
# Transportation Asset Management Plan

## BIL-Compliant Version • December 2022

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# Chapter 1: Introduction

## OVERVIEW

A safe, efficient, sustainable, and resilient transportation system is critical to Kentucky's economic vitality and the quality of life for its residents. The Kentucky Transportation Cabinet (KYTC) is responsible for managing the Commonwealth's transportation system to achieve these objectives in a fiscally responsible manner. 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.**

The Department of Highways manages Kentucky's state-maintained roads and bridges, including the ancillary infrastructure assets (such as signs, lighting, messaging boards) that ensure the system operates safely. KYTC has made a strong commitment to on-going investments to preserve asset conditions and system performance as cost-effectively as possible. This approach reflects the principles behind Transportation Asset Management (TAM), which provides a strategic and systematic framework for managing infrastructure that:

- Links planned investments to performance expectations.
- Extends the service life of the transportation system economically using low-cost treatments early in an asset's service life.
- Reduces agency risk or exposure.
- Enhances the system's resilience.

TAM relies on asset inventory and condition data to drive performance-based resource allocation and project selection decisions. These results are crucial elements for achieving the Cabinet's mission, vision, and goals and enables KYTC to be accountable to its customers by:

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

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

KYTC's plans for managing the state-maintained pavement and bridge network are described in this Transportation Asset Management Plan (TAMP), which satisfies the federal requirements described in the next section.

## TAMP REQUIREMENTS

Since 2012, federal legislation has required all state transportation agencies to develop a risk-based TAMP that describes how the state's roads and bridges "will be managed to achieve system performance effectiveness and State Department of Transportation (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), KYTC went beyond the minimum requirements by incorporating all its state-maintained roads and bridges into its TAMP. Their inclusion in the TAMP reflects KYTC's focus on system preservation and demonstrates the Cabinet's commitment to managing these assets in a financially responsible manner at the lowest practical cost.

State TAMPs are required to be updated and certified by the Federal Highway Administration (FHWA) at least every four years. KYTC's initial TAMP was certified by FHWA in 2018 and updated in 2019. Since the initial TAMP was certified in 2018, this TAMP satisfies the federal requirement to recertify KYTC's TAMP within the 4-year period.

This updated TAMP reflects 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 TAMP does not replace any existing plans; rather, it builds on and provides critical input to existing plans by linking capital and maintenance expenditures to asset conditions.

**The TAMP presents KYTC's planned road and bridge investments for the next 10 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, presents current conditions, and estimates asset value.
- **Chapter 4: Life Cycle Planning—**explains how pavements and bridges are managed cost-effectively over their service lives.
- **Chapter 5: Risk and Resilience—**identifies key risks that might impact KYTC and potential mitigation strategies to manage risks and build resilience.
- **Chapter 6: Financial Plan and 10-Year Investment Strategies—**presents anticipated 10-year investment levels for pavement and bridge preservation and describes expected gaps between desired and anticipated performance.
- **Chapter 7: Planned Enhancements—**describes steps that KYTC is planning to further strengthen its asset management practices.

There are also three appendices that support specific TAMP requirements. Appendix A includes a listing of NHS routes regardless of ownership. Appendix B presents NHS investments and forecasted conditions and Appendix C summarizes locations that have been damaged two or more times due to emergencies.

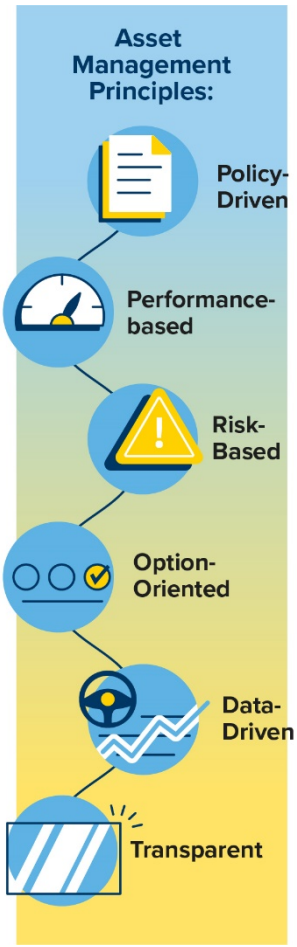
# Chapter 2: Asset Management Objectives

## OVERVIEW

KYTC has strong business processes in place to ensure its planned infrastructure investments align with the Cabinet's strategic objectives. KYTC's 2021 *Strategic Plan* outlines the goals that drive the strategies and tactics executed by the Cabinet's business units to achieve its performance objectives. Its goals are to:

- Promote safety in all decision making.
- Strengthen stakeholder and customer relationships.
- Deliver economic opportunities and enhance quality of life.
- Optimize performance through people and innovation.
- Nurture a culture of diversity and inclusion.

KYTC uses its *Long-Range Statewide Transportation Plan* (LRSTP) to provide a roadmap that guides KYTC's investments in current and long-term needs. These needs reflect KYTC's efforts to balance the competing demands on the transportation system using data and analysis tools to model the future impacts of each potential scenario. These types of analyses enable KYTC to objectively evaluate the trade-offs between investments needed to preserve asset conditions versus those intended to relieve congestion. With limited funding available to address all its needs, KYTC must make difficult decisions between these priorities and does so in consultation with the Governor, the Kentucky General Assembly, and other transportation partners.




To ensure that available resources for infrastructure assets are used as effectively as possibly, KYTC has made a strong commitment to asset management. Asset management is "a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the life cycle of the assets at minimum practicable cost[1]." It is based on the following core principles[2]:

- **Policy-Driven** – Decisions are aligned with policy goals and objectives that define the desired system conditions and service levels.
- **Performance-Based** – Reliable condition and performance information is used to establish targets, allocate funding, and monitor progress.

[1] 23 CFR 515.5 https://www.ecfr.gov/current/title-23/chapter-I/subchapter-F/part-515

[2] FHWA. 2020. *An Introduction to Transportation Asset Management, Instructor Guide*. FHWA-NHI-17-061, Federal Highway Administration, Washington, D.C.

- **Risk-Based** – A formal risk-management process is used to prioritize mitigation strategies to reduce the likelihood and/or impact of uncertainty while enhancing system resilience.
- **Option-Oriented** – Comprehensive choices and trade-offs are evaluated at each level of decision making in alignment with strategic objectives and consideration of available resources.
- **Data-Driven** – Credible and current data are evaluated using analysis tools that support investment decisions.
- **Transparent** – Decisions are based on performance-based results that are clearly conveyed to stakeholders.

## ASSET MANAGEMENT INITIATIVES

KYTC's commitment to asset management is founded in the agency's efforts to use an objective and transparent approach to balance infrastructure preservation needs with other competing priorities across the Commonwealth. A prioritization process, known as SHIFT, assists the Cabinet in prioritizing the investment of limited transportation dollars through an objective approach that addresses capacity and safety needs while also taking into consideration system preservation and other important factors. The project selection and prioritization processes used to develop the Six-Year Plan is presented in figure 2-1.

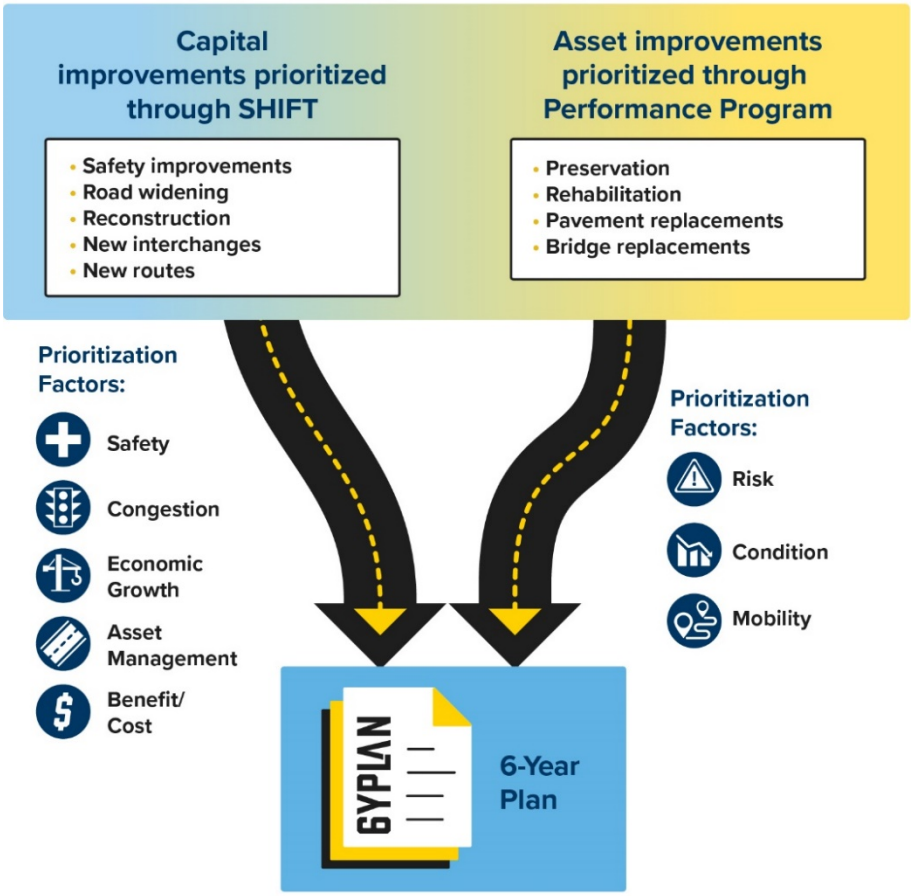



*Figure 2-1. The project selection and prioritization processes used in developing the Six-Year Plan*

SHIFT allows 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 submitted in the most recent 6-year Highway Plan, submitted for to the State Legislature in 2022, were prioritized based on the SHIFT criteria as in years past.

KYTC's asset management efforts rely heavily on asset preservation techniques that emphasize the importance of preventive maintenance treatments applied early in an asset's service life to slow the rate of deterioration. KYTC's pavement preservation program has been in place since 2007 and has seen significant expansion beginning in 2016 based on proven performance and cost-effectiveness. A pilot preservation program for bridges was initiated in 2018 and its success led to its implementation on a statewide basis.

An effective pavement or bridge management program does not rely exclusively on the use of preservation treatments. To be most effective, these programs require a balance between preservation, rehabilitation, reconstruction, and reactive maintenance as shown in figure 2-2. This combination of treatments is important to optimize system performance in a cost-effective manner and extend the service life of existing assets.

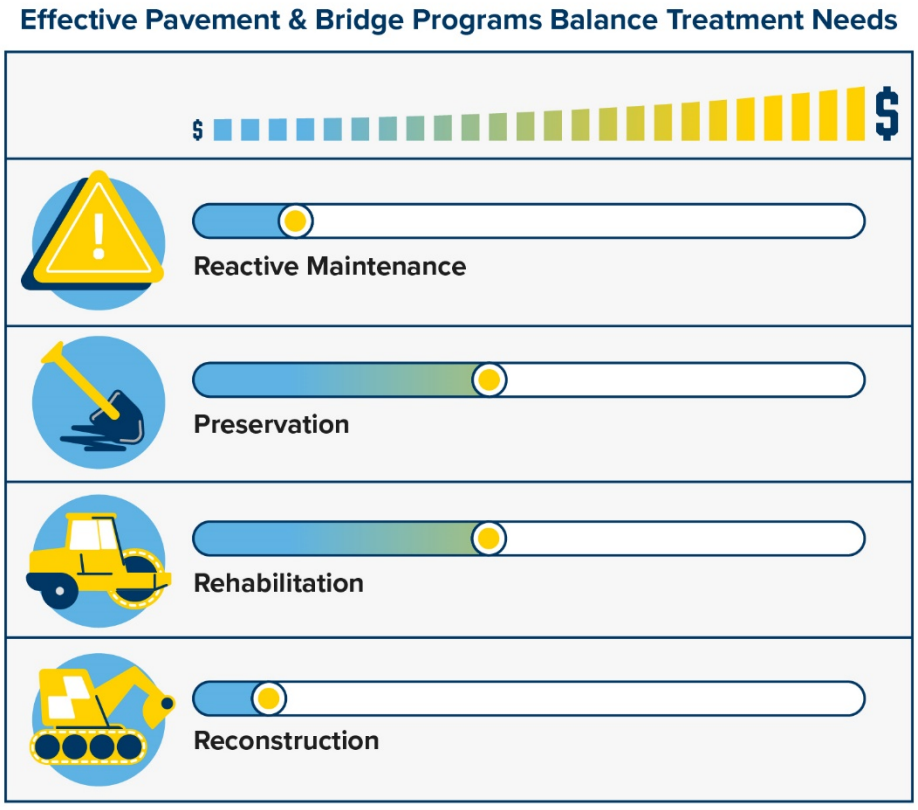



*Figure 2-2. Effective pavement or bridge management program balance*

Based on the success of its asset management efforts, KYTC established performance goals for its pavements and bridges. The desired State of Good Repair (SOGR) is generally defined as the condition at which the assets are performing at an acceptable level. Since agencies are not always funded at a level that can achieve the desired SOGR, fiscally constrained targets are

**Performance GOALS**

**Pavements**
- **At least 92% in Good or Fair condition**

**Bridges**
- **At least 97% in Good or Fair condition**

established to reflect the conditions that are expected to be achieved with the expected levels of funding. For pavements, the desired SOGR is for 92% of the system in *Fair or Better* condition[3]. For bridges, the objective is to reduce the percentage of bridge deck area in *Poor* condition. This has led to a desired SOGR with at least 97% of the statewide bridge deck area in *Good* or *Fair* condition. As discussed in Chapter 6, Financial Plan and 10-Year Investment Strategies, achieving the pavement and bridge SOGR will require additional resources, but the commitment to preservation has resulted in improvements in system condition since the 2019 TAMP was published. The progress being made demonstrates the importance to an on-going commitment to investments in system preservation.

As discussed later in the TAMP, KYTC has accomplished several other asset management goals established in its 2019 TAMP. The increased focus on preservation activities, the expanded use of performance measures to drive investments, the inclusion of performance projects in the Six-Year Plan, and the balancing of expansion and safety needs with asset management needs in SHIFT all reflect accomplishments that KYTC has made in recent years. The Cabinet has further supported its asset management efforts through the adoption of new technology to support its efforts to collect pavement condition data and the implementation of new pavement and bridge analysis tools to support investment planning. Other on-going and expected enhancements, including efforts to build the asset management culture within the Cabinet, are presented in Chapter 7, Enhancements.

## EXISTING PLANNING EFFORTS THAT SUPPORT ASSET MANAGEMENT

KYTC planning efforts are designed to ensure that the Cabinet achieves its performance goals for safety, mobility, and asset conditions. These planning efforts are aimed at investing available funding effectively to address short-, medium-, and long-term agency priorities. The plans increase accountability and transparency in the Cabinet's decision-making processes and ensure that investments are aligned with the Cabinet's strategic objectives. The development of this TAMP supports these efforts by demonstrating the cost-effectiveness of planned pavement and bridge management programs and establishing performance targets that are linked to available funding.

A description of these plans is provided. Figure 2-3 illustrates the relationship between the plans and the TAMP.

[3] See chapter 3 for more information on how pavement and bridge conditions are rated.

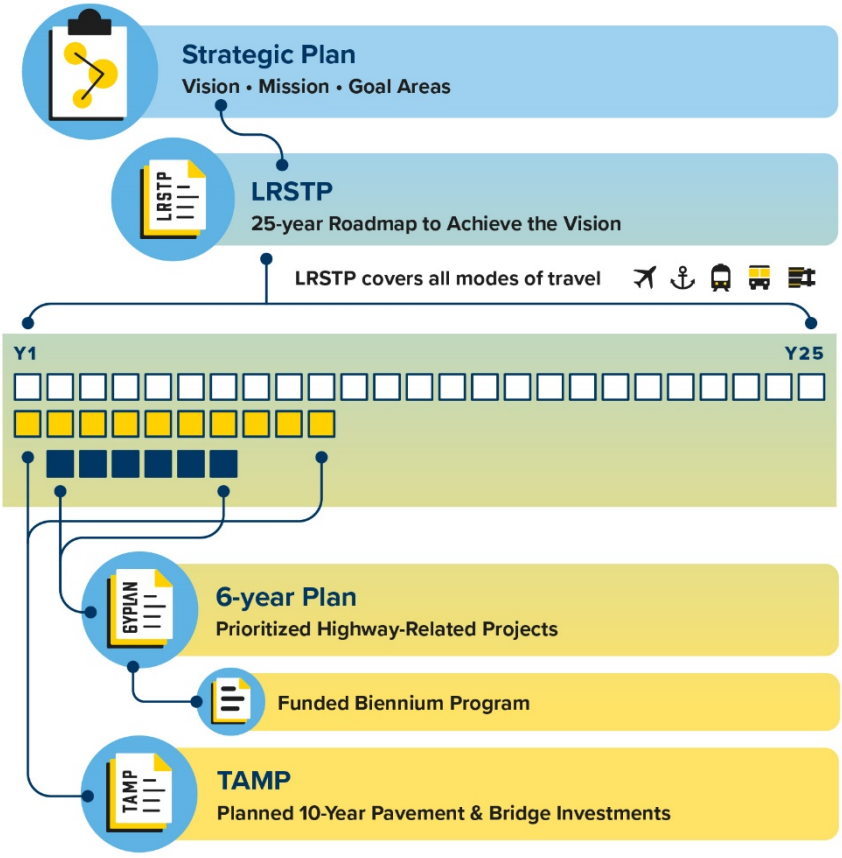



*Figure 2-3. Relationship between planning and the TAMP*

## KYTC Strategic Plan


The KYTC Strategic Plan, which is currently being updated, presents a roadmap to meet and deliver a 21st century transportation system and best-in-class services to improve the quality of life for Kentuckians. The Strategic Plan establishes KYTC's vision and mission and outlines the following goals:

1. Promote safety in all decision making.
2. Strengthen stakeholder and customer relationships.
3. Deliver economic opportunities and enhance quality of life.
4. Optimize performance through people and innovation.
5. Nurture a culture of diversity and inclusion.

Goal 4 establishes a clear link to the Cabinet's asset management objectives and promotes the use of innovative approaches to manage system performance.

## Long-Range Statewide Transportation Plan (LRSTP)

The 2022-2045 LRSTP is a policy plan with a scope of over 20 years that sets the vision for the state's transportation system across all modes and defines the goals, objectives, and performance measures for the system's development, maintenance, and operations. The LRSTP includes a comprehensive transportation inventory, forecasts, and analysis of trends,

issues, and possible future scenarios affecting all modes of transportation through Kentucky.

The LRSTP relies on a performance-based planning and programming (PBPP) process that uses data to support decisions that help achieve the desired outcomes. The performance-based planning and programming framework identified within the previous 2014 LRSTP was continued within the 2022-2045 LRSTP with the description of KYTC's SHIFT process that provides a data-driven pathway for improvements from need identification to prioritization and programming.

The plan's vision is usually expressed as a succinct statement of the desired ideal for the future multimodal transportation system and can be considered as the description of the future condition that is reached through a series of actions. The overarching vision statement describes the desired transportation system to be delivered regardless of the challenges or opportunities with the possible futures or scenarios. The 2022-2045 LRSTP Vision is for a viable, reliable, and resilient multimodal transportation system to provide access and mobility for all users for the safe movement of people and goods.

**The 2022-2045 LRSTP envisions a viable, reliable, & resilient multimodal transportation system to provide access and mobility for all users for the safe movement of people and goods.**

The 2022-2045 LRSTP provides a basis for meeting the vision for Kentucky's multimodal transportation system by clearly identifying goals and objectives, guiding principles, and implementable strategies which support the achievement of that shared vision.

To achieve that expressed vision, a set of five goals were derived from the collected input. These goals were aligned with the seven national performance goals of: Safety, Infrastructure Condition, Congestion Reduction, System Reliability, Freight Movement and Economic Vitality, Environmental Sustainability, and Reduced Project Delivery Delays.

The five interconnected 2022-2045 LRSTP Goals which support the delivery of the LRSTP Vision for the Commonwealth of Kentucky are shown in figure 2-4.


*Figure 2-4. Five interconnected 2022-2045 LRSTP Goals*

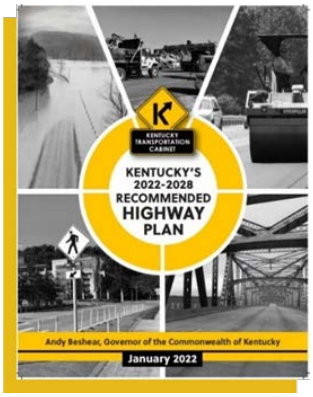
The investment plans outlined in this TAMP support the goals outlined in the 2022-2045 LRSTP through the analysis of pavement and bridge data to assess funding needs and program priorities. Preservation remains a key component of the planned investments based on a holistic approach to managing long-life assets such as pavements and bridges. The TAMP outlines expected progress towards performance expectations and identifies strategies for closing the gap between desired and expected performance.

## Department of Highways (DOH) Operational Plan

The KYTC Department of Highways developed an Operational Plan to establish specific goals, strategies, and tactics that support the implementation of the goals outlined in the Strategic Plan. For each of the five goals identified in the Strategic Plan, specific strategies and tactics are outline for highway-related programs and processes. Examples of specific strategies outlined in the DOH Operational Plan that support asset management are listed below.

- Establish and sustain a performance-driven culture.
  - Establish annual performance goals for each Department/Office and a progress report to measure success rates.
- Ensure resources are invested appropriately.
  - Establish a State Highway Engineer's Office position to lead performance management activities across the DOH.
  - Update and implement the TAMP.

## Six-Year Highway Plan (SYP)




The PBPP processes used in the development of the LRSTP provide the foundation for generating the Six-Year Highway Plan, which identifies the short-range list of priority projects that are a key element of the State Biennial Budget. Using input provided by the District Offices, the ADDs, and MPOs, the Cabinet prepares and presents the proposed Plan 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. Both chambers of the legislature must approve the SYP as separate legislation in each budget cycle. The recommended SYP was submitted to the Governor in January 2022 during the development of this TAMP.

The recommended SYP includes three distinct focus areas to address the existing backlog of pavement and bridge needs while pursuing highway improvement projects that provide enhanced roadway safety, improved regional access, and increased economic opportunity for each geographic region in Kentucky. These focus areas include:

- A commitment to the performance of the existing highway system.
- Highway improvement projects that provide new and wider roads to handle future traffic needs.
- Funding to address past commitments and support various on-going program activities.

The first 2 years of projects in the SYP are funded through the biennial budget process and the remaining 4 years of projects are included for planning purposes. Once the SYP is signed by the Governor, it becomes the Cabinet's roadmap for projects and spending for the next 2 years.

Highway Improvement Projects in the SYP are prioritized with SHIFT. This prioritization process allows tradeoffs between capacity and safety needs while also taking into consideration system preservation needs. KYTC developed the SHIFT process in 2017 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 mobility, safety, system preservation, and economic development through sound investments.

The SYP's pavement and bridge projects on the existing highway provide for their preservation, rehabilitation, and replacement. Existing highway system performance projects are selected using a data-driven process that considers pavement and bridge conditions, estimated project cost and value, and performance goals. Prioritization models include mobility impacts, asset condition, anticipated deterioration, risk, and benefit. For bridges, a prioritization process was developed that considers statewide bridge needs alongside minor and local route structure to provide long-lasting safety and reliability benefits to the Commonwealth. A similar prioritization process for pavements is under development.

## Other Program Plans


The Kentucky transportation system includes various inter-connected modes of travel, including highways, airways, waterways, railways, and public transportation. The needs within each mode of travel vary and KYTC uses a suite of statewide plans to cover all aspects of transportation. In addition to the plans discussed earlier in this section, these plans include:

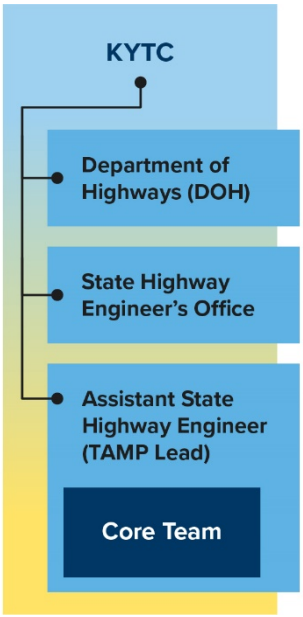
- Freight Plan—identifies key freight routes and transportation facilities that are critical to the Commonwealth's economy.
- Statewide Rail Plan—identifies systemwide strategies and policies, develops specific goals and objectives, and provides a vehicle to identify future rail issues to meet federal funding requirements (should the funding become available).
- Aviation System Plan—presents a 20-year plan of airport construction projects and operational enhancements at Kentucky's regional and city airports without a financial commitment.

In addition, DOH programs have developed plans to guide investments in strategic priorities as the TAMP does for pavements and bridges. Critically important to system operations are the Strategic Highway Safety Plan (SHSP) and the Transportation Systems Management and Operations (TSMO) Program Plan.

- The SHSP establishes 5-year strategies, goals, objectives, and opportunities to prevent transportation-related deaths and injuries in the Commonwealth. It addresses the four, highway safety "Es" (Education, Emergency Management, Enforcement, and Engineering) to determine actionable solutions to the Commonwealth's most pressing highway safety challenges.
- The TSMO Program Plan will provide the structure for KYTC's comprehensive TSMO program, which uses technology to optimize traffic flow, improve safety, and reduce congestion. The Plan, which is under

development, will include both strategic and tactical goals and strategies to address the vision established in the Strategic Plan. One of the important steps in this process has been linking TSMO's impact on system performance objectives such as safety, reliability, and economic development. Because of the importance of the assets supporting the TSMO program, KYTC is considering adding these assets to a future TAMP.

## ASSET MANAGEMENT IMPLEMENTATION




The State Highway Engineer's Office in the DOH is responsible for KYTC's asset management implementation, 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 is aligned with the planning and programming documents discussed in this chapter 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 ensures a more directed effort towards system preservation and improved transparency and accountability in the Cabinet's planning and programming processes.

To demonstrate the Cabinet's commitment to asset management and its performance-based planning and programming process, the DOH recently established a leadership position in the State Highway Engineer's Office to oversee Performance Management as suggested in its Operational Plan. The position, held by the Assistant State Highway Engineer, serves as the Chair of the Asset Management Core Team and the lead on the TAMP development. The Assistant State Highway Engineer is also leading upcoming initiatives to develop Communication and Outreach Plans to further institutionalize asset management into KYTC's programs and practices.

# Chapter 3: Asset Inventory and Conditions

## OVERVIEW

The public roads system within the Commonwealth of Kentucky (shown in figure 3-1) includes approximately 80,006 centerline miles of streets and highways. KYTC is responsible for the maintenance and preservation of 27,695 centerline miles of that network. While that is only one-third of the total mileage, the state-maintained system serves nearly 90% of the vehicle-miles of travel within the Commonwealth. KYTC manages many different types of transportation assets within its highway right-of-way; however, this TAMP focuses on the needs of the state-maintained pavements and bridges (including bridge-sized culverts as defined by National Bridge Inspection Standards [NBIS]).

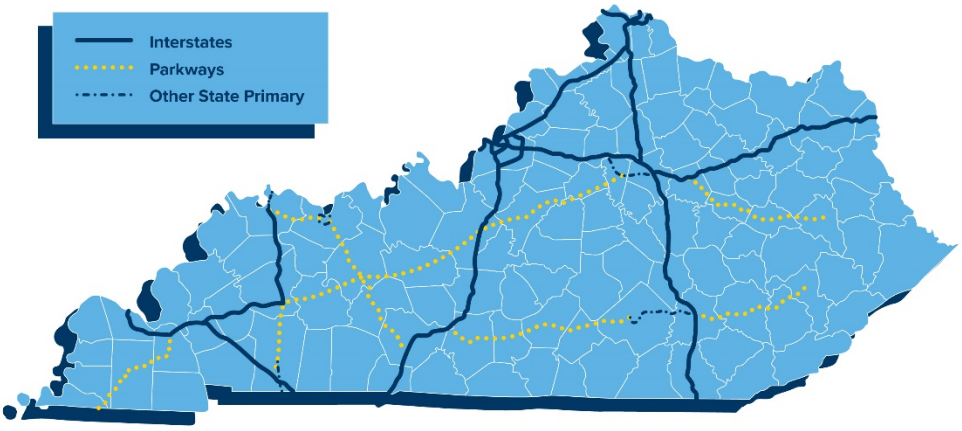



*Figure 3-1. KYTC's highway system*

## HIGHWAY SYSTEMS

Kentucky's highway network was designed to meet various transportation needs within the Commonwealth, 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 highway system elements 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

*Typical Interstate Pavement*

*Typical Parkway Pavement*

*Typical MP Pavement*

*Typical RS Pavement*

are called out in the Kentucky biennial budget process, which contains specific funding for Maintenance Priority (MP) and for rural secondary routes.

- **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.
- **Parkway system:** This system consists of multilane limited-access expressways that are not part of the Interstate system. The Parkway system was originally constructed as a network of toll roads, but all Parkways currently operate as freeways.
- **Maintenance Priority (MP) system:** This system is comprised of State Primary pavement not classified as Interstate or Parkway, 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 consists of the following three subsystems.
  - **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 Commonwealth.
  - **State Secondary routes:** This system consists of short-distance MP routes of regional significance that functions as both access to land use activity and mobility. These routes generally serve smaller cities and county seats within a region.
  - **Supplemental routes:** This system consists of all other state-maintained MP routes that are not included in the higher classifications. They are generally short-distance routes with main functions as frontage roads, crossroads, and local-access roads, such as farm-to-market routes.
- **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.

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.

A portion of the network is included in the National Highway System (NHS), which is a network of strategic highways identified by the U.S. Department of Transportation in cooperation with states, local officials, and metropolitan planning organizations (MPOs) and approved by the U.S. Congress. NHS routes include Interstates and additional roads that serve major airports, ports, and other strategic transport facilities. Inventory and condition information for the pavements and bridges on the NHS that are maintained by KYTC is presented in Appendix A. The condition information presented in Appendix B uses federally mandated performance measures to report NHS conditions.

# INVENTORY

## KYTC Pavements

The 27,695 centerline miles maintained by KYTC include highways with two or more lanes of traffic. When all lanes are considered, KYTC is responsible for maintaining over 64,026 pavement lane-miles across the four highway systems. Figure 3-2 summarizes the distribution of pavement inventory within each highway system. The MP system (including the State Primary, State Secondary, and Supplemental routes) contains 50% of the lane-miles, and the rural secondary routes contain 40%.

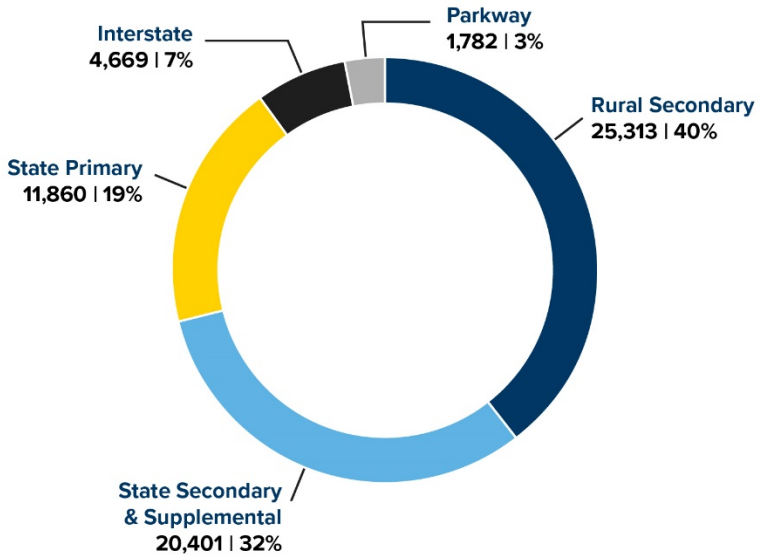



*Figure 3-2. State-maintained highway system in lane-miles by highway network*

The vast majority of KYTC's pavements (95.3%) are constructed with an asphalt concrete surface, as shown in figure 3-3, with the remaining 4.7% constructed with a Portland cement concrete (PCC) surface. Approximately 35% of all PCC pavements are on the Interstate system.

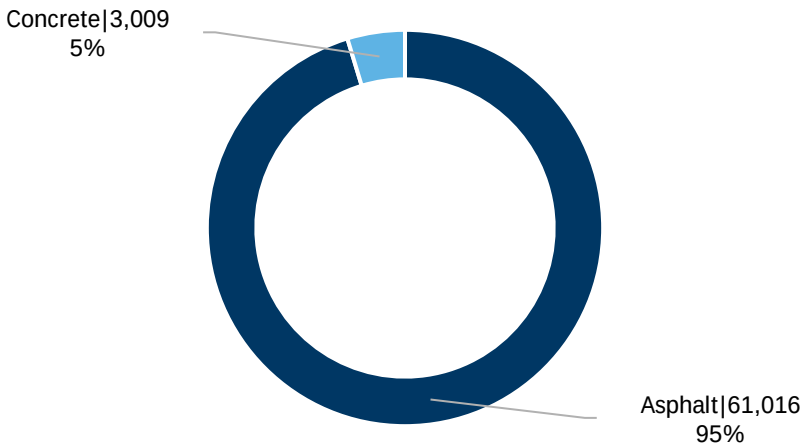



*Figure 3-3. Pavement surface type distribution by lane-miles*

## KYTC Bridges

KYTC owns and maintains 9,069 bridges, which comprise about 62 million square feet ($ft^2$) of bridge deck area. Figures 3-4 and 3-5 summarize KYTC's bridge inventory by count and deck area,respectively[4]. The Interstate system contains only 10% of the bridges (925) but 25% of the bridge deck area (15.4 million $ft^2$). Conversely, the Rural Secondary routes (including supplemental and unclassified) contain 41% of the bridges (3,703), but only 17% of the deck area (10.5 million $ft^2$).

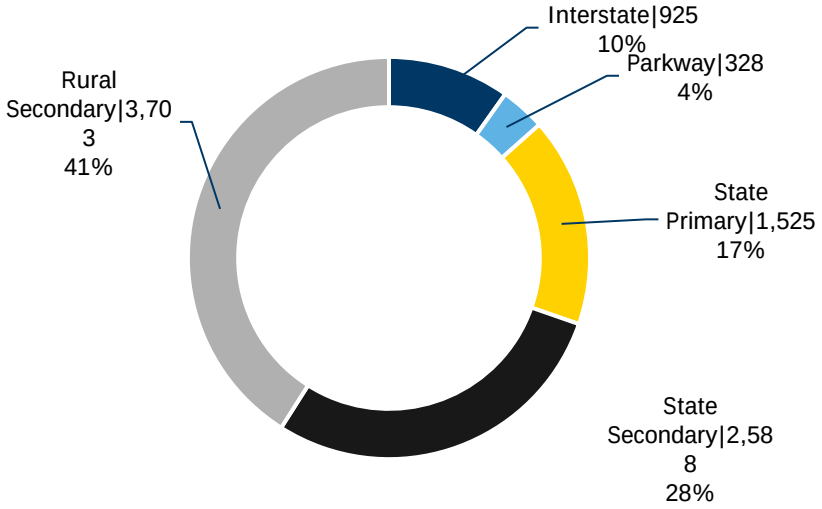



*Figure 3-4. KYTC bridge inventory by count*

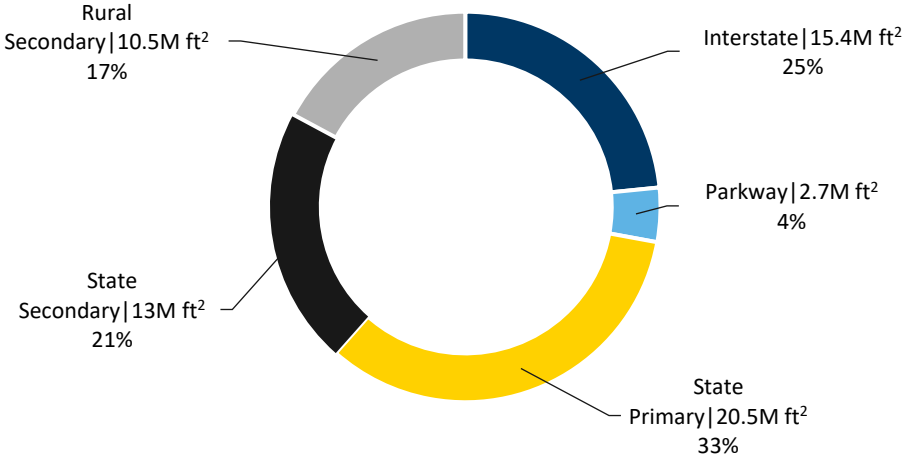



*Figure 3-5. KYTC bridge inventory by deck area*

[4] State Secondary contains bridges included in the inventory with no network designation

# FACTORS INFLUENCING PERFORMANCE

## Pavement Performance Factors

**Pavement Performance Factors**

- **Pavement type and material properties**
- **Traffic weight and volumes**
- **Environmental factors**
- **Quality of underlying materials**
- **Maintenance frequency**
- **Construction quality**

Pavement condition declines over time due to exposure to traffic and weather. Traffic is the most influential factor in pavement performance in Kentucky, which is why KYTC currently factors traffic volumes and loadings into treatment selection and timing decisions.

**Managing the MP system pavements is a challenge since many of these roads were originally trails and gravel roads rather than designed pavement structures.**

Pavement structural design is another significant factor that drives performance. KYTC's Interstate and Parkway pavements are designed following engineering standards for structural capacity and include features such as subsurface drainage to maximize service life. Other pavement systems, such as the MP system, contain many pavements that were originally trails and gravel roads, but were later converted to paved asphalt surfaces. Over time, these pavements have been resurfaced multiple times and may have received surface drainage improvements. Even with these treatments, they are not considered 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 deterioration models based on this data. These models are implemented in the pavement management system and used to predict future conditions under different treatment and budget scenarios.

## Bridge Performance Factors

**The average age of KYTC's bridges is 49.33 years, nearly 14% older than the national average of 43 years.**

The average age of KYTC's bridges is 49.33 years, nearly 14% older than the national average of 43 years[5]. The advanced age of its bridges is one of the primary challenges facing KYTC today. Figure 3-6 shows the age profile for the state-owned highway bridges, with approximately 51% of these bridges built before the early 1970s. The major spike in activity during the late 1950s through the 1960s represents the construction of the Interstate system, 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.

[5] 2017 Infrastructure Report Card, American Society of Civil Engineers. www.infrastructurereportcard.org, Accessed on Oct 9, 2017.

Among KYTC's bridges, the bridges on State Secondary routes have the highest average age (58 years), and those on the State Primary route have the lowest average age (39 years).

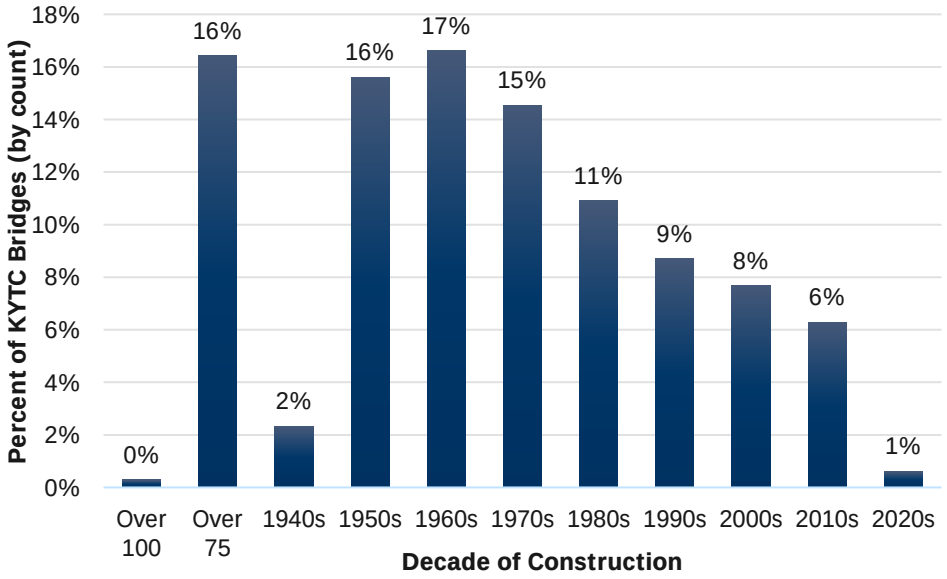



*Figure 3-6. Age profile of state-owned bridge (based on KYTC highway system)*

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 bridge conditions, forecast future conditions for decision-making purposes (such as capital investment planning and prioritization), monitor performance trends, and use the trends to inform analytical predictive models and investment plans. When forecasting the condition of bridges, it is important to recognize the factors influencing their life cycle performance. Among the factors that have the highest effect on bridge performance are age, type and quality of construction, climate conditions (including both normal and extreme climatic conditions), environment, and traffic demand have the highest effect on bridge performance.

### Bridge Performance Factors

- **Bridge type and material properties**
- **Deicing chemicals used during winter operations**
- **Proximity to water bodies**
- **Traffic volumes and weight**
- **Environmental factors**

# MEASURING CONDITIONS

## Measuring Pavement Conditions

*KYTC's automated pavement data collection equipment*

KYTC collects pavement condition data on 35,000 lane-miles of pavement each year, using the high-speed automated equipment shown in the photo. Visual assessments of pavement condition data are also collected on all Interstates, Parkways, and MP pavements with traffic levels of 375 vehicles per day or higher.

Data collection is performed by technicians in the Operations and Pavement Management Branch, using collection vehicles equipped with mapping-grade Global Positioning System (GPS), an inertial measurement unit, three forward facing digital cameras, and a Laser Crack Measurement System (LCMS2). This data collection equipment provides automated pavement distress,

rutting, cross slope,roughness, joint and crack faulting, texture, roadway geometry (curve & grade), GPS data, and roadway images.

Data quality is a critical aspect of performance-based management of highway pavements. KYTC established a Data Quality Management Plan (DQMP) in 2018 that was certified by FHWA. The DQMP identifies the quality-related responsibilities of the data collection team prior to the beginning of surveys, during surveys, and after surveys have been conducted.

KYTC currently uses the data to assess pavement condition, using four performance measures: an overall Pavement Distress Index (PDI), average Remaining Service Interval (RSI), Pavement Sustainability Ratio (PSR), and the International Roughness Index (IRI). These measures are used by KYTC to report pavement performance and make project and treatment recommendations.

### 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. It is calculated from longitudinal pavement profiles captured using the automated data collection equipment (LCMS 2).

### Condition Rating

KYTC's condition rating 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 procedures, 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 pavement in *Poor* condition.

Since Kentucky's highways serve the public, KYTC places a greater emphasis on maintaining pavements with high 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 on the overall level of distress and the total traffic volume.

The condition rating is based on two factors:

- The time remaining before the pavement requires corrective work to be performed, and
- An assessment of the general condition of the pavement quantified by the Pavement Distress Index (PDI). The PDI is calculated based on the extent and severity of various distresses observed in conjunction with the traffic (AADT) and IRI data for each pavement section. The PDI is based on a 0 to 1.0 scale, with values of less than 0.35 indicating a pavement in generally *Good* condition. PDI values between 0.36 and 0.65 indicate a pavement in *Fair* condition and values higher than 0.65 are typically representative of pavements in *Poor* condition.

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 in the condition analysis requires that each pavement is rated based on pavement distresses, traffic volume, and roughness as defined in table 3-1. This step may result in a decline in 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 RS routes, the pavement condition rating is based on IRI and traffic volume, according to table 3-1.

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

| ADT | *Poor* Condition | *Fair* Condition | *Good* Condition |
|---|---|---|---|
| Above 12,000 | 130 or higher | 98-129 | 97 or lower |
| 10,001-12,000 | 136 or higher | 102-135 | 103 or lower |
| 8,001-10,000 | 143 or higher | 111-142 | 110 or lower |
| 6,001-8,000 | 149 or higher | 117-148 | 116 or lower |
| 4,001-6,000 | 155 or higher | 124-154 | 123 or lower |
| 2,001-4,000 | 162 or higher | 130-161 | 129 or lower |
| 1,501-2,000 | 168 or higher | 136-167 | 135 or lower |
| 1,001-1,500 | 175 or higher | 143-174 | 142 or lower |
| 801-1,000 | 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 |

### Pavement Sustainability Ratio (PSR)

The PSR measures how well KYTC's pavement preservation and rehabilitation treatments are keeping up with pavement wear on a system level. It explains the amount of life put back into the pavement system during the year to restore the amount of service consumed. A PSR of 1.0 indicates that the pavement treatments delivered in a year offset the level of deterioration that took place in that year.

## Measuring Bridge Conditions

KYTC conducts NBIS bridge safety inspections and element-level inspections on all public bridges in Kentucky in support of its bridge management system, AASHTOWare Bridge Management (BrM). KYTC uses BrM to manage bridge inventory and inspection data, forecast bridge conditions, and support capital investment prioritization. Element-level inspections have been conducted in Kentucky since the early 2000s in compliance with federal requirements.

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

At KYTC, the bridge inspections are conducted at the district level and coordinated through the central office. KYTC also utilizes consultants for bridge inspections to supplement in-house crews. KYTC has 58 bridge inspectors in-house, with some districts having 2 bridge inspectors and others having 4 to 5. KYTC also has 20 bridge inspectors certified for the use of rope climbing techniques often used on large trusses and other complex structures.

Bridge inspectors are required to train through National Highway Institute (NHI) courses on bridge inspection. KYTC also organizes an annual bridge refresher workshop to share best practices in bridge inspection, review bridge inspection policy, and showcase bridge preservation projects.

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 among bridge inspections across the districts.

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

# PERFORMANCE

## Summary of Pavement Performance

**KYTC's emphasis on pavement preservation has contributed to improved network conditions in recent years.**

Table 3-2 provides a summary of KYTC's pavement inventory and conditions using data collected in 2020. While the largest portion of KYTC's pavement network is rated in *Good* condition (40%), almost one third of all pavement segments (27%) are rated in *Poor* condition. These conditions reflect improvements from the conditions reported in the 2019 TAMP, especially in terms of the network percentage in *Good* condition and the reduced network percent in *Poor* condition. These improved network conditions can be attributed in part to the increased emphasis on pavement preservation activities in recent years.

*Table 3-2. Pavement condition summary (2020 data)*

| Network | Lane-Miles Good | % Good | Lane-Miles Fair | % Fair | Lane-Miles Poor | % Poor | Lane-Miles Untested | % Untested |
|---|---|---|---|---|---|---|---|---|
| Interstate | 1,550 | 33% | 1,695 | 36% | 1,424 | 30% | 1 | 0.0% |
| Parkway | 817 | 46% | 489 | 27% | 461 | 26% | 14 | 0.8% |
| MP | 12,996 | 40% | 10,867 | 34% | 8,384 | 26% | 14 | 0.0% |
| **Dept. of Highway Subtotal** | **15,363** | **40%** | **13,051** | **34 %** | **10,269** | **27 %** | **29** | **0.1%** |
| Rural Secondary | N/A | N/A | N/A | N/A | N/A | N/A | 25,314 | 100% |

Figures 3-7 through 3-9 provide historic trends for pavement conditions for Interstates, Parkways, and the MP system. The trends show that prior to 2015, the percent of pavements in *Good* condition had decreased, while the percent of pavements in *Fair* and *Poor* condition had increased. This was generally true for each highway system, as well as the entire network. In 2015, the Pavement Management Branch implemented a methodology to focus on the distribution between *Fair* and *Good* pavements based on improved data sources. As a result, the percentage of *Fair* pavements began increasing. Furthermore, the increased investments in preventive maintenance over the last several years have begun changing the trends with increases in the amount of *Good* pavement and decreases in the systemwide percentage of *Poor* pavements.

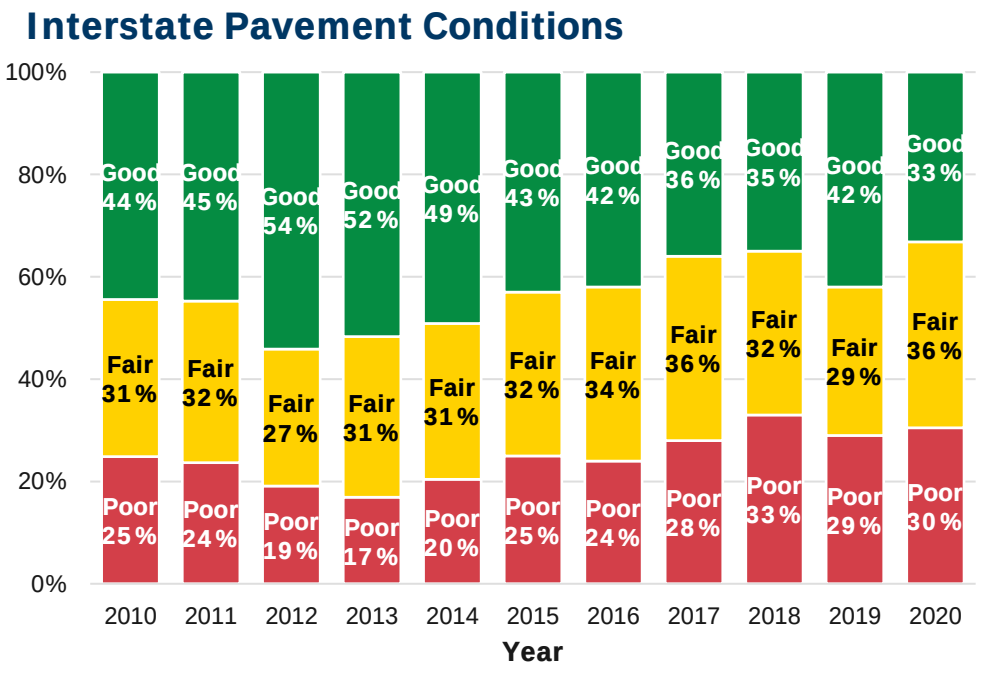



*Figure 3-7. Historic trends for Interstate pavement conditions*

## Parkway Pavement Conditions

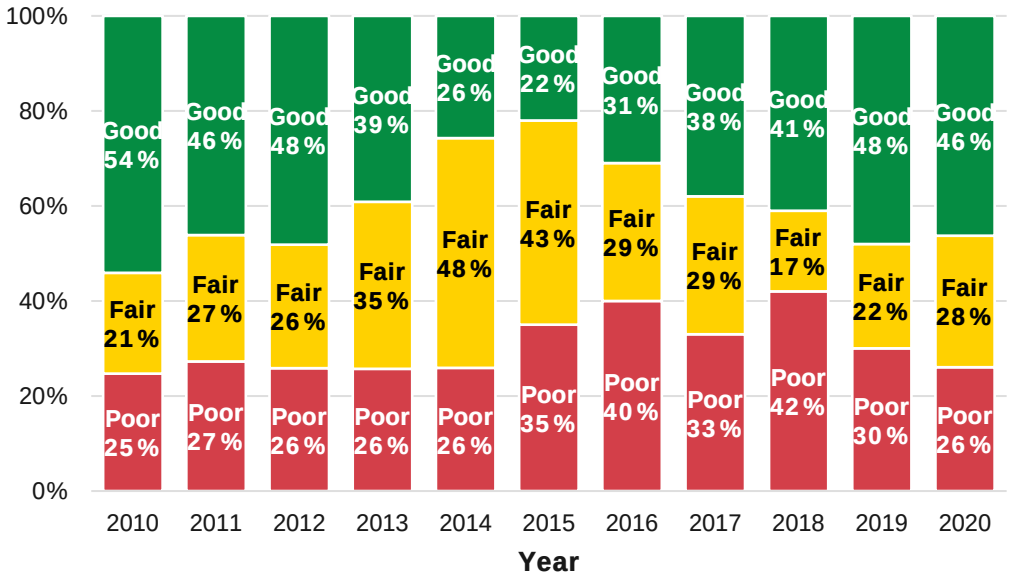



*Figure 3-8. Historic trends for Parkway pavement conditions*

## MP Pavement Conditions

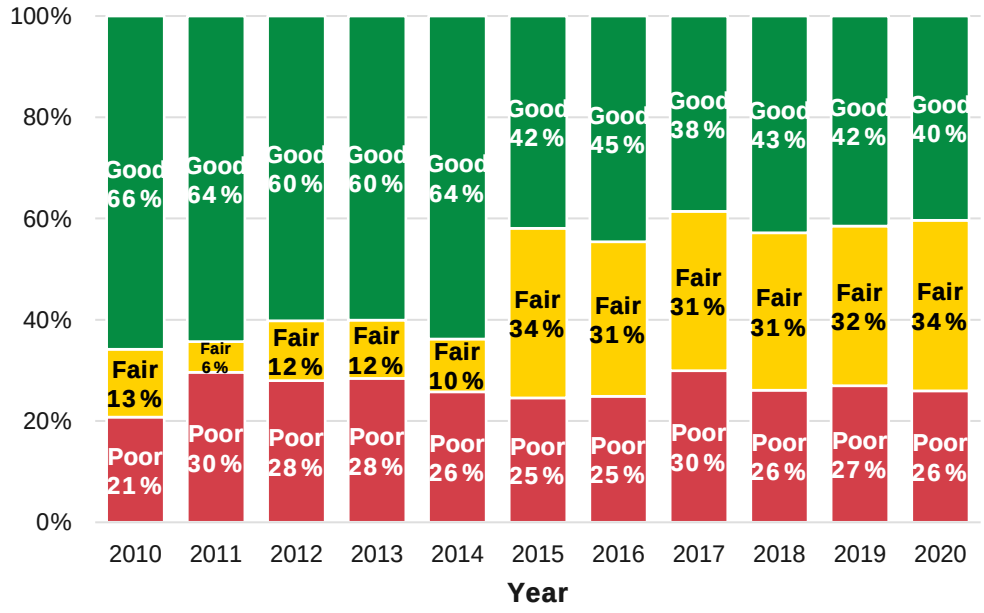



*Figure 3-9. Historic trends for MP pavement conditions*

## Summary of Bridge Performance

Table 3-3 summarizes condition statistics for KYTC's bridges. On average, 5.9% of KYTC's bridges by count and 4.6% 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

**NBI Rating Scale**

| | |
|---|---|
| 9<br>8<br>7 | Good |
| 6<br>5 | Fair |
| 4<br>3<br>2<br>1 | Poor |

count. However, in this TAMP, bridge inventory and condition are presented using both units. Among KYTC's highway systems, Interstate bridges have the highest percent (7.3%) of *Poor* bridges by deck area.

*Table 3-3. Summary of KYTC bridge inventory and condition by highway systems (2020 data)*

| Network | *Good* | | *Fair* | | *Poor* | |
|---|---|---|---|---|---|---|
| | % Count | % Deck Area | % Count | % Deck Area | % Count | % Deck Area |
| Interstate | 22% | 23% | 76% | 70% | 3% | 7% |
| Parkway | 25% | 30% | 74% | 69% | 1% | 1% |
| State Primary (Other) | 37% | 38% | 61% | 60% | 2% | 2% |
| State Secondary | 24% | 34% | 69% | 62% | 6% | 4% |
| Rural Secondary | 26% | 29% | 66% | 64% | 8% | 7% |
| Total | 27% | 31% | 67% | 64% | 6% | 5% |

Note: Includes bridges in the inventory without network designation.

Figures 3-10 and 3-11 illustrate the historic trends for the state-owned bridges, by both count and deck area respectively. In 2010, 7.1% of bridges by count were in *Poor* condition, whereas in 2020 this number dropped to 5.9%. For bridge deck area in *Poor* condition, this number was at 6.8% in 2010 and dropped to 4.5% in 2020.

**Since 2015, the percentage of bridges in *Fair* condition has been growing. This indicates an increasing need for preservation activities to shift more bridges into *Good* condition.**

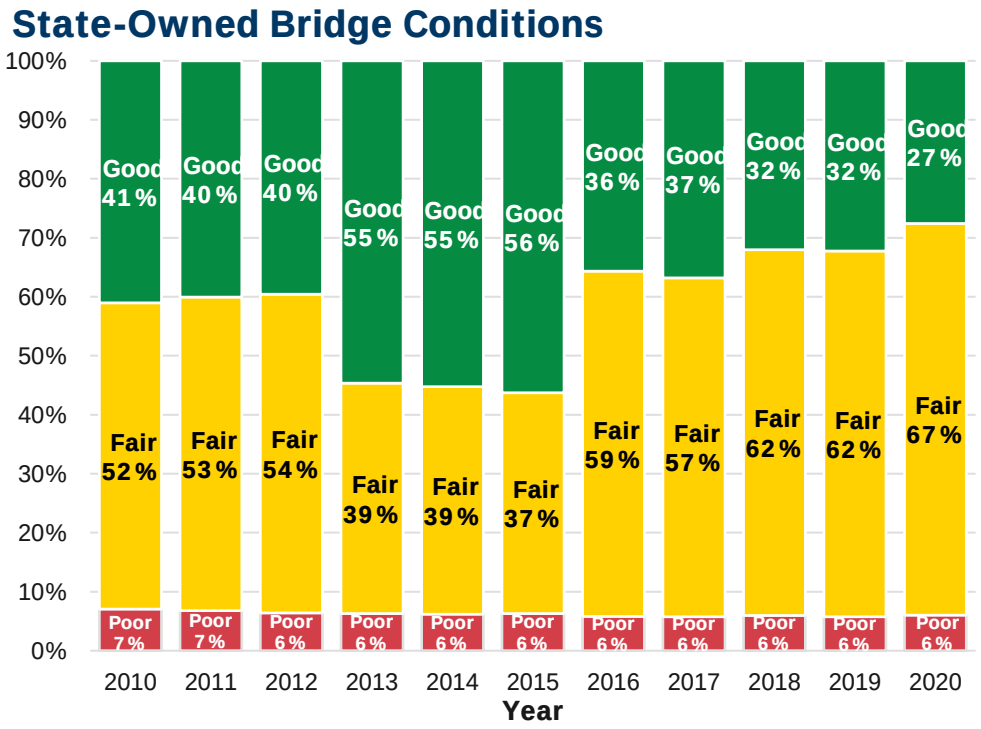



*Figure 3-10. Historic trends for state-owned bridge conditions (count)*

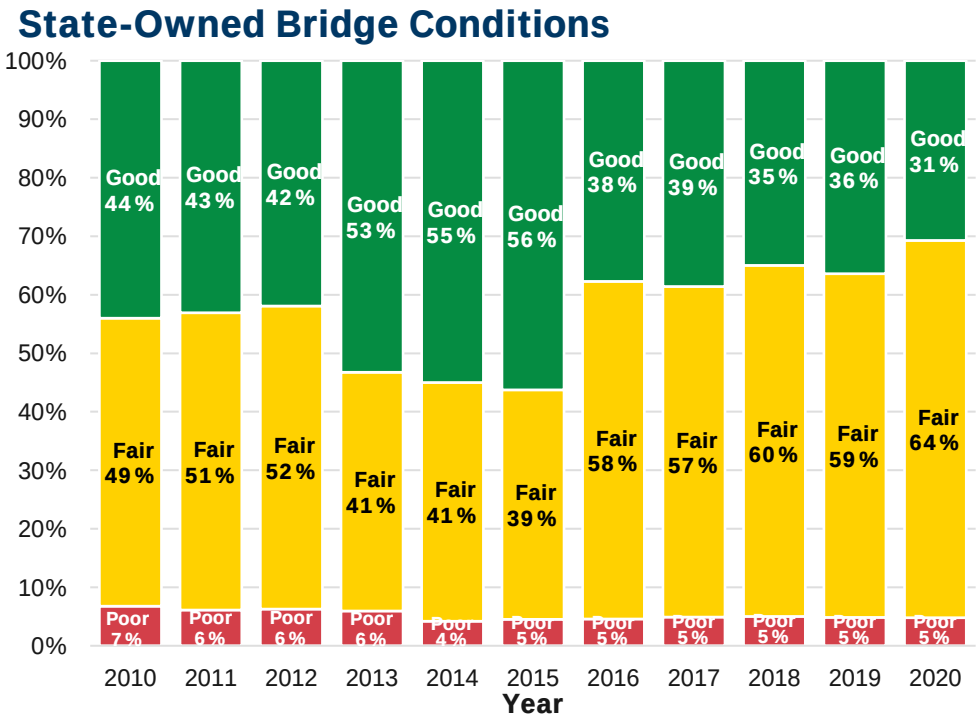



*Figure 3-11. Historic trends for state-owned bridge conditions (deck area)*

There has been a concerning trend toward declining conditions since 2015. As seen in the figures, there has been a steady decline of bridges in *Good* as well as *Poor* condition, leaving a larger share in the *Fair* condition category. This indicates an increasing need for preservation activities to shift more bridges into *Good* condition.

KYTC has been aggressively addressing a large group of smaller bridges in *Poor* condition, by reconstructing or rehabilitating them in the Bridging Kentucky Program. The relatively small size of these bridges means they have only a small effect on the size-weighted performance measures, even though these structures provide essential links in the Commonwealth's network .The current Kentucky Bridge Program is building upon program delivery and scoping process improvements gleaned from the recent Bridging Kentucky effort and these lessons learned will increase the efficiency of individual bridge project delivery.

## TARGETS AND LONG-TERM GOALS

KYTC is currently using a performance-based approach for asset management that relies on performance measures to assess system performance, identify needs, and develop investment priorities. As part of this process, KYTC establishes goals that represent the desired SOGR for its entire state-managed transportation system. These performance measures are also used to establish budget requirements and life cycle plans for pavements and bridges as described in this TAMP.

In addition to KYTC's performance measures, federal legislation requires states to report pavement and bridge conditions using federally established performance measures. Therefore, since the implementation of MAP-21 and the issuance of the final rule-making on transportation performance

management, KYTC has established and reported federal measures and targets for pavements and bridges on the NHS that are included in Appendix A.

## Pavements

KYTC's Long Range Statewide Transportation Plan includes a goal to increase the percentage of pavements in the *Good* and *Fair* categories to a desired SOGR of 92%. This is not achievable with anticipated resources so more realistic, constrained targets have been established. To achieve the best possible conditions with available funding, PSR is one metric used to manage the annual paving program.

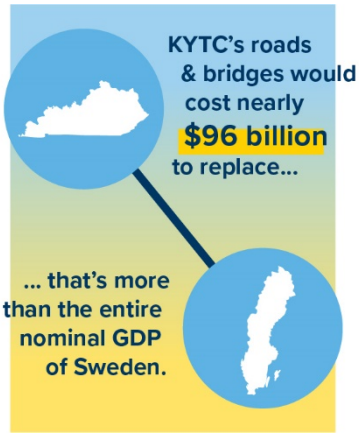
In addition to its desired SOGR, KYTC is required to report pavement conditions and set targets using federally required pavement performance measures for the pavements on the NHS. Appendix A summarizes pavement conditions reported using the required National Highway Performance Program (NHPP) performance measures.

## 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* condition generally require only maintenance activities, whereas bridges in *Poor* condition are reaching a point where replacement may be necessary. *Fair* condition often represents an opportunity for cost-effective preservation. KYTC has adopted a desired SOGR of 97% bridge deck area in *Good* or *Fair* condition.

For bridges, the federal performance measures for the NHS bridges align with the measures KYTC uses for bridge management. However, the short-term targets established based on federal targets are for only NHS bridges and not all bridges represented by the desired SOGR.

# ASSESSING TRANSPORTATION INFRASTRUCTURE ASSET VALUE




The pavements and bridges represented in KYTC's TAMP represent the Commonwealth's largest capital investment and one of the largest components of Kentucky's public wealth. The inclusion of asset values in the TAMP illustrates the importance of the systematic asset management practices outlined in this document 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 the intervention treatment is applied. This approach is valid for KYTC since its pavement management practices ensure that treatments are only applied to appropriate pavements.

In this approach, the value of a pavement segment depreciations at a rate based on the next treatment it is expected to receive and the time remaining until that treatment is applied. KYTC expects an overlay cycle of 11 years, so the pavement deteriorates by 1/11$^{th}$ 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 continues to depreciate based on the cost of the next expected treatment, and time until that treatment is expected. This approach accounts for pavements that have deteriorated beyond the opportunity for an overlay are allowed to deteriorate further before more substantial treatments are applied. This is done to receive the full benefit of the more substantial treatment. The approach recognizes that pavements in this state of greater deterioration are depreciating at a faster rate than pavements not yet 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. The total replacement cost of KYTC's pavement is almost $60 billion. The current depreciated replacement cost is approximately $54 billion. This valuation does not replicate or correlate to the valuation performed by KTYC to comply with Governmental Accounting Standards Board Statement 34 (GASB 34) standards. It is performed only to inform asset management analysis.

The RS system was not considered in the pavement asset valuation, nor in the TAMP investment plans since it has a separate source of funding and is managed separately outside the Department of Highways.

**It would take nearly**

**$60 billion**

**to replace KYTC's pavement network.**

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

| Highway System | Replacement Cost ($ billion) | DRC ($ billion) |
|---|---|---|
| Interstate | $10.3 | $8.9 |
| Parkway | $3.9 | $3.7 |
| MP | $43.6 | $41.3 |
| **Total** | **$ 57.8** | **$53.9** |

## Bridge Asset Valuation

There are multiple frameworks to calculate asset valuation for transportation assets, such as bridges. The framework outlined in GASB 34, modified GASB-34, and depreciated replacement cost framework are among the most popular methods adopted by transportation agencies. Depreciated value can

be based on either the age of the asset, or the condition of the asset. In the former, the total replacement cost of the asset in the 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 depreciates current value 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.

For this TAMP, figure 3-12 illustrates the assumed bridge asset value depreciation for each possible rating of bridge components (deck, superstructure, substructure, culvert). It is assumed that on average, bridge components will lose 90% of their value when their condition rating reaches 4 and linearly decreases to 0 when the rating reaches a 2.

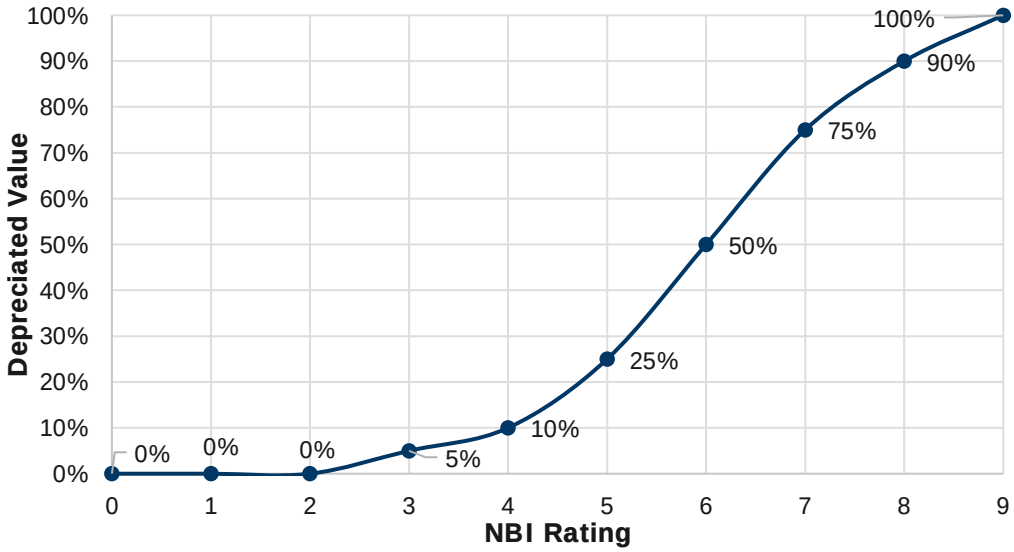



*Figure 3-12. Assumed bridge asset value depreciation by NBI component rating*

Based on KYTC bridge and culvert replacement data for 2022, and consistent with the KYTC SYP, average bridge replacements cost $612 per square foot of deck area. The bridge deck rating is given 50% of the total bridge value, with superstructure and substructure each given 25% of the total bridge value. Table 3-5 summarizes the resulting undepreciated and depreciated replacement values for KYTC's bridge assets.

**It would take over**

**$38 billion**

**to replace KYTC's bridge network.**

*Table 3-5. Bridge asset valuation for KYTC system designations*

| Highway System | Replacement Value ($ billion) | Depreciated Value ($ billion) |
|---|---|---|
| Interstate | 9.4 | 5.1 |
| Parkway | 1.7 | 1.0 |
| State Primary | 12.6 | 7.8 |
| State Secondary | 9.7 | 5.7 |
| Rural Secondary | 4.7 | 2.7 |
| **Total** | **38.1** | **22.4** |

# Chapter 4: Life Cycle Planning

## OVERVIEW

**Life Cycle Planning**

**Life Cycle Planning enables asset managers to extend the useful life of assets through the strategic use of treatments that provide long-term benefit.**

KYTC manages 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 asset treatment strategies that are effective in managing asset deterioration in the most cost-effective manner.

LCP for pavements and bridges is based on a long-term, network-level analysis of system performance to determine the best actions to manage these assets over their whole life. 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 the timely application of low-cost preventive maintenance treatments reduces the rate of deterioration and will lead to longer asset service lives in comparison to traditional strategies that let assets deteriorate until major repairs are needed.

Asset condition deteriorates over time due to exposure to traffic and the environment. Different treatments can be applied to slow the rate of deterioration or repair damage. Figure 4-1 illustrates a generic asset life cycle, where different treatments are applied at different times over the life of the asset. Asset management uses asset condition information and analysis techniques to determine the appropriate treatment for each asset and the best time to apply that treatment.

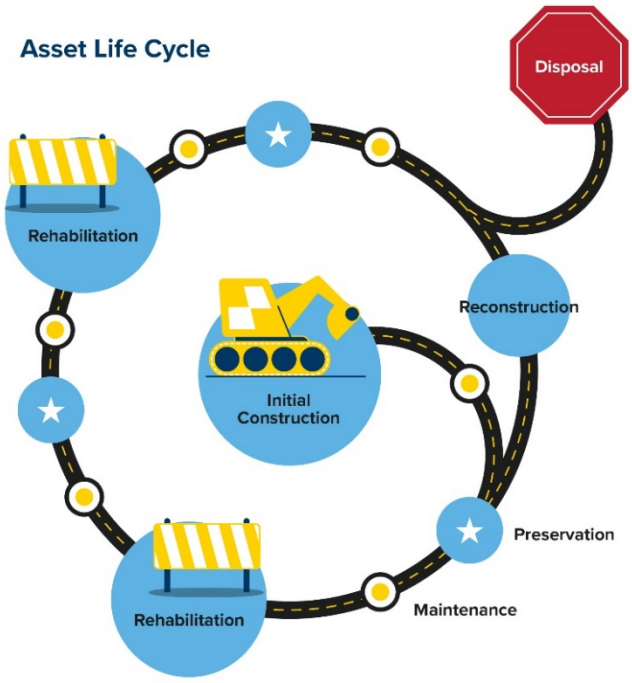



*Figure 4-1. Asset life cycle stages*

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 address the deteriorated areas, and eventually, the asset will need to be replaced. As the graphic shows, the cost of each level of repair increases exponentially as the overall asset condition deteriorates. That is why treatment strategies that prevent an asset from deteriorating to the replacement category are so cost-effective.

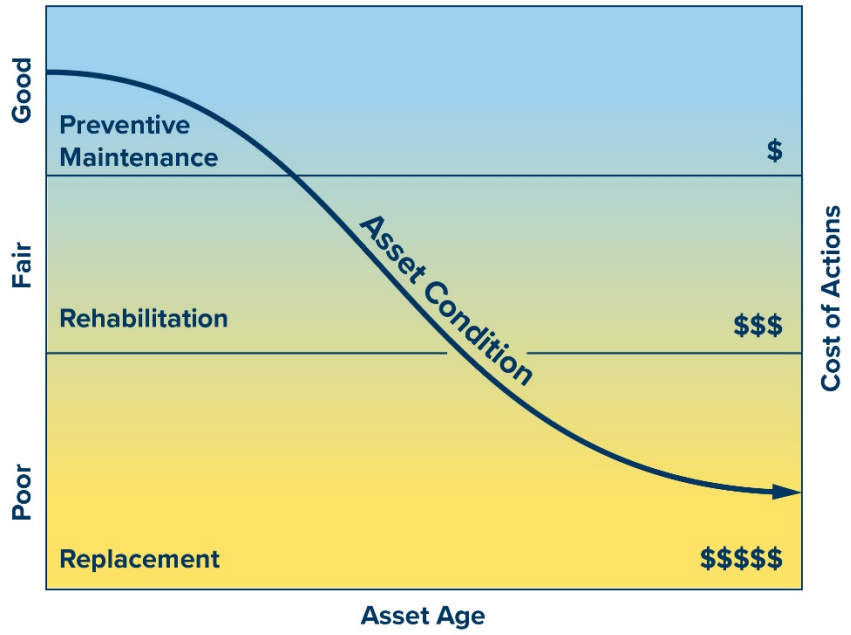



*Figure 4-2. Illustration of the relationship between asset condition and treatment cost*

**LCP Considerations**

**Increased travel demands**

**Increased labor and material costs**

**Impact of extreme weather events**

**Historical asset performance**

Factors such as increasing travel demands, and rising 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.

Bridges and culverts spanning waterways pose additional challenges, including vulnerability to scour around their foundations and periodic flood damage. A bridge management system can incorporate certain common resilience characteristics into its analysis to influence the priority of functional improvements and replacements.

LCP approaches the development of long-term treatment strategies from a high-level perspective. 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.

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

The LCP approach adopted by KYTC evaluates the long-term impacts of multiple life-cycle 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 the LCP analysis.

As figure 4-3 shows, ongoing investments in low-cost preservation treatments defer, or eliminate, the need for more costly repairs by keeping pavements in *Good* condition for a long period of time. The application of the right preservation treatments at the right time can keep pavements 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 short-term, it is very expensive in the long-run. The preservation strategy provides better long-term conditions at a lower life-cycle cost.

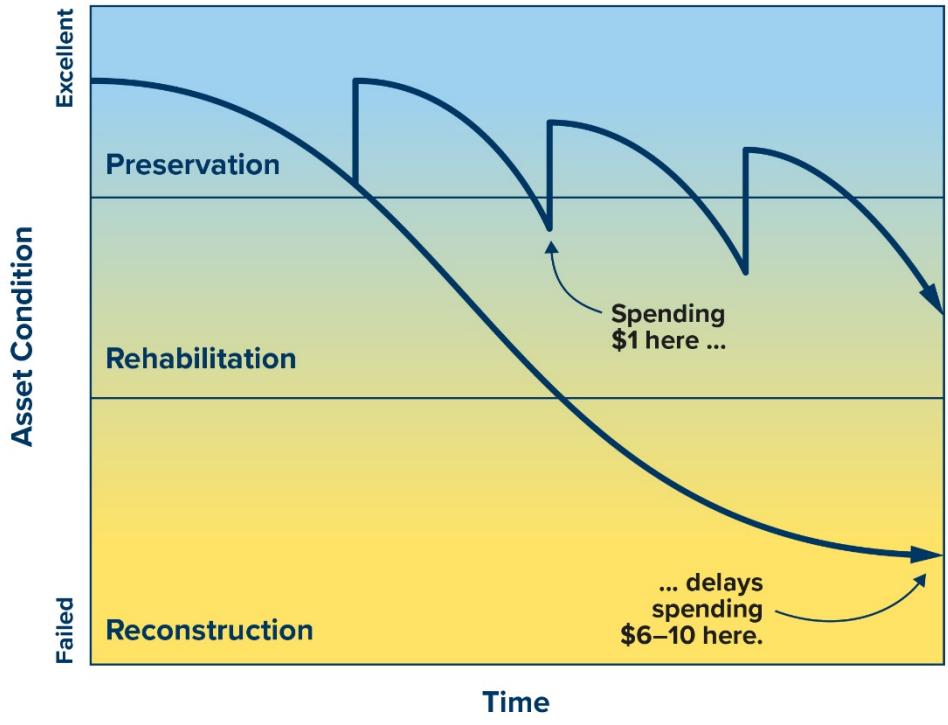



*Figure 4-3. Example showing the cost-effectiveness of preservation treatments*

## Pavement Preservation Treatments and Costs

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.

*Table 4-1. Summary of KYTC pavement treatments by work type*

| Work Type | Typical Treatments | Typical 2021 Costs per Lane-Mile | Feasible Networks |
|---|---|---|---|
| Maintenance | Sweeping, Crack Sealing | $5000 or less | All |
| | Pothole Patching | N/A | All |
| | Shoulder Work | N/A | All |
| Preservation | Chip Seal, Slurry Seal | $26,000 | MP |
| | Microsurfacing | $42,000 | All |
| | 0.75" Asphalt Overlay | $42,000 | |
| | Cape Seals | $48,000 | All |
| | Thin Overlay | $75,000 | RS and MP |
| | Thin Overlay | $220,000 | Interstates and Parkways |
| | Diamond Grind and Repair | $250,000 | RS and MP |
| | Diamond Grind and Repair | $350,000 | Interstates and Parkways |
| Rehabilitation | Intermediate Overlay, generally 3.5-5.5 inches | $375,000 | Interstates and Parkways |
| | Thick Overlay | $500,000 | Interstates |
| | Structural Overlay | $1,100,000 | Interstates |
| Replacement | Replace | $2,200,000 | Interstates and Parkways |
| | Replace | $1,350,000 | RS and MP |

Note: KYTC classifies Chip Seals, Slurry Seals, Cape Seals, Microsurfacing and ¾" Asphalt Overlays as "Preventive Maintenance" (PM) treatments; Thin Overlays and Diamond Grind and Repair are classified as "Preservation" treatments.

## Pavement LCP Strategies

KYTC evaluated the impacts of three LCP strategies on pavement conditions and total preservation liability. Strategy 1 (Optimized Preservation) optimizes the use of preservation treatments on the Interstate, MP, and Parkway systems and reflects KYTC's current treatment strategy. Under Strategy 2 (No Preventive Maintenance on MP), Diamond Grinding treatments are included but the Strategy 1 budget allotted to Preventive Maintenance (PM) treatments is shifted to thin overlays on the MP system. Strategy 3 represents a traditional "worst-fist" approach, in which pavements are allowed to deteriorate to the lowest tolerable condition before a major treatment is applied. To model this scenario, funding normally allocated to Preservation work is shifted to the Rehabilitation category.

Strategy 2 was included in the analysis to better understand the impact of PM treatments on asset condition and Strategy 3 was included to illustrate the potential consequences of following KYTC's historical practices (prior to 2015). Since 2015, KYTC has been strong stewards of pavement preservation and has been increasing its use on the MP and Parkway systems, as reflected in Strategy 1.

In an LCP analysis, each of the strategies is analyzed at the same funding level. This allows the differences in the expected conditions to be compared on an equal basis. Figures 4-4 thru 4-6, illustrate the differences in how the available funding is allocated to each treatment category for the three LCP strategies evaluated.

**LCP Strategies Evaluated**

**Strategy 1: Optimized Preservation**

**Strategy 2: Shift the PM budget on the MP system to thin overlays**

**Strategy 3: Shift a large portion of the Thin Overlay budget under Strategy 2 to rehabilitation treatments**

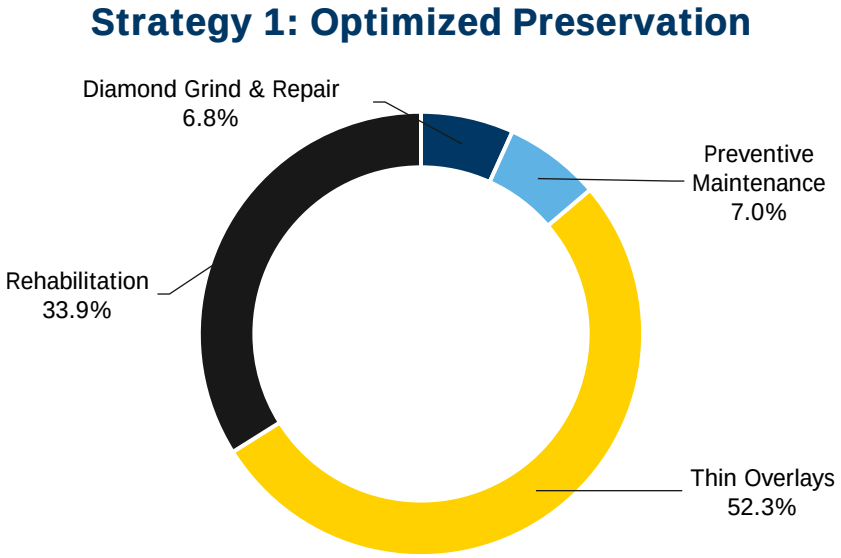



*Figure 4-4. Budget allocation by work type for Strategy 1: Optimized Preservation*

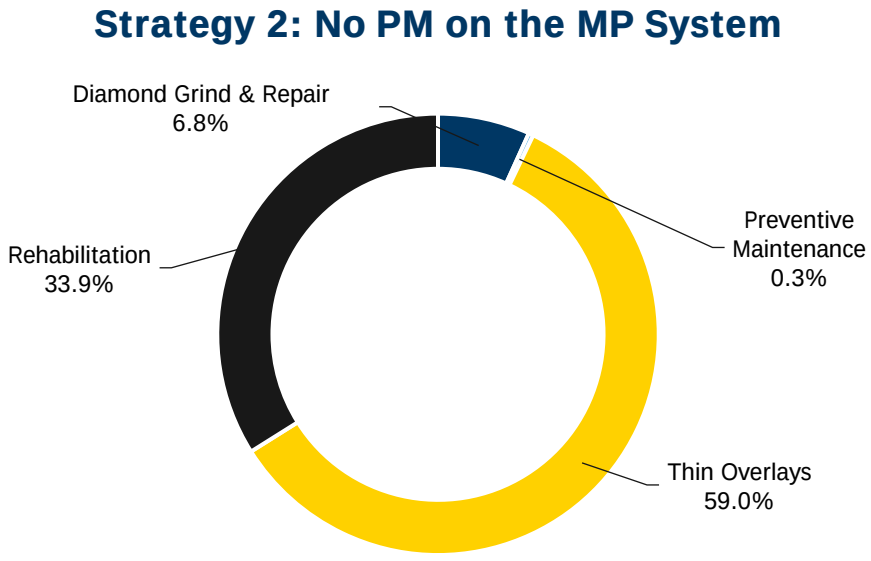



*Figure 4-5. Budget allocation by work type for Strategy 2: No PM on the MP system*

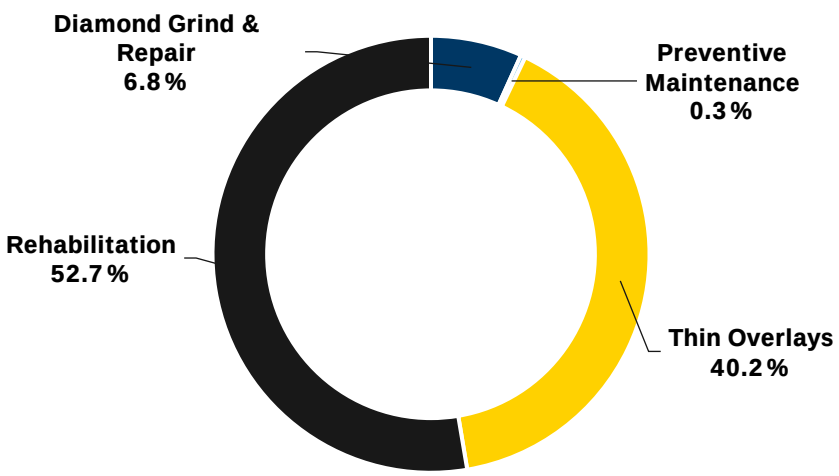



*Figure 4-6. Budget allocation by work type for Strategy 3: Worst First*

## Pavement LCP Tools

For this TAMP, KYTC utilized a Microsoft Excel-based spreadsheet tool to conduct the pavement LCP analysis. The tool, which was used in developing previous TAMPs, evaluates the future impacts of various treatment strategies based on the expected budget. One drawback associated with the tool is its inability to evaluate future impacts beyond a 10-year window.

**KYTC is enhancing its LCP analysis capabilities by implementing a comprehensive pavement management system to perform more detailed, longer-term analyses.**

To overcome this limitation, KYTC is currently advancing its implementation of a comprehensive pavement management system. The new software allows KYTC to perform more detailed, longer-term analyses. KYTC is currently working with the University of Louisville on the development of pavement performance models that reflect expected deterioration rates based on various factors such as surface type, traffic, and location. While the models are being developed, other initiatives are underway to configure the pavement management software to reflect KYTC's decision processes and to verify the reasonableness of the analysis results. As detailed in Chapter 7, KYTC anticipates that the performance models will be developed and integrated into the PMS by 2023. Validation of the PMS analysis results will continue through 2024 through concurrent use of both the spreadsheet tool and the PMS. KYTC anticipates that the system will be ready for use in 2024, which means it will be available for use in developing the 2026 TAMP.

## Pavement LCP Analysis Results

Using pavement condition data from 2021 as the baseline, the LCP analysis covers the 10-year period from 2023 to 2032. Figure 4-7 shows the initial condition of KYTC's pavement network (based on year 2021) and the projected conditions at the end of the analysis period (year 2032) for each of the three LCP strategies evaluated. The analyses used an expected annual budget of $420 million.

As the figure shows, the Optimized Preservation strategy (Strategy 1) results in the lowest percentage of *Poor* pavements by 2032 (30 percent, or approximately 11,307 lane-miles). As seen in figure 4-7, when the budget allocated to PM treatments is completely shifted to thin overlays on the MP system, the percentage of pavements in *Poor* condition increases to 33 percent (or 12,717 lane-miles), a 3 percent increase over Strategy 1. By 2032, Strategy 2 results in 1,410 lane miles of additional *Poor* pavements than Strategy 1, which is nearly equivalent to the size of the entire FY05 program. Another way of interpreting this difference is that in a 10-year program, the entirety of one year's budget is needed just to cover the added cost associated with the non-optimized strategy.

Under the Worst-First strategy (Strategy 3), the percentage of pavements in *Poor* condition is 46 percent (17,686 lane-miles), which represents a 16 percent increase in comparison to the Strategy 1. The differences between the three strategies are magnified when viewed over a longer period of time.

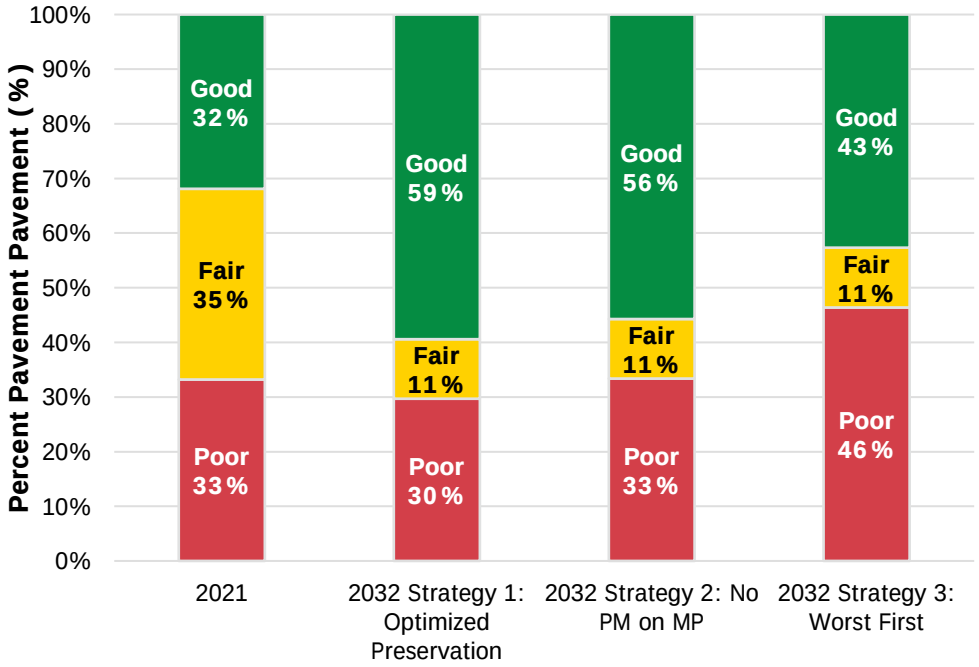



*Figure 4-7. Initial and 10-year projected network pavement conditions*

Figure 4-8 highlights the impact of each LCP strategy on pavements in *Poor* condition over the 10-year analysis period at the anticipated annual budget level of $420M. Between 2023 and 2032, the outcomes from Strategies 1 and 2 are very similar, with Strategy 2 resulting in a slightly higher fraction of *Poor* pavements by 2032. Under Strategy 3, the fraction of *Poor* pavements increases at a very rapid rate between 2022 and 2027 and eventually results in approximately 46 percent of the pavement network being in *Poor* condition.

The results from the analysis indicate that the anticipated annual budget level of $420 million may be adequate to sustain current performance levels for the next 10 years, but the increase in pavements in *Poor* condition indicates that conditions are deteriorating in the long run. To address this concern, KYTC also evaluated the impacts of an increased budget scenario of

$450 million per year. This funding level proved sufficient to improve pavement conditions over the 10-year period, as evidenced by the significant reduction in the percentage of the network in *Poor* condition. The results are presented in figure 4-9.

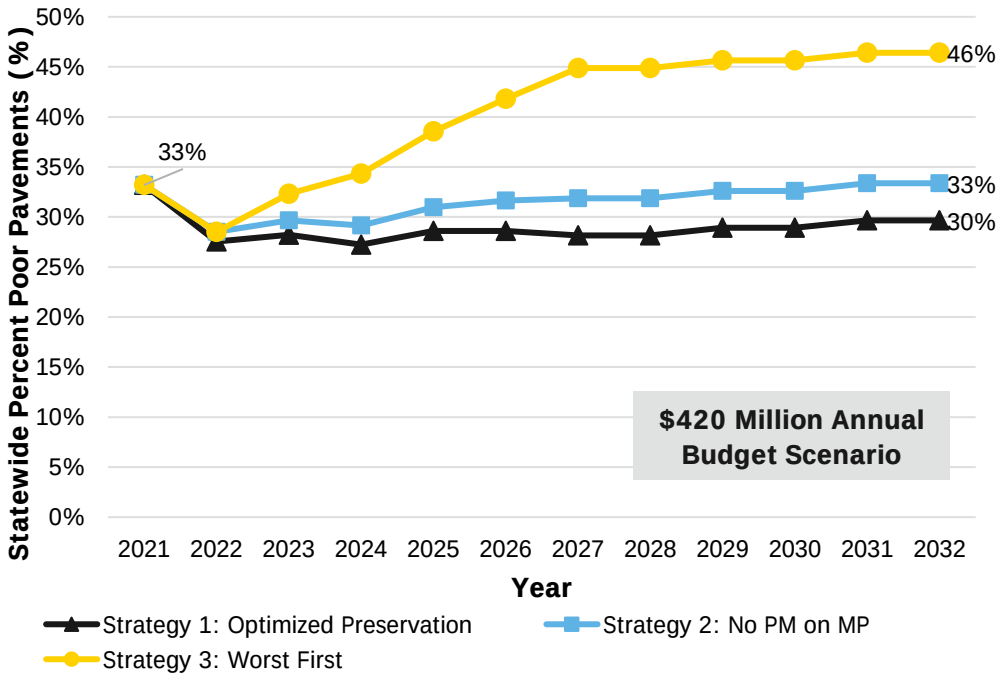



*Figure 4-8. Pavement performance outcomes for each LCP strategy at a $420 million annual budget level*

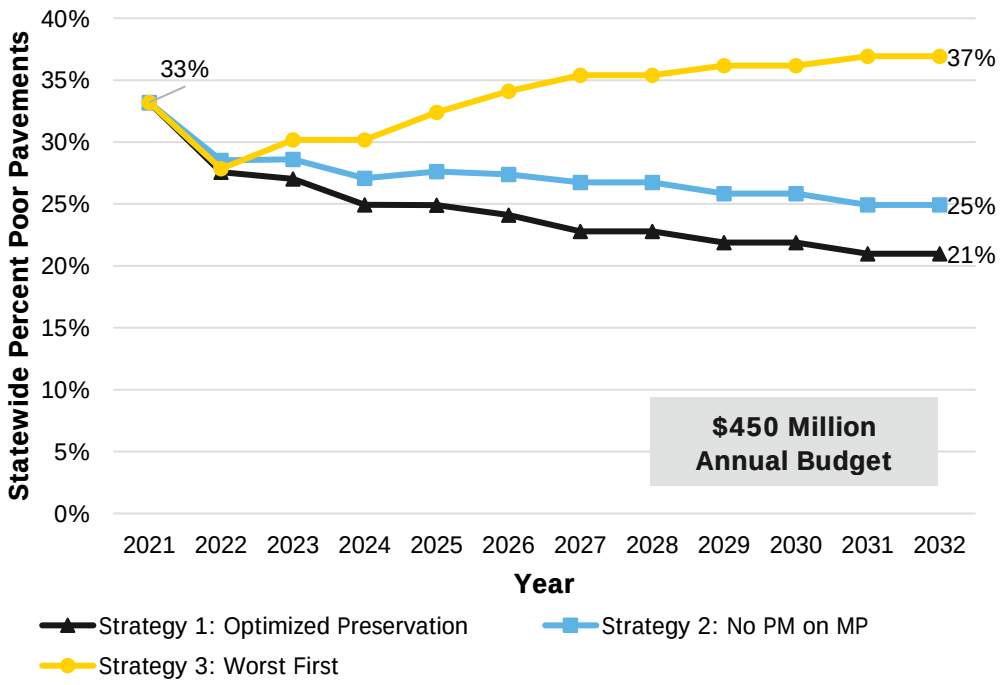



*Figure 4-9. Pavement performance outcomes for each LCP strategy at a $450 million annual budget level*

The increased budget level results in gradually improving pavement conditions for Strategies 1 and 2, with Strategy 1 exhibiting the highest improvement over the baseline condition. Under Strategy 1, the percentage of pavements in *Poor* condition decreases to 21 percent, which represents a 7 percent drop from the initial conditions.

KYTC uses a performance measured called the "preservation liability" to understand the financial impacts associated with different treatment strategies. Preservation liability represents the cost to treat all *Poor* pavements in each year of the analysis. The liability increases as the number of miles in *Poor* condition increases, corresponding to an increase in the number of candidates for rehabilitation and reconstruction. Figure 4-10 compares the preservation liability that is developed under each treatment strategy using an annual budget of $420 million.

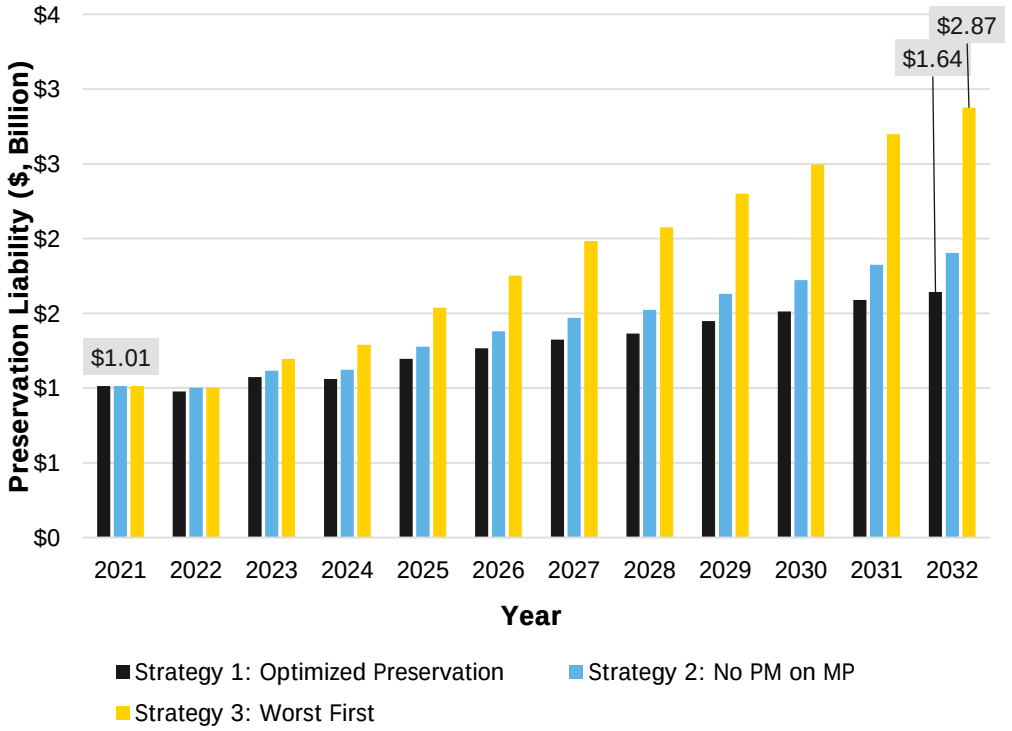



*Figure 4-10. Preservation liability comparison*

**The LCP analysis clearly demonstrates the benefits associated with the increased use of preventive maintenance.**

For a $420 million annual budget, the preservation liability under Strategy 1 increases by approximately 62 percent by 2032 due to the increasing percentage of pavements in *Poor* condition. In comparison, Strategy 3 results in a 184 percent increase in the preservation liability. The results illustrate the burden imposed by deferring Preventive Maintenance and Preservation needs to the point that more expensive treatments are necessary.

For the increased budget scenario evaluated ($450 million annual budget), the preservation liability under Strategies 1 and 3 increases by approximately 19 and 114 percent respectively over the 2023 level. This example illustrates the financial benefits to KYTC associated with increased investment in the preservation of its pavement network.

The LCP analysis clearly demonstrates the benefits associated with the increased use of preventive maintenance, and other low-cost treatments to

manage KYTC's road network. Based on the results of this analysis, KYTC is continuing its pavement strategy that seeks to optimize the use of preventive maintenance on all networks: Interstate, Parkways, and MP roads (Strategy 1). Under this strategy the proactive application of preservation treatments is used to delay the progression of deterioration and the need for overlays or other major rehabilitation actions. Treatments are prioritized by traffic volume to support KYTC's efforts to achieve its pavement condition goals and targets.

The predicted future conditions based on actual investment strategies are provided in Chapter 6, Financial Plan and 10-Year Investment Strategies.

## Improving Pavement System Resilience

Building on the guidance published by FHWA (FHWA 2015) and the Cabinet's Resiliency Improvement Plan, KYTC has taken a holistic approach to build a more resilient pavement network for its citizens. The main environmental risks that impact the resilience of KYTC's pavement systems include:

- Temperature extremes (high and low)
- Higher average precipitation levels
- More extreme rainfall events
- Increasing numbers of flooding events

For the key risks identified, some of the main pavement vulnerabilities include the following:

- Increased rate of asphalt binder aging
- Increased curling and warping stresses in concrete pavements that can result in more blow-ups during the summer months
- Reduced pavement structural capacity of unbound base layers and subgrade due to increased precipitation and flooding
- Reduced surface friction due to more extreme rainfall events

For the key risks and vulnerabilities identified for pavements, KYTC considers a range of adaption strategies that can be implemented at various stages of the pavement life cycle. These strategies, which are shown in figure 4-11, include adaptions to:

## Optimizing Mix Designs for Improved Friction

**KYTC is initiating a project to develop a procedure that will consider asphalt pavement surface friction levels over its service life. The project will:**

- **Establish sustainable friction and macrotexture requirements for various KYTC road network applications to meet safety performance needs**
- **Develop a friction index use in KTYC's balanced-mix design specifications**
- **Document the processes and procedures to facilitate implementation by other agencies**

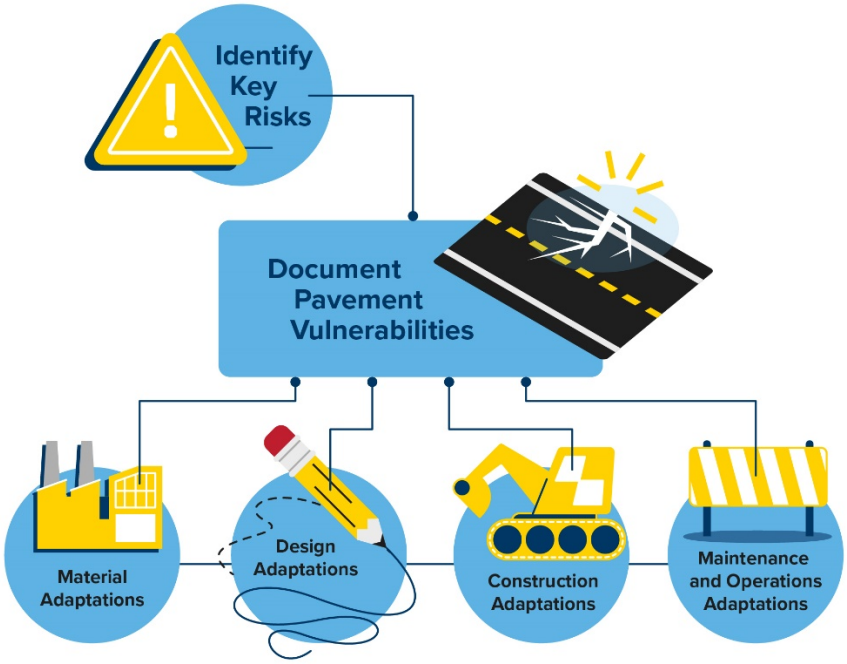



*Figure 4-11. Framework for considering pavement resilience*

- **Material selection**. KYTC is routinely evaluating potential issues such as suitability of asphalt binder grades based on temperature gradient trends across the Commonwealth.
- **Design approaches**. KYTC is conducting research on optimizing asphalt mix designs that will enable the consideration of friction over the service life of the asphalt pavement surface layer. KYTC is also planning on conducting additional structural testing on its pavement network to determine appropriate future treatment needs based on structural capacity.
- **Construction procedures**. KYTC is improving the quality of pavement construction by placing increased emphasis on construction inspection, acceptance, and project delivery.
- **Maintenance and operation activities**. KYTC has increased efforts to seal cracks and joints in existing pavements and is currently investigating the use of asphalt pavement preservation techniques (e.g., chip seals, fog seals, microsurfacing etc.) that are more effective in reducing permeability. KYTC is also in the process of inventorying various drainage assets using a mobile app system to help identify areas of concern and prioritize project selection.

Extreme weather events can potentially influence pavement treatment strategies over the long-term and KYTC considers these risks and adaption approaches while developing its LCP strategies. KYTC considers a balanced priority between preservation and major rehabilitation/reconstruction actions that not only ensures that *Good* pavements continue to provide a good level-of-service for the road users, but pavement sections that are more vulnerable to extreme weather events receive a fair allocation of funding to address imminent risks. Based on routine vulnerability assessments, if a certain portion of the KYTC pavement network is found to be more vulnerable to

extreme weather events, the pavement deterioration models, and treatment strategies will be recalibrated to help improve the network's overall resilience.

### Opportunities to Improve Pavement LCP

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.

- As noted earlier, KYTC is in the process of 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. As part of the PMS implementation, KYTC is:
  - Testing the developed treatment 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.
  - Testing the developed deterioration models for its pavement treatments. These updated models will improve the consistency and accuracy of predicted future conditions.

## LIFE CYCLE PLANNING FOR BRIDGES

Over the past three years KYTC has made significant progress expanding its bridge program to implement a more comprehensive set of preservation activities. This implementation has required training of personnel, acquisition of new materials and equipment, and facilitation of new capabilities in the contractor community.

The agency is expanding the use of its Bridge Management System (BMS), known as AASHTOWare Bridge Management (BrM), to include modeling. The expanded use of the BMS will further enhance KYTC's ability to plan future preservation work in a way that minimizes the long-term cost of keeping the transportation network in service while considering normal deterioration and system resilience. The analysis supporting this TAMP was largely conducted using the new BMS. KYTC created and staffed a new position to focus on bridge management, enabling the agency to upgrade its technology and work smarter. The small investment in better planning leverages tens of millions of dollars in cost savings and improved outcomes.

## Midwest Bridge Deterioration Study

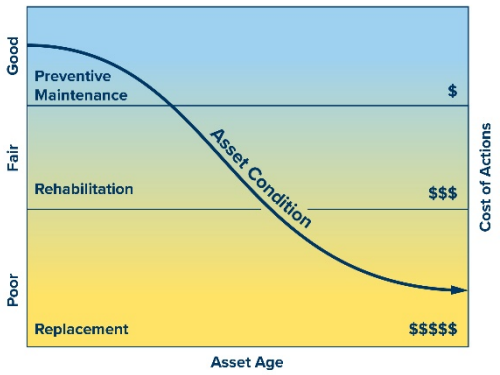
**KYTC is cooperating with the Federal Highway Administration and eleven Midwest states to develop a set of deterioration models for Bridge Management Systems.**

**These models take advantage of a significant body of data and experience, and modern statistical analysis, to quantify how quickly new preservation needs arise under different conditions and circumstances.**

**The models will significantly enhance the quality of condition forecasts and help optimize bridge preservation investments.**

# Bridge Preservation Treatments and Costs

Effective bridge preservation strategies delay the need for costly bridge replacement projects. These strategies typically consist of the treatments listed in table 4-2. As shown conceptually earlier in figure 4-2 (and repeated here), 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 bridges deteriorate into *Fair* and *Poor* conditions. Generally, preservation strategies are effective in improving the performance of a bridge 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 4-2.




An effective bridge preservation program should include the following components, all of which are addressed by a sound LCP strategy:

- 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. These reports summarize the cost and effectiveness of different maintenance and preservation practices, which include routine and condition-based preventive maintenance activities.

*Table 4-2. Typical feasible bridge actions for different component or element conditions*

| Component Rating | Commonly Employed Feasible Actions |
|---|---|
| 9, 8, 7 (*Good*) | Routine Preventive Maintenance |
| 6, 5 (*Fair*) | Preservation<br>Rehabilitation |
| 4, 3, 2, 1, 0 (*Poor*) | Major Rehabilitation<br>Replacement |
| **Element Condition State (CS)** | **Commonly Employed Feasible Actions** |
| 1 (*Good*) | Routine Preventive Maintenance |
| 2 (*Fair*) | Condition-Based Preventive Maintenance<br>Preservation |
| 3 (*Poor*) | Condition-Based Preventive Maintenance<br>Rehabilitation |
| 4 (*Severe*) | Major Rehabilitation<br>Replacement |

Table 4-3 summarizes the KYTC bridge treatment 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 within a transportation agency). The differences are based on the practices, policies, and climatic conditions where the bridges are located as well as the availability of experienced contractors and high-quality materials. These types of cost factors are configured into KYTC's BMS and used in its work planning processes.

*Table 4-3. Summary of KYTC bridge treatments by work types*

| Work Type | Typical Treatments | Typical 2021 Costs per Lane-Mile | Units |
|---|---|---|---|
| Maintenance | Deck-Wash | $ 3 | sq.ft |
| | Deck-Wash with Sealing | $ 8 | sq.ft |
| | Abutment/Pier Seat Cleaning | $ 3 | sq.ft |
| | Abutment/Pier Seat Cleaning with Concrete Coating | $ 8 | sq.ft |
| | Joint-Cleaning | $ 20 | Linear Feet (LF) |
| Preservation | Paint Superstructure | $ 18 | sq.ft |
| | Latex Overlay | $ 45 | sq.ft |
| | Repair Joint Seals | $ 400 | LF |
| | Paint/Clean Bearings | $ 25 | sq.ft |
| Rehabilitation | Reset Bearings | $ 400 | each |
| | Superstructure Replacement | $ 150 | sq.ft |
| | Deck Replacement | $ 100 | sq.ft |
| Replacement | Bridge Replacement | $ 288 | sq.ft |

**Bridge LCP Analysis Priorities**

**Cost-effective preservation opportunities**

**Resilience characteristics affecting safety and mobility**

## Bridge LCP Analysis

KYTC's BMS includes an LCP analysis to identify the best opportunities for long-term cost savings, and to prioritize investments appropriately to ensure that the right amount of preservation work is completed in a timely manner.

The analysis focuses on the unique conditions and characteristics of each element of each bridge, using research on element deterioration rates to forecast future needs for preservation, rehabilitation, and replacement. It simulates a life cycle plan of bridge work over a period of 75 years and considers the benefit of postponing significant costs for as long as possible without disrupting service. The benefit of postponing major costs is known as the time value of money and is quantified using a discount rate of two percent per year. A small amount spent on preservation may postpone a large cost such as replacement, and this is the tradeoff that the model evaluates for each bridge. The most cost-effective preservation opportunities receive highest priority.

In addition, the BMS considers resilience characteristics of a bridge affecting road user safety and mobility, including advanced deterioration, clearances, and scour. Bridges having significant risk of service disruption receive greater priority for improvements or replacement.

### LCP Strategies

As an illustration of the analysis, a strategy that implements a sound preservation policy can be 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.

For the analysis an Optimized Preservation strategy is compared to a Worst First strategy at a funding level of $250 million per year. The Worst First strategy contains no preservation work, only rehabilitation and replacement, and gives no consideration to future costs.

### Analysis Results

The results from the analysis are presented in Figure 4-12. These results compare current (2021 National Bridge Inventory submittal) systemwide bridge conditions with forecasts of 2032 conditions under each of the two LCP strategies. The results show the Worst First strategy is effective at reducing the number of bridges in *Poor* condition to 2.1% by deck area (compared to 4.5% in 2021) and improving the percent of bridge deck area in *Good* condition to 37% (compared to 29.5% in 2021). In contrast, the Optimized Preservation strategy with the same funding reduces the amount of bridge deck area in *Poor* condition to 4.2% and increases the percentage in *Good* condition to 41.5%, a gain of 4.5% over the Worst First strategy. Over the long-term, this is a more cost-effective result for road users and for taxpayers.

Considering a range of fiscal scenarios, a 1% increase in the state-owned bridges in *Good* condition would require an additional annual investment of about $17 million per year for 10 years. Funding to address this improvement in condition is possible due to KYTC's transition from a Worst First strategy to an Optimized Preservation strategy. This change reduced the annual cost of bridge preservation by about $75 million per year. This enables KYTC to shift bridge funding to better benefit the people of Kentucky by improving bridge conditions. About half of this benefit accrues to the National Highway System (NHS), and half to the non-NHS state network. In the Optimized Preservation strategy, approximately 32 percent of the available bridge funding is spent on

maintenance and preservation, yielding a return on investment of 92 percent. KYTC's BMS can evaluate a wide variety of strategies to find the one that yields the best long-term value.

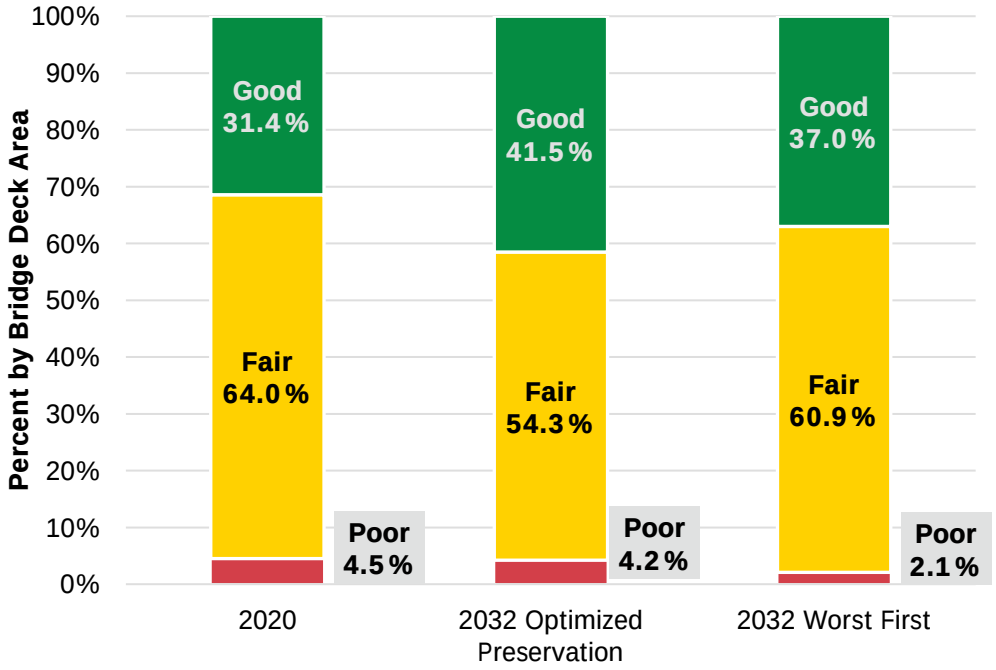



*Figure 4-12. Initial and 10-year projected network bridge conditions*

## Bridge Life Cycle Management Process

KYTC has implemented a statewide bridge program for Asset Management and Replacement projects. Planning activities proceed in three steps:

1. The Central Office develops an optimized list which includes cost estimates. This work is now done primarily using the BMS.
2. The Central Office integrates required programs from existing policies and directives, such as 3-ton metal culverts, timber piles, reinforced concrete deck girders, border bridges, and the Interstate 65 rehabilitation.
3. Districts submit their recommendations, which pick up needs based on local knowledge and maintenance activities.

The products of these steps are combined and constrained by the allocated budget, then undergo final checks, to ensure that the SYP:

- Is risk based (highest risk structures are included),
- Is equitable among districts,
- Targets *Fair* bridges (as well as *Poor*), in line with the TAMP, to guard against falling back to a worst-first process.

KYTC sends the recommended SYP to be reviewed by the legislature. Once reviewed, the final recommended highway plan turns into Enacted Highway Plan.

Based on the results from the LCP analysis, the KYTC strategy creates a balanced approach to Asset Management and bridge replacement projects. 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. This, in turn, will yield ineffective results leading to more costly repairs or replacements in the future. KYTC avoids this by using its asset management program to target *Fair*-condition bridges where strategic preservation and rehabilitation can restore *Good* condition or keep them well away from the *Poor* category.

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 and within the national and state-specific performance criteria. The recommended bridge life cycle management strategy addresses a balanced program of preventive maintenance, rehabilitation, functional improvement, and replacement, as explained below.

**A Balanced Bridge Management Program Includes:**

**Preservation $**

**Rehabilitation $$**

**Major Rehabilitation $$$**

**Functional Improvements $$$$**

- Preservation of Bridges in *Fair* and *Good* Condition
  - Cyclical preventive maintenance based on a preset schedule of activities, or preset intervals.
  - Condition-based preservation and spot repairs, when deteriorated elements are found on bridges that are otherwise rated *Good* or can be restored to *Good*.
  - The life cycle management strategy includes the following preservation activities:
    - Resealing and repairing of joints.
    - Cleaning and sealing of bearings.
    - Bridge washing and cleaning (including deck, super- and substructure).
    - Sealing of decks.
    - Painting of steel members.
    - Patching and/or overlays of bridge decks.
    - Cleaning and painting of 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 on:
  - Bridges having deficiencies in their geometry, clearances, foundations, or condition which restrict the flow of traffic, or which increase the risk of service disruption from extreme weather events.
  - Bridges with 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 Commonwealth level, practiced by the central office and district offices.

The analysis discussed in the preceding section explored levels of preservation ranging from 0 to 43% of the bridge program, and also explored a wide range of funding levels. It was determined that reversing the recent decline in bridge conditions in a sustainable and fiscally responsible manner requires an increase in bridge funding to at least $250 million per year, of which 32% is preservation and maintenance. The Financial and Investment Plans discussed in the following chapters provide more information on KYTC's fiscal constraints and their effect on forecasted performance outcomes as estimated in the BMS.

## Recent LCP Enhancements

KYTC has significantly upgraded its bridge life cycle planning capabilities by fully implementing the AASHTOWare BMS. The agency has new staffing and training to support strategic asset management and has been using these new capabilities to update the SYP, the 2024-2045 LRSTP, and this TAMP. The forecasting models used in the BMS are calibrated to fit Kentucky's conditions and costs. KYTC is currently participating in a 12-state research effort to further refine its bridge deterioration models, slated for completion in late 2022.

### Recent Bridge LCP Enhancements

**Full BMS implementation**

**Calibrated forecasting models**

**New staffing and training**

**Bridge Prioritization Index to consider resilience**

## Improving Resilience

As noted in the Resiliency Improvement Plan, bridge resilience encapsulates characteristics of the transportation network, and particularly its bridges, to resist disruption and remain functional in the face of unexpected and extreme events, such as major storms, earthquakes, truck collisions with bridges, metal fatigue cracks, and overloads. To enhance its ability to manage resilience of the bridge inventory, KYTC has developed, in cooperation with the Kentucky Transportation Center, a Bridge Prioritization Index. This index quantifies concerns of safety, condition, mobility, and risk. Researchers used the Analytic Hierarchy Process to calibrate the index, considering:

- Condition
- Age
- Scour criticality
- Fracture criticality
- Existence of fatigue-prone details
- Vertical and horizontal clearance
- Frequency of inspection
- Bridge load posting

- Traffic and truck volume
- Detour length
- Route designation: National Highway System, emergency route, school bus route

The index is used as a supplement to the BMS to ensure that all relevant goals and objectives, particularly safety and mobility, are appropriately considered in programming decisions.

# Chapter 5: Managing Risk and Resilience

## OVERVIEW

**Risk Management**

**"... the processes and framework for managing potential risks, including identifying, analyzing, evaluating, and addressing the risks to assets and system performance."**

KYTC manages 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 risk events may cause, the Cabinet has adopted a risk management framework to identify, evaluate, and mitigate uncertainties. Through this process KYTC develops action plans for the most significant risks to reduce the likelihood that risks occur, reduce the potential impact if an event does take place, or better prepare the agency to address the risk impact. This chapter describes KYTC's process for identifying, documenting, and addressing risks in a coordinated manner to minimize the impacts of unplanned events on the agency, the infrastructure assets, and the public. The mitigation strategies identified in this chapter are delivered through a coordinated "enterprise" that can involve each office of the Cabinet.

### KYTC's Asset Management Risks

The business processes that KYTC has in place to align planned infrastructure investments with strategic objectives are in place to ensure that available resources for infrastructure assets are used as effectively as possible. These processes include performance-based planning activities to balance competing priorities for limited transportation dollars over both the short- and long-terms. Inherent to these planning activities is uncertainty. Uncertainty, which can be both positive and negative, can impact KYTC in many ways. From an asset management perspective, uncertainty can impact the rate at which asset deteriorate, the quality of construction, and the availability of data and tools to plan effectively. Risks associated with uncertainty can also impact the available workforce, the level of funding available to support asset management, and the federal or state requirements that are in place. It is within this environment that KYTC must recognize the uncertainties that have the potential to impact its asset management objectives and identify steps to reduce their impact. Over the 10-year period covered in the TAMP, these risks may include:

- The loss of experienced staff, caused largely through retirements, that will impact KYTC's ability to effectively manage its assets.
- 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 possibility of construction cost increases or price instability leading to reduction in the buying power of available funding.

- The impact of supply chain disruptions that impact the availability of needed construction resources.
- The possibility that internal and external stakeholders will divert funding in support of the Cabinet's asset management strategies and plans due to other priorities.
- The likelihood that extreme weather events could damage highway assets or require a substantial commitment of agency resources for response and recovery efforts. This risk has become more prominent in recent years with significant flooding events and severe tornadoes in 2021.

### Benefits to Risk Management

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 associated with the many uncertainties the Cabinet faces, and to prepare and respond appropriately. Additionally, risk management 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 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 is one of the tools 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. KYTC's risk management framework is presented in figure 5-1.

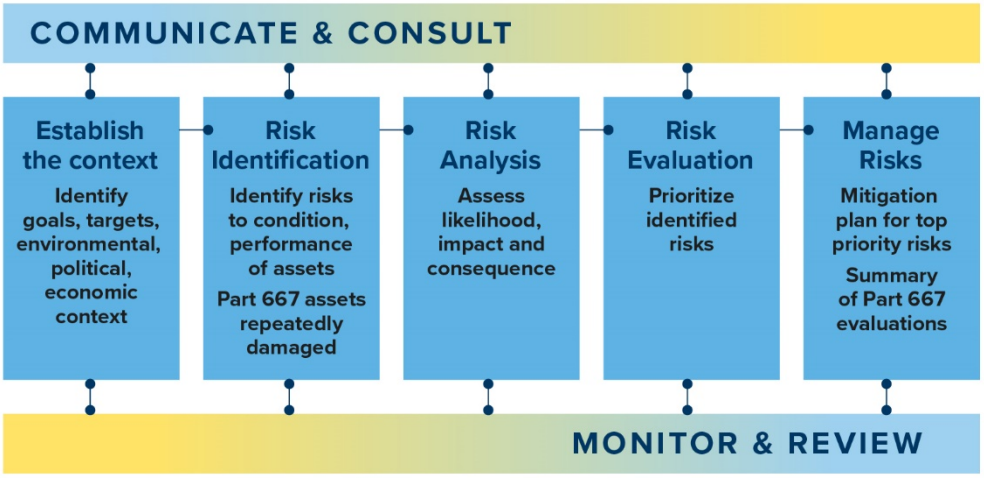



*Figure 5-1. Risk management framework*

This risk management framework consists of five core activities. The five activities in the center of the figure 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 from each activity. The five core activities are connected through the activities on the top and bottom of figure 5-1: Communicate and Consult and Monitor and Review. 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 a Risk Work Group comprised of staff from Planning, Operations, Engineering, and Asset Management. 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 process.

**Typical Risk Categories**

- **Financial**
- **Environmental**
- **Workforce**
- **Construction**
- **Materials**
- **Technology**
- **Organizational**

## Identify Risks to TAM Objectives

The Risk Work Group identified areas of uncertainty that could impact the physical condition of KYTC's pavement and bridge assets, or the agency's ability to manage those assets. The resulting risks arose in areas such as finance, climate, extreme weather, technology, workforce development, construction materials, and organizational 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 Table 5-1. 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 as Table 5-2. The remaining risks were captured in a more extensive Risk Register being managed by the State Highway Engineer's Office.

*Table 5-1. Risk rating 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 than10 years | Once between 1-3 years | Once a year | Several times a year |
| Impact | Catastrophic | Potential for multiple deaths and injuries or substantial public and private cost | Medium | Medium | High | Very High | Unacceptable |
| | Major | Potential for multiple injuries, substantial public or private cost, and/or impedes 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 manage-able with normal agency practices | Low | Low | Low | Low | Medium |

**"The Five T's" for Risk Mitigation Techniques**

**Treat—Take steps to address the risks**

**Tolerate—Accept the risk**

**Transfer—Shift the risk to a third party**

**Terminate—End the situation that creates the risk**

**Take Advantage of— Capitalize on the risk**

## 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 Core Team developed mitigation strategies for each risk included in the Risk Register. Risk mitigation strategies involved the five techniques for mitigating risks that are summarized in the call-out box. 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.

## Risk Monitoring and Review

KYTC plans to use the Risk Register as a tool to guide the monitoring of risks in the future. The 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 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 types of changes described below.

### New Objectives

If new asset management objectives are developed, risks impacting their achievement 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 Core Team will take the lead on tracking progress toward the implementation of the risk mitigation strategies and updating the Risk Register. The Pavement and Bridge Work Groups 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 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 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 Core Team's intention to integrate asset management risk management with other risk management efforts currently and soon to be underway at the Cabinet or at stakeholder agencies. For example, KYTC's initiatives to assess and address highway infrastructure vulnerabilities due to natural hazards such as floods, sinkholes, earthquakes, and other events

demonstrates the links between asset management and risk mitigation strategies conducted elsewhere within the Cabinet.

## 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 continuing efforts to understand and develop resilience to risks from natural events, such as extreme weather.
- 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.

The Risk Register is presented in table 5-2. The table summarizes the highest-rated risks from the risk workshops conducted with the Risk Work Group. likelihood and impact scores for each risk are presented, along with mitigation strategies. The risks identified by the Work Group will be actively monitored and managed under the direction of the State Highway Engineer's Office.

It is worth noting that the two highest risks in the risk register concern the availability and retention of key staff. These risks emerged from the risk assessment due to their potential to impact KYTC's ability to effectively manage its highway assets. The loss of key staff in both the central office and the districts impacts the availability of engineers and others to collect crucial data, analyze needs, and make effective decisions regarding the most cost-effective strategies for preserving system conditions. The potential lack of adequately trained and experienced bridge inspection staff to address inspections immediately after extreme weather events was specifically called out. In the absence of these inspectors, KYTC is concerned that bridges impacted by the weather events may not be inspected in a timely manner. Mitigation strategies to address these concerns reflect the need for more formal career steps to attract and retain personnel in key positions, documentation of practices and procedures to support transitions, and advanced training to build necessary skillsets.

*Table 5-2. Risk register*

| Risk Statement | Likelihood | Impact | Consequence | Mitigation Strategies |
|---|---|---|---|---|
| If we continue losing key staff in the central office or the districts:<br>1. We will lack the expertise to effectively manage our highway assets.<br>2. We will not have the key personnel needed to achieve our asset management objectives. | Almost Certain | Major | Very High | ▶ Continue providing staff with necessary resources (funding, education opportunity).<br>▶ Document current practices and procedures.<br>▶ Advocate for retention strategies. |
| If we don't have adequately trained and experienced bridge inspection staff, we will not be able to promptly inspect bridges after extreme weather events, which could lead to an unsafe bridge remaining in service. | Almost Certain | Major | Very High | ▶ Coordinate with Personnel to revise the bridge inspection series, allowing for more career steps.<br>▶ Continue to develop advanced training for the inspection series. |
| If construction costs increase significantly or are highly unstable:<br>1. Estimates will increase and the number of projects within the program will decrease.<br>2. The strategies for pavements and bridges will not be optimized. | Almost Certain | Moderate | High | ▶ Add flexibility to approved programs and treatments for changes to the work plan based on available funding and best outcome. |
| If district maintenance crews do not have the capacity, skills, or resources to deliver needed bridge preservation work effectively, treatments may not as effective as expected, and bridges may deteriorate prematurely. | Very Likely | Major | High | ▶ Provide training on preservation work and equipment operation.<br>▶ Align work assignments with each District's resources and capabilities.<br>▶ Coordinate between project design and Maintenance to align project scopes to deliver needed maintenance that is beyond District capacity or capability. |
| If industry is not open to learning new preservation techniques:<br>1. We will be unable to meet targets.<br>2. We may incur higher bid prices.<br>3. We will be unable to deliver needed preservation work. | Likely | Major | Medium | ▶ Educate and partner with industry.<br>▶ Maintain attractive volumes of preservation project lettings.<br>▶ Communicate commitment to preservation to industry. |
| Without a well-communicated asset management plan, we could lose support and trust from external stakeholders (legislature, contractors, public, local elected officials). | Very Likely | Moderate | Medium | ▶ Show the results of a well-supported and delivered asset management plan.<br>▶ Develop approaches for demonstrating lower lifecycle, lower future costs, and longer asset life spans. |

*Table 5-2. Risk register (continued)*

| Risk Statement | Likelihood | Impact | Consequence | Mitigation Strategies |
|---|---|---|---|---|
| If we do not have adequately trained and experienced staff to identify scour vulnerabilities and address scour countermeasure repairs, it can accelerate bridge degradation and failures. | Very Likely | Moderate | Medium | ▶ Ensure qualified inspectors are assigned to identify scour vulnerabilities in existing structures.<br>▶ Consider scour vulnerabilities in treatment identification and project prioritization.<br>▶ Establish and maintain design standards to avoid scour vulnerabilities in new structures. |
| If we lack legislative approval for asset management projects, our program of projects will be changed and there will be greater bridge and pavement deterioration. | Likely | Major | Medium | ▶ Demonstrate how the lack of asset management projects affects our network. Demonstrations must target appropriate audiences (e.g., planners, engineers, legislators, MPOs, and local governments). |
| If we don't develop the staff and internal organizational structure, we will not be able to start and sustain a bridge preservation program, which could lead to higher maintenance and replacement costs. | Very Likely | Moderate | Medium | ▶ Organize and staff the new preservation section in the Structures Maintenance Branch.<br>▶ Keep personnel trained and retain experienced staff. |
| If we do not have construction inspectors who understand preservation work, we will not get the project quality we need and preservation treatments may not be as effective as expected, leading to an increased rate of deterioration. | Very Likely | Moderate | Medium | ▶ Continue to train and qualify construction and project delivery staff statewide on preservation techniques.<br>▶ Continue to identify new training needs and regularly update preservation inspection training materials. |
| If we have increasing precipitation:<br>1. We will experience increased flooding and scour.<br>2. We may have more safety incidents due to low skid-resistance.<br>3. The increased use of deicing chemicals will accelerate bridge deterioration. | Very Likely | Moderate | Medium | ▶ Keep Plans Of Action (POAs) up to date for scour critical bridges.<br>▶ Train inspectors and other staff on typical extreme weather response practices. Prepare staff to adapt as needed to unpredictable situations.<br>▶ Consider pavement friction in aggregate selection.<br>▶ Update design practices to identify and address vulnerabilities in project development. |
| 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. | Very Likely | Moderate | Medium | ▶ Continue to develop and refine robust models to estimate deterioration rates and costs, building on progress to-date. This includes leveraging information from the Midwest Pooled Fund as it becomes available.<br>▶ Develop preservation programs that are data-supported. |
| If funding is unpredictable throughout the fiscal year, we may not be able to optimize our pavement or bridge treatments. | Very Likely | Moderate | Medium | ▶ Have additional "ready to let" projects beyond anticipated funding levels.<br>▶ Communicate with District staff to ensure delayed projects and treatments are still viable. |

*Table 5-2. Risk register (continued)*

| Risk Statement | Likelihood | Impact | Consequence | Mitigation Strategies |
|---|---|---|---|---|
| If the districts lack preservation treatment knowledge, they will not be able to manage a preservation program in terms of handling inspections, making treatment selection, and allocating resources, effectively. | Very Likely | Moderate | Medium | ▶ Work with the Districts to continue to extend the preservation program to require less Central Office oversight.<br>▶ Train bridge crews and maintenance crews to deliver bridge repairs and preventive maintenance for bridges and pavements.<br>▶ Continue to coordinate equipment and materials purchases with training. |
| If we allow scope creep to occur unchecked or if programs are developed with uncertain scopes, then a preservation project could expand to a more expensive rehabilitation project, which means other planned projects may be deferred. | Very Likely | Moderate | Medium | ▶ Improve scoping process to better identify needs in addition to the primary need driving the project.<br>▶ Establish a delivery model that requires project managers to check scope and be guided by program managers.<br>▶ Evaluate approaches to improve the tracking of investments by asset type and program. |
| If we do not receive adequate and stable funding:<br>1. We will not be able to make the systematic and regular investments needed to treat assets at the correct time.<br>2. We will not achieve our State of Good Repair target for pavements.<br>3. We will not be able to perform enough warranted bridge preservation work. | Very Likely | Moderate | Medium | ▶ Model scenarios with different funding amounts (low, expected, and high funding) to assess the best ways to optimize the bridge and pavement program in case of inadequate/unstable funding.<br>▶ Communicate forecasted outcomes clearly and share results with external stakeholders such as legislators.<br>▶ Engage the Districts and local elected officials to get their support for an asset management approach.<br>▶ Engage legislators and share credit for safer and improved roadway conditions possible through our asset management program.<br>▶ Identify asset management projects and dedicated funding from highway improvement projects in KYTC's 6-year plan to emphasize the commitment to achieving asset management goals and targets. |
| If we do not implement our planned asset management strategies:<br>1. Life cycle costs will increase since we may not be implementing the most economical long-term strategy. For example, if work type needs change from preventive maintenance and preservation to rehabilitation or reconstruction system preservation costs will increase.<br>2. We will incur higher maintenance and repair costs to keep assets operational and functional. | Likely | Major | Medium | ▶ Use pavement and bridge management systems to justify requests for additional funding.<br>▶ Educate and communicate asset management strategies and successes.<br>▶ Track and demonstrate impacts of decisions. |

*Table 5-2. Risk register (continued)*

| Risk Statement | Likelihood | Impact | Consequence | Mitigation Strategies |
|---|---|---|---|---|
| If the bridge and pavement preservation programs expand too quickly, then:<br>1. We will lack inspection staff.<br>2. We may experience a contractor shortage.<br>3. We may experience reduced quality in the projects delivered.<br>4. We could potentially see increased project costs.<br>If we accelerate the pace of our bridge program to reach our target before 2035:<br>1. We may lack enough construction inspectors to meet the demand. | Likely | Moderate | Medium | ▶ Utilize consultant inspectors when needed.<br>▶ Coordinate with Personnel to revise the bridge inspection series, allowing for more career steps.<br>▶ Continue to develop advanced training for the inspection series.<br>▶ Evaluate moving to a risk-based inspection program. |
| If we replace or repair additional large structures without additional funding, such as the I-65 or Brent Spence bridges:<br>1. It could consume funds needed to achieve our bridge target.<br>2. It could consume funds needed to achieve our pavement target. | Likely | Moderate | Medium | ▶ Advocate for allocating additional funding to bridge preservation, as needed.<br>▶ Advocate for increased revenues to address major projects either through traditional funding or innovative financing mechanisms.<br>▶ Communicate impacts of reducing bridge preservation allocations. |
| If we cannot find a way to start the bridge preservation 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 | Moderate | Medium | ▶ Develop risk-based assessments to bundle large bridge projects with smaller ones.<br>▶ Evaluate opportunities for using Construction Manager/General Contractor (CMGC) or design-build delivery methods. |
| If we are unable to maintain sufficient bridge projects in the pipeline, we will be able to make full use of unspent funds from highway improvement projects that are under budget or delayed. | Very Likely | Moderate | Medium | ▶ Refine the scoping process.<br>▶ Begin preliminary engineering on bridge candidates to reduce project delivery time. |
| If we do not meet our State of Good Repair targets:<br>1. KYTC will experience a backlog of pavements and bridges needing treatment that will lead to higher costs and lower conditions.<br>2. The Parkway pavements will show advanced deterioration first followed by the lower-volume routes.<br>3. The public will experience more delays due to more frequent maintenance activities. | Likely | Moderate | Medium | ▶ Engage the Districts and local elected officials to build support for an asset management approach.<br>▶ Engage legislators and share the credit for safer and improved roadway conditions that are possible through our asset management program.<br>▶ Identify asset management projects and dedicated funding from highway improvement projects in KYTC's 6-year plan to emphasize the commitment to achieving asset management goals and targets. |

*Table 5-2. Risk register (continued)*

| Risk Statement | Likelihood | Impact | Consequence | Mitigation Strategies |
|---|---|---|---|---|
| If we are unable to coordinate projects across programs:<br>1. Efficiencies will be lost due to lack of bundling or coordination of project timing.<br>2. The public will be exposed to repeated delays.<br>3. The safety workers and traveling public could potentially be impacted. | Likely | Moderate | Medium | ▶ Continue scoping efforts to visualize active and planned projects.<br>▶ Begin preliminary engineering on bridge candidates to reduce project delivery time. |
| If we unable to maintain sufficient pavement projects in the pipeline, we will not be able to make full use of available funds from highway improvement projects that are under budget or delayed. | Likely | Moderate | Medium | ▶ Maintain the list of ready-to let projects.<br>▶ Evaluate methods for improving the project scoping process.<br>▶ Accelerate the pavement project development and delivery process. |
| If we experience major storm events that impact multiple communities:<br>1. It can increase damage to our structures.<br>2. It will increase the threat of flooding and pavement washouts.<br>3. It will Increase the need for debris removal and storm recovery efforts. | Unlikely | Catastrophic | Medium | ▶ Keep Plans Of Action (POAs) up to date for scour critical bridges.<br>▶ Train inspectors and other staff on typical extreme weather response practices. Prepare staff to adapt as needed to unpredictable situations.<br>▶ Update design practices to identify and address vulnerabilities in project development. |
| If native, or typically available, materials are not sufficient to meet program needs:<br>1. It could lead to increased costs.<br>2. We will experience delays due to supply chain and schedule issues. | Likely | Major | Medium | ▶ Use blends of native and non-native materials to meet needs and limit imports.<br>▶ Develop better techniques to utilize native materials to meet needs. |
| If we do not implement defined asset management roles and responsibilities:<br>1. We will not be able to deliver the needed preservation program.<br>2. The program may not be sustainable through staffing changes. | Unlikely | Major | Medium | ▶ Develop documentation of current asset management practices and procedures so progress isn't lost with staffing changes.<br>▶ Define asset management responsibilities and roles within position descriptions and titles. |
| If our asset management effort is not well supported and well communicated:<br>1. We will not achieve our objectives.<br>2. We will not be able to implement the preservation programs. | Unlikely | Major | Medium | ▶ Communicate with, educate, and train staff and stakeholders about asset management and the progress KYTC has made.<br>▶ Develop specific materials and curriculums targeted to the intended audiences. |

*Table 5-2. Risk register (continued)*

| Risk Statement | Likelihood | Impact | Consequence | Mitigation Strategies |
|---|---|---|---|---|
| If we do not have adequate staff and equipment for pavement inspections:<br>1. We may not have quality data to make and defend pavement management decisions.<br>2. Pavement treatments may not be as effective as expected, leading to an increased rate of deterioration.<br>3. Deterioration may go unmonitored or undetected. | Likely | Moderate | Medium | ▶ Keep training up to date.<br>▶ Work with Personnel to support recruitment and retention efforts. |
| If a certain geographic region gets oversaturated or overwhelmed with modernization/expansion projects, it could reduce our ability to address other needs in that area. | Likely | Moderate | Medium | ▶ Develop tools to visualize active and planned projects.<br>▶ Evaluate options for creating a project impact index. |
| If extreme temperature events (extreme heat or cold) continue to increase:<br>1. Pavements will deteriorate more rapidly.<br>2. Challenges during construction could lead to delays or poor quality.<br>3. More frequent freeze-thaw cycles could increase concrete deterioration for pavements and bridges. | Likely | Moderate | Medium | ▶ Keep Plans Of Action (POAs) up to date for scour critical bridges.<br>▶ Train inspectors and other staff on typical extreme weather response practices. Prepare staff to adapt as needed to unpredictable situations.<br>▶ Update design practices to identify and address vulnerabilities in project development. |
| If our contractors are not experienced with bridge preservation work, treatments may not be as effective as expected and bridges may experience premature deterioration. | Likely | Moderate | Medium | ▶ Provide training to contracting industry on performing preservation activities.<br>▶ Identify opportunities to improve specifications to for clarity of expectations and quality of final work.<br>▶ Keep construction training up to date. |

## CONSIDERATION OF EXTREME WEATHER AND RESILIENCE

**Focus on System Resilience**

**The current federal legislation includes requirements for the TAMP to consider extreme weather and resilience in LCP and risk management**

**23 USC 119(e)(4)(D)**

Climate and extreme-weather events pose recognized risks to KYTC's transportation infrastructure. Unexpected events and long-term changes caused by these risks can have broad social, economic, and environmental consequences. While it is not realistic to be able to completely prevent the impacts related to climate risks, agencies can implement adaptation strategies that will help its infrastructure become more resilient to such events. The first steps towards building a more resilient transportation infrastructure system are to identify the most significant risks and assess system vulnerability to these risks. The vulnerability assessment involves a critical assessment of infrastructure assets in terms of robustness and redundance. The results suggest the following approaches will improve system resilience:

- Prioritize the maintenance and management of routes that do not have redundancies.
- Maintain and update emergency response plans frequently.
- Update the asset vulnerability assessment periodically to address changes that occur.
- Monitor asset deterioration rates to determine appropriate asset life-cycle treatment strategies that consider unexpected events.

## KYTC'S CLIMATE RESILIENCY PILOT PROJECT

In 2019, KYTC completed a federally funded Climate Resiliency Pilot Project conducted in collaboration with the University of Kentucky Transportation Center (UKTC) (Blandford, et. al. 2019). The study focused on opportunities to better address the impacts of extreme weather and climate stressors on Kentucky's transportation system. The study involved a review of pavements and bridges in relation to extreme heat and precipitation. The study included two technical analyses:

- A potential screening tool to assess the vulnerability of bridges to flooding.
- A methodology for modeling pavement performance under hotter and wetter conditions.

The report also provides several potential strategies for improving KYTC's asset management program, particularly regarding the consideration of extreme weather and resilience. These include:

- Improved FHWA Emergency Relief (ER) project monitoring procedures.
- Development of a resilience-themed GIS database.
- Formation of a KYTC Resilience Working Group.

The full report can be accessed on FHWA's website. KYTC is actively developing the three recommendations listed above and incorporated them into the mitigation strategies presented in table 5-2.

## Bridge Flooding Vulnerability

The flooding vulnerability tool uses NBI data to develop flood and scour risk indicators. The tool uses three parameters to identify relative risks between different structures.

- Structural Condition—Evaluates the overall structural integrity based on NBI data.
- Geomorphic Sensitivity—Evaluates channel condition, scour potential, and observed scour.
- Criticality—Evaluates how integral an asset is to the transportation network.

These three factors are quantified, weighted, and combined to provide an overall value from 1-3, with 3 representing the highest sensitivity to flooding or scour. This Bridge Prioritization Index is considered in project prioritization. Figure 5-2 shows the results of an analysis to identify hot spots for structures with high sensitivity to scour and flooding. A hot spot indicates an area where several sensitive structures are close together.

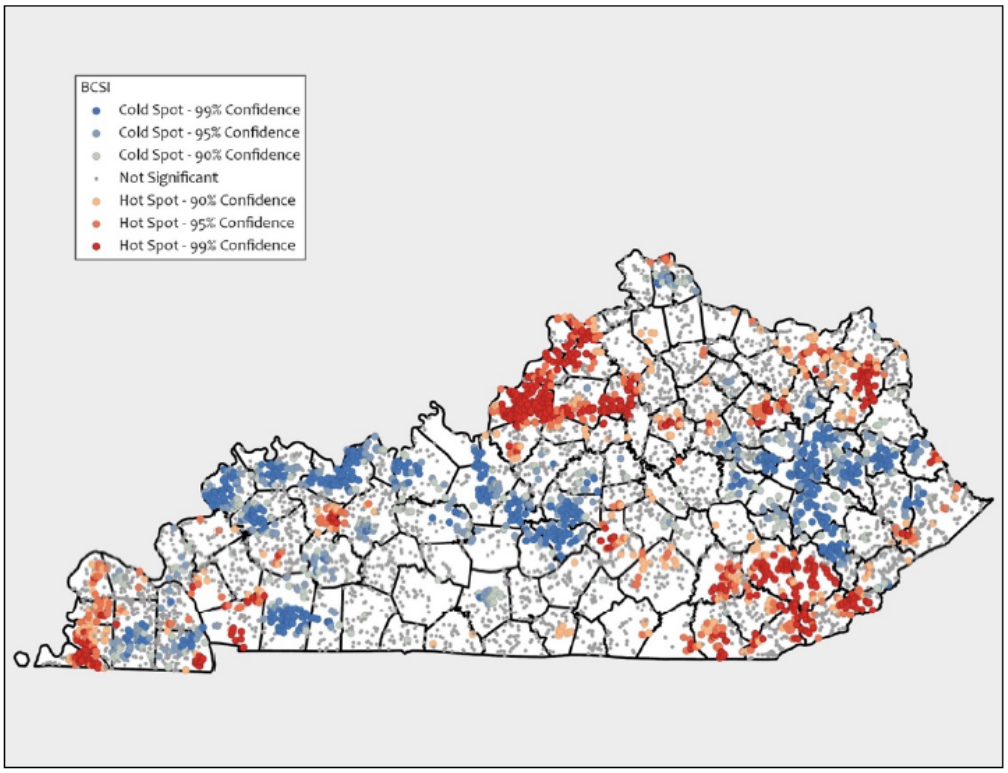



*Figure 5-2. Bridge Scour Criticality Index hot spots (Blandford, et. al. 2019)*

## Pavement Performance Under Increased Heat and Precipitation

The study used the software application that KYTC uses to design pavement thicknesses to evaluate the performance of KYTC's standard pavement designs under future scenarios with increased temperature and precipitation over 20- and 40-year periods. While the simulations indicated increased levels of distress, compared to current temperatures and precipitation, the

increase was not significant enough to warrant a change in pavement design or materials standards. KYTC can rerun this analysis in the future as climate models are updated to determine how the outcome may change.

## Additional Suggested Process Improvements

The pilot project also identified opportunities for KYTC to enhance its asset management processes to better account for or respond to extreme weather and other climate stressors.

The first of these recommendations was to develop a Geographic Information System (GIS) database to support compliance with 23 CFR 667 Periodic Evaluation of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events. This database is in use by the Cabinet and described in more detail in Appendix Cr

The project also recommended several next steps, including:

- Continued integration of KYTC systems that track and monitor all costs associated with ER events.
- Development of KYTC maintenance activities that can proactively prepare for extreme precipitation in advance of the event.
- Establishment of a Resiliency Working Group.
- Continued incorporation of extreme weather risk into asset management and KYTC's TAMP.

### Transportation Resiliency Improvement Plan

**KYTC is increasingly experiencing the impacts of extreme weather and associated natural hazards, such as flooding, slides, and sinkholes. Climate projections indicate that Kentucky's climate is shifting toward more warmth and precipitation.**

**In partnership with the University of Kentucky, KYTC is conducting a research project to comprehensively identify transportation vulnerabilities to natural hazards and guide efforts to improve system resiliency. The study results will be used to determine the cost of action and inaction related to community resiliency involving public infrastructure assets.**

# 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 assets included in the TAMP.
- The level of investment in bridges and pavements needed to meet the asset condition targets, 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, replace, or construct new pavement and bridge assets.
- The level of asset conditions 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 and investment projections. The process begins with forecasting expected revenue from various sources and monitoring 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 objectives, along with systematically improving and sustaining the assets in a state of good repair. The investment strategies included in the TAMP reflect KYTC's continued focus on preserving and maintaining existing pavement and bridge conditions. While not all system conditions are projected to meet desired conditions due to funding constraints, KYTC is confident the federal targets and minimum conditions for NHS pavements and bridges will be achieved over the 10-year period covered in the TAMP.

**Prioritizing Preservation**

**The investment strategies included in the TAMP reflect KYTC's continued focus on preserving and maintaining existing pavement and bridges.**

**Revenue**

**KYTC received over $1.6 billion in state road funds and over $900 million in Federal aid funding in FY 2021.**

## PROJECTED REVENUE

In fiscal year (FY) 2021, KYTC received a total of approximately $2.8 billion dollars in revenue. Of this, more than $900 million came from the Federal-Aid Program. Approximately $1.64 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.

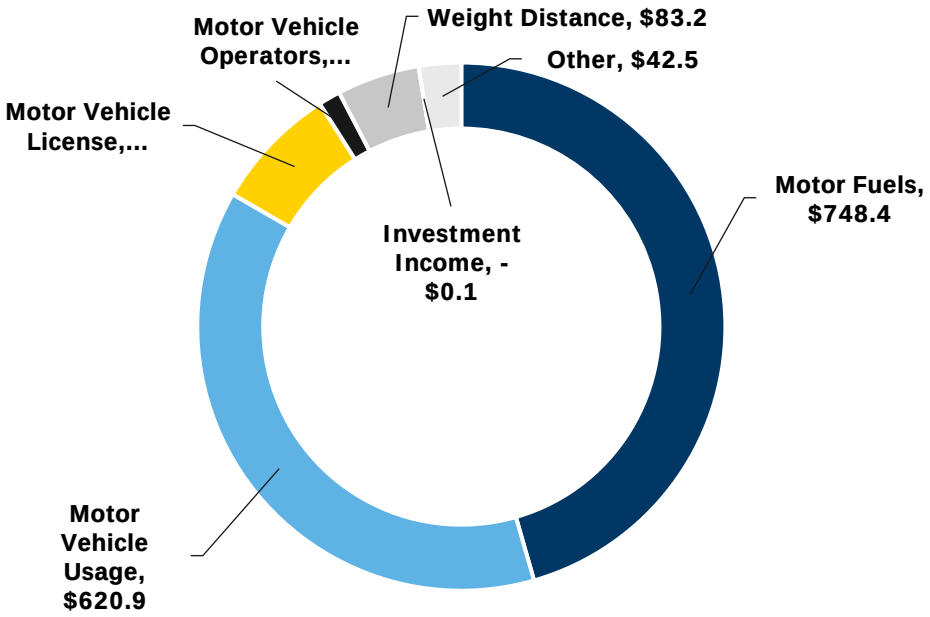



*Figure 6-1. FY 2021 road fund revenue sources ($ millions)*

## Process for Projecting Revenue

Annual road fund projections are developed by a group of economists selected from around the Commonwealth, known as the Consensus Forecasting Group (CFG), before each upcoming biennial legislative budget session. The CFG reviews revenue sources and analyzes any 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 reviews federal revenue sources annually and makes projections of the expected future funding levels. Once the state and federal projections are established, the KYTC finance team continues to monitor changes in road fund revenues to compare projections with actual receipts. Shortfalls and surpluses are closely tracked to support flow estimates.

Table 6-1 presents a summary of the planned and actual revenue receipts from the various state road fund revenue sources for FY 2021. On the federal side, the overall funding projections for the last several years have not changed significantly.

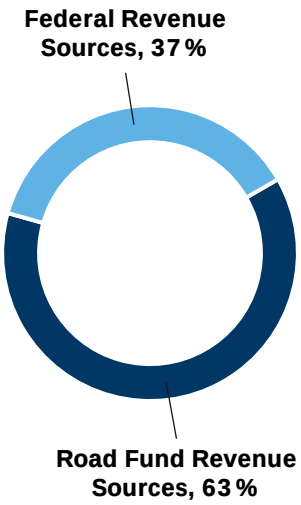



*Table 6-1. FY 2021 actual versus estimated road fund revenue comparison ($ millions)*

| Road Fund Revenue Sources | FY 21 Actual | FY 21 Estimate |
|---|---|---|
| Motor Fuels | 748.4 | 756.2 |
| Motor Vehicle Usage | 620.9 | 568.6 |
| Motor Vehicle License | 125.5 | 117.2 |
| Motor Vehicle Operators | 22.1 | 17.2 |
| Weight Distance | 83.2 | 79.7 |
| Investment Income | -0.1 | 0.2 |
| Other | 42.5 | 38.6 |
| **Total** | **1,642.3** | **1,577.7** |

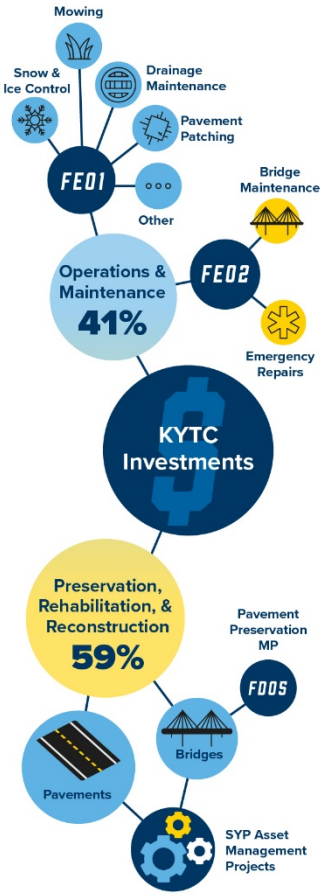
## Funding Asset Management

Based on current estimates, KYTC projects a total of $27.6 billion to be available over the 10-year TAMP period starting in FY 2023. Approximately $10.3 billion (37%) of this is from FHWA fund sources and the remaining $17.3 billion (63%) from state road fund sources. KYTC has numerous financial obligations that must be addressed each year, as shown in tables 6-2 (projected federal revenues) and 6-3 (projected road fund revenue). Some of these financial obligations are mandatory, such as making semi-annual debt service payments. Others are discretionary and established through Kentucky's biennial budget process. All of these financial obligations were accounted for during the development of the TAMP financial plan.

The first row in table 6-2 indicates the total projected amount of Federal Aid to be available to KYTC in each year. The next three rows indicate the amount of the total federal funding that is expected to address obligations other than maintaining or improving pavement and bridge conditions. The last row in table 6-2 indicates that, after accounting for these other obligations, approximately $4.2 billion in Federal Aid is expected to be available to address asset management objectives over the 10-year TAMP period.

Table 6-3 shows the projected level of Kentucky road funds for the TAMP period along with the financial obligations that must be addressed with these funds, other than asset management needs. For instance, KYTC must make nearly $1 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 response, that do not impact pavement or bridge conditions. Approximately $570 million is directly appropriated to other state agencies, $3.8 billion in revenue sharing to local governments, $1.7 billion to administrative costs, and $3.2 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 $2.8 billion is expected to be available for asset management activities over the 10-year period.

The relative magnitude of KYTC's investments in pavements and bridges is illustrated in the side graphic. Approximately 41% of KYTC's total investment is used for operational and maintenance expenses. A portion of this goes to FE01 activities, such as mowing, snow and ice control, pavement patching,



and drainage maintenance. The remainder of the funds are FE02 funds used for bridge maintenance and emergency repairs. These expenses generally do not improve pavement and bridge conditions, but support system safety and mobility. Approximately 59% goes toward the preservation, rehabilitation, and reconstruction of pavements and bridges. These include FD05 funds for pavement preservation on the MP and asset management projects.

In summary, approximately $7.06 billion of the total $27.6 billion from federal and state sources is expected to be available over the next 10 years to support KYTC's asset management investment strategies for pavements, bridges, and other system preservation needs. This funding is comprised of $4.2 billion from federal revenue and $2.8 billion of state revenue. In addition to pavement and bridge preservation, this funding supports additional activities such as guardrail installation and maintenance, pavement markings, and culvert maintenance and repair.

*Table 6-2. Projected available federal revenues ($ millions)*

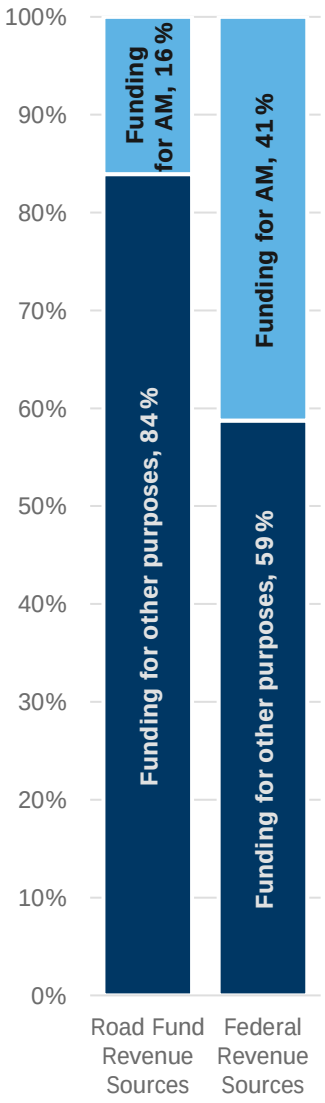
| Federal Revenues and Expenditures | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 10-Year Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Anticipated Federal Highway Funding | 986 | 1,004 | 1,022 | 1,040 | 1,040 | 1,040 | 1,040 | 1,040 | 1,040 | 1,040 | 10,292 |
| GARVEE Bond Debt Service * | (72) | (74) | (75) | (75) | (15) | 15 | 15 | 15 | 15 | 15 | (388) |
| Other Dedicated Federal Funds (TAP, SPR, CMAQ, etc.) | (127) | (130) | (132) | (135) | (135) | (135) | (135) | (135) | (135) | (135) | (1,336) |
| Non-Asset Management Federal Aid Projects | (354) | (375) | (372) | (401) | (472) | (470) | (470) | (470) | (470) | (470) | (4,324) |
| Total Federal Funding for Other Uses | (553) | (579) | (579) | (612) | (622) | (620) | (620) | (620) | (620) | (620) | (6,047) |
| Remaining Projected Available Federal Revenues | 433 | 425 | 443 | 428 | 418 | 420 | 420 | 420 | 420 | 420 | 4,245 |

*Total Debt Currently Outstanding = $370.5M Federal + $1.11B state ($1.48B combined). This includes principal and interest. Includes $62.5M of authorized but unissued road fund bonds. Does not include KPTIA bonds (paid with LSIORB toll revenue)

*Table 6-3. Projected available state road fund revenues ($ millions)*

| State Revenues and Expenditures | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 10-Year Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Anticipated State Road Fund Revenues | 1,722 | 1,679 | 1,695 | 1,723 | 1,749 | 1,749 | 1,749 | 1,749 | 1,749 | 1,749 | 17,310 |
| Revenue Sharing | (373) | (365) | (370) | (381) | (388) | (388) | (388) | (388) | (388) | (388) | (3,814) |
| Vehicle Regulations | (46) | (47) | (48) | (48) | (49) | (49) | (49) | (49) | (49) | (49) | (484) |
| Cabinet Administrative Costs | (162) | (159) | (168) | (168) | (173) | (173) | (173) | (173) | (173) | (173) | (1,698) |
| Non-Highway Capital and Other Construction | (50) | (33) | (50) | (50) | (50) | (50) | (50) | (50) | (50) | (50) | (483) |
| Direct Appropriations to Other State Agencies | (59) | (59) | (57) | (57) | (57) | (57) | (57) | (57) | (57) | (57) | (575) |
| Routine Maintenance (Exclude Pavement Surface and Bridge Activities) | (377) | (349) | (425) | (412) | (429) | (484) | (450) | (432) | (431) | (431) | (4,220) |
| TAK Debt Service * | (137) | (137) | (138) | (119) | (103) | (108) | (84) | (73) | (54) | (48) | (980) |
| State Road Fund Construction Expenditures Required to Pay Previous Commitments | (107) | (67) | (41) | (25) | (15) | (9) | (7) | (5) | (1) | 0 | (277) |
| State Match to Non-AM Federal Aid Projects | (136) | (176) | (130) | (185) | (192) | (192) | (218) | (231) | (254) | (261) | (1,975) |
| Total State Funding for Other Uses | (1,447) | (1,393) | (1,426) | (1,445) | (1,456) | (1,511) | (1,476) | (1,458) | (1,458) | (1,458) | (14,527) |
| Projected Road Fund Revenue Available for Asset Management | 275 | 286 | 268 | 279 | 293 | 238 | 272 | 290 | 291 | 291 | 2,783 |

*Total Debt Currently Outstanding = $370.5M Federal + $1.11B state ($1.48B combined). This includes principal and interest. Includes $62.5M of authorized but unissued road fund bonds. Does not include KPTIA bonds (paid with LSIORB toll revenue)




# FORECASTING PAVEMENT AND BRIDGE ALLOCATIONS

KYTC allocates funding to programs to maintain and improve pavement and bridge conditions through several mechanisms, including the SYP, the MP Pavement Preservation Program, and the KYTC maintenance budget. 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 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 commitment to implementing the LCP strategies for pavement and bridge assets that are described in Chapter 4. These strategies prioritize maintenance and preservation work types. This continues the strategy established in the 2018 and 2019 TAMPs. KYTC will continue to work with its stakeholder groups through the annual budget and biennial capital programming processes to sustain and improve its pavement and bridge life cycle strategies over time.

Tables 6-4 through 6-8 detail KYTC's planned investments to manage pavement and bridge conditions over the 10-year TAMP period. Collectively, they show an overall projected investment level of $9.75 billion in federal and state funding. This total is comprised of $7.03 billion in asset management projects and $2.72 billion in projects selected through SHIFT. The projects selected through SHIFT are expected to minimally impact pavement and bridge conditions but are primarily selected to address other performance needs through the modernization or expansion of the highway system. For pavements, SHIFT projects are shown as investments in initial construction and reconstruction work. For bridges, SHIFT projects are shown as investments in initial construction. At this time there are no new bridges planned for initial construction.

## Planned 10-Year Pavement Investments

As shown in table 6-4, KYTC expects to invest $725 million per year in pavement projects. Approximately 63 percent of this total investment is planned to maintain, preserve, and rehabilitate pavements, based on KYTC's pavement life cycle plan. These investments provide the most significant impact to overall pavement conditions. This includes $125 million per year in road fund revenues dedicated to pavement preservation. Approximately $36 million per year is allocated from the highway maintenance budget to support routine maintenance and maintenance agreements with local governments. The remaining 37 percent supports initial construction and reconstruction of pavements, through projects selected under the SHIFT program. Initial construction includes projects that replace existing highways with significantly improved, relocated, or modernized facilities.

*Table 6-4. Planned 10-year pavement investments ($ millions)*

| Work Types | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 10-Year Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Construction | 193 | 193 | 193 | 193 | 193 | 193 | 193 | 193 | 193 | 193 | 1,930 |
| Maintenance | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 360 |
| Preservation | 304 | 252 | 289 | 249 | 319 | 273 | 273 | 273 | 273 | 273 | 2,776 |
| Rehabilitation | 116 | 168 | 131 | 171 | 101 | 147 | 147 | 147 | 147 | 147 | 1,424 |
| Reconstruction | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 760 |
| **Total Projected Funding Allocations** | **725** | **725** | **725** | **725** | **725** | **725** | **725** | **725** | **725** | **725** | **7,250** |

KYTC's investment strategy for pavements places a priority on addressing the needs of the higher-volume facilities that carry the most freight traffic. The following subsections provide details on how this strategy is expected to impact funding allocations to Interstate, Non-Interstate NHS, and Non-NHS pavements.

## Planned Interstate Investments

The planned investments for the Interstate system over the 10-year period are presented in table 6-5. 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. KYTC expects to invest a total of $2.78 billion in Interstate pavements, comprised of $50 million for surface maintenance, $1.86 billion in asset management projects and $870 million in projects selected through the SHIFT program.

*Table 6-5. Planned FY 2023-2032 Interstate pavement investments ($ millions)*

| Work Types | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 10-Year Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Construction | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 670 |
| Maintenance | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 50 |
| Preservation | 141 | 84 | 81 | 60 | 76 | 84 | 84 | 84 | 84 | 84 | 863 |
| Rehabilitation | 54 | 108 | 94 | 146 | 74 | 104 | 104 | 104 | 104 | 104 | 995 |
| Reconstruction | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 200 |
| **Total Projected Funding Allocations** | **287** | **284** | **267** | **299** | **242** | **280** | **280** | **280** | **280** | **280** | **2,778** |

## Planned Parkway Pavement Investments

The planned investments for the Parkway pavements over the 10-year period are presented in table 6-6. 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. KYTC expects to invest a total of $2.19 billion in Parkway pavements, comprised of $10 million for surface maintenance, $362 million in asset management projects and $1.82 billion in projects selected through the SHIFT program.

*Table 6-6. Planned FY 2023-2032 Parkway pavement investments ($ millions)*

| Work Types | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 10-Year Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Construction | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 1,260 |
| Maintenance | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 |
| Preservation | 16 | 21 | 51 | 15 | 75 | 32 | 32 | 32 | 32 | 32 | 338 |
| Rehabilitation | - | - | 8 | - | - | 3 | 3 | 3 | 3 | 3 | 23 |
| Reconstruction | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 560 |
| **Total Projected Funding Allocations** | **199** | **204** | **242** | **198** | **258** | **218** | **218** | **218** | **218** | **218** | **2,191** |

### Planned (MP) Pavement Investments

The planned investments for the MP pavements over the 10-year period are presented in table 6-7. The first 6 years of this plan are based on SYP recommendations with the rest based on anticipated levels of federal funding and priorities identified by KYTC on non-NHS routes. These investments exclude maintenance of KYTC's RS roads. KYTC expects to invest a total of $2.28 billion in pavements on the MP system. These investments are comprised of $300 million for surface maintenance and $1.98 billion in asset management projects. No initial or reconstruction projects are expected for the MP system.

*Table 6-7. Planned FY 2023-2032 MP pavement investments ($ millions)*

| Work Types | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 10-Year Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Construction | - | - | - | - | - | - | - | - | - | - | - |
| Maintenance | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 300 |
| Preservation | 146 | 147 | 157 | 173 | 169 | 156 | 156 | 156 | 156 | 156 | 1,574 |
| Rehabilitation | 62 | 60 | 30 | 25 | 27 | 40 | 40 | 40 | 40 | 40 | 405 |
| Reconstruction | - | - | - | - | - | - | - | - | - | - | - |
| **Total Projected Funding Allocations** | **239** | **237** | **217** | **228** | **226** | **227** | **227** | **227** | **227** | **227** | **2,280** |

## Planned 10-Year Bridge Investments

KYTC plans to allocate $2.5 billion to bridges for the 10-year period, as shown in table 6-8. The cost of bridge treatments varies depending on the size of the structure and the type or complexity of the necessary treatment. All planned bridge investments are asset management projects and maintenance. Although some SHIFT projects may impact the operation and safety of existing bridges, they are not expected to impact bridge conditions and, therefore, are not included in table 6-8.

Project timing can vary and may influence the year-to-year allocation of funds. For planning purposes, a uniform year-to-year allocation is shown. The BrM analysis assigns bridge projects to implementation years based strictly on a utility/cost ratio because it does not have any data about the status of the planning and design process, environmental reviews, land acquisition, related non-bridge projects nearby, and other variables affecting project timing. As a result, the timing of individual projects can vary significantly.

Replacement projects, in particular, often have a long and uncertain lead time. As a result, the investment plan does not attempt to precisely specify annual variations in costs. Rather, the total planned investment over 10 years is divided equally among the 10 years of the plan. Like all transportation agencies, KYTC mitigates project timing risk by over-programming to ensure sufficient projects are on the shelf and available for letting as funding becomes available, consistent with staff and industry capacity. Approximately 68% of the $250 million in bridge funding KYTC directs to bridges comes from the SYP to address major rehabilitation and replacements. KYTC directs approximately 30 percent of bridge funds towards preservation activities, including painting and repairs. An additional $5 million is dispersed from the highway maintenance budget to the 12 highway districts to perform routine maintenance, including pothole patching of decks and substructures, and drain cleaning.

*Table 6-8. Planned 10-Year bridge funding allocations ($millions)*

| Work Types | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 10-Year Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Maintenance | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 50 |
| Preservation | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 765 |
| Rehabilitation | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 212 |
| Reconstruction | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 148 | 1,473 |
| **Total Projected Funding Allocations** | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 2,500 |

## Managing Program Fluctuations

The investment levels shown in tables 6-4 through 6-8 represent KYTC's planned funding to implement its asset management investment strategies. However, actual investment levels are likely to vary based on changes in costs, projects schedules, project scopes, and actual funding levels. KYTC plans for and expects revenue fluctuations and changes in project schedules to occur. Revenue changes influence the amount available to address various types of agency needs. Project schedule changes impact the funding available to deliver the rest of the program. Small fluctuations in either of these do not affect major projects for bridges and pavements that are already in progress. However, if the projections indicate major reductions in revenues or project schedules, discussions are triggered between Cabinet leadership, the finance team, and the bridge and pavement managers. The potential 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.

# 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 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.

While KYTC's investment strategy makes the most of available funding, KYTC does not have adequate funding to achieve its desired state of good repair for pavements or bridges by 2032. This performance gap was analyzed using the same analysis tools used to develop KYTC's life cycle strategies so different approaches to addressing the gap in asset conditions, system performance, and risk could be evaluated.

## Pavement Performance Gap

**Performance Gap**

**A performance gap analysis addresses the gaps between current and state DOT targets for asset condition, and the gaps in system performance effectiveness, that are best addressed by improving the physical assets (23 CFR 515.5).**

As detailed in Chapter 2, KYTC defines the state of good repair for pavements, as 92% of pavements in *Good* or *Fair* condition, based on KYTC's pavement condition rating system. Figure 6-2 shows the 10-year projected conditions for the KYTC pavement network. The graph shows that despite the improvement in condition achieved by the recommendations from the SYP, the desired state of good repair will not be met by 2032.

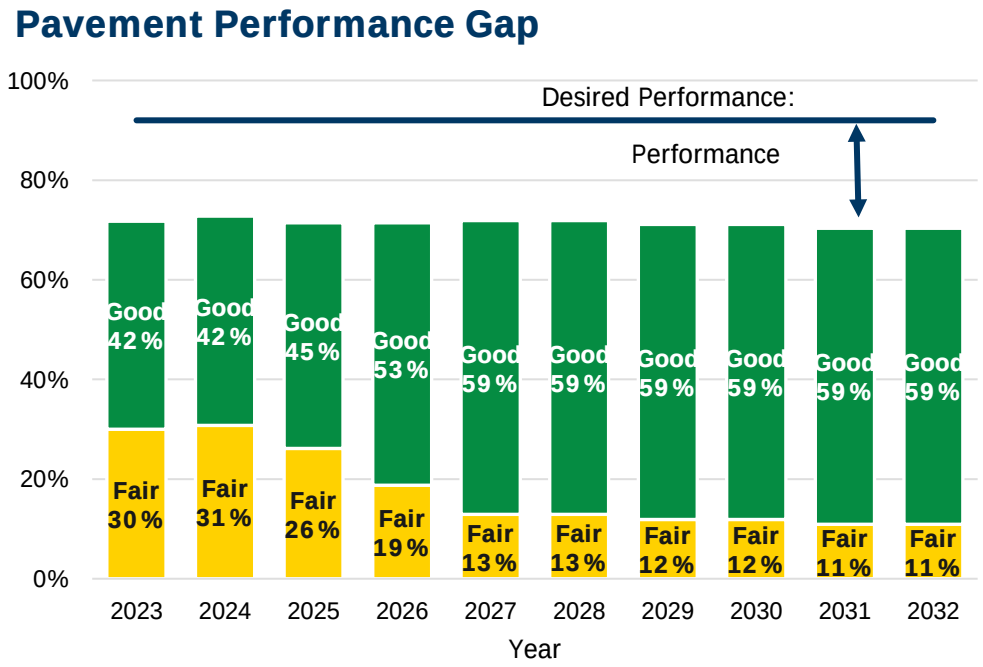



*Figure 6-2. Forecasted systemwide pavement performance gap*

Figures 6-3 thru 6-6 shows the 10-year projected conditions on a statewide basis and by highway system (Interstate, Parkways, and MP). These figures show that none of these networks are expected to achieve the desired state of good repair by 2032.

Current projections indicate a slight improvement in conditions based on the recommendations from SYP over the 10-year period. This indicates that the

KYTC's Optimize Preservation strategy is effective in improving and sustaining pavement conditions. The Optimized Preservation strategy includes expanding the use of preventive maintenance treatments on MP and Parkway pavements and beginning their use on Interstates.

KYTC's increased use of preventive maintenance overlays is expected to have a positive impact on pavement conditions. This expectation is based on an LCP analysis that shows these overlays result in a significant improvement in the percent of *Good* pavements over the 10-year period. 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 the development of future TAMPs, 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 raise KYTC's level of confidence in long-term pavement condition forecasts. At the present time, KYTC has confidence in the PMS's ability to accurately forecast the percentage of pavements in poor condition. However, additional refinement is needed improve the precision of forecasted splits between Good and Fair pavements.

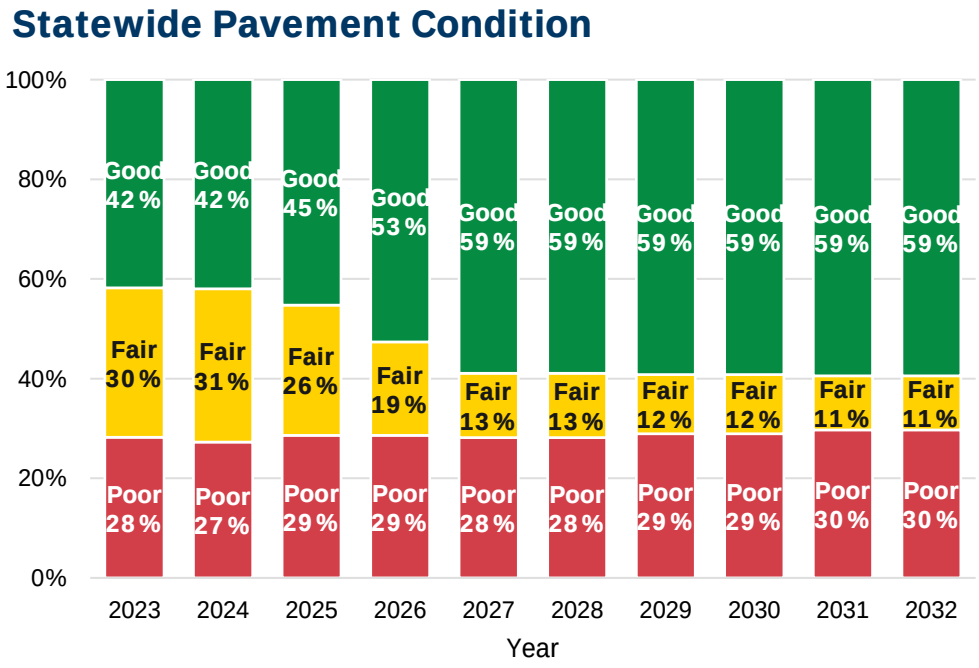



*Figure 6-3: Forecasted statewide pavement conditions based on planned investments*[6]

[6] The forecasted pavement condition trends shown in figures 6-3 through 6-6 for years 2023 through 2026 are based on projects committed in the SYP. The condition forecasts for years 2027 through 2031 are based on historical investments and condition outcomes from years 2021 through 2026.

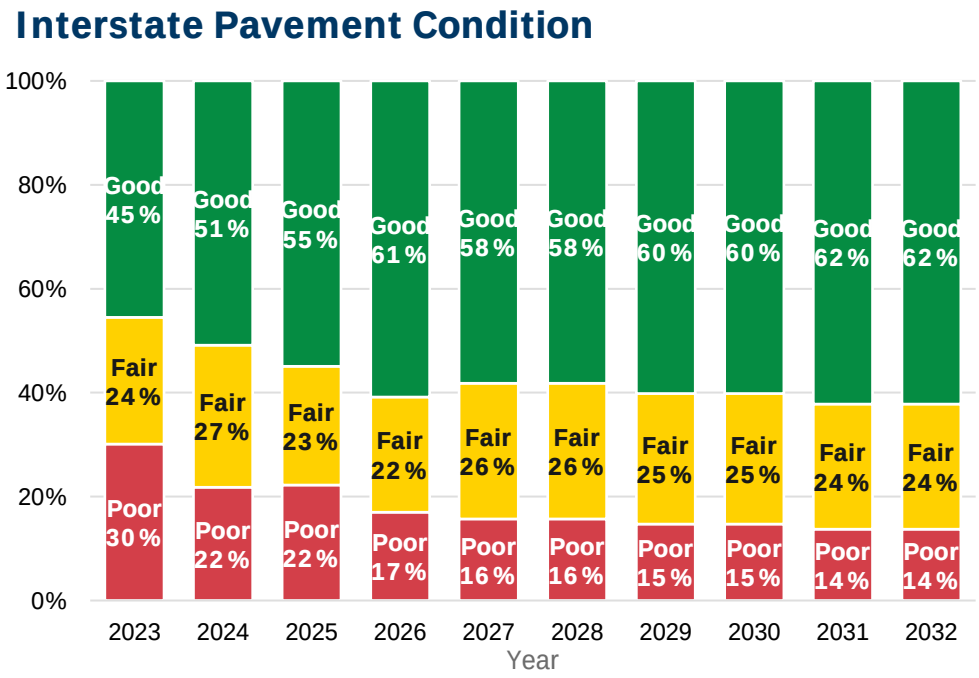



*Figure 6-4: Forecasted Interstate pavement conditions based on planned investments*

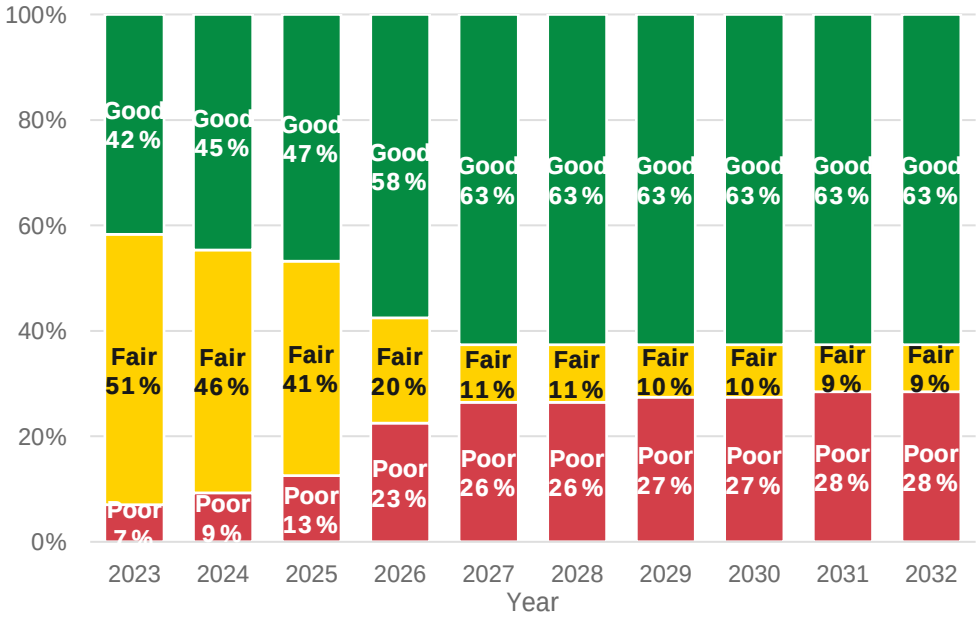



*Figure 6-5: Forecasted Parkway pavement conditions based on planned investments*

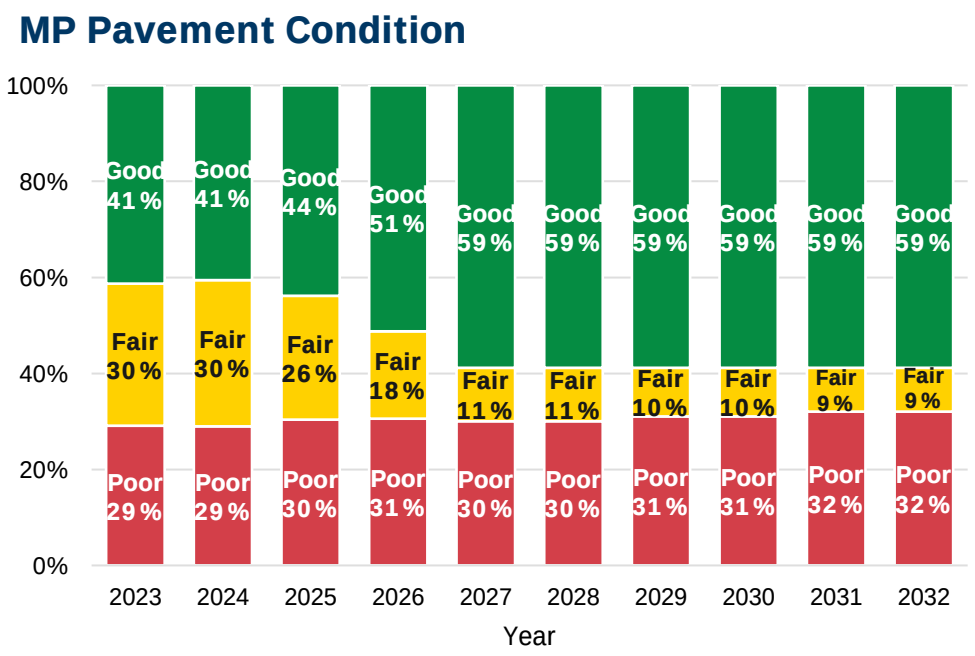



*Figure 6-6. Forecasted MP pavement conditions based on planned investments*

KYTC does not forecast a performance gap in terms of the federal targets for the condition of Interstate and Non-Interstate NHS pavements, as required by 23 USC 150(d). KYTC's 2021 targets and conditions, as of 2020, are shown in table 6-9. As described in Appendix B, these targets are based on different performance measures than KYTC's desired state of good repair. While KYTC does not currently have the ability to forecast conditions in terms of the federal measures, the agency is confident that overall pavement conditions are improving and there is no gap in performance either currently or forecasted for the TAMP period.

*Table 6-9. National Highway Performance Program targets and conditions*

| Network | 2021 Target %*Good* | 2021 Target %*Poor* | 2020 Actual %*Good* | 2020 Actual %*Poor* |
|---|---|---|---|---|
| Interstate | 50.0 | 4.0 | 53.0 | 1.0 |
| Non-Interstate NHS | 35.0 | 6.0 | 60.0 | 0.0 |

## Closing the Pavement Performance Gap

To achieve the desired state of good repair for pavements within the next 10 years, pavement investments in asset management activities must increase to an estimated $6.5 billion as documented in Table 6-10. This is in addition to investments made in reconstruction and initial construction, through the SHIFT Program. As shown in the table, the projected investment needs fluctuate each year, but increase substantially beginning in FY 2026.

*Table 6-10. Anticipated 10-year pavement needs ($ millions)*

| Work Types | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 10-Year Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Maintenance | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 360 |
| Preservation | 332 | 290 | 352 | 344 | 429 | 459 | 507 | 560 | 607 | 660 | 4,541 |
| Rehabilitation | 116 | 168 | 140 | 185 | 116 | 183 | 183 | 183 | 183 | 183 | 1,642 |
| Replacement | - | - | - | - | - | - | - | - | - | - | - |
| **Total Projected Investment Needs** | **485** | **494** | **528** | **565** | **581** | **678** | **726** | **779** | **827** | **879** | **6,543** |

KYTC's analysis indicates that most of the funds (69%) are needed to address pavement preservation and preventive maintenance work activities, while only 31% is needed to address rehabilitation and replacement work activities. This illustrates KYTC's commitment to 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.

Figure 6-7 presents a comparison of the projected planned and forecasted funding levels for pavements on each of the three major highway systems. The total funding gap is approximately $1.98 billion over the 10-year TAMP period.

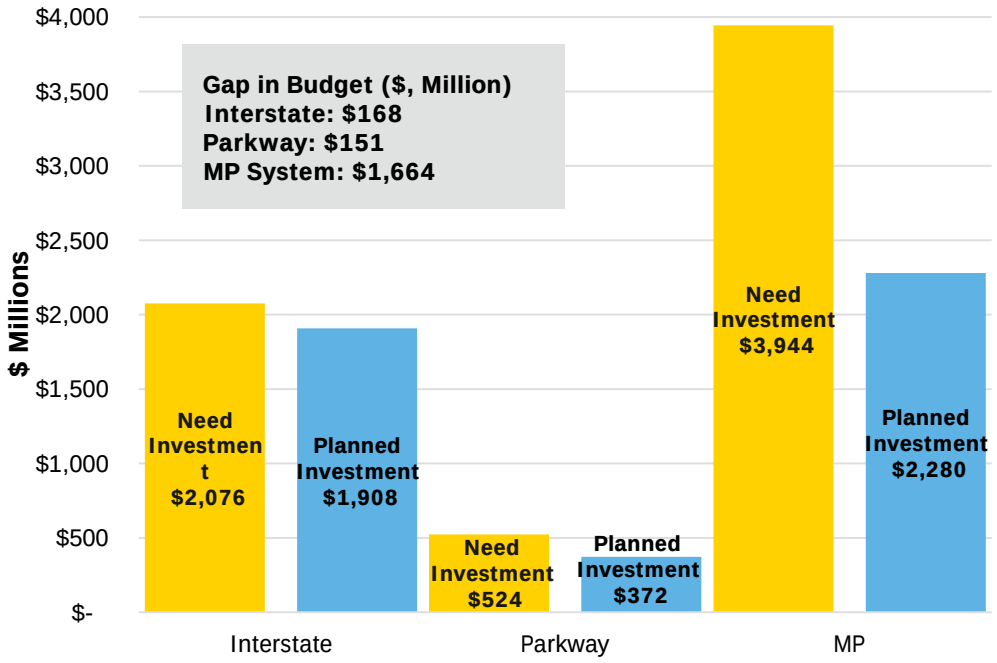



*Figure 6-7. Pavement need vs. planned investment allocated by network ($ millions)*

## Bridge Performance Gap

For long-range planning purposes, KYTC uses the federal standards to report current and expected bridge conditions in terms of the percentage of deck area on bridges in *Good*, *Fair*, or *Poor* condition, which is described in more detail in Chapter 3. The desired state of good repair and projected KYTC bridge conditions are established using this condition rating system.

For other management purposes, including deterioration modeling and life cycle cost analysis, KYTC uses a more detailed condition rating system based on the AASHTO Manual for Bridge Element Inspection. The more detailed analysis indicates a sizable population of bridges that are in *Fair* condition but at risk of moving to the *Poor* category over the next 10 years. As a result, the deterioration model reports a significant number of impending replacement needs. Network condition has been declining in recent years as described in Chapter 3 and currently does not meet the agency' s performance targets.

KYTC's is recent *Bridging Kentucky* program alleviated the replacement needs on many of the state's smallest and bridges in need. However, life cycle cost analysis indicates a continuing need for further replacements on an incoming class of somewhat larger bridges, which have a greater effect on the size-weighted performance measures.

Recent legislation at the federal level has created an opportunity to meet this oncoming challenge while at the same time significantly increasing the Cabinet's preservation program. The anticipated funding is sufficient to create a balanced program that reverses the recent decline and moves the bridge inventory in the desired direction once again. Most importantly, the enhanced preservation program will spur added capacity in the Cabinet and in the Commonwealth's construction industry for bridge preservation work, setting the stage for a program that is more economically sustainable in the long run.

Based on its BMS analysis, the Cabinet has decided on a plan that accomplishes these goals and fits within the available resources. Currently 4.5% of the inventory is in *Poor* condition. Given the expected large influx of bridges into this category, KYTC has decided to hold the line, to spend enough on replacements and rehabilitation to slow the pace and, if funding materializes as anticipated, make a modest improvement to 4.2% *Poor*. The 10-year state of good repair goal for *Poor* will be set slightly more conservatively at 4.5%. The NHS will benefit the most, with Poor bridges expected to improve from the current 3.9% to 3.3%, as reported in Appendix B.

Most importantly, a significant increase in preservation spending, to thirty-one percent of the total funding for existing bridges, will begin to protect a large class of bridges from approaching the *Poor* category. KYTC's desired SOGR goal for *Good* and *Fair* condition is 97%, which the inventory currently does not satisfy. The preservation program will begin at once to address this situation. The anticipated funding is forecast to improve the inventory to 96% *Good* and *Fair* in 10 years.

Figure 6-8 shows the 10-year projected conditions for KYTC's state-owned bridges. Current BMS projections indicate that the recommendations from the SYP extended over the 10-year period will result in conditions that nearly satisfy the desired state of good repair. It is estimated that increasing the annual bridge investment from $250 million to $300 million in each of the 10 years would address the gap.

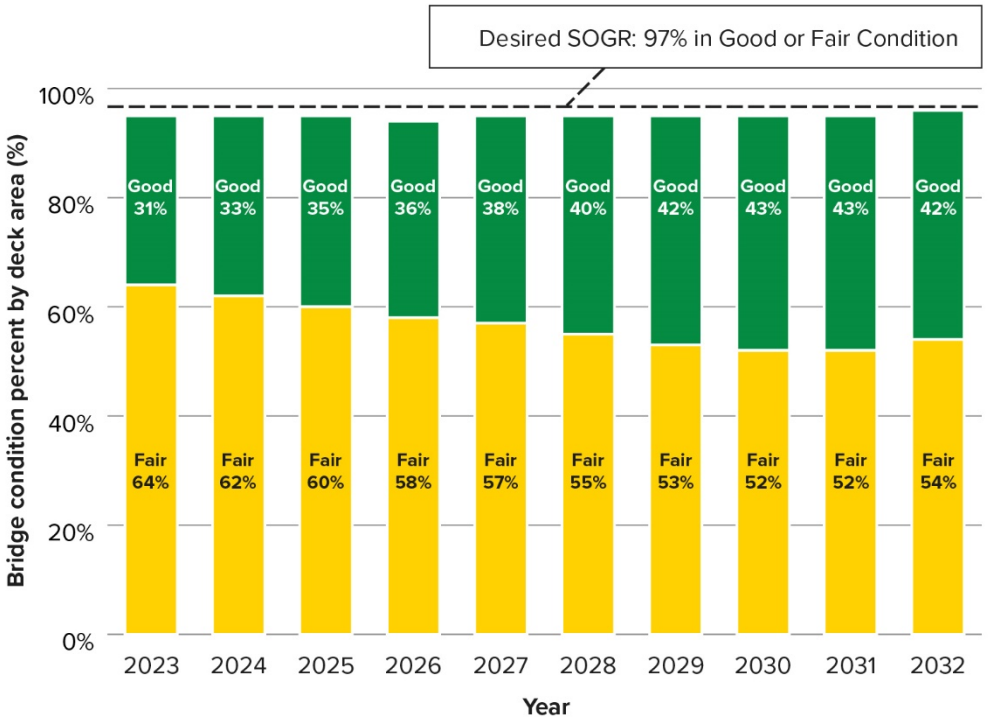



*Figure 6-8: Forecasted state-owned bridge conditions based on planned investments*

# 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, across all seven required National Goal Areas.

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 using a balanced approach. KYTC achieves this balance both through the existing system performance prioritization process and the SHIFT program.

## Existing Highway System Performance Projects

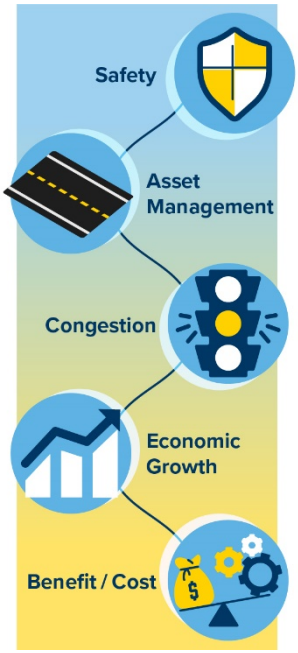
Projects in the existing highway system performance category provide for pavement and bridge preservation, rehabilitation, and replacement. KYTC selects existing highway system performance projects through a data-driven process that considers the overall system needs, the existing condition of each specific asset, estimated project costs and value, and performance goals. Prioritization models include mobility impacts, asset condition, anticipated deterioration, risk, and benefit. Through this process KYTC takes

advantage of opportunities to improve multiple performance areas and reduce risks with each project.

KYTC prioritizes projects to deliver the preferred life cycle plans for bridges and pavements within the available budget. As shown earlier, KYTC's pavements and bridges show a trend of decreasing *Good* and increasing *Fair* conditions. This indicates a greater urgency for focused investments to maintain assets in a state of good repair. The performance investment strategies allow KYTC to seek additional value from each transportation dollar while also meeting program goals and seeking network improvement. Projects prioritized through the existing highway performance prioritization process will:

- Improve the overall condition of Kentucky's pavements and bridges.
- Increase preservation spending to end the cycle of increasing needs.
- Replace poor condition bridges and pavements.
- Mitigate risk to the travelling public by considering safety in project selection.
- Continue to invest in local needs and honor commitments to maintain structures with bordering states.

## Highway Improvement Projects



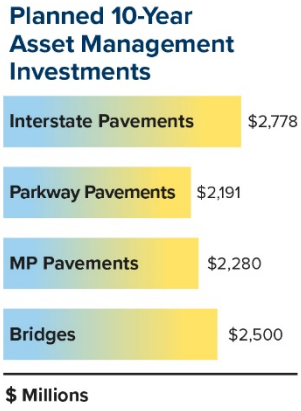

SHIFT incorporates benefits in each of the national goal areas into a common, objective project prioritization process. This process is used to rank capital projects for inclusion in the SYP. The formula is an objective approach that uses data on safety, congestion, asset management, economic growth, and cost-benefit ratios. SHIFT is a data-driven tool to help prioritize spending of limited transportation dollars. The statewide and regional lists developed under SHIFT scoring are incorporated into the SYP, 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. These projects are recommended through the statewide funding pool. 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, along with local transportation leaders (Area Development Districts, Metropolitan Planning Organizations, and KYTC District Offices), meet to establish priorities for funding in the SYP, at the regional level.

Through the SHIFT process, projects are prioritized based on their contributions to multiple performance areas. Projects that may reduce congestion and also address a *Poor* pavement section or bridge are scored higher than projects that only reduce congestion. Projects receiving the highest combined scores are included in the draft recommended SYP.

# IMPLEMENTING KYTC'S INVESTMENT STRATEGIES

KYTC is managing pavements and bridges to achieve the best overall possible conditions with available resources. Table 6-4 shows an anticipated $7.25 billion investment in pavements and table 6-8 shows another $2.5 billion investment in bridges by KYTC in the 10-year plan period. The planned investments and resulting forecasted conditions indicate KYTC will achieve its federal targets for NHS pavement and bridge conditions. When internal performance targets are considered, a financial gap exists between the overall investment needs and the projected budget allocations for both pavements and bridges. However, the planned pavement investments reflect KYTC's strategy to prioritize preservation and systematically improve overall conditions over time.




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.

KYTC is implementing its planned strategy for asset management but will need to continue increasing the use of pavement preservation in future years to meet its long-term performance targets. The implementation is further strengthened through the close coordination that took place between the development of the 10-year TAMP recommendations and the FY 2022-2028 SYP.

# Chapter 7: Asset Management Implementation and Enhancements

## OVERVIEW

KYTC is committed to the implementation and enhancement of its asset management processes. Since the development of the 2019 TAMP, KYTC has demonstrated its commitment to asset management through its increased investment in preservation activities, the expanded use of performance measures to drive investments, and the balancing of system preservation needs with safety and expansion needs in the SHIFT prioritization process. KYTC has also acquired new data collection technology to evaluate pavement conditions and implemented pavement and bridge management systems to support investment planning. These efforts are reflected in the improved pavement and bridge conditions presented in Chapter 3 and in the planned 10-year investment strategies proposed in this TAMP.

### Continual Improvement

KYTC recognizes that transportation asset management is a continual improvement process with advancements made by regularly assessing performance and determining the best course of action to facilitate improvement. The continual improvement process has four primary steps, as shown in figure 7-1.

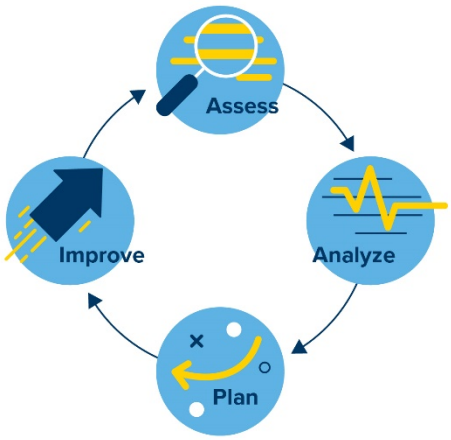



*Figure 7-1. Continual improvement process*

### 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 its initial TAMP. This effort focused on the skills, tools, and data needed to develop the required 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 initial TAMP, as well as enhancements to KYTC's asset management practices, tools, and organization that have been implemented since that time.

### Analyze

The self-assessment process included discussions on the best means of developing the TAMP and maturing the agency's asset management practices. For the development of the initial TAMP, KYTC relied on existing analysis tools. Since that time, KYTC has implemented new pavement and bridge management systems to support life cycle and investment planning activities. KYTC has also expanded its use of performance measures to drive investments and has increased its investment in preservation activities. These changes have led to improvements in both pavement and bridge conditions and remain the foundation for future investments outlined in the TAMP. Future enhancements are focused on continuing to advance the implementation of asset management throughout the agency.

### Plan

The process gaps were documented in a report that was used to guide early TAMP development. The 2018 and 2019 TAMPs served as roadmaps to help guide TAM implementation efforts so KYTC could achieve its asset management goals and objectives. KYTC is on track to achieve its long-term performance targets with its planned, on-going investments in preservation activities that extend pavement and bridge service life.

### Improve

KYTC has demonstrated its commitment to implementing the asset management enhancements suggested in its self-assessment and incorporated into the 2018 and 2019 TAMPs. Further enhancements are outlined in this TAMP, describing activities that KYTC will use to widen the implementation of asset management throughout the DOH. These activities are targeted at develop outreach and communication plans that share

benefits that have been realized and build buy-in for asset preservation strategies. 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. As part of these activities, the Core Team will host a workshop with KYTC leadership and managers to:

- Review asset management principles.
- Discuss the use of performance-based management principles for managing transportation assets.
- Highlight the interaction between the TAMP and existing project selection and programming processes
- Build executive support 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 identify further enhancements needed to integrate asset management into existing practices.

# ASSET MANAGEMENT IMPLEMENTATION

## TAMP Development

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 7-2, leads and support all aspects of the TAMP development and oversee continuing implementation efforts. The team is led by an Assistant State Highway Engineer in the State Highway Engineer's Office who oversees Performance Management. In addition to her duties with Performance Management, this individual leads the Core Team activities and manages the TAMP update efforts. She is also leading upcoming initiatives to develop asset management communication and outreach plans.

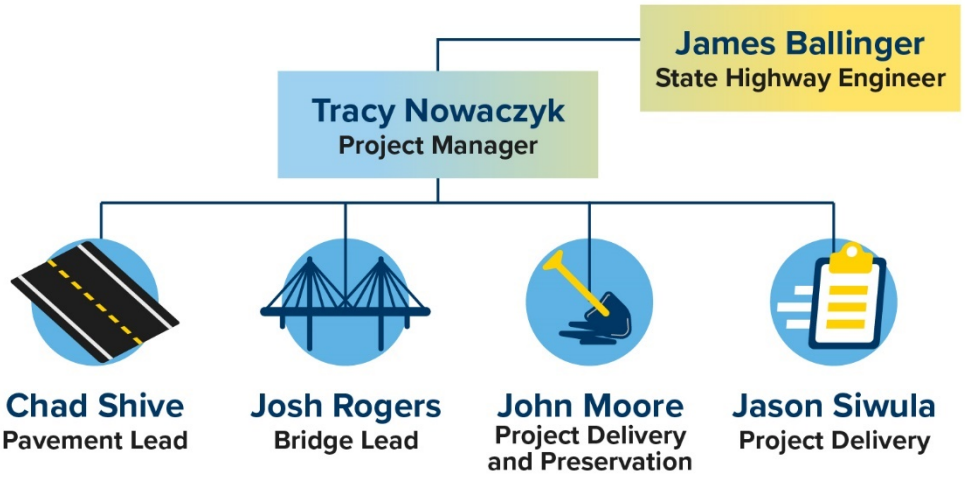



*Figure 7-2. TAMP Core Team members*

The Core Team is supported by four work groups to oversee critical TAMP components, as shown in figure 7-3. 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.

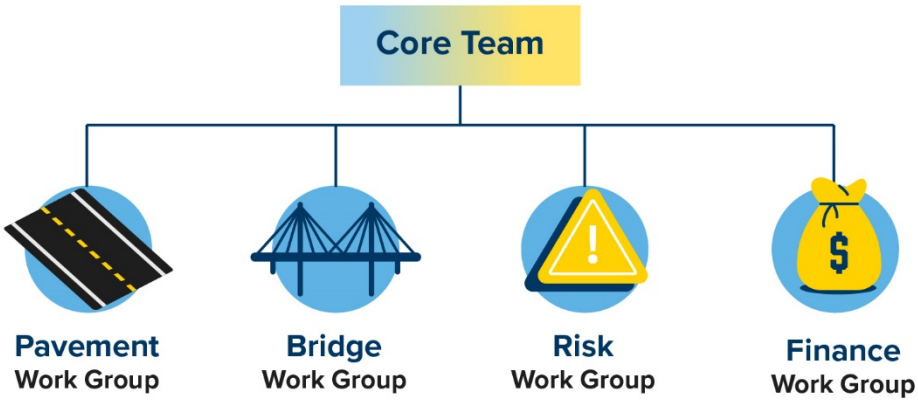



*Figure 7-3. TAMP work groups*

### 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 the work groups. KYTC will continue to evaluate opportunities to enhance the effectiveness of asset management concepts and implementation. Since asset management is the responsibility of the entire Cabinet, KYTC has established this structure as a way 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.

## ENHANCEMENTS

Table 7-1 presents the planned enhancements to further develop KYTC's asset management practices. The table identifies the business units responsible for each enhancement and the desired schedule for completion. The work will be conducted with guidance and direction from the Core Team.

*Table 7-1. Planned asset management enhancements*

| Enhancement | KYTC Lead | Schedule |
|---|---|---|
| Assess the performance benefits realized through the SHIFT prioritization process for use in outreach efforts | Planning | Start: 2023<br>Finish: 2024 |
| Develop a TAM outreach & communication plan for internal & external audiences | Core Team | Start: 2022<br>Finish: 2023<br>Implementation: 2023-24 |
| Continue efforts with the University to develop reliable pavement deterioration models for the PMS | Pavement | Start: Underway<br>Finish: 2023 |
| Configure the resulting deterioration models into the PMS | Pavement | Start: 2023<br>Finish: 2023 |
| Verify the PMS configuration by running concurrent analyses with existing tools and adjust PMS models as needed | Pavement | Start: 2022<br>Finish: 2024 |
| Develop & implement a plan for obtaining District input on PMS project & treatment recommendations | Pavement | Start: 2022<br>Finish: 2023 |
| Develop a Pavement Priority Index similar to the Bridge Priority Index | Pavements | Start: 2022<br>Finish: 2023 |
| Continue building the statewide bridge preventive maintenance program | Maintenance | Start: Underway<br>Finish: On-Going |
| Incorporate Midwest Pooled Fund study results into BrM deterioration model | Bridge Maintenance & Design | Start: 2022<br>Finish: 2023 |
| Integrate project delivery status (projects in the pipeline) into AASHTOWARE (BrM) Optimization Modules | Bridge Maintenance & Design | Start: Underway<br>Finish: 2023 |
| Conduct sensitivity analysis & refinements of BrM model parameters | Bridge Maintenance & Design | Start: Underway<br>Finish: On-Going |
| Review the Bridge Priority Index to include a flood vulnerability index | Bridge Maintenance & Design | Start: 2022<br>Finish: 2023 |
| Improve bridge management documentation | Bridge Maintenance & Design | Start: 2019<br>Finish: 2021 |
| Manage TAMP program delivery | Bridge Maintenance & Design<br><br>Pavements | Start: Underway<br>Finish: On-Going |

# Appendix A: National Highway System (NHS) Asset Inventory, Condition, and Value Summary

## OVERVIEW

Federal regulations (23 CFR 515) requires that each state provide a summary of the inventory, condition, and value of pavements and bridges on the National Highway System (NHS), regardless of ownership.

KYTC manages and maintains approximately 12,395 lane-miles of the NHS within the Kentucky Commonwealth. Approximately 108 lane-miles (roughly 50 centerline miles) are managed by local governments. This equates to less than 1% of the total NHS lane-milage. Figure A-1 shows the location of the NHS highway system in Kentucky. KYTC manages an even larger portion of the NHS bridges. Only one bridge in Kentucky is managed by local governments, comprising approximately 0.5% of the total deck area in the Commonwealth. Based on these figures, it is evident that KYTC's asset management practices have the most significant contribution to preserving NHS performance.

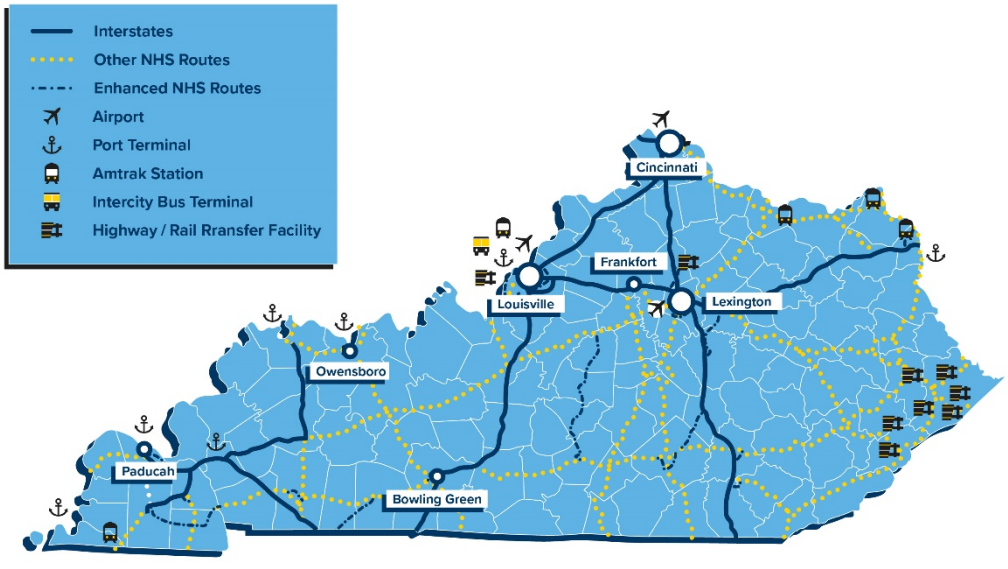



*Figure A-1. Kentucky's NHS routes*

# NHS PAVEMENT SUMMARY

NHS pavement condition is reported according to federal standards, in terms of the percentage in *Good*, *Fair*, and *Poor* condition. The federal measures for *Good*, *Fair*, and *Poor* are determined from an evaluation of cracking, joint faulting, rutting, and ride quality in accordance with the National Highway Performance Program (NHPP). Differences in the use of pavement condition metrics by surface type are presented in Table A-1.

*Table A-1. Federal NHPP pavement condition metrics*

| Condition Type | Metric | AC[1] | CRCP[2] | JCP[3] | *Good* | *Fair* | *Poor* |
|---|---|---|---|---|---|---|---|
| Ride Quality | International Roughness Index (IRI) | ✓ | ✓ | ✓ | <95 in/mi | 95-170 in/mi | >170 in/mi |
| Rutting | Average rut depth | ✓ | | | <0.20in | 0.20-0.40 in | >.40in |
| Wheel Path Cracking | Percent of wheel path area with cracks | ✓ | | | <5% | 5%-20% | >20% |
| Slab Cracking | Percent of slabs with cracks | | | ✓ | <5% | 5%-15% | >15% |
| Cracking | Percent of area with longitudinal cracks, spalls, or punchouts | | ✓ | | <5% | 5%-10% | >10% |
| Joint Faulting | Average fault height | | | ✓ | <0.10in | 0.10-0.15 in | >.15in |

1 Asphalt concrete pavement
2 Continuously reinforced concrete pavement
3 Jointed concrete pavement

The pavement condition metrics shown in Table A-1 are used to calculate pavement performance measures on a 1/10-mile basis. These performance measures are reported to FHWA in its Highway Performance Monitoring System (HPMS). Pavements are reported to be in *Good* condition if all three of the metrics reported for the appropriate surface type are in *Good* condition. Pavements are reported in *Poor* condition if two or more of the metrics are rated as *Poor*. All other pavements are classified in *Fair* condition. Table A-2 provides a summary of NHS pavement inventory and conditions using the most recent HPMS report card. To meet federal minimum condition requirements, no more than 5% of the Interstate pavement may be in Poor condition. As shown in the table, KYTC is not in danger of exceeding the federal minimum condition requirement.

*Table A-2. Summary of NHS pavement conditions*

| Highway System | Lane-Miles *Good* | % *Good* | Lane-Miles *Fair* | % *Fair* | Lane-Miles *Poor* | % *Poor* | Unreported Lane-Miles | Total Lane-Miles Inspected |
|---|---|---|---|---|---|---|---|---|
| Interstate | 3,167 | 72% | 1,200 | 27% | 29 | <1% | 97 | 4,397 |
| Non-Interstate | 4,018 | 53% | 3,459 | 46% | 66 | 1% | 183 | 7,543 |
| **Total** | **7,185** | **60%** | **4,659** | **39%** | **95** | **<1%** | **280** | **11,940** |

State DOTs are required to set targets for their NHS bridges and pavements; targets that are also consistent with the agency's asset management objectives. The performance targets reported to FHWA for both Interstate and Non-Interstate NHS pavements are presented in Table A-3. A comparison of the values in tables A-2 and A-3 indicate that KYTC's management of the NHS pavements has resulted in conditions that are better

than the established targets for both the Interstate and Non-Interstate systems.

*Table A-3. National Highway Performance Program targets*

| Network | Current *Good* | 2019 Target *Good* | 2021 Target *Good* | Current *Poor* | 2019 Target *Poor* | 2021 Target *Poor* |
|---|---|---|---|---|---|---|
| Interstate | 72.0% | n/a | 50% | 0.7% | n/a | 4% |
| Non-Interstate NHS | 53.3% | 35% | 35% | 0.9% | 6% | 6% |

The current value of the pavements on the NHS is presented in Table A-4 using the two valuation methods discussed in Chapter 3.

*Table A-4. NHS pavement value*

| Highway System | Replacement Value ($ billion) | Depreciated Replacement Value ($ billion) |
|---|---|---|
| Interstate | $9.2 | $8 |
| Non-Interstate NHS | $9.6 | $9.1 |
| **Total** | **$18.8** | **$17** |

Tables A-5 and A-6 summarize the locally owned NHS pavements and connectors, respectively.

*Table A-5. Locally owned NHS pavements*

| District | County | Centerline Miles |
|---|---|---|
| Covington | Campbell | 0.094 |
| Lexington | Fayette | 41.517 |
| Louisville | Jefferson | 2.936 |
| **Total** | | **44.547** |

*Table A-6. Locally owned NHS connectors*

| NHS Connector | Description | Centerline Miles |
|---|---|---|
| Ashland Amtrak/greyhound bus terminals | From US 23 (Greenup Avenue) East to Amtrak Station Entrance | 0.065 |
| Owensboro riverport | From KY 331 East to Owensboro Riverport | 0.356 |
| Ivel coal tipple | From US 23 South to Ivel Coal Tipple Entrance | 0.207 |
| Amtrak station - Fulton | From US 51 to Entrance to Amtrak Station | 0.025 |
| Louisville international airport | From I-65 southbound ramp to Midfield Access Road | 1.043 |
| Name not provided | Description unavailable | 0.343* |
| Campground Rd Petro/ chem cluster | From I-264 to KY 2051 | 0.65 |
| Norfolk southern - Louisville | From CR 1016G (Jennings Lane) to KY 1703 | 0.603 |
| Campground Rd petro/ chem cluster | From KY 1934 to KY 2051 | 0.858 |
| Norfolk southern - Louisville | From CR 1010G (Bishop Lane) West to Norfolk Southern Intermodal Terminal Entrance | 0.2 |
| Greyhound bus station - Louisville | From CS 1046A (Roy Wilkins Avenue) to CS 1011F (7th Street) | 0.172 |
| Greyhound bus station - Louisville | From 8th St to Roy Wilkins Ave | 0.091 |
| Greyhound bus station – Louisville | From CS 1004A (West Chestnut Street) to CS 1001A (West Muhammad Ali Boulevard) | 0.152 |

| NHS Connector | Description | Centerline Miles |
|---|---|---|
| Greyhound bus station - Louisville | From I-64 ramps at US 31W (Market Street) to CS 1009A (Magazine Street) | 0.532 |
| Greyhound bus station - Louisville | Description unavailable | 0.532* |
| Greyhound bus station – Louisville | From CS 1001A (West Muhammad Ali Boulevard) to CS 1009A (Magazine Street) | 0.243 |
| | **Total** | **6.072** |

*Description unavailable

# NHS BRIDGE SUMMARY

In addition to the targets set for NHS bridges and pavements 23 CFR Part 490, Subpart D, "National Performance Management Measures for Assessing Bridge Condition," and Section 490.411, "Establishment of Minimum Level for Condition for Bridges", state DOTs should maintain bridges so that the percentage of the NHS bridge deck area in *Poor* condition (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% of the total bridge deck maintained by the state. KYTC has been setting targets that are more ambitious than the national goals. In addition, KYTC has set the same targets for non-NHS bridges, to emphasize the need for preservation of these bridges that cover 50% of the inventory maintained by the state. These targets are summarized in table A-7.

*Table A-7. Performance measures and targets for KYTC bridges (percent by deck area)*

| Highway Network | *Current Good* | 2019 Target *Good* | 2021 Target *Good* | *Current Poor* | 2019 Target *Poor* | 2021 Target *Poor* |
|---|---|---|---|---|---|---|
| National Highway System | 29.2% | 35% | 35% | 3.8% | 3.7% | 3.2% |
| Non-NHS State-Owned Bridges | 33.5% | 35% | 35% | 5.2% | 3.7% | 3.2% |

The replacement value and depreciated value of NHS and non-NHS state-owned bridges is shown in table A-8. The methodology for these calculations is described in Chapter 3.

*Table A-8. Bridge asset valuation*

| Highway Network | Replacement Value ($ billion) | Depreciated Value ($ billion) |
|---|---|---|
| National Highway System | 19.40 | 11.29 |
| Non-NHS State-Owned Bridges | $ 18.70 | $ 11.11 |
| Total | 38.11 | 22.40 |

# Appendix B: Summary of Investment Strategies and Forecasted Conditions for the NHS

## FORECASTED NHS 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 0.7% *Poor*, based on data collected in 2020 and reported in KYTC's 2021 HPMS submission.

At this time, KYTC is not able to predict pavement conditions in terms of the NHPP pavement measures. Figure B-1 illustrates the NHS pavement condition based on the KYTC measures. As shown in the figure, there is a steady improvement in NHS pavement condition expected over the next 10-year period as per the SYP. This improvement in conditions is expected to ensure that KYTC continues to perform at levels that are better than its federal targets require.

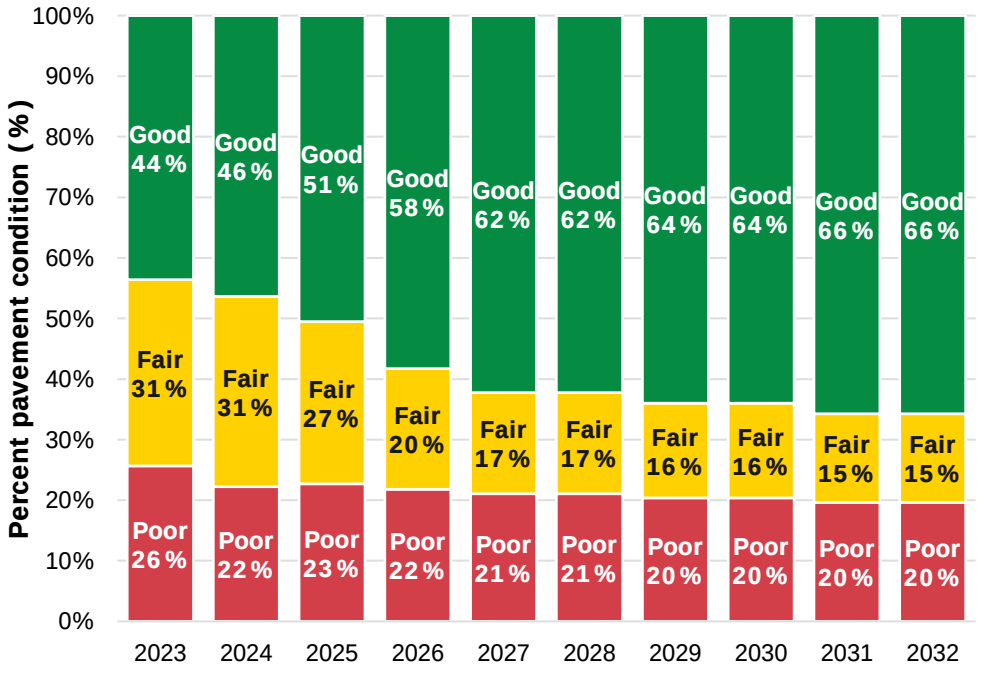



*Figure B-1. Forecasted pavement conditions for the NHS (KYTC measures)*

# FORECASTED NHS BRIDGE CONDITIONS

Federal statute 23 USC 119 and regulation 23 CFR 490 establish a threshold of no more than 10% of NHS bridges in *Poor* condition, as measured by deck area, which will result in specific restrictions to KYTC's use of federal funding if the minimum conditions are exceeded. As shown in figure B-2, KTYC expects its NHS bridges to continue to improve in condition over the next 10 years. As discussed in Chapter 6, this improvement in conditions, which will enable KYTC to greatly surpass the federal limit, is largely due to plans to expand the statewide bridge preservation program, as discussed in Chapter 6. Figure B-2 presents the forecasted 10-year condition improvements based on KYTC's BMS analysis. Figure B-3 shows the effect of funding uncertainty, using the same rationale and goals as for statewide bridges presented in Chapter 6.

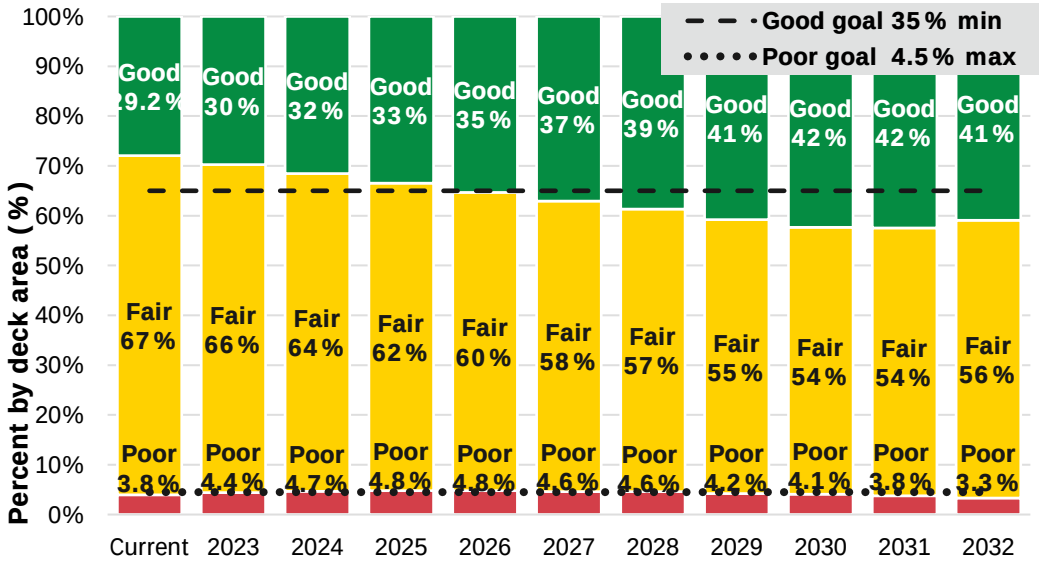



*Figure B-2. Forecasted conditions for NHS bridges under the anticipated funding scenario*

# Appendix C: Locations Requiring Multiple Repairs Due to Emergency Events

**KYTC has performed over $176 million in emergency repairs since 2009.**

## OVERVIEW

Federal regulation 23 CFR 667 requires each state to periodically conduct a statewide evaluation to determine if there are reasonable alternatives to repairing or reconstructing roads, highways, and bridges on the NHS with two or more emergency events.

KYTC worked with the Kentucky FHWA Division Office to perform an initial evaluation of emergency repair sites in 2018. The evaluation resulted in a database of over 1,200 Emergency Relief (ER) program records for highway damage and repairs dating back to 2009. KTYC updates this database following each new emergency event. Figure C-1 shows the estimated costs of ER repairs in the database, now totaling $176 million to address 1,980 sites.

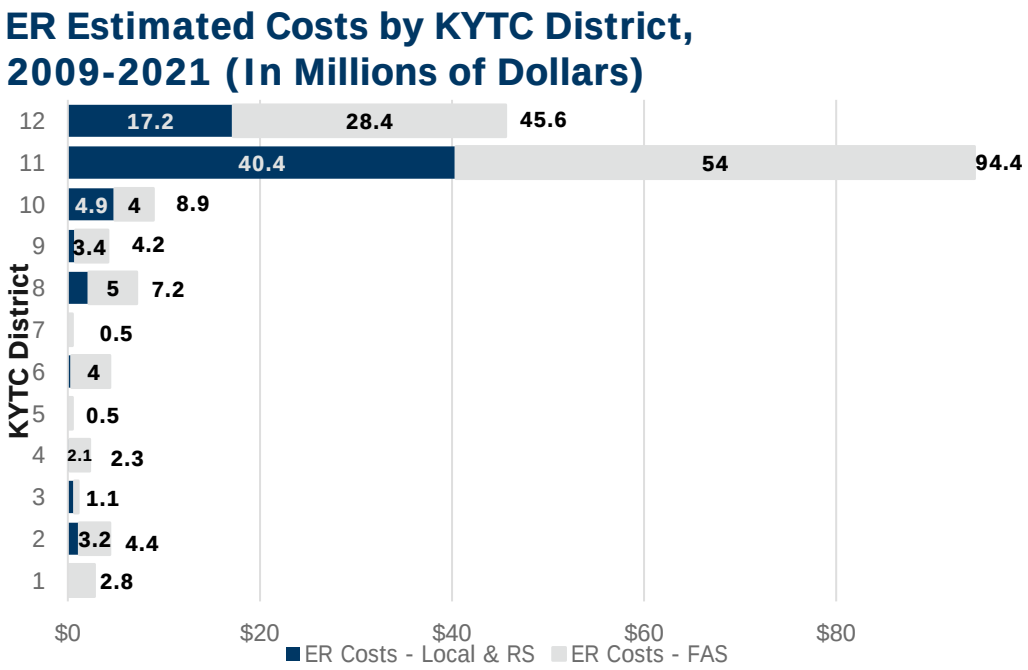



*Figure C-1. Estimated cost of emergency repairs by KYTC District*

Of this total, 82.2 percent ($145.0 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 repairs stemming from damage associated with natural disasters or failures caused by external causes. In Kentucky, this type

**Emergency repairs are most frequently required in Kentucky's eastern, mountainous areas.**

of damage is most commonly associated with the effects of severe storms and flooding.

Though Kentucky's ER sites are spread 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, which, during a heavy rain event, funnels the water down slopes and into stream channels in the valleys. This results in a 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 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.

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, 90 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 approximately 90 percent ($160 million) of the statewide total.

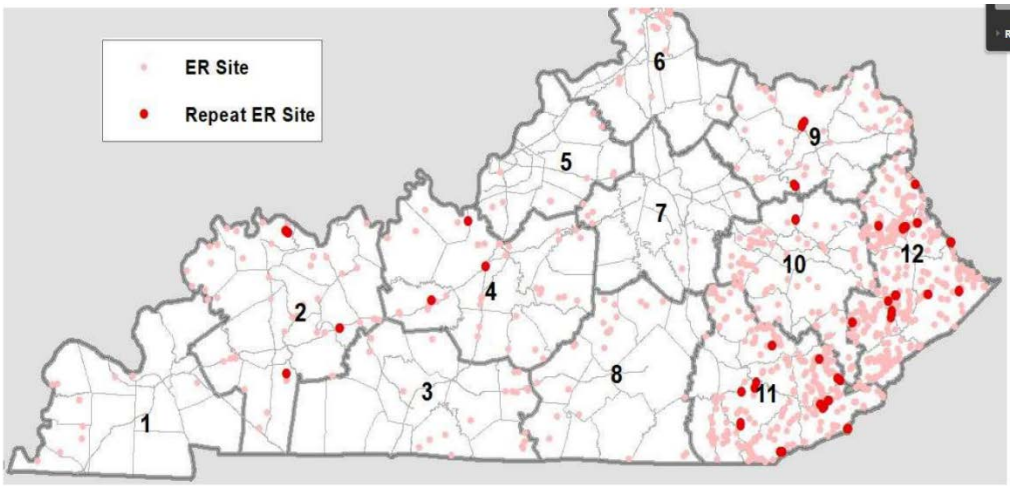



*Figure C-2. Emergency repair sites on Kentucky's highways: 2009 to 2019*

Using the ER database, KYTC has identified 103 locations where emergency repairs appear to have been necessary on more than one occasion across multiple years (Table C-1). KYTC uses the information contained in this database to perform the necessary site evaluations to identify alternatives for mitigating the root cause of the recurring damage, estimating the repair costs, and determining the estimated life of the solution as required by 23 CFR 667.3.

KYTC currently performs an annual review of ER data to repeatedly damaged sites. This information is coordinated with KYTC's Planning, Design, and Program Management personnel to consider these sites in the SYP, other planning or corridor studies, and for STIP implementation. More formal procedures are currently being developed to help identify and implement mitigation strategies for roadways and project corridors that have been subject to repeated damage from ER events.

KYTC is also developing and implementing the First Look tracking system app to enable real-time, automated updating of ER records. This app allows for improved ER site tracking to record labor, equipment, and materials used in response to emergency events by state forces and contractors. This information is captured in a geodatabase that is made available to KYTC staff who are involved in planning, project selection, and design. Additionally, as data is submitted through First Look, it can be joined to the existing database of historical ER records.

This data is used to perform regular, on-going evaluations of NHS needs. For locations off the NHS, this information is considered as a regular part of planning and project development activities.

**KYTC is currently implementing the First Look tracking system app to enable real-time, automated updating of ER records.**

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

| Dist. | County | Route | Start M.P. | End M.P. | Description | Estimated Repair Cost |
|---|---|---|---|---|---|---|
| 2 | Christian | KY 189 | 9.98 | 10.50 | Slide | $394,000 |
| 2 | Christian | KY 189 | 12.50 | 12.50 | Slide | $353,000 |
| 2 | Henderson | US 60 | 21.00 | 24.00 | Road Flooded/Pavement Failure | $108,000 |
| 2 | Ohio | WK 9001 | 68.60 | 69.00 | Slide | $515,000 |
| 2 | Ohio | WK 9001 | 83.40 | 83.80 | Slide | $225,000 |
| 4 | Grayson | US 62 | 23.20 | 23.30 | Slide | $160,000 |
| 6 | Kenton | KY 1486 | 3.14 | 4.21 | Embankment Failure | $405,000 |
| 9 | Greenup | KY 2 | 8.65 | 8.70 | Slide | $245,000 |
| 9 | Greenup | KY 2 | 16.40 | 16.43 | Slide | $326,000 |
| 9 | Lewis | KY 377 | 2.00 | 5.00 | Road Flooded/Pavement Failure | $59,000 |
| 9 | Rowan | KY 801 | 5.00 | 9.00 | Slide | $76,000 |
| 10 | Menifee | US 460 | 17.80 | 19.39 | Road Flooded/Pavement Failure | $46,000 |
| 11 | Bell | KY 190 | 5.00 | 12.93 | Embankment Failure | $535,000 |
| 11 | Bell | KY 217 | 0.00 | 2.00 | Road Flooded/Slide | $995,000 |
| 11 | Bell | KY 221 | 6.05 | 6.23 | Slide | $53,000 |
| 11 | Bell | KY 221 | 10.80 | 11.33 | Slide | $275,000 |
| 11 | Bell | KY 66 | 2.22 | 2.40 | Slide | $37,000 |
| 11 | Bell | KY 66 | 10.50 | 11.05 | Slide/Culvert Failure | $530,500 |
| 11 | Bell | KY 987 | 6.30 | 18.90 | Road Flooded/Pavement Failure | $650,900 |
| 11 | Clay | KY 11 | 5.00 | 6.10 | Slide/Roadway Failure | $370,000 |
| 11 | Clay | KY 11 | 14.80 | 25.30 | Slide/Roadway Failure | $2,071,920 |
| 11 | Clay | KY 66 | 1.61 | 2.87 | Slide/Embankment Failure | $337,100 |
| 11 | Clay | KY 66 | 13.45 | 13.54 | Slide/Embankment Failure | $652,118 |
| 11 | Clay | KY 66 | 31.00 | 32.10 | Slide/Embankment Failure | $598,975 |
| 11 | Clay | KY 11 | 14.10 | 15.90 | Slide/Embankment Failure | $1,143,960 |

| Dist. | County | Route | Start M.P. | End M.P. | Description | Estimated Repair Cost |
|---|---|---|---|---|---|---|
| 11 | Harlan | KY 160 | 0.50 | 2.63 | Slide/Roadway Failure | $1,171,837 |
| 11 | Harlan | KY 160 | 2.70 | 2.83 | Slide/Roadway Failure | $438,957 |
| 11 | Harlan | KY 160 | 3.85 | 4.74 | Slide/Roadway Failure | $266,637 |
| 11 | Harlan | KY 221 | 3.15 | 4.61 | Slide/Roadway Failure | $229,500 |
| 11 | Harlan | KY 221 | 6.00 | 6.60 | Slide/Roadway Failure | $210,689 |
| 11 | Harlan | KY 221 | 8.09 | 9.78 | Slide/Roadway Failure | $105,213 |
| 11 | Harlan | KY 221 | 12.10 | 13.70 | Slide/Roadway Failure | $192,000 |
| 11 | Harlan | KY 221 | 19.80 | 21.77 | Slide/Roadway Failure | $319,727 |
| 11 | Harlan | US 421 | 0.00 | 1.60 | Slide/Embankment Failure | $471,842 |
| 11 | Harlan | US 421 | 5.88 | 6.10 | Slide/Embankment Failure | $405,175 |
| 11 | Harlan | US 421 | 17.00 | 23.00 | Road Flooded/Pavement Failure | $1,567,439 |
| 11 | Knox | KY 11 | 0.94 | 4.30 | Road Flooded/Pavement Failure/Slide | $978,950 |
| 11 | Knox | KY 11 | 17.80 | 17.80 | Slide/Embankment Failure | $1,512,449 |
| 11 | Knox | KY 229 | 6.00 | 8.27 | Road Flooded/Pavement Failure/Slide | $1,911,540 |
| 11 | Knox | Ky 6 | 7.73 | 8.59 | Slide/Embankment Failure | $691,155 |
| 11 | Leslie | KY 406 | 7.92 | 8.10 | Slide/Embankment Failure | $186,100 |
| 11 | Leslie | KY 406 | 10.64 | 10.67 | Slide/Embankment Failure | $244,775 |
| 11 | Leslie | KY 699 | 0.98 | 4.50 | Slide/Embankment Failure | $421,100 |
| 11 | Leslie | KY 699 | 8.58 | 9.15 | Slide/Embankment Failure | $236,600 |
| 11 | Leslie | KY 699 | 12.41 | 12.44 | Slide/Roadway Failure | $76,300 |
| 11 | Leslie | KY 699 | 14.40 | 14.48 | Slide/Roadway Failure | $166,800 |
| 11 | Leslie | KY 699 | 15.48 | 15.80 | Slide/Roadway Failure | $1,215,000 |
| 11 | Leslie | KY 80 | 0.38 | 3.23 | Slide/Roadway Failure | $202,600 |
| 11 | Leslie | KY 80 | 6.55 | 9.00 | Slide/Roadway Failure | $703,948 |
| 11 | Leslie | US 421 | 29.50 | 31.33 | Shoulder Break | $1,540,058 |
| 11 | Leslie | US 421 | 9.05 | 9.13 | Slide/Roadway Failure | $65,145 |
| 11 | Leslie | US 421 | 19.68 | 20.55 | Shoulder Break | $333,725 |
| 11 | Whitley | KY 1259 | 0.35 | 0.40 | Roadway/Shoulder Failure | $104,221 |
| 11 | Whitley | KY 26 | 0.12 | 0.58 | Slide/Roadway Failure | $379,753 |
| 11 | Whitley | KY 26 | 9.24 | 10.10 | Slide/Roadway Failure | $319,916 |
| 11 | Whitley | KY 856 | 0.29 | 1.53 | Slide/Roadway Failure | $175,000 |
| 11 | Whitley | KY 92 | 13.22 | 15.82 | Slide/Roadway Failure | $1,833,983 |
| 11 | Whitley | KY 92 | 30.29 | 32.94 | Slide/Shoulder Failure | $646,010 |
| 11 | Whitley | US 25W | 8.80 | 9.75 | Roadway/Shoulder Failure | $190,000 |
| 12 | Floyd | KY 122 | 15.87 | 16.40 | Road Flooded/Pavement Failure | $340,280 |

| Dist. | County | Route | Start M.P. | End M.P. | Description | Estimated Repair Cost |
|---|---|---|---|---|---|---|
| 12 | Floyd | KY 122 | 32.70 | 33.55 | Road Flooded/Pavement Failure | $110,178 |
| 12 | Floyd | KY 550 | 2.24 | 2.73 | Embankment Failure | $70,110 |
| 12 | Floyd | KY 7 | 2.97 | 3.09 | Embankment Failure | $49,000 |
| 12 | Floyd | KY 7 | 4.92 | 5.54 | Embankment Failure | $87,642 |
| 12 | Floyd | KY 979 | 0.75 | 6.43 | Embankment Failure | $187,114 |
| 12 | Johnson | KY 1428 | 0.87 | 2.06 | Roadway/Shoulder Failure | $140,000 |
| 12 | Johnson | KY 172 | 9.40 | 10.10 | Roadway/Shoulder Failure | $285,000 |
| 12 | Johnson | KY 40 | 4.25 | 4.93 | Roadway/Shoulder Failure | $239,000 |
| 12 | Johnson | KY 40 | 16.20 | 18.62 | Roadway/Shoulder Failure | $300,800 |
| 12 | Johnson | KY 40 | 20.36 | 23.22 | Roadway/Shoulder Failure | $708,200 |
| 12 | Knott | KY 550 | 2.60 | 2.70 | Embankment Failure | $91,400 |
| 12 | Knott | KY 582 | 2.19 | 2.52 | Embankment Failure | $138,450 |
| 12 | Knott | KY 582 | 4.98 | 5.80 | Embankment Failure | $120,800 |
| 12 | Knott | KY 582 | 6.77 | 11.10 | Embankment Failure | $619,613 |
| 12 | Knott | KY 7 | 2.15 | 2.91 | Embankment Failure | $348,200 |
| 12 | Knott | KY 7 | 8.06 | 16.02 | Embankment Failure | $455,569 |
| 12 | Lawrence | KY 3 | 5.65 | 6.06 | Roadway/Shoulder Failure | $245,000 |
| 12 | Lawrence | KY 3 | 12.20 | 13.17 | Roadway/Shoulder Failure | $76,000 |
| 12 | Lawrence | KY 32 | 0.25 | 0.45 | Roadway/Shoulder Failure | $50,000 |
| 12 | Lawrence | KY 32 | 1.00 | 1.05 | Roadway/Shoulder Failure | $30,000 |
| 12 | Lawrence | KY 644 | 1.67 | 2.78 | Roadway/Shoulder Failure | $42,000 |
| 12 | Letcher | KY 160 | 1.30 | 3.66 | Embankment Failure | $238,400 |
| 12 | Letcher | KY 160 | 4.94 | 9.46 | Embankment Failure | $1,528,700 |
| 12 | Letcher | KY 463 | 0.73 | 2.39 | Embankment Failure | $246,900 |
| 12 | Letcher | KY 805 | 0.88 | 1.72 | Shoulder Break | $84,200 |
| 12 | Letcher | KY 931 | 5.48 | 11.14 | Embankment Failure | $643,500 |
| 12 | Letcher | US 119 | 15.10 | 15.46 | Embankment Failure | $326,200 |
| 12 | Martin | KY 1714 | 9.03 | 9.79 | Road Flooded/Pavement Failure | $116,600 |
| 12 | Martin | KY 2032 | 0.87 | 1.40 | Road Flooded/Pavement Failure | $82,000 |
| 12 | Martin | KY 2032 | 3.62 | 4.17 | Road Flooded/Pavement Failure | $85,000 |
| 12 | Martin | KY 292 | 0.95 | 1.56 | Road Flooded/Pavement Failure | $324,121 |
| 12 | Martin | KY 40 | 0.00 | 1.00 | Slide/Roadway Failure | $105,000 |
| 12 | Martin | KY 40 | 6.43 | 6.43 | Embankment Failure | $215,000 |
| 12 | Pike | KY 1056 | 4.78 | 5.52 | Embankment Failure | $115,000 |

| Dist. | County | Route | Start M.P. | End M.P. | Description | Estimated Repair Cost |
|---|---|---|---|---|---|---|
| 12 | Pike | KY 1056 | 6.38 | 9.09 | Embankment Failure | $393,652 |
| 12 | Pike | KY 1460 | 3.89 | 4.46 | Embankment Failure | $139,653 |
| 12 | Pike | KY 194 | 67.95 | 69.84 | Roadway/Shoulder Failure | $242,847 |
| 12 | Pike | KY 199 | 8.31 | 11.31 | Embankment Failure | $426,427 |
| 12 | Pike | KY 319 | 0.02 | 0.52 | Embankment Failure | $68,972 |
| 12 | Pike | KY 319 | 2.07 | 4.85 | Road Flooded/Pavement Failure | $382,205 |
| 12 | Pike | KY 632 | 3.55 | 3.79 | Road Flooded/Pavement Failure | $31,480 |
| 12 | Pike | KY 632 | 5.48 | 6.60 | Road Flooded/Pavement Failure | $114,480 |
| 12 | Pike | US 460 | 8.40 | 8.72 | Embankment Failure | $1,423,078 |