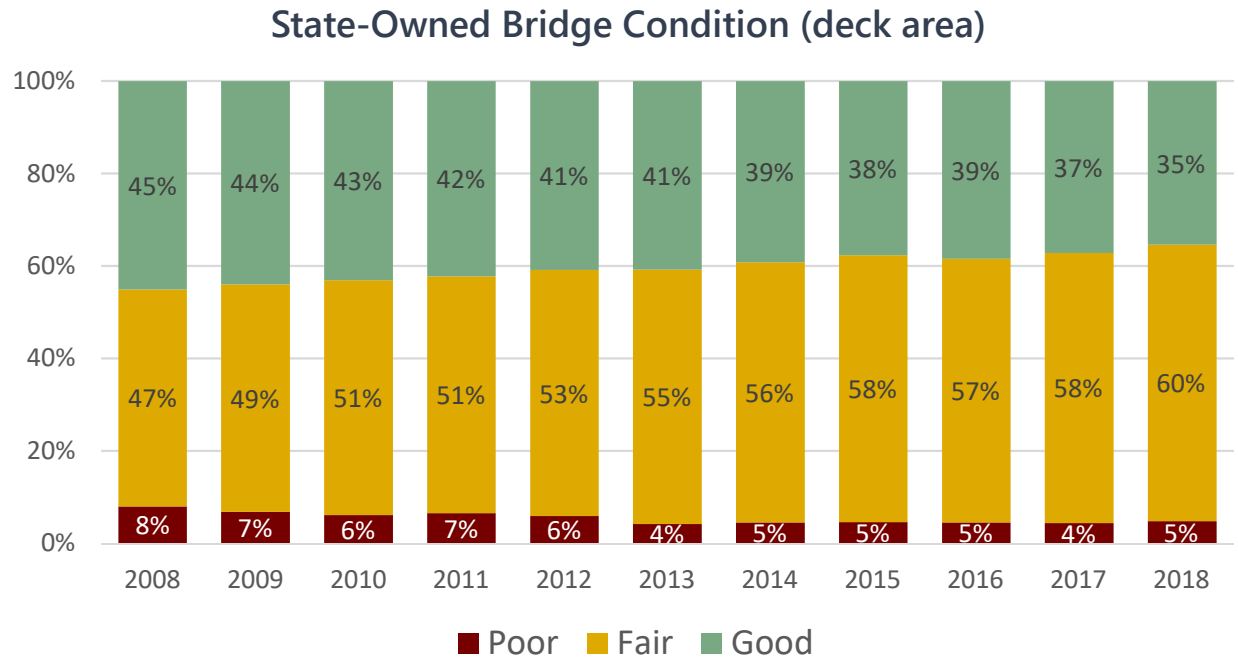


Figure 3-19. Historic inventory and condition trend for state-owned bridges (deck area)

TARGETS AND LONG-TERM GOALS

KYTC is shifting towards a performance-based approach for asset management that relies on performance measures to assess system performance, identify needs, and develop investment priorities.

Historically, KYTC has used pavement and bridge conditions to inform its asset management practice, but after the implementation of MAP-21 and the issuance of the final rulemaking on performance management of transportation assets, KYTC is establishing and adopting formal performance measures for its pavements and bridges which will, in turn, be used to establish budget requirements and life cycle plans for these assets.

Pavements

With the adoption of its *Long Range Statewide Transportation Plan* in 2014, KYTC established a goal to increase the percentage of pavements in the *Good* and *Fair* categories to a target of 92 percent by 2035 (KYTC, 2014). This is not an achievable target with anticipated resources. Instead, it represents the desired state of good repair for pavement assets. ASR is the primary metric used to manage the annual paving program. Instead of setting short-term condition-based pavements, KYTC works to achieve an asset sustainability ratio of at least 1.0 for each annual pavement program. An ASR of 1.0 indicates that the total value and type of investments being made are sufficient to address overall network deterioration. This is discussed further in Chapter 4, Life Cycle Planning.

Bridges

KYTC is in the process of complying with federal requirements to set and achieve bridge condition targets, which is described in greater detail in Appendix A. For bridges, the performance measure used is the percentage of deck area for bridges with *Poor* condition rating. The logic behind this measure is that bridges in *Good* or *Fair* condition generally require only maintenance or preservation activities, whereas bridges in *Poor* condition are reaching a point where it is necessary to either replace the bridge or extend its service life through significant investment. KYTC has adopted a desired state of good repair of no more than 3 percent of its bridges, by deck area, in *Poor* condition, and no less than 35 percent of its bridges, by deck area in *Good* condition. Using this measure, currently 4.8 percent of KYTC's bridges are rated *Poor*, and 35.5 percent are rated *Good*.

ASSESSING THE VALUE OF TRANSPORTATION INFRASTRUCTURE ASSETS

Asset valuation is an important part of the TAMP for KYTC because it emphasizes that transportation assets, including pavements and bridges, represent the state's largest capital investment, and together they comprise one of the largest components of Kentucky's public wealth. Highlighting asset values also illustrates the importance of a systematic asset management practice to manage and preserve these valuable assets.

Pavement Asset Valuation

KYTC has chosen to assess the value of its pavements using a modified depreciated replacement cost (DRC). This method takes advantage of KYTC's knowledge of RSI for each pavement segment.

Depreciated replacement cost reduces the current replacement cost of a mile of pavement by the amount of life that has been expended, as represented by deteriorated conditions. For this analysis, KYTC assumed that pavement value depreciated by the cost of a necessary intervention treatment, such as an overlay, from the time the pavement is constructed until the time that the intervention treatment is applied. This approach is valid for KYTC since their pavement management practices ensure that treatments are only applied to appropriate pavements. The value of a pavement segment depreciates at a rate based on the treatment it received. For example, an overlay is expected to last 11 years, so the pavement deteriorates by 1/11th the cost of an overlay each year, until the pavement either receives another overlay, or becomes a candidate for a more substantial treatment. In the case of the latter, the pavement depreciates based on the life and cost of the next expected treatment. This approach takes into account that pavements in need of rehabilitation or replacement are depreciating at a faster rate than pavements in need of a thin overlay. This enables KYTC to estimate the annual investment necessary to offset 1-year's depreciation by looking at the additional depreciation that would take place if no work was performed on the system in the analysis year.

Table 3-4 provides the total asset values, in terms of the condition-based depreciated replacement cost for the pavements managed by KYTC Department of Highways. The total replacement cost of KYTC's pavement is over $44 billion. The current depreciated replacement cost is over $42 billion. However, the annual depreciation is over $354 million, representing the annual investment level needed to sustain the current system value.

The RS system was not considered in the pavement asset valuation, nor in the TAMP at large. This is because the RS system has a separate source of funding from the rest of the KYTC network and thus it is managed separately.

Table 3-4. Pavement asset valuation for KYTC system designations

	Current Replacement Value	Depreciated Current Replacement Value	Annual Depreciation
Interstate	$8,173,150,000	$7,449,901,842	$75,321,058
Parkway	$4,078,308,000	$3,707,782,800	$38,428,017
MP	$32,496,168,600	$31,202,825,094	$240,319,393
Total	**$44,747,626,600**	**$42,360,509,736**	**$354,068,468**

Bridge Asset Valuation

There are multiple frameworks to calculate asset valuation for transportation assets, such as bridges. The framework outlined in Governmental Accounting Standards Board Statement 34 (GASB 34), modified GASB-34, and depreciated replacement cost framework are among the most popular methods adopted by transportation agencies. The depreciated replacement cost provides a more realistic value for transportation assets. There are two ways to deal with a depreciated cost, either based on the age of the asset, or based on the condition of the asset. In the former, the total replacement cost of the asset in current year is depreciated based on the remaining life of the asset (given a generic life span for the asset, e.g. 75 years for bridges). For example, if replacing a bridge would cost $1M in the current year, and the bridge is 50 years old, the depreciated replacement cost of the bridge would be $333,333.33, assuming a 25-year remaining service life. The drawback of this approach is that it does not consider the condition of the bridge, and old bridges that are in *Good* condition will have a much lower value than younger bridges in worse condition, or vice versa.

The method adopted in this TAMP for bridge asset valuation is a modified approach in which bridge replacement cost is depreciated based on the bridge component condition ratings. Thus, bridges with lower condition ratings would have lower value than those in better condition, disregarding their age. This method is outlined below.

To calculate bridge asset values based on this method, certain assumptions have to be made regarding asset value depreciation rate, and relative value of each bridge component. Figure 3-20 illustrates the assumed bridge asset value depreciation versus NBI rating of bridge components (deck, superstructure, substructure, culvert). It is assumed that on average, bridge components will lose 90 percent of their value when their condition rating reaches 4 and linearly decreases to 0 when the rating reaches a 2.

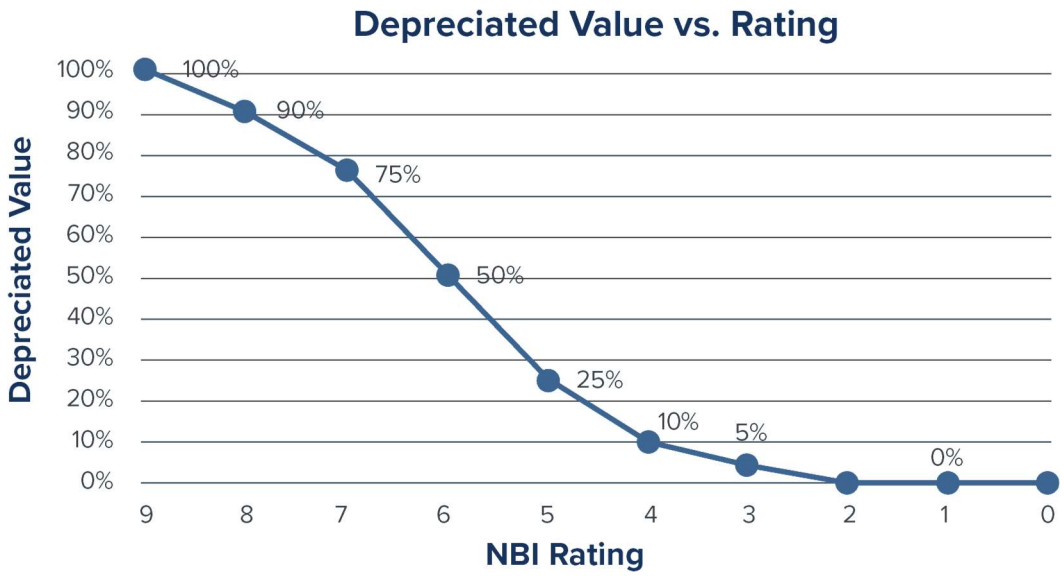


Figure 3-20. Assumed bridge asset value depreciation versus NBI rating of bridge components

Based on KYTC bridge and culvert replacement data for 2018, on average bridge replacements would cost $213/ft^2 of bridge deck (the national average is also $213/ft^2), and culverts would cost about $1,400/lineal foot of culverts along the centerline of the stream. Cost of replacement for bridges varies between different construction types and structural systems, and for culverts, size of culvert affects the cost of replacement. However, these values are adopted as average network-wide values for asset valuation purposes. Based on 2018 KYTC data, bridge deck replacement costs about $100/ft^2.

Also, since the bridge deck is a protection system over the other components of the bridge against environmental factors and carries the weight and wearing cause by vehicular traffic, bridge deck is assigned a higher value compared to other components of the bridge. Based on these numbers, it is assumed that bridge deck comprises 50 percent of the total bridge value, and superstructure and substructure split the remaining 50 percent value equally, at 25 percent of the total bridge value each. These assumptions are outlined in table 3-5.

Table 3-5. Total bridge value breakdown per bridge component

Bridge Component	Percent of Total Asset Value
Deck	50%
Superstructure	25%
Substructure	25%

Based on these assumptions and the depreciation chart above, the value of each bridge's components was calculated separately, and total asset value for each bridge was calculated as a sum of its components' depreciated values. For culverts, the depreciated value was calculated based on the length of the culvert. The total asset values, as condition-based depreciated replacement cost, for KYTC's bridges are presented in table 3-6 for KYTC's highway network designations.

Table 3-6. Bridge asset valuation based on KYTC highway system

Highway Network	Depreciated Replacement Cost
Interstate	$1,596,498,754
Parkway	$422,008,754
State Primary	$2,769,035,386
State Secondary	$1,665,356,982
Rural Secondary	$1,284,587,013
Total	$7,737,486,889

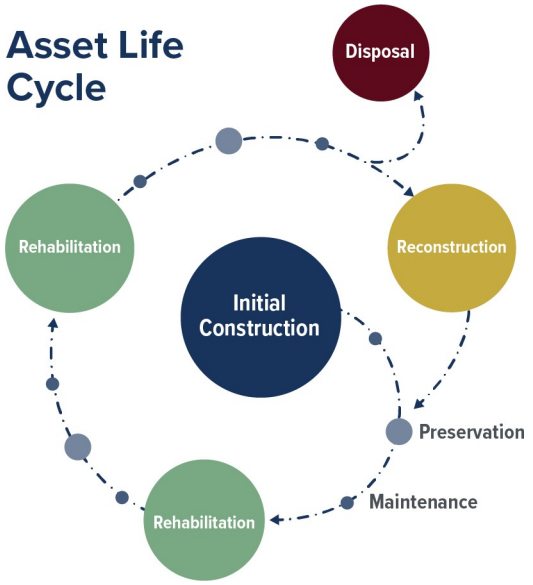
CHAPTER 4:
LIFE CYCLE PLANNING

INTRODUCTION

KYTC is committed to managing its highway infrastructure to support the health, safety, and economic vitality of the Commonwealth's citizens, at the lowest practical cost to the taxpayers. Life cycle planning (LCP) provides a means for KYTC to evaluate the types of investments that will prevent and address asset deterioration, while providing the lowest practical life cycle cost and the best practical asset conditions.

LCP for pavements and bridges takes a long-term, network-level view of performance to determine the best actions to maintain, preserve, rehabilitate, or reconstruct these assets. LCP enables asset managers to extend the useful life of assets through the strategic use of treatments that provide long-term benefit. LCP recognizes that, in general, reducing the rate of deterioration through the appropriate use of low-cost preventive maintenance treatments, applied before assets show significant deterioration, will lead to longer asset service lives than traditional strategies that let assets deteriorate until major repairs are needed.

As soon as an infrastructure asset is constructed, its condition begins to deteriorate due to exposure to traffic and the environment. As assets deteriorate, different treatments can be applied to slow the rate of deterioration or repair damage. Figure 4-1 shows an asset life cycle, where different treatments are applied at different times through an asset's service life. Asset management uses data about asset conditions and analysis techniques to determine the appropriate treatment for each asset and the best time to apply that treatment.



4-1. Asset life cycle stages

Figure 4-2 illustrates the connection between asset condition, treatments, and cost. The asset condition curve shows that early in the useful life of an asset, preventive maintenance treatments can delay the onset or stop the progression of distress. As deterioration progresses, rehabilitation is needed to fix the deteriorated areas. Eventually, the asset needs to be completely replaced. As the cost curve shows, the cost of each level of repair increases exponentially as the amount of distress increases and the overall asset condition decreases.

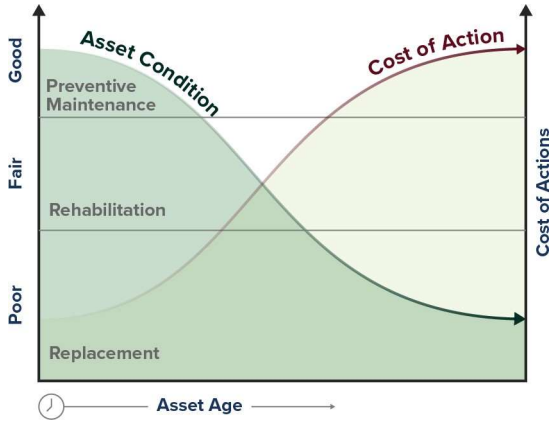


Figure 4-2. Illustration of the relationship between asset conditions and cost

Factors such as increasing travel demands (both weight and volume) and increasing labor and material costs must be addressed when evaluating long-term strategies for managing asset conditions. If not planned and managed properly, these factors can lead to higher repair costs or failure to achieve desired asset conditions.

Assets are also susceptible to deterioration from weather and extreme weather events.

Bridges and culverts spanning waterways pose additional challenges, including vulnerability to scour around their foundations, and periodic flood damage. KYTC's current LCP tools are not able to incorporate vulnerability to such events in the analysis. However, the agency regularly reviews annual condition data for trends that might indicate whether asset performance is varying from historic trends, so the cause of the variation can be identified.

LCP approaches the development of long-term treatment strategies from a high-level perspective. Rather than focus on the needs of each mile of pavement or each bridge component, LCP uses data aggregated from the entire asset population to develop treatment strategies that use a combination of actions that keep pavements, bridges, and other assets operational at the lowest possible cost. LCP is a core component of asset management because it establishes a cost-effective and practical approach to managing assets, providing valuable input to an agency's processes for prioritizing maintenance work, developing repair and rehabilitation plans, and selecting projects for implementation.

LCP requires the ability to forecast asset conditions, and an understanding of how applying various treatments impacts those asset conditions. Mathematical models are used to analyze data to establish the most practical, cost-effective, long-term approach to meet the agency's asset management objectives.

This chapter describes KYTC's processes for establishing LCP strategies for pavements and bridges and describes the agency's current treatment strategies. The processes and strategies described apply to the entire KYTC highway network, including the NHS.

LIFE CYCLE PLANNING FOR PAVEMENTS

For the LCP analysis, KYTC adopted an approach of evaluating the long-term impacts of different treatment strategies using the same total budget for each strategy. This approach demonstrates the relative differences in asset conditions at the end of the analysis period for the same level of investment. For future TAMPs, KYTC

anticipates utilizing its fully-functional pavement management system for conducting an LCP analysis.

As figure 4-3 shows, ongoing investments in low-cost preservation treatments defer, or eliminate, the need for most costly repairs by keeping pavements in *Good* condition for a long period of time.

The figure shows that the application of the right preservation treatments at the right time can keep pavement in relatively good condition, while a do-nothing approach causes the asset to deteriorate to the point of requiring reconstruction in the same timeframe. While the do-nothing strategy saves money in the near term, the preservation strategy provides better conditions at a lower overall cost.

KYTC employs a wide variety of treatments to manage its pavements, all of which are considered in the LCP process. Table 4-1 provides a summary of the pavement treatments and their typical costs. For the LCP analysis, more specific cost information was used based on actual bid costs from recent construction contracts with inflation estimates included.

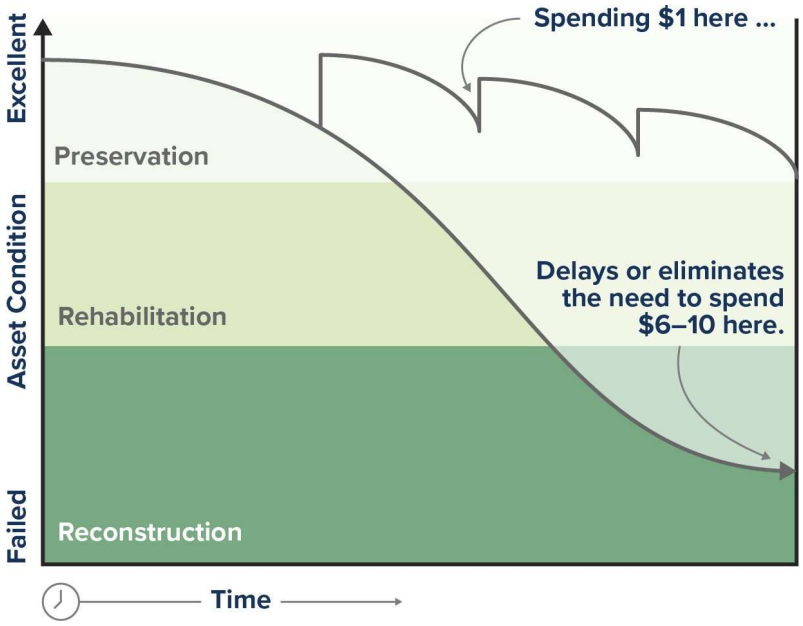


Figure 4-3. Conceptual model of asset deterioration and treatment impacts

Table 4-1. Summary of KYTC pavement treatments by work type[10]

Work Type	Typical Treatments	Typical Cost per Lane-mile	Feasible Networks
Maintenance	Sweeping, Crack Sealing	$5,000 or less	All
	Pothole Patching	N/A	All
	Shoulder Work	N/A	All
Preservation	Chip seal, Slurry seal	$26,000	MP
	Microsurfacing, ¾" Asphalt Overlay	$34,000	All
	Cape Seals	$40,000	All
	Thin Overlay	$75,000	RS and MP
	Thin Overlay	$220,000	Interstates and parkways
	Diamond Grind and Repair	$200,000	RS and MP
	Diamond Grind and Repair	$275,000	Interstates and parkways
Rehabilitation	Intermediate Overlay	$275,000	Interstates and parkways
	Thick Overlay	$350,000	Interstates
	Structural Overlay	$1,100,000	Interstates
Reconstruction	Replace	$2,200,000	Interstates and parkways
	Replace	$1,350,000	RS and MP

Pavement LCP Analysis

The pavement LCP analysis compares the long-term impacts of two different treatment strategies on pavement conditions and total preservation liability. Preservation liability represents the cost to treat all *Poor* pavements in a given year. The liability increases as the number of miles in *Poor* condition, and the number of candidates for rehabilitation and reconstruction, increase. The analysis primarily evaluated the impacts of:

- Varying the amount of preventive maintenance.
- Shifting investment priorities between systems to provide the best possible long-term pavement conditions and lowest future preservation liability. For example, one strategy prioritized preservation treatments on the parkways.

10 Table 4-1 includes typical treatments for RS pavements; however, RS pavements were not included in the LCP analysis, because they are funded by the Department of Rural and Municipal Aid, not the Department of Highways.

The analysis results from a strategy that optimizes the use of preservation treatments (referred to as "optimize preservation") when compared to a traditional "worst-first" strategy, in which pavements are allowed to deteriorate to the lowest tolerable condition before a substantial treatment is applied. Under a worst-first strategy, funding is allocated to the pavements in need of expensive overlays and rehabilitation, and low-cost preventive maintenance treatments are rarely used. KYTC followed a strategy similar to worst-first until recently. Since 2015, KYTC has been increasing its use of preventive maintenance on MP roads and parkways.

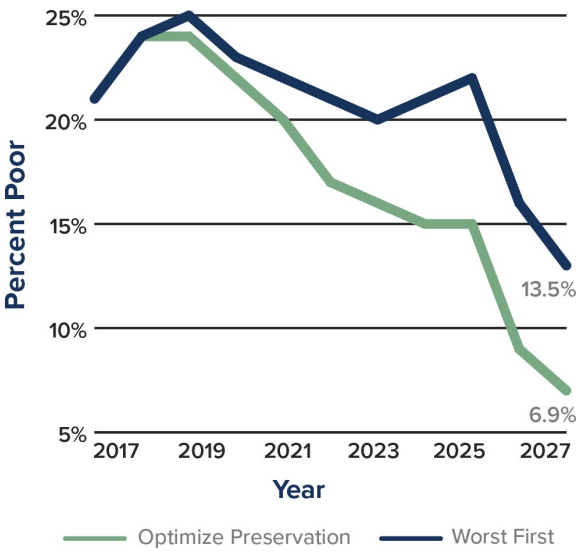


Figure 4-4. Comparison of network pavement conditions

Pavement Life Cycle Strategy

Based on the results of this analysis, KYTC is adopting a pavement strategy that seeks to optimize the use of preventive maintenance on all networks: interstate, parkways, and MP roads. Crack sealing is used to delay the progression of deterioration and the need for overlays. As shown in figure 4-4, the preferred LCP strategy (optimize preservation) significantly reduces the percentage of pavements in *Poor* condition by 49 percent, or approximately 2,380 lane-miles, over the 10-year period when compared to a worst-first strategy.

Preventive maintenance treatments, which are applied to pavements in *Fair* condition, provide the greatest return on investment. To support the analysis, KYTC's pavement management tools were used to identify the pavements in *Fair* and *Poor* condition so the appropriate treatment could be scheduled over the 10-year analysis period. Under the recommended LCP strategy, pavements in *Poor* condition (indicating an immediate need for some level of repair) were treated with the appropriate treatment, with priority given to thin overlays on high-volume sections to support KYTC's efforts to achieve its pavement condition goals and targets.

Figure 4-5 compares the preservation liability that is developed under each strategy. By implementing an optimize preservation strategy, KYTC will reduce the future liability associated with deferred preservation activities by $644 million, or 53 percent.

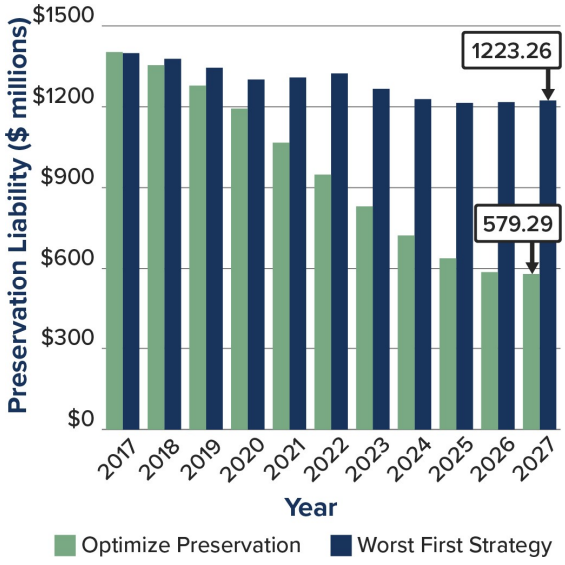


Figure 4-5. Preservation liability comparison

The LCP analysis clearly demonstrates the benefits associated with the increased use of preventive maintenance, and other low-cost treatments, to address pavement distress on KYTC's road network. It is important to keep in mind that the analysis results represent conditions for only one assumed investment level. The same trends can be expected at virtually any level of funding, illustrating the financial benefits associated with KYTC's LCP strategy. The predicted future conditions based on actual investment strategies are provided in chapter 6, *Financial Plan* and *10-Year Investment Strategies*.

Opportunities to Improve Pavement Life Cycle Planning

KYTC is actively pursuing several ways to improve its pavement LCP processes, including improvements to data collection and analysis tools. Several of these improvements are expected to be in place for KYTC to use in developing its next TAMP. Some of the key improvements that are being made are described below.

- In 2013, KYTC began collecting pavement cracking data using a laser crack measuring system (LCMS) as part of its annual pavement data collection process. The agency is still in the process of incorporating this data into its pavement management practices, but the information is expected to improve pavement condition data consistency and allow for more detailed analyses.
- KYTC is implementing a comprehensive pavement management system, which will greatly improve the agency's analysis capabilities. The system will allow KYTC to perform more detailed, longer-term analyses, including LCP. As part of the pavement management system implementation, KYTC is:

- Developing decision trees, which will document the conditions under which each treatment can be applied. This will improve the consistency of treatment recommendations over time and will support the long-term analysis needed for LCP.
- Developing deterioration curves for its pavement treatments. These curves will improve the consistency and accuracy of predicted future conditions.

- Once the pavement management system is in place, KYTC will enhance the decision trees to consider life-cycle costs. This improvement will allow future costs to be considered during the treatment selection process. The decision trees will also be used in LCP to determine the type and timing of treatments under each LCP strategy.

  By incorporating life-cycle costs in the LCP analysis, KYTC will be better able to evaluate the long-term financial implications of different LCP strategies.

LIFE CYCLE PLANNING FOR BRIDGES

KYTC is adopting and implementing a strategic, preventive maintenance process for its bridge preservation. To develop the process, KYTC conducted a survey of its districts and some of the Midwest DOTs (including Oklahoma, Missouri, Kansas, and West Virginia) to obtain information on their bridge preventive maintenance (PM) and preservation activities.[11] A summary of this survey is presented in table 4-2. The results indicate that KYTC districts were not following a systematic PM program for their bridges, but KYTC expected the implementation of a systematic approach would provide significant improvement in terms of long-term statewide bridge performance. In response, KYTC initiated an effort to pilot bridge preservation in Districts 3 and 9. Based on the knowledge gained from this ongoing pilot project, KYTC is moving forward with implementation of a systematic bridge preservation program.

11 "A Programmatic Approach to Long-Term Bridge Preventive Maintenance," Kentucky Transportation Center (KTC), 2017

Table 4-2. Basic preservation activities practiced by different state DOTs and KYTC districts

Agency	Deck Patching	Re-Seal and Repair Joints	Sealing Decks	Bridge Cleaning and Washing	Spot Painting	Clean/ Paint Pier Caps and Abutments	Clean and Seal Bearings	Scour, Drift, & Bank Stabilization
Michigan DOT	●	●						
Missouri DOT		●	●	●	●			●
Oklahoma DOT		●	●	●	●			
KYTC D1	●			●	●			●
KYTC D2	●	●						●
KYTC D3	●	●		●			●	●
KYTC D4	●	●				●	●	●
KYTC D5	●							
KYTC D6	●	●						
KYTC D7	●	●		●				●
KYTC D8	●	●		●			●	
KYTC D9	●	●		●			●	●
KYTC D10	●			●				
KYTC D11	●							
KYTC D12	●		●	●	●	●		●

Effective bridge preservation strategies delay the need for costly bridge replacement projects. These strategies typically consist of the treatments listed in table 4-3. As shown conceptually earlier in figure 4-3, different types of treatments are appropriate for different stages of asset condition, which applies to most assets,

including bridges. This figure also illustrates that the cost of preservation actions increases significantly as a bridge deteriorates into *Fair* and *Poor* conditions. Generally, preservation strategies are effective in improving the performance of a bride when applied to bridges in *Good* and *Fair* condition, referred to as the "Window of Opportunity." These conditions and the commonly employed preservation actions for each condition category are outlined in table 4-3.

Table 4-3. Commonly employed feasible bridge actions for different component or element conditions

NBI Bridge Component Rating	Commonly Employed Feasible Actions
9, 8, 7 (Good)	Routine Preventive Maintenance
6, 5 (Fair)	Condition-Base Preventive Maintenance Rehabilitation
4, 3, 2, 1, 0 (Poor)	Major Rehabilitation Replacement
AASHTO Bridge Element Condition State (CS)	**Commonly Employed Feasible Actions**
1 (Good)	Routine Preventive Maintenance
2 (Fair)	Condition-Base Preventive Maintenance Rehabilitation
3 (Poor)	Condition-Base Preventive Maintenance Rehabilitation
4 (Severe)	Major Rehabilitation Replacement

An effective bridge preservation program should include the following components, all of which are addressed by a sound LCP strategy, through Systematic Bridge Preventive Maintenance (SBPM)[12]:

- Long-term network-level strategies and practices that are designed and implemented to preserve the condition of bridges and extend their useful life.
- Appropriate treatments at the appropriate time over a bridge's service life.
- Sustainable and adequate resources to fund such strategies.

To estimate costs for bridge maintenance activities, KYTC used the results of research performed by the Kentucky Transportation Center (KTC) on maintenance of bridges managed by the state highway agency members of the Midwest Region of the Midwest Bridge Preservation Partnership (MWBPP) formed under the Transportation System Preservation Technical Services Program (AASHTO, TSP2).[13,14] These reports summarize the cost and effectiveness of different maintenance and preservation practices, which include routine and condition-based preventive maintenance activities. In addition, other state highway agencies, including Ohio and Michigan, have published guidelines on the best practices and costs for preventive maintenance activities specific to their states that may be applicable to KYTC's practices.[15,16] Tables 4-4 and 4-5 summarize some of these activities and the costs associated with them. It should be noted that the cost, interval, and effectiveness of these activities vary from one agency to another (or even between districts of a state highway agency), and depend on the practices, policies, and climatic condition of the region as well as availability of experienced contractors and high-quality materials. KYTC is developing a PM program that will provide state-specific costs and guidelines for PM activities upon implementation.

12 "Asset Management Guide for Local Agency Bridges in Michigan," Michigan Department of Transportation

13 "Preventive Maintenance Program for Bridges," Kentucky Transportation Center (KTC), Research Report KTC-15-07/SPR11-424-1F, 2015

14 "A Programmatic Approach to Long-Term Bridge Preventive Maintenance," Kentucky Transportation Center (KTC), Research Report KTC-16-22/SPR15-504-1F, 2017

15 "Ohio DOT On-line Bridge Maintenance Manual, Preventive Maintenance/Repair Guidelines for Bridges and Culverts," Accessed November 27, 2017

16 "Bridge Capital Scheduled Maintenance Manual," Michigan DOT, 2010

Table 4-4. Routine preventive maintenance (RPM) costs and intervals

Activity	Cost (for different states)	Recommended Interval (Years)
Clean/Flush Deck	MI: $50.00/hour by state forces IA: $12,500/bridge by contract	1-2 Or as needed
Clean/Seal Expansion Joints	IA: $70.00/LF MN: $123.00/LF WI: $150.00/bridge.	1-2 Or as needed
Minor Concrete Patching and Repair	MI: $4.50/LF OK: $7.50/LF WI: $2.50/LF	5-7
Seal Deck – Chip Seal	MN: $7.00/SF	20
Seal Joints	NE: $80.00/LF OH: $250.00/hour OK: $350.00/LF	4-8

Table 4-5. Condition-based preventive maintenance (CBPM) costs and intervals

Action	Cost (for different states)	Typical Effectiveness (Condition Improvement)
Approach Slab Overlay	MN: $5.50/SF NE: $7.50/SF OH: $70/CY	From CS* 3.0 to CS 1.0
Deck Joint Repair	MI: $300.00/LF NE: $80.00/LF OH: $86.82/LF	From CS 3.0 to CS 1.0
Deck Joint Replacement	IA: $1,000.00/LF KS: $200/LF OH: $382.21/LF	From CS 4.0 to CS 1.0 (or From CS 3.0 to CS 1.0)
Deck Repair- Full Depth	IA: $43/SF MI: $70/SF OH: $400/CY	From CS 4.0 to CS 1.0 (or From CS 3.0 to CS 1.0)
Epoxy Overlay	IA: $45/SY KS: $35/SY OH: $75/SY	From CS 2.0 to CS 1.0
Patching with concrete	•IA: $60/SF •NE: $24/SF •OH: $55.6982/SF	From CS 3.0 to CS 1.0 (or to CS 2.0)

*CS: Element Level Condition State

Bridge LCP Analysis

The Bridge LCP analysis compares the long-term impact of two different treatment strategies on future bridge conditions. The analysis results from a strategy that implements SBPM compared to a traditional worst-first strategy, in which bridges are allowed to deteriorate to the lowest tolerable condition before being rehabilitated or replaced. KYTC followed a strategy similar to worst-first until recently. In recent years, KYTC has begun increasing its use of preventive maintenance on bridges through a pilot study in Districts 3 and 9. In addition, KYTC has been exploring preventive maintenance projects at the corridor level. As part of these projects, many of the bridges located on multiple parkway systems across the state have received preventive maintenance work, such as:

- Deck cleaning.
- Gutter and drain cleaning.
- Barrier wall and substructure coating.
- Bearing lubrication.
- Beam-end spot painting.
- Rust inhibitor application.

KYTC will continue to grow its preventive maintenance program based on the lessons learned from these projects, as well as the performance of other preventative maintenance programs around the nation.

Effectiveness of SBPM at an agency, and the timeliness of preservation activities, are among the most critical factors influencing long-term bridge performance. The timing of a preservation activity on a bridge or its elements can drastically change the course of the bridge's performance. Forecasting when a bridge's element might reach a certain condition state to trigger a specific preservation activity, and forecasting how that activity will improve the condition of the element (or bridge), are useful LCP tools for bridge management.

Modern bridge management systems employ deterioration models that enable agencies to conduct such forecasting at element, component, system, or network levels through sophisticated analytics by predicting the future condition of the bridge components based on selected actions.

KYTC has adopted the AASHTOWare Bridge Management (BrM) system as its official system to store bridge inspection data and to analyze the data for its decision-making purposes. KYTC is working with Mayvue and the KTC on developing agency-specific deterioration models, life cycle cost analysis (LCCA), and prioritization models for KYTC. These features should be available to KYTC staff in the first half of 2020.

It should be noted that because of AASHTO's recent transition to the new element-level inspection manual, most of the past data collected based on AASHTO's CoRE (Commonly Recognized Elements) cannot be directly used for deterioration modeling and requires some migration analysis[17]. Most of the modern bridge management software programs, such as AASHTOWare BrM, have built-in functions to address the migration. The models developed by KTC will be incorporated into AASHTOWare BrM for KYTC.

Bridge Life Cycle Strategy

The Current Approach

Since KYTC has not yet fully implemented a statewide preventive maintenance or bridge preservation program, most decisions regarding maintenance, repair, and rehabilitation are made by districts based on engineering judgment, knowledge of the inventory, and experiences with recurring issues. Bridge replacements are decided by the central office, based on district recommendations. Currently, bridges are slated for replacement using federal funds based on the following criteria, but exceptions may be made in extenuating circumstances:

- The bridge must be classified as Structurally Deficient according to the FHWA definition, and
- The bridge must have a Sufficiency Rating of 50.0 or less.

The central office shares a list of bridges that qualify for federal replacement funds, and the 12 districts review the information and submit their prioritized lists (based on engineering judgment) to the central office along with cost estimates. The central office ranks the 12 district lists to develop a statewide prioritized list. The consolidated list of all district bridge replacement suggestions is sent to the Division of Planning, which then helps develop the recommended *6-Year Highway Plan*. However, the final decision as to which bridges should be included in the *SYP* is a result of the legislative process.

Currently, the criteria for NHS and Non-NHS bridge selection are essentially the same and funding for these bridges comes from the same budget. Approximately 75 percent of the funding KYTC directs to bridges comes from the *SYP* to address major rehabilitation and replacements. KYTC directs approximately 25 percent of bridge funds towards maintenance activities, including painting and repairs. Districts also spend an additional $5M

17 Thompson, P (2017), "Migration Probability Matrix for Bridge Element Deterioration Models," Proceedings of 2017 TRB Annual Meeting, Washington DC

from separate funds on routine maintenance, including pothole patching of decks and drain cleaning. The two districts participating in the bridge maintenance pilot receive approximately 2 percent of the bridge funds for additional maintenance activities on bridges. Central Office staff determines how the preventive maintenance budget is divided between the two districts, based on an analysis of bridge inspection data. Programming of maintenance funds, including allocations to different asset classes, is at the districts' discretion.

The Recommended LCP Strategy

Based on the results of the LCP analysis, the proposed LCP strategy creates a balanced approach to bridge preservation and replacement. The analysis recognizes that the worst-first approach, which focuses on replacement of bridges when they deteriorate into *Poor* condition, will leave less money for preservation of bridges in *Good* and *Fair* conditions, and in turn, will yield ineffective results leading to more costly repairs or replacements in the future.

KYTC utilizes four different types of projects as part of its bridge management practice, all aimed at keeping the condition of its bridge inventory in a state of good repair (SOGR) and within the national and state-specific performance criteria. The recommended bridge LCP strategy addresses a Balanced Program of preventive maintenance, rehabilitation, functional improvement, and replacement, as explained below.

- Maintenance of Bridges in *Fair* and *Good* Condition.
  - » Cyclical preventive maintenance (CPM) based on a preset schedule of activities, or preset intervals.
  - » Condition-based preventive maintenance (CBPM) based on the results of bridge condition assessment (e.g. bridge inspection) when certain elements reach certain conditions in *Fair* or *Poor* range, even though the bridge as a whole may be rated *Good*.
  - » The recommended LCP strategy includes the following preventive maintenance strategies:
    - Resealing and repairing joints.
    - Cleaning and sealing bearings.
    - Bridge washing and cleaning (including deck, super- and substructure).
    - Sealing decks.
    - Spot painting steel members.
    - Patching bridge decks.
    - Cleaning and painting pier caps and abutments.

- Addressing stream channel risks (e.g. scour, drift, sediment, and bank stabilization).

- Rehabilitations of Bridges in *Fair* Condition.
- Major Rehabilitation or Replacements of Bridges in *Poor* Condition.
- Bridge Functional Improvements. KYTC is planning to gradually address functional improvements at the network level, as described below.
  - » Functionally Obsolete Bridges: This term was previously defined by FHWA as having an appraisal rating of 3 or less for Item 68 (Deck Geometry), Item 69 (Underclearances), or Item 72 (Approach Roadway Alignment), OR having an appraisal rating of 3 for Item 67 (Structural Condition) or Item 71 (Waterway Adequacy) and was used to implement the Highway Bridge Program. However, since the enactment of MAP-21, FHWA has discontinued that program, and thus this term is no longer in use.
  - » Sub-Standard Bridges: This is a KYTC-specific term, and is used for bridges that have a weight limit less than that of the approach roadway.

This Balanced Program, incorporated into KYTC's holistic bridge preservation program over time in a systematic manner, will require sufficient funding levels backed by implementation of appropriate guidance, specifications, and practices at the state level, practiced by the central office and district offices.

To support the analysis, FHWA's National Bridge Investment Analysis System (NBIAS) and AASHTOWare BrM were utilized to identify the effects of the two strategies (worst-first and the Recommended LCP strategy) on the condition of bridges over the 10-year analysis period, when funded at an equal investment level. As shown in figure 4-6, the recommended LCP strategy significantly reduces the percentage of bridges in *Poor* condition by deck area by 47 percent, or approximately 127,040 ft^2, over the 10-year period when compared to a worst-first strategy. This difference is even more significant, and the strategy is more effective, when the analysis period is lengthened.

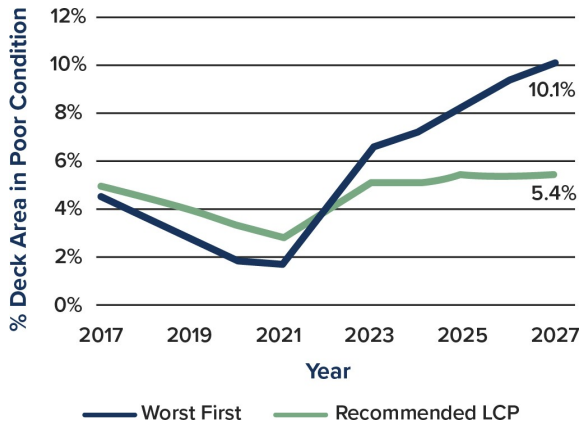


Figure 4-6. Comparison of network bridge conditions

These results demonstrate the importance and effectiveness of systematic preventive maintenance for the management of KYTC's bridges and the benefits associated with the increased use of preventive maintenance and other low-cost treatments. It is important to keep in mind that the analysis results are not expected to represent the conditions expected under various funding scenarios. Rather, they illustrate the benefits associated with the recommended LCP strategy. The predicted future conditions based on actual investment strategies are provided in chapter 6, *Financial Plan* and *10-Year Investment Strategies*.

Opportunities to Improve Bridge Life Cycle Planning

KYTC is actively pursuing several ways of improving its bridge LCP processes, and promoting implementation of the recommended LCP strategy. Several of these improvements are expected to be in place for KYTC to use in developing its next TAMP. Some of the key improvements are described below.

- KYTC is developing a bridge rehabilitation/replacement policy based on a data-driven, objective prioritization framework. The framework may include multiple factors with different weighting factors that can be state- or district-specific. These factors may include:
  - Condition.
  - Load carrying capacity relative to the roadway.
  - Criticality of the bridge (e.g. located on a major road, STRAHNET, or evacuation route).
  - Detour (Evaluate traffic volume, and delay time of the detour route in addition to the distance).
  - Operational characteristics (e.g. functionally obsolete or sub-standard bridge).
  - Cost and duration of the service recovery effort after an extreme event.
- KYTC is adopting the AASHTOWare BrM bridge management software. The system's benefit cost analysis will be incorporated into the agency's decision-making processes at the Central Office- and district-levels. Essential ingredients include training and continued improvement for the technical staff and managers of the bridge program at KYTC. Implementation of this software will promote investment decisions that are consistent with the recommended LCP strategy.
- KYTC is working with Mayvue and the KTC on developing agency-specific deterioration models, life cycle cost analysis (LCCA), and prioritization models for KYTC bridges. These features should be available to KYTC staff in the first half of 2020 and will improve the accuracy of future LCP analyses. ■

CHAPTER 5: RISK IDENTIFICATION AND MANAGEMENT

OVERVIEW

FHWA defines a risk as, "the positive or negative effects of uncertainty or variability upon agency objectives." Highway agencies face a wide array of risks, ranging from daily events, such as traffic incidents, to major economic swings or natural disasters. To offset the potential damage these events may cause, transportation agencies use a risk management framework to identify, evaluate, and mitigate these uncertainties. Through that process, agencies can develop action plans that reduce the likelihood that risks occur or the potential impact if an event does take place. This chapter describes the process used by the Cabinet to identify, document, and address risks in a coordinated manner to minimize the impacts of unplanned events on the agency, the infrastructure assets, and the public.

KYTC ASSET MANAGEMENT RISKS

The KYTC asset management effort has the support of the leadership, which is an important first step in the successful implementation of asset management. This support is reflected in leadership's overall

engagement and support for the TAMP, as well as its support for Governor Bevin's SHIFT initiative. However, like other transportation agencies across the nation, KYTC still faces many uncertainties beyond its control that could impact the implementation of its TAMP. Over the 10-year period covered in the TAMP, these risks may include:

The uncertainty in federal and (to a lesser extent) state road fund revenues, which is compounded by funding uncertainties for major projects, such as the Brent Spence Bridge replacement, that require significant funding beyond traditional revenue streams.

The loss of experienced staff, caused largely through retirements will impact KYTC's ability to effectively manage its assets.

The potential for a shift in programming focus from preservation to new capital projects due to leadership changes. Since bridges, pavements, and other high value infrastructure assets are assets with long lives, effective asset management requires a long-term commitment to implement strategies that improve, preserve, and sustain the value and condition of these assets over time. Though KYTC's current leadership has embraced asset management and committed to long-term investment strategies, the Cabinet faces the possibility that changes in agency leadership could redirect the planned 10-year investment strategies.

The possibility that internal and external stakeholders will not fully support the implementation of the Cabinet's asset management strategies and plans. Internally, this risk centers on the Cabinet's decentralized approach to managing the capital program, which is designed to focus on local needs, but could lead to inconsistent investment strategies between geographic areas without adequate coordination. This risk also addresses the possibility that the public and other external stakeholders will not understand and support the Cabinet's increased focus on preserving existing assets.

Other events, such as seismic risks, that may occur. For example, the New Madrid fault line has been discussed in the 2009 studies[18] funded by the Federal Emergency Management Agency. KYTC must be vigilant about managing this risk, although it is not likely to impact Kentucky's transportation system during the TAMP time period.

18 Einashai, A., et. Al. 2009. "Impact of New Madrid Seismic Zone Earthquakes on the Central USA." Mid-America Earthquake Center, Urbana, IL.

BENEFITS OF MANAGING RISKS

There are many benefits to using risk management to support decision-making at all levels of an agency. Risks are inevitable and it is important for KYTC to acknowledge and manage them. A formal risk management process provides a means for decision makers to understand the impact, severity, consequence, and priority of the many uncertainties the Cabinet faces, and to prepare and respond appropriately. Additionally, managing risks is important to achieving performance objectives. The 10-year TAMP timeframe makes the risk management process even more important, since uncertainty increases with time. KYTC's risk management practices allow the agency to prepare for potential events so threats can be minimized or eliminated, and opportunities can be fully realized.

THE KYTC TAMP RISK MANAGEMENT APPROACH

KYTC has established objectives and targets to support the cost effective, long-term life cycle management of its assets. The Cabinet is integrating risk management into its decision processes to proactively manage the uncertainties that could prevent achievement of its targets and minimize management by crisis. By implementing risk management, KYTC will explicitly recognize the uncertainties that its pavement and bridge programs face. Risk management will be another tool that informs KYTC's decision-making processes so staff can proactively plan and implement appropriate risk mitigation strategies. It also serves as a data-driven tool to communicate decisions to stakeholders.

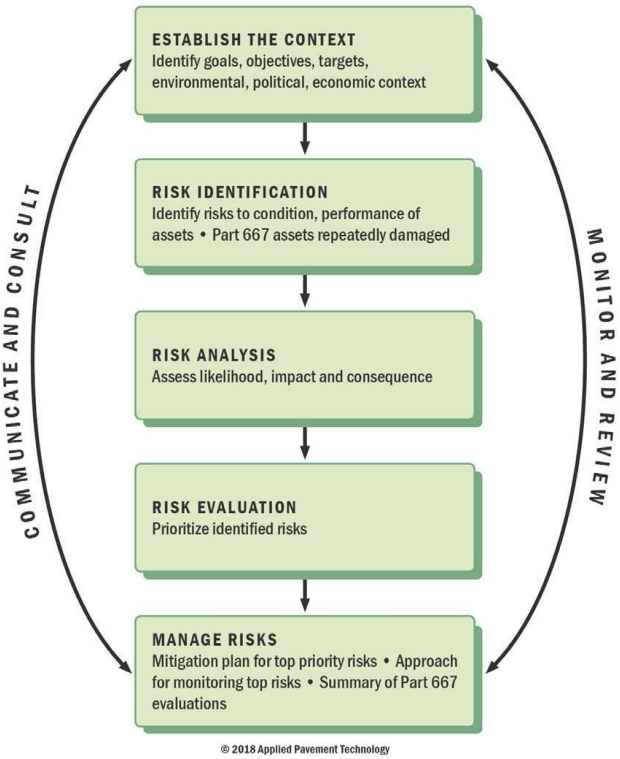


Figure 5-1. Risk management framework

KYTC has employed the risk management framework, shown in figure 5-1, as the model for its risk management efforts. This model consists of five primary activities. The five activities in the center of the graphic are performed in a cyclical fashion on a regular basis. This allows KYTC to be aware of how its risk profile is changing, and how best to manage the risks it is facing at the present time. The results of these activities are

continually updated in the agency's Risk Register, which summarizes and connects the findings of each activity, presented at the end of this chapter in tables 5-1 and 5-2. The five core activities are connected through the activities on the sides of figure 5-1: *Monitor and Review* and *Communicate and Consult*. Each risk included in the Risk Register is assigned to a business unit to monitor and review. If it becomes apparent that a change has taken place that requires a risk to be reconsidered, the business unit communicates this need and consults with other impacted groups and individuals to determine the best course of action.

To develop the Risk Register, KYTC conducted a series of workshops with the Pavement and Bridge Work Groups. Through these workshops, KYTC identified, analyzed, and evaluated risks to its asset management objectives, and developed mitigation strategies for the most significant risks. The following sections provide additional detail on KYTC's risk management procedures.

Identify TAM Objectives

The Core Team established the context for TAM risk management as threats or opportunities to the Cabinet's TAM objectives. These TAM objectives included both the Cabinet's high-level objectives for asset performance, described in Chapter 2 of this TAMP, as well as program-level objectives that facilitate the accomplishment of the Cabinet's objectives. The identified objectives are presented in the Risk Register.

Identify Risks to TAM Objectives

After documenting the TAM objectives, the Pavement and Bridge work groups identified risks to achieving those objectives. The risks arise from several uncertainties related to areas such as finance, climate, technology, workforce development, construction materials, and government processes. The risks were documented and then analyzed and evaluated to determine if they warrant active management and inclusion in the Risk Register.

Analyze and Evaluate Risks

Analyzing risks involves quantifying the likelihood that the risk may occur, and the relative impact if the risk does occur. Risk analysis was performed based on the opinion of the subject matter experts present at the workshops, available data, and the risk matrix shown in figure 5-2. Through this process, each risk was assigned an overall consequence rating of: Low, Medium, High, Very High, or Unacceptable based on the combination of the likelihood and impact classifications. Risks classified as High, Very High, or Unacceptable were included in the Risk Register presented in the TAMP. The remaining risks were captured in a more extensive Risk Register being managed by the State Highway Engineer's Office.

Risk Matrix							
Risk Matrix with Impact and Likelihood Definitions			Likelihood				
			Rare	Unlikely	Likely	Very Likely	Almost Certain
			Less than once every 10 years	Once in more than 3 but less than 10 years	Once between 1-3 years	Once a year	Several times a year
Impact	Catastrophic	Potential for multiple deaths and injuries, substantial public and private cost	Medium	Medium	High	Very High	Unacceptable
	Major	Potential for multiple injuries, substantial public or private cost and/or foils agency objectives	Low	Medium	Medium	High	Very High
	Moderate	Potential for injury, property damage, increased agency cost and/or impedes agency objectives	Low	Medium	Medium	Medium	High
	Minor	Potential for moderate agency cost and impact to agency objectives	Low	Low	Low	Medium	Medium
	Insignificant	Potential impact low and manageable with normal agency practices	Low	Low	Low	Low	Medium

Figure 5-2. Risk rating matrix

Risk Mitigation

The State Highway Engineer's Office will be responsible for managing the risks and assigning responsibility for mitigation actions to other groups and agency personnel. The TAMP work group developed mitigation strategies for each risk included in the Risk Register. Risk mitigation strategies involved the five techniques for mitigating risks shown in figure 5-3. The Risk Register is organized by pavements and bridges, representing the TAM Work Group that will be assigned responsibility for monitoring and mitigating each risk.

Mitigation Strategies	
1	**Treat** — Take steps to reduce the risks
2	**Tolerate** — Decide the risk is not worth treating or you can't treat it
3	**Transfer** — Shift risk to a third party
4	**Terminate** — End the situation that creates the risk
5	**Take Advantage of** — Capitalize on the risk

Figure 5- 3. Risk mitigation strategies

Risk Monitoring and Review

KYTC plans to use the Risk Register as a tool to guide the monitoring of risks in the future. The TAMP Core Team will be responsible for overseeing periodic updates to the TAMP Risk Register following the processes described in this chapter.

The Pavement and Bridge work groups will review the TAMP Risk Register at least once every six months. Reviews may be performed more frequently if a significant event or risk trigger occurs. Risk triggers can be events such as major changes in funding, new unplanned initiatives taking priority, significant natural events such as floods, leadership changes, or any event that has an impact on the agency's progress towards achieving its TAM objectives. Reviews of the Risk Register will consider the following types of changes.

New Objectives

If new asset management objectives are developed, they will be added to the Risk Register. The steps in the Risk Management Framework will then be repeated to identify risks to these new objectives.

Changes to Known Risks

The Risk Registers will be updated to reflect any changes to existing risks including the changes to the likelihood, impact, and consequence ratings. The changes will be clearly highlighted.

Newly Identified Risks

New risks to existing objectives will be added where appropriate. For all new risks added to the Risk Register, the steps in the Risk Management Framework shown in figure 5-1 will be repeated and the Risk Register will be updated to show the likelihood, impact, and consequence of each new risk. The risks will be prioritized based on the consequence ratings. Mitigation strategies will be developed for all new high-priority risks.

Archiving of Risks

Risks that are no longer of sufficient consequence for inclusion in the Risk Register will be archived to reflect that they are no longer applicable.

Ongoing Communication

Monitoring and managing risks will be the shared responsibility of KYTC staff across multiple offices and geographic locations. The TAMP Core Team will take the lead on tracking progress toward the implementation of risk mitigation strategies and updating the Risk Register. The TAM work group will support the Core Team in this effort. Regular means of reporting progress and communication will be established between these groups and the State Highway Engineer's Office. This will allow the groups responsible for monitoring and mitigating risks to inform the TAMP Core Team of any changes that might impact KYTC's pursuit of its TAM objectives.

In addition to tracking the progress of risk mitigation efforts and updating the Risk Register, the TAMP Core Team will be responsible for the regular review and improvement of risk management practices, including the tools and data used to assess risks and track risk mitigation.

It is the intention of the TAMP Core Team to integrate TAM risk management with other risk management efforts currently and soon to be underway at the Cabinet and at stake-holder agencies. A primary example of risk management efforts that directly impact KYTC's TAM objectives is assessing and addressing vulnerabilities to the Kentucky highway infrastructure from natural hazards such as floods, sinkholes, earthquakes, and other events.

MANAGING RISKS TO KYTC'S TAM OBJECTIVES

KYTC is actively managing risks throughout the agency. The following sections summarize risks to KYTC's TAM objectives that have been identified and are being managed through three separate but coordinated efforts.

- The Risk Register developed as part of this TAMP.
- KYTC's efforts to document and manage risks from natural hazards.
- Periodic evaluation of facilities requiring repeated repair and reconstruction due to emergency events.

As described earlier, KYTC is working to integrate these efforts through the State Highway Engineer's Office. Each of these efforts has a direct bearing on KYTC's efforts to achieve its asset management objectives. The risks described below are all taken into consideration at some point in the capital program development and delivery processes. The following sections provided detail on identified risks and current risk management practices.

Asset Management Risk Register

The Risk Register is presented as two tables: table 5-1 includes pavement objectives and risks, and table 5-2 summarizes bridge

objectives and risks. These tables summarize the results from the workshops conducted with the Pavement and Bridge work groups. Tables 5-1 and 5-2 identify risks that were rated as High, Very High or Unacceptable. The tables present the scores for likelihood and impact for each risk, along with mitigation strategies. The risks identified by the work groups will be actively monitored and managed under the direction of the State Highway Engineer's Office.

Table 5-1. Pavement objectives and risks

	Risk	Likelihood	Impact	Consequence	Mitigation Strategies
Objective 1: Optimize our investments to improve user experience, reduce negative impacts, and support and enhance economic growth.					
1	If we continue losing key staff in the central office or the districts, we will lack the expertise to effectively manage our highway assets.	Almost Certain	Major	Very High	1. Transfer knowledge of senior staff and key specialists to junior staff members. 2. Create incentive programs to retain staff. 3. Conduct succession planning to develop staff with needed skills. 4. Rely on consultants and contractors to provide the needed skills.
Objective 2: Adopt a "fix it first" mentality to adequately fund condition-based asset management projects.					
1	If we lack legislative approval for the asset management projects, our program of projects will be changed and there will be greater deterioration of bridge and pavement conditions.	Likely	Catastrophic	High	1. Actively engage legislators about the benefits of asset management. 2. Reach out to the public to address their concerns.
2	If we have too few projects on the shelf, we will not be able to make full use of unspent funds from capital projects that are under budget or delayed.	Very Likely	Major	High	1. Develop master agreements and fixed-price contracts to quickly authorize asset management pavement treatments.
Objective 3: Achieve stabilized funding for more predictable asset investments and ensure a fiscally realistic plan.					
1	If the legislature does not support adequate and stable funding, we will not be able to make the systematic and regular investments needed to treat assets at the correct time.	Almost Certain	Major	Very High	1. Demonstrate the long-term value of asset management to save money and improve roadway conditions. 2. Engage the districts and local elected officials to get their support for an asset management approach. 3. Engage legislators and share the credit for safer and improved roadway conditions possible through our asset management program.

	Risk	Likelihood	Impact	Consequence	Mitigation Strategies
2	If we do not receive stable and adequate funding, we will not achieve our target of no more than 8% of all pavements being in poor condition.	Almost Certain	Major	Very High	1. Develop a communication effort to demonstrate the value of asset management. 2. Demonstrate the long-term value of asset management to save money and improve roadway conditions. 3. Engage the districts and local leadership to get their support for an asset management approach. 4. Engage legislators and share the credit for safer and improved roadway conditions possible through our asset management program.
3	If funding is unpredictable, we may not be able to optimize our paving treatments.	Very Likely	Major	High	1. Conduct multiple pavement management model runs to illustrate which treatment scenarios provide us the best long-term return on investment. 2. Increase the flexibility to the preventive maintenance alliance (PMA) groups. 3. Develop a decision tree to indicate how to use money appropriately for the best life-cycle treatments.
Objective 4: Have no more than 8% poor pavements across all functional classes.					
1	If pavement conditions deteriorate, maintenance will experience increased risk because they will work more frequently under traffic.	Almost Certain	Major	Very High	1. Increased use of long patching, crack sealing, or inlays to reduce the need to patch. 2. Explore the use of automated patching equipment. 3. Adopt more rigorous traffic-control practices for patching.
2	If we fail to achieve and sustain our target of no more than 8% pavements in poor condition, Kentucky will experience a backlog of pavements needing treatment that will lead to higher costs and lower conditions.	Almost Certain	Major	Very High	1. Prioritize higher-volume routes for higher conditions. 2. Accept lower conditions on lower-volume roadway sections. 3. Train staff on proper construction inspection of new pavement maintenance treatments and techniques.
3	If we cannot afford to sustain our target of no more than 8% poor across the network, we may have to accept reduced conditions on low-volume sections.	Almost Certain	Major	Very High	1. Prioritize treatments by traffic volume or functional class. 2. Communicate the need to accept lower conditions and document the results in terms of reduced ride quality and higher costs to restore conditions. 3. Develop more refined modeling techniques for lower-volume roads to assess the effects of lower-cost treatments.

	Risk	Likelihood	Impact	Consequence	Mitigation Strategies
4	If we cannot afford to sustain our target of no more than 8% of pavements in poor condition, the parkways will be the first to deteriorate followed by the lower-volume routes.	Almost Certain	Major	Very High	1. Examine lower-cost treatments that could preserve conditions for less cost. 2. Further prioritize the routes on the parkway network by volume or other criteria to maintain conditions on the most important sections.
5	If we cannot sustain our target of no more than 8% of pavements in poor condition, the public will experience repeated maintenance activities.	Almost Certain	Moderate	High	1. Communicate the impacts to the public and legislators, and inform motorists of the need for additional maintenance activities. 2. Develop master agreements for low-cost treatments. 3. Train staff on proper construction inspection of new pavement maintenance treatment and techniques.
6	If we do not implement our asset management strategies, we will incur higher future maintenance costs.	Almost Certain	Moderate	High	1. Request more funds for maintenance. 2. Consider the use of federal-aid funds for eligible preservation activities. 3. Adopt more long-patching, crack sealing, or inlays to address deteriorated pavement joints.
Objective 5: Prioritize capital projects that improve asset conditions.					
	No risks of high, very high, or unacceptable consequence were identified.				
Objective 6: Ensure asset management decisions are well understood and well communicated.					
1	If asset management effort is not well supported and well communicated, we will not achieve our pavement objectives.	Very Likely	Major	High	1. Develop efforts to communicate and educate stakeholders about asset management. 2. Develop training programs so that staff understands asset management. 3. Engage the public information officers early in the efforts to promote asset management. 4. Be transparent about asset management.
2	If asset management is not well supported and well communicated internally, we will not be able to implement the program.	Very Likely	Major	High	1. Develop efforts to communicate and educate stakeholders about asset management. 2. Develop training programs so that staff understands asset management. 3. Engage the public information officers early in the efforts to promote asset management. 4. Be transparent about asset management. 5. Provide widespread knowledge about preservation treatments.
3	If we have a well-communicated asset management plan, we can earn support and trust from external stakeholders.	Likely	Catastrophic	High	1. Follow through on our efforts and implement our asset management strategies. 2. Show the results of our asset management efforts.

Table 5-2. Bridge objectives and risks

	Risk	Likelihood	Impact	Consequence	Mitigation Strategies
Objective 1: Have no more than 3% of structures by deck area structurally deficient (poor) by 2035.					
1	If we continue losing key staff at the central office and the districts, we will not have the key personnel needed to achieve our bridge target.	Almost Certain	Moderate	Very High	1.Develop job classifications for inspectors and other bridge personnel. 2. Dedicate staff to bridge asset management. 3. Determine the level of effort needed to use BrM bridge software and to provide the necessary staff and resources.
2	If our large inventory of aging bridges deteriorates more quickly than we forecast, it will increase our costs and could prevent us from achieving our statewide target.	Almost Certain	Moderate	High	1. Develop a more robust model to estimate deterioration rates and costs. 2. Develop a preservation program specifically for large structures. 3. Train staff on proper application of bridge preservation treatments
3	If we accelerate the pace of our bridge program to reach our target before 2035, we will lack the construction inspection staff to keep up with the demand.	Very Likely	Major	High	1. Actively engage upper management on the demands to meet our targets. 2. Increase construction inspection staff. 3. Hire consultants to inspect bridge preservation projects.
4	If we replace or repair additional large structures such as the I-64 or Brent Spence bridges, it could consume funds needed to achieve our bridge target.	Almost Certain	Moderate	High	1. Reduce capital projects to allocate additional funding to bridge preservation. 2. Increase KYTC revenues to address major projects either through traditional funding or innovative financing mechanisms.
Objective 2: Eliminate substandard bridges on state routes with a priority on bridges that are posted at three tons for more than two inspection cycles.					
1	If we accelerate the pace of our bridge program to reach our target before 2035, we may lack enough construction inspectors to meet the demand.	Very Likely	Major	High	1. Utilize innovative procurement methods to shift QA/QC risk to contractors. 2. Increase KYTC construction inspection staff. 3. Actively engage upper management on the demands to meet our targets 4. Hire consultants to inspect bridge preservation projects.
2	If we replace or repair additional large structures such as the I-64 or Brent Spence bridges, it could consume funds needed to achieve our bridge target.	Almost Certain	Moderate	High	1. Reduce capital projects to allocate additional funding to bridge preservation. 2. Increase KYTC revenues to address major projects either through traditional funding or innovative financing mechanisms.
Objective 3: Systematically address scour-critical structures.					
1	If we don't have adequate bridge inspection staff, we will not be able to promptly inspect bridges after flood events, which could lead to an unsafe bridge remaining in service.	Very Likely	Major	High	1. Develop plan to shift inspectors from neighboring districts during extreme events. 2. Ensure that consultant inspection contracts provide for widespread response to emergency situations. 3. Develop plan to close large numbers of structures until inspection is completed and to prioritize critical structures for inspection.

	Risk	Likelihood	Impact	Consequence	Mitigation Strategies
2	If we have increased storm events and severity, it can increase the threat of scour to our structures.	Very Likely	Major	High	1. Include structures with unknown foundations in this mitigation. 2. Keep POAs up to date for each scour critical bridge.
3	If we do not have staff to adequately address scour countermeasure repairs, it can accelerate the threats of bridge degradation and failures.	Very Likely	Major	High	1. Increase staff. 2. Have a statewide design contract for scour countermeasure design.
Objective 4: Develop the appropriate approach to reduce the number of functionally obsolete structures.					
	No risks of high, very high, or unacceptable consequence were identified.				
Objective 5: Put a program in place that stresses maintaining structures in good condition instead of replacing them.					
1	If we do not have construction inspectors who understand preservation work, we will not get the project quality we need.	Almost Certain	Catastrophic	Unacceptable	1. Increase training. 2. Have dedicated staff at Central Office or in Districts who can serve as a resource to inspectors. 3. Consider specialized inspectors who can cross district lines to assist and train (Bridge Liaisons) 4. Utilize consultant inspectors. 5. Train staff on proper application of bridge preservation treatments.
2	If the bridge program is not adequately funded, we will not be able to perform enough warranted bridge preservation.	Almost Certain	Major	Very High	1. Shift funding from capital program to bridge program. 2. Prioritize preservation over replacement to stretch funding. 3. Train staff on proper application of bridge preservation treatments.
3	If we don't develop the staff and internal structure, we will not be able to start and sustain a bridge preservation program leading to higher maintenance and replacement costs.	Almost Certain	Moderate	High	1. Consider alternative organizational structure for bridge preservation at the central office and district level. 2. Create job classifications for bridge preservation staff. 3. Train staff on proper application of bridge preservation treatments.
4	If we cannot find a way to start the program economically and overcome barriers such as having a large number of small, geographically isolated projects, then project costs could be unacceptably high.	Very Likely	Major	High	1. Focus limited funding on small geographic areas to reduce costs. Move funding across state each year. 2. Increase efforts to perform in-house work by bridge crews. 3. Prioritize routes/counties and do group projects. 4. Have a statewide or district-specific mater agreement for preservation work, like current guardrail maintenance master agreement. 5. Train staff on proper application of bridge preservation treatments.

	Risk	Likelihood	Impact	Consequence	Mitigation Strategies
5	If our contractors are not experienced with these projects, the quality of the projects could be low.	Very Likely	Major	High	1. Utilize innovative procurement methods to shift QA/QC risk to contractors. 2. Engage industry and encourage training for treatments that may be unfamiliar. 3. New Position for Bridge Liaisons to perform field work necessary to develop sound contracts and also be onsite during preservation work. (Similar to our construction and maintenance liaisons). 4. Employ or train inspection staff that are adequately trained.
6	If we allow scope creep to occur, then a low-cost preservation project could expand to a more expensive maintenance or rehabilitation project.	Very Likely	Major	High	1. Don't budget more for a bridge than the scope calls for. 2. Communicate the project intent to the project-development staff. 3. Manage change orders effectively. 4. Track the project burn down to ensure it stays within scope. 5. Provide a unique funding code with unique approval authority for these projects. 6. Provide QA/QC for these projects. 7. Rely on product manufacturers to help ensure proper installation, of products. 8. Consider contractor certification for preservation projects. 9. Assign a gate keeper for these projects. 10. Charge change orders to next year's district budget. 11. Review FD05
7	If the districts lack the skills for bridge preservation, they will not be able to manage a preservation program effectively.	Very Likely	Major	High	1. Increase training. 2. Dedicated Central Office resource to assist districts. But also have an asset management engineer in the district who is solely over the bridge crews.

Managing Vulnerabilities from Natural Hazards

Overview of the Vulnerability Assessment

In 2016, KYTC conducted a federally-funded natural hazard vulnerability assessment of NHS routes[19]. As part of the assessment, KYTC's NHS assets, including highway segments, bridges and culverts, were assessed for risk against earthquakes, floods, landslides, and sinkholes using available data. Each of the 12 KYTC districts were engaged in separate workshops to

[19] KYTC. 2016. "Transportation System Vulnerability and Resilience to Extreme Weather and Other Natural Hazards: report for Pilot Project – KYTC District 1, KTC_16-20/SPR16-524-1F."KYTC. Frankfort, KY.

identify the most critical extreme weather and natural hazards related to the four hazards in each KYTC district.

Nationally, Kentucky ranks fifth in terms of impact from sinkholes. Sinkhole formations pose many risks, including that of bridge foundations and roadway surfaces collapsing. With over 90,000 miles of streams, Kentucky is particularly vulnerable to flooding. Also, landslides are common in the mountains and plateaus of eastern Kentucky, the Outer bluegrass, the Knobs region, and the Ohio River Valley.

For the study, the NHS was divided into 287 segments. The team conducted the assessment using a modified version of the FHWA's Vulnerability Assessment Scoring Tool (VAST). Each segment was scored against 22 data layers for risk exposure, asset sensitivity, and system adaptive capacity using a scale of 1 to 4, with 4 representing the highest vulnerability. The districts identified several vulnerabilities and mitigation strategies to address these natural hazards.

Integration with TAM Risk Management

The integration of the risks and mitigation strategies identified by each of the districts along with those identified in the Risk Register is ongoing. This integrated asset management and hazard vulnerability Risk Register will represent a comprehensive summary of all the vulnerable assets, which will enable KYTC to proactively mitigate the effects of natural hazards to assets. As part of the mitigation, the KYTC is developing processes and procedures to account for the effects of natural hazards to KYTC assets for Planning, Design, Maintenance, and Environmental Divisions. The overall risk monitoring process discussed in this chapter will be used to monitor and manage all KYTC asset and natural hazard related risks.

Preliminary Results of the Vulnerability Assessment

The results of the vulnerability assessment showed 83 of the 287 NHS segments had high vulnerability to the hazards. Of these 83 segments, one segment had vulnerability to three different hazard types. 13 had high vulnerability to two hazard types, 4 were vulnerable to earthquakes, 27 were vulnerable to floods, 45 were vulnerable to landslides, and 22 were vulnerable to sinkholes.

According to the vulnerability assessment, 55 percent of the land in the state has the potential for karst development. Karst topography, as illustrated in figure 5-4, is "terrain with distinctive hydrology and landforms that arise from a combination of high rock solubility and well developed secondary (fracture) porosity". Sinkholes, caves, sinking streams, and springs are commonly found in karst landscapes. The

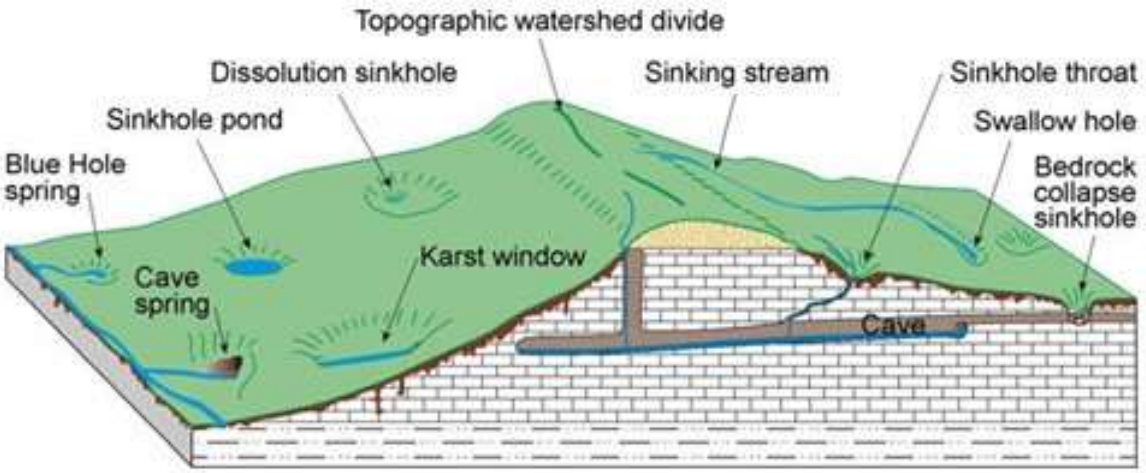


Figure 5- 4. Karst topography
(Source: Kentucky Geological Survey (KGS), http://www.uky.edu/KGS/water/general/karst/index.htm)

report also states that "38 percent of the state has enough karst development to be recognized topographically, and 25 percent has well-developed karst features." Two types of sinkholes occur commonly in Kentucky – subsidence and cover collapse. Karst potential in Kentucky is highest in the Inner Bluegrass Region, the Western Pennyrile region and the Eastern Pennyrile region.

Strategies Under Consideration

The KYTC is in the process of developing mitigation strategies for all the high priority risks that were identified during the vulnerability assessment. Each of the 12 districts developed mitigation strategies for identified high priority risks. These strategies are considered when developing the SYP, as well as during the preliminary engineering and final design phases of project development. The intention is that by identifying and addressing the potential for these hazards, KYTC can minimize the consequence of future events.

District 1 workshop participants identified sections of US 51 and I-24 as vulnerable to flood and earthquake. They also identified a section of I-24 north of and downstream from the Kentucky Dam and Barkley Dam as vulnerable to earthquake and flooding associated with dam failure.

District 2 identified poor land-use management, linked to the right of way outside the KYTC's control, as the cause for flooding. Figure 5-5 shows the impact of major flooding on western Kentucky in 2011. The district workshop participants recommended having a dedicated maintenance program to work with these external stakeholders to seek special permission to address such problems on an

ongoing basis. Clogged culverts were identified as the cause of some of the 2016 flooding in District 2. Team members also identified that several of the roadways flooded were in the 100-year floodplain.

Figure 5-5. Western Kentucky flooding in 2011
Source: Commonwealth of Kentucky Enhanced Hazard Mitigation Plan: 2013 Version

District 3 has thousands of sinkholes, sinking streams, springs, and caverns, with sinkholes posting the highest risks. Participants identified a high risk for a sinkhole forming under I-65 that has an Average Annualized Daily Traffic of over 50,000. This section of I-65 is one of the major freight corridors connecting Gulf of Mexico ports with Midwestern Markets and manufacturing centers. The District 3 participants recommended regularly scheduled maintenance with special procedures to ensure that I-65 is properly drained. An additional mitigation recommended by the District 3 team is to consider using US 31W, which parallels I-65, as an alternative route. The team also identified vulnerabilities to roadways outside of the NHS in District 3 that were prone to flooding with 2 to 3 inches of rainfall.

District 4 identified sinkholes as the greatest natural hazard for NHS assets and flooding as the second major natural hazard.

District 5 did not identify any major hazards.

District 6 identified floods and landslides as major natural hazards. District 6 personnel reported the possibility of landslides wherever a road was located next to a river or stream, with areas along the Ohio River at particularly high risk of experiencing landslides. District 6 personnel identified geological instability near one of the piers of the Brent Spence Bridge and identified the need to proactively address the bridge and the approach as mitigation. District 6 also identified several other flooding risks including undersized culverts that are unable to handle large water flows and culverts blocked by debris.

District 7 identified floods and sinkholes as hazards but none were identified as critical. Figure 5-6 shows an assessment of flood risk by county across the Commonwealth.

District 8 identified sinkholes as a significant natural hazard for NHS assets.

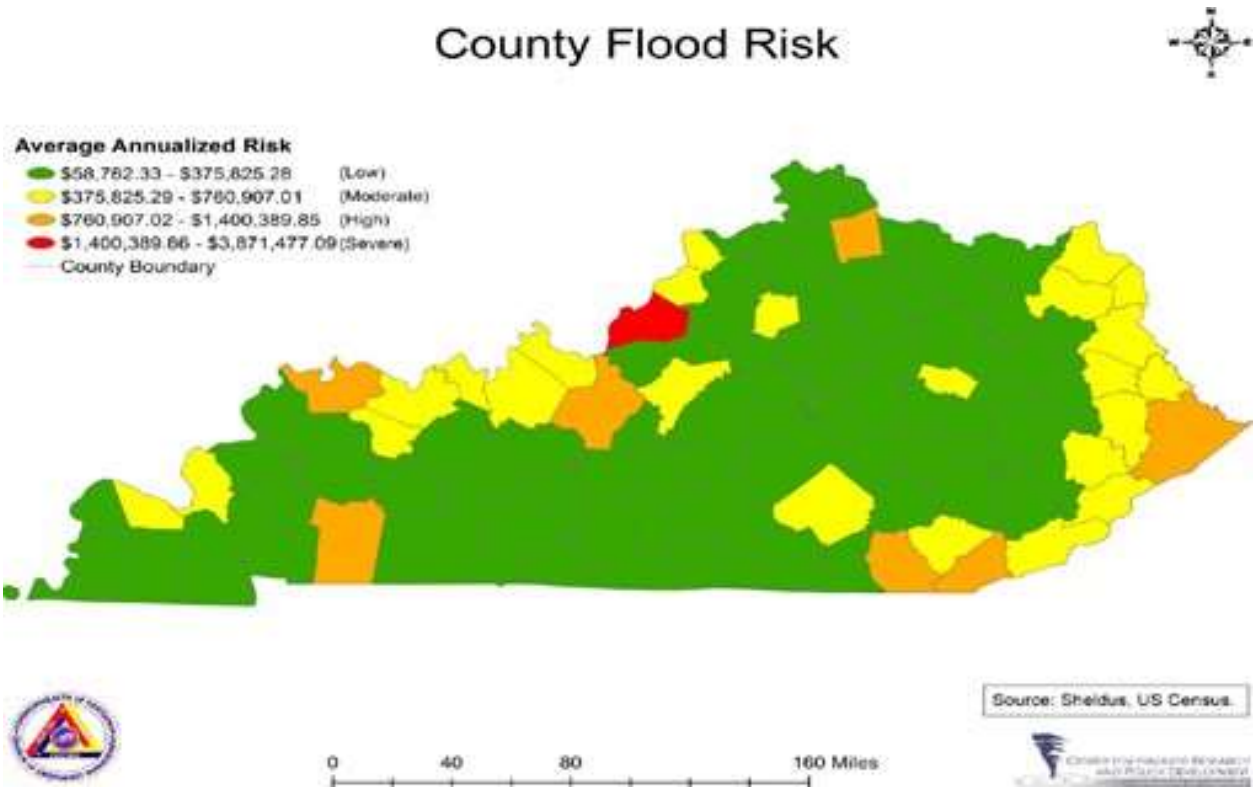


Figure 5- 6. County flood risk
Source: Commonwealth of Kentucky Enhanced Hazard Mitigation Plan: 2013 Version

They also identified problems with flooding, landslides, and sinkhole-related drainage. Though not currently considered a major risk, any flooding and/or related landslide on I-75 and its detour route US 25 that could result in closure of both highways would have a major impact.

District 9 experienced extreme rainfall events (greater than 3" of rain in a single day) from 1981 to 2015, on average, every 5 to 10 years. This compares to the statewide average of an extreme rainfall event every 4 years. In 2010, heavy precipitation led to flooding that cut off Morehead from access to the interstate. Similarly, in 2012, flooding caused disruption and closure of access to US-60. Several sections of I-64 were also impacted by landslides and rockfalls. Any major event that results in the prolonged closure of I-64 would have significant economic, safety, and mobility impact for the state.

District 10 identified flooding and landslides as the two most common hazards in the district. The district has steep mountainous topography where roads are commonly built along stream channels in the valleys, making them vulnerable to flash

flooding and erosion. District 10 has several methods for mitigating against landslides and shoring up roadbeds located along streams, including drilling rail steel along the roadbed to increase stability and using soil nails with concrete to mitigate slips.

District 11 identified sinkholes, landslides, and rockfalls as major hazards. Major landslides and rockfalls have resulted in the closure of I-75, including a landslide in 2012. In 2016, a rockfall caused the closure of the interstate for several weeks. The district also identified some vulnerability to earthquakes due to its proximity to the Eastern Tennessee Seismic Zone.

District 12 identified landslides and flash flooding as major hazards. In 2015, flash floods caused four fatalities and left hundreds of homes damaged or destroyed.

Figure 5- 7. Flood damage in Pike County, KY 2010. Source: Commonwealth of Kentucky Enhanced Hazard Mitigation Plan: 2013 Version.

Flash flooding in the district was identified as having the potential to flood roads and cut off communities. The 2015 flash floods critically damaged a bridge on KY 1559 and a bridge on KY 689. Figure 5-7 shows an example of devastating landslides in Pike County.

CHAPTER 6:

FINANCIAL PLANNING

OVERVIEW

TAM financial planning consists of a set of processes that allow a rigorous, long-term assessment of:

- The revenue available to an agency to manage the physical conditions of the assets managed within the TAMP.
- The level of investment in bridges and pavements needed to meet the asset condition targets, to preserve and sustain improved asset conditions, and maintain these assets in a state of good repair.
- The investment strategies that the agency will follow to construct, maintain, preserve, rehabilitate, or replace pavement and bridge assets.
- The level of asset condition and system performance that can be expected based on the selected investment strategies.
- The additional resources or other means required to address current or forecasted differences between desired and expected conditions.

KYTC employs a systematic process to make, track, and refine annual revenue projections. Although historically this process has been used for 6-year projections, the process has been modified to address the 10-year projections included in the TAMP. The process begins with forecasting expected revenue from various sources and monitoring the receipts during each year. This requires significant collaboration between the finance and asset management teams to adjust asset investments and treatment expenditures based on variations between planned and actual revenue figures. This collaborative process engages Cabinet leadership in resolving funding differences in a way that best addresses agency objectives.

The investment strategies included in the TAMP present planned funding levels by work type (i.e., new construction, maintenance, preservation, rehabilitation, and replacement) and year to achieve the Cabinet's asset management targets, and to systematically improve and sustain the assets in a state of good repair. The investment strategies included in the TAMP reflect KYTC's shift towards an in- creased focus on preserving and maintaining existing pavement and bridges. Since not all system conditions are projected to meet de- sired conditions due to funding constraints, the financial plan also includes a gap analysis that identifies the additional resources, or other means, by which KYTC can better achieve its desired performance objectives.

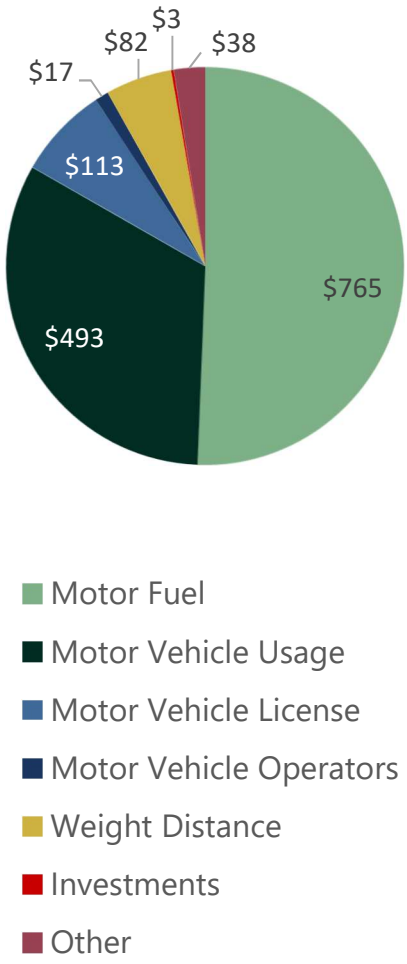


Figure 6-1. 2018 road fund revenue sources ($ millions)

PROJECTED REVENUE

In fiscal year (FY) 2017 KYTC received a total of approximately $2.2 billion dollars in revenue. Of this, approximately $1.51 billion came from various road fund revenue sources, including motor fuel tax, motor vehicle usage tax, vehicle and boat registration fees, motor vehicle operators' licenses and interest. These funds are used by KYTC for engineering (including

highway-related construction, preservation, maintenance, and operations), planning, research, and administrative costs. Some of these funds are directed to local agencies and other agencies for specific uses. Figure 6-1 shows the amounts received through each of the different road fund sources.

Process for Projecting Revenue

A group of economists selected around the state, known as the Consensus Forecasting Group (CFG), has a process to develop annual road fund revenue projections before each upcoming biennial budget legislative session. The CFG reviews revenue sources and analyzes any trends. The team analyzes the trends for gas consumption and vehicle purchases to make realistic projections of the revenue growth from these sources for the next 2 to 3 years. KYTC looks at federal revenue sources and makes projections of the expected funding levels. Once these projections are established, the KYTC finance team continues to monitor the change in road fund revenues to compare projections with actual receipts. Shortfalls and surpluses are closely tracked for cash flow.

Table 6-1 presents a summary of the planned and actual revenue receipts from the various road fund revenue sources for FY 2018. On the federal side, the overall funding projections for the last several years have not changed significantly.

Table 6-1: FY 2018 actual versus estimated road fund revenue comparison ($ millions)

Road Fund Revenue Sources	2018 Actual	2018 Official Estimate
Motor Fuel	$765	$761
Motor Vehicle Usage	$493	$494
Motor Vehicle License	$113	$113
Motor Vehicle Operators	$17	$17
Weight Distance	$82	$81
Investments	$3	$2
Other	$38	$35
Total	**$1,511**	**$1,503**

As shown in table 6-1, the total road fund revenue actually received in FY 201 was slightly higher than the initial projections. Based on this information, the CFG adjusted its FY 2018-2020 revenue estimates to the values shown in table 6-2. The projection for FY 2018-2020, shows an estimated $3 million increase in FY 2019 revenues followed by another $3 million in FY 2020.

Table 6-2: Projected FY 2018-2020 road fund revenue estimates ($ millions)

Road Fund Revenue Sources	2018	2019 Estimate	2020 Estimate
Motor Fuel	$765	$759	$761
Motor Vehicle Usage	$493	$494	$493
Motor Vehicle License	$113	$116	$116
Motor Vehicle Operators	$17	$17	$17
Weight Distance	$82	$82	$83
Investments	$3	$3	$3
Other	$38	$35	$35
Total Revenue	**$1,503**	**$1,506**	**$1,509**

The same trends used to develop table 6-2 were then used to project the road fund revenues for the remaining years included in the TAMP, as shown in table 6-3.

KYTC plans for, and expects, revenue fluctuations to occur. Revenue changes influence the amount available to address various types of agency needs. Small fluctuations in revenue projections do not affect major projects for bridges and pavements that are already in progress. However, if the projections indicate major reductions in revenues, then the start dates for capital projects may be pushed back. In the FY 2016 timeframe, for example, when revenue reductions had been projected, KYTC delayed some large rehabilitation and reconstruction projects and instead used available funds for maintenance and preservation activities that addressed safety needs and prevented further deterioration. Project delays such as these are carefully analyzed so that preservation and maintenance fixes are used to address safety needs and to ensure that severe deterioration, which may be expensive to fix, can be avoided.

If revenue projections are significantly less than the amounts planned, discussions are triggered between Cabinet leadership, the finance team, and the bridge and pavement managers. Bridges and pavements are high-value assets that are among the last to be impacted by minor reductions in funding. However, if the projections for revenue trends show major reductions, then the potential

Table 6-3. Projected 10-year road fund revenue ($ millions)

TAMP Period	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Anticipated Road Fund Revenues	$1,506	1509	$1,509	$1,505	$1,509	$1,505	$1,509	$1,509	$1,509	$1,509

impacts are discussed, and alternate treatment strategies and/or financial scenarios are produced to address the anticipated funding gap. The financial team then presents the recommendations to Cabinet leaders for approval.

Historically, KYTC's financial planning process has given priority to the preservation and maintenance of interstate and NHS pavements and bridges during times of reduced revenue. The sources of the revenues also influence the financial allocation decisions. For example, federal funds come with some restrictions and can be used for only certain types of projects.

FUNDING ASSET MANAGEMENT

KYTC has numerous financial obligations that must be addressed each year, as shown in tables 6-4 (projected federal revenues) and 6-5 (projected road fund revenue). Some of these financial obligations are mandatory, such as making semi-annual debt service payments. All of these financial obligations were accounted for during the development of the TAMP financial plan.

The reduction in federal funding addresses obligations associated with GARVEE bond debt servicing and restrictions in the use of dedicated funds for programs, such as the Surface Transportation Program (STP) and the Congestion Mitigation/Air Quality (CMAQ) program. When GARVEE bonds are issued, they are backed with future federal highway funds. Therefore, table 6-4 reflects the repayment of previously issued GARVEE funds as a reduction in federal revenue. After both GARVEE bond debt and dedicated funds are deducted from the total federal revenue, approximately $5.9 billion remains available for the 10-year period covered in the TAMP.

Table 6-4. 2019-2028 projected federal revenues ($ millions)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Anticipated Federal Highway Funding	$846	$804	$804	$804	$736	$736	$736	$736	$736	$736	$7,674
GARVEE Bond Debt Service	$97	$81	$81	$81	$72	$72	$72	$72	$12	$0	$640
Other Dedicated Federal Funds (STP, TE, CMAQ, etc.)	$108	$105	$110	$110	$110	$110	$110	$110	$110	$110	$1,093
Remaining Project Available Federal Revenues	**$641**	**$618**	**$613**	**$613**	**$554**	**$554**	**$554**	**$554**	**$614**	**$626**	**$5,941**

Similarly, there are many financial obligations that must be addressed from the projected state road fund revenues, as shown in table 6-5. For instance, KYTC must make approximately $1.4 billion dollars in debt service payments from state road fund sources. KYTC will also invest $4.2 billion in essential routine maintenance activities, such as snow and ice removal. Also included within routine maintenance are pavement maintenance activities performed by KYTC field crews, including crack sealing and pothole patching, which average approximately $25 million per year. Approximately $1.1 billion is directly appropriated to other state agencies, $3.4 billion in revenue sharing to local governments, $1.6 billion to administrative costs, and $1.5 billion to pay previous project commitments and to address vehicle regulations, state match and other construction costs. After subtracting these financial obligations from the total state road fund revenue amount, approximately $1.3 billion is available for asset management activities over the 10-year period.

Table 6-5. Projected FY 2019-2028 state road fund revenues ($ millions)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Anticipated Road Fund Revenues	$1,506	$1,509	$1,505	$1,509	$1,505	$1,509	$1,509	$1,509	$1,509	$1,509	$15,079
Direct Appropriations to Other State Agencies	$111	$112	$112	$112	$112	$112	$112	$112	$112	$112	$1,119
Debt Service	$174	$161	$161	$149	$142	$142	$142	$124	$110	$98	$1,403
Routine Maintenance (snow and ice, mowing, etc.)	$387	$389	$389	$389	$440	$440	$440	$440	$440	$440	$4,194
Road Fund Construction Expenditures Required to Pay	$188	$126	$83	$55	$36	$24	$16	$11	$7	$5	$551
Cabinet Administrative Costs	$144	$144	$153	$154	$164	$164	$174	$174	$174	$174	$1,619
Revenue Sharing	$342	$343	$342	$343	$342	$343	$343	$343	$343	$343	$3,427
Total Vehicle Regulations, State Match, and Other Construction	$82	$123	$138	$138	$168	$168	$168	$168	$168	$168	$1,489
Additional Anticipated Reductions to Road Fund	$1,428	$1,398	$1,378	$1,340	$1,404	$1,393	$1,395	$1,372	$1,354	$1,340	$13,802
Remaining Projected Available Road Fund Revenue	**$78**	**$111**	**$127**	**$169**	**$101**	**$116**	**$114**	**$137**	**$155**	**$169**	**$1,277**

Based on current estimates, the KYTC projects a total of $22.75 billion to be available over the 10-year TAMP period starting in FY 2019. Approximately $7.7 billion of this is from federal highway fund sources and the remaining $15.1 billion from state road fund sources. Figure 6-2 shows approximately 68 percent of the total funding projected to be available for the 10 years included in the TAMP will be derived from state road fund sources and 32 percent will be derived from federal highway fund sources.

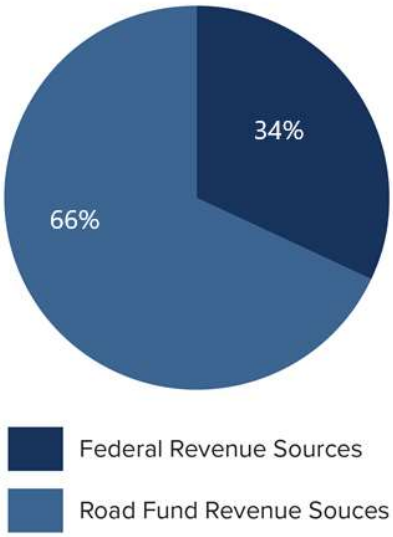


Figure 6-3. 10-year revenue split

Although the KYTC is projected to have over $22.75 billion in state road and federal highway revenue over the 10-year period, approximately 68 percent of this total will go toward addressing KYTC's financial obligations. Only 10 percent of the total state road fund revenue and 73 percent of the federal highway fund sources are expected to be available to fund asset management needs as shown in figure 6-3.

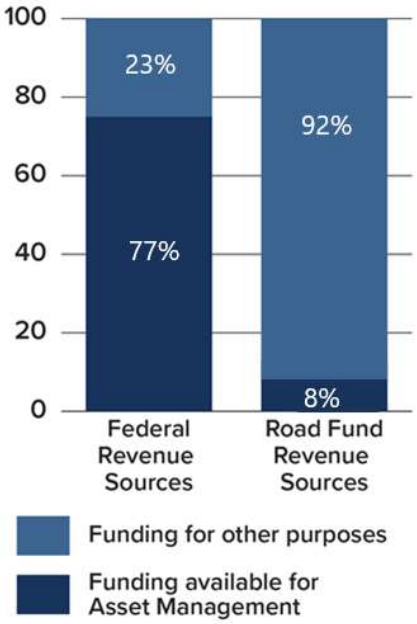


Figure 6-2. Revenue available for asset management after routine reductions

Table 6-6 summarizes the total projected federal highway funding and state road fund revenue and the amount remaining for asset management after other financial obligations are addressed. As shown, approximately $7.2 billion (or 31 percent of the total amounts projected to be available over 10 years) is available to address asset management activities. The bridge and pavement investment strategies are funded from the $7.2 billion, as are other system preservation needs, such as guardrail installation and maintenance, pavement markings, and culvert maintenance and repair.

Table 6-6: Projected 10-year available revenue after financial obligations ($ millions)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Total projected federal and state road fund revenue	$2,352	$2,313	$2,309	$2,313	$2,241	$2,245	$2,245	$2,245	$2,245	$2,245	$22,753
Total federal and state road funding after deductions	$719	$729	$740	$782	$655	$670	$668	$691	$769	$795	$7,218

FORECASTING PAVEMENT AND BRIDGE ALLOCATIONS AND NEED

KYTC allocates funding to programs to maintain and improve pavement and bridge through several mechanisms, including the *SYP*, the MP Paving program, and the KYTC maintenance budget. In the past, KYTC asset managers have collaborated with leadership to develop short-term forecasts based on cash balance projections from the KYTC finance team. These forecasts served to guide the development of specific bridge and pavement preservation projects. This year, the process was expanded to develop 10-year forecasts in accordance with TAMP requirements. This collaborative process is expected to continue in the future, as KYTC increasingly relies on long-term projections.

Pavement and bridge funding allocations are developed based on an analysis of anticipated revenue forecasts and estimates of funding needs for each asset class based on the life cycle planning (LCP) processes described in Chapter 4.

In some cases, the KYTC budget restricts how certain funds can be allocated. Examples include specific allocations for Highway Maintenance forces, or paving MP highways. Other funding allocations are established through capital planning and programming processes, such as the *SYP*, described in Chapter 2.

The funding allocations described in this Chapter represent KYTC's first steps toward implementing the LCP strategies for pavement and bridge assets that are described in Chapter 4. These strategies apply significantly higher priorities to maintenance and preservation work types than the Cabinet has used historically. However, the proposed funding allocations do not fully implement the preferred life cycle strategies outlined in Chapter 4 since it will take time for guidance to be developed on the use of appropriate treatments, for agency staff to be trained, and for contractors to build up their capabilities. KYTC will work with its stakeholder groups through the annual budget and biennial

capital programming processes, to incrementally implement and improve its pavement and bridge life cycle strategies over time.

Planned 10-Year Pavement Funding Allocations

Table 6-7 presents the planned funding allocation for pavements over the 10-year period covered in the TAMP. It shows an overall projected revenue allocation of $3.4 billion in federal and road funding to improve and sustain interstates, parkways, and MP pavements. The table shows the costs varying between a low of $255 million in FY 2020 and reaching a high of $362 million which remains constant for fiscal years 2025-2028. The average over the 10-year period is $337.3 million.

10-Year Pavement Needs

Table 6-8 shows that the total investment level required for the KYTC road network to achieve the desired state of good repair is estimated to be $4.954 billion over the 10-year period. As shown in the table, the projected investment needs fluctuate each year, but increase substantially beginning in FY 2024. The gap between the total amount needed to address pavements, and the amount expected to be available, is discussed in the following section.

Table 6-7 Planned 10-year pavement funding allocations ($ millions)

Projected Pavement Funding Allocations	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Projected Federal Pavement Allocations	$207	$115	$192	$175	$187	$201	$222	$222	$222	$222	$1,965
Projected Road Fund Pavement Allocations	$148	$140	$140	$140	$140	$140	$140	$140	$140	$140	$1,408
Total Projected Funding Allocations	**$355**	**$255**	**$332**	**$315**	**$327**	**$341**	**$362**	**$362**	**$362**	**$362**	**$3,373**

Table 6-8. Expected 10-year pavement needs ($ millions)

Work Types	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Maintenance	—	—	—	—	—	—	$2	$2	$1	$1	$6
Preservation	$234	$247	$298	$365	$306	$606	$571	$627	$681	$785	$4,720
Rehabilitation	$27	$23	—	—	—	—	—	—	—	—	$55
Replacement	$25	$79	$27	—	—	—	$21	$26	—	—	$178
Total Pavement Investment Needs	**$286**	**$349**	**$325**	**$365**	**$306**	**$606**	**$594**	**$655**	**$682**	**$786**	**$4,954**

The anticipated needs shown in table 6-8 show that most of the funds (95 percent) are needed to address pavement preservation and preventive maintenance work activities, while only 5 percent is needed to address rehabilitation and replacement work activities. This illustrates KYTC's commitment to its pavement investment strategies that use pavement preservation and preventive maintenance activities to maintain the pavement network in relatively good condition, while systematically addressing the pavement rehabilitation and replacement needs that exist.

Funding Needs and Planned Pavement Investments by Network

As discussed in the previous section, there is a gap between the funding needed to address the pavement needs and the funding available. This section of the TAMP outlines the funding needs by system and presents KYTC's plans for using available funds to address the needs on interstates, parkways, and MP routes. The planned investments place a priority on addressing the needs of the higher-volume facilities that carry the most freight traffic.

Interstate Needs and Planned Investments

The interstate highway investment needs to achieve the desired state of good repair within the 10-year timeframe are shown in table 6-9. As shown, the needs on this system increase by more than 500 percent over the 10-year period, with funding needs of $48 million in FY 2019 and $250 million in FY 2028. Most of the interstate needs can be addressed with preservation activities. The total preservation needs fluctuate annually but increase from $72 million in FY 2019 to $251 million by FY 2028.

Table 6-9: Anticipated FY 2019-2028 interstate system pavement investment needs ($ millions)

Work Types	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Maintenance	—	—	—	—	—	—	$2	$2	$1	$1	$6
Preservation	$48	$43	$81	$86	$148	$214	$197	$223	$254	$250	$1,458
Rehabilitation	$24	$21	—	—	—	—	—	—	—	—	$45
Replacement	—	—	—	—	—	—	$16	—	—	—	$16
Total	**$72**	**$64**	**$81**	**$86**	**$148**	**$214**	**$215**	**$225**	**$255**	**$251**	**$1,611**

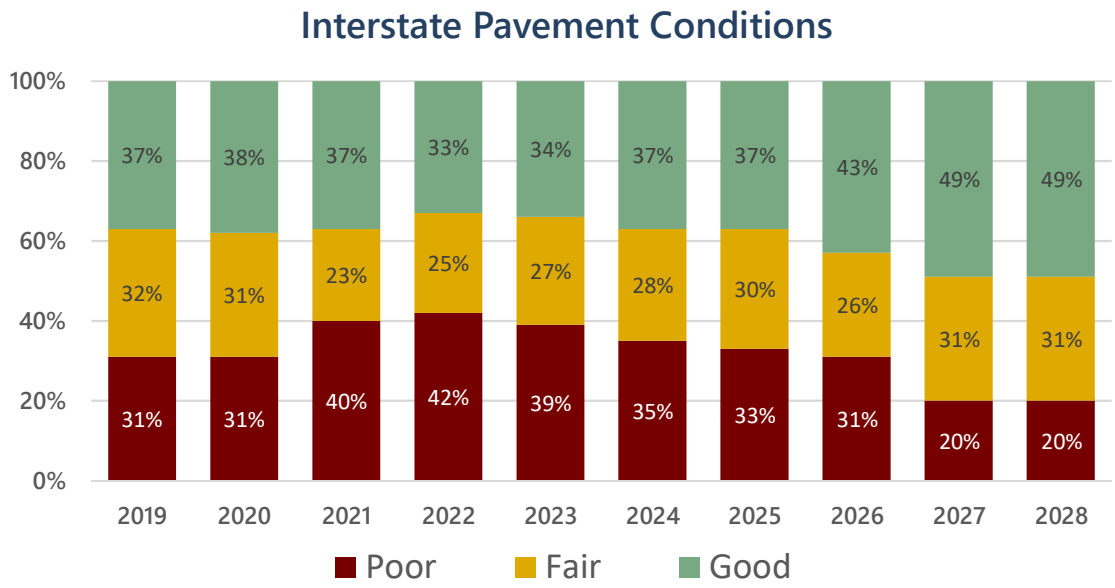


Figure 6-4: Interstate pavement conditions

The planned investments for the interstate system over the 10-year period are presented in table 6-10. The first 6 years of this plan are based on specific projects currently recommended in the *SYP*. The final 4 years are based on anticipated levels of federal funding and priorities identified by KYTC on interstate routes. Figure 6-4 shows the forecasted conditions for interstate pavements based on the planned investments.

Table 6-10: Planned FY 2018-2027 interstate pavement investments ($ millions)

Work Types	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Maintenance	—	—	—	—	—	—	$2	$2	$1	$1	$6
Preservation	$48	$43	$81	$86	$148	$139	$97	$98	$104	$104	$948
Rehabilitation	$24	$21	—	—	—	—	—	—	—	—	$45
Replacement	—	—	—	—	—	—	$16	—	—	—	$16
Total	**$72**	**$64**	**$81**	**$86**	**$148**	**$139**	**$115**	**$100**	**$105**	**$105**	**$1,015**

Parkway Needs and Planned Investments

The projected needs for parkway pavements are presented in table 6-11. This investment level is needed to allow the parkway pavements to achieve the desired state of good repair. KYTC plans to address all the needs on the parkway system over the 10-year period, using its optimized preservation life cycle strategy. This strategy begins with a $5 million investment in preventive maintenance overlays in FY 2019 that increases to $10 million over the remaining plan years. The resulting conditions are presented in figure 6-5.

Table 6-11. Anticipated FY 2019-2028 parkway pavement investment needs ($ millions)

Work Types	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Preservation	$60	$79	$92	$91	$22	$60	$30	$35	$35	$35	$539
Rehabilitation	$3	$2	—	—	—	—	—	—	—	—	$5
Replacement	—	—	—	—	—	—	$5	$10	—	—	$15
Total	**$63**	**$81**	**$92**	**$91**	**$22**	**$60**	**$35**	**$45**	**$35**	**$35**	**$559**

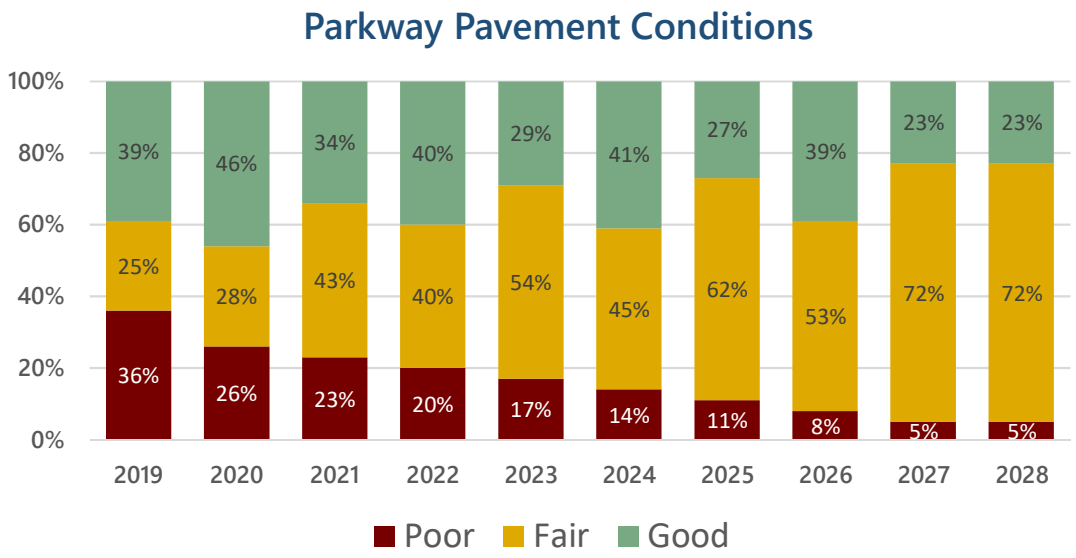


Figure 6-5. Forecasted FY2019-2028 parkway pavement conditions

MP Needs and Planned Investments

Table 6-12 shows the MP system needs to achieve the desired state of good repair. It shows a $25 million need in reconstruction and replacement in FY 2019 to address assets that are in *Poor* condition, requiring reconstruction or replacement. There is a significant need for thin treatments in the later years. The anticipated thin treatment needs are based on the currently available data from KYTC's relatively new preservation program, therefore, KYTC chose to provide conservative estimates for their future needs. As a result, KYTC is optimistic that its planned optimized preservation strategy will reduce these needs without increasing required funding by slowing the overall rate of system deterioration.

Table 6-12. Anticipated FY 2019-2028 MP pavement investment needs ($ millions)

Work Types	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Preservation	$125	$125	$125	$188	$137	$332	$344	$369	$392	$392	$2,529
Replacement	$25	$79	$27	—	—	—	—	—	—	—	$131
Total	**$150**	**$204**	**$152**	**$188**	**$137**	**$332**	**$344**	**$369**	**$392**	**$392**	**$2,660**

Table 6-13 shows the planned investments for the MP pavements between FYs 2019 and 2028. This investment level assumes that no new funding will be provided for MP highways over the 10-year period covered in the TAMP. Figure 6-6 shows the resulting forecasted MP pavement conditions.

Table 6-13. Planned FY 2019-2028 MP pavement investments ($ millions)

Work Types	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Preservation	$125	$125	$125	$188	$137	$132	$119	$119	$117	$117	$1,304
Replacement	$25	$79	$27	—	—	—	—	—	—	—	$131
Total	**$150**	**$204**	**$152**	**$188**	**$137**	**$132**	**$119**	**$119**	**$117**	**$117**	**$1,435**

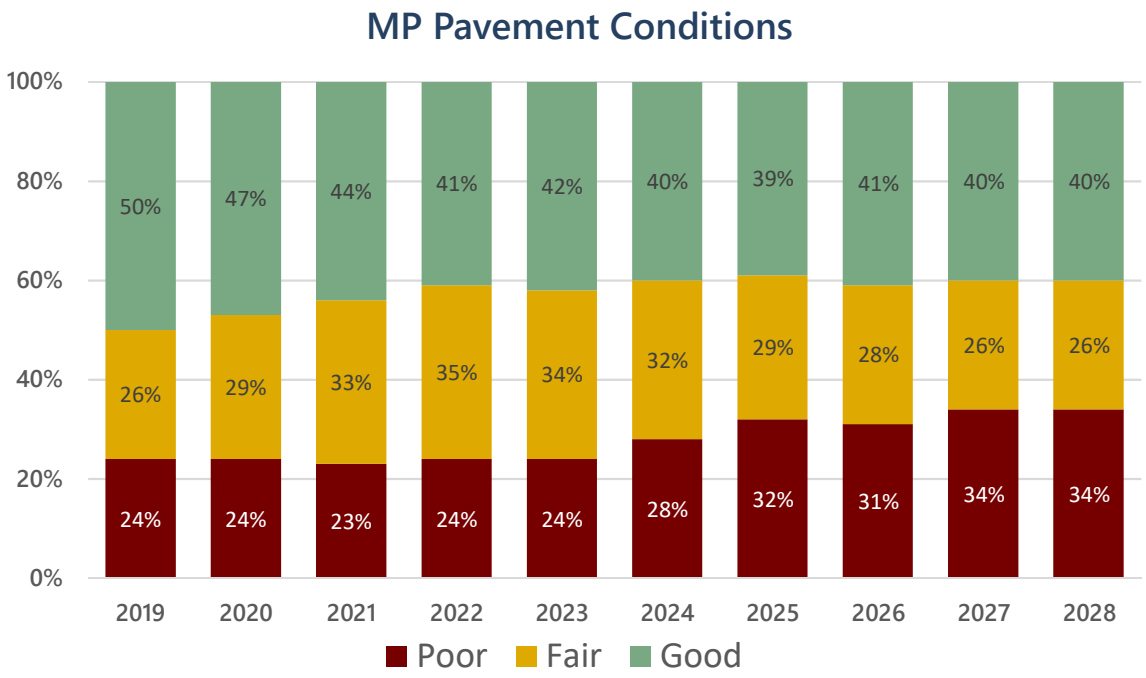


Figure 6-6 Forecasted 2019-2027 MP pavement conditions

Planned 10-Year Bridge Funding Allocations

KYTC plans to allocate $1.8 billion to bridges for the 10-year period from FY19 to FY28. Table 6-14 shows annual fluctuations in the funding available that reflect anticipated bridge needs in specific years. The cost of bridge treatments varies depending on the size of the structure and the type or complexity of the necessary treatment. The table shows the costs varying from a high of $282 million in FY 2020 to a low of $130 million in FY 2021, with an average of $180 million over the 10-year period.

Table 6-14. Planned 10-Year bridge funding allocations ($millions)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Projected Federal Bridge Allocations	$185	$257	$100	$100	$209	$134	$122	$122	$122	$122	$1,473
Projected State Bridge Allocations	$25	$25	30	$30	$30	$30	$30	$30	$30	$30	$290
Total	**$210**	**$282**	**$130**	**$135**	**$239**	**$164**	**$152**	**$152**	**$152**	**$152**	**$1,763**

10 Year Bridge Needs

Table 6-15 presents the projected investment needed to achieve the condition targets shown in figure 6-7, which shows forecasted conditions for state-owned bridges. Bridge conditions are compared to targets in figures 6-8 and 6-9. Table 6-15 shows an increase in projected investment needed for rehabilitation, preservation, and maintenance, and a systematic reduction in the projected investment for replacement over the TAMP period. This need is aligned with the bridge life cycle strategy described in Chapter 4. KYTC has expanded its pilot of its bridge preservation program in FY 2018.

Table 6-15. Expected 10-year bridge needs ($millions)

Work Types	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Routine Maintenance	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$50
Preservation and Preventive Maintenance	$26	$26	$26	$26	$35	$35	$35	$35	$35	$35	$314
Rehabilitaiton	$53	$53	$70	$70	$70	$70	$70	$70	$79	$79	$684
Replacement	$96	$96	$79	$79	$70	$70	$70	$70	$61	$61	$752
Total Bridge Needs/Year	**$180**	**$180**	**$180**	**$180**	**$180**	**$180**	**$180**	**$180**	**$180**	**$180**	**$1,800**

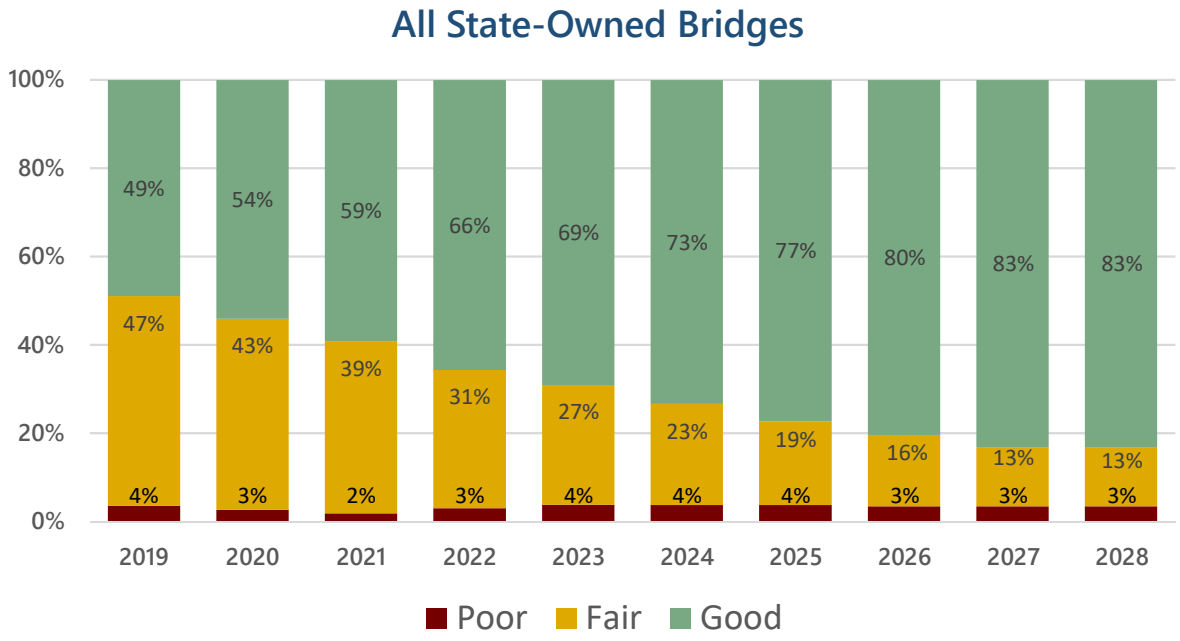


Figure 6-7: Forecasted FY 2019-2028 state-owned bridge conditions by deck area

In FY 2019, the projected funding for preservation and maintenance is $26 million. This increases to $35 million in 2023 and remains at this increased amount for the remainder of the analysis period. Similarly, the projected FY 2019 investment in rehabilitation is $53 million in FY 2019 and to $70 million in FY 2021, where it remains for the duration of the 10-year period. In contrast, the projected expenditure for replacement decreases gradually from $96 million in FY 2019 to $61 million in FY 2027. The result of these shifts is that preservation expenditures grow by 33 percent over the 10-year period, rehabilitation increases by 80 percent, and replacement decreases by 42 percent. As a result of this strategy, KYTC will be reducing the life cycle cost of managing its bridge inventory each year.

PERFORMANCE GAP ANALYSIS

The KYTC asset management philosophy is that "good assets cost less to maintain". This philosophy is reflected in the Cabinet's optimized preservation strategy that keeps assets in *Good* condition at that condition level while those in *Fair* condition are either improved or preserved, so they do not drop into a *Poor* category. The optimized preservation strategy also includes a systematic approach to managing assets in *Poor* condition that addresses their needs with rehabilitation or reconstruction, so they can be preserved with low-cost treatments in future years. This philosophy is reflected in the planned investment strategies presented in this TAMP.

KYTC does not have adequate funding to achieve its desired state of good repair by 2027, so a funding gap exists. This funding gap was analyzed using the same analysis tools used to develop KYTC's life cycle strategies. The funding gap analysis looked at different strategies that could be employed to eliminate the gap and improve system performance.

Pavement Performance Gap

KYTC uses a customized condition rating system to report current and expected pavement conditions in terms of the percentage of the network in *Good*, *Fair*, or *Poor* condition. This rating system, which is described in more detail in chapter 2, is directly related to the need to perform work on the pavement network, which KYTC believes reflects the expectations of its highway users. The desired state of good repair and projected KYTC pavement conditions are established using this condition rating system.

Quantifying the Pavement Performance Gap

As described in chapter 2, KYTC's desired state of good repair for pavements is no more than 8 percent of the pavement network in *Poor* condition. Figure 6-8 shows the 10-year projected conditions for the KYTC pavement network, which show that conditions are expected to decline slightly and the desired state of good repair will not be met by 2028.

Pavement Performance Gap Analysis

Current projections indicate a slight decline in conditions over the TAMP timeframe, the increased use of preventive maintenance treatments in the recommended *SYP* results in a smaller performance gap than would be expected under historic spending levels. This is demonstrated in figure 6-9. By adopting the recommended *SYP*, KYTC will keep approximately 18 percent more lane-miles from falling into *Poor* condition over the TAMP timeframe.

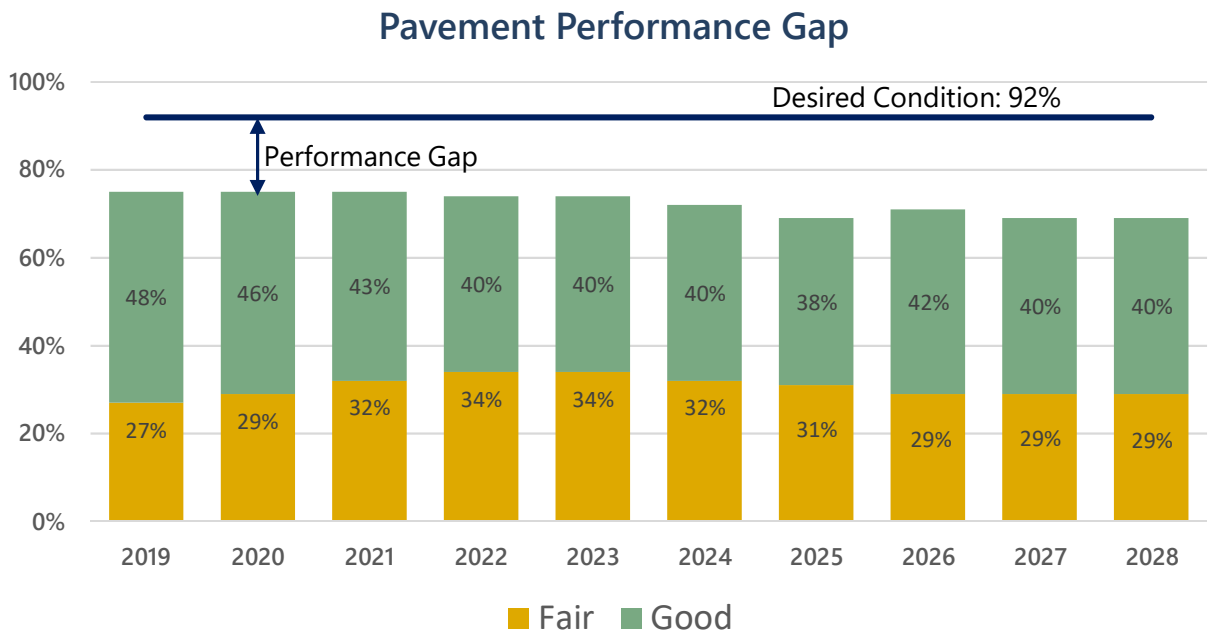


Figure 6-8. Forecasted systemwide pavement performance gap

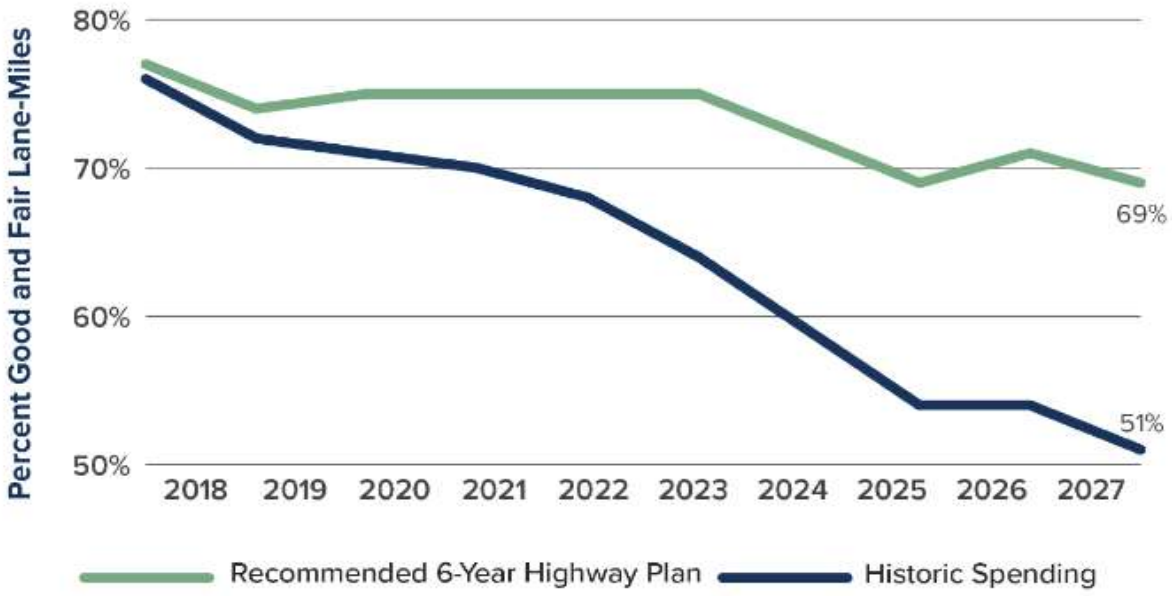


Figure 6-9. Benefits of recommended pavement investment strategy

In addition to the benefits expected from the change in investment strategy described above, it is possible that the conditions will not decline as severely as projected in figure 6-9 once KYTC has fully implemented its *optimize preservation* life cycle strategy for pavements. KYTC's *optimize preservation* strategy includes expanding the use of preventive maintenance overlays on MP and parkway pavements and beginning their use on interstates. The full impact of these treatments may not be known for a few years, as KYTC introduces the use of preventive maintenance treatments on interstates. KYTC is currently evaluating the use of preventive maintenance overlays on interstate pavements but has not used them to date. Experience in other states has shown that preventive maintenance overlays can be a cost-effective means of improving interstate pavement conditions. However, their use on interstates requires the use of higher-quality materials and tighter control of construction practices to perform. This is due to the higher traffic levels and truck loadings that are typical on interstate pavements. As KYTC and the contracting industry become more familiar with these products, and the specifications mature, improved performance may be possible.

KYTC is optimistic regarding the potential impact of preventive maintenance overlays on interstates because its LCP analysis showed these overlays will have a dramatic impact on parkway conditions. Pavement conditions on parkways are expected to improve over the TAMP timeframe to achieve the desired state of good repair, as shown earlier in figure 6-6. The significant improvement expected on the parkway system is largely a result of increasing the use of preventive maintenance over- lays on this network. As the use of preventive maintenance overlays increases across the network, it is possible that conditions will improve to a greater degree than the current pavement prediction spreadsheet is indicating. For development of its final TAMP, KYTC expects to have its fully-functional pavement management system available. This system will be better able to model the behavior of all treatments and should allow KYTC to have greater confidence in long-term pavement condition forecasts.

Closing the Pavement Performance Gap

This is KYTC's first attempt to predict pavement conditions over a 10-year period, and it is being performed at a time when the agency is changing its pavement life cycle strategy, capital program development process, and analysis tools. Each of these may have a significant impact on the accuracy of forecasted conditions. KYTC feels the current forecast is conservative but provides a good basis to understand what will be needed if improved tools and treatments do not result in improved performance.

Using the current pavement condition forecasts, KYTC analyzed a scenario to determine

the level of funding needed to achieve the desired state of good repair for pavements. Figure 6-10 shows the result of this analysis, comparing projected pavement funding levels to the forecasted funding needs. The resulting funding gap is approximately $1.8 billion or $180 million per year between 2019 and 2028. As described above, KYTC is currently optimistic that actual results will be better than what is currently predicted, and the performance gap can be closed at a lower level of investment.

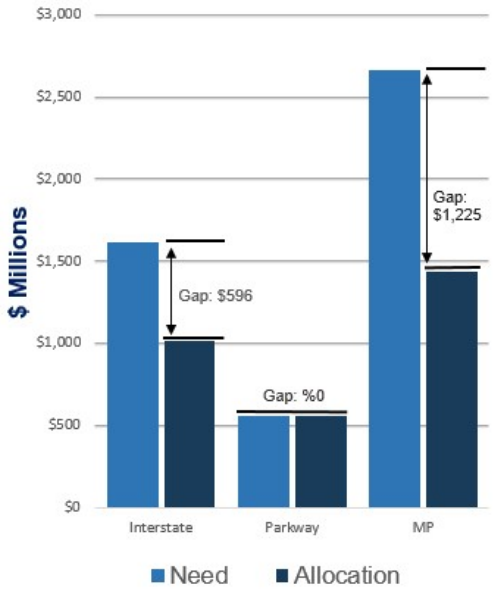


Figure 6-10. Pavement Need vs. Allocation by Network ($ millions)

Bridge Performance Gap Analysis

As described in Chapter 2, KYTC has established a desired state of good repair of no more than 3 percent of the bridge deck area in *Poor* condition. Figure 6-11 shows that KYTC's planned investment strategy will allow its bridges to maintain the current state of good repair conditions throughout the TAMP time period. Therefore, there is no anticipated performance gap for bridges.

CONSIDERATION OF SYSTEM PERFORMANCE

KYTC uses an objective, data-driven approach to project prioritization that considers the needs within each performance area. This approach allows KYTC to develop a program that balances the needs of the highway network across all performance areas and objectives. This process supports achieving the best balance of performance for all highway users. Federal regulations require that states manage and report system performance in the following national goal areas:

- Safety.
- Infrastructure Condition.
- Congestion Reduction.
- System Reliability.
- Freight Movement and Economic Vitality.
- Environmental Sustainability.
- Reduced Project Delivery Delays.

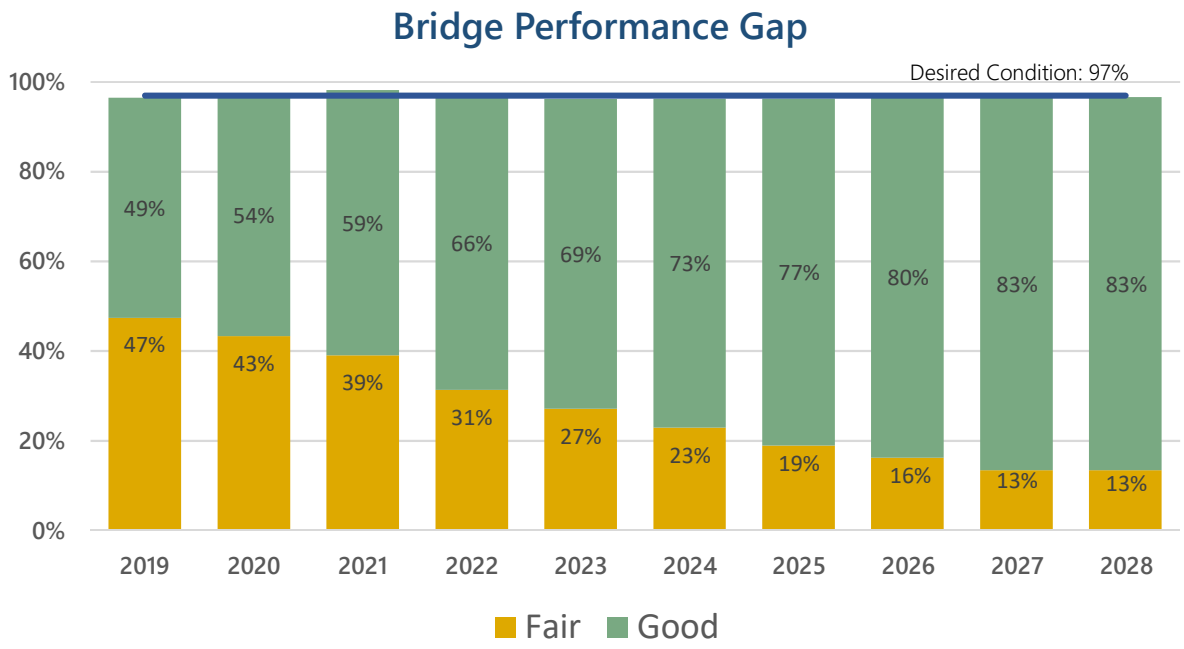


Figure 6-11. Forecasted conditions for KYTC bridges

Effective performance management requires an understanding of the interconnection between performance areas. For example, an improvement in highway conditions has a positive impact in the other performance areas. However, maximizing asset conditions at the expense of needed investments in the other performance areas would not lead to the best overall system performance. The KYTC program must support all areas of system performance in a balanced way and the SHIFT program has helped achieve this.

SHIFT KENTUCKY AHEAD

SHIFT incorporates benefits in each of the national goal areas into a common, objective project prioritization process. This process is used to rank capital projects for inclusion in the 6-year Capital Investment Plan. The formula is an objective approach that uses data on safety, congestion, asset management, economic growth, and cost-benefit ratios.

SHIFT is a data-driven tool to help prioritize spending of limited transportation dollars, estimated at $2.6 billion over the next 6-year cycle (FY 2018–FY 2024) based on current funding sources. The statewide and regional lists developed under SHIFT scoring are incorporated into the 6-Year Highway Program, which is proposed by the Governor, and finalized through the legislative process.

The first step in identifying funding priorities is to identify and rank projects with statewide significance—interstates and highways that move people and goods from one Kentucky region to another and to other states. The statewide list identifies projects that are part of the NHS as projects of statewide significance. These projects were recommended through the statewide funding pool, which was recently approved for the *2018 to 2024 Highway Plan*.

The next step in the SHIFT process focuses on ranking regional projects and transportation improvements within geographical sections of the Commonwealth. For this process, KYTC has grouped the state's 12 highway districts into four geographic regions—North, South, East, and West— consisting of three districts each. Cabinet leadership met with local transportation leaders (Area Development Districts, Metropolitan Planning Organizations, and KYTC District Offices) within each region to decide which projects to prioritize for consideration for funding in the *SYP*, at the regional lev- el. In the first application of SHIFT in 2017, the groups considered more than 1,000 projects that had been scored using SHIFT, including those NHS projects that were determined not to have statewide significance.

Through the SHIFT process, asset condition and the ability to improve that has been considered along with economic growth opportunity, safety enhancements, congestion improvements, and project benefit-cost as leaders determine project priorities for the proposed budget cycle. Projects that may reduce congestion and also address a *Poor* pavement section or bridge scored higher than projects that only reduce congestion. Projects receiving the highest combined scores were included in the draft recommended *SYP*.

IMPLEMENTATION REVIEW

Subsequent to the development of KYTC's initial TAMP in 2018, the Kentucky General Assembly passed House Bill 202: the 2018-2024 Kentucky Six-Year Highway Plan, which was signed into law by Governor Bevin on April 13, 2018. The enacted SYP incorporated the recommended programmatic changes to the identification and prioritization of highway construction projects, including the KYTC's emphasis on Asset Management and SHIFT. Minor changes were made to the schedule of some projects – primarily to accelerate construction ahead of the recommended schedule – but the final enacted plan closely aligned with the draft plan submitted by the Governor's Office.

Separately, the biennial Transportation Cabinet Budget was enacted on April 26, 2018 which provides maintenance funding for KYTC's bridge and pavement needs as well as construction funding that is utilized in the annual resurfacing program. This section outlines the total funding amounts made available in FY 2019 to the various asset management efforts and compares those amounts to the expected funding identified in the initial TAMP.

PAVEMENT FUNDING

Pavement funding in FY 2019 was moderately consistent with anticipated spending levels identified in the initial TAMP. However, the advancement of one large Parkway project from to FY 2018 reduced the amount of funding available in FY 2019, while also addressing a major pavement need. The project was located on the Pennyrile Parkway in Christian County, and was awarded in 2018 for $40 million. Table 6-16 shows total pavement funding for all work types in FY 2019.

Total pavement funding for FY 2019 fell short of the $286 million anticipated, with much of the difference due to a reduced amount of overall preservation spending. Reduced spending on pavement replacement projects was largely offset by increased spending on rehabilitation projects.

Work Types	Anticipated FY19 Funding	Actual FY19 Funding
Maintenance	$0	$0.3
Preservation	$234	$185.8
Rehabilitation	$27	$49.8
Replacement	$25	$0.2
Total	$286	$236.1

Table 6-16. Anticipated and Actual FY 19 Pavement Funding

BRIDGE FUNDING

The total bridge funding in FY 2019 aligned well with anticipated funding defined by KYTC's initial TAMP and shown in table 6-17. Although Rehabilitation and Replacement have been identified as separate work types within the TAMP, the SYP did not distinguish between the two. Instead, bridges in need of rehabilitation or replacement were identified with project descriptions which indicated the project would "address deficiencies" of the structure. The intent of this language was to allow KYTC the flexibility to modify the work type for individual structures based upon the level of effort necessary to eliminate any load posting requirements. The total funding provided to address deficiencies was intended to be roughly equivalent to the total rehabilitation and replacement needs identified in the TAMP. As shown in Table 6-17, the SYP provided $150.5 million for these needs, as compared to $149 million identified in the TAMP.

Table 6-17. Anticipated and Actual FY 19 Bridge Funding

Work Types	Anticipated FY19 Funding	Actual FY19 Funding
Routine Maintenance	$5	$4.8
Preservation and Preventive Maintenance	$26	$24.7
Rehabilitation	$53	$150.5
Replacement	$96	
Total	**$180**	**$180**

TAMP INFLUENCE ON HIGHWAY PLAN DEVELOPMENT

While the overall asset management spending in FY 2019 did not perfectly align with the funding levels called for in KYTC's initial TAMP, these minor discrepancies are not indicative of a lack of support for asset management within the agency. It is anticipated that all of the planned asset management projects will ultimately be delivered in a timeframe consistent with the overall goals of the program. Furthermore, current efforts underway for development of the FY 2020-2026 Six-Year Highway Plan have relied heavily upon the TAMP to establish spending levels for pavements and bridges in a way that will support KYTC's long term asset management goals. The inclusion of these projects in the SYP is a good indicator of KYTC's commitment to asset management principles and intent to use the TAMP as a tool which will guide the cabinet's long-term decision-making processes.

SUMMARY

KYTC expects to achieve the desired state of good repair for bridges by the end of 10 years and is managing pavements to achieve the best overall possible conditions with available resources. Table 6-7 shows $3.37 billion anticipated revenue allocation for pavements in the 10-year plan period. Table 6-14 shows that the anticipated revenues allocated by KYTC for bridges is $1.8 billion. The revenue allocations and the predicted expenditures by work type and year discussed in this chapter clearly show that the projected investment levels will enable KYTC to achieve the mandated asset condition targets for NHS pavements and bridges. Also, the investments reflected in the financial plan shown in this chapter are adequate to ensure that the pavements on the interstate and non-interstate NHS and the bridges on the NHS will be in a state of good repair. There is some financial gap between the overall pavement investment needs and projected budget allocations to achieve the KYTC's desired state of good repair for all pavements.

However, the investments in the pavement network reflects KYTC's strategy to rehabilitate the pavements in the earlier years and systematically move towards increased preservation and maintenance.

As demonstrated in this chapter, KYTC has a detailed financial plan as well as a systematic process to forecast, monitor, and revise its revenue sources where appropriate. It has a methodical approach to project investment needs based on asset conditions and targets. The KYTC strategy that drives the selection of treatments and investments in the different work types each year of the 10-year plan clearly shows the focus on asset management. The SHIFT program further corroborates the KYTC's philosophy to fix and keep the pavements and bridges in a state of good repair.

Since the submittal of the initial TAMP, KYTC has largely implemented its planned strategy for asset management – particularly for bridges – but will need to increase pavement preservation funding in future years in order to meet long-term performance targets. Furthermore, the cabinet has demonstrated a commitment to implementation of asset management by incorporating the recommendations of the TAMP into the development of the FY 2020-2026 SYP. ■

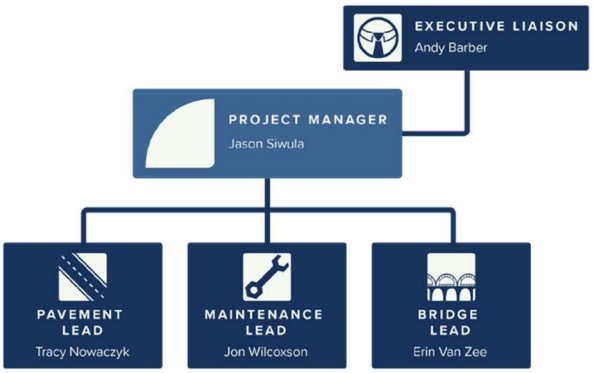
CHAPTER 7: ASSET MANAGEMENT ENHANCEMENTS

OVERVIEW

TAMP Development Team

Transportation asset management is a cross-functional discipline that requires communication and coordination across nearly all business units within a transportation agency and with external stakeholders. KYTC's TAMP efforts are led by a cross-functional team from multiple business units, referred to as the TAMP Core Team. The Core Team, as shown in figure 7-1, is organized to represent the key stakeholder groups involved in developing and implementing the TAMP. The Core Team members led and supported all aspects of the TAMP development and will coordinate continuing implementation efforts. In support of the Core Team, four work groups oversee critical TAMP components, as shown in figure 7-2.

Figure 1. TAMP core team roles



The TAMP work groups provided technical expertise in support of documenting current practices for life cycle planning, risk management, gap identification, financial planning, and investment strategy development. The TAMP work groups also helped develop and review defined levels of service, performance measures and targets, and maintenance and capital cost estimates for pavements and bridges. During the TAMP development, there were several TAMP work group meetings to discuss the above information.

Overseeing Asset Management After the TAMP

Moving forward, asset management will continue to be championed and supported by the State Highway Engineer's Office, as well as members of the Core Team and work groups. KYTC will continue to evaluate opportunities to enhance the effectiveness of asset management concepts and implementation. Asset management is the responsibility of the entire Cabinet. This structure will allow KYTC to work across organizational units in a collaborative way and ensure responsibility for managing KYTC's pavement and bridge assets is shared across the agency.

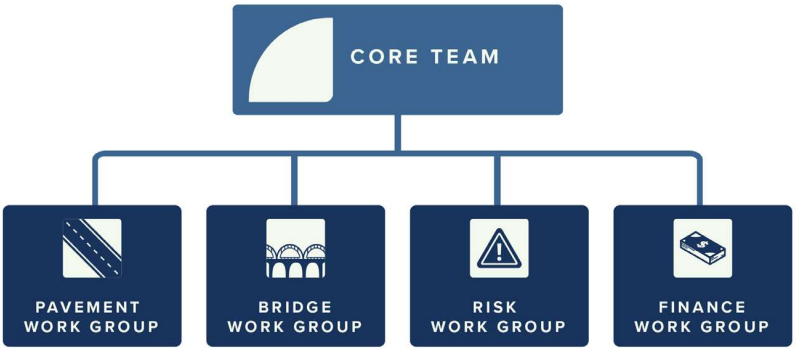


Figure 2. TAMP work groups

CONTINUAL IMPROVEMENT

Transportation asset management is a continual improvement process. Advancements in asset management are made by regularly assessing performance, and determining the best course of action to facilitate improvement. The continuous improvement process has four primary steps, as shown in figure 7-3.

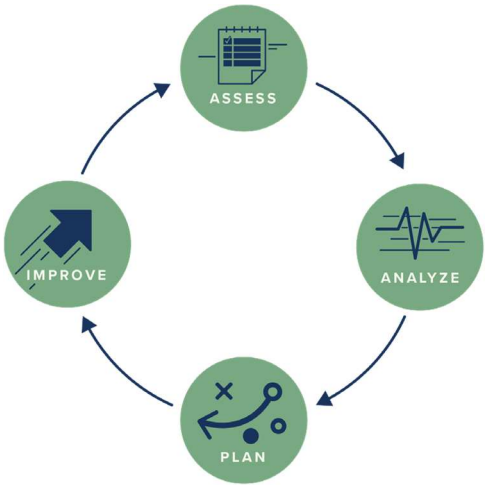


Figure 3. Continual improvement process

Assess

Implementing asset management requires changes and improvements to business processes, technology, and organizational capacity. Several models exist for assessing the maturity of an agency's asset management program. KYTC conducted a self-assessment of its asset management practices as part of developing the TAMP. This effort focused on the skills, tools, and data needed to develop the TAMP components listed below.

- Asset Management Objectives
- Asset Inventory and Performance
- Life Cycle Planning
- Risk Management
- Financial Plan
- 10-year Investment Strategies

For each of these areas, the current capabilities, gaps between current and desired practices, and actions to address each gap were assessed. This assessment led to many improvements that were implemented to develop the TAMP, as well as enhancements to KYTC's asset management practices, tools, and organization that will be implemented following the TAMP.

Analyze

The self-assessment process included discussions on the best means of developing the TAMP and maturing the agency's asset management practices. In the case of both pavements and bridges, this approach led to the use of existing analysis tools for developing the TAMP, while ongoing efforts were conducted to implement more robust management systems that could be used in developing future TAMPs.

Identifying gaps in asset management bus-

iness practices also led to discussions on how best to develop the Risk Register, 10-year financial plan, and other TAMP components.

Plan

The process gaps were documented in a report that was used to guide TAMP development. Following delivery of the TAMP, this report will be further expanded with lessons learned through the TAMP-development process to create a TAM Roadmap that identifies technical, organizational, workforce development, and policy issues to be resolved. The Roadmap will serve as a tool to help guide implementation of the TAMP within KYTC to achieve the asset management goals and objectives. The Roadmap will summarize the need for enhancements in asset management practice, including changes that are needed to advance the implementation of asset management using a common framework. In addition, the Roadmap will consider the availability of asset data and analysis tools to support performance-based decision making, and the consideration of life cycle strategies, risk, and strategic objectives as the basis for developing investment strategies.

Improve

KYTC is committed to delivering the enhancements described in this TAMP. Each enhancement will be delivered by staff who will utilize the enhancement in their routine work, not simply for updating the TAMP every 4 years. In this manner, asset management tools and processes are being implemented throughout the Cabinet, making asset management part of the new way of doing business.

Asset management tools and principles are being implemented at all levels of the Caibnet. Following completion of the TAMP, the Core Team will hold an executive workshop to:

- Review asset management principles
- Discuss the use of performance-based management principles for managing transportaion assets
- Highlight the interaction between the TAMP and existing project selection and programming processes
- Build executive supprot for organizational and business process changes that may be needed to support asset management
- Discuss roles and responsibilities to ensure a sustainable program

The results from this workshop will be used to finalize the TAM implementation effort that will be in place until the next TAMP update is initiated.

ENHANCEMENTS

able 7-1 provides an overview of the enhancements to asset management practices, tools, and organization identified by KYTC during the self-assessment conducted as part of developing the TAMP. The identified business units will implement these enhancements under the direction of the TAMP Core Team within the identified timeframe. ■

Enhancement	TAMP Process	KYTC Lead	Schedule
Implement SHIFT based strategic prioritization process	Objectives & Measures	Planning	Start: Underway Finish: 2022
Develop TAMP communication plan	Programming/ Implementation	TAMP Steering Committee	Start: 2018 Finish: 2020
Develop a TAM outreach plan	Programming/ Implementation	TAMP Steering Committee	Start: 2018 Finish: 2022
Implement fully-functioning pavement management system (PMS)	Programming/ Implementation	Pavement	Start: Underway Finish: 2019
Develop pavement deterioration models to support life cycle planning	Condition	Pavement	Start: Underway Finish: After 2022
Incorporate pavement condition into project prioritization	Programming/ Implementation	Pavement	Start: Underway Finish: After 2022
Increase use of PMS data in Districts	Objectives & Measures	TAMP Steering Committee	Start: 2018 Finish: 2020
Develop decision trees for PMS	Life Cycle Planning	Pavement	Start: Underway Finish: After 2022

Enhancement	TAMP Process	KYTC Lead	Schedule
Refine preservation treatment costs	Inventory	Pavement	Start: Underway Finish: 2019
Implement statewide bridge preventive maintenance program	Life Cycle Planning	Maintenance	Start: Underway Finish: After 2022
Develop improved bridge prioritization framework	Programming/ Implementation	Bridge Preservation	Start: 2018 Finish: 2020
Implement AASHTOWARE (BrM) Optimization Modules	Programming/ Implementation	Bridge Preservation	Start: 2018 Finish: 2022
Establish target for acceptable level of service for bridge conditions	Objectives & Measures	Executive	Start: 2018 Finish: 2019
Improve bridge management documentation	Inventory	Bridge Preservation	Start: 2019 Finish: 2021

APPENDIX A: SUMMARY OF INVENTORY, CONDITION AND VALUATION FOR THE NATIONAL HIGHWAY SYSTEM (NHS)

OVERVIEW

KYTC manages and maintains the vast majority of the National Highway System (NHS) within the state of Kentucky. Of the 12,071 lane-miles of NHS within the state, KYTC maintains 11,697. Local governments manage the remaining 374 lane-miles. KYTC owns an even larger portion of NHS bridges: only 5 bridges are owned by local governments, comprising 1.8 percent of the total deck area in the state. Figure A-1 shows the NHS highway system in the state of Kentucky.

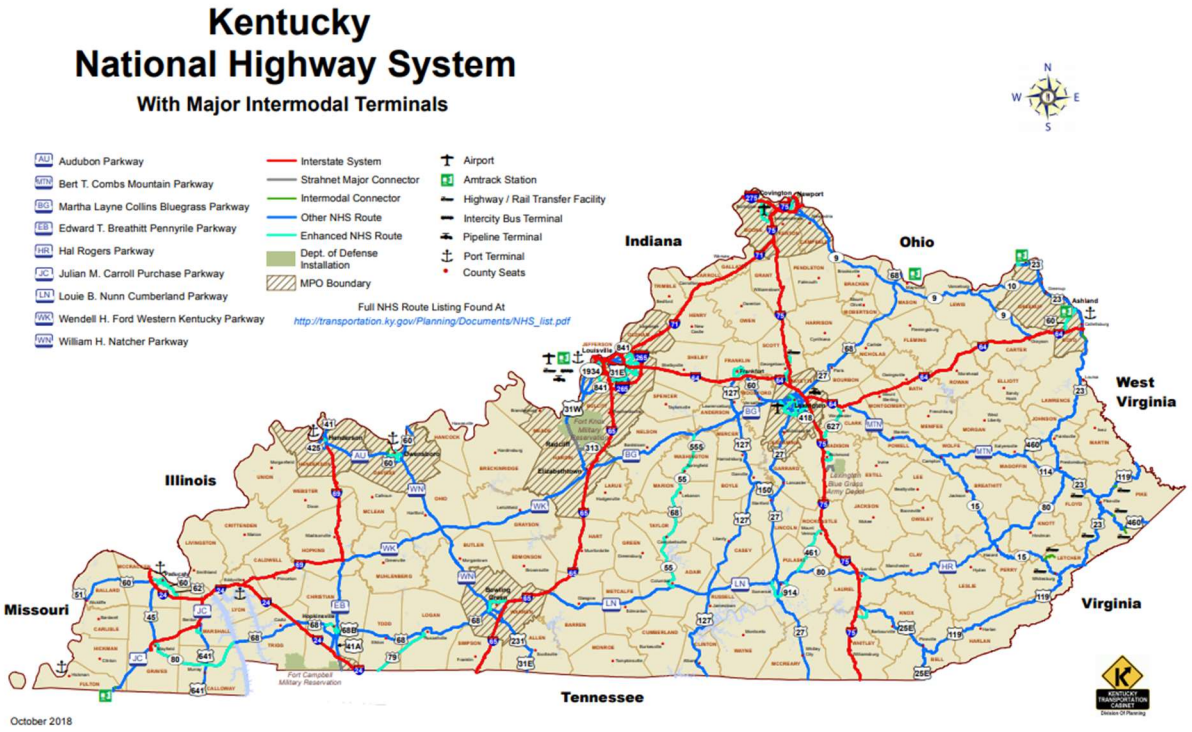


Figure A-1. Kentucky National Highway System

NHS PAVEMENTS

Federal regulation 23 CFR 515 requires that KYTC provide a summary of asset inventory, condition, and value for pavements on the NHS. Pavement condition for the NHS is reported according to federal standards, in terms of the percentage of assets in *Good, Fair,* and *Poor* condition. The federal measures for *Good*, *Fair,* and *Poor* are determined by evaluation of visible cracking, joint faulting, rutting, and ride quality.

Table A-1 provides an overview of how the National Highway Performance Program (NHPP) pavement measures are calculated for different types of pavements. Table A-2 provides a summary of NHS pavement inventory and conditions. Table A-3 provides a summary of the value of NHS pavements.

Table A- 1. Federal NHPP pavement condition metrics

Condition Type	Metric	Asphalt Pavements	CRCP[1]	JCP[2]	Good	Fair	Poor
Ride Quality	International Roughness Index (IRI)	●	●	●	<95 in/mi	95 to 170 in/mi	>170 in/mi
Rutting	Average rut depth	●			<0.20 in	0.20 to 0.40 in	>0.40 in
Wheel Path Cracking	Percent of wheel path area with cracks		●		<5%	5% to 20%	>20%
Slab Cracking	Percent of slabs with cracks			●	<5%	5% to 15%	>15%
Cracking	Percent of area with longitudinal cracks, spalls, or punchouts		●		<5%	5% to 10%	>10%
Joint Faulting	Average fault height			●	<0.10 in	0.10 to 0.15 in	>0.15 in

1 Continuously reinforced concrete pavement
2 Jointed Concrete Pavement

Table A- 2. Summary of NHS pavement inventory and condition

	Lane-Miles Good	Percent Good	Lane-Miles Fair	Percent Fair	Lane-Miles Poor	Percent Poor	Unreported Lane-Miles	Total Lane-Miles
Interstate	2,584	66.1%	1,322	33.8%	1	0.0%	113	4,020
Non-Interstate	3,286	44.8%	4,002	54.6%	40	0.5%	723	8,051
Total	5,870	52.2%	5,324	47.4%	41	0.4%	836	12,071

Table A- 3. NHS pavement valuation

	Current Replacement Value	Depreciated Current Replacement Value	Annual Depreciation
Interstate	$8,990,465,000	$8,387,520,194	$86,285,939
Non-Interstate NHS	$9,223,278,000	$8,645,492,348	$69,946,747
Total	$18,213,743,000	$17,033,012,542	$156,232,687

NHS BRIDGES

Table A-4 lists KYTC's performance measures and targets for the state-owned bridges for different highway systems.

State DOTs are required to set targets for their NHS bridges and pavements; targets that are also consistent with the state DOT's asset management objectives. According to 23 CFR Part 490, Subpart D, "National Performance Management Measures for Assessing Bridge Condition," Section 490.411, "Establishment of minimum level for condition for bridges", state DOTs should maintain bridges so that the percentage of the deck area of bridges with *Poor* condition carrying the NHS (which includes on-and off-ramps connected to the NHS within a state, and bridges carrying the NHS that cross a state border) does not exceed 10 percent of the total bridge deck maintained by the state. This national target is adopted by KYTC as the target for bridges. In addition, KYTC has set the same target for non-NHS bridges, to emphasize the need for preservation of these bridges that cover 50 percent of the total bridge deck maintained by the state. These targets are summarized in table A-4.

Table A- 4. Performance measure and targets for KYTC bridges

Highway Network	Current Poor Condition		Do Not Exceed Targets (by Deck Area)
	Sum of Deck Area	% Deck Area	
Interstate	995,643	7.4%	10%
Non-Interstate NHS	239,051	1.6%	10%
Total	1,234,694	4.3%	10%

Table A-5 summarizes KYTC's bridge inventory and condition based on FHWA sub-network designations (NHS-Interstate, and non-Interstate NHS). Overall, 4.3 percent of the NHS bridge inventory in Kentucky is rated *Poor* by deck area. The value of NHS bridges is shown in table A-6. ■

Table A- 5. Inventory and condition of state-owned bridges (FHWA highway system)

Sub-Network	Good			Fair			Poor			Total	
	Count	Deck Area (s.f.)	%	Count	Deck Area (s.f.)	%	Count	Deck Area (s.f.)	%	Count	Deck Area (s.f.)
Interstate	212	2,672,418	20%	558	9,701,746	73%	27	995,643	7%	797	13,369,807
Non-Interstate NHS	553	6,847,392	45%	663	8,071,755	53%	18	239,051	2%	1234	15,158,198
Total	765	9,519,810	33%	1216	17,773,501	62%	45	1,234,694	4%	2026	28,528,005

Table A- 6. Bridge asset valuation based on FHWA highway system

FHWA Sub-Network	Total Replacement Cost (Condition Based)
Interstate	$1,596,498,754
Non-Interstate NHS	$2,172,882,719
Total	$3,769,381,473

APPENDIX B: SUMMARY OF INVESTMENT STRATEGIES AND FORECASETED CONDITIONS FOR THE NHS

FORECASTED INTERSTATE PAVEMENT CONDITIONS

Federal regulation 23 CFR 490.317 establishes minimum conditions for interstate pavements based on the NHPP pavement measures described in chapter 2. Currently, KYTC's interstate pavements have 1.1 percent *Poor,* as calculated by the Federal highway Administration, based on data collected on 2016 and reported in KYTC's 2017 Highway Performance Monitoring System (HPMS) submission. Based on the projection that overall interstate conditions will remain stable during the TAMP period, KYTC predicts that the percent *Poor* interstate pavement will remain below 1 percent.

At this time, KYTC is not able to predict pavement conditions in terms of the NHPP pavement measures. However, figure 6-5 demonstrates that interstate conditions will remain relatively steady over the next 10 years. Figure B-1 demonstrates that the non-interstate NHS pavement conditions will remain relatively steady over that time as well. This is due to the imrpvoement expected for the parkway pavements, as shown in figure 6-6, offsetting the decline in MP pavement conditions.

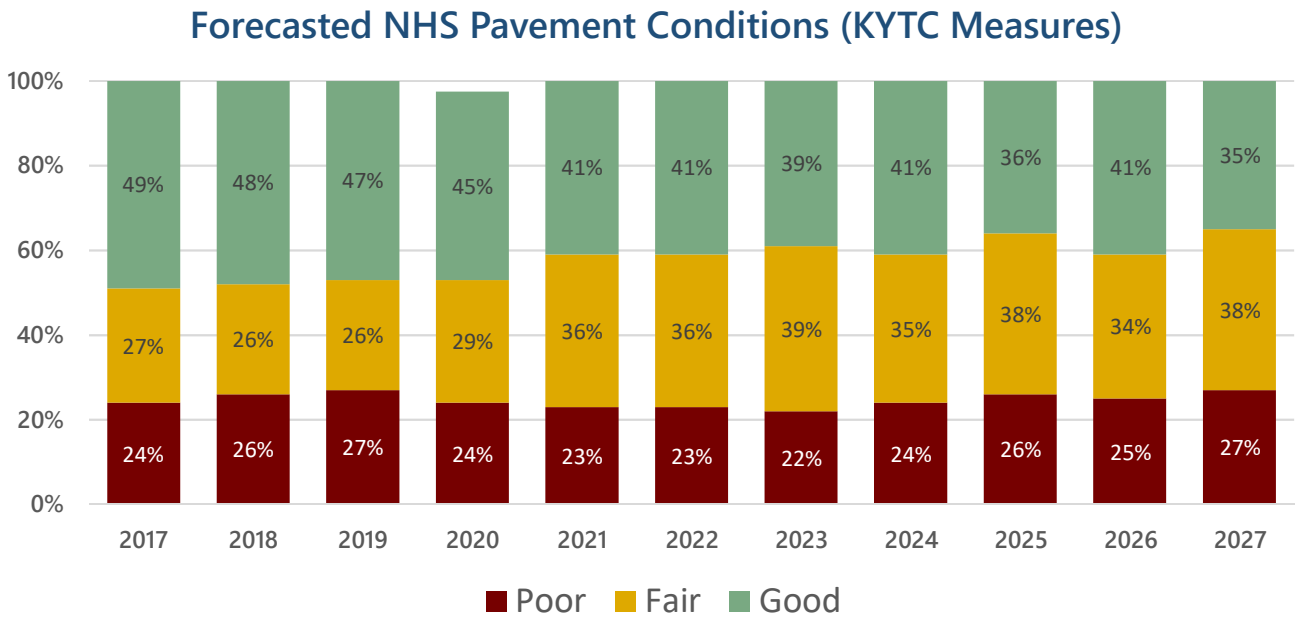


Figure B-1. Forecasted pavement conditions for the NHS (KYTC Measures)

FORECASTED NHS BRIDGE CONDITIONS

Federal statute 23 USC 119 and regulation 23 CFR 490 establish a threshold of no more than 10 percent of NHS bridges in *Poor* condition, as measured by deck area,k above which will result in specific restrictions to KYTC's use of federal funding. As shown in figure B-2, KTYC expects its NHS bridges to improve in condition because of plans to expand the bridge preservation pilot program to the entire bridge network. KYTC's NHS bridges are not expected to exceed the threshold of 10 percent *Poor* at any point during the 10-year analysis period. This information will be used to establish 2- and 4-year condition targets for bridges, which will be incorporated into the fully-compliant TAMP.

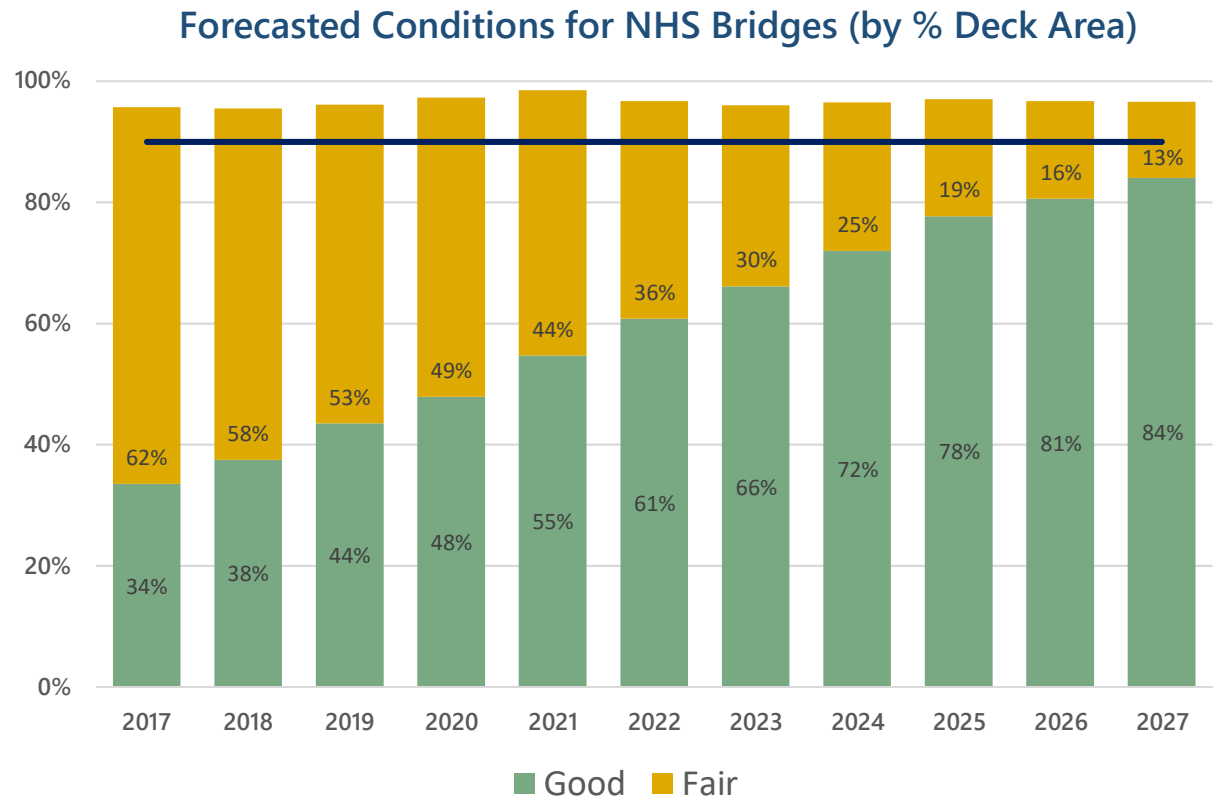


Figure B-2. Forecasted conditions for NHS bridges

APPENDIX C: LOCATIONS REQUIRING MULTIPLE REPAIRS DUE TO EMERGENCY EVENTS

OVERVIEW

Federal regulation 23 CFR 667 requires each state to conduct a statewide evaluation to determine if there are reasonably alternative solutions to roads, highways, and bridges that have required repair or reconstruction activities on two or more occasions due to emergency events. KYTC worked with the Kentucky FHWA Division Office to perform this evaluation in 2018.

KYTC has begun compiling past Emergency Relief (ER) records of highway damage and repairs back to 2009. The resulting database includes ER records for 1,264 sites which are distributed across more than 400 routes in 92 of Kentucky's 120 counties. Figure C-1 shows the estimated costs of ER repairs totaling $107 million dollars. Of this total, 71.5 percent ($76.5 million) accounts for damage to roads included in the Federal-Aid Highway System (FAS) and potentially eligible for reimbursement through the

FHWA Emergency Relief Program. This program assists states in the funding of repairs stemming from damage associated with natural disasters or failures caused by external causes. In Kentucky, this type of damage is most commonly associated with the effects of severe storms and flooding.

which, during a heavy rain event, funnels the water down slopes and into stream channels in the valleys. This results in rapid rise of water levels and swift currents. Due to the topography, highways are commonly built alongside these streams in the valleys. As a result, flash flooding in such areas is

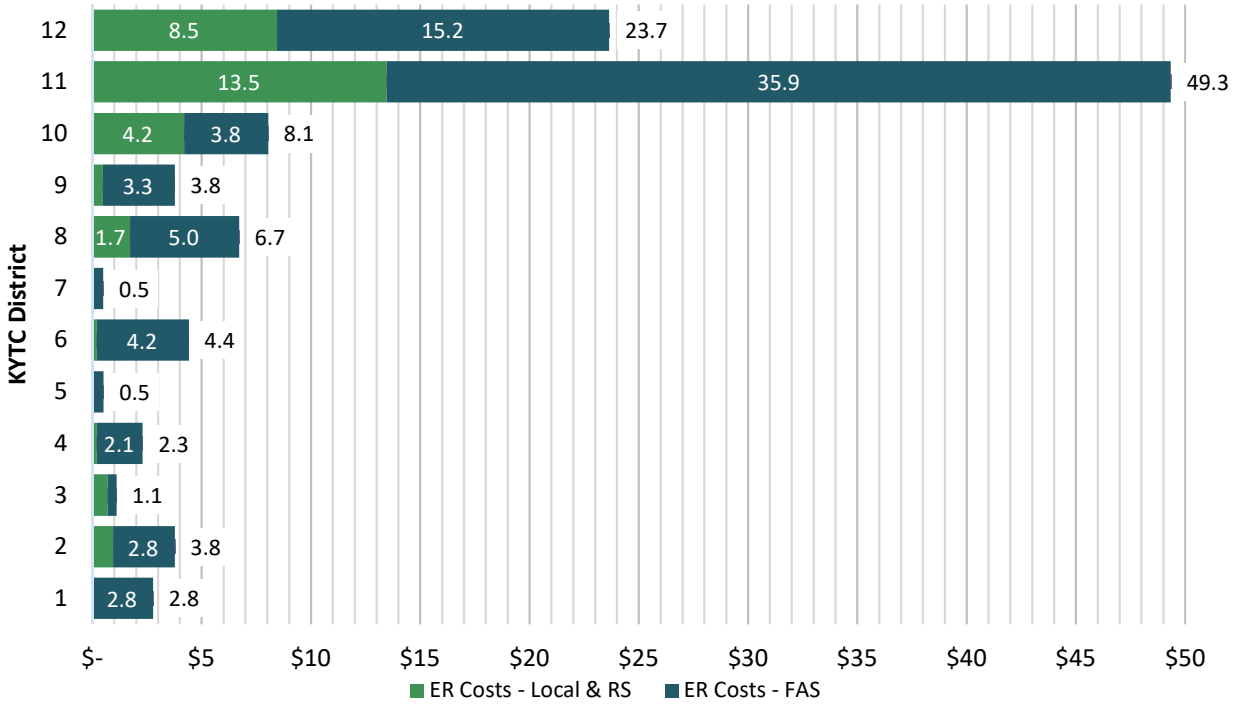
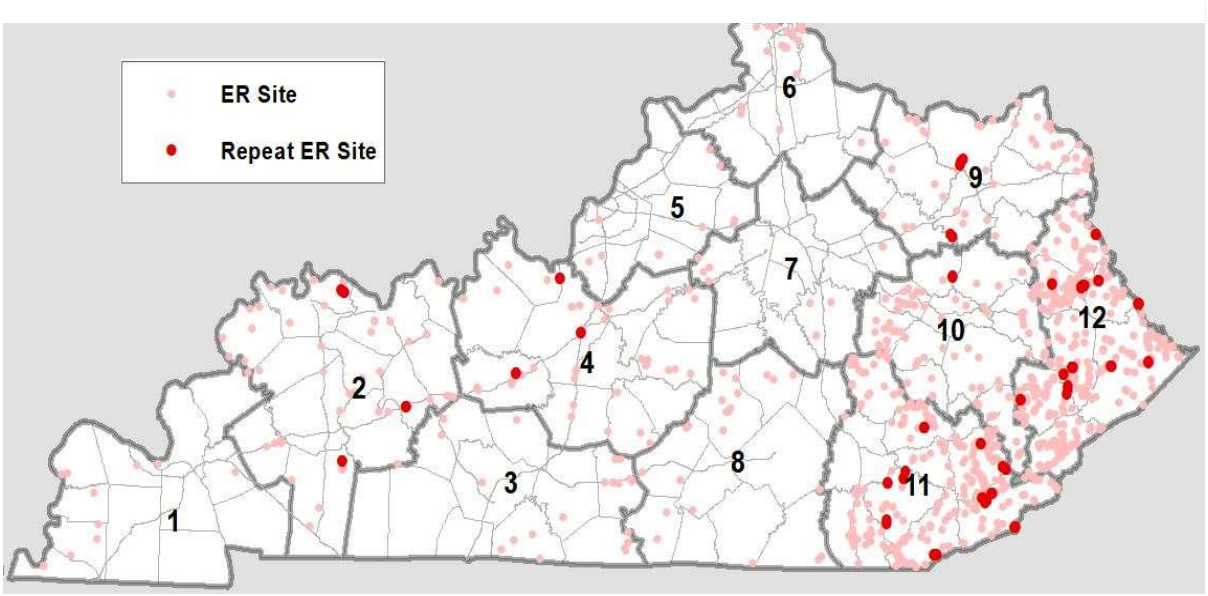


Figure C-1. Estimated cost of emergency repairs by KYTC District

Though the ER sites documented for Kentucky occur throughout the state, they are concentrated most heavily in the eastern, mountainous areas. These areas are particularly vulnerable to storm-related damage due to the rugged topography, particularly destructive and can lead to roadway flooding, embankment failures, slips, slides, and washouts. The majority of ER records in the database reflect this type of damage and the necessary repairs.

Figure C-2. Emergency repair sties on Kentucky Highways: 2009 to 2019



In Kentucky, 54 of the 120 counties are included in the Appalachian region, as defined by the Appalachian Regional Commission. These counties make up the bulk of KYTC Districts 8, 9, 10, 11, and 12. Analysis of the ER database reveals that, since 2009, 83 percent of the ER sites have been located in Districts 8 through 12 as shown in figure C-2. Damage repairs for these sites account for 86 percent ($92 million) of the statewide total.

Using the newly created ER database, KYTC has identified 31 locations where emergency repairs appear to have been necessary on more than one occasion across multiple years (Table C-1). Due to inconsistencies in the dataset, further investigation is needed for some sites to determine if the duplicate repairs were actually representative of damage occuring at the same location or if they were due to distinct issues occuring in proximity of each other. KYTC will use this database to perform the necessary site evaluations to identify alternatives for mitigating the root cause of the recurring damage, estimate the costs of the solution and determine the duration of the solution as required by 23 CFR 667.3.

Additionally, KYTC is evaluating the means of improving the software system it uses to track labor, equipment, and materials used in response to emergency events by state forces and contractors. This information will be

Table C-1. Locations appearing to require multiple repairs due to emergency events

District	County	Route	Mile Point(s)	Description	Estimated Cost to Repair
2	Christian	KY 189	12.5	Slide	*1*
	Henderson	US 60	21.5 to 22.5	Washout	*2*
	Ohio	WK 9001	67.8	Slide	$1,000,000
4	Grayson	US 62	23.2	Slide; embankment failure	$300,000
	Hardin	I 65 Ramp	0.1	Slide; embankment failure	$600,000
	Meade	US 31W	0.8	Embankment failure	$300,000
9	Lewis	KY 377	3 to 4	Flooding	$500,000
	Rowan	KY 801	5.6	Flooding	$7,000,000
10	Menifee	US 460	17.8	Break in roadway	*1*
11	Bell	KY 217	1	Break in roadway	$2,000,000
	Clay	KY 11	14.9	Shoulder break	$20,000,000
	Harlan	KY 221	12.3	Break in roadway	$1,000,000
	Harlan	US 421	0.5 to 0.9	Break in roadway	$500,000
	Harlan	US 421	18 to 22	Break in roadway	$60,00,000
	Knox	KY 11	4.2	Roadway slip	*1*
	Knox	KY 11	22.6	Slide	*1*
	Knox	KY 229	6	Embankment failure	*3*
	Leslie	KY 699	14.4 to 15.8	Shoulder break	$1,000,000
	Leslie	KY 80	2	Shoulder break	*3*
12	Floyd	KY 122	15.9 to 16	Embankment failure	*1*
	Floyd	KY 7	3	Embankment failure	*1*
	Johnson	KY 172	10.1	Roadway slip	*3*
	Johnson	KY 40	22.4 to 22.6	Roadway slip	*3*
	Knott	KY 550	2.6	Embankment failure	*3*
	Knott	KY 7	9.6 to 13.18	Embankment failure	$400,000
	Lawrence	KY 3	11.9	Roadway slip	*3*
	Martin	KY 292	1.4 to 1.5	Embankment failure	$200,000
	Martin	KY 40	0.7 to 1	Flooding	$300,000
	Martin	KY 40	8.75	Slide	$100,000
	Pike	KY 1460	4.5	Flooding	$1,000,000
	Pike	KY 632	5.4	Flooding	*2*

1 Permanent repair already completed

2 Further analysis required to determine appropriate remedy

3 Permanent repairs currently underway

captured in a geodatabase that will be made available to KYTC staff who are involved in planning, project selection, and design. KYTC is developing a cell phone and tablet based app for use by personnel in the field responding to and assessing emergency damage to facilities. As data is submitted through the app, it will be joined to the existing database of historical ER records. This information will be consulted as a regular part of planning and project development activities. ■