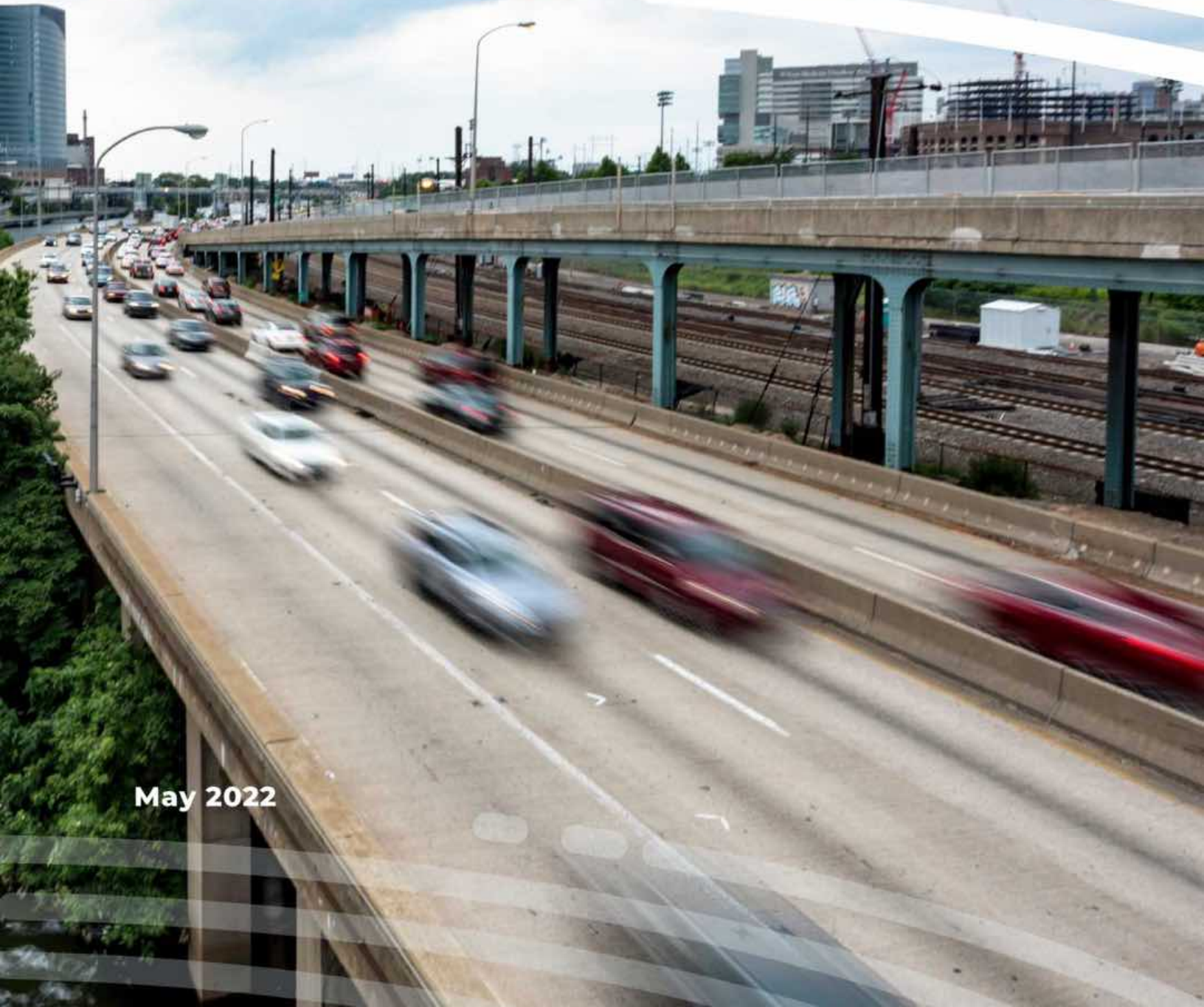
pennsylvania
DEPARTMENT OF TRANSPORTATION

TRANSPORTATION ASSET MANAGEMENT PLAN



May 2022

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
HARRISBURG, PENNSYLVANIA 17120

Pennsylvania's transportation system is critical to the state's economy, and serves the essential needs of Pennsylvanians each and every day. While all aspects of the system are important, perhaps the most critical infrastructure assets are the roads and bridges on the National Highway System. These are the higher-volume roads – including Interstates, tollways and other important routes – that connect communities, enable the speedy transport of essential cargo, and serve the most vital destinations in the state.

The Pennsylvania Department of Transportation (PennDOT) is responsible for the largest share of these roads and bridges, but not all of them. That's why it's so important that PennDOT work closely with its partners at the state, local and federal levels to manage these assets in the most efficient and cost-effective manner.

The asset management approach embraced by PennDOT and encouraged among its partners is designed to achieve the maximum benefit for the least cost. This Transportation Asset Management Plan explains Pennsylvania's asset management efforts, the current condition of our infrastructure assets, and their projected future condition based on current investment levels. The plan also describes potential future investment proposals developed by both PennDOT and by Governor Wolf's Transportation Revenue Options Commission (TROC), which will be essential to improving the condition of this important transportation network. Finally, this TAMP describes our approach to managing potential future risks posed by factors like climate change, increasing costs, or increasing truck traffic that can impact the viability and longevity of the state's infrastructure.

As stewards of the statewide transportation network, PennDOT and our partners strive to ensure that the investments made in roads and bridges today will achieve benefits well into the future. With the help of asset management's data-driven approach to future investment, the Commonwealth's transportation system can continue to support the state's economy and provide opportunities for the people of Pennsylvania for years to come.

Yassmin Gramian, P.E.

Secretary
Pennsylvania Department of Transportation

pennsylvania
DEPARTMENT OF TRANSPORTATION

TRANSPORTATION ASSET MANAGEMENT PLAN

Executive Summary

May 2022

Pennsylvania's Transportation Assets

Pennsylvania's Transportation Asset Management Plan (TAMP) outlines a 10-year strategy for managing the state's pavements and bridges. The strategy includes setting goals and objectives, reporting the current conditions of assets, projecting conditions 10 years into the future, and providing a strategy for implementation of asset management into the project selection process. The TAMP also details life cycle planning, presents a financial plan, and discusses how to manage risk. Taken together, these elements give Pennsylvania a path towards transparent and efficient use of taxpayer dollars.

- 39,714 Linear Miles (33%)
- 81,189 Linear Miles (67%)

- 111,733,312 ft² Deck Area (78%)
- 32,175,155 ft² Deck Area (22%)

PennDOT owns and maintains 39,714 linear miles of pavement in the state, representing 33 percent of the total network. PennDOT also owns and maintains roughly 78 percent of bridges with a span greater than 20 feet – over 111 million square feet of bridge deck area.

The National Highway System (NHS) is the federal designation of the network of roads and bridges that are vitally important to the nation's economy, mobility, and security. While this TAMP meets federal requirements to report on NHS pavements and bridges, this TAMP also includes the entire PennDOT-owned system of pavements and bridges. Pennsylvania's residents and businesses depend on the full network of roadways and bridges that connect people and goods with homes, employers, retailers, schools, medical facilities, and more – not only the major routes through the state.

Measuring Performance

PennDOT and its state, regional, and local partners recognize the importance of maintaining all roads and bridges appropriately to minimize life-cycle cost. Maintaining the existing complete network to its current condition requires adequate funding for all business plan networks.

Whether based on age, condition, level of service, or simply frequency of repair, a performance measure is critical to actively managing the preservation of an asset. In the Pennsylvania TAMP, asset performance is reported based on the percentage of the asset classes in Good, Fair, and Poor condition.

PennDOT uses state measures of asset condition for state-owned assets and performance measures established by FHWA to calculate asset condition for NHS assets. PennDOT uses both state and federal measures because they serve distinct purposes.

PennDOT Performance Measures

PennDOT's performance measures for state-owned assets are the measures used to manage the system, drive decision-making, and track progress on state goals.

PennDOT tracks a variety of measures across the six goal areas defined in its LRTP (Safety, Mobility, Equity, Resilience, Performance, and Resources). The TAMP includes two Performance measures, one each for pavement and bridge conditions.

Why We Measure

PennDOT manages the state-owned system using these measures. Asset condition is a key input to the capital decision-making process.

What We Measure

- All state-owned pavements and bridges
- Four business plan networks (BPNs)

How We Measure

PAVEMENT

% linear miles by condition

Good | Fair | Poor

Based on roughness

BRIDGE

% deck area by condition

Good | Fair | Poor

Minimum component rating

Federal Performance Measures

Federal performance measures for NHS pavements and bridges are required for use by state DOTs to carry out the National Highway Performance Program (NHPP).

The NHPP is a core federal-aid highway program that provides support for the condition and performance of the NHS and the construction of new facilities on the NHS. The NHPP also ensures that investments of federal-aid funds in highway construction support progress toward performance targets for the NHS established in a state's TAMP.

Why We Measure

Federal measures are used to compare performance across states and to determine federal funding flexibility.

What We Measure

All NHS pavements and bridges (regardless of owner)

How We Measure

PAVEMENT

% lane miles by condition

Good | Fair | Poor

Based on roughness and three distress metrics

BRIDGE

% deck area by condition

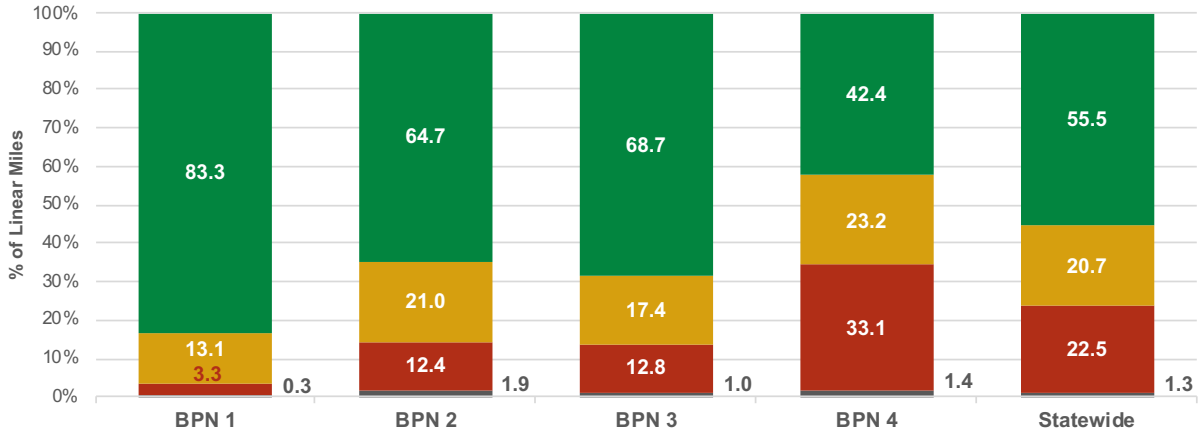
Good | Fair | Poor

Minimum component rating

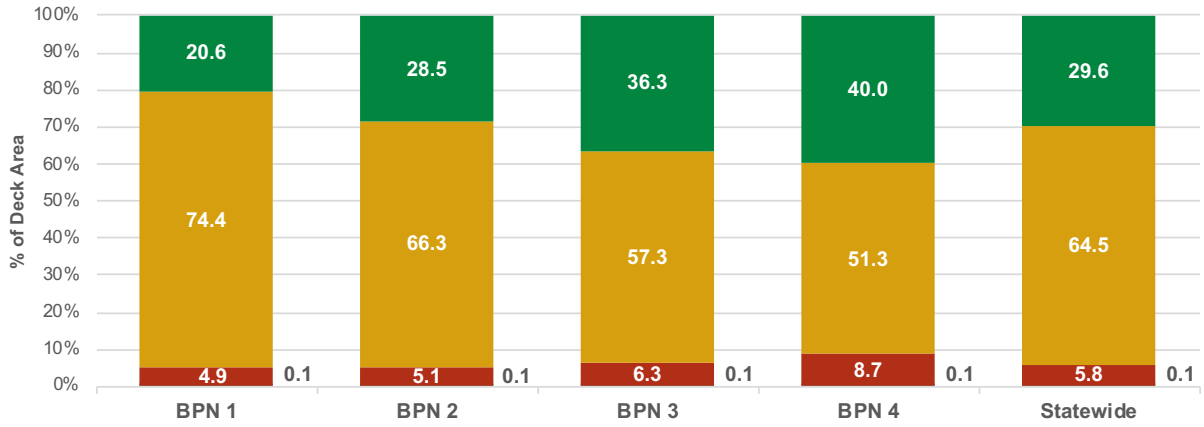
Inventory and Conditions for Pennsylvania Pavement and Bridges

The NHS represents 25 percent of PennDOT's pavements by lane mile, but 66 percent of the bridge deck area that PennDOT owns and maintains. In Pennsylvania, 75 different entities own portions of the NHS pavement network and 45 different entities own portions of the NHS bridge network, but make up just 10% of the overall total.

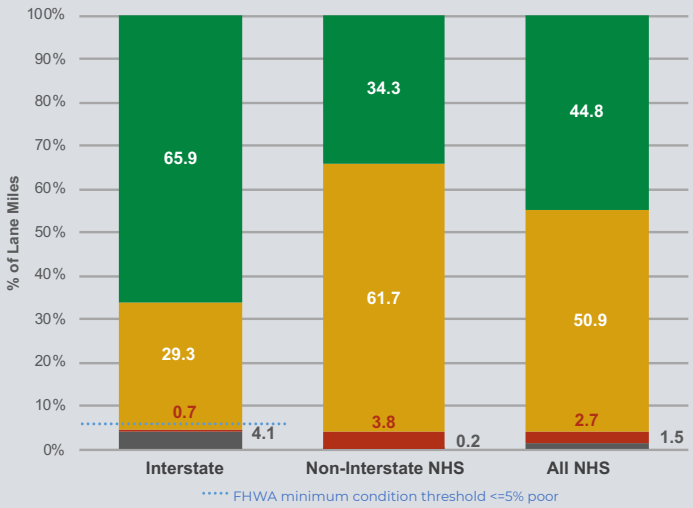
PennDOT Pavement



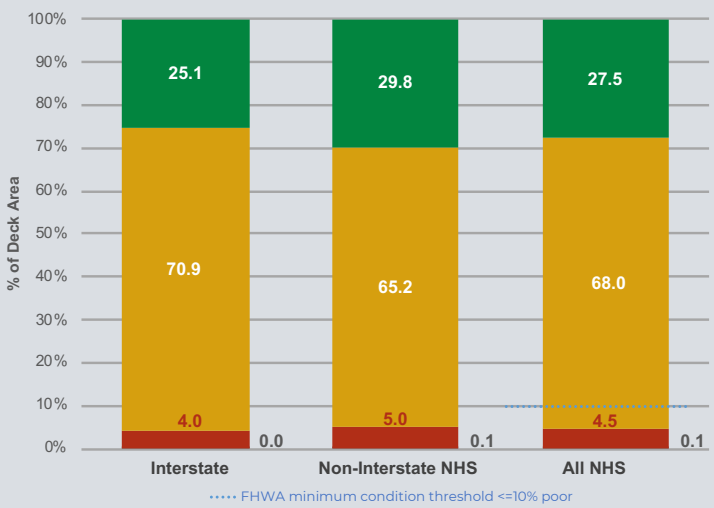
PennDOT Bridges



NHS Pavement



NHS Bridges



System Performance

The TAMP assesses condition and performance of NHS pavements and bridges, but PennDOT is responsible for a broader array of assets. PennDOT roads and bridges are managed and categorized among four business plan networks (BPNs). Maintaining the full network to its current condition requires adequate funding for all BPNs. As conditions warrant, we will support the moving of funds from non-NHS assets to the NHS to meet federal requirements.

Given projected funding, and using state performance measures, state-owned pavement condition is forecasted to decline over the 10-year period for all BPNs. Likewise, for bridges, despite additional new federal funding, state-owned bridge conditions are also forecasted to decline, especially on the non-NHS networks.

State-Owned Performance Projections

Pavement	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
BPN 1 (IRI Measure)										
Good %	85.9	83.2	77.3	73.7	69.0	67.1	62.6	59.3	57.9	56.5
Fair %	12.7	14.3	18.4	20.0	22.8	22.7	23.4	23.4	23.4	23.1
Poor %	1.4	2.5	4.2	6.4	8.2	10.2	14.1	17.3	18.6	20.3
BPN 2 (IRI Measure)										
Good %	69.4	68.4	67.3	66.3	66.8	64.5	60.7	58.1	54.5	52.6
Fair %	22.5	24.0	25.1	26.6	27.0	28.7	31.5	34.0	36.5	37.4
Poor %	8.1	7.6	7.6	7.0	6.2	6.8	7.7	7.9	9.1	10.0
BPN 3 (IRI Measure)										
Good %	72.3	71.9	71.9	71.3	71.7	71.3	71.2	70.1	69.8	68.9
Fair %	19.0	20.5	21.5	22.9	23.3	23.8	24.1	24.9	25.2	25.6
Poor %	8.7	7.5	6.5	5.8	5.0	4.9	4.7	5.0	5.0	5.5
BPN 4 (IRI Measure)										
Good %	45.1	47.1	48.6	49.8	50.7	52.0	53.1	54.3	54.4	55.4
Fair %	24.4	23.9	23.6	23.8	23.6	23.5	23.0	22.0	21.4	20.8
Poor %	30.6	29.1	27.7	26.4	25.6	24.5	23.9	23.7	24.2	23.8

Bridge	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
State-Owned Bridge										
Good %	30.5	31.7	31.0	30.3	28.8	27.2	24.9	23.4	21.3	19.3
Fair %	64.1	63.1	62.8	62.6	63.1	63.2	63.9	64.1	65.4	66.9
Poor %	5.4	5.3	6.2	7.1	8.1	9.6	11.2	12.5	13.3	13.8

Pennsylvania Business Plan Networks. BPNs include Interstate (BPN 1), Non-Interstate NHS (BPN 2), Non-NHS with traffic greater than 2000 vehicles per day (BPN 3) and Non-NHS with traffic less than 2000 vehicles per day (BPN 4). Funding projections for the 10-year time frame are derived based on 2023 Financial Guidance for pavements, but do not include Turnpike funding or local funding for NHS pavements. Funding projections for bridges are also based on the 2023 Financial Guidance document, which includes additional new federal funds available for bridges. PennDOT's Asset Management Division relies on its enterprise Bridge and Pavement management systems to develop these condition projections.

NHS Performance Projections

Pavement	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Interstate (FHWA Measure)										
Good %	70.5	69.9	68.7	65.4	62.0	56.8	51.8	45.8	40.0	36.9
Fair %	29.0	29.7	30.9	34.2	37.6	42.7	47.7	53.7	59.5	62.5
Poor %	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6
Non-Interstate NHS (FHWA Measure)										
Good %	36.3	34.2	33.0	31.6	29.3	26.3	21.6	17.8	14.6	10.2
Fair %	59.7	61.6	62.5	63.5	65.4	67.9	72.0	75.4	78.0	81.7
Poor %	4.0	4.2	4.5	4.9	5.3	5.8	6.4	6.8	7.4	8.0

Bridge	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
All NHS										
Good %	28.5	29.7	29.2	28.8	27.6	24.9	22.9	20.8	18.5	16.5
Fair %	67.4	66.3	65.3	64.2	64.6	66.5	67.3	68.6	70.4	72.1
Poor %	4.1	4.0	5.5	7.0	7.8	8.6	9.9	10.6	11.2	11.4

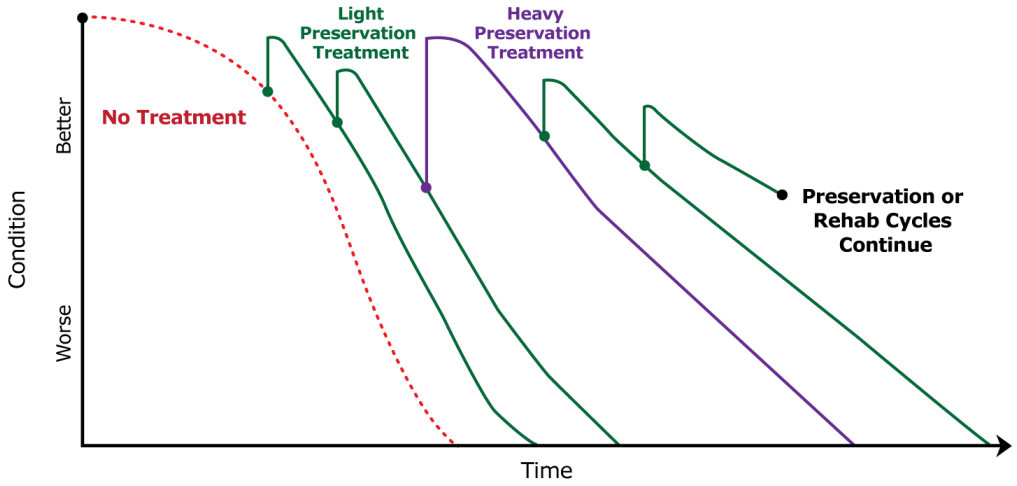
Federal performance measures for the NHS provide a similar condition forecast. While there are no Interstate performance gaps, PennDOT expects a gap on non-Interstate NHS at the end of the 10-year TAMP period. PennDOT expects a condition gap on NHS bridges at the end of the 10-year TAMP period.

Pavement	2023 Target	2025 Target	2031 Predicted	2031 Desired SGR
Interstate				
Good	69.0%	65.0%	36.9%	n/a
Poor	2.0%	2.0%	0.6%	5.0%
Non-Interstate NHS				
Good	31.0%	29.0%	10.2%	n/a
Poor	6.0%	6.0%	8.0%	5.0%

Bridge	2023 Target	2025 Target	2031 Predicted	2031 Desired SGR
NHS				
Good	28.0%	28.0%	16.5%	n/a
Poor	7.5%	7.5%	11.4%	10.0%

Life Cycle Planning at PennDOT

Life cycle planning recognizes that applying the right treatment at the right stage in an asset's life cycle can have a profound effect on the total cost to maintain an asset in a state of good repair over its whole life. It is almost always more cost-effective to perform multiple, lower cost maintenance and preservation treatments than to allow an asset to deteriorate to the point of requiring a major rehabilitation or even complete replacement.

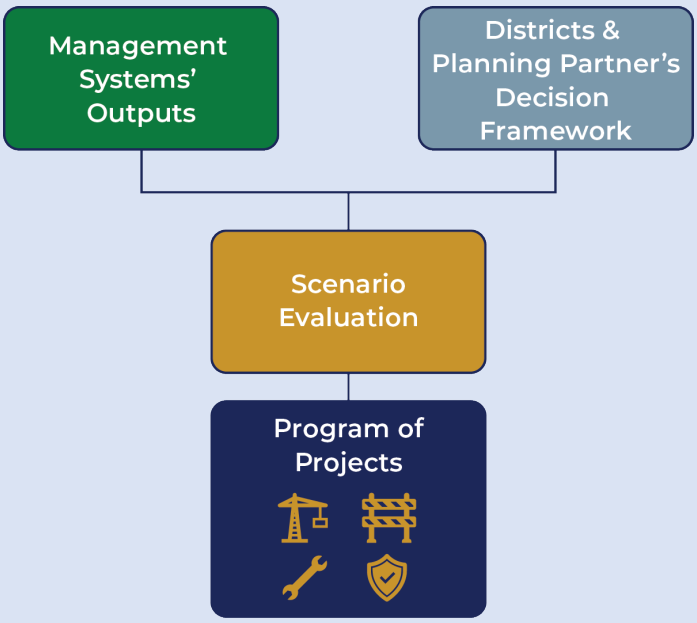


Benefits of LLCC

- Extend life of bridge/pavement assets
- Lower annual cost over the life of assets
- More effective use of resources
- Assets are in better overall condition

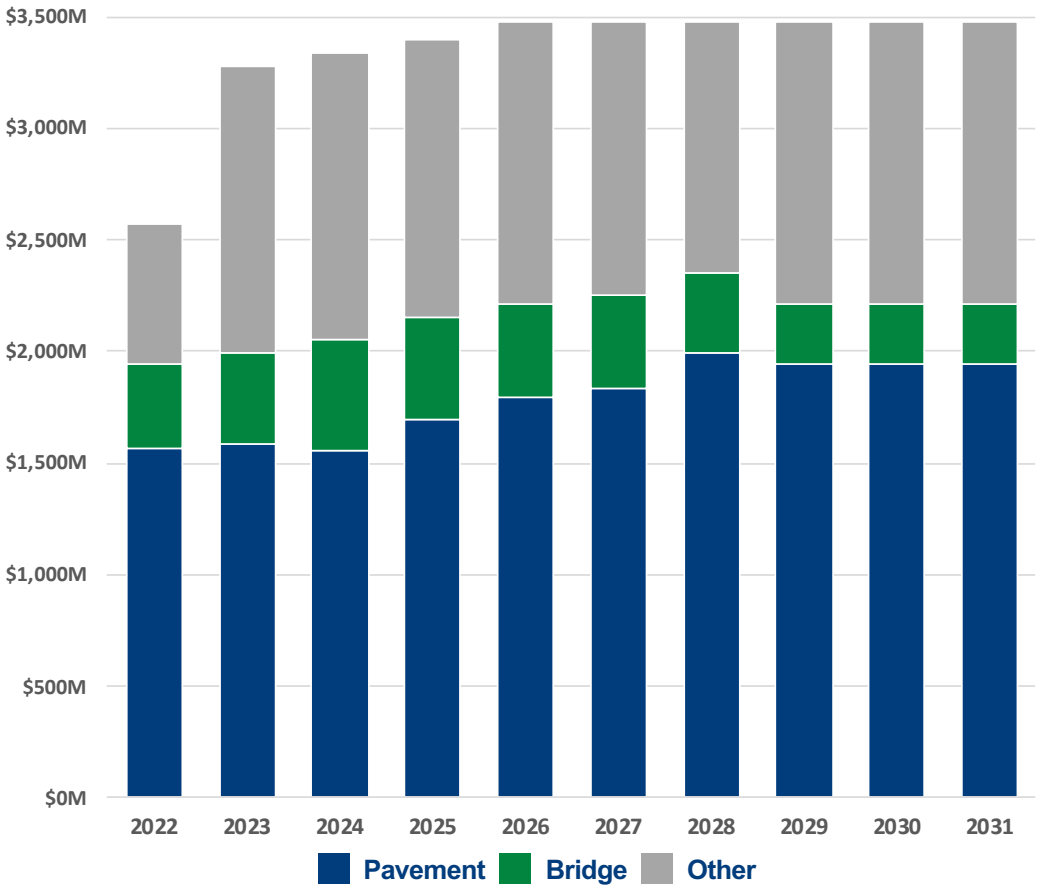
PennDOT's life cycle planning process is led by the TAM Leadership and is actively being integrated into Pennsylvania's statewide and regional planning and programming processes.

Lowest practical life-cycle cost (LLCC) is PennDOT's asset management strategy designed to maximize the life of an asset at the lowest cost through a risk-based prioritization of preservation, rehabilitation, and reconstruction. This strategy is reflected in PennDOT's asset management slogan and guiding principle: "The right treatment at the right time." It is PennDOT's overall implementation and investment strategy for achieving its asset condition targets, sustaining the performance of the NHS, and supporting progress toward the national goals identified in 23 U.S.C. 150(b) (23 CFR 515.13(b) (2)). This approach enables PennDOT to effectively invest its resources and encourages uniformity in how assets are invested in across the state.

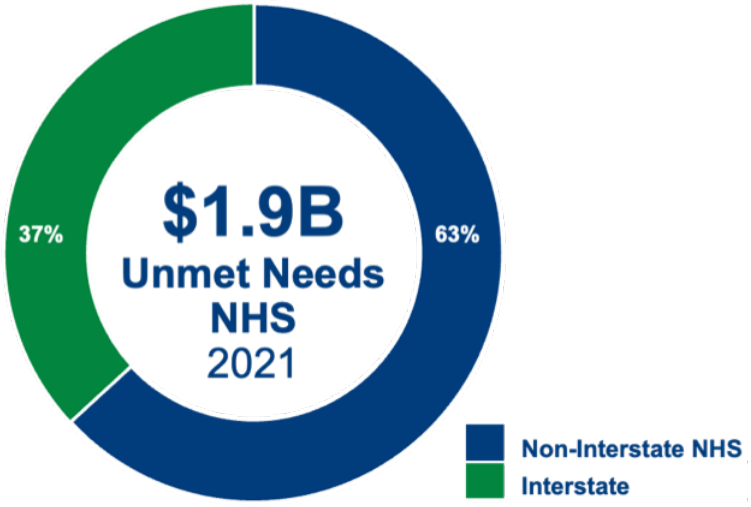


PennDOT develops financial spending projections for all its assets as part of its Twelve Year Program and Statewide Transportation Improvement Program. For the subset of assets covered by the TAMP, PennDOT's expected expenditures average $1.8 billion on pavements and $373 million on bridges over the ten-year period.

This level of investment does not meet the asset maintenance and preservation needs.



Annual unmet cyclical needs on the NHS total $1.9 billion in 2021, including $700 million on the Interstate and $1.2 billion on non-Interstate NHS roadways.



The unmet needs for the NHS are predicted to grow to almost **$3 billion by 2030**

Transportation Revenue Options Commission

The Transportation Revenue Options Commission (TROC) was established by the Governor to develop a strategic proposal to close the transportation funding gap in Pennsylvania. The TROC proposal identified a $9.35 billion annual funding gap for cyclical state transportation needs in Fiscal Year 2021-2022, including $8.15 billion in total unfunded needs for highways and bridges.

The TROC's goal is to bring revenue back in sync with the costs of sustaining Pennsylvania's essential multimodal transportation system, and to fairly distribute those costs to those who directly and indirectly benefit from the system. The TROC report builds on the results of the PEL Study and recommends a number of funding solutions, framed within the context of state government funding. The following is a summary of the proposed key actions that will improve funding for transportation assets.

Tolling can generate revenue from corridor tolling and managed lanes (limited lane tolling). Corridor tolling of Interstate highways and expressways based on distance traveled is both feasible and fair.

Road User Charges consist of two sources: Mileage-Based User Fees (MBUF) and an Electric Vehicle (EV) MBUF Pilot. MBUF presently appears to be the best long-term funding solution for Pennsylvania.

Redirection of Funding by eliminating transfers from the Motor License Fund (MLF) to the Pennsylvania State Police.

Fees from new and increases to existing fees (Vehicle Registration Fee, Electric Vehicle Fee, Vehicle Lease Fee, Vehicle Rental Fee, Transportation Network Company (rideshare) Fee, Aircraft Registration Fee, and Goods Delivery Fee)

Taxes can generate additional funds from increases to the present vehicle sales tax and the jet fuel tax, as well as indexing the gas tax to inflation.

Risks to the System

PennDOT's proactive risk management helps ensure that the entire state transportation system remains safe for users of all modes and is maintained at the appropriate level for the lowest cost. Risk management plays an important role in TAM as it guides decision-making and optimization in not only asset management but also performance management and strategic investment. Working with agency subject matter experts, PennDOT used its risk mitigation process to compile proposed mitigation strategies and actions for the priority risks.

Risk	Mitigation Strategy	Mitigation Action
Inadequate funding	Apply innovative design that extends life of assets, Apply asset management techniques to maximize infrastructure life	• Continued executive buy-in and enforcement • Continued tool development and implementation
Labor & Material Cost Increases	PennDOT needs a future-proof mechanism to fund existing transportation assets	• Update the funding mechanisms of the DOT • Provide accurate condition forecasts at funding levels
Heavy Truck Traffic	Continuous asset improvements, Accurately reflect impacts	• Innovative materials • Updated deterioration modeling
Loss of Workforce Knowledge	Workforce development, Workforce retention	• Provide heightened workforce development • Identify mechanisms to reduce the pay gap
Extreme Weather	Asset protection	• Identify vulnerable assets and address while under construction • Update design manuals to reflect environmental changes
Political Influence	Enforce transportation asset management (TAM) policies	• TAM system updates to meet all user requirements • Education of the value of TAM
Ransomware & Cyberattacks	Improve IT security	• Raise awareness of the risk and cost of cyberattacks • Maintain up-to-date IT software, technologies, and systems including support for strong IT personnel and consistent funding • Expand the security focus not only to employees but also to contractors and consultants.
Poor Construction Quality	Improve QC program	• Make information available from construction to other systems
Aging IT Systems	Update IT systems	• Ensure all systems that generate management decisions are kept functional

Asset Management Mission and Objectives

PennDOT will continue to work with its partners and stakeholders as it transitions to LLCC. As part of this transition, projects currently included in the STIP/TIPs, TYP and LRTPs will be reviewed, evaluated, and prioritized to reflect current asset condition data and funding levels as well as shifting needs, changes in demand, and impacts related to extreme weather. PennDOT will work with its districts and MPOs/RPOs to recommend the prioritization of specific projects in order to prevent bridge or pavement conditions from falling below FHWA minimum condition thresholds, recognizing that flexible Federal and State funding may be needed to help achieve these targets.

In addition, PennDOT will continue to improve its data, systems and processes to monitor and improve the condition of its transportation networks and help ensure that the transportation needs of Pennsylvania’s residents and businesses will be appropriately met

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Introduction

What's in this Chapter?

This chapter summarizes the context, scope, and organization of the 2022 Pennsylvania Department of Transportation (DOT) Transportation Asset Management Plan (TAMP). It discusses relevant federal requirements and describes how the TAMP satisfies these requirements. It also provides a brief summary of future enhancements considered for subsequent editions of the PennDOT TAMP.

- The **PennDOT TAMP Overview** sets the context and describes the scope of the 2022 TAMP
- The **TAMP Organization** summarizes the contents of each chapter of the TAMP

Pennsylvania DOT TAMP Overview

Federal regulations require each state department of transportation to develop and implement a risk-based asset management plan in accordance with 23 U.S.C. 119. The intent is to encourage states to achieve and sustain a state of good repair over the life cycle of transportation assets—regardless of ownership—and to preserve or improve the condition of the National Highway System (NHS).

This document satisfies the requirements of 23 CFR 515, which provides detailed guidance on developing and implementing state Transportation Asset Management Plans (TAMPs).

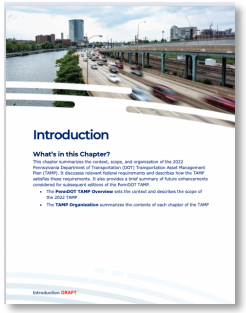
The Pennsylvania Department of Transportation's (PennDOT's) TAMP demonstrates that its asset management practices are consistent with federal requirements. This document:

- Summarizes Pennsylvania's inventory of NHS pavement and bridge assets;
- Forecasts NHS asset condition by year for at least a 10-year planning horizon at current funding levels;
- Establishes targets for NHS pavement and bridge condition; and
- Outlines Pennsylvania's asset management processes, which are integrated into long-range planning, project programming, financial planning, and risk assessment processes.

This 2022 edition of the TAMP analyzes NHS pavement and bridge assets as well as all PennDOT-owned pavement and bridge assets, both NHS and non-NHS. Accurate fiscally-constrained asset condition analyses and projections must consider all the financial responsibilities of a DOT and its state and local partners. As PennDOT systematically expands the scope of its asset management tools and processes to analyze an increasing percentage of Pennsylvania's transportation assets, asset management practices will become more fully integrated into the operations of asset owners statewide. This will result in continually refined project selection processes, with more in-depth and accurate cost and condition projections, providing a clear picture of the current and needed level of investment to maintain Pennsylvania's complete transportation system at the current state of repair.

TAMP Organization

The 2022 PennDOT TAMP includes eight chapters.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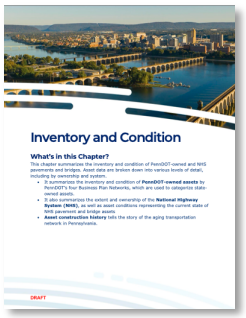
Inventory and Condition

What's in this Chapter?

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- It summarizes the inventory and condition of **PennDOT-owned assets** by PennDOT's four Business Plan Networks, which are used to categorize state-owned assets.
- It also summarizes the extent and ownership of the **National Highway System (NHS)**, as well as asset conditions representing the current state of NHS pavement and bridge assets.
- **Asset construction history** tells the story of the aging transportation network in Pennsylvania.

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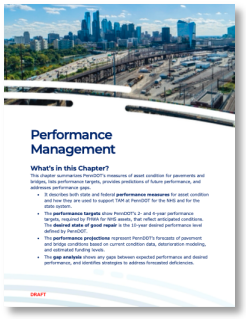
Performance Management

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This chapter summarizes PennDOT's measures of asset condition for pavements and bridges, lists performance targets, provides predictions of future performance, and addresses performance gaps.

- It describes both state and federal **performance measures** for asset condition and how they are used to support TAM at PennDOT for the NHS and for the state system.
- The **performance targets** show PennDOT's 2- and 4-year performance targets, required by FHWA for NHS assets, that reflect anticipated conditions. The **desired state of good repair** is the 10-year desired performance level defined by PennDOT.
- The **performance projections** represent PennDOT's forecasts of pavement and bridge conditions based on current condition data, deterioration modeling, and estimated funding levels.
- The **gap analysis** shows any gaps between expected performance and desired performance, and identifies strategies to address forecasted deficiencies.

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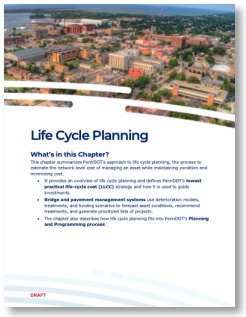
Life Cycle Planning

What's in this Chapter?

This chapter summarizes PennDOT's approach to life cycle planning, the process to estimate the network level cost of managing an asset while maintaining condition and minimizing cost.

- It provides an overview of life cycle planning and defines PennDOT's **lowest practical life-cycle cost (LLCC)** strategy and how it is used to guide investments.
- **Bridge and pavement management systems** use deterioration models, treatments, and funding scenarios to forecast asset conditions, recommend treatments, and generate prioritized lists of treatments which can be used to build projects.
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Life Cycle Planning

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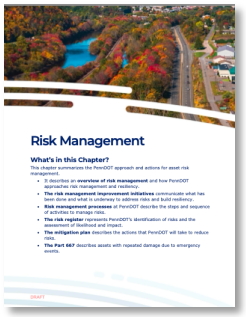


Risk Management

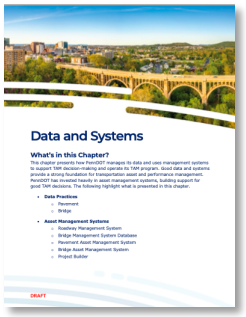
This chapter summarizes the PennDOT approach and actions for asset risk management.

- It describes an **overview of risk management** and how PennDOT approaches risk management and resiliency.
- **The risk management improvement initiatives** communicate what has been done and what is underway to address risks and build resiliency.
- **Risk management processes** at PennDOT describe the steps and sequence of activities to manage risks.
- **The risk register** represents PennDOT's identification of risks and the assessment of likelihood and impact.
- **The mitigation plan** describes the actions that PennDOT will take to reduce risks.
- **The Part 667** describes assets with repeated damage due to emergency events.

Financial Plan and Investment Strategies

This chapter summarizes the cost of future programmed work to implement the investment strategies outlined in this asset management plan and expected levels of funding over a 10-year period.

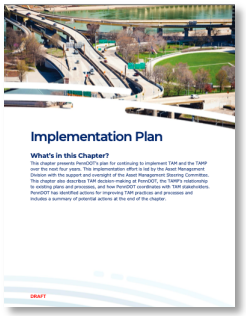
- It describes **funding sources** and how they are used to support TAM at PennDOT for the NHS and for the state system, comprised of all state-maintained roads and provides a valuation of assets included in the TAMP.
- **The financial plan** shows PennDOT's planned and estimated available funds for TAM and anticipated allotments for bridges and pavements over the 10-year period of the TAMP.
- **The investment strategies** represent an approach to applying the resources described in the financial plan, using the treatment strategies described in the Life Cycle Planning chapter, managing the risks presented in the Risk Management chapter, and closing the performance gaps detailed in Performance Management chapter.



Data and Systems

This chapter presents how PennDOT manages its data and uses management systems to support TAM decision-making and operate its TAM program. Good data and systems provide a strong foundation for transportation asset and performance management. PennDOT has invested heavily in asset management systems, building support for good TAM decisions. The following highlight what is presented in this chapter.

- **Data Practices**
  - Pavement
  - Bridge
- **Asset Management Systems**
  - Roadway Management System
  - Bridge Management System Database
  - Pavement Asset Management System
  - Bridge Asset Management System
  - Project Builder



Implementation Plan

This chapter presents PennDOT's plan for continuing to implement TAM and the TAMP over the next four years. This implementation effort is led by the Asset Management Division with the support and oversight of the Asset Management Steering Committee. This chapter also describes TAM decision-making at PennDOT, the TAMP's relationship to existing plans and processes, and how PennDOT coordinates with TAM stakeholders. PennDOT has identified actions for improving TAM practices and processes and includes a summary of potential actions at the end of the chapter.

Inventory and Condition

What's in this Chapter?

This chapter summarizes the inventory and condition of PennDOT-owned and NHS pavements and bridges. Asset data are broken down into various levels of detail, including by ownership and system.

- It summarizes the inventory and condition of **PennDOT-owned assets** by PennDOT's four Business Plan Networks, which are used to categorize state-owned assets.
- It also summarizes the extent and ownership of the **National Highway System (NHS)**, as well as asset conditions representing the current state of NHS pavement and bridge assets
- **Asset construction history** tells the story of the aging transportation network in Pennsylvania.

Inventory and Condition Overview

While this TAMP meets federal requirements to report on NHS pavements and bridges, Pennsylvania's residents and businesses depend on the full network of roadways and bridges, regardless of ownership, that connect people and goods with homes, employers, retailers, schools, medical facilities, and more – not only the major routes through the state. This TAMP includes the entire PennDOT-owned system of pavements and bridges and uses linear miles to describe PennDOT-maintained pavements and lane miles to describe NHS pavements. As of 2021, PennDOT owns and maintains 39,714 linear miles of pavement in the state (88,315 lane miles), representing 33 percent of the total network. PennDOT also owns and maintains roughly 78 percent of bridges with a span greater than 20 feet, also known as National Bridge Inspection Standard (NBIS) bridges, (111,733,312 square feet of deck area). In addition to PennDOT, the Pennsylvania Turnpike Commission (PTC) and other local owners maintain bridges and pavements that are used every day by the traveling public.

PennDOT publishes Pub 600, which a comprehensive summary of pavement inventory, which can be found here.

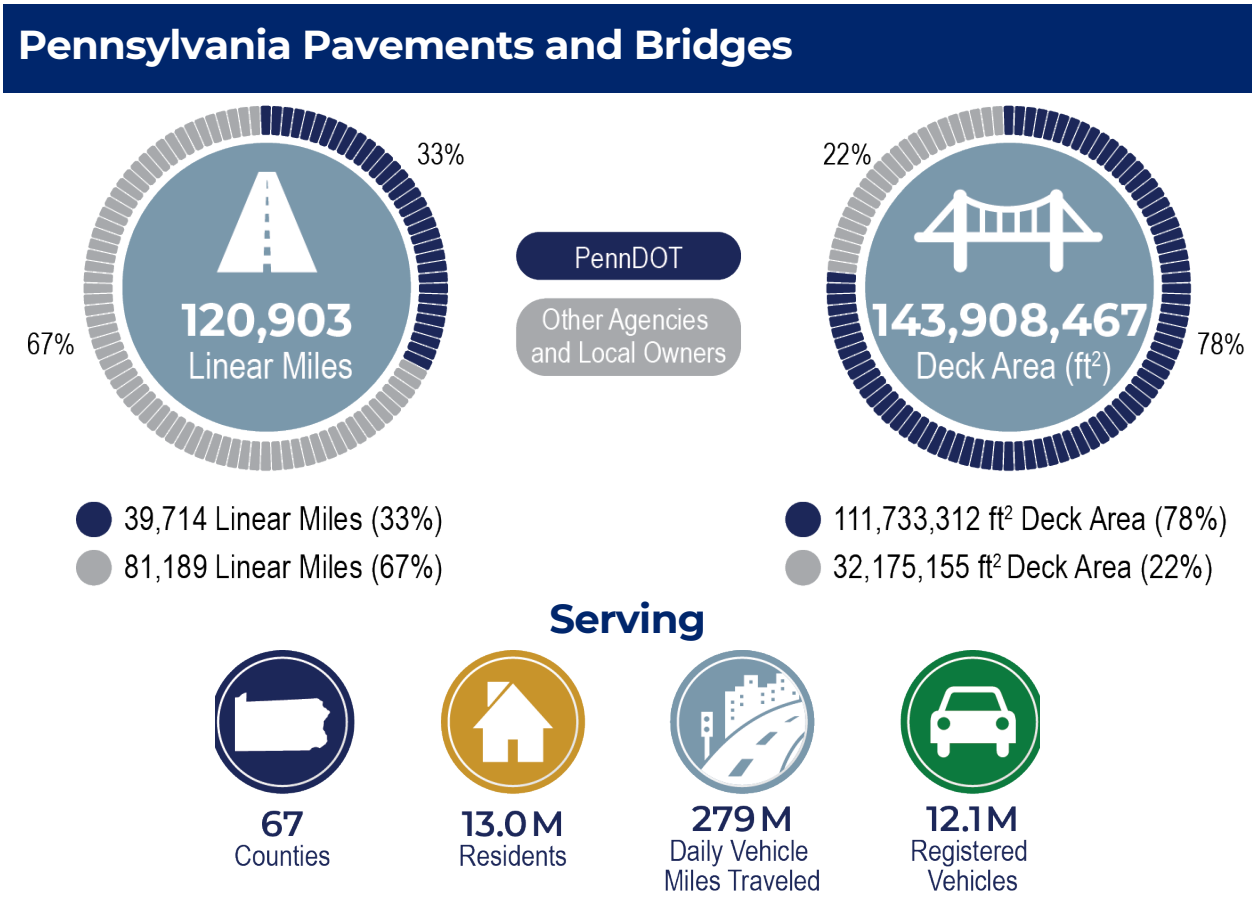


Figure 2-1. Pennsylvania Transportation Summary

Source: Bridge data: BMS2, using December 31, 2021 data; pavement data: Pennsylvania Highway Statistics Pub-600 (2021)
Note: There are 7 additional linear miles of NHS that are owned and maintained by other entities that are not captured in RMS.

PennDOT manages its pavements using linear miles, but FHWA requires NHS pavement conditions to be reported in lane miles. This TAMP shows pavement inventory using both linear and lane miles for NHS and PennDOT-maintained assets.

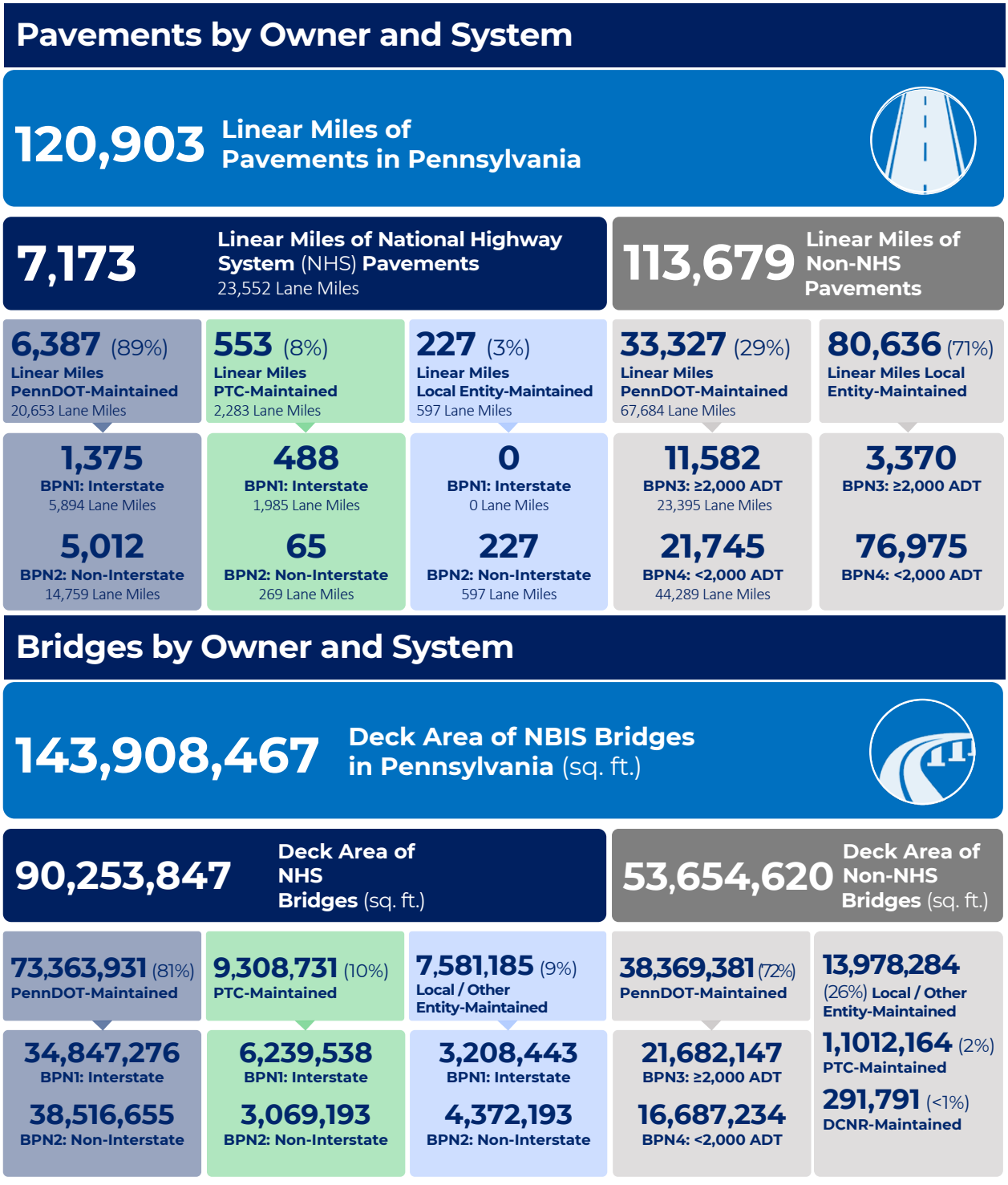


Figure 2-2. Pennsylvania Pavement and Bridge Summary by Owner and System
Source: Bridge data from BMS2, using December 31, 2021 data; pavement linear mile data from Pennsylvania Highway Statistics Pub-600 (2021); pavement lane mile data from RMS, using December 31, 2021 data
Note: The total lane mileage does not include locally maintained assets, as lane mileage is only required for NHS for performance measures. The total also does not include 963.6 lane miles of ramps for which condition data is not collected, but are part of the PennDOT inventory, which is different than 'Missing'. 847.6 lane miles of ramps are on the NHS, with the remaining 115.9 not on the NHS. This inventory also excludes pavement lane miles coded as bridge, as those assets are accounted for under the Bridge asset.

Inventory by Business Plan Network

PennDOT and its state, regional, and local partners recognize the importance of maintaining all roads and bridges appropriately to minimize life-cycle cost. Maintaining the existing complete network to its current condition requires adequate funding for all business plan networks. If budgets are inadequate to maintain all roadways appropriately, PennDOT will prioritize Interstate roadways and NHS bridges to meet federal requirements and may have to make tradeoffs on other networks. PennDOT roads and bridges are managed and categorized among four business plan networks (BPNs), shown in Table 2-1. Pennsylvania also includes roads and bridges owned by local entities, the PTC, and the Department of Conservation and Natural Resources (DCNR).

Pavement and Bridge Assets by Business Plan Network

Table 2-1. Pavement and Bridge Assets by Business Plan Network

Owner and Description	Bridge Count	Bridge Deck Area (sq. ft.)	NHS Pavement Lane-Miles	All Pavement Linear Miles
PennDOT				
BPN1: NHS Interstate	2,012	34,847,276	5,894	1,375
BPN2: NHS Non-Interstate	3,104	38,516,655	14,759	5,012
BPN3: Non-NHS with ADT ≥ 2,000	3,887	21,682,147	–	11,582
BPN4: Non-NHS with ADT < 2,000	6,360	16,687,234	–	21,745
Local / Other				
Locally-owned roads and bridges	6,751	21,559,470	597	80,636
PTC				
Turnpike-owned roads and bridges	760	10,320,895	2,283	553
DCNR				
DCNR-owned roads and bridges	302	294,791	–	–
Total				
Total	23,176	143,908,467	23,533	120,903

Source: Bridge data from BMS2, using December 31, 2021 data; pavement linear mile data from Pennsylvania Highway Statistics Pub-600 (2021); pavement lane mile data from RMS, using December 31, 2021 data
*80,636 linear miles represents the locally-maintained pavement network, both NHS and non-NHS. Of those linear miles, there are 597 lane miles of NHS pavement.
Note: some values may not sum due to rounding.

A detailed breakdown of pavement and bridge ownership by is provided in Appendix A.

PennDOT Owned Pavement and Bridge Condition

This TAMP includes the condition of all PennDOT-owned pavements in Pennsylvania, NHS and non-NHS. PennDOT manages its 39,714 linear miles of pavement using four business plan networks. Pavement conditions are defined using the International Roughness Index (IRI), defined in greater detail in Chapter 3, Performance Management.

Note that the IRI is a measure of roughness, which is perceived by the road user differently at different speeds of travel. An appropriate level of roughness on pavement with high speed limits, like interstates, is excessive on a low-speed local road. In other words, lower speed roads may be rated harshly by the IRI performance measure because they are held to the standard appropriate for faster, smoother roads. In order to mitigate this, PennDOT uses different IRI condition thresholds for each BPN.

IRI is used to define condition in this section instead of the FHWA performance measure, which specifies thresholds for roughness, cracking, rutting, and faulting. These thresholds have only been defined for NHS pavements and are not applicable to non-NHS pavements.

Pavement condition is summarized by BPN in Figure 2-3 and Table 2-2. Conditions are also summarized by PennDOT-owned NHS (BPN 1 + 2) and PennDOT-owned non-NHS (BPN 3+4) in Figure 2-4 and Table 2-3. Pavement condition data represent conditions in 2021.

Note that there may be small discrepancies between pavement conditions in the TAMP and conditions reported in other PennDOT reports or documents. This is due to differing approaches to treating pavement miles for which condition data is missing. In the TAMP, conditions are based on the total mileage of pavements, including missing miles (i.e. the percentages of good, fair, poor, and missing add up to 100%). In other documents, PennDOT calculates conditions based on the total mileage for which there are condition data (i.e. the percentages of good, fair, and poor add up to 100%). While the underlying data are the same, this may result in small differences.

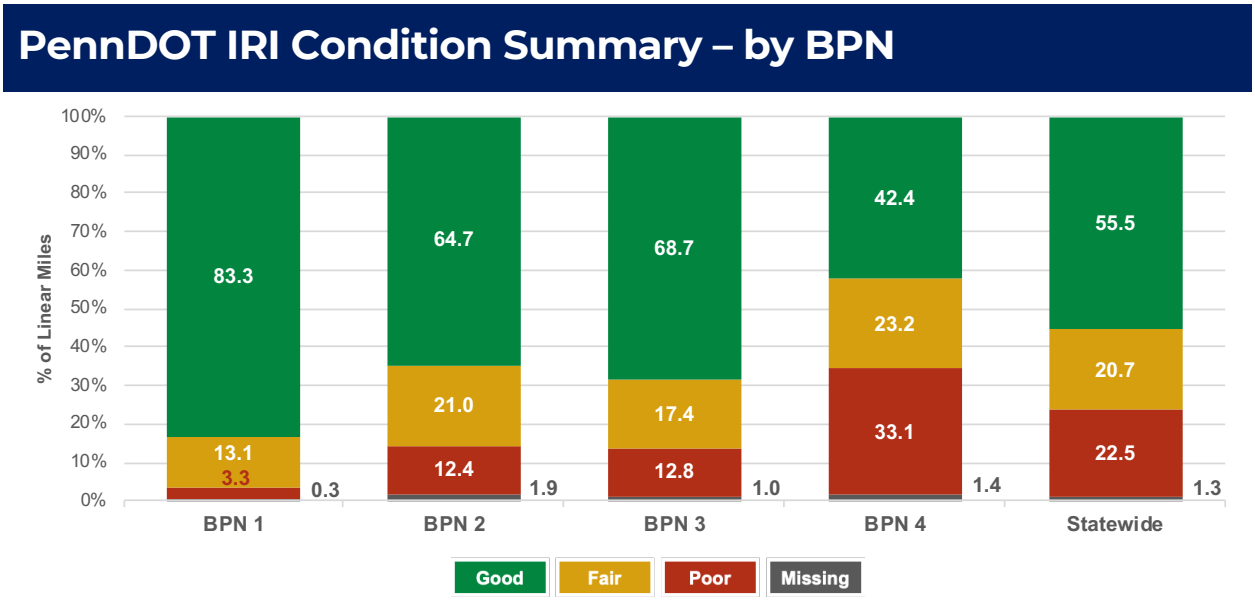


Figure 2-3. PennDOT Pavement Condition by BPN (IRI)

Source: RMS, using December 31, 2021 data

Table 2-2. PennDOT Pavement Condition by BPN (IRI)

	BPN 1	BPN 2	BPN 3	BPN 4	Statewide
Good %	83.3	64.7	68.7	42.4	55.5
Fair %	13.1	21.0	17.4	23.2	20.7
Poor %	3.3	12.4	12.8	33.1	22.5
Missing %	0.3	1.9	1.0	1.4	1.3

Source: RMS, using December 31, 2021 data

PennDOT IRI Condition Summary – by NHS

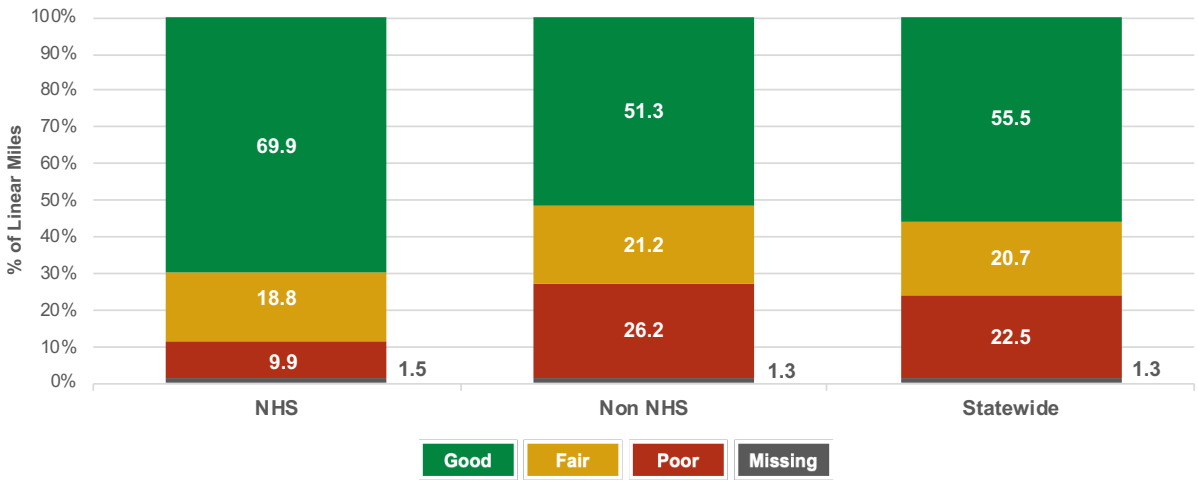


Figure 2-4. PennDOT Pavement Condition by NHS (IRI)

Source: RMS, using December 31, 2021 data

Table 2-3. PennDOT Pavement Condition by NHS (IRI)

	NHS	Non-NHS	Statewide
Good %	69.9	51.3	55.5
Fair %	18.8	21.2	20.7
Poor %	9.9	26.2	22.5
Missing %	1.5	1.3	1.3

Source: RMS, using December 31, 2021 data

This TAMP also includes the condition of all PennDOT-owned bridges in Pennsylvania, NHS and Non-NHS. PennDOT manages its 111,733,312 square feet of bridge deck using the same four business plan networks as for pavement. Bridge conditions are summarized using the FHWA performance measure by BPN in Figure 2-5 and Table 2-4. Bridge performance measures are defined in greater detail in Chapter 3, Performance Management. Conditions are also summarized by PennDOT-owned NHS (BPN 1 + 2) and PennDOT-owned non-NHS (BPN 3+4) in Figure 2-6 and Table 2-5. Bridge condition data represent conditions in 2021.

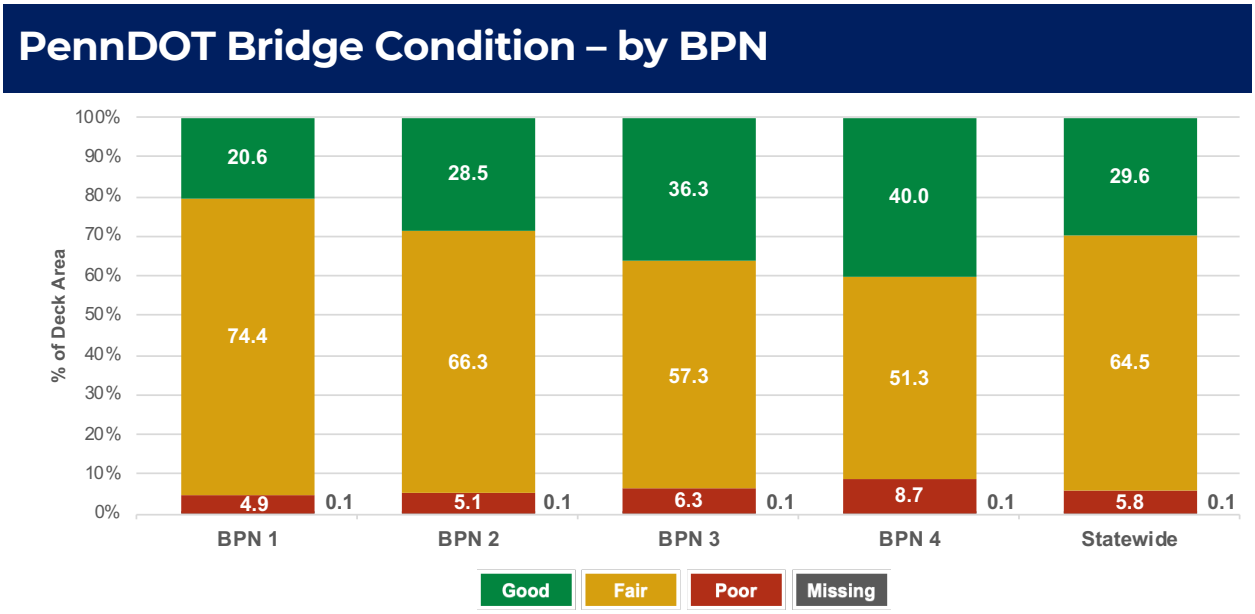


Figure 2-5. PennDOT Bridge Condition by BPN (FHWA measure)

Source: BMS2, using December 31, 2021 data

Table 2-4. PennDOT Bridge Condition by BPN (FHWA measure)

	BPN 1	BPN 2	BPN 3	BPN 4	Statewide
Good %	20.6	28.5	36.3	40.0	29.6
Fair %	74.4	66.3	57.3	51.3	64.5
Poor %	4.9	5.1	6.3	8.7	5.8
Missing %	0.1	0.1	0.1	0.1	0.1

Source: BMS2, using December 31, 2021 data

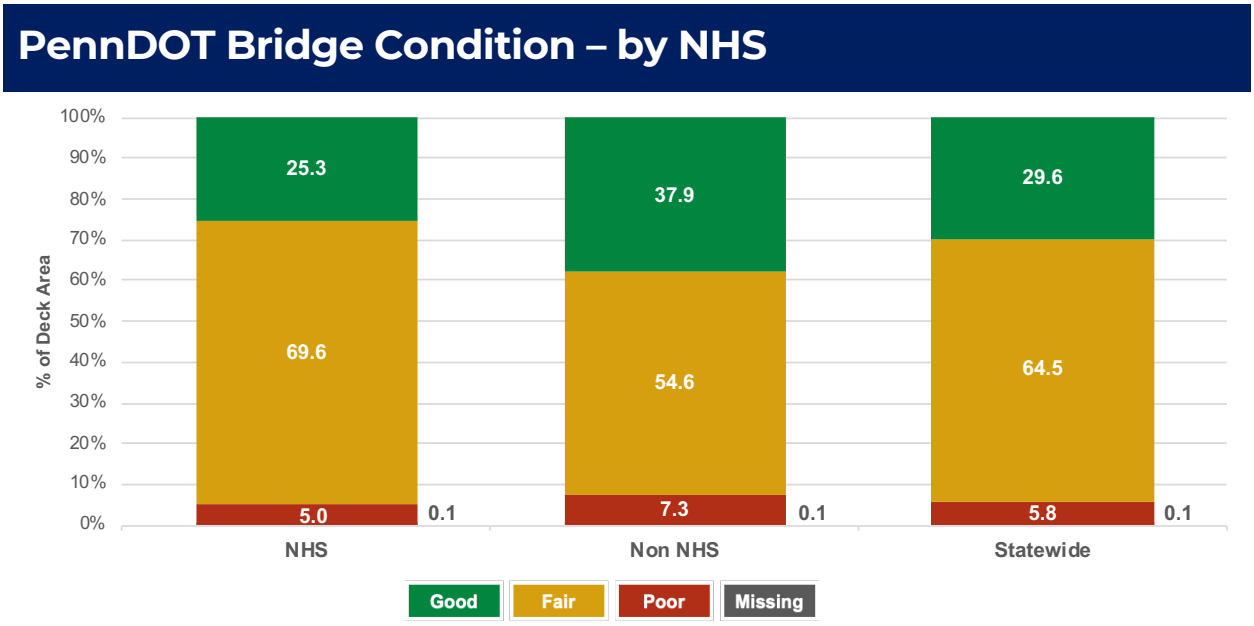


Figure 2-6. PennDOT Bridge Condition by NHS (FHWA measure)

Source: BMS2, using December 31, 2021 data

Table 2-5. PennDOT Bridge Condition by BPN (FHWA measure)

	NHS	Non-NHS	Statewide
Good %	25.3	37.9	29.6
Fair %	69.6	54.6	64.5
Poor %	5.0	7.3	5.8
Missing %	0.1	0.1	0.1

Source: BMS2, using December 31, 2021 data

National Highway System

The National Highway System (NHS) is the federal designation of the network of roads and bridges that are vitally important to the nation's economy, mobility, and security. The core TAMP requirement is to include an analysis of NHS pavements and bridges. A map of PennDOT's network in shown in Figure 2-7. The NHS represents 25 percent of PennDOT's pavements by lane mile, but 66 percent of the bridge deck area that PennDOT owns and maintains as shown in Figure 2-8.

PennDOT's Network: NHS vs. Non-NHS

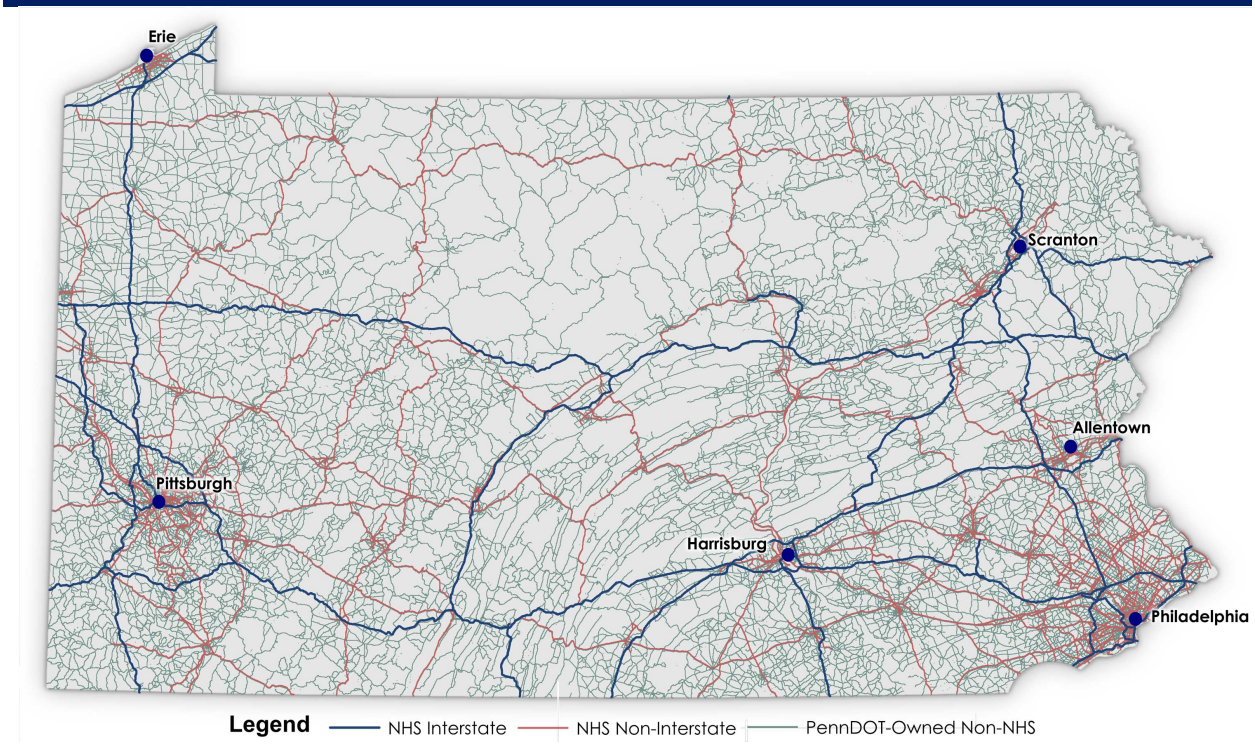


Figure 2-7. PennDOT Network Map
Sources: 2021 NHS Routes Shapefile and 2022 PennDOT RMS Shapefile

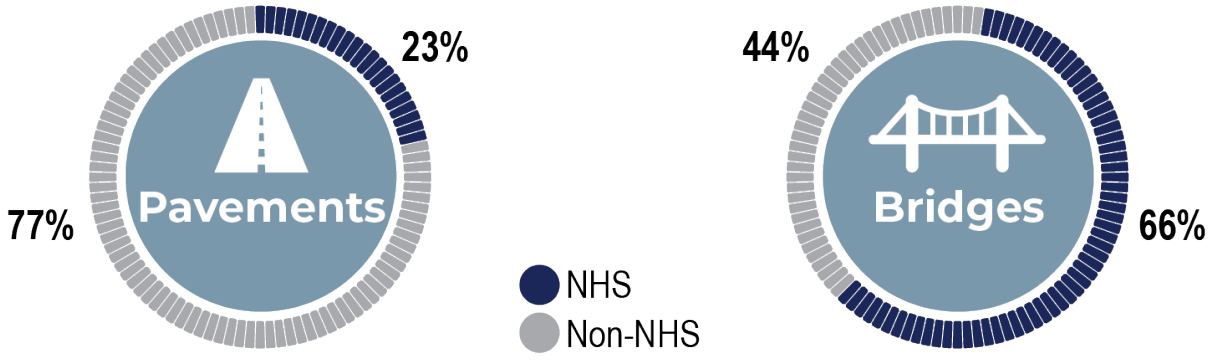


Figure 2-8. PennDOT Network, NHS v Non-NHS
Sources: Bridge data from BMS2, December 31, 2021; pavement data from RMS, December 31, 2021

NHS Ownership

In Pennsylvania, 75 different entities own portions of the NHS pavement network and 45 different entities own portions of the NHS bridge network. There are two major pavement and bridge owners, and several "other" owners, which are defined in this chapter and its appendices. The remaining portion of the NHS network is owned, operated, and maintained by other (mainly local) entities. NHS pavement and bridge ownership are summarized in Figures 2-9 and 2-10, respectively.

NHS Pavements by Owner

PennDOT owns 88% of lane miles of NHS pavement, PTC owns 10%, and local entities own the remainder.

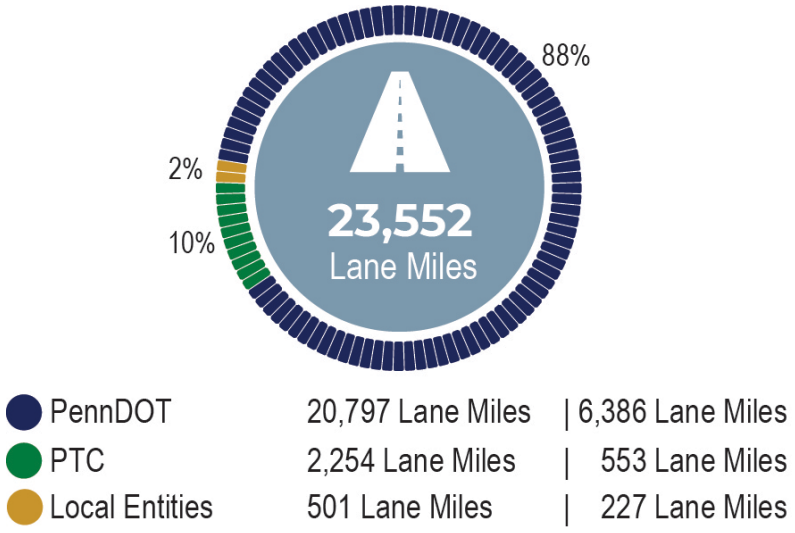


Figure 2-9. NHS Pavements by Owner

Source: Pavement linear mile data from Pennsylvania Highway Statistics Pub-600 (2021); pavement lane mile data from RMS, using December 31, 2021 data

NHS Bridges by Owner

PennDOT owns 81% of NHS bridge deck area, PTC owns 10%, and local entities own the remainder.

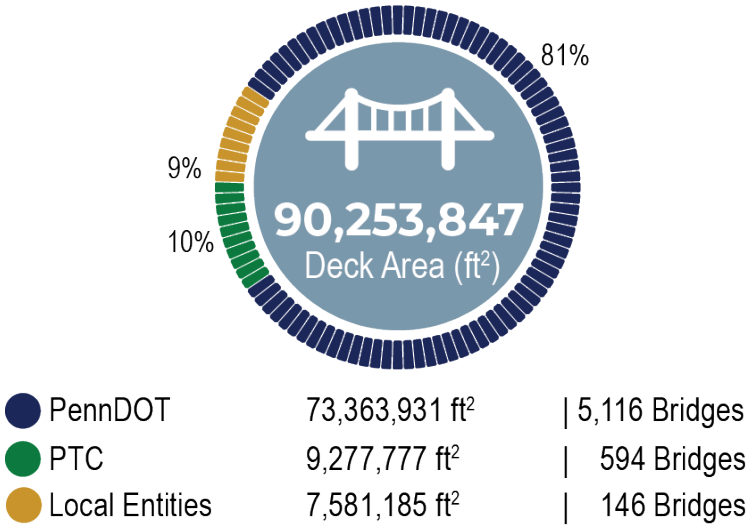


Figure 2-10. NHS Bridges by Owner

Source: BMS2, using December 31, 2021 data

NHS Interstate Ownership

The Interstate Highway System is part of the NHS and connects principal metropolitan areas, cities, and industrial centers, in order to serve the National Defense and routes of national importance. This network includes some of the most important corridors for freight and travel in Pennsylvania and across the country. Interstate pavement and bridge ownership are summarized in Figures 2-11 and 2-12, respectively.

NHS Interstate Pavements by Owner

Nearly 74% of Interstate lane miles in Pennsylvania are owned by PennDOT. The remaining miles are owned by PTC.

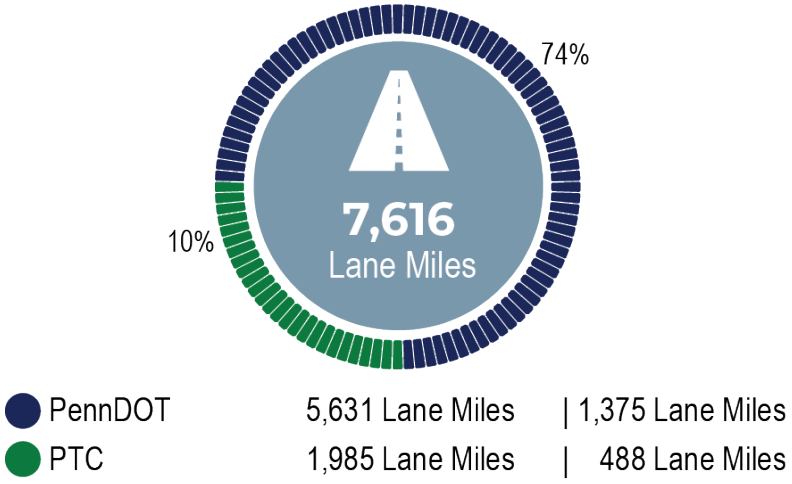


Figure 2-11. Interstate Pavements by Owner

Source: Pavement linear mile data from Pennsylvania Highway Statistics Pub-600 (2020); pavement lane mile data from RMS, using December 31, 2020 data

NHS Interstate Bridges by Owner

PennDOT owns 79% of Interstate bridge deck area in Pennsylvania, PTC owns 14%, and the remainder is owned by local entities.

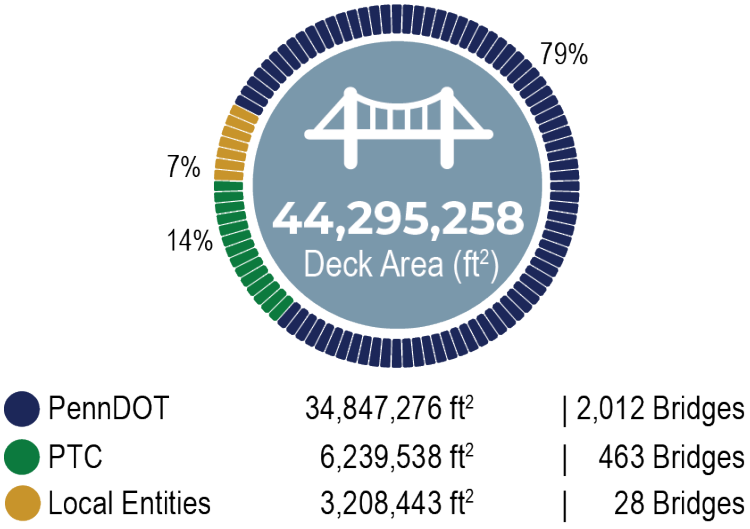


Figure 2-12. Interstate Bridges by Owner

Source: BMS2, using December 31, 2021 data

NHS Pavement and Bridge Condition

The scope of this TAMP includes Interstate and Non-Interstate NHS pavements in Pennsylvania, regardless of owner. Data representing conditions in 2021 are summarized in Figure 2-13 and Table 2-6 for Interstate, Non-Interstate NHS, and total NHS using performance measures defined by FHWA. Performance measures are described in greater detail in Chapter 3 Performance Management.

NHS Pavement Condition – FHWA Measure

Current baseline conditions meet the FHWA minimum condition threshold of having no more than 5 percent Interstate pavement rated as poor.

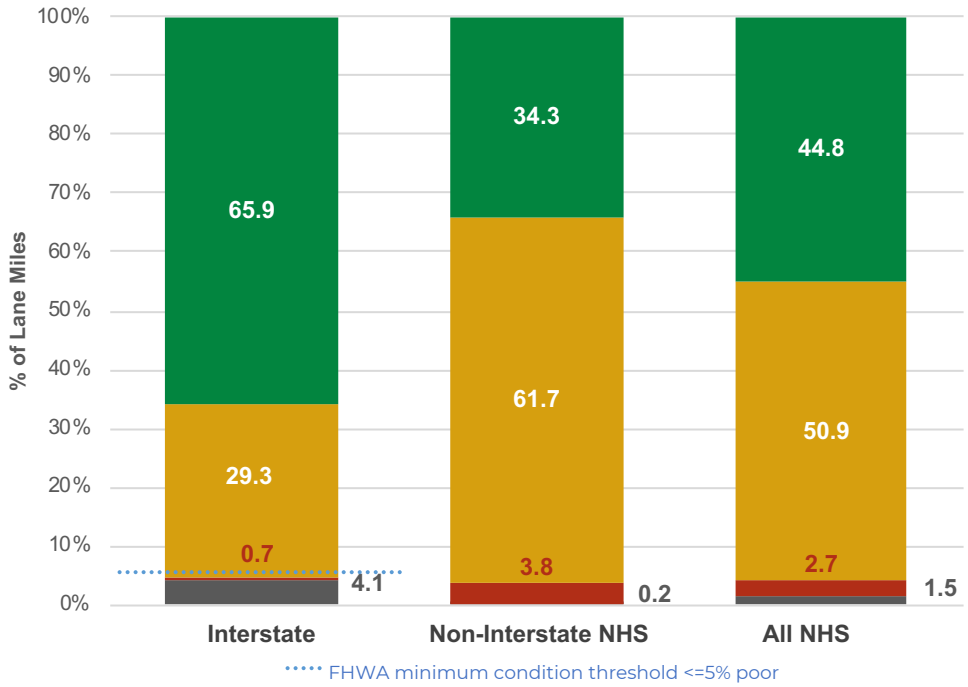


Figure 2-13. NHS Pavement Condition (FHWA measure)
Source: Pavement lane mile data from RMS, using December 31, 2021 inventory data, 2021 condition data from PAM JML Tool

Table 2-6. NHS Pavement Condition (FHWA measure)

	Interstate	Non-Interstate NHS	All NHS
Lane Miles			**23,533**
Good %	65.9	34.3	44.8
Fair %	29.3	61.7	50.9
Poor %	0.7	3.8	2.7
Missing %	4.1	0.2	1.5

Source: Pavement lane mile data from RMS, using December 31, 2021 inventory data; 2021 condition data from PAM JML Tool

Determining pavement condition requires rigorous data collection. In the past, all PennDOT data was collected for each half-mile roadway segment. Federal rulemaking 23 U.S.C. 119 requires that all distress component information be collected for one-tenth-mile increments. PennDOT and its partners have adjusted their pavement data collection to meet FHWA requirements. Data collection at the tenth-mile increment level was adjusted beginning in 2017 for cracking, rutting, and faulting. Note that the FHWA pavement condition measures evaluate the surface only, and do not reflect system age, or the condition of the underlying roadway structure.

For context, it is useful to look at the construction history of NHS pavements in Pennsylvania, summarized in Figure 2-14. Older pavements are more likely to be in need of more extensive treatments due to underlying conditions. NHS pavement construction peaked in the 1960's and some of the network dates back to the early 1900's and earlier. Managing an aging system of pavements with constrained funding is a key challenge for PennDOT.

NHS Pavement by Date Constructed

A significant portion of Pennsylvania's infrastructure is more than 50 years old and has exceeded its original design life.

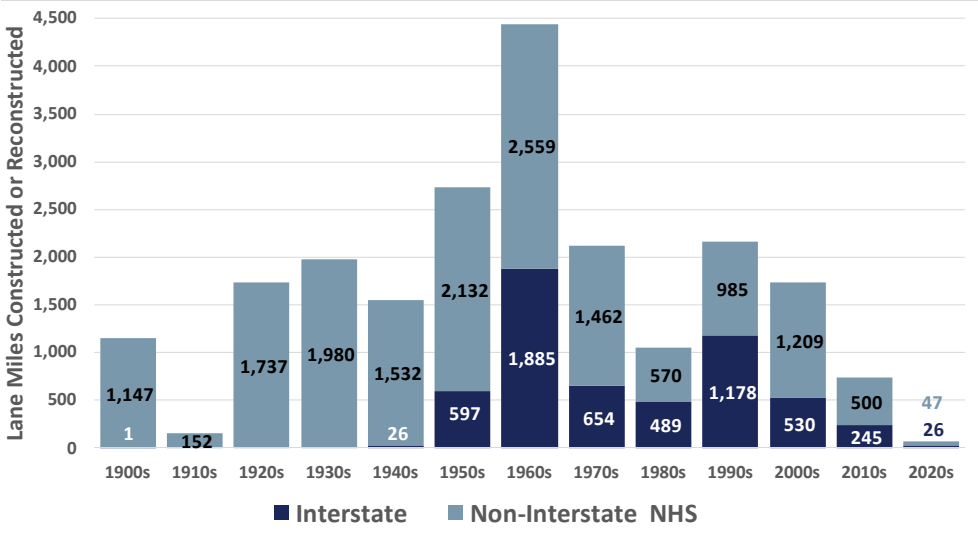


Figure 2-14. NHS Pavement by Date Constructed

Source: RMS, using December 31, 2020 data
Note: "1900s" includes pavements pre-1900.

This TAMP includes the condition of NHS bridges in Pennsylvania, regardless of owner. Data representing conditions in 2021 are summarized in Figure 2-15 and Table 2-7 for Interstate, Non-Interstate NHS, and total NHS. Performance measures are defined in greater detail in Chapter 3. Performance Management.

NHS Bridge Condition – FHWA Measure

Current baseline conditions meet the FHWA minimum condition threshold of having no more than 10 percent of NHS bridges by deck area be in poor condition.

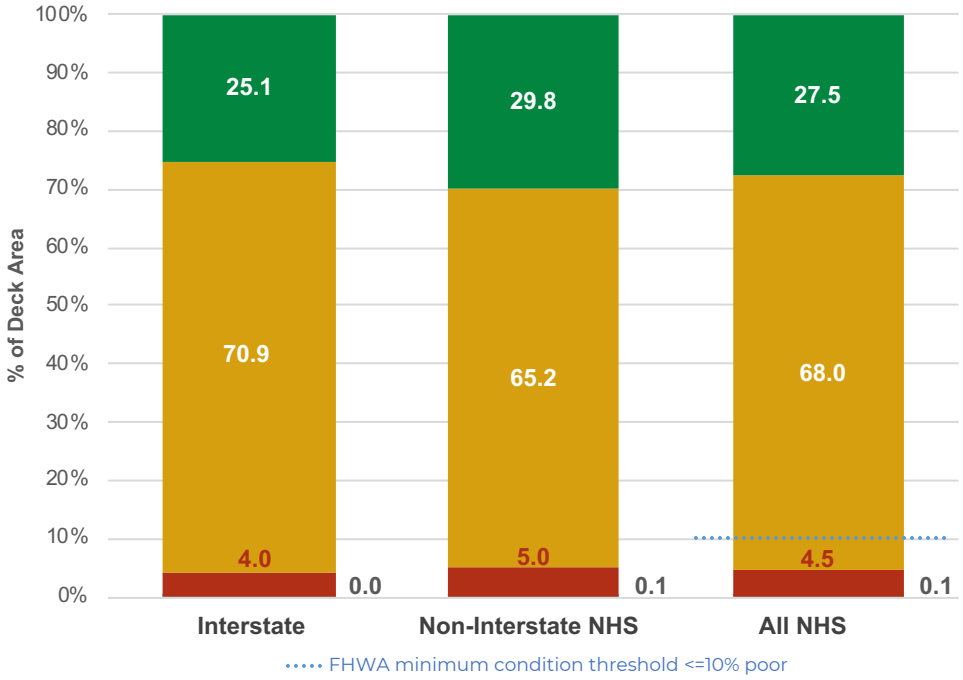


Figure 2-15. NHS Bridge Condition (FHWA measure)

Sources: BMS2, using December 31, 2021 data

Table 2-7. NHS Bridge Condition (FHWA measure)

	Interstate	Non-Interstate NHS	All NHS
Deck Area (sq. ft.)	**44,295,258**	**45,958,590**	**90,253,847**
Good %	25.1	29.8	27.5
Fair %	70.9	65.2	68.0
Poor %	4.0	5.0	4.5
Missing %	0.0	0.1	0.1

Sources: BMS2, using December 31, 2021 data

As with NHS pavements, it is useful to look at the construction history of NHS bridges in Pennsylvania, shown in Figure 2-16. While bridges generally have a longer design life than pavements, older bridges are more likely to be in lower condition and more expensive to maintain. NHS bridge construction peaked in the 1960's and some of the network dates back to the early 1900's and earlier. Managing an aging system of bridges with constrained funding is a key challenge for PennDOT.

NHS Bridges and Culverts by Date Constructed

A significant portion of Pennsylvania's infrastructure is more than 50 years old and has exceeded its original design life.

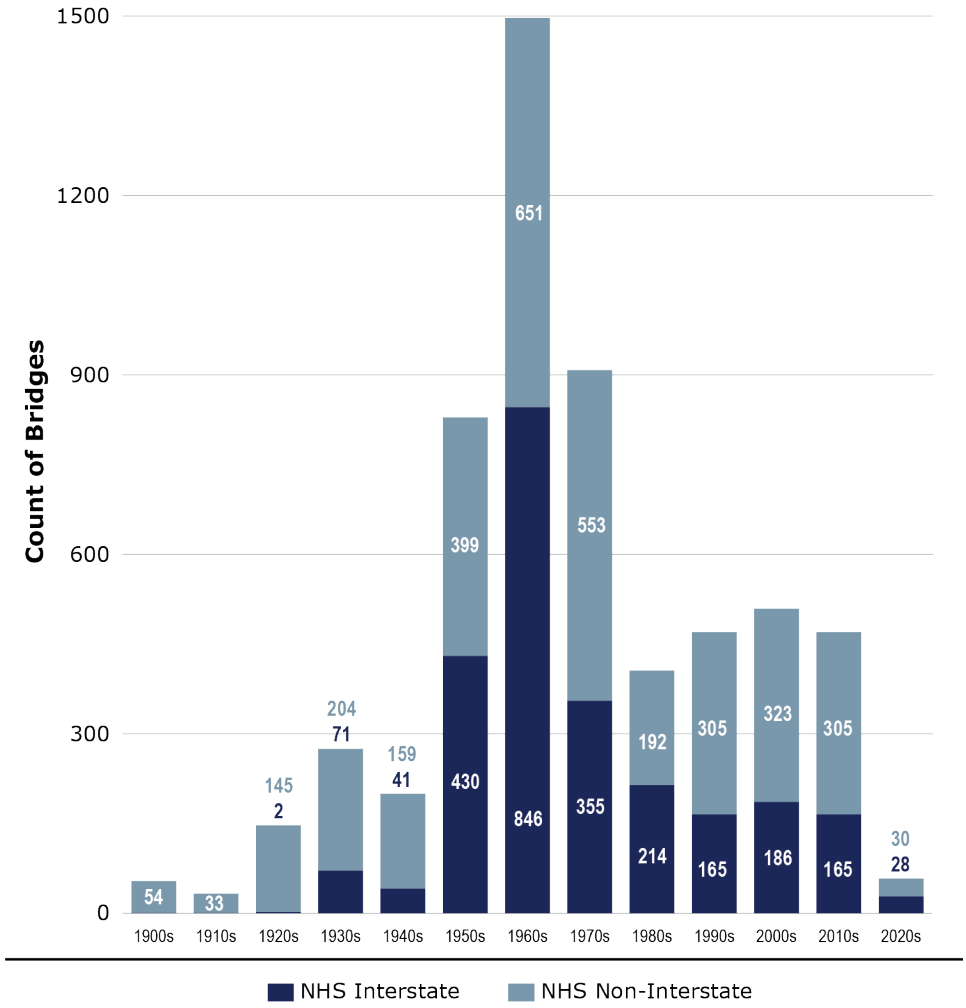


Figure 2-16. NHS Bridges and Culverts by Date Constructed

Sources: BMS2, using December 31, 2021 data
Note: Includes PennDOT and all other owners. "1900s" includes bridges pre-1900.

Performance Management

What's in this Chapter?

This chapter summarizes PennDOT's measures of asset condition for pavements and bridges, lists performance targets, provides predictions of future performance, and addresses performance gaps.

- It describes both state and federal **performance measures** for asset condition and how they are used to support TAM at PennDOT for the NHS and for the state system.
- The **performance targets** show PennDOT's 2- and 4-year performance targets, required by FHWA for NHS assets, that reflect anticipated conditions. The **desired state of good repair** is the 10-year desired performance level defined by PennDOT.
- The **performance projections** represent PennDOT's forecasts of pavement and bridge conditions based on current condition data, deterioration modeling, and estimated funding levels.
- The **gap analysis** shows any gaps between expected performance and desired performance, and identifies strategies to address forecasted deficiencies.

Performance Overview

PennDOT uses state measures of asset condition for state-owned assets and performance measures established by FHWA to calculate asset condition for NHS assets, as summarized in Figure 3-1. PennDOT uses both state and federal measures because they serve distinct purposes.

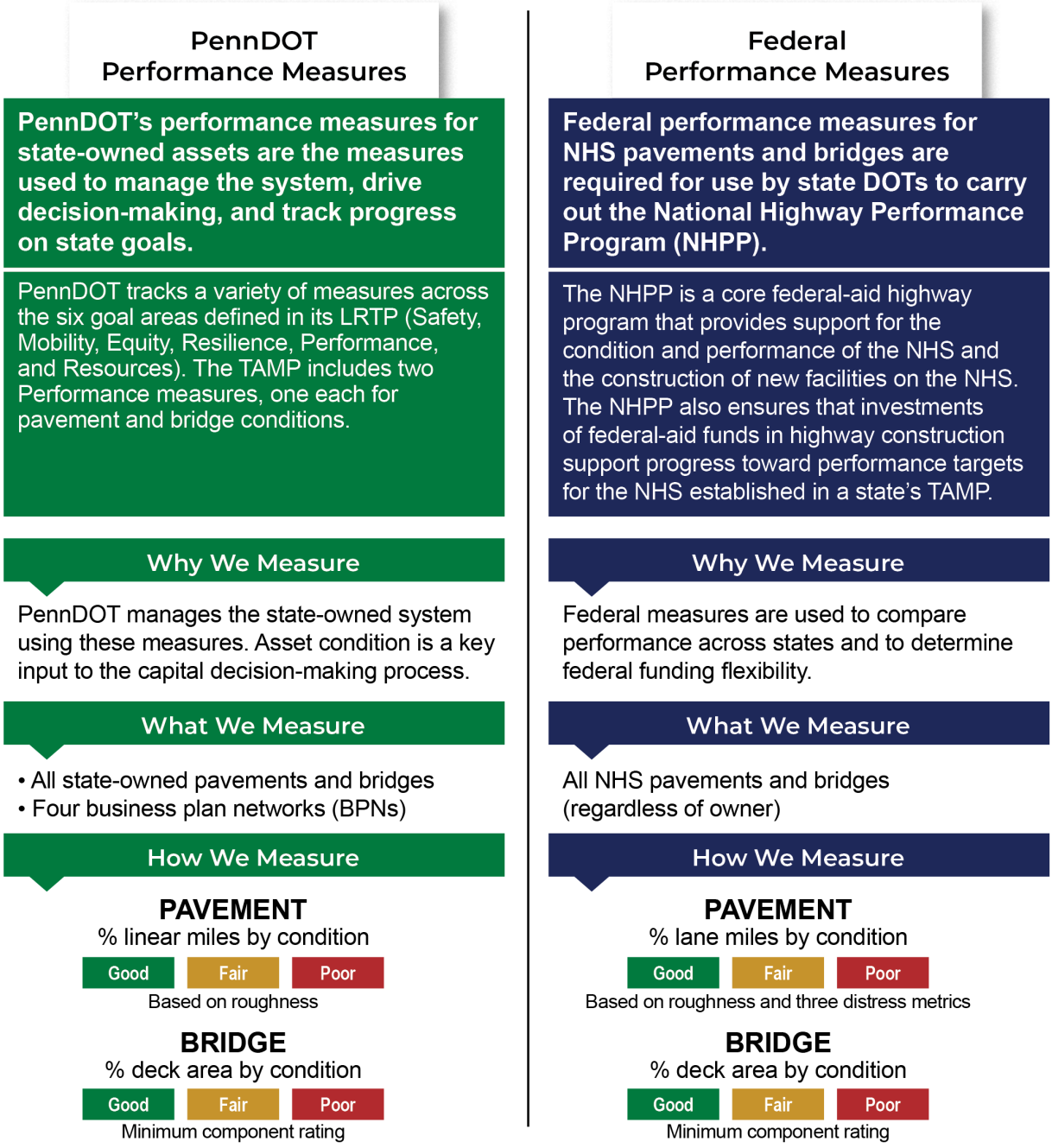


Figure 3-1. PennDOT and Federal Performance Measures Summary

PennDOT Performance Measure Definitions

For state-owned pavements, PennDOT uses IRI to calculate asset condition based on a set of condition thresholds defined for each BPN, shown in Table 3-1.

Table 3-1. PennDOT Pavement Performance Measure Thresholds (IRI)

	BPN 1	BPN 2	BPN 3	BPN 4
Good	<101	<121	<151	<171
Fair	101-150	121-170	151-195	171-220
Poor	>150	>170	>195	>220

For state-owned bridges, PennDOT uses National Bridge Inventory (NBI) component ratings to calculate asset condition. The lowest of the three ratings for deck, superstructure and substructure (or a culvert rating for a culvert) determines the overall rating of the bridge, as shown in Table 3-2.

If this value is 7 or greater, the bridge is classified as being in good condition. If it is 5 or 6, the bridge is classified as being in fair condition, and if it is 4 or less, the bridge is classified as being in poor condition.

Table 3-2. NBI Ratings and Bridge Condition

	Deck	Superstructure	Substructure	Culvert
Good	>6	>6	>6	>6
Fair	5-6	5-6	5-6	5-6
Poor	<5	<5	<5	<5

Federal Performance Measures

For NHS pavements, PennDOT uses the federal measures which are calculated based on metrics reported to the HPMS. For asphalt pavements, IRI, rutting, and cracking are used to calculate the pavement condition performance measures. For concrete pavements, in addition to IRI described for asphalt pavements, faulting and cracking are used to calculate the pavement condition performance measures.

For each of the metrics, FHWA has established thresholds for good, fair and poor condition, shown in Table 3-3. An individual 0.1 mile section is rated as being in good overall condition if all of the metrics are rated as good, and poor when two or more are rated as poor. All other combinations are rated as fair. The lane miles in good, fair, and poor condition are tabulated for all sections to determine the overall percentage of pavement in good, fair, and poor condition.

Table 3-3. FHWA Pavement Performance Measure Thresholds

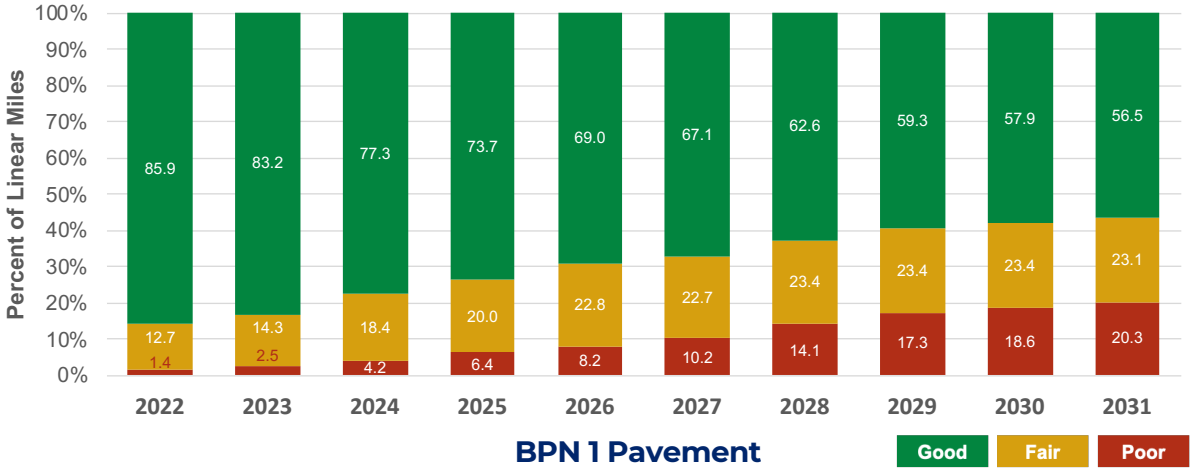
	IRI (inches/mile)	Rutting (inches)	Cracking (%)			Faulting (inches)
			Asphalt	Jointed Concrete	Continuously Reinforced Concrete	
Good	>95	<0.2	<5	<5	<5	<0.1
Fair	95-170	0.2-0.4	5-20	5-15	5-10	0.1-0.15
Poor	>170	>0.4	>20	>15	>10	>0.15

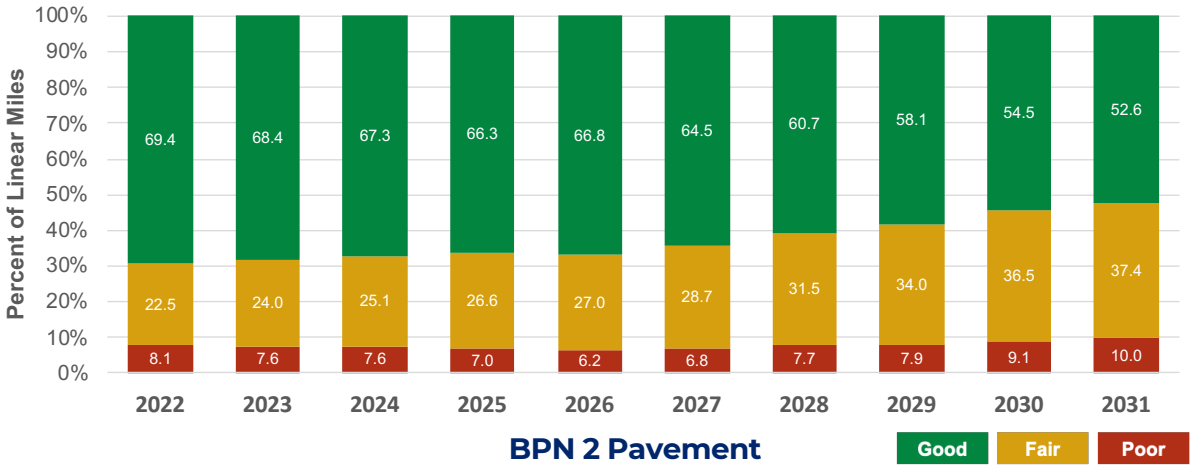
For NHS bridges, PennDOT uses the same performance measures based on NBI ratings as for state-owned bridges, as defined in Table 3-2.

PennDOT Performance Projections and Targets

PennDOT's Asset Management Division is responsible for developing performance targets and projections of asset conditions using its enterprise Bridge and Pavement systems. The state-owned pavement condition forecasts in this TAMP, shown in Figure 3-2 and Table 3-4, use IRI and are based on an expected average annual funding level of $1.63 billion for pavement construction and maintenance. This funding assumption is based on 2023 Financial Guidance. This funding does not include Turnpike funding or local funding for NHS pavements.

State-Owned Pavement





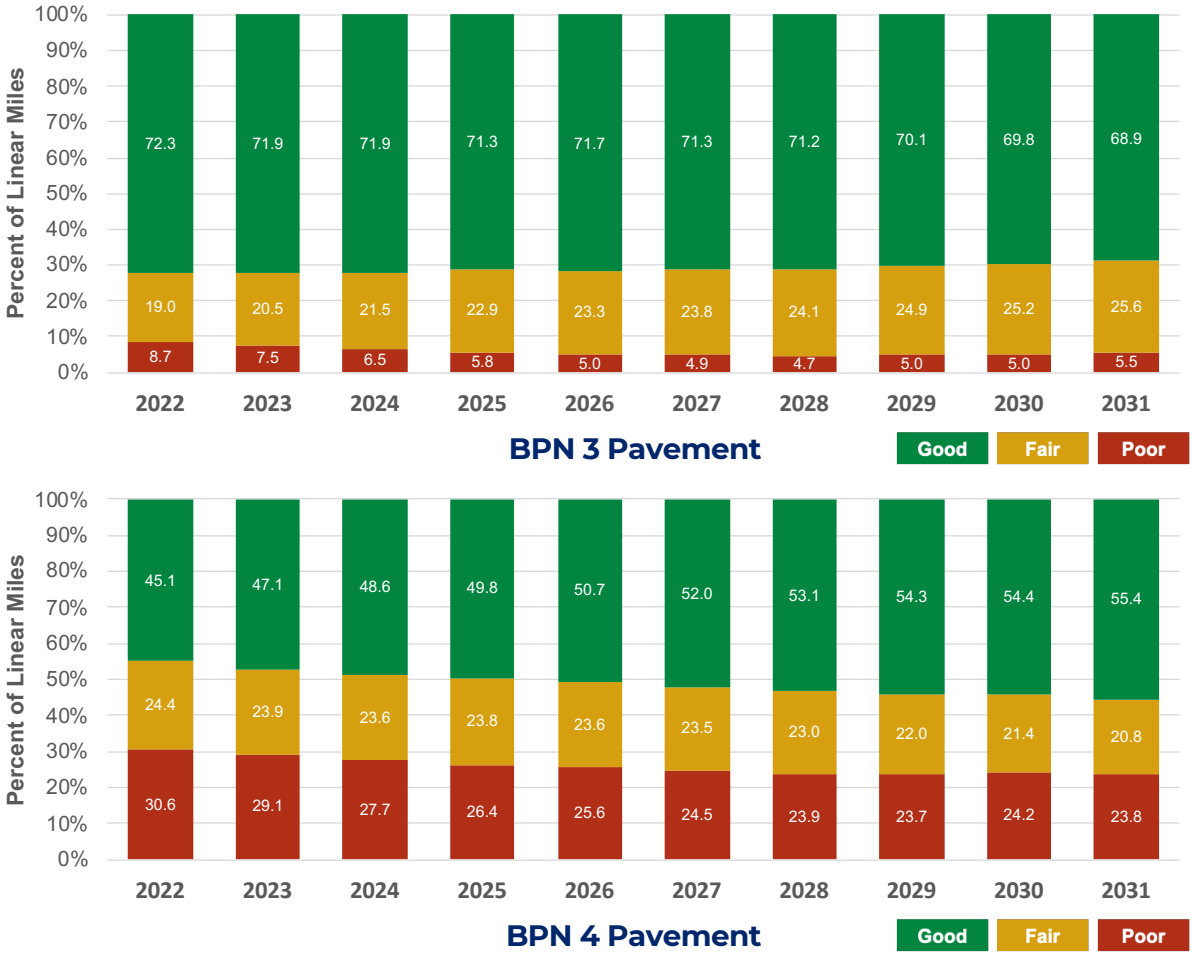


Figure 3-2. State-Owned Pavement Performance Projections (IRI)

Sources: PAMS run as of November 2022, using December 31, 2021 data

State-owned pavement projection details are included in Table 3-4.

Table 3-4. State Owned Pavement Performance Projections (IRI)

Asset	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
BPN 1										
Good %	85.9	83.2	77.3	73.7	69.0	67.1	62.6	59.3	57.9	56.5
Fair %	12.7	14.3	18.4	20.0	22.8	22.7	23.4	23.4	23.4	23.1
Poor %	1.4	2.5	4.2	6.4	8.2	10.2	14.1	17.3	18.6	20.3
BPN 2										
Good %	69.4	68.4	67.3	66.3	66.8	64.5	60.7	58.1	54.5	52.6
Fair %	22.5	24.0	25.1	26.6	27.0	28.7	31.5	34.0	36.5	37.4
Poor %	8.1	7.6	7.6	7.0	6.2	6.8	7.7	7.9	9.1	10.0

Asset	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
BPN 3										
Good %	72.3	71.9	71.9	71.3	71.7	71.3	71.2	70.1	69.8	68.9
Fair %	19.0	20.5	21.5	22.9	23.3	23.8	24.1	24.9	25.2	25.6
Poor %	8.7	7.5	6.5	5.8	5.0	4.9	4.7	5.0	5.0	5.5
BPN 4										
Good %	45.1	47.1	48.6	49.8	50.7	52.0	53.1	54.3	54.4	55.4
Fair %	24.4	23.9	23.6	23.8	23.6	23.5	23.0	22.0	21.4	20.8
Poor %	30.6	29.1	27.7	26.4	25.6	24.5	23.9	23.7	24.2	23.8

Sources: PAMS run as of November 2022, using December 31, 2021 data

State-owned pavement condition is forecasted to decline over the 10-year period in the expected funding scenario. Over time, conditions on all BPNs are expected to decline as predicted funding is insufficient to meet forecasted needs.

The bridge condition forecasts in this TAMP are based on an expected average annual funding level of $868 million for bridges. This funding assumption is based on the 2023 Financial Guidance document and includes roughly $370 million in additional funds to be provided by the IIJA / BIL. It also includes Turnpike funding, but does not include local funding for NHS bridges.

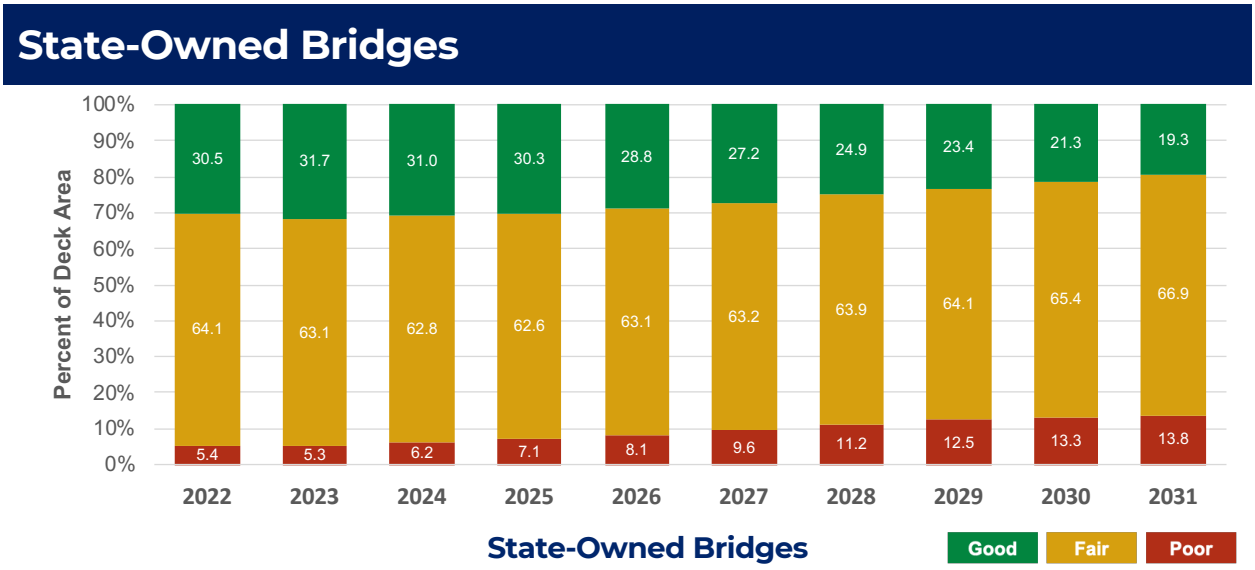


Figure 3-3. State-Owned Bridges Performance Projections

Sources: BAMS run as of November 2022, using December 31, 2021 data

Despite the additional funding from IIJA / BIL, state-owned bridge conditions are forecasted to decline over the 10-year period in the expected funding scenario. State-owned bridge projection details are included in Figure 3-3 and Table 3-5.

Table 3-5. State-Owned Bridges Performance Projections

Asset	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
State-owned Bridge										
Good %	30.5	31.7	31.0	30.3	28.8	27.2	24.9	23.4	21.3	19.3
Fair %	64.1	63.1	62.8	62.6	63.1	63.2	63.9	64.1	65.4	66.9
Poor %	5.4	5.3	6.2	7.1	8.1	9.6	11.2	12.5	13.3	13.8

Sources: BAMS run as of November 2022, using December 31, 2021 data

NHS Performance Projections and Targets

The NHS pavement condition forecasts in this TAMP, shown in Figure 3-4 and Table 3-6, use FHWA performance measures by lane mile and are based on an expected average annual funding level of $1.63 billion for pavement. This funding assumption is based on 2023 Financial Guidance. This funding does not include Turnpike funding or local funding for NHS pavements.

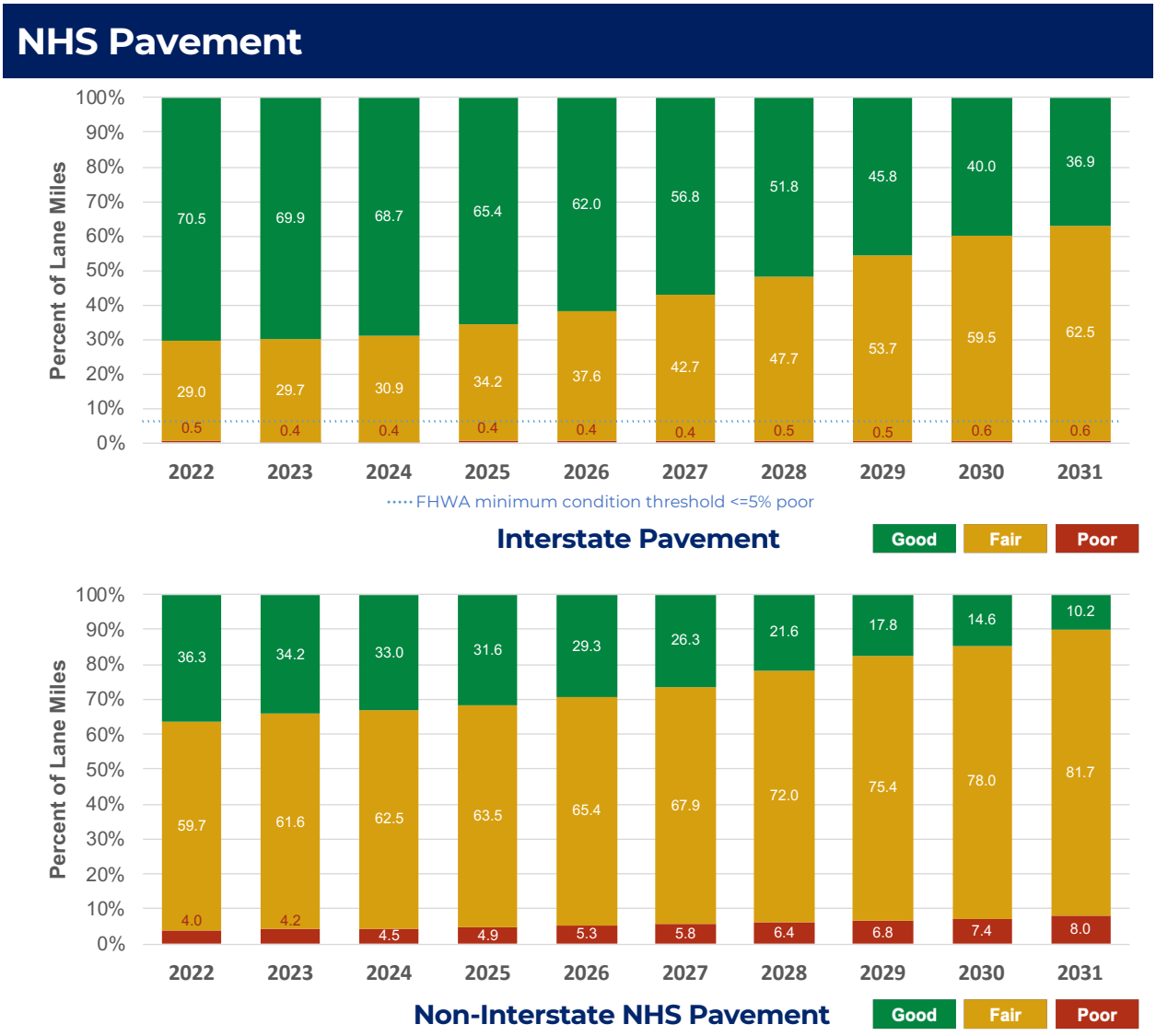


Figure 3-4. NHS Pavement Performance Projections (FHWA Measure)

Sources: PAMS run as of January 2022, using December 31, 2020 data

Table 3-6. NHS Pavement Performance Projections (FHWA Measure)

Asset	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Interstate										
Good %	70.5	69.9	68.7	65.4	62.0	56.8	51.8	45.8	40.0	36.9
Fair %	29.0	29.7	30.9	34.2	37.6	42.7	47.7	53.7	59.5	62.5
Poor %	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6
Non-Interstate NHS										
Good %	36.3	34.2	33.0	31.6	29.3	26.3	21.6	17.8	14.6	10.2
Fair %	59.7	61.6	62.5	63.5	65.4	67.9	72.0	75.4	78.0	81.7
Poor %	4.0	4.2	4.5	4.9	5.3	5.8	6.4	6.8	7.4	8.0

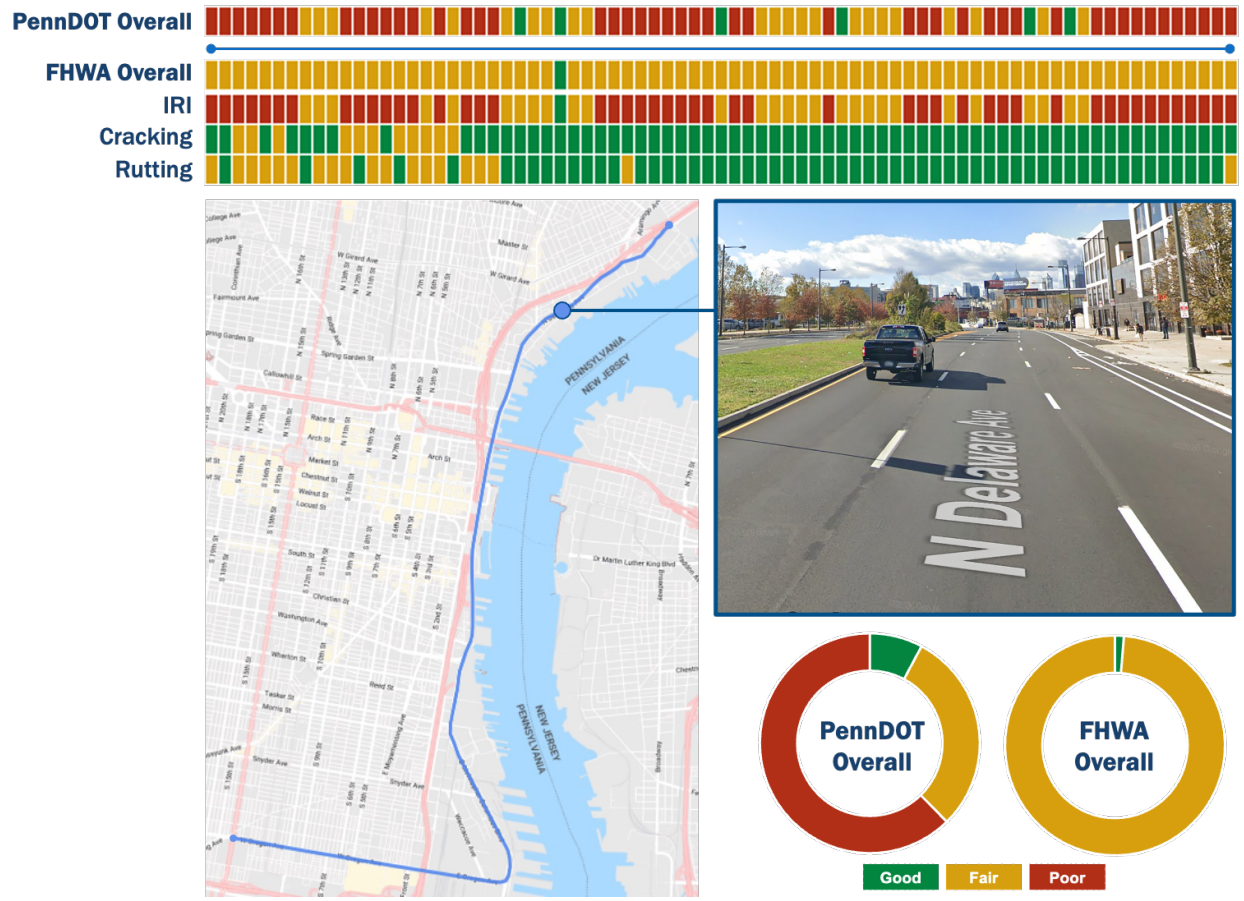
Sources: PAMS run as of November 2022, using December 31, 2021 data

Both Interstate and Non-Interstate NHS pavement condition are forecasted to decline over the 10-year period in the expected funding scenario. The expected decline in Interstate condition and non-Interstate NHS condition is the result of investment priorities and limited funding.

PennDOT and FHWA Pavement Condition Measures

The calculation of pavements in good, fair, or poor conditions can result in significantly different performance results depending on the performance measure that is used for pavement performance. PennDOT's measure is the International Roughness Index (IRI), which measures pavement roughness. The FHWA pavement performance measure uses multiple factors (roughness, cracking and rutting/faulting). Using the FHWA measure, a section will be poor if two or more metrics are poor. A section of pavement may have been rated poor, based on PennDOT's IRI measure, but if cracking and rutting or faulting are fair or good, the pavement will not be rated poor using the FHWA measure.

The example shown in Figure 3-5 below illustrates the different results for a sample section of pavement in Philadelphia. PennDOT's measure represents the pavement as mostly poor based on IRI, while FHWA's measure rates the pavement as almost all in fair condition because only one of the metrics (IRI) falls into the poor thresholds.



Southbound State Route 2001
Via Richmond St, Delaware Ave, Christopher Columbus Blvd, and Oregon Ave

Image Capture: Nov 2019 Maps Data: ©2022 Google

Figure 3-5. Example Pavement Condition – Philadelphia, PA

NHS Pavement – PennDOT's Targets and Desired SGR

While there are no Interstate performance gaps, PennDOT expects a gap on non-Interstate NHS at the end of the 10-year TAMP period.

Table 3-7. NHS Pavement Targets and Desired SGR

Pavement	2023 Target	2025 Target	2031 Predicted	2031 Desired SGR
Interstate				
Good	69.0%	65.0%	36.9%	n/a
Poor	2.0%	2.0%	0.6%	5.0%
Non-Interstate NHS				
Good	31.0%	29.0%	10.2%	n/a
Poor	6.0%	6.0%	8.0%	5.0%

Sources: PAMS run as of November 2022, using December 31, 2021 data

Pennsylvania currently defines its desired state of good repair (SGR) as no more than 5 percent of NHS Interstate lane miles shall be rated in poor condition, which is also the FHWA minimum condition thresholds for pavement (23 CFR part 490.315(a), Subpart C). Pennsylvania's desired SGR for NHS non-Interstate pavements is also defined as having no more than 5 percent of lane miles be rated in poor condition. Pennsylvania's targets and desired SGR for NHS pavement are summarized in Table 3-7.

Non-Interstate NHS pavement condition is expected to fall short of the desired SGR in 2026. While PennDOT and federal policies will prioritize funding to the NHS, it will be inadequate to maintain conditions on the Non-Interstate portion of the NHS network.

Based on the projections of future conditions in this TAMP, PennDOT's target is for Interstate pavements to be 69.0% good and 2.0% poor in 2023, and 65.0% good and 2.0% poor in 2025. Non-Interstate NHS is targeted to be 31.0% good and 6.0% poor in 2023, and 29.0% good and 6.0% poor in 2025.

PennDOT is continually improving its pavement modeling capabilities. Currently, confidence in the agency's modeling accuracy is at an intermediate level. PennDOT is actively working to address any projection errors in order to improve its confidence in the model.

The NHS bridge condition forecasts in this TAMP, shown in Figure 3-6 and Table 3-5, use FHWA performance measures by deck area and are based on an expected average annual funding level of $868 million for bridge. This funding assumption is based on the latest revisions to the 2023 Financial Guidance document and includes roughly $370 million in additional funds to be provided by the IIJA / BIL. It also includes Turnpike funding, but does not include local funding for NHS bridges. The projections include all NHS bridges in the state of Pennsylvania, regardless of owner. NHS bridge projection details are included in Figure 3-6 and Table 3-8.

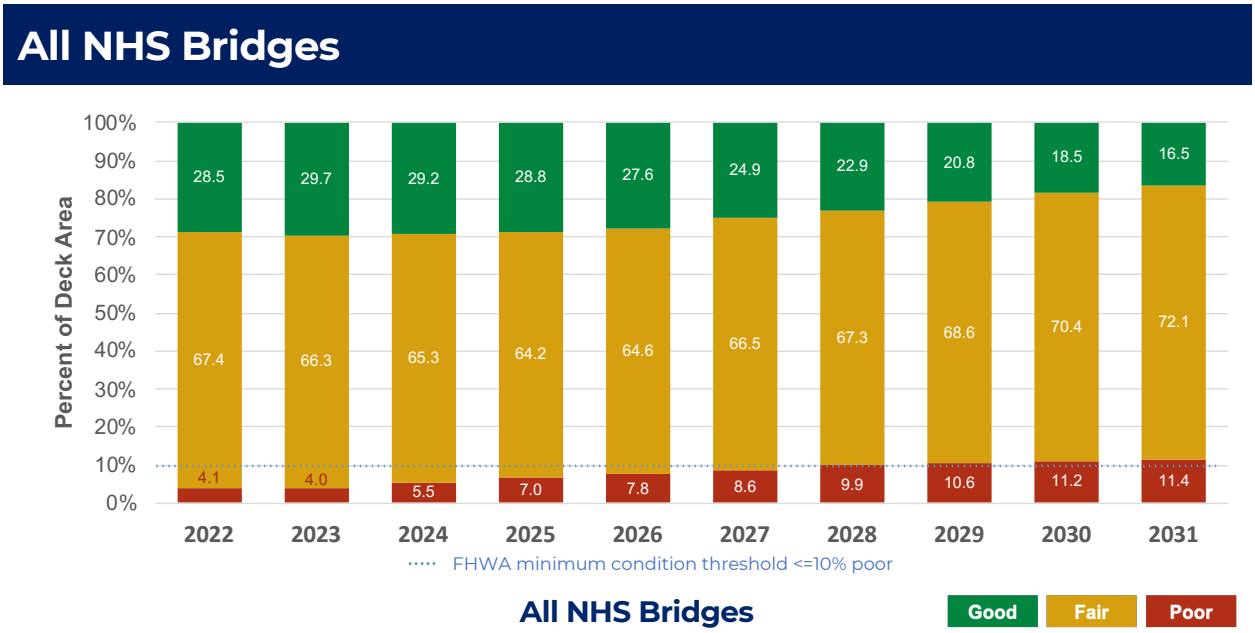


Figure 3-6. NHS Bridge Performance Projections

Sources: BAMS run as of November 2022, using December 31, 2021 data

Table 3-8. All NHS Bridge Performance Projections

Asset	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
All NHS										
Good %	28.5	29.7	29.2	28.8	27.6	24.9	22.9	20.8	18.5	16.5
Fair %	67.4	66.3	65.3	64.2	64.6	66.5	67.3	68.6	70.4	72.1
Poor %	4.1	4.0	5.5	7.0	7.8	8.6	9.9	10.6	11.2	11.4

Sources: BAMS run as of November 2022, using December 31, 2021 data

NHS bridge conditions are forecasted to decline over the 10-year period. This is due to insufficient funding to maintain current performance and SGR through the next ten years.

NHS Bridges – PennDOT's Targets and Desired SGR

PennDOT expects a condition gap on NHS bridges at the end of the 10-year TAMP period.

Table 3-9. NHS Bridges Targets and Desired SGR

Bridge	2023 Target	2025 Target	2031 Predicted	2031 Desired SGR
NHS				
Good	28.0%	28.0%	16.5%	n/a
Poor	7.5%	7.5%	11.4%	10.0%

Sources: BAMS run as of November 2022, using December 31, 2021 data

Pennsylvania defines its desired state of good repair as no more than 10 percent of total NHS bridge deck area poor, which is also the FHWA minimum condition thresholds for bridges (23 U.S.C. 119(f)(1)). PennDOT has not yet established SGR targets for non-NHS assets. NHS bridge condition is expected to fall short of the desired SGR in 2029, summarized in Table 3-9.

Based on the projections of future conditions in this TAMP, PennDOT's target is for NHS bridges to be 28.0% good and 7.5% poor in 2023, and 28.0% good and 7.5% poor in 2025.

Performance Gap Analysis Methodology

PennDOT identifies performance gaps by forecasting asset conditions for NHS pavements and bridges over the 10-year period of the TAMP and comparing predicted values to the desired state of good repair, defined previously in Chapter 3. If predicted values fall short of desired values, PennDOT works to develop strategies to address the gap. Strategies are discussed in greater detail in the Chapter 6, Financial Plan and Investment Strategies.

Gap Summary/Discussion

The current practice of prioritizing NHS assets over other networks has had a positive impact on the effectiveness of the NHS system, as both bridge and pavement conditions meet PennDOT's desired state of good repair. However, PennDOT's forecasted conditions show the risk of NHS bridges and non-Interstate NHS pavements failing to meet PennDOT's desired state of good repair at the end of ten years due to a combination of a lack of funding and insufficient LLCC based planning.

Currently, the financial burden of maintaining the NHS at the federally mandated condition levels for pavements and bridges will create a shortfall for the rest of the transportation system, as PennDOT does not receive sufficient funding to maintain NHS and non-NHS pavements and bridges to the same standard.

While the focus of the TAMP is on asset conditions, the TAMP gap analysis also considers effectiveness of the system without regard for condition through the risk management and investment strategies sections of the TAMP.

Strategies to Address Gaps

Identifying forecasted performance gaps enables PennDOT to develop corrective actions to improve pavement and bridge conditions and prevent any actual performance gaps. PennDOT has adopted the following strategies to address the forecasted performance gap while continuing to implement LLCC:

- Manual assessment and tracking of projections versus condition thresholds to verify actual gap.
- Evaluate funding allocation of pavements versus bridges to address system-level deficiencies.
- Reallocation of a portion of funding from non-NHS pavements and bridges to NHS pavements and bridges.
- Identify and evaluate potential new revenue sources (see Chapter 6, Financial Plan and Investment Strategies, for more detail)

Life Cycle Planning

What's in this Chapter?

This chapter summarizes PennDOT's approach to life cycle planning, the process to estimate the network level cost of managing an asset while maintaining condition and minimizing cost.

- It provides an overview of life cycle planning and defines PennDOT's **lowest practical life-cycle cost (LLCC)** strategy and how it is used to guide investments.
- **Bridge and pavement management systems** use deterioration models, treatments, and funding scenarios to forecast asset conditions, and recommend treatments.
- The chapter also describes how life cycle planning fits into PennDOT's **Planning and Programming process**.

Life Cycle Planning Overview

Life cycle planning recognizes that applying the right treatment at the right stage in an asset's life cycle can have a profound effect on the total cost to maintain an asset in a state of good repair over its whole life. It is almost always more cost-effective to perform multiple, lower cost maintenance and preservation treatments than to allow an asset to deteriorate to the point of requiring a major rehabilitation or even complete replacement.

Simplified Asset Life Cycle

Life Cycle Planning, as defined in the FHWA Asset Management Rule (23 CFR 515.5), is "a process to estimate the cost of managing an asset class, or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition."

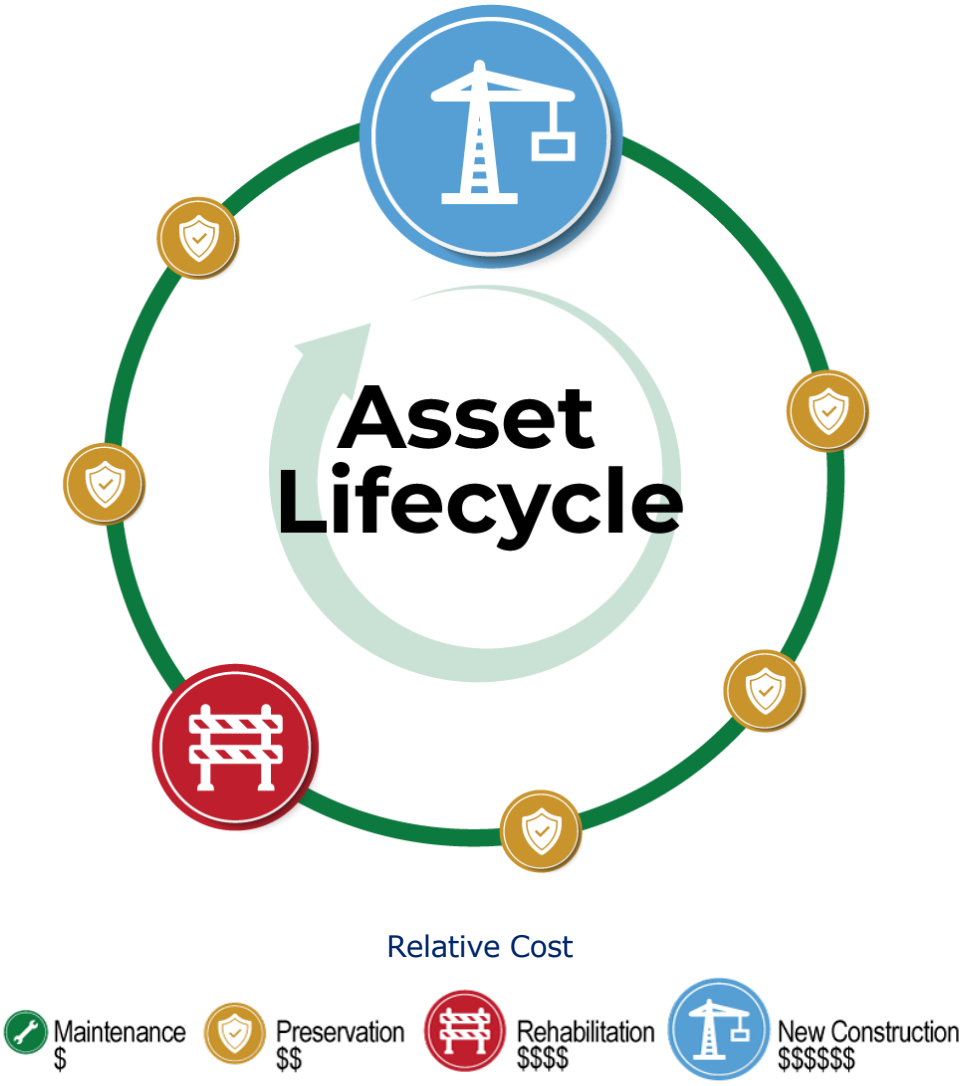


Figure 4-1. Example Asset Life Cycle and Treatments

Lowest Practical Life Cycle Cost

Lowest practical life-cycle cost (LLCC) is PennDOT's asset management strategy designed to maximize the life of an asset at the lowest cost through a risk-based prioritization of preservation, rehabilitation, and reconstruction. This strategy is reflected in PennDOT's asset management slogan and guiding principle: "The right treatment at the right time." It is PennDOT's overall implementation and investment strategy for achieving its asset condition targets, sustaining the performance of the NHS, and supporting progress toward the national goals identified in 23 U.S.C. 150(b) (23 CFR 515.13(b) (2)). This approach enables PennDOT to effectively invest its resources and encourages uniformity in how assets are invested in across the state. Figure 4-2 presents an example of different life cycle scenarios.

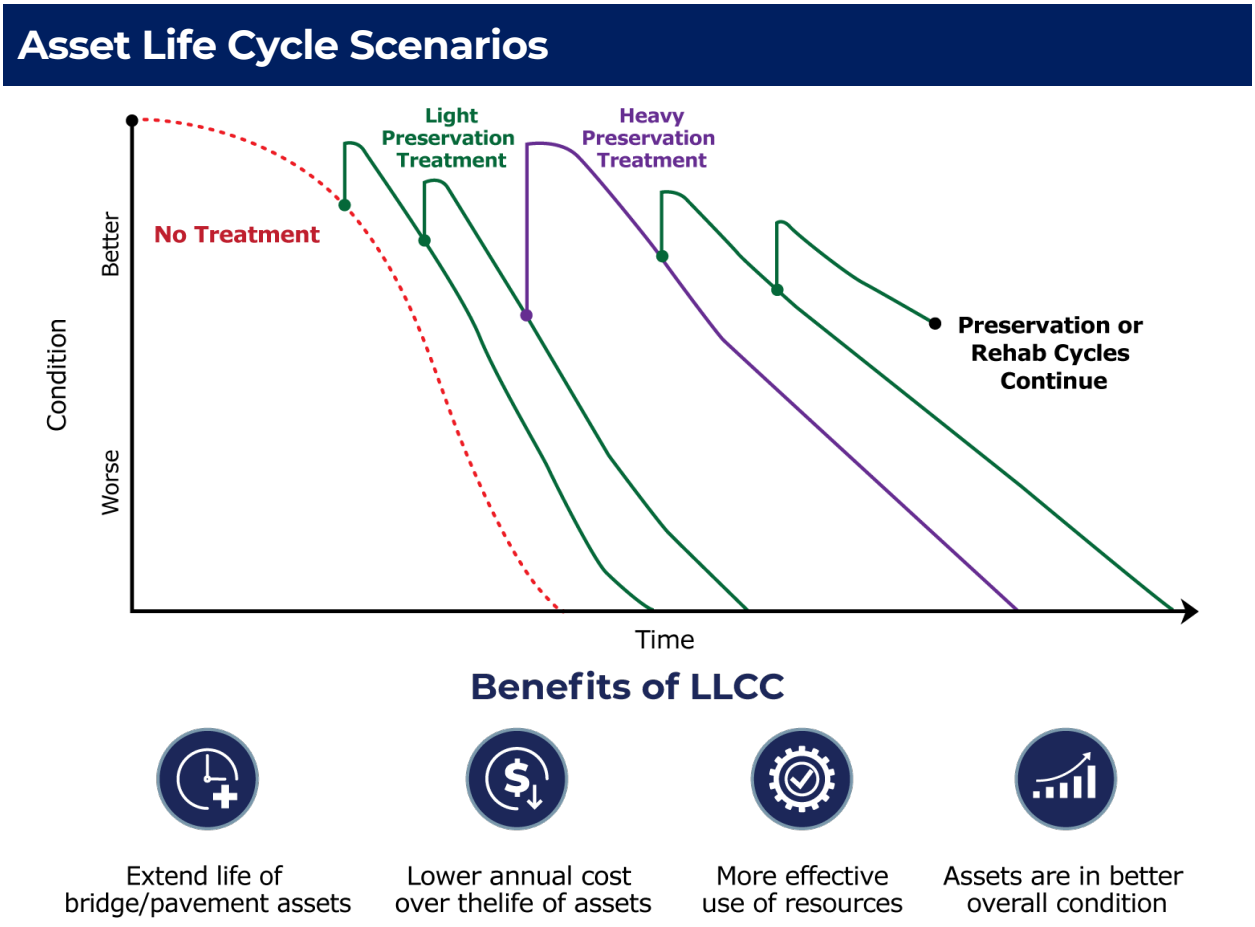


Figure 4-2. Example Asset Life Cycle Scenarios

The trend of asset condition with no treatment applied is represented by the dotted red curve. The green curve depicts the reset of the asset condition trend if a preservation treatment is applied while the asset is in good or satisfactory condition. If the asset condition is left to deteriorate below a certain level, preservation treatments are not feasible or effective and the substantial expense of a major rehabilitation or replacement will be required.

Pavement and Bridge Management Systems

PennDOT conducts life cycle planning for its pavements and bridges using specialized, sophisticated pavement and bridge management systems, referred to as PAMS and BAMS. While running on different software platforms, the pavement and bridge management systems each have similar components, as shown in Figure 4-3.

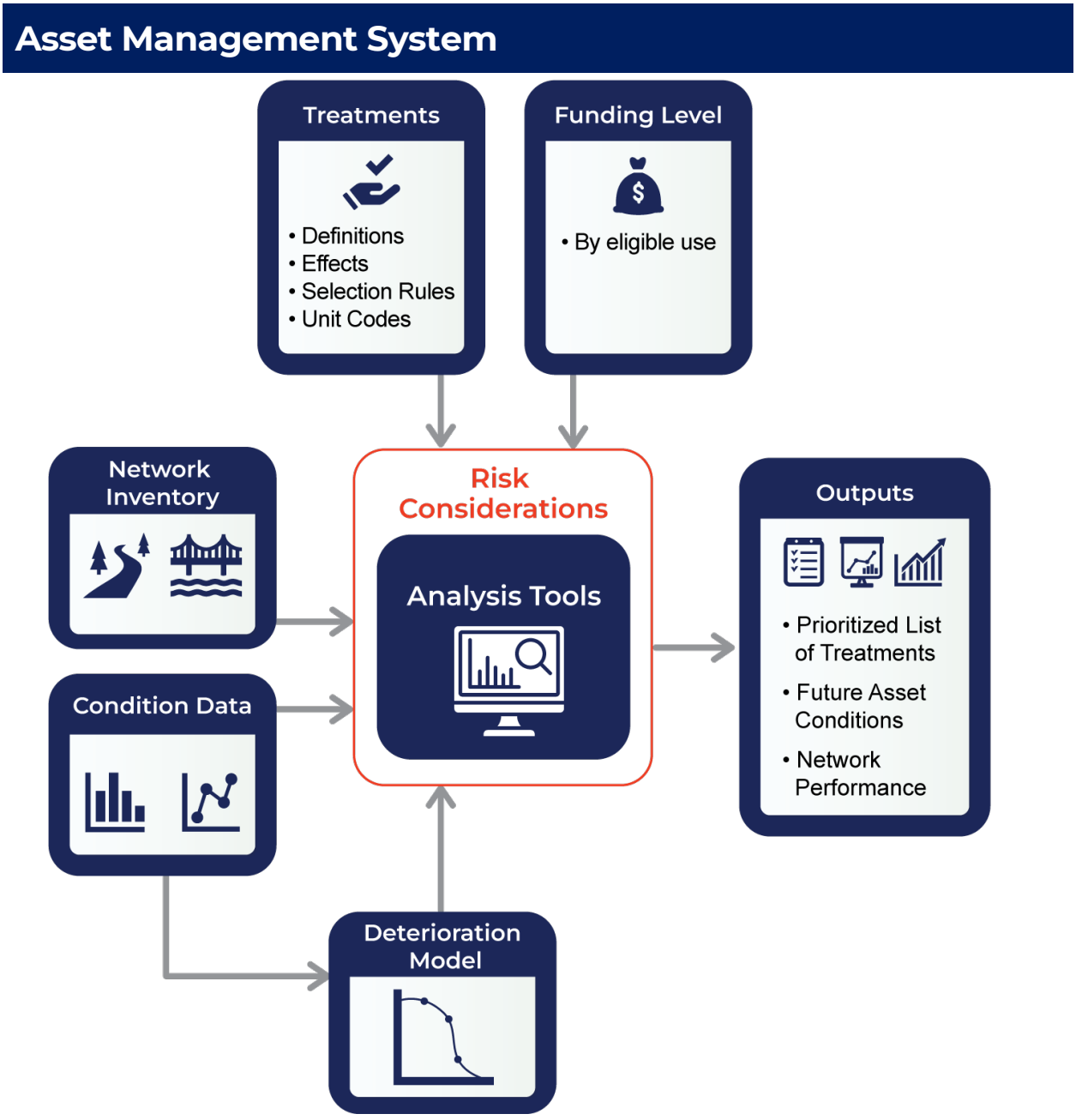


Figure 4-3. Asset Management System Components

Components of an Asset Management System

Network Inventory

Information that identifies and characterizes each asset, including geographic location, PennDOT jurisdiction, and Business Plan Network, as well as annual average daily traffic (AADT), physical features such as bridge length, lane width, construction type, material of construction, maintenance history, and other asset data attributes.

Inspection Condition Data

Numerical ratings of the asset condition. **Bridge** – general condition ratings of major components, on the Federal National Bridge Inspection Standards (NBIS) 0-9 scale. **Pavement** – Quantities in each of several applicable measures of pavement defect, such as cracking, rutting, International Roughness Index (IRI).

Deterioration Model

Mathematical models used to project future asset condition in the absence of any treatment. All deterioration models used in PennDOT bridge and pavement management systems are based on historical PennDOT condition and work records. Bridge deterioration modeling is specific to each PennDOT district and family, while pavement modeling is specific to each of the 54 pavement families, which in turn are specific to location.

Treatments

Asset treatments are the preservation, rehabilitation, and replacement actions that are analyzed and ranked in the analysis module. Treatment data needed by the modeling system include triggers, effects, and unit costs. Treatment triggers are the inventory characteristics and inspection condition combinations that trigger the modeling system to select a treatment for evaluation in any given analysis year. Treatment Effects (or "Consequences") refers to the modeled changes in conditions resulting from implementing the treatment. PennDOT bridge and pavement treatments are described in more detail in the following section.

Funding Allocation

The user inputs the amount of funding available for each analysis year by Business Plan Network and geographic unit (e.g., MPO/RPO and district combinations), with a separate allocation for the interstate system. The optimization module, described below, will select treatments that maximize the treatment benefits, given the funding constraints. PennDOT has been using a calculated cost escalation rate of 3% per year to adjust the purchasing power of the allocated funding. Treatment costs are expressed in year of expenditure dollars based on the schedule. The Bridge and Pavement Management Systems account for projects that are already planned and programmed.

Analysis Tools

The management system software runs an optimization engine that calculates, for each asset (bridge, pavement segment) and each analysis year, the benefits, and costs of each feasible treatment alternative. A “feasible” treatment is one that is identified by the selection rules (triggers) described above. The "benefit" of the treatment is measured using the difference in condition rating with the treatment compared to a no-treatment baseline condition rating. The bridge benefit is weighted with risk score that includes factors for deck area, annual average daily traffic, percent truck traffic, detour length, scour rating, fracture criticality, and history of flooding. The pavement benefit is weighted with a risk criticality factor based on Business Plan Network and including similar factors as the bridge score. The optimization module is designed to select the combination of treatments that yield the highest benefit possible given the funding constraint.

Pavement and Bridge Treatments

The FHWA Asset Management Rule requires state TAMPs to classify asset management investments into five work types: new construction, maintenance, preservation, rehabilitation, and reconstruction. PennDOT's asset management systems are largely geared to the contract level maintenance, preservation, rehabilitation and reconstruction activities, while other systems are used to plan internal maintenance level work. None of these systems are used to determine capacity adding projects.

Both bridge and pavement management systems have an extensive set of possible treatments, and every treatment is specific to each of three pavement types. There are five treatment groups (routine maintenance, preservation, minor rehabilitation, major rehabilitation, and reconstruction) which can be mapped to the five FHWA work types, as shown in Table 4-1. The treatments, treatment selection rules, and unit costs are detailed in the document *Pennsylvania Treatment Matrices, Material Quantities & Dollar Needs Calculations.*

Treatment Groups in the Pavement Management System

A treatment group is assigned based on the treatments that have been triggered. The five treatment groups and the bituminous pavement treatments assigned to each group are shown below. Trigger rules for each treatment are specific to Business Plan Network.

Table 4-1. Typical Pavement Treatments and FHWA Work Types

Routine Maintenance – FHWA Maintenance Work Type	
Routine Maintenance	Mechanized Patch
Crack Seal	Mill, Manual Patch
Spray Patch	Mill, Mechanized Patch
Skin Patch	Base Repair, Manual Patch
Manual Patch	Base Repair, Mechanized Patch
Manual Patch, Skin Patch	
Seal Coat – FHWA Preservation Work Type	
Seal Coat	Widening, Seal Coat
Level, Seal Coat	Scratch Level, Seal Coat
Minor Rehabilitation – FHWA Rehabilitation Work Type	
Microsurface/Thin Overlay	Level, Resurface
Major Rehabilitation – FHWA Rehabilitation Work Type	
Mill, Concrete Patch, Level, Resurface	Mill, Level, Resurface, Base Repair
Level, Resurface, Base Repair	Construct Paved Shoulder
Mill, Level, Resurface	
Reconstruction – FHWA Reconstruction Work Type	

The PennDOT *BridgeCare Treatment Criteria and Consequences* document contains the full set of treatment triggers ("feasibility criteria"), treatment effects, and unit costs that are used in the BridgeCare software. Treatment triggers are specific to Business Plan Network. Typical bridge treatments and corresponding FHWA work types are shown in Table 4-2.

Treatments in BridgeCare

The bridge management system considers 14 contract level treatments. The table at right shows how PennDOT's treatments align with FHWA work types.

Table 4-2. Typical Bridge Treatments and FHWA Work Types

Treatment	FHWA Work Type
County Maintenance – Deck Work	Maintenance
County Maintenance – Superstructure Work	Maintenance
County Maintenance – Substructure Work	Maintenance
Epoxy Overlay	Preservation
Structural Overlay	Preservation
Bituminous Overlay	Preservation
Bridge Painting (steel superstructure) – Full Bridge	Preservation
Bridge Painting (steel superstructure) – Joint/Spot/Zone Painting	Preservation
Deck Replacement	Rehabilitation
Substructure Rehabilitation	Rehabilitation
Superstructure Replacement/Rehabilitation	Rehabilitation
Culvert Rehabilitation	Rehabilitation
Culvert and Small Bridge (<30') Replacement	Reconstruction
Bridge Replacement	Reconstruction

Sources: PennDOT. PennDOT BridgeCare Treatment Criteria and Consequences (Full Version). 1/13/2021 Edition

Typical unit costs for pavement and bridge treatments are included in Appendix B.

Life Cycle Planning in the Project Planning and Programming Process

The management systems described previously inform the project planning and programming process, which is data-driven yet based on strategic decision-making by professionals familiar with actual conditions as well as state and regional priorities.

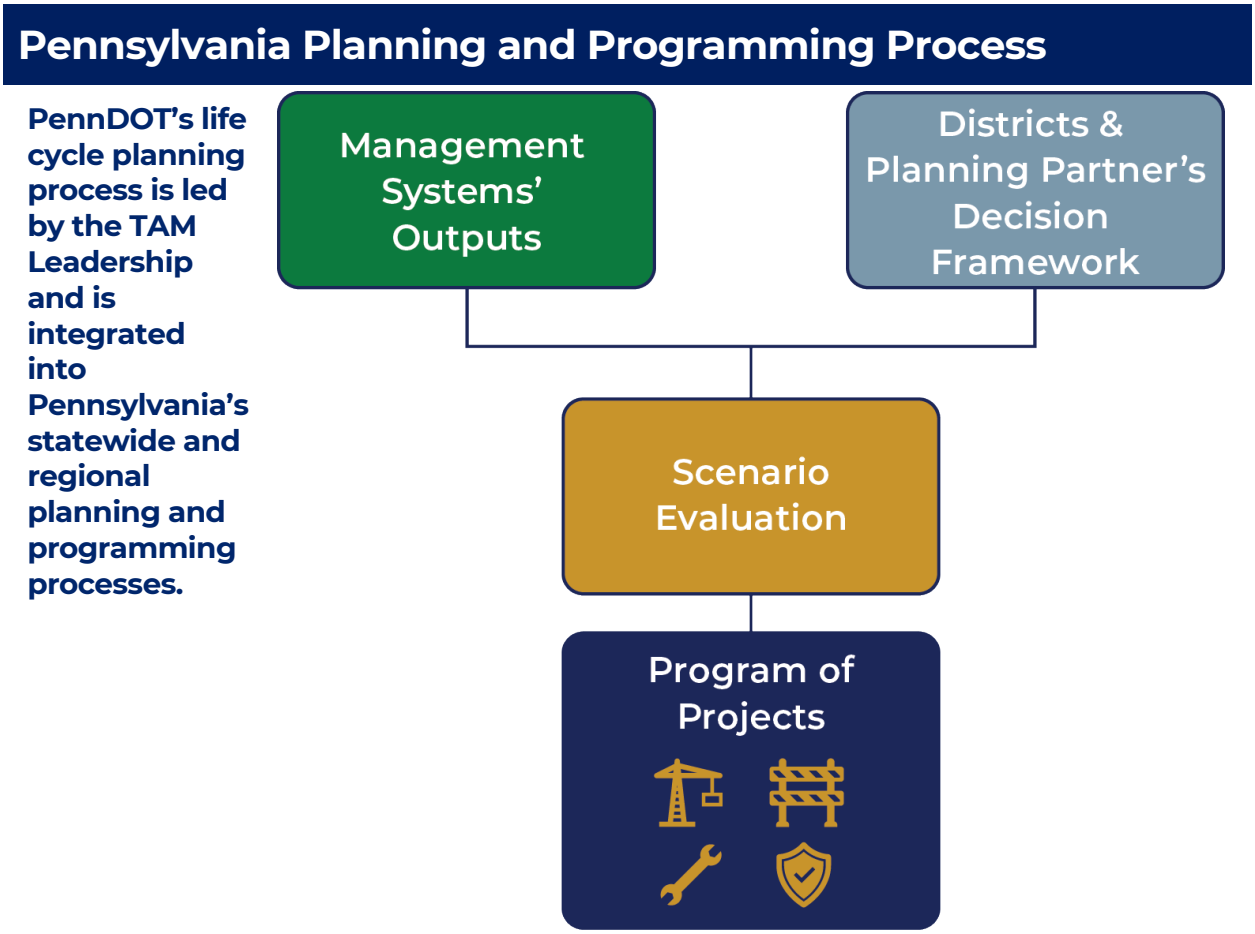


Figure 4-4. PennDOT Life Cycle Planning and Programming

Project-level planning and programming is a coordinated effort led by the state's Metropolitan Planning Organizations and Regional Planning Organizations (MPO/RPO), collectively referred to as "Planning Partners". Each two-year update to the Statewide Transportation Improvement Program (STIP), which addresses all modes of transportation, is guided by two guidance documents: *Transportation Program Financial Guidance* and *General and Procedural Guidance*. The current guidance documents can be found at: https://talkpatransportation.com/how-it-works/stip. Pennsylvania's mid-range planning document, the Twelve Year Plan (TYP), includes the STIP plus eight additional years of projects and funding.

The *Transportation Program Financial Guidance* document, described in greater detail in Chapter 6, Financial Plan and Investment Strategies, lays out the anticipated federal and state funding through defined formulas for distribution to the statewide programs and regional Planning Partners. The most recent version of the document was updated to include BIL funding and guidance. The funding formula includes an Asset Management Factor (AMF), which allows for adjusted funding in areas that demonstrate greater need. The method to calculate the Asset Management Factor is provided in Appendix C.

The *General and Procedural Guidance* document informs how the funding should be invested and what requirements must be met. This document also addresses MAP-21/FAST Act performance-based planning and programming requirements, Transportation Performance Management, and TAMP requirements. It includes information from the Asset Management Steering Committee, the Asset Management Division, and the bridge and pavement management systems to provide enhanced support for project programming to achieve Lowest Practical Life Cycle Cost. PennDOT's Center for Program Development and Management (CPDM) works with the Asset Management Division to provide each Planning Partner with a list of recommended treatments derived from PennDOT's pavement and bridge asset management systems, based on the Lowest Life Cycle Cost objective embedded in the management systems, with funding allocations from the *Transportation Program Financial Guidance* document.

PennDOT's federally-required 2 and 4-year performance targets for NHS pavement and bridge condition are based on planned projects, which themselves in turn were informed by treatment selections resulting from use of the pavement and bridge management systems, as described above. Long term performance is projected by applying expected funding in the management system optimization analyses. These analyses are aimed at achieving lowest practicable life cycle cost, with project performance as an output. Performance targets and projected performance are presented in more detail in Chapter 3, Performance Management.

With increasing emphasis and implementation of the Life Cycle Cost Principles and risk-based prioritization in its pavement and bridge management systems, PennDOT is enhancing its pavement and bridge management systems to facilitate their use by the Districts and Planning Partners to review and analyze investment decisions and make condition projections based on available funding levels. Until system access is available to partners, Asset Management staff provide Districts and Planning Partners with treatments recommended by the management systems.

Implementation of Life Cycle Cost Principles

Training for the Districts and Planning Partners regarding the transition to Lowest Life Cycle Cost and risk-based programming has been completed by PennDOT Central Office Asset Management and CPDM.

The Lowest Life Cycle Cost and risk-based programming training for Districts and Planning Partners includes general guidance on:

- Achieving Lowest practical Life Cycle Cost
- Considering new asset condition targets and metrics and how to apply them
- Maintaining Transportation Improvement Program development (current planned work will be maintained in order to preserve planning efforts and development dollars)
- Applying the new methodology to Transportation Improvement Program adjustments
- Moving toward "on-cycle" programming with the next 12-Year Program
- Utilizing the Pavement Asset Management System/Bridge Asset Management System tools to assist in Transportation Improvement Program/12-Year Program project selection
- Training on the software systems and interim tools

Figure 4-5. LLCC Implementation Guidance

Achieving a LLCC based program will take a number of years to be fully implemented because of the timeline from project identification to completion. The timeline until the benefits of this transition can be realized is even longer, as lowest life cycle cost management is aimed at spending today to yield benefits in future in the form of better asset performance.

Accounting for Changes in Future Demand, Environmental Conditions, and Other Factors

Transportation infrastructure such as pavement and bridges are intended to be long-lived assets. This makes anticipating and planning for potential future changes especially important. Anticipating the future can include evaluating whether assets may deteriorate faster, may become more likely to experience sudden catastrophic damage, or will have higher than anticipated costs due to changes in traffic demand, extreme weather, and other various impacts related to environmental conditions. These risks and costs to transportation infrastructure are further discussed in Chapter 5, Risk Management. Examples of how PennDOT considers these factors in life cycle planning are provided here:

- Future demand in terms of AADT and truck traffic are factored in the design for new construction and reconstruction of pavement and bridges.
- Bridge treatment selection includes scour and flood risks in the risk score that is used in weighting benefits for the net benefit maximization computations in PennDOT BridgeCare.
- The Extreme Weather Vulnerability Study, described in Chapter 5, Risk Management, is influencing design directives. For example, Chapter 7 of the design manual pertaining to Drainage Structures, Scour, and Culverts instructs that the process is to consider the Study as an additional source for flooding history of the project site.
- The PennDOT Design Manual is in the process of being updated and will include a new chapter to cover resiliency, which will summarize all of the current work on the subject.

Risk Management

What's in this Chapter?

This chapter summarizes the PennDOT approach and actions for asset risk management.

- It describes an **overview of risk management** and how PennDOT approaches risk management and resiliency.
- **The risk management improvement initiatives** communicate what has been done and what is underway to address risks and build resiliency.
- **Risk management processes** at PennDOT describe the steps and sequence of activities to manage risks.
- **The risk register** represents PennDOT's identification of risks and the assessment of likelihood and impact.
- **The mitigation plan** describes the actions that PennDOT will take to reduce risks.
- **The Part 667** describes assets with repeated damage due to emergency events.

Risk Management Overview

Risk management involves the identification, assessment, and mitigation of threats and hazards at an enterprise, program, project, or activity level. At PennDOT, risk management is institutional. Groups all across the agency participate in rigorous, routine risk management to prevent the worst threats from materializing. PennDOT's approach to infrastructure design is to build in resiliency so that assets can withstand possible risks and perform to the maximum intent possible. This approach and practice have reduced some of the risks being experienced in other transportation agencies. PennDOT's proactive risk management helps ensure that the entire state transportation system remains safe for users of all modes, and is maintained at an acceptable level for the level of funding provided. In addition, as MPOs and RPOs have a strong role in the identification and selection of STIP/TIP projects, they play a key role in the risk management process. Risk management plays an important role in TAM, as it guides decision-making and optimization in not only asset management but also performance management and strategic investment. Figure 5-1 shows the linkages between risk management, performance management, strategic investment, and asset management.

Risk Management and Asset Management

Through the union of Asset Management, Risk Management, Performance Management, and Strategic Investment, PennDOT is able to effectively reduce the most severe risks facing the agency.

Figure 5-1. Risk Management and Asset Management

PennDOT has historically been committed to resiliency-building through its engineering standards, infrastructure design, and construction of resilient infrastructure. There is now a greater awareness of resiliency building due to the increase in extreme weather events, and PennDOT's culture of resilience has served Pennsylvania's assets well in this regard. Across PennDOT, independent but similar approaches have been taken to create a resilient system, and with the advent of FHWA requirements, these independent actions are being summarized and included in PennDOT's standard publications. One example of this is bridge design, which is captured in Publication DM-4. In this publication, PennDOT is in the process of creating a completely new chapter that summarizes risk and resiliency in design choices.

Through the support of PennDOT executives, TAM staff engage in a series of risk-focused practices which inform risk management analysis. These include the Extreme Weather Vulnerability Study conducted in 2017, the Resiliency of Design Task Force, Bridge & Pavement Risk Scores, and Agency-Wide Integration of Risk Management. Each of these practices support the PennDOT TAM Risk Management Process.

FEDERAL REQUIREMENTS

IDENTIFICATION
of risks that can affect the condition of NHS pavements and bridges and the performance of the NHS

ASSESSMENT
of identified risks in terms of likelihood of consequence

EVALUATION AND PRIORITIZATION
of the identified risks

MITIGATION
plan for addressing the top priority risks

MONITORING
the top priority risks

SUMMARY,
for NHS bridges and pavement, of facilities repeatedly damaged by emergency events

Risk Management Governance

As part of the TAMP update process, PennDOT's asset management team compiles a list of asset-related risks, establishes which risks present the greatest threat, and develops a plan for addressing them. PennDOT has adopted the FHWA risk framework, which categorizes risk as a function of likelihood and consequence. In addition to this framework, the Steering Committee analyzes risks for detectability and timeframe, identifying how easy the risks are to predict and perceive and when they occur or how long they last. PennDOT's risk management framework is shown in Figure 5-2 and PennDOT's risk prioritization matrix is shown in Figure 5-3.

PennDOT's Risk Management Framework

PennDOT's risk management framework, adapted from FHWA.

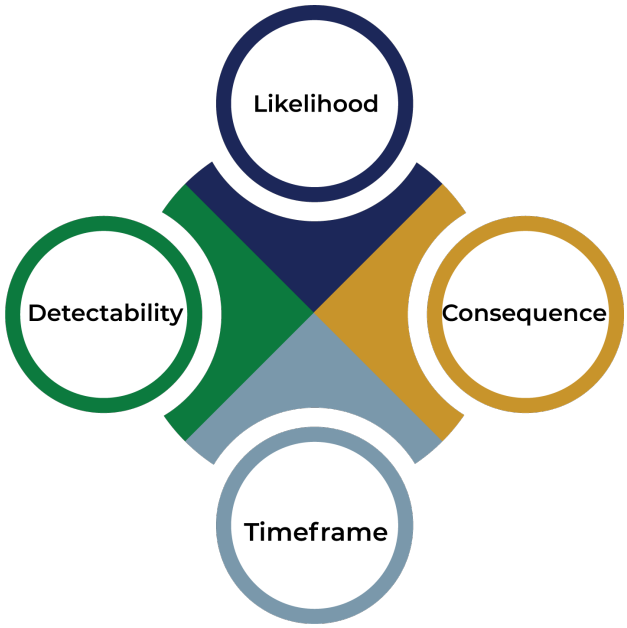


Figure 5-2. PennDOT's Risk Management Framework

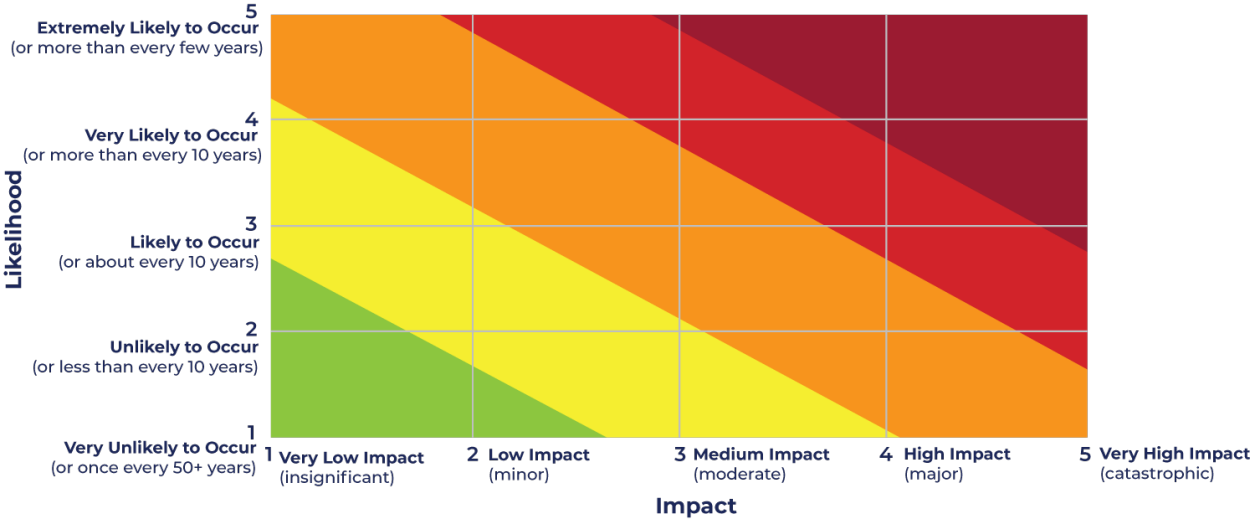


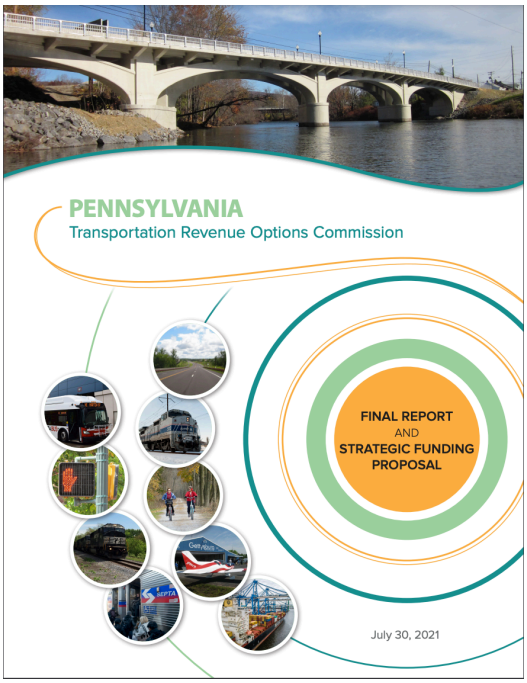
Figure 5-3. PennDOT Risk Prioritization Matrix

Risk Management Improvement Initiatives

Managing risks is a priority for PennDOT and for the state. Progress is being made and there is a continuous improvement approach to build resiliency and manage known risks. The following are some of the initiatives that have been taken or are underway to manage risk to Pennsylvania's assets.

Strengthening Financial Vulnerability

The Transportation Revenue Options Commission (TROC) was established by the Governor to develop a strategic proposal to close the transportation funding gap in Pennsylvania. The TROC proposal identified a $9.35 billion funding gap for state transportation needs, including $8.15 billion in total unfunded needs for highways and bridges.



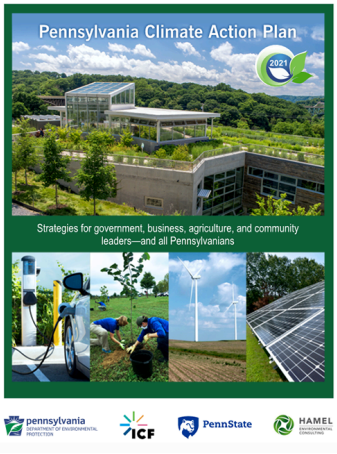
Recommendations have been made to increase revenue and to close the funding gap, they include:

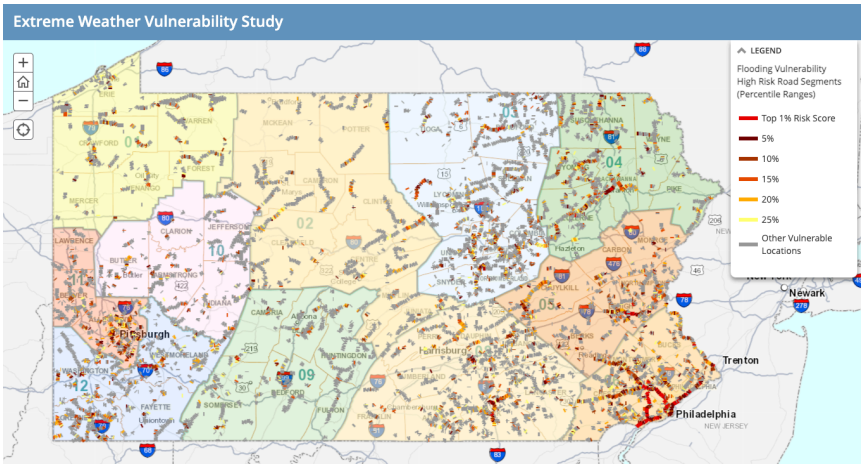
- **Road User Charges** consisting of two sources: Mileage-Based User Fees (MBUF) and an Electric Vehicle (EV) MBUF Pilot. MBUF presently appears to be the best long-term funding solution for Pennsylvania.
- **Tolling** can generate revenue from corridor tolling and managed lanes (limited lane tolling). Corridor tolling of Interstate highways and expressways based on distance traveled is both feasible and fair.
- **Redirection of Funding** by eliminating transfers from the Motor License Fund (MLF) to the Pennsylvania State Police.
- **Fees** from new sources or from increases to existing fees , such as the Vehicle Registration Fee, Electric Vehicle Fee, Vehicle Lease Fee, Vehicle Rental Fee, Transportation Network Company (rideshare) Fee, Aircraft Registration Fee, and Goods Delivery Fee
- **Taxes** can generate additional funds from increases to the present vehicle sales tax and the jet fuel tax, as well as indexing the gas tax to inflation.

In addition to the TROC recommendations, Pennsylvania will receive $4.05 billion in additional funding from the IIJA/BIL for five years.

Extreme Weather and Climate Change

PennDOT and other parts of Pennsylvania's government are working together to mitigate risks due to extreme weather and climate change. A lot of progress has been made in the past few years. Some of PennDOT's efforts to be more sustainable include a commitment to be 25% electric vehicles by the year 2025 for all of PennDOT's vehicles. The Pennsylvania Department of Environmental Protection published a Climate Action Plan in 2021.





Vulnerability Study

The Extreme Weather Vulnerability Study focuses primarily on flooding, as it presents the greatest and most-likely risk to PennDOT assets, though the study also identifies temperature extremes, precipitation, sea-level rise, and hurricanes as additional extreme weather patterns to watch for.

Phase 1 of this program was completed in Spring 2017, resulting in a detailed report and Geographic Information System (GIS) product which covers historic patterns and future trends of flooding, a flood risk framework, strategies for resiliency, and steps for integrating and implementing the findings. The GIS tool highlights areas with an increased risk of flooding and may be used to identify locations where additional drainage capacity should be considered.

This study directly influences the risk management process by establishing revised risk assessment criteria for flooding, calculating risk levels based on historic data, and forecasting future risks for different scenarios.

Updating the PennDOT Design Manual

PennDOT is currently updating its design manual (DM4). It will include a new chapter focused on resiliency and risk mitigation. The chapter will allow PennDOT to compile various resiliency topics in one location.

Asset Management Systems

Since the last TAMP, PennDOT has been working on building robust management systems in order to make better decisions and to mitigate the risks of bad information. This investment in better data and systems is helping PennDOT build resiliency and mitigate the risks of uninformed decision-making. Chapter 7, Data and Systems, describes these systems in greater detail.

Resiliency of Design Task Force

The Resiliency of Design Task force was created as a part of the Extreme Weather Vulnerability Study. The task force was developed with the goal of reducing the risk of extreme weather events on the state transportation system. It employs innovative engineering, design, construction, and maintenance practices to proactively address some of the greatest risks facing Pennsylvania's infrastructure. The task force is valuable to the overall risk management and resiliency building process, as it intercepts and addresses many resilience-related risks.

Bridge & Pavement Risk Scores

In the 2019 TAMP, PennDOT developed a new methodology for calculating the risk scores of the state's bridge and pavement assets. These scores demonstrate the criticality of each asset in the event that the asset is closed for maintenance or repairs, often due to an adverse event. Both bridge and pavement scores are applied in the LLCC methodology to account for the cost of unmitigated risks. Asset risk scores are described in detail in Appendix D.

Agency-Wide Integration of Risk Management and Resiliency

PennDOT has many examples of the integration of risk management across divisions and programs. The use of the bridge and pavement risk scores for LLCC, the application of the findings from the Extreme Weather Vulnerability Study toward updated design guidelines, and commitment to robust engineering standards all represent ways in which PennDOT institutionalizes risk management and resiliency.

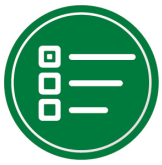
Risk Management Process

PennDOT has established processes for managing risks. They include key risk management activities shown below.

Risk Management Process

Identify

- Develop a full set of potential risks based on past TAM risks and newly identified risks.
- Rely upon the knowledge of agency experts, MPOs/RPOs, and examples from peer states.
- These risks span a number of different topics and levels of severity.



Prioritize

- Sort the risks into priority order by determining their likelihood, consequence, timeframe, and detectability.
- Risks are aligned with a specific level of severity using the PennDOT Risk Prioritization table.
- Only the risks with the highest severity are considered for further analysis.

Mitigate

- After prioritizing the risks, a set of mitigation alternatives are devised to prevent or limit the impact of each prioritized risk.
- Each risk is also assigned to a group which is responsible for overseeing the implementation of the mitigation strategies and actions.

Monitor

- The risk mitigation plan is implemented by the groups responsible within PennDOT.
- Progress of the mitigation plan is regularly monitored by the AMSC over the plan period, and it is adjusted as risks lessen or materialize.

Candidate Risks

In 2022, a candidate risk register was generated using the 2019 risk register, review of risks from other states, and a discussion of possible risks with PennDOT TAM leadership and staff. The following represents the list of 2022 candidate risks.

1. **Transportation funding** will be inadequate to sustain the current level of service due to increasing materials costs and increasing construction needs due to infrastructure age.
2. Increases in the **costs of labor and materials** could reduce the number of projects that can be undertaken and could threaten the ability to meet asset condition targets.
3. If industry trends continue, **trucking** will continue to grow. Increased heavy truck traffic reduces the service life of roads and bridges, which could deteriorate faster than projected, requiring increased investment to meet asset condition targets.
4. PennDOT and other agencies' **workforce** is turning over and there are not adequate systems or programs in place to capture the knowledge accumulated by experienced employees. This can lead to gaps in knowledge and skill sets resulting in inadequate decisions.
5. If the trend of **extreme weather** (mostly floods and landslides) continues, it will erode PennDOT and other agency's ability to perform regular maintenance activities and impact the ability to let new projects.
6. **Political influence in project selection** can undermine efforts to move the best projects forward at the lowest practical life-cycle cost.
7. **Ransomware and/or cyberattack** could result in loss of efficiency or impact the delivery of programs.
8. **Poor-quality construction and materials** lead to shorter asset life and higher life-cycle costs. There is a risk of not detecting poor workmanship or inferior/unproven materials, potentially compromising the quality and ultimately the service life of newly constructed assets.
9. **Aging information systems** with storage limits and insufficient data management practices could lead to incomplete support for good decisions.

The candidate risks were then presented in a survey to a group of TAM stakeholders including PennDOT staff from Bureau of Planning and Research, districts, and local partners. Survey participants were asked to rate each risk for likelihood and impact on a scale of 1-5 using PennDOT's risk prioritization framework (based on the FHWA risk framework). Survey participants also weighed-in on each risk and offered suggestions for mitigation strategies and actions. The following section provides PennDOT's 2022 risk register.

Categorization of Risk Severity

The identified risks are categorized into severity levels based on their likelihood and impact:

- **Severe Risk**
- **Very High Risk**
- **High Risk**
- **Medium Risk**
- **Low Risk**

Only the risks ranked High or above are selected for inclusion in the TAMP.

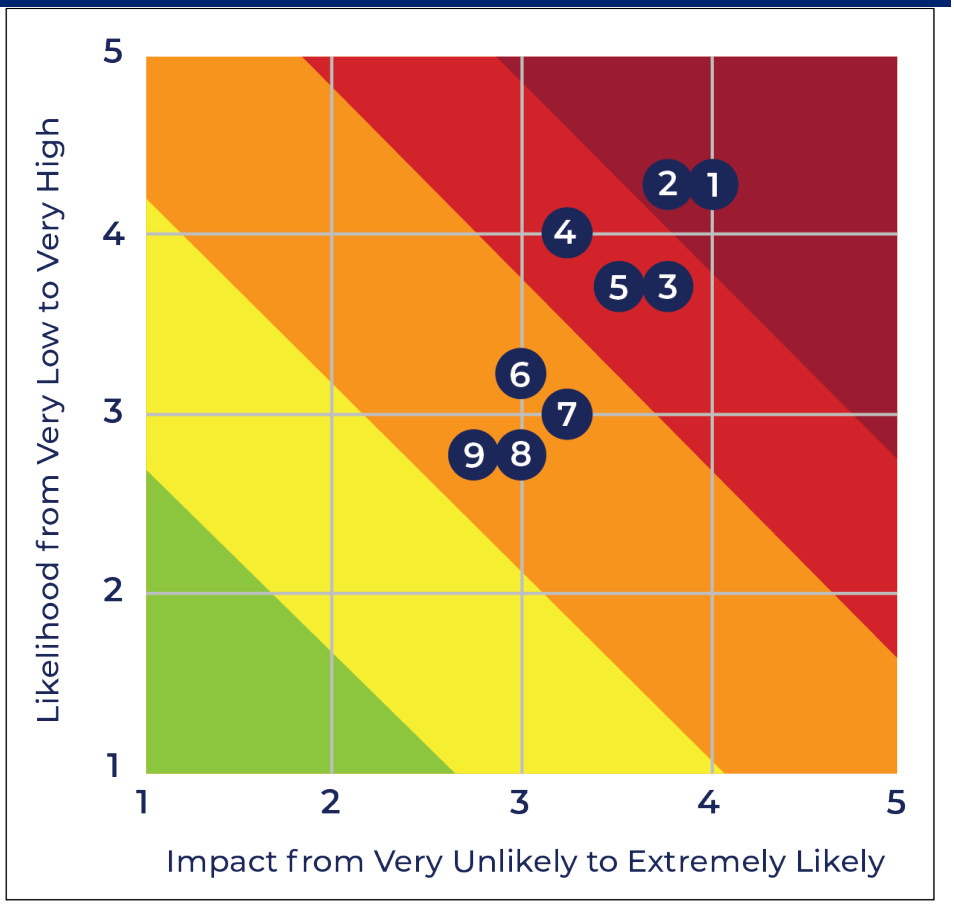


Figure 5-4. Risk Severity Ranking

The nine candidate risks are shown organized by severity in Figure 5-4. The risk numbers above correspond to the candidate risks listed on the previous page.

Risk Register

PennDOT generated a prioritized list of the highest risks based on their likelihood and impact ratings, shown below in Table 5-1.

Table 5-1. PennDOT TAM Risk Register

Risk (ID)	Risk Description	Likelihood	Impact	Owner
 **Inadequate funding**	Transportation funding will be inadequate to sustain the current level of service due to increasing materials costs and increasing construction needs due to infrastructure age.	**4.25**	**4.00**	Executive staff, AM staff
 **Labor & Material Cost Increases**	Increases in the costs of labor and materials could reduce the number of projects that can be undertaken and could threaten the ability to meet asset condition targets.	**4.25**	**3.75**	Executive staff, AM staff
 **Heavy Truck Traffic**	If industry trends continue, trucking will continue to grow. Increased heavy truck traffic reduces the service life of roads and bridges, which could deteriorate faster than projected, requiring increased investment to meet asset condition targets.	**3.75**	**3.75**	DOT materials division, AM staff
 **Loss of Workforce Knowledge**	PennDOT and other agencies' workforces are turning over and there are not adequate systems or programs in place to capture the knowledge accumulated by experienced employees. This can lead to gaps in knowledge and skill sets resulting in inadequate decisions.	**4.00**	**3.25**	Workforce development division, Executive staff

Risk (ID)	Risk Description	Likelihood	Impact	Owner
 **Extreme Weather**	If the trend of extreme weather (mostly floods and landslides) continues, it will erode PennDOT and other agencies' abilities to perform regular maintenance activities and impact the ability to let new projects.	**3.75**	**3.50**	Program center, Planning
 **Political Influence**	Political influence in project selection can undermine efforts to move the best projects forward at the lowest practical life-cycle cost.	**3.25**	**3.00**	AM staff
 **Cyberattacks**	Ransomware and/or cyberattack could result in loss of efficiency or impact delivery of programs.	**3.00**	**3.25**	IT
 **Poor Construction Quality**	Poor-quality construction and materials lead to shorter asset life and higher life-cycle costs. There is a risk of not detecting poor workmanship or inferior/unproven materials, potentially compromising the quality and ultimately the service life of newly constructed assets.	**2.75**	**3.00**	Executive staff
 **Aging IT Systems**	Aging systems with storage limits and insufficient data management practices could lead to incomplete support for good decisions.	**2.75**	**2.75**	IT, AMD

Mitigation Plan

Working with agency subject matter experts, PennDOT used its risk mitigation process to compile proposed mitigation strategies and actions for the priority risks, as shown in Table 5-2.

Table 5-2. Risk Mitigation Plan

Risk (ID)	Mitigation Strategy	Mitigation Action	Owner
 **Inadequate funding**	Apply innovative design that extends life of assets, Apply asset management techniques to maximize infrastructure life	• Continued executive buy-in and enforcement • Continued tool development and implementation	Executive staff, AM staff
 **Labor & Material Cost Increases**	PennDOT needs a future-proof mechanism to fund existing transportation assets	• Update the funding mechanisms of the DOT • Provide accurate condition forecasts at funding levels	Executive staff, AM staff
 **Heavy Truck Traffic**	Continuous asset improvements, Accurately reflect impacts	• Innovative materials • Updated deterioration modeling	DOT materials division, AM staff
 **Loss of Workforce Knowledge**	Workforce development, Workforce retention	• Provide heightened workforce development • Identify mechanisms to reduce the pay gap	Workforce development division, Executive staff
 **Extreme Weather**	Asset protection	• Identify vulnerable assets and address while under construction • Update design manuals to reflect environmental changes	Program center, Planning

Risk (ID)	Mitigation Strategy	Mitigation Action	Owner
 **Political Influence**	Enforce AM policies	• AM system updates to meet all user requirements • Education of the value of AM	AM staff
 **Cyberattacks**	Improve IT security	• Raise awareness of the risk and cost of cyberattacks • Maintain up-to-date IT software, technologies, and systems including support for strong IT personnel and consistent funding • Expand the security focus not only to employees but also to contractors and consultants.	IT
 **Poor Construction Quality**	Improve QC program	• Make information available from construction to other systems	Executive staff
 **Aging IT Systems**	Update IT systems	• Ensure all systems that generate management decisions are kept functional	IT, AMD

Summary of Assets Damaged by Emergency Events

The Federal Transportation Asset Management Plan Rulemaking part 667 requires the periodic evaluation of facilities repeatedly requiring repair and reconstruction due to emergency events.

PennDOT has summarized and analyzed the emergency events that occurred from January 1, 1997, through 2022, and found that while Pennsylvania has had significant damage throughout the state from past named and un-named storms, there has been no "contract-level" damage on two or more occasions on a single asset due to these events. Table 5-3 lists the declared emergencies in Pennsylvania that were a part of this analysis.

Table 5-3. Summary of Declared Emergencies

Year	Disaster Declaration Number	Declared Major Disaster	Federal Disaster Funding
2021	DR-4618	Pennsylvania Hurricane Ida	Yes
2020		Pennsylvania Tropical Storm Isaias	No
2018	DR-4408	Pennsylvania Severe Storms and Flooding	Yes
2016	DR-4929	Pennsylvania Severe Storms and Flooding	Yes
2013	DR-4030	Pennsylvania Tropical Storm Lee	Yes
2013	DR-4099	Pennsylvania Hurricane Sandy	Yes
2013	DR-4149	Pennsylvania Severe Storms, Tornadoes, and Flooding	Yes
2011	DR-4003	Pennsylvania Severe Storms and Flooding	Yes
2011	DR-4025	Pennsylvania Hurricane Irene	Yes
2007	DR-1684	Pennsylvania Severe Storms and Flooding	Yes
2006	DR-1649	Pennsylvania Severe Storm, Flooding, and Mudslides	Yes
2005	DR-1587	Pennsylvania Severe Storms and Flooding	Yes
2004	DR-1557	Pennsylvania Tropical Depression Ivan	Yes
2003	DR-1485	Pennsylvania Severe Storms, Tornadoes, and Flooding	Yes
1999	DR-1294	Pennsylvania Hurricane Floyd	Yes

Financial Plan and Investment Strategies

What's in this Chapter?

This chapter summarizes the cost of future programmed work to implement the investment strategies outlined in this asset management plan and expected levels of funding over a 10-year period.

- It describes **funding sources** and how they are used to support TAM at PennDOT for the NHS and for the state system, comprised of all state-maintained roads and provides a valuation of assets included in the TAMP.
- **The financial plan** shows PennDOT's planned and estimated available funds for TAM and anticipated allotments for bridges and pavements over the 10-year period of the TAMP.
- **The investment strategies** represent an approach to applying the resources described in the financial plan, using the treatment strategies described in the Life Cycle Planning chapter, managing the risks presented in the Risk Management chapter, and closing the performance gaps detailed in Performance Management chapter.

Financial Overview

PennDOT's Center for Program Development and Management (CPDM) is responsible for financial planning and works closely with the Asset Management Division, PennDOT Districts, and regional MPOs/RPOs to develop detailed forecasts of needed projects, estimate the future cost of work, and compare need with expected funding levels. Pennsylvania's Secretary of Transportation leads efforts to maximize efficiency and secure adequate funding for PennDOT to properly meet its responsibilities. PennDOT doesn't currently track spending specifically on NHS assets, so this chapter presents funding for the entire PennDOT-maintained system. PennDOT's expected expenditures for SFY2021-2022 are shown in Figure 6-1. This budget was summarized in the Transportation Revenue Options Commission report which predated the IIJA/BIL, and thus doesn't include the latest federal funding.

Expected Expenditures

PennDOT's overall budget for SFY 2021-22 is approximately $8.8 billion. Based on historical spending trends, 29% of the budget is dedicated to Highway and Bridge Capital Expenditures, 33% to Highway and Bridge Non-Capital Expenditures, 25% to Multimodal and 13% to Other.

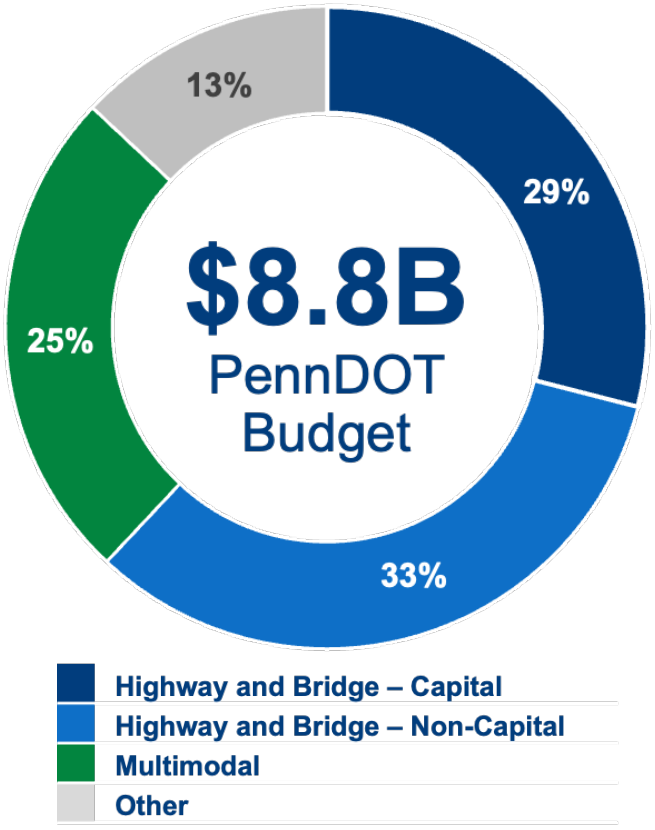


Figure 6-1. Overall PennDOT Budget - Expected Expenditures

Source: https://www.penndot.gov/about-us/funding/Documents/TROC-Meeting_03-25-21/1pgr-Where-Does-PennDOTs-Budget-Go_3-22-21.pdf; PennDOT – Governor's Budget Sources and Uses of Funds to Support 21-22 Programs

See Appendix E for a detailed breakdown of the '21-'22 budget that does not include IIJA funding. Note that values differ slightly between the budget and the TROC report.

PennDOT's *Transportation Program Financial Guidance* document, developed as part of the biennial process to update Pennsylvania's Twelve Year Program (TYP), Statewide Transportation Improvement Program (STIP) and each regional Transportation Improvement Program (TIP), describes available revenues and funding distribution strategies. The 2023 version of the Financial Guidance used to develop this TAMP includes funding from IIJA / BIL. The distribution of federal funds to bridge and pavement assets, particularly related to TAM, is largely dictated by the formulas defined in the Financial Guidance shown below in Figure 6-2. As mentioned in Chapter 4, the Asset Management Factor (AMF) also allows for funding flexibility to address areas of greatest need as identified by TAM and LLCC principles.

Financial Guidance Distribution Formula Summary

Category	2023 Financial Guidance	
NHPP	40% Bridge	3/4 Deck Area Non-Interstate NHS Bridges > 20 feet
		1/4 Bridge AMF*
	60% Highway	1/4 Non-Interstate NHS Lane Miles
		1/4 Non-Interstate NHS VMT
		1/4 Non-Interstate NHS Truck VMT
		1/4 Pavement AMF*
	Interstate -- 26/55ths of Apportionment in 2021; $50,000,000 additional in each subsequent year to a maximum of $1 billion for the entire program	
STP	40% Bridge	Deck Area Non-NHS State and Local Bridges > 20 feet
	60% Highway	1/2 Non-NHS Lane Miles
		1/4 Non-NHS VMT
		1/4 Non-NHS Truck VMT
State Highway	1/4 VMT	
	1/4 Truck VMT	
	1/2 Lane Miles	
State Bridge	Deck Area State bridges > 8 feet and Local bridges > 20 feet	
Federal Off-System Bridge	Deck Area State and Local Bridges > 20 feet	
HSIP	39:1 Crash Severity Weighting (Fatal and Injury Crashses versus Property Damage only Crashes) $500,000 base to each Planning Region, $35 million Statewide	
Rail	Statewide Program	
NHFP	Interstate Program	
CMAQ	Population with CMAQ Factor Multiplier Based upon regional air quality classification for non-attainment/maintenance counties	
TAP	Statewide Program; funds designated to urban areas distributed according to federal formula	
STP-Urban	Funds distributed according to federal formula	
Bridge Investment Program	60% NHS Bridges	3/4 Bridge Deck Area NHS and Interstate Bridges > 20 feet
		1/4 Bridge AMF*
	40% STP Bridge	Deck Area Non-NHS State and Local Bridges > 20 feet

Figure 6-2. 2023 PennDOT Financial Guidance Formula Allocations

Source: Pennsylvania 2023 Transportation Program Financial Guidance

Capital funding allocated to highway and bridge programs makes up a portion of the overall funding. Only a portion of capital funds are dedicated to asset management for PennDOT's pavements and bridges.

Expected bridge and pavement expenditures are taken from the MPMS based on the existing TIP that preceded the IIJA/BIL, which represented the best available data at the time. While data for the TAMP was processed in February 2022, the revised FY23 TIP which included IIJA/BIL funding was not finalized until October 2022. As such, the planned investments in this chapter do not take into account the new federal funding. However, the overall capital funding expected to be available comes from updated 2023 Financial Guidance and does take into account the IIJA/BIL funding. The Other funding category shown in Figure 6-3 below is the difference between total funding (including IIJA/BIL) and expected expenditures (excluding IIJA/BIL) and includes investments such as safety improvements, capacity adding projects, or investments in other assets. Once programmed, PennDOT expects some of the IIJA/BIL funding currently marked as Other to be dedicated to pavement and bridge.

Expected Allocation of Capital Funding

PennDOT's expected expenditures average $1.8 billion on pavements and $373 million on bridges over the period of the TAMP.

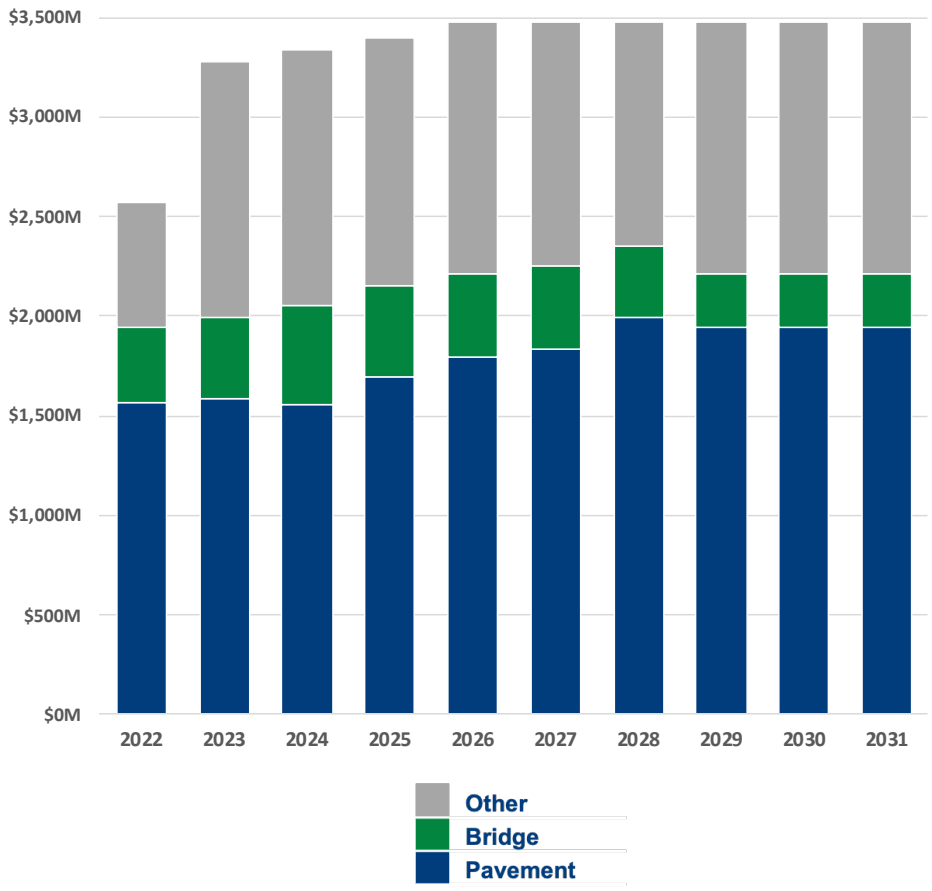
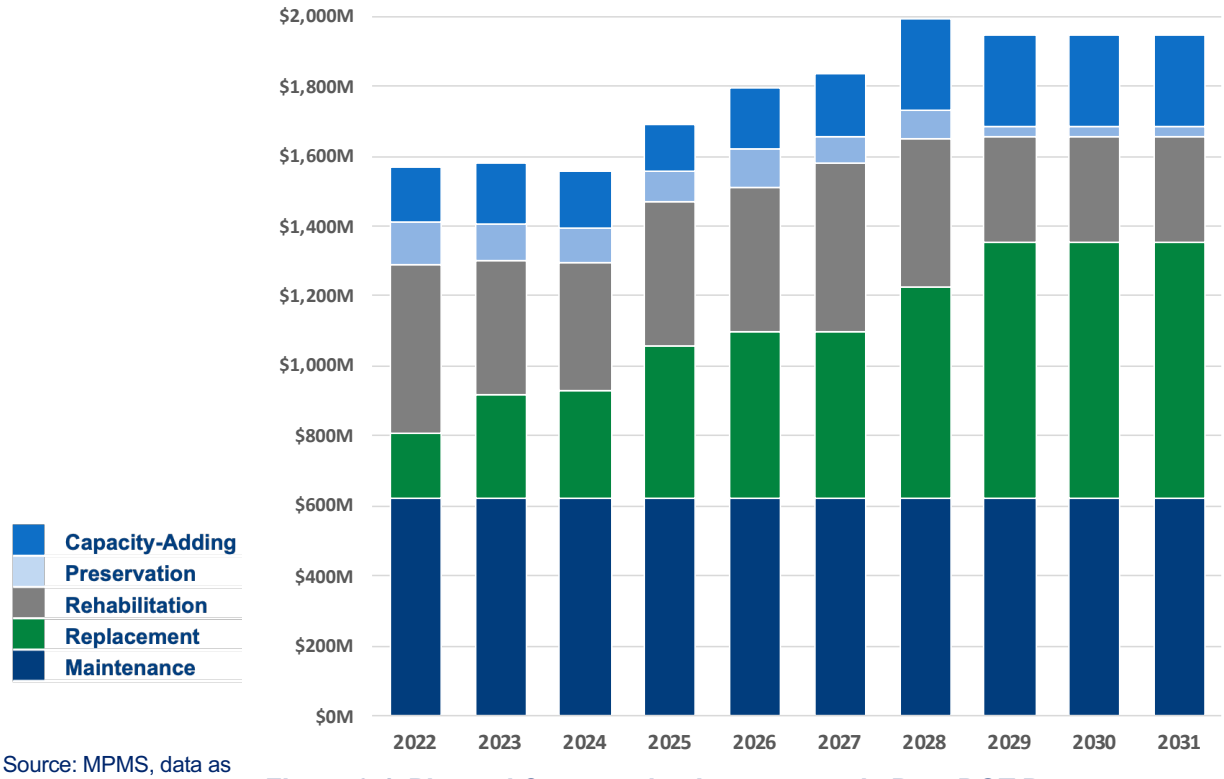


Figure 6-3. Expected Allocation of Capital Funding
Source: MPMS, data as of 2/10/22; 2023 Financial Guidance including IIJA/BIL

TAM Financial Plan

FHWA requires the TAMP to list planned investments over a ten-year period according to five work types. The TYP and STIP include projects delivering initial construction, reconstruction, rehabilitation, and preservation. Maintenance activities are programmed and prioritized under a separate program that is much more reactive, or based on shorter-term planning, than the STIP. Maintenance funding is split 80% to pavement and 20% to bridge based on historical spending from SAP. Summaries of planned investments by work type and year are presented in Figure 6-4 and Table 6-1 for pavement, without IIJA/BIL funding.

Planned Pavement Investments



Source: MPMS, data as of 2/10/22

Figure 6-4. Planned Construction Investments in PennDOT Pavement

Table 6-1. Planned Pavement Investments by Work Type ($ million)

Work Type	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Capacity-Adding	$154.9	$178.7	$163.9	$132.9	$172.2	$180.2	$262.4	$259.5	$259.5	$259.5
Preservation	$124.4	$100.4	$97.8	$86.0	$110.9	$73.9	$81.8	$26.0	$26.0	$26.0
Rehabilitation	$482.5	$384.7	$366.0	$416.5	$412.6	$483.1	$422.1	$304.4	$304.4	$304.4
Replacement	$183.7	$296.9	$308.7	$433.7	$474.9	$475.2	$606.3	$731.5	$731.5	$731.5
Maintenance	$622.0	$622.0	$622.0	$622.0	$622.0	$622.0	$622.0	$622.0	$622.0	$622.0
Total	$1,567.4	$1,582.6	$1,558.4	$1,691.1	$1,792.6	$1,834.4	$1,994.7	$1,943.4	$1,943.4	$1,943.4

While the values in Figure 6-4 and Table 6-1 show preservation work declining for pavement, PennDOT continues to transition to a LLCC programming approach and intends to make progress over the period of the TAMP. Current projects in the MPMS have been in the system for years and predate the increased focus on LLCC. As existing projects cycle through the system and are replaced by new projects selected under the LLCC approach, planned investments should reflect more preservation work.

In addition, preservation activities are not currently planned or programmed until 2-4 years before the work is needed. Thus, in the second and third portions of the TAMP period, preservation activities are largely unaccounted for. To stay consistent, PennDOT has chosen to show the actual data from our MPMS system, with the expectation that future improvements in the planning process and systems will reflect more accurate future preservation activities, which is expected to be significantly larger than current MPMS data shows.

Summaries of planned investments by work type and year are presented in Figure 6-5 and Table 6-2 for bridge, without IIJA/BIL funding. While the performance projections in Chapter 4 take IIJA/BIL funding into account for bridges, planned investments shown here in the TAMP for pavements and bridges are extracted from MPMS and do not reflect the new federal funding.

Planned Bridge Investments

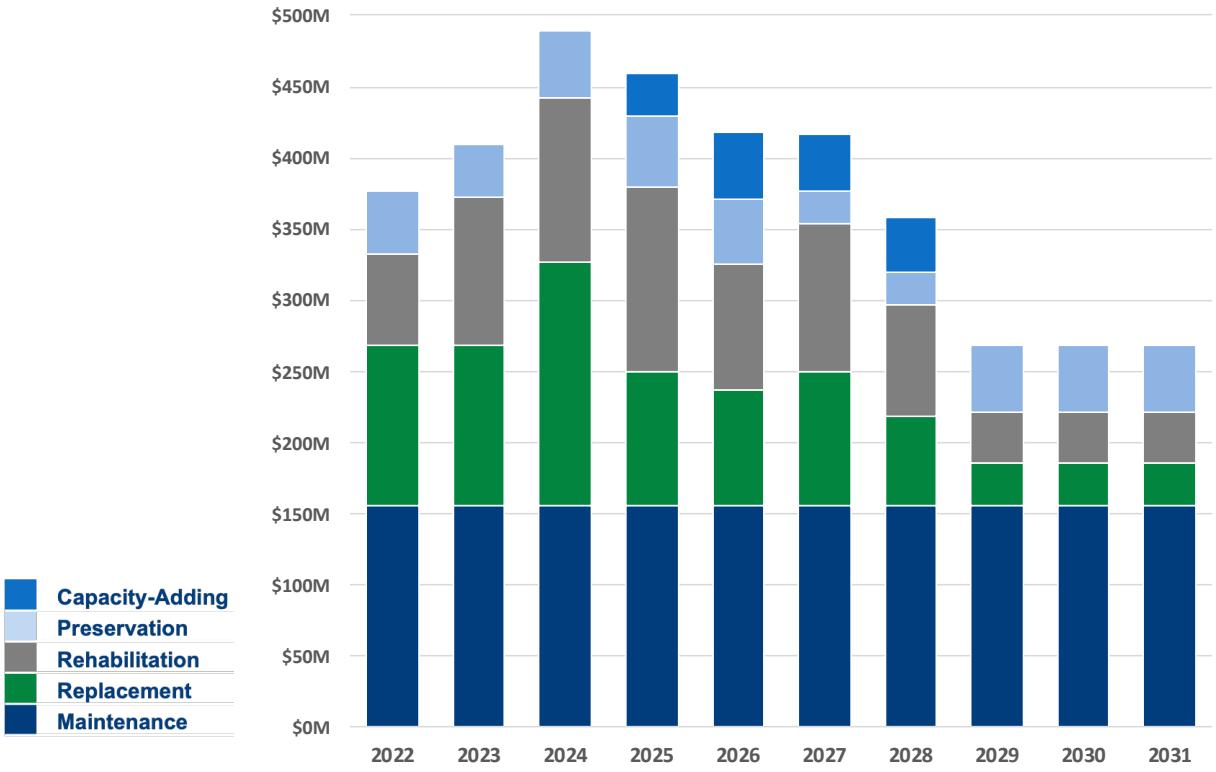


Figure 6-5. Planned Construction Investments in PennDOT Bridges

Source: MPMS, data as of 2/10/22

Table 6-2. Planned Bridge Investments by Work Type ($ million)

Work Type	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Capacity-Adding	$0.0	$0.0	$0.0	$30.0	$47.0	$40.0	$39.3	$0.0	$0.0	$0.0
Preservation	$43.7	$36.4	$47.2	$50.1	$46.3	$22.3	$21.7	$47.3	$47.3	$47.3
Rehabilitation	$65.0	$104.1	$116.1	$130.5	$87.2	$104.2	$78.3	$35.0	$35.0	$35.0
Replacement	$112.3	$113.2	$171.0	$94.0	$82.2	$94.5	$63.7	$30.5	$30.5	$30.5
Maintenance	$155.5	$155.5	$155.5	$155.5	$155.5	$155.5	$155.5	$155.5	$155.5	$155.5
Total	$376.5	$409.3	$489.8	$460.1	$418.2	$416.5	$358.4	$268.3	$268.3	$268.3

Funding Sources

PennDOT's overall budget for SFY 2021-22 is approximately $8.8 billion. Funding comes from a number of state and federal sources, summarized at a high level in Figure 6-6.

Expected Funding Sources

PennDOT's overall budget for SFY 2021-22 is approximately $8.8 billion. The PA Motor License Fund is the largest funding source, followed by federal funds for highway and bridge.

Source: TROC Report, July 30, 2021

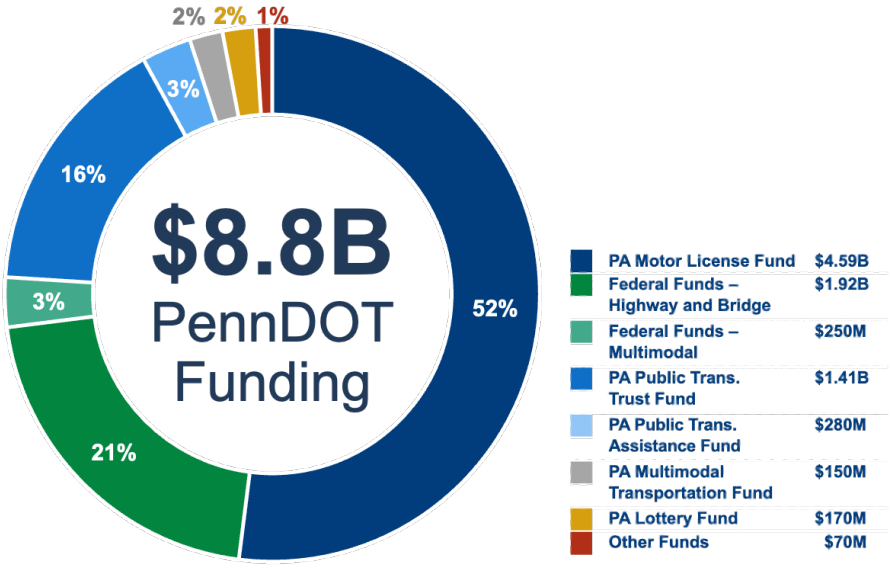


Figure 6-6. Expected PennDOT Funding Sources

PennDOT's capital program is funded by a variety of state of federal sources, summarized in Table 6-3. The funding sources estimate for the capital program in this TAMP includes additional funding allocated to Pennsylvania by the IIJA / BIL, but the planned investments predate the new federal funding.

Table 6-3. Funding Sources for Capital Program ($ million)

Type	Source	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Federal	NHPP	$991	$1,173	$1,196	$1,220	$1,245	$1,245	$1,245	$1,245	$1,245	$1,245
	STP	$468	$571	$582	$594	$605	$605	$605	$605	$605	$605
	HSIP	$101	$126	$129	$131	$134	$134	$134	$134	$134	$134
	CMAQ	$110	$114	$116	$118	$121	$121	$121	$121	$121	$121
	NHFP	$61	$57	$58	$59	$60	$60	$60	$60	$60	$60
	RRX	$7	$7	$7	$7	$7	$7	$7	$7	$7	$7
	BIL	$27	$465	$468	$470	$472	$472	$472	$472	$472	$472
	Subtotal	$1,765	$2,512	$2,556	$2,600	$2,645	$2,645	$2,645	$2,645	$2,645	$2,645
State	Highway	$479	$479	$508	$516	$555	$555	$555	$555	$555	$555
	Bridge	$323	$282	$277	$277	$276	$276	$276	$276	$276	$276
	Subtotal	$802	$761	$785	$793	$831	$831	$831	$831	$831	$831
Total	Total	$2,567	$3,273	$3,341	$3,393	$3,476	$3,476	$3,476	$3,476	$3,476	$3,476

** Includes Bridge Formula Funding, PROTECT, and Carbon Reduction Program*

Source: 2023 Financial Guidance including IIJA/BIL

Funding Needs and Context

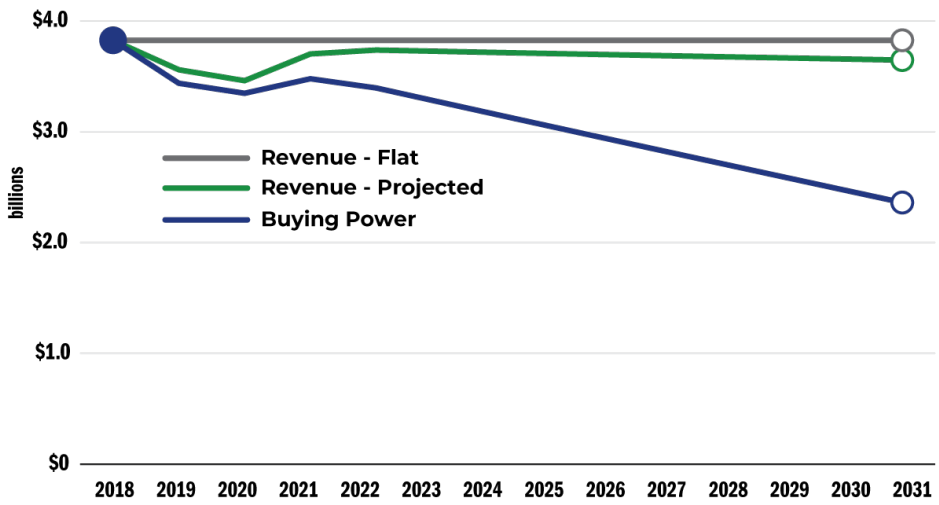
PennDOT faces near- and long-term funding challenges due to declining revenue sources and growing (and inflating) costs. Prior to and separate from the TAMP, PennDOT launched the Pathways Program to reimagine transportation funding and identify solutions. The first step in the Pathways Program is the Planning and Environmental Linkages (PEL) Study which defines transportation funding needs, identifies potential near-term and potential longer-term funding options that could be implemented, and lays out a proposed path for moving our transportation funding forward. The needs identified in the PEL study go beyond the state of good repair needs in the TAMP.

There are multiple factors that influence PennDOT's ability to meet the needs of the transportation system.

- **Declining gas tax revenue** due to increased fuel efficiency, adoption of electric vehicles, and reduced vehicle miles traveled (VMT)
- **Increasing emergency repair costs** due to rising frequency of extreme weather events resulting from climate change
- **Federal requirements** for minimum Interstate pavement conditions necessitate high funding levels for these assets
- **Federal gas tax** is not indexed to inflation and hasn't increased since 1993
- **Deferred maintenance** costs more because small problems devolve into larger problems
- **Inflation** erodes purchasing power – and transportation revenue is not indexed to inflation. An example of inflation's impact is shown in Figure 6-7.

Impact of Inflation and Reduced Consumption on Motor Fuels Revenue

Inflation and reduced motor fuel consumption will generate a $7.6 billion cumulative loss in buying power from FY 2021-22 through FY 2030-31



Source: TROC Report, July 30, 2021

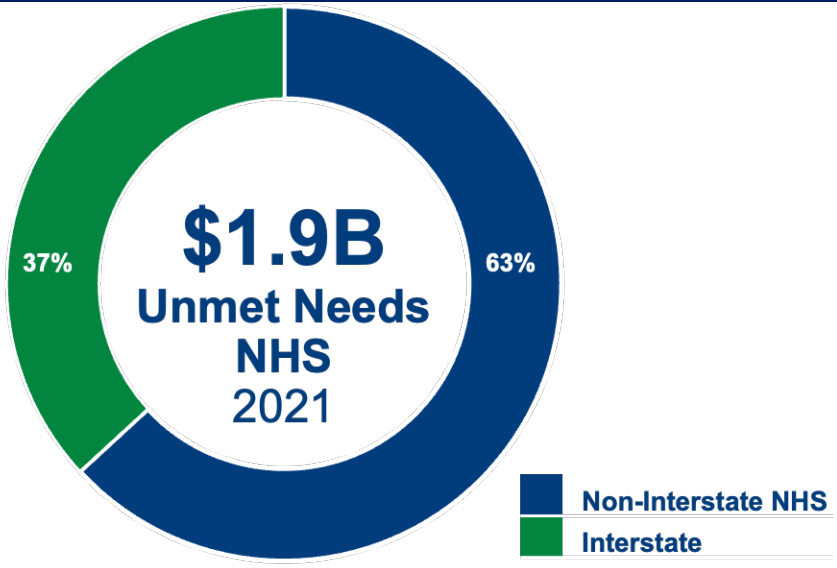
Figure 6-7. Impact of Inflation and Reduced Consumption

TROC Funding Gap

In addition to PennDOT's PEL Study, the Transportation Revenue Options Commission (TROC) was established by the Governor to develop a strategic proposal to close the transportation funding gap in Pennsylvania. The TROC proposal identified a $9.35 billion funding gap for all state transportation needs, including $8.15 billion in total unfunded needs for highways and bridges. Note that this gap was calculated based on cyclical needs and is distinct from the funding required to achieve the desired state of good repair. Funding needs on the NHS are summarized in Figure 6-8 and total transportation funding needs are summarized in Table 6-4. While the TROC report is comprehensive and focuses on the whole transportation system, this TAMP uses PAMS and BAMS to identify performance gaps on NHS pavements and bridges.

TROC Estimated Funding Gap

Unmet needs on the NHS total $1.9 billion in 2021, including $700 million on the Interstate and $1.2 billion on non-Interstate NHS roadways.



Source: TROC Report, July 30, 2021

Figure 6-8. Unmet NHS Funding Needs

Table 6-4. TROC State-Level Transportation Unmet Funding Need Forecast ($ million)

Work Type	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
NHS	$1,900	$1,995	$2,095	$2,199	$2,309	$2,425	$2,546	$2,673	$2,807	$2,948
System Modernization and Upgrades	$2,100	$2,205	$2,315	$2,431	$2,553	$2,680	$2,814	$2,955	$3,103	$3,258
Non-NHS and Maintenance and Operations	$4,100	$4,305	$4,520	$4,746	$4,984	$5,233	$5,494	$5,769	$6,058	$6,360
Facilities	$50	$53	$55	$58	$61	$64	$67	$70	$74	$78
Multimodal	$1,200	$1,260	$1,323	$1,389	$1,459	$1,532	$1,608	$1,689	$1,773	$1,862
Total	$9,350	$9,818	$10,308	$10,824	$11,365	$11,933	$12,530	$13,156	$13,814	$14,505

Source: TROC Report, July 30, 2021

TROC Recommendations

The TROC's goal is to bring revenue back in sync with the costs of sustaining Pennsylvania's essential multimodal transportation system, and to fairly distribute those costs to those who directly and indirectly benefit from the system. The TROC report builds on the results of the PEL Study and recommends a number of funding solutions, framed within the context of state government funding. The following is a summary of the proposed key actions that will improve funding for transportation assets.

Tolling can generate revenue from corridor tolling and managed lanes (limited lane tolling). Corridor tolling of Interstate highways and expressways based on distance traveled is both feasible and fair.

Road User Charges consist of two sources: Mileage-Based User Fees (MBUF) and an Electric Vehicle (EV) MBUF Pilot. MBUF presently appears to be the best long-term funding solution for Pennsylvania.

Redirection of Funding by eliminating transfers from the Motor License Fund (MLF) to the Pennsylvania State Police.

Fees from new and increases to existing fees (Vehicle Registration Fee, Electric Vehicle Fee, Vehicle Lease Fee, Vehicle Rental Fee, Transportation Network Company (rideshare) Fee, Aircraft Registration Fee, and Goods Delivery Fee)

Taxes can generate additional funds from increases to the present vehicle sales tax and the jet fuel tax, as well as indexing the gas tax to inflation.

Other proposed revenue sources include an Ad Valorem Vehicle Tax (for passenger vehicles only) based on the value of the vehicle. Also in this category are two revenue offsets, one that reflects the reduction in registration fees associated with those paying the Ad Valorem instead, and the other reflecting the Phase 3 elimination of the gas tax.

The TROC report proposes a set of new funding sources to address future unmet needs over three phases, summarized in Table 6-5. By Phase 3, the needs should be fully met by the new revenue sources. The primary component of this plan is a mileage-based user fee that would eventually replace the state gas tax while providing significantly more funding.

Table 6-5. Phased TROC Funding Sources – Estimated Additional Revenue by Revenue Type

Proposed Revenue Type	Phase 1 (Years 1 and 2)	Phase 2 (Years 3 and 4)	Phase 1 (Years 5+)
Road User Charges (MBUF)	$2,000,000	$2,122,000	$8,932,316,000
Tolling	$0	$2,705,040,000	$2,543,716,000
Funding Redirection	$673,000,000	$609,000,000	$545,000,000
Fees	$1,712,420,000	$1,991,864,000	$2,072,438,000
Taxes	$635,167,000	$786,798,000	$992,343,000
Other	$450,000,000	$468,180,000	$487,095,000
Eliminate Gas Tax	$0	$0	-$4,088,301,000
Total	$3,472,587,00	$6,563,004,000	$11,484,607,000

Source: TROC Report, July 30, 2021

The Pathways PEL Study is a planning document, so it can act as a resource for the TROC as they work to identify which funding options will best meet Pennsylvania's needs and eliminate the state's reliance on the gas tax. As new information and data are collected and analyzed, the PEL can be updated. Down the road, developments within the TROC could be incorporated into an update of the PEL. In this sense, the PEL can act as a living document for evaluating addition funding options for implementation.

The TROC report was based on the best data available at the time, but more precise forecasting of conditions and needs are now possible. PennDOT has invested heavily in overall asset management systems, with the dividend being specific asset level need for the entirety of the road and bridge inventory. PennDOT will be utilizing these systems for future submission of our annual consistency report and TAMP and making the systems available for other DOT's to utilize as well.

Asset Valuation

Asset value is an approximation of the benefits a physical asset is expected to yield. Together with other supporting measures, asset value helps define the scope of Pennsylvania's investment in roads and bridges, and helps establish the level of investment required to sustain those assets over time. The figure below summarizes the replacement cost and current asset value for bridges and pavement. Separate totals are shown for all PennDOT assets and for the NHS. As shown in Figure 6-9 and Table 6-6, the current value of PennDOT's bridges and pavement total $191.4 billion and the value of NHS bridges and pavements is $87.9 billion.

Pavement and Bridge Asset Valuation

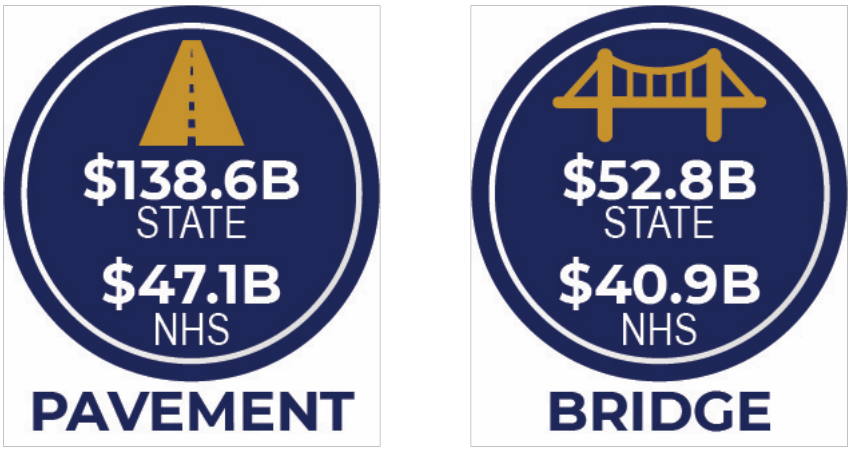


Figure 6-9. Summary of Current Asset Value

The current value of Pennsylvania's pavement and bridges is based on the cost of replacing these assets adjusted based on their expected remaining life. PennDOT's bridge and pavement assets are valued at $191.4B

Table 6-6. Replacement Value and Current Value by System

System	Replacement Cost ($B)	Current Asset Value ($B)
Pavement		
All NHS	$55.9	$47.1
All PennDOT	$187.8	$138.6
Bridge		
All NHS	$71.8	$40.9
All PennDOT	$92.3	$52.8
Total		
All NHS	$127.7	$87.9
All PennDOT	$280.1	$191.4

Source: Bridge data from BMS2, using December 31, 2020 data; asset value calculated in 2022 TAMP Bridge Asset Valuation spreadsheet. Pavement data from RMS, using December 31, 2020 data; asset value calculated in 2022 TAMP Pavement Asset Valuation spreadsheet

For this plan asset value is based on the current replacement cost of Pennsylvania's roads and bridges, adjusted downward (depreciated) to account for remaining asset life. This approach is consistent with international practice, as well as recent U.S. TAM guidance developed through National Cooperative Highway Research Program (NCHRP) Project 23-06 on this topic. However, the calculation differs from that presented in the Commonwealth of Pennsylvania Comprehensive Annual Financial Report (CAFR). The value presented in the CAFR is based on historic costs rather than current replacement cost, combines other assets besides bridges and pavements, and cannot be easily subdivided by NHS and non-NHS assets. Note that remaining life data were not available for NHS pavements owned by PTC and local entities and thus the current value of those assets was not depreciated.

PennDOT is committed to making the best investments of its limited resources to maximize the useful life of its bridges and pavements, however current investment levels are not keeping pace with system deterioration.

- **PennDOT NHS pavement assets** have an average life expectancy of approximately 65 years. This figure is based on 20 years of data comparing the difference between the year of construction and the year of reconstruction of roadway segments.
- However, the remaining life of a pavement section is estimated based on its current condition rather than its actual age.
- The unit replacement cost for Interstate pavement was assumed to be $2.6 million per lane mile and the cost for Non-Interstate NHS pavement was assumed to be $2.1 million per lane mile.
- To calculate value, the remaining service life was calculated for each pavement section in the network using PennDOT's Pavement Asset Management System (PAMS) described in Chapter 7.
- Current asset value was calculated as the remaining life divided by 65 years multiplied by the replacement cost.
- **PennDOT NHS bridges** have an average life expectancy of approximately 85 years. This figure is based on 10 years of data on age of structure at time of replacement.
- However, the remaining life of a bridge or culvert is estimated based on its current condition rather than its actual age.
- To support this calculation the minimum rating of a bridge or culvert's components is used to calculate value for each bridge and culvert.
- The unit replacement cost for bridges was assumed to be $800 per square foot of deck area for bridges and $650 per square foot of deck area for culverts.
- Given a life expectancy of 85 years, the value of bridge assets depreciates at approximately 1.25 percent per year.
- The 2018 average investment was below 1.0 percent of current value—less than is required to maintain bridges at the desired state of good repair.

Investment Strategies

PennDOT's investment decision-making process has been evolving. PennDOT's processes rely heavily on local partner's input as well as districts. Over the recent past, a concerted effort to move from a worst-first policy for asset investments towards a lowest life cycle cost (LLCC) approach has been underway. PennDOT is currently using federal guidance along with state guidance to combine asset performance, LLCC, financial resources, and risk management to optimize the performance of assets given available resources. Figure 6-10 summarizes the key tenets of asset management and how they fit together.

Figure 6-10. Key Tenets of Asset Management

Investment Strategies from 2023 General and Procedural Guidance

PennDOT's *General and Procedural Guidance* document provides detailed direction for MPOs/RPOs as well as PennDOT staff for selecting projects in a manner that complies with state and federal requirements and is consistent with statewide priorities. PennDOT's 2023 General and Procedural Guidance was used in developing the 2023 TYP/TIP and describes the TAMP along with directions on using BAMS and PAMS and the shift from worst-first programming to LLCC. Key elements of the 2023 guidance are listed below. While the 2025 General and Procedural Guidance is expected to remain largely unchanged, PennDOT is developing language to require the use of BAMS and PAMS to achieve LLCC-based project selection starting with the 2027 General and Procedural Guidance.

Overview

To the maximum extent practicable, project selection, evaluation, and prioritization has been designed to be a clear and transparent process. PennDOT District and MPO/RPO staff work together to identify risk-based candidate projects for the highway/bridge portion of the 2023 TYP/TIP that work toward the overarching goals of managing to LLCC and achieving a desired state of good repair, as well as national and state transportation goals. The national goals, identified in 23 U.S.C. 150(b), include:

- **Safety** – To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.
- **Infrastructure Condition** – To maintain the highway infrastructure asset system in a state of good repair.
- **Congestion Reduction** – To achieve a significant reduction in congestion on the National Highway System.
- **System Reliability** – To improve the efficiency of the surface transportation system.
- **Freight Movement and Economic Vitality** – To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development.
- **Environmental Sustainability** – To enhance the performance of the transportation system while protecting and enhancing the natural environment.
- **Reduced Project Delivery Delays** – To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices.

Based on the funding projected to be available for pavement and bridges, life cycle planning, risk management and resiliency building, and funding levels scenarios that are most likely to be available, investments are being made to determine the strategy most feasible to maximize performance of the assets for the given amount of funding available.

Project Selection: Carryover Projects

The initial focus in the investment decision-making process is on carryover projects, which must be carried forward onto the 2023 TIP from a previous TIP. These include:

- Projects that are still advancing through the project delivery process
- Projects with unforeseen cost increases
- Projects with anticipated advance construct (AC) conversion

Despite PennDOT's shift in project prioritization discussed below, these previously programmed projects should remain on the TIP to retain the investment already made in their planning and project development.

Highway/bridge carryover project scopes, costs, and schedules will be reviewed and updated based on information obtained through project management and from local input/outreach sources such as the State Transportation Commission (STC) Public Survey, MPO/RPO public involvement, PennDOT Connects (PennDOT's municipal outreach initiative), and Environmental Justice Core Elements and Analysis. PennDOT Districts will update this project information in PennDOT's Multimodal Project Management System (MPMS) and share this information with the MPOs/RPOs and PennDOT CPDM.

Project Selection: New Projects

Next, PennDOT District staff and MPO/RPO staff meet to evaluate highway/bridge project ideas or additional needs that have been identified through the statewide and regional Long Range Transportation Plans (LRTPs), transportation performance measures, the TAMP/PennDOT's asset management systems, and local public involvement. PennDOT CPDM will ensure that adequate coordination meetings are occurring and appropriately documented for the STIP/TIP submission.

Based upon this continued coordination throughout the TIP development process, PennDOT District staff will create project scopes, costs, and schedules in MPMS for the mutually agreed-upon new projects. To allow for open discussion and collaboration, cooperative discussions about candidate projects under consideration should occur between the MPOs/RPOs and the Districts prior to preparation of a fiscally constrained project list.

While this is true for developing the new STIP or TIPs during the biennial STIP/TIP update cycle, when the Districts add new projects to the STIP/TIPs between the biennial STIP/TIP cycles, the projects added are identified as "Carryover Projects". This can reduce the number of "New Projects' that can be added during the biennial STIP/TIP cycle.

Managing FHWA Pavement and Bridge Condition Performance Measures (PM2)

PennDOT Bureau of Maintenance and Operations (BOMO) analyzed PA NHS pavement and bridge data and made overall projections regarding future asset conditions. PennDOT's pavement and bridge condition targets for the NHS system are included in PennDOT's TAMP, which also documents PennDOT's asset management approach of managing to lowest life cycle cost (LLCC).

While the federal measures currently only focus on the NHS, PennDOT and the MPOs/RPOs must ensure that projects are selected through LLCC and risk-based methodologies and prioritized for the entire state-owned and locally owned Federal-Aid network. In coordination with PennDOT Districts, the MPOs/RPOs document how their program development process:

- Relies on data for regional highway and bridge system assets
- Considers existing conditions on the NHS
- Considers projected future conditions on the NHS
- Develops strategies/priorities to continue to improve the system at the LLCC
- Informs plans, programs, and project implementation as part of annual budgets

Implementation of improved asset management practices will begin with the Interstate Highway System, then progress to the rest of the National Highway System (NHS) and other state-owned and local networks. This will help PennDOT and the MPOs/RPOs to select and prioritize projects that enhance the overall performance of the entire network.

Transition to LLCC Methodology

In recent years, PennDOT successfully reduced its backlog of Structurally Deficient (SD) bridges through a focused investment strategy that prioritized rehabilitation and replacement projects for SD structures. This approach is known as "worst-first" programming.

While this strategy was successful in terms of reducing the number of SD bridges (now referred to as "poor"), worst-first programming prioritizes work on the poorest-condition structures at the expense of preventative maintenance on other structures in better condition. The previous SD Bridge Risk Score was utilized to prioritize these project selections, as it utilized a combination of project-level risk and structure condition without regard to network level risk.

PennDOT has transitioned from the previous focus on poor to a true overall risk-based prioritization and selection of projects based on LLCC. New Pavement and Bridge Risk Scores have been developed to assist in prioritizing preservation, rehabilitation, and replacement projects. These scores do not include condition in the calculation so that risk can be addressed independently, and each asset is ranked on the same scale. It should be noted that risk scores cannot be compared between asset classes at this time. Please see Appendix D for more information regarding the Pavement and Bridge Risk Score calculations.

Additionally, PennDOT is enhancing its BAMS and PAMS to allow the Districts and MPOs/RPOs to review and analyze investment decisions and make condition projections based on available funding levels. PennDOT has adopted commercial level BAMS and PAMS for use in PennDOT's Central Office in order to comply with 23 CFR 515. The Asset Management Division is working to make these systems available to District Bridge Engineers, Pavement Engineers, and MPOs/RPOs.

Until complete roll-out of these systems is complete, Asset Management staff will provide Districts and MPOs/RPOs with BAMS- and PAMS-recommended treatments to achieve LLCC to the extent budgets allow.

Once the system rollouts are complete, a guidance document for the Districts and MPOs/RPOs regarding the transition to LLCC programming will be developed by PennDOT Central Office Asset Management and CPDM. Key points of the document will include general guidance on:

- Transitioning from worst-first to LLCC
- Considering new asset condition targets and metrics and how to apply them
- Maintaining TIP program development (current planned work will be maintained in order to preserve planning efforts and development dollars)
- Applying the new methodology to TIP adjustments
- Moving toward "on-cycle" programming with the next TYP
- Utilizing the PAMS/BAMS tools to assist in TIP/TYP project selection
- Training on the software systems and interim tools

Roll-out of the guidance documents will be performed by both PennDOT Asset Management and CPDM through MPO/RPO meetings and calls, BAMS and PAMS implementation meetings, engineering and county maintenance meetings, and workshops as needed.

Prioritize Preservation over Expansion

One PennDOT strategy to deliver optimal asset performance with the limited funding resources available is to maximize the amount of funding dedicated to maintaining existing infrastructure (vs. expanding the transportation system). Therefore, PennDOT aims to limit capacity-adding projects to 3 percent of its total construction budget, with a maximum of 5 percent allowed. The proportion of replacement, rehabilitation, and preservation projects is determined by output of PennDOT's asset management systems combined with professional engineering judgment.

Investment Strategies Aligned with Other PennDOT Plans

TAM investments in NHS pavements and bridges are aligned with objectives and actions in other Pennsylvania plans. Figure 6-11 illustrates how the plans work together to deliver optimal asset performance given resources available.

Figure 6-11. Alignment of PennDOT Plans

Some of the objectives that will guide asset investments include:

- **Performance** – Improve the condition and performance of transportation assets. *Pennsylvania's 2045 Long-Range Transportation Plan (LRTP)*.
    - Continue to integrate enhanced asset management approaches and methods with project planning and programming
    - Expand and/or build upon existing technical assistance and education to local communities and MPOs/RPOs.
- **Resilience** – Strengthen Pennsylvania transportation resilience to climate change and other risks and reduce the environmental impacts associated with transportation improvements. *Pennsylvania's 2045 Long-Range Transportation Plan (LRTP).*
    - Employ resiliency measures/actions to ensure long-term system stability.
    - Evaluate projects for their expected climate change and resiliency impact and implications.
    - Improve environmental stewardship during and before project construction.

- **Prioritize investment** in critical urban freight corridors and critical rural freight corridors. *Pennsylvania's 2045 Freight Movement Plan (FMP).*
- **Add pedestrian safety considerations** in project evaluation and prioritization. *2022 State Highway Safety Plan.*
- **Invest to address the impacts of a changing climate**. *2021 Pennsylvania Climate Action Plan.*

Anticipated Outcomes of Investment Strategies

The LLCC-based project selection described in this section supports progress toward achieving the goals and objectives described in Chapter 1, Introduction. The investment strategies also serve to mitigate the stated risks that were identified as part of the risk analysis described in Chapter 5, Risk Management. The top risks are funding shortfall, inflation, increasing truck volume on Pennsylvania roads, workforce shortages, and extreme weather. PennDOT's adoption of LLCC effectively mitigates financial risks by maximizing the utility of the funding available. A further step to greatly enhance and accelerate this transition would be to help MPOs/RPOs to adopt LLCC in project selection and decision-making processes. It is recognized that damage from extreme weather events will have to be funded and repaired regardless of planned investment. However, PennDOT has revised its planning and programming processes to mitigate extreme weather event risks, by adding resiliency consideration to programming processes, and undergoing vulnerability assessments.

In the long term, funding levels are projected to be insufficient to maintain PennDOT's defined state of good repair. As discussed in the performance gap analysis, if funding remains inadequate, meeting the FHWA minimum condition thresholds and preventing a performance gap from materializing could require non-LLCC, worst-first project selection as a short-term strategy. This would result in short term gains to keep asset conditions under the FHWA minimum condition thresholds but in the long term make Pennsylvania's bridge and pavement assets in worse condition. To maintain our defined state of good repair, additional funding will be needed as described in detail in the PEL Study and TROC report.

New Capabilities to Improve Investment Decision-Making

PennDOT's vision of comprehensive asset management systems is being realized through the current effort of creating "Project Builder." This component is designed to take available information from core PennDOT bridge and pavement asset management systems, as well as other existing and future management systems, such as the environmental management system, and combine them with GIS and LLCC logic to make it possible to identify and build optimal projects. Some of the elements of this tool include:

- Combining needs in a geographic area to compose projects
- Multi-objective decision analysis where users can place weights on all objectives which are then applied to prioritize projects
- Visualizations that compare program and project options
- Options for improved scenario planning at LLCC

An example map view from Project Builder is shown in Figure 6-12. More information on these capabilities is described in Chapter 7. Data and Systems.

Project Builder Map View

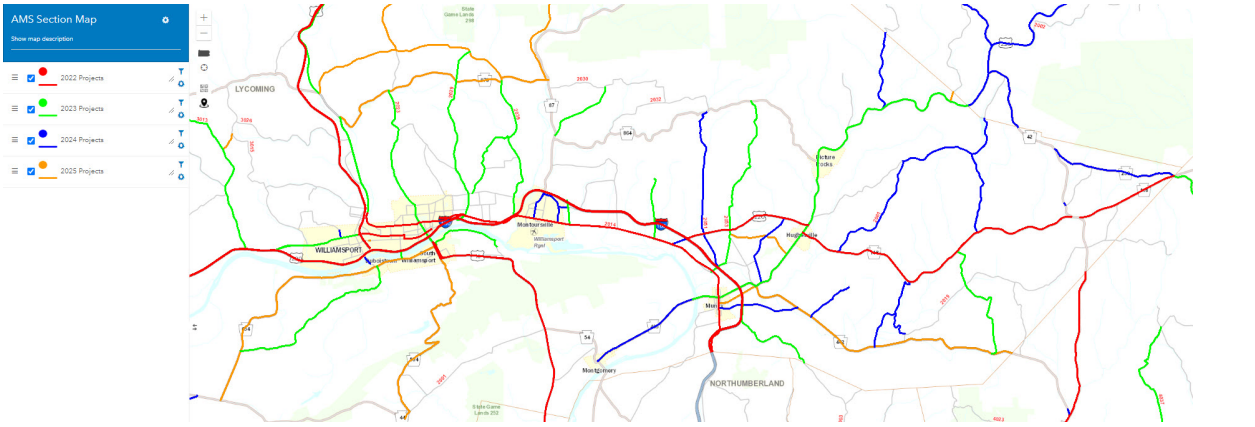


Figure 6-12. Project Builder Map View

TAMP Consistency Documentation

One key method for measuring the implementation of TAM at PennDOT is comparing the investments by work types selected through the life cycle planning process with the actual programmed investments for the previous year. This reality check illustrates the alignment between the TAM Processes (life cycle planning, risk management, financial planning, investment strategies) and existing business processes. As is PennDOT transitioning to using LLCC to select projects, many of the existing planned projects are carryovers that were not selected using LLCC.

Table 6-7 below shows the planned investments for 2020 vs. the reported actual spending by work type.

PennDOT's FFY 2020 investments in capacity-adding, reconstruction, rehabilitation, preservation, and maintenance projects were generally consistent with its planned levels of investment, although the COVID-19 pandemic temporarily impacted both the ability to perform work and the funding streams that pay for the work.

Table 6-7. Consistency Summary Table

Work Type	Pavements		Bridges	
	2020 Planned	2020 Actual	2020 Planned	2020 Actual
Maintenance	$466,487,295.6	$466,487,295.6	$310,991,530.4	$310,991,530.4
Preservation	$146,895,828	$132,114,759.9	$81,470,945.0	$37,197,965.7
Rehabilitation	$487,753,443	$434,372,652.1	$123,917,961.0	$114,450,739.1
Reconstruction	$110,928,094.0	$206,187,981.4	$189,050,701.0	$86,609,205.3
New Construction	$221,391,015.0	$178,407,511.2	$73,121.0	$18,272,591.7
Total	$1,433,455,675.6	$1,417,570,200.3	$705,504,258.4	$567,522,032.1

Source: PennDOT TAMP Implementation Documentation, July 29, 2021. Data as of 6/4/21 from MPMS (planned) and ECMS (actual)

Data and Systems

What's in this Chapter?

This chapter presents how PennDOT manages its data and uses management systems to support TAM decision-making and operate its TAM program. Good data and systems provide a strong foundation for transportation asset and performance management. PennDOT has invested heavily in asset management systems, building support for good TAM decisions. The following highlight what is presented in this chapter.

- **Data Practices**
  - Pavement
  - Bridge
- **Asset Management Systems**
  - Roadway Management System
  - Bridge Management System Database
  - Pavement Asset Management System
  - Bridge Asset Management System
  - Project Builder

PennDOT has embarked on an asset management journey to improve its decision-making processes for resource allocation and improve the efficiency and effectiveness of how projects and actions deliver value to its customers. Figure 7-1 communicates the key elements of the approach.

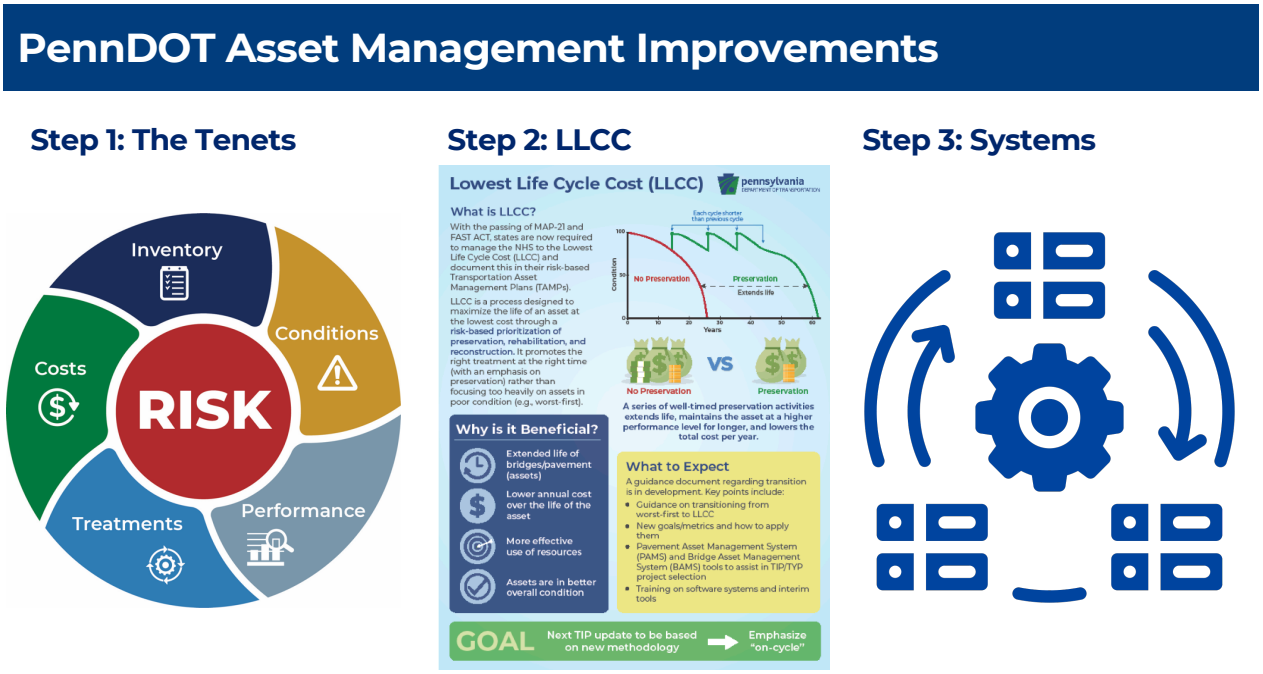


Figure 7-1. PennDOT Asset Management Approach

In step one, PennDOT is working to adopt the basic tenets of asset management into its business practices. In step two, this focus is on developing a lowest life cycle cost strategy and educating the PennDOT and Business Partner communities. In step three, the agency is building reliable data and robust tools to support better decision-making. All three of these steps are occurring simultaneously and are in different stages of development in PennDOT. The steps highlight the sequence of focus for TAM implementation throughout the agency and with PennDOT's partners.

Data Practices

Good data leads to good decisions so PennDOT has established processes for acquiring and managing data for its asset management needs. PennDOT uses the best available data and bridge and pavement management systems meeting the requirements of 23 CFR 515.17 to analyze the condition of NHS pavements and bridges for the purpose of developing and implementing the TAMP. The following describes the key data collection activities that support PennDOT management of pavement and bridge assets.

Pavement and Bridge Data Collection

Pavement Data Collection

PennDOT has long-established processes for collecting, storing, and analyzing pavement data that spans over 40 years. For data collection, PennDOT contracts with a vendor to collect data annually on 100 percent of the PennDOT-owned NHS pavements and 50 percent of the non-NHS PennDOT-owned system, thus completing data collection on all non-NHS assets every two years. This schedule translates to approximately 28,500 segment-miles surveyed per year. Survey data is collected using transverse and single-point laser profilers, as well as high-definition video images. The system generates semi-automated condition ratings for pavement distresses, which are collected using tenth-mile increments. In addition, PennDOT performs quality assurance surveys using its own staff and equipment.

After survey sections are completed, the data are post-processed, quality assurance / quality control (QA/QC) checks are performed, and the pavement data are batch-uploaded into PennDOT's custom pavement database, Roadway Management System (RMS). This is the linear reference system and system of record and core database for PAMS. PennDOT's Pavement Asset Management System (PAMS) pulls data from RMS annually to use for updated pavement modeling and forecasting.

Bridge Data Collection

PennDOT has a similarly long-established processes for collecting, storing, and analyzing bridge data. Condition data on Pennsylvania bridges is collected by certified bridge inspectors from both an in-house and consultant workforce. The inspections are typically performed biennially, but can vary in time from months to 4 years depending on structure condition. Inspection data is captured using an in-house mobile platform called iForms and is uploaded to PennDOT's custom Bridge Management System version 2 database (BMS2). This database serves as PennDOT's system of record for all bridge inspection data and history, and is the core database for PennDOT's bridge asset management system, BridgeCare. BMS2 is also integrated with PennDOT's SAP-

based maintenance system and can push recorded inspection issues to maintenance personnel.

BMS2 houses inspection data for:

- All PennDOT-owned bridges greater than 8 feet long;
- All structures greater than 20 feet long that are owned by other state entities (PTC, Department of Conservation and Natural Resources [DCNR], etc.);
- Locally owned structures greater than 20 feet long; and
- Other assets that require inspections regardless of owner, such as high mast lights, retaining walls, noise walls, and tunnels.

Process for Obtaining Data from Other Owners

PennDOT obtains pavement and bridge condition data from multiple other owners, which generally fall into two categories: the Pennsylvania Turnpike Commission (PTC) and local municipal owners. Bridge information is collected by these entities and shared with PennDOT for reporting requirements and planning use by PennDOT and its MPOs/RPOs. PennDOT's Bureau of Planning and Research (BPR) collects pavement condition data for Local Federal-Aid roads.

For the PTC, PennDOT receives pavement data annually via Microsoft Excel spreadsheets. The data is then uploaded into the Highway Performance Monitoring System (HPMS) system. Currently, PennDOT only receives the minimum required pavement data items, including Year of Last Improvement, Year of Last Construction, IRI, Rutting, Faulting, and Cracking Percent. PennDOT and the PTC are in the process of implementing an upgrade to PTC's system that will allow them to share more information in future submissions, including Last Overlay Thickness, Structural Thickness of both rigid and flexible pavement, and Base Type Thickness. The PTC also shares its annual budget, planned expenditures, and cost data so that PennDOT can improve the precision of its asset management models.

For other municipal Local Federal-Aid (LFA) owners, four pavement condition data items are collected for the LFA routes every two years: IRI, Rutting, Faulting, and Cracking Percent. These items are collected by a contractor, currently FUGRO, who uses the same collection method PennDOT uses for the state-owned routes.

Condition Forecasting

Pavement and bridge condition forecasts for state-owned assets and all NHS asset regardless of owner are generated by PennDOT's Asset Management Division using its enterprise Pavement Asset Management System (PAMS) and Bridge Asset Management System (BAMS). The projections are based on current condition data housed in PennDOT databases and the improved conditions expected as a result of future projects. Planned transportation system investments are derived from financial information provided in PennDOT's General Procedural Guidance document and lists of programmed projects from the Multi-modal Project Management System (MPMS).

PennDOT has adopted a strategy of Kaizen, or continuous improvement, in its condition forecasting to minimize projection errors. The current focus is on forecasting error in forecasted treatments as compared to projects. The systems deliver recommended treatments, but PennDOT delivers projects, which include individual treatments. Aligning the predicted treatments with programmable projects is a key next step of the asset management practice at PennDOT.

Management Systems

PennDOT has invested in robust tools to help manage its pavement and bridge assets. These tools help deliver to Pennsylvania travelers the best asset performance for the resources available. The tools used are not static, they are continuously improving to take advantage of better data and technology. They also accommodate progress being made amongst decision-makers on process improvements.

PennDOT has a vision for a fully integrated asset management system that brings together information from a wide array of tools to provide guidance on the best projects to advance. Figure 7-2 shows the set of core systems will be used to deliver actionable intelligence that includes asset insights into the project composition process.

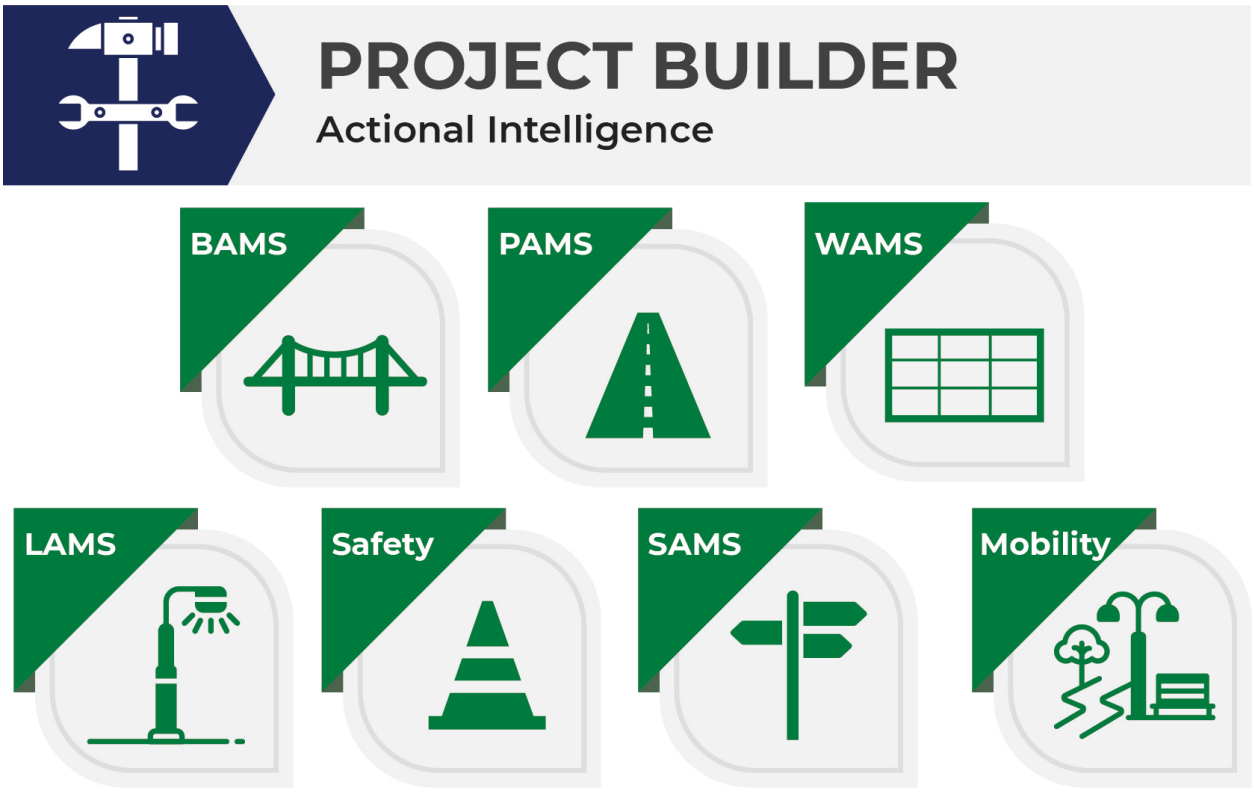


Figure 7-2. Project Builder Elements

The following describes the key elements of the systems that exist to support TAM.

Roadway Management System (RMS)

Summary

Pavement database that serves as system of record for inventory and condition.

Description

RMS is a legacy database that also contains location referencing, pavement history, condition data, traffic information, as well as other administrative and inventory data for the state-owned roadway network.

QA/QC processes are in place to ensure data integrity and quality for various RMS data elements. Specifically, and most important to pavement asset management, annual QA/QC analysis and reporting is generated for location referencing, pavement history, and condition data.

Data Sources

Annual pavement survey data collection

Information Products

Pavement inventory and condition tables

Improvement Needs

RMS is currently a mainframe legacy system. Plans are being discussed to move to a more modern platform.

Bridge Management System 2 Database (BMS2)

Summary

Bridge database that serves as system of record for inventory and condition.

Description

BMS2 is a custom Oracle-based platform that houses all current and historical bridge inspection data for each bridge in Pennsylvania, as well as various plans and notes. Certain larger local owners have independent systems that house additional inventory or condition data, but BMS2 is the system of record for all structures. As the system of record, BMS2 has no predictive or analytical capabilities, but does interface with SAP to push required maintenance activities to maintenance staff.

BMS2 is updated with inspection records from i-Forms, another in-house software that allows inspectors to perform field inspections and upload the results electronically to BMS2. Collecting inspection data digitally enhances efficiency, reduces human error, and provides an automated means of validating entries.

Data Sources

Certified bridge inspections

Information Products

BMS2 has a snapshot of data taken quarterly and published on PennDOT's website:

https://www.penndot.gov/ProjectAndPrograms/Bridges/pages/default.aspx

Improvement Needs

BMS2 is in the initial stages of a rewrite to accommodate new federal reporting requirements. In the process of meeting these requirements, the features of i-Forms will be integrated into the core system, eliminating the stand-alone i-Forms application.

Pavement Asset Management System (PAMS)

Summary

Pavement management system which predicts asset conditions and generates prioritized lists of treatments based on funding levels.

Description

The PAMS is used to estimate future network pavement conditions under various investment scenarios. This analysis includes an optimization function that selects a set of pavement treatments to maximize benefits for a given budget. Benefits are calculated based on condition improvement relative to doing nothing, weighted by traffic volume estimates. By modeling future conditions and potential treatments, PAMS helps inform pavement project scoping and development. PAMS is also used to forecast pavement conditions using federal performance measures. PAMS currently meets the minimum requirements of federal requirement 23 CFR 515.17.

Data Sources.

RMS

MPMS (Multi-modal Project Management System)

Information Products

Future pavement performance by geography and investment levels

Improvement Needs

- Greater flexibility to be able to explore varying funding scenarios and pavement scopes
- Improved reporting functions to meet PennDOT's business needs
- More faithful adherence to PennDOT's overall budgetary requirements

Bridge Asset Management System (BAMS)

Summary

Management system which predicts asset conditions and generates prioritized lists of treatments based on funding levels

Description

PennDOT's BAMS uses LLCC methodology to generate prioritized lists of recommended treatments (maintenance, preservation, rehabilitation, and replacement) based on inputs including current condition data, deterioration models, committed projects, budgets, condition targets, and specific network and management priorities. Within those specified parameters, the software evaluates the benefit/cost ratio for feasible treatments and selects a program of treatments that meets targets and criteria most cost-effectively. The system also generates condition forecasts based on that investment scenario. BAMS uses benefit/cost as the metric for evaluating the value for a treatment. Calculations of both benefits and costs have been updated in PennDOT's BAMS implementation. BAMS currently exceeds the minimum requirements of federal requirement 23 CFR 515.17.

Data Sources

BMS2

MPMS (Multi-modal Project Management System)

Information Products

Bridge performance scenarios by geography and investment levels

Improvement Needs

- Better data visualization
- Functionality targeted for district users

Asset Management System – Project Builder

PennDOT is building an asset management system that will make it easier to add new assets to its information systems and bring together asset information with other data to make the best investment decisions possible for Pennsylvania's transportation system. The high-level diagram for this system is shown above on page 6 of this chapter.

PennDOT has performed initial algorithm development on the system and is now in the process of develop a test version of Project Builder. Key elements of Project Builder are the following.

- Asset needs analysis
- Project optimization and packaging
- Multi-objective decision analysis
- Visualization engine
- District decision support

Asset Needs Analysis

The system will assemble pavement and bridge treatment alternatives into candidate projects that minimizes life cycle costs subject to budget and other constraints, as shown in Figure 7-3.

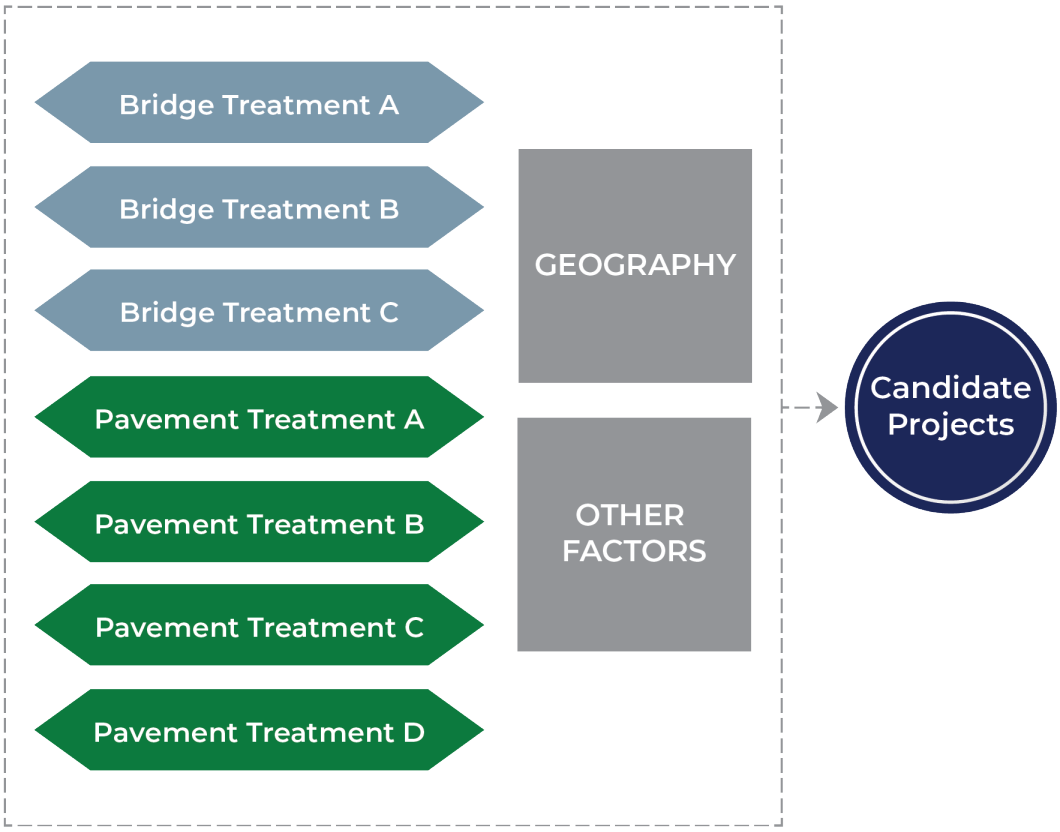


Figure 7-3. Project Builder Process for Assembling Candidate Projects

Multi-Objective Decision Analysis

Once candidate projects have been created, the system will have functions to help PennDOT apply agency objectives to help prioritize the projects. This involves determining the objectives to apply, weighing the value of each of the objectives, and conducting analyses of project performance and overall system performance. An example is shown in Figure 7-4.

Desc	Cost	Travel Time Savings	Increase in Jobs Accessible	Increase in Jobs Accessible - Disadvantaged Populations	Increase in Pavement in Good Condition	Increase in Bridges in Good Condition	Crash Reduction	Crash Cost Reduction	Safety Improvement Score
01 - Bridge Functional Improvement - Route 95	48400000.00	0.00	0.00	0.00	0.00	66.40	0.00	0.00	0.00
02 - Bridge Rehab - Route 39	23400000.00	0.00	0.00	0.00	0.00	97.50	0.00	0.00	0.00
03 - Bridge Rehab - Route 85	3700000.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00
04 - Bridge Seismic Retrofit - Route 56	12700000.00	0.00	0.00	0.00	0.00	11.90	0.00	0.00	0.00
05 - Bridge Seismic Retrofit - Route 56	10400000.00	0.00	0.00	0.00	0.00	27.40	0.00	0.00	0.00
06 - BRT System - Route 685	80000000.00	89.00	300.00	260.00	0.00	0.00	1.00	190.00	3.00
07 - Intersection Improvements - Route 114	2200000.00	0.00	0.00	0.00	0.00	0.00	0.40	73.20	3.00
08 - Intersection Improvements/Bike Path - Rou	18200000.00	20.80	310.00	245.00	0.00	0.00	0.00	0.00	0.00
09 - Intersection/Pedestrian Improvements - Ro	4100000.00	5.00	0.00	0.00	0.00	0.00	0.60	106.20	3.00
10 - ITS Deployment - Route 16	38500000.00	140.60	2000.00	1500.00	0.00	0.00	0.00	0.00	0.00
11 - Minor Mobility Enhancements - Route 8	23000000.00	58.90	250.00	190.00	0.00	0.00	0.00	0.00	0.00
12 - Mobility Improvements - Route 25	14400000.00	140.60	1800.00	1200.00	0.00	0.00	0.00	0.00	0.00
13 - Multmodal Improvements/Pavement Rehal	9700000.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00
14 - New Interchange - Route 12	266000000.00	70.00	400.00	380.00	43.00	5.20	2.00	350.00	4.00
15 - Pavement Rehab - Route 317	21000000.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00

Figure 7-4. Multi-Objective Decision Analysis Example

Project Optimization and Packaging

The system will optimize a capital plan of asset management projects that can be used as a starting point for PennDOT's funded program.

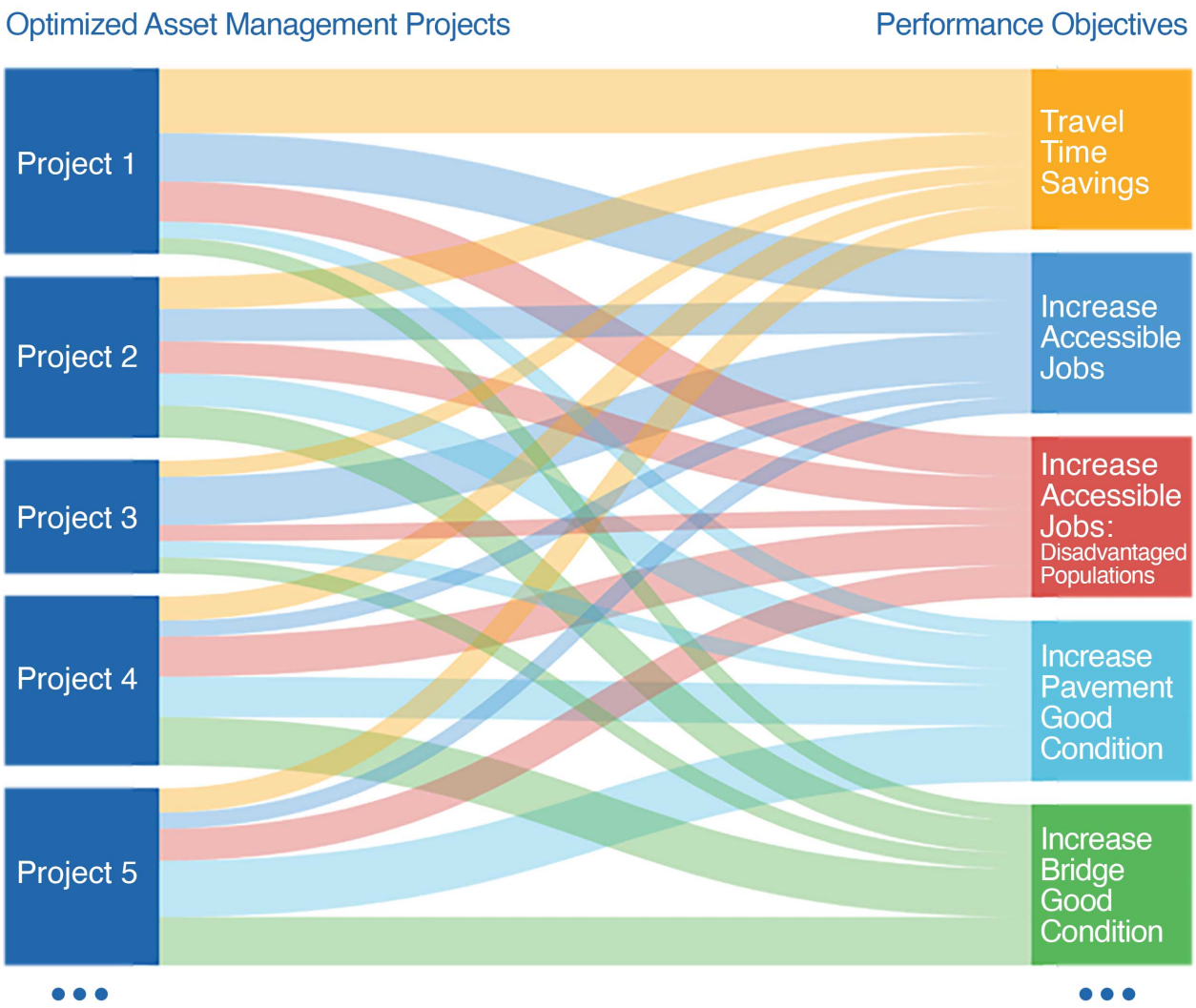


Figure 7-5. Example Optimized Projects and Performance Objectives

Visualization Engine

PennDOT decision makers need information that is easier to digest and provided in a way that provides insights that help with better decision-making. The PennDOT Asset Management System infrastructure will include a wealth of data that can be used for powerful visualizations. This engine will have pre-designed reports and visuals that can be frequently used. It will also have user-friendly connections between reporting, GIS, and other visualization tools and the data to make it easier to generate ad hoc reports and visuals. An example is shown in Figure 7-6.

Asset	Inventory (unit)	Replacement Value ($M)	Current Value($M)	Condition
Pavement	573.7 lane miles	$573.7	$393.8	
Bridges	63 bridges	$95.0	$80.7	
Culverts	844 culverts	$26.9	$13.7	
Signalized Intersections	52 intersections	$20.8	$10.0	
Medians	843,591 (sf) median 120,632 (lf) curb	$6.0	$6.0	
Guardrail	31,633 linear ft	$3.0	$1.7	

Figure 7-6. Visualization Engine Example

District Decision Support

District staff play the central role in the development of projects and programs for their districts. The system will have functions designed to support each district's project development process. These functions will make it easier for the district to accomplish its tasks and repeat the process with consistency from year to year.

Implementation Plan

What's in this Chapter?

This chapter presents PennDOT's plan for continuing to implement TAM and the TAMP over the next four years. This implementation effort is led by the Asset Management Division with the support and oversight of the Asset Management Steering Committee. This chapter also describes TAM decision-making at PennDOT, the TAMP's relationship to existing plans and processes, and how PennDOT coordinates with TAM stakeholders. PennDOT has identified actions for improving TAM practices and processes and includes a summary of potential actions at the end of the chapter.

TAM Framework at PennDOT

Leadership

PennDOT's Asset Management Division (AMD) leads the development and implementation of the TAMP, with the oversight and support of the Asset Management Steering Committee, which comprises representatives of PennDOT Central Office and executive leadership, and FHWA. The TAMP development process also includes CPDM, Bureau of Planning and Research, PennDOT Districts, and MPOs/RPOs.

Decision-Making

PennDOT will use outputs from its asset management systems as the basis for determining project programming to achieve LLCC. System outputs will define recommended treatments, but not necessarily complete project scopes and limits. PennDOT Districts will work with MPO/RPOs to generate lists of recommended treatments by work type (such as highway resurfacing and bridge rehabilitation), based on LLCC and condition recommendations derived from PennDOT's PAMS and BAMS. These treatments will serve as a guide to assist in the prioritization and selection of new projects to be considered for the program.

While the TAMP requirements and PM2 measures only focus on the NHS, PennDOT and the MPOs/RPOs will be required to ensure that projects are selected and prioritized for the entire state-owned and locally owned Federal-aid network. In coordination with PennDOT Districts, the MPOs/RPOs will consider and document how the following was utilized as part of their program development process:

- regional highway and bridge system assets
- existing conditions on the NHS
- projected future conditions on the NHS
- development of strategies/priorities to continue to improve the system at the LLCC
- planning and programming of projects as part of fiscal constraint

As Pennsylvania transitions to LLCC, projects currently included in the STIP/TIPs, TYP and LRTPs will need to be reviewed, evaluated, and prioritized to reflect current asset condition data and funding levels as well as shifting needs, including unanticipated changes in demand and impacts related to extreme weather events. This may include replacing existing projects with higher priority LLCC projects. PennDOT BOMO will work with PennDOT CPDM, PennDOT Districts and the MPOs/RPOs to recommend the prioritization of specific bridge projects over specific roadway projects and vice versa to prevent bridge or pavement conditions from falling below FHWA minimum condition thresholds. This prioritization will be undertaken using a combination of advanced asset management tools, professional engineering judgment by Central Office and District personnel, and local MPO/RPO input. Flexible Federal and State funding may

need to be utilized to help achieve NHS minimum condition thresholds, if available. This will be based on coordination between PennDOT BOMO AMD, PennDOT CPDM and the MPOs/RPOs, in consideration of other required performance measures and state initiatives.

As part of the regional TIP development process mentioned above, the MPOs/RPOs and PennDOT Districts will be required to document the differences between the PennDOT asset management system treatment and funding level recommendations and their selected projects as part of their TIP submissions. They will also be required to document the coordination with the PennDOT District(s) and Central Office that occurred as part of this decision-making process. This information will be used not only by PennDOT BOMO AMD to improve future asset management system recommendations, but also to improve how Districts/MPOs select projects.

Relationship with Other Plans and Processes

PennDOT has a comprehensive, three phase planning and programming process that predates the TAMP, shown in Figure 8-1. In the first phase "Planning", the Long Range Transportation Plan (LRTP) sets the direction for the DOT over a 20 year period, identifying goals, objectives, and measures along with implementation strategies and priorities. The second phase is "Programming", in which PennDOT engages stakeholders and prioritizes projects based on the strategic direction set by the LRTP, listing funded projects for a 12-year period in a Twelve-Year Program (TYP). The TYP is updated every two years and the first four years of the TYP represent the Statewide Transportation Improvement Program (STIP). The third phase is "Performance Measurement", in which PennDOT monitors performance across a number of performance areas and evaluates that performance in the biennial Transportation Performance Report (TPR), updated in years between TYP updates. The performance results are then used as feedback to guide the update of the LRTP as well as project prioritization and programming.

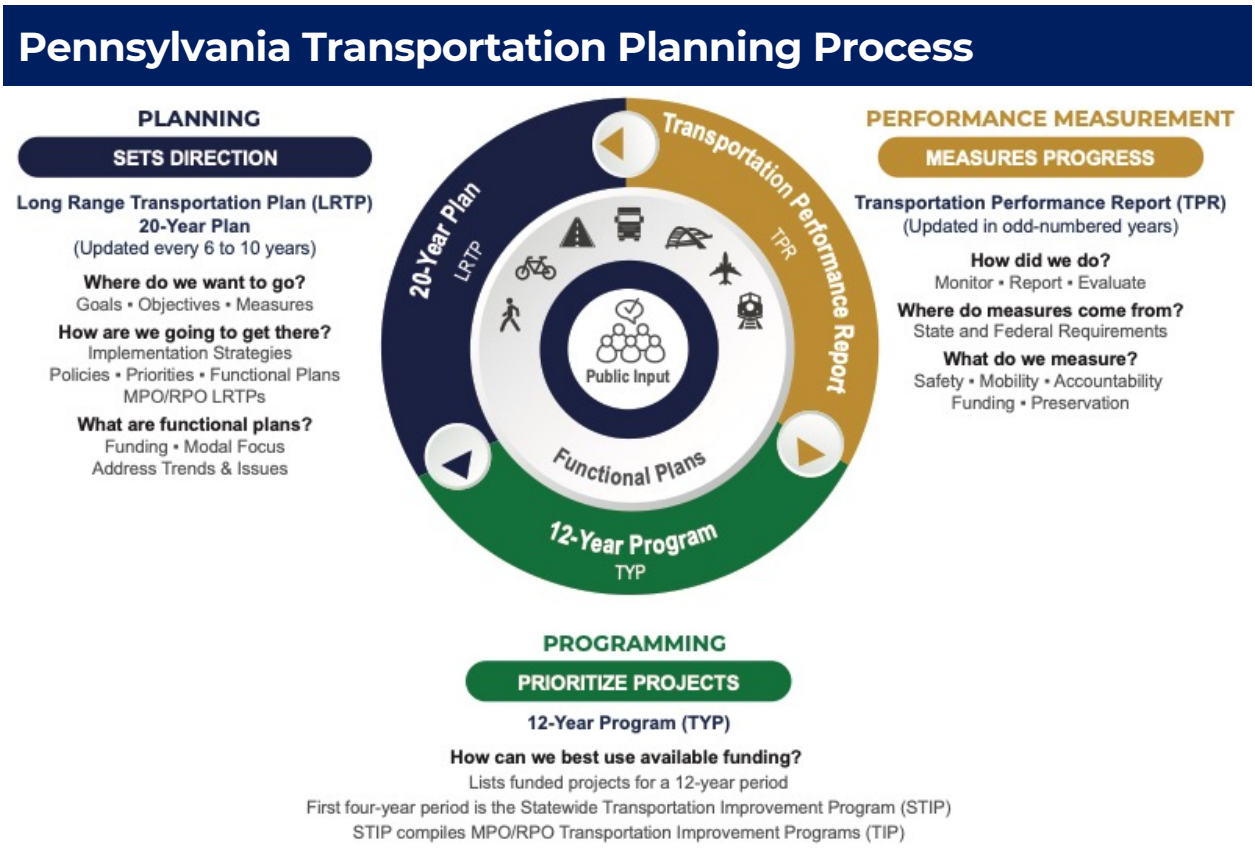


Figure 8-1. Pennsylvania's Transportation Planning Process

The TAMP is a relatively new addition to this process and fits into the "Programming" phase. The TAMP is aligned with the goals of the LRTP. The prediction results and suggested treatments generated for the TAMP should also be used to help Districts, MPOs, and RPOs evaluate projects and estimate future performance.

Coordination with Stakeholders

Federal Government

PennDOT receives substantial funding from the federal government—PennDOT's largest partner—to operate, advance, and manage PennDOT's assets. The primary federal agency responsible for overseeing the appropriation and implementation of this funding for PennDOT is the Federal Highway Administration (FHWA), a division of the United States Department of Transportation (U.S. DOT). FHWA develops and regulates rulemaking in support of legislation, such as the MAP-21 funding legislation, which requires risk-based TAMPs in support of funding requests. FHWA oversees PennDOT's use of federal funds for preservation and construction of Interstates, U.S. routes, and eligible state and locally-owned routes. PennDOT has included FHWA in the TAMP development process, soliciting and incorporating feedback from Division office partners.

Regional Planning Organizations

Metropolitan and Rural Planning Organizations (MPOs/RPOs) are responsible for their region's long-range transportation plan (LRTP), the annual unified planning work program (UPWP), and managing the transportation improvement program (TIP). These planning documents prioritize projects and funding that impact PennDOT's assets.

Each MPO/RPO leads the development of a regional LRTP. These plans are consistent with the goals of the statewide LRTP, are based on extensive public and stakeholder involvement, and include a list of fiscally constrained projects supportive of regional goals and objectives. PennDOT has developed a Developing Regional Long Range Plans guidebook (PUB 575) to assist MPOs/RPOs in effective, inclusive, compliant, performance-based planning.

PennDOT and the MPOs/RPOs evaluate candidate projects based on statewide and regional LRTP goals and recommendations; statewide policy, plans, and goals; PennDOT Connects outreach; and LLCC outputs, data, and guidance provided by PennDOT Central Office and its Engineering Districts. The first four years of the TYP are the Transportation Improvement Program (TIP)—a federally-required, fiscally-constrained list of projects that are expected to be undertaken within the next four federal fiscal years (FFY).

Municipalities

Municipalities typically own, operate, and maintain roads, bridges, signs, traffic signals, and other assets in their jurisdiction. Any major project or any project with state or federal funding requires PennDOT involvement. Municipalities may also receive grants or set-aside funding for construction or maintenance. Municipalities impact PennDOT's assets through joint maintenance and the interconnection points between municipal roadways and PennDOT-operated roadways and freeways. Municipal stakeholders include but are not limited to:

- Streets Departments
- Public Works Departments
- City/Township/Borough Engineers
- Parks Departments

Pennsylvania Turnpike Commission

The PTC owns NHS assets and works with PennDOT to effectively manage them. PTC was created in 1937 by the General Assembly as an instrumentality of the Commonwealth. The commission currently operates 68 toll interchanges, 17 services plazas, 22 maintenance facilities, two regional offices, and a main headquarters/ administrative building located in Middletown, Pennsylvania. PennDOT reports on PTC-owned NHS bridges and pavements in the Pennsylvania TAMP, and shares their data through MS Excel files for the report.

Public

The most important stakeholders for all transportation assets are the general public and Pennsylvania businesses. These groups depend on the transportation system in their daily lives. It is essential to keep the general public in mind as the ultimate beneficiary of the transportation system.

Implementation Actions

Inventory and Condition

- Improve coordination with local NHS owners to collect condition data
- Establish mechanism for information sharing with the Turnpike
- Explore potential for shared IT with partners

Performance Management

- Align performance measures with LLCC
  - Remove measures that prioritize / incentivize worst first
- Update metrics that reflect worst first orientation

Life Cycle Planning

- Continue to implement lowest life cycle cost approach
- Complete implementation of management systems
- Improve modeling
- Add emphasis on resiliency in life cycle planning

Risk Management

- Risk Mitigation Actions
  - Maintain continued executive buy-in and enforcement
  - Continue tool development and implementation
  - Update/improve the funding mechanisms of PennDOT
  - Provide accurate condition forecasts at funding levels
  - Employ innovative materials
  - Update deterioration modeling
  - Provide heightened workforce development
  - Identify mechanisms to reduce the pay gap
  - Identify vulnerable assets and address while under construction
  - Update design manuals to reflect environmental changes
  - Update AM system to meet all user requirements
  - Educate staff, the public, and elected officials on the value of AM
  - Raise awareness of the risk and cost of cyberattacks
  - Maintain up-to-date IT software, technologies, and systems including support for strong IT personnel and consistent funding
  - Expand the security focus not only to employees but also to contractors and consultants.
  - Make information available from construction to other systems

  - Ensure all systems that generate management decisions are kept functional
- 2021 Pennsylvania Climate Action Plan
  - Governor Tom Wolf issued an executive order in 2019 that established a Pennsylvania climate goal of a 26% reduction in net GHG emissions statewide by 2025 and an 80% reduction by 2050, from 2005 levels. (2021 Pennsylvania Climate Action Plan)
  - Incorporate adaptation strategies for TAMP related topics:
    - Address the impacts of a changing climate on built infrastructure
      - *Increased disruption and damage, especially from direct flooding in the Southwestern region*
      - *Higher risks of cascading impacts from infrastructure service disruptions*
      - *Increased flood risk to infrastructure in Southeastern Pennsylvania from flooding related to sea level rise and coastal storms*
    - Address the impacts of landslides on built infrastructure
      - *Closures of state and local roads for long periods of time*
      - *Short-term losses of emergency routes*

Financial Plan & Investment Strategies

- Advocate for new dedicated sources of funding (see Financial Plan and TROC recommendations)
- Improve integration of engineering side of PennDOT with the performance-based programming and planning side
- Improve project selection processes at PennDOT Districts and MPOs/RPOs

Data and Systems

- Build Asset Management System – Project Builder
- Strive for continuous improvement of data and systems

PennDOT TAMP Acronyms

AADT –Annual Average Daily Traffic

AC – Advance Construct

AMD – Asset Management Division

AMF – Asset Management Factor

BAMS – Bridge Asset Management System

BAMS2 – Bridge Asset Management System, Version 2

BIL – Bipartisan Infrastructure Law

BOMO - Bureau of Maintenance and Operations

BPN – Business Plan Network

MBUF – Mileage-Based User Fees

CAFR – Pennsylvania Comprehensive Annual Financial Report

CMAQ – Congestion Mitigation and Air Quality funding program

CPDM – Center for Program Development and Management

DCNR – Department of Conservation and Natural Resources

EV – Electric Vehicle

FAST Act – Fixing America's Surface Transportation Act

FFY – Federal Fiscal Year

FHWA – Federal Highway Administration

GIS – Geographic Information System

HPMS – Highway Performance Monitoring System

HSIP – Highway Safety Improvement Program

IIJA - Infrastructure Investment and Jobs Act

IRI – International Roughness Index

LLCC – Lowest Life Cycle Cost, or Lowest (Practical) Life Cycle Cost

LRTP – Long Range Transportation Plan

MAP-21 – Moving Ahead for Progress in the 21st Century Act

MBUF – Mileage-Based User Fees

MLF – Motor License Fund

MPMS – Multimodal Project Management System

MPO – Metropolitan Planning Organization

NBIS – National Bridge Inspection Standards

NCHRP – National Cooperative Highway Research Program

NHFP – National Highway Freight Program

NHPP – National Highway Performance Program

NHS – National Highway System

PAMS – Pavement Asset Management System

PMS - Pavement Management System

PEL – Planning and Environmental Linkages

QA/QC – Quality Assurance/Quality Control

RMS – Roadway Management System

RPO – Rural Planning Organization

RRX – Railway Crossings Safety Program

SD – Structurally Deficient

SFY – State Fiscal Year

SGR – State of Good Repair

STC – State Transportation Commission

STIP – Statewide Transportation Improvement Program

STP – Surface Transportation Program

TAM – Transportation Asset Management

TAMP – Transportation Asset Management Plan

TAP – Transportation Alternatives Program

TIP – Transportation Improvement Program

TPR – Transportation Performance Report

TROC – Transportation Revenue Options Commission

TYP – PennDOT's Twelve Year Program

UPWP – Unified Planning Work Program

U. S. DOT – United States Department of Transportation

VMT – Vehicle Miles Traveled

Appendix A – Pavement and Bridge Asset Ownership

This appendix focuses on the breakdown of pavement and bridge asset owners. There are 23,552 NHS pavement lane miles in Pennsylvania split among 75 pavement owners: PennDOT, PTC, and municipalities. Table A-1 provides the number and percentage of lane miles by NHS pavement owner.

Table A-1: Detailed Breakdown of NHS Pavement Asset Owners

Pavement Owner	Lane Miles	% of Total	Pavement Owner	Lane Miles	% of Total
PennDOT	20,797.51	88.3%	Swissvale	2.2	0.0%
State Toll Authority (PTC)	2,253.73	9.6%	Upper St Clair T	2.2	0.0%
Pittsburgh	105.1	0.4%	Braddock	2.1	0.0%
Philadelphia	87.1	0.4%	Blakely	1.9	0.0%
Lower Merion T	30.8	0.1%	Monroeville	1.8	0.0%
Wilkes Barre	23.9	0.1%	Sunbury City	1.8	0.0%
Harrisburg	17.2	0.1%	Warren City	1.7	0.0%
East Norriton	16.7	0.1%	Kilbuck	1.6	0.0%
Lebanon	16.3	0.1%	Millcreek	1.6	0.0%
Allentown	15.6	0.1%	Edgewood	1.4	0.0%
York City	15.5	0.1%	North Braddock	1.4	0.0%
Erie City	14.1	0.1%	North Wales	1.4	0.0%
Plymouth T	12.2	0.1%	Ohio	1.4	0.0%
Whitemarsh	9.8	0.0%	South Lebanon	1.2	0.0%
Dickson City	7.3	0.0%	Chester City	1.1	0.0%
Lower Providence	6.5	0.0%	Huntingdon	1.1	0.0%
Williamsport	6.5	0.0%	Emsworth	1	0.0%
Bethlehem City	5.4	0.0%	West Conshohocken	1	0.0%
Norristown	5.4	0.0%	Springfield T	0.9	0.0%
Upper Gwynedd T	5.4	0.0%	Ingram	0.8	0.0%
Upper Dublin T	5.2	0.0%	Washington	0.8	0.0%
Lancaster	4.4	0.0%	Mt Lebanon T	0.7	0.0%
Lower Gwynedd	4.2	0.0%	New Castle	0.7	0.0%
Mckeesport	4.2	0.0%	Phoenixville	0.7	0.0%
Ross T	4.2	0.0%	Rankin	0.7	0.0%
Worcester	4.1	0.0%	Yeadon	0.7	0.0%
Bethlehem	3.8	0.0%	Philipsburg	0.5	0.0%
Scott T	3.6	0.0%	Wall Borough	0.5	0.0%
Neville T	3.4	0.0%	Wilmerding	0.5	0.0%
Towamencin	3.3	0.0%	Collier T	0.4	0.0%
Altoona City	3.2	0.0%	Dingman	0.4	0.0%
Scranton	3.2	0.0%	East Pittsburgh	0.4	0.0%
Kingston	3	0.0%	Crafton	0.3	0.0%
East Mckeesport	2.9	0.0%	Northumberland	0.3	0.0%
Millvale	2.6	0.0%	Coraopolis	0.1	0.0%
Plum Borough	2.6	0.0%	New Kensington	0.1	0.0%
Easton City	2.5	0.0%	Wilkes Barre T	0.1	0.0%
Johnstown	2.4	0.0%			
			Total	**23,552.24**	**100.00%**

Source: RMS, December 2020

NHS bridges total 5,856 and are divided among 39 owners. Table A-2 provides the number, deck area, and percentage of total bridges by NHS bridge owner.

Table A-2. Detailed Breakdown of NHS Bridge Owners

Bridge Owner	Owner Category	Bridge Count	% of Total	Deck Area	% of Total
PennDOT	State Highway Agency (PennDOT)	5116	87.36%	73,363,931	81.29%
PA Turnpike	State Toll Authority (PTC)	594	10.14%	9,308,73	10.31%
Delaware River Port Authority	Local Toll Authority	19	0.32%	3,901,504	4.32%
Delaware River Joint Toll Bridge Comm.	Local Toll Authority	25	0.43%	1,021,888	1.13%
Allegheny County	County Highway Agency	19	0.32%	1,008,796	1.12%
New Jersey Turnpike and PennDOT	Other State Agencies	1	0.02%	523,709	0.58%
City of Pittsburgh	City, Municipal Highway Agency, or Borough	10	0.17%	291,131	0.32%
City of Philadelphia	City, Municipal Highway Agency, or Borough	11	0.19%	148,198	0.16%
PA Department of General Services	Other State Agencies	1	0.02%	110,208	0.12%
New York State and PennOT	Other State Agencies	2	0.03%	94,942	0.11%
Montgomery County	County Highway Agency	13	0.22%	92,677	0.10%
Lehigh County	County Highway Agency	3	0.05%	85,337	0.09%
Burlington County - New Jersey	Local Toll Authority	1	0.02%	57,295	0.06%
Pittsburgh Port Authority	Other Local Agencies	3	0.05%	26,798	0.03%
Northampton County	County Highway Agency	1	0.02%	25,860	0.03%
City of Lebanon	City, Municipal Highway Agency, or Borough	7	0.12%	23,964	0.03%
City of Allentown	City, Municipal Highway Agency, or Borough	2	0.03%	19,104	0.02%
Millvalle Borough	City, Municipal Highway Agency, or Borough	6	0.10%	15,172	0.02%
City of Erie	City, Municipal Highway Agency, or Borough	1	0.02%	14,560	0.02%
City of Warren	City, Municipal Highway Agency, or Borough	1	0.02%	13,350	0.01%
York City	City, Municipal Highway Agency, or Borough	1	0.02%	12,720	0.01%
City of Johnstown	City, Municipal Highway Agency, or Borough	1	0.02%	12,528	0.01%
City of Bethlehem	City, Municipal Highway Agency, or Borough	1	0.02%	9,511	0.01%
York County	County Highway Agency	1	0.02%	8,431	0.01%

Bridge Owner	Owner Category	Bridge Count	% of Total	Deck Area	% of Total
City of Harrisburg	City, Municipal Highway Agency, or Borough	2	0.03%	7,882	0.01%
US Silica Co.	Private (other than Railroad)	1	0.02%	7,524	0.01%
Philadelphia Water Department	Other Local Agencies	1	0.02%	7,280	0.01%
Chester City	City, Municipal Highway Agency, or Borough	1	0.02%	7,183	0.01%
Norfolk Southern	Railroad	1	0.02%	5,878	0.01%
Dauphin County	County Highway Agency	2	0.03%	5,660	0.01%
City of reading	City, Municipal Highway Agency, or Borough	1	0.02%	5,148	0.01%
Norristown	Town or Township Highway Agency	2	0.03%	4,734	0.01%
Lower Merion Township	Town or Township Highway Agency	1	0.02%	4,235	0.00%
ARMCO Steel	Private (other than Railroad)	1	0.02%	3,360	0.00%
Upper Gwynedd Township	Town or Township Highway Agency	1	0.02%	1,775	0.00%
City of Scranton	City, Municipal Highway Agency, or Borough	1	0.02%	1,676	0.00%
South Lebanon Township	Town or Township Highway Agency	1	0.02%	1,170	0.00%
Total		**5,856**	**100.0%**	**90,253,847**	**100.0%**

Source: BMS2, December 2021

*Note that the PennDOT inventory differs slightly from the inventory presented in Chapter 2 of the TAMP. This is due to some bridges being subject to shared custody and thus labeled 'border bridges'. These bridges may be listed under ownership other than PennDOT in this table.

Table A-3. NHS Bridge Count by Owner and PennDOT District

District	State Highway Agency (PennDOT)	State Toll Authority (PTC)	City, Municipal Highway Agency, or Borough	County Highway Agency	Local Toll Authority	Railroad	Town or Township Highway Agency	Private (other than Railroad)	Other Local Agencies	Other State Agencies	District Total
1	321	0	2	0	0	0	0	0	0	0	**323**
2	448	0	0	0	0	0	0	0	0	0	**448**
3	378	0	0	0	0	0	0	0	0	0	**378**
4	373	20	1	0	1	0	0	0	0	2	**397**
5	500	54	4	4	11	0	0	0	0	0	**573**
6	1035	128	12	13	33	1	4	0	1	1	**1228**
8	563	90	10	3	0	0	1	0	0	1	**668**
9	302	74	1	0	0	0	0	1	0	0	**378**
10	247	5	0	0	0	0	0	1	0	0	**253**
11	642	102	16	19	0	0	0	0	3	0	**782**
12	307	121	0	0	0	0	0	0	0	0	**428**

Source: BMS2, December 2020

Table A-4. NHS Bridge Deck Area (sq. ft.) by Owner and PennDOT District

District	State Highway Agency (PennDOT)	State Toll Authority (PTC)	City, Municipal Highway Agency, or Borough	County Highway Agency	Local Toll Authority	Railroad	Town or Township Highway Agency	Private (other than Railroad)	Other Local Agencies	Other State Agencies	District Total
1	3,193,584	0	27,910	0	0	0	0	0	0	0	**3,221,494**
2	4,288,636	0	0	0	0	0	0	0	0	0	**4,288,636**
3	4,223,332	0	0	0	0	0	0	0	0	0	**4,223,332**
4	4,106,623	380,285	1,676	0	36,120	0	0	0	0	94,942	**4,619,647**
5	5,612,669	756,730	33,763	111,197	368,624	0	0	0	0	0	**6,882,982**
6	22,773,635	1,651,413	155,381	92,677	4,575,943	5,878	10,744	0	7,280	523,709	**29,796,658**
8	7,627,366	1,336,621	44,567	14,091	0	0	1,170	0	0	110,208	**9,134,022**
9	3,170,365	575,351	12,528	0	0	0	0	7,524	0	0	**3,765,768**
10	3,061,638	60,906	0	0	0	0	0	3,360	0	0	**3,125,904**
11	11,860,880	1,804,020	306,302	1,008,796	0	0	0	0	26,798	0	**15,006,795**
12	3,445,205	2,743,405	0	0	0	0	0	0	0	0	**6,188,611**

Source: BMS2, December 2021

Table A-5. Pavement Owners – Linear Miles by District

PennDOT District	Linear Miles	Percentage of Total
PennDOT-Owned		
1	3,686.1	9.3%
2	3,478.2	8.8%
3	4,239.7	10.7%
4	3,614.2	9.1%
5	3,286.6	8.3%
6	3,552.3	8.9%
8	5,228.9	13.2%
9	3,750.7	9.4%
10	3,122.7	7.9%
11	2,159.9	5.4%
12	3,594.7	9.1%
Pennsylvania Turnpike Commission-Owned		
1	-	0.0%
2	-	0.0%
3	-	0.0%
4	33.1	6.0%
5	57.3	10.4%
6	85.2	15.4%
8	108.5	19.6%
9	87.9	15.9%
10	4.4	0.8%
11	78.4	14.2%
12	98.2	17.8%
Other Entity-Owned		
1	6,559.1	8.1%
2	5,289.8	6.6%
3	7,248.6	9.0%
4	5,280.9	6.6%
5	8,422.3	10.4%
6	11,813.6	14.7%
8	11,793.9	14.6%
9	5,170.9	6.4%
10	6,021.7	7.5%
11	6,510.7	8.1%
12	6,510.0	8.1%

Source: PA Highway Statistics, Publication 600, 2020

Appendix B – Typical Treatment Costs

Table B-1. Overall Average Pavement Treatment Costs Per Segment Mile

Pavement	Maintenance	$ 51,665.52
	Preservation	$ 482,950.47
	Rehab	$ 1,052,959.33
	Reconstruction	$ 3,075,376.67

Table B-1. Average Pavement Treatment Costs by Type Per Segment Mile

Asphalt	Maintenance	$ 37,934.36
	Preservation	$ 422,348.50
	Rehab	$ 990,885.80
	Reconstruction	$ 3,056,062.00
Composite	Maintenance	$ 38,256.36
	Preservation	$ 427,733.83
	Rehab	$ 1,036,819.20
	Reconstruction	$ 3,075,377.00
Concrete	Maintenance	$ 78,805.83
	Preservation	$ 598,769.08
	Rehab	$ 1,131,173.00
	Reconstruction	$ 3,094,691.00

Table B-3. Unit Costs of Structural Treatments Recommended in BridgeCare

Treatment	Treatment Unit Cost
Epoxy Overlay	$25 per ft² deck area
Structural Overlay	$75 per ft² deck area
Bituminous Overlay	$7 per ft² deck area
Deck Replacement	$250 per ft² deck area
Bridge Painting (steel) – Full Bridge	$95 per ft² deck area (truss bridges) $35 per ft² deck area (non-truss bridges)
Bridge Painting (steel) – Joint/Spot/Zone Painting	$20 per ft² deck area
Substructure Rehabilitation	$1000 per ft bridge length
Superstructure Replacement/Rehabilitation	$500 per ft² deck area (all bridges except open or closed spandrel deck arch bridges) $300 per ft² deck area (only bridges with open or closed spandrel deck arches)
Bridge Replacement	$800 per ft² deck area, with a minimum replacement cost of $900,000
Culvert Rehabilitation – Culvert Family ID = C5	$250 per ft² deck area
Culvert/Small Bridge Replacement	$650 per ft² deck area (culverts) $650 per ft² deck area, with a minimum replacement cost of $900,000 (small bridges)
County Maintenance – Deck Work	$0.70 per ft² deck area + $1000
County Maintenance – Superstructure Work	$0.90 per ft² deck area + $1000
County Maintenance – Substructure Work	$1.60 per ft² deck area + $1000

Appendix C – Asset Management Factor

The National Highway Performance Program (NHPP) provides funding to states for construction and maintenance of NHS assets. PennDOT distributes most of its share of NHPP funding to MPOs and RPOs, which program and manage projects in their region. Funding historically has been allocated using formulas that factor in a region's relative need, considering its inventory of NHS infrastructure, traffic volume, and asset condition. Beginning in FFY2023, funding will be distributed using an updated formula, depicted in Figure C-1.

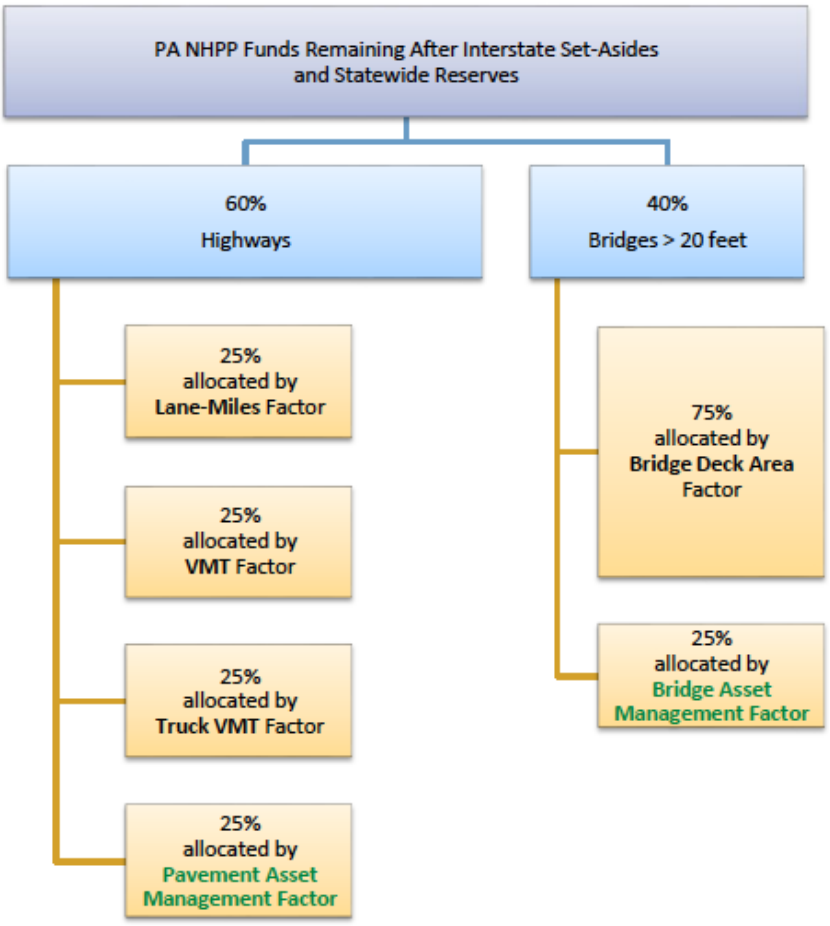


Figure C-1. NHPP AMF Distribution

The proportion of total NHPP funding dedicated to pavements vs. bridges is based on the total annual life cycle need of these assets. The pavement need is 60 percent of the total annual life cycle need.

The pavement and bridge asset management factors (AMFs) are calculations designed to consider treatment needs by dollar value to maintain existing NHS pavements and bridges in a state of good repair, consistent with Pennsylvania's TAMP. The amount of bridges and pavements in poor condition is no longer a factor in the funding allocation.

The Pavement or Bridge AMF for each county is the ratio of that county's dollar value of NHS infrastructure needs divided by Pennsylvania's total NHS needs.

PennDOT's Asset Management Division calculates the Pavement AMF and Bridge AMF using the methods outlined below.

Pavement AMF Calculation

Pavement treatment needs and the dollar value of those needs are calculated for each segment of the NHS using the following major steps.

1. **Identify asset condition**. The Asset Management Division accesses the latest pavement condition data for each roadway segment. PennDOT's Automated Pavement Distress Condition Surveying Program, which includes video-logging of all pavements, began in 1997. Pavement condition data for locally owned Federal-Aid roads is also collected. Pavement condition surveys are conducted according to Publication 336: Pavement (Bituminous & Jointed Concrete).

2. **Determine appropriate treatments, consistent with the TAMP**. The Asset Management Division uses matrices to assign treatments to a segment's pavement based on condition and business plan network. Table C-1 presents a sample matrix and Table C-2 provides the corresponding treatment codes.

Table C-1. Bituminous Pavement Fatigue Cracking (High Severity) Treatment Matrix

Length	BPN1	BPN2	BPN3	BPN4
>0 – 10%	10	10	10	5
11 – 25%	11	11	11	11
26 – 50%	21	11	11	11
51 – 75%	23	11	11	19
>75%	23	23	23	23

Table C-2. Pavement Treatment Codes

Treatment Code	Treatment Description
1	Crack Seal
2	Spray Patch
3	Skin Patch
4	Manual Patch
5	Manual Patch, Skin Patch
6	Mechanized Patch

Treatment Code	Treatment Description
7	Mill, Manual Patch
8	Mill, Mechanized Patch
9	Mill, Mechanized Edge Patch
10	Base Repair, Manual Patch
11	Base Repair, Mechanized Patch
12	Seal Coat
13	Level, Seal Coat
14	Widening, Seal Coat
15	Scratch, Level, Seal Coat
16	Microsurface/ Thin Overlay
17	Level, Resurface
18	Mill, Conc. Patch, Level, Resurface
19	Level, Resurface, Base Repair
20	Mill, Level, Resurface
21	Mill, Level, Resurface, Base Repair
22	Construct Paved Shoulder
23	Reconstruction

3. **Establish materials lists to perform the treatment.** Materials and quantities are derived from the treatment code and segment characteristics and dimensions.

4. **Calculate the cost of the treatment**. The total materials required for the needed treatment are translated to a dollar value using price lists that are updated with the latest actual cost data from recent projects.

5. **Repeat for each segment; sum dollar needs by route and county**.

6. **Divide county's dollar needs by state's total dollar needs**. The resulting ratio, the Pavement AMF, expresses the county's pavement needs as a proportion of the total needs of the state. The PennDOT District or MPO/RPO needs can also be expressed as a portion of the total needs, summing data for their counties.

Bridge AMF Calculation

Treatment needs and the cost of those needs are determined for each bridge on the NHS, following the same general steps used for pavements.

Bridge condition data is derived from inspections conducted every two years or more frequently, depending on bridge condition. PennDOT has conducted bridge inspections to increasingly rigorous federal standards since 1971. PennDOT Publication 100A is the current bridge condition survey field manual.

Appropriate treatments for bridges and culverts are also determined using matrices, such as Figure C-2.

Culvert Preservation	1	10		[BRIDGE_TYPE]='C' AND [BUS_PLAN_NETWORK]='1' AND [CULV_SEEDED]>='6' AND [CULV_SEEDED]<='7'
				[BRIDGE_TYPE]='C' AND [BUS_PLAN_NETWORK]<>'1' AND [CULV_SEEDED]>='5' AND [CULV_SEEDED]<='6'
Culvert Rehabilitation	1	20		[BRIDGE_TYPE]='C' AND [BUS_PLAN_NETWORK]='1' AND [CULV_SEEDED]>='5' AND [CULV_SEEDED]<='6'
				[BRIDGE_TYPE]='C' AND [BUS_PLAN_NETWORK]<>'1' AND [CULV_SEEDED]>='4' AND [CULV_SEEDED]<='5'
Culvert Replacement	1	65		[BRIDGE_TYPE]='C' AND [BUS_PLAN_NETWORK]='1' AND [CULV_SEEDED]<='5'
				[BRIDGE_TYPE]='C' AND [BUS_PLAN_NETWORK]<>'1' AND [CULV_SEEDED]<='4'
Deck Replacement	1	20	Deck replacement with work on beam ends and beam seats	[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]='1' AND [YEAR_BUILT]<='1983' AND [DECK_SEEDED]<='5'
				[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]<>'1' AND [YEAR_BUILT]<='1983' AND [DECK_SEEDED]<='4'
				[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]<>'1' AND [YEAR_BUILT]<='1983' AND [DECK_SEEDED]<'5' AND [DECK_SEEDED]>='4' AND [DECK_DURATION_N]>='20'
Superstructure Replacement	1	30	Superstructure Replacement with work on beam seats	[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]='1' AND [YEAR_BUILT]<='1983' AND [DECK_AREA]<='30000' AND [SUP_SEEDED]>='3' AND [SUP_SEEDED]<='5'
				[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]<>'1' AND [YEAR_BUILT]<='1983' AND [DECK_AREA]<='30000' AND [SUP_SEEDED]>='3' AND [SUP_SEEDED]<'4'
				[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]<>'1' AND [YEAR_BUILT]<='1983' AND [DECK_AREA]<='30000' AND [SUP_SEEDED]>='5' AND [SUP_SEEDED]<'6' AND [SUP_DURATION_N]>='18'
				[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]<>'1' AND [YEAR_BUILT]<='1983' AND [DECK_AREA]<='30000' AND [SUP_SEEDED]>='4' AND [SUP_SEEDED]<'5' AND [SUP_DURATION_N]>='18'
Bridge Replacement	1	65	Complete bridge replacement	[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]='1' AND [YEAR_BUILT]<='1983' AND [DECK_AREA]<'30000' AND [SUB_SEEDED]<='5'
				[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]<>'1' AND [YEAR_BUILT]<='1983' AND [DECK_AREA]<'30000' AND [SUB_SEEDED]>='4' AND [SUB_SEEDED]<'5' AND [SUB_DURATION_N]>='20' AND [SUP_SEEDED]<='6'
				[BRIDGE_TYPE]='B' AND [BUS_PLAN_NETWORK]<>'1' AND [YEAR_BUILT]<='1983' AND [DECK_AREA]<'30000' AND [SUB_SEEDED]<='4'

Figure C-2. Sample Bridge and Culvert Treatment Matrix

As with pavements, a Bridge AMF is calculated for each county to express the county's bridge needs as a proportion of the state's total bridge needs.

Appendix D – Pavement and Bridge Risk Score

PennDOT developed new pavement and bridge risk score calculations to assist in prioritizing preservation, rehabilitation, and replacement projects in light of true network-level risk, based on LLCC. These scores do not include condition in the calculation so that risk can be addressed independently, and each asset is ranked on the same scale. It should be noted that risk scores cannot be compared across asset classes at this time.

Pavement Risk Score Calculation

The risk score for each pavement segment is calculated using the formula below. Table D-1 defines the factors and the parameters that determine factor values.

$$\text{Pavement Risk} = (\sqrt{\text{Surface Area} \times \text{Annual Average Daily Traffic}}) \times F_{aadtt} \times F_{ffcc}$$

Table D-1. Pavement Risk Score Factors

Factor	Definition	Parameter	Factor Value
F_{aadtt}	Annual Average Daily Truck Traffic	Truck traffic is >20% total traffic	2.00
		Truck traffic is ≥ 10% total traffic	1.50
		Truck traffic is <10% total traffic	1.00
		Truck traffic is >20% total traffic	2.00
F_{ffcc}	Federal Functional Class Code	Rural Principal Arterial–Interstate	2.25
		Rural Principal Arterial-Other	2.20
		Rural Minor Arterial	2.15
		Rural Major Collector	2.10
		Rural Minor Collector	2.05
		Rural Local	2.00
		Urban Principal Arterial–Interstate	1.25
		Urban Principal Arterial-Other Freeways	1.20
		Urban Other Principal Arterial	1.15
		Urban Minor Arterial	1.10
		Urban Collector	1.05
		Urban Local	1.00

Bridge Risk Score Calculation

The risk score for each bridge is calculated using the formula below. Table D-2 defines the factors and the parameters that determine factor values.

$$\text{Bridge Risk} = (\sqrt{\text{Deck Area} \times \text{Annual Average Daily Traffic}}) \times F_s \times F_{fc} \times F_{det} \times F_{aadtt} \times F_{flood}$$

Table D-2. Bridge Risk Score Factors

Factor	Definition	Parameter	Factor Value
F_s	Scour Factor	Scour Rating = A	1.2
		Scour Rating ≠ A	1.0
F_{fc}	Fracture Critical Factor	Fracture Critical Rating < 5	1.4
		Fracture Critical Rating ≥ 5	1.0
F_{det}	Detour Length Factor	Detour Length > 30 miles	2.0
		Detour Length ≥ 10 miles	1.5
		Detour Length < 10 miles	1.0
F_{aadtt}	Annual Average Daily Truck Traffic Factor	Truck traffic > 20% total traffic	2.0
		Truck traffic ≥ 10% total traffic	1.5
		Truck traffic < 10% total traffic	1.0
F_{flood}	Bridge Closed for Flooding Event Factor	Bridge has been closed for flooding	3.0
		Bridge has been overtopped due to flooding	1.5
		Bridge has not been closed or overtopped due to flooding	1.0

Appendix E – '21-'22 PennDOT Budget Breakdown