Transportation Asset Management Plan

West Virginia Division of Highways

MOTT MACDONALD

December 2022

West Virginia Department of Transportation

Transportation Asset Management Plan

December 22, 2022
Respectfully submitted:

Jimmy Wriston, P.E.
Secretary of Transportation
Commissioner of Highways

Gehan Elsayed, P.h.D., P.E.
Chief Engineer of Programs & Performance Management
WVDOT TAMP Manager

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
Division of Highways
1900 Kanawha Boulevard East • Building Five • Room 110
Charleston, West Virginia 25305-0430 • (304) 558-3505

D. Alan Reed, P.E.
State Highway Engineer

Jimmy Wriston, P. E.
Secretary of Transportation
Commissioner of Highways

December 22, 2022

Jeff Blanton
Division Administrator
West Virginia Division
Federal Highway Administration
154 Court Street
Charleston, WV 25301

Dear Mr. Blanton:

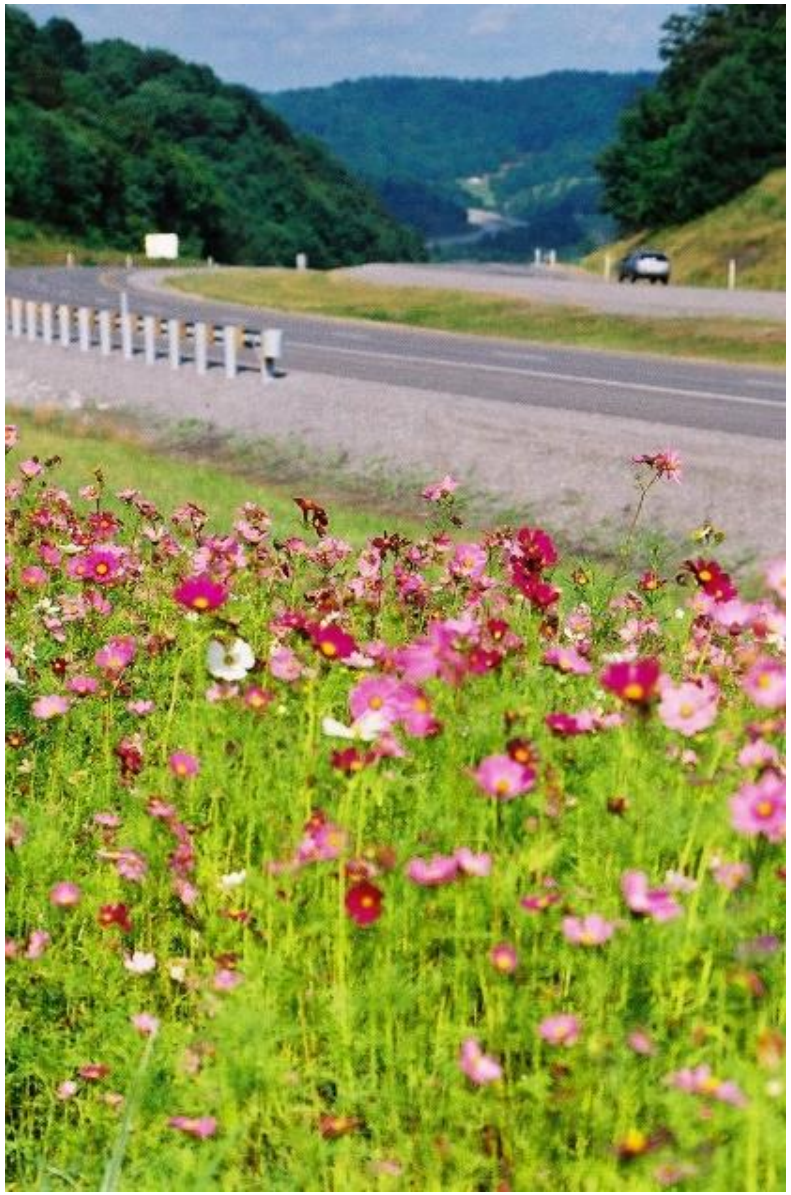
On behalf of the West Virginia Department of Transportation (WVDOT), and the West Virginia Division of Highways (DOH), I am pleased to submit our Transportation Asset Management Plan (TAMP) for review and certification by the Federal Highway Administration (FHWA) in compliance with the Moving Ahead for Progress in the 21st Century Act (MAP-21), as well as, the subsequent 2015 Fixing America's Surface Transportation Act (FAST Act), as codified in 23 U.S.C. 119 and 23 CFR part 515 and the Infrastructure Investment and Jobs Act (IIJA), enacted on November 15, 2021.

Should you have any questions, please contact Gehan Elsayed, Ph.D., P.E., Chief Engineer of Programs and Performance Management, and WVDOT TAMP Manager, Gehan.M.Elsayed@wv.gov or (304) 414-6912.

Sincerely,

Jimmy Wriston, P.E.
Secretary of Transportation/
Commissioner of Highways

Table of Contents



Source: WVDOT

Executive Summary

The West Virginia Department of Transportation (WVDOT) utilizes data-driven methods to manage more than 34,000 miles of state roads and 7,200 bridges. Transportation asset management (TAM) is one of the many tools WVDOT utilizes to manage the state's transportation systems in a cost-effective manner. This Transportation Asset Management Plan (TAMP) describes how WVDOT utilizes TAM methods to manage the state's highways and bridges to maximize performance, condition, and financial resources.

WVDOT believes that a commitment to continuous improvement is fundamental for effective asset management. Adopting these principles will enhance the Agency's asset management processes while aligning with the Agency's vision and long-term goals. Since the previous TAMP certification, the West Virginia Division of Highways (WVDOH) has undertaken several integral steps to further implement and engrain the TAMP into Agency workflows, project development and programming thus making TAM part of our everyday routine. Changes include:

- Improving bridge and pavement management software (BMS/PMS) outputs by revisiting unit cost values, updating deterioration curves, using historical data and industry standard models.
- Enhancing treatment decision trees and time in condition though a collaborative approach.
- Developing a process for vetting modelling outputs with development staff to review recommendations and aggregate and analyze modifications.

- Ensuring resilience and extreme weather are considered throughout the asset management process (specifically in life cycle planning and risk management analyses) to fulfil new requirements instituted by the Infrastructure Investment and Jobs Act (IIJA).
- Improving confidence in the TAM process though transparent data-sharing, through single source, dynamic datasets, among multiple stakeholders to promote collaboration Agency-wide.
- Integrating the TAMP into long-range and short-range planning by incorporating results into the West Virginia Long Range Transportation Plan (LRTP) and the State Transportation Improvement Plan (STIP).
- Creating standard operating procedures (SOPs) to support TAM processes and reviews and solidify continuity of operations.
- Determining a better source and process for identifying repeatedly repaired locations for use in risk management.

Results of these Agency-wide changes are featured in this TAMP update, which outlines a 10-year strategy for managing the state's bridges and pavements on the National Highway System (NHS). Like many state departments of transportation, WVDOH utilizes bridge and pavement management software (BMS/PMS) to understand and forecast bridge and pavement conditions in the future. This software assists the Agency in reviewing, evaluating and prioritizing projects based on asset condition and budget forecasts, allowing WVDOH the foresight to preempt known issues and mitigate the unknown.

Utilizing TAM methods and scenario planning allows WVDOH to enact measurable change from a "worst-first" to a more data-driven approach that adapts analytic system outputs to identify specific treatment types and best lifecycle cost application to benefit the entire network.

In the 2018 TAMP, WVDOH previously identified a "wave" of bridges projected to fall into the poor condition category. TAM approaches to Agency decision-making and improvement of the BMS/PMS outputs through multiple scenarios shows improvement in the long-term projections for NHS bridges and nearly eliminated the previous projected wave of poor condition bridges, into a manageable and predictable trend. Improvement of the BMS/PMS systems through recalibration resulted in the ability to forecast the results of the repairs made to the State's bridges through a recent bond improvement program, thus reducing the wave of bridge repairs needed in the future. Figures 1-4 show the bridge scenario results from the previous TAMP compared to the current scenario.

In addition to these enhancements, a process was developed for vetting the BMS outputs with the District managers to confirm or validate the system project recommendations. This allowed for confident process modification to eventually leverage the systems to develop the Agency's STIP with these data-driven methodologies. As with any process implementation, culture change will occur. WVDOH has utilized open and transparent communication throughout the Agency to propagate TAMP principals and ideals through all levels of the organization. From initial TAMP certification in 2018, through implementation and into the current 2022 TAMP update, WVDOH has taken positive strides in our asset management journey. As an Agency, we will continue to evolve and continuously improve our standards as we improve data, systems and process to monitor and improve the condition of our transportation network for the benefit of West Virginia's businesses, residents and visitors.

FIGURE 1: 2019 PROJECTED FHWA CONDITION METRICS FOR BASELINE FUNDING ON NHS BRIDGES

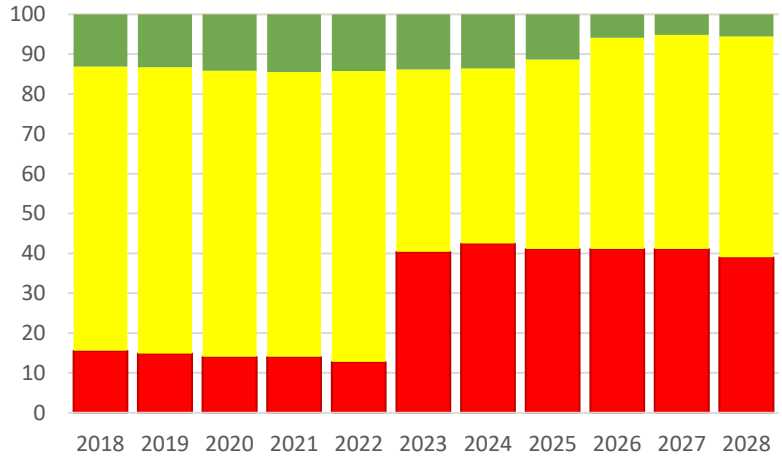


FIGURE 2: 2019 PROJECTED FHWA CONDITION METRICS FOR BASELINE FUNDING ON NON-NHS BRIDGES

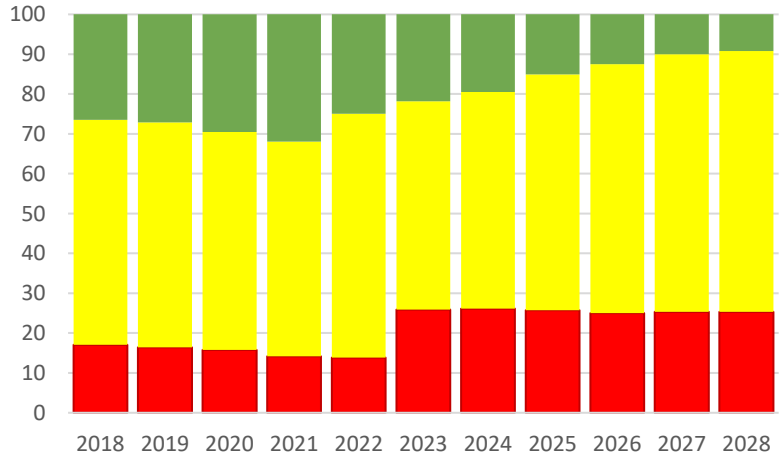


FIGURE 3: 2022 PROJECTED FHWA CONDITION METRICS FOR BASELINE FUNDING ON NHS BRIDGES

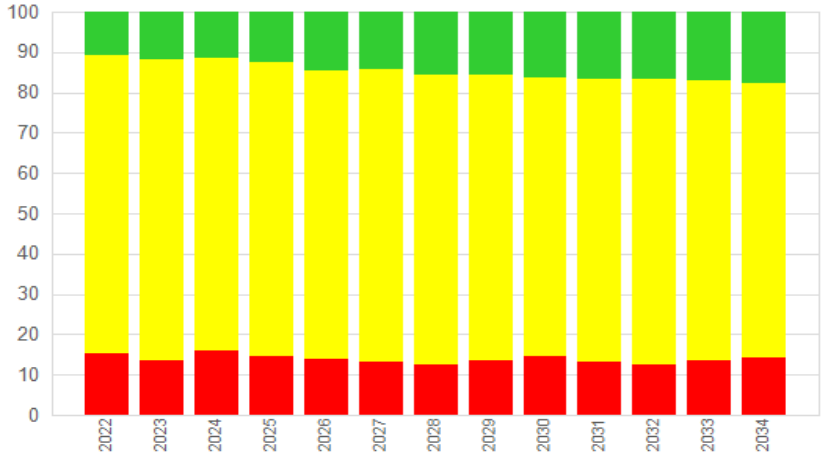
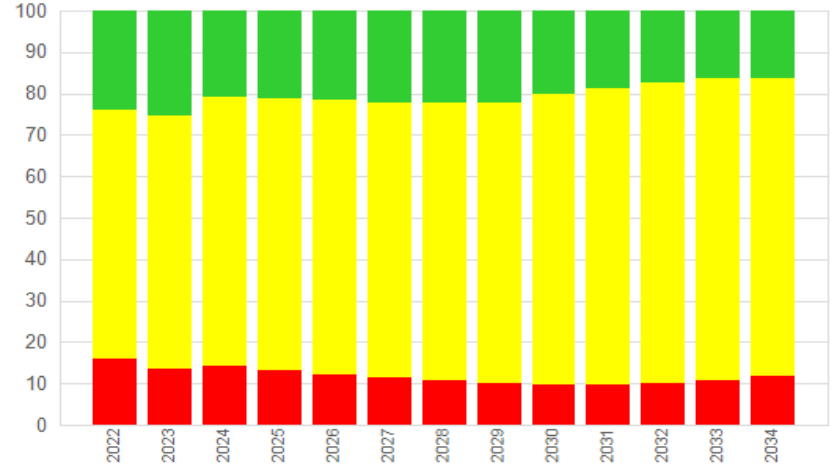


FIGURE 4: 2022 PROJECTED FHWA CONDITION METRICS FOR BASELINE FUNDING ON NON-NHS BRIDGES



Source: WVDOT

Source: Mott MacDonald

Chapter 1

Overview and Purpose

The West Virginia Transportation Asset Management Plan, or TAMP, documents information about the National Highway System (NHS) detailing bridge and pavement assets, their condition, performance and the process to manage those assets across the state. The TAMP aims to document current asset management practices of the West Virginia Department of Transportation (WVDOT) and identify process improvements WVDOT is undertaking to improve asset performance, decision-making, financial planning and investment strategies to maximize the functional life of our NHS bridge and pavement assets.

The Infrastructure Investment and Jobs Act (IIJA) (Public Law 117-58) was signed into law on November 15, 2021. The IIJA is the largest long-term investment in our infrastructure and economy in our Nation's history. It provides $550 billion over fiscal years 2022 through 2026 in new Federal investment for infrastructure, including roads, bridges, and mass transit, water infrastructure, resilience, and broadband. It makes a once-in-a-generation investment of $350 billion in highway programs. This includes the largest dedicated bridge investment since the construction of the Interstate Highway System. Based on formula funding alone, West Virginia expects to receive approximately $3.8 billion over five years in Federal highway formula funding for highways and bridges. On an average annual basis, this is about 35.2% more than the State's Federal-aid highway formula funding under current law.

The IIJA continued previous federal legislation initiatives in the areas of a performance-based highway program with the goal of ensuring federal transportation funds are fully leveraged to provide the greatest benefit with respect to safety, mobility, and highway and bridge asset condition. Additionally, the IIJA requires states to consider extreme weather and resilience as part of the lifecycle planning and risk management analyses in a state's TAMP. Together these regulations require each state department of transportation (DOT) to develop a risk based TAMP that contains the following elements:

1. A summary listing of the pavement and bridge assets on the NHS in the State, including a description of the condition of those assets
2. Asset management objectives and measures
3. Performance gap identification
4. Lifecycle cost, risk management and resiliency analysis
5. A financial plan
6. Investment strategies.

Asset Management is defined in the Code of Federal Regulations[1] (CFR) as "a strategic systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair[2] over the lifecycle of the assets at minimum practicable cost." Following established federal rule making protocols, a series of amplifying rules governing TAMP development and Transportation Performance Management (TPM) were codified in the CFR. As such, each State DOT is required to submit a complete TAMP update at least every four years to their respective Federal Highway Administration (FHWA) Division office, based on the certification date of the previous TAMP. In addition, each State DOT is required to submit an annual consistency determination to FHWA show readiness and implementation documentation.

Within the WVDOT, the West Virginia Division of Highways (WVDOH) is responsible for planning, engineering, rights-of-way acquisition, construction, reconstruction, traffic regulation and maintenance of more than 34,000 miles of state roads and 7,200 bridges. As the responsible division within the WVDOT, WVDOH is leading the development of the state's TAMP to meet federal requirements.

WVDOH completed the Agency's previous TAMP in August 2019 and subsequently submitted the document to FHWA for certification. FHWA certified the WVDOH TAMP, and this updated document builds upon the prior TAMP by refining the Agency's business practices and utilizing the forecasting capabilities of the Agency's enhanced bridge and pavement management systems. Throughout this process, WVDOH staff have gained a deeper understanding of the benefits of transportation asset management (TAM) for supporting Agency investment decision making.

The WVDOH TAMP addresses pavements and bridges, as follows:

[1] See 23 CFR 515.5 "Definitions"

[2] Further discussion and definitions of the state of good repair are detailed in Chapter 2 – Managing Bridge Assets and Chapter 3 – Managing Pavement Assets.

- Pavements - Those pavements on the NHS Only. The remainder of state-owned pavements may be added in subsequent TAMP updates.
- Bridges - Those bridges on the NHS Only. The remainder of state-owned bridges may be added in subsequent TAMP updates.

Additional asset classes may be added in future versions of the TAMP.

TAMP Development Approach

Well before the submission of the first TAMP, WVDOH was initiating data driven business processes alongside collaborative approaches to managing the state's bridge and pavement assets. New processes and changes to business practices have also been instituted that allow for continuous improvements and a focus on transparency and data-driven decision making. WVDOH along with a team of consultants, have crafted a TAM program that includes not only this TAMP document, but the implementation and refinement of bridge and pavement management software (BMS/PMS) and development of Standard Operating Procedures (SOPs) to ensure alignment of data needs with asset management processes.

The TAMP Team working under the leadership of the Chief Engineer of Programs and Performance Management, has provided oversight and guidance to the consultant team throughout the development process for the 2018, 2019 and 2022 TAMPs. For the initial TAMP, numerous workshops were conducted throughout the life of the project, first validating existing or "as is" conditions and processes, followed by an extensive gap analysis effort and development of a Risk Register. From there, the TAMP Team and a group of WVDOH stakeholders worked collaboratively with the consultant team to draft the TAMP document for the initial submission to FHWA. A similar approach was followed for the development of this 2022 Updated TAMP document as well. The extensive commitment of time, valuable feedback and subject matter expertise provided by WVDOH stakeholders was critically important to ensuring that the TAMP becomes a "living document" that not only meets Federal requirements; but more importantly serves the unique needs of WVDOH.

Overview of West Virginia

West Virginia is the 41st largest and the 39th most populous state in the nation. The 2020 Census indicated West Virginia's population to be 1.79 million.[3] Despite its relatively small size, West Virginia is home to approximately 3,100 cities, towns, and small communities. Linking them are approximately 38,879 miles of public roads, of which about 89% are owned and operated by the WVDOH, making it the 6th largest state-maintained highway network in the nation. WVDOH does not maintain federal or municipal system streets, but is one of a few states (Alaska, Delaware, North Carolina, Virginia, and West Virginia) in the nation to manage virtually all other public road mileage, down to the county level. The WVDOH maintained system includes over 7,000 bridges exclusive of the WV Turnpike, which operates an 87-mile toll facility with 101 bridges, of which 99 are NHS bridges. Turnpike pavement and bridge assets located on the NHS have been included in

[3] U.S. Quick Facts, West Virginia, U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/WV/PST045221

the TAMP inventory, analysis and investment strategies. Figure 5 details the public road mileage in West Virginia.

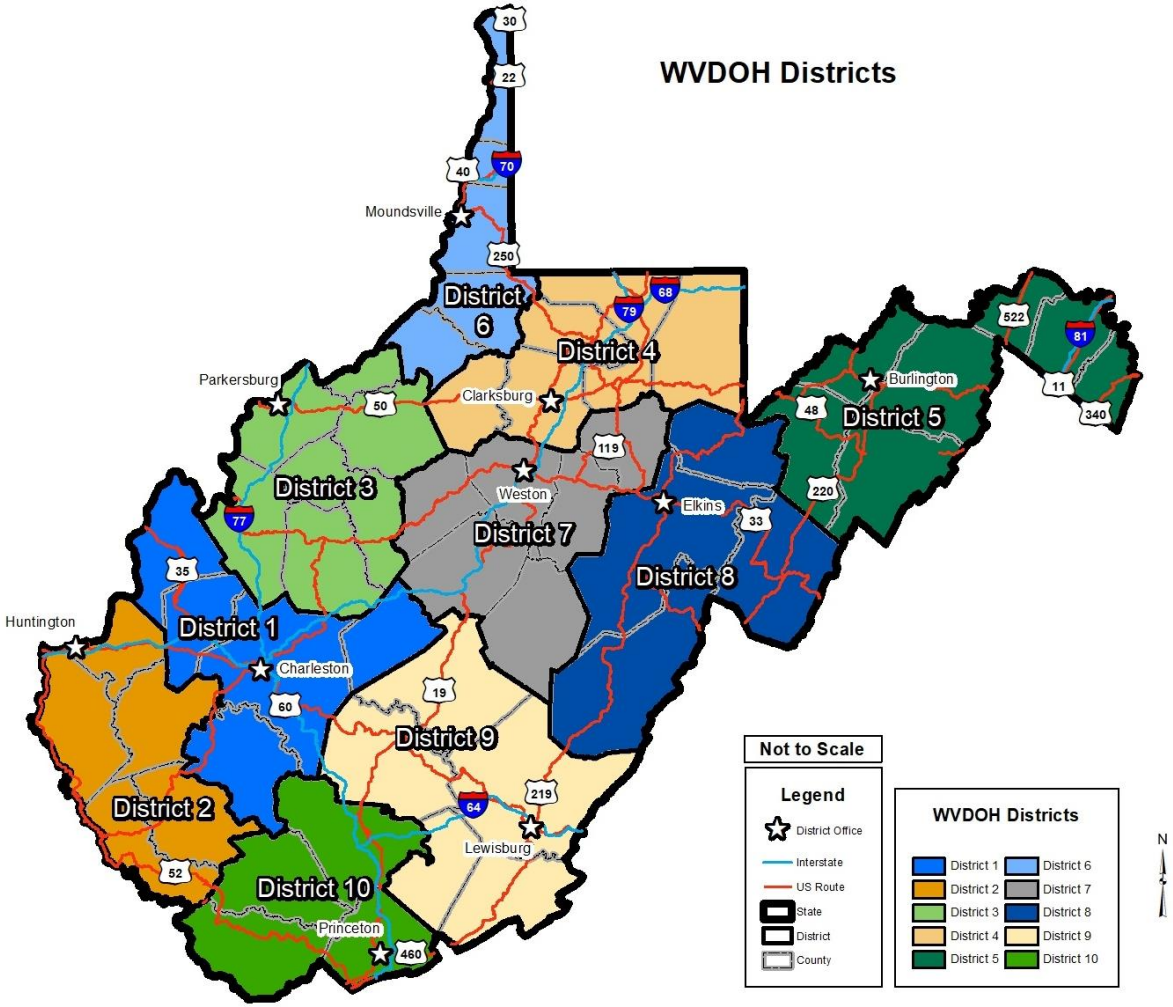
FIGURE 5: WEST VIRGINIA PUBLIC ROAD SYSTEM

	Mileage
State Owned Highways	34,421
Federally Owned	919
Municipally Owned	3,539
Total Public Roads	38,879
Interstate Highway	556
WV Turnpike	87
National Highway System	1,990

Source: 2020 Public Certified Mileage (HM-10, HM-15), Federal Highway Administration Highway Statistics 2020,

The WVDOH is divided into 10 geographic Districts (Figure 6) which are responsible for delivering the Division's construction, maintenance, and operations programs. District Maintenance and Bridge Engineering staff are integral players in the bridge and pavement program development process for the NHS.

FIGURE 6: WV DISTRICT MAP

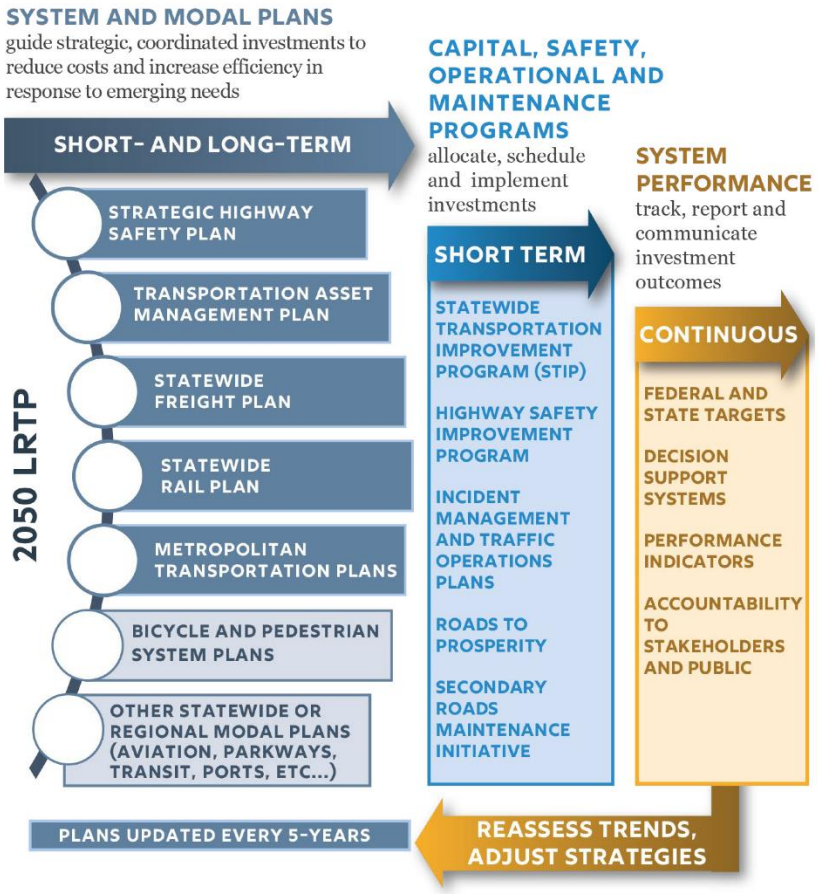


Source: WVDOH

Long Range Transportation Plan

The 2050 West Virginia Long Range Transportation Plan (LRTP) was initiated in 2020 to position WVDOT and the multimodal system it manages to support the state's economy, enhance quality of life, foster safe and reliable transportation options, and better connect West Virginia residents and businesses to opportunities. The 2050 LRTP creates a platform for ongoing and future planning, programming, and performance management activities that connect to the WVDOT mission, vision, and goals. The 2050 LRTP is the policy document to guide and develop the WVDOT "family of plans", creating unified, consistent, and strategic actions that coordinate system-wide, mode-specific regional and corridor plans. This TAMP is one component in the family of plans and supports the 2050 LRTP by drafting analysis, formulating strategies necessary to operate, maintain, and improve highway physical assets cost effectively through their lifecycle.

FIGURE 7: LRTP CONNECTION TO PLANS AND PROGRAMS



Source: 2050 West Virginia Long Range Transportation Plan, WVDOT

Importance of the National Highway System

The NHS in West Virginia is comprised of the WV Turnpike (portions of I-77/ I-64), Interstate Highway network, Appalachian Development Highway System (ADHS), and other primary highways. The Interstate and ADHS are multi-lane freeway and expressway facilities while the remaining NHS routes are typically two-lane facilities. A comparison of NHS mileage and vehicle miles traveled (VMT) on the public roadway network (including WV Turnpike) is provided in Figure 8. The NHS serves as the backbone of the state transportation system. While it represents only 5% of public road centerline miles, it carries 53% of the VMT. Similarly, 17% of the total number of state-owned bridges are located on NHS routes, representing 59% of the total deck area.

FIGURE 8: 2020 PUBLIC ROAD MILEAGE AND VEHICLE MILES TRAVELED

System	Miles	VMT (M)	% Total Mileage	%Total VMT
Interstate	556	4,796	1.4%	30%
Non-IS NHS	1,434	3,725	3.7%	23%
NHS Total	1,990	8,521	5.1%	53%
Other FA*	8,562	5,727	22.0%	36%
FA Total	10,552	14,248	27.1%	89%
Non-FA	28,237	1,805	72.6%	11%
Totals	38,879	16,053	100.0%	100%

**FA: Federal Aid*

Source: 2020 Highway Travel (VM-3), Federal Highway Administration Highway Statistics 2020, https://www.fhwa.dot.gov/policyinformation/statistics/2020/

The strategic importance of the NHS to commerce and overall economic vitality of West Virginia, as is the case with other states, led Congress to enact MAP 21, FAST Act, and subsequently IIJA, ensuring state of good repair standards were instituted to maintain this critical network. WVDOH has historically given priority to projects that protect the investment in NHS pavements and bridges, utilizing the best data available to drive decisions. However, it is important to note that WVDOH is also responsible for managing a very large highway network with many competing needs and a finite budget. Accordingly, WVDOT Leadership must make investment trade-off decisions which require careful assessment of all transportation needs.

As WVDOH continues to implement TAM practices, it will leverage refined business processes combined with the extensive analysis and forecasting functionality associated with its robust bridge and pavement management systems to inform long-term programming decisions. These enhanced capabilities will better enable WVDOH to sustain or improve NHS infrastructure conditions while addressing other transportation needs. The asset management business processes related to bridges, pavements, risk, and finance, detailed in subsequent chapters of this TAMP, have been thoughtfully developed to meet the spirit and intent of MAP 21, FAST Act, and the recent IIJA legislation.

NHS Effectiveness Performance

The MAP 21 and FAST Act legislation focused on multiple aspects of NHS performance, including condition, safety, mobility, congestion, and freight, in addition to TAMP requirements. While the goal of the legislation is to ensure safe and efficient movement of people and goods on the NHS, WVDOH has the added challenge of maintaining the entire network of pavements and bridges throughout West Virginia.

Accordingly, WVDOH recognizes the need to balance investments made to maintain targets in the areas of condition, safety, mobility, congestion, and freight. Within the framework of the TAMP, the program of projects not only will focus on perpetually maintaining a

state of good repair[4] for NHS pavements and bridges, but within the context of the LRTP, work to close the gaps identified, in a coordinated approach, in those related areas of safety, mobility, congestion and freight. This integrated approach, while focusing on the NHS, recognizes that the WVDOH has additional responsibilities that include the entire network of roads and bridges for the remainder of the state network, and all which are to be maintained within budget.

Based on the performance targets submitted to FHWA in 2021, WVDOH's analysis has determined that travel time reliability performance targets are conservative, indicating that significant gaps do not currently exist for the efficient movement of people and freight.

Future issues and concerns relative to climate-change and extreme weather are also being considered in risk management scenarios and are being added to discussions on how best to manage the overall program.

Additionally, as NHS facilities are widened for capacity or modernized to enhance mobility or safety, lifecycle management of the associated improvements must be planned. WVDOH is already working proactively to extend the performance life of its critical assets by employing pavement and bridge preservation strategies which minimize construction delays by pushing rehabilitation to a later date.

The TAMP is integrated, alongside the West Virginia 2050 LRTP including the planning the performance measures and the 2022 TAMP. Thus, ensuring the overall effectiveness of the NHS as well as the rest of the WVDOH highway network and the implementation and coordination of the TAMP.

Asset Management at WVDOH

WVDOH's asset management strategy has continued to evolve with the Agency placing a high priority on development and implementation of integrated Enterprise Resource Planning (ERP) and asset management systems. When fully implemented, this integrated systems approach will efficiently track asset, budget, project delivery, and expenditure information and provide continuous data to inform investment and programming decisions.

There is a well-established program and associated procedures for performing routine maintenance and repairs on roadway and bridge assets. The management system identifies projects currently underway or planned for the near-term. It will also bolster maintenance, operations, preservation, and capital investment decision making. For example, in recent years the Agency has become an active participant in the American Association of State Highway and Transportation Officials (AASHTO) sponsored regional bridge and pavement preservation partnerships. Preservation is an important asset management strategy, and since the engagement with peer states, WVDOH is now integrating preservation actions into its work program to cost-effectively extend the life of these critical assets. Not only is WVDOH working TAM principles into its operation but also aligning with long-range plans and performance measures.

[4] Further discussion and definitions of the state of good repair are detailed in Chapter 2 – Managing Bridge Assets and Chapter 3 – Managing Pavement Assets.

Management Systems

WVDOH has been a key participant in the State's multi-Agency ERP project, known as wvOASIS, which began in 2012 to modernize financial and human resource systems and processes through a phased approach. Integrated with the ERP, WVDOH has also been developing enterprise asset management systems (AMS) for managing roadway maintenance operations and assets, signs and signals, safety, fleet, facilities, and right of way. Additionally, implementation of the ESRI Roads and Highways (R&H) tool for managing the Agency's road inventory and Linear Referencing System (LRS) is complete. A new software solution has been implemented to replace the existing mainframe Project Tracking System (PTS). The new software, known as the 'Hub', will modernize programmatic workflow, analytics, and data accessibility to better enable project management, reporting, and decision making.

Automated pavement inventory and condition data has been collected on Interstate and ADHS routes for more than 20 years. Inventory and condition data has also been collected on the remaining NHS routes, though not historically analyzed in the pavement management system (PMS) until the TAMP requirements were established. A Data Quality Management Plan has been certified by FHWA and is now in place to govern the collection of data for Highway Performance Monitoring System (HPMS) 0.10-mile pavement segments on the entire NHS. WVDOH has utilized Deighton dTIMS™ PMS for analysis of pavement data and project identification for many years. The PMS models and decision trees that support scenario analysis and have been recently calibrated to improve analysis results required for this TAMP using HPMS data. The PMS can perform scenario analysis based upon budget and condition objectives, which produce an optimized workplan with recommended projects.

The Bentley AssetWise Bridge Inspection System supports management of National Bridge Inventory (NBI) bridges. The Agency follows well established inspection and quality assurance protocols for the collection of bridge inspection data and its importation into the system as inspections are completed. This system is used for warehousing bridge and inspection data, generating reports on condition data to FHWA on an annual basis, providing asset condition data for Deighton dTIMS™, and for identifying maintenance repair needs and replacement candidates.

To support TAMP development, WVDOH implemented the Deighton dTIMS™ Bridge Management System (BMS) in 2019. Similar to the pavement system, the BMS is successfully being used to perform data analysis and the 10-year forecasts required for the TAMP. Together, these asset management systems support lifecycle planning and strategic investment decision making employed by WVDOH. The vision is for these systems to interface with the ERP, Roads and Highways, Project Tracking, and other Agency asset management systems, providing enhanced Agency-wide access to critical data.

This TAMP, describes how WVDOH manages its bridges and pavements throughout their lifecycle. It also provides a framework to guide funding decisions to maintain bridge and pavement assets in a state of good repair. In addition to meeting federal requirements, WVDOH's TAMP meets the following objectives:

- Establishes a process to complete a performance gap analysis and to identify strategies to close gaps
- Identifies a process to complete lifecycle planning
- Verifies the developed risk analysis process and develops a risk management plan

- Considers extreme weather and resiliency in the asset management process
- Creates a process to develop a financial plan covering at least a 10-year period
- Establishes a process to develop investment strategies
- Determines a process to obtain necessary data from NHS owners other than the WVDOH
- Ensures the TAMP is developed with the best available data and that WVDOH uses bridge and pavement management systems meeting the requirements in 23 CFR 515.17[5] to analyze NHS bridge and pavement condition.

[5] https://www.ecfr.gov/current/title-23/section-515.17

TAMP Process Overview

The overall TAMP development process, and how this interacts with the State Transportation Improvement Plan (STIP) and the Long Range Transportation Plan (LRTP), is shown in Figure 9. This diagram describes the elements and processes required in the TAMP. The processes for obtaining data from NHS owners other than WVDOH, ensuring use of the best available data, and management systems, are descibed in this document. These processes are not part of the diagram.

As shown in Figure 9, a portion of the process takes place separately within each of the groups managing the different asset types. For instance, the Pavement Management group is responsible for updating inventory and condition, as well as lifecycle planning for that asset type.

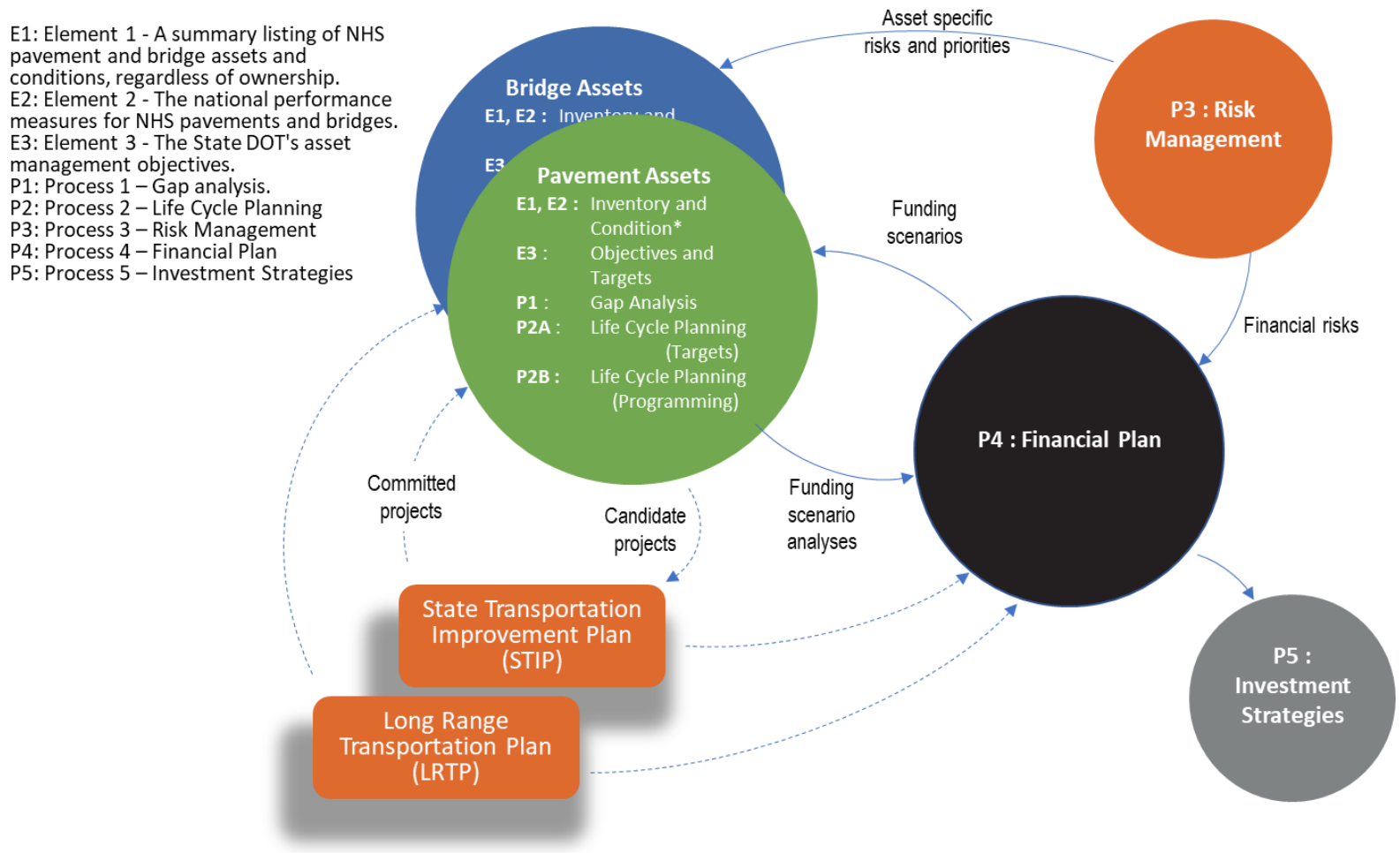
Other portions of the TAMP development process are conducted more centrally as interactions and trade-offs between asset types are being considered. The WV Turnpike system is included in the WVDOH PMS/BMS analysis process but its program is separately funded by WV Turnpike accounts and not accounted for in the STIP or LRTP.

This document uses a similar structure to describe the processes and associated analysis where applicable. The Bridge (Chapter 2) and Pavement (Chapter 3) processes are discussed first. Thereafter the processes for Risk Consideration (Chapter 4), Financial Planning (Chapter 5), and Investment Strategies (Chapter 6) are described.

Regarding the timing of the processes, while there is a 'consistency determination' every year, the TAMP will be updated and re-certified at least at the beginning of each 4-year Performance Period. At this point analysis will be conducted by WVDOH, using the processes described in this TAMP, for setting targets and developing financial plans for the next 10 years. These targets, as well as discussion of the baseline condition at the beginning of the Performance Periods, will be included in the Baseline Performance Period Reports submitted by October in the first year of the Performance Period.

In addition, at the mid-point of each performance period, progress towards targets will be analyzed using the Gap Analysis and Lifecycle Analysis described in this TAMP. This will enable WVDOH to set, revise, and report on progress towards the targets. The results of this analysis will be submitted in the Progress Reports that are required by 23 CFR 490 in October of years following the mid-points of the Performance Periods. These processes are described in more detail in the remainder of this document.

FIGURE 9: TAMP PROCESS



*Note: Condition is reported in terms of the national performance measures for pavements and bridges.

Source: WVDOT

Chapter 2

Managing Bridge Assets

Inventory

On the NHS, West Virginia has 1,299 bridges comprising 24,741,000 square feet of deck area. These are split relatively equally between Interstate and Non-Interstate systems as can be seen in Figure 10 and Figure 11.

In total, WVDOH owns 1,198 (92%) of the NHS bridges and 22,815,000 square feet (92%) of the total NHS deck area. The West Virginia Parkways Authority (WV Turnpike or Turnpike) owns 99 (8%) of the NHS bridges and 1,835,000 square feet (7%) of the total NHS deck area. Two bridges, totaling approximately 90,000 square feet are owned by private entities as shown in Figure 12 and Figure 13.

FIGURE 10: BRIDGE STATISTICS – NHS BRIDGES

	WVDOH	WV Turnpike	Other	Total
Interstate (bridges)	555	97	0	652
Non-IS NHS (bridges)	643	2	2	647
Interstate (sf)	9,756,000	1,818,000	0	11,574,000
Non-IS NHS (sf)	13,059,000	18,000	90,000	13,167,000

Source: National Bridge Inventory (NBI) Data, 2021

FIGURE 11: NHS BRIDGES BY OWNER

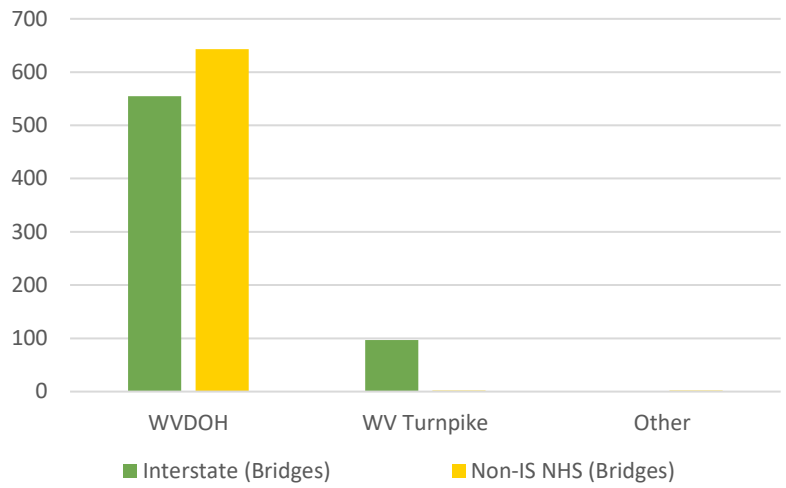


FIGURE 12: NHS BRIDGES

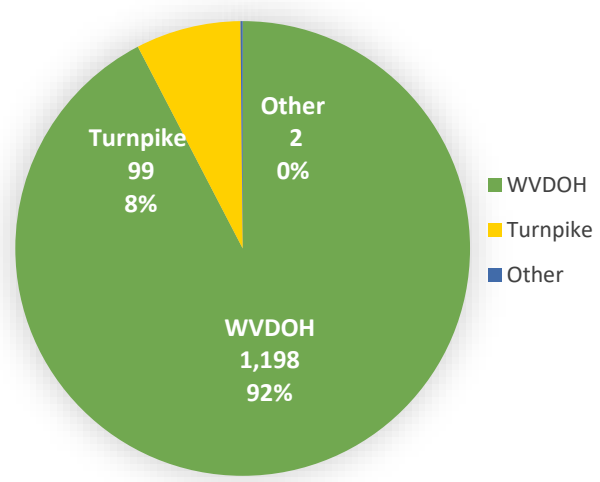
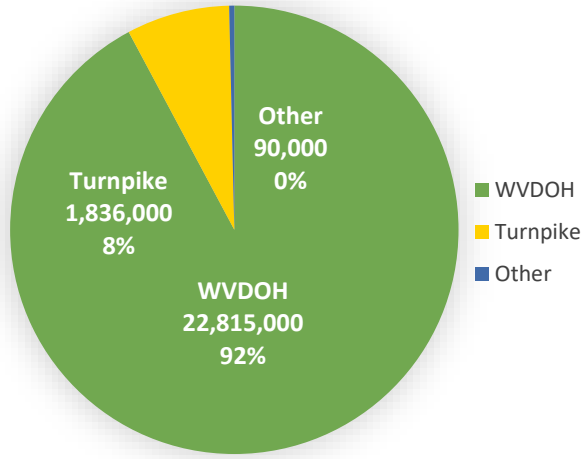


FIGURE 13: NHS BRIDGES BY SQUARE FEET



Condition

Based on the 2021 NBI data, the majority of WVDOH NHS bridges are in Fair condition, with 10.9% of deck area in good condition and 14.0% in poor condition. This is shown in Figure 14: Condition of NHS Bridges by Deck Area (2021)

.

FIGURE 14: CONDITION OF NHS BRIDGES BY DECK AREA (2021)

The deck and superstructure elements are in better condition (3.4% and 6.3% Poor respectively) than the substructure element (10.2% Poor) as seen in Figure 15.

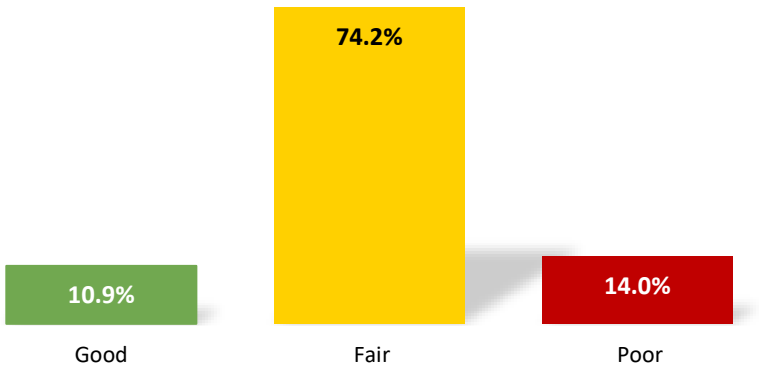
FIGURE 15: CONDITION OF WVDOH NHS BRIDGE COMPONENTS BY DECK AREA

	Good	Fair	Poor
Deck	28.0%	68.7%	3.4%
Superstructure	35.4%	58.3%	6.3%
Substructure	23.1%	66.6%	10.2%
Culvert	24.1%	73.2%	2.7%
Overall NBI Bridge	10.9%	74.2%	14.0%

Source: National Bridge Inventory (NBI) Data, 2021

Trends Over Time

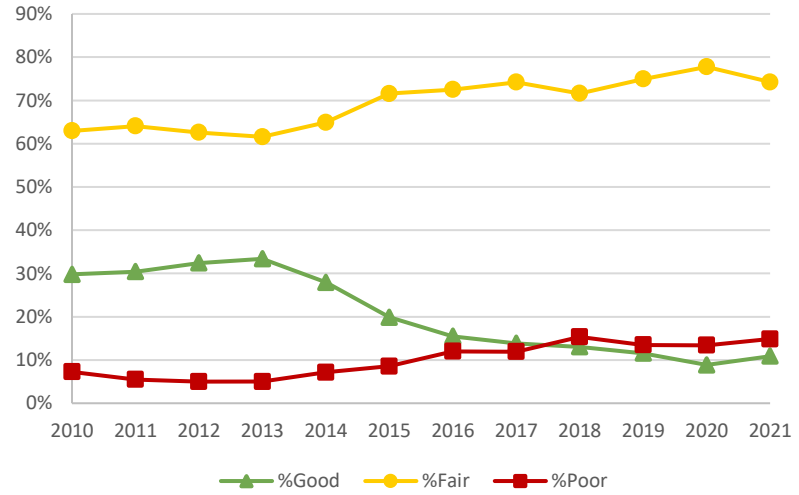
The proportion of NHS bridges in good condition by deck area has declined over time. Historically it has remained in the 30% range, but it has recently been approximately 10%. The proportion of NHS bridges in Poor condition by deck area has been gradually increasing since 2104 to near 15% in 2021. The Fair proportion of NHS bridges by deck area has slowly risen over the last 6 years from near 60% in 2013 to 74% in 2021 as shown in Figure 16.



Process for Obtaining Data from NHS Owners other than WVDOH

Owners input condition data directly into WVDOH's bridge inspection system and central data storage, AssetWise. WVDOH analyzes the data for errors and works with other NHS bridge owners, principally the WV Turnpike, to correct any errors prior to federal submittal. Any corrections are communicated back to the WV Turnpike or other owners for clarity.

FIGURE 16: NHS BRIDGE CONDITION OVER TIME (2010-2021)



Objectives and Targets

WVDOH desires to maintain the NHS bridges in a state of good repair (SOGR) by adopting the following objectives:

- Use the Deighton dTIMS™ Bridge Management System (BMS) to project deterioration and show benefit of maintenance, preservation, rehabilitation, and replacement projects to analyze different funding scenarios.
- Maximize the average of the weighted NBI rating by deck area for the deck, superstructure, and substructure (or culvert rating) over a 10-year analysis period, subject to budget constraints. This involves:
  - Using maintenance and preservation treatments on bridges to keep them in Good or Fair condition since maintenance and preservation treatments show a high benefit-cost ratio.
  - Replacing bridges to minimize the number and deck area of bridges in Poor condition and minimize the number of load posted bridges where the benefit-cost ratio supports this.
- Include the following weighting factors for replacement candidates in the calculation of benefit for assessment of benefit-cost ratios over the lifecycle of the structures:
  - Risks from scour and low vertical clearance,
  - Annual Average Daily Traffic (AADT),
  - Detour length,
  - District priority, and
  - Repeated emergency response claims evaluated based on 23 CFR 667.

WVDOH established the following targets for the end of the previous and next federal performance periods:

- The percentage of bridges on the NHS in a Good condition [23 CFR 490.407(c)(1)] by deck area should be at least 11% in 2023, and 12% in 2025.
- The percentage of bridges on the NHS in a Poor condition [23 CFR 490.407(c)(2)] by deck area should not exceed 13% in 2023, and 13% in 2025.

Bridge State of Good Repair

Based on current projected conditions and the 2- and 4-year targets noted above, WVDOH defines the SOGR for bridges as follows:

- The SOGR for percent of NHS deck area in Good condition should be considered to be not less than 12% in 2025, and
- The SOGR for percent of NHS deck area in Poor condition should be considered to be not greater than 13% in 2025.

Scenario comparisons in Chapter 6 demonstrate the expected performance of bridges over the ten-year timeframe of the TAMP.

Gap Identification and Strategies for Attaining Targets

Physical Condition of Assets

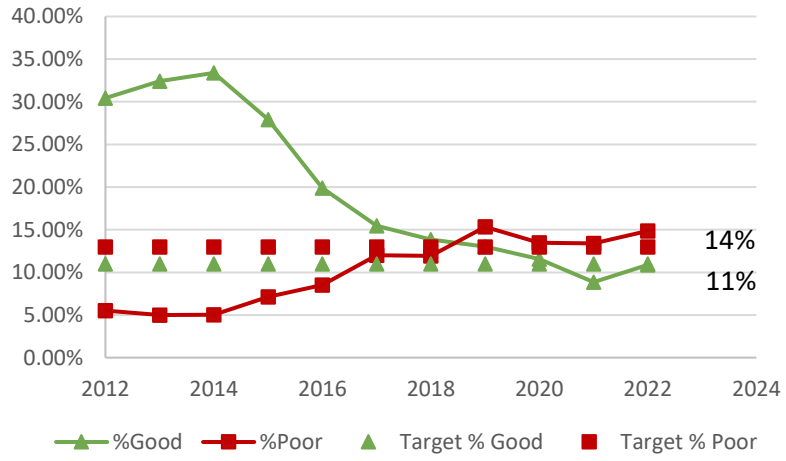
Based on the current conditions shown in the beginning of this chapter (Inventory and Condition) and the targets defined in the previous section, there are currently gaps between the present condition of the NHS bridges and the target condition.

Currently there is a 1.1% gap between the current good condition value of 10.9% and the 2025 target value of 12.0%. Projects currently listed in the STIP are expected to narrow this gap and will help ensure that it does not get appreciably wider over the next 2-year period. The current gap for Poor condition is at 1.0%, as shown in Figure 17 and Figure 18.

FIGURE 17: BRIDGE CONDITIONS TARGETS AND GAPS

	Current Condition	2025 Target	Gap
% Good	10.9%	12.0%	1.1%
% Poor	14.0%	13.0%	1.0%

FIGURE 18: NHS BRIDGES – CONDITION VS TARGETS



Discussion of Deficiencies

Based on the 10-year projections, some of the deficiencies affecting WVDOH's ability to make progress towards the desired goals include:

- Prior to the significant increase of federal funding in the IIJA, overall funding has remained a challenge however, Management has dedicated additional funding for NHS bridges in the recent years. The commitments made for the 2019 TAMP to emphasize funding for bridges has essentially softened the wave of poor bridges that faced WVDOH beginning in the next few years.
- Project delivery poses some challenges since there is a relative shortage of internal pre-construction staffing in the areas of design, utilities, permitting and environmental, creating a bottleneck in the programming and delivery pipeline.

Identification of Alternative Strategies

As noted above, because all program areas compete for funding, one of the primary ways in which WVDOH develops funding strategies is using their BMS to analyze and run scenarios to be able to project the effects of different funding levels. WVDOH began this process with the first TAMP and continues to improve through multiple scenarios and funding adjustments.

In addition to developing alternative funding strategies, increases in state and federal funding should also mitigate any potential deficiencies. The 2017 Roads to Prosperity state legislation provided increased state funding for transportation needs, especially major capital projects over the past several years. Looking ahead, the over 30% in additional funding included in the IIJA, the largest infrastructure bill in United States history, will provide funding for critically needed improvements to roadways and bridges across the country.

The process for identifying alternative strategies, and specifically the identification of specific alternative funding strategies that need to be analyzed, is undertaken as part of the Financial Planning processes described later in this document. Examples are given in the more detailed section on Lifecycle Planning.

In addition to those strategies identified in in this chapter and the Financial Planning processes, the Bridge Management group may also analyze alternative strategies informally to test different policies (such

as differing budgets for different work types) and objective functions. The analysis process is outlined in the Process for Performing Lifecycle Optimization Analysis section later in this chapter. However, it should be noted that the BMS generates an optimal strategy for each funding scenario that defines the ideal mix of work types. While it is interesting to view the results, manual adjustment of the optimum recommended mix of work types will invariably result in a nonoptimal strategy.

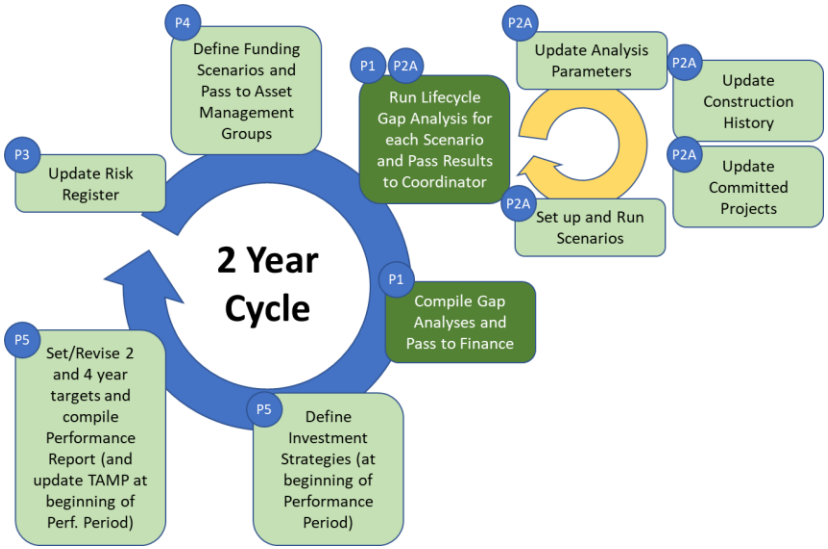
Process for Performing Gap Analysis

The methodology for Gap Analysis consists of four main steps:

1. Update Inventory and Condition.
2. Check progress against current Targets and Objectives.
3. Project future gap between Condition and Targets at the end of the Performance Period under different scenarios.
4. Compile Gap Analysis.

The assumption is that targets are already in place for specific future years (in this case the targets are for the FHWA Performance Period ending in 2025).

FIGURE 19: TWO-YEAR PERFORMANCE PERIOD



This process is depicted as part of the larger process shown in Figure 19. Note that the lifecycle analysis is conducted to project conditions out over a 10-year analysis period, and this is used to inform the two and four-year targets.

1. **Update Inventory and Condition** – The first step in the process of identifying and analyzing gaps between current condition and future targets is to update the inventory and condition. Both datasets are updated using the latest NBI condition data (2022 submittal year in this case). The latest percentage of Good and percentage of Poor conditions are calculated using the worst rating across Deck, Superstructure, and Substructure, or Culvert rating to define a bridge as being in Good or Poor condition as specified in 23 CFR 490.407. Thereafter, percentage of Good and percentage of Poor are calculated based on summing the deck area of the bridges in each condition and dividing by the total deck area.

2. **Check Progress against Targets and Identify Gaps** – Targets for percentage of Good and percentage of Poor metrics are discussed in the previous section. To check progress against these targets, the trend of these metrics during the current performance period will be plotted against the targets to identify current gaps.
3. **Project future gap between Condition and Targets** – The WVDOH then completes lifecycle planning analysis, discussed in the next section, to forecast the condition of bridges out to the end of the current performance period for each of the different funding scenarios identified in the Financial Plan. This process is outlined in the subsequent sections regarding the lifecycle planning process.
4. **Compile Gap Analysis** – Once the scenarios have been analyzed, the results are provided to the Asset Management Coordinator (by each asset management group). The Asset Management Coordinator will then compile these and provide the gap analysis to the Executive Leadership for consideration in the next budget cycle.

Lifecycle Planning Analysis for Gap Analysis and Target Setting

WVDOH has successfully implemented a BMS since the previous TAMP was completed in 2019, and the BMS has been updated and improved for the current TAMP. This system has greatly increased the capacity to analyze multiple scenarios using potential work types and deterioration modeling over chosen analysis periods to generate multiple workplan strategies. The process of generating these lifecycle planning strategies is described in the following sections: *Process for Selecting Scenarios*, and *Process for Performing Lifecycle Optimization Analysis*).

The analysis conducted is not completely based on the Statewide Transportation Improvement Plan (STIP). Near-term projects from the STIP that are in the process of being contracted or constructed, are considered underway projects and 'fixed' during this analysis process and as such are included in the projections. However, in the projections, the process is reversed with the analysis occurring first, and the recommended projects from the analysis being added to the STIP.

For the 2022 TAMP the detailed configuration (such as deterioration models, treatments, triggers, reset values, etc.) of the BMS has been refined with the new BMS configuration being used for planning analysis and the 2022 TAMP.

Regarding the projected conditions, 30% of the bridges currently in service in West Virginia were built in the 1960's and 1970's. Specifically for bridges on the NHS, this percentage is even higher at 38%. This indicates that between a third and a half of all NHS bridges are about 50 years old and, based on the design standards of the time, are approaching their original design life. The distribution of bridge age based on decade of construction is outlined in Figure 20. This indicates that a large portion of the State's bridges could cross the threshold into the Poor category if preservation and rehabilitation actions are not strategically completed. A Poor bridge is one where the lowest of the NBI general condition ratings for deck, superstructure and substructure is designated as NBI 4 or lower. Also, as bridges age, there will be fewer bridges in good condition, and some preservation actions result in adding service life to the component in Fair condition (NBI 5) or result in the component being rated NBI 6 "Satisfactory", but not achieving Good (NBI 7-9).

The projections from the funding scenarios show the 'wave' of bridges built in the 1960's and 1970's starting to slide into the Poor category However, by using the BMS tools, WVDOH was able to identify this wave and plan ahead to manage it. WVDOH's increased funding, in

addition to the new funding from the IJJA federal legislation, has influenced the forecasted NHS bridges condition to trend closer to the 2025 13% poor federal target in the analysis for the 10-year forecast.

FIGURE 20: PERCENT OF BRIDGES CURRENTLY IN SERVICE BY DECADE OF CONSTRUCTION

Decade	Individual Decade %/Total Deck Area			Cumulative %/Total Deck Area		
	Total	NHS	Non-NHS	Total	NHS	Non-NHS
1880s	0%	0%	0%	0%	0%	0%
1890s	0%	0%	0%	0%	0%	0%
1900s	0%	0%	0%	0%	0%	1%
1910s	1%	0%	1%	1%	0%	2%
1920s	1%	0%	3%	2%	0%	5%
1930s	2%	1%	4%	4%	1%	9%
1940s	1%	0%	3%	6%	2%	11%
1950s	5%	4%	7%	11%	6%	19%
1960s	9%	12%	5%	20%	18%	23%
1970s	23%	29%	15%	43%	47%	38%
1980s	15%	16%	14%	58%	63%	52%
1990s	14%	12%	18%	73%	74%	70%
2000s	15%	14%	18%	88%	88%	88%
2010s	11%	11%	11%	99%	99%	99%
2020s	1%	1%	1%	100%	100%	100%

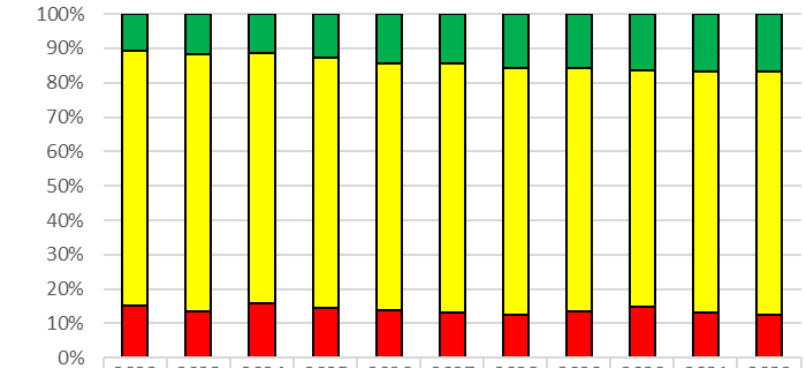
Investment Scenarios Analysis

Multiple funding scenarios were considered for analysis in cooperation with leadership which resulted in several scenarios being analyzed in detail for bridges using the lifecycle planning benefit cost analysis processes described in the Section - *Process for Performing Lifecycle Optimization Analysis*. The funding scenarios selected for detailed modeling and analysis are described in detail in *Chapter 6 - Investing Wisely*. This includes a baseline scenario plus several additional scenarios showing variations of funding and strategy and the effect they have on the NHS and non-NHS bridge network. Each of these funding scenarios included a specific change to the baseline funding scenario (Scenario 1) that is described in detail in *Chapter 6 – Investing Wisely*. Figure 52 in *Chapter 5– Managing Finances* shows the forecasted revenue for the baseline scenario.

Figure 67 in Chapter 6 represents a consolidated view of the condition output from the BMS for the various scenarios, and the baseline funding scenario upon which the other scenarios are based. For example, the baseline funding results are discussed in this chapter and shown in Figure 21 for NHS bridges and Figure 22 for non-NHS bridges. When comparing to the West Virginia 2019 Transportation Asset Management Plan report, the NHS projection of percent poor bridges no longer has a large spike in 2023. This is the result of WVDOH providing needed funding for their NHS bridges, adjusting strategy, and refining their BMS.

Projections for the baseline scenario show that percent Good NHS bridges will increase from 11% in 2022 to approximately 17% in 2032, however this does not meet WVDOH's current 11% Good target. Baseline projections show that Poor NHS bridges will decrease from 15% in 2022 to approximately 13% in 2032. This does meet WVDOH's current target for Poor bridges of 13%.

FIGURE 21: PROJECTED FHWA CONDITION METRICS FOR BASELINE FUNDING ON NHS BRIDGES

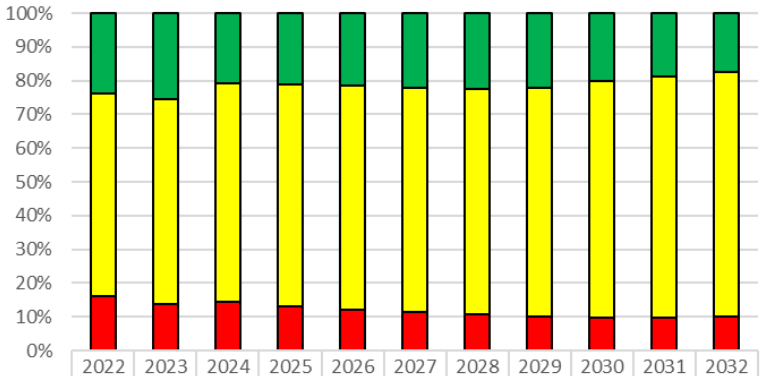


	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Good	10.83	11.68	11.52	12.58	14.48	14.33	15.68	15.65	16.51	16.61	16.84
% Fair	74.00	74.75	72.58	72.77	71.63	72.57	71.83	70.98	68.79	70.27	70.68
% Poor	15.17	13.57	15.90	14.65	13.89	13.11	12.50	13.37	14.70	13.13	12.48

Projections for the baseline scenario also show that percent Good Non-NHS bridges will decrease from 24% in 2022 to approximately 17% in 2032, and the percent Poor Non-NHS bridges will decrease from 16% in 2022 to approximately 10% in 2032.

As noted, further scenarios were analyzed to make progress towards these goals. Discussion of a recommended scenario for NHS and non-NHS is provided in *Chapter 6- Investing Wisely*.

FIGURE 22: PROJECTED FHWA CONDITION METRICS FOR BASELINE FUNDING SCENARIO ON NON-NHS BRIDGES



	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Good	23.88	25.53	20.74	21.16	21.56	22.12	22.42	22.20	20.02	18.77	17.48
% Fair	60.05	60.86	64.94	65.82	66.32	66.45	66.99	67.85	70.27	71.58	72.39
% Poor	16.08	13.61	14.33	13.02	12.13	11.43	10.58	9.95	9.71	9.66	10.13

Each of the alternate scenarios discussed in *Chapter 6 – Investing Wisely* represents a recommended workplan consisting of projected projects and project costs over the next 10 years. Each project is categorized as a specific work type ranging from preservation treatments to replacement as shown in Figure 23. Based on each of these workplans, the resulting investment strategy in terms of planned investment in dollars across the mix of work types can therefore be projected over the 10-year analysis period. Again, as noted previously, the specifically chosen investment strategy is discussed in *Chapter 6– Investing Wisely*.

Process for Selecting Scenarios

At the beginning of the performance period, the targets from the previous performance period are re-adopted or new targets are set. During the performance period, a gap analysis is conducted. In both cases, the Asset Management Coordinator works with the Executive Leadership and the Planning and Programming Division to decide on a set of scenarios for analysis by the different asset management groups.

Process for Performing Lifecycle Optimization Analysis

Analyzing a specific scenario involves following the basic steps:

1. **Update or confirm available treatment actions and unit costs** [6] - The treatments that are currently used in the BMS are shown in Figure 23. Bridge type structures have three major components, a deck which carries traffic loads, a superstructure that carries the deck and spans an expanse, and the substructure which carries load to the ground. When WVDOH does rehabilitation of preservation treatments to one component on a bridge, they also do preservation of the other major components as determined during the scoping and design phase of the project. The costs of these treatments are also reviewed and updated annually per the BMS configuration SOP (*BMS-DATA-04 Update Treatment Unit Costs*). This practice provides optimum benefit and service life to the structure.

FIGURE 23: TREATMENT ACTIONS AND DESCRIPTIONS

Treatment	Work Type	Cost Range	Description and Benefit
Seal Deck	Preservation	$2-3	Seal deck with linseed oil or epoxy resin. Adds 5 years of service life to the deck index
Replace Joints	Preservation	$850-925	Replace deck joints. Adds 10 years of service life to the superstructure index and 5 years to the substructure index.
Spot Paint	Preservation	$80-120	Painting approximately 20% of surface area. Adds 5 years of service life to the Superstructure and Paint indices.
Superstructure Rehabilitation	Rehabilitation	$80-100	Steel repairs (approximately 5% of structural steel) and full painting. Adds 5 years of service life to the deck, increases the NBI condition rating of the superstructure by 2, adds 8 years of service life to the substructures, and places the steel protective coating in a good condition state.

[6] Note that the actions listed here are those modeled in the management system. For the FHWA work type 'New Construction', these projects are included in the plan but sourced outside the management system.

Treatment	Work Type	Cost Range	Description and Benefit
Deck Overlay	Preservation	$45-60	Hydro demolish the deck to remove unsound concrete, place deck overlay, and replaces deck joints. Increases the NBI condition rating of the deck by 2.
Substructure Rehabilitation	Rehabilitation	$90-100	Patching concrete surfaces at bearing seats and exposed areas. Increases the NBI condition rating of the substructure by 2, adds 10 years of service life to the superstructure, and 5 years of service life to the deck.
Re-Paint	Preservation	$25-35	Paint 100% of superstructure surface area. Adds 10 years of service life to the Superstructure index.
Re-deck	Rehabilitation	$125-160	Replaces the deck. Resets the NBI deck condition rating to 8. If the superstructure condition rating is less than 6 then increases the superstructure rating by 1. If the superstructure condition rating is less than 6 then increases the superstructure rating by 1. Resets deck joint elements to a good condition.
Superstructure Replacement	Rehabilitation	$100-115	Replace the superstructure and deck. Resets the NBI deck and superstructure condition ratings to 8 and places all element condition states to good condition.
Structure Replacement	Replace	$250-300	Reconstruct the entire bridge and bring it up to current standards. Resets the NBI deck, superstructure, and substructure condition ratings to 8, and places all element condition states to good condition.
Culvert Re-Lining	Rehabilitation	$85-110	Culvert relining on pipe culverts including culvert headwall repair, patching, and sealing joints. Increases the NBI culvert condition rating by 3.
Culvert Replacement	Replace	$345-375	Reconstructs the entire culvert. Resets the NBI culvert rating to 8.

Note: Cost ranges are per square foot of deck area except for joint replacement which is per linear foot of joint

2. **Update or confirm deterioration models** – Deterioration models for the following performance indices are incorporated into the BMS.

FIGURE 24: PERFORMANCE INDICES

Index	Source
Deck	NBI Condition Rating
Superstructure	NBI Condition Rating
Substructure	NBI Condition Rating
Wearing Surface	Wearing Surface Age Counter (yrs.)
Joints	Deck Joint Elements
Paint	Superstructure Element Steel Protective Coating Element
Culverts	NBI Condition Rating

3. **Update or confirm benefit calculations** – The benefit is calculated as the area between the 'Do Nothing' projection of the objective function (e.g., NBI condition rating) and the projection for the proposed treatment, multiplied by various structure weight factors.
4. **Update construction history** – Projects that have been completed in the last year are updated by first capturing in the bridge inspection system and then bringing them into the BMS.
5. **Update Committed Projects (including STIP)** – The list of committed bridge projects that have been funded for delivery are a manually maintained list in the BMS and are updated based on the current STIP. Each project is given a status that allows it to be considered during the scenario analysis. If it is considered, the analysis assumes that the project is already committed and so assumes it is fixed and does not attempt to find alternatives.
6. **Identify Objectives and Constraints for Scenarios** – The objective function for the scenario is confirmed. The objective function defines what the optimization is attempting to maximize or minimize. In addition to the objective function, the constraints for each scenario are confirmed. For example, if the scenario is 'maintain current funding levels', the analysis may be to maximize the average weighted NBI utility rating (objective function), subject to an annual budget equal to the current or latest budget (constraint). If the scenario was 'meet target' the analysis may be to minimize cost (objective function) subject to the target metric value for the scenario being no worse than the set target value (constraint).
7. **Run scenarios** – Once all the inputs for the scenarios have been confirmed, multiple long-term alternative strategies for the scenarios are generated and evaluated.
8. **Review and Adjust Scenario Results** – At this point, the user has the option to review and adjust scenario strategies, to accept, or override them.
9. **Run optimization** – After candidate strategies have been evaluated, the optimization analysis for each scenario is run. This results in an optimum strategy being recommended for each bridge included in the analysis. These strategies result in an overall workplan for the scenario detailing each treatment for each year (including 'do nothing' treatments) for each bridge.
10. **Analyze effect of scenarios on metrics** – Because each scenario analysis results in a workplan strategy for each bridge, this allows the values of all metrics to be predicted for the analysis period (e.g., 10 years).

11. **Predict gap at end of performance period for each scenario** – The predicted values over the analysis period can then be used to see if, for any scenario, these values meet, exceed, or fall short of target values that have been set for the year.

12. **Submit results of analyses to Asset Management Coordinator** – The results, including the predicted metrics over time for each scenario, are given by the Bridge Management lead to the Asset Management Coordinator. As part of this submission there is a discussion of any gaps between scenarios and current/future targets, including explanations and possible reasons and solutions. In addition, if it is a year in which targets are to be adjusted, or new targets are to be set, the submission may also include discussion of possible target values. However, targets can only be finalized once the financial analysis of funding tradeoffs between pavement and bridge has been conducted and shared with the Executive Leadership.

Once that analysis is complete, a specific scenario and funding strategy is adopted and used for allocating a budget. This budget (and subsequent funding scenario) is communicated back to the Bridge Management group for use in Lifecycle Planning Analysis for Work Planning and Programming as described in the next section.

Source: WVDOT

Lifecycle Planning Analysis for Work Planning and Programming

The full, detailed process for work planning and programming is included in the internal document titled, *Bridge Project Selection SOP*. This process is summarized here. Once a budget has been set for the current year, it is communicated to the Bridge Management group along with a funding scenario to be used for analysis for work planning and programming near term (over the next two to three years) projects. Once already committed projects are updated, the analysis identifies specific short term recommended projects based on long term deterioration projections, benefit cost ratio calculations, and optimization analysis.

The funding scenario is analyzed to generate a recommended optimum workplan over the next 10 years. From this analysis, recommended projects for the near term are generated based on optimization and benefit cost considerations.

Process for Selecting Scenarios

Once the budget for the year has been allocated, it is communicated to the Bridge Management group by the Asset Management Coordinator. This budget is the full budget for the program, including the cost of upcoming committed projects. This constitutes the funding scenario to be analyzed.

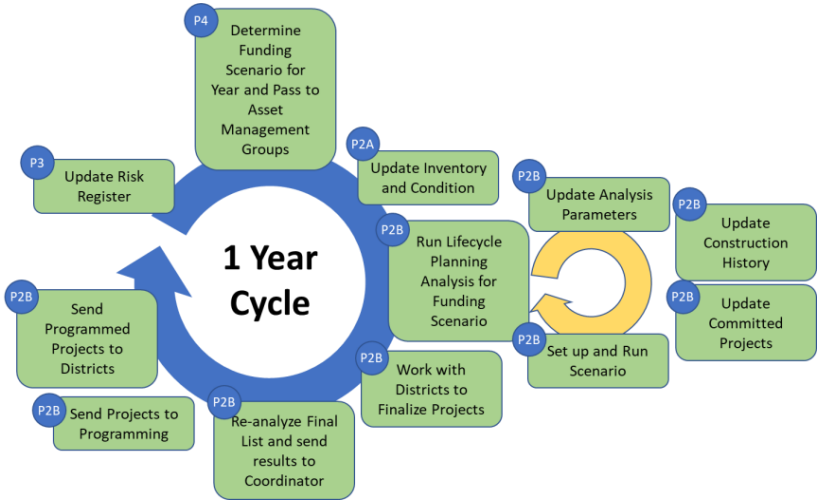
In addition to this funding scenario, the Bridge Management group may run other scenarios informally to test different policies (such as differing budgets for different work types) and objective functions.

Process for Performing Lifecycle Optimization Analysis

Analyzing a specific scenario involves many of the same basic steps as described above for the Lifecycle Planning Analysis for Gap Analysis and Target Setting, except that the results are used for short term work planning and programming. These steps are comparable to the 1 year cycle listed in Figure 25:

1. **Update or confirm available treatment actions**
2. **Update or confirm deterioration models**
3. **Update or confirm benefit calculations**
4. **Update construction history**
5. **Update committed projects (including STIP)**
6. **Identify objective functions and constraints for scenarios** – The objective function, as described in the section on
7.
8.
9. Objectives and Targets, maximizes the weighted average NBI utility index. The constraints is defined by the funding scenario.
10. **Run scenario** – The goal is to run the designated budget and funding scenario, but other scenarios involving different work types etc. may also be run informally.
11. **Analyze resulting workplan** – The list of recommended projects resulting from the scenario optimization analysis is analyzed to ensure they are reasonable and practical.

FIGURE 25: ONE-YEAR WORKPLAN CYCLE



12. **Send recommended projects list to Districts for review** – After running the budget scenario and checking the resulting recommended workplan, 5-year project lists are sent by the Bridge Management group to the Districts for review.
13. **Receive District project lists** – Districts review and refine the project list and then compile a final list based on District priorities, budget, etc. Each District's list is finalized with justifications for any differences from the Bridge Management group list and returned to the Bridge Management group.
14. **Validate treatment selections** – The recommended projects from the analysis run are validated by the Bridge Management group against the District recommendations and the project list finalized. During this process, the Bridge Management group and Districts discuss the results and comments to show how the system is impacted by adjusting different mixes of projects or treatment types. This serves to ensure Districts understand the effects of different scenarios. It also serves as feedback to continue to improve the modeling in the management system.
15. **Send Project List to Programming Division** – The Bridge Management group sends the final list of projects to the Programming Division to initiate the project development processes. This list is also sent to the Districts.
16. **Send Final Programmed Projects to Districts** – The Bridge Management group then sends final programmed projects to the Districts.

Ensuring Use of Best Available Data and Use of Management Systems

The most recent inventory and condition data are used as inputs as part of the Gap Analysis process and the Lifecycle Planning Analysis process as described in the previous section. The Lifecycle Planning process includes use of a commercial bridge management system (Deighton dTIMS™) to perform optimization analyses of various scenarios. This software and associated processes enable:

- Collecting, processing, storing, and updating inventory and condition data.
- Forecasting deterioration.
- Determining the benefit-cost over the lifecycle of assets to evaluate alternative actions (including no action decisions).
- Identifying short- and long-term budget needs; and
- Recommending work plans and project implementation schedules.

The process also involves using the current STIP as input for maintaining a list of committed projects that is used in the scenario analyses. The procedures for using the BMS for short- and long-term planning are described in the sections on Lifecycle Planning Analysis

for Gap Analysis and Target Setting and Lifecycle Planning Analysis for Work Planning and Programming respectively. Testing and validation of WVDOH's BMS was done in 2021 and the configuration of the system was updated in early 2022 prior to running scenarios for the 2022 TAMP. Review by central office and region bridge engineers confirmed the system was making acceptable bridge treatment recommendations.

Source: WVDOT

Source: WVDOT

Chapter 3

Managing Pavement Assets

Inventory

The highway network maintained and operated by WVDOH consists of several different systems as shown in Figure 26, including the Home Access Road Program (HARP) The discontinued HARP are local roadways serving two or more homes acquired by the DOH between 1998 and 2001.

FIGURE 26: TOTAL MILEAGE BY SYSTEM

	Centerline Miles	Lane Miles
Interstate	556	2,368
US	3,640	9,093
WV	3,805	8,029
CO	28,883	57,788
State Park/Forest	197	394
Federal Aid Non-State	278	570
HARP	879	1,757

Note: Centerline miles include dual direction when designated. Interstate includes the Turnpike as well as I-68. Data was pulled from the Road Inventory Log as of 8/1/2022.

The owners of the NHS pavements within the state of West Virginia are WVDOH and the WV Turnpike Authority. The breakdown of mileage[7] between these owners is shown in Figure 27 and Figure 28.

FIGURE 27: NHS ROADWAY BY OWNER

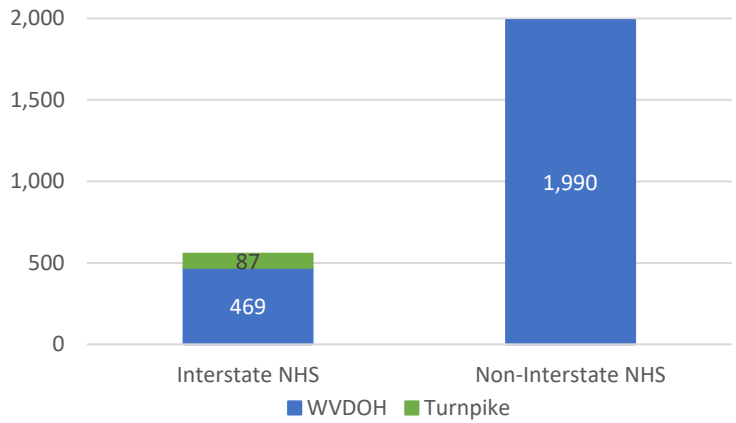


FIGURE 28: NHS CENTERLINE MILEAGE BY OWNER

	WVDOH	Turnpike	Total
Interstate NHS	469	87	556
Non-IS NHS	1,990	-	1,990
Total	2,459	87	2,546

Source: 2020 Public Certified Mileage (HM-10, HM-15), Federal Highway Administration Highway Statistics 2020, https://www.fhwa.dot.gov/policyinformation/statistics/2020/

Condition

The majority of the NHS Interstate in West Virginia and about half of the Non-Interstate NHS is generally in good condition based on the FHWA metrics adopted through the rule making process for MAP-21 and the FAST Act. The FHWA metrics are based upon the percentage of tenth-mile Highway Performance Monitoring System (HPMS) section data that are in Good, Fair, or Poor condition. Each tenth mile HPMS section is classified as being in Good, Fair, or Poor condition based on the 23 CFR 490.313(c) where:

(1) A pavement section shall be rated an overall condition of Good only if the section is exhibiting good ratings for all three conditions (IRI, Cracking Percent, and rutting or faulting).

(2) A pavement section shall be rated an overall condition of Poor if two or more of the three conditions are exhibiting Poor ratings (at least two ratings of Poor for IRI, Cracking Percent, and rutting or faulting).

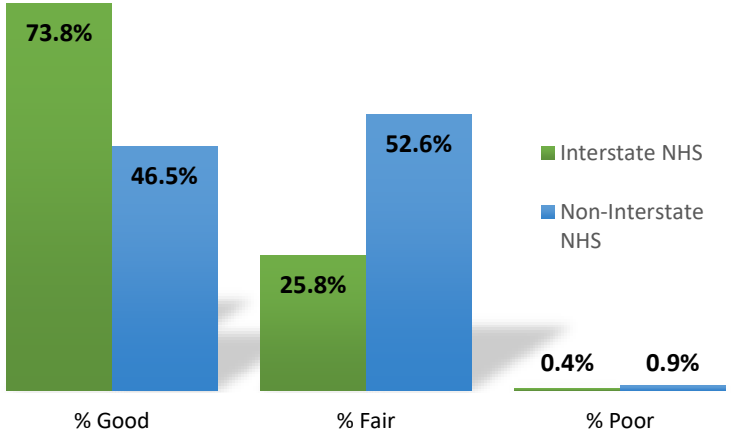
(3) A pavement section shall be rated an overall condition of Fair if it does not meet the criteria in paragraphs (c)(1) or (c)(2) of this section.

Agencies are required to set targets for percentage of Good and percentage of Poor for Interstate and the Non-Interstate NHS. As expected, the Interstate, with 73.8% in good condition, is generally in better condition than the Non-Interstate NHS, with 46.5% in good condition as of the most recent data collection cycle in 2021 (reported in 2022). For the Interstate, only 0.40% is in Poor condition, whereas for the Non-Interstate NHS, 0.9% is currently in Poor condition.

[7] Centerline miles on mainline highway. Source: MAP-21 Reporting Criteria Summary 2014-2017.

WVDOH Interstate pavements are currently well below the 5% maximum threshold for poor condition (See Figure 29).

FIGURE 29: NHS CONDITION (2021)

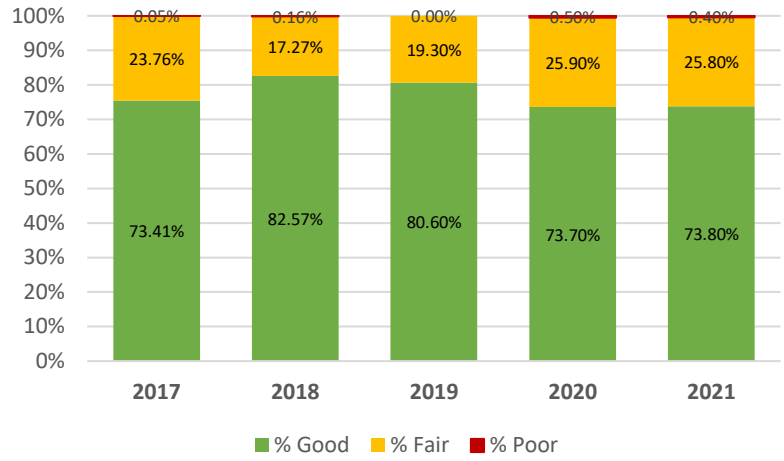


Trends Over Time

Using data from 2022 and previous HPMS Pavement Report Cards where available and the dTIMS™ system to fill in any gaps, trends can be plotted in pavement performance over time. For interstates, the proportion of roadway in good condition has been slowly declining since 2018. The reverse of this can be seen for the proportions of roadway in Fair condition where a steady increase in Fair can be noted.

The proportion of Interstate pavements in Poor condition has fluctuated yearly but overall continues to trend downward and is currently at 0.4% (See Figure 30).

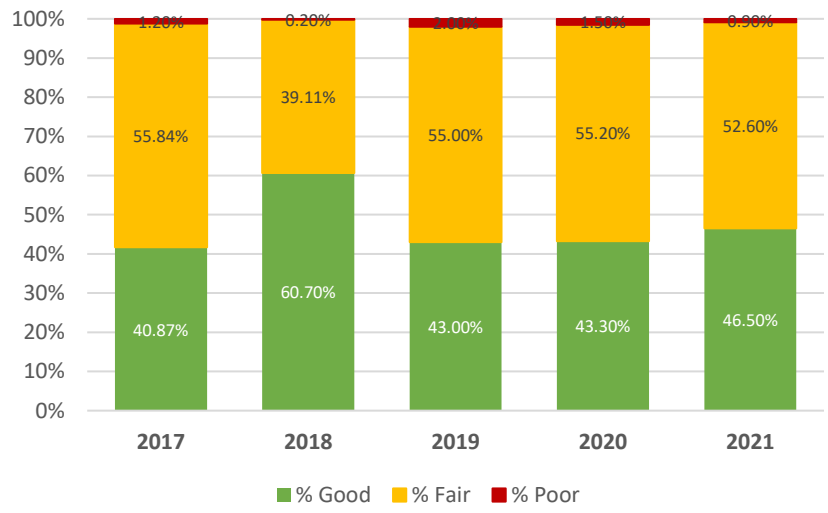
FIGURE 30: INTERSTATE NHS CONDITION TRENDS



Note: Percentages shown exclude missing data and thus do not necessarily sum to 100%.

For Non-Interstate NHS, the proportion of roadway pavements in good condition has fluctuated between 40 and 50% over time, except for an increase in condition in 2018, created by an influx of a bond program that year. Otherwise, condition has slowly trended upwards since 2019. The proportion of roadway in Fair condition has decreased due to this increase in good condition. Importantly, the percentage of pavement in poor condition remains very low and demonstrates very little variance over time.

FIGURE 31: NON-INTERSTATE CONDITION TRENDS



Note: Percentages shown exclude missing data and thus do not necessarily sum to 100%.

Process for Obtaining Data from NHS Owners other than WVDOH

Pavement condition data for the full NHS, including the WV Turnpike, is collected each year, by contract. This data is imported directly into the dTIMS™ PMS.

Objectives and Targets

WVDOH desires to maintain the NHS pavements in a state of good repair by adopting the following objectives:

- Use a PMS to project deterioration and effects of maintenance, preservation, rehabilitation, and reconstruction projects to analyze different funding scenarios.
- Maximize the average of the weighted WVDOH Composite Condition Index (CCI) rating over a 10-year analysis period, subject to budget constraints. The CCI Index is weighted by the square root of the AADT multiplied by the lane miles for each section.
- Effectively use maintenance and preservation treatments on pavements to keep them in good condition since maintenance and preservation treatments show a high benefit-cost ratio.

Based on the objectives above, WVDOH established the following targets for the end of the previous and next federal performance periods:

- The percent of Interstates in a Good condition [23 CFR 490.307(a)(1)] by tenth-mile section mileage should be at least 75% in 2021, and 70% in 2025.
- The percent of Interstates in a Poor condition [490.307(a)(2)] by tenth-mile section mileage should not exceed 4.0% in 2021, and 4.0% in 2025.
- The percent of Non-Interstate NHS in a Good condition [23 CFR 490.307(a)(3)] by tenth-mile section mileage should be at least 45% in 2021, and 45% in 2025.
- The percent of Non-Interstate NHS in a Poor condition [490.307(a)(4)] by tenth-mile section mileage should not exceed 5.0% in 2021, and 5.0% in 2025.

Pavement State of Good Repair

Based on current projected conditions and the 2- and 4-year targets noted above, WVDOH defines the State of Good Repair for pavements as follows:

- The SOGR for percent of Interstates in a Good condition by tenth-mile section mileage should be considered to be 70%.
- The SOGR for percent of Interstates in a Poor condition by tenth-mile section mileage should not exceed 4.0%.
- The SOGR for percent of Non-Interstate NHS in a Good condition by tenth-mile section mileage should be considered to be 45%
- The SOGR for percent of Non-Interstate NHS in a Poor condition by tenth-mile section mileage should not exceed 5.0%.

Scenario comparisons in *Chapter 6* demonstrate the expected performance of pavements over the course of the TAMP.

Gap Identification and Strategies for Attaining Targets

Physical Condition of Assets

Based on the current pavement conditions shown and the targets outlined in the previous sections, the current gaps are shown in Figure 32. The current metric value for Interstate percentage of Good is slightly below the target value of 75% and has been for 2 years. The most recent value of 73.8% indicates a gap of 1.2%. The current percentage of Poor for Interstates is well below the allowable 5% mandated threshold as well as the 4.0% target that has been established. Again, no major changes in condition values are expected over the near-term planning horizon, though minor fluctuations may occur.

The current percentage of good condition value of 46.5% for Non-IS NHS routes is above the target value of 45%. The current state of Poor condition on Non-IS NHS routes is 0.9%, well below the target of 5.0%, allowing for fluctuations in actual values over a 4-year horizon, as shown in Figure 33.

FIGURE 32: CURRENT NHS CONDITION TARGETS AND GAPS

Metric		Current Condition	2021 Target	Gap
Interstate	% Good	73.8%	75.0%	1.2%
	% Poor	0.4%	4.0%	No Gap
Non-IS NHS	% Good	46.5%	45.0%	No Gap
	% Poor	0.9%	5.0%	No Gap

FIGURE 33: INTERSTATE CONDITIONS VS TARGETS

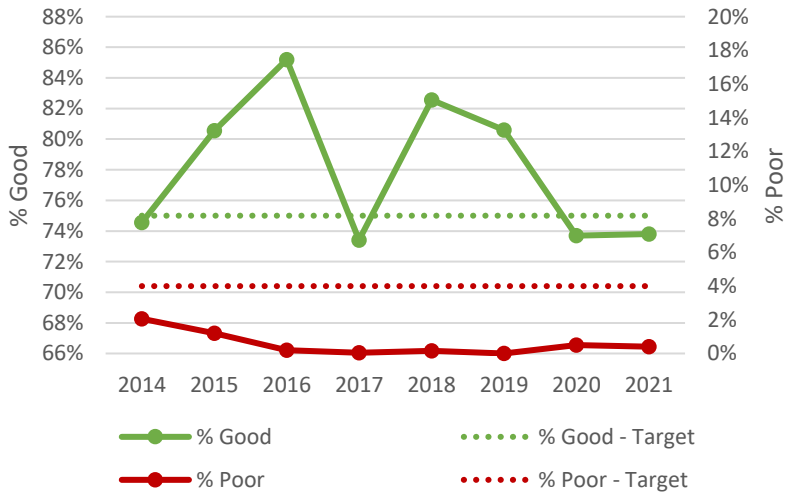
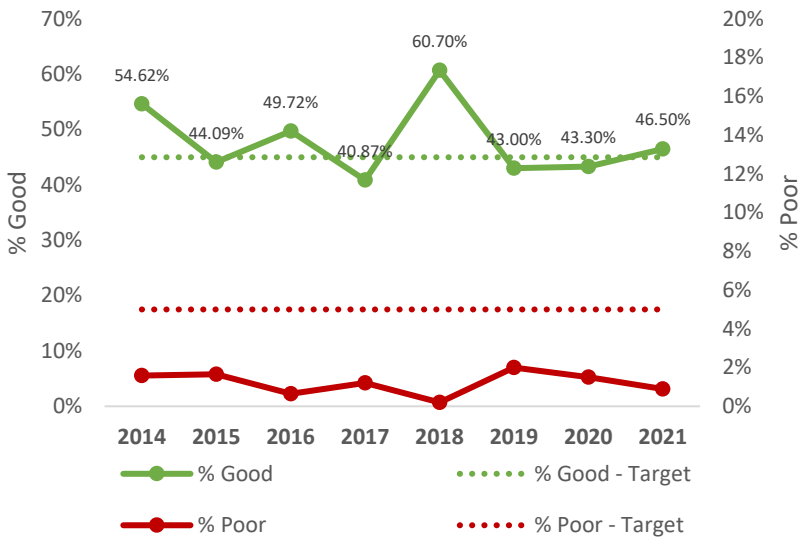


FIGURE 34: NON-INTERSTATE CONDITIONS VS TARGETS



Discussion of Deficiencies

For NHS pavements, both Interstate and Non-Interstate, no gaps exist for the percentage of Poor targets (See Figure 32). A small gap exists for the percentage of Good on Interstate pavements, and no gap exists for Non-Interstate NHS pavements. The main challenge with Non-Interstate NHS pavements will be maintaining the system at a level above 45% Good. On the other hand, the percent poor is unlikely to change substantially under the baseline funding scenarios. The small gap in interstate pavements may be addressed as additional projects are constructed and maintenance is carried out. Regular data collection on the network will capture these changes.

Identification of Alternative Strategies

Like programs for other asset types, funding for NHS pavements must be balanced, and traded off, against other WVDOH objectives such as Bridge and general maintenance, as well as non-NHS pavements. To make these trade-offs as objective as possible, WVDOH analyzes the effects of different levels of funding on the NHS pavements. As a result, multiple funding strategies are developed and passed to the Pavement Management group so that the condition resulting from each funding scenario can be projected over the next 10 years.

In addition to developing alternative funding strategies, the following are also anticipated to help maintain the percentage of good condition targets identified above:

- There is now a bond program to leverage funding for larger projects.
- The Roads to Prosperity initiative is expected to increase the funding available for pavement projects on the NHS.

Process for Performing Gap Analysis

The methodology for Gap Analysis consists of four main steps:

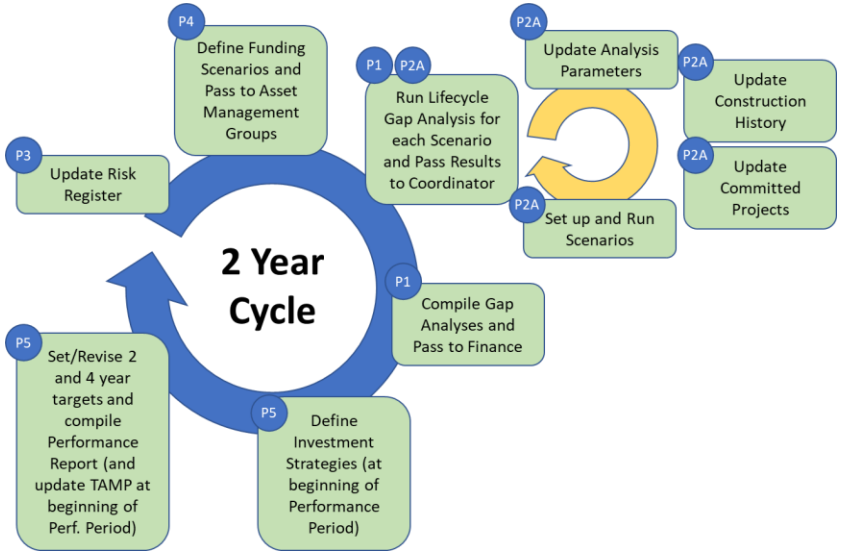
1. Update Inventory and Condition.
2. Check progress against current Targets and Objectives.
3. Project future gap between Condition and Targets at the end of the Performance Period under different scenarios.
4. Compile Gap Analysis.

The assumption is that targets are already in place for specific future years (in this case the targets are for the Performance Period ending in October 2025). Note that the lifecycle analysis is conducted to project

conditions out over a 10-year analysis period, and this is used to inform the two and four-year targets.

This process is depicted as part of the larger process shown in Figure 35 and described in the following pages.

FIGURE 35: GAP ANALYSIS 2 YEAR CYCLE



5. **Update Inventory and Condition** – To update the inventory and condition of the network, the Pavement Management group notifies Planning and Programming which roads are going to have condition data collected each year. Planning and Programming then informs the data collection vendor. Data collection typically starts in March. Interstates are completed in April or May while data collection continues on remaining roads throughout the summer. Condition data is collected and summarized for each tenth mile of the network. Data collection is governed by a data quality management plan (DQMP) developed by WVDOH. Once data collection is complete, the % Good, % Fair, and % Poor FHWA metrics, as well as numerous state statistics can be evaluated for the latest year.
6. **Check Progress against Targets and Identify Gaps** – Targets for % Good and % Poor metrics are discussed in the previous section. To check progress against these targets, the trend of these metrics during the current performance period are plotted against the targets to identify current gaps.
7. **Project future gap between Condition and Targets** – In the future, the Agency will use the PMS, as discussed in the next section, to project the condition of NHS pavements out to the end of the current PMS performance period for each of the different funding scenarios identified in the Financial Plan (Chapter 5). This process is outlined in the subsequent sections regarding the lifecycle planning process.
8. **Compile Gap Analysis** – Once the scenarios have been analyzed, the results are provided to the Asset Management Coordinator (from each asset management group). The Asset Management Coordinator then compiles these and provide the gap analysis to the Executive Leadership for consideration in the next budget cycle.

Identification of Alternative Strategies

The process for identifying alternative strategies, and specifically the identification of specific alternative funding strategies that need to be analyzed, is undertaken as part of the Financial Planning processes described in Chapter 5. Examples are given in the more detailed section on Lifecycle Planning Analysis for Gap Analysis and Target Setting.

In addition to the strategies identified in the Financial Planning processes (Chapter 5) the Pavement Management group may also analyze alternative strategies informally to test different policies (such

as differing budgets for different work types) and objective functions. However, it should be noted that the PMS generates an optimum strategy for each funding scenario that defines the ideal mix of work types. Note that while it is interesting to view results, manual adjustment of the optimum recommended mix of work types will invariably result in a less optimal strategy.

Lifecycle Planning Analysis for Gap Analysis and Target Setting

The WVDOH PMS has been recently modified to enhance its capacity to analyze multiple scenarios using pavement work types and deterioration modeling over chosen analysis periods to generate multiple workplan strategies. The process of generating these lifecycle planning strategies is described in the following section (

Process for Performing Lifecycle Optimization Analysis).

Scenario Analysis Results

For pavements, comparisons between multiple alternatives were analyzed. The example in this chapter looks at the baseline funding scenario while Chapter 6 contains a comparison and summary of additional investment alternatives and tradeoffs. It should be noted that in all cases, rehabilitation and preservation are included in dTIMS™ analysis. The baseline projected funding for pavements over the 10-year analysis period is summarized in Figure 36 below. This table does not include the committed projects which in the early years consumed the expenditure projections.

Reviewing multiple funding scenarios, combined with the deterioration modeling and lifecycle benefit cost optimization processes described later under the section

Process for Performing Lifecycle Optimization Analysis, the projected conditions for the baseline scenario were forecast as shown in Figure 37 (Interstates) and Figure 38 (Non-Interstate).

FIGURE 36: SCENARIO 1 - BASELINE FUNDING

Capital Program NHS and Non-NHS Expenditure Projections (Millions $)

	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032
Pavements Program (NHS)	$210	$210	$180	$190	$190	$160	$150	$150	$150	$150
Pavements Program (Non-NHS)	$400	$400	$340	$360	$360	$300	$290	$290	$290	$290
Total	$210	$210	$180	$190	$190	$160	$150	$150	$150	$150

FIGURE 37: SCENARIO 1 - PROJECTED FHWA CONDITION METRICS FOR BASELINE FUNDING SCENARIO ON INTERSTATE PAVEMENTS

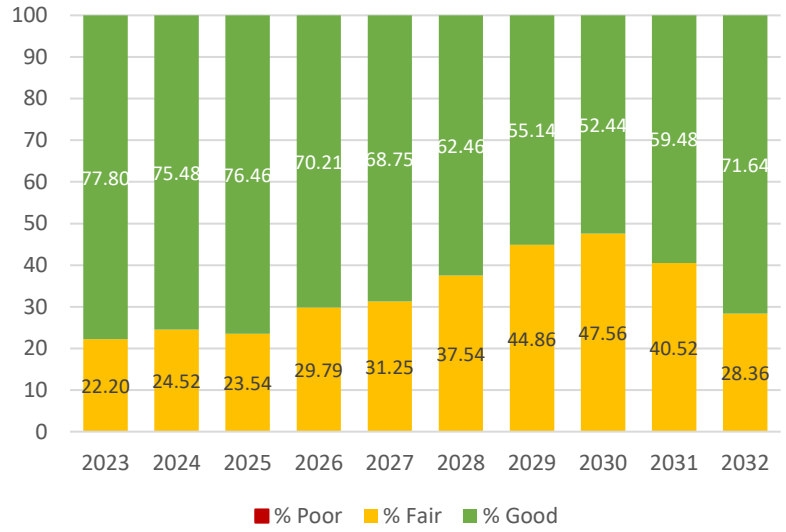
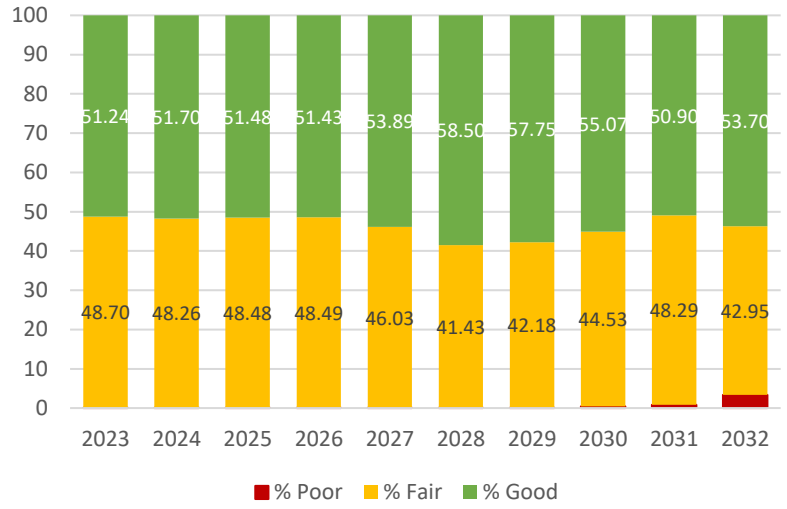


FIGURE 38: SCENARIO 1 - PROJECTED FHWA CONDITION METRICS FOR BASELINE FUNDING SCENARIO ON NON-INTERSTATE NHS PAVEMENTS



The projections from the Baseline funding scenario in Figure 37 show an initial increase in the percent of good pavement in the case of Interstates, improving above the 2021 75% Good goal, followed by a slow decline. Towards the end of the 10-year analysis period, as additional projects are recommended, the % Good pavement begins to improve. Percent poor stays effectively zero throughout the entire period.

In Figure 38 for Non-Interstate NHS pavement, the percent Good remains steady for the first several years of the analysis period while percent poor remains very low, only becoming visible in the final two years of the analysis. The results of the analysis never fall below the 2021 performance goal of 45% Good.

These projections show that consideration is required prior to changing the baseline funding for pavements to maintain good performance. However, there is room to consider shifting funding to other priorities as the scenario results indicate strong continued performance. Pavement condition data monitoring will help to monitor and validate results versus scenario projections.

As an example, specifically for the baseline scenario, summary projected statistics are shown in the table below.

FIGURE 39: SUMMARY PROJECTED STATISTICS FOR NHS PAVEMENTS

		Interstate		Non-Interstate NHS	
Scenario	Year	% Lane Miles Good	% Lane Miles Poor	% Lane Miles Good	% Lane Miles Poor
Baseline Funding Scenario	2023	77.80%	0.00%	51.24%	0.06%
	2032	71.64%	0.00%	53.17%	3.35%

Because the lifecycle benefit cost optimization generates not just projected condition but also a simulated workplan of specific projects, these workplans can be summarized to give an investment strategy in terms of anticipated funding per work type per year in each year of the analysis period. Note the mapping of treatment to work type in Figure 40. *Chapter 6 – Investing Wisely* includes a summary of those expenditures and additional analysis of trade-offs between asset and pavement network types.

Process for Selecting Scenarios

At the beginning of the performance period, the targets from the previous performance period will be re-adopted or new targets will be set. During the performance period, a gap analysis will be conducted. In both cases, the Asset Management Coordinator will work with the Executive Leadership and the Planning and Programming Division to decide on a set of scenarios for analysis by the different asset management groups.

Process for Performing Lifecycle Optimization Analysis

Analyzing a specific scenario involves following these basic steps:

1. **Update or confirm available treatment actions** – The treatments[8] currently included in the PMS are shown in Figure 40.

FIGURE 40: TREATMENT ACTIONS

Treatment	Work Type	Cost Range	Description
Crack Seal (BC)	Preservation	$2-2.5K	Bituminous pavements
Crack Seal (CO)	Preservation	$125-135K	Concrete pavements
Chip Seal	Preservation	$40-50K	One or more layers of asphalt and fine aggregate
Microsurfacing	Preservation	$110-140K	May include Cape Seal.
Preservation	Preservation	$350-425K	Examples include High-Friction Surface Treatments and other seal treatments.
Saw Seal Joints	Preservation	$350-375K	
Ultra-Thin Overlay	Preservation	$110-125K	Asphalt overlays 1/2" to 1" thick
Thin Overlay	Preservation	$200-$240K	Thin overlays are 2” or less. May include milling.

[8] Note that the treatments listed here are those modeled in the management system. For the FHWA work type ‘New Construction’, these projects are included in the plan but sourced outside the management system.

Treatment	Work Type	Cost Range	Description
Major CPR Diamond Grind	Preservation	$1-1.2M	
Minor CPR Diamond Grind	Preservation	$140-160K	Minor Concrete Pavement Restoration activities assumes no major repair other than joint reseal.
Thick Overlay	Rehabilitation	$280-320K	Thick overlays are assumed to be more than 2". May include milling.
Reconstruction	Reconstruction	$1-1.2M	

Note: Costs are per lane mile

2. **Update or confirm deterioration models** – Deterioration models for the following key performance indices (KPI's) are currently used:
   - PSI = Present Serviceability Index
   - NCI = Net Cracking Index
   - SCI = Structural Cracking Index
   - ECI = Environmental Cracking Index
   - RDI = Rut Depth Index
   - JCI = Joint Condition Index
   - CSI = Concrete Slab Index
   - CCI = Composite Condition Index

   These indices are on a 0-5 scale with 0 being the worst and 5 being perfect.
3. **Update or confirm benefit calculations** – The benefit is calculated as the area between the 'do nothing' projection of the objective function (e.g. CCI condition rating) and the projection for the proposed treatment, multiplied by various priority factors as discussed in the previous section, Objectives and Targets on page 28.
4. **Update construction history** – Projects that have been completed in the last year are updated by obtaining the Construction History File and STIP Project Listing in October and importing these into the PMS.
5. **Update Committed Projects (including STIP)** – The list of committed projects is updated by obtaining the Construction History File and STIP Project Listing in October and importing these into the PMS.
6. **Identify Objectives and Constraints for Scenarios** – The objective function for the particular scenario is confirmed. The objective function defines what the optimization will attempt to maximize or minimize. In addition to the objective function, the constraints for each scenario are confirmed. For example, if the scenario is 'maintain current funding levels', the analysis may be to maximize the average CCI index rating (objective function), subject to an annual budget equal to the current or latest budget (constraint). If the scenario was 'meet target' the analysis may be to minimize cost (objective function) subject to the target metric value for the scenario being no worse than the set target value (constraint).
7. **Run scenarios** – Once all the inputs for the scenarios have been confirmed, multiple long-term alternative strategies for the scenarios are generated and evaluated.

8. **Review and Adjust Scenario Results** – At this point, the user has the option to review and adjust scenario strategies, to accept, or override them.
9. **Run optimization** – After candidate strategies have been evaluated, the optimization analysis for each scenario is run. This results in an optimum strategy being recommended for each Pavement Management Section included in the analysis. These strategies result in an overall workplan for the scenario detailing treatments for each year (including 'do nothing' treatments) for each Pavement Management Section.
10. **Analyze effect of scenarios on metrics** – Because each scenario analysis results in a workplan strategy for each Pavement Management Section, this allows the values of all metrics to be predicted for the analysis period (e.g., 10 years).
11. **Predict gap at end of performance period for each scenario** – The predicted values over the analysis period can then be used to see if, for any scenario, these values meet, exceed, or fall short of target values that have been set for any particular year.
12. **Submit results of analyses to Asset Management Coordinator** – The results, including the predicted metrics over time for each scenario, are given by the Pavement Management Lead to the Asset Management Coordinator. As part of this submission there is a discussion of any gaps between scenarios and current/future targets, including explanations and possible reasons and solutions. In addition, if it is a year in which targets are to be adjusted, or new targets are to be set, the submission may also include discussion of possible target values. However, targets can only be finalized once the financial analysis to analyze funding trade-offs between pavement and bridges has been conducted with the Executive Leadership. Once that analysis is complete, a specific scenario and funding strategy is adopted and used for allocating a budget. This budget (and subsequent funding scenario) is communicated back to the Pavement Management group for use in Lifecycle Planning Analysis for Work Planning and Programming as described in the following section.

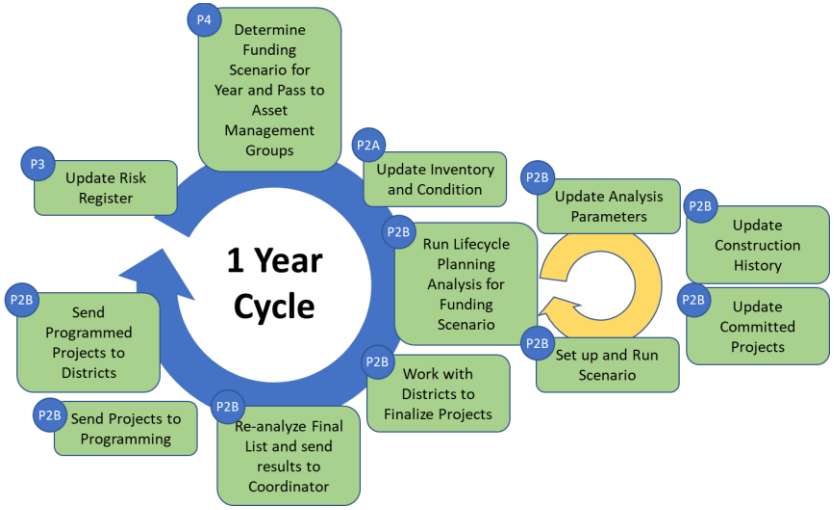
Source: WVDOT

Lifecycle Planning Analysis for Work Planning and Programming

Once a budget has been set for the current year, it is communicated to the Pavement Management group along with a funding scenario to be used for analysis for work planning and programming near term (over the next two to three years) projects. Once already committed projects are updated, the analysis identifies specific short term recommended projects based on long term deterioration projections and benefit cost ratio calculations and optimization.

The funding scenario is analyzed to generate a recommended optimum work plan over the next 10 years. From this analysis, recommended projects for the near term are generated based on optimization and benefit-cost considerations. The complete one-year work plan cycle is shown in Figure 41.

FIGURE 41: WORK PLAN ONE YEAR CYCLE



Process for Selecting Scenarios

The funding scenario is determined when the Pavement Management group receives a directive (Memo) from Executive Leadership giving Budgets for Interstates and ADHS in October for the following year. The funding scenario used as the input for the pavement optimization analyses assumes this budget remains constant for future years in the analysis (level budget analysis).

The Pavement Management group may also perform additional scenario analyses to test different mixes of work types and objective functions other than the Composite Condition Index (CCI). It should be noted however, that when unconstrained by forcing certain proportions of work types, the PMS will generate workplans containing an optimum mix of work types for the specific funding scenario being analyzed.

Process for Performing Lifecycle Optimization Analysis

The full, detailed process for work planning and programming is included in the internal document titled, *Pavement Project Selection SOP*. This process is summarized here and involves many of the same basic steps as described above for the Lifecycle Planning Analysis for Gap Analysis and Target Setting except that the results will be used for short term work planning and programming:

1. **Update or confirm available treatment actions**
2. **Update or confirm deterioration models**
3. **Update or confirm benefit calculations**
4. **Update construction history**
5. **Update committed projects (including STIP)**
6. **Identify Objectives and Constraints for Scenarios** – The objective function, as described in the section on Objectives and Targets,

maximizes the CCI. The constraint is the budget for the year (assumed to remain constant for future years).

7. **Run scenario** – The objective of this step is to run the designated budget and funding scenario, but other scenarios involving different work types etc. may also be run informally.
8. **Analyze resulting workplan** – The list of recommended projects that is the result of the scenario optimization analysis is analyzed to ensure the resulting projects are reasonable and practical.
9. **Send recommended projects list to Districts for review** – After running the budget scenario and checking the resulting recommended workplan, 5-year project lists are sent by the Pavement Management group to the Districts for review.

Source: WVDOT

10. **Receive District project lists** – Districts review and refine the project list and compile a final list based on District priorities, budget etc. Each District's list is finalized with justifications of why they are different from the Pavement Management list and returned to the Pavement Management group.
11. **Validate treatment selections** – The recommended projects from the analysis run are validated by the Pavement Management group against the District recommendations and the project list finalized. During this process, the Pavement Management group and Districts discuss the results and comments to show how the system is impacted by adjusting different mixes or treatment types. This serves to ensure Districts understand the effects of different scenarios. It also serves as feedback to continue to improve the modeling in the management system.
12. **Send Project List to Planning and Programming Division** – The Pavement Management group sends the final list of projects to the Planning and Programming Division to initiate the project development processes. This list is also sent to the Districts.
13. **Send Final Programmed Projects to Districts** – The Pavement Management group then sends final programmed projects to the Districts.

Ensuring Use of Best Available Data and Use of Management Systems

As part of the Gap Analysis process and the Lifecycle Planning Analysis process described above, the most recent inventory and condition data are used as input to the Gap Analysis process as described in that section above. This updated inventory and condition data is then the starting point for the Lifecycle Planning process also described above. The Lifecycle Planning process includes use of a commercial PMS (Deighton dTIMS™) to perform optimization analyses of various scenarios. This software and associated processes enable:

- Collecting, processing, storing, and updating inventory and condition data.
- Forecasting deterioration.
- Determining the benefit-cost over the lifecycle of assets to evaluate alternative actions (including no action decisions).
- Identifying short- and long-term budget needs; and
- Recommending workplans and project implementation schedules.

The process also involves using the STIP as part of the input for maintaining a list of committed projects that is used in the scenario analyses. The procedures for using the management system for short and long-term planning are described previously in the sections on Lifecycle Planning Analysis for Gap Analysis and Target Setting and Lifecycle Planning Analysis for Work Planning and Programming respectively.

Note on Lifecycle Planning and Analysis

By using a PMS, lifecycle costs are inherently included in all analyses conducted for the TAMP and WVDOH work planning. The use of calibrated deterioration models and treatment improvements capture the lifecycles of specific treatments and pavement types.

At least annual re-calibration of the system insures reasonable estimates of the benefit and duration of treatment application. Lifecycles of specific treatments are evaluated during calibration efforts, including comparison with historic performance of those treatments.

Source: WVDOT

Source: WVDOT

Chapter 4

Consideration of Risk

Risk Management Overview

WVDOH balances multiple types of risks in the management of the NHS pavements and bridges. Risks are first categorized by level of impact: agency, program, and location/asset. WVDOH maintains two risk registers, one for the agency and program level risks and one for the location or asset level risks. The development and maintenance of the two main risk registers constitutes the majority of WVDOH's risk management plan. However, risk mitigation and recognition are carried throughout the TAMP and implemented asset management processes.

With the passing of the IIJA in November 2021, states are required to consider extreme weather and resilience as part of the risk management and life cycle analysis processes. Extreme weather and resilience are inherently included in WVDOH's risk management process. For this iteration of the TAMP, the areas of consideration are explicitly outlined within the risk and lifecycle analyses. The last section in this chapter summarizes the consideration of extreme weather and resilience in the risk management processes and analyses.

As part of the development process for the 2022 TAMP, a risk workshop was conducted with representatives from various WVDOH Divisions and Districts on May 31 and June 1, 2022, to update the 2019 TAMP Risk Register. The 2019 Risk Register was reviewed by the team selected by the Asset Management Coordinator following the processes

described within this chapter to review and update the Risk Register annually.

In general, WVDOH incorporates aspects of ISO's risk management framework[9] into the risk management process. A summary of this framework is depicted in Figure 42.

FIGURE 42: RISK MANAGEMENT FRAMEWORK

Agency and Program Level Risk Register

The top priority agency and program level risks identified during the latest Risk Workshop are shown in the prioritized Risk Register in Appendix A. The scoring regarding likelihood and consequence of these risks was updated during the risk workshop. The likelihood and consequence scales were also revisited and revised slightly. These scales are shown, along with the scoring process, in the Risk Management Process - Agency and Program Level section.

Asset Level Risk Evaluations of Pavements and Bridges pursuant to 23 CFR part 667

Previously, WVDOH used a list of projects where emergency funding was used, as reported from the project tracking/financial authorization system, to determine whether any locations qualified as repeatedly repaired due to emergency events. While this was an appropriate starting point for the initial identification process, WVDOH has since determined a better source for identifying these locations. Following declared disasters, an identification number is assigned to the disaster and work completed to address the disaster is recorded in spreadsheets by each District. The work recorded includes anything from debris removal to repairing or replacing damaged infrastructure. This data is then compiled into a master spreadsheet titled *Disaster Summary Analysis* where projects are tracked.

Prior to the workshop, the *Disaster Summary Analysis* spreadsheet was reviewed to determine whether any STIP eligible pavement or bridge locations were repeatedly repaired or reconstructed due to declared disasters. Locations were identified and then evaluated following the respective processes detailed in the next section. In the future, WVDOH plans to maintain the list of emergency projects with a Geographic Information System (GIS) location and any sites with more than one project will be more easily identified.

[9] AASHTO TAM Guide: https://www.tamguide.com/subsection/2-2-3-risk-management/

Current Risks and Mitigation Efforts

High Priority Agency and Program Level Risks

In WVDOH's agency and program level risk workshop, 24 risks were identified and scored. Once scored, the risk scores were sorted to determine the highest priority risks for WVDOH. A mitigation strategy was also selected for each of the identified risks. The full process for this workshop is detailed later in this chapter. This section presents the top four risks identified for WVDOH in 2022 as well as the planned approach for addressing those risks.

The figures below present the top 4 risks, all with a risk score greater than 60. These each have either Agency or Program defined as the risk level. Agency level risk indicates that when the risk occurs, it affects the whole agency. Program level risk indicates that when the risk occurs, it affects one or more asset programs (like pavements or bridges). The asset classes affected are also identified for each risk. The Event/Occurrence description outlines the definition of the risk to WVDOH and what characterizes that risk. The total risk score is listed for each of the top assets. This risk score is out of 100. The detailed scoring can be found in Appendix A.

West Virginia, like many other states, is dealing with staff shortages. This risk has moved to be WVDOH's highest priority since the previous TAMP as staffing shortages have continued to grow as an issue across the nation. This shortage is likely to continue and affects all activities within an agency, thus was given the highest risk score. WVDOH's specific experiences, challenges, and evaluations for each of the risks scored greater than 60 are summarized in Figure 43 through Figure 46. This information is available for all identified risks in Appendix A. Note that lower priority risks are more often tolerated than treated.

FIGURE 43: EVALUATION OF RISKS TO STAFFING

Risk ID	1 – Staffing
Impact Level	Agency
Asset Class	Pavement/Bridge
Event/Occurrence	Staff shortages - lack of personnel, vacant positions, and uncertainty in being able to backfill employees who leave
2022 Risk Score	85
Risk Owner	WVDOH
Accomplishments	WVDOH has moved HR functions inhouse and reduced delays in HR administration and hiring.
Impacts	Adequate candidates / applicants and retention remain an issue. Due to the significant "root cause" potential of personnel issues, the impacts range from clear to obfuscated. As an example, a delayed bridge project due to personnel issues may shift rehabilitation into costlier replacement. Determining what portion of program wide issues, delays, change orders, etc. could have been avoided by either more or more experienced personnel is a difficult task. While Human Resources, Performance Management, and Organizational Performance groups have moved towards evaluating these big picture questions, their efforts and the information required to perform evaluations are also dependent on personnel.
Risk Management Plan (Treat, Tolerate, Transfer, Terminate, Take Advantage)	Studies have been conducted to analyze this issue. WVDOH is considering the following recommendations to **Treat** this risk: 1. Change compensation structure to add more tiers per level - has improved, continue to improve. 2. Insurance stability - has stabilized, more work to do. 3. Respond to offers/HR communication - moved inhouse and reduced delays 4. Flexible schedule (e.g., part time, telework) 5. Public service recognition 6. Enhance recruiting 7. Monitor market rates for starting engineers 8. Monitor pay as it responds to inflation

FIGURE 44: EVALUATION OF RISKS TO ON-TIME DELIVERY OF PROGRAMMED BRIDGE PROJECTS

Risk ID	2 – On-Time Delivery of Programmed Bridge Projects
Impact Level	Program
Asset Class	Bridge
Event/Occurrence	Not delivering programmed bridge projects on time (even when budget is available)
2022 Risk Score	80
Risk Owner	WVDOH
Impacts	WVDOH has challenges to on-time delivery of programmed bridge projects due to factors including environmental, ROW, utilities, historical (SHPO), manpower, etc. On average, STIP projects are delayed 3-5 years from original committed date. With limited availability of capable contractors and an increase in material shortages, this risk has increased in impact since identified in 2019.
Accomplishments	
Risk Management Plan (Treat, Tolerate, Transfer, Terminate, Take Advantage)	WVDOH is **Treating** and **Transferring** this risk by: - Completing more acquisition work up front, transferring risk to utility companies by requiring them to be timelier. - Reviewing project delivery process to identify pain points, measure, and enforce. - Increasing use and efficiency of consultants to develop plans to add capacity.

FIGURE 45: EVALUATION OF RISKS TO COMPLETING THE RIGHT TREATMENTS AT THE RIGHT TIME

Risk ID	10 – Right Treatments, Right Time
Impact Level	Program
Asset Class	Bridge
Event/Occurrence	Not doing the right maintenance, preservation, and rehabilitation at the right time in the right location.
2022 Risk Score	65
Risk Owner	WVDOH
Impacts	Inefficient allocation of funding, deteriorating network conditions
Accomplishments	Completing proper treatments at the right time is important for the longevity of a state's bridge network. Previously, WVDOH did not have a plan in place for how maintenance occurs. However, WVDOH recently developed and is working to implement a maintenance plan for bridges titled *Bridges: Key Activities for Maintenance and Preservation Plan* (BKAMPP).
Risk Management Plan (Treat, Tolerate, Transfer, Terminate, Take Advantage)	WVDOH is **Treating** this risk by: - Implementing the BKAMPP. - Adding codes to maintenance management system to track maintenance and preservation work. - Developing full paint and overlay programs with specific budget. - Using bridge management system to identify recommended work types per year. In the future, WVDOH will consider:

Risk ID	10 – Right Treatments, Right Time
	- Dedicating funding specifically for preservation and rehab projects, and ensuring projects are undertaken on the right locations.

FIGURE 46: EVALUATION OF RISKS TO FUNDING ALLOCATIONS - POLITICAL

Risk ID	12 – Funding Allocations – Political Influences
Impact Level	Agency
Asset Class	Bridge/Pavement
Event/Occurrence	Political influence changes allocations late in the process where allocations increase in one area without expectation of reductions in others.
2022 Risk Score	65
Risk Owner	WVDOH
Impacts	As with most state agencies, political influences can affect budget allocations and work completed in WVDOH. For instance, capital budgets for bridge are often reduced to fund requested pavement projects. This can impact the delivery of projects that fix safety, mobility, or other existing problems.
Accomplishments	WVDOH is improving the use of management systems to illustrate the impacts of moving money on future conditions.
Risk Management Plan (Treat, Tolerate, Transfer, Terminate, Take Advantage)	WVDOH is **Tolerating** and **Treating** this risk by: - Predicting impact of decisions regarding increased and decreased funding in bridge and pavement management systems. - Utilizing long range plans to help with trade off and cross asset decisions.

For each of the risks identified in the workshop, the workshop attendees selected a risk management option. Each of the risk management options selected have a description of plan of action, including any mitigation actions that are either being reviewed or implemented. WVDOH considers the five Ts as the defining risk management options. These five Ts are Treat, Tolerate, Transfer, Terminate, and Take Advantage. These are explained further in the next section that details the risk management process.

High Priority Asset Level Risks

Using the process outlined later in this section, WVDOH identified multiple potentially repeatedly damaged locations using the data obtained by the disaster response team in the *Disaster Summary Analysis* spreadsheet. The TAMP Team provided these potential locations to the Districts for further review. Most of WVDOH's potential locations were in Districts two and six, which is largely due to a combination of geological, topographical conditions and the proximity of the assets to major tributaries that are more susceptible to the impact of the noted event. Ultimately, two locations (in this case, sections of routes) qualified as Part 667 locations and were evaluated for alternative strategies. The roadway sections were located along Fish Creek Road and Middle Grave Creek Road which are both located in Marshall County in District 6. As their names suggest, both routes run alongside creeks, making them more vulnerable to extreme events causing flooding. All other locations were either determined to not have repeated damage (i.e., the damaged locations were too far apart to address in a single project) or are not eligible for inclusion in the STIP.

The ineligible locations are tracked separately and not included as part of the TAMP.

Both evaluated locations are located within District 6's jurisdiction and were damaged in the same two events (disaster numbers 4331 and 4359). Each roadway was evaluated for improved drainage to further mitigate the impacts of potential future events of the same intensity. In each case, improving the drainage along the segments would be a feasible mitigation option according to the resulting benefit cost ratios from the evaluations. Therefore, if these locations are considered for a project in the STIP, additional mitigation actions will be considered for inclusion with that project to improve each asset's resilience to future threats. The detailed evaluations are included in Appendix A.

Risk Management Process - Agency and Program Level

The process summarized below is also captured in detail in internal documentation to ensure continuity and consistency across the Agency.

Risk Identification and Assessment Workshop

While certain aspects of risk have traditionally been factored into highway design and operational processes, it has only been in recent years that broader applications of risk consideration and strategies for mitigation have become integrated into Executive Leadership decision making. MAP-21 and FAST Act legislation requires state DOTs to develop risk-based asset management plans. As part of the risk assessment update process for the TAMP, the Asset Management Coordinator follows the processes described within this chapter to review and update the Risk Register on a regular basis.

Frequency and Attendees

The Asset Management Coordinator arranges for a Risk Assessment Workshop to be conducted annually to review the Risk Register and make updates as necessary. The workshop is attended by a diverse group of representatives both from the Districts and Central Office including Planning, Bridge, and Pavement sections. It is assumed that participants in the workshop may change from year to year, therefore a refresher on risk fundamentals is typically be incorporated into the agenda. Rotating the Risk Workshops around the Districts allows opportunities for field site visits that may be beneficial with respect to applying the consideration of risk to real world situations and developing effective and practical mitigation strategies. When it comes to risk identification and evaluation, there is no substitute for local, tacit knowledge and understanding.

Agenda

The workshop begins with an introduction to risk assessment that includes training for the group on:

- Definitions and Terminology
  - What is "Risk"?
  - Why manage risk?
  - Risk Management – overall process
- Risk Register Components
  - Types of risk
  - Impacts of uncertainty
  - Scoring of risk impacts
  - Proposed "remedies" for increasing resilience and reducing vulnerability
- Previous lessons learned

- Processes used in previous workshops
- Feedback on previous risk register from FHWA
- Etc.

Thereafter, the group participates in a facilitated exercise to confirm existing or identify new major risks to the Agency's goals and vision.

Scope

Risks covering a wide range of risk types are assessed, including:

- Natural Hazards – Geo-hazards, flooding, extreme weather
- Man-made or induced hazards – utility mishaps, barge/bridge strikes, etc.
- Materials (e.g., Asphalt) price variability – due to statewide monopoly, market anomalies
- Personnel and hiring issues – some of these issues have significant uncertainties associated with them
- Bad or ineffective processes and practices causing wrong treatments to be applied
- Program and project delivery uncertainties affecting performance and safety

As instructed, the group limited risk identification strictly to those risks that would affect Pavement and Bridge assets on the NHS to align with the current scope of the TAMP. However, while only considering the asset classes of pavement and bridges, the levels of risk include Agency, Programmatic, and Project levels and thus span the vertical dimension of the organization. A representative set of risks were therefore posed and scored. The final scores reflect the importance of the risk to the organization.

Scoring

The scoring framework and methods used are shown in Figures 47 and 48. These include descriptions for each consequence scoring level, as well as the frequency ranges used for the likelihood or probability ratings.

During the development and confirmation of the Risk Register, the group should continuously refer to scoring tables (Figures 47 and 48) throughout the workshop. These shall be distributed prior to the start of the scoring process. Note that the ranges of "consequence" are important for an agency to reflect on the scales they use for rating various risks.

The consequence scoring is divided into the following areas:

- Safety
- Mobility
- Asset Damage
- Financial and Other Impacts - Consider negative impacts to future funding, insurance costs, regulatory compliance, political issues, and public reputation.

It is imperative that the group is attentive and engaged, and understands the concepts of risk in general, including the methods used and the objectives of the workshop.

FIGURE 47: CONSEQUENCE TERMINOLOGY

		Consequence to Public		Corridor / Region / Department	
Level	Descriptor	Safety	Mobility	Asset	Financial Impact
1	Negligible	Negligible safety hazard	Minimal delay	Minimal or cosmetic damage	Cost < $200K
2	Minor	Minimal safety hazard	Minor delay	Minor damage requiring repair	Cost $200K to $1M
3	Major	Likely minor injuries	Major delay	Moderate damage requiring repair	Cost $1M to $10M
4	Critical	Likely major injuries	Critical delay	Extensive damage requiring significant repair or replacement	Cost $10M to $25M
5	Catastrophic	Likely fatalities and major injuries	Catastrophic delay	Destroyed or large-scale damage requiring replacement	Cost > $25M

FIGURE 48: LIKELIHOOD TERMINOLOGY

Level	Descriptor	Description	Annual Probability Range	Probability
1	Low	50 years or more between events	<2%	1.0%
2	Moderate	20 to 50 years between events	2% to 5%	3.5%
3	Medium	5 to 20 years between events	5% to 20%	12.5%
4	High	1 to 5 years between events	20% to 100%	60.0%
5	Very High	One to several events per year	100%	99.0%

A question which commonly arises is whether an issue involves a business decision, indicates a capability "gap", or whether it is truly a "risk". At times, it can be difficult to determine what part of the problem involves just making a management decision, or needs capability development, and which part of the problem warrants on-going risk management due to the inherent uncertainties/variability of the situation. Therefore, analysis for risks no matter their source should be viewed as a useful prioritization tool. Even if risks are procedural and are occurring with near 100% likelihood, it should be noted that the consequences of not managing these risks can be severe.

It is also important to note that bad, or deficient, processes and practices can introduce "uncertainties". For instance, non-repeatable project development processes can lead to inconsistencies in achieving targets, and the inability to manage performance effectively. Thus, uncertainties (and resulting consequences) are sometimes derived or propagated from the variability or ineffectiveness of current processes.

Hence, these situations may be worth analyzing as opportunities for reducing variability and uncertainty in business processes.

Methodology

After the initial introductory training session, and before discussing the current Risk Register, the group is challenged to identify a few new risks. The new risks identified are then discussed and compared to the current Risk Register to check whether these risks are already present in the register in some form and need to be modified, or if they are new risks. Each existing risk should have an associated management strategy identified. Where the risk management strategy involved specific actions or tracking activities, the responsible party should provide an update on how that risk has been managed and potentially mitigated since the previous workshop.

The methodology for scoring the likelihood and consequences across the high-level areas of safety, mobility, asset damage, and other financial impacts are discussed, and it is clear the group fully understands the process. If a workshop ever extends over two days, the participants are typically challenged to think of other risks overnight prior to resuming the workshop on the morning of the second day.

The following process is used to identify risks:

- Aided by the facilitator, a risk is identified by someone in the group and discussed to distill it to a meaningful item and captured in the spreadsheet template (see the full Risk Register in Appendix A) projected on the screen and therefore visible to everyone in the workshop for discussion.
- Some notes and comments to further detail the risks are captured by the note taker in the spreadsheet displayed on the screen.
- Once the risk has been sufficiently discussed, the group analyzes each risk and decides on likelihood and consequence scores based on their scoring handouts. These scores are also captured on the screen and therefore again visible to everyone in the workshop for discussion.

As the individual 'raw' scores are filled in for each risk, the total score for the risk was calculated as follows:

$$Risk\ score = \left(\sum_{i=1}^{4} consequence\ scores\right) \times likelihood\ score$$

Where:

- Risk score is the combined effect of likelihood of the event occurring and the consequence of the event should it occur. It thus represents the overall potential impact to the Agency. The maximum score is 100.
- Consequence scores are the individual scores for safety, mobility, asset damage, and other financial impacts between 1 and 5 based on the scoring guidelines (See Figures 47 and 48).
- Likelihood score is the score between 1 and 5 based on the scoring guidelines (See Figures 47 and 48**FIGURE 48**).

Risk Register

The risks identified during the latest Risk Workshop are shown in the prioritized Risk Register in Appendix A. Ranking the risks based on scores identified in the workshop provides a prioritized view of the risks for context. This allows for informed decision making on evaluating each risk for management and mitigation efforts.

Risk Mitigation

Once the Risk Register has been revised and updated, the next part of the process is to **evaluate** each risk and determine a **management**

approach. Specific initiatives are then identified, implemented, and **monitored** to address the highest priority risks where appropriate.

The process will typically be a continuation of the Risk Register development or revision workshop but may also be conducted as a future session. As such, it is important that the attendees be the same or similar to those for the Risk Register sessions.

The goal is to start with the top ten risks based on the Risk Register scores and identify options to address each risk. Options are also considered for the remaining risks, but it is more likely they will be tolerated.

For each of the risks in the Risk Register, the following steps are undertaken to assure consideration of risk mitigation opportunities.

1. **Identify strategy options** - Consider at least one strategy option for **managing** the risk. The following options[10] should be considered:

   Tolerate – For high scoring risks this is typically not a desirable option unless it is already being mitigated to the extent possible, in which case the only option for the remaining risk may be to monitor it.

   Treat – It is typically a desirable option to mitigate a risk if large benefits can be attained at relatively low cost.

   Transfer – This is sometimes possible and should certainly be considered. The most common method of transferring risk is through insurance. However, distributing risk between groups in an organization is also possible.

   Terminate – Where possible, this is the most desirable option. If the risk can be removed altogether, for instance by reconstructing an asset in a different location (for example raising or relocating a bridge), then this option should be considered but will need to be weighed against cost.

   Take Advantage – In some cases, risks may be identified for a new process or policy but if the probability of considerable benefits significantly outweighs the probability of negative outcomes, it may still be desirable to adopt the process or policy.

2. **Implement high ranked strategies** – Pick high ranked strategies for implementation. Continue to monitor the implementation of these strategy initiatives in future Risk Mitigation workshops to gauge their status and how well they are working.
3. **Monitor and review** – The responsible party for each risk identified should keep track of the risk and identified management strategies. If actions were identified, these should be accounted for on the appropriate timeline.

Because of the interactive session, candidate strategies can be ranked, and high value initiatives can be identified and planned. The outcome of this effort should be a set of initiatives that can be justified because they address the top-ranking risks faced by the Agency and provide strategies to manage them.

[10] The Five T's: AASHTO Guide for Enterprise Risk Management

Risk Management Process - Asset Level (Pursuant to 23 CFR Part 667)

Process for Identifying Pavements and Bridges Repeatedly Damaged by Emergency Events

States are required[11] by 23 CFR Part 667 (Part 667) to maintain a list of facilities repeatedly requiring repair and reconstruction due to emergency events[12]. In addition to the risk assessment workshop described above, as part of this requirement, WVDOH conducts a statewide process to:

- Determine any emergency event (natural disaster or catastrophic failure[13]) resulting in an emergency declared by the State Governor or an emergency or disaster declared by the US President since January 1, 1997.
- Determine if any roads, highways, or bridges have required repair and reconstruction activities (permanent repairs, not including emergency repairs[14]) on 2 or more occasions due to emergency events.

Initially, WVDOH used the project tracking system as a source of this data and was unable to identify any repeatedly damaged locations. Projects were filtered for the use of FEMA or ER funds to identify repeated projects with emergency funding. There were no projects for the same location across events using this method. For the 2022 TAMP, WVDOH identified a more comprehensive source of data for this identification process.

Following a declared disaster, each District is provided an event identification number to record work completed in response to the disaster. The work recorded includes anything from debris removal to repairing or replacing damaged infrastructure. The data is recorded by each District and provided back to central office to be included and tracked in the *Disaster Summary Analysis* spreadsheet. The following steps were followed to identify any Part 667 qualifying locations in the spreadsheet. The detailed process is captured in internal documentation to ensure continuity and consistency across the Agency. This process will be followed at least biennially and after each declared disaster.

1. **Combined** information for all events into one worksheet. Included applicable descriptive, event, and location information for each project. At a minimum, the associated event ID, county, District, route number, location description (latitude/longitude or begin/end mile points if available), work category, project description, and cost information should be included.
2. **Filtered** the project list for those completed on specific routes (i.e., not countywide, or Districtwide). To date, specific and consistent location data is not available for all projects recorded in the *Disaster*

[11] 23 CFR 667 – Periodic evaluation of facilities repeatedly requiring repair and reconstruction due to emergency events: https://www.ecfr.gov/cgi-bin/text-idx?SID=b0579fc62bbaad143582510cc037c22e&mc=true&node=pt23.1.667&rgn=div5

[12] *Emergency event means a natural disaster or catastrophic failure resulting in an emergency declared by the Governor of the State or an emergency or disaster declared by the President of the United States.*

[13] *Catastrophic failure* means the sudden failure of a major element or segment of a road, highway, or bridge due to an external cause. The failure must not be primarily attributable to gradual and progressive deterioration or lack of proper maintenance.

[14] *Emergency Repairs. Those repairs including temporary traffic operations undertaken during or immediately following the disaster occurrence for the purpose of minimizing the extent of the damage, protecting remaining facilities, or restoring essential traffic.*

Summary Analysis. Thus, the county and route number were used as an initial way to narrow down the full list for further review.

3. **Developed** a *Damaged Facilities List* where each location recorded in the spreadsheet was recorded, even if the location was damaged in only one event. This list will be added to after each declared event so that newly repeatedly repaired locations can be identified.
4. **Identified** where projects were completed on the same route and county for multiple event IDs.
5. **Compiled** a list of potentially repeatedly repaired locations for each District. The list was broken out by projects completed on the same route in the same county.
6. **Provided** the list of projects to Districts for review. Districts reviewed the resulting list to determine whether any locations are within 50 feet of each other. This produced the final list of locations that WVDOH considers repeatedly repaired.

Once the Districts determined whether any locations have been repeatedly repaired due to emergency events, each identified location could be evaluated following the process below.

Process for Evaluating Pavements and Bridges Repeatedly Damaged by Emergency Events

WVDOH conducts statewide evaluations for each identified location in accordance with 23 CFR 667 to determine if there are reasonable alternatives to roads, highways, and bridges that have required repair and reconstruction activities on two or more occasions due to emergency events.

The process of evaluating and identifying high value alternatives is to conduct an interactive session either in conjunction with the Risk Register and Risk Mitigation sessions or through a separate effort with stakeholders directly involved or affected by the evaluation and decision-making process. The goal and outcome of this effort is to evaluate possible mitigation strategies for identified locations as part of risk management, and to include the beneficial projects as part of the programming process.

The following methodology describes the process that is used to incorporate the results of the evaluation into risk management.

1. **Create an Emergency Event Risk Register** – Use the list of facilities identified in 23 CFR 667 statewide identification effort to create a risk list similar to the Risk Register described above. First, each repeatedly damaged facility is listed. This asset could be a specific bridge or culvert, or it could be the location of a recurring slip. Each facility should have at least the following information:
    a. **Facility Name**: A unique description of the facility (e.g., Bridge ID) if available.
    b. **Location**: Latitude and Longitude of location, including linear reference (Route, Begin Milepoint, End Milepoint) if available.
    c. **NHS (Y/N)**: A flag noting whether the facility is on the National Highway System.
    d. **STIP Eligible (Y/N)**: A flag noting whether projects on the facility are eligible for inclusion in the STIP.
    e. **Repeated Damage (Y/N)**: A flag noting whether the facility has been damaged more than once.
    f. **Most Recent Damage Project Description**: Description of the project to repair the facility from the most recent damage.
    g. **Work Start and End**: The start and end dates of the work.
    h. **Total Authorized and Expended**: The authorized and expended dollar amount for the project.

2. **Identify alternative strategies for each asset** – Using the most recent project description and District knowledge, identify potential mitigation projects that would partially or fully mitigate the threat to the asset. For each repeatedly damaged location, list several possible mitigation actions.

   The process for evaluating asset level risks begins with analyzing the 'Do-Nothing' scenario. In other words, what is the impact of doing nothing to mitigate the risk? Then additional mitigation projects are identified and compared to the Do-Nothing option to determine their benefit-cost ratio.

3. **Evaluate and prioritize the strategy options** – For each alternative identified in the 23 CFR 667 effort, use the process described to prioritize the alternatives. Each possible mitigation action is evaluated as follows:

   a. **Action** – First evaluate a Do-Nothing action. Then define at least one other possible mitigation action to alleviate the consequence of a similar event to the latest event which damaged the asset. These actions are essentially mitigation projects that could be undertaken now to mitigate risk in the future. Each action is evaluated separately.

   b. **Cost of Action** – Estimate the Agency cost of the mitigation action. In the case of the Do Nothing alternative, this can be assumed to be zero.

   c. **Duration of Fix** – Estimate the duration before the asset will need to be repaired or replaced in years.

   d. **Annualized Cost of Action** – The cost of the action is divided by the duration of the fix to obtain an annualized cost.

   e. **Event Frequency (Likelihood)** – Estimate the frequency of the future event being evaluated.

   f. **Cost Exposure after Action (Consequence)** – Estimate the User Costs, Repair Costs, Safety Costs and Other costs and sum these as the consequence of the event assuming the mitigation action had been implemented. The consequence is then annualized based on the event frequency to give the annualized expected consequence.

   g. **Expected Annualized Consequence reduction** – Calculate the annualized Consequence for both the 'Do Nothing' scenario and the 'Alternative Mitigation Action' scenario. This reduction is calculated using this equation: = 1 - ([Consequence of Alternative Mitigation Action] / [Consequence of Do Nothing]). Thus, this value is the percentage that the impacts of the risk were reduced by the action (always 0% for a Do Nothing action, should be >0% for any mitigation action, 100% if the mitigation protects the asset from the risk totally).

   h. **Benefit Cost Ratio** – Calculate the benefit to cost ratio (B/C Ratio) by dividing the expected annualized consequence reduction by the annualized cost of the action (described above). If this B/C ratio is greater than one, the mitigation action could be considered. If the ratio is less than one, the risk could be tolerated.

4. **Implement high ranked strategies** – Pick high ranked alternatives for implementation and add these projects into the programming process. While the pavement and bridge management processes include a method for submitting condition-related projects for inclusion in the STIP, WVDOH's future Resiliency Plan is expected to include a method for prioritizing and submitting mitigation and resilience related projects for inclusion in the STIP. Continue to monitor the implementation of these projects in future risk workshops.

Resilience and Extreme Weather in Risk Management

The Federal Highway Administration (FHWA) defines resiliency as the ability to anticipate, prepare for, and adapt to changing conditions in order to withstand, respond to, and recover rapidly from disruptions.[15] FHWA guidelines emphasize resilience as a planning factor for state and metropolitan long-range transportation plans and discuss the importance of a "performance-driven, outcome-based approach to planning," mandating that statewide planning concentrate on "the resiliency and reliability of the transportation system."[16] With the passing of the IIJA in October 2021, TAMPs are required to consider extreme weather and resilience in the life cycle planning and risk management analysis processes. This section summarizes how WVDOH has addressed this requirement in the risk management process.

Consideration Across Plans and Divisions – Weather-related impacts affect every aspect of a transportation system from maintenance and mobility to life-cycle costs. By incorporating resiliency into the transportation system, WVDOT can increase the viability and reliability of the state's infrastructure. The West Virginia Legislature passed House Bill 2935[17], which established a joint legislative committee to address flooding and created a new state office focused on resiliency. The WV State Resiliency Office (SRO) was established in April 2017 to coordinate all economic and community resiliency planning and implementation efforts, including but not limited to flood protection programs. The office is also responsible for updating the state's flood

Source: WVDOT

[15] U.S Department of Transportation. Federal Highway Administration. Climate Change Adaptation Guide for Transportation Systems Management, Operations, and Maintenance. 2020.
[16] U.S Department of Transportation. Fixing America's Surface Transportation (FAST) Act. 2015.
[17] WV Legislature. House Bill 2935. 2017

protection plan[18] and recommending legislation to reduce and/or mitigate flood damage. The most frequent natural hazards and extreme weather events West Virginia faces are floods and drought, landslides, mudslides, and severe storms. As weather becomes increasingly unpredictable and natural disasters continue to increase in frequency and duration, WVDOH has begun to address resiliency in long-range planning though the recently updated long-range transportation plan and TAMP risk management approaches. In the future, WVDOH expects to expand on planning for resilient infrastructure in its future Resiliency Plan. This plan will include processes related to integrating resilience into long term planning, project programming, and design.

Consideration in Agency & Program Level Risk Management – WVDOH's risk identification and management approach inherently considers extreme weather and resilience. In the Agency and program level risk identification process, WVDOH identifies and evaluates multiple risks related to extreme weather. In the asset and/or location level risk management process, WVDOH identifies and evaluates specific locations that are vulnerable to extreme weather events. In both processes, once the risks are identified, mitigation efforts are considered to improve the resilience of the Agency, program, and/or asset to occasions of extreme weather.

In the Agency and program level risk register, WVDOH lists **flooding events** as a risk (risk IDs #3 and #11) to both the pavement and bridge programs. As climate change continues, the frequency of extreme weather events causing 50-year flood levels is expected to increase. These flood events have significant effect on pipes and culverts. WVDOH is currently tolerating and treating this risk on a case-by-case basis. However, as these assets are scheduled for reconstruction, resilience is improved by increasing pipe sizes, improving end treatments, and using better materials. Additionally, there is a program in place to monitor backwater and scour and bridges are often reconstructed to be longer when replaced. It is not feasible to change the design standards for all roadways due to the elevation of many cities and towns in the state. Thus, other resilience improving actions are considered or the risk is tolerated.

Consideration in Landslide Hazard Management – West Virginia experiences both major and minor landslides, rockslides, and rockfall (risk IDs #7 and #8) on a regular basis. Major and minor slides are typically differentiated by their impacts on accessibility more so than economic impacts. For instance, if a slide blocks entrance to a hospital or emergency services, it is more likely to be considered a major slide even if the cost to fix is relatively low. These occasions pose a threat to safety and can often disrupt the service of a roadway leading to extensive detours. Landslides are typically caused by slope saturation, which is caused or exacerbated by intense rainfall, snowmelt, changes in ground-water levels, and water level changes along coastlines, earth dams, and the banks of lakes, reservoirs, canals, and rivers.[19] Thus, floods and extreme weather that causes floods are closely linked to landslides. WVDOH has multiple mitigation efforts in place to address these events:

[18] WV Flood Plan. https://www.wvca.us/flood/

[19] *Development of Digital Inventory and GIS Web-Based Applications for West Virginia's Landslide Hazard Management Program*. Dr. Wael Zatar. Marshall University Research Corporation in corporation with WVDOH, FHWA, and USDOT. 2014.

- landslide hazard management tool
  - identifying high risk locations for monitoring and maintenance
- supplying drills to Districts for quicker response
- tracking hazard work and costs, downtime, etc. for in-house vs contracting

These efforts improve the WVDOH system's resilience to these events, lowering the system's vulnerability to the threats and decreasing the response time given an event does occur.

Consideration in Asset Level Risk Management – WVDOH tracks projects completed in response to declared emergencies in the disaster summary records. Thus, the impacts of and responses to extreme weather events are recorded in this list. As discussed earlier in this chapter, WVDOH uses the disaster summary list as the sources for identifying Part 667 assets. Potential mitigation projects are then identified for each Part 667 asset for consideration in the project selection process. If a project is determined to be beneficial in terms of cost and improved resilience to future extreme weather or emergency events, it is selected as part of the project work plan and included in the appropriate management system for life cycle planning.

Consideration in Safety Planning – An example of initial efforts is included in the Medical Access Roads Project (MARP). A $50 million program comprised of multiple projects looks at removing the impediments and increasing access to medical facilities on transportation routes through maintenance improvements. Some of the projects are working to eliminate high water flooding concerns in areas of the state by providing new paving, drainage, and intersection designs to increase hospital accessibility. During extreme weather events, emergency response personnel have difficulty responding to calls due to drainage issues and infrastructure damage. The MARP Program is indirectly working to address environmental resiliency issues across the state and improve transportation infrastructure to prepare for future weather events. WVDOH considers resilience to extreme weather a high priority and plans to continue developing and improving programs that address these topics.

Source: WVDOT

Chapter 5

Managing Finances

Financial Plan

The current federal transportation legislation is the IIJA which establishes funding for federal fiscal years 2022 through 2026. Many of the requirements contained within the previous federal transportation bill, continues under IIJA, especially as it pertains to the requirements for the Transportation Asset Management Plan. According to the FHWA Asset Management Financial Report Series, Report 2, Components of a Financial Plan[20], a comprehensive financial plan that supports long-term transportation asset management (TAM) will at a minimum include the following primary components:

- The various uses of funds based on forecasted system conditions and performance targets. It will include assumptions related to future projections.
- Projected revenues from all available and anticipated sources of funds including related assumptions.
- Projected gaps or surpluses based on the above.
- Scenarios reflecting adjustments necessary to address gaps, if any, along with related consequences.

[20] https://www.fhwa.dot.gov/asset/plans/financial/hif15017.pdf

- Final proposed financial plan to support the Agency's asset management plan.

By expanding on each of these areas in the financial plan, a realistic picture of WVDOH's projected future financial health will come into focus.

Revenue and Expenditures

This section presents the processes, documentation, and analysis that are required in an asset management financial plan. The financial plan discusses estimated funding levels projected to be available and outlines the expected funding allocations directed toward WVDOH's pavement and bridge assets over the next 10 years. The financial plan relies on outputs from the annual budget process, the program distribution process and the TAMP processes discussed in other chapters of this document.

Financial data presented in this chapter was extracted from the WVDOH Annual Financial Statements, the recently completed 2050 Statewide Long-Range Transportation Plan, the 2023-2028 Statewide Transportation Improvement Plan (STIP), as well as WVDOH staff.

WVDOH Revenue Sources

Transportation funding in West Virginia is derived from several primary sources: fuel taxes, automobile privilege taxes, motor vehicle registration and license fees, less the administrative costs incurred by the Division of Motor Vehicles in collecting these funds. Revenues are deposited in the State Road Fund for funding of general maintenance and construction of the WVDOH roadway network and for providing resources to match available Federal funds.

Motor Fuel Tax:

West Virginia levies excise taxes on gasoline, diesel fuel, and special fuels used by motor vehicles that travel public highways. Likewise, the Federal government levies excise taxes on gasoline, diesel fuel, and special fuels used by motor vehicles on public highways. The West Virginia motor fuel tax rate is composed of two components: a fixed rate per gallon and a variable rate per gallon that is indexed to the wholesale price of fuel and calculated annually. The motor fuel tax rate is 20.5 cents for the flat rate. The variable rate was 11.7 cents on January 1, 2017, but changed on July 1, 2017, to 15.2 cents as the result of SB1006. The rate has not changed since. The Federal rate is 18.4 cents per gallon for gasoline and 24.4 cents per gallon for diesel. WVDOH receives most of this revenue back in the form of Federal-aid reimbursable funds.

Registration Fees:

Registration fees include not only vehicle registration fees but also driver's licenses, permits, and litter control fees. Vehicle registration fees are based on a vehicle's classification and are renewed annually or on a multi-year basis. To account for lost revenues on fuel tax from alternative fuel, electric or hybrid vehicles, the state enacted additional registration fees above the base passenger vehicle registration fee. Driver's licenses and learner's permit fees are paid by licensed motor vehicle operators.

Privilege Tax:

The privilege tax, imposed when a vehicle certificate of title is issued, was first enacted in 1935 at a rate of 2% of the vehicle value. The rate was increased to 5% in 1971 and increased to 6% in 2017.

Miscellaneous Fees:

Miscellaneous revenue sources include revenue from interest on investments, map sales, permits, and special revenue funds such as the A. James Manchin Fund (title fees) and the Coal Resource Transportation System (CRTS) fund (permit tonnage fees). It also previously includes a yearly transfer of revenue from the State's general fund to the State Road Fund which was intended to offset costs incurred by the WVDOH when its contractors pay state sales tax on construction materials. The amount of the transfer varied yearly depending on the size and scope of the WVDOH's construction program, but typically added several million dollars to the State Road Fund annually. The mandated transfer was eliminated in 2017

Federal Aid:

The WVDOH also relies heavily on Federal funds as a source of revenue for the transportation program. On November 15, 2021, the IIJA (Public Law 117-58) was signed into law. The IIJA is the largest long-term investment in our infrastructure and economy in our Nation's history. Federal aid is obtained in the form of reimbursable grants. Federal transportation legislation provides funds that are available for obligation for eligible projects on the Federal-aid system. WVDOH, like most other State DOTs, expects to continue obligating all available Federal funds.

WVDOH Historical Revenues

The WVDOH is dependent on State and Federal revenues generated from the purchase and use of motor fuel, motor vehicle fees and privilege tax on purchases of motor vehicles. Figure 49, summarizes historical tax and fee collections.

Some key highlights are:

- Total WVDOH revenue averaged approximately $1.35 billion per year over the last three years. The average annual growth over the last 10 years was approximately 1.7 percent per year.
- In 2022, the state fuel tax made up approximately 31% of the total revenue and has seen an increase of approximately 0.2% per year since 2013.
- In 2022, Federal funding made up approximately 35% of total revenue and experienced an average annual increase of 0.1% per year since 2013. It should be noted that although the IIJA provided a substantial increase in FY 2022, the official WVDOH Annual Financial Statement does not reflect these reimbursable grants as collected revenue.
- The third largest revenue stream, automobile privilege tax, made up approximately 22% of the total revenue in 2022 and increased by an approximately annual rate of 6% per year mostly due to the increase in the tax rate and the increase in the price of vehicles.
- Revenue data taken from WVDOH Annual Financial Statements.

FIGURE 49: WVDOH HISTORICAL REVENUE

(Millions $) Year of Expenditure Dollars	FY2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
State Road Fund Revenues	Historical									
Motor Fuel Tax	$409	$441	$435	$396	$383	$420	$443	$428	$400	$420
Privilege Tax	$187	$194	$206	$206	$204	$227	$236	$266	$301	$301
Registration Fees	$90	$97	$101	$87	$104	$149	$169	$123	$136	$136
Other	$35	$16	$21	$25	$24	$56	$23	$38	$78	$21
Intergovernmental							$104		$150	
Federal Funds	$433	$405	$350	$396	$442	$391	$367	$405	$374	$474
Total Revenues	$1,154	$1,153	$1,113	$1,110	$1,157	$1,243	$1,342	$1,260	$1,439	$1,352
Revenue Growth/Decline	-0.3%	-0.1%	-3.5%	-0.3%	4.2%	7.4%	8.0%	-6.1%	14.2%	-6.0%

WVDOH Historical Expenditures

WVDOH has statutory responsibility for construction, operation, and maintenance of all Federal-aid highways, except for the WV Turnpike, as well as all other state highways and county roads. Municipalities are generally responsible for maintenance of non-primary roadways within their corporate limits. A description of the expenditure categories across divisions are as follows:

- Capital Improvements – State and Federal construction projects, equipment, vehicles, etc.
- Routine Maintenance – Operations costs, maintenance projects, etc.
- Administrative Support – Staff salaries and general expenses to include Department of Motor Vehicles as well as contractual costs and studies.
- Debt Service – Cost to repay bond issuances and interest.

The budget allocation is based on processes that consider available funding, basic administrative costs such as salaries and operating expenses, maintenance and capital project needs and debt service. Overall, the budget allocations have been approximately level over the past ten years. Figure 50 shows the breakdown of expenditures into major subcategories for FY 2013 through FY 2022.

Some key observations are:

- The annual expenditures for capital outlay and other road operations over the past ten years fluctuated between $564 million (FY 2013) and $441 million (FY 2022). The decrease is partially due to increased maintenance and administrative costs.
- Expenditures for the budget categories other than capital outlay increased from $549 million in 2013 to $957 million in 2022 or an increase of approximately $400 million.

- Administrative support, which is composed primarily of salaries, increased by $84 million from FY 2013 – 2022, $44 million of this occurring in 2022, due to a budgeting change associated with materials and inventory.
- GARVEE bond debt service does not appear as a historical expenditure as Federal revenue is utilized before being realized as a reimbursement
- Expenditure data taken from WVDOH Annual Financial Statements

FIGURE 50: WVDOH HISTORICAL EXPENDITURES

(Millions $) Year of Expenditure Dollars	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
State Road Fund Expenditures						Historical				
Road Maintenance Total	$425	$426	$434	$450	$406	$315	$420	$625	$535	$661
Support And Administrative Operations	$45	$51	$54	$37	$37	$(10)	$74	$111	$85	$129
Division of Motor Vehicle Operations	$37	$36	$39	$39	$40	$39	$39	$39	$43	$48
Office of Administration Hearings Operations	$2	$2	$2	$2	$1	$1	$1	$2	$1	$-
Claims	$2	$1	$1	$1	$1	$1	$-	$3	$1	$1
Support admin, DMV, Admin Hearings, Claims Total	$86	$89	$95	$78	$79	$31	$114	$155	$130	$178
Debt Service GO Bonds	$38	$37	$39	$15	$24	$25	$79	$94	$109	$118
State Road Fund Expenditures Other Than Capital Outlay	$549	$552	$567	$543	$509	$371	$613	$874	$774	$957
Capital Outlay and Other Road Operations										
Road Construction and Other Road Projects										
Interstate Highways	$104	$146	$76	$149	$103	$82	$89	$109	$97	$134
Appalachian Highway	$90	$77	$64	$76	$114	$97	$88	$60	$76	$48
Other Federal Aid Programs	$353	$369	$325	$402	$430	$387	$359	$335	$351	$256
Nonfederal Aid Construction and Road Operations	$17	$17	$13	$15	$17	$218	$156			
Industrial Access Roads						$3	$3	$3	$3	$3
Capital Outlay and Other Road Operations Total	$564	$609	$478	$642	$664	$787	$695	$507	$527	$441
Total Expenditures	**$1,113**	**$1,161**	**$1,045**	**$1,185**	**$1,173**	**$1,158**	**$1,308**	**$1,381**	**$1,301**	**$1,398**

WVDOH Budget Allocation Process

The WVDOH annual budget process begins with an estimate of the revenues expected for the upcoming fiscal year. The State Revenue Department forecasts motor fuel taxes. Vehicle registrations and privilege taxes are forecasted by the Division of Motor Vehicles (DMV). Other funds are forecasted internally by WVDOH. The Programming Division forecasts Federal reimbursements.

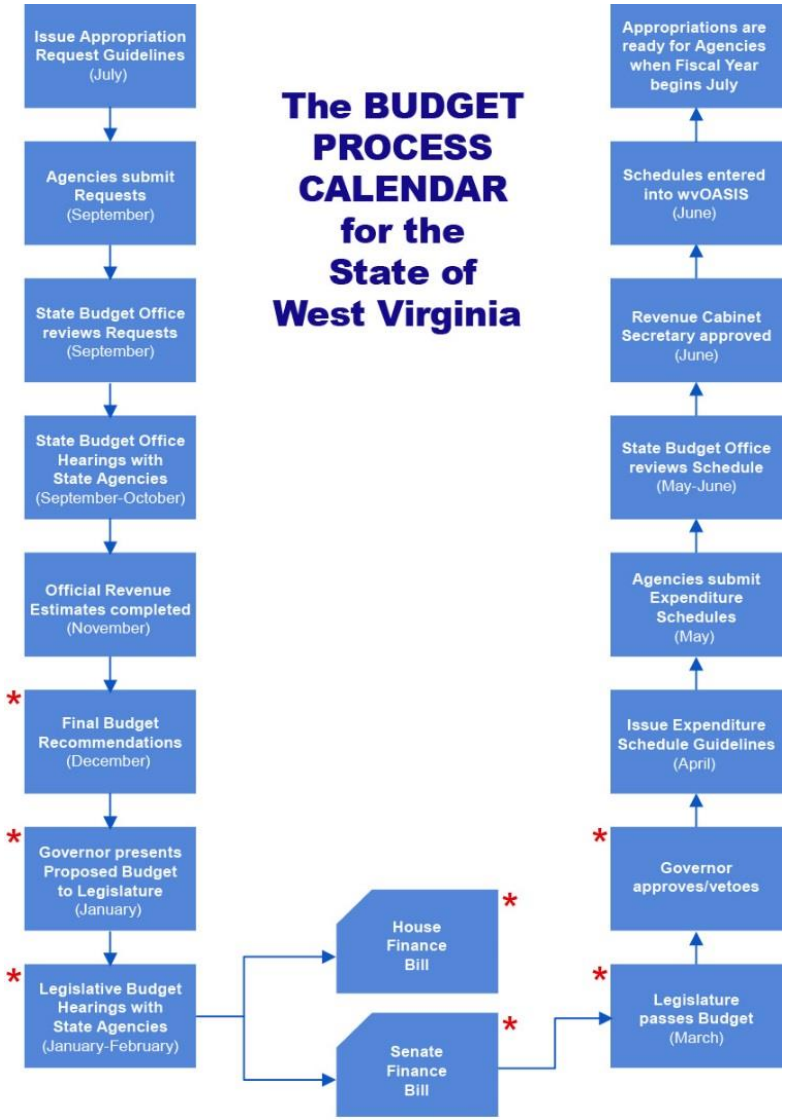
Many factors affect revenues including state and national economic conditions, world events affecting availability and pricing of fuel, and fuel consumption rates for motor vehicles. Nationally, the forecast for fuel consumption is anticipated to trend downward as fuel efficiency increases. The 2017 WVDOH Annual Financial Report states revenue collections in the short term will be enhanced by the state legislation that raised the average wholesale price for motor fuel. The same legislation also increases rates of both privilege taxes and registration fees which are forecasted to increase revenues in FY 2018 and beyond.

WVDOH budget allocations are mostly determined by historical trends, available funding, and projects in the delivery pipeline. High-level funding allocation areas in order of priority are:

- Debt service,
- General operations and administration costs (including equipment),
- Routine maintenance, and
- Capital programming.

Once the WVDOH proposed budget is developed, it is then submitted to the State Budget Office and then to the Legislature. Figure 51 shows this process.

FIGURE 51: WVDOH BUDGET PROCESS



WVDOH Revenue Projections

The WVDOH departmental budget in the 2023 – 2028 Statewide Transportation Improvement Plan (STIP) is projected over six years. The analysis conducted for the TAMP includes a 10-year forecast horizon. The TAMP budget begins with the STIP budget forecast and uses historical trends to develop the forecast for the remaining four years. These budget forecasts are reasonable estimates typically using a straight-line projection based on historical data and known funding initiatives and anticipated trends. The budget forecast then becomes the baseline budget forecast scenario on which resulting pavement and bridge conditions are analyzed by the bridge and pavement management systems.

The key assumptions that were used for the 2023 – 2032 revenue forecasts are as follows:

1. The 2023 – 2028 STIP revenue and expenditure budget data is used for the first six years of the forecast.
2. The 2050 Long-Range Transportation Plan forecasted growth/reduction percentages are used for revenue and expenditure forecast for the last four years of the 10-year forecast period.
3. No inflation or discount has been applied to revenue as construction inflation will be considered within the bridge and pavement management systems analysis. (2% construction inflation and 4% discount rate.)
4. The baseline TAMP forecast does not include WV Turnpike revenue.

The results of the baseline budget forecast as well as additional investment scenarios are discussed in more detail within *Chapter 6 - Investing Wisely*. The funding levels from each scenario are used to inform the analysis performed by the pavement and bridge management systems. This iterative process is used to refine the budget allocation levels that will lead to scenarios that best utilize available resources to meet target condition levels on the NHS pavements and bridges. Figure 52 shows the breakdown of the baseline revenue forecast for FY 2023 through FY 2032.

Some key observations are:

The forecasted revenue is taken from the 2023-2028 STIP. The remaining four years are forecast using growth factors from the LRTP.

- Overall revenue is forecasted to grow from $1.6 billion FY 2023 to approximately $1.8 billion in FY 2032 or approximately 1 percent. This is due to relatively flat revenue and increasing overhead.
- Federal funds increased significantly from $474 million in 2022 to $735 million in 2023 (55%) due to the IIJA.
- Federal funding forecast is based on IIJA apportionments. August redistribution funding is not included as this is uncertain. STIP document provides additional assumptions.
- Forecasted revenue is in year of expenditure dollars.

FIGURE 52: WVDOH FORECASTED BASELINE REVENUE SCENARIO

(Millions $) Year of Expenditure Dollars	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032
State Road Fund REVENUES						Forecasted				
Motor Fuel Tax	$448	$455	$462	$469	$476	$483	$490	$497	$504	$511
Privilege Tax	$282	$287	$293	$301	$307	$313	$319	$326	$332	$339
Registration Fees	$128	$130	$132	$135	$138	$140	$143	$146	$149	$152
Other	$42	$44	$46	$48	$50	$53	$54	$57	$59	$61
Intergovernmental										
Federal Funds	$735	$749	$699	$699	$699	$715	$726	$737	$748	$759
State Road Fund Revenues Total	**$1,635**	**$1,665**	**$1,632**	**$1,652**	**$1,670**	**$1,704**	**$1,731**	**$1,762**	**$1,791**	**$1,821**
State Road Fund Revenues Growth / Decline	20.9%	1.8%	-2.0%	1.2%	1.1%	2.0%	1.6%	1.7%	1.7%	1.7%

WVDOH Forecasted Expenditures

As previously stated, the forecasted expenditures for the first six years of the TAMP uses the data from the 2023 – 2028 STIP. The remaining four years utilize the growth factors from the LRTP. Figure 53 shows the breakdown of forecasted expenditures into major high-level subcategories for FY 2023 through FY 2032.

Some key observations are:

- GARVEE and GO bond fund balances as of the end of FY2021 were used to approximate the amount of bond proceeds used in the capital program each year going forward.
- GARVEE bond debt service is counted as an expenditure due to the Federal funding revenue forecast in the STIP is based on Federal apportionments, not collected revenue.
- This forecast does not include the expenditures of the WV Turnpike.
- GO and Turnpike bond proceeds are forecasted to be used in 2023 – 2027.
- After bond proceeds are exhausted, the capital outlay expenditures are forecasted to be relatively flat.
- Forecasts are shown in year of expenditure dollars.

FIGURE 53: WVDOH FORECASTED EXPENDITURES BASELINE SCENARIO

(Millions $) Year of Expenditure Dollars	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032
State Road Fund EXPENDITURES					Forecasted					
Road Maintenance										
Expressway, Trunkline & Feeder, State & Local	$414	$414	$430	$447	$465	$484	$503	$523	$544	$566
Litter Control Program	$2	$1	$1	$2	$2	$2	$2	$2	$2	$2
Road Maintenance Total	$416	$415	$431	$449	$467	$486	$505	$525	$546	$568
Support And Administrative Operations	$202	$198	$198	$200	$207	$216	$225	$234	$243	$253
Division Of Motor Vehicle Operations	$43	$44	$46	$48	$50	$52	$54	$56	$58	$61
Office Of Administration Hearings Operations	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1
Claims	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1
Support, Admin, DMV, Admin Hearings, Claims Total	$247	$244	$246	$250	$259	$270	$281	$292	$303	$316
Debt Service GARVEE Bonds	$32	$32	$32	$32	$32	$32	$32	$32	$8	$8
Debt Service GO Bonds	$134	$136	$139	$116	$116	$116	$116	$116	$116	$116
State Road Fund Expenditures Other Than Capital Outlay	$829	$827	$848	$847	$874	$904	$934	$965	$974	$1,007
Available For Capital Outlay from State Road Fund (Revenues Minus SRF Non-Capital)	$806	$838	$784	$805	$796	$800	$798	$797	$817	$813
Bond Fund Proceeds Used in Capital Program										
Go Bonds	$155	$155	$155	$155	$155					
Turnpike Bonds	$141	$141								
Total Bond Funds Used	$296	$296	$155	$155	$155					
Total Road Fund Capital Program Plus Bonds	$1,102	$1,134	$939	$960	$951	$800	$798	$797	$817	$813

WVDOH Forecasted Expenditures for NHS Pavements and Bridges

The WVDOH does not presently have an easy way of breaking out the forecasted expenditures for NHS pavements and bridges. For purposes of this TAMP 10-year forecast, a methodology was used to approximate the expenditures under the baseline. Once the overall WVDOH revenue and expenditures are forecasted, the administrative costs, district maintenance costs, the Division of Motor Vehicles and debt service are subtracted from the forecasted revenues. This results in the total expenditures available for capital outlay. The next step is to determine how to distribute the forecasted amount between NHS and Non-NHS pavement and bridge expenditures. To do this, the process for the annual consistency reporting analysis submitted to FHWA on July 1st of each year from previous years is used as a guide. This complicated annual consistency reporting analysis starts with a data dump of expenditure data from the wvOASIS system. Over 300,000 lines in 72 columns are then pared down to a manageable size so that the wvOASIS construction codes for capital outlay expenditures can be cross-referenced to the TAMP work types. The resulting total actual expenditures by NHS and Non-NHS Pavement and Bridges is then reduced to a percentage of the total available expenditures for capital outlay. The resulting percentage is used to proportion the forecasted expenditures available for capital outlay into the forecasted expenditures for NHS and non-NHS pavement and bridges. The proportioning used for baseline forecast in this TAMP are: NHS Bridges (15%), Non-NHS Bridges (15%), NHS Pavements (20%), non-NHS Pavements (18%). The remaining 32% is related to non-bridge and pavements capital expenditures.

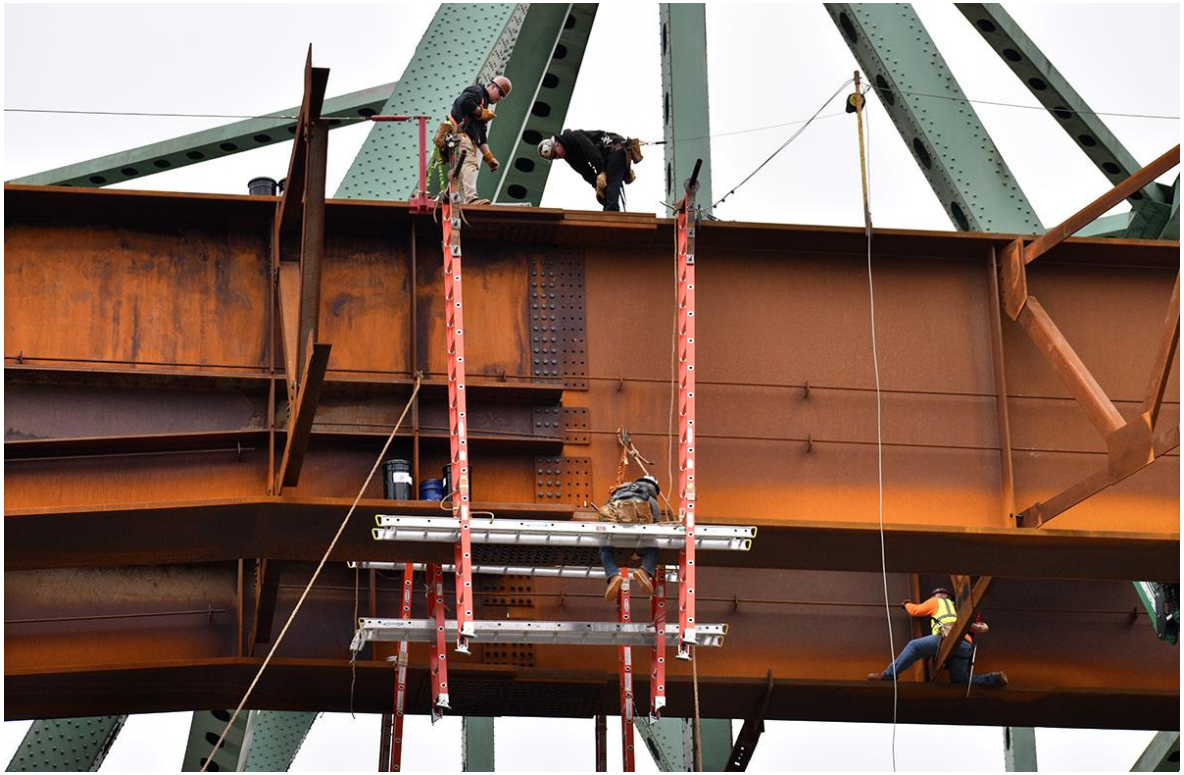
Figure 54 shows the breakdown of forecasted baseline expenditures scenario for the for the bridge and pavement programs.

Some key observations are:

- The funding available for NHS bridges over the TAMP 10-year period from FY 2023 to 2032 is forecasted to relatively flat due to the increase in federal funding being offset by increases in maintenance and administrative costs.
- The funding available for NHS pavements over the TAMP 10-year period from FY 2023 to 2032 is forecasted to be approximately $220 million in 2023 but declines to $160 million by 2032.
- The bridge forecast includes an extra $50 million per year starting in FY 2024. The source of this funding increase has not been determined. It may be federal or state or a combination thereof.
- The forecasted data in these tables are year of expenditure dollars.
- The forecast represents the baseline funding scenario. Additional scenarios are discussed in the Investing Wisely chapter.
- This table does not include committed project expenditures.

FIGURE 54: WVDOH BRIDGE AND PAVEMENT CAPITAL PROGRAM BASELINE SCENARIO

Year of Expenditure Dollars	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032
(Millions $)	Forecasted									
NHS Bridges Expenditures	$170	$220	$190	$190	$190	$170	$170	$170	$170	$170
Non-NHS Bridge Expenditures	$170	$170	$140	$140	$140	$120	$120	$120	$120	$120
NHS Pavement Expenditures	$220	$230	$190	$190	$190	$160	$160	$160	$160	$160
Non-NHS Pavement Expenditures	$200	$200	$170	$170	$170	$140	$140	$140	$150	$150
Total NHS & Non-NHS Pavements & Bridges	$760	$820	$690	$690	$690	$590	$590	$590	$600	$600



Source WVDOT

West Virginia Turnpike

The West Virginia Parkways Authority operates and maintains the WV Turnpike, an 87-mile toll facility which includes 97 bridges. The WVDOT owns the WV Turnpike which is part of the NHS. The funding for operation and maintenance is supported by tolls and toll revenue bonds. The toll revenue funding does not flow through the WVDOH and is not included in the previous tables, however, some of the recent WV Turnpike bonds have been utilized on the WVDOH system that is in immediate proximity of and feeds traffic into the WV Turnpike. The data in the following figures shows the historical and forecasted revenue and expenditures on the WV Turnpike.

Some key observations are:

- Data includes only the WV Turnpike.
- Tolls increased January 1, 2019.
- FY 2019 – 2028 revenue without toll revenue bonds is forecasted to increase at an annual rate of approximately 2%.

FIGURE 55: WV TURNPIKE HISTORICAL REVENUES

Revenues	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
(Millions $)						Historical					Estimated
WV Turnpike Tolls & Misc.	$91	$91	$92	$96	$101	$100	$102	$133	$157	$158	$167
Turnpike Revenue Bonds								$184		$423	
Total WV Turnpike Revenue	$91	$91	$92	$96	$101	$100	$102	$317	$157	$581	$167

FIGURE 56: WV TURNPIKE HISTORICAL EXPENDITURES

Expenditures	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
(Millions $)						Historical					
Debt Service	$11	$10	$8	$8	$7	$8	$8	$20	$10	$10	$31
Administrative Support	$21	$21	$24	$25	$25	$28	$28	$19	$19	$19	$20
Routine Maintenance	$22	$23	$23	$26	$25	$25	$25	$25	$25	$26	$27
Regular Capital Program	$37	$37	$38	$38	$44	$40	$40	$40	$62	$40	$40
Bonds Capital Program											
Total WV Turnpike Expenditures	$91	$91	$93	$97	$101	$101	$101	$104	$116	$95	$118
Total WV Turnpike Capital Program	$37	$37	$38	$38	$44	$40	$40	$40	$62	$40	$40

FIGURE 57: WV TURNPIKE FORECASTED REVENUES

Revenues	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032
(Millions $)	Forecast									
WV Turnpike Tolls & Misc.	$174	$178	$182	$185	$190	$195	$198	$202	$207	$211
Turnpike Revenue Bonds										
Total WV Turnpike Revenue	$174	$178	$182	$185	$190	$195	$198	$202	$207	$211

FIGURE 58: WV TURNPIKE NHS FORECASTED EXPENDITURES

Expenditures	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032
(Millions $)	Forecast									
Debt Service	$31	$31	$31	$31	$31	$31	$31	$31	$31	$31
Administrative Support	$20	$21	$21	$22	$22	$23	$23	$24	$24	$25
Routine Maintenance	$28	$28	$29	$29	$30	$30	$31	$31	$32	$32
Regular Capital Program	$149	$115	$56	$68	$48	$50	$43	$44	$46	$48
Bonds Capital Program										
Total WV Turnpike Expenditures	$228	$195	$137	$150	$131	$134	$128	$130	$133	$136
Total WV Turnpike Capital Program	$149	$115	$56	$68	$48	$50	$43	$44	$46	$48

FIGURE 59: WV TURNPIKE FORECASTED EXPENDITURES FOR NHS BRIDGES AND PAVEMENTS

Expenditures	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032
(Million$)	Forecast									
WV Turnpike Bridge System Program (NHS)	$27	$23	$19	$31	$21	$21	$26	$27	$28	$28
WV Turnpike Pavement System Program (NHS)	$40	$15	$16	$16	$17	$17	$17	$17	$18	$18
WV Turnpike Other Capital Programs (NHS)	$84	$79	$21	$21	$11	$13	$2	$2	$2	$2
WV Turnpike Total Capital Program	$151	$117	$56	$68	$49	$51	$45	$46	$48	$48

Asset Valuation

Asset valuation is a required element of annual financial reporting by government agencies. The details of these requirements are included in the Government Accounting Standards Board Statement 34 (GASB 34). Asset valuation can be used to establish asset value, track asset depreciation, and estimate the asset service life. There are different approaches to meeting GASB 34, including straight-line depreciation and the "modified approach", which relies on data analysis to confirm that asset conditions are sustained over time by employing appropriate investment strategies. The data required to estimate the asset value will depend upon the approach used.

WVDOH Asset Valuation

WVDOH, like many state DOT's, uses the GASB 34 depreciation method to determine the value of transportation assets on an annual basis. This information is included in its annual financial report. In this method, the collective original construction cost of all road and bridge assets is determined, then each year the value of all new construction is added, and then depreciation is subtracted. The valuation for roads includes the cost of pavement and bridge construction and all other assets necessary for the operation of the highway, such as signs, striping and drainage. Capital assets are depreciated on the straight-line method over the assets' estimated useful lives. There is no depreciation recorded for land and construction-in-progress. Generally, estimated useful lives are as follows:

- Infrastructure: roads - 30 years.
- Infrastructure: bridges - 50 years.

It should be noted that asset valuation is not reported in subcategories such as NHS, state-owned and non-state owned. Although breaking out NHS pavements and bridges is desirable for tracking and communicating the value of the NHS pavements and bridges; the present method for reporting asset value can still be used to communicate the value of the infrastructure and consequences of under-investing to the transportation stakeholders. Using the best available data, a reasonable approximation of the NHS asset value can be calculated using the percentage of the NHS roads in lane-miles as compared to the total state-maintained roads in lane miles and the percentage of the NHS bridges in deck area as compared to the total state-maintained bridge deck area. The results can then be multiplied by the total state-owned asset values in Figure 60. Based on this calculation, NHS roads represent approximately 5% of the total state-maintained lane-miles. NHS bridges represent 60% of the total state-maintained bridges as a function of deck area.

Figure 60 shows the historical value of the WVDOH transportation components: land, pavement, and bridge assets over the FY 2013 through FY 2022 timeframe.

Some key observations are:

- Infrastructure Land - $1.3 billion (2022) (17% of total)
- Construction in Progress - $2.2 billion (2022) (24% of total)
- All State-owned Roads - $3.0 billion (33% total)
- All State-owned Bridges - $2.4 billion (27% of total)
- NHS Roads - $150 million (5% of total roads)
- NHS Bridges - $1.5 billion (60% of total bridges)
- Total asset value increased by an average annual rate of 1.2% over the last 10 years.

FIGURE 60: WVDOH TRANSPORTATION ASSET VALUATION

$Thousands	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Land	$1,039,165	$1,071,733	$1,097,423	$1,124,458	$1,187,099	$1,204,877	$1,226,804	$1,244,134	$1,269,745	$1,295,794
Construction in Progress	$783,128	$623,444	$785,262	$768,570	$717,875	$907,787	$1,163,867	$1,690,845	$1,934,663	$2,175,658
Roads	$3,938,068	$3,841,535	$3,638,959	$3,574,749	$3,630,308	$3,465,639	$3,348,839	$3,176,333	$3,091,322	$2,966,225
Bridges	$2,266,793	$2,433,040	$2,442,434	$2,496,309	$2,473,187	$2,476,229	$2,472,312	$2,443,296	$2,456,649	$2,430,016
Total	**$8,027,154**	**$7,969,752**	**$7,964,078**	**$7,964,086**	**$8,008,469**	**$8,054,532**	**$8,211,822**	**$8,554,608**	**$8,752,379**	**$8,867,693**

Note: Data taken from WVDOH Annual Financial Statements - Statement of Net Position

Source: WVDOT

Source: WVDOT

Chapter 6

Investing Wisely

Investment Strategies

FHWA defines Investment Strategies as a set of strategies that result from evaluating various levels of funding to achieve State DOT targets for asset condition and system performance at a minimum practicable cost while managing risks.

The investment strategies outlined in this TAMP document are the result of the policies, goals, and measures identified within the context of asset data, forecasted demand, available funding, and other factors which have been detailed in preceding chapters. Ultimately, this results in a well-defined plan that specifies how funds will be allocated across pavement and bridge assets on the NHS by work types such as construction, reconstruction, rehabilitation, and preservation treatments by fiscal year in both the short and long-term.

The investment strategies in this chapter will support progress in achieving the national goals in 23 USC 150(b). These strategies are shown in Figure 61.

FIGURE 61: NATIONAL PERFORMANCE GOALS AND TAMP INTEGRATION STRATEGIES

National Performance Goal	Strategy
(1) Safety - To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.	Project selection through the TAMP will be integrated with the West Virginia Highway Safety Improvement Program (HSIP), and the West Virginia Strategic Highway Safety Plan.
(2) Infrastructure condition - To maintain the highway infrastructure asset system in a state of good repair.	The TAMP will be integrated with the project selection and STIP process as documented in this plan.
(3) Congestion reduction - To achieve a significant reduction in congestion on the National Highway System.	The TAMP will be integrated with the Congestion Mitigation and Air Quality Improvement Program (CMAQ), National Highway Performance Program (NHPP), and Surface Transportation Program (STP) as part of the project selection and STIP development process.
(4) System reliability - To improve the efficiency of the surface transportation system.	Projects to enhance system performance will be integrated with projects resulting from the TAMP as part of the project selection and STIP process.
(5) Freight movement and economic vitality - To improve the National Highway Freight Network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development.	Projects identified as part of the TAMP will be coordinated where applicable with projects identified in the West Virginia State Freight Plan.
(6) Environmental sustainability - To enhance the performance of the transportation system while protecting and enhancing the natural environment.	Projects identified as part of the TAMP will continue to be designed and implemented within the established environmental permitting process. In addition, projects will be integrated with the CMAQ Program as noted previously.
(7) 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.	With increased funding from the West Virginia Roads to Prosperity program, projects resulting from the TAMP will need to be efficiently delivered with minimal project delays.

The Investment Strategy process outlined in this TAMP follows these steps:

- Translation of Agency goals and objectives into levels of service and performance targets.
- Forecast available revenue that can be used on the NHS.
- Analyze assets to determine short-term and long-term needs using the PMS and BMS.
- Determine performance gaps based on targets.
- Assess gaps and recommendations contained in the safety, mobility, congestion, and freight plans for possible integration to improve effectiveness of the NHS and other critical infrastructure.
- Consider how investment strategies are influenced by lifecycle planning, risk analysis and anticipated levels of funding.
- Create investment plans that detail short-term and long-term work by TAMP work types: maintenance, preservation, rehabilitation, and replacement by fiscal year.
- Repeat the process to develop multiple investment scenarios for consideration by Executive Leadership; and
- Document and communicate the investment scenario chosen by Executive Leadership.

Because of this process, several investment scenarios can be developed and incorporated into pavement and bridge management analysis to forecast asset condition. Some of these scenarios may include:

- Projected condition performance based on current funding levels with conservative assumptions for modest growth as outlined in the 2050 Long Range Transportation Plan (baseline scenario).
- Condition levels resulting from decreased funding levels (Decreased revenue scenario).
- Condition levels resulting from increased funding levels (Increased revenue scenario).
- Funding amount needed to meet condition targets and goals (Funding needed scenario).
- Pavement and Bridge trade-off analysis (Trade-off scenarios).

The goal of the strategies is to develop a program that will:

- Achieve and sustain a desired state of good repair[21] over the life cycle of the assets.
- Improve or preserve the condition of pavement and bridge assets and the overall performance of the NHS with respect to these critical physical assets.
- Make progress toward achievement of the established targets for asset condition of the NHS; and
- Support progress toward the achievement of national goals.

WVDOH staff have diligently worked to enhance the Pavement and Bridge Management Systems so that pavement and bridge conditions can be forecasted assuming various funding scenarios. Continued refinements of the PMS and BMS will enable robust analysis capabilities for forecasting pavement and bridge performance. Several generalized

[21] Further discussion and definitions of the state of good repair are detailed in Chapter 2 – Managing Bridge Assets and Chapter 3 – Managing Pavement Assets.

strategies were utilized to make the best use of resources programmed for pavement and bridge projects, including:

Pavements:

- Design and schedule pavement projects to align with a roadway's lifecycle needs whenever possible utilizing the recommendations from the Deighton dTIMS™ pavement management system (PMS)
- Continue the use of pavement preservation strategies, such as thin-lift treatments to cost-effectively extend pavement life
- Evaluate innovative contracting methods and potential advantages of bundling projects to lower costs

Bridges:

- Continue to conduct frequent and regular inspections.
- Continue to expand the use of preservation strategies that extend the service life of bridge components
- Invest in rehabilitation at appropriate times in a bridge's lifecycle by utilizing the recommendations from the Deighton dTIMS™ Bridge Management System (BMS)
- Have more bridge projects "on the shelf"

Investment Scenarios

Various funding scenarios were analyzed using the lifecycle planning analysis processes described in the section Process for Performing Lifecycle Optimization Analysis in Chapter 2 for bridges, and in the equivalent section

Process for Performing Lifecycle Optimization Analysis in Chapter 3 for pavements. The funding scenarios that were analyzed using the PMS and BMS are following.

Source: WVDOT

FIGURE 62: FUNDING SCENARIOS

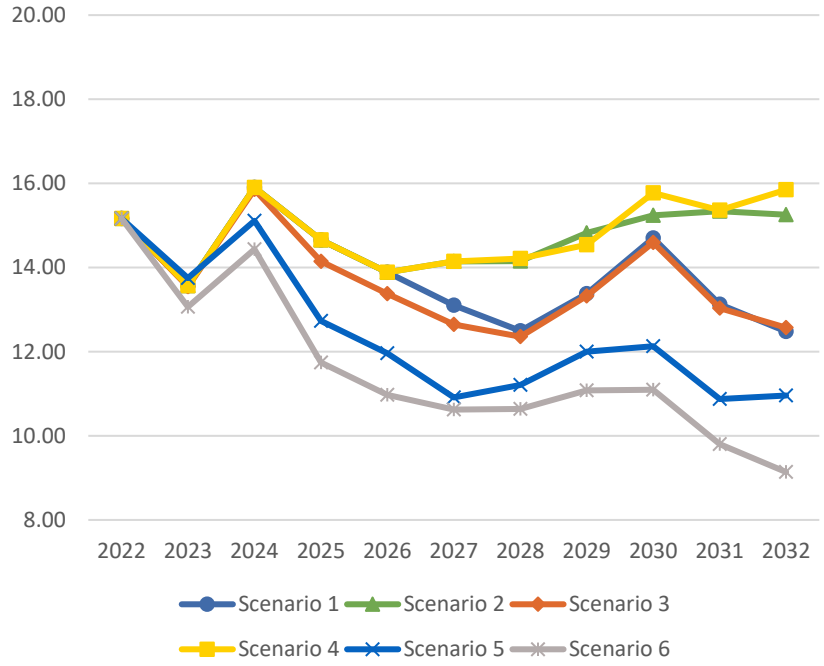
Scenario	Description
1 - Baseline Funding	The projected funding for NHS pavements and bridges based on historical revenues and expenditures along with reasonable assumptions described in the 2050 LRTP and staff input over the 10-year analysis period. This scenario includes an extra $50 million per year for NHS bridges from 2024 onwards. The expenditure forecast matches that of the 2023-2032 STIP. This baseline funding scenario is further described in chapter 5, Managing Finances.
2	Scenario 1 without the extra $50 million for NHS bridges beginning in 2024. Pavement funding remains the same as in Scenario 1.
3	Scenario 1 without the IIJA Bridge Program funding extending past 2026. Pavement funding changes slightly from scenario 1 due to distribution of capital funding between bridges and pavements.
4	Scenario 1 without the extra $50 million for NHS bridges beginning in 2024 and the IIJA Bridge Program funding extending past 2026. Pavement funding changes slightly from scenario 1.
5	Scenario 1 with assumption that 60% of baseline capital budget for bridges goes to NHS bridges and 40% goes to non-NHS bridges as opposed to the 50/50 split in the baseline budget. Pavement funding remains the same as in scenario 1.
6	Scenario 1 with the assumption that 70% of baseline capital budget for bridges goes to NHS bridges and 30% to goes non-NHS bridges as opposed to a 50/50 split in the baseline budget. Pavement funding remains the same as in scenario 1.
7	Scenario 1 with the assumption that 10% of NHS pavements funding is moved to NHS bridges.
8	Scenario 1 with the assumption that 20% of NHS pavements funding moved to NHS bridges.
9	Scenario 1 with the assumption that 30% of NHS pavement funding moved to NHS bridges.

The Pavement Management System and Bridge Management systems were used to run these nine funding scenarios. The analysis produced output for Good, Fair, Poor as well as recommended treatments that have been optimized to extend the life of the pavement and bridge assets and best utilize the funding provided.

Investment Scenarios for Bridges

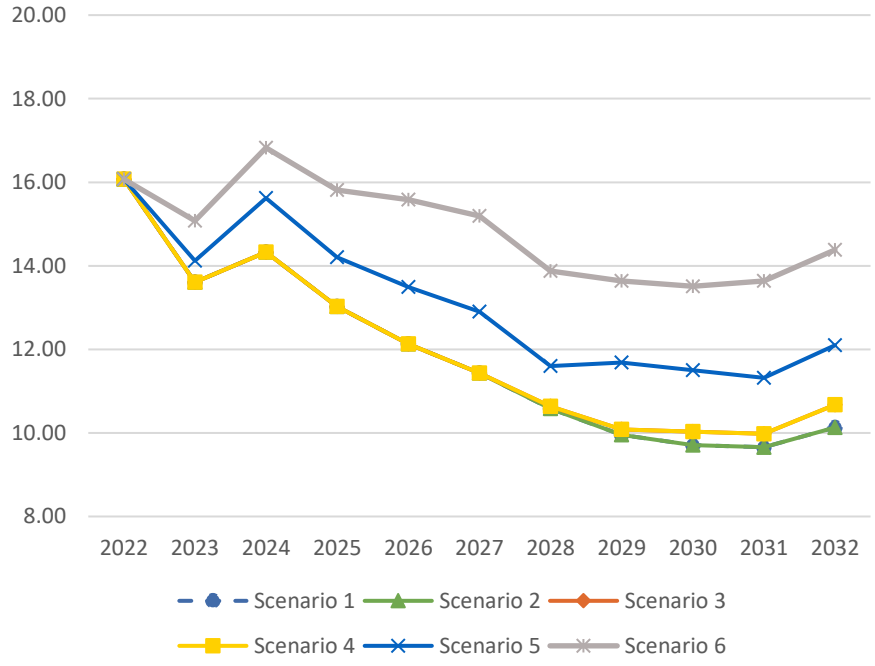
Funding scenarios one through six as described above were analyzed for NHS and non-NHS bridges. Each of these funding scenarios included a specific change to the baseline funding scenarios described above. Figure 63 represents a consolidated view of the condition output from the BMS.

FIGURE 63: NHS BRIDGE CONDITION % POOR



This series of scenarios is focused on the NHS bridge deck condition percent poor as one of the goals of the WVDOH is to ensure the bridges are safe for the traveling public and meet the Federally set requirement for maximum bridge deck % poor. As can be seen, the NHS bridge deck % poor reaches the 10% federal minimum conditions requirement in 2031 under funding scenario 6. Scenario 5 shows the NHS bridge condition just under 11% poor in 2031 and holding.

FIGURE 64: NON-NHS BRIDGE CONDITION % POOR



Although this TAMP is focused on the NHS, it is important to pay attention to what happens to the non-NHS bridge deck condition. As discussed in the section

Investment Scenarios Analysis, Chapter 2 the non-NHS bridges also have a wave of older bridges that were built in the 1970's that are projected to cross into the poor category in the same timeframe. Figure 64 shows the non-NHS bridge deck condition reaching approximately 10% poor for scenarios 1-4. However, it is important to note that under the preferred scenarios for NHS bridges, scenarios 5 and 6, the bridge deck condition stays in the 11 – 14 % poor range.

Chosen scenarios For Bridges

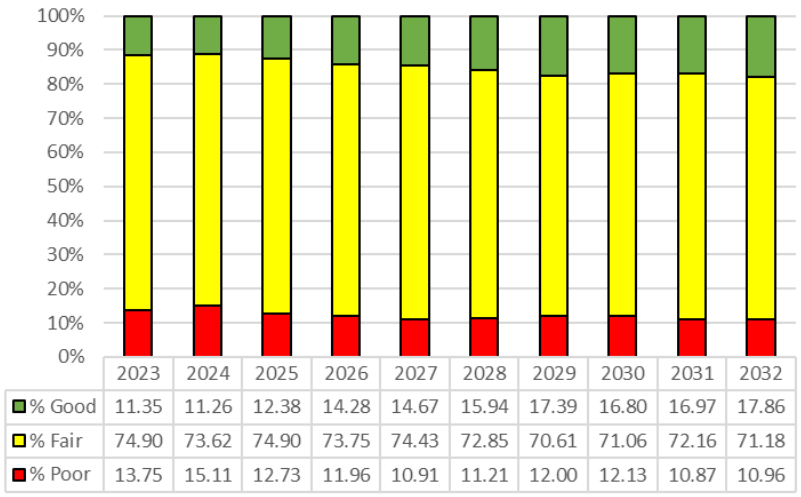
After careful consideration, the WVDOH Administration has chosen to base the ten-year TAMP forecast on a combination of scenarios. For NHS bridges, scenario 5 will be utilized and for non-NHS bridges, scenario 1 (baseline) will be used. This allows for the NHS bridges to reach 11 percent poor in 2032 and holding while not taking funding from non-NHS bridges. Rather, the additional funding will be taken from NHS pavements. This will be discussed later in this chapter under the pavement scenarios section. The main reason for not taking the added funding from non-NHS bridges is that it is very important to keep these bridges in an acceptable state of good repair as there are many more bridges in this category. Even though the non-NHS bridges don't carry the traffic volume as the NHS bridges do, they are very important to the citizens of West Virginia.

Figure 65 shows the forecasted funding for NHS and Non-NHS bridges for FY 2022 – FY 2032. The funding for NHS bridges comes from scenario 5 and for non-NHS from scenario 1. It should be noted that in the early years, the funding is higher due to the committed projects which have brought some of the funding forward from earlier years. The BMS results using this forecasted funding are forecasted to result in the NHS bridge conditions in Figure 66. The non-NHS bridge condition results are shown in Figure 67.

FIGURE 65: BRIDGE FORECASTED FUNDING

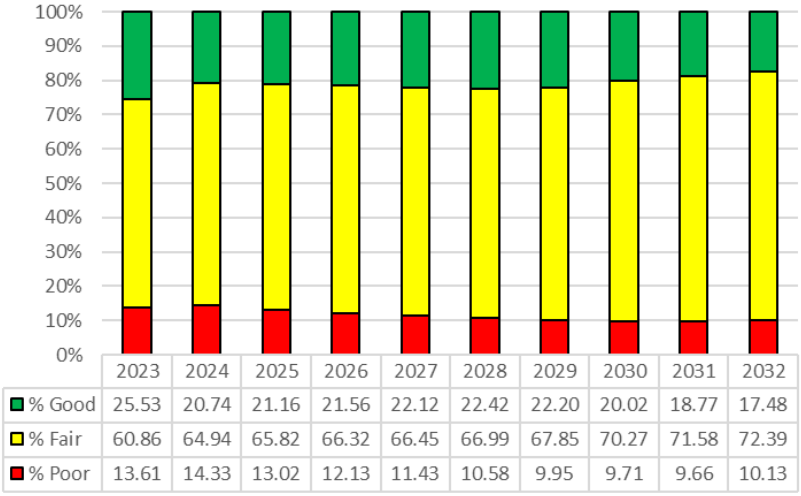
(Millions $) Year of Expenditure $	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032
NHS Bridge Expenditures (S5)	$262	$240	$337	$220	$220	$190	$190	$190	$190	$190
Non-NHS Bridge Expenditures (S1)	$170	$170	$140	$140	$140	$120	$120	$120	$120	$120
Total NHS & Non-NHS Bridges	$432	$410	$477	$360	$360	$310	$310	$310	$310	$310

FIGURE 66: NHS BRIDGES CONDITION FORECAST (SCENARIO 5)



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Good	11.35	11.26	12.38	14.28	14.67	15.94	17.39	16.80	16.97	17.86
% Fair	74.90	73.62	74.90	73.75	74.43	72.85	70.61	71.06	72.16	71.18
% Poor	13.75	15.11	12.73	11.96	10.91	11.21	12.00	12.13	10.87	10.96

FIGURE 67: NON-NHS BRIDGE CONDITION FORECAST (SCENARIO 1)



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Good	25.53	20.74	21.16	21.56	22.12	22.42	22.20	20.02	18.77	17.48
% Fair	60.86	64.94	65.82	66.32	66.45	66.99	67.85	70.27	71.58	72.39
% Poor	13.61	14.33	13.02	12.13	11.43	10.58	9.95	9.71	9.66	10.13

A requirement of the federal IIJA legislation and its predecessors stipulates that the TAMP must show the forecasted investments by Work Type. TAMP work types are discussed in Chapter 2. Figure 68 shows the investment by work types for the NHS bridges (excluding Turnpike bridges). Each year, the federal legislation requires a consistency review that will compare these forecasted expenditures by work type to the actual expenditures for the immediate preceding 12 months prior to the July 1st deadline. This will provide an indication of how close the Agency has followed the TAMP investment strategies to achieve the stated condition goals.

FIGURE 68: SUMMARIZED INVESTMENT STRATEGY FOR SELECTED FUNDING SCENARIO ON NHS BRIDGES (SCENARIO 5)

Investment by Work Type ($ Millions)

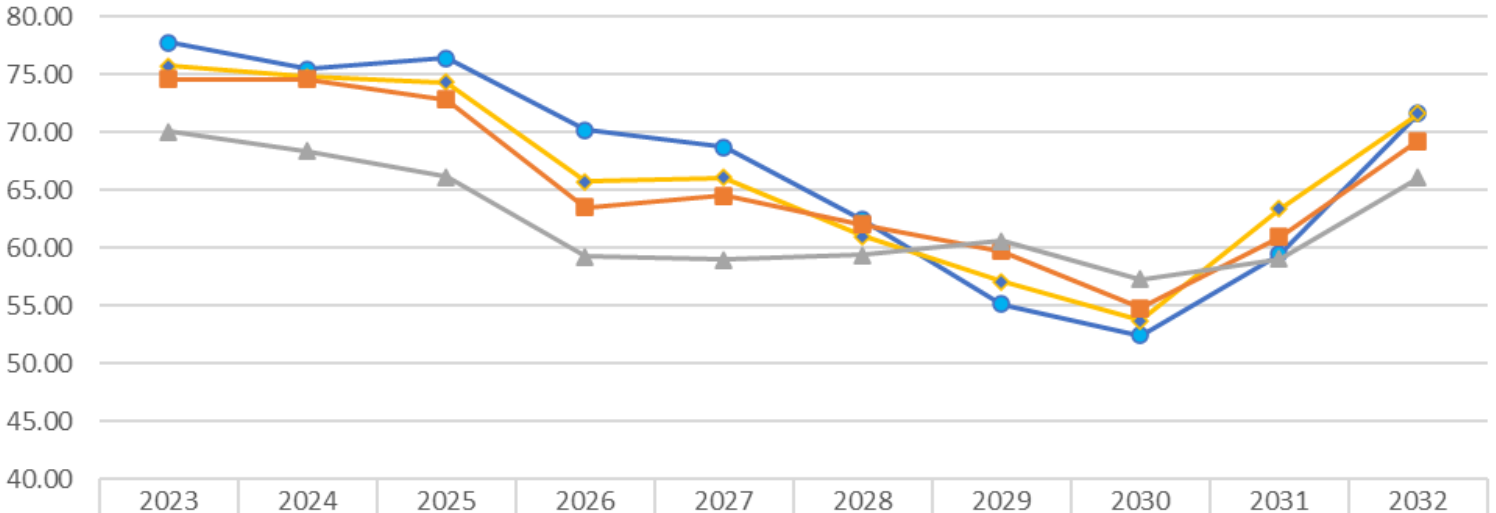
($ Millions)	Preservation	Rehabilitation	Replace	Total
2023	$10	$227	$25	$262
2024	$30	$123	$86	$239
2025	$1	$74	$262	$337
2026	$31	$110	$79	$220
2027	$57	$118	$44	$219
2028	$37	$129	$24	$190
2029	$31	$159	$0	$190
2030	$33	$157	$1	$191
2031	$28	$155	$7	$190
2032	$27	$164	$0	$191

Investment Strategies for Pavements

Three of the nine funding scenarios specifically address pavements. Scenarios 7, 8 and 9 include specific changes to the baseline funding scenario shown in Chapter 5, Managing Finances. The funding scenarios are described previously in this chapter under investment scenarios. It should be noted that Scenario 3 changed the pavement funding makeup in the later years, but not enough to be mentioned here. These condition projections show a general decrease in the percent good for Non-Interstate NHS pavements while Interstate pavements follow the same general trend in the three scenarios. Any decrease in pavement funding should be considered very carefully, as baseline funding sees a steady decrease in % Good for interstates and a flat state for Non-Interstate NHS. The following charts represent a consolidated view of the condition output from the PMS.

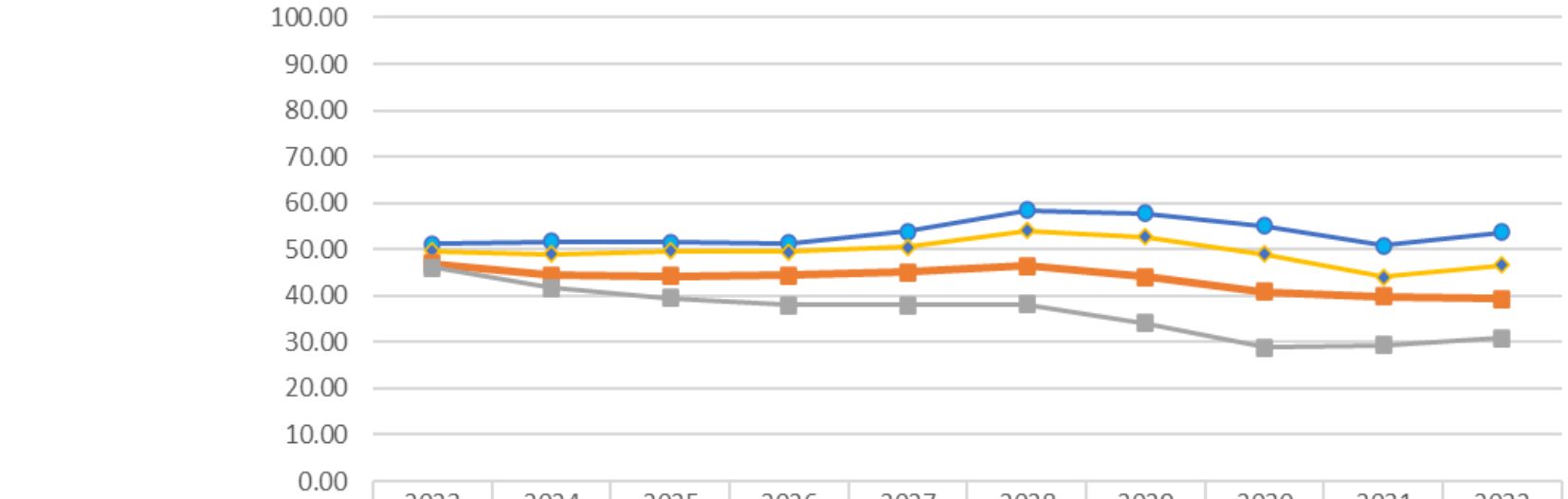
Figure 69 shows a declining percentage of interstate in good condition however, it should be noted that the percent of interstate pavement in poor condition remains zero and later years see an increase in % good.

FIGURE 69: FORECASTED INTERSTATE CONDITION - % GOOD



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
S1_IS_% Good	77.80	75.48	76.46	70.21	68.75	62.46	55.14	52.44	59.48	71.64
S7_IS % Good	75.75	74.83	74.33	65.74	66.08	61.00	57.12	53.74	63.35	71.64
S8_IS_% Good	74.64	74.62	72.83	63.49	64.51	62.00	59.76	54.82	60.97	69.27
S9_IS_% Good	70.07	68.39	66.18	59.24	58.97	59.41	60.61	57.32	59.02	66.07

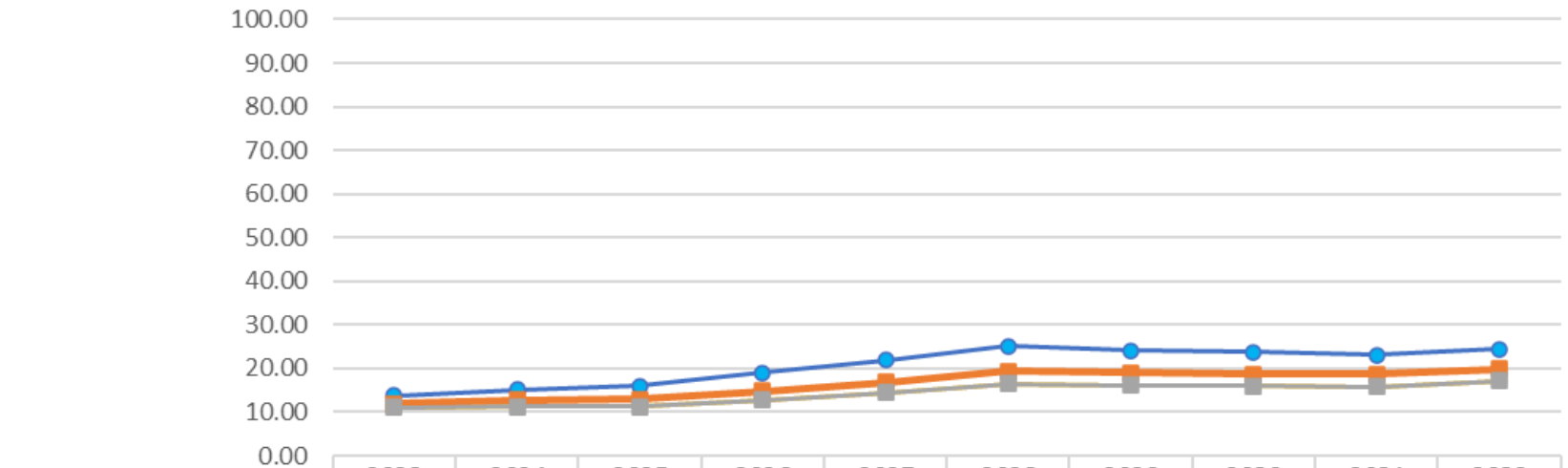
FIGURE 70: FORECASTED NON-INTERSTATE NHS PAVEMENT CONDITION



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
S1_non-IS_NHS% Good	51.24	51.70	51.48	51.43	53.89	58.50	57.75	55.07	50.90	53.70
S7_Non_IS_NHS_% Good	49.64	48.91	49.58	49.58	50.53	54.02	52.66	49.00	44.03	46.58
S8_non-IS_NHS_% Good	46.95	44.49	44.27	44.49	45.16	46.44	44.06	40.93	39.87	39.43
S9_non-IS_NHS_% Good	46.11	41.76	39.56	38.06	37.99	38.15	34.03	28.90	29.34	30.85

Figure 70 above shows a relatively level percentage of Non-Interstate NHS pavement in good condition over the length of the forecast. Here again, it should be noted that the percentage of Non-Interstate NHS in poor condition is less than one percent for all scenarios until 2028 when it begins to increase.

FIGURE 71: NON-NHS PAVEMENT CONDITION - % GOOD



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
S1_Non-NHS_% Good	13.73	15.17	16.05	19.10	21.85	25.18	24.17	23.73	23.18	24.37
S7_Non-NHS_% Good	11.05	11.33	11.27	12.82	14.52	16.59	16.19	15.96	15.82	17.18
S8_Non-NHS_% Good	11.97	12.73	12.92	14.75	16.83	19.46	18.99	18.65	18.74	19.82
S9_Non-NHS_% Good	11.05	11.33	11.27	12.82	14.52	16.59	16.19	15.96	15.82	17.18

Figure 71 above shows the condition of non-NHS pavement in good condition remains between 10 and 30 percent over the forecast period with a slight betterment after 2028. The percentage of non-NHS pavement in poor condition remains below 6% until the later years.

Chosen Scenarios for Pavements

After careful consideration, the WVDOH Administration has chosen to base the ten-year forecast on a combination of scenarios. Scenario 8 will be utilized for NHS pavements and Scenario 1 (baseline) will be used for non-NHS pavements. The 20% funding reduction in scenario 8 will only be taken from NHS pavements and will not be taken from the non-NHS pavements. The main reason for not taking the funding from non-NHS pavements is that it is very important to keep these pavements in an acceptable state of good repair. Even though the non-NHS system doesn't carry the traffic volume as the NHS does, they are very important to the citizens of West Virginia.

FIGURE 72: SELECTED PAVEMENT FORECASTED FUNDING (S8)

(Millions $) Nominal $	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032
NHS Pavement Expenditures (S8)	$168	$168	$144	$152	$152	$128	$120	$120	$120	$128
Non-NHS Pavement Expenditures (S1)	$200	$200	$170	$170	$170	$140	$140	$140	$150	$150
Total NHS & Non-NHS Pavements	$368	$368	$314	$322	$322	$268	$260	$260	$270	$278

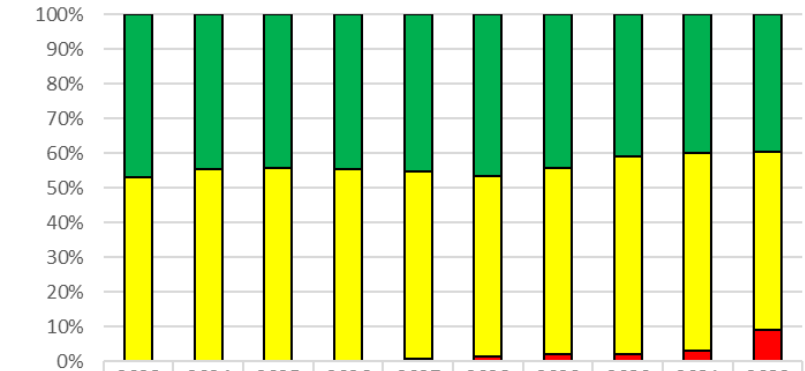
Figure 72 shows the forecasted expenditures for NHS and Non-NHS pavements for FY 2022 – FY 2032. The expenditure forecast for NHS pavements comes from scenario 8 and for Non-NHS from Scenario 1.

The PMS results using the forecasted funding in Figure 72 above will result in the NHS Pavement conditions in Figure 73 and Figure 74. The non-NHS pavement condition results are shown in Figure 75.

FIGURE 73: INTERSTATE PAVEMENT CONDITION (SCENARIO 8)

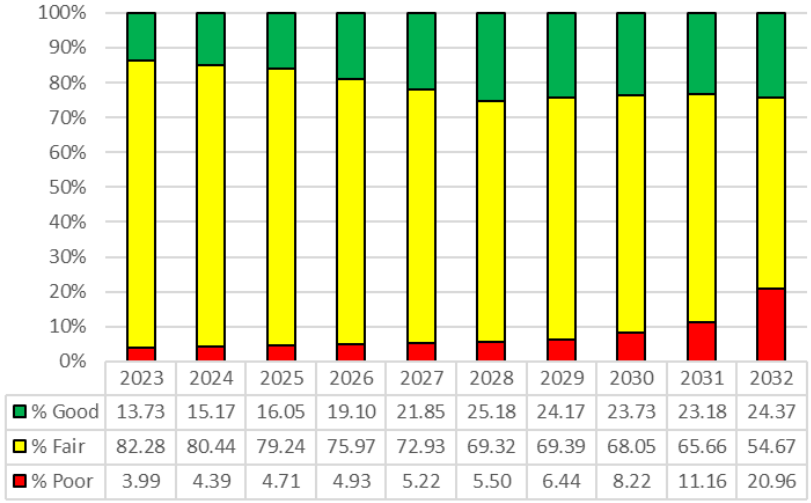
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Good	74.64	74.62	72.83	63.49	64.51	62.00	59.76	54.82	60.97	69.27
% Fair	25.36	25.38	27.17	36.51	35.49	38.00	40.24	45.18	39.03	30.73
% Poor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE 74: NON-INTERSTATE NHS PAVEMENT CONDITION – 20% FUNDING REDUCTION (SCENARIO 8)



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Good	46.95	44.49	44.27	44.49	45.16	46.44	44.06	40.93	39.87	39.43
% Fair	52.91	55.37	55.59	55.35	54.02	51.99	53.88	57.04	57.11	51.51
% Poor	0.14	0.14	0.14	0.17	0.82	1.57	2.06	2.03	3.02	9.07

FIGURE 75: NON-NHS PAVEMENT CONDITION (SCENARIO 1)

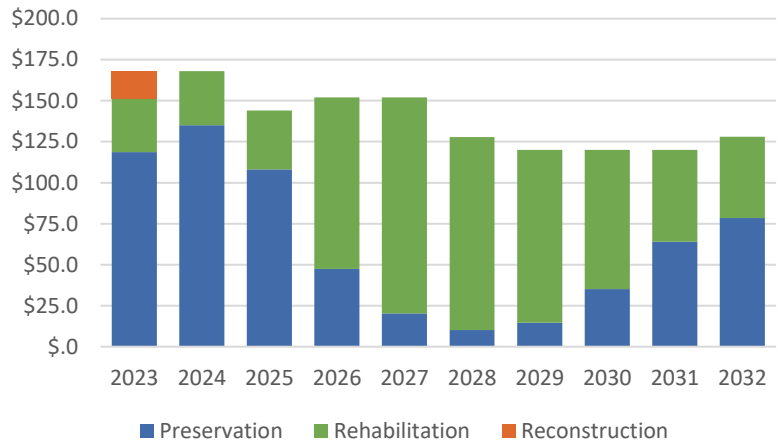


	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Good	13.73	15.17	16.05	19.10	21.85	25.18	24.17	23.73	23.18	24.37
% Fair	82.28	80.44	79.24	75.97	72.93	69.32	69.39	68.05	65.66	54.67
% Poor	3.99	4.39	4.71	4.93	5.22	5.50	6.44	8.22	11.16	20.96

The detailed lifecycle benefit cost optimization analysis conducted in the pavement management system allows projection of the condition of the pavement network over the 10-year analysis period. However, because the analysis also generates a work program consisting of simulated projects over the analysis period, these projects can be used to define the planned investment strategy in terms of anticipated spending per work type in each year using the mapping of treatment to work type given in Figure 40.

The anticipated investment strategies for the selected funding scenario for pavements are summarized in Figure 76 and Figure 77. Note that this investment strategy is for NHS pavements (interstate and non-interstate NHS) excluding Turnpike pavements.

FIGURE 76: DETAILED INVESTMENT STRATEGY FOR FUNDING SCENARIO 8 ON NHS PAVEMENTS



A requirement of the federal IIJA legislation and its predecessors stipulates that the TAMP must show the forecasted investments by Work Type. TAMP work types are discussed in Chapter 3. Figure 77 shows the investment by work types for the NHS pavements (excluding Turnpike pavements). Each year, the federal legislation requires a consistency review that will compare these forecasted expenditures by work type to the actual expenditures for the immediate 12 months prior to the July 1st deadline. This will provide an indication of how close the Agency has followed the TAMP investment strategies to achieve the stated condition goals.

FIGURE 77: SUMMARIZED INVESTMENT STRATEGY FOR FUNDING SCENARIO 8 ON NHS PAVEMENTS

Investment by Work Type ($ Millions)				
Year	Preservation	Rehabilitation	Reconstruction	Total
2023	$114.0	$34.0	$20.0	$168.0
2024	$118.7	$32.3	$16.9	$167.9
2025	$135.0	$32.9	$.0	$168.0
2026	$108.2	$35.8	$.0	$144.0
2027	$47.4	$104.5	$.0	$151.9
2028	$20.3	$131.7	$.0	$152.0
2029	$10.2	$117.7	$.0	$127.9
2030	$14.6	$105.4	$.0	$119.9
2031	$35.1	$84.9	$.0	$120.0
2032	$64.1	$55.9	$.0	$120.0

The projections from the Baseline funding scenario in Figure 37 show an initial increase in the percent of good pavement in the case of Interstates, improving above the 75% good goal, followed by a slow decline. Towards the end of the 10-year analysis period, as additional projects are recommended, the % Good pavement begins to improve. Percent poor stays effectively zero throughout the entire period.

In Figure 38 for Non-Interstate NHS pavement, the percent Good remains steady for the first several years of the analysis period while percent poor remains very low, only becoming visible in the final two years of the analysis. The results of the analysis never fall below the good performance goal of 45%.

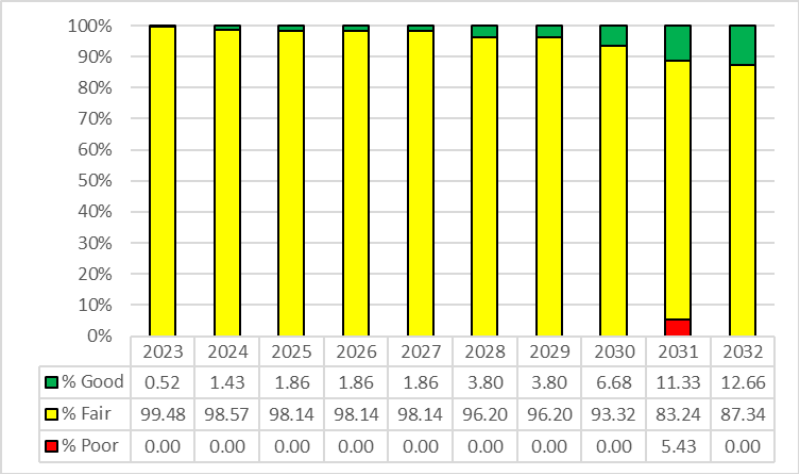
As with bridges, although this plan is focused on the NHS network, it should be noted that no funding is being removed from the non-NHS pavements and the funding levels for this part of the network remain at the levels anticipated from the Baseline funding scenario. Figure 75 demonstrates the low percentages of good pavements in scenario 1 (the baseline) for non-NHS pavements with 12.66% good in the first year and 23.18% good in the final year of the analysis period. At the same time, percent poor increases from 4.26% to 11.16%.

WV Parkways Authority toll road bridges and pavement

The West Virginia Parkways Authority operates and maintains the WV Turnpike, an 87-mile toll facility which includes 97 bridges. The West Virginia Department of Transportation owns the WV Turnpike which is part of the NHS. The funding for operation and maintenance is supported by tolls and toll revenue bonds. The toll revenue funding does not flow through the WVDOH. However, being part of the NHS, the Turnpike bridges and pavements should be included in this TAMP analysis. Chapter 5 provides a summary of the WV Turnpike revenue and expenditures as well as a forecast of funding available for bridges and pavements on the NHS.

The forecasted funding was used in the PMS and BMS analysis which resulted in the bridge and pavement conditions in the following figures.

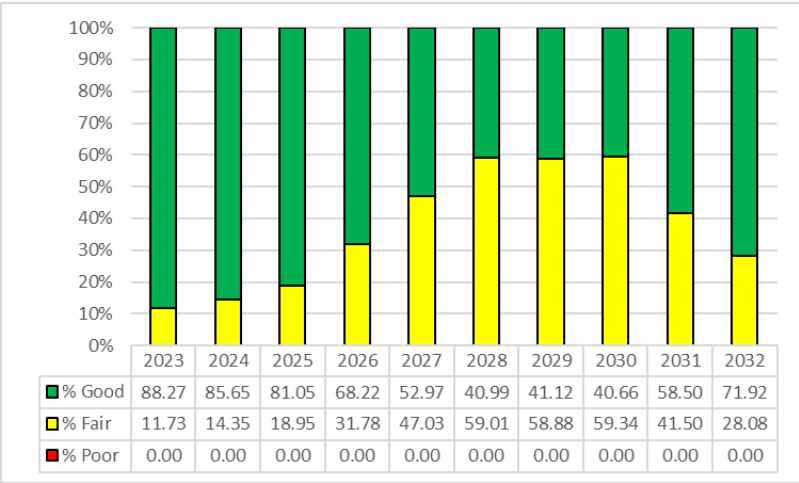
FIGURE 78: WV TURNPIKE BRIDGES



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Good	0.52	1.43	1.86	1.86	1.86	3.80	3.80	6.68	11.33	12.66
% Fair	99.48	98.57	98.14	98.14	98.14	96.20	96.20	93.32	83.24	87.34
% Poor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.43	0.00

As can be seen in the Figure 78, the West Virginia Parkway Authority is keeping the Turnpike bridges at 0 % poor except for 2031 when the BMS analysis quickly treated returned to 0% poor.

FIGURE 79: WV TURNPIKE PAVEMENTS



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Good	88.27	85.65	81.05	68.22	52.97	40.99	41.12	40.66	58.50	71.92
% Fair	11.73	14.35	18.95	31.78	47.03	59.01	58.88	59.34	41.50	28.08
% Poor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Pavements are also doing very well as there is 0% poor on the system.

Since, the Turnpike bridges and pavements are in such good condition, there were no additional funding scenarios analyzed by the BMS and PMS.

A requirement of the federal IIJA legislation and its predecessors stipulates that the TAMP must show the forecasted investments by Work Type. TAMP work types are discussed in Chapter 3. Figure 80 and Figure 80 shows the investment by work types for the Turnpike pavements and bridges. Each year, the federal legislation requires a consistency review that will compare these forecasted expenditures by work type to the actual expenditures for the immediate 12 months prior to the July 1st deadline. This will provide an indication of how close the Agency has followed the TAMP investment strategies to achieve the stated condition goals.

FIGURE 80: SUMMARIZED INVESTMENT STRATEGY FOR TURNPIKE BRIDGES

Investment by Work Type ($ Millions)

Year	Preservation	Rehabilitation	Reconstruction	Total
2022	$.0	$.0	$.0	$.0
2023	$26.7	$.0	$.0	$26.7
2024	$13.9	$.0	$.0	$13.9
2025	$15.3	$.0	$.0	$15.3
2026	$11.2	$.0	$.0	$11.2
2027	$.0	$4.1	$.0	$4.1
2028	$.0	$13.7	$.0	$13.7
2029	$10.0	$.0	$.0	$10.0
2030	$3.7	$8.4	$.0	$12.1
2031	$17.5	$.0	$.0	$17.5

FIGURE 81: SUMMARIZED INVESTMENT STRATEGY FOR TURNPIKE PAVEMENTS

Investment by Work Type in $ Millions				
Year	Preservation	Rehabilitation	Replace	Total
2023	$15.0	$11.3	$0	$26.3
2024	$7.3	$15.2	$0	$22.5
2025	$0.4	$16.7	$0	$17.1
2026	$7.5	$22.1	$0	$29.6
2027	$6.9	$13.9	$0	$20.8
2028	$ 0.5	$19.9	$0	$20.4
2029	$2.5	$23.4	$0	$25.9
2030	$1.4	$25.1	$0	$26.5
2031	$0.5	$27.0	$0	$28.4
2032	$4.1	$22.9	$0	$27.0

Source: WVDOT

Glossary

AASHTO	American Association of State Highway and Transportation Officials
ADHS	Appalachian Development Highway System
AMS	Asset Management System
BMS	Bridge Management System
CCI	Condition Composite Index
CFR	Code of Federal Regulations
CMAQ	Congestion Mitigation and Air Quality Improvement Program
CRTS	Coal Resource Transportation System
CSI	Concrete Slab Index
dTIMS™	Deighton Total Infrastructure Management System; asset management software
DMV	Department of Motor Vehicles
DOT	Department of Transportation
ECI	Environmental Cracking Index
FAST Act	2015 Federal Transportation Bill: Fixing America's Surface Transportation Act
ERP	Enterprise Resource Planning
FHWA	Federal Highway Administration

GARVEE Bonds	Grant Anticipation Revenue Vehicle Bonds
GASB	Governmental Accounting Standards Board
GO Bonds	General Obligation Bonds
HPMS	Highway Performance Monitoring System
HSIP	Highway Safety Improvement Program
IHS	Interstate Highway System
IIJA	Infrastructure Investment and Jobs Act
IRI	International Roughness Index
JCI	Joint Condition Index
KPI	Key Performance Indices
LCCA	Life Cycle Cost Analysis
LOS	Level of Service
LRS	Linear Referencing System
LRTP	Long Range Transportation Plan
MAP-21	2012 Federal Transportation Bill: Moving Ahead for Progress in the 21st Century Act
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NCI	Net Cracking Index
NHPP	National Highway Performance Program
NHS	National Highway System
PMS	Pavement Management System

PSI	Present Serviceability Index
PTS	Project Tracking System
R&H	Roads and Highways: ESRI proprietary software for managing the Linear Referencing System
RDI	Rut Depth Index
ROI	Return on Investment
SCI	Structural Cracking Index
STIP	Statewide Transportation Improvement Program
STP	Surface Transportation Program
TAM	Transportation Asset Management
TAMP	Transportation Asset Management Plan
VMT	Vehicle Miles Travelled
WVDOH	West Virginia Division of Highways
wvOASIS	West Virginia Our Advanced Solution with Integrated Systems

Appendix A

Risk Register - Agency and Program Level

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Impacts	2022 Risk Score	Comments	Risk Management Options (Treat, Tolerate, Transfer, Terminate, Take Advantage)
1	Agency	Pavement / Bridge	Lack of personnel, vacant positions, uncertainty in being able to backfill employees who leave	5	4	4	4	5	**85.0**	WVDOH has moved HR functions inhouse and reduced delays in HR administration and hiring. However, adequate candidates / applicants and retention remain an issue. Due to the significant "root cause" potential of personnel issues, the impacts range from clear to obfuscated. As an example, a delayed bridge project due to personnel issues may shift rehabilitation into costlier replacement. Determining what portion of program wide issues, delays, change orders, etc. could have been avoided by either more or more experienced personnel is a difficult task. While Human Resources, Performance Management, and Organizational Performance groups have moved towards evaluating these big picture questions, their efforts and the information required to perform evaluations are also dependent on personnel.	Various studies have been conducted to analyze this issue. WVDOH is considering the following recommendations from these studies to **Treat** this risk: 1. Change compensation structure to add more tiers per level - has improved, **continue to improve.** 2. Insurance stability - has stabilized, more work to do. 3. Respond to offers/HR communication - moved inhouse and reduced delays. 4. Flexible schedule (e.g., part time, **telework**) 5. Public service recognition 6. Enhance recruiting 7. Rescind pay cut for starting engineers 8. Monitor pay as it responds to inflation

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Impacts	2022 Risk Score	Comments	Risk Management Options (Treat, Tolerate, Transfer, Terminate, Take Advantage)
2	Program	Bridge	Not delivering programmed bridge projects on time (even when budget is available)	5	4	3	4	5	**80.0**	WVDOH has dealt with challenges to on-time delivery of programmed bridge projects due to factors including environmental, ROW, utilities, historical (SHPO), manpower, etc. On average, STIP projects are delayed 3-5 years from the date committed to originally. With limited availability of capable contractors and an increase in material shortages, this risk has increased in impact since being identified in 2019.	WVDOH is **Treating** and **Transferring** this risk by: - Completing more acquisition work up front, transferring risk to utility companies by requiring them to be timelier. - Reviewing project delivery process to identify pain points, measure, and enforce. - Increasing use and efficiency of consultants to develop plans to add capacity. - Using BMS to develop a ten-year work plan to improve foresight and scheduling - Reorganizing District Development Staff to improve cross-training and utilization
10	Program	Bridge	Not doing the right maintenance, preservation, and rehabilitation at the right time in the right location.	5	2	2	5	4	**65.0**	Completing proper treatments at the right time is important for the longevity of a state's bridge network. Previously, WVDOH did not have a plan in place for how maintenance occurs. However, WVDOH recently developed and is working to implement a maintenance plan for bridges titled *Bridges: Key Activities for Maintenance and Preservation Plan* (BKAMPP).	WVDOH is **Treating** this risk by: - Implementing the BKAMPP. - Adding codes to maintenance management system to track maintenance and preservation work. - Developing full paint and overlay programs with specific budget. - Using bridge management system to identify recommended work types per year. In the future, WVDOH will consider: - Dedicating funding specifically for preservation and rehab projects, and ensuring projects are undertaken on the right locations.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Impacts	2022 Risk Score	Comments	Risk Management Options (Treat, Tolerate, Transfer, Terminate, Take Advantage)
12	Agency	Bridge/ Pavement	Political influence changes allocations late in the process where allocations increase in one area without expectation of reductions in others.	5	2	3	4	4	**65.0**	As with most state agencies, political influences can affect budget allocations and work completed in WVDOH. For instance, capital budgets for bridge are often reduced to fund requested pavement projects. This can impact the delivery of projects that fix safety, mobility, or other existing problems. WVDOH is improving the use of management systems to illustrate the impacts of moving money on future conditions.	WVDOH is **Tolerating** and **Treating** this risk by: - Predicting impact of decisions regarding increased and decreased funding in bridge and pavement management systems. - Utilizing long range plans to help with trade off and cross asset decisions.
4	Agency	Pavement / Bridge	Variability in materials costs and availability based on uncertainty in competition	5	1	1	5	5	**60.0**	While WVDOH is constrained to only one major supplier of asphalt over two thirds of the state, increasing shortages of materials and supply chain problems across all building materials have presented a new challenge. This challenge applies to bridges, culverts, and most, if not all, other assets as well.	WVDOH is **Treating** this risk by: - Improving bid monitoring. - Continuing to monitor problems. - Developing alternative delivery methods. - Considering alternative options for materials.
5	Program	Bridge	Not performing routine maintenance	5	1	3	5	3	**60.0**	Budget variability can affect the delivery of routine maintenance. Funding can be cut or increased in particular years. Sometimes lack of resources can impact routine maintenance even when there is enough money.	WVDOH is **Treating** this risk by: - Implementing BKAMPP, a routine core maintenance program for bridges. - Reviewing maintenance allocation formulas. - Monitoring and tracking maintenance being performed.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Impacts	2022 Risk Score	Comments	Risk Management Options (Treat, Tolerate, Transfer, Terminate, Take Advantage)
6	Program	Pavement	Not doing the right maintenance, preservation, and rehabilitation at the right time in the right location.	5	2	2	4	4	**60.0**	Similar to bridge, completing proper treatments at the right time is important for the longevity of a state's pavement network. Maintenance funding could be prioritized higher than it is as performance standards are not consistently met. This risk includes missing treatments like not sealing a longitudinal joint and generally producing a lower level of service than intended.	WVDOH has **Treated** and is currently **Treating** this risk by: - Ensuring education of DOH staff (project selectors and field staff) including sending staff to the annual Pavement Preservation conference. - Introducing pavement preservation technician certification and added that Contractor's personnel must be certified to the Standard Specifications. - Continuing to monitor funding specifically for preservation and rehab projects, and ensure projects are undertaken on the right locations. - Using pavement management systems to identify recommended work types per year. - Proactively educating the public.
14	Program	Pavement	Not performing routine maintenance	5	2	2	4	4	**60.0**	Similar to bridge, budget variability can affect the delivery of routine maintenance. Funding can be cut or increased in particular years. For instance, pothole patching may be completed, but drainage may suffer. This can also affect the annual snow and ice program.	WVDOH is **Treating** this risk by: - Emphasizing core maintenance to drastically mitigate risk. - Publishing information to public with core maintenance dashboards. - Increasing funding and improving planning and reporting.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Impacts	2022 Risk Score	Comments	Risk Management Options (Treat, Tolerate, Transfer, Terminate, Take Advantage)
3	Program	Bridge/ Pavement	Minor (50yr events) flooding events	5	3	2	3	3	**55.0**	West Virginia has experienced 25 disaster declarations across multiple types of events. These disasters cause significant damage that the DOH must repair. There is also consistent flooding and/or overtopping of minor routes for more frequent lesser events. With the impacts of climate change, extreme weather events that cause minor flooding are becoming more frequent.	WVDOH has **Treated** this risk by minimizing use of CMP, which lengthens life of drainage pipes, and reemphasizing core maintenance plan, ditching, and drainage. WVDOH is currently Tolerating and Treating this risk on a case-by-case basis by: - Improving resilience when reconstructed by increasing pipe sizes, improving end treatments, using better materials, and determining reasonable alternatives. - Monitoring backwater and scour. - Taking opportunities to build bridges longer when replacing.
15	Program	Bridge	Minor bridge hits	4	2	4	3	4	**52.0**	There are a handful of bridges that have been hit and repaired multiple times. There are 5-10 bridges that have had multiple minor bridge hits.	WVDOH is currently **Tolerating** this risk with future intent to **Treat** by: - Tracking bridge hits to analyze problem areas and investigate mitigation strategies. - Adding crash walls to existing bridges and designing new walls to AASHTO LRFD Bridge Design Specifications.
7	Program	Pavement	Minor geohazards such as rockfalls, slippage	5	2	2	4	2	**50.0**	Minor geohazards are determined by their economic impacts and are considered minor if not blocking important points of access. With the many mountains, rivers, and steep slopes in West Virginia, there comes the risk of landslides. Landslides are typically caused by slope saturation and can be mitigated by implementing slope stabilization solutions or reducing the saturation of the area. They can cause damage to infrastructure, traffic delays, and a threat to traveler safety.	WVDOH is currently **Treating** this risk by pursuing and implementing the following: - Landslide hazard management tool and program - inventory of existing landslide locations, GIS-based database of landslides, standardized rating matrix for landslide prioritization, maintenance. - Supplying drills to Districts for quicker response. - Tracking hazard work, costs, downtime, etc. for in-house vs contracting.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Impacts	2022 Risk Score	Comments	Risk Management Options (Treat, Tolerate, Transfer, Terminate, Take Advantage)
24	Agency	Pavement/ Bridge	Alternative fuel vehicles - adding to traffic, reducing gas tax revenues	5	2	2	2	4	**50.0**	There has been a national push to increase the use of alternative fuel vehicles. This has the potential to increase the alternative fuel vehicle market share and decreased the fuel tax receipts relative to travel demand and vehicle ownership. This could cause a loss of revenue for WVDOH if alternative revenue sources are not identified.	WVDOH is currently **Tolerating** with future intent to **Treat** this risk by: - Increasing registration fees for alt fuel vehicles. - Incorporating funding ideas like vehicle miles traveled fees, sales taxes for transportation, and other user fees can augment or ultimately replace the motor vehicle fuel tax
26	Agency	Pavement/ Bridge	Changing legislation - additional requirements, increased emphasis on grant funding	5	2	2	2	4	**50.0**	The new IIJA has increased emphasis on using grants that require matches for federal funding, which can cause competition between initiatives and core programs. This changes the implications of funding decisions as big initiatives may or may not be funded by grants because of competing programs.	WVDOH is currently **Tolerating** and **Treating** this risk by: - Addressing new requirements in the appropriate documents. - Analyzing impacts of increased emphasis on grant funding
8	Program	Pavement	Major geohazards such as rockfalls, slippage	4	3	3	3	3	**48.0**	Major geohazards are determined by their impact on accessibility as well as economic impacts, especially when they block access to hospitals, emergency services, etc. With the many mountains, rivers, and steep slopes in West Virginia, there comes the risk of landslides. Landslides are typically caused by slope saturation and can be mitigated by implementing slope stabilization solutions or reducing the saturation of the area. They can cause damage to infrastructure, traffic delays, and a threat to traveler safety.	WVDOH is currently **Treating** this risk by pursuing and implementing the following: - Landslide hazard management tool and program - inventory of existing landslide locations, GIS-based database of landslides, standardized rating matrix for landslide prioritization, maintenance. - Supplying drills to Districts for quicker response. - Tracking hazard work, costs, downtime, etc. for in-house vs contracting.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Impacts	2022 Risk Score	Comments	Risk Management Options (Treat, Tolerate, Transfer, Terminate, Take Advantage)
9	Program	Pavement/ Bridge	Poor workmanship reduces quality of work. Lack of performance standards and lack of measurement against standards.	5	2	2	3	2	**45.0**	WVDOH has challenges with workmanship produced by contractors. There is concern that new infrastructure may not meet performance standards if accountability is not improved. Sometimes specifications are not enforced if projects are on a tight timeline. These poor workmanship practices can also produce safety problems like slick asphalt, mobility issues due to more frequent road work, asset damage or increased deterioration because of poor quality, and more. More accountability and process enforcement is needed to reduce these outcomes.	WVDOH is **Treating** this risk with the implementation of a performance-based pre-qualification. For pavements, e.g., PWL specifications with bonus and penalty over multiple years. For bridges, construction inspection is currently not doing full NBE inspection but may be an option.
11	Program	Bridge/ Pavement	Major (>50 yr. events) flooding events	2	5	5	5	5	**40.0**	WVDOH has previously used 500-year floods to design for bridge scour, but it does not take a 500-year flood to cause major damage. With the impacts of climate change, extreme weather events that cause major flooding are becoming more frequent and more intense.	WVDOH is currently **Tolerating** this risk by: - Maintaining current standards for design as changing roadway design standards is not feasible in a lot of cases due to elevation of towns/cities.
13	Program	Pavement	Short term and long-term increases in traffic loading causing unexpected damage to pavement	5	1	2	4	1	**40.0**	Traffic loads can increase due to changes in industry or the economy. For example, coal prices increased and caused an increase in haul traffic. This may become an even larger issue due to the Mountain Valley pipeline (a natural gas pipeline system spanning approximately 303 miles from northwestern West Virginia to southern Virginia).	WVDOH is currently **Treating** this risk with: - Agreements developed with industry to mitigate effects of increases in traffic loading for local and state roads (implemented since 2019).

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Impacts	2022 Risk Score	Comments	Risk Management Options (Treat, Tolerate, Transfer, Terminate, Take Advantage)
16	Agency	Pavement	Not delivering programmed pavement projects on time.	4	1	1	5	2	**36.0**	After a project is let, delivering the projects in the planned year is a problem due to contractor availability among other uncertainties. Project selection and STIP processes are challenging because projects can be added to the program easily while being added to the STIP is more of a challenge. For example, a thin overlay project was change ordered into a mill and fill. This indicates that this is not only just a STIP problem but can lead to asset deficiencies if projects are delayed too long.	WVDOH has **Treated** this risk by: - Emphasizing on-time project delivery. WVDOH is also: - Working to increase efficiency of programming system.
18	Agency	Pavement	Mines causing damage to NHS through subsidence etc.	3	3	3	3	1	**30.0**	There has been a permit granted to mine under I-70. Mining under an interstate poses a risk of damage to the NHS.	WVDOH is currently **Tolerating** this risk while reviewing options to: - Require permits. - Review mineral acquisition policy.
19	Program	Pavement	Utility cuts take place in newer pavement (more on non-IS NHS)	5	1	1	2	1	**25.0**	Utility cuts in pavements can pose a problem to the condition of a pavement section. This is especially true of newer pavements. WVDOH comes across this issue with new pavement on the non-Interstate NHS frequently. This is typically due to lack of communication and availability of information regarding planned utility and pavement projects.	WVDOH is **Treating** this risk by: - Developing work plans with long-term outlook to improve communication. - Improving communication and availability of information regarding planned utility and pavement projects. This involves scheduling monthly coordination meetings.
21	Program	Pavement/ Bridge	Gas lines causing fires that damage pavement and bridge infrastructure.	2	2	3	3	3	**22.0**	WVDOH has 42" and 36" gas lines under many highways and across bridges with an increase in this number expected. Older lines have a higher chance of failing. For example, a previous failure due to a short circuit of the cathodic protection shut down an interstate for two days.	WVDOH is **Tolerating** this risk with plans to: - Create a GIS layer to show location information. - Coordinate with gas companies to obtain inspection records.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Impacts	2022 Risk Score	Comments	Risk Management Options (Treat, Tolerate, Transfer, Terminate, Take Advantage)
22	Program	Bridge	Catastrophic bridge failure due to condition	1	5	5	5	5	**20.0**	While not likely, a catastrophic bridge failure could have extremely impactful consequences. This risk is included on the list even though WVDOH has a robust system in place to monitor bridge conditions and address any risks to bridges well in advance of failure.	WVDOH is **Treating** this risk by: - Analyzing data collected in the federal bridge inspection program to track and manage the deterioration of bridges and their components to avoid catastrophic failures. - Monitoring and closing when obsolete bridges fall below a safe condition threshold
23	Program	Bridge	Catastrophic bridge hits	1	5	5	5	5	**20.0**	While unlikely, catastrophic bridge hits are possible from both traffic and barges in the case of river bridges.	WVDOH is currently **Tolerating** and **Treating** this risk by: - Adding crash walls to existing bridges and designing new walls to AASHTO LRFD Bridge Design Specifications. - Considering designing for barge hits. - Analyzing vulnerability and preparing response plans.
25	Agency	Pavement/ Bridge	Population decline - reducing revenue	4	1	1	1	1	**16.0**	Declining populations in many West Virginia communities has created transportation funding challenges from flat or declining local and State tax revenues, while younger residents move to urban areas and demand emerging transportation options.	WVDOH is currently **Tolerating** this risk and analyzing potential population projections and their impacts on funding.

Risk Register - Asset Level (Part 667)

ID	Name:	Location:	Maint. District:	Federal STIP Eligible:	Repeated Damage: *	Times Damaged: *	Funds Used	Damage Type / Fix:	Damage Cost:	Event Name:	Gov. Declared Event:	Date:	Current Vul.: **	Comments (as of 2022):
11	Fish Creek Road (Route 74)	Marshall	6	Y, for most of route	Y	2	FEMA	4331: Embank. fail/ obst. / clogged culverts 4359: Roadway scour, clogged culverts, embank. fail	$8,000	4359	Y	Feb 2018	50%	Much of the embankment failures/damage was due to improper ditching. This is now properly ditched. Pipes still get clogged due to creek rising. Lowered vulnerability, but mitigation action is still feasible.

Action:	Cost of Action:	Duration of Fix (Yrs):	Annual Cost of Action:	Consequence:	Risk Reduction:	B/C Ratio:	Comment:	Event Freq.	User Costs	Repair	Safety	Other	Total
0 - Do Nothing				$4,316				0.1	$32,157	$10,000	$1,000		$43,157
1 – Add/ enlarge pipe along roadway	$30,000	30	$1,000	$-	100%	4.3	B/C > 1, mitigation feasible						

ID	Name:	Location:	Maint. District:	Federal STIP Eligible:	Repeated Damage:*	Times Damaged:*	Funds Used	Damage Type / Fix:	Damage Cost:	Event Name:	Gov. Declared Event:	Date:	Current Vul.:**	Comments (as of 2022):
16	Middle Grave Creek Road (Route 34)	Marshall	6	Split	Y	2	FEMA	4331: Embank. fail/ culvert sep./ shoulder scour 4359: Roadway scour, clogged culverts	$18,000	4359	Y	Feb 2018	50%	Two disasters in succession - this amplified the repairs of the second event. Vulnerability lowered due to mitigation effort, but mitigation is still feasible.

Action:	Cost of Action:	Duration of Fix (Yrs):	Annual Cost of Action:	Consequence:	Risk Reduction:	B/C Ratio:	Comment:	Event Freq.	User Costs	Repair	Safety	Other	Total
0 - Do Nothing				$4,760				0.1	$28,596	$18,000	$1,000		$47,596
1 – Add/ enlarge pipe along roadway	$30,000	30	$1,000	$-	100%	4.8	B/C > 1, mitigation feasible						

* Damage implies that a repair or reconstruction project occurred.

** Likelihood of consequence given event occurs. If 0, can filter out of list.

West Virginia Division of Highways

Transportation Asset Management Plan

December 2022

MOTT MACDONALD