NEW JERSEY
TRANSPORTATION ASSET MANAGEMENT PLAN

December 2022

2022 TAMP
Transportation Asset Management Plan

Governor Phil Murphy | Lieutenant Governor Sheila Oliver | NJDOT Commissioner Diane Gutierrez-Scaccetti

NEW JERSEY TRANSPORTATION ASSET MANAGEMENT PLAN

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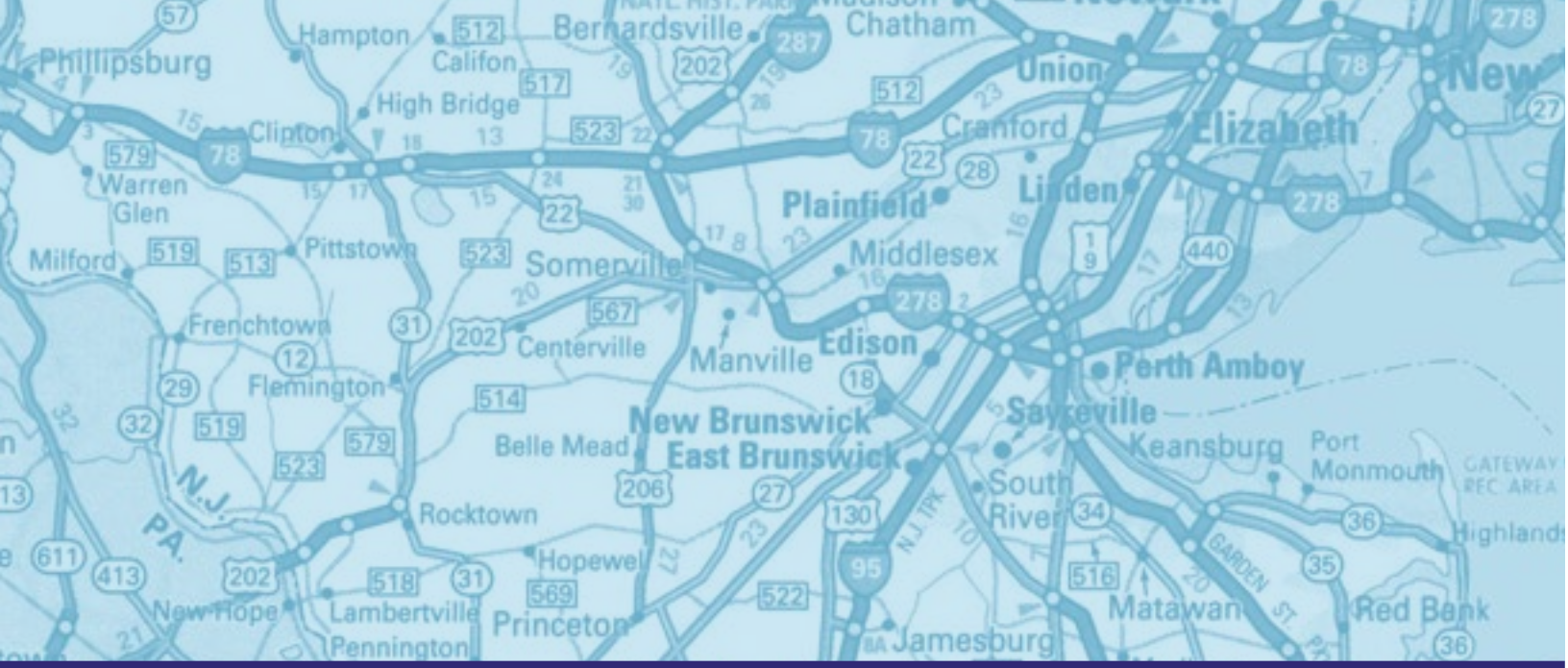
Cover Image: Route 36 Highlands Bridge, Monmouth County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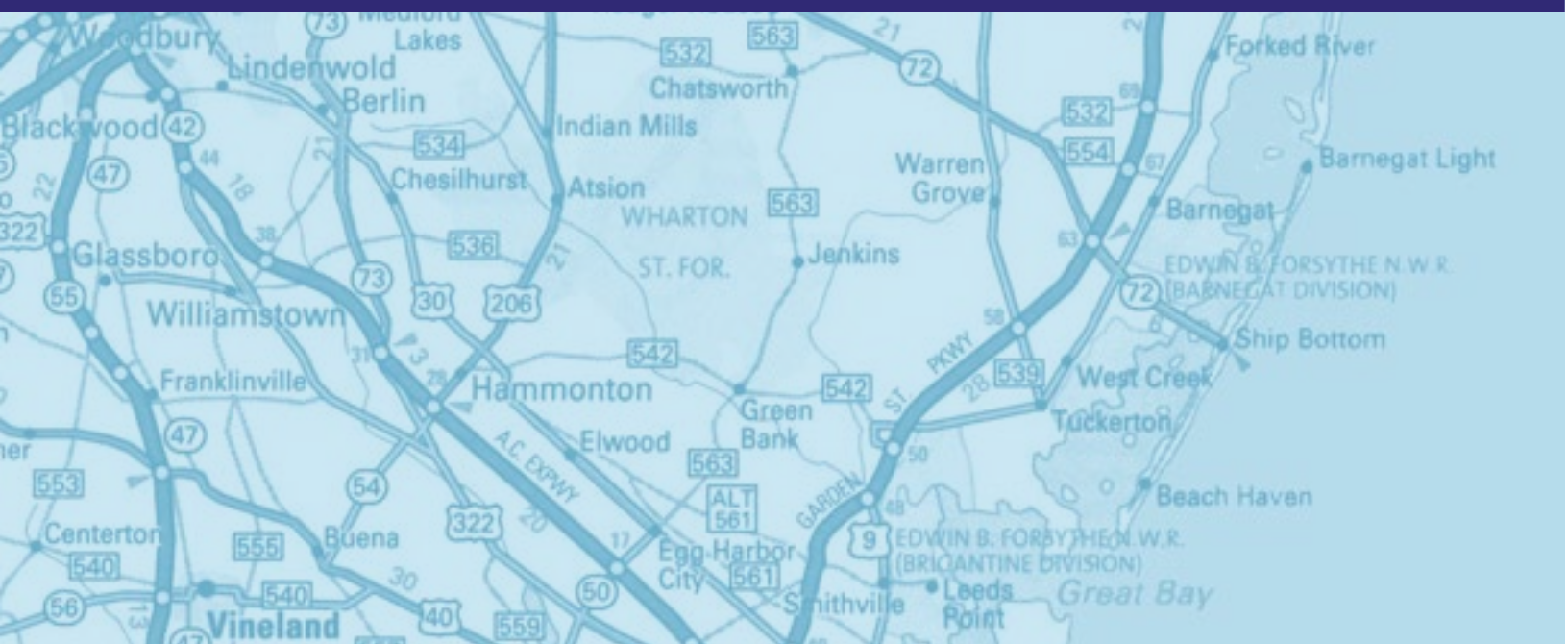
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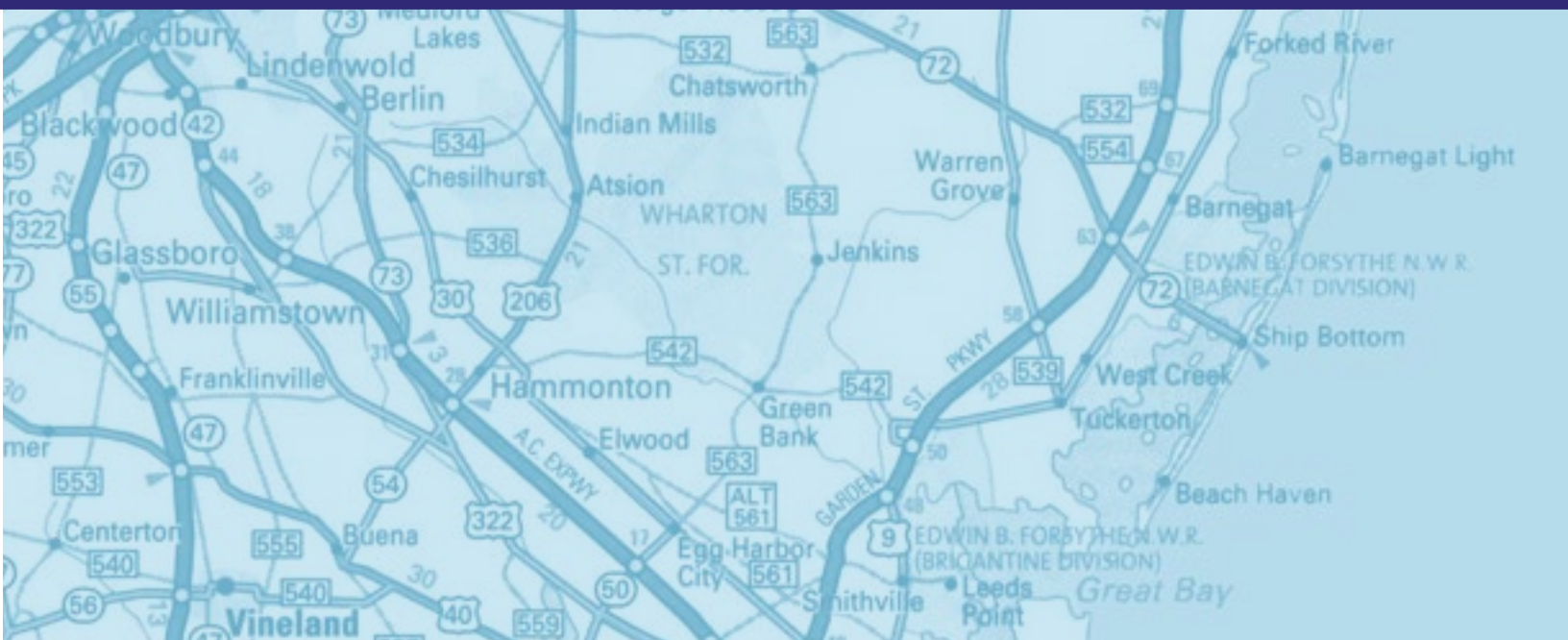
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EXECUTIVE SUMMARY

The New Jersey Transportation Asset Management Plan (TAMP) is a risk-based plan for highway asset preservation. The TAMP describes the policies, procedures, data, and tools used to preserve pavement and bridge assets on the National Highway System (NHS) for various asset owners and the State Highway System (SHS) managed by New Jersey Department of Transportation (NJDOT). It establishes objectives and investment strategies to manage the condition of New Jersey's pavements and bridges. The NJDOT pavement and bridge management systems are used to determine the most cost-effective allocation of resources among different types of preservation and rehabilitation approaches across the life cycle of pavement and bridge assets.

The TAMP, at the planned level of investment, predicts that the condition of bridge assets will improve by the year 2032, meanwhile the condition of pavement assets will generally remain steady over the same period. To make progress toward the TAMP's objectives, NJDOT must follow the strategies outlined in this TAMP.

What is Transportation Asset Management?

Transportation asset management is the risk-based process through which highway assets are managed across their whole life cycle to serve the needs of roadway users most cost-effectively. Asset managers rely on data-driven decisions to ensure that the right work is done at the right time to minimize the costs of ownership while providing safe and reliable roads.

The New Jersey TAMP

The TAMP describes New Jersey's ongoing asset management process that guides the preservation of pavement and bridge assets in New Jersey with a primary focus on the NHS. Additionally, the TAMP addresses federal asset management and performance management reporting requirements regarding pavement and bridge assets. The TAMP sets policy goals and objectives for these assets, and outlines investment plans for their accomplishment.

TAMP Policy Goals

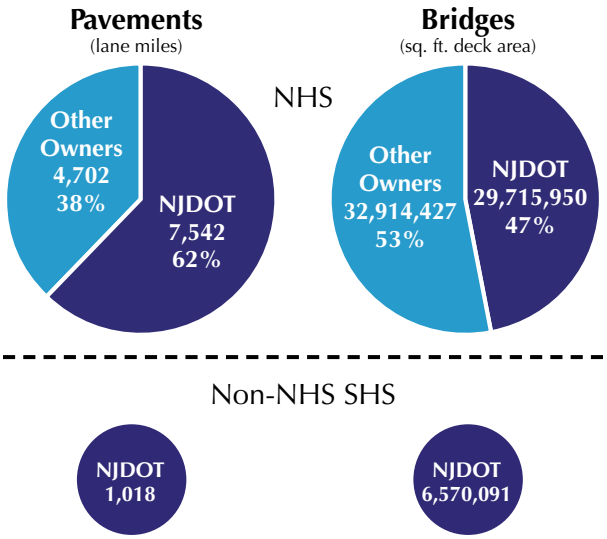
The TAMP is the planning-level document detailing NJDOT's plan to keep the State's infrastructure in a state of good repair. The TAMP is an important foundation for NJDOT's mission to provide a world class transportation system. It provides the strategies that will keep infrastructure in a state of good repair. The TAMP sets the following asset management policies to advance the NJDOT mission:

- Provide a safe, reliable roadway system.
- Achieve and maintain a state of good repair for transportation infrastructure assets.
- Manage the roadway system to reduce life cycle costs.
- Increase resilience of the system to the impacts of extreme weather events.
- Establish ongoing asset management as a data-driven process linking targets to outcomes through NJDOT performance-based planning and programming processes.

The TAMP Addresses the National and State Highway Systems

The TAMP addresses the management of all New Jersey's NHS pavements and National Bridge Inspection Standard (NBIS) bridges, regardless of ownership. Federal law and rulemaking have set specific requirements for the assets included in a TAMP. New Jersey's TAMP also includes pavement and bridge assets on the SHS[1] that are not on the NHS because this is the network that NJDOT manages. Exhibit ES-1 shows the assets addressed in the TAMP, which are also summarized by highway system and owner category. As shown, the majority of SHS assets are also on the NHS.

Exhibit ES-1: TAMP Asset Inventory



State of Good Repair Objectives

State of good repair objectives for the measured physical condition of pavement and bridge assets are set through the TAMP. The TAMP specifies the life cycle planning approach and the investment strategies that support the accomplishment of the policy goals and state of good repair objectives.

The objectives are expressed in terms of percent of the asset in a state of good repair. Assets in a state of good repair are those that are in *Good* or *Fair* condition.

The TAMP establishes the following state of good repair objectives:

- 80 percent of pavements on SHS roadways (by lane miles) in a state of good repair.
- 94 percent of NBIS bridges on SHS roadways (by deck area) in a state of good repair.
- 95 percent of NBIS bridges on NHS roadways (by deck area) in a state of good repair.

Performance Measures

The conditions of NHS assets are reported to the Federal Highway Administration (FHWA) in measures established through the National Highway Performance Program (NHPP) along with a set of statewide targets for pavement and bridge assets on the NHS. Additionally, for pavement assets, the TAMP reports NJDOT's Condition Status performance metric. This is a more refined metric that NJDOT uses for managing pavements and allocating resources because it is better suited to model and optimize pavement network performance. These performance measures are used to provide a summary of highway asset conditions and state of good repair. Exhibit ES-2 provides a description of how the condition ratings manifest on these assets.

Exhibit ES-2: Condition Descriptions by Asset Class

Asset	Good	Fair	Poor
Pavements	Pavement in *Good* condition has minimal deterioration. Road users experience a smooth ride without cracks/ruts/faults. Preserving the road optimizes performance.	Some deterioration, such as minor cracking, rutting or faulting. Road users experience acceptable ride. Preserving or repairing the road minimizes costs.	Advanced deterioration and poor ride that can damage vehicles. Requires significant reactive repairs until costlier road treatments can be programmed.
NBIS Bridges	Bridges in *Good* condition range from those with no problems to those having only minor deterioration.	Primary structural elements are sound; may have more noticeable deterioration. This is the most cost-effective time to rehabilitate.	Advanced deterioration or seriously affected structural components. Bridges are still safe to travel but require greater rehabilitation.

Baseline Conditions and Performance Projections

The asset condition and performance measure data contained in this TAMP are prefaced with a "Collection Year" (CY) to clarify what period the data represents. "CY" refers to information gathered in a given year. In the TAMP, data from a given CY is treated as the starting point, or baseline, for the following year. For instance, CY 2021 data (or collected during 2021), which is the best available data, becomes the baseline data for the TAMP.

Baseline asset conditions (CY 2021 data) and projected future asset conditions are reported in terms of the measures described above. In addition, two- and four-year statewide targets are established and reported as short-term benchmarks to measure progress toward achieving the TAMP state of good repair objectives. Future asset conditions are projected using pavement and bridge management systems that forecast the combined impacts of the planned asset investments and treatments and predicted deterioration on the overall condition of

Exhibit ES-3: State of Good Repair Summary for SHS Pavement and NBIS Bridge Assets

Performance	Pavement		Bridge	
	CY 2021	2032 Planned	CY 2021	2032 Planned
	Good or Fair		Good or Fair	
State of Good Repair Objective	80.0%		94.0%	
Planned Condition	78.9%	80.5%	90.5%	93.6%
Performance Gap	-1.1	+0.5	-3.5	-0.4
Average Annual Investment Fiscal Years 2022–2032				
To Achieve Objective	$340 million		$790 million	
Planned Funding	$360 million		$755 million	
Projected Funding Gap	+$20 million		-$35 million	

Note: Pavement data shown using NJDOT Condition Status metric. Bridge data shown using NHPP measures.

Exhibit ES-4: State of Good Repair Summary for NHS Pavement and NBIS Bridge Assets

Performance	Pavement (Interstate / Non-Interstate)		Bridge	
	CY 2021	2032 Planned	CY 2021	2032 Planned
	Good or Fair		Good or Fair	
State of Good Repair Objective	N/A[1]		95.0%	
Planned Condition	99.9% / 95.2%	99.9% / 94.3%	93.4%	95.3%
Performance Gap	—	—	-1.6	+0.3

[1] No state of good repair objective for NHS pavements has been defined.
Note: Pavement and bridge data shown using NHPP measures.

the network. Baseline and projected asset conditions are compared against state of good repair objectives to establish the performance gaps. Projected asset conditions at the planned level of investment are shown in Exhibit ES-3 for the SHS, and Exhibit ES-4 for the NHS.

The projected performance and associated funding needed to meet the state of good repair objectives for SHS assets are shown in Exhibit ES-3. NJDOT has substantially achieved its state of good repair goal for SHS pavements. There is a minimal performance gap (1.1%) in the 2021 baseline condition, but NJDOT projects to fully achieve and maintain the state of good repair goal with the planned funding level. The planned funding level also allows for additional investments in reconstruction projects that minimize pavement life cycle costs and address Department objectives in other goal areas such as safety and mobility.

NHS bridges also are projected to achieve and exceed the state of good repair objective at the planned investment level by the end of the TAMP period, overcoming a small gap in the 2021 baseline condition. While projects are completed in support of achieving the state of good repair objectives, SHS bridges will come closer toward meeting its objective at the planned investment level. There is an average annual funding gap for SHS bridges of approximately $35 million. The projected performance for NHS assets is shown in Exhibit ES-4.

TAMP Risks

The two greatest risks to accomplishing this plan are:

- Firstly, that shortfalls in planned funding levels occur or investment levels by work type are less than established in the investment strategies.
- Secondly, that extreme weather adversely impacts highway assets through damage or accelerated deterioration.

How the TAMP considers resilience:

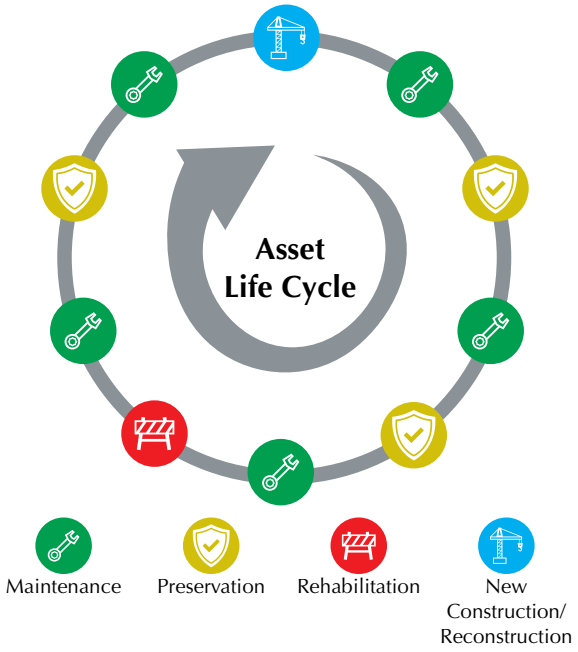
NJDOT and other owners of the NHS in New Jersey have proactively incorporated resiliency planning into their asset management policies in recent years. With the passage of the Bipartisan Infrastructure Law (BIL) in 2021, which expanded federal funding and requirements related to resiliency planning and transportation asset management, States are required to consider resilience and extreme weather events within their life cycle and risk management practices. More information on how NHS owners in New Jersey are meeting this new requirement can be found in the following sections:

- Considerations within life cycle planning (Section 5.2.1 for pavements and Section 5.3.1 for bridges)
- Considerations within risk management practices (Sections 6.2.1 and 6.3.2 for risk framework considerations, Section 6.3.3 for details on initiatives to incorporate planning for resilience to extreme weather and climate change at NJDOT).

Life Cycle Planning

Successful highway asset management applies a whole life approach, planning for all the stages of an asset's life cycle—maintenance, preservation, rehabilitation, and eventual replacement or removal. Life cycle planning determines the best sequence of actions (or "treatments") across the network of assets to meet condition objectives for the lowest practicable cost. This approach incorporates engineering, economic, risk, and financial analysis into the whole life cycle.

Exhibit ES-5: Asset Life Cycle



Financial Plan

The 2023 Capital Program (fiscal years 2023–2032) serves as the basis for the TAMP's 10-year budget for the preservation of the SHS (which includes state-owned NHS). Additionally, the TAMP estimates the level of investment planned on non-NJDOT-owned NHS assets using the best available data collected from the owners. Together, these funding assumptions provide the budget for the TAMP analyses. Future 10-year STIP investment levels for infrastructure preservation will be informed by the TAMP. These analyses will enable NJDOT leadership to make trade-offs between the objectives in support of NJDOT's overall mission and other performance objectives.

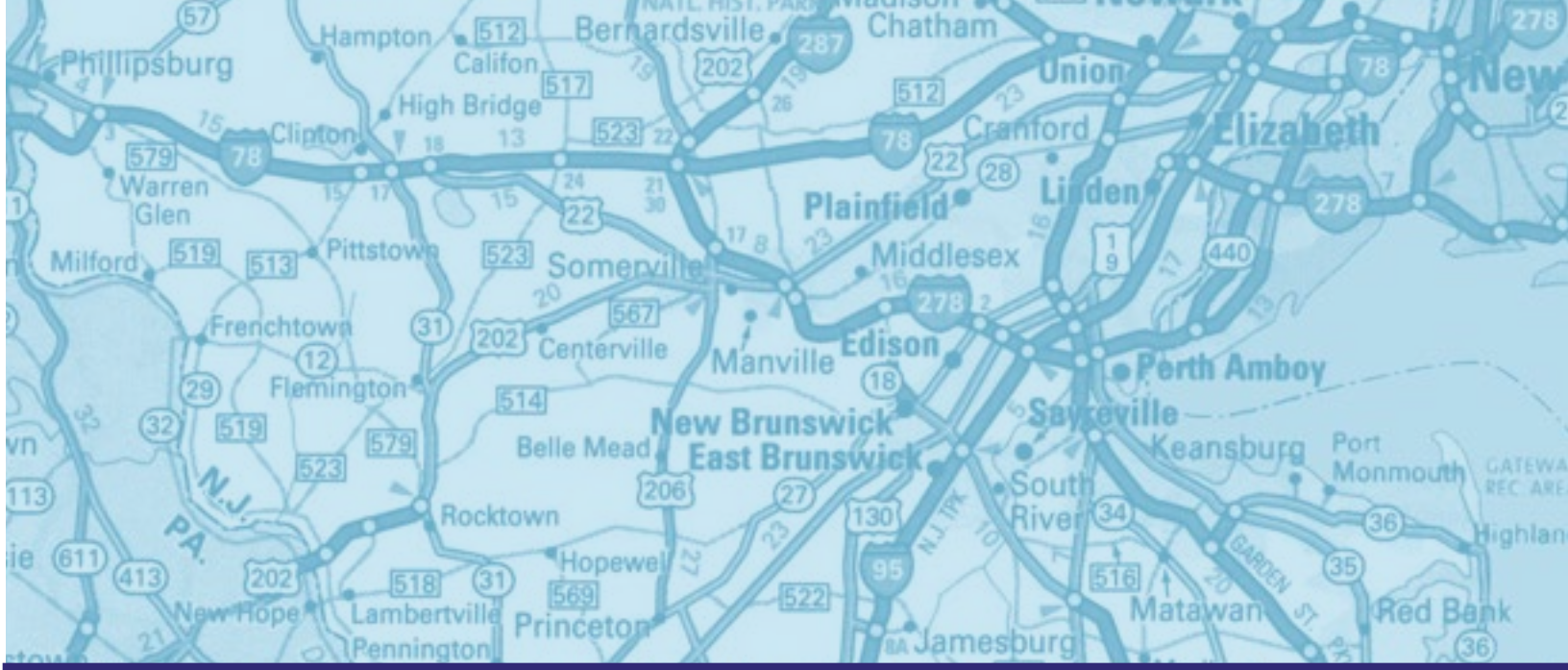
Exhibit ES-6: Investment Strategy for NHS Pavement and NBIS Bridges

Asset	Investment by Fiscal Year ($ millions)										
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Average
Pavements	$485	$445	$375	$555	$450	$400	$580	$390	$530	$355	**$450**
Bridges	$1,295	$1,090	$1,275	$1,050	$1,180	$1,215	$1,055	$1,205	$1,025	$1,330	**$1,170**

Note: See *Chapter 8: Investment Strategies* for further details on the investment strategies for the SHS and NHS.

Investment Strategies

The TAMP describes the funding amounts ("investment strategies") to be invested in different work types (i.e., maintenance, preservation, rehabilitation, and reconstruction) annually by asset class through the TAMP analysis period ending in CY 2032. They represent the optimal allocation of resources, identified through TAMP analyses, to pursue TAMP policy goals and state of good repair objectives. On an annual basis FHWA will conduct a consistency review to assess the compliance of NJDOT's expenditures to the investment levels outlined in the TAMP according to work type. While the level of detail for non-NJDOT owner expenditures does not support a breakdown by work type, the NHS investment strategy for pavement and bridge assets is presented in Exhibit ES-6.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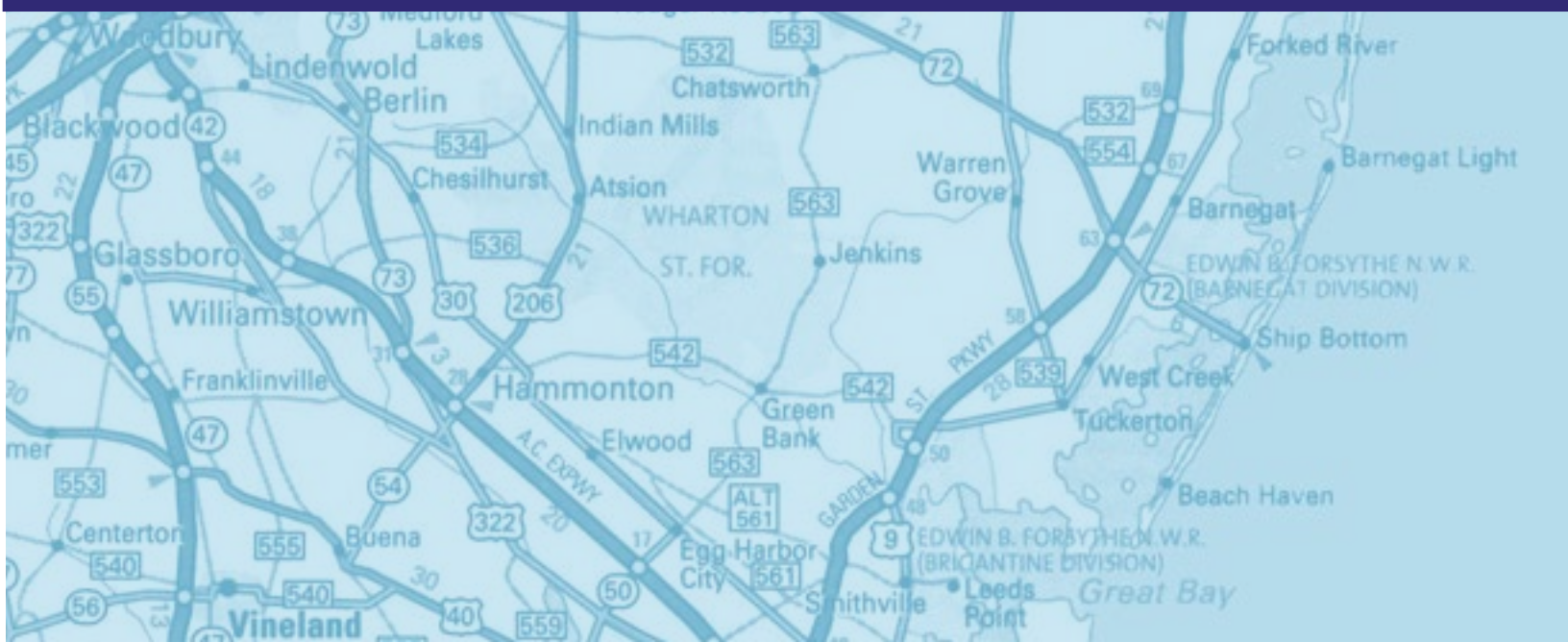
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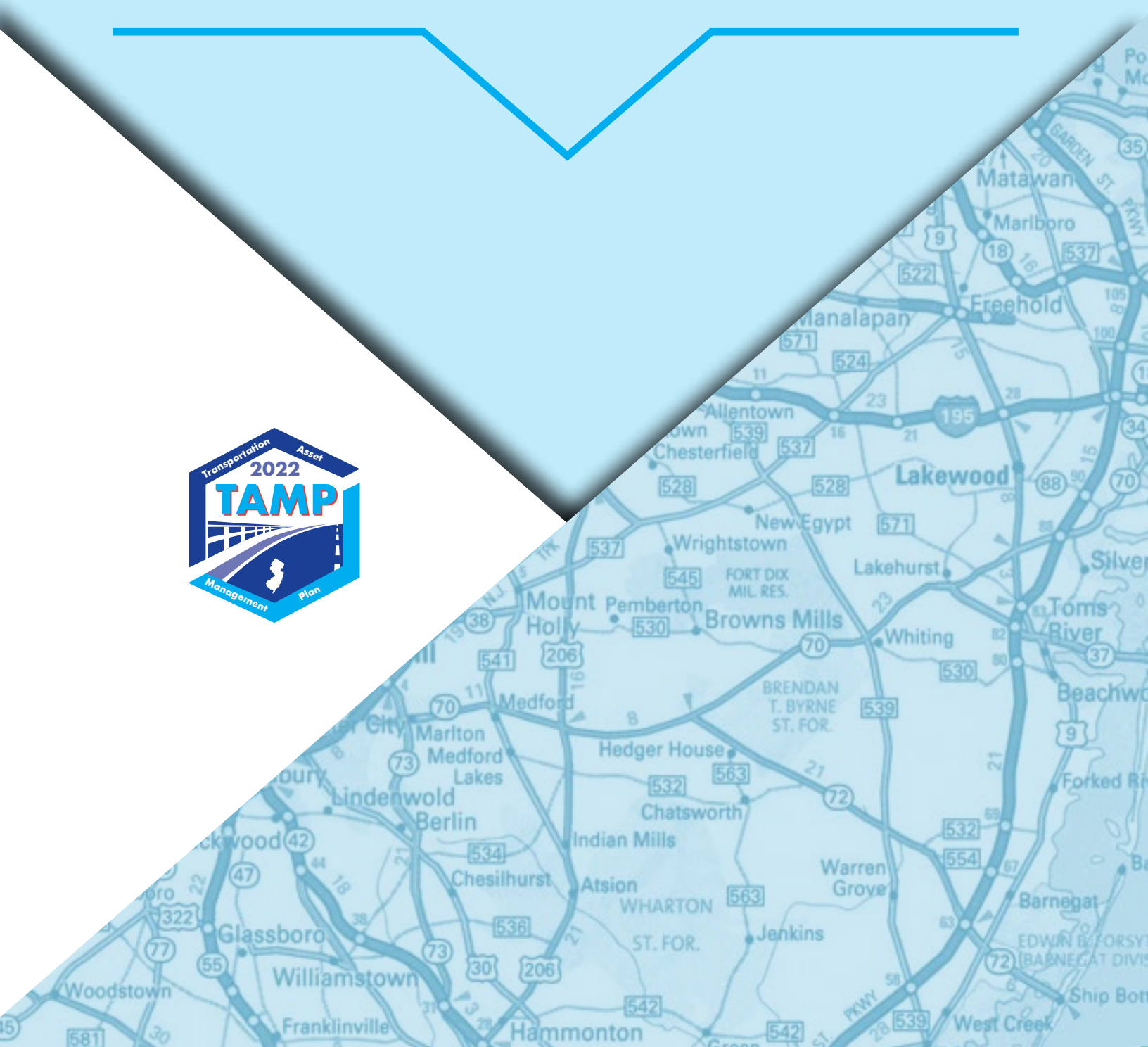
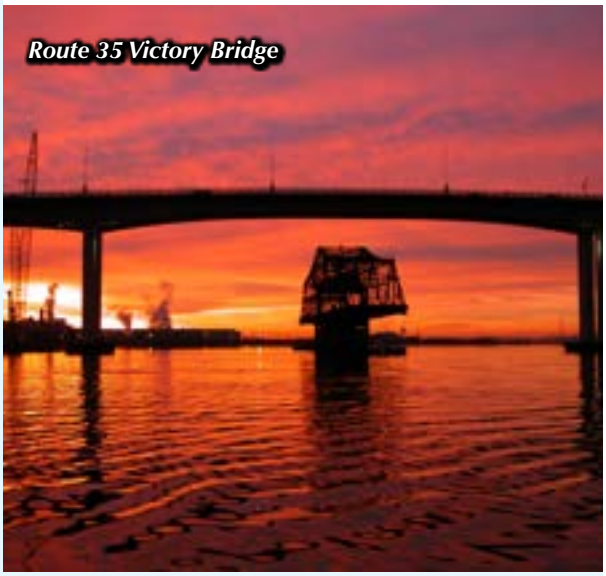
Chapter 1:
INTRODUCTION



BACKGROUND: New Jersey's highway system is critical to the economic and social well-being of the state's residents and is of strategic importance to both the regional and national economies. The highway system moves people and goods through the state and provides a vital link to some of the busiest airports and ports in the United States. The systematic projection of how highway assets will perform over time and the use of this information to plan for their cost-effective preservation is referred to as "transportation asset management." New Jersey's Transportation Asset Management Plan (TAMP) plays a key role in the accomplishment of the New Jersey Department of Transportation's (NJDOT's) mission of providing a world class transportation system. It addresses the safety and reliability of the transportation network by establishing investment strategies for the preservation of infrastructure assets in a state of good repair.

In fact, NJDOT has five stated core missions related to transportation: infrastructure preservation, safety, mobility and congestion relief, operations and maintenance, and mass transit, the last belonging to NJ TRANSIT. The preservation of highway infrastructure includes inspection, preventive maintenance, application of preservation treatments, repair, rehabilitation, and reconstruction of New Jersey's highway infrastructure assets. Managing these assets is a complex process that requires evaluating system safety, asset conditions, and performance risks in the context of available funding to make good life cycle planning decisions. The TAMP positions NJDOT to employ technology and expertise to cost-effectively achieve safety and reliability through the preservation of its highway infrastructure.

NJ Governor Phil Murphy and DOT Commissioner Diane Gutierrez-Scaccetti onsite discussion with project team members



Route 35 Victory Bridge

Highway infrastructure preservation requires a significant ongoing investment that must be balanced against funding needs for NJDOT's other missions. Considering these competing needs, there is a strategic advantage to determining how actions can be taken in the near future to improve asset longevity and reduce total expenditures.

New Jersey's Transportation Asset Management Plan (TAMP) describes the ongoing asset management process and constitutes the plan for the preservation of New Jersey's highway assets.

1.1 ROLE OF THE TAMP

The Code of Federal Regulations (23 CFR 515.5) defines "asset management" as:

...a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the life cycle of the assets at minimum practicable cost.

The TAMP provides a data-driven, risk-based framework guiding the management of National Highway System (NHS) assets within New Jersey consistent with federal regulatory guidelines. The TAMP also provides the foundation upon which NJDOT manages State Highway System (SHS) assets, fulfilling its mission to achieve consistent progress through focused investments toward keeping infrastructure in a state of good repair and supporting one of its core missions of infrastructure preservation.

The TAMP sets overall policy and state of good repair objectives for assets, and outlines investment plans for achieving the desired performance levels for each asset.

The TAMP formalizes and documents the following processes and key information:

- The desired state of good repair for highway assets
- Current conditions (performance) of highway assets
- Federal requirements for the TAMP
- Risk-based tradeoff analysis (also referred to as cross-asset allocation for TAMP purposes) within and among selected asset types through the gap analysis process
- Life cycle planning strategies that reduce the total cost of ownership of highway assets over their life cycle
- Impact of investment scenarios upon asset performance for each asset type
- Risk management to support the implementation of the TAMP and asset-management activities
- TAMP-related communication and collaboration among all owners of the NHS in New Jersey and in National Highway Performance Program (NHPP) target setting (23 CFR 490)
- Process to identify enhancements to strengthen NJDOT's organizational capabilities for asset management and advance practices for New Jersey as a whole

1.2 FEDERAL REQUIREMENTS

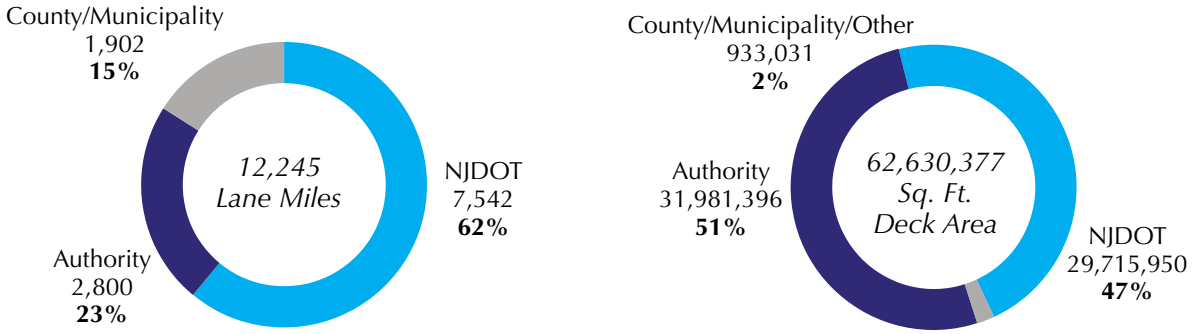
Three landmark pieces of federal transportation legislation created a performance-based approach to the management of federal highway programs. The Moving Ahead for Progress in the 21st Century Act (MAP-21) was enacted on July 6, 2012 and its asset management provisions were subsequently amended by the Fixing America's Surface Transportation Act (FAST Act) on December 4, 2015. The federal approach codified in this legislation, found at 23 U.S.C. 119, focuses on national transportation goals, increasing the transparency and accountability for federal highway programs, and improving transportation investment decision-making through performance-based planning and programming. Most recently, the Infrastructure Investment Jobs Act, the largest long-term investment in infrastructure signed on November 15, 2021, created an emphasis to consider extreme weather and resilience within life cycle planning and risk management analysis.

As part of this performance-based framework, federal law requires states to develop a risk-based TAMP to preserve or improve the condition of highway assets and the performance of the NHS. Federal requirements adopted to implement the legislation were added to the Code of Federal Regulations in 23 CFR Part 515 on October 2, 2017. This "Asset Management Rule" provides guidance on the process, contents and role of the TAMP.

Federal law for the TAMP requires that it includes, at a minimum, all NHS pavement and National Bridge Inspection Standard (NBIS) bridge assets, whether owned or maintained by NJDOT or by other entities. Accordingly, the TAMP process engages 84 non-NJDOT jurisdictional entities that have ownership and/or maintenance responsibilities for pavement and bridges on the NHS in New Jersey, briefly summarized in Exhibit 1-1. The communication and collaboration process through which these jurisdictions are involved in the TAMP is described in *Chapter 3: TAMP Governance, Policy, and Objectives*.

The State of New Jersey, compared to other states has a substantial portion of NHS pavement and NBIS bridge assets that are owned and/or maintained by non-NJDOT entities, which requires NJDOT to collaborate with other jurisdictions to ensure it collects accurate data and describes the processes pertaining to the preservation of these assets.

Exhibit 1-1: NHS Pavement (left) and NBIS Bridges (right) by Owner



Source: NJDOT Bureau of Transportation, Data and Support, Roadway Systems Section and NJDOT Bureau of Structural Evaluation and Bridge Management. Note: "Other" includes NJ TRANSIT and private entities. A maximum of +/- 1 lane mile or +/- 1% discrepancy might appear in the summations, which is due to rounding.

The federal requirements and how they are achieved through the TAMP are listed in Exhibit 1-2. This exhibit shows the criteria the Federal Highway Administration (FHWA) uses to certify compliance (per 23 CFR 515.9) and where each criterion is addressed within the TAMP.

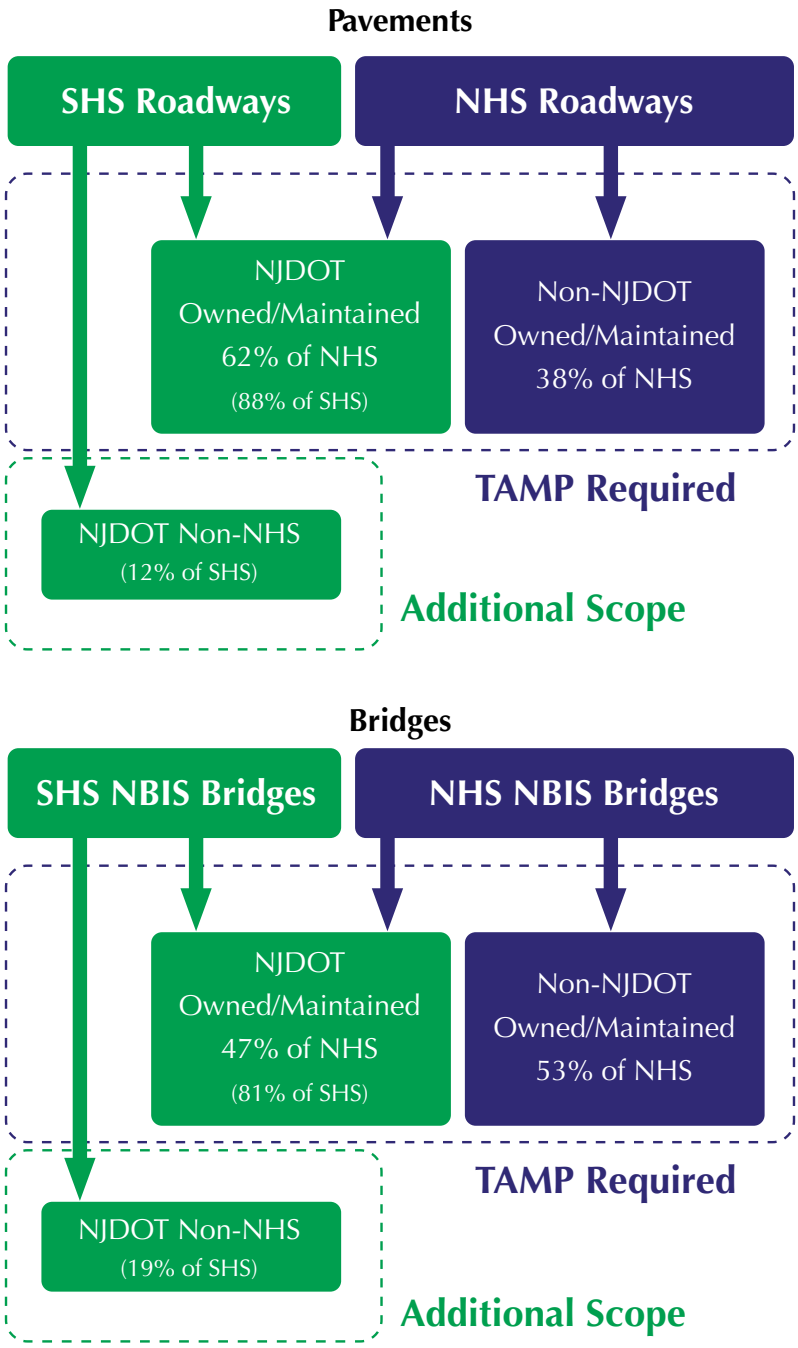
Exhibit 1-2: FHWA Asset Management Plan Requirements per 23 CFR 515.9

§	Requirements and Elements	Chapter /Date
A	A state DOT shall develop and implement an asset management plan to improve or preserve the condition of the assets and improve the performance of the NHS in accordance with the requirements of this part.	All
B	An asset management plan shall include, at a minimum, a summary listing of NHS pavement and bridge assets, regardless of ownership.	2
C	In addition to the assets specified in paragraph 515.9(b), state DOTs are encouraged, but not required, to include all other NHS infrastructure assets within the right-of-way corridor and assets on other public roads.	N/A
D	The minimum content for an asset management plan under this part includes a discussion of each element: ■ Asset management objectives. The objectives should align with the state DOT's mission. ■ Asset management performance measures and state DOT targets for asset condition for NHS pavements and bridges. ■ A summary description of the condition of NHS pavements and bridges, regardless of ownership. ■ Performance gap identification; life cycle planning; risk management analysis; financial plan; and investment strategies.	2-8
E	An asset management plan shall cover, at a minimum, a 10-year period.	4-8
F	An asset management plan shall discuss how the plan's investment strategies collectively would make or support progress toward: ■ Achieving and sustaining a desired state of good repair over the life cycle of the assets; ■ Improving or preserving the condition of the assets and the performance of physical assets on the NHS; ■ Achieving the state DOT targets for asset condition and performance of the NHS; and, ■ Achieving the national goals.	4, 5, 8
G	A state DOT must include in its plan a description of how the analyses support the state DOT's asset management plan investment strategies.	5, 8
H	A state DOT shall integrate its asset management plan into its transportation planning processes that lead to the statewide transportation improvement program to support its efforts to achieve the aims of the TAMP.	3, 8
I	A state DOT is required to make its asset management plan available to the public and is encouraged to do so in a format that is easily accessible.	*
J	Inclusion of performance measures and state DOT targets for NHS pavements and bridges in the asset management plan does not relieve the state DOT of other performance management requirements/reporting.	2–4
K	The head of the state DOT shall approve the asset management plan.	Dec. 2022
L	If the state DOT elects to include other NHS infrastructure assets or other public roads assets in its asset management plan, the state at a minimum shall address the following, using a level of effort consistent with the state DOT's needs and resources: ■ Summary listing of assets, including a description of asset condition; ■ Asset management measures and state DOT targets for asset condition; ■ Performance-gap analysis, life cycle planning, risk analysis, financial plan, and investment strategies.	N/A
M	The asset management plan of a state may include consideration of critical infrastructure in the state.	All

* Upon certification, between December 2022 and March 2023

1.3 SCOPE OF THE TAMP

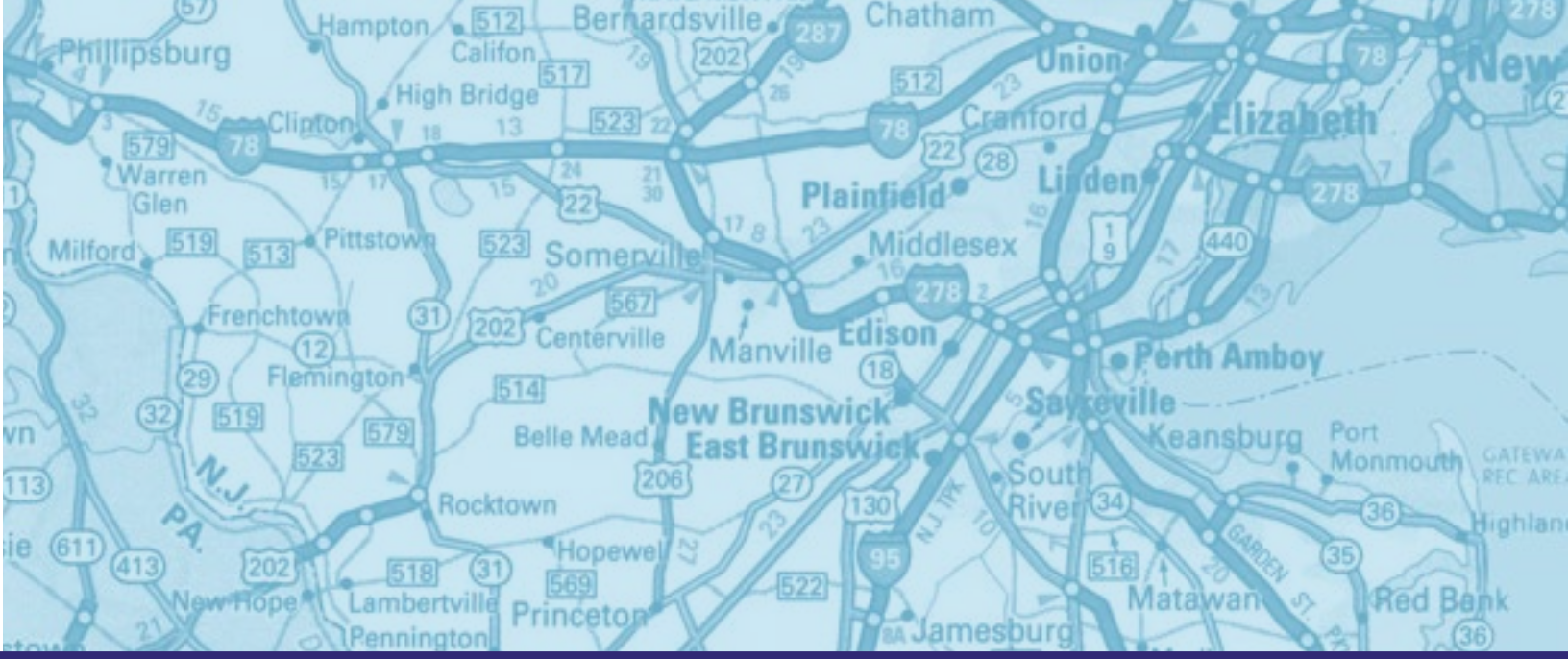
The TAMP addresses the management of all NHS pavement and NBIS bridge assets, regardless of ownership, consistent with federal requirements. Additionally, the TAMP process supports a data-driven capital planning process for NJDOT, which informs the development of the New Jersey's Statewide Transportation Improvement Program (STIP). The STIP documents major transportation improvements planned in the State of New Jersey, identifying capital projects and programs, as well as funding allocations and sources for each of the STIP's 10 years. The categories of assets addressed by the TAMP are summarized below.



1.4 TAMP ORGANIZATION

The TAMP is documented in the following chapters:

1. ***Introduction –*** provides an overview of the role of the TAMP in the management of the New Jersey SHS and in addressing federal requirements for the NHS. This chapter provides background information on the NHS in New Jersey, role of the TAMP, federal requirements, the scope of the TAMP, and organization of the TAMP.
2. ***Asset Inventory, Performance Measures, and Baseline Conditions –*** describes the asset classes addressed in the TAMP, the performance measures used to track their condition, as well as presents baseline asset conditions and historical progress toward state of good repair objectives. The established two- and four-year NHPP targets are included and discussed.
3. ***TAMP Governance, Policy, and Objectives –*** describes NJDOT's ongoing business practices and accountabilities for asset management. This chapter describes governance for the implementation of the TAMP, engagement of stakeholders, risk management, and the monitoring and reporting of asset conditions reporting. Additionally, NJDOT's asset management-related policies are outlined. These provide the policy context for the TAMP state of good repair objectives, which are also presented.
4. ***Performance-Gap Analysis –*** documents the analytical process and assumptions used to perform the TAMP gap analysis. This process documents the methods used to project the performance gaps over the two- and four-year horizons for the NHPP targets, and 10-year horizon for the state of good repair objectives. The alternative investment scenarios for the TAMP analysis period are evaluated, compared, and presented in this chapter.
5. ***Life Cycle Planning –*** describes NJDOT's whole-life planning strategies and business practices for the management of the different asset classes. This chapter describes and summarizes the plan for managing the assets to achieve the TAMP state of good repair objectives while minimizing costs and risks.
6. ***Risk Management –*** describes the TAMP risk management process and presents the risk register. Responsibilities for risk management and the framework to ensure that risks are appropriately addressed and mitigated are also outlined in Chapter 6.
7. ***Financial Plan –*** presents planned capital investments in highway infrastructure preservation over the TAMP analysis period, a 10-year period from FY 2023 through FY 2032, as well as details, key sources, and uses of the investments, particularly those related to asset management. Additionally, this chapter discusses broader financial risks and opportunities are reviewed and discussed in Chapter 7.
8. ***Investment Strategies –*** describes investment strategy for each asset class that is derived from the preceding TAMP analyses and consists of the optimal allocation of resources across the asset portfolio. The investment strategies balance the funding amounts to be invested according to work type, which will be defined in the chapter, that enable NJDOT to pursue the TAMP policy and state of good repair objectives.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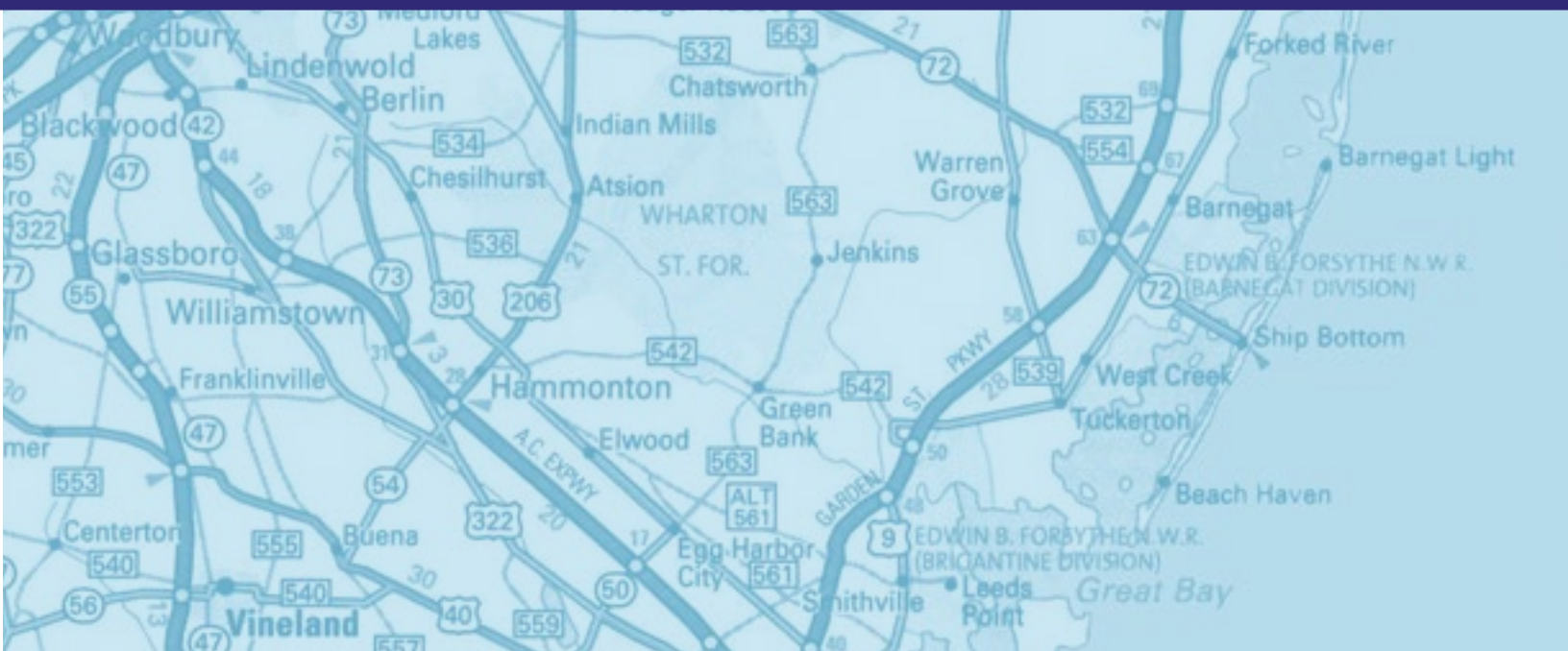
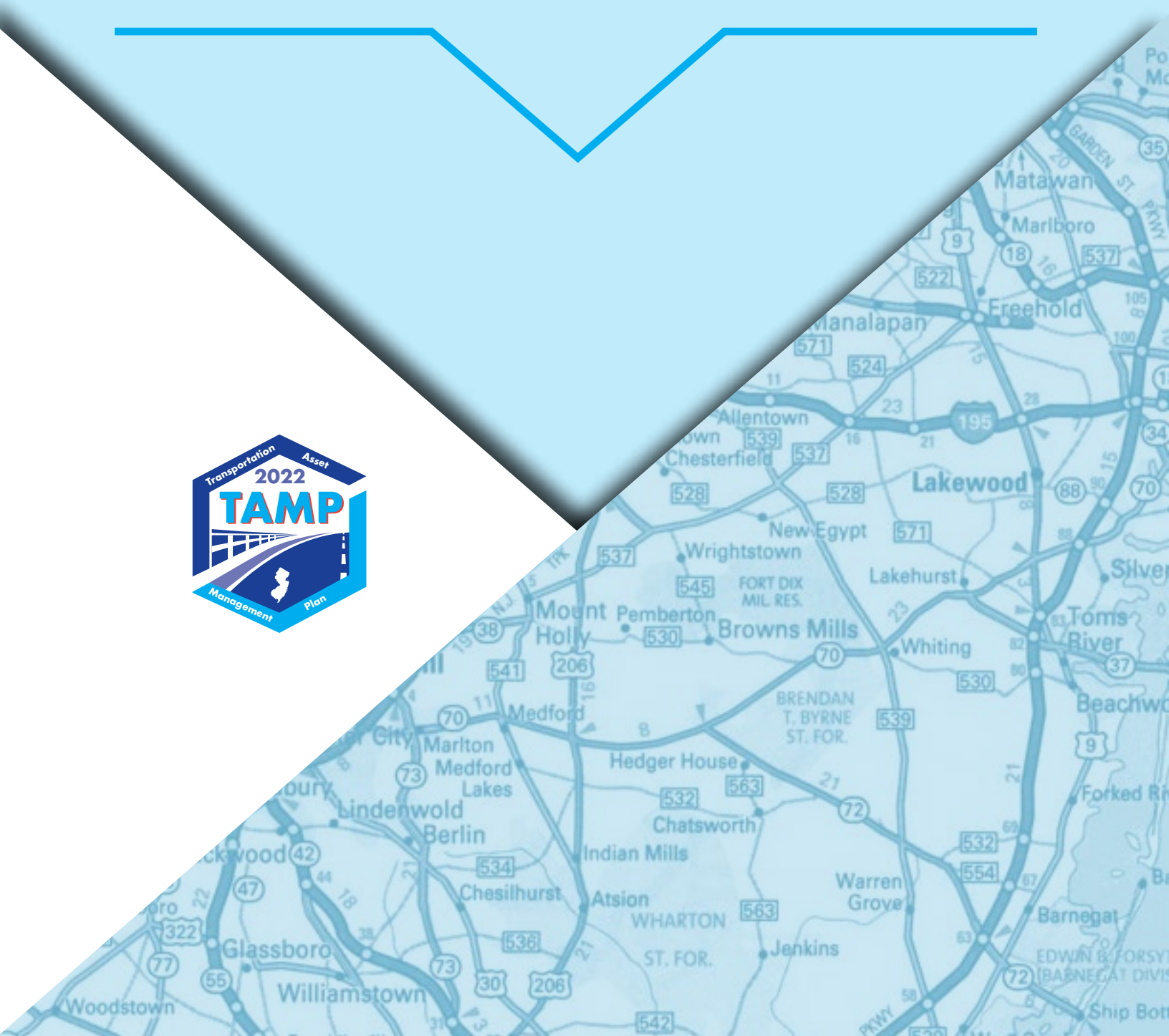
Hampton
Califon
Bernardsville
Chatham
Union
Elizabeth
High Bridge
Clinton
Cranford
Warren Glen
Plainfield
Linden
Milford
Pittstown
Somerville
Middlesex
Frenchtown
Centerville
Manville
Edison
Perth Amboy
Flemington
Sayreville
New Brunswick
East Brunswick
Belle Mead
Keansburg
Port Monmouth
South River
Rocktown
Hopewell
Matawan
Red Bank
New Hope
Lambertville
Pennington
Princeton
Jamesburg
N.J.
PA.


N.J. Turnpike


Woodbury
Lakes
Lindenwold
Berlin
Chatsworth
Forked River
Blackwood
Indian Mills
Chesilhurst
Atsion
Warren Grove
Barnegat Light
WHARTON
Barnegat
Glassboro
ST. FOR.
Jenkins
EDWIN B. FORSYTHE N.W.R. (BARNEGAT DIVISION)
Williamstown
Ship Bottom
Franklinville
Hammonton
West Creek
Green Bank
Elwood
Tuckerton
A.C. EXPWY
Beach Haven
Centerton
Buena
Egg Harbor City
EDWIN B. FORSYTHE N.W.R. (BRIGANTINE DIVISION)
Leeds Point
Great Bay
Vineland

CHAPTER 2:

ASSET INVENTORY, PERFORMANCE MEASURES, AND BASELINE CONDITIONS



BACKGROUND: Effective asset management requires timely and accurate asset information. The asset management process measures and monitors the inventory, condition, and performance of transportation assets to provide the foundation for the management of these assets across their life cycle.

2.1 OVERVIEW

This chapter describes the New Jersey Transportation Asset Management Plan (TAMP) asset inventory, performance measures, baseline conditions, and National Highway Performance Program (NHPP) two- and four-year targets. The TAMP addresses assets within two category groupings, according to the two different roadway networks that are the subject of the TAMP: the National Highway System (NHS) and the State Highway System (SHS). Reference to the SHS consists of the roadway networks owned and/or maintained by NJDOT, which includes the pavement and bridge assets profiled in the TAMP, as well as other assets not included in the TAMP (e.g., high-mast light poles, overhead signs).

It is important to note that these roadway networks are not mutually exclusive—a large portion of the SHS is comprised of NHS roadways.

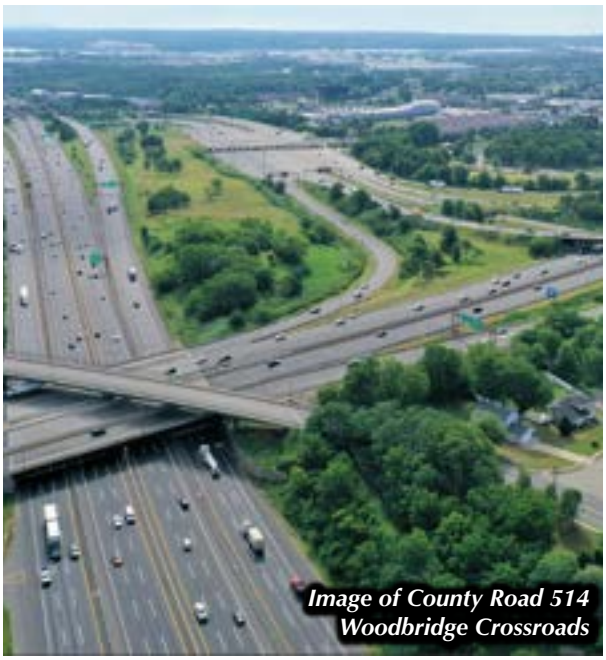


Image of County Road 514 Woodbridge Crossroads

The asset condition and performance measure data contained in this chapter are prefaced with a "Collection Year" (CY) which refers to information gathered within a given year. In the TAMP, data from a given CY is treated as the starting point, or baseline, for the following year. For instance, in this chapter, CY 2021data (e.g., collected during 2021), which is the best available data, becomes the baseline data for 2022.

2.2 SCOPE OF THE TAMP

2.2.1 Assets Included in the TAMP

Pavements

- Pavements in the National Highway System (NHS)*
- Pavements in the State Highway System (SHS)**

Bridges

- National Bridge Inspection Standard (NBIS) Bridges on the NHS*
- NBIS Bridges in the SHS**

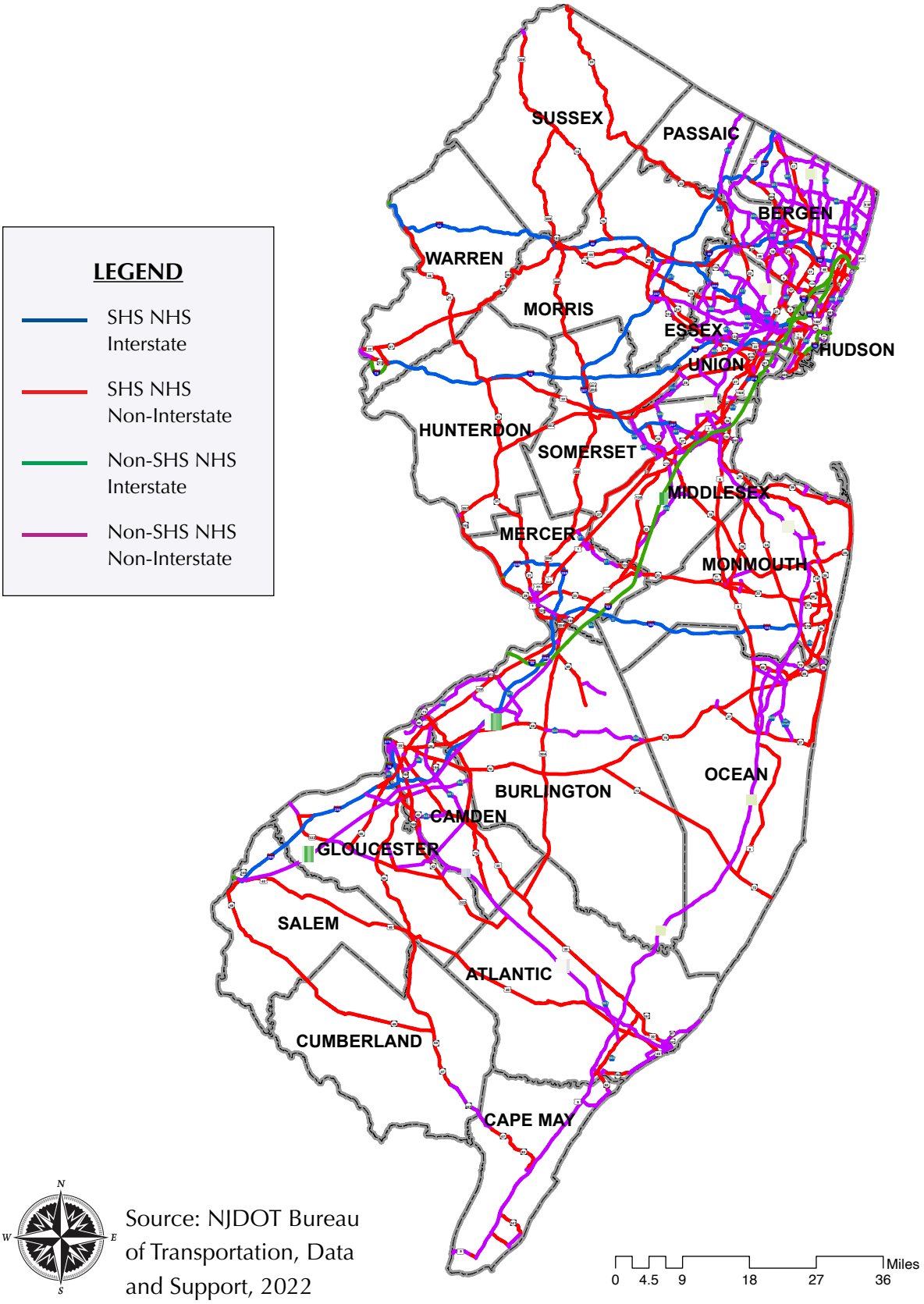
*Assets required in the TAMP per 23 CFR 515.
**Roadway assets that the New Jersey Department of Transportation (NJDOT) owns and/or maintains.

New Jersey Roadways — Networks and Jurisdictional Responsibilities

National Highway System

There are presently 12,245 pavement lane miles (CY 2021) on the NHS in New Jersey. The NHS as defined by the Federal Highway Administration (FHWA) is broken down into two categories: interstate and non-interstate. Interstate NHS highways are controlled-access and long-distance highways designated by the United States Department of Transportation and signed as part of the interstate system. Non-interstate NHS highways also are important to the State's economy, defense, and mobility because they connect transportation facilities such as interstate highways, transit centers, airports, or ports. While the NHS in New Jersey is a single network, it is owned and maintained by 84 different agencies. Each entity is free to manage its portion of the system to meet its own objectives, and using its own resources, management approaches, measures, and tools. Each entity has its own funding streams which may also include federal aid through the National Highway Performance Program (NHPP).

Exhibit 2-1: NHS Roadways in New Jersey



Source: NJDOT Bureau of Transportation, Data and Support, 2022

State Highway System

The SHS with approximately 8,560 pavement lane miles, includes all the roadways owned and/or maintained by the State of New Jersey. The SHS includes a significant amount of NHS roadways (7,542 pavement lane miles), both interstate and non-interstate, as well as 1,018 pavement lane miles of non-NHS roads and highways.

Other Roadways

The other NHS roadways include the approximately 4,702 pavement lane miles owned by authorities, counties and municipalities. The remaining and largest portion of roadway mileage in New Jersey (approximately 72,956 pavement lane miles) is comprised of non-NHS roadways under the jurisdiction of counties, municipalities, and parks. The roadways include minor arterials, major and minor collectors, and local roadways that are primarily intended to provide access from residential and commercial areas. While these roadways may handle significant levels of traffic for short distances, local roads typically have the lowest speed limits and carry the lowest traffic volumes. Assets on these roadways are not addressed in the TAMP.

2.2.2 New Jersey Highway Assets and Owners

This section presents the TAMP asset quantities by network and the categories of owner.

Exhibit 2-2: Required TAMP Assets — CY 2021

Asset Class	Network	Type	NHS Totals
NHS Pavements (Lane Miles)	**All**		**12,245**
		Interstate	2,984
		Non-Interstate	9,261
	SHS		**7,542**
		Interstate	1,974
		Non-Interstate	5,568
	Other*		**4,702**
		Interstate	1,009
		Non-Interstate	3,693
NHS NBIS Bridges (Deck Area Sq. Ft.)	**All**		**62,630,377**
	SHS		**29,715,950**
	Other*		**32,914,427**

*Other includes authorities/commissions, counties, municipalities, and others; all defined later.

Sources: NJDOT Bureau of Transportation, Data and Support; Bureau of Structural Evaluation and Bridge Management.

Notes: NHS = National Highway System. SHS = State Highway System. NBIS = National Bridge Inspection Standard.

Exhibit 2-3: Assets in SHS – CY 2021

Asset Class	Units	SHS Totals
Pavements	*Lane Miles*	**8,560**
NHS Bridges	*Deck Area (Sq. Ft.)*	**36,286,041**

Notes: Assets may be on the SHS and NHS. NBIS = National Bridge Inspection Standard.
Sources: Bureau of Transportation, Data and Support; NJDOT Bureau of Structural Evaluation and Bridge Management

Pavements — The TAMP pavement inventory includes all mainline travel pavement on NHS roadways, regardless of owner. The TAMP inventory also includes all mainline travel pavement on SHS roadways regardless of whether on or off the NHS. Mainline pavement does not include shoulders, turn lanes, or entry/exit ramps and these are not included in the TAMP pavement inventory totals. The pavement inventory is reported in terms of lane-miles which consider the number of travel lanes in each inventory section, for example, one mile of interstate pavement with four travel lanes contains four lane-miles of pavement.

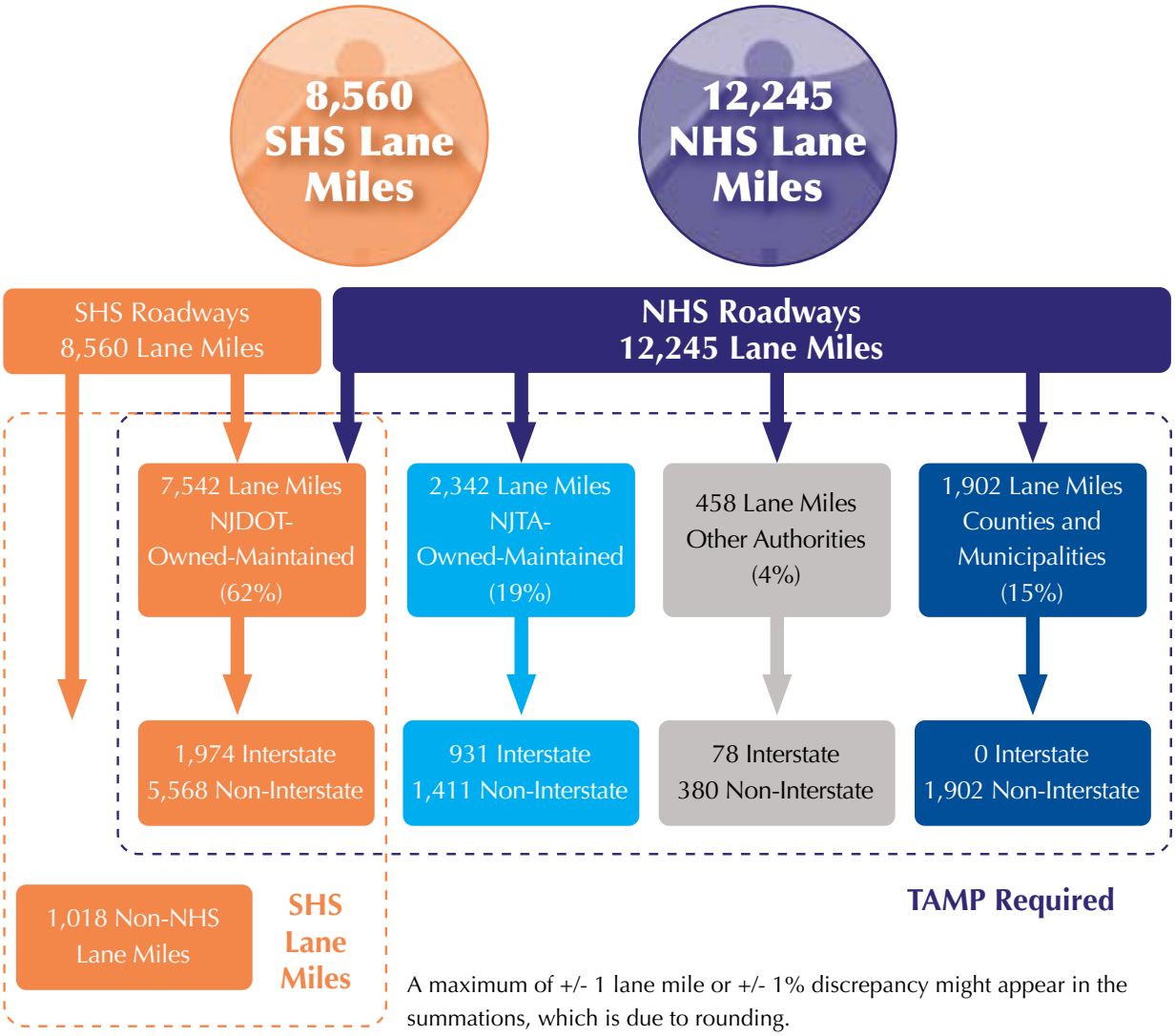
Bridges — The TAMP bridge inventory includes all National Bridge Inspection Standard (NBIS) bridges on the NHS, regardless of owner. NBIS bridges are bridges carrying public roads with a span greater than 20 feet as measured along the centerline of the roadway. These bridges are inspected every two years, as required by federal law. The TAMP bridge inventory also includes all NBIS bridges maintained by NJDOT (Delaware & Raritan Canal, New Jersey DEP, and orphan bridges), regardless of whether they are on or off the NHS.

Ownership of TAMP Pavement Assets

The summary asset inventory in Exhibits 2-2 and 2-3 lists New Jersey's inventory of pavement by lane miles and by system (NHS vs. SHS). Exhibit 2-4 portrays the breakdown in responsibility for these pavement assets. All pavement assets represented in Exhibit 2-4 are included in the TAMP. NJDOT experiences minimal growth in its pavement inventory each year. The reason for this limited increase is because New Jersey is a highly urbanized state with a fully built-out highway network and limited space to expand right-of-way remains. These limited increases are a result of NJDOT's approach of focusing on system preservation efforts vs. system expansion. In the past, NJDOT has acknowledged multiple negative and unsustainable outcomes of system expansion and the importance to preserve its current transportation system.

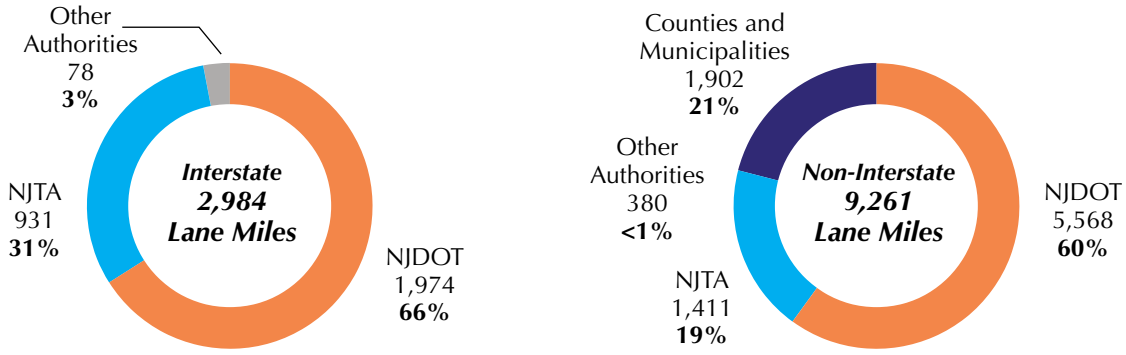
In total, there are 12,245 lane miles of pavement on the NHS, according to the best data available. As of CY 2021 data, NJDOT maintains approximately 62 percent (7,542) of these pavement lane miles, as well as 1,018 pavement lane miles as part of the SHS. The New Jersey Turnpike Authority (NJTA), which owns the New Jersey Turnpike and the Garden State Parkway, accounts for another 19 percent (2,342) of NHS pavement lane miles. Exhibit 2-5 provides a breakdown of NHS pavement assets by category of interstate and non-interstate, as well as by ownership.A more detailed breakdown of NHS pavement assets by owner is presented in Exhibit 2-6.

Exhibit 2-4: NHS and SHS Pavements by Lane Miles and Category, by Owner – CY 2021



A maximum of +/- 1 lane mile or +/- 1% discrepancy might appear in the summations, which is due to rounding.

Exhibit 2-5: NHS Pavement Lane Miles by Owner and Category – CY 2021



Source: NJDOT Bureau of Transportation, Data and Support; Roadway Systems Section.
Note: NJTA = New Jersey Turnpike Authority.
A maximum of +/- 1 lane mile or +/- 1% discrepancy might appear in the summations, which is due to rounding.

Exhibit 2-6: NHS Pavement Lane Miles by Jurisdiction Type – CY 2021

TAMP Owner Category	Owner Name	NHS Lane Miles	% of Total
Department of Transportation		**Subtotal = 7,542.27**	**61.6%**
	New Jersey Department of Transportation	7,542.27	61.6%
Authority		**Subtotal = 2,800.03**	**22.9%**
	New Jersey Turnpike Authority	2,342.15	19.1%
	South Jersey Transportation Authority	268.55	2.2%
	Palisades Interstate Parkway Commission	46.64	0.4%
	Port Authority of NY & NJ	46.17	0.4%
	Delaware River Port Authority	43.17	0.4%
	Delaware River Joint Toll Bridge Commission	34.13	0.3%
	Delaware River & Bay Authority	16.47	0.1%
	Burlington County Bridge Commission	2.75	<0.1%
County		**Subtotal = 1,655.05**	**13.5%**
	Bergen County	343.10	2.8%
	Essex County	246.16	2.0%
	Middlesex County	146.95	1.2%
	Camden County	142.96	1.2%
	Ocean County	133.99	1.1%
	Passaic County	132.34	1.1%
	Burlington County	130.52	1.1%
	Hudson County	87.69	0.7%
	Morris County	51.05	0.4%
	Gloucester County	47.46	0.4%
	Atlantic County	46.76	0.4%
	Union County	37.59	0.3%
	Monmouth County	35.89	0.3%
	Mercer County	27.78	0.2%
	Cape May County	19.54	0.2%
	Somerset County	14.00	0.1%
	Cumberland County	11.26	0.1%
Municipality		**Subtotal = 247.13**	**2.0%**
	City of Newark	70.73	0.6%
	City of Trenton	21.63	0.2%
	City of Elizabeth	21.04	0.2%
	City of Atlantic City	15.81	0.1%
	City of Paterson	12.26	0.1%
	City of Jersey City	9.75	0.1%

Ownership by municipality continues on following page

Owner Name	NHS Lane Miles	% of Total
Municipality (continued from previous page)		
Hamilton Township	7.70	0.1%
City of Ocean City	6.86	0.1%
Wayne Township	6.68	0.1%
City of Camden	6.00	0.1%
Maplewood Township	5.65	<0.1%
Middletown Township	5.40	<0.1%
City of East Orange	4.86	<0.1%
Edison Township	4.68	<0.1%
West Windsor Township	4.34	<0.1%
City of Woodbury	3.84	<0.1%
Woodbridge Township	3.54	<0.1%
Lyndhurst Township	3.12	<0.1%
Town of Phillipsburg	2.94	<0.1%
City of New Brunswick	2.56	<0.1%
Borough of Freehold	2.56	<0.1%
Town of Morristown	1.94	<0.1%
City of Ventnor	1.66	<0.1%
City of Orange	1.60	<0.1%
Town of West New York	1.56	<0.1%
City of Englewood	1.48	<0.1%
Milburn Township	1.34	<0.1%
City of Somers Point	1.30	<0.1%
Morris Township	1.24	<0.1%
City of Gloucester City	1.08	<0.1%
Municipality (continued)		
City of Wildwood	1.04	<0.1%
West Orange Township	0.90	<0.1%
Town of Secaucus	0.90	<0.1%
Weehawken Township	0.84	<0.1%
Monroe Township	0.80	<0.1%
Washington Township	0.80	<0.1%
Municipality of Princeton	0.78	<0.1%
Village of Ridgewood	0.74	<0.1%
Borough of Madison	0.72	<0.1%
Borough of Atlantic Highlands	0.48	<0.1%
Harrison Township	0.46	<0.1%
Union Township	0.46	<0.1%
Borough of Highlands	0.44	<0.1%
City of Bayonne	0.40	<0.1%
Borough of Metuchen	0.36	<0.1%
Egg Harbor Township	0.36	<0.1%
Borough of Tenafly	0.30	<0.1%
Borough of Franklin Lakes	0.30	<0.1%
Borough of Fort Lee	0.24	<0.1%
East Brunswick Township	0.24	<0.1%
Freehold Township	0.14	<0.1%
Borough of River Edge	0.14	<0.1%
Town of Westfield	0.08	<0.1%
Borough of Fair Lawn	0.06	<0.1%
GRAND TOTAL FOR ALL OWNERS	**12,244.47**	

Source: NJDOT Bureau of Transportation, Data and Support.

Ownership of TAMP NBIS Bridges

The summary asset inventory in Exhibits 2-2 and 2-3 lists New Jersey's inventory of highway carrying NBIS bridges by deck area and by system (NHS vs. SHS). Exhibit 2-7 breaks down ownership. All bridges represented in Exhibit 2-7 are included in the TAMP.

In total, there is 62,630,377 ft^2 of bridge deck area on the NHS in New Jersey. Based on CY 2021 data, NJDOT maintains 36,286,041 ft^2 of deck area, of which 6,570,091 ft^2 is in the SHS but not on the NHS. NJDOT's maintenance responsibility represents about 47 percent of the total NHS deck area in New Jersey. As presented in Exhibit 2-7, NJTA structures, including the New Jersey Turnpike and the Garden State Parkway, are tabulated separately since these represent a large part of the NHS ownership. Together, both NJTA roadways have 907 bridges on the NHS. Their NHS ownership represents about 34 percent of NHS bridges by deck area in New Jersey. This leaves about 19 percent of NHS bridges by deck area owned and maintained by others (approximately 17 percent other authorities and 2 percent various counties and municipalities and other owners). In total, approximately 53 percent of NHS bridges by deck area is not maintained by NJDOT as shown in Exhibit 2-8.

A more detailed breakdown of NHS bridges by county and jurisdiction owner is presented in Exhibit 2-9.

Included in the bridge inventory is a total of 36 border bridges, with 9,411,851 ft^2 deck area, that span between New Jersey and its neighboring states (New York, Pennsylvania, and Delaware). None of the border bridges are owned or maintained by NJDOT; they are owned and maintained by a variety of authorities and commissions. These bridges will also be included in the border states' TAMPs.

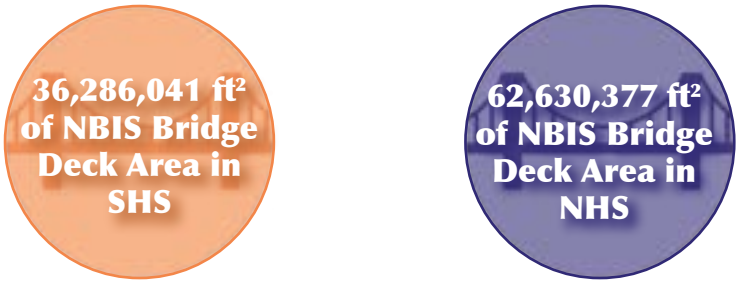
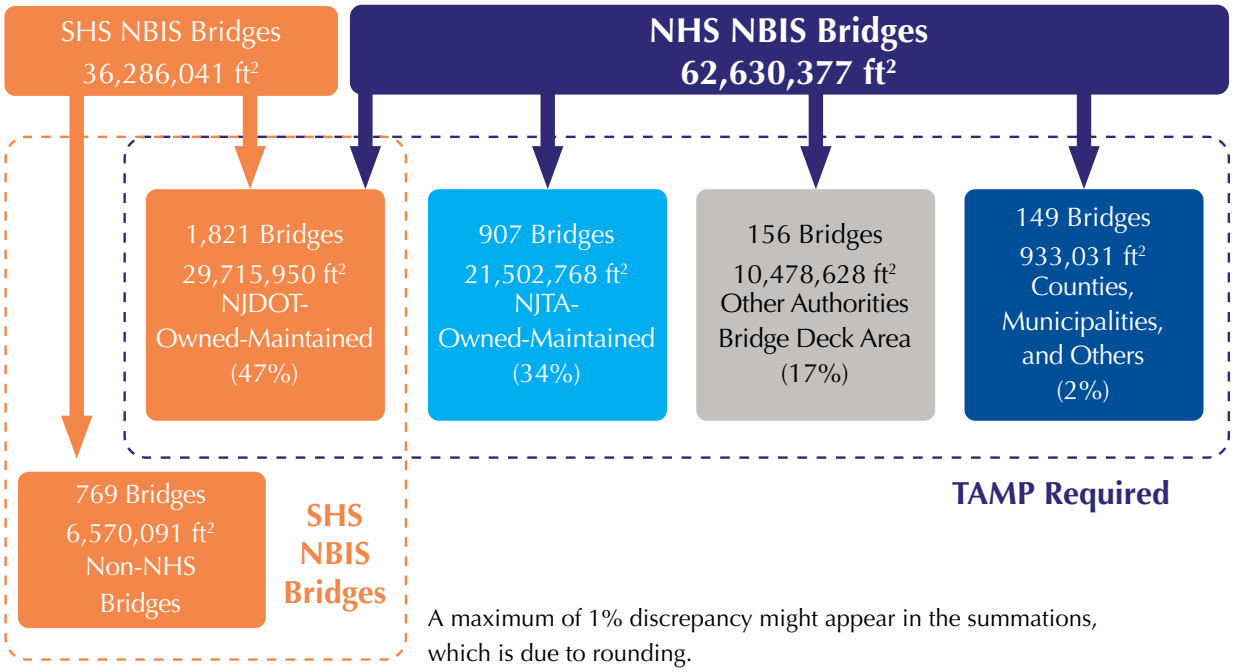
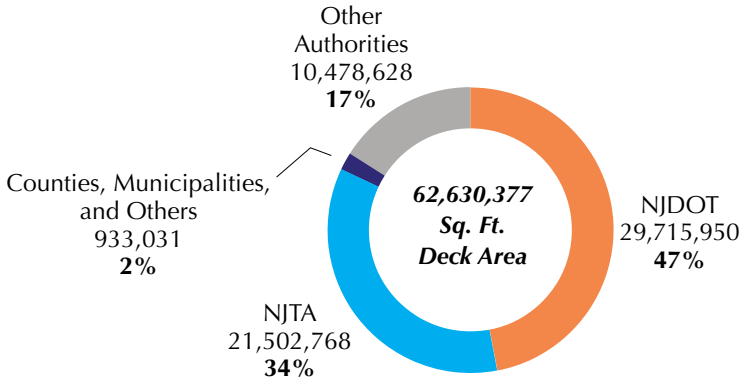


Exhibit 2-7: NHS and SHS NBIS Bridges by Count and Deck Area, by Owner – CY 2021



A maximum of 1% discrepancy might appear in the summations, which is due to rounding.

Exhibit 2-8: NHS NBIS Bridge Deck Area (ft2) by Owner – CY 2021



Source: NJDOT Bureau of Structural Evaluation and Bridge Management.
Notes: NJTA = New Jersey Turnpike Authority. "Others" (not "Other Authorities") includes NJ TRANSIT and private entities.
A maximum of 1% discrepancy might appear in the summations, which is due to rounding.

Exhibit 2-9: NHS NBIS Bridge Deck Area (ft²) by Jurisdiction Type – CY 2021

TAMP Owner Category	Owner Name	NHS Deck Area (Sq. Ft.)	% of Total
Department of Transportation		**Subtotal = 29,715,950.02**	**47.4%**
	New Jersey Department of Transportation[1]	29,715,950.02	47.4%
Authority		**Subtotal = 31,981,396.39**	**51.1%**
	New Jersey Turnpike Authority	21,502,768.40	34.3%
	Delaware River Port Authority	3,737,035.12	6.0%
	Port Authority of NY & NJ	3,666,880.46	5.9%
	Delaware River & Bay Authority	1,263,393.12	2.0%
	Delaware River Joint Toll Bridge Commission	1,058,122.47	1.7%
	South Jersey Transportation Authority	419,261.79	0.7%
	Burlington County Bridge Commission	271,211.97	0.4%
	Palisades Interstate Parkway Commission	62,723.06	0.1%
County		**Subtotal = 792,916.06**	**1.1%**
	Passaic County	153,139.45	0.2%
	Hudson County	113,317.45	0.2%
	Bergen County	89,242.24	0.1%
	Essex County	75,880.25	0.1%
	Middlesex County	80,279.32	0.1%
	Atlantic County	61,815.10	0.1%
	Cape May County	57,142.80	0.1%
	Camden County	32,338.08	0.1%
	Mercer County	29,760.35	<0.1%
	Ocean County	26,411.77	<0.1%
	Burlington County	23,845.85	<0.1%
	Monmouth County	17,063.20	<0.1%
	Morris County	10,705.05	<0.1%
	Gloucester County	8,891.19	<0.1%
	Union County	6,271.00	<0.1%
	Somerset County	2,905.30	<0.1%
	Warren County	2,653.66	<0.1%
	Cumberland County	1,254.00	<0.1%
Municipality		**Subtotal = 66,903.85**	**0.1%**
	City of Newark	66,903.85	0.1%
Other		**Subtotal = 73,211.06**	**0.1%**
	NJ TRANSIT	64,762.06	0.1%
	Pfizer Company	8,449.00	<0.1%
GRAND TOTAL FOR ALL OWNERS		**62,630,377.38**	

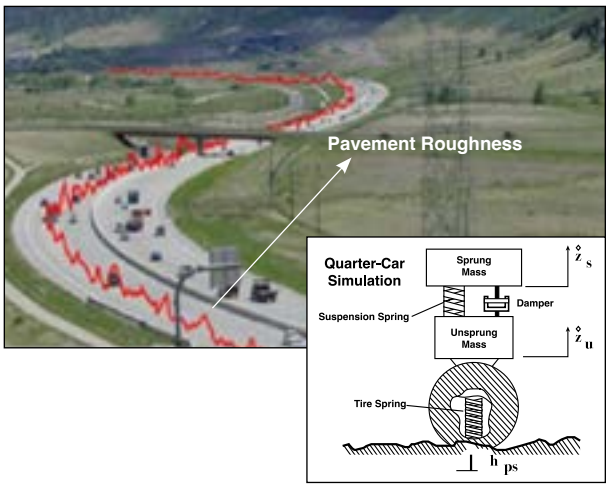
[1] Includes NJDOT, Delaware & Raritan Canal, and orphan bridges.
Source: NJDOT Bureau of Transportation, Data and Support.

2.3 PAVEMENT PERFORMANCE METRICS, MEASURES, AND BASELINE CONDITIONS

2.3.1 Pavement Condition Distresses, Data Collection, and Reporting

FHWA Rule, 23 CFR 490 Subpart C requires state DOTs to report condition information for each 1/10-mile segment of NHS pavement in the interstate system annually, and for non-interstate NHS pavement biennially based on the specific condition metrics. A metric is defined as a quantifiable indicator of performance or condition. The metrics established by the FHWA to measure pavement condition and performance are described below and illustrated in Exhibits 2-10 through 2-13.

Exhibit 2-10: International Roughness Index Data Collection Illustration



International Roughness Index (IRI)

IRI is a measure of ride quality, defined as the roughness felt by vehicle occupants driving over pavement in a measure of inches of vertical movement per mile traveled.

Exhibit 2-11: Block and Longitudinal Cracking

Cracking

Cracking is measured as the percent of the pavement surface area exhibiting cracking, within the wheel path, per 1/10-mile of pavement. The intent of this metric is to determine the amount of load-related cracking, indicating structural failure of the pavement.

Rutting

Rutting is a measure of surface depression (in inches) in a pavement's wheel path, as demonstrated in Exhibit 2-12. It is reported as the average depression depth per 1/10-mile of asphalt pavement.

Faulting

Faulting is a measure of difference in elevation (in inches) across a jointed concrete pavement's transverse joints or cracks. It is reported as the average difference in elevation across joints or cracks per 1/10-mile of pavement.

NJDOT Condition Status Performance Metric

Condition Status is a composite performance metric determined from the following indices, for each 1/10-mile segment of SHS pavement:

- International roughness index
- Surface distress index (SDI) — a composite index, developed by and for NJDOT, that considers structural and nonstructural distresses that can be observed at the pavement surface, including cracking, faulting, joint deterioration, and rutting

Pavement Data Collection and Reporting

NJDOT uses automated equipment to collect data on pavement roughness in accordance with American Association of State Highway and Transportation Officials (AASHTO) standard R 43-13, which is used by NJDOT as an input into its Condition Status performance metric. The data collection van, depicted in Exhibit 2-14, is outfitted with lasers, sensors, and cameras to collect information on cracking, ride quality, wheel-path rutting, and faulting. The van also takes photos of the entire roadway during data collection.

Exhibit 2-12: Rutting

Exhibit 2-13: Faulting

Data are collected and reported annually for all SHS and all NHS roads through three separate efforts:

- NJDOT Pavement Management Unit collects data for all SHS, South Jersey Transportation Authority, and Palisades Interstate Parkway pavements.
- NJDOT Bureau of Transportation, Data and Support Unit manages collection of data for all remaining non-SHS pavements on the NHS except for the NJTA.
- The NJTA collects condition data for its own pavements.

NJDOT compiles and reports pavement condition data for all SHS pavements, as well as the full NHS in accordance with requirements for the FHWA Highway Performance Monitoring System.

Exhibit 2-14: Pavement Condition Data Collection Vehicle

2.3.2 Pavement Performance Measures

23 CFR 490 defines a performance measure as "an expression based on a metric that is used to establish targets and assess progress toward achieving the established targets." Many states, including New Jersey, have already established performance measures for their pavement assets to monitor and report asset condition and assist in planning and funding decisions. Described below are the federal performance measures for the NHS and NJDOT's performance measures for the SHS.

NHS Pavement Performance Measures — NHPP Measures

FHWA's transportation performance management regulations (23 CFR 490 subpart C) define specific performance measures to be used in condition reporting and targets established for pavements on the NHS (see Section 2.5 for NHPP targets).

- The percentage of **interstate** pavement lane miles in *Good* condition.
- The percentage of **interstate** pavement lane miles in *Poor* condition.
- The percentage of **non-interstate** NHS pavement lane miles in *Good* condition.
- The percentage of **non-interstate** NHS pavement lane miles in *Poor* condition.

From NJDOT's annual NHS data submission, FHWA calculates and reports the performance of NHS pavements in New Jersey based on the NHPP metrics and the rating system in Exhibit 2-15.

Exhibit 2-15: Pavement Condition Metrics and Rating Criteria for NHPP Performance Measures

		Rating Defined by 23 CFR 490 for Each Performance Measure		
Metric	**Units**	**Good**	**Fair**	**Poor**
Ride Quality (measured in IRI)	Inches/Mile	<95	95–170	>170
Cracking (jointed concrete)	Percent	<5	5–15	>15
Cracking (asphalt)	Percent	<5	5–20	>20
AND EITHER				
Rutting (asphalt pavements only)	Inches	<0.20	0.20–0.40	>0.40
OR				
Faulting (Portland cement concrete only)	Inches	<0.10	0.10–0.15	>0.15

Note: For lower-speed roads (<40 MPH), PSR is used in lieu of IRI per 1/10th mile of pavement.

Depending on pavement type, three of the four metrics are used to calculate the NHPP measures. For asphalt-surfaced pavements, the measures are based on IRI, cracking, and rutting. For Portland cement concrete surfaced pavements, the measures are based on IRI, cracking, and faulting. The FHWA has defined *Good* to mean that values for all three metrics for each pavement type must fall in the *Good* range for that 1/10-mile segment of pavement to be rated as *Good*. For a pavement segment to be rated in *Poor* condition, values for two of the three metrics must fall within the *Poor* range. The results of the 1/10-mile segment evaluation are then accumulated for each condition category resulting in an overall percentage of each condition category, representing the overall performance, for the network. This methodology is very forgiving and results in most of the network being rated as *Good* or *Fair* with a limited ability to discern any differences between pavement conditions within these condition categories. Furthermore, the methodology is impractical to utilize to effectively manage the pavement network.

SHS Pavement Performance Measures — NJDOT Measures

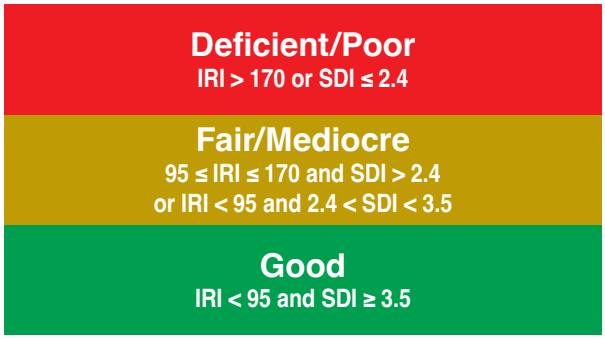
There are many means of measuring pavement condition, and few national standards. The pavement performance measures and metrics that were established by the FHWA in 2017 for NHS performance reporting differ from those established by the NJDOT for SHS pavement management and performance reporting. While these national measures are adequate for national reporting purposes, they do not provide NJDOT with sufficiently detailed information on pavement conditions to effectively manage pavements on the SHS. The NJDOT has been collecting pavement condition data and using it to manage pavement since 2000.

Over that time, the NJDOT has developed and refined its performance metrics and rating criteria to best support pavement management—considering the types of pavements in its inventory, the traffic loading on its pavements, the types of distresses and modes of failure experienced, and the types of treatments proven effective for improving pavement condition within New Jersey. The NJDOT uses these performance measures to report pavement condition, set state of good repair objectives, identify appropriate treatments, and prioritize paving projects.

The NJDOT's performance measure for the SHS is the percent of pavement in *Good* or *Fair* condition. Pavements meeting the threshold of *Good* or *Fair* condition are considered to be in a state of good repair. The TAMP state of good repair objectives for the SHS are described in *Chapter 3: TAMP Governance, Policy, and Objectives*.

Exhibit 2-16 indicates how the IRI and SDI factor into the Condition Status performance metric ratings of *Good*, *Fair*, and *Poor*.

Exhibit 2-16: Pavement Condition Metrics and Rating Criteria for NJDOT's Performance Measures



Notes: SDI = Surface Distress Index.
IRI = International Roughness Index.

Similar to FHWA's methodology, both International Roughness Index (IRI) and Surface Distress Index (SDI) values must fall within the *Good* range for a pavement segment to be considered *Good*. Unlike FHWA, if either IRI or SDI values fall within the *Poor* range, the pavement segment is considered *Poor*. Additionally, based on the IRI and SDI values, each pavement section is assigned a numerical value that allows NJDOT to distinguish pavements within the *Good, Fair* and *Poor* categories to better identify treatment strategies and more effectively manage the network.

Exhibit 2-17: NJDOT and NHPP Performance Measure Comparison

Distress	Measure	
	NHPP	NJDOT
IRI	•	•
HMA Rutting	•	•
HMA Wheel-Path Cracking	•	
HMA Cracking (full lane width)		•
PCC Faulting	•	•
PCC Total Cracking/Spalling	•	•
PCC Joint Deterioration		•

To further clarify the differences between NJDOT's performance measure for the SHS and the NHPP performance measure for the NHS, Exhibit 2-17 illustrates which underlying distress metrics are used in each performance measure.

2.3.3 Baseline and Historical Pavement Conditions

Baseline Pavement Conditions

Pavement conditions throughout New Jersey's highway systems are dynamic, changing over time due to a combination of deterioration and damage, and on the other hand improvements through rehabilitation and replacement projects.

Effective management of SHS and NHS pavement assets requires timely, accurate, and complete data on baseline condition, as well historical data that helps to characterize condition trends. Exhibits 2-18 and 2-19 provide a summary of New Jersey's baseline pavement condition based on CY 2021 data. Exhibit 2-18 reports the baseline condition for pavement on the NHS using the NHPP performance measures.

Exhibit 2-18: NHS Pavement Baseline Condition by System (NHPP Measures) — CY 2021

Asset Class	System	Lane Miles		Condition Status by % of Lane Miles	
		Total	Collected	% Good	% Poor
Pavements	Interstate*	2,984	2,736.303	75.7	0.1
	Non-Interstate NHS**	9,261	8,934.106	41.6	4.8

Source: FHWA Highway Performance Monitoring System 2021 Pavement Report Card.
* Total interstate pavement lane miles missing/invalid data = 17.112; coded as bridge = 230.883 miles.
** Total non-interstate pavement lane miles missing/invalid data = 64.064; coded as bridge = 262.377 miles.

Exhibit 2-19 presents the SHS pavement performance measured according to the NJDOT's Condition Status performance metric. The exhibit indicates that approximately 79 percent of SHS pavement is in *Good* or *Fair* condition, or in a state of good repair, and 21 percent is rated *Poor*, when using the Condition Status performance metric.

Historical Pavement Condition

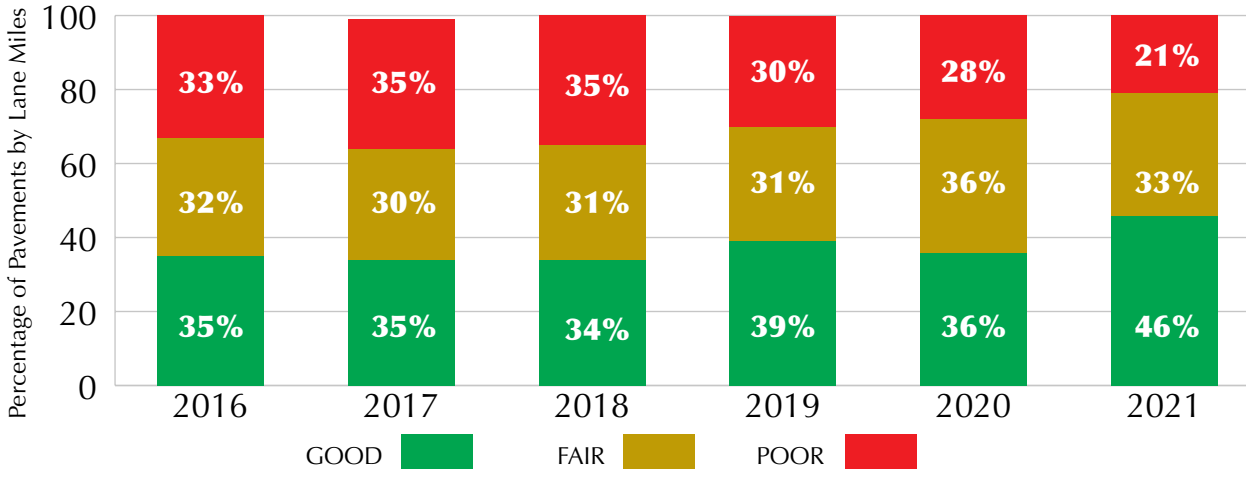
The NJDOT has improved pavement condition within the SHS over the past ten years through effective asset management practices. Exhibit 2-20 shows how pavement condition has improved from 67 percent of pavement lane miles in a state of good repair (*Good* or *Fair*) in CY 2016 and approached 79 percent in CY 2021.

Exhibit 2-19: SHS Pavement Baseline Condition (NJDOT's Condition Status) – CY 2021

Asset Class	State System	Total Lane Miles	Condition Status by % of Lane Miles		
			% Good	% Fair	% Poor
Pavements	SHS	8,560	46.4	32.5	21.1

Source: NJDOT Pavement Management Unit.

Exhibit 2-20: SHS Pavement Historical Conditions (NJDOT's Condition Status) – CY 2016–2021



Source: NJDOT Pavement Management Unit.

2.4 BRIDGE PERFORMANCE MEASURES AND BASELINE CONDITIONS

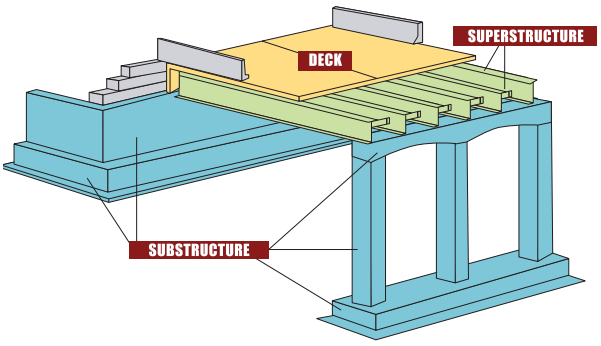
This section summarizes the performance measures used, the baseline condition, and the targets established for New Jersey's bridges (see Section 2.5 for NHPP targets) included in the TAMP. Unlike the case with pavements, the same performance measures are used for SHS reporting and NHS performance reporting to FHWA.

2.4.1 Bridge Components and Ratings, Data Collection, and Reporting

Bridge Components

NJDOT-owned bridges are presently designed for a service life of 75 years. However, many bridges in the highway network are older than 75 years while some bridges have had to be taken out of service at earlier ages. If a bridge has deteriorated to the point where it cannot safely handle applicable legal loads, it may need to be posted at lower weight limits or even be closed until it can be repaired or replaced.

Exhibit 2-21: Bridge – Basic Components



Since the 1970s, federal law has required that all bridges on public roads with a span over 20 feet be inspected at least once every two years. The three basic components of a bridge, shown in Exhibit 2-21, are the deck, superstructure, and substructure. Each component receives a condition rating, which is described below.

Exhibit 2-22: Culvert

Culverts are structures that carry vehicular traffic and allow water to flow from one side to the other side. Culverts with a total length greater than 20 feet (measured along the centerline of the roadway) are also subject to the federal NBIS requirements. Culverts have a single component ("culvert") that receives a condition rating.

Bridge Component Ratings

NBIS assigns ratings on a scale of 0 (*Failed* condition, not shown) to 9 (*Excellent* condition) to each component of a bridge (deck, superstructure, or substructure) or to the culvert based on physical conditions observed during inspections. The ratings are assigned based on an inspection checklist and inspector judgement; therefore, there are no underlying metrics for bridge component ratings that roll up to the overall bridge ratings as there are for overall pavement ratings. Exhibit 2-23 displays the relationship between the ratings and the performance measures (*Good/Fair/Poor*).

Bridge Data Collection and Reporting

The NJDOT collects information on all NBIS bridges that it owns or maintains for annual reporting to the FHWA. The NJDOT also manages inspection contracts for the collection of data on county, municipal, and some smaller-entity bridges. Condition data for bridges owned by other agencies such as the NJTA and others, are collected by those respective agencies. The NJDOT receives the inspection data on these bridges for reporting to the FHWA. The NJDOT is responsible for the maintenance of the bridges it owns, as well as orphan bridges, New Jersey Department of Environmental Protection (NJDEP) bridges, and Delaware and Raritan Canal bridges that carry state highways.

Exhibit 2-23: NBIS Component Ratings and Corresponding Performance Measures

Rating Codes for Deck, Superstructure, and Substructure, or for Culvert		Performance Measures
Code	Description	
1	Imminent Failure	Poor
2	Critical	
3	Serious	
4	Poor	
5	Fair	Fair
6	Satisfactory	
7	Good	Good
8	Very Good	
9	Excellent	

2.4.2 Bridge Performance Measures

NHS and SHS Bridge Performance Measures – NHPP Measures

The NJDOT is using the NHPP measures as the performance measures for NBIS bridges (23 CFR 490 Subpart D) in the TAMP. The NHPP measures set the overall condition of the bridge or culvert based on the lowest component rating [per 23 CFR 490.409(b)]. If all three of the deck, superstructure, and substructure components of a bridge or the culvert component is rated 7 or greater, the bridge is classified as being in *Good* condition. If the lowest component is rated 5 or 6, it is classified as *Fair* condition, and if the lowest component is 4 or less, it is classified as being in *Poor* condition.

FHWA Rule, 23 CFR 490.407(c) specifically states that the NHPP shall use two of the classifications (*Good* and *Poor*) to assess bridge condition on the NHS. A bridge in Poor condition is also sometimes referred to as "structurally deficient." A bridge that is flagged as "structurally deficient" does not imply that it is unsafe; this just means that deficiencies have been identified that require maintenance, rehabilitation, or replacement.

The NJDOT uses these performance measures to report bridge condition, set state of good repair objectives, identify appropriate treatments, and prioritize bridge projects. The NJDOT's performance measure for bridges is the percent of bridges by deck area in *Good* or *Fair* condition. Bridges meeting the requirements to be rated as *Good* and *Fair* are in a state of good repair. The TAMP state of good repair objectives for bridges are described in *Chapter 3: TAMP Governance, Policy, and Objectives*.

2.4.3 Baseline and Historical Bridge Conditions

Baseline Bridge Conditions

The condition of bridges throughout New Jersey's highway systems is dynamic, changing over time due to a combination of deterioration and damage, and on the other hand improvements through rehabilitation and replacement projects.

To effectively manage bridges, it is imperative to know the baseline condition of the structures and maintain historical data on the measured conditions. The TAMP baseline condition for bridges is presented using CY 2021 data. Exhibit 2-24 and Exhibit 2-25 describe bridge conditions.

Less than 7 percent of the bridges by deck area on the NHS are in *Poor* condition. This meets the NHPP requirement that no more than 10 percent of NHS bridges by deck area shall be in *Poor* condition. It should be noted that, excluding NJTA-owned bridges, the percent *Poor* for authority-owned bridges averages less than 1 percent, while the percent *Poor* for SHS bridges is over 9 percent, and the percent *Poor* for all other owners is nearly 13 percent.

Exhibit 2-25 reports the baseline condition for all SHS bridges. As of CY 2021, over 9 percent of SHS bridges by deck area are in *Poor* condition. The proportion of SHS bridge deck area in *Poor* condition on the NHS is greater than the proportion in the same condition off the NHS. However, when measured by percent rated *Good*, bridges on the NHS are in slightly better condition than bridges off the NHS.

Exhibit 2-24: NHS NBIS Bridge Baseline Condition by Owner – CY 2021

Asset Class	Owner	Deck Area (ft²)	% of Total	Condition by % of Deck Area		
				% Good	% Fair	% Poor
NBIS Bridges	NJDOT	29,715,950	47.45	25.45	64.82	9.73
	NJTA	21,502,768	34.33	16.79	78.15	5.07
	Other Authorities	10,478,628	16.73	19.28	80.26	0.46
	Others	933,031	1.49	13.02	74.08	12.90
	NHS Total	**62,630,377**	**100.00**	**21.26**	**72.12**	**6.62**

Source: NJDOT Bureau of Structural Evaluation and Bridge Management. Notes: "Other Authorities" include Delaware River Port Authority, Port Authority of New York & New Jersey, Delaware River and Bay Authority, Delaware River Joint Toll Bridge Commission, South Jersey Transportation Authority, Burlington County Bridge Commission, and Palisades Interstate Parkway. "Others" includes counties, municipalities, NJ TRANSIT, and private entities. A maximum of 0.01% discrepancy might appear in the summations, which is due to rounding.

Exhibit 2-25: SHS NBIS Bridge Baseline Condition by System – CY 2021

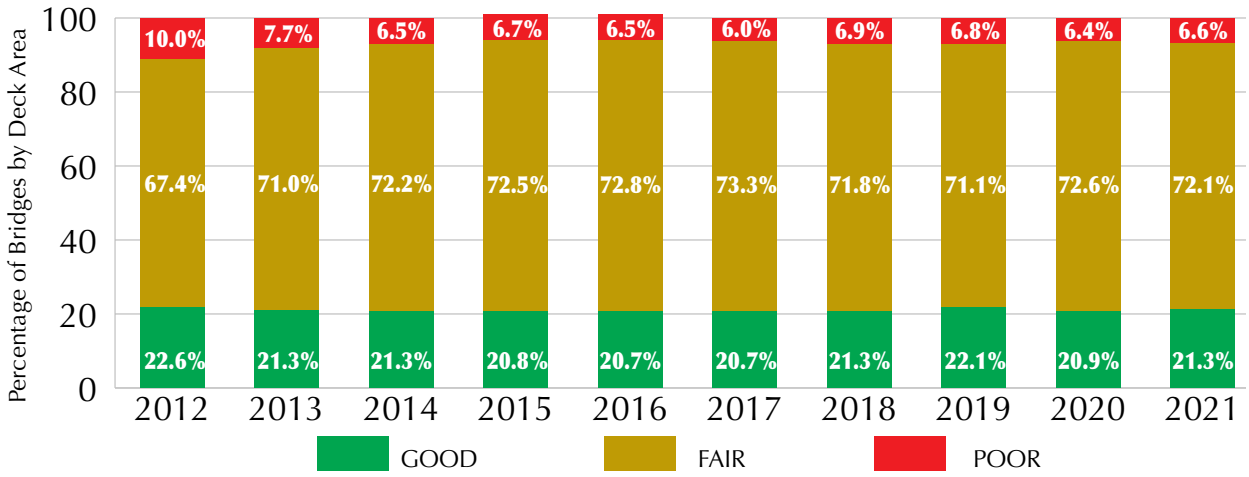
Asset Class	System	Deck Area (ft²)	% of Total	Condition by % of Deck Area		
				% Good	% Fair	% Poor
NBIS Bridges	NHS	29,715,950	81.89	25.45	64.82	9.73
	Non-NHS	6,570,091	18.11	23.15	68.62	8.23
	NJDOT Total	**36,286,041**	**100.00**	**25.04**	**65.51**	**9.46**

Source: NJDOT Bureau of Structural Evaluation and Bridge Management.

Historical NBIS Bridge Conditions

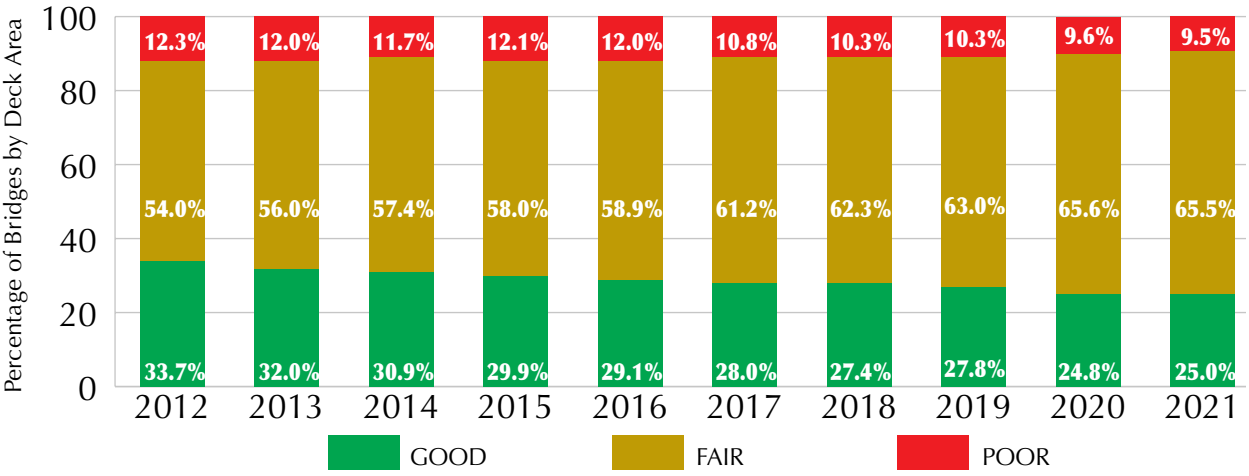
Through progressive asset management practices, owners of NHS bridges have been able to improve conditions in New Jersey over the past nine years. According to Exhibit 2-26, the percentage of *Good* and *Fair* (i.e., in a state of good repair) has been fairly stable over an eight-year time frame, ranging between 93 and 94 percent. However over the full ten-year period shown, the proportion of NHS bridges by deck area that are in *Fair* condition has increased while that in *Good* condition has decreased, and those no longer in *Poor* condition have become *Good* or *Fair*. Yearly data show a shift into a greater proportion into *Fair*. This reflects a combination of good bridges deteriorating to *Fair* condition and the improvement of some bridges from *Poor* to *Good* and others from *Poor* to *Fair*.

Exhibit 2-26: NHS NBIS Bridge Condition History – CY 2012 to CY 2021



Source: NJDOT Bureau of Structural Evaluation and Bridge Management.
Note: Due to rounding, totals as shown may not add up to 100 percent.

Exhibit 2-27: SHS NBIS Bridge Condition History – CY 2012 to CY 2021



Source: NJDOT Bureau of Structural Evaluation and Bridge Management.
Note: Due to rounding, totals as shown may not add up to 100 percent.

Similarly, through progressive asset management practices, NJDOT has been able to steadily improve bridge conditions in New Jersey over the past five years. Exhibit 2-27 shows a steady improvement from 88 percent of SHS bridges by deck area in *Good* and *Fair* condition in CY 2012 data to 90 percent *Good* and *Fair* in CY 2020 data. This exhibit shows that the share of SHS bridges by deck area in a state of good repair has increased by 2 percentage points in the nine-year period. NJDOT plans to continue to increase the percentage in a state of good repair by implementing life cycle strategies described in *Chapter 5: Life Cycle Planning* and continue improving the ongoing TAMP process.

2.5 NATIONAL HIGHWAY PERFORMANCE PROGRAM (NHPP) TARGETS

Pursuant to 23 U.S.C. 150 to measure pavement and bridge conditions on the NHS, the TAMP includes the two- and four-year statewide targets established by the NJDOT. The statewide targets are short-term benchmarks for making progress toward achieving TAMP state of good repair objectives (as detailed in *Chapter 3: TAMP Governance, Policy, and Objectives*).

Exhibit 2-28: NHPP Two- and Four-Year Targets for Pavements

	Two-Year (CY 2023)		Four-Year (CY 2025)	
NHS	**Good**	**Poor**	**Good**	**Poor**
Interstate Pavements Target (%)	75.7	0.1	77.0	0.1
Non-Interstate Pavements Target (%)	41.6	4.8	43.0	4.0

Note: Targets set using NHPP performance measures. NHS includes all pavement assets regardless of ownership.

Exhibit 2-29: NHPP Two- and Four-Year Targets for NBIS Bridges

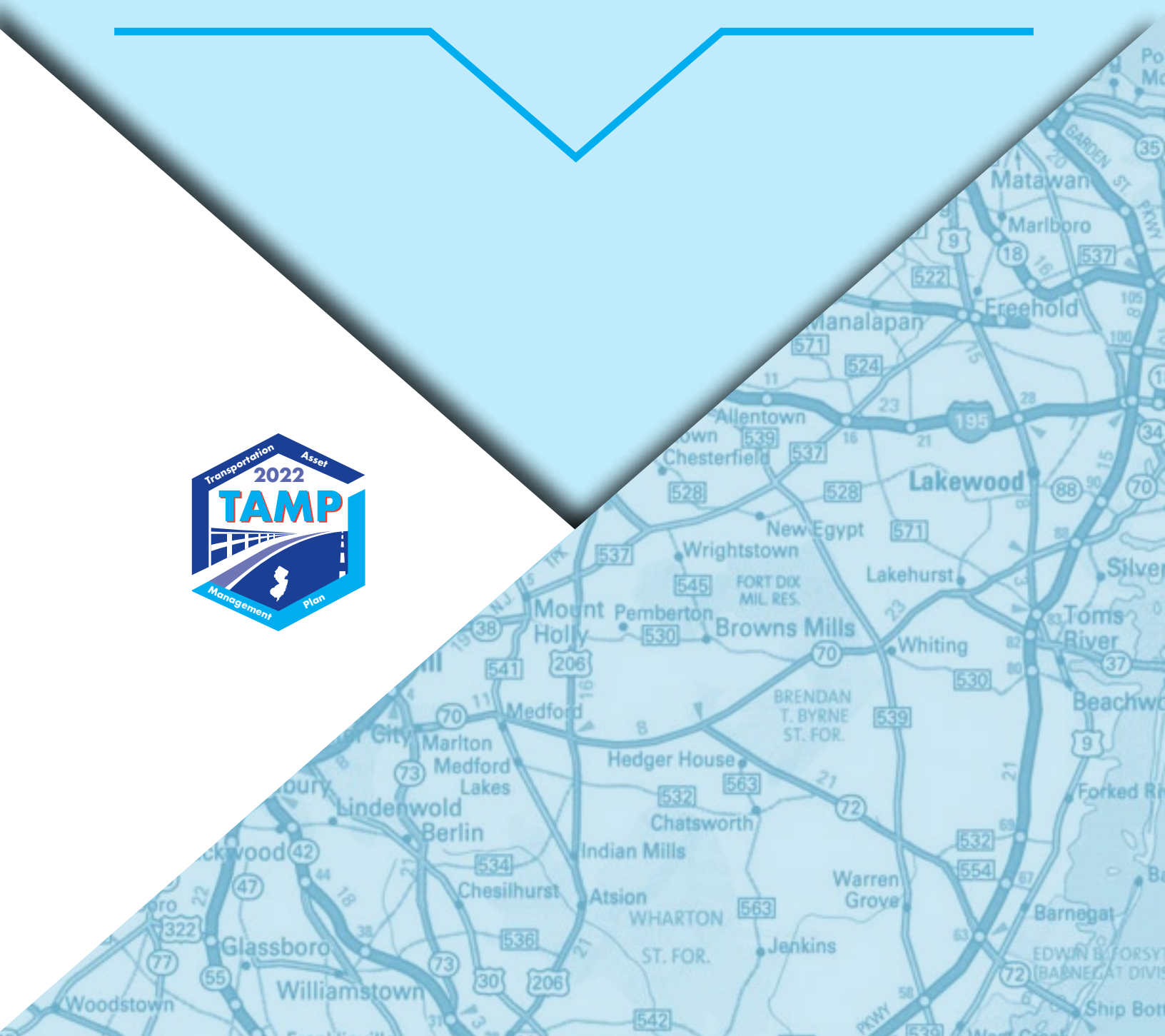
	Two-Year (CY 2023)		Four-Year (CY 2025)	
NHS	**Good**	**Poor**	**Good**	**Poor**
NBIS Bridges Target (%)	21.3	6.6	23.0	6.0

Note: Targets set using NHPP performance measures. NHS includes all NBIS bridge assets regardless of ownership.

The two-and four-year targets shown in the exhibits above represent New Jersey's targets for the second performance period, which were updated in the fall of 2022, after coordination with other non-NJDOT NHS owners.

CHAPTER 3:

TAMP GOVERNANCE, POLICY, AND OBJECTIVES



BACKGROUND: New Jersey's Transportation Asset Management Plan (TAMP) is a product of the ongoing asset management process that the New Jersey Department of Transportation (NJDOT) has established over the past several years. The TAMP is governed by several policies, involves many key personnel, and is driven by an iterative process to improve transportation asset management.

The TAMP is the result of a collaborative and consultative process involving internal and external stakeholders that own National Highway System (NHS) and State Highway System (SHS) assets, as well as New Jersey's Metropolitan Planning Organizations (MPO). Careful coordination and a clear delineation of the responsibilities within this process are required for the objectives to be achieved.

3.1 OVERVIEW

Chapter 3 introduces the ongoing governance structure that supports the TAMP and its objectives, including the responsibilities of the different committees and constituent team members. The chapter also discusses the results of external stakeholder engagement efforts conducted to adequately address the entire NHS. Finally, the policy context for the TAMP as well as the policy and state of good repair objectives for the asset classes included in the TAMP are presented.

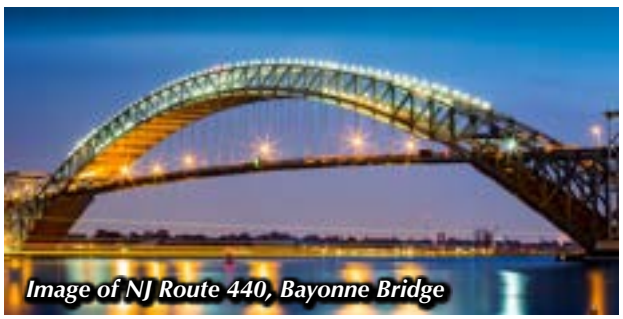


Image of NJ Route 440, Bayonne Bridge


Image of I-676, Benjamin Franklin Bridge


Image of I-95, New Jersey Turnpike


Image of I-295, Scudder Falls Bridge

3.2 ASSET MANAGEMENT GOVERNANCE

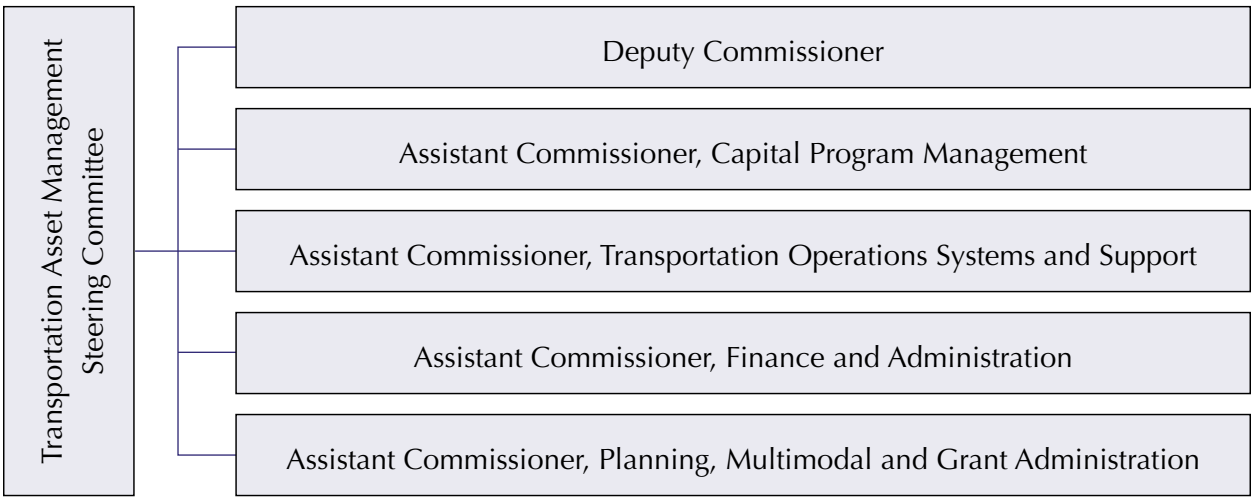
Asset management is central to the accomplishment of NJDOT's mission. NJDOT's focus on infrastructure preservation as part of the TAMP shows its commitment to make progress toward achieving the eponymous core mission, while the other four include safety, mobility and congestion relief, operations and maintenance, and mass transit, which belongs to NJ TRANSIT. The transportation asset management process provides the mechanism to achieve progress toward keeping infrastructure in a state of good repair and achieve the infrastructure preservation core mission. The TAMP builds on existing business practices to establish the ongoing governance, technical, and management processes necessary to meet federal asset management requirements, as well as established state of good repair objectives.

The governance structure, responsibilities for the ongoing asset management process, and TAMP implementation are described in the following sections.

3.2.1 Transportation Asset Management Steering Committee

The Transportation Asset Management Steering Committee is comprised of NJDOT senior leadership. The committee sets policy direction and provides executive oversight and leadership for the performance management of New Jersey's transportation system. The committee provides general direction to the TAMP effort and assists in communicating the purpose and progress to other stakeholders. The composition of the committee is displayed below in Exhibit 3-1.

Exhibit 3-1: Transportation Asset Management Steering Committee



Key Responsibilities

- Establish asset management policy and state of good repair objectives.
- Validate and recommend National Highway Performance Program (NHPP) targets addressing bridge and pavement preservation.
- Provide oversight in the management of enterprise-level risks to the accomplishment of asset management policy and state of good repair objectives.
- Monitor and review, on an annual basis, the status of TAMP strategies and actions to improve NJDOT's asset management business practices.
- Monitor and review, on an annual basis, the performance and condition of NJDOT assets and the NHS to evaluate progress toward achieving NHPP targets and the TAMP objectives.
- Communicate the investment strategies to executive management for consideration during New Jersey's Transportation Capital Program and STIP development processes.
- Communicate the implications of not addressing performance gaps, such as impacts on other performance areas, and consequences of not meeting NHPP targets.

3.2.2 Transportation Asset Management Directors Group

The TAMP directors group is comprised of NJDOT directors of the organizational units responsible for elements of the TAMP process. This group provides general direction to the TAMP effort, monitors progress, and supports resolution of issues requiring coordination across functional areas. The directors group supports change management, organizational development, and the implementation of the TAMP process as an agency-wide, enterprise-wide process, and provides guidance to both the Transportation Asset Management Steering Committee and the TAMP Team.

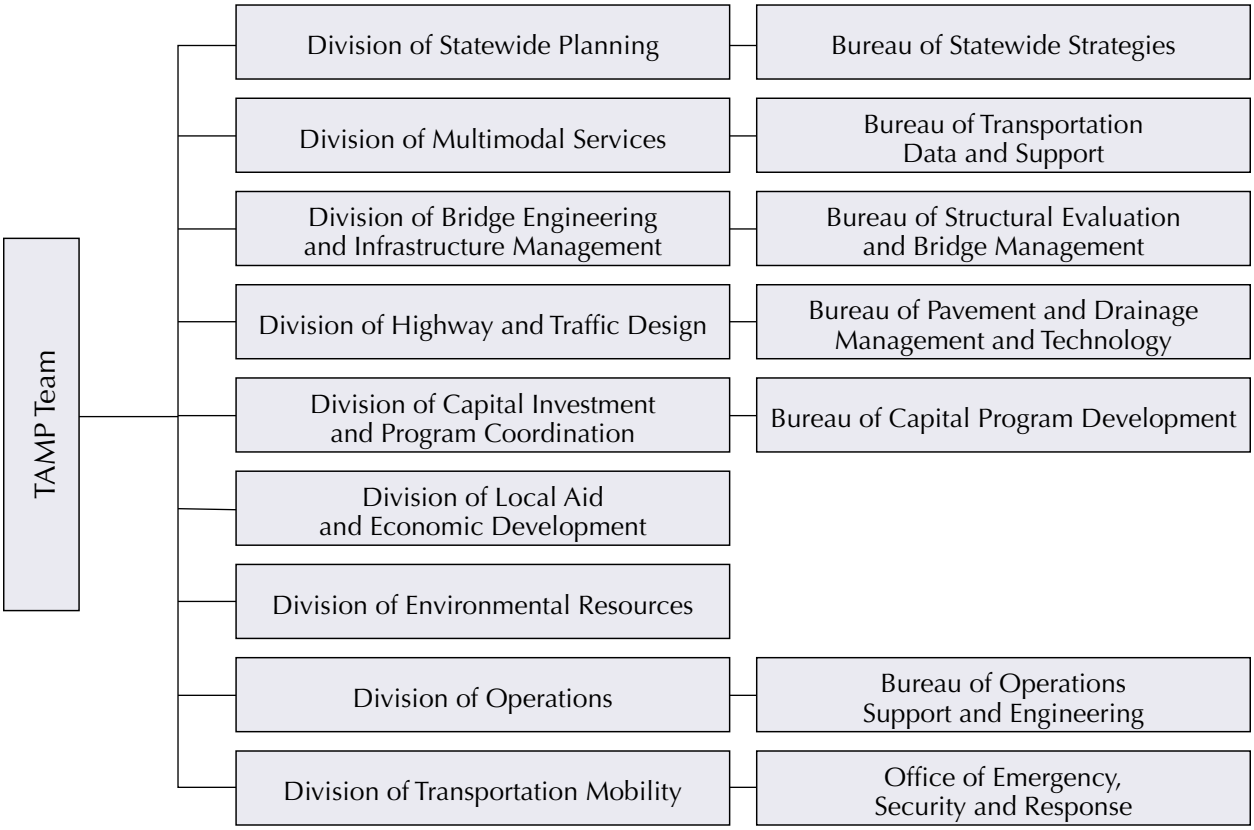
Key Responsibilities

- Review and support asset management policy and state of good repair objectives.
- Guide the TAMP effort, progress, and resolutions requiring coordination among different units.
- Manage agency-wide decisions to implement asset management in business activities.
- Assist in communicating the purpose and progress of the TAMP to other stakeholders.
- Support risk management process and provide guidance on risk mitigation strategies.

3.2.3 Transportation Asset Management Plan (TAMP) Team

The TAMP Team is a cross-functional team of program managers and key personnel with responsibilities for agency-wide asset management processes and asset management programs for specific asset classes identified within the TAMP. The team establishes NJDOT's overall asset management approach to address federal requirements and the NJDOT's business management needs and coordinates the implementation of enhancements to the TAMP process. The composition of the TAMP Team is displayed in Exhibit 3-2.

Exhibit 3-2: TAMP Team



Key Responsibilities

- Manage the TAMP process to meet federal and NJDOT business requirements.
- Propose, adopt, and manage technical procedures for the TAMP process.
- Evaluate investment scenarios to support the Transportation Asset Management Steering Committee in investment decisions for asset management in New Jersey's Transportation Capital Program and STIP development processes.
- Ensure that NJDOT asset managers are adopting and utilizing life cycle planning and life cycle planning strategies.
- Coordinate and collaborate with all non-NJDOT NHS owners and MPOs.
- Manage the implementation of TAMP strategies and actions.
- Manage and maintain the TAMP risk register and risk management process.

3.3 EXTERNAL STAKEHOLDER PARTICIPATION

The TAMP process includes an extensive communications and consultation program involving all 84 non-NJDOT NHS owners and the three MPOs in New Jersey.

3.3.1 Communication and Consultation with NHS Owners

The TAMP communications program informs and educates all 84 non-NJDOT NHS owners and three MPOs about the purpose and scope of the TAMP while encouraging their participation during TAMP development. The TAMP communications program is designed to enable NHS owners to:

- ***Become informed*** about the TAMP at key milestones.
- ***Provide data*** for inclusion in the TAMP.
- ***Review and provide input*** for TAMP analysis.
- ***Participate in target setting*** for NHPP measures.

In this iteration of the TAMP, non-NJDOT NHS owners were surveyed to provide data and asked to validate information regarding the NHS assets in their jurisdiction.

The following are the broad aims of the communications and consultative process:

Communication of Asset Management Purpose, Objectives, and Requirements – To enable meaningful input, communication, and involvement, including providing an overview of the TAMP; its purpose, objectives, and requirements; as well as the TAMP process and the role of non-NJDOT owners in the TAMP process. Communications are to afford non-NJDOT owners the opportunity to provide data on the NHS that they manage, to review and comment on TAMP analysis results, to provide input and comment on TAMP plan strategies, to comment on and provide input on the TAMP document, and to participate in the NHPP target-setting process.

Establish Ongoing Communication with NHS Owners – In the TAMP development process, non-NJDOT NHS owners receive project communications sent directly to a single point of contact within each organization. The point of contact serves as the liaison between the TAMP Team and their respective agencies. They are invited to participate in all stakeholder meetings; they direct project communications to applicable staff in their organization; they coordinate and manage the disposition of data requests; they coordinate their organization's review and validation of technical analysis; and they direct any input or comment from their organization on the TAMP to the TAMP Team.

Ensure Direct Engagement – The TAMP Team project management (provided by Division of Statewide Planning – Bureau of Statewide Strategies) communicates plan processes and updates on the TAMP development to all stakeholders to ensure expedient and centralized transmissions related to the TAMP. Email correspondence from project management to stakeholders provides information on the progress of the TAMP development and how the stakeholders fit into the process. Direct engagement may take the following forms:

- Face-to-face/telephone sub-group meetings.
- Stakeholder workshops/web-conferences.
- Periodic communication via email.

Ensure Quality Data – The TAMP Team directly enlists the support of the three MPOs to assist NJDOT during the TAMP communication process. Specifically, the MPOs assist in the collection of data and information from the various jurisdictions for NHS assets.

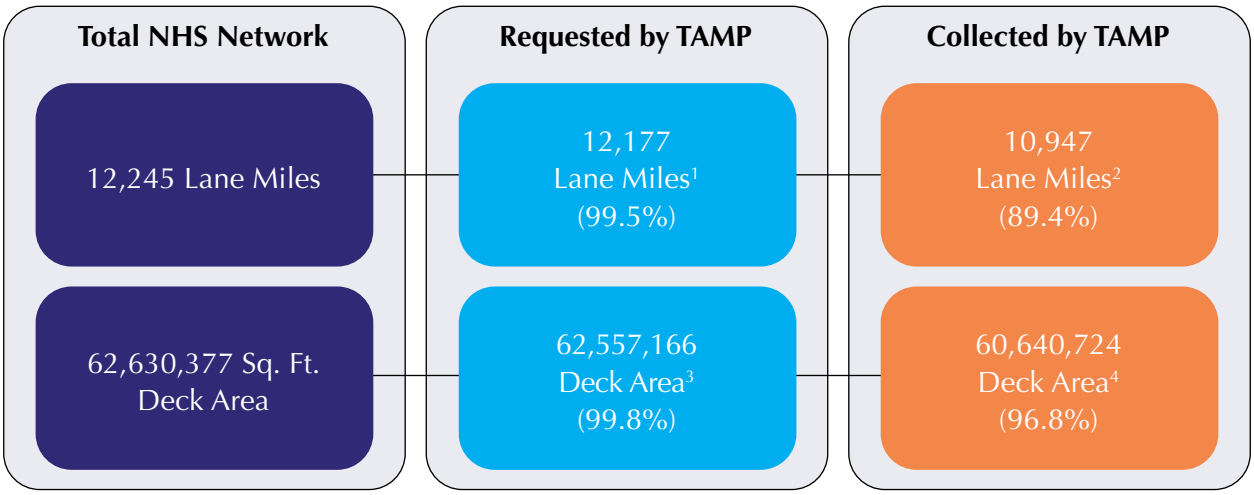
3.3.2 Data Collection

The TAMP process collects data from non-NJDOT NHS owners regarding their NHS asset inventory, including recent and planned expenditures on those NHS assets. The actions and data requested from each non-NJDOT NHS owner includes:

- Review and confirmation of the accuracy of NJDOT-provided maps and data relating to non-NJDOT NHS pavement and NBIS bridge assets, including roadway segment and bridge identifying information.
- Information relating to past project work, planned expenditures, and expected asset condition trends for non-NJDOT NHS pavement and NBIS bridge assets.

Exhibit 3-3 provides an overview of the data collection effort for the TAMP, representing the asset totals for which data was verified, and a more detailed summary is included in Appendix B.

Exhibit 3-3: Results from Data Collection Efforts with Non-NJDOT NHS Owners



[1] 67 lane miles not requested from municipal owners.

[2] 1,230 lane miles not collected from authority/commission (84 pavement lane miles) and county/municipal (1,146 lane miles) owners.

[3] 73,211 square feet of deck area not requested from other owners.

[4] 1,917,042 square feet of deck area not collected from authority/commission (1,392,058 sq. ft.) and county/municipal (524,984 sq. ft.) owners.

3.3.3 Additional Engagement

NJDOT staff regularly engaged external stakeholders regarding several transportation asset management- and transportation performance management-related events and activities, and the sharing of subject matter, including but not limited to the TAMP. Some of these events include National Highway Institute or FHWA training courses, webinars, and web conferences; NJDOT's quarterly MPO collaboration meetings; NJDOT Local Aid Division's New Jersey State Association of County Engineers quarterly meetings; and TAMP-related stakeholder coordination workshops; and other local events. The attendees included state agencies, authorities, MPOs, counties, municipalities, and the consultant community as needed.

3.4 POLICY AND OBJECTIVES

The TAMP documents NJDOT's asset management policy and state of good repair objectives, also known as the desired performance levels for each asset. These policies and objectives are intended to guide NJDOT's asset management activities and improve its ability to meet its mission of providing a world-class transportation system to support the infrastructure preservation core mission. The TAMP is a living document and its analytical activities serve as an ongoing means for not only achieving its policy and state of good repair objectives, but also as a continual source of information for NJDOT's broader planning efforts.

3.4.1 Policy Context

The preservation of highway infrastructure is central to the accomplishment of NJDOT's overall mission of providing a world-class transportation system. Infrastructure preservation is one of four core missions owned by NJDOT that are addressed in New Jersey's Transportation Capital Program and STIP development processes, as outlined in Exhibit 3-4; the other core missions owned by NJDOT include safety, mobility and congestion relief, and operations and maintenance.

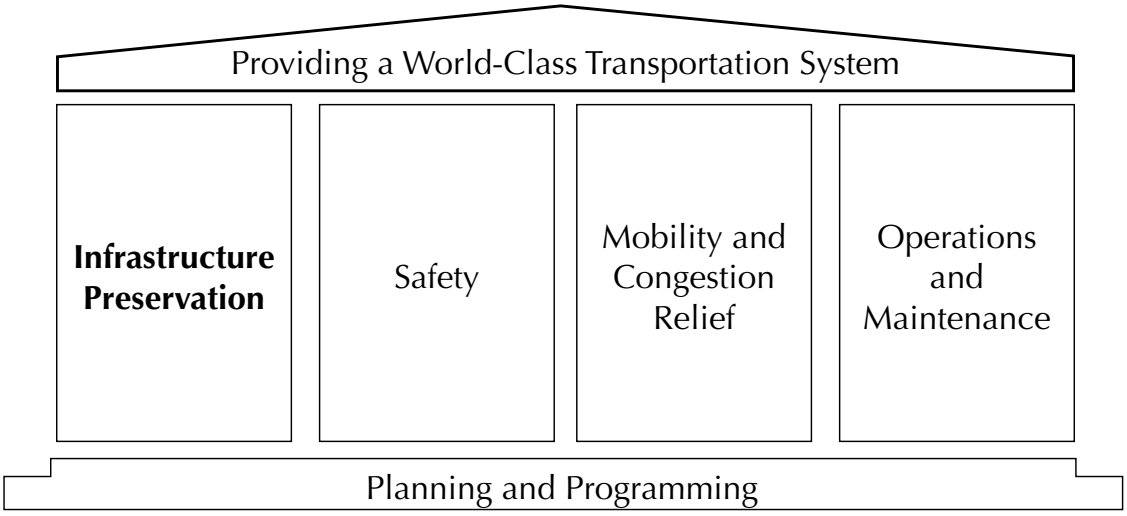
The TAMP provides the policy, measurable objectives, and implementation strategies that fulfill the infrastructure preservation core mission.

3.4.2 NJDOT Asset Management Policy

The TAMP recognizes that improving asset management practices and outcomes is a continuous process that requires top-down leadership reinforced by policy direction and management actions in concert with bottom-up staff involvement that continually refines practices and processes. The TAMP acknowledges that funding the transportation improvements required to achieve and maintain a state of good repair for the state's roadway network competes with funding to accomplish NJDOT's other objectives.

NJDOT is in the process of updating its transportation asset management policy to provide executive-level direction on expectations and requirements and communicate to internal and external stakeholders the agency's commitment to maintaining assets in a state of good repair. The agency is leaning toward a revised transportation asset management policy that places emphasis on a holistic approach toward addressing global warming and climate change, sustainability, equity, and resiliency. This approach will serve to support

Exhibit 3-4: NJDOT Core Missions and Overall Mission



Note: Fifth core mission is mass transit and belongs to NJ TRANSIT.

and complement the 10-year Statewide Capital Transportation Improvement Program, the Annual Transportation Capital Program, State Transportation Improvement Program and the Annual Study and Development Program.

NJDOT's current transportation asset management policy is presented below:

"The mission of NJDOT is to improve lives by improving transportation. Within that construct, NJDOT's core functions are to operate, maintain and improve the state's transportation system. Resources to effectively carry out those functions are finite: needs always exceed resources. It is, therefore, essential that NJDOT uses those resources in the most cost-effective manner.

NJDOT will utilize an asset management approach to preserve and improve NJDOT's infrastructure assets, focusing on roads, bridges and culverts."

Asset Management Policy Objectives

The following policy objectives have been established to support NJDOT's overall asset management policy. These policy objectives are designed to help NJDOT achieve and maintain a desired state of good repair through its underlying asset management activities. The TAMP is NJDOT's plan for advancing these policy objectives. They are accomplished through the programs and projects that preserve New Jersey's infrastructure included in the TAMP. Central to advancing the policy is the continuous improvement of NJDOT's organizational and analytical capabilities for asset management identified in the TAMP. Enhancements identified and documented as part of the TAMP development process will be integrated through the implementation and future updates to the TAMP.

Exhibit 3-5: Asset Management Policy Objectives

- Provide a safe, reliable roadway system.
- Achieve and maintain a state of good repair for transportation infrastructure assets.
- Manage the roadway system to reduce life cycle costs.
- Increase resilience of the system to the impacts of extreme weather events.
- Establish ongoing transportation asset management as data-driven process linking targets to outcomes through NJDOT performance-based planning and programing (i.e., New Jersey's Transportation Capital Program and 10-year STIP) processes.

Exhibit 3-6: TAMP State of Good Repair Objectives

Pavements

- 80 percent of pavement lane miles on State Highway System roadways in a state of good repair (*Good* or *Fair* condition) as measured by NJDOT's Condition Status performance metric.

Bridges

- 94 percent of State Highway System National Bridge Inspection Standard (NBIS) bridges (measured by deck area) in state of good repair (Good or Fair condition).
- 95 percent of National Highway System NBIS bridges (measured by deck area) in state of good repair (Good or Fair condition).

State of Good Repair Objectives

The TAMP defines the desired state of good repair for select highway assets in New Jersey in terms of measurable objectives for their condition. To achieve these objectives, NJDOT has adopted and continues to examine the most cost-effective life cycle and investment strategies, which will be detailed in later chapters. First, the performance measures that NJDOT uses as indicators of the state of good repair are described in *Chapter 2: Asset Inventory, Performance Measures, and Baseline Conditions*. Objectives in terms of these measures are outlined in Exhibit 3-6.In 2011, NJDOT developed a state of good repair objective for SHS pavements to achieve 80 percent of pavement lane miles in *Good* or *Fair* condition by CY 2021. Based on the condition data collected in 2021, NJDOT has largely achieved this objective, with 79 percent of pavement lane miles in *Good* or *Fair* condition. This represents an improvement of twelve percentage points

since 2016 (see Exhibit 2-20). This objective is being retained as the state of good repair objective for SHS pavements in the TAMP, providing continuity between NJDOT's condition-tracking efforts, as well as life cycle and investment strategy planning efforts.

As part of a strategic planning effort in 2011, NJDOT developed a state of good repair objective that no more than six percent of NJDOT bridges by deck area should be in *Poor* condition (minimum 94 percent in *Good* or *Fair* condition). Based on the condition data collected in 2021, NJDOT has made progress toward the SHS objective, with greater than 90 percent of SHS bridges by deck area in *Good* or *Fair* condition, which represents an improvement of more than two percentage points since 2016 (see Exhibit 2-27). This objective is being retained as the state of good repair objective for SHS bridges in the TAMP, thereby providing continuity between NJDOT's management processes and federal TAMP measurement and reporting requirements. A different state of good repair objective, a minimum 95 percent of bridges by deck area in *Good* or *Fair* condition, is set for the NHS.

3.4.3 TAMP Supports Progress Toward Achieving the National Goal Areas

In addition to establishing the Transportation Asset Management Planning process, MAP-21 set in motion the development of a structured set of goals and performance measures for the National Highway System that profoundly influences how states go about managing their transportation systems. In MAP-21, Congress established the following seven national goals as the focus for the Federal-Aid Program (23 USC 150(b)):

- Infrastructure condition
- Safety
- Congestion reduction
- System reliability
- Freight movement and economic vitality
- Environmental sustainability
- Reduced project delivery delays

In furtherance of these national goals, MAP-21 directed the FHWA to establish Transportation Performance Management (TPM) programs with performance measures, state target-setting, and progress reporting for the following measurement areas for the National Highway System:

- Pavement and bridge condition
- Safety
- Travel time reliability
- Truck travel time reliability
- Traffic congestion
- Pollutant emissions

Recognizing that infrastructure conditions can affect performance in other goal areas, and vice versa, the ongoing TAMP process supports efforts aimed at reducing performance gaps identified for other national goal areas by means of appropriately managing infrastructure asset conditions. The NJDOT performance management processes and analyses are currently being evaluated to determine methods for implementing all national goal areas and for evaluating synergies and trade-offs among the goals. NJDOT plans to expand the TAMP process to include additional asset classes and is currently evaluating which asset classes to add in the near term and when and how to begin applying the TAMP process to these classes.

3.4.4 Linking the TAMP to the 10-Year STIP

The TAMP is informed by, and will in turn inform, transportation planning and capital programming in New Jersey. The primary New Jersey program development products are the New Jersey STIP, the New Jersey statewide Transportation Capital Program, regional transportation improvement plans (produced by metropolitan planning organizations), and the capital plans of authorities and commissions that own NHS pavement and bridge assets. The TAMP investment strategies are intended to guide funding allocations in New Jersey's STIP development process, with implementation through New Jersey's Transportation Capital Program development process.

The TAMP process provides asset performance projections and recommended actions to the Transportation Asset Management Steering Committee and to NJDOT senior leadership. The Transportation Asset Management Steering Committee and NJDOT senior leadership review the projections and recommended actions, along with information related to other NJDOT objectives regarding the other core missions of safety, mobility and congestion relief, and operations and maintenance, to determine the best balance of investments to achieve policy objectives across asset classes within the New Jersey STIP.

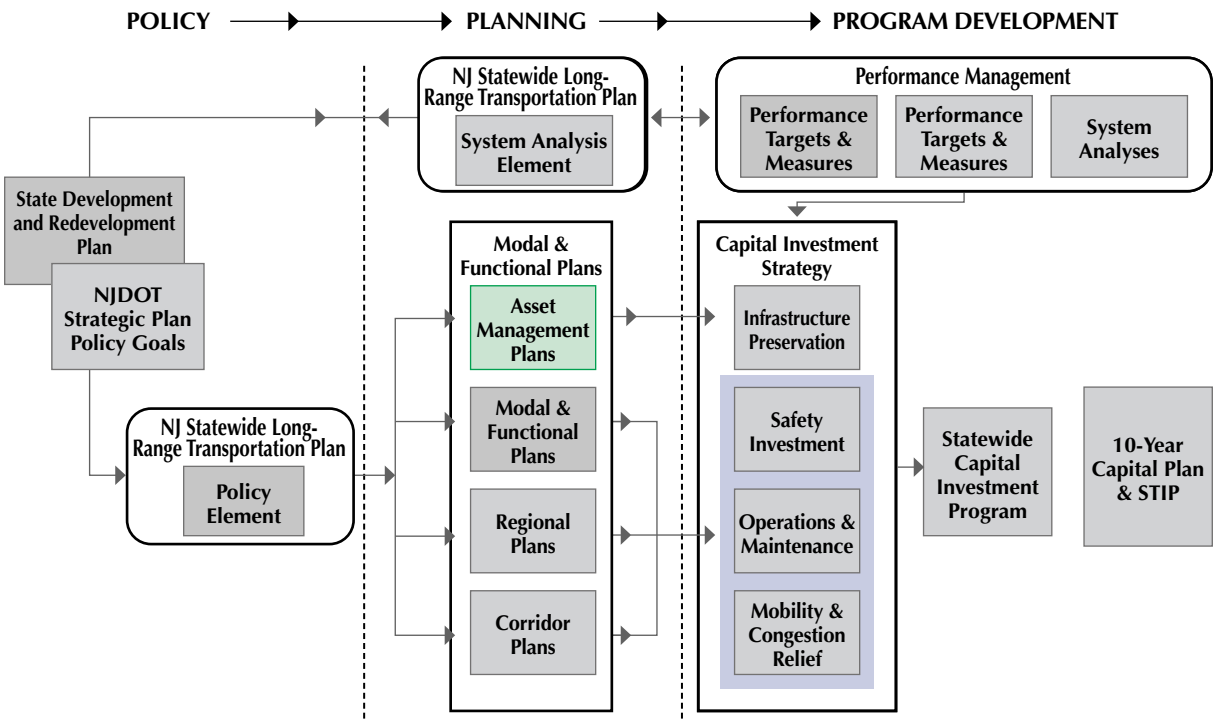
Exhibit 3-7 (on following page) depicts the role of the TAMP process in the NJDOT statewide planning process. The TAMP provides the framework for data-driven scenario analysis used in New Jersey's STIP development process. New Jersey will continue to work towards incorporating data from the TAMP process prior to allocating funding in the STIP development.

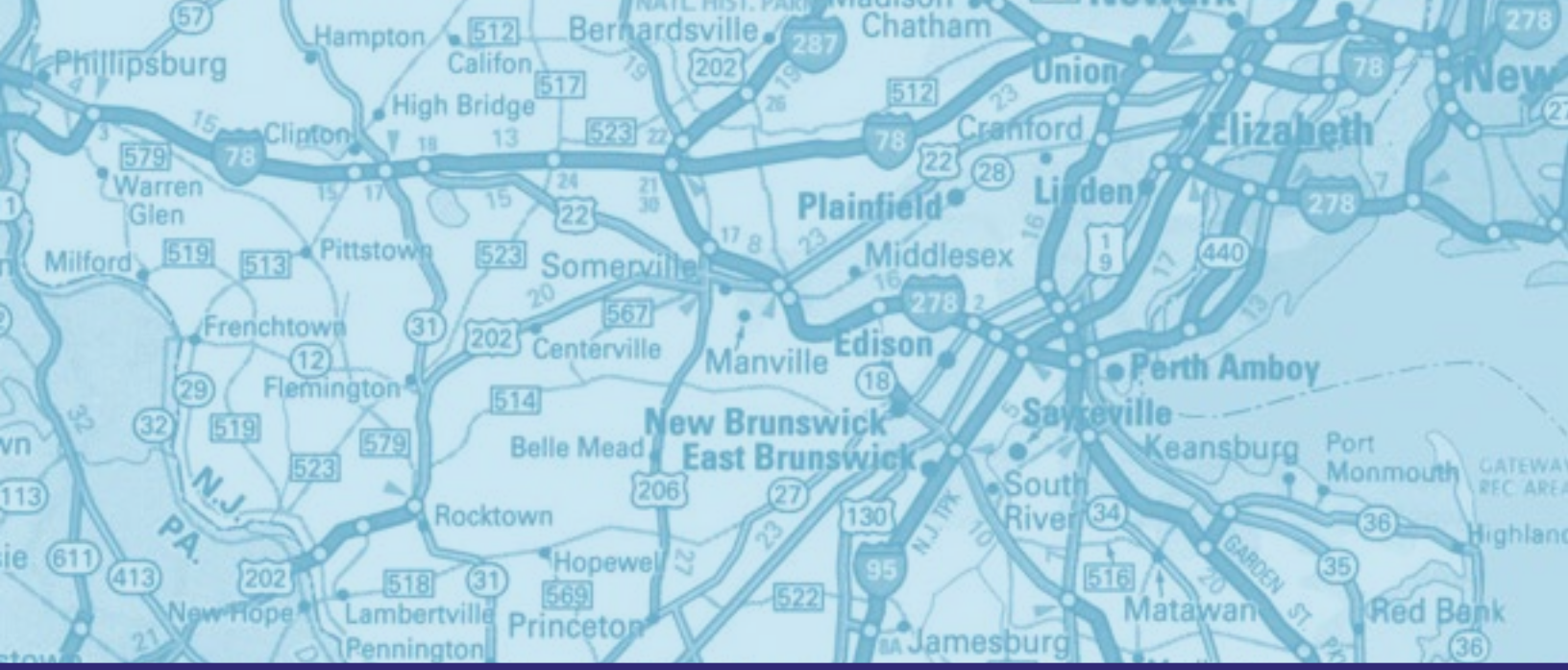
The development of future New Jersey STIPs will rely upon the collaborative effort of NJDOT senior leadership to determine funding priorities. The TAMP process offers the following support and guidance to NJDOT senior leadership:

- Describes current asset conditions by program category.
- Provides the source and use of funds by asset program category.
- Facilitates dialogue among NJDOT senior leadership about the STIP level of performance, trade-offs among asset programs, and impact on core missions.
- Initiates transition to performance-based resource allocation.

Upon completion, future New Jersey STIPs become the funding plan for addressing bridge and pavement performance through the programmatic allocation of resources.

Exhibit 3-7: TAMP Process Within NJDOT Integrated Planning Process

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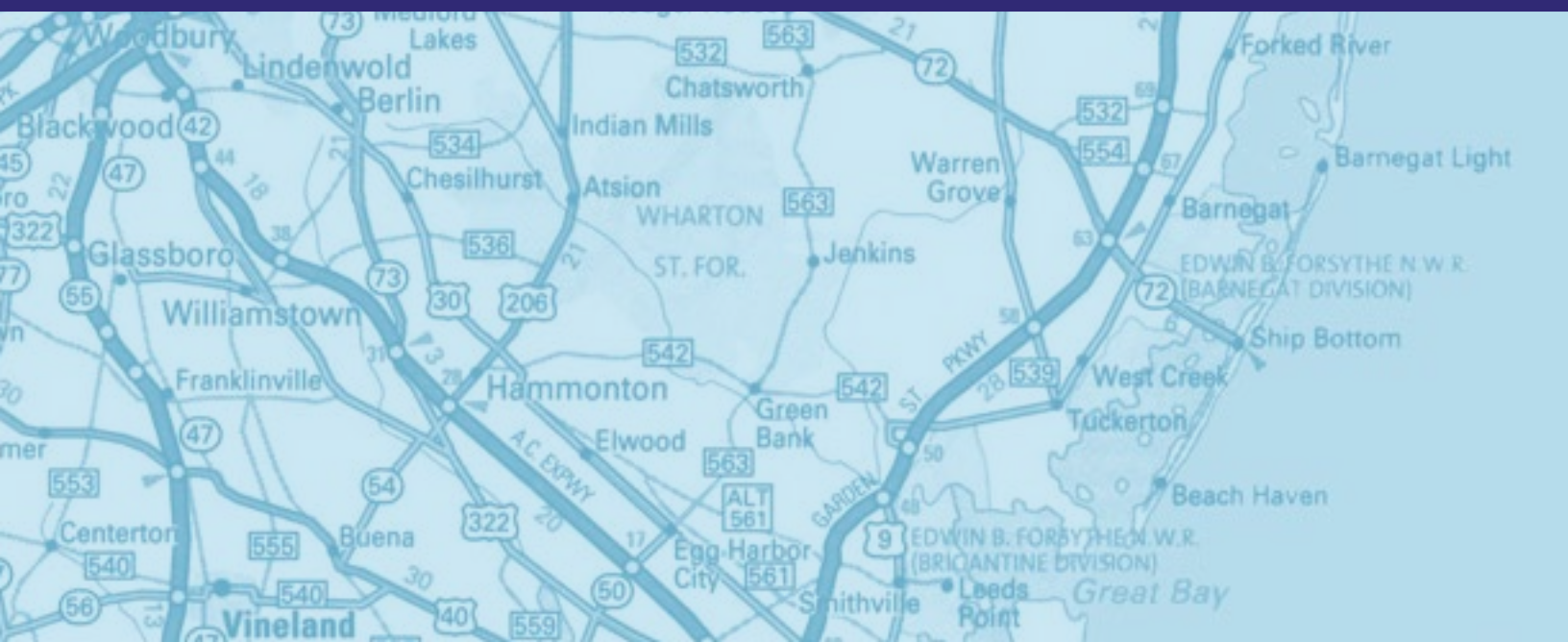
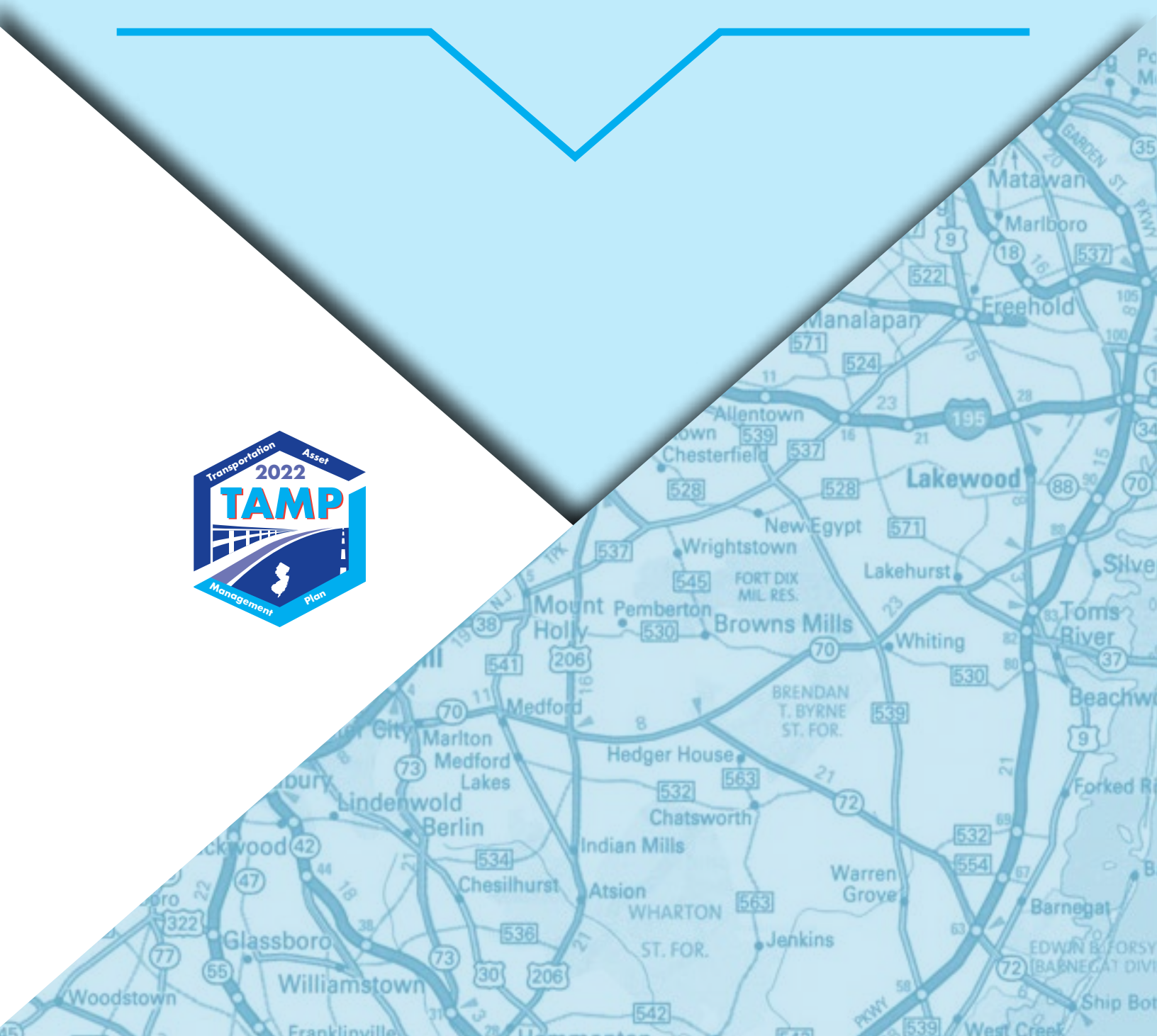
Hampton
Califon
Bernardsville
Chatham
Union
Elizabeth
High Bridge
Clinton
Cranford
Warren Glen
Plainfield
Linden
Milford
Pittstown
Somerville
Middlesex
Frenchtown
Centerville
Manville
Edison
Perth Amboy
Flemington
New Brunswick
East Brunswick
Sayreville
Belle Mead
Keansburg
Port Monmouth
Rocktown
South River
Hopewell
Lambertville
New Hope
Princeton
Jamesburg
Matawan
Red Bank
N.J.
PA.


Woodbury
Lindenwold
Berlin
Chatsworth
Forked River
Blackwood
Indian Mills
Chesilhurst
Atsion
Warren Grove
Barnegat Light
Barnegat
WHARTON ST. FOR.
Jenkins
Glassboro
Williamstown
Franklinville
Hammonton
Green Bank
Elwood
West Creek
Tuckerton
Ship Bottom
Beach Haven
Centerton
Buena
Egg Harbor City
Smithville
Leeds Point
Great Bay
Vineland
A.C. EXPWY
GARDEN ST. PKWY
EDWIN B. FORSYTHE N.W.R. (BARNEGAT DIVISION)
EDWIN B. FORSYTHE N.W.R. (BRIGANTINE DIVISION)

CHAPTER 4:
PERFORMANCE GAP ANALYSIS



BACKGROUND: Performance gap analysis is a federally required part of the Transportation Asset Management Plan (TAMP) [23 CFR Part 515.7(a)(3)27]. Performance gap is defined as "the gaps between the current asset condition and state targets for asset condition, and the gaps in system performance effectiveness that are best addressed by improving the physical assets" (23 CFR 515.5). The TAMP gap analysis consists of developing future performance projections and evaluating gaps between current and projected performance and state of good repair objectives.

4.1 OVERVIEW

Chapter 4 includes the following: (1) An overview of the gap analysis process, (2) A summary presentation of the gaps between baseline and projected performance objectives and targets, (3) Separate pavement and bridge sections with more detailed descriptions of the specific analysis processes and results. Separate gap analyses are conducted and presented for the SHS (i.e., state-maintained assets) and the NHS. The chapter concludes with a discussion of how the gap analysis results are used in planning and programming processes to improve investment decision-making.

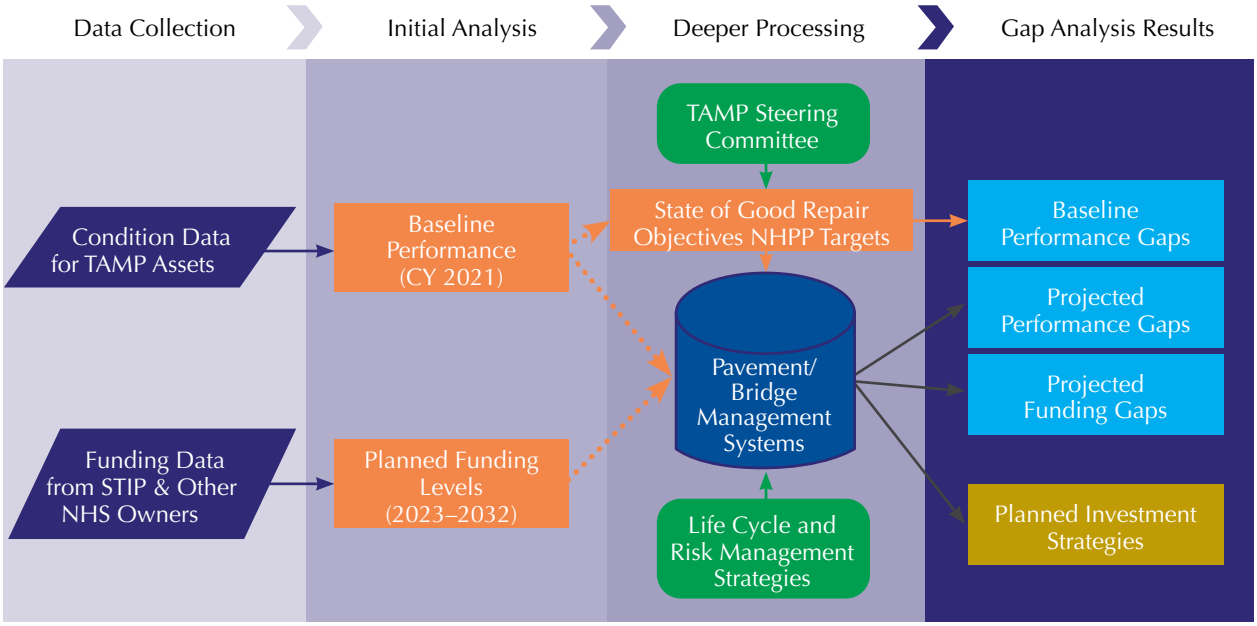
The gap analysis for the SHS includes projections of performance/estimation of funding needs for three different investment-level scenarios:

- **Planned Funding** — This scenario develops the projected performance based on the funding for the asset class, by year, in the 2023 Capital Program, as shown in the TAMP Financial Plan (*Chapter 7: Financial Plan*).
- **Funding to Achieve State of Good Repair Objectives** — This scenario identifies funding required to accomplish the TAMP state of good repair objectives for the SHS by the end of the TAMP analysis period (CY 2032).
- **Funding to Maintain CY 2021 Condition** — This scenario determines the funding required to maintain the baseline (CY 2021) level of performance of the SHS.

The TAMP gap analysis process is depicted in Exhibit 4-1 on the next page.

- **Data Collection —** Asset condition data are gathered using the data collection and reporting processes as described in *Chapter 2: Asset Inventory, Performance Measures, and Baseline Conditions*. Planned funding for the SHS is from the 2023 Capital Program and is presented in *Chapter 7: Financial Plan*. Funding for non-NJDOT owners of NHS assets is collected through a communications outreach program with owners and is detailed in *Chapter 7: Financial Plan*.
- **Initial Analysis —** Baseline asset performance is determined from CY 2021 condition data for both the SHS (NJDOT-owned and/or maintained assets) and the entire NHS, regardless of ownership. Planned funding is established in *Chapter 7: Financial Plan*. The initial analysis includes an examination of recent historical performance trends along with recent spending levels.

Exhibit 4-1: TAMP Gap Analysis Process for the NHS and SHS



- **Deeper Processing —** A review of historical performance and spending provided guidance in determining the TAMP state of good repair objectives adopted by the Transportation Asset Management Steering Committee. Pavement and bridge management systems apply life cycle and risk management strategies (see *Chapter 5: Life Cycle Planning*) to develop projected performance of SHS pavement and bridge assets for each year of the analysis period under planned funding levels.

  NJDOT management systems are used to estimate the gaps in performance and/or funding using the three investment scenarios described previously. Funding projections developed through outreach with non-NJDOT owners of NHS assets are applied in the context of historical performance trends to develop performance projections for the non-NJDOT owned NHS assets.

- **Gap Analysis Results —** The gap analysis results identify (1) the difference between baseline performance and projected performance for each asset and the state of good repair objectives, (2) the difference between projected performance of select assets and NHPP targets, (3) the gaps in system performance revealed through the analysis, and, (4) the gaps in funding to achieve the state of good repair objectives.

The gap period extends to FY 2032. Performance is projected from the CY 2021 baseline through CY 2032. Planned funding levels for NJDOT follow the state fiscal year (July 1—June 30) as they are determined from the 2023 Capital Program that also follows the state fiscal year. The analysis applies a lag between the funding amount (in state fiscal year) and performance effect (in "Collection Year" which is also the "calendar year"). The typical lag for pavement projects is at least one year and the lag for bridge projects is at least two years, and can be considerably longer.

4.2 GAP ANALYSIS RESULTS SUMMARY

4.2.1 Pavement Gap Summary

Exhibits 4-2 through 4-4 present a summary of the pavement gap analysis results. Notable findings from the analysis are as follows:

- SHS pavement performance will remain relatively constant beginning at 78.9 percent of pavement lane miles in a state of good repair in CY 2021 and ending at 80.5 percent by CY 2032.
- For the SHS, all three funding scenarios achieve similar performance with the planned funding meeting the state of good repair objective and maintaining the current condition.
- Planned funding exceeds optimized SOGR investment needs by approximately 5.5 percent. This "excess" funding is largely allocated to reconstruction projects currently in the project delivery pipeline that address pavement structure to minimize life cycle costs and meet other strategic objectives.
- Interstate and non-Interstate NHS pavements are not projected to meet most of the aspirational NHPP targets but will maintain a low percentage of *Poor* pavement throughout the TAMP analysis period. Modeling does not include year-end funding reallocations that often increase pavement preservation spending and sustain the percentage of *Good* pavement.

The SHS pavement performance relative to the SOGR is expressed in terms of NJDOT performance measures. The NHS performance relative to NHPP two- and four-year targets is expressed in terms of the federal NHPP performance measures. Both sets of performance measures are defined in detail in *Chapter 2: Asset Inventory Performance Measures, and Baseline Conditions*. Pavement gap analysis methods and SHS pavement performance projections under three investment scenarios are detailed in Sections 4.3.2 and 4.3.3.

The pavement gap analysis indicates that interstate pavements on the NHS in New Jersey will meet the additional condition requirement of 23 CFR 490 that no more than five percent of interstate pavements are in *Poor* condition during the entire TAMP analysis period.

Exhibit 4-2: SHS Pavement — State of Good Repair Gap Analysis Summary

Performance	Baseline CY 2021	CY 2032 Planned
NJDOT's Condition Status Measures	**Good or Fair**	**Good or Fair**
State of Good Repair Objective (%)	80.0	80.0
Condition (%)	78.9	80.5
Performance Gap[1] (percentage points)	**-1.1**	**+0.5**
Investment	**Average Annual Investment, FY 2023–2032**	
Investment Required to Achieve Objective	$340 million[3]	
Planned Funding[2]	$360 million[3]	
Funding Gap	**+$20 million**[4]	

Note: SHS includes all NJDOT-owned and/or maintained pavements.
[1] Positive and negative signs indicate extent of performance above and below goal respectively.
[2] Consistent with 2023 Capital Program.
[3] Total includes design.
[4] Indicates amount exceeding funding required to meet a state of good repair goal.

Exhibit 4-3: NHS Interstate Pavement — Target Gap Analysis Summary

	Two-Year (CY 2023)		Four-Year (CY 2025)	
NHPP Measures	**Good**	**Poor**	**Good**	**Poor**
Target (%)	75.7	0.1	77.0	0.1
Planned Condition (%)	74.9	0.0	67.3	0.3
Performance Gap[1] (percentage points)	**-0.8**	**+0.1**	**-9.7**	**-0.2**

Note: NHS includes all pavement assets regardless of ownership.
1 Positive and negative signs indicate extent of performance above and below goal respectively.

Exhibit 4-4: NHS Non-Interstate Pavement — Target Gap Analysis Summary

	Two-Year (CY 2023)		Four-Year (CY 2025)	
NHPP Measures	**Good**	**Poor**	**Good**	**Poor**
Target (%)	41.6	4.8	43.0	4.0
Planned Condition (%)	31.1	5.5	24.0	5.9
Performance Gap[1] (percentage points)	**-10.5**	**-0.7**	**-19.0**	**-1.9**

1 Negative signs indicate extent of performance below goal..

4.2.2 Bridge Gap Summary

All bridge gaps are expressed in terms of NHPP performance measures for bridges. These performance measures are defined in detail in *Chapter 2: Asset Inventory Performance Measures, and Baseline Conditions*. Bridge gap analysis methods and SHS bridge performance projections under the three investment scenarios are detailed in Sections 4.4.2 and 4.4.3.

The following findings are summarized from the bridge gap analysis results shown in Exhibits 4-5 through 4-7:

- SHS bridge performance will improve from 90.5 percent of NBIS bridges by deck area in a state of good repair (*Good* or *Fair*) in CY 2021 to 93.6 percent by CY 2032.
- For the SHS, a 0.4 percentage point shortfall from the state of good repair objectives remains by the end of the TAMP analysis period.
- NHS bridges will meet the federal performance requirement of no more than 10 percent *Poor* by deck area throughout the TAMP analysis period.
- NHS bridges will meet the NJDOT objective of at least 95 percent *Good* or *Fair* by the end of the TAMP analysis period.

Exhibit 4-5: SHS NBIS Bridges – State of Good Repair Gap Analysis Summary

Performance	Baseline CY 2021	CY 2032 Planned
NHPP Measures[1]	**Good or Fair**	**Good or Fair**
State of Good Repair Objective (%)	94.0	94.0
Condition (%)	90.5	93.6
Performance Gap[1] (percentage points)	**-3.5**	**-0.4**
Investment	**Average Annual Investment, FY 2023–2032**	
Investment Required to Achieve Objective	$790 million[3]	
Planned Funding[2]	$755 million[3]	
Funding Gap	**-$35 million**[3]	

Note: SHS Bridges include all NJDOT maintained NBIS bridges.

[1] Using measures defined in 23 CFR 490. Positive and negative signs indicate extent of performance above and below goal respectively.

[2] Consistent with FY 2023 NJ Transportation Capital Program. Includes funding for NBIS bridge maintenance, preservation, rehabilitation, replacement. Excludes funding for inspections, administration of the bridge management system, and management of other structures (culverts, sign structures, etc.), which averages approximately $45 million per year. All dollar totals are rounded to the nearest multiple of $5 million.

[3] Indicates amount of additional funding required to meet a state of good repair goal. See Section 4.4.3 for an important caveat about the size of the funding gap in light of the anticipated completion of the Pulaski Skyway Rehabilitation Project.

Exhibit 4-6: NHS NBIS Bridges — Target Gap Analysis Summary

	Two-Year (CY 2023)		Four-Year (CY 2025)	
NHPP Measures[1]	**Good**	**Poor**	**Good**	**Poor**
Target (%)	21.3	6.6	23.0	6.0
Planned Condition (%)	21.3	6.6	23.0	6.0
Performance Gap[1] (percentage points)	**0.0**	**0.0**	**0.0**	**0.0**

Note: NHS bridges includes all NBIS bridges carrying the NHS, regardless of ownership.

[1] Using measures defined in 23 CFR 490. Positive and negative signs indicate extent of performance above and below goal respectively.

Exhibit 4-7: NHS NBIS Bridges — State of Good Repair Gap Analysis Summary

	Baseline (CY 2021)	CY 2032 Planned
NHPP Measures[1]	**Good or Fair**	**Good or Fair**
State of Good Repair Objective (%)	95.0	95.0
Condition (%)	93.4	95.3
Performance Gap[2] (percentage points)	**-1.6**	**+0.3**

Note: NHS bridges includes all NBIS bridges carrying the NHS, regardless of ownership.
[1] Using measures defined in 23 CFR 490. Positive and negative signs indicate extent of performance above and below goal respectively.

4.3 PAVEMENT PERFORMANCE GAP ASSESSMENT

4.3.1 Pavement Performance Measures

NJDOT assesses pavement performance using the measures defined in *Chapter 2: Asset Inventory, Performance Measures, and Baseline Conditions*. NJDOT uses performance measures based on its Condition Status performance metric for the SHS, which provides the agency with more actionable information in setting and applying its pavement management strategies. This measure differs from the federally required NHPP measures for the NHS. To address the difference in measures, NJDOT has developed processes that allow its pavement management system to correlate the NJDOT Condition Status measures to the NHPP measures for the NHS portion of the SHS.

4.3.2 Pavement Gap Analysis Methods

Pavement gap analysis has been a routine practice for NJDOT beginning in 2011 when state of good repair objectives were first established. NJDOT has tracked the condition of SHS pavements and compared the result to the (pre-TAMP) objective of achieving 80 percent of pavement lane miles in *Good* or *Fair* condition by CY 2021. The gap analysis data has been used to continually adjust pavement life cycle planning and investment strategies.

The NJDOT Pavement Management Unit uses a pavement management system (PMS) (described in greater detail in *Chapter 5: Life Cycle Planning*) to forecast the performance of the SHS under various combinations of life cycle strategies and funding scenarios. This helps to determine the best long-term investment approach to achieve and sustain the desired performance. The results of the gap analysis, risk analysis and the TAMP financial plan are used to establish investment strategies for pavements. Appendix C describes the technical approach used to support analysis using the NHPP measures for gap analysis of the full NHS pavement network.

Total planned funding for the four work types of pavement maintenance, preservation, rehabilitation, and replacement approximates $360 million per year for the TAMP analysis period FY 2023–2032. Actual funding levels for each year included in the 2023 Capital Program are used in the analysis as presented in *Chapter 7: Financial Plan*. Annual funding levels vary substantially from the $360 million average. Early years generally have higher

funding amounts due to the additional funding provided by the Bipartisan Infrastructure Law. Isolated funding spikes occur in later years where large investments are planned for several major reconstruction projects currently in the delivery pipeline.

The pavement analysis uses the funding in aggregate and does not restrict project selection to amounts consistent with allocations in the 2023 Capital Program to each work type. The resulting optimized distribution of spending totals among work types is presented in *Chapter 8: Investment Strategies*.

4.3.3 Projected Pavement Performance and Gaps

The following sections further elaborate on the baseline and projected performance gaps for SHS and NHS pavements. Analysis results for the SHS are provided in terms of NJDOT's Condition Status performance metric, and the results for NHS pavements are provided in terms of NHPP measures.

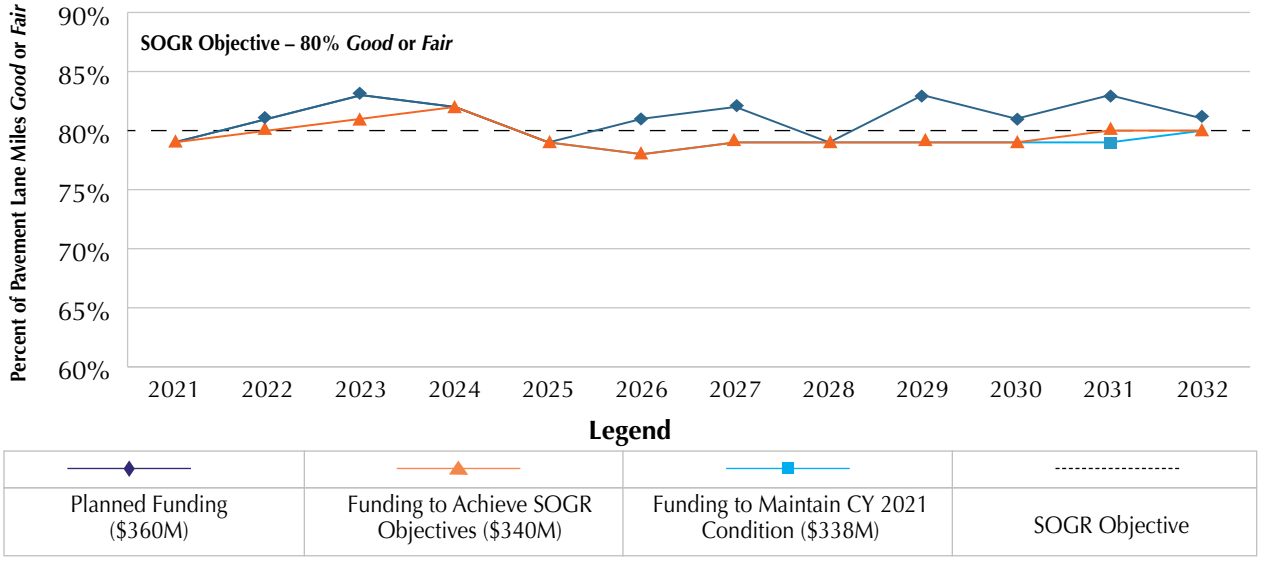
Baseline SHS Performance

As of CY 2021 data, 78.9 percent of NJDOT pavements are in *Good* or *Fair* condition, as shown in Exhibits 4-8 and 4-9. While this is slightly below the desired goal of 80 percent *Good* or *Fair,* NJDOT has substantially achieved its SOGR for pavement.

Projected SHS Performance

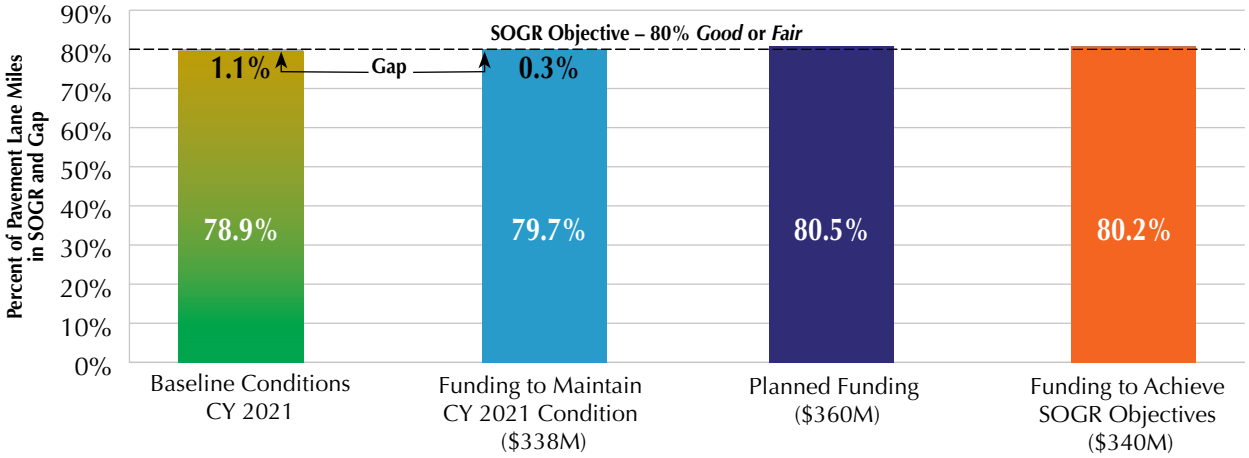
The projected outcomes of the three investment scenarios described in Section 4.1 are summarized in Exhibits 4-8 and 4-9. Exhibit 4-8 presents a line graph depicting the year-by-year performance of pavement on the SHS for each of the three investment scenarios. Exhibit 4-8 illustrates both of the following: (1) the baseline context for the projected performance, and (2) the projected paths of each investment scenario. Exhibit 4-9 presents baseline performance and performance at the end of the analysis period for each investment scenario, providing a comparison of the performance gaps for each scenario.

Exhibit 4-8: Projected SHS Pavement Performance Under Investment Scenarios – CY 2021–2032



Notes: SOGR = State of good repair. The vertical scale begins at 60%; changes over time and differences are exaggerated by the shortened scale.

Exhibit 4-9: SHS Pavement Performance by Investment Scenario — CY 2032 and Baseline CY 2021



Notes: SOGR = State of good repair. SHS includes all NJDOT-maintained pavement assets. The "Funding to Maintain CY 2021 Conditions" scenario does not yield the exact same performance as CY 2021 conditions because of the way the PMS software works; funding must be input and adjusted iteratively until the condition percentage is met. 79.7% *Good* or *Fair* was regarded as sufficiently close to CY 2021 conditions.

The scenario analysis shown in Exhibit 4-9 reveals that all three funding scenarios project similar performance and maintain the desired state of good repair. It should be noted that the scenario to achieve the SOGR and the scenario to maintain the current condition are almost identical because the current condition at 78.9 percent *Good* or *Fair* pavement has substantially met the SOGR condition of 80 percent *Good* or *Fair*.

The planned funding scenario is projected to result in relatively stable conditions, which also maintains the SOGR. The planned funding scenario is based on the actual annual planned investments identified in the capital program, which vary substantially from year to year and include some significant investments in reconstruction projects. These reconstruction projects are cost-effective in the long term based on life cycle planning strategies to reduce the whole life maintenance cost of individual pavement sections, but in the near term, they require a large investment to treat a small number of lane miles.

The result is that although the average annual planned funding level of $360 million would suggest an increase in performance by the end of the analysis period over the $338 and $340 million optimized scenarios, the additional funding in the planned funding scenario is dedicated to reconstruction projects which do not immediately or commensurately contribute to maintaining the SOGR at the network level. While these projects do improve pavement conditions, a significant amount of the funding towards these projects, goes to improving the safety and functionality of the highway network at these locations.

Projected NHS Performance

For NHS pavements, NJDOT is required to establish two- and four-year targets, with conditions reported utilizing NHPP measures, as described in *Chapter 2: Asset Inventory, Performance Measures, and Baseline Conditions*. The measures report pavement condition in terms of the percentage of pavements in *Good* and *Poor* condition on interstate and non-interstate NHS pavements. The reporting

requirements are applicable to all pavements on the NHS, regardless of ownership.

In 2022, NJDOT established NHS performance targets for the second reporting period (CY 2023 and CY 2025). Federal Transportation Performance Management regulations under 23 USC 490 establish that no more than five percent (5%) of lane miles of interstate pavement should be rated *Poor*.

Exhibits 4-10 and 4-11 present projected performance of interstate and non-interstate NHS pavements over the TAMP analysis period and the established targets for the percentage of *Good* and *Poor* pavement for each. The projections shown in these exhibits represent a combination of investments planned to be made by NJDOT and non-NJDOT owners of NHS assets in the State of New Jersey, as described

Exhibit 4-10: NHS Interstate Pavement Performance and NHPP Targets — CY 2021 to CY 2032

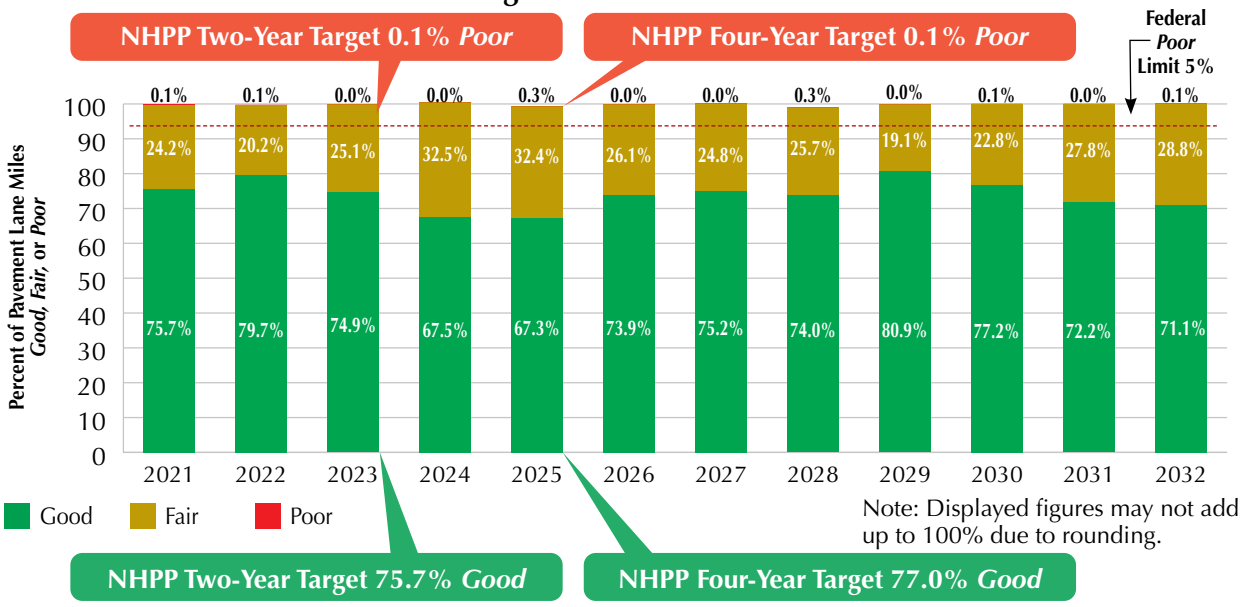
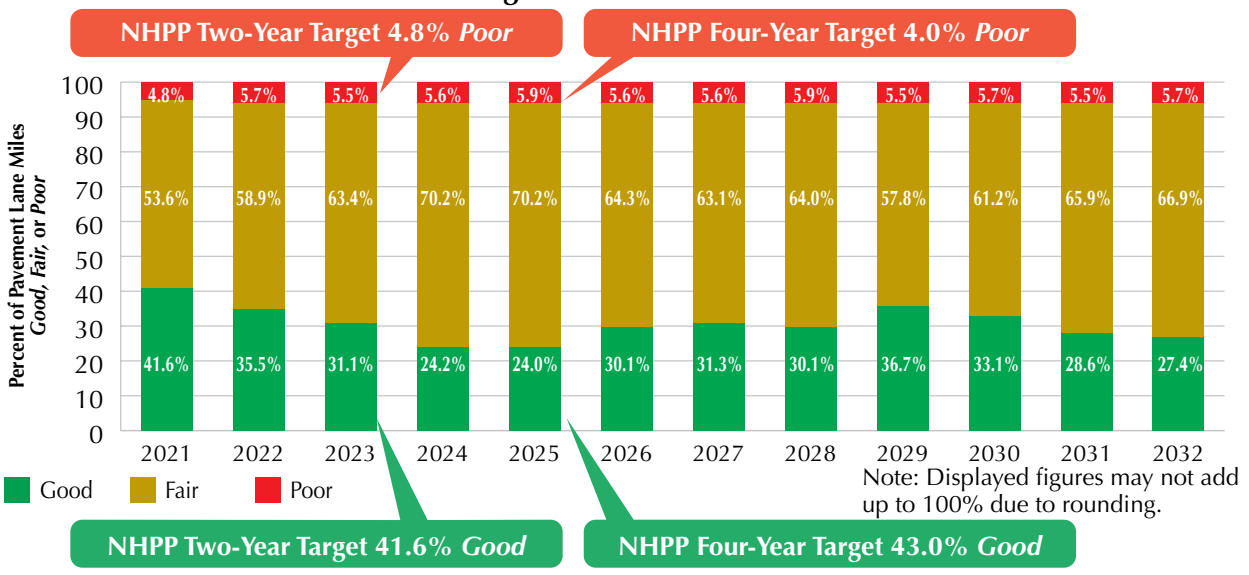


Exhibit 4-11: NHS Non-Interstate Pavement Performance and NHPP Targets — CY 2021 to CY 2032



in *Chapter 7: Financial Plan*. The trends in these graphs show a steady state in the percentage of pavement in *Poor* condition, with projected declines in the percentage of pavement in *Good* condition. It should be noted that the modeling does not account for year-end funding reallocations based on unavoidable changes in project deliverability. These reallocations often allow the Department to deliver additional pavement preservation projects each year which substantially contribute to maintaining the percentage of pavements in *Good* condition. NJDOT and other owners will continue to prioritize preservation of pavements over the long term, as detailed in *Chapter 5: Life Cycle Planning*. NJDOT began implementing this approach approximately 10 years ago, and the long-term benefits are evident in the consistent improvement in network condition over that period including substantially attaining the Department's goal of achieving a state of good repair on its SHS pavement network by 2021.

4.4 NBIS BRIDGE PERFORMANCE GAP ASSESSMENT

4.4.1 NBIS Bridge Performance Measures

All bridge gaps are expressed in terms of NHPP performance measures for bridges. These performance measures are defined in detail in *Chapter 2: Asset Inventory Performance Measures, and Baseline Conditions*.

4.4.2 NBIS Bridge Gap Analysis Methods

The NJDOT Bureau of Structural Evaluation and Bridge Management (SEBM) uses various bridge management system (BMS) tools to implement life cycle planning and formulate its investment strategy. The technical capabilities, details, and uses of the BMS tools are summarized in *Chapter 5: Life Cycle Planning*.

Total expected funding for work types of maintenance, preservation, rehabilitation, and replacement approximates $755 million per year on average from FY 2023 to FY 2032. Actual funding levels in each year from the 2023 New Jersey Transportation Capital Program are used in the analysis (and presented in *Chapter 7: Financial Plan*).

The BMS analysis is focused on the SOGR performance effects of the projected funding for Rehabilitation and Replacement. Maintenance and preservation work, while critical to good asset management, is not expected to determine whether a bridge's state of good repair status over the limited time horizon of the TAMP analysis period.

State of good repair performance projection begins with an identification of the funding planned for existing programmed projects and a projection of when they will be completed, and the bridge condition will improve. Spending on programmed projects accounts for much of the planned funding for bridge rehabilitation and replacements.

The BMS analysis considers the balance of available funding tofor replacement and rehabilitation (net of programmed project funding) in aggregate. That is, the BMS analysis does not restrict project selection to amounts consistent with each of these two Capital Program funding categories. The resulting distribution of spending totals between rehabilitation and replacement work types is presented in *Chapter 8: Investment Strategies*.

There is a lag between funding and its effect on performance. Programmed projects generally have funding distributed over multiple years, representing different project phases from concept development

through construction. Major rehabilitation or replacement projects on very large-scale bridges can take place over many years. Modeling for new (i.e., not programmed) projects applies the total cost in a single year and takes credit for the condition improvement two years later.

4.4.3 Baseline and Projected NBIS Bridge Performance and Gaps

The following discussion elaborates on the baseline and projected performance gaps for SHS and NHS bridges. Exhibit 4-12 presents the year-by-year performance of SHS bridges for each of the investment scenarios. The performance graph begins in CY 2018 to provide historical context to the projections. Exhibit 4-13 presents a bar chart displaying comparisons among baseline (CY 2021) asset performance and projected end year (CY 2032) asset performance for each investment scenario.

Baseline SHS Performance

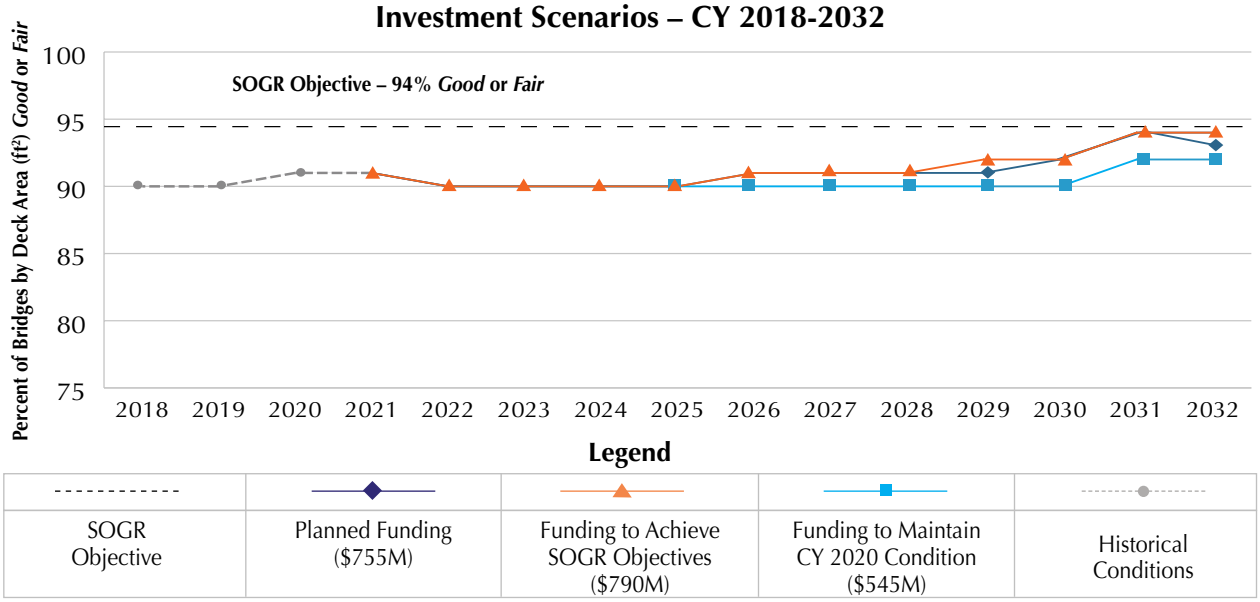
Exhibit 4-12 shows that the historic performance was marked by a generally increasing trend from CY 2018 to the baseline year, but with a slight decrease from CY 2020 to CY 2021. Despite the genrealeral increasing trend, the CY 2021 performance remains below the state of good repair of objective.

Exhibit 4-13 depicts the 3.5 percentage point gap between the CY 2021 baseline performance (90.5% of deck area in *Good* or *Fair* condition) and the state of good repair objective of 94 percent.

Projected SHS Performance

The Pulaski Skyway Rehabilitation Project exerts a strong influence on performance projections in all three investment scenarios. With costs exceeding one billion dollars, the rehabilitation of the Pulaski Skyway is one of NJDOT's largest-ever construction projects. The

Exhibit 4-12: Projected SHS NBIS Bridge Performance Under Investment Scenarios – CY 2018-2032



Notes: SOGR = State of good repair. SHS Bridges include all NJDOT-maintained NBIS bridges. The vertical scale begins at 75%; changes over time and differences are exaggerated by the shortened scale.

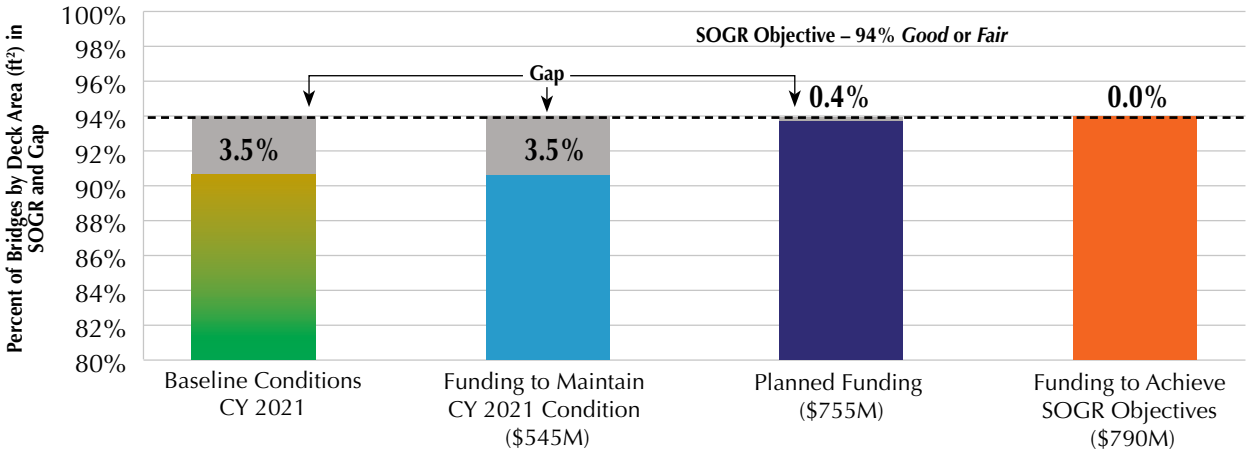
rehabilitation work has been ongoing a number of years prior to the TAMP analysis period and will continue through FY 2032. By 2031, the rehabilitation will be sufficiently completed to result in over 778,000 square feet of deck area (over 2% of all SHS deck area) to move into a state of good repair. Because of the extensive prior investment in this project, the full costs to achieve this providing a substantial increase in network performance are not reflected in the costs shown in this TAMP.

Because it takes several years to develop a bridge rehabilitation or replacement project, the early years of the TAMP analysis period are limited to projects that are already programmed. This limitation, combined with the two-year lag from funding to when the credit is taken for improved condition for modeling of new projects, is reflected in the overlap of the performance of the four investment scenarios in the earlier years of the TAMP analysis period. Late in the analysis period (CY 2031), the expected substantial completion of the Pulaski Skyway Rehabilitation Project has a significant effect on performance of all scenarios. The dramatic jump in performance that occurs when this project is completed attests to the challenge of projecting bridge network performance. Very large bridges can have significant impacts on network performance, while their deterioration to *Poor* from *Fair* can be difficult to predict, and the completion date of planned projects can be very uncertain.

The "Funding to Maintain Baseline Performance" scenario is approximated by limiting rehabilitation and replacement funding to the projects that are already programmed. This funding path achieves a fairly stable level of performance, with a jump upon substantial completion of the Pulaski Skyway project in 2031.

In all scenarios, performance declines slightly in the last year of the TAMP analysis period. This decline reflects the continuous need for substantial investment to achieve and sustain the desired state of good repair. In the long run (i.e., well beyond the TAMP

Exhibit 4-13: SHS NBIS Bridge Performance by Investment Scenario — Baseline CY 2021 and Projected CY 2032



Notes: SOGR = State of good repair. SHS includes all NJDOT-maintained bridges.

analysis period), the increased emphasis that NJDOT has placed on preservation should be reflected in a reduction in the level of major rehabilitation and renewal work required. However, in at least the first few years beyond the TAMP analysis period, a continued decline in performance can reasonably be expected, even if the current high levels of funding could be sustained. If funding declines back to its pre-Infrastructure Investment and Jobs Act (IIJA) levels, continued performance declines from the 2031 high point are a near certainty for the early years of the next decade.

Exhibit 4-13 summarizes the baseline and projected performance gaps in achieving the TAMP state of good repair objective for SHS bridges under the three investment scenarios. The gap shown for the scenario to maintain baseline performance uses the baseline gap. In reality, the performance is projected to vary slightly around this gap, and actually to finish with a lower gap in the final year.

The "Planned Funding" scenario achieves a substantial improvement over the baseline, and is projected to nearly achieve the 94% state of good repair objective in the last two years of of the TAMP analysis period.

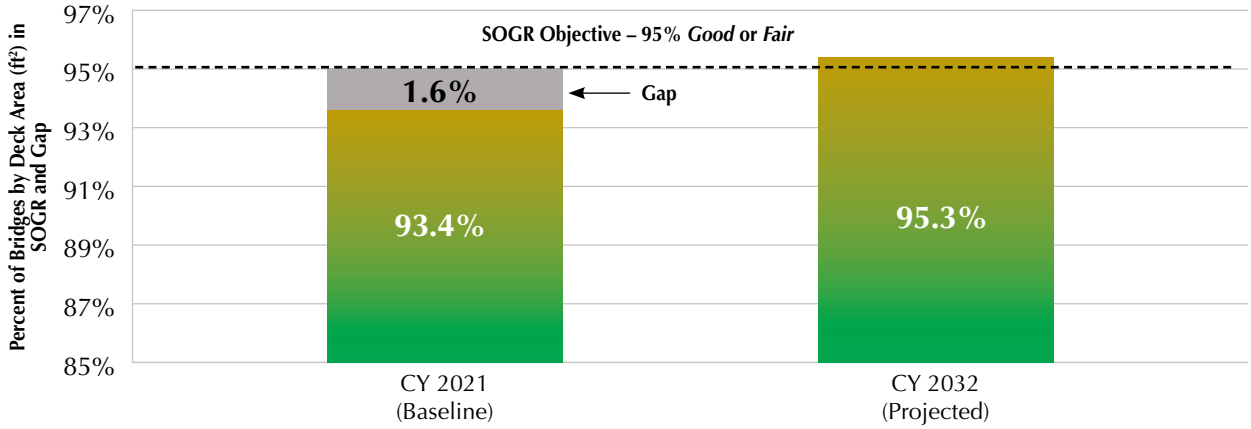
Projected NHS Performance

The projected NHS NBIS bridge conditions are based on the funding levels detailed in *Chapter 7: Financial Plan*, which reflect the 2023 New Jersey Transportation Capital Program along with information reported by non-NJDOT owners of NHS assets.

Non-NJDOT NHS

Toll authorities own the vast majority of the non-NJDOT NHS bridge network. Over 96% of these owners' bridges, by deck area, are in a state of good repair, which makes an important contribution towards the performance for the NHS overall. The TAMP uses the conservative assumption that the total deck area of non-NJDOT NHS bridges in a state of good repair will remain the same as it is in the baseline year (CY 2021). This assumption is supported by the major owners' performance projections gathered during the outreach for this TAMP, and by the generally increasing spending trends by non-DOT owners. The non-NJDOT NHS bridge population includes border bridges.

Exhibit 4-14: NHS NBIS Bridge Performance and Gaps — Baseline CY 2021 and Projected CY 2032



NJDOT NHS

The state of good repair status of NJDOT NHS bridges is extracted from the planned funding scenario BMS analysis results for the SHS. For the NJDOT NHS, the deck area in a state of good repair is projected to increase by nearly 1.2 million square feet between the CY 2021 baseline and CY 2032. This increase would bring the percentage of bridges by deck area that are in a state of good repair from 90.3 percent in the baseline (CY 2021) to 94.7 percent in CY 2032.

Combined NJDOT and Non-NJDOT NHS

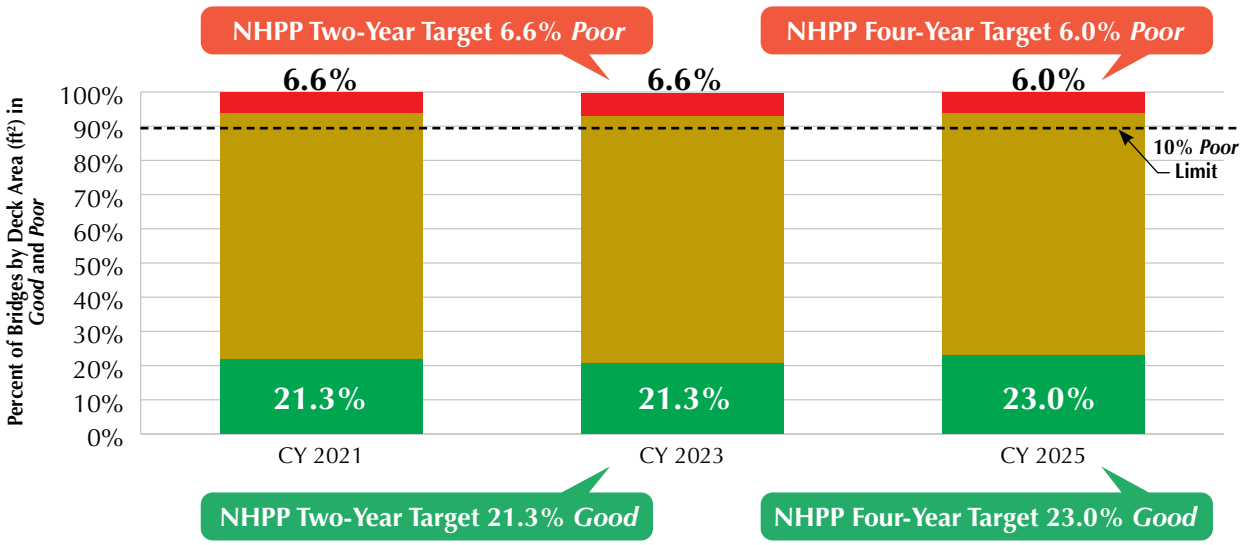
The performance measure for the full NHS is calculated by adding the NJDOT NHS deck area in a state of good repair to that of non-NJDOT NHS owners. The resulting projection is that 95.3 percent of all NHS bridges by deck area will be in a state of good repair in CY 2032. This projected performance slightly exceeds the 95 percent state of good repair objective that NJDOT has established for NHS bridges.

Exhibit 4-14 displays this CY 2032 NHS performance projection alongside the baseline performance. The exhibit depicts a 1.6 percentage point performance gap in the baseline, with performance slightly exceeding the SOGR objecteve by 2032. A substantial contributor to the improved performance by 2032 is the Pulaski Skyway project, which will add 1.2 percentage points to the state of good repair performance of the NHS. As noted above, the completion of the Pulaski Skyway Rehabilitation Project results in a substantial increase in bridge performance with a less than commensurate expenditure over the TAMP analysis period. Sustained funding at higher levels is necessary to maintain this higher level of NHS performance.

NHPP Two- and Four-Year Performance Targets for the NHS

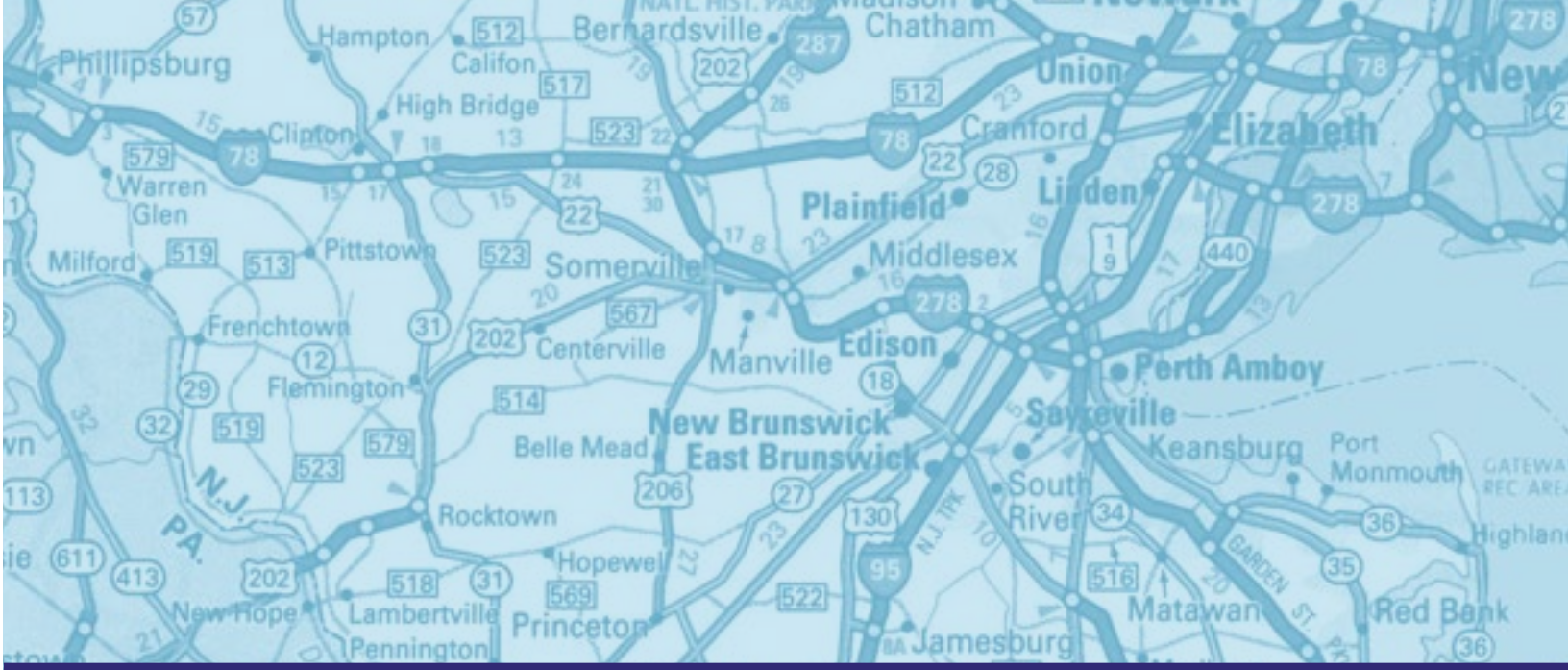
NJDOT is required to set two-year and four-year performance targets for NHS bridges, regardless of ownership. The targets are stated in terms of the NHPP measures described

Exhibit 4-15: NHS NBIS Bridge Performance and NHPP Targets — CY 2021, CY 2023, and CY 2025



in *Chapter 2: Asset Inventory, Performance Measures, and Baseline Conditions*. The measures express bridge performance in terms of the percentage of NHS bridges by deck area in *Good* and *Poor* condition. The NHPP performance targets and projected performance are depicted in Exhibit 4-15.

Because of the long timespan required to develop major bridge projects, the four-year performance horizon can only be affected by projects that are already programmed. Stated another way, bridge performance in a four-year horizon is incapable of meeting a higher performance level than the level projected for programmed projects. Accordingly, NJDOT determined projected NHS conditions in years CY 2023 and CY 2025 and set performance targets consistent with projected performance.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Somerville
Middlesex
Frenchtown
Centerville
Manville
Edison
Perth Amboy
Flemington
New Brunswick
East Brunswick
Sayreville
Belle Mead
Keansburg
Port Monmouth
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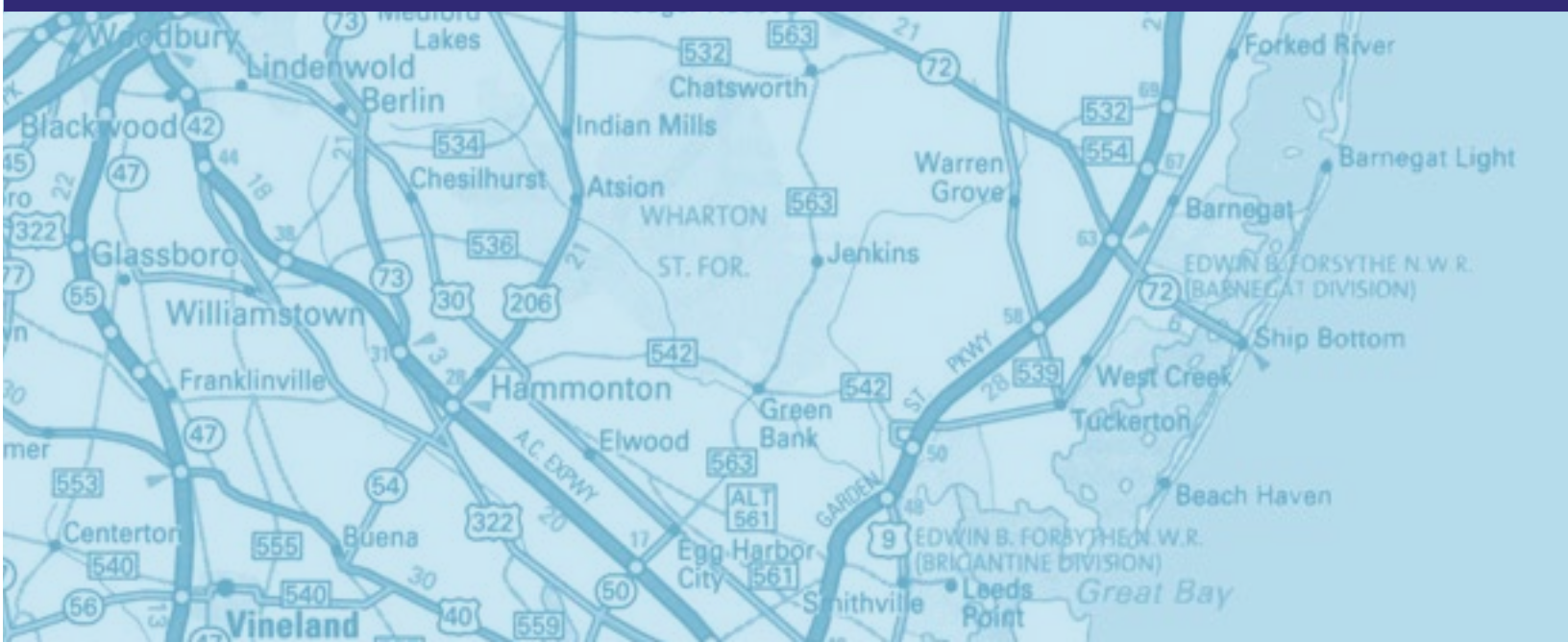
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Barnegat
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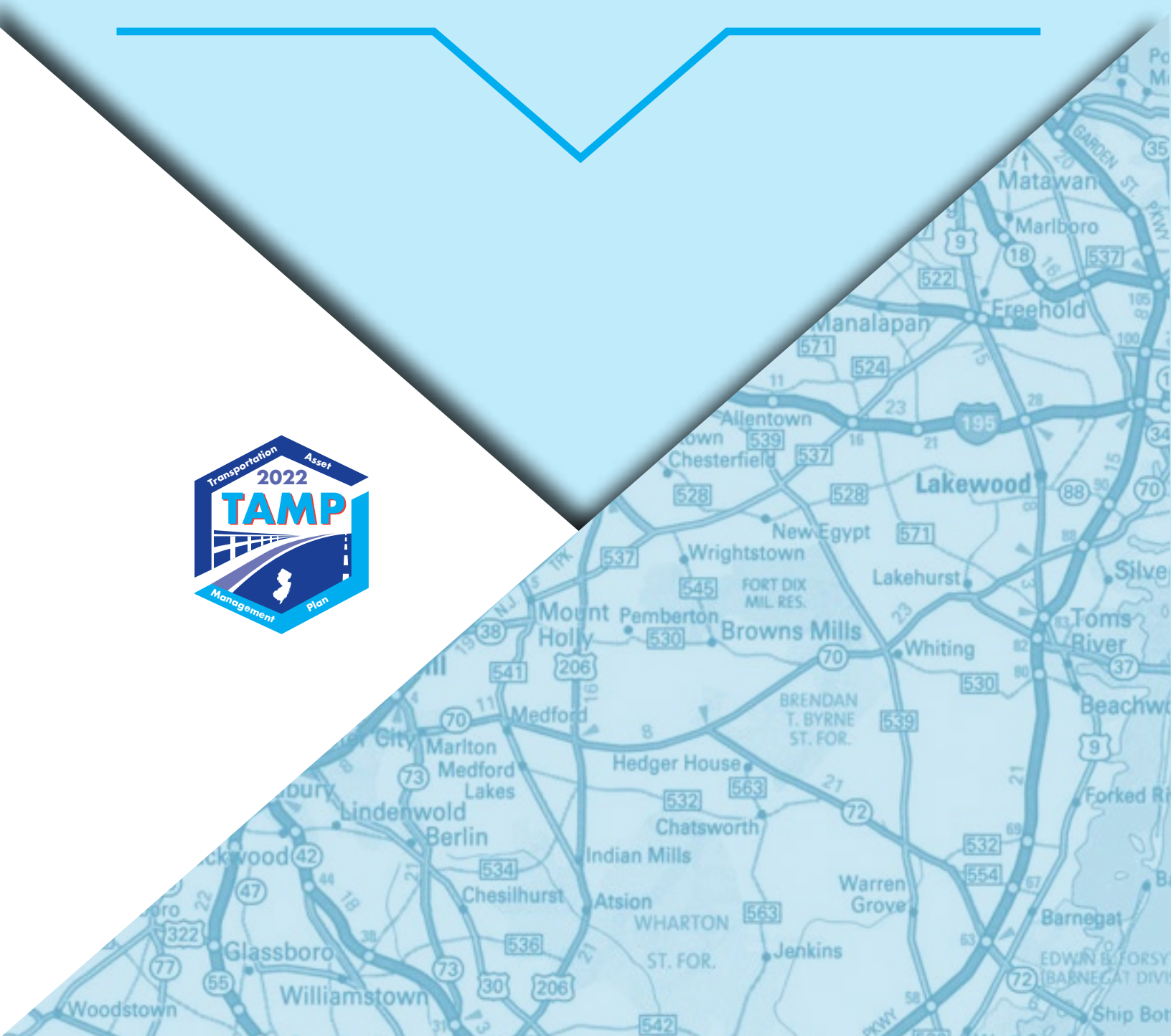
Jenkins
Glassboro
Williamstown
EDWIN B. FORSYTHE N.W.R. (BARNEGAT DIVISION)
Ship Bottom
Franklinville
Hammonton
West Creek
Green Bank
Tuckerton
Elwood
A.C. EXPWY
Beach Haven
Centerton
Buena
Egg Harbor City
EDWIN B. FORSYTHE N.W.R. (BRIGANTINE DIVISION)
Leeds Point
Great Bay
Vineland

CHAPTER 5:
LIFE CYCLE PLANNING



OVERVIEW: Chapter 5 describes the major processes affecting pavement and bridge asset life cycles. It introduces the analytical tools that NJDOT uses to support its pavement and bridge management decision-making. The chapter identifies the types of treatments that can be applied at each stage of an asset's life cycle and describes how NJDOT selects among these treatments in developing its investment strategies. The chapter concludes with overviews of life cycle planning practices of the other owners of NHS pavement and bridge assets.

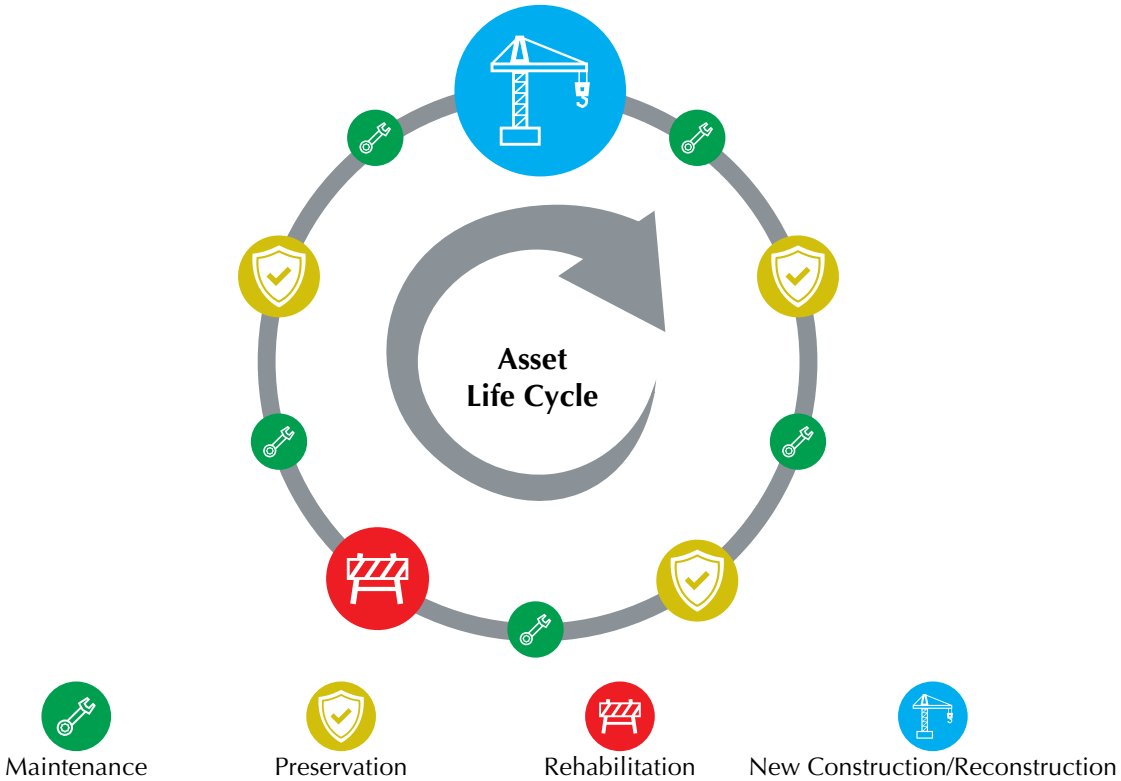
5.1 DEFINING LIFE CYCLE PLANNING

5.1.1 Managing Across the Whole Life Cycle

Life cycle planning, as defined in the Federal Highway Administration (FHWA) Asset Management Rule (23 CFR 515.5), is "a process to estimate the cost of managing an asset class, or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition." A depiction of stages of a simplified asset life cycle is depicted in Exhibit 5-1.

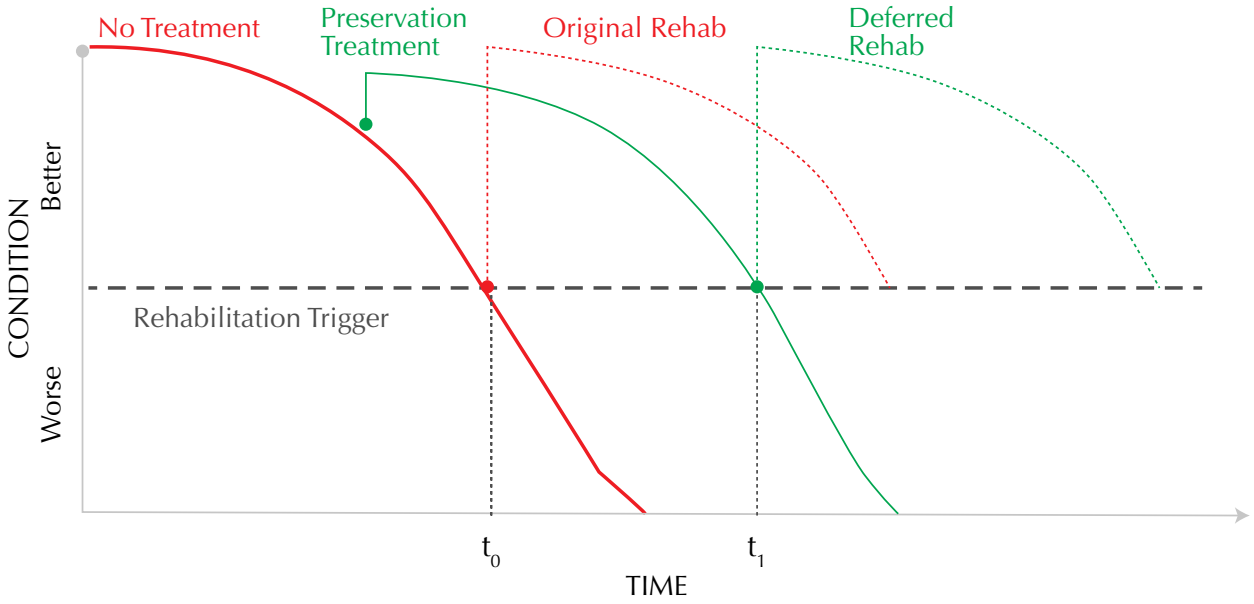
Life cycle planning recognizes that applying the *right* asset design at the construction stage and applying the *right* treatment at the *right* stage across an asset's life cycle can have a profound effect on the total cost to maintain an asset in a state of good repair over its whole life.

Exhibit 5-1: Simplified Asset Life Cycle



Circle sizes vary in proportion to the spending associated with each life cycle activity.

Exhibit 5-2: Simplified Asset Life Cycle



For example, it is almost always more cost-effective to perform multiple, lower-cost preservation treatments than to allow an asset to deteriorate to the point of requiring a major rehabilitation or even complete replacement. Exhibit 5-2 presents a simplified illustration of this concept. The asset condition with no treatment applied is represented by the red curve. Without any treatments, by time t_0, the asset will have deteriorated to a point at which preservation treatments are not feasible or effective and the substantial expense of a major rehabilitation or replacement will be required. The asset condition, if preservation treatments are applied while the asset is in good or satisfactory condition, is represented by the green curve. The small condition level jump at the onset of the green curve represents the condition improvement from application of a preservation treatment. The preservation allows for an extension of the time until the asset requires a major rehabilitation, from t_0 to t_1.

5.1.2 NJDOT Management Systems, Planning, and Programming

Asset management systems, planning processes, and programming considerations vary by asset owner. The following sections characterize some of the key uses and considerations of these at NJDOT. Each is supported by a matrix of key resources and defined procedures, as well as regular consideration for how they can be enhanced to improve life cycle planning for pavement and bridge assets at NJDOT.

Pavement and Bridge Management Systems

To perform life cycle planning at the network level, NJDOT employs bridge and pavement management systems, which are a collection of databases and software tools, in conjunction with staff expertise and established business processes to perform a variety of functions, namely:

- Manage asset data including inventory, condition, etc.

- Develop life cycle plans and investment strategies
- Initiate preservation, rehabilitation, and reconstruction projects
- Provide information and reports to external stakeholders and other business units

A generalized, high-level schematic of the inputs and analytical tools of an asset management system is displayed in Exhibit 5-3.

Components of Pavement and Bridge Asset Management Systems

Network Inventory

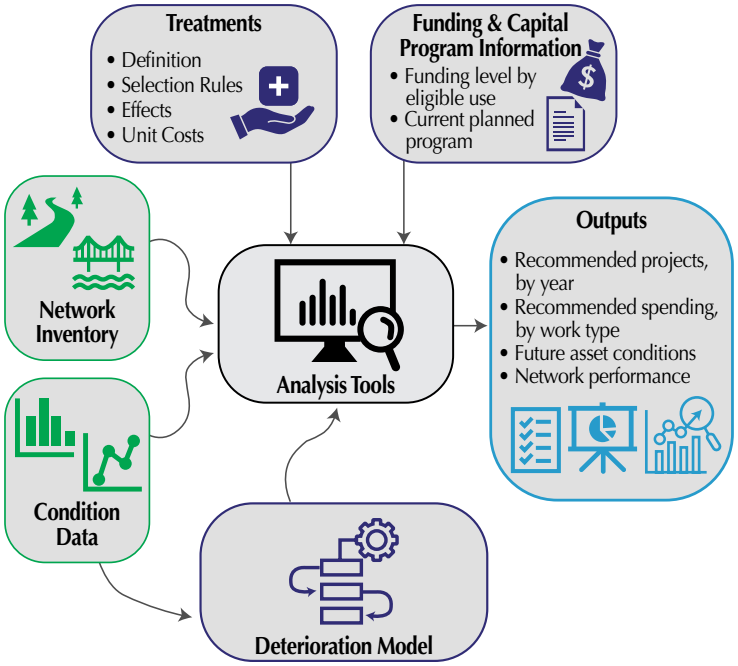
Information that identifies and characterizes each asset, including, among many other items: geographic location; annual average daily traffic (AADT); physical features such as structure type; material; geometric data such as structure length, lane width, detour length; and year of construction. Appraisal information (e.g., load capacity, scour criticality ratings).

Condition Data

Inspection methods and condition ratings are described in *Chapter 2: Asset Inventory, Performance Measures, and Baseline Conditions*.

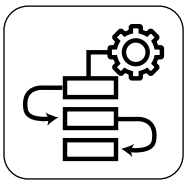
Bridge Condition Data — General condition ratings of major components using the National Bridge Inspection Standards (NBIS) 0-9 National Bridge Element (NBE) scale. Quantities in each of the four condition states (good-fair-poor-severe) for American Association of State Highway and Transportation Officials (AASHTO) elements.

Exhibit 5-3: Asset Management System Conceptual Schematic



Pavement Condition Data — Quantities in each of several applicable measures of pavement defect, such as cracking, rutting, or faulting.

Deterioration Model



Mathematical models used to project future asset conditions in the absence of any treatment. Deterioration models used in NJDOT pavement and bridge management systems are based on historical New Jersey SHS condition and work records. Deterioration models are specific to construction type and materials. Models include an adjustment factor to account for different conditions, such as differences in weather and traffic loading, across various locations.

The deterioration parameters themselves cannot be programmed to vary over the analysis period. That is, they cannot build into the modeling the factors to account for projected changes in conditions that could affect deterioration such as increasing traffic loadings or increasing stressors from extreme weather events. However, the models are periodically recalibrated using new inspection condition data, which makes them somewhat responsive to changing deterioration rates as conditions change. Also, users can run the analyses multiple times with different settings for the deterioration parameters to explore the potential sensitivity to these different conditions.

Treatments

Asset treatments are the preservation, rehabilitation, and replacement actions that are analyzed and ranked in the analysis tools component. Treatment data needed by the modeling system include triggers, effects, and unit costs, each described below.

Treatment Triggers —Treatment triggers are the inventory characteristics and inspection condition combinations that trigger the modeling system to select a treatment for evaluation in any given analysis year. One of the "levers" for evaluating alternative investment strategies is to run the analysis module with different trigger settings and/or with entirely different sets of available treatments and examine the resulting asset conditions and network performance.

Treatment Effects — Treatment effects (i.e., consequences) refers to the modeled changes in conditions resulting from implementing the treatment. For example, a bridge replacement is modeled as changing each bridge element's condition quantity and rating to 100 percent in Condition State 1 (Good). The treatment effects form the basis for calculating the benefits of a treatment (described below). Bridge treatment effects modeling also provides for measuring impacts in the form of changes to other criteria of interest besides condition, such as changes in scour critical and fracture critical status. Pavement treatment effects modeling is limited to pavement condition measures.

Treatment Unit Costs — Treatment costs currently used in the analysis modules are order-of-magnitude, loaded unit costs for each treatment, as computed from historical NJDOT project costs. Bridge costs are expressed per square foot deck area, and pavement costs per lane mile.

Funding and Capital Program Information

The amount of funding available for each analysis year and projects that are already part of the planned program are captured as given

inputs (they are not subject to review by the management system). Another "lever" for evaluating alternative investment strategies is to allocate different funding levels to different asset classes or network segments and or to different treatment types (e.g., preservation versus rehabilitation) and examine the resulting project selections and time path of network performance.

Analysis Tools

The management system software runs an optimization engine that calculates, for each asset (bridge, pavement segment) and each analysis year, the benefits and costs of each eligible treatment alternative. A treatment is eligible if the treatment triggers (described previously) are met. The benefit of the treatment is measured using the net improvement in condition rating with the application of a treatment compared to a no-treatment baseline condition rating.

In both management systems, the optimization engine can be applied to select the combination of treatments that yield the highest benefit possible given funding constraints. Both pavement and bridge optimization engines use incremental benefit-cost analysis to select treatments. Optimization is achieved by ordering the feasible treatments for each year according to their incremental benefit-cost ratio and then moving down this ordered list, selecting treatments until the total funding allocation for the year is exhausted.

This network optimization process is different from the life cycle cost analysis process used to find the minimum cost sequence of treatments for a single asset over its entire life. In other words, network optimization will not be the same as the aggregation of individual asset minimum life cycle cost treatments. At the network level, with constrained funding, trade-offs are made between individual assets to maximize network benefits.

Life Cycle Planning and Project Programming

Life cycle planning provides data-driven input to NJDOT's processes for prioritizing maintenance work, developing repair and rehabilitation plans, selecting projects for implementation, and allocating funds to asset preservation. The analytical tools described previously are by no means the last word in the programming and selection of projects. Subject matter experts in the roadway and bridge management units apply engineering expertise with regard to considerations like constructability and accommodate other relevant considerations. These can include, for example, conflicts or synergies with other projects in the vicinity and other project benefits that might not be accounted for in the quantitative analytical tools. These needs and benefits may include enhanced safety; improved mobility; and increased resilience in the face of hazards such as extreme weather, seismic events, and increased vehicle loads, among others.

Life Cycle Planning and Performance Targets

Pursuant to the National Highway Performance program, NJDOT establishes two- and four-year performance targets for the condition of pavement and bridge assets on the NHS. The targets are intended as short-term benchmarks to measure progress toward achieving NJDOT's state of good repair objectives. NJDOT applies its pavement and bridge management systems to project the lane miles and deck area on the state-maintained NHS in good, fair, and

poor condition. Information from other NHS owners is used to project condition on their assets, which is added to the SHS projections to prepare projected performance measures for the NHS in New Jersey. Because of the time lag from programming to project completion, these short-term performance projections reflect life cycle planning decisions made in previous years. Life cycle planning that is being carried out presently informs the setting of future performance targets.

Resilience Considerations in Life Cycle Planning

New Jersey is a densely populated state with a heavily used transportation network. Resilience of this system, including resilience of the physical assets that make up this system, has always been of highest importance at NJDOT. Climate change, with its attendant sea level rise and more extreme weather events, is altering the risk calculus and raising the stakes for resilience. Deterioration processes, risks of asset damage, and examples of measures to increase the resilience of the pavement and bridge assets are addressed ahead in Sections 5.2.1 and 5.3.1.

Two statewide geographic information system (GIS) tools currently being developed will help bridge and pavement managers identify what structures and road segments are especially subject to heightened requirements for resilience measures as a result of climate change-related extreme weather and sea level rise. The Climate Hazards Visualization Tool will help to identify assets that could be exposed to future climate hazards including inland and coastal flooding and heat impacts. NJDOT has placed increased emphasis on incorporating extreme weather, climate change, and resilience into asset management. NJDOT previously participated in FHWA's 2018 Asset Management, Extreme Weather and Proxy Indicators Pilot Program and committed to the development of these tools to identify assets exposed to climate and weather hazards. A criticality tool will help to identify the most essential assets and areas of the transportation network. These tools, as well as other New Jersey initiatives and practices regarding climate change risks and resilience, are described in more detail in Section 6.3.3 of *Chapter 6: Risk Management*.

5.2 PAVEMENT LIFE CYCLE PLANNING

Life cycle strategies for pavement are specific to the type of pavement. The three types of pavements in New Jersey are as follows:

- **Flexible pavement** is constructed with layers of hot mix asphalt concrete.
- **Composite pavement** is comprised of relatively thick slabs of Portland cement concrete overlaid with an asphalt wearing surface.
- **Rigid pavement** is constructed with slabs of Portland cement concrete separated by contraction joints.

The majority of the pavement in New Jersey is either flexible or composite pavement which has a bituminous surface course. Both are evaluated using the criteria for flexible pavements. Rigid pavement is the least common pavement type, accounting for only 3.4 percent of total NHS lane miles and 3.9 percent of the NHS lane miles on the New Jersey SHS. While the specifics of life cycle strategies may vary among these pavement types, the objectives and principles are the

same. An effective life cycle strategy can allow a pavement to provide 50 years or more of service life before the pavement structure requires full reconstruction.

5.2.1 Pavement Deterioration and Damage

All pavements decline in condition over time because of regular use and exposure to seasonal weather fluctuations. Variations in use (i.e., loading) and environmental conditions can introduce risk and affect the rate at which pavement deteriorates.

Traffic Loading Stressors

Pavement flexes under traffic loading, and over time this flexing causes the pavement to weaken and lose structural integrity. Typical pavements, properly maintained and subjected only to the loading for which they were designed, should not expect structural failure to occur before 50 or more years of service.

The asset management rule states that the life cycle planning process should include "future changes in demand" (23 CFR 515.7(b)). The analysis tools in the pavement management system software that supports life cycle planning do not provide a method to account for possible future *changes* in demand and associated traffic loading and resulting changes in deterioration rates. That is, the software cannot accommodate multiple demand and loading profiles simultaneously. (The pavement software is described below in section 5.2.4.) However, as noted previously in Section 5.1.2, deterioration models are updated periodically with new data. Also, asset managers apply judgement and can factor in expected changes in loading when selecting and scoping projects and deciding their timing. Finally, changes in demand are addressed in new roadway construction, reconstruction, and rehabilitation, because such projects are designed using projected future vehicle loads.

Environmental Stressors

New Jersey's climate exposes pavements to several stressors that can accelerate deterioration or can even cause catastrophic failure. The routine stressor of **exposure to air and the sun's rays** causes asphalt pavement to oxidize (i.e., dry out and become brittle). The result of this exposure is surface cracking which, if not addressed, can accelerate pavement deterioration. Moreover, water can infiltrate the pavement from surface cracks resulting from wear, oxidation, or joints, or even from below because of insufficient drainage. With average annual temperatures and the frequency of extreme weather events expected to increase in the future, the impact of these stressors on pavement deterioration is expected to become more significant. Additional expected weather changes include deviations to freeze-thaw cycles, more frequent and severe heat waves, and more frequent and severe precipitation events.

Freezing and thawing of water within or between the pavement layers can cause rapid deterioration and potholes.

> *Mitigation* — NJDOT uses materials that are more resistant to freeze-thaw damage and has incorporated preservation treatments into pavement life cycle plans to keep pavement surfaces from deteriorating prematurely.

High-temperature events and rapid extreme swings in temperature can accelerate deterioration of flexible and composite pavements. Composite pavements, which make up a significant portion of NJDOT's

pavement inventory, are susceptible to blow-ups during these events when the underlying concrete slabs expand to a greater degree than can be accommodated through their transverse joints. Temperature gradients due to heat waves also can result in block (thermal) cracking in both composite and flexible pavements.

Mitigation — NJDOT is addressing the climate change-related increase in heat stressors by utilizing crack-sealing treatments, programming preservation treatments, and performing rehabilitation at optimal times to address block cracking. NJDOT also is designing and constructing high-performance mixes such as interlayers and polymer modified binders (i.e., stone matrix asphalt (SMA)) to make pavements more resilient to future changes in temperatures.

Non-flooding water damage — Pavement structures must be kept dry to avoid early structural failure. Water weakens the soil beneath the pavement, which can lead to failure resulting from increased flexing under regular use.

Mitigation — NJDOT designs pavements with adequate drainage and regularly reviews its standards to ensure drainage will continue to be adequate throughout the design life. NJDOT also has constructed porous pavements to improve drainage. Roadside ditches and storm sewers must be maintained to support proper drainage.

Flooding is another weather-related stressor that is expected to increase in frequency and severity as a part of climate change. Significant water flow across pavement can weaken pavement structure and can even cause catastrophic failure.

Mitigation — Beyond maintaining drainage structures and optimizing catchment basins, NJDOT has limited options available to mitigate flood hazards to pavement. Increases in road profile (i.e., elevation) are restricted in coastal flood plains due to environmental regulations that are in place to protect adjacent land uses. Opportunities to increase the road profile also are restricted in low-lying urban areas across the state due to geometric constraints of surrounding infrastructure, including utility and drainage structure elevations.

NJDOT maintains a database of flooding incidents by location. Assets in areas experiencing repeat flooding can be prioritized for maintenance, mitigation actions can be identified and added to existing project agreements, or further investigations can be performed, as appropriate to each location.

NJDOT envisions that the forthcoming Climate Hazards Visualization Tool and the Transportation System Criticality Tool will support project prioritization processes for the targeting of investments in pavement resilience against the stressors and associated hazards described previously.

5.2.2 Pavement Treatments

NJDOT pavement managers regard pavement treatments as falling into one of five categories: maintenance, preservation, resurfacing, rehabilitation, and reconstruction. These five categories roughly align with four of the five FHWA work types. Pavement resurfacing can

Exhibit 5-4: Typical NJDOT Pavement Treatment Types and Costs

NJDOT Category	FHWA Work Type	Treatment Number and Type		Average Project Cost Per Lane Mile
Maintenance	Maintenance	0	Crack Sealing and Pothole Repair	Varies
Preservation/ Resurfacing	Preservation	1	Chip Seal	$170,000
		2	Cape Seal (Treatments # 1+ 3)	$210,000
		3	Micro-Surfacing or Slurry Seal	$170,000
		4	High-Performance Thin Overlay	$230,000
		5	Ultra-Thin Friction Course	$220,000
		6	Treatments # 3 + 4 or 3 + 5	$300,000
	Rehabilitation	7	Resurfacing (2")	$325,000
		8	Resurfacing (3")	$350,000
		9	Resurfacing (2 lifts of 3" or more)	$385,000
Rehabilitation		10	Concrete Pavement Rehab (CPR)	$400,000
		11	CPR + HPTO (#10 & 4)	$350,000
Reconstruction	Reconstruction	12	Reconstruction	$3,500,000

Source: NJDOT Pavement Management Unit, NJDOT Pavement Management System June 2022.

be regarded as an example of the FHWA rehabilitation work type. Exhibit 5-4 shows the typical treatment types by category and FHWA work type, along with costs used by NJDOT to maintain or improve pavement conditions.

Maintenance Treatments

Maintenance treatments are performed to prevent or repair damage but do not significantly impact a pavement's measured condition. Examples of maintenance treatments include crack sealing and pothole repair. These treatments are typically performed by NJDOT maintenance personnel. As such, they are not a part of the capital planning and program process that the NJDOT Pavement Management Unit supports through its life cycle planning processes.

Preservation Treatments

Preservation treatments are performed to address minor surface distresses and extend pavement service life. Because such treatments do not restore or improve a pavement's structural capacity, their application is typically limited to pavements rated *Fair* or better by NJDOT's Condition Status performance metric (see *Chapter 2: Asset Inventory, Performance Measures, and Baseline Conditions* for more details). Pavements in the *Fair* category are generally those with slight or moderate surface distresses but little-to-no loss of pavement structural capacity. Therefore, the ideal timing of preservation treatments is that they are performed prior to advanced condition deterioration.

Resurfacing Treatments

Resurfacing treatments are performed to address more significant surface distresses and to restore pavement condition. As the name implies, resurfacing treatments remove the damaged portion of the existing pavement surface (typically 2 to 3 inches) through

a milling operation, which is followed by replacement of an equal depth of new asphalt material. These treatments do not restore or improve a pavement's structural capacity. The treatments are selected based on pavement type and past performance of previous treatments. On composite pavements constructed with expansion joints, a strain-tolerant intermediate course, i.e., binder rich intermediate course (BRIC) is used as an interlayer to accommodate slab movements associated with temperature change or vertical movement under load. These treatments are typically applied to pavements in *Fair* condition by NJDOT's Condition Status performance metric but also can be used to treat some *Poor* pavements. NJDOT regards resurfacing treatments as falling within the FHWA rehabilitation work type within the TAMP pavement investment strategy.

Rehabilitation Treatments

In NJDOT usage of the term, "rehabilitation," treatments are those that restore pavement surface conditions and restore or improve a pavement's structural capacity. For flexible pavements, these treatments are comprised of overlays or mill and replacements where the resultant pavement thickness is increased. For rigid pavements, these treatments include slab stabilization using polyurethane grout and repairs to the concrete slabs or the load-transfer devices between slabs. Rehabilitation is typically done to pavements that are at the low end of the *Fair* range or are rated as *Poor* by NJDOT's Condition Status performance metric.

Reconstruction

Reconstruction is needed when a pavement has reached the end of its functional life and its structural capacity is insufficient to carry the required traffic loads. Reconstruction typically requires complete removal of the pavement and replacement with new drainage assets. However, NJDOT uses rubblization where feasible to reconstruct rigid or composite pavements. Rubblization—the breaking up of old roadway to form a base for new pavement—is a sustainable, efficient, cost-effective and environmentally conscientious alternative to traditional reconstruction. Additionally, NJDOT uses a specially designed asphalt mix, binder rich base course (BRBC) in its rubblization designs to meet or exceed the tensile strain demand at the bottom of the asphalt mixture, allowing a thinner pavement box without compromising the structural capacity of the new pavement box. This allows NJDOT to consider reconstruction in areas that would otherwise be infeasible due to geometric constraints of the adjacent infrastructure or environmental restrictions on profile in floodplains, thereby reducing future life cycle costs. Pavements needing reconstruction are identified by a project-level pavement evaluation. Once identified and reconstruction is recommended, a pavement may be resurfaced to maintain it in a serviceable condition until the reconstruction can take place. Reconstructed pavement is designed as a perpetual pavement to be structurally sufficient for the anticipated traffic loading for the full 50-year design life of the pavement, requiring only preservation and minor rehabilitation to renew the riding surface during the pavement's planned life cycle. This reduces the need for more frequent and costly major rehabilitation treatments or premature reconstruction.

Initial (new) Construction

Initial construction is the construction of a new pavement where none had existed before.

Initial construction is not a part of pavement asset management; it is not recommended, modeled, or managed by the NJDOT pavement management system. New pavement construction needs are identified by other performance areas, such as safety or congestion relief, rather than from the asset management performance area. Although initial construction is not initiated through pavement life cycle planning, new pavements are designed to minimize life cycle cost. NJDOT considers perpetual pavement design (described above) as a standard practice for designing new hot mix asphalt (HMA) pavements.

New Jersey's dense population and development results in limited opportunities to construct additional pavement facilities. Accordingly, NJDOT prioritizes system preservation of its existing network to maintain it in a state of good repair.

5.2.3 NJDOT Pavement Life Cycle Planning Practice

Software Tools

Pavement asset management planning, including life cycle planning, is performed routinely by the Pavement Management Unit as part of its regular responsibilities. The unit revisits its alternative life cycle strategies at least annually. The frequency of these evaluations allows NJDOT to update its modeling configuration (treatment effectiveness, deterioration models, etc.) to account for the new data on pavement condition.

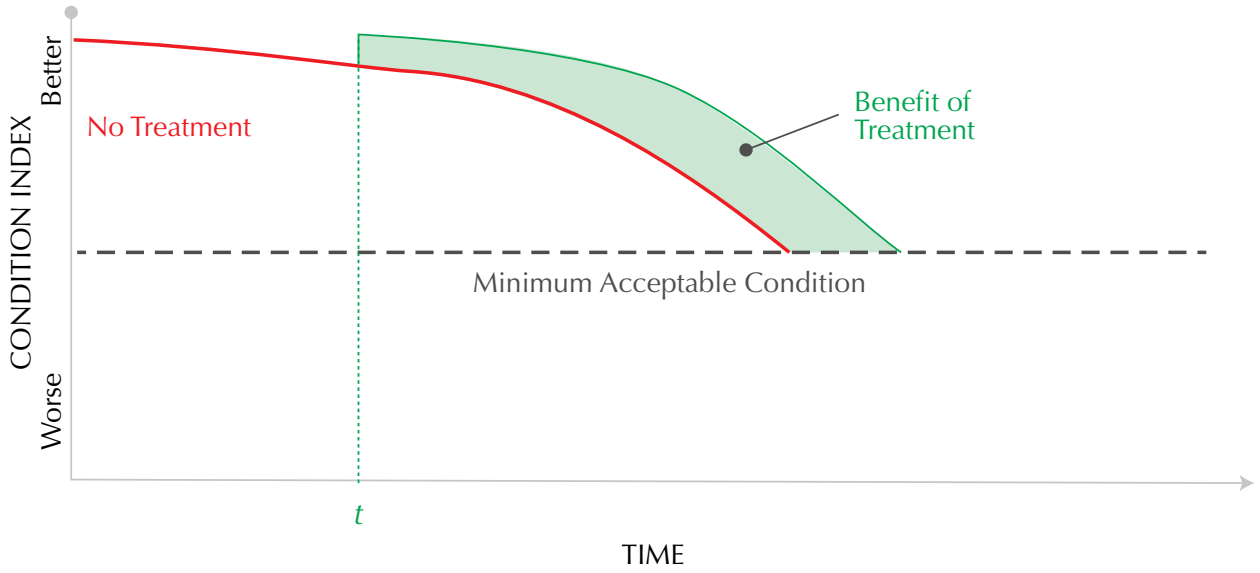
NJDOT uses Deighton's Total Infrastructure Management System (dTIMS) pavement management software to model future pavement conditions under alternative life cycle strategies and funding levels. The Pavement Management Unit configures the software to NJDOT-specific values for inputs such as deterioration rates and treatments. The system uses data from the pavement condition database, as described in Section 2.3.1, to analyze the needs of all NJDOT pavements. The system contains data on cracking, rutting, ride quality, age, traffic volumes, and physical attributes. The modeling applies several treatment trigger rules that identify treatments eligible for benefit-cost evaluation. Three primary trigger rules that parse pavement segments between consideration for preservation versus more costly and involved treatments are as follows:

- Surface distress index (SDI) 3.5 or higher — considered for various preservation treatments, depending on age and physical attributes such as curbs and utilities.
- Surface distress index (SDI) higher than 2.4 and less than 3.5 — do nothing, unless specific distresses require corrective action.
- Surface distress index (SDI) less than 2.4 — considered for resurfacing, rehabilitation, or reconstruction based on project-level pavement screening data and other factors, including traffic level, structural integrity, and geometric constraints.

These three trigger rules are a part of a more complex decision tree that further refines the eligible treatments into more specific treatments.

As outlined in Section 5.1, the trigger rules identify eligible treatments, which are then

Exhibit 5-5: Measurement of Treatment Benefit



evaluated in an optimization module using incremental benefit-cost analysis. The cost of the eligible treatment is calculated as the unit cost multiplied by the number of units (lane miles). The benefits are calculated using the action-effectiveness models to model the initial improvement in condition and the revised deterioration (the "reset" of the deterioration curve). The benefit is the difference in condition between the with-treatment and no-treatment alternatives. Roughly speaking, the difference in condition rating for each year is summed to yield a total benefit from the treatment. This calculation is represented graphically in Exhibit 5-5. The red curve represents the pavement condition with no treatment and the green curve represents the new condition path with a treatment applied at time t. The treatment benefit is calculated as the area between these two curves. This approach to benefit measurement captures the life cycle benefit of the treatment.

The benefit area is scaled by average annual daily traffic (AADT) before comparing it to cost; this scaling makes the benefit quantity a more accurate measure of the treatment benefit as enjoyed by the traveling public.

Improvements and Enhancements in Pavement Life Cycle Planning

With the implementation of automated distress data collection, NJDOT is reevaluating the current trigger statements in dTIMS, particularly the distress-based triggers for preservation, to produce more refined preservation treatment recommendations.

As NJDOT acquires more treatment performance information (through annual data collection efforts), particularly on preservation and specialty mixes, staff will continue to refine the deterioration models to more accurately represent the deterioration patterns of pavements that have received such treatments.

Use of Pavement Life Cycle Planning Results

The NJDOT Pavement Management Unit is responsible for establishing the pavement life cycle strategy and using NJDOT's pavement management system (PMS) to develop annual

paving plans. The modeling functionality of NJDOT's PMS (dTIMS) is used to evaluate and recommend both short- and long-term strategies for pavements that inform programming processes such as the STIP. The Pavement Management Unit applies these strategies when it reviews inventory and condition data to develop lists of potential pavement segments for treatment projects. The Pavement Management Unit then performs detailed project level evaluations of these candidate sites to determine the optimal treatment for each location including reviewing the performance of the last treatment to verify treatment selection or identify opportunities for high-performance mixes. The Pavement Management Unit works closely with both Capital Program Management and Operations and Maintenance staff to ensure that selected projects receive cost-effective treatments that best fit the pavement life cycle strategy while accommodating the specific circumstances of each site.

Pavement network modeling is also performed as part of the TAMP performance gap analysis, where combinations of investment levels and life cycle planning strategies are used to project pavement asset performance under different investment scenarios.

5.2.4 NJDOT's Pavement Life Cycle Strategy

Consistent with NJDOT's system preservation focus at the enterprise level, NJDOT's life cycle planning strategy for pavements maximizes the use of pavement preservation to the greatest extent practicable. Based on the analysis of historic pavement conditions, NJDOT has determined that the time required between preservation treatments is approximately 10 years for most of the treatment types listed in Exhibit 5-4. These treatments address surface distress resulting from regular use and exposure to the elements. A flexible (asphalt) pavement surface will typically require a preservation overlay after 10 to 12 years of service from new construction/reconstruction. The one exception to this 10-year rule of thumb is micro-surfacing and slurry seal (treatment type number 3), This treatment is not only the least expensive per lane mile but the thinnest, and it requires reapplication more frequently. Since preservation treatments are typically a small fraction of the cost of reconstruction, maximizing their application provides the most cost-effective means of maintaining and improving network-wide conditions.

This preservation-oriented strategy originated in 2011, when NJDOT began life cycle planning for pavements. At that time, it was determined that it would be cost prohibitive to achieve the state of good repair objective of 80 percent of pavements in *Good* or *Fair* condition by CY 2021 by relying on resurfacing overlays or even more significant treatments. In response, NJDOT began to investigate the use of less expensive preservation treatments such as micro-surfacing and thinner asphalt overlays. NJDOT determined that the service life difference between preservation and traditional treatments is often minimal, provided that the preservation treatments are applied to appropriate pavements. This new understanding has led NJDOT to increase the priority of preservation treatments in developing annual paving programs.

NJDOT has been a leader in pavement preservation nationally and participated in the FHWA Every Day Counts (EDC)-6 Targeted Overlay Pavement Solutions (TOPS) initiative for asphalt pavements as a lead state in the use of highly modified asphalt in thin overlays to resist reflective cracking and

rutting. NJDOT successfully implemented alternative asphalt mix design procedures for high-performance thin overlays (HPTO) to minimize reflective cracking and routinely utilizes other TOPS treatments including stone matrix asphalt (SMA), binder rich intermediate course (BRIC) for crack attenuation and ultra-thin friction course (UTFC). These treatments have significantly contributed to NJDOT's improvement in their network pavement conditions by extending pavement service life. NJDOT continuously seeks opportunities to improve performance and minimize costs in order to achieve and maintain the desired state of good repair at the least practicable cost.

5.3 BRIDGE LIFE CYCLE PLANNING

There are several considerations unique to bridges that are particularly relevant for life cycle planning:

- **Bridges are expensive and long-lived assets** with high construction and reconstruction costs.
- **Bridges are complex assets with multiple components and design types** (deck, superstructure, and substructure, joints, bearings) that affect each other.
- **Bridges are exposed to environmental factors that impact their condition**, affecting their anticipated life span. For example, snow requires the use of de-icing salts, which are corrosive to the structural elements, and high-water events can cause scour of bridge foundations, etc.
- **Bridges are treated with a wide range of maintenance, preservation, and rehabilitation actions** to extend their life span. Industry best practices in the application of these treatments change over time, incorporating new materials and details developed to improve life cycle performance.

5.3.1 Bridge Deterioration and Damage

Bridges deteriorate over time due to their use and exposure to seasonal weather fluctuations. Variations in use (loading) and in weather can affect the rate at which a bridge deteriorates. Bridges are also subject to damage from hazards such as collisions, seismic events, and weather events such as flooding.

Traffic Loading Stressors

Repeated deflection under traffic loading causes bridge structural members to weaken over time. Future increases in heavy-vehicle traffic may accelerate deterioration of these structural members as well as accelerate the deterioration of deck-wearing surfaces. Also, future growth in vehicle traffic increases the likelihood of direct damage from vehicle collision with bridges.

The asset management rule states that the life cycle planning process should include "future changes in demand" (23 CFR 515.7(b)). The analysis software used in bridge life cycle planning does not provide a method to account for possible future changes in demand and associated traffic loading and resulting changes in deterioration rates. That is, the software cannot accommodate multiple demand and loading profiles simultaneously. Within the software, a way to account for faster deterioration is to perform

a sensitivity analysis, running the program with alternative (faster) deterioration rates and applying judgement regarding how to use the different results.

Changes in demand may factor into bridge management in other ways. As noted in Section 5.1 on asset management systems, deterioration models are updated periodically with new data. Another way that changes in demand may play a role is through load ratings. Inspection reports identify changes in condition that may trigger a reevaluation of the load rating, which may lead to a re-rating of the capacity of the bridge and the posting of a load limit. The reduced load rating capacity will be a factor in future treatment decision-making for the bridge. Also, asset managers apply judgement and can factor in expected changes in loading when selecting and scoping projects and deciding their timing. Finally, as with roadways, changes in demand are addressed in major rehabilitations, reconstruction and new construction, because such projects are designed using projected future vehicle loads.

Environmental Stressors

New Jersey's climate exposes bridges to several stressors that can accelerate deterioration or can even cause catastrophic failure.

High temperature events and rapid extreme temperature changes — Expansion and contraction of structural members (particularly steel members) occurs with increases and decreases in ambient temperature. Bridges are designed to withstand a certain amount of expansion and contraction. More frequent temperature swings would increase the number of cycles of expansion and contraction, thereby accelerating deterioration. Also, more extreme temperature changes than those used as the basis of design could cause the expansion and contraction to exceed design tolerances, resulting in accelerated deterioration and possibly even failure (complete loss of structural integrity) of a structural member.

> *Mitigation* — Use of elastomeric bearings, which perform better in temperature swings. Specifying steel that is more resilient to damage from temperature swings.

Winter Weather — Use of de-icing salts introduces corrosive chemicals that interact with and speed the deterioration of unprotected steel. **Freezing and thawing** of water within small concrete cracks will expand the cracks, leading to further deterioration. This deterioration pathway is compounded when water is corrosive with de-icing salts.

> *Mitigation* — Sealing cracks, especially on deck surface. Protecting steel girders, rebar, and railings through hot-dip galvanizing. Using epoxy-coated rebar in reinforced concrete. Painting exposed steel elements (e.g., girders, bearings). Using a thicker concrete cover to further isolate the steel reinforcement. Performing timely repairs and replacement of joints. Implementing bridge designs that avoid placing joints over elements that are vulnerable to water and corrosion damage such as jointless decks. The more innovative of these measures are described in more detail in Appendix D.

Flooding — Floodwaters can damage a bridge through overtopping or through the force of debris- and sediment-laden water against the various bridge elements and embankment

protection structures. Especially vulnerable to these forces are appurtenances such as parapets and bridge railings; scour countermeasures; and embankment stabilization structures such as wingwalls, slope protection, and rip rap. Flooding also can create or exacerbate scour conditions, in which material is eroded away from pier and abutment foundations. Increased exposure of bridges to flooding can be driven by several processes. Climate change is projected to increase the severity of precipitation events. Bridges in coastal areas may also be subject to a rising sea level, in addition to more extreme precipitation events. Also, increasing land development tends to increase stormwater flows and exacerbate flooding of waterways in the drainage area.

Mitigation — Possible mitigation measures to build resilience against flood damage include measures to reduce the impacting factors (floodwater height and force). Examples of such measures are channel maintenance (clearing debris and sedimentation), improving drainage, and increasing the capacity of catchment basins. Also, the bridge itself could be made less vulnerable to overtopping by raising the deck and superstructure elevation. Finally, the traveling public can be made less vulnerable by good planning and communication for effective detours around flood prone bridges during high-water events.

5.3.2 Bridge Treatments

Bridge treatments may be grouped into four general categories or work types: maintenance, preservation, rehabilitation, and reconstruction, as shown in Exhibit 5-6 on the following page.

Maintenance

NJDOT defines maintenance as a reactive approach to unforeseen situations that arise requiring immediate or prompt repairs. Examples of such situations requiring maintenance include severe deck spalls, over-height trucks hitting the girders, or severe scour or undermining. In these cases, maintenance actions must be taken to keep the bridge in service and safe for use by the public. This work is typically performed by NJDOT maintenance forces or by job order contracts for more complex repairs. On a unit cost basis, this work tends to be more expensive than planned preservation or rehabilitation activities. Also, aging bridges in deteriorated condition tend to have more maintenance needs and therefore a greater maintenance expense burden.

Preservation

Bridge preservation is defined as actions or strategies that prevent, delay, or reduce the deterioration of bridges or bridge elements, restore the function of existing bridges, keep bridges in *Good* condition, and extend serviceability. Preservation actions are considered to be a planned approach as opposed to a reactive approach, and may be cyclical or condition-driven, or a combination.

The preservation work type in the TAMP bridge investment strategy includes actions that NJDOT refers to as preventive maintenance. The NJDOT Bridge Preventive Maintenance Program was developed in response to an October 8, 2004, FHWA memorandum stating that highway bridges will be eligible for federal aid for maintenance activities if NJDOT can demonstrate that the treatments are a cost-

Exhibit 5-6: Typical NJDOT Bridge Treatment Types and Costs

NJDOT Category	FHWA Work Type	Example Treatment	Estimated Project Cost Per SF Deck Area
Maintenance	Maintenance	Repair collision damage	Varies
Preventive Maintenance*	Preservation	Seal cracks	$206
		Replace joints	
		Lubricate bearings	
		Repaint beam ends	
Rehabilitation	Rehabilitation	Partial deck replacement	$119
		Full deck replacement	$511
		Superstructure rehabilitation	$149
		Superstructure replacement	$882
		Substructure rehabilitation	$124
Reconstruction	Reconstruction	Reconstruction	$2,556

*An illustrative subset of preventive maintenance treatments is shown here. A more detailed list, with intervals, is in Exhibit 5-7. Cost shown is for the generic preservation treatment currently used in the NJDOT bridge management system software (BrM).

effective means of extending the useful life of a federal highway.

The Bridge Preventive Maintenance Program is updated regularly with treatments applied to all NJDOT National Bridge Inspection Standard (NBIS) bridges. NJDOT currently implements the program under several contracts.

The program's various treatments are identified in Exhibit 5-7 on the following page. The treatments are applied only if the component is rated 5 (*Fair*) or higher. This threshold ensures that preventive maintenance activities for an element are not performed if the overall component is deteriorated to the point where replacement is required soon. Also, some treatments are applied only if specific element rating criteria are met. For example, crack sealing of bare concrete deck is performed every two years, provided that the deck element ratings indicate that the deck is in reasonably good condition, with less than 25 percent of the deck area in Condition State 2 (fair), and none of the deck in Condition State 3 (poor) or 4 (severe).

The preventive maintenance program is implemented by Transportation Operations Systems and Support (TOSS). TOSS and the Division of Bridge Engineering and Infrastructure Management are separate organizational units within NJDOT. NJDOT plans to eventually integrate preventive

Exhibit 5-7: NJDOT Bridges —— Preventive Maintenance Treatment Types

Bridge Component	Treatment Type	Cycle
Deck	Bridge cleaning, washing, sweeping	Every 2 years
	Seal cracks on wearing surface — asphalt overlay	Every 2 years
	Seal cracks on deck	Every 2 years
	Seal cracks on parapet	Every 2 years
	Seal concrete deck	Every 5 years
	Corrosion inhibitor	Every 5 years
	Repair/replace joints	Every 10 years
	Repair concrete deck/sidewalk	Every 10 years
	Repair concrete parapet	Every 10 years
	Reseal base plates and curb	Every 10 years
	Repair approach slabs	As needed**
	Hot mix asphalt patch	As needed**
	Safety improvements	As needed**
Superstructure	Superstructure concrete repair	As needed
	Lubricate bearings	Every 4 years**
Substructure	Seal cracks on substructure	Every 5 years
	Substructure concrete repair	Every 10 years
	Substructure carbon wrap	As needed
	Seal substructure concrete	As needed**
	Repair erosion/scour	As needed**
	Scour countermeasures	As needed**

Source: NJDOT Bridge Preventive Maintenance Program, Revision IV, April 2016.

Note: ** Indicates that the treatment type is only applied if other work is being performed on the same structure.

maintenance treatments into AASHTOWare's Bridge Management software (BrM), the bridge management system's software tool (described below in Section 5.3.3). Until this integration is complete, the selection, implementation, and recordkeeping of preventive maintenance work is entirely within the jurisdiction of TOSS.

Besides the treatments listed in Exhibit 5-7 on the following page, the NJDOT Bridge Preventive Maintenance Program includes three levels of painting treatments, from painting beam ends, through zone painting along the entire structure, to full blast cleaning of the entire structure to bare metal, followed by repainting. NJDOT's

Movable Bridge Engineering Group leads the design, analysis, inspection, investigation, construction support, and emergency response and assistance for NJDOT's 18 movable bridges. The various mechanisms on a movable bridge require mechanical and electrical system preventive maintenance that is more complex than a standard fixed bridge. Regular preventive maintenance of the cables, motors, gates, and other warning devices must be performed to ensure that they function properly.

Rehabilitation

Rehabilitation involves the major work required to restore the structural integrity of a bridge, as well as work necessary to correct major safety defects. Rehabilitation work may be done on one or multiple elements and/or components to restore them. These projects typically require significant engineering resources for design and are costly. Examples of bridge rehabilitation include partial or complete deck replacement, superstructure replacement, and superstructure strengthening. Incidental widening is often associated with some of these activities. NJDOT has standards for which rehabilitation treatments are warranted at which specific condition states across the life cycle of different structure types.

Reconstruction

Reconstruction is the total replacement of a bridge with an entirely new structure. Reconstruction is needed when the bridge has reached the end of its functional life and its structural capacity is insufficient to carry the required vehicular and permit loads. A bridge may also be replaced when several components have reached *Poor* condition and the bridge is limited by other shortcomings (e.g., insufficient under-clearance, insufficient shoulder width) that will be remedied with a replacement project. In some cases, a bridge is reconstructed before it has reached *Poor* condition because it is part ofa project to fulfill other NJDOT objectives, such as a roadway widening project for congestion mitigation.

Exhibit 5-8: South Front Street Single-Leaf Bascule Bridge, Union County, New Jersey

Source: Bridgehunter.com

Note: Bridge for illustration only. No longer in operation.

Initial (new) Construction

Initial construction is the construction of a new structure where none had existed before. Initial construction is not a part of the NJDOT bridge management system. New bridge construction projects originate from safety or congestion relief needs, which are initiated as part of other (i.e., non-asset management) NJDOT planning activities. While initial construction is not a part of bridge life cycle planning, minimizing life cycle cost is an important factor in conceptual and final design for new bridge construction.

New Jersey is a densely developed state with a road network that is substantially built out.

The great majority of NJDOT investment goes toward the management of this existing network and to its improvement.

5.3.3 NJDOT Bridge Life Cycle Planning Practice

Software Tools

NJDOT uses Bentley's AssetWise Asset Reliability Inspection software version 7.5 (also called Combined Inspection System or CombIS) as the primary tool for data collection and data quality assurance. NJDOT uses AASHTOWare's Bridge Management software Version 6.5.0 (BrM 6.5) as the primary tool for data analysis. A detailed presentation of BrM 6 is in Appendix D. A brief overview follows.

BrM 6.5 is a software tool developed primarily for modeling bridge deterioration, life cycle planning, and performing optimization analysis. The tool is structured and implemented with the components presented in Section 5.1.

The software system has the capability to support network planning, developing a set of bridge projects that optimize user-defined objectives, subject to funding constraints. The utility score is the heart of this BrM optimization function. The BrM utility score can incorporate four objectives: (1) bridge condition, (2) life cycle cost, (3) mobility, and (4) risk. The score is computed as a weighted sum of the scores for each of these objectives. NJDOT selects the weights and configures the scoring for each of the several factors that are used to compute each objective's overall score. For each bridge, BrM calculates a utility score for each eligible treatment type (including a "no treatment" alternative). BrM uses incremental benefit-cost analysis (described in section 5.1) to identify the set of treatments that maximize the sum of utility scores across all bridges, subject to the funding constraint. The network optimization can be run to support the evaluation of life cycle planning strategies by using varying settings for inputs such as funding levels and treatment selection rules.

Improvements and Enhancements in Bridge Life Cycle Planning

Implement Improved Life Cycle Planning Tools to Support Project Selection

BrM is a software tool that is continuously being enhanced by the vendor and its implementation at NJDOT is continuously being refined. Some examples of enhancements and refinements are described below. A comprehensive summary of the functions of the NJDOT bridge management system and near-term improvement plans is contained in the *2021–2022 State Planning and Research Program Statement for the Bridge Management System*, provided in Appendix D.

Refinements to the BrM Configuration

NJDOT's configuration of BrM has matured to a point that it can start performing life cycle planning analyses. However, the configuration is not sufficiently refined for NJDOT to rely on its network optimization outputs as a primary input to bridge project selection. Some of the components of the system that are being refined include the following:

- **Deterioration modeling —** NJDOT has commissioned a research project to review and improve the deterioration modeling.

- **Action triggers and action effects modeling —** Loosely speaking, BrM groups actions and their triggers into network policies and life cycle policies. NJDOT is at the beginning stages of setting action triggers that use AASHTO National Bridge Elements (NBE) condition data. Previously, NJDOT exclusively used major component NBI ratings (the 0–9 rating scale applied to deck, superstructure, substructure, and culvert). Concurrently, NJDOT is refining the action effects modeling; these models are critical to creating the benefit results that are used to select optimized treatments (treatments that maximize total benefit for the given funding level).
- **Weighting schemes —** These schemes include the weights assigned to elements that make up condition indices, as well as the weights applied to various objectives to calculate the utility score, such as condition measures, risk measures, life cycle cost scores, and mobility effect measures.

Calibrating and Using the New Life Cycle Cost Analysis Module in BrM

BrM 6.5 introduced an advanced life cycle cost analysis module. This module can compute a very large number of alternative year-by-year sequences of bridge preservation, rehabilitation, and replacement treatments to find the sequence that minimizes the life cycle cost of keeping the bridge in service. The module is applied to a single bridge and focuses only on its life cycle cost. In contrast, the network optimization module described above optimizes over multiple objectives for a collection of bridges, albeit with a more limited life cycle computational algorithm than the life cycle cost module.

The life cycle cost module can also be used in a more constrained manner, for example by running on multiple alternatives for a first action and finding the resulting sequence of treatments and life cycle cost for each alternative. NJDOT will use the module in this manner when scoping projects for bridges identified as in need of treatment. Application of the module in these project scoping endeavors will have the collateral benefit of strengthening network life cycle planning processes by helping NJDOT to refine and inform life cycle investment strategies more generally.

Expanding the Menu of Preventive Maintenance Treatments in BrM

BrM 6.5 is currently formulated with a generic preservation treatment and unit cost. NJDOT plans to develop a more detailed menu of preventive maintenance treatments with BrM. This initiative to integrate preventive maintenance planning support in BrM includes the integration of data from NJDOT's maintenance management system.

Improve Planning for Preventive Maintenance Treatments

NJDOT has implemented a Bridge Preventive Maintenance Program that undertakes actions to extend the life of a bridge component before reaching the point of requiring major rehabilitation or replacement. This program is a key part of the life cycle plan and a significant improvement over prior "worst first" approaches in which a component or the entire structure is replaced at the end of its

service life without extending that life through maintenance and preservation treatments.

The NJDOT Transportation Operations Systems and Support (TOSS) is the owner of the Bridge Preventive Maintenance Program. TOSS plans preventive maintenance treatments after reviewing bridge inspection reports and then selects projects based on the condition of bridge elements and components. TOSS and the Structure Evaluation and Bridge Management Unit (SEBM) are collaborating to improve the process and program results.

Implement an Enhanced Bridge Risk Assessment Framework

NJDOT is creating a framework that assigns a risk score for the following seven categories of risk:

- Fatigue
- Overload
- Vehicle collision with structure
- Vessel collision with structure
- Seismic event
- Scour
- Flooding

Each bridge will be assigned a score for each risk. The score will be based on the location, bridge characteristics, environment, and other related attributes. The study creating this framework also will create a menu of mitigation actions. NJDOT will use the risk score and menu of mitigation actions to identify and prioritize mitigation measures for SHS bridges. The prioritization also will be informed by the Climate Hazards Visualization Tool and transportation criticality tool that are being developed for NJDOT. More information on these tools can be found in Section 6.3.3 of *Chapter 6: Risk Management*.

NJDOT envisions that some of the risk mitigation measures will be implemented and funded under dedicated line items in the capital plan, similar to the existing scour countermeasures program. Besides dedicated line-item funding, the scour countermeasures program has streamlined implementation procedures that save time and resources compared to the standard capital project development process.

The risk assessment framework will also be integrated into life cycle planning through use of the risk score in the BrM network optimization module (described previously in Section 5.3.3 and in more detail Appendix D). Also, the enhanced risk assessment framework will support NJDOT bridge managers in considering identified risks when scoping projects for bridges that are selected for work based on other criteria, such as bridges with one or more components with an NBI rating of *Poor*.

Use of Bridge Life Cycle Planning Analysis Results

Within the Division of Bridge Engineering and Infrastructure Management, the SEBM is responsible for the Bridge Management System (BMS) and for establishing the bridge life cycle strategy. SEBM uses the modeling functionality of BrM to identify potential rehabilitation and replacement projects. The selection of projects from among the work candidates advanced by the software remains subject to review by NJDOT subject matter experts. Their reviews include considerations of:

- Risks to the asset
- Ability to deliver the project
- Work history on the asset

- Life cycle cost analysis of alternative treatments and project timing
- Implications of other work on the network in the vicinity
- Significance of the asset to the transportation system.

Besides those projects identified by the BrM network optimization module, project candidates also originate from inspection reports, and, to a lesser extent, from other units within NJDOT. As BrM software functionality improves and as NJDOT calibration of the software continues to advance, NJDOT anticipates BrM to take on an increasingly greater role in project selection. NJDOT also is beginning to use the new BrM life cycle cost analysis module in the study and development phases of a project.

The BrM network optimizer was run in support of the TAMP performance gap analysis. The optimizer was set to maximize utility as measured by a weighted average of element condition state quantities, subject to various funding constraints as defined by the investment scenarios. The resulting bridge projects selected were input into a spreadsheet which performed post-processing calculations to yield projected network performance measured as deck area *Good*, *Fair*, and *Poor* over the TAMP planning period. The post processing consisted of: (1) factoring in condition improvements from projects that are already in the pipeline ("frozen projects"); (2) simple deterioration modeling that applies a fixed annual transition percentage of *Fair* bridges to *Poor* (by deck area); and (3) crediting an improved condition for the bridges selected by BrM according to their BrM-selected treatments.

5.3.4 NJDOT Bridge Life Cycle Strategy

NJDOT recognizes that it is typically more cost-effective to apply repeated repairs and preservation treatments to maintain a bridge in good condition than to replace a bridge, superstructure, and/or deck that has deteriorated beyond repair. Accordingly, the Department has been increasing funding allocated to preservation treatments. At the same time, NJDOT has an objective of having at least 94% of the deck area in its bridge network in a state of good repair (*Good* or *Fair* condition). While preservation spending helps to reduce the growth in the backlog of bridges needing major investments, there is an existing backlog that still needs to be addressed with major rehabilitation and reconstruction projects. NJDOT's bridge life cycle investment strategy is to balance the prudence of preservation spending with the need to continue to invest heavily in major renewal projects to reduce the backlog of bridges rated *Poor*.

5.4 LIFE CYCLE PLANNING OF OTHER NHS OWNERS IN NEW JERSEY

5.4.1 New Jersey Turnpike Authority (NJTA)

NJTA Pavement Life Cycle Planning

NJTA owns and manages approximately 2,342 lane miles (19%) of NHS pavement on two major highway networks: the New Jersey Turnpike and the Garden State Parkway. Both roadways carry considerable travel volumes, with the New Jersey Turnpike also carrying significant freight volumes. When considering interstate pavement only, NJTA owns 31 percent of the interstate pavement lane miles in New

Jersey. Presently, the majority of NJTA pavement is in *Excellent/Good* condition. NJTA's pavement condition maintenance strategy consists of the following four components:

- Condition assessments using collected pavement data
- Prioritization of pavement needs based on condition assessments
- Completion of projects to address pavements in *Poor* condition
- Completion of projects to prevent pavements from reaching *Poor* condition

NJTA has implemented a pavement management system (PMS) to manage collected data and condition assessment results. The PMS also provides information used to estimate needed treatments and their timing, based on projected condition.

The PMS is comprised of four key elements:

- Detailed pavement surface condition data (pavement roughness, cracking, and rutting) collected annually by an instrumented van that also captures panoramic images of the roadway pavement and appurtenances.
- A decision support system (DSS) that utilizes AASHTOWare's Pavement ME Design software to measure and analyze pavement behavior and life cycle performance. The DSS also calculates the NJTA Pavement Rating (NPR), the Authority's unique pavement performance rating that is consistent with the Authority's 5-level rating program: *Excellent, Good, Fair, Poor*, and *Very Poor*.
- Annual pavement inspection by Authority engineers utilizing a mobile device to rate pavement segment conditions and determine where mill and resurface (M&R) and interim repairs may be needed.
- A pavement condition view, that is a web-based geospatial application that enables the Authority to compare and understand the large volume of pavement condition data over multiple years, display pavement section life cycle performance, and generate reports with cost estimates for the most cost-effective M&R schedules.

The Authority utilizes M&R as the primary pavement maintenance and repair method. The DSS is used to measure pavement condition and predict future behavior and pavement life cycles for the Turnpike and Parkway. The timing of M&R cycles was initially analyzed based on the FHWA's recommended minimum pavement level of service for interstate highways. The timing of M&R cycles at current service levels and schedules is compared to the PMS-analyzed level identified as part of Goal #4 of the Authority Strategic Plan 2020–2029 that was adopted in 2020. This goal is to have 100 percent of pavement sections meeting or exceeding the average NJTA pavement rating of 3.5 and no pavement in any section with a rating of less than 2.8.

NJTA collects detailed distress data on all lanes of the New Jersey Turnpike and the Garden State Parkway every five years and annually on the heaviest-travelled lane of each. Visual observations augment the data to identify sections of each roadway for resurfacing projects (i.e., mill and overlay).

The current life cycle strategy for the Garden State Parkway (GSP) is to perform a mill and resurfacing of each of the GSP's 15 resurfacing sections every 10 to 12 years. Dividing the roadway into 15 separate sections assists in tracking pavement condition and the identification of annual projects.

The Garden State Parkway (GSP) has divided entire roadway network in 15 sections which assists in tracking pavement condition and the identification of annual projects. The current life cycle strategy for the GSP is to perform a mill and resurfacing of each of the GSP's 15 resurfacing sections every 10 to 12 years.

For the New Jersey Turnpike, the life cycle strategy is to perform a mill and resurfacing of each of the 23 sections every 8 to 9 years. The shorter resurfacing frequency on the Turnpike roadway is due to a higher volume of heavy-truck traffic. To achieve this goal additional funding has been allocated.

NJTA utilizes the PMS to quantify pavement conditions and make decisions on M&R and interim needs. The PMS has been instrumental in providing appropriate supporting documentation to justify the allocation of NJTA funding to support our strategic goal. Further details about NJTA funding for pavement resurfacing and capital projects are provided in *Chapter 7: Financial Plan*.

Regarding improving the resilience of the NJTA network and mitigating the risks associated with climate change and extreme weather events, NJTA is responding to NJ Executive Orders 89 and 100 issued in 2019 and 2020 and developing a resilience program through a phased set of tasks that focus on leveraging planning processes, design procedures, and maintenance/ operations efforts as opportunities to protect and prolong the life of existing assets and to improve planning and asset management for the future of NJTA's toll road system. This approach will enable NJTA's actions to align with the New Jersey statewide efforts on resilience. For sustainability, pavement mixes also use recycled material.

NJTA Bridge Life Cycle Planning

NJTA owns and manages approximately 21,205,768 square feet (34%) of NHS NBIS bridge deck area. Presently, the majority of NJTA bridges by deck area are in *Good* or *Fair* condition (94.9%). NJTA's strategy to maintain the condition of its bridges consists of four components:

- Condition assessments using bridge inspection data
- Prioritization of bridge needs based on inspection findings
- Completion of projects to address bridges in *Poor* condition
- Completion of projects to prevent bridges from reaching *Poor* condition

The NJTA's life cycle planning strategy for bridges programs repairs in response to bridge inspection findings. NJTA screens bridges based on routine inspection findings and includes any repairs in its annual maintenance program. The NJTA strategy develops capital programs encompassing several years to include structures scheduled to be rehabilitated or replaced. The effectiveness of the current NJTA approach is supported by data predicting that less than 10 percent of its bridges by deck area will be rated as *Poor* by CY 2027 and CY 2032. Considering the

success of the current strategy, NJTA is not planning on any significant changes in how it maintains its bridges.

Historically, the annual NJTA maintenance program funding increases annually to address anticipated needs. Between FY 2018 and FY 2020 the maintenance program expenditures increased by almost 25 percent, indicating that the current repair strategy provides a flexible approach. Bridge repairs include projects not only on bridges in *Poor* condition, but also includes repairs on bridges to prevent them from reaching *Poor* condition. In May of 2020, NJTA announced its 2020 long-range capital plan, which includes a multitude of bridge projects to address and prevent deterioration on both the New Jersey Turnpike and Garden State Parkway roadways. Further details about NJTA funding and planned bridge repair and capital projects are provided in *Chapter 7: Financial Plan*.

Additionally, NJTA has a culvert program that includes inspection of NJTA culverts and programming culvert improvements based on existing conditions and need. The culvert program minimizes risk of pavement damage due to culvert failures.

5.4.2 South Jersey Transportation Authority (SJTA)

SJTA Pavement Life Cycle Planning

SJTA manages 269 lane miles (2%) of non-interstate NHS pavement on the Atlantic City Expressway, Atlantic City Expressway Connector, and NJ Routes 30, 87, and 187. SJTA is transitioning its life cycle planning practices to a holistic transportation asset management-led approach. Currently, SJTA pavement life cycle plan applies a traditional mill and hot mix asphalt overlay on a 10- to 11-year cycle. The SJTA conducts annual visual inspections along with periodic International Roughness Index (IRI) testing. The results of the observations and tests are incorporated into the planning and prioritization of rehabilitation projects. The SJTA data supports the effectiveness of the current approach, predicting that no SJTA pavement will be rated as *Poor* by CY 2027 and CY 2032. Additional improvements in SJTA pavement conditions are anticipated under the holistic transportation asset management approach.

SJTA Bridge Life Cycle Planning

SJTA manages approximately 419,262 square feet (1%) of NHS NBIS bridge deck area on the Atlantic City Expressway. SJTA is transitioning its life cycle planning practices to a holistic transportation asset management led approach. Currently, the SJTA life cycle plan for bridges utilizes biennial inspection program data to determine the deterioration rates of bridge elements. Bridges are repaired annually to address the findings from the biennial inspections. The SJTA capital program budgets vary from $0.5 million up to $10 million annually to repair, rehabilitate, and reconstruct the condition of bridges. The consultant-led effort prepares a five-year outlook into capital planning needs for SJTA. The effectiveness of the current approach taken by SJTA is supported by data predicting that none of its bridges by deck area will be rated as *Poor* by CY 2027 and CY 2032. Additional improvements in SJTA bridge conditions are anticipated under the holistic transportation asset management approach.

5.4.3 Port Authority of New York and New Jersey (PANYNJ)

PANYNJ Pavement Life Cycle Planning

Details for the Port Authority life cycle planning practices are described within the following section on bridges, as pavements are typically managed as part of a facility-based project and not separately by lane mile. Most of the Port Authority's facilities included in the TAMP are bridges. The Port Authority's share of NHS pavements (<0.4%, 46.2 lane miles) is considerably less than its share of NHS bridges by deck area.

PANY&NJ Bridge Life Cycle Planning

The Port Authority of New York and New Jersey owns and manages 3,666,880 square feet (6%) of NHS NBIS bridge deck area in New Jersey. The Port Authority's life cycle planning practices can be broadly divided into three phases: (1) Project Planning, (2) Project Initiation/Definition Scoping, and (3) Project Prioritization.

- **Project Planning** — This first phase begins with the Engineering Department's Quality Assurance Division (QAD) completion of a biennial inspection for a facility, including the inspection report, summary of findings, and potential recommendations. Once completed, these reports are transmitted to the facility manager, the Tunnels, Bridges, and Terminals Department (TB&T); and the Engineering and Architectural Design Division (EADD). The recipients review each of the reports as a team to identify the repairs that address the findings of the inspections.

  Led by TB&T, specific repairs are added to one of two lists: "Immediate and Miscellaneous Repairs Log" or the "Priority Repairs Log." Both lists track repairs from discovery to execution. Before a repair is formally added to one of the two lists, TB&T (along with QAD and EADD) reviews the current lists of repairs to ensure that any existing repair on the lists is not duplicated. This review affords TB&T the opportunity to identify any trends that may be developing among the logged repairs. QAD reviews the lists and potential additions to ensure that the asset element/component requiring repair has at least two years of remaining service life.

- **Project Initiation/Definition Scoping** — The second phase begins as TB&T and EADD (with support from QAD) group needed repairs by facility to form "projects" addressing the facility's needs either as a Short-Term Priority Repair Project or a Comprehensive Long-Term Replacement/Rehabilitation Project. If there are few repairs for a given facility that are unrelated to each other, are not critical, or that can be completed in the short term, the repairs will not be grouped into projects but simply remain in their respective repair lists. In the case of non-project repairs, the Capital Planning Office manages how and when the repairs are addressed. The repairs may be included in the Operating Major Works Program (OMWP), or accomplished through

work requests with existing contractors, new work orders, or new RFPs. For repairs that are grouped into projects, TB&T and EADD develop a scope of work and magnitude of cost estimate for each of the proposed projects.

- **Project Prioritization —** The third phase begins as a Project Initiation Request Form (PIRF) is developed for each project. A state of good repair scorecard is completed by the project manager and lead engineer for the facility. The scorecard considers not only the physical condition of a facility but also considers the operational impact associated with its failure. Meetings are held with staff to review the various scores on the scorecard and to achieve consensus on the final score. Projects are ranked based on overall scores into categories based on pre-defined thresholds. Projects receiving an overall score equal to or higher than an established threshold are grouped with other projects of the same priority for potential funding as part of the Port Authority's capital plan or OMWP.

If a facility has an overall rating of *Fair* or lower, the project may require the completion of a PIRF and state of good repair scorecard. If this trigger is met, EADD will complete a full life cycle analysis for the facility ("Comprehensive Condition Assessment") outlining recommendations for the facility. As the Capital Planning Office develops the Port Authority's capital plan and OMWP, high priority projects, any comprehensive condition assessments, and lower priority projects are subject to review.

5.4.4 Other Jurisdictions

Pavement Life Cycle Planning

An additional 2,045 lane miles (17%) of NHS pavement in New Jersey is owned by a large number of other municipal, county, and authority owners. These pavements are managed in different ways by each owner. Much of the total 2,045 pavement lane miles is comprised of short sections managed as part of the management of other roadways. Typically, work done on these pavements responds to significant pavement distress and local priorities. Some owners have begun to enforce ride quality standards for NHS pavements to improve conditions, which will support the achievement of the NHPP targets for pavements. Funding for work on these pavements is typically provided through authority tolls or a combination of federal, state, and local funding. As described in *Chapter 7: Financial Plan*, the average level of annual expenditures on NHS pavements is expected to increase beyond recent expenditure levels, suggesting that owners are taking the appropriate steps to maintain the condition of their NHS pavements. NJDOT continues to refine its data collection process (described in *Chapter 3: TAMP Governance, Policies, and Objectives*) to improve on the management of New Jersey's NHS pavement assets.

Bridge Life Cycle Planning

An additional 7,325,516 square feet (12%) of NHS NBIS bridge deck area in New Jersey is owned and maintained by a variety of other municipal, county, and authority owners. These bridges are managed with a condition-based strategy; repairs to the structures are based on

the findings of biennial inspections. Presently, non-authority and non-commission bridge owners' preventive maintenance programs, or equivalent, are unknown to NJDOT.

Based on outreach results, the average level of annual expenditures on NHS bridges is expected to increase, suggesting that owners are taking positive steps to maintain the condition of their NHS bridges, as detailed in *Chapter 7: Financial Plan*. NJDOT continues refining its data collection process (described in *Chapter 3: TAMP Governance, Policies, and Objectives*) resulting in improvements in the management of New Jersey's NHS bridge assets.

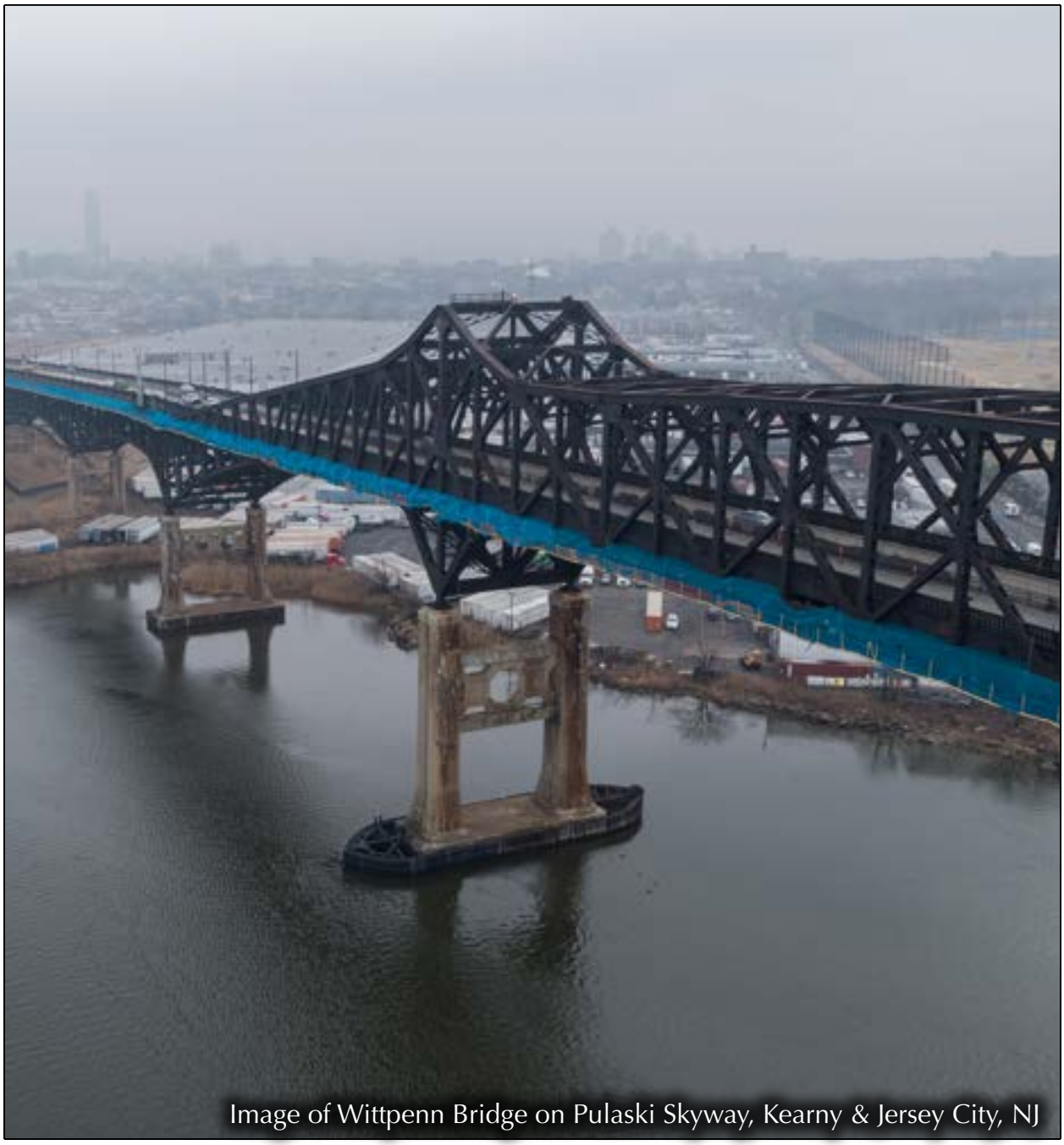
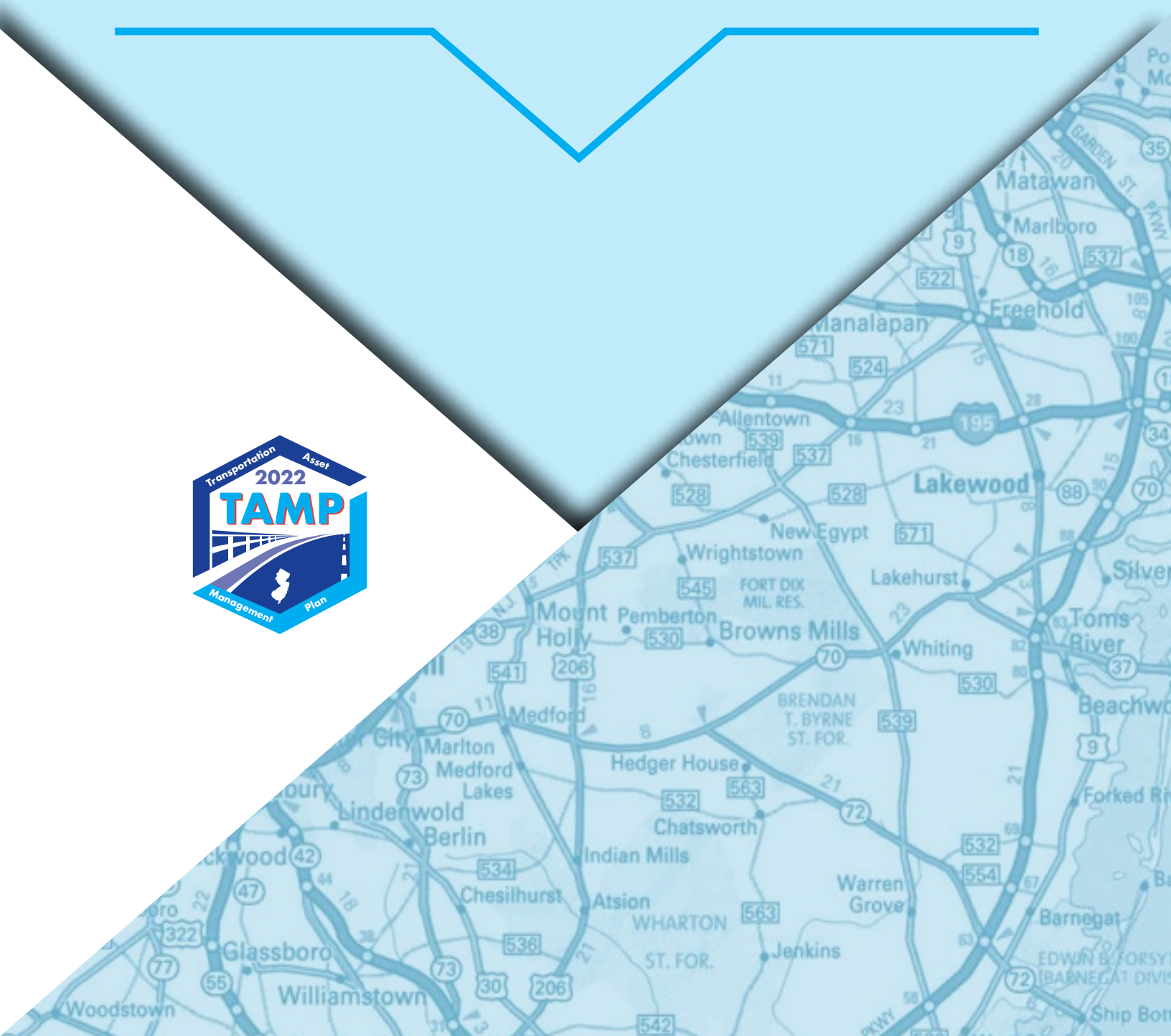


Image of Wittpenn Bridge on Pulaski Skyway, Kearny & Jersey City, NJ

CHAPTER 6:
RISK MANAGEMENT



BACKGROUND: Risk management involves addressing vulnerability, uncertainty, and threats to the achievement of objectives. The risk management process outlined in the New Jersey Transportation Asset Management Plan (TAMP) is intended to provide a mechanism for the New Jersey Department of Transportation (NJDOT) to manage the effects of uncertainty on the TAMP policy, extreme (weather/external) events, and state of good repair objectives. It identifies critical risks to the accomplishment of these objectives and establishes an ongoing process to evaluate and address those risks to enhance the resilience of New Jersey's transportation asset management program.

6.1 OVERVIEW

Risk management is an established practice at NJDOT. NJDOT's delivery process has incorporated risk management practices as integral features in its overall planning processes.[1] The TAMP risk management process builds on the following guidelines:

- NJDOT's *Risk Management Guidelines* (2017) provides NJDOT project managers with standardized procedural guidance on project-level risk assessment and management.
- ISO31000:2009, *Risk Management—Principles and Guidelines* provides NJDOT management with standards of practice for enterprise risk management that are applied to incorporate risk into the TAMP process.

Image of Bridge Deck Patching, NJ 4 / Passaic River, NJ 20, & River Road (CR 507)

Image of NJ Route 35 after Hurricane Sandy

The TAMP risk management process identifies and categorizes risks, evaluates risks, and provides a framework for addressing these risks within the context of the TAMP policy and state of good repair objectives. The evaluation identifies risks to achieving the state of good repair objectives established for the National Highway System (NHS) and State Highway System (SHS). The process results in a risk register, a tool used to monitor and manage high impact risks to the TAMP objectives.

[1] See https://www.state.nj.us/transportation/capital/pd/process_riskmgt.shtm for more details

6.2 RISK MANAGEMENT FRAMEWORK AND PROCESS

6.2.1 Role of and Responsibilities for Risk Management

Role of Risk Management

Risk is the "effect of uncertainty on objectives."[2] The management of risk as a business practice prepares NJDOT for managing internal and external uncertainties regarding future events and conditions. The role of risk management is to develop a systematic approach to anticipating adverse and unexpected situations and responding effectively to these situations in the event they arise. The risk management process allows management to understand the risk and define actions that avoid, reduce, address, or accept the risk.

Risk management serves a critical role in the ability to fulfill the TAMP policy and state of good repair objectives. While there are multiple ways to use risk management information in asset management plans and processes, the role of risk management in the TAMP is outlined in the five steps below.

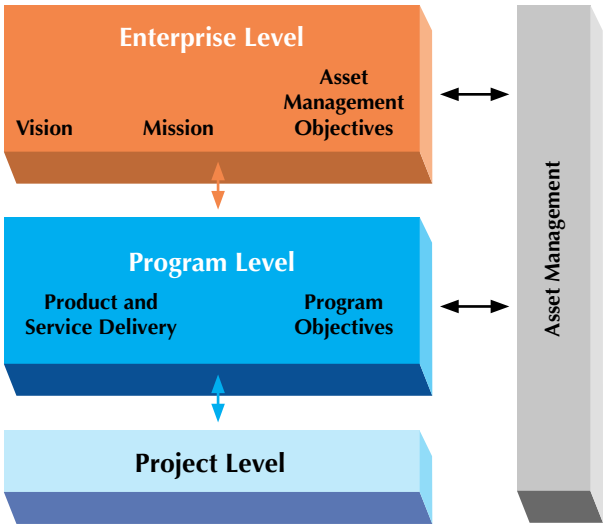
1. ***Provide Information***
   The identification of risks informs key players (Transportation Asset Management Steering Committee, Directors Group, TAMP Team, and other stakeholders) that these risks could potentially obstruct the implementation and accomplishment of the TAMP as planned.
2. ***Reduce Risks to Performance***
   Through the use of risk information, NJDOT identifies and addresses internal and external risks to the likelihood of implementing the TAMP or achieving TAMP objectives.
3. ***Set Priorities for TAMP Enhancements***
   By utilizing the risk management process, NJDOT identifies specific staff needs to improve system-wide performance. Such needs may include increasing data collection efforts and providing training to improve modeling and forecasts for planning purposes.
4. ***Prioritize Capital Investments***
   NJDOT determines which at-risk transportation assets or networks merit increased investment or monitoring, as well as which high-value, high-risk assets merit closer administration.
5. ***Improve Resilience***
   Resilience is the capacity to prevent, withstand, respond to, and recover from a disruption.[3] Extreme weather events and their effects on the transportation system are risks considered in the TAMP risk management process. By utilizing the risk management process, NJDOT identifies mitigation strategies that can "harden" the system and make it more resilient to hazards associated with climate change and other stressors.

[2] ISO 31000 definition
[3] U.S. Climate Resilience Toolkit

Responsibilities for Risk Management

The TAMP process manages risk at the enterprise level and program level as shown in Exhibit 6-1.

Exhibit 6-1: NJDOT Manages Risk Through an Enterprise Risk Management Approach in the TAMP



Enterprise-Level Responsibilities

Enterprise-level risk affects the ability of NJDOT to accomplish its overall mission and achieve its strategic goals and objectives. Enterprise-level risk is concerned with the upper levels of an organization and includes the management of overall policy objectives and investment priorities for asset management. The Transportation Asset Management Steering Committee manages risks that require policy-maker action and enterprise-level action. The Transportation Asset Management Steering Committee meets annually to review TAMP risks and monitor the status of the TAMP implementation and risk management actions (see Section 6.3).

Program-Level Responsibilities

Program-level risks threaten accomplishment of objectives for programs that manage a specific asset class (i.e., pavement, bridges, others). Accountability for the execution of risk-management activities at the program level is overseen by the TAMP Team. The TAMP Team is comprised of program managers and technical leaders with program management responsibilities for the accomplishment of the TAMP state of good repair objectives. Risks are subsequently monitored and reviewed annually in a dedicated TAMP Team risk management workshop. The workshop is facilitated by reference to the TAMP risk register and the agenda is to monitor and refine risk mitigation and response actions or strategies (see Section 6.3).

6.2.2 Risk Management Process

The TAMP risk management process identifies and addresses risks that may impact NJDOT's ability to fulfil its overall mission. The TAMP risk management process is consistent with industry best practices as outlined in the framework for managing risk (based on ISO 31000), AASHTO's *Guide for Enterprise Risk Management*, and FHWA's *Risk-Based Transportation Asset Management* reports.

6.2.3 Risk Management and NJDOT's Broader Planning Process

The risk management process is closely tied to other TAMP processes, including life cycle planning and financial planning, which influence the development of investment strategies. The risks to the accomplishment of the TAMP policy and state of good repair objectives also influence other NJDOT planning processes, such as New Jersey's Transportation Capital Program development process. The relationship between the TAMP risk management process and NJDOT's broader planning processes is shown in Exhibit 6-2 on the following page. The risk management mitigation strategies identified on the following page are to be followed through to avoid negative impacts upon other NJDOT processes.

6.2.4 Risk Management Process Steps

NJDOT's process to manage risks is shown in Exhibit 6-3 on the following page. The exhibit depicts how asset management is an enterprise-wide activity and is central to NJDOT's overall mission. Program areas including bridge, pavement, and others are each responsible for the work activities and products required to accomplish the objectives set by the agency.

NJDOT's risk management process applies to the development of the TAMP and provides the foundation for the practice of risk management in future TAMP updates. The application of this process follows the steps outlined in the following sections.

Step 1. Establish the Context, and Step 2. Identify Risks

The first step establishes the context by identifying the circumstances that form the setting for asset management at NJDOT. Context includes the social, cultural, legal, regulatory, economic, extreme events and natural environments to which NJDOT must be sensitive.

For the TAMP, the context and the risks are closely related. For example, NJDOT must comply with the regulatory requirement for the TAMP to address the full NHS; however, because much of the NHS is owned by other jurisdictions within New Jersey, there are risks associated with data accuracy.

To adequately manage risks, NJDOT must first define the internal and external environments that comprise the context for asset management. NJDOT's internal environment is shaped by its internal stakeholders, governance structure, capabilities, and overall objectives. The external environment is shaped by local, state, and federal policy environments, jurisdictional roles, and priorities. Once the full context is established, risk identification can take place. The risks that may affect the achievement of the TAMP policy and state of good repair objectives are identified, defined, and categorized according to their potential impact upon NJDOT and its different programs.

The TAMP risk management process combines these two steps in a collaborative effort consisting of the brainstorming of hazards, identification of associated impacts, and development of detailed risk statements to be analyzed and addressed. This collaborative effort takes place as part of the TAMP process during the TAMP Team risk management workshop. The key participants include TAMP Team members and representatives from key functional areas and NJDOT business units.

Types of Risk

Exhibit 6-2: TAMP Risk Management Relationship to NJDOT's Planning Processes

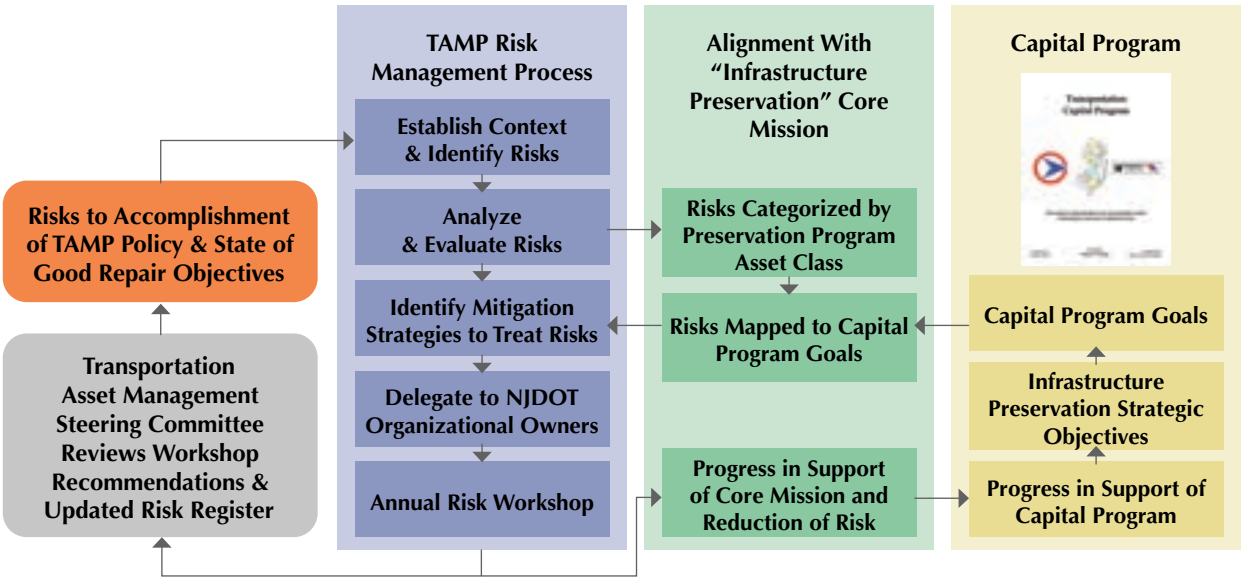
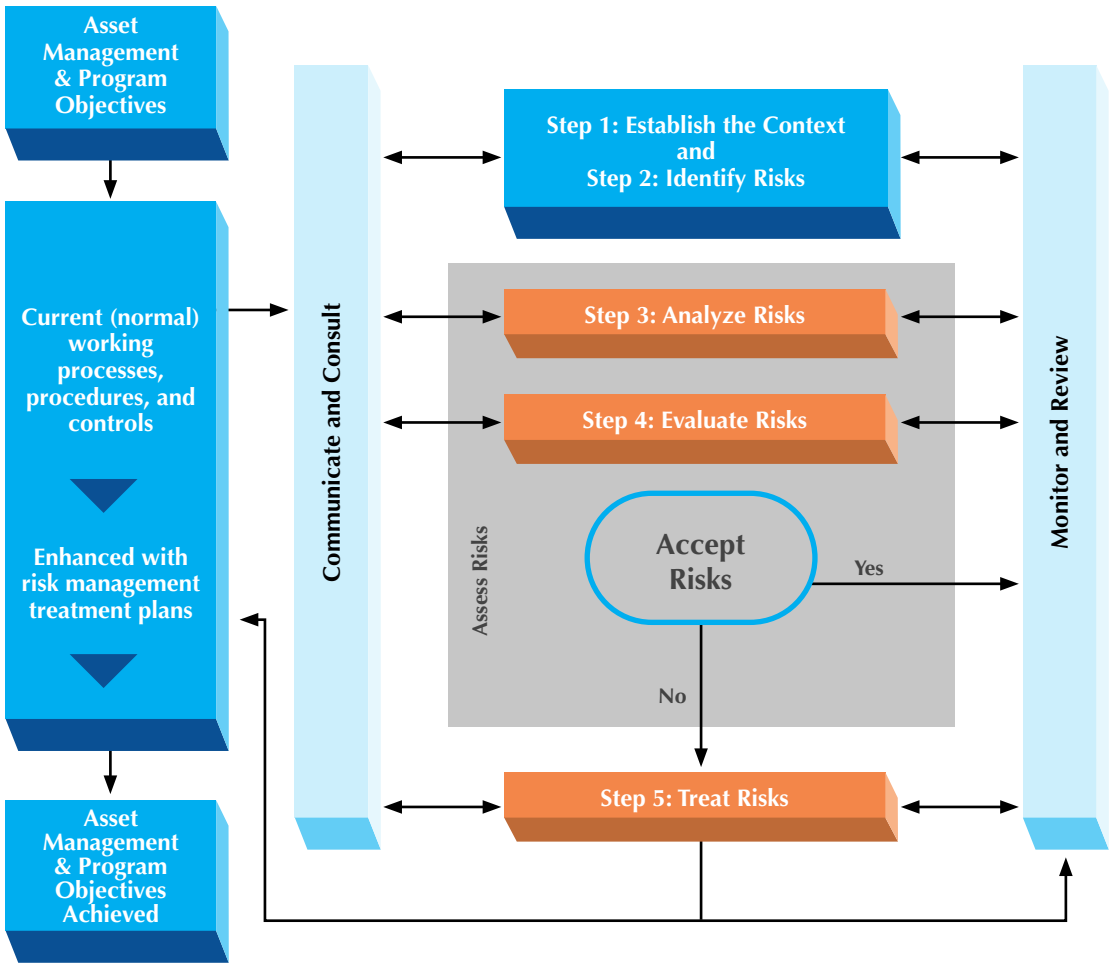


Exhibit 6-3: NJDOT ISO-Based Risk Management Framework



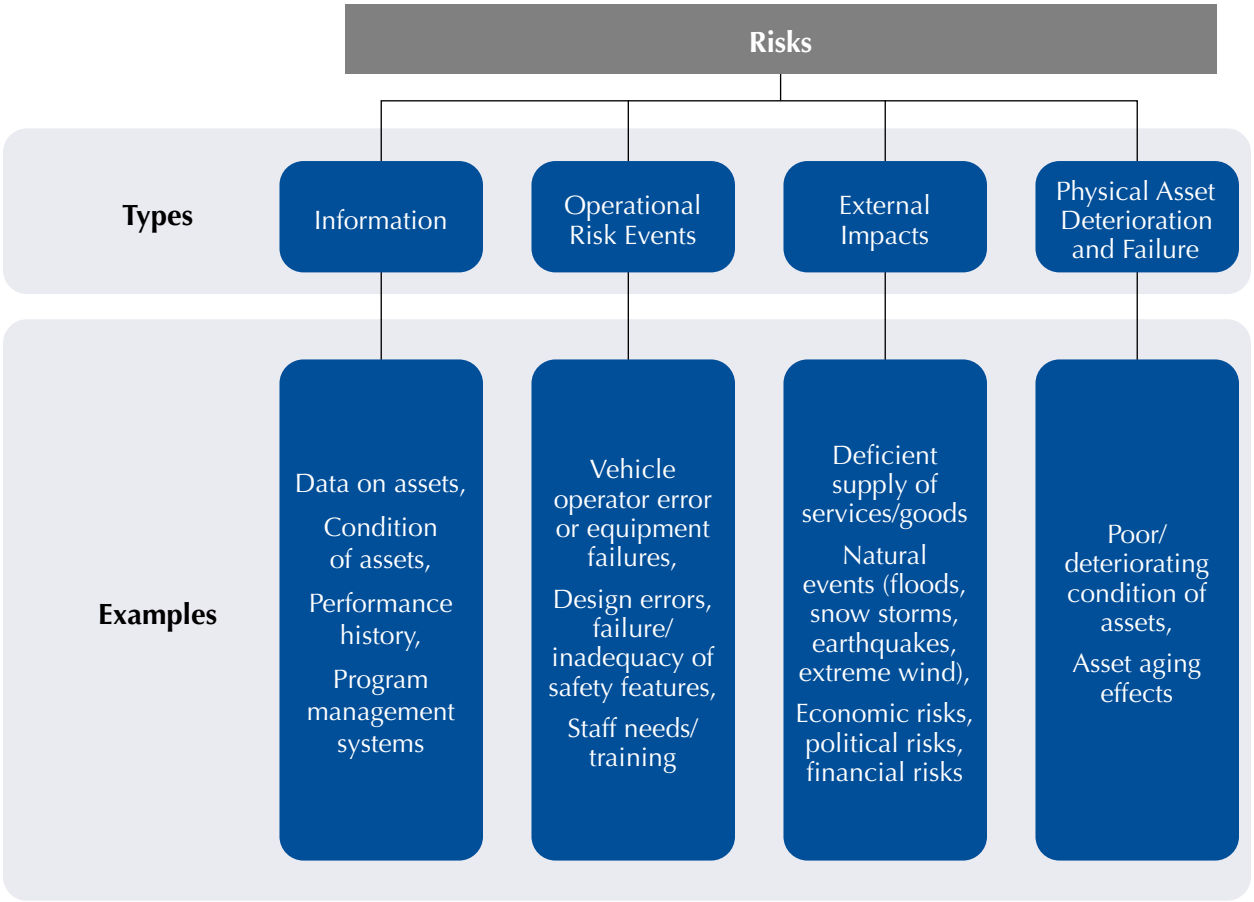
management workshops and are described below and shown in Exhibit 6-4. The risk types shown in this exhibit are now the foundation for the TAMP risk management process, with any additions being new or emergent. Each of the asset classes and systems that comprise the overall transportation network is susceptible to the sources and types of risks depicted in Exhibit 6-4, below.

Additionally, the ownership of New Jersey's NHS roadway assets is distributed across many jurisdictions (a total of 84 non-NJDOT NHS owners), further complicating the risk management process. A detailed description of each of the risk types follows Exhibit 6-4.

Information

Information plays a key role in effectively establishing, managing, and accomplishing TAMP objectives. Analyses, objectives, strategies, and decision guidance are all dependent on the quality of the data used to compute these items, which directly impacts the accuracy of the analytical processes used to prepare the TAMP. The possibility of inaccurate or incomplete information poses risks to the accuracy and usefulness of the analysis outcomes used in developing the TAMP and more generally, in managing the assets.

Exhibit 6-4: NJDOT Identified Risks – Types and Examples



Operational (Internal) Risk Events

Operational risks are internal to NJDOT and pose threats to the TAMP process in a variety of ways. Changes in staff, changes in program priorities, such as a reduction in funding for maintenance, a reduction in funding for design, or operational errors that result in project failures or changes to project schedule, all have the potential to negatively impact the implementation of the TAMP and its recommended investment strategies.

External Impacts

External impacts (including impacts upon third parties that support NJDOT's operations) are those risks that are beyond the control of NJDOT. Such risks include, among others, political, financial, environmental, fraud or malfeasance (security issues, terrorism, vandalism). External risks have the potential to affect the accomplishment of the TAMP objectives.

New Jersey has experienced several extreme weather events in recent years, spawning research efforts to better understand the specific risks posed by climate change and extreme weather events. Specifically, NJDOT's *Asset Management, Extreme Weather and Proxy Indicators* pilot study (2018) initiated a process that assesses the impacts of extreme or repeat weather events upon the conditions of New Jersey's highway assets. While most external risks cannot be controlled, NJDOT can prepare for and mitigate against the negative effects in advance.

Physical Asset Deterioration and Failure

Deterioration is a physical process that affects all pavement and bridge assets. If deterioration is not addressed, the asset can decay to the point that it cannot serve its intended function, resulting in disruptions to the broader transportation system and the need for expensive remedial action. A major goal of asset management is the development of analytical tools that predict how assets will perform over time. Uncertainty in the pace of deterioration means there is the risk that the appropriate measures to address deterioration will not be implemented and/or that an asset will reach its failure point before expected. The lack of analytical tools or a lack of knowledge of their limitations can in turn become risks contributing to physical asset failure.

Step 3. Analyze Risks, and Step 4. Evaluate Risks

The identified risks are analyzed and evaluated as part of a facilitated discussion during a TAMP Team risk management workshop to determine their individual likelihoods and impacts upon the achievement of the TAMP objectives. Participants reach a consensus during the workshop on the likelihood and impact rating values assigned to each of the risks.

First, risks are evaluated according to their impact on the achievement of the TAMP objectives (ranging from 1 to 10, where 1 is very low and 10 is very high). Risks are then evaluated by their likelihood of occurrence (ranging from 1 to 5, where 1 is very low and 5 is very high). The impact rating is multiplied by the likelihood rating to compute an overall risk rating value, which represents the relative magnitude of the risk.

Risk rating values can range from as low as 1 to as high as 50 (for example, if the impact rating of Very High [rating of 10] is multiplied by a likelihood rating of Very High [rating of 5], this will result in the highest risk rating value of 50).

These resulting risk rating values are then used to rank the risks according to their relative ability to impede the fulfillment of the TAMP policy and state of good repair objectives. The risk evaluation is facilitated through the TAMP risk register tool, in the form of a spreadsheet, which has been calibrated to apply the TAMP process risk rating approach.

Risk Rating Approach

The TAMP risk rating process is consistent with the approach used at the project level at NJDOT. Risk is evaluated along the following dimensions:

Impact – Impact (or consequence) refers to the extent to which a risk event might affect NJDOT or the TAMP. Impacts are defined for each risk.

Likelihood – Risks are assigned a descriptor that represents the possibility that a given risk event will occur.

Risk Rating – The risk rating is the result of the risk evaluation and is the mathematical product of a risk's likelihood rating and its impact rating. Risk rating values range from 1 to 50, and are categorized as follows:

- **Critical** – Requires elevating decision-making to the Transportation Asset Management Steering Committee; requires prompt action to implement new enterprise-level controls. Values in this category, shown in red in Exhibit 6-7, range from 31 to 50.
- **High** – Affects the ability of the agency to carry out its mission or strategic plan. Existing controls may be effective; however, additional action and/or controls may be required. Values in this category, shown in orange in Exhibit 6-7, range from 16 to 30.
- **Medium** – Impacts completion of a critical agency function. Existing controls may be effective; however, additional actions may need to be implemented. Values in this category, shown in yellow in Exhibit 6-7, range from 6 to 15.

Exhibit 6-5: Impact Rating Approach

Likelihood Rating	Definition	Effects
Very High = 10	This event will result in a major impact to achieving policy objectives and system performance.	Affects the health and well-being of the citizenry, the agency's ability to comply with statutes, the ability to achieve objectives, or the cost of programs by more than 20%.
High = 7	This event will result in moderate impact on achieving policy objectives and desired/ required system performance.	Affects the safety of individuals or the ability to achieve objectives or causes a more-than-10% change in program budgets.
Moderate = 4	This event will result in limited-to-minor impact on policy objectives and system performance.	Affects objectives or budgets by between 5% and 9%.
Low = 2	This event will result in little-to-no impact on policy objectives and system performance.	Affects objectives or budgets by less than 5%.
Very Low = 1	This event will result in no impact on policy objectives and system performance.	Does not affect objectives or budgets.

Exhibit 6-6: Likelihood Rating Definitions

Likelihood Rating	Definition	Probability
Very High = 5 (Almost Certain)	This event occurs frequently at NJDOT. Current controls or circumstances suggest a likely occurence.	There is a greater than 90% chance of the event happening in the next 12 months. It is likely to occur at least once over the next 12 months.
High = 4 (Likely)	This event may occur at NJDOT on a regular basis. Current controls or circumstances suggest there is a distinct possibility of occurrence.	There is a between a 60–90% chance of the event happening in the next 12 months. It is likely to occur once in 1 to 4 years.
Medium = 3 (Possible)	This event may occur occasionally at NJDOT. Current controls or circumstances suggest there is a possibility of occurrence.	There is a between a 30–60% chance of the event happening in the next 12 months. It is likely to occur once in 5 to 7 years.
Low = 2 (Unlikely)	This event may occur infrequently at NJDOT. Current controls or circumstances suggest the occurrence would be considered highly unusual.	There is a between a 5–30% chance of the event happening in the next 12 months. It is likely to occur once in 8 to 20 years.
Very Low = 1 (Rare)	This event may have happened previously at NJDOT. However, in the absence of other information or exceptional circumstances, NJDOT would not expect it to happen in the foreseeable future.	There less than a 5% chance of the event happening in the next 12 months. It is likely to occur less than once in 15 years.

- **Low** – Managed with current practices and procedures. Impacts are addressed with routine operations monitored for effectiveness. Values in this category, shown in green in Exhibit 6-7, range from 1 to 5.

Risk Rating Matrix

As mentioned previously, risk ratings are calculated by multiplying the impact rating by the likelihood rating. The range of risk ratings is displayed as a heat map, ordered by their relative criticality, in Exhibit 6-7. The risk evaluation process uses a four-level rating system to characterize a risk's relative criticality: low, medium, high, and critical. For example, a risk rated with a "Moderate" degree of impact and "Possible" likelihood, would result in an overall criticality of "Medium."

Step 5. Treat Risks

The treatment of risks consists of developing response strategies and actions for addressing each risk using the risk register; those with the highest risk ratings are prioritized.

The risk register records the response to each risk and specifies the organizational ownership for the response. The selected risk management responses are accompanied by related implementation actions identified by the TAMP Team. Many risk responses can be expected to impact and alter current working processes at NJDOT. Responses for critical risks may initiate more significant shifts in business processes to ensure the achievement of the TAMP objectives. The range of risk responses that appear in the risk register are shown in Exhibit 6-8 (on following page).

Exhibit 6-7: Risk Rating Heat Map

Likelihood	Very High = 5 (Almost Certain)	Low = 5	Medium = 10	High = 20	Critical = 35	Critical = 50
	High= 4 (Likely)	Low = 4	Medium = 8	High = 16	High = 28	Critical = 40
	Medium= 3 (Possible)	Low = 3	Medium = 6	Medium = 12	High = 21	High = 30
	Low= 2 (Unlikely)	Low = 2	Low = 4	Medium = 8	Medium = 14	High = 20
	Very Low= 1 (Rare)	Low = 1	Low = 2	Low = 4	Medium = 7	Medium = 10
Risk Heat Map		Very Low = 1	Low = 2	Moderate = 4	High = 7	Very High = 10
		Impact				

Exhibit 6-8: Risk Responses

Risk Type	Response	Explanation
Adverse Risks	**Avoid**	Terminating the risk by stopping a practice or eliminating the source of the risk.
	Transfer Threat	Shift the impact of a risk to a third party together with ownership of the response.
	Mitigate Threat	If treatment is possible and its benefits outweigh its costs, NJDOT could decide to act on and mitigate the risk.
	Accept Threat	Accepting the risk and providing regular monitoring or treatment of the risk.
Beneficial Risks	**Exploit Opportunity**	Aggressive response strategy to ensure opportunity is realized.
	Share Opportunity	Allocate risk ownership of an opportunity to another party to maximize its likelihood/impact, maximizing benefits.
	Enhance Opportunity	Aim to modify the "size" of the positive risk and increase risk likelihood/impact, maximizing benefits.
	Accept Opportunity	Accepting the risk and providing regular monitoring or treatment of the risk.

Monitor and Review

Risk responses are actionable items managed through the TAMP risk management process. As depicted in Exhibit 6-9, several risk response explanations involve modifying existing business processes so that a risk may be reduced or eliminated. Ideally, a risk can be retired from the risk register when the required response is implemented. However, it is expected that many responses, once implemented, will still require monitoring and review on a periodic basis.

The majority of the risks (e.g., those that are not retired from the risk register) are managed on an ongoing basis through the periodic review and update of the risk register. The TAMP project manager in the Division of Statewide Planning is presently responsible for reviewing the risk register on an annual basis with all the identified organizational owners to ensure that there has been progress in the implementation of a risk response. Continuous communication between NJDOT divisions is critical during this ongoing process. This review is to be submitted to the Directors Group and the Transportation Asset Management Steering Committee to report on the status of all risk responses.

As part of the risk register annual update, the TAMP project manager and the TAMP Team conduct the risk management process of review of information and updates after discussions with each of the organizational owners. Revisiting the risk identification, risk analysis, evaluation, and determination of risk responses (e.g., treating risks) allows the risk manager[4] to objectively update information within the risk register. Post-treatment risk ratings are incorporated into the risk register based on updates to the likelihood and impact ratings that result from implemented risk responses. Risks that have been addressed and are no longer considered "adverse" risks are taken off the risk register. An annual validation of the risk register by the Transportation Asset Management Steering Committee and Directors Group are part of the ongoing process to address risks elevated from the annual TAMP Team risk management meeting.

6.3 ONGOING TAMP RISK MANAGEMENT PROCESS

6.3.1 Using the Risk Register

The risk register is the managed report tool used to support risk management in the TAMP process. Effective risk management has two elements:

- Management accountability for the risk responses.
- Regular monitoring of risks, including addressing new and emergent risks, and the annual assessment and review of TAMP risks.

Management accountability for risk management is embedded into the governance of the TAMP. *Chapter 3: TAMP Governance, Policy, and Objectives* describes the risk-related responsibilities for the following groups:

[4]Risk manager varies depending on the risk level (enterprise, program, project levels) and the identified responsible division(s). The risk management process is overseen by NJDOT Statewide Strategies Division, which manages the development of the TAMP.

- **Transportation Asset Management Steering Committee** – The senior management team accountable for setting overall policy direction for the performance of New Jersey's transportation system.
- **Transportation Asset Management Directors Group** – The management team responsible for the different elements and implementation of the TAMP process.
- **TAMP Team** – The management team responsible for managing the program that accomplishes the TAMP Policy and state of good repair objectives.

The process through which these three groups use the risk register is outlined in Exhibit 6-9.

6.3.2 Managing High and Critical Risks Going Forward

TAMP Team risk management workshops are one of the tools utilized in the risk management process. These workshops empower participants to collaborate and identify mitigation strategies for risks that may exist beyond NJDOT's traditional project-level risk assessment framework. Initial risk management workshops were held in advance of the first fully compliant TAMP submitted in 2019. A series of additional risk management workshops were held to support preparation of this TAMP. Participants in the risk management workshops span across organizational units and beyond the TAMP Team to account for a broad range of enterprise risks.

Exhibit 6-9: Ongoing TAMP Risk Management Process

TAMP Team Conducts Risk Monitoring and Risk Treatment Status Reviews on an Ongoing Basis

The TAMP Team reviews the risk register to check on the status of risk responses. This review is to be done by each of the responsible NJDOT business units and its respective TAMP Team representatives. During this review, any new or emergent risks may be flagged for potential inclusion in the annual risk assessment review.

Annual TAMP Risk Assessment and Review

Annually, the TAMP Team, other applicable program managers and the Transportation Asset Management Directors Group conduct a TAMP Team risk management meeting reviewing and reevaluating the risk register. Existing risks are reevaluated alongside new and emergent risks within the context of the TAMP. The annual update results in the risk register reflecting changed circumstances.

Annual Transportation Asset Management Steering Committee Review of Risk Register

Annually, and ahead of the 10-year Statewide Transportation Improvement Program development process, the Transportation Asset Management Steering Committee reviews the updated risk register. This risk management review provides accountability and opportunity for the committee to take action addressing risks which require policy or management-level action.

Examples of highly rated risks and associated management strategies identified through the workshop include the following:

- **Risk – Extreme Weather Events**
  The impacts of extreme weather events on NJDOT's highway infrastructure are projected to increase. The frequency and severity of rain events, excessive temperatures, and other stressors associated with climate change will continue to present challenges to maintaining a state of good repair for transportation assets. More importantly, factors related to extreme weather must be considered when conducting life cycle planning efforts to ensure adequate investments are made in the appropriate categories to achieve the desired objectives. Additional detail on how extreme weather and resilience are considered as part of life cycle planning is provided in Section 5.2 and Section 5.3 of *Chapter 5: Life Cycle Planning*.

  The objective and scope to link extreme weather and asset management begins with the compilation of data, assessing vulnerabilities, and analyzing adaptation strategies. NJDOT is currently conducting multiple initiatives to incorporate extreme weather events and climate change into asset management as well as other areas. Section 6.3.3 provides an overview of these ongoing and future initiatives.

- **Risk – Funding Levels and Project Cost Increases**
  The ability to achieve the state of good repair objectives is contingent on certainty of federal funding levels and predictable project costs. The 2021 Infrastructure Investment and Jobs Act (IIJA) also known as the Bipartisan Infrastructure Law (BIL) provides certainty of federal funding for highway programs through 2026. However, many roadway infrastructure assets are long-life assets (i.e., 50 years and beyond) and many highway projects take years to complete from concept to delivery. While the IIJA provides an infusion of funding for highway programs through the Transportation Trust Fund (TTF), beyond 2026 there is uncertainty related to sustainable future funding of the TTF. In addition, there is uncertainty related to stability and predictability of future project costs. This uncertainty is a risk to the achievement of state of good repair objectives. To mitigate this risk, NJDOT intends to work in close coordination with the TAMP Team to monitor and document any changes of costs, and consider best alternatives to establish a consistent approach to estimate costs.

- **Risk – Clear Communication Regarding Asset Management**
  The ability of NJDOT to effectively communicate the how and why of asset management is an essential aspect of obtaining adequate funding for the transportation program. There are additional consequences related to tradeoff decision making and optimization between pavement and bridge.

In addition, the ability of NJDOT to effectively communicate about asset management affects transportation program funding and delivery for other highway owners. To mitigate this risk, NJDOT intends to continue to engage and regularly communicate the goals and objectives of the TAMP, both within NJDOT and with other highway owners, emphasizing the roadway networks and associated metrics.

- **Risk – Asset Management Knowledge Management and Succession Planning**
  Asset management at NJDOT cuts across many organizational units and draws upon institutional knowledge and resource allocation that supports the achievement of TAMP objectives. To ensure continued success of its asset management program, and to continue its ability to carry out internal initiatives related to asset management, NJDOT has identified the need to establish a formal asset management knowledge management program and develop staff succession plans for asset management-related roles. Recently, NJDOT participated in FHWA's Let's Go Workshop, and the team identified the need for continued participation and involvement in succession planning from Department leadership and those with core responsibilities related to personnel actions. As part of its strategic workforce development program, the Department is focused on:
  - Formulating a Department-wide mentorship program;
  - Identifying emerging skillset needs with partners;
  - Continuing industry association outreach; and
  - Continuing college / university outreach.

- **Risk – Resources for Required Software and Equipment**
  The data required for asset management, performance management, and Highway Performance Monitoring System (HPMS) reporting on pavements needs to be obtained accurately and in a timely fashion. To gather needed data, required software and equipment must be properly maintained and upgraded. To mitigate this risk, and to help ensure that dedicated resources for necessary software and equipment are adequately maintained moving forward, the Pavement Management Unit will continue to communicate the importance and need for the resources required for software and equipment and continue to train and grwo expertise within the unit. Continuity of reporting is required to ensure compliance with asset management, performance management, and HPMS reporting regulations.

- **Risk – Pavement Materials Specification**
  The reduction in the quality of asphalt binder material continues to directly affect the timing of treatments as part of pavement life cycle planning, resulting in the premature deterioration of the roadway network. To mitigate this risk and address the continued

deterioration, NJDOT will continue to improve performance-related materials specifications on a number of high-performance treatments where the binder quality is most essential. This action has been initiated by NJDOT's materials group, who have implemented a number of performance-related specifications on NJDOT's most expensive mixes where the risk is the greatest to ensure the investment results in the anticipated performance and value.

6.3.3 Incorporating Extreme Weather, Risk and Resilience

NJDOT is currently undertaking multiple initiatives to incorporate extreme weather, climate change and resilience into areas across the Department, including asset management. As an outcome of NJDOT's 2018 Asset Management, Extreme Weather and Proxy Indicators Pilot Study, NJDOT committed to the full development of an ArcGIS tool that identifies assets exposed to future climate hazards. This tool intersects various data layers such as flood hazard zones, land use, and other environmental and socioeconomic factors that can identify areas subject to extreme weather events. Transportation assets can then be added to perform GIS intersection analysis for the development and identification of a need to study, and determination of assets' exposure to hazards. This review considers prioritizing further analysis to convey the need for and extent of appropriate mitigation measures to reduce risk.

An initial working group was created by engaging with Department directors and managers and to request that they identify staff representatives to join the Resilience Working Group. Key units within the Department that have involvement with project delivery in specific areas were identified. Identification of the leadership in those units was key to successful engagement and to get buy-in at the leadership level to enable the DOT to move forward on the resilience initiatives. The working group consists of approximately 40 individuals from across different DOT areas forming different groups such as policy, asset management, design standards, project delivery, and operations to consider how resilience could be incorporated in those areas.

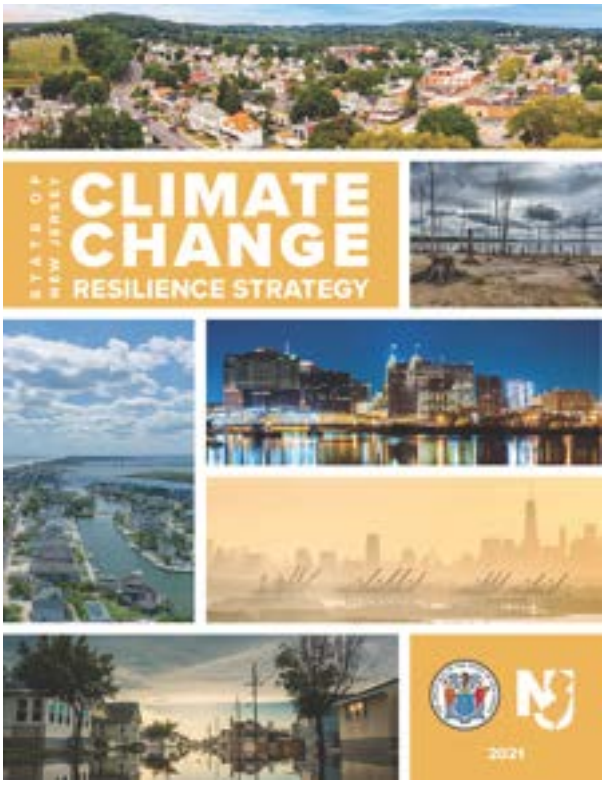
The Resilience Working Group has enabled NJDOT to mitigate risks through the development of various tools, and through the collaboration of various activities. This collaboration led to a series of recommendations that were the base of current and future resilience initiatives. These initiatives were presented to the Department's senior leadership, which helped foster buy-in from the top and provided momentum to allow the Department to move forward with its resilience efforts. Through this enhanced communication effort, asset owners and managers are able to collaborate on cross-cutting issues related to extreme weather and establish sound business practices to address risks associated with extreme weather and climate change, not only in asset management but in the day-to-day functions of NJDOT.

To further address the potential impacts of extreme weather events and climate change, and to increase the resilience of the state, Governor Murphy signed Executive Order 89 in October 2019 to establish an

Interagency Council on Climate Resilience. The Department of Environmental Protection (DEP) led the development of the State's first Climate Change Resilience Strategy[6] for the transportation system. To establish collaboration among different agencies, the Interagency Council on Climate Resilience was created, with NJDOT being one of the key agencies that participated in the development of the Climate Change Resilience Strategy. As part of this effort, six climate resilience priorities were identified as follows:

- Build resilient and healthy communities
- strengthen the resilience of New Jersey's ecosystems
- Promote coordinated governance
- Invest in information and increase public understanding
- Promote climate-informed investments and innovative financing
- Coastal resilience plan

Exhibit 6-10: State of New Jersey Climate Change Resilience Strategy



[6]2021 State of New Jersey Climate Change Resilience Strategy

NJDOT acknowledges that the transportation system is vulnerable to a range of extreme weather and climate change hazards, including extreme temperatures, intense precipitation, drought, sea-level rise, and storm surges. These events pose a great risk to the accomplishment of the TAMP objectives due to the potential for accelerated deterioration and reduced performance of highway assets.

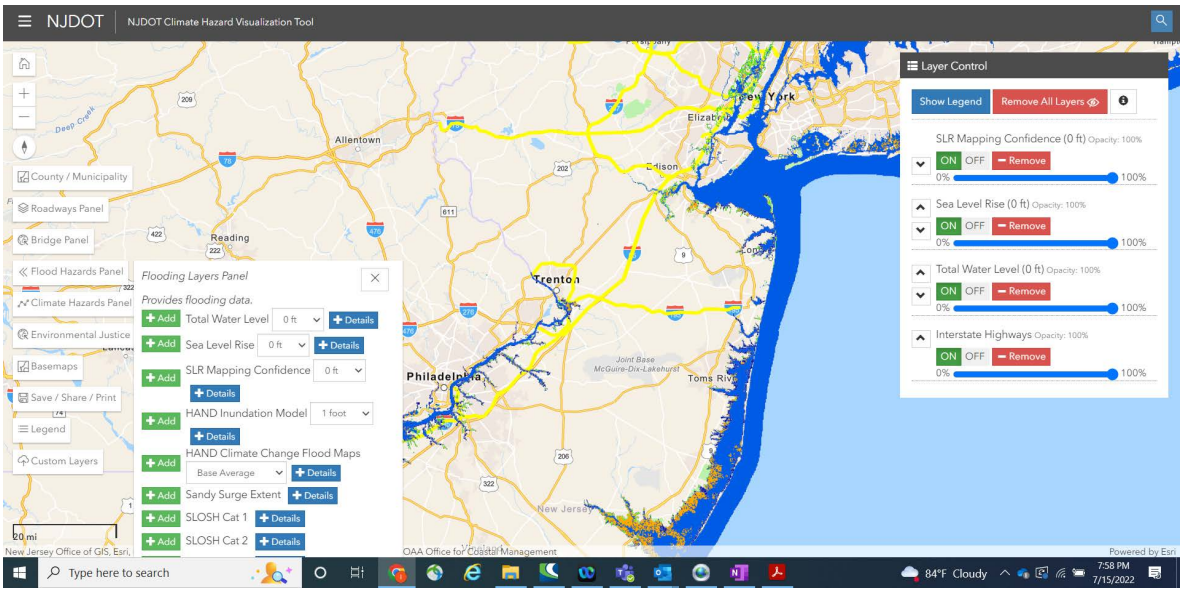
Driven by the Climate Change Resilience Strategy, and the continuous desire of the Department to advance its resilience initiatives, NJDOT has sponsored multiple initiatives and collaborated with multiple partner agencies. Some of these initiatives include:

- **Resilience Program**
  NJDOT has been developing a program to incorporate resilience to extreme weather and climate conditions, as well as resilience to more routine environmental stressors, into its business practices.
- **Climate Hazard Visualization Tool**
  NJDOT has developed a visualization tool to help personnel identify future climate hazards ranging from coastal flooding to heat impacts. The tool uses NJDEP data regarding flood inundation. In addition, the tool will incorporate modeling of increased precipitation from different storm events, as well as projected sea level rise, to help

assess potential vulnerabilities in the future. While not a full vulnerability assessment, the tool will help to visually identify areas and assets that could be exposed and vulnerable under future conditions.

These assessments will better inform NJDOT asset management and project development decisions as well as operations and maintenance procedures. The integration of flood hazard exposure data into existing capital planning and asset management processes will, over time, improve the overall durability and resilience of transportation infrastructure to extreme weather and climate hazards. To promote utilization of the tool, NJDOT staff will participate in internal training sessions to expose personnel to the availability of the tool and identify ways to incorporate flood resilience considerations as part of NJDOT's capital planning, project design, operations, maintenance, and the project delivery process. The Climate Hazard Visualization Tool is expected to be finalized by the end of 2022.

Exhibit 6-11: NJDOT Climate Hazard Visualization Tool



- **Pavement and bridge deterioration and performance tracking**
  The NJDOT Pavement & Drainage Management and Technology (PDMT) unit tracks deterioration rates and performance of pavements over time. NJDOT bridge and pavement subject matter experts (SMEs) noted the difficulty to link deterioration to climate change. Climate is considered during pavement design through models built into the mechanical empirical (ME) pavement software developed through Federal Highway Administration (FHWA) and research. Post-event pavement conditions are evaluated by Transportation Operations Systems and Support (TOSS) with support from PDMT. If there are locations that are washed out, for example, TOSS lets the PDMT group know so that the design group can assist with repairs. NJDOT tracks pavement problem area data (flooding events) through the drainage management system. This considers annual average daily traffic (AADT) as well as frequency of flooding events that cause lane closures as reported by TOSS. NJDOT does annual inspection of their pavements and bridges and is working on tracking the deterioration of assets based on the fluctuations in temperature, increased precipitation, and other stressors associated with climate change. In addition, NJDOT also tracks data related to repairs during an emergency per Part 667 requirements and evaluation reports. In the future, these data will be incorporated into the Climate Hazards Visualization Tool to identify areas that are flooded repeatedly along with possible causes.

- **Incorporation of climate change into the life cycle planning of pavements and bridges**
  NJDOT sponsored a comprehensive study to investigate ways in which climate change affects the life cycle of pavement and bridge assets. As part of this study, the agency obtained information on the current state of materials science as it relates to pavement and bridge design to further integrate climate resilience. The study recognizes that continued research on this topic is required as the effects of climate change on materials science continues to evolve. This research included the review of multiple reports from FHWA, state transportation agencies, Transportation Research Board (TRB), and academic institutions pertaining to the impact of heat and other climate stressors on pavement and bridge assets life cycles. In addition, interviews with multiple state transportation agencies, FHWA and NJDOT bridge and pavement SMEs were conducted to gather further information regarding asset resilience. The goal of this initiative was to obtain information to further integrate climate resilience into the TAMP processes. NJDOT continues to consider multiple criteria including asset condition, traffic loading stressors, environmental

stressors, and climate change as detailed in Section 5.2.1 and Section 5.3.1 of *Chapter 5: Life Cycle Planning*, to determine the best life cycle planning strategies and updates to the design standards.

- **Criticality tool**
  NJDOT is finalizing a tool to help analyze data pertaining to infrastructure assets to identify the most essential assets or sections of the transportation system. The criteria used for the selection of critical segments has been selected and agreed upon by the relevant stakeholders involved in the development of the tool. Currently, NJDOT is working on the visualization features that will enhance the end-user experience. The criticality tool will be used in combination with the GIS Climate Hazards Visualization Tool to help identify critical and vulnerable areas to support the decision-making process for project prioritization and resilience improvement strategies. Moreover, the agency is working to identify key factors to consider in emergency evacuation routes during emergency response under different scenarios.

- **Data gathering system**
  NJDOT's Resilience Working Group is working to strengthen the relationship between internal represented groups and maintenance and operations groups to better integrate data related to recent events into the resilience tools being developed.

- **Resilience in the project delivery process**
  The Department is working on recommendations to incorporate the resilience tools into the problem screening and concept development phases of NJDOT's project delivery process. This will ensure that resilience is considered at the early stages of the project delivery process.

- **Policy development**
  NJDOT has developed a draft resilience policy which emphasizes the need to integrate resilience into all other performance-based efforts within the Department. The goal is to gain final approval on the draft policy and finalize the resilience-related tools by the end of 2022 to move towards implementation.

- **Identification of funding for resilience initiatives**
  NJDOT is looking to expand their resilience efforts through the use of funding opportunities provided by IIJA. The Department will continue to work with relevant stakeholders and local agencies to collaborate on the development of resilience improvement plans and identification of new projects.

Future engagements with senior leadership will take place at the end of 2022 to present the final versions of the resilience tools and seek final approval. Some of the recommendations being considered by NJDOT to further improve resilience initiatives include:

- **Data Collection and Data Management**
  - Track and centralize asset data such as maintenance reports, repairs and associated costs, key design parameters (for example stage-discharge rating curves and low chord elevations), and problem areas.
  - Communicate with external stakeholders to share relevant geographic and/or asset-specific data and research related to climate change impact mitigation and prevention. Keeping open dialogue with other DOTs and FHWA will foster data, technology, and research sharing.
  - Stay up to date on current materials science studies as they relate to pavement design and structural design.
- **Project Prioritization and Planning**
  - Use the visualization and criticality tool, along with condition assessments, to inform project prioritization and capital planning.
  - Incorporate resilience into life cycle analyses and benefit-cost analyses.
- **Project Design**
  - Continue to test and use pavement overlays developed by NJDOT and incorporate these into project design where appropriate.
  - Continue to lead Every Day Counts (EDC)-6 efforts in targeted overlay pavement solutions to resist cracking and rutting. (See more details in Section 5.2.4 of *Chapter 5: Life Cycle Planning*).
  - Continue to revisit design standards and update as needed to account for future climate conditions.
- **Inspections and Maintenance**
  - Increase inspection frequency in known problem areas (for example, locations rated as high critical/vulnerable).
  - Continue to consider inspection and maintenance staff safety with regard to extreme weather events and temperature.
  - Leverage the routine inspections to gather important data sets to better assess the vulnerability of assets.

NJDOT's current approach for project selection includes several factors such as congestion, safety, mobility, asset condition, and other factors, and is done through the use of the Department's management systems. Several of these management systems include resilience criteria. The agency continues to work to centralize resilience efforts, consider resilience in parallel to the current criteria in project selection, and emphasize the need to address it through the project delivery process.

6.4 PERIODIC EVALUATION OF FACILITIES REPEATEDLY REQUIRING REPAIR AND RECONSTRUCTION DUE TO EMERGENCY EVENTS (PART 667)

Pursuant to the 23 CFR 667 rule, NJDOT conducted a statewide evaluation 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 since January 1997 through November 2022. As part of its Part 667 evaluation, NJDOT conducted an analysis of past Emergency, Major Disaster and State of Emergency Declarations.

The TAMP process allows for the improvement and enhancement of the Part 667 evaluation process in future TAMPs. NJDOT submitted a Part 667 evaluation for the NHS in 2018 and for all public roadways in 2020 and 2022. The Part 667 database and and report will be maintained and updated on a regular basis. In future submissions, NJDOT may look to harmonize the Part 667 evaluations so that the evaluation of affected roads, highways, or bridges in the STIP are considered.

The NJDOT 2022 Part 667 evaluation process revealed that multiple assets have been damaged in emergency events since 1997 1997; however, NJDOT has not identified any repeated major damages for pavement and bridge assets structurally as relevant to Part 667. The section below provides an overview of the 2022 NJDOT part 667 evaluation process. More details from the 2022 NJ Evaluation Report to CFR Part 667 can be found in Appendix F.

Process to Identify Locations Subject to Part 667 Evaluation Process — Evaluation

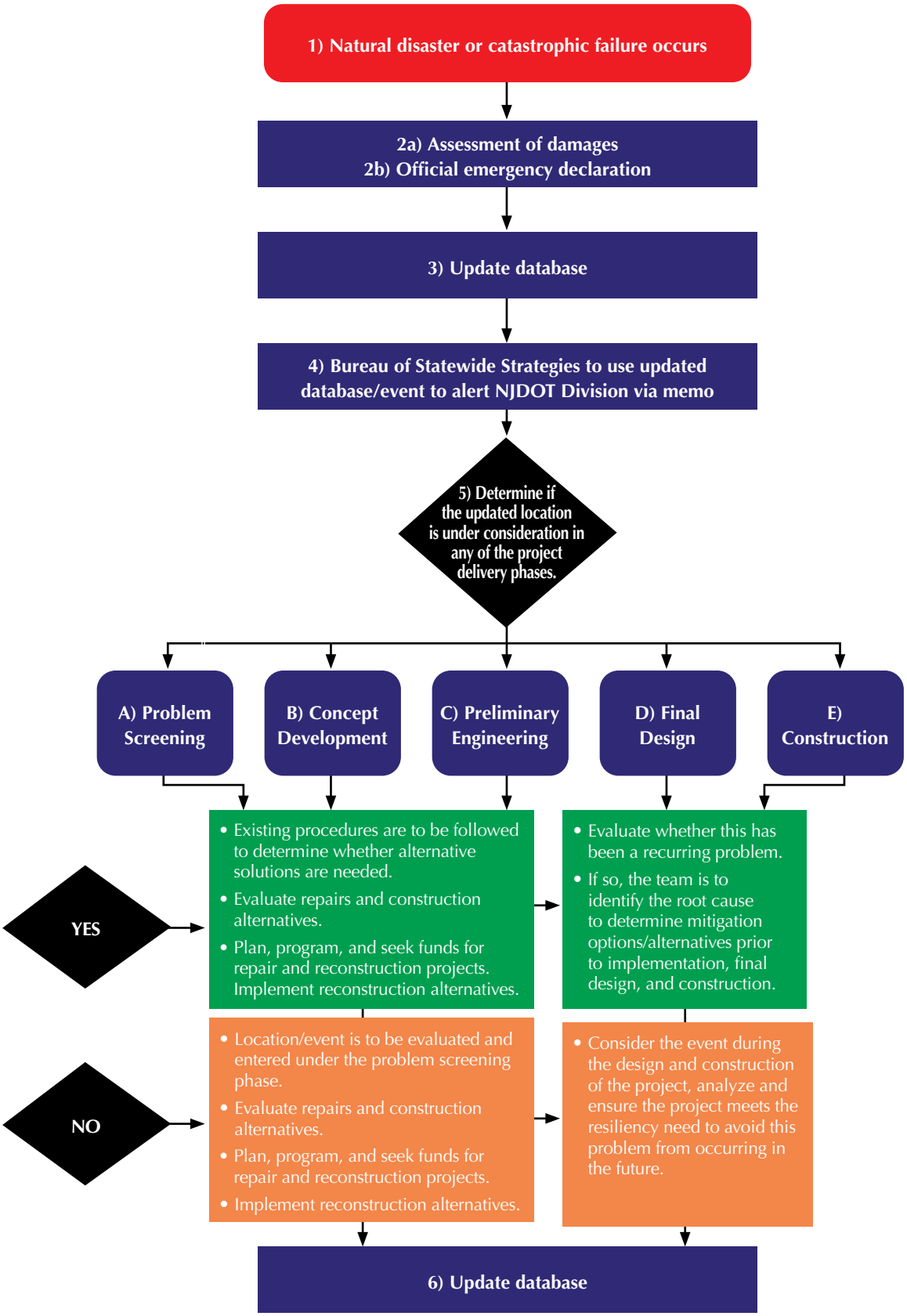
Multiple representatives from the TAMP Team and other divisions within NJDOT followed a multi-step process to identify "repeatedly repaired and reconstructed" assets affected by emergency events. The effort included:

- Review of requirements for Part 667.
- Creation of a Federal Emergency Management Agency (FEMA) list of emergency declarations in New Jersey since 1997 and organizing these into an emergency declarations database (the majority of these declarations are related to severe storms and flooding).
- Creation of a separate events database to identify locations of frequently repaired and reconstructed facilities on the NHS.
- Identification of assets with recurring damage that are subject to the Part 667 requirements. Using the data collected, NJDOT manually reviewed all repair locations to identify any assets that were damaged and subsequently repaired or reconstructed two or more times by emergency events.

Process to Update Database and Evaluations

To establish a continuous process to integrate Part 667 evaluation into NJDOT's business practices, NJDOT has identified the following steps shown in Exhibit 6-12 as the process to update the "Events Database" and perform future evaluations under Part 667. NJDOT Bureau of Statewide Strategies, as the Part 667 evaluation manager, is to follow this process for future evaluations.

Exhibit 6-12: Part 667 Evaluation Process



Integration of Process into Asset Management Practices — Risk Register

NJDOT incorporated this evaluation and process into the TAMP risk management process by adding a detailed risk statement to the risk register for the events database to be updated and managed as an ongoing risk.

Next Steps and Enhancements

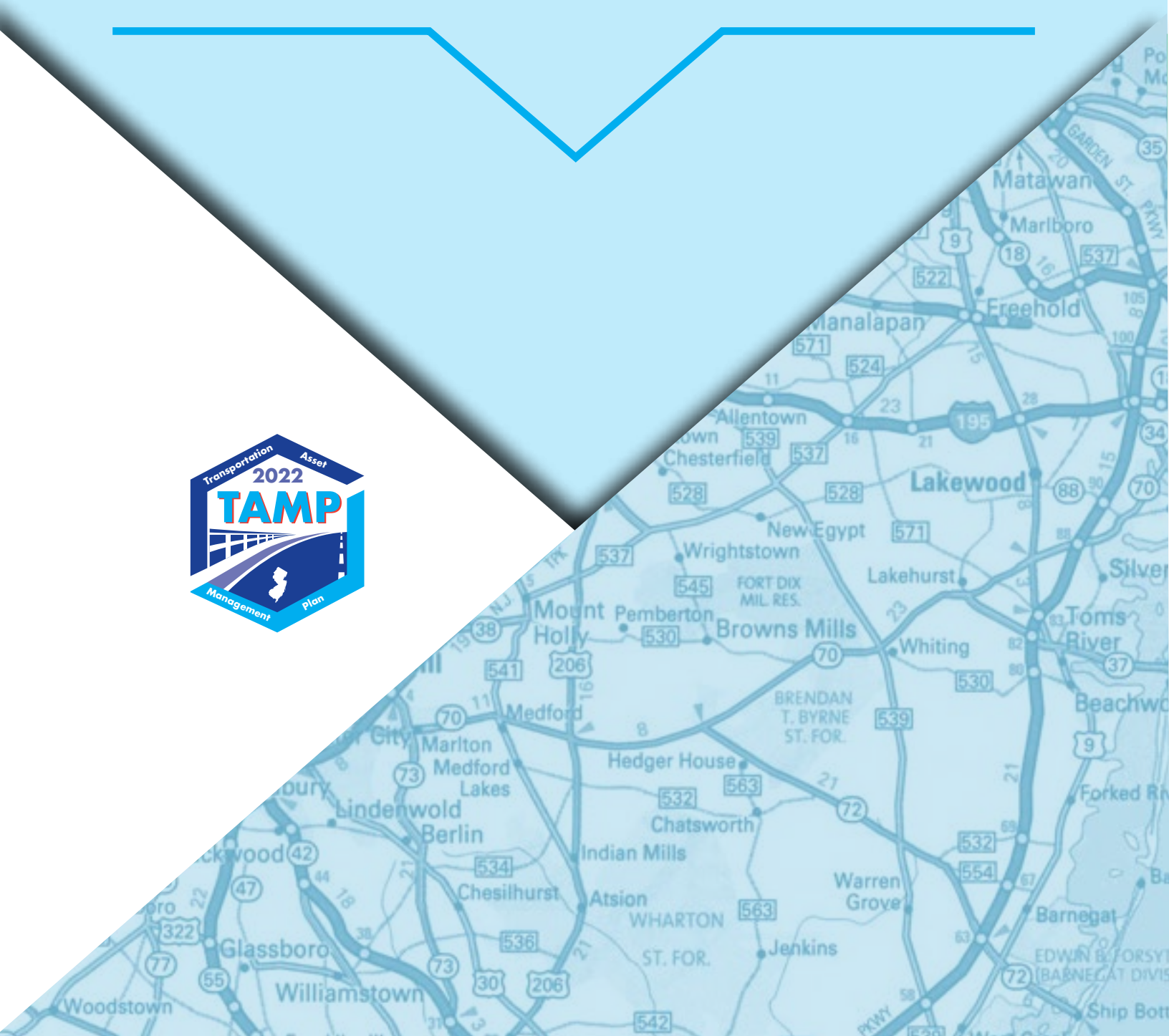
To proactively determine if there are reasonable alternatives to roads, highways, and bridges that have required repair and reconstruction activities on two or more occasions due to emergency events, NJDOT will continue to collaborate internally with representatives Operations, IT, Program Management Office for the integration of the Part 667 process into the project delivery process. Continuous improvement efforts include the following steps:

- Build additional logic into existing events database to identify assets that have been repaired or reconstructed two or more times based on the relevant NJDOT Standard Route Identifier (SRI).
- Develop a roles and responsibilities document for the management of risk and resiliency in NJDOT's asset management program.
- Develop a form or tool to collect a standardized set of data related to repairs and reconstruction due to emergency events.
- Develop process for continuous coordination with non-NJODT NHS owners in meeting requirements of Part 667.
- Develop a process to address or cover the evaluation, mitigation, and identification of project alternatives by other owners (i.e., county, municipal), which also would involve the metropolitan planning organizations (MPOs) and the NJDOT local aid office if an event resulted in damages to a county- or municipal-owned road or bridge.
- Add the fields of the Part 667 database as part of a layer in a resiliency management GIS database[5] to expedite the review of impacted locations and serve as a visual representation during the different project delivery process phases.

NJDOT is making considerable efforts to improve the Part 667 evaluation process, data collection, and coordination among different groups. Connecting the results of the Part 667 evaluation process with the project delivery process will allow NJDOT to establish an additional linkage between resilience and asset management and improve the decision-making process.

[5] The database is a recommendation from NJDOT's Asset Management, Extreme Weather and Proxy Indicators pilot study.

CHAPTER 7:
FINANCIAL PLAN



BACKGROUND: The financial plan describes the funding available to the New Jersey Department of Transportation (NJDOT)'s Transportation Asset Management Plan (TAMP) and identifies expected infrastructure enhancement (new construction), improvement, and preservation expenditures for pavement and bridge assets over the TAMP analysis period. The financial plan describes the funding available for NJDOT to meet state of good repair objectives and goals. The financial plan provides context for these expenditures by presenting the recent history and projections included within the New Jersey Transportation Capital Program. The financial plan also estimates the value of NJDOT pavement and bridge assets along with the investment required to maintain their asset value.

7.1 OVERVIEW

The TAMP financial plan uses New Jersey's Transportation Capital Program for fiscal year[1] (FY 2023) as the basis for a ten-year budget for the enhancement (new construction), improvement, and preservation of the State Highway System (SHS). Additionally, the TAMP estimates the planned level of expenditure on non-NJDOT National Highway System (NHS) assets using the best available data collected from the other NHS owners. The planned SHS funding together with expenditure estimates provided by other NHS owners are used to project the condition of the NHS and SHS through FY 2032.

7.2 NJDOT FUNDING SOURCES

The Transportation Capital Program is funded mainly through federal aid and appropriations from the New Jersey Transportation Trust Fund (TTF) as described below.

7.2.1 New Jersey Transportation Trust Fund

Sources and Uses of Funds in the New Jersey Transportation Trust Fund

The TTF is managed by the New Jersey Transportation Trust Fund Authority (TTFA). The TTFA is an independent agency of state government whose sole purpose is to finance the annual New Jersey Transportation Capital Program. The principal revenue sources for the TTF are: (1) tax revenues and (2) proceeds from bond sales. The revenue is used to fund NJDOT, New Jersey Transit (NJ TRANSIT), and local aid projects, and to pay debt service on the bonds it has issued.

All Motor Fuels Tax and Petroleum Products Gross Receipt Tax (PPGRT) revenues are constitutionally dedicated for transportation purposes and are ultimately directed by annual legislative appropriation to the TTF. The Motor Fuels Tax is levied primarily on the sale of gasoline and diesel fuel and is collected at the wholesale level from distributors. The PPGRT is imposed, at first sale, on all companies engaged in refining and/or distributing petroleum products for distribution in New Jersey. The New Jersey State Constitution also requires the dedication of no less than $200 million of annual sales and use tax revenues for transportation purposes.

Beyond the constitutional dedications of the tax revenues noted previously, the TTFA also receives annual revenue from contributions authorized by contracts entered with the state's toll road authorities. Statutory dedications from certain motor vehicle violations and heavy truck registrations are also authorized; however, the legislature has not appropriated any of these latter fees to the TTF in the past several years.

[1]NJDOT follows the State of New Jersey's Fiscal Years, which means FY 2022 spans from July 1, 2021, through June 30, 2022.

Separate annual legislative actions are required to move funding into and out of the TTF. The TTF's annual spending authorization supporting NJDOT, NJ TRANSIT, and local aid is distinct from the legislature's appropriation of transportation revenues to the TTFA. The legislature's annual spending authorization enables NJDOT and NJ TRANSIT to issue contracts and purchase orders for projects. In contrast, the revenue appropriation to the TTFA provides the funding source for debt service payments and pay-as-you-go appropriations. "Pay-as-you-go" refers to the spending that is funded by the tax revenue and bond sale proceeds that remain after paying debt service.

New Jersey Transportation Trust Fund Authority Act of 2016

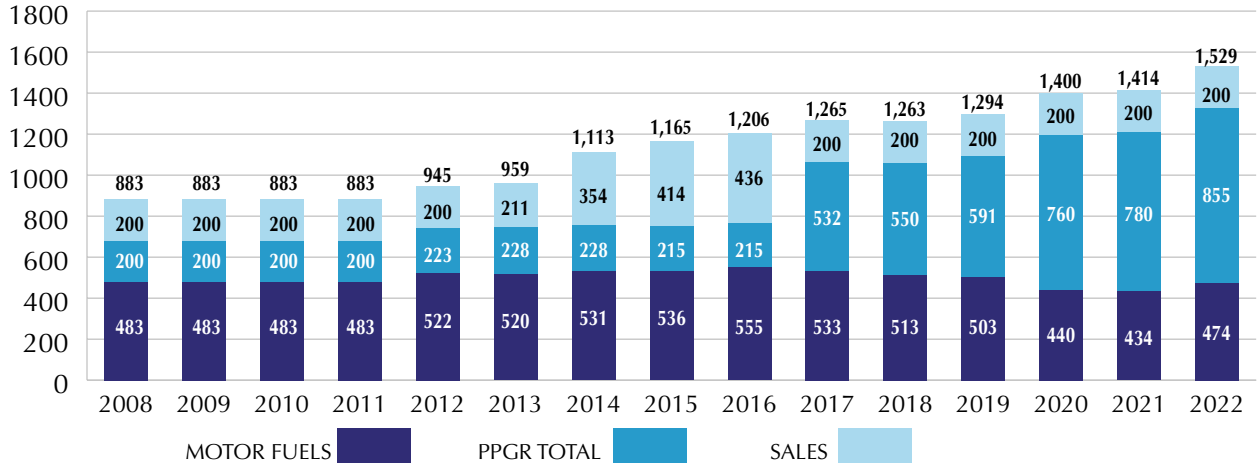
In October 2016, the New Jersey Transportation Trust Fund Authority Act was reauthorized (P.L. 2016, c.56) to support New Jersey's annual Transportation Capital Program for FY 2017 through FY 2024. The reauthorization provides a total of $16 billion in capital spending over the eight-year period, supported by $12 billion in bonding authority and pay-as-you-go appropriations of motor fuels, petroleum gross receipts, and sales and use tax revenues. The excess fuel tax revenue over the amount needed for debt service is deposited into the TTF sub-account for capital reserves, from which it is available as needed for appropriation to the New Jersey Transportation Capital Program. The TTF anticipates that a total of $1.3 billion in new pay-as-you-go funding will be funded through this TTF sub-account through FY 2024.

Transportation Trust Fund Trends

Exhibit 7-1 presents the legislative appropriations of constitutionally and statutorily dedicated revenues to the TTF from FY 2008 through FY 2022. The exhibit illustrates the relatively flat trajectory of fuel tax-related appropriations to the fund through FY 2022 (i.e., Motor Fuels Tax and PPGRT). Exhibit 7-1 also illustrates that the increased appropriation of sales and use tax revenues was the main source of appropriations growth from FY 2013 to FY 2017.

The fuel tax rate increases taking effect in FY 2018 resulted in the sales and use tax appropriations reverting to their statutory minimum of $200 million a year. The substantial increases in PPGRT revenues shown for FY 2018 more than offset the decline in sales and use tax appropriations to the TTF. The total appropriations for FY 2018 through FY 2022 do not reflect all dedicated tax revenues from those sources. Revenues in excess of the appropriations shown are deposited into the TTF sub-account for capital reserves (described above).

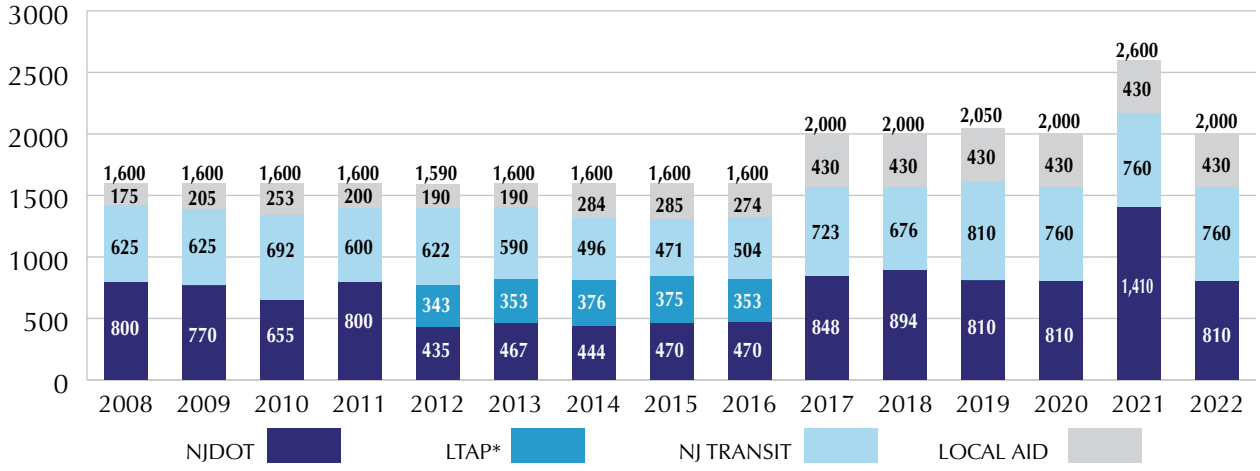
Exhibit 7-1: Appropriations to the Transportation Trust Fund (TTF) ($ millions) – FY 2008–2022



Source: New Jersey TTFA, 2022. https://www.state.nj.us/ttfa/financing/apprevenues.shtm

Note: Additionally, contributions to the TTF from toll road authorities (i.e., statutorily dedicated funds) have been $12 million per year since FY 2007 with the exception of FY 2012 at $78 million.

Exhibit 7-2: Appropriations from the Transportation Trust Fund (TTF) ($ millions) – FY 2008–2022



Source: New Jersey TTFA, 2022. https://www.state.nj.us/ttfa/capital/

Notes:

*FY 2012–2016: Funding provided by the PANYNJ for the Lincoln Tunnel access projects (Pulaski Skyway, Wittpenn Bridge, etc.) was provided directly to the Transportation Capital Program. It was not actually appropriated from the TTF; it is shown here to present the consistency in total non-federal funding over the period FY 2007 through FY 2016.

FY 2016: October 2016 reauthorization $1.6B plus $400M supplemental appropriation.

FY 2019: Includes a $50 million supplemental appropriation for NJ TRANSIT preventative maintenance projects.

FY 2021: The adjusted appropriation includes an additional $600 million for the advancement of DOT projects.

The annual totals listed for each column do not always equal sum of the individual appropriations due to rounding.

Exhibit 7-2 presents the history of appropriations from the TTF to NJDOT, NJ TRANSIT, and local aid projects from FY 2008 through FY 2022. Exhibit 7-2 illustrates the significant increase in appropriations to NJDOT, NJ TRANSIT, and local aid resulting from the 2016 Trust Fund Reauthorization. Exhibit 7-2 also illustrates the critical role of the Port Authority of New York and New Jersey (PANYNJ) funding in supplementing funding from the TTF toward the Lincoln Tunnel access projects (LTAP).

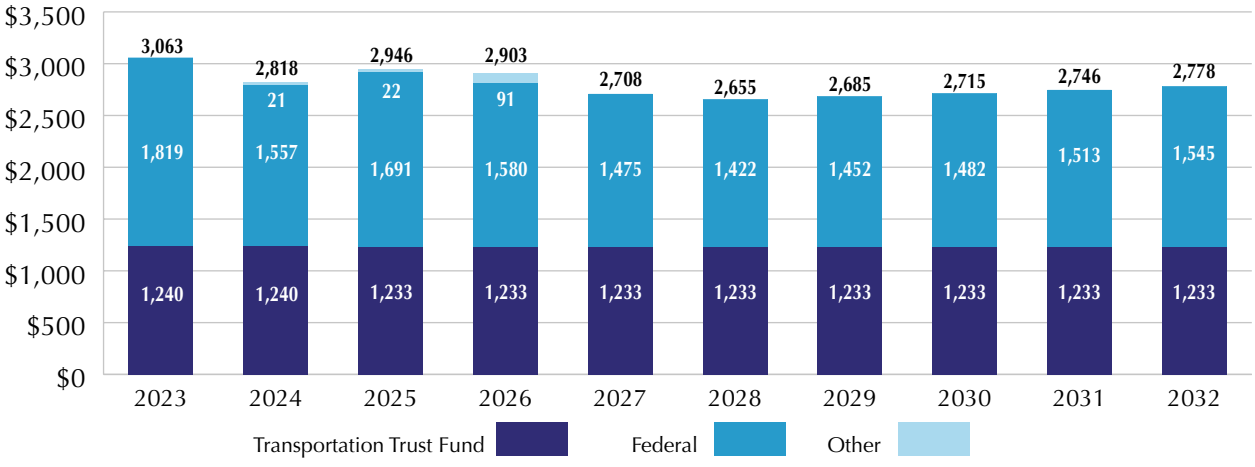
The annual appropriations from the TTF shown in Exhibit 7-2 exceed the appropriations to the TTF shown in Exhibit 7-1. This is made possible by the use of the TTF sub-account for capital reserves combined with the use of proceeds from the sale of TTF bonds and notes. By funding the New Jersey Transportation Capital Program through a trust fund, empowered to issue debt and to hold dedicated funds in reserve, NJDOT enjoys greater stability and predictability in capital planning than would be possible if the state transportation funds available to NJDOT were limited to annual tax revenues. To be sustainable over the longer term, the New Jersey Transportation Capital Program must match long-term spending with long-term tax revenues.

7.2.2 NJDOT Ten-Year Funding Projections

Exhibit 7-3 displays New Jersey's annual Transportation Capital Program projected funding amounts by source from FY 2023through FY 2032. The revenue estimates were developed cooperatively by NJDOT, NJ TRANSIT, and New Jersey's three metropolitan planning organizations (MPOs), in full consultation with the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA).

The future funding stream is subject to

Exhibit 7-3: Projected NJDOT Funding, by Source ($ millions) – FY 2023–2032



Source: New Jersey Transportation Capital Program FY 2023.

*"Other" funding sources can include authorities, private entities, and local governments.

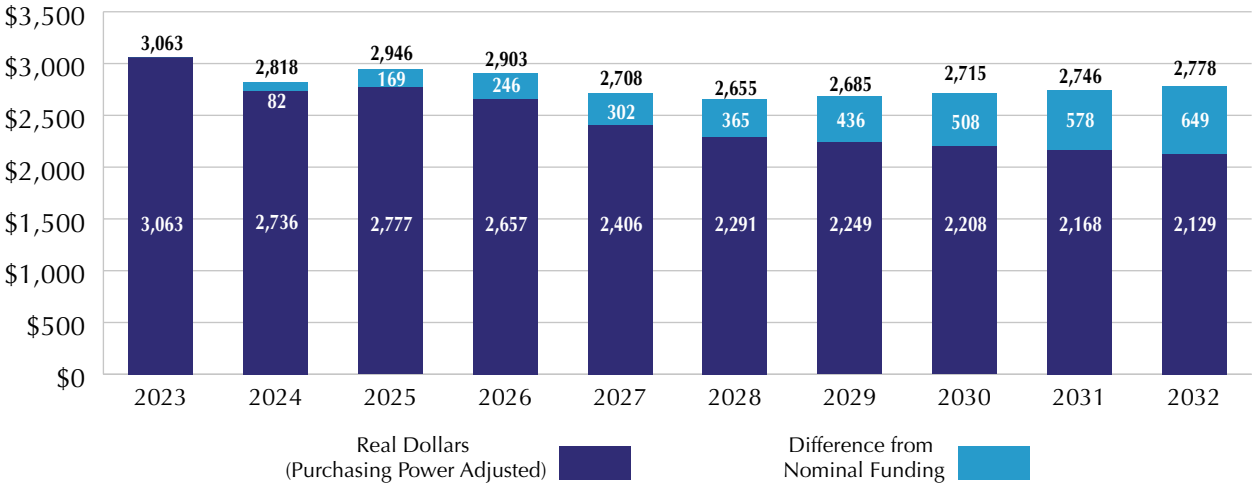
considerable uncertainty. NJDOT's share of the annual funding appropriated from the New Jersey TTF can vary from year to year. Moreover, the current Trust Fund Authorization ends in 2024, with amounts to be authorized beyond that year unknown. On the federal side, the Fast Act, which expired after a one-year extension on September 30, 2021, was replaced after a gap period without federal funding authorization, with the Infrastructure Investment and Jobs Act (IIJA, also known as the Bipartisan Infrastructure Law, or BIL). The IIJA authorizes funding for five fiscal years through federal FY 2026. The FY 2023 Capital Program incorporates the federal transportation funding authorized in IIJA.

The erosion of future funding purchasing power resulting from cost escalation adds another degree of uncertainty to projecting the resources available in the future for asset management. Exhibit 7-4 displays the effect of an assumed three percent rate of annual inflation on the real purchasing power of this funding stream. Three percent is the inflation rate used in preparing the project cost estimates for the 2023 Capital Program. The current (2022) high inflation suggests that the erosion of purchasing power will be even more severe than what is shown in the exhibit.

7.3 FUNDING ALLOCATIONS FOR CORE MISSIONS AND ASSET PROGRAM CATEGORIES

Total NJDOT spending is projected at an annual average of $2.80 billion per year (comprised of state and federal sources). This spending is divided among NJDOT's four core missions: infrastructure preservation, mobility and congestion relief, operations and maintenance, and safety. Infrastructure preservation is the core mission that is the focus of transportation asset management planning and is the area where funds

Exhibit 7-4: Projected NJDOT Capital Funding – Nominal and Real Inflation-Adjusted Dollars ($ millions) – FY 2023–2032



Source: New Jersey Transportation Capital Program FY 2023.
Note: Real dollars purchasing power incorporates the effects of an assumed three percent rate of annual inflation. The annual totals listed for each column do not always equal sum of the individual values due to rounding.

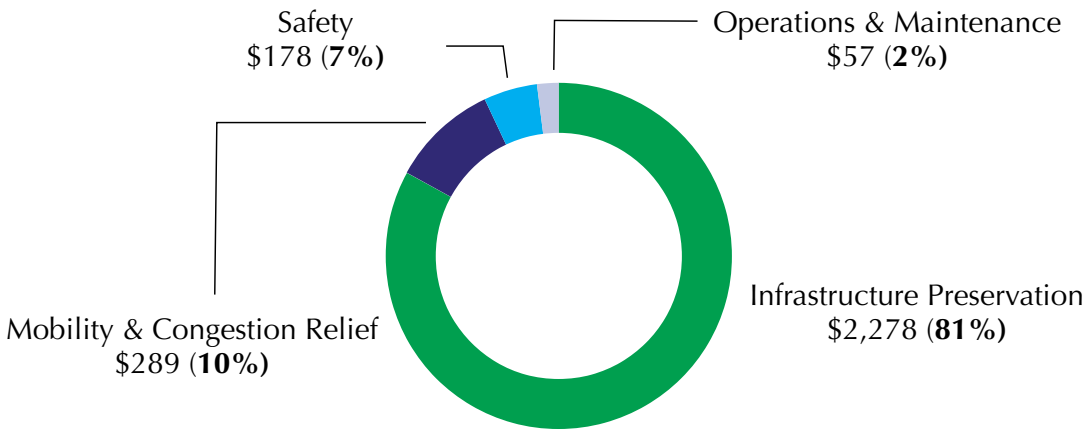
available to accomplish the TAMP state of good repair objectives are allocated.

Exhibit 7-5 shows that for the period FY 2023–2032, the average annual expenditure for the infrastructure preservation core mission totals slightly more than $2.28 billion. This amount is approximately 81 percent of total spending across NJDOT's core missions, demonstrating the priority that NJDOT places on managing its assets.

The other funding categorization that the New Jersey Transportation Capital Program uses is asset categories. These categories correspond to the nature of activity funded, regardless of the core mission. Exhibit 7-6 represents the annual average funding for each combination of core mission and category.

- **Bridge Assets**
  This classification includes projects which are designed to keep existing bridges functioning and in a state of good repair, as well as the bridge inspection program and administration of the bridge management system (BMS). It also includes the management of other structures including minor bridges, dams carrying SHS roadways, overhead sign structures, and high mast light poles, and the New Jersey Route 29 northbound tunnel.
- **Road Assets**
  This classification includes projects to keep the existing roadways functioning and in a state of good repair. Assets funded under this category include not only pavement but also appurtenant assets such as drainage infrastructure, guiderails, and traffic signals.

Exhibit 7-5: NJDOT Average Annual Expenditure by Core Mission ($ millions) – FY 2023–2032



Source: New Jersey Transportation Capital Program FY 2023.
Note: The operations and maintenance core mission relates to capital funding for NJDOT vehicles and facilities. Capital funding for maintenance of pavement and bridge assets is accounted for within the infrastructure preservation mission. Percentages do not add to 100% due to rounding.
Note: Fifth core mission for the State of New Jersey of mass transit is excluded since it belongs to NJ TRANSIT.

- **Airport Assets**
  This classification includes projects to preserve, maintain, and improve aviation facilities.
- **Local System Support**
  This classification encompasses funding distributed to counties and municipalities for planning, infrastructure preservation, mobility improvements, and local safety improvements, among other dedicated purposes.
- **Capital Program Delivery**
  The NJDOT salaries and other administrative expenses which directly relate to developing and delivering the New Jersey Transportation Capital Program are funded through this category. This classification includes efforts such as planning and research, environmental reviews, and right-of-way acquisition assistance.
- **Multimodal Programs**
  This classification includes projects for Americans with Disabilities Act (ADA) compliance, pedestrian and bicycle, rail and maritime transportation, among others.
- **Congestion Relief**
  This classification encompasses work that improves the flow of people and goods. Programs include highway operational improvements, intelligent transportation systems, missing links, bottleneck widening, major widening, and travel demand management.
- **Transportation Support Facilities**
  This classification includes projects to preserve, maintain, and improve physical plant infrastructure including office buildings, rest areas, maintenance facilities, and park-and-ride locations.
- **Safety Management**
  Examples of safety management projects and programs include rail highway grade crossings, traffic signal replacement, maintenance of crash records, rockfall mitigation, and intersection improvements.

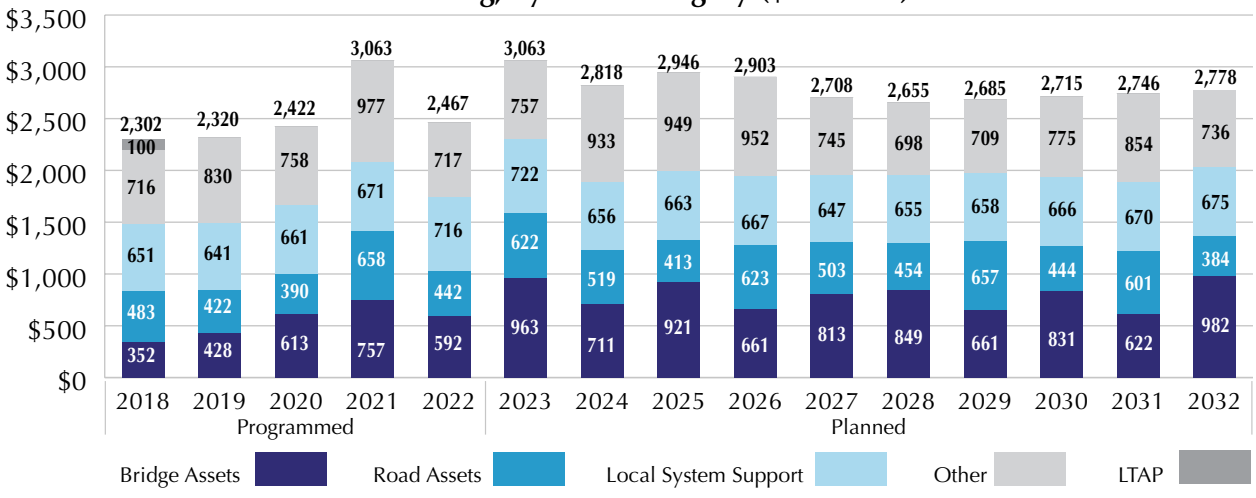
Exhibit 7-7 presents the historic funding levels and planned funding levels for each transportation improvement program asset category for the period FY 2018 through FY 2032. Funding values for bridge assets, road assets, and local system support are displayed within the chart. The other categories are grouped together. The 2018 funding includes $100 million from the Port Authority of New York and New Jersey provided in support of the Lincoln Tunnel Access Project (LTAP, also known as the PANYNJ–NJDOT Project Program). The Port Authority had also provided $1.8 billion over the period 2021–2016, for a total contribution of $1.9 billion toward the program. The LTAP is a program of significant structure rehabilitation and replacement projects on four NJDOT structures in and near Jersey City and Newark including, among others, the Wittpenn Bridge (recently completed) and the Pulaski Skyway.

Exhibit 7-6: Average Annual Expected Funding by Core Mission and Asset Category ($ millions) – FY 2023–2032

Asset Category ($ million)	Core Mission: Mobility & Infrastructure Preservation	Core Mission: Congestion Relief	Core Mission: Operations & Maintenance*	Core Mission: Safety	Subtotal	Share of Category Total
Bridge Assets	801	—	—	—	**801**	29%
Road Assets	522	—	—	—	**522**	19%
Airport Assets	5	—	—	—	**5**	0%
Local System Support	595	31	—	42	**668**	24%
Capital Program Delivery	303	—	2	2	**307**	11%
Multimodal Programs	52	10	—	—	**62**	2%
Congestion Relief	—	248	—	—	**248**	9%
Transportation Support Facilities	—	—	55	—	**55**	2%
Safety Management	—	—	0	135	**135**	5%
Subtotal	**2,278**	**289**	**57**	**178**	**2,802**	100%
Share of Mission Total	81.3%	10.3%	2.0%	6.4%	100.0%	

Source: New Jersey Transportation Capital Program FY 2023. Percentages may not add to 100% due to rounding.
* The operations and maintenance core mission relates to capital funding for NJDOT vehicles and facilities. Note: Fifth core mission for the State of New Jersey of mass transit is excluded since it belongs to NJ TRANSIT.

Exhibit 7-7: Annual Funding, by Asset Category ($ millions) – FY 2018–2032

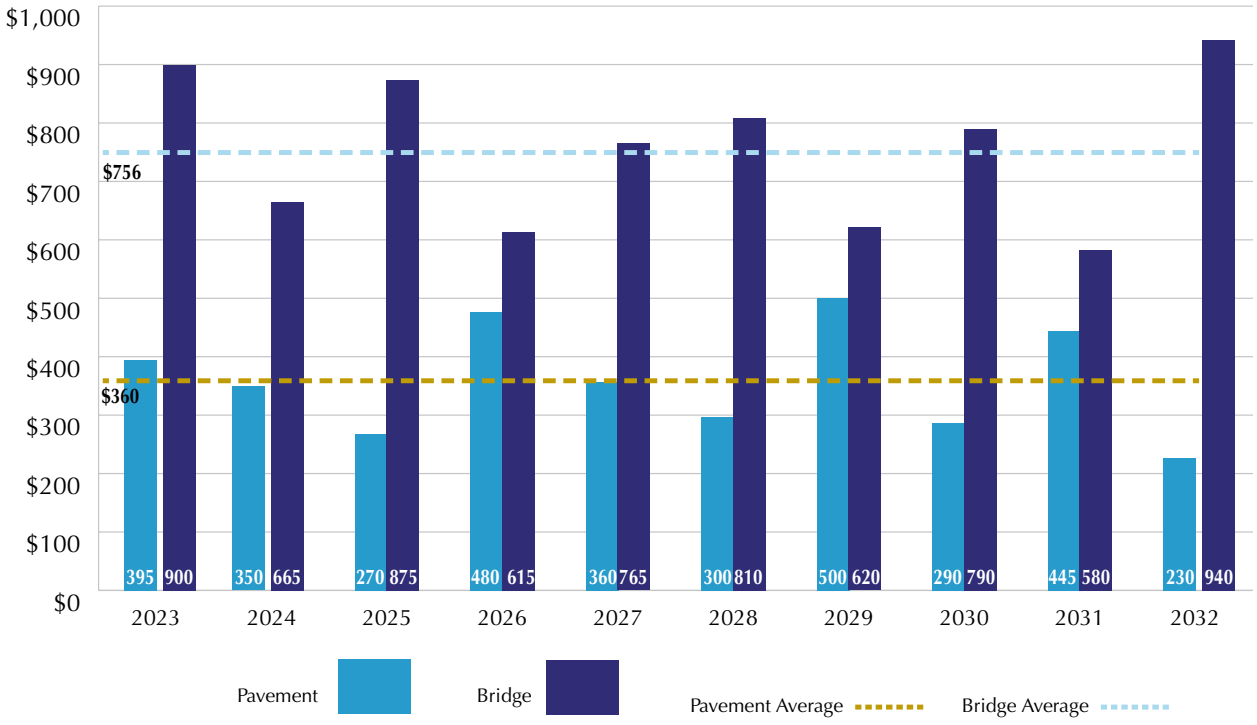


Source: Programmed funding is from the New Jersey Transportation Capital Program documents for each fiscal year and Planned Funding is from the FY2024 Capital Program.
Notes: LTAP = the Lincoln Tunnel access projects (aka the PANYNJ–NJDOT Project Program); the funding applies to the Bridge Assets category. "Other" category includes airports, capital program delivery, congestion relief, multimodal programs, safety management, and transportation support facilities. The annual totals for each column do not always equal sum of the individual assets due to rounding.

7.4 FUNDING ALLOCATIONS FOR SHS ASSET MANAGEMENT

The TAMP uses the dollar amounts shown below in Exhibit 7-8 to establish the planned condition of NJDOT pavement and NBIS bridge assets. The dollar amounts form the budget constraints used in the performance gap analysis to project pavement and bridge conditions over the TAMP analysis period. The dollar amounts represent the portions of planned funding for pavement and bridge assets that are applicable to the asset management activities that directly affect the performance projections. In contrast to Exhibit 7-7, the values shown in Exhibit 7-8 exclude funding for expenses such as drainage management, structure inspections, and replacement of sign structures. Expenditure projections specific to assets on the NHS are not shown because the NJDOT capital planning and budgeting process does not distinguish between assets on and off the NHS, except for the allocation of federal National Highway Performance Program (NHPP) funds that are only available for projects on the NHS.

Exhibit 7-8: Projected Funding Available for NJDOT Pavement and Bridge Asset Management ($ millions) – FY 2023–2032



Sources: New Jersey Transportation Capital Program FY 2023.
Note: Only includes funding for maintenance, preservation, rehabilitation, and reconstruction of pavements and NBIS bridges. Bridge data excludes funding for inspections, administration of the BMS and management of other structures (culverts, sign structures, etc.), which is about $51 million per year. Pavement data excludes non-pavement roadway funding (e.g., drainage, signs) of approximately $163 million per year.

7.5 PROJECTED EXPENDITURES FOR NON-NJDOT NHS ASSETS

The responsibility for approximately 38 percent of pavement lane miles and approximately 52 percent of bridges by deck area on the NHS is dispersed across 84 non-NJDOT entities. Many of these jurisdictions do not distinguish in their business practices or fixed-asset accounting between their NHS and other roadway assets. Consequently, funds available for asset management-related expenditures for the owners of the balance of the NHS assets are challenging to identify. The TAMP, as part of its consultative process with other NHS owners, conducted a data collection survey and communications activities to assemble the data. This cooperative effort provides the best available data from which to predict the expenditures that will be applied to the non-NJDOT NHS pavement and bridge assets.

7.5.1 New Jersey Turnpike Authority

The New Jersey Turnpike and Garden State Parkway, both owned by the New Jersey Turnpike Authority (NJTA), account for 2,342 pavement lane miles (19%) and 21,502,768 square feet (34%) of NBIS bridges by deck area on the NHS in New Jersey. NJTA is fully funded by user fees (tolls). NJTA is nearing completion of its 10-year, $7 billion Capital Improvement Program which funded capacity enhancements, interchange improvements, bridge projects and to maintain its assets in overall good condition. In 2019, NJTA adopted its 2020–2029 strategic plan that outlines several performance measures for assets. In 2020, NJTA received approval for a long-range capital plan and implemented its first toll increase in nearly eight years to provide a funding stream for the capital projects included in the plan, which are similar in type to the previous 10-year plan. This new funding stream supports the goals of the strategic plan that established metrics of performance for NJTA facilities including the pavement and bridge assets.

Pavements

Funding for pavement resurfacing projects is primarily earmarked in the Authority's maintenance reserve fund on an annual basis during the fall budget process. The funding allocation for pavement resurfacing projects, is in alignment with the goals of the strategic plan and has steadily increased in amount from 2019 to 2021 (by approximately 40%) based on needs identified by the pavement management system (see *Chapter 5: Lifecycle Planning*). NJTA annually incorporates data from its pavement management system to project pavement needs and project costs in a five-year rolling forecast. Projected funding to be allocated to pavement resurfacing projects for FY 2022 is approximately $111 million with $127 million projected for FY 2023. Of the FY 2022 total, approximately 78 percent is funded through the maintenance reserve fund, and of the FY 2023 total, nearly 100 percent is funded through the same fund; whereas the balance is funded through other sources as described in the 2020 long-range capital plan.

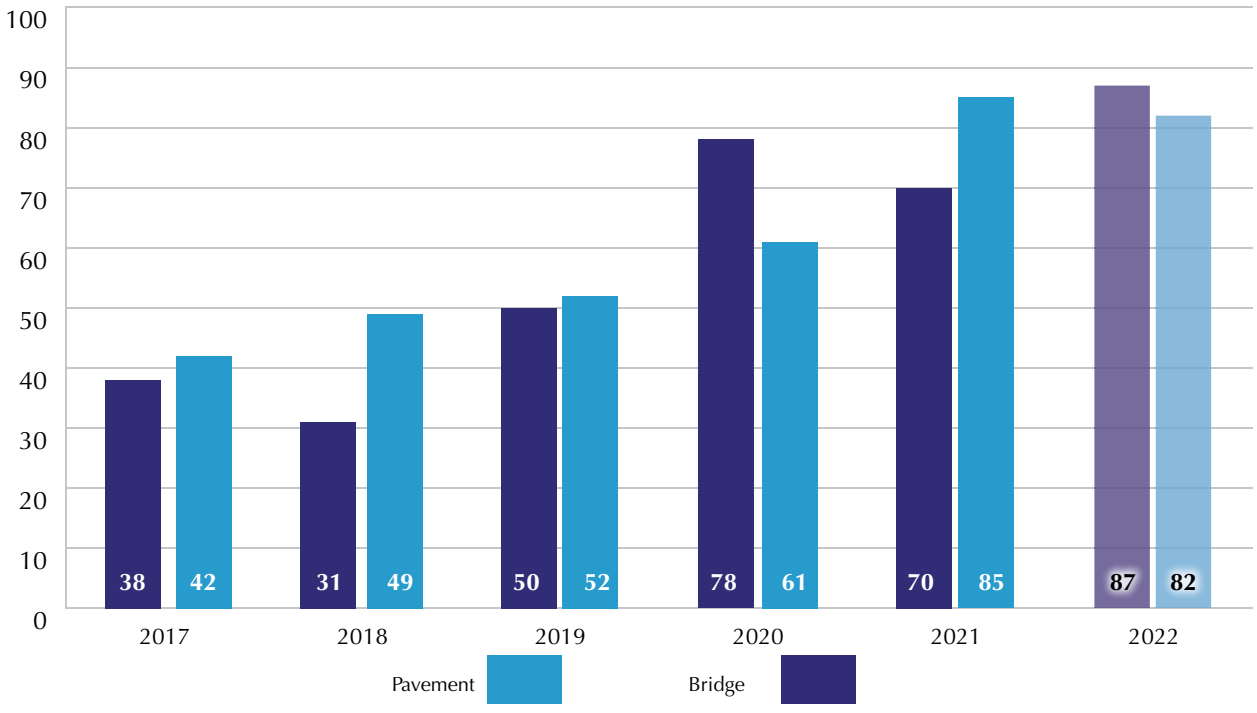
Bridges

Funding for bridge repair projects is in part earmarked in the Authority's long-range capital plan on an annual basis during the fall budget process. In prior years, the dollar amount allocated for bridge repair projects, if not included in the Capital Improvement Program,

has been based on historical information and projected needs (see *Chapter 5: Lifecycle Planning*). NJTA annually incorporates data from its bridge inspection to project bridge repair needs and project costs in a rolling five year rolling forecast. Projected funding to be allocated from the Authority's various funding sources, which includes the long-range capital plan, for bridge repair projects for FY 2022 is approximately $356 million with $479 million projected for FY 2023. Of the FY 2022 total, approximately 23 percent is funded through the long-range capital plan, and of the FY 2023 total, nearly 12 percent is funded through the same fund; whereas the balance is funded through other sources as described in the 2020 long-range capital plan.

Annual expenditures for the maintenance reserve fund pavement resurfacing and bridge repair projects for the six-year period spanning FY 2017–2022 are presented in Exhibit 7-9 (figures for FY 2022 are budget estimates). The exhibit shows a long-term trend of increasing expenditures. The increase in pavement expenditures is approximately 27 percent, with bridge expenditures increasing approximately 14 percent over the FY 2017–2022 period.

Exhibit 7-9: NJTA Annual Expenditures for Pavement Resurfacing and Bridge Repair Projects from the Maintenance Reserve Fund ($ millions) – FY 2017-2022



Source: NJTA Annual Budget Reports FY 2012–2019.
Note: FY 2022 figures are budget estimates and FY 2017 to FY 2021 figures are actuals.

Exhibit 7-10: Average Annual Funding for the NJTA NHS Pavement and NBIS Bridges

Asset Class	Average Annual Expenditure ($ millions)		
	Prior (2012–2021)	Estimated[1] (2022–2026)	Projected[2] (2027–2032)
Pavement	40.3	108.1	103.1
NBIS Bridges	50.0	395.5	73.5

Source: NJTA Annual Budget Reports FY 2012–2019.
[1] Average annual spending is derived using budget estimate data for FY 2022 through FY 2026.
[2] Average annual spending is derived using maintenance reserve fund budget estimate data for FY 2022–2026 based on NJTA's stated intent to increase spending greater than long-term averages.
Note: "Prior" and "Projected" amounts only reflect work funded by the maintenance reserve fund. "Estimated" amounts reflect work funded by the maintenance reserve fund plus that from the 2020 long-range capital program, which only extends out through FY 2026.

The sum total of pavement and bridge allotments from the maintenance reserve fund has increased substantially over the recent past. During the historical 10-year period from FY 2012 through FY 2021, pavement resurfacing, and bridge repair projects combined to an approximately $90.4 million per year. Meanwhile, budget estimates for combined pavement and bridge projects in FY 2022 through FY 2026 are approximately 85 percent higher than the 2012–2021 period at nearly $168.2 million per year.

Exhibit 7-10 presents the annual average spending levels for pavements and bridges during the FY 2012–2021 period. This financial data is also used to project pavement resurfacing and bridge repair expenditures in the TAMP analysis period.

7.5.2 Port Authority of New York and New Jersey

The Port Authority of New York and New Jersey (PANYNJ) owns 46 pavement lane miles (0.4%) and 3,666,880 square feet (5.9%) of NBIS bridges by deck area on the NHS. The PANYNJ's capital plan for the 10-year period FY 2017–2026 includes $6.1 billion in bridge and tunnel projects, including approach roadways in New Jersey. Of the $6.1 billion total, approximately $2.7 billion is related to Authority-owned bridge deck, superstructure, and substructure components and roadway surfaces. Exhibit 7-11 shows the PANYNJ's planned expenditures on pavements and bridges.

7.5.3 South Jersey Transportation Authority

The South Jersey Transportation Authority (SJTA) owns 269 pavement lane miles (2.2%) and 419,262 square feet (0.7%) of NBIS bridges by deck area on the NHS. These assets are located on the Atlantic City Expressway, the Atlantic City Expressway Connector, and New Jersey Routes 30, 87, and 187. SJTA provided its five-year past and five-year projected spending plan for its NHS pavement and bridges as shown in Exhibit 7-12. Spending for the TAMP analysis period was estimated by calculating a simple average of the spending for the prior and planned periods. As a measure of conservatism, equal weight to spending estimates for the prior and

Exhibit 7-11: Average and Estimated Annual Funding for the PANYNJ NHS Pavement and NBIS Bridges

Asset Class	Average Annual Expenditure ($ millions)	
	Planned (2017–2026)	Projected[1] (2022–2032)
NBIS Bridges & Pavements[2]	232.3	232.2

[1] Average annual spending for the TAMP analysis period is estimated as equal to the average spending level in the period (FY 2017–2026).
[2] NBIS bridge and pavement project expenditures are estimated by facility and not by bridge/pavement asset types.

Exhibit 7-12: Average and Estimated Annual Funding for SJTA NHS Pavement and NBIS Bridges

Asset Class	Average Annual Expenditure ($ millions)		
	Prior (2017–2021)	Planned (2022–2026)	Projected[1] (2022–2032)
Pavement	4.1	4.6	4.3
NBIS Bridges	2.9	3.9	3.4

[1] Average annual spending for the TAMP analysis period is estimated as the average of the spending level in the prior period (FY 2017–2021) and the planned spending level for the immediate future period (FY 2022–2026).

planned periods was used due to the risk that the increase in planned spending may not be sustained over the entire TAMP analysis period. In addition to the spending plans captured in Exhibit 7-12, there is currently a road-widening project in the project design phase that would include the replacement of four NHS bridges; however, the cost of the project is not included because the construction timeframe is not yet finalized (the work may occur in 2025 or 2026).

7.5.4 Other Toll Authorities

The Delaware River Port Authority (DRPA) owns 3,737,035 square feet of NHS NBIS bridge deck area and 43 lane miles of NHS pavement. The bridge figure ranks third highest behind NJDOT and NJTA. During the TAMP data collection process, the Authority indicated that it spent nearly $425 million on both asset classes during the FY 2017 to FY 2021 period with plans to spend an additional $522 million from FY 2022 to FY 2026.

The Delaware River and Bay Authority (DRBA) owns 1,263,393 square feet of NHS NBIS bridge deck area and 16 lane miles of NHS pavement. During the TAMP data collection process, the Authority indicated that it spent nearly $55.6 million on these assets during the FY 2017 to FY 2021 period with plans to spend an additional $76.8 million from FY 2022 to FY 2026.

The Delaware River Joint Toll Bridge Commission (DRJTBC) owns 1,058,122 square feet of NHS NBIS bridge deck area and 34 lane miles of NHS pavement. During

the 2019 TAMP data collection process (no data was provided for the 2022 TAMP), the commission indicated that it planned to spend approximately $16 million on these assets from FY 2018 to FY 2022.

The Palisades Interstate Park Commission (PIPC) owns approximately 47 lane miles of NHS pavement and 62,723 square feet of NHS NBIS bridge deck area in New Jersey. PIPC is not a toll authority and does not collect user fees. During the 2019 TAMP data collection process (no data was provided for the 2022 TAMP), PIPC indicated that it planned to spend approximately $490,000 from FY 2018 to FY 2022 on these assets. These expenditures represent maintenance costs.

The Burlington County Bridge Commission (BCBC) owns 271,212 square feet of NHS NBIS bridge deck area and three lane miles of NHS pavement. BCBC's five-year capital plan for FY 2022–2026 is projected to be $57.7 million for these assets. Additionally, BCBC's FY 2021 budget is approximately $16 million. Of the total amount, $37.1 million in expenditures is projected for non-maintenance work on bridge deck, superstructure, and substructure components. Of the FY 2021 budget, approximately $6.1 million is for work on the same components.

7.5.5 Other Owners

The remaining assets on the NHS are owned predominantly by county agencies. A questionnaire requesting recent spending history and spending plans was sent to county and municipal NHS asset owners. Responses were received from 11 of the 29 county and municipal owners, representing approximately 40 percent of NHS pavement lane miles and NHS NBIS bridge deck area owned by counties and municipalities. However, as summarized in *Chapter 3: TAMP Governance, Policy, and Objectives*, data was collected to represent approximately 89 percent of all NHS pavements and approximately 97 percent of all NHS NBIS bridges.

Exhibit 7-13 presents the estimation of NHS pavement preservation spending by these agencies. Exhibit 7-14 presents the estimation of NHS NBIS bridge-related spending by these agencies.

The estimating procedure for county and municipal owners uses the responses received during the TAMP outreach program to estimate a unit spending rate to apply to the entire population of such owners. For example, the respondents accounted for 688 pavement lane miles and reported $9,808,127 average annual spending in the immediate five-year period ending in FY 2021. This produces an average annual spending per lane mile of $14,255, which is applied to the total pavement lane miles for the group, yielding a total estimated annual expenditure of $27,113,010.

The respondents provided their spending plans out to FY 2026. Spending for the TAMP analysis period was estimated by calculating a simple average of the spending for the prior and planned periods. Because there is a risk that the increase in planned spending will not be sustained over the entire TAMP analysis period, giving equal weight to spending estimates for the prior and planned periods was used as a measure of conservatism.

An additional, ongoing risk related to estimating the expenditures by county and municipal NHS owners is related to the requirement for NJDOT to collect accurate data on the spending plans of these owners; moreover, the ability of

these owners to accurately review records of completed projects and programmed projects related to NHS pavement and bridge assets.

For example, the respondents accounted for 335,435 square feet of bridge deck area and reported $2,016,652 average annual spending in the immediate five-year period ending in FY 2021. This produces an average annual spending per square foot of $6.01, which is applied to the total square feet of bridge deck area for the group, yielding a total estimated annual expenditure of $5,167,518.

Exhibit 7-13: Estimated NHS Pavement Management Expenditure by County and Municipal Owners

	Average per Year ($)		
	Prior (FY 2017–2021)	**Planned (FY 2022–2026)**	**Projected[1] (FY 2022–2032)**
Questionnaire Respondents			
Average Annual Spending	$9,808,127	$7,653,577	$8,730,852
Pavement Lane Miles	688	688	688
Average Annual Spending/Lane Miles	$14,255	$11,124	$12,690
All County and Municipal Owners			
Total Pavement Lane Miles	1,902	1,902	1,902
Estimated Total Spending of Group	**$27,113,010**	**$21,157,848**	**$24,136,380**

Source: Survey administered during early 2022. Note: For respondents, if the amount of spending specific to NHS assets was not provided, NHS spending was estimated to be proportional to the share of the asset that is on the NHS.
[1] Average annual spending for the TAMP analysis period is estimated as the simple average of the spending in the prior period (FY 2017–2021) and the planned spending for the immediate future period (FY 2022–2026).

Exhibit 7-14: Estimated NHS NBIS Bridge Management Expenditure by County and Municipal Owners

	Average per Year ($)		
	Prior (FY 2017–2021)	**Planned (FY 2022–2026)**	**Projected[1] (FY 2022–2032)**
Questionnaire Respondents			
Average Annual Spending	$2,016,652	$14,260,000	$8,138,326
Bridge Deck Area (Sq. Ft.)	335,435	335,435	335,435
Average Annual Spending/Sq. Ft.	$6.01	$45.51	$24.26
All County and Municipal Owners			
Total Bridge Deck Area (Sq. Ft.)	859,820	859,820	859,820
Estimated Total Spending of Group	**$5,167,518**	**$39,130,408**	**$20,859,233**

Source: Survey administered during early 2022. Note: For respondents, if the amount of spending specific to NHS assets was not provided, NHS spending was estimated to be proportional to the share of the asset that is on the NHS.
[1] Average annual spending for the TAMP analysis period is estimated as the simple average of the spending in the prior period (FY 2017–2021) and the planned spending for the immediate future period (FY 2022–2026).

Exhibit 7-15: Estimated NHS Expenditures by Non-NJDOT Asset Owners ($ millions)

Owner	Projected Average Annual Expenditure ($ millions) (FY 2022–2032)	
	Pavements	Bridges
New Jersey Turnpike Authority	106	235
Port Authority of New York & New Jersey	0[1]	232
South Jersey Transportation Authority	4	3
Other Authorities	5[2]	29[3]
Counties and Municipalities	24	21
Total[4]	**139**	**520**

Source: See prior sections and exhibits for source information.
[1] Expenditures for PANYNJ pavements included with dollar amount for bridges.
[2] Includes the Delaware River and Bay Authority (DRBA) and DRPA. Expenditures for the PIPC, DRJTBC, and BCBC excluded due to challenges in corroborating reported data, 2022 STIP data, and published capital programs. The excluded authorities collectively own 0.7% of NHS pavements.
[3] Includes the DRBA, BCBC, and DRPA. Expenditures for the PIPC and DRJTBC excluded because they did not respond to data request, and due to challenges in corroborating 2022 STIP data and published capital programs. The excluded authorities collectively own 1.6% of NHS bridges by deck area.
[4] Estimates account for approximately 72 percent of all NHS pavement lane miles and approximately 94 percent of all NHS bridges owned by non-NJDOT owners.

7.5.6 Summary of Projected Expenditures for Non-NJDOT NHS Assets

Exhibit 7-15 presents the projected NHS asset management expenditures for each grouping of non-NJDOT asset owners. The projected totals for NHS pavement and bridge assets represent an increase from prior spending totals. This projected increase supports the conservative projection shown in the performance-gap analysis that the performance of the non-NJDOT NHS pavement and bridge assets will remain at the same level as in the TAMP baseline (CY 2021).

The TAMP presents these estimates using the best available data, assumptions noted previously, and does not represent a complete set of financial plans for asset management by each of the other NHS owners. The pavement expenditure estimate accounts for 72 percent of all non-NJDOT NHS pavement lane miles. The bridge expenditure estimate accounts for 93 percent of all non-NJDOT NHS bridges by deck area.

7.6 THE VALUE OF NJDOT'S SHS PAVEMENT AND NBIS BRIDGE ASSETS

7.6.1 Asset Valuation Method

The New Jersey SHS constitutes a massive investment of public resources. There are a variety of approaches to represent the value of this investment. The TAMP uses a modified depreciated replacement cost approach to valuation. For each category of asset valued, a unit cost to replace the asset is estimated. For bridges the unit costs vary by the type of bridge. The unit cost multiplied by the number of units (e.g., lane miles) represents an approximation of what it would cost to replace all of the State's

Exhibit 7-16: Asset Valuation of NJDOT SHS Pavement and NBIS Bridge Assets ($ millions)

Asset Type	Unit Totals by Condition (Lane Miles and Deck Area 000 Sq. Ft.)				Unit Replacement Cost	Replacement Cost ($ millions)	
	Total	Good	Fair	Poor		Full, Undepreciated	Depreciated
Pavement	8,560	3,972	2,782	1,806	3.6	30,816	22,005
Bridge Subtotal	35,293	8,925	23,612	3,444	NA	125,319	91,590
Significant Bridges	3,386	687	1,921	778	7,668	25,963	17,279
Moveable Bridges	1,297	379	919	0	6,390	8,288	6,579
Large-Scale Bridges	5,603	1,917	3,036	653	3,834	21,492	15,970
Medium-Scale Bridges	8,207	2,271	5,357	580	3,195	26,223	19,828
Conventional-Scale Bridges	17,213	3,703	12,035	1,337	2,556	43,997	32,709
Small-Scale Bridges	577	129	365	83	2,428	1,400	996
					Pavement and Bridge Total	**158,180**	**113,645**

Notes: Unit replacement costs, and therefore the valuations, include only the depreciable portion of the assets and exclude items such as right-of-way.
Asset valuation is based on FY 2023 unit cost levels applied to CY 2021 (baseline) asset conditions. Pavement asset conditions are based on the NJDOT Condition Status metric.
Definitions: Significant Bridges: Deck Area ≥ 300,000 sq. ft. Moveable Bridges: Moveable Bridges. Large-Scale Bridges: Deck Area ≥ 100,000 sq. ft. and < 300,000 sq. ft. Medium-Scale Bridges: Deck Area ≥ 25,000 sq. ft. and < 100,000 sq. ft. Conventional-Scale Bridges: Deck Area ≥ 2,500 sq. ft. and < 25,000 sq. ft. Small-Scale Bridges: Deck Area < 2,500 sq. ft.

holdings of that asset. The replacement cost applies only to the non-depreciable portion of the asset. The value of right-of-way and off-site work costs for roadways are examples of items excluded from the asset valuation.

Transportation assets deteriorate with use and with exposure to harsh environmental conditions and eventually require replacement. Asset valuation incorporates the diminished service life of an asset to measure accumulated depreciation. The TAMP uses asset condition ratings to estimate remaining service life. This method was selected rather than age-based depreciation because upcoming replacement needs are determined more by asset condition than by asset age.

A newly constructed asset in perfect condition is expected to have 100 percent of its service life remaining. At the other end of the asset life cycle, an asset in *Poor* condition is expected to require replacement or reconstruction in the near future. NJDOT's asset valuation approach uses overall assumptions regarding the percentage of remaining service life for assets in *Good, Fair*, and *Poor* condition and assigns an assumed percentage of remaining service life, accordingly. An asset listed in *Good* condition is assumed to have 90 percent of its service life remaining, so it is valued at 90 percent of its estimated replacement cost. An asset in *Fair* condition is assumed to have 75 percent of its service life remaining, while one in *Poor* condition is assumed to have 25 percent of its service life remaining.

These remaining service life assumptions are used to calculate a depreciated value for an asset class. The calculations apply the following formula:

Remaining value of asset class
= replacement unit cost
× [(units in Good *condition ×0.9) +*
(units in Fair *condition x 0.75)*
+(units in Poor *condition x 0.25)]*

The results of this calculation for NJDOT SHS pavements and bridges are presented above in Exhibit 7-16.

7.6.2 Estimating Investment Required to Maintain Asset Value

In a conventional asset valuation, capital asset values are reduced by accumulated depreciation and increased by capital investment. For example, if the level of investment in a given year is equivalent to the depreciation charged for that year, the capital asset valuation would remain unchanged. Therefore, efforts to preserve a level of transportation asset valuation can consist of investing a sufficient amount to maintain the existing level of "accumulated depreciation."

Investments that maintain the current level of performance are the equivalent to investments that maintain the asset valuation as it is calculated for the TAMP, in which condition rating is used for measuring depreciation. The investment levels are defined in *Chapter 4: Performance Gap Analysis*. One of the four investment scenarios analyzed was "Funding to Maintain CY 2021 Condition," which is the investment required to maintain baseline (CY 2021) conditions. As noted in *Chapter 4: Performance Gap Analysis*, a $338 million annual average investment over the TAMP analysis period is required to maintain baseline pavement conditions for the SHS and 545 million annual average investment is required to maintain baseline NBIS bridge conditions.

For the NHS, the investment required to maintain value was estimated by applying the NHS share of the asset's depreciated value to the investment required to maintain the value for all of the assets on the SHS. Additional details on the levels of investments required to preserve the valuation of NJDOT's pavement and bridge assets is presented in the following section.

7.6.3 Value of the NJDOT State Highway System and Investment Required to Maintain Value

The values of all NJDOT pavement and NBIS bridge assets are presented in Exhibit 7-17. The total asset valuation exceeds $113 billion, with 86 percent of this valuation (over $95 billion) accounted for by the assets on the NJDOT NHS (88% of SHS pavement lane miles are on the NHS; 82% of SHS bridges by deck area are on the NHS). At more than $93 billion, NBIS bridges account

Exhibit 7-17: Asset Valuation of NJDOT SHS and NJDOT-NHS Assets ($ millions)

Asset Type	Unit Totals (Lane Miles and Deck Area 000 Sq. Ft.)		Total Depreciated Asset Value ($ millions)		Annual Investment Required to Maintain Asset Value ($ millions)	
	SHS	NJDOT NHS	SHS	NJDOT NHS	SHS	NJDOT NHS
Pavement	8,560	7,542	22,005	19,364	338	297
Bridge Subtotal	35,982	29,206	91,590	77,867	490	417
	Pavement and Bridge Total		**111,310**	**95,289**	**828**	**715**

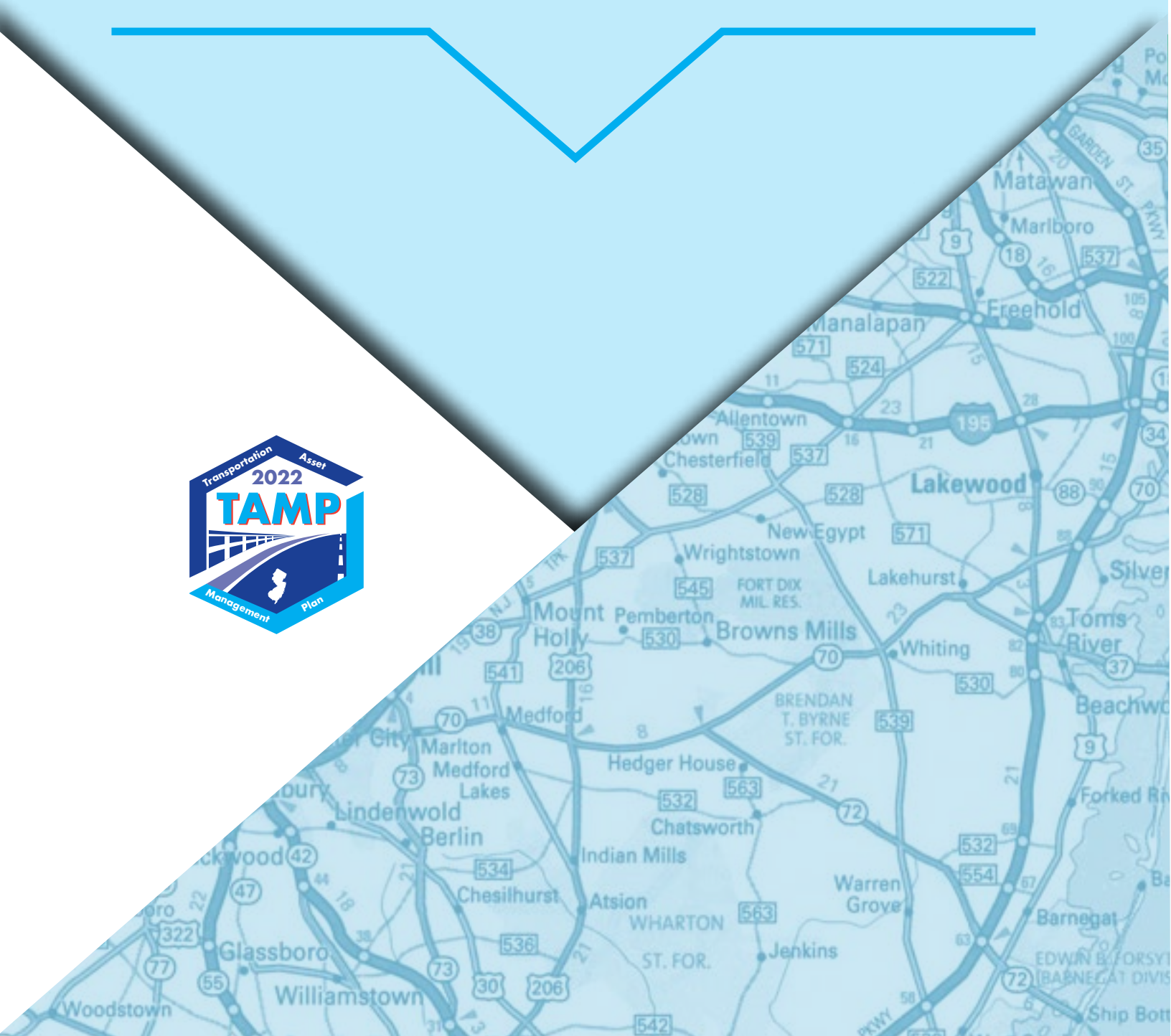
for the overwhelming majority (82%) of the valuation of SHS pavement and bridge assets. The bridge share of the undepreciated value is similar, at nearly 81 percent.

An estimated total exceeding $883 million per year in asset management investment is required to maintain the value of all NJDOT pavement and NBIS bridge assets. The investment required to maintain the value of all NJDOT pavement and bridge assets on the NHS is $759 million per year. The relatively short service life of pavement compared to bridges is evidenced in the comparison of relative asset valuations of the two types of assets in contrast to the required investment to maintain their value. Bridges account for 82 percent of the depreciated valuation but only 62 percent of investment required to maintain this value. These required investment levels are limited to maintenance, preservation, rehabilitation, and replacement expenditures. They do not include other required expenditures to manage the assets, such as inspections and administration of the bridge and pavement management systems.

The average planned funding of $360 million per year exceeds the funding required to maintain the baseline (2021) SHS pavement asset value. It should be noted that the planned funding includes investments in several reconstruction projects as described in *Chapter 4: Performance Gap Analysis*. While these projects do not contribute significantly to maintaining overall network conditions in the near term, they are consistent with the pavement life cycle strategy of minimizing maintenance costs over the life of the asset as described in *Chapter 5: Life Cycle Planning*. They also address DOT objectives in other national goal areas such as safety and mobility.

Planned bridge funding of $755 million per year is much greater than the amount needed to maintain asset values for the TAMP analysis period. This favorable result aligns with the projected increase in the percentage of bridges in a state of good repair, which would increase the depreciated asset value based on the formula shown in Section 7.6.1.

CHAPTER 8:
INVESTMENT STRATEGIES



BACKGROUND: New Jersey's Transportation Asset Management Plan (the TAMP) describes investment strategies for pavement and bridge assets. The investment strategy for each asset class is derived from the preceding TAMP processes and consists of the optimal allocation of resources across the asset portfolio. The investment strategies balance the funding amounts based on the risks identified and life cycle analyses at the asset level and network level to be invested according to work type (i.e., maintenance, preservation, rehabilitation, and reconstruction) enabling the New Jersey Department of Transportation (NJDOT) to pursue TAMP policy and state of good repair objectives.

8.1 OVERVIEW

The TAMP investment strategies for the State Highway System (SHS) are the planned funding levels among asset management work types for each asset class. The strategies are derived from the application of each asset's preferred life cycle strategy over the TAMP analysis period based on available funding, risk analysis, and asset condition. Chapter 8 includes the following:

- An overview of how NJDOT develops investment strategies.
- The NJDOT investment strategies for SHS pavement and National Bridge Inspection Standard (NBIS) bridge assets by year.
- A comparison of investment strategies to funding needed to achieve the TAMP state of good repair objectives.
- Investment strategies for the National Highway System (NHS) pavement and NBIS bridge assets

8.2 NJDOT Investment Strategy for the SHS

8.2.1 Development of Investment Strategies

The NJDOT pavement and bridge management systems use analytical software to support life cycle planning to develop investment strategies. The investment strategies optimize planned funding and forecast expenditures to make progress toward the TAMP state of good repair objectives at the lowest life cycle cost, while incorporating the consideration of risk. The management systems and life cycle planning processes are detailed in *Chapter 5*.

Image of NJ Route 7, Wittpenn Bridge

NJDOT makes use of management system software as an integral part of the overall investment strategy development and project selection processes; however, the selection of projects from among the work candidates advanced by the software remains subject to review by NJDOT subject matter experts, as detailed in *Chapter 5: Life Cycle Planning*. Considerations include risk, ability to deliver the project, traffic projections, resilience in regard to climate change, work history on the asset, implications of other work on the network in the vicinity, and significance of the asset to the transportation system.

The funding allocations among the four work types represent NJDOT's strategies to optimize its use of the total available funding for bridge and pavement asset management. These funding allocations are presented in the following sections.

8.2.2 NJDOT Pavement Investment Strategy

The investment strategy for SHS pavements is to increase preservation expenditures that prevent pavement assets from deteriorating to a point of requiring even greater investment. The pavement investment strategy prioritizes pavement treatments to maximize the benefits in terms of long-term cost savings and network performance by improving pavement conditions. The overall investment strategy is driven by cost effectiveness, prioritizing funding for the most cost-effective treatments first, (preservation and resurfacing) and allocating the remaining funding based on individual project deliverability.

Exhibit 8-1 (following page) presents the allocation of planned pavement asset management funding among the work types identified in the Federal Highway Administration (FHWA) asset management rule. These work types are summarized in the following sections.

Initial Construction

A planned investment level for initial (new) construction of pavement is not included because planning for construction of new pavement assets is beyond the purview of the Pavement Management Unit and its Pavement Management System (PMS). Projections for new pavement construction spending over the TAMP analysis period are unavailable. Moreover, NJDOT has not focused on new roadway expansion for many years; instead, it continues to focus on maintaining its existing infrastructure.

Maintenance

Maintenance treatments are those which are performed to delay, prevent, or repair damage but do not significantly impact a pavement's measured condition. Examples of maintenance treatments include crack sealing and pothole repair. These treatments are typically performed in-house by NJDOT staff along with other work, making it problematic to isolate pavement maintenance cost for purposes of modeling or developing investment strategies; therefore, a planned investment level for pavement maintenance is not included in Exhibit 8-1.

Preservation

Treatments classified under the preservation work type are performed to address minor surface distresses, improve pavement surface conditions, and extend pavement service life without restoring or improving the pavement's structural capacity. Examples of

Exhibit 8-1: Investment Strategy for SHS Pavements

Work Type	Pavement Investment by Fiscal Year ($ millions)										
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Average
Initial Construction	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Maintenance[1]	—	—	—	—	—	—	—	—	—	—	—
Preservation	$75	$75	$75	$35	$90	$90	$90	$90	$90	$90	**$80**
Rehabilitation	$290	$205	$185	$355	$165	$145	$220	$125	$80	$135	**$190**
Reconstruction	$35	$70	$10	$85	$100	$60	$190	$70	$275	—	**$90**
Total	**$395**	**$350**	**$270**	**$475**	**$355**	**$295**	**$500**	**$285**	**$445**	**$225**	**$360**

Source: NJDOT pavement management system analyses based on the 2023 Capital Program.

[1] Pavement maintenance work is performed in-house by NJDOT staff, along with other work. As a result, it is not possible to isolate a pavement maintenance cost for purposes of modeling or developing of investment strategies.

Note: Dollar amounts are rounded to the nearest $5 million.

NJDOT preservation treatments include micro-surfacing, slurry seal, and thin asphalt overlays (less than 2 inches).

The NJDOT investment strategy for pavement includes a significant and sustained investment in preservation treatments over the TAMP analysis period. This reflects the Department's commitment to achieving the preservation investment level recommended by the pavement management system consistent with the life cycle planning strategy for pavements. It is possible the actual investment may be higher than indicated as pavement preservation is prioritized when savings are found on other projects.

The NJDOT Pavement Management Unit has determined that increased use of preservation treatments reduces life cycle costs. The increased emphasis on preservation aligns with the asset management emphasis in the Moving Ahead for Progress in the 21st Century (MAP-21) legislation. Preservation treatments reduce the risk that assets will require more expensive major rehabilitation treatments in the future by protecting the integrity of the pavement structure from routine wear, water infiltration, and freeze thaw damage.

Rehabilitation

Treatments classified under the rehabilitation work type are those which restore a pavement's surface condition, such as resurfacing, and those that restore or improve a pavement's structural capacity typically in the top layers of the pavement structure. Pavement rehabilitation investment levels vary over the TAMP analysis period, beginning with a higher level in the initial years (FY 2023–2026) and due to additional IIJA funding and declining in later years (FY 2027–2032) to a more typical level. The bulk of the pavement program continues to be rehabilitation work. There is an annual Transportation Trust Fund (State funding) allocation of $90M for resurfacing to promptly restore pavement surface condition at critical locations. Federal funding allocations to rehabilitation are based on project deliverability and on the amount of federal funds remaining after allocation to

preservation and reconstruction.

Reconstruction

Reconstruction projects renew or replace the entire depth of the pavement structure. Reconstruction projects are very involved with very long delivery schedules (10 to 15 years or longer). They are identified through rigorous project-level pavement condition, design, and cost-benefit analyses. They often include much more than just pavement work, as reconstruction offers the opportunity to consider correction of all roadway deficiencies, such as those relating to drainage, geometry, structures, safety, mobility, freight, etc. Due to its very high cost, reconstruction is typically the last resort. Such projects are fit into the program as they become deliverable. For this reason, funding for the reconstruction and rehabilitation categories tend to vary inversely to accommodate project schedules within the two work types.

8.2.3 NJDOT NBIS Bridge Investment Strategy

The investment strategy for SHS bridges includes an increase in funding for preservation treatments to prevent a bridge from deteriorating to a point of requiring even greater investment. The substantial increase in funding provided under the recent IIJA is concentrated on rehabilitation treatments and bridge reconstruction. Exhibit 8-2 (following page) presents the allocation of planned bridge asset management funding among the work types identified in the FHWA asset management rule. The text that follows briefly describes the NJDOT activities that accord with each work type.

Initial Construction

A planned investment level for initial (new) construction of bridges is not included. New bridge construction projects originate from safety or congestion relief needs, which are initiated and implemented as part of other (i.e., non-asset management) NJDOT planning activities. Projections of spending on construction of new bridges over the TAMP analysis period are currently unavailable.

Maintenance

Treatments classified under bridge maintenance are those which are a reaction to unforeseen situations that arise and require immediate or prompt repairs. As such, the investment strategy for maintenance funding is based on anticipated reactive maintenance needs. The planned maintenance dollar amounts are steady at $90 million per year. After adjusting for an assumed three percent annual cost escalation, the purchasing power of the $90 million in FY 2032 would be $69 million. Besides inflation risk, there is a risk that the level of unforeseen repairs due to extreme weather or other events could be exceptionally high in one or more years.

Preservation

Treatments classified under the preservation work type are those which prevent, delay, or otherwise reduce deterioration of bridge elements. NJDOT has adopted a bridge preventive maintenance program that specifies treatments, their cycle, and element condition criteria used to determine when each treatment should be applied. The preventive maintenance program was developed and is administered by Transportation Operation Systems and Support (TOSS).

The investment strategy amounts for preservation reflect the increased emphasis on preservation spending compared to past levels,

Exhibit 8-2: Investment Strategy for SHS NBIS Bridges

Work Type	Bridge Investment by Fiscal Year ($ millions)										
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Average
Maintenance	$90	$90	$90	$90	$90	$90	$90	$90	$90	$90	**$90**
Preservation	$135	$125	$145	$145	$145	$145	$145	$145	$145	$145	**$140**
Rehabilitation	$275	$160	$145	$210	$220	$215	$170	$185	$165	$295	**$205**
Reconstruction	$400	$290	$495	$170	$315	$360	$215	$375	$185	$410	**$320**
Total	**$900**	**$665**	**$875**	**$615**	**$770**	**$810**	**$620**	**$795**	**$585**	**$940**	**$755**

Source: NJDOT bridge management system analyses based on the 2023 Capital Program.
Note: Dollar amounts are rounded to the nearest $5 million.

an increase which had been recommended by both the Bridge Management Unit and TOSS. The main factor behind this recommended increase is the projected long-run benefit to the system condition that results from increased preservation investment amounts.

The TAMP investment strategy for maintenance and preservation applies the funding as planned in the 2023 Transportation Capital Program. This funding allocation is consistent with the bridge life cycle planning strategy presented in *Chapter 5: Life Cycle Planning*.

Rehabilitation and Reconstruction Treatments classified under the rehabilitation work type involve major work to restore a bridge's structural integrity and to correct major safety defects. Examples include deck replacements and superstructure replacements. Reconstruction is the complete replacement of the bridge with a new structure. The relative investment levels of rehabilitation versus reconstruction are greatly influenced by projects that are already programmed. Approximately 60 percent of the available funding for rehabilitation and reconstruction is already accounted for in programmed projects. The Pulaski Skyway rehabilitation project accounts for a nearly half of the rehabilitation spending, averaging nearly $100 million per year over the analysis period. It bears noting that most of the bridge projects that are already programmed for rehabilitation and reconstruction are themselves output of the BMS as it was applied prior to the preparation of this TAMP. The BMS software tool, AASHTOWare BrM, was used to inform the allocation of the balance of the 2023 Transportation Capital Program funding remaining (i.e., the dollars not allocated to specific projects) for the rehabilitation and reconstruction work types.

The annual funding amounts to rehabilitation and reconstruction display considerable variation from year to year. The average annual projected investment levels over the TAMP analysis period are moderately higher for reconstruction than for rehabilitation. NJDOT could maximize the short-run performance improvement by emphasizing rehabilitation rather than reconstruction of bridges rated *Poor*. However, there are other management considerations in the selection of bridges and in the decision-making on project scope. Life cycle cost (including the traveler cost of repeat bridge repairs) is an important factor in the scoping decision. Functional inadequacies, risk-related and congestion-related, are also important considerations in scoping decisions.

Risk-based considerations include the need for and merits of design measures to increase the resilience of the structure in the face of changing environmental conditions.

8.2.4 SHS Funding Needs and Gaps

The level of investment required to meet the TAMP state of good repair objectives for the SHS are presented in Exhibit 8-3 and Exhibit 8-4 (following pages). Exhibit 8-3 shows that an average expenditure of $340 million per year is required to achieve the state of good repair objectives for SHS pavements by CY 2032. The planned investment of $360 million per year sustains the SOGR and allows for investment in planned reconstruction projects consistent with life cycle planning objectives. Reconstruction projects address pavement structure to minimize life cycle costs as well as other strategic objectives. The long-term performance benefits of these projects are not reflected within the displayed performance period.

Exhibit 8-4 shows that an average of $790 million per year is required to achieve the state of good repair objective for SHS NBIS bridges by CY 2032. The planned investment of $755 million per year leaves an average annual gap of $35 million.

The state of good repair funding needs and

Exhibit 8-3: Investments and Gaps to Meet State of Good Repair Objectives for SHS Pavements

	Pavement Investment by Fiscal Year ($ millions)										
	2023	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**Average**
Needed for SOGR	$350	$265	$320	$330	$335	$340	$350	$355	$365	$370	**$340**
Investment Strategy	$395	$350	$270	$475	$355	$295	$500	$285	$445	$225	**$360**
Gap	-$45	-$85	$50	-$145	-$20	$45	-$150	$70	-$80	$145	**-$20**

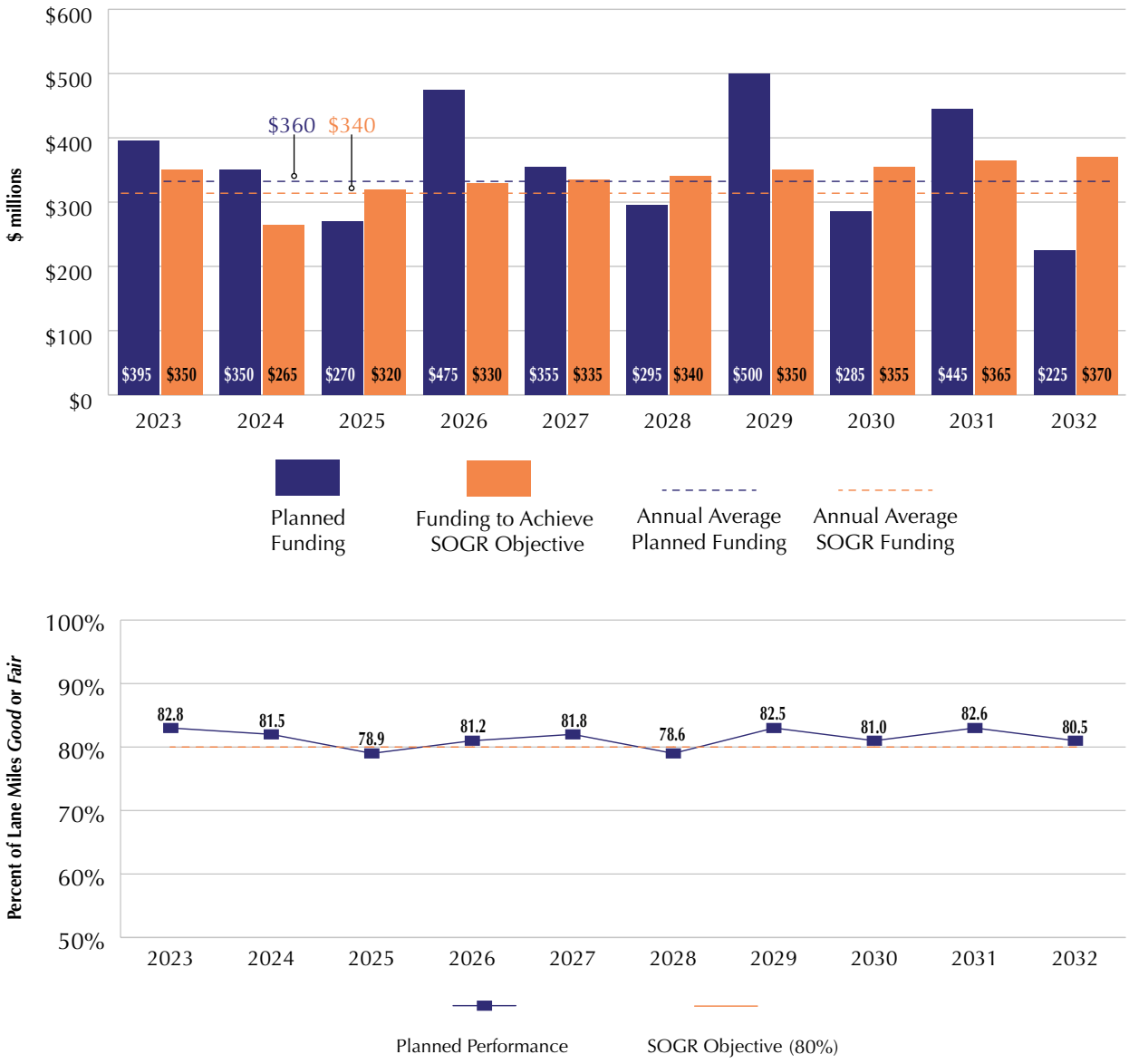
Source: NJDOT pavement management system.
Notes: SOGR = State of good repair (i.e., in Good or Fair condition, by NJDOT metric). Objective is 80% of lane miles in SOGR. The dollar amounts shown are from *Chapter 4: Performance Gap Analysis*; however, they are rounded here to the nearest $5 million. Annual average planned funding exceeds the amount needed to meet the ten-year SOGR objective. The additional $20 million, for reconstruction projects, helps to sustain the performance beyond the ten-year analysis period.

Exhibit 8-4: Investments and Gaps to Meet State of Good Repair Objectives for SHS NBIS Bridges

	Bridge Investment by Fiscal Year ($ millions)										
	2023	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**Average**
Needed for SOGR	$900	$700	$910	$655	$805	$850	$660	$830	$625	$985	**$790**
Investment Strategy	$900	$665	$875	$615	$765	$810	$620	$790	$580	$940	**$755**
Gap	$0	$35	$35	$40	$40	$40	$40	$40	$40	$40	**$35**

Source: NJDOT bridge management system.
Notes: SOGR = State of good repair (i.e., in *Good* or *Fair* condition). Objective is 94% of bridges by deck area in SOGR by deck area in *Good* or *Fair* condition. Approximately $45 million per year funding for inspections, administration of the bridge management system, and management of other structures (culverts, sign structures, etc.) is additional to the dollar amounts shown here for both the state of good repair needs and the investment strategy.

Exhibit 8-5: SOGR Funding Needs and Planned Investment for SHS Pavement Assets ($ millions) and Projected Performance (% *Good* or *Fair*)



Source: NJDOT pavement management system.
Note: SOGR = State of good repair (80% *Good* or *Fair* condition). Based on NJDOT Condition Status performance metric. Note also that the vertical scale for performance (% SOGR) is shortened and begins at 50%. This shortening exaggerates the performance changes for time

Exhibit 8-6: SOGR Funding Needs and Planned Investment for SHS NBIS Bridges ($ millions) and Projected Performance (% *Good* or *Fair*)

Source: NJDOT bridge management system.
Note: Bridge performance reflects a lag between rehabilitation and replacement spending and change in condition. The length of lag varies by project; minimum is two years. SOGR = State of good repair (*Good* or *Fair* condition). Note also that the vertical scale for performance (% SOGR) is shortened and begins at 50%. This shortening exaggerates the performance changes for time.

gaps are based on an assumed three percent annual increase in unit costs of all pavement and bridge treatments. There is the risk that the funding gap could be greater than shown, if cost escalation exceeds this assumed rate, or if the legislature does not appropriate the funding projected in the TAMP financial plan used to formulate these investment strategies.

Exhibit 8-5 and Exhibit 8-6 (following pages) compare needed and planned total investments for each year of the TAMP analysis period, along with lines connecting performance in each year. It bears noting that there are many other possible funding and performance time paths for achieving the state of good repair objectives by 2032. The time paths shown are based on a relatively steady spending time trend that is also reasonably plausible to implement.

8.3 INVESTMENT STRATEGY FOR THE NHS

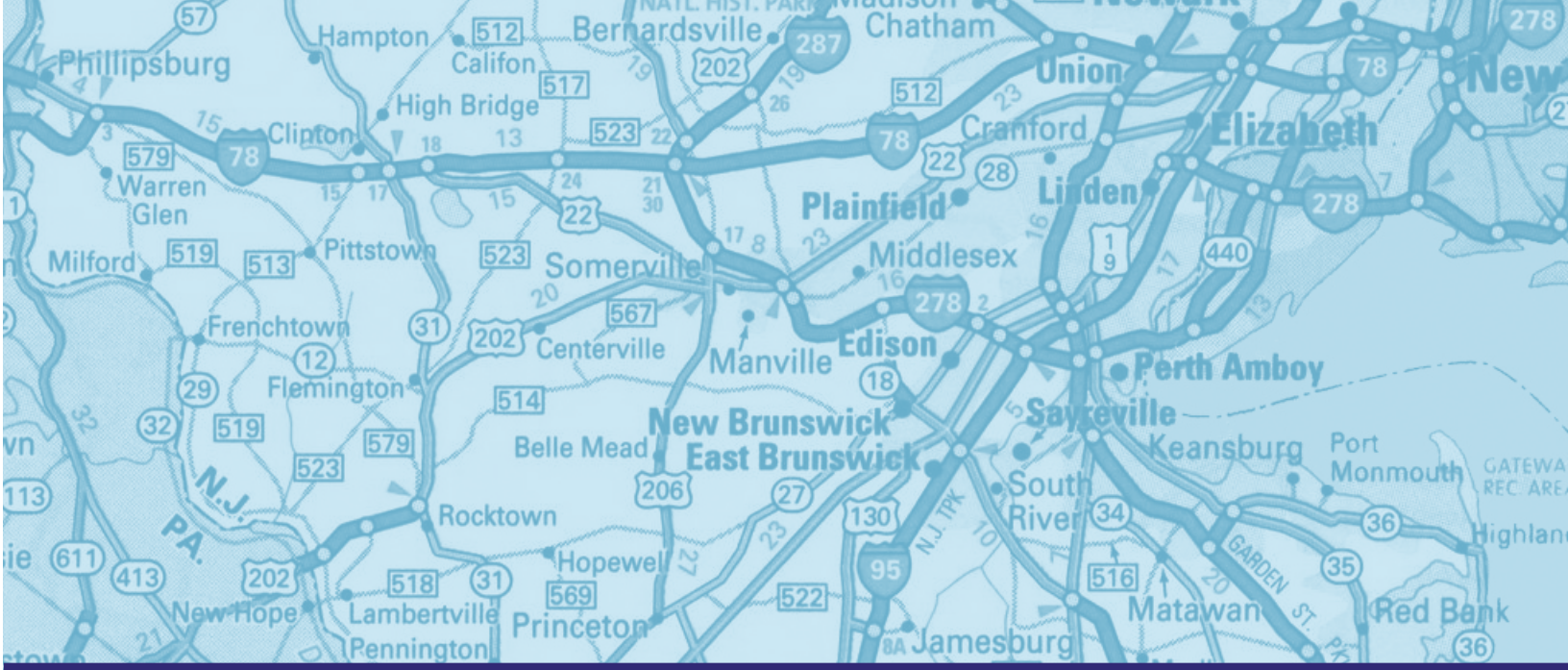
The NHS investment strategy is a compilation of NJDOT investment strategies and planned expenditures by non-NJDOT NHS owners. The NJDOT investment strategies for SHS pavement and bridge assets are noted in Section 8.2. The NJDOT investment strategy for the SHS is the foundation for the NHS investment strategy. NJDOT manages its pavement and NBIS bridge assets without distinguishing between assets on or off the NHS. The investment level on NJDOT NHS pavement is projected to be 88 percent of the total NJDOT pavement investment. That level of investment reflects the percentage of SHS pavement lane miles on the NHS. The level of investment on NHS bridges is projected to be approximately 85 percent of the total NJDOT bridge investment. The 85 percent expenditure is slightly higher than the 82 percent of SHS bridges by deck area on the NHS in CY 2021.

The NJDOT investment levels are combined with estimates of expenditures from other NHS owners, as noted in *Chapter 7: Financial Plan* (see Section 7.5). Collected financial data from other NHS owners is used to estimate expenditures on the non-NJDOT NHS assets. The level of detail in the information from other NHS owners does not support a breakdown of spending by work type for the NHS. The NHS investment strategy is presented in Exhibit 8-7 below.

Exhibit 8-7: Investment Strategy for NHS Pavement and NBIS Bridges

Asset	Investment by Fiscal Year ($ millions)										
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Average
Pavements	$485	$445	$375	$555	$450	$400	$580	$390	$530	$335	**$450**
Bridges	$1,295	$1,090	$1,275	$1,050	$1,180	$1,215	$1,055	$1,205	$1,025	$1,330	**$1,170**

Note: SHS data based on the planned funding scenario. NHS data gathered through the TAMP outreach program. Dollar amounts are rounded to the nearest $5 million.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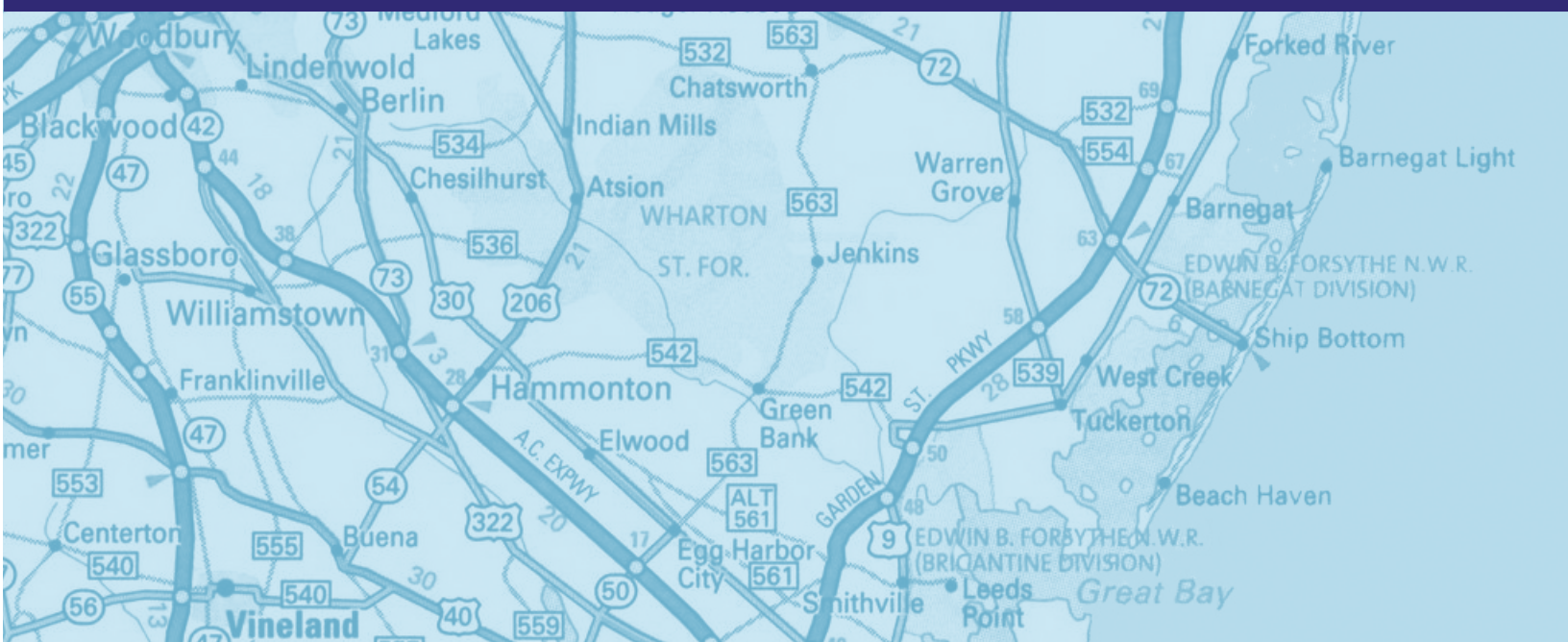
Califon
Bernardsville
Chatham
Union
Elizabeth
Clinton
High Bridge
Cranford
Warren Glen
Plainfield
Linden
Milford
Pittstown
Somerville
Middlesex
Frenchtown
Centerville
Manville
Edison
Perth Amboy
Flemington
New Brunswick
East Brunswick
Sayreville
Belle Mead
Keansburg
Port Monmouth
South River
Rocktown
N.J.
PA.
Hopewell
New Hope
Lambertville
Pennington
Princeton
Jamesburg
Matawan
Red Bank
N.J. TPK
GARDEN ST. PK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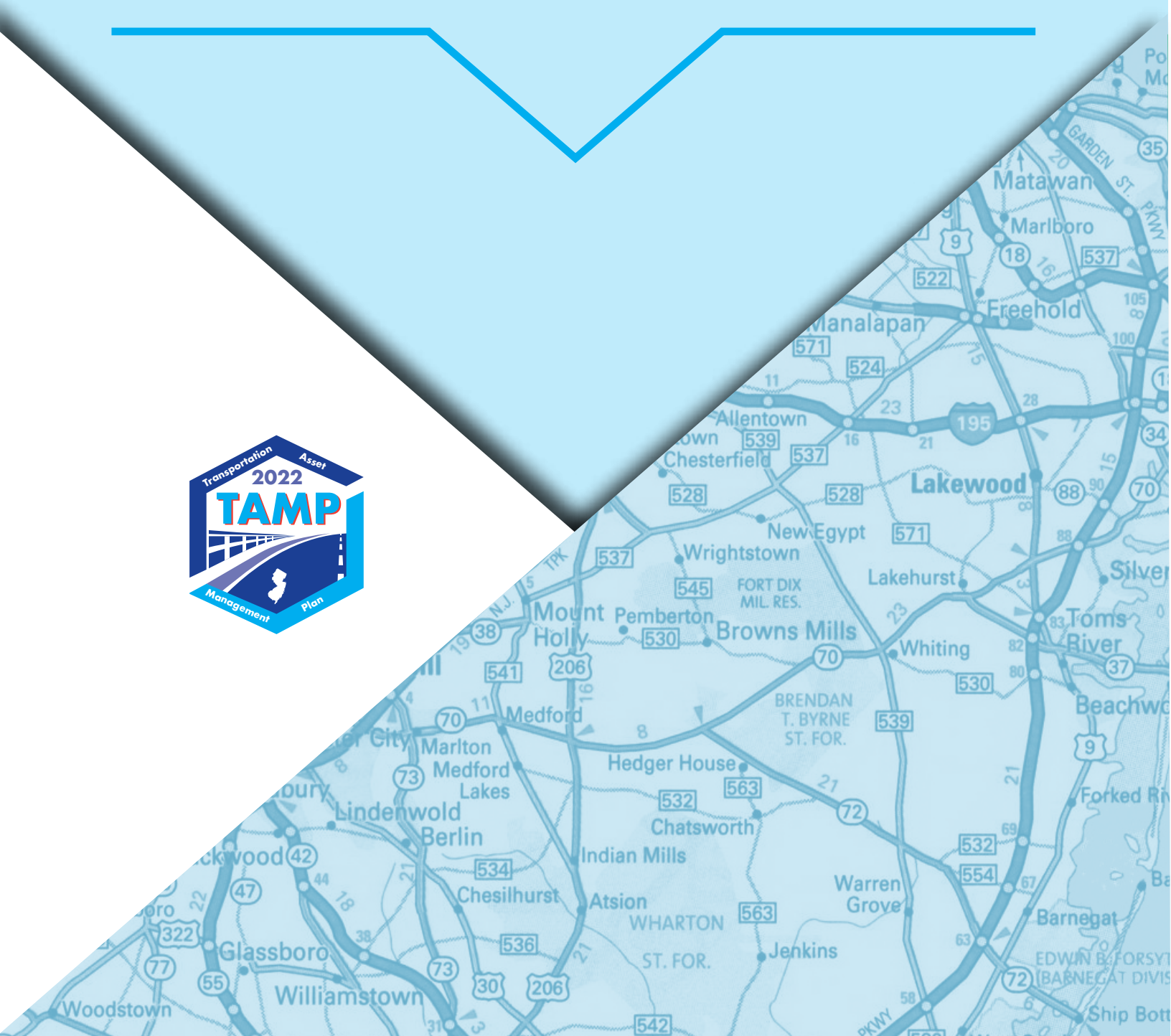
Lindenwold
Berlin
Lakes
Chatsworth
Indian Mills
Forked River
Blackwood
Chesilhurst
Atsion
Warren Grove
Barnegat Light
WHARTON
ST. FOR.
Barnegat
Glassboro
Jenkins
EDWIN B. FORSYTHE N.W.R. (BARNEGAT DIVISION)
Williamstown
Ship Bottom
Franklinville
Hammonton
West Creek
Green Bank
Tuckerton
Elwood
A.C. EXPWY
GARDEN ST. PKWY
Beach Haven
Centerton
Buena
Egg Harbor City
EDWIN B. FORSYTHE N.W.R. (BRIGANTINE DIVISION)
Leeds Point
Great Bay
Smithville
Vineland

APPENDICES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Marlboro
Freehold
Manalapan
Allentown
Chesterfield
Lakewood
New Egypt
Wrightstown
Lakehurst
FORT DIX
MIL. RES.
Mount
Holly
Pemberton
Browns Mills
Whiting
Toms
River
Medford
Marlton
Medford
Lakes
Lindenwold
Berlin
Hedger House
Chatsworth
Indian Mills
Chesilhurst
Atsion
WHARTON
ST. FOR.
Warren
Grove
Barnegat
Jenkins
Glassboro
Williamstown
Woodstown
BRENDAN
T. BYRNE
ST. FOR.

Appendix A: Glossary of Acronyms and Definitions

Acronyms

AADT – Annual Average Daily Traffic
AASHTO – American Association of State Highway and Transportation Officials
BIL – Bipartisan Infrastructure Law (see IIJA)
BMS – Bridge Management System
BRBC – Binder Rich Base Course
BRIC – Binder Rich Intermediate Course
BrM – AASHTOWare Bridge Management software
CFR – Code of Federal Regulations
CY – Collection Year
DSS – Decision Support System (New Jersey Turnpike Authority)
dTIMS – Deighton's Total Infrastructure Management System
EADD – Engineering and Architectural Design Division (PANYNJ)
FAST – Fixing America's Surface Transportation
FEMA – Federal Emergency Management Agency
FHWA – Federal Highway Administration
FY – Fiscal Year
GIS – Geographic Information System
GSP – Garden State Parkway
HMA – Hot Mix Asphalt
HPMS – Highway Performance Monitoring System
IRI – International Roughness Index
IIJA – Infrastructure Investment and Jobs Act
ISO – International Standards Organization
M&R – Mill and Resurface
MAP-21 – Moving Ahead for Progress in the 21st Century
ME – Mechanical Empirical [Pavement Software]
MPO – Metropolitan Planning Organization
NBI – National Bridge Inventory
NBIS – National Bridge Inspection Standard
NCHRP – National Cooperative Highway Research Program
NEPA – National Environmental Policy Act
NHPP – National Highway Performance Program
NHS – National Highway System
NJDEP – New Jersey Department of Environmental Protection (also "DEP")
NJDOT – New Jersey Department of Transportation
NJTA – New Jersey Turnpike Authority
OMWP – Operating Major Works Program (PANYNJ)
PANYNJ – Port Authority of New York and New Jersey
PDMT – Pavement & Drainage Management and Technology
PIRF – Project Initiation Request Form (PANYNJ)
PMS – Pavement Management System
QAD – Quality Assurance Division (PANYNJ)
SDI – Surface Distress Index
SEBM – Structural Evaluation and Bridge Management
SHS – State Highway System
SJTA – South Jersey Transportation Authority
SMA – Stone Matrix Asphalt
SME – Subject Matter Expert
SOGR – State of Good Repair
STIP – Statewide Transportation Improvement Program
TAMP – Transportation Asset Management Plan
TB&T – Tunnels, Bridges and Terminals (Port Authority of New York and New Jersey)
TOSS – Transportation Operations Systems and Support
TRB – Transportation Research Board
TTF – Transportation Trust Fund
TTFA – Transportation Trust Fund Authority
USC – United States Code

Definitions

The primary sources of information for this glossary are the AASHTO Transportation Asset Management Guide: A Focus on Implementation (AASHTO 2011), and the Code of Federal Regulations, Title 23, Chapter I, Subchapter F, Part 515.5.

Asset – All physical highway infrastructure located within the right-of-way corridor of a highway. The term asset includes all components necessary for the operation of a highway including pavements, highway bridges, tunnels, signs, ancillary structures, and other physical components of a highway.

Asset Class – Assets with the same characteristics and function (e.g., bridges, culverts, tunnels, pavements, or guardrail) that are a subset of a group or collection of assets that serve a common function (e.g., roadway system, safety, Intelligent Transportation (IT), signs, or lighting).

Asset Criticality – The importance of an asset and the level of risk that it may be exposed to.

Asset Management (AM) – The strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life cycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well-defined objectives.

Asset Management Plan – A document that describes how a State DOT will carry out asset management, including how the State DOT will make risk-based decisions from a long-term assessment of the National Highway System (NHS), and other public roads included in the plan at the option of the State DOT, as it relates to managing its physical assets and laying out a set of investment strategies to address the condition and system performance gaps.

Baseline Condition – The initial condition of an asset at the start of an analysis period.

Capital Investment – Funds used by an agency to purchase assets, which generate revenue or value over the course of time.

Critical Infrastructure – Facilities of great importance, such that if they were to fail or be incapacitated, would have a debilitating impact on national or regional economic security, national or regional energy security, national or regional public health or safety, or any combination of those matters.

Condition – An indication of the physical state of the asset, which may or may not affect its performance.

Core Missions – NJDOT's mission has been broken up into five Core Missions. Performance data and expenditures are tied to the Core Missions: Infrastructure Preservation, Safety, Operations and Maintenance, Mobility and Congestion Relief, and Mass Transit.

Department of Transportation (DOT) – The agencies responsible for owning, maintaining, and improving transportation systems.

Depreciation – An expression of the consumption of the economic value of the asset through use. The value, capacity, or capability of the asset that is lost this way is restored through periodic replacement or reconstruction.

Deterioration Model – A model used to predict future asset condition and to estimate funding requirements.

Enhancement – When used in reference to the TAMP, an enhancement is defined as a significant modification or improvement that substantially changes a business practice or process, thus requiring an action plan and recertification upon implementation of the enhancement.

Extreme Weather – While dependent on the exact context, generally, this refers to weather events occurring outside of typical thresholds (i.e., related to occurrence or magnitude).

Financial Plan – A long-term plan spanning 10 years or longer, presenting a State DOT's estimates of projected available financial resources and predicted expenditures in major asset categories that can be used to achieve State DOT targets for asset condition during the plan period, and highlighting how resources are expected to be allocated based on asset strategies, needs, shortfalls, and agency policies.

Gap Analysis – The area of deviation between the current and desired states, which can be used to determine the areas of TAM that require improvement.

Inventory – Provides a data infrastructure to tie together the various data sets required for a comprehensive, mature asset management process. Additionally, the term can also apply to the identification and classification of the assets owned or maintained by an organization.

Investment Strategy – A set of strategies that result from evaluating various levels of funding to achieve State DOT targets for asset condition and system performance effectiveness at a minimum practicable cost while managing risks.

Level of Service (LOS) – Classifications or standards that describe the quality of service offered to road users, usually by specific facilities or services against which service performance can be measured.

Life Cycle – The phases of the life of an asset, which are planning, design, construction, operations, and disposal.

Life Cycle Cost – All the costs that an agency incurs in managing assets from the creation of the asset to its ultimate disposal.

Life Cycle Planning – A process to estimate the cost of managing an asset class, or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition.

Minimum Practicable Cost – The lowest feasible cost to achieve the objective.

Mobility – The ability of people of all ages and abilities to move from one place to another.

National Highway System – The National Highway System (NHS) is a network of strategic highways within the United States, including the interstate highway system and other roads serving major airports, ports, rail or truck terminals, railway stations, pipeline terminals, and other strategic transport facilities.

Performance – The ability of an asset to provide the required level of service.

Performance Gap – The difference between the desired performance and the current or projected performance.

Performance Measure – Quantifies how well the agency is accomplishing its strategic goals and objectives as described in the TAM.

Periodic Maintenance – Activities that are done at a regular frequency to help preserve the inherent levels of service of an asset, including reliability and safety, at minimum cost.

Planned Maintenance – Activities that are planned and not done as a response to an event. Planned maintenance processes include condition monitoring, periodic maintenance, and preventive maintenance.

Preservation Activities – Actions or strategies that prevent, delay or reduce deterioration of assets, restore the function of assets, keep assets in good condition and extend their useful life.

Preventive Maintenance – Activities that are regularly performed on an asset to lessen the likelihood of it failing. It is performed while the asset is still in acceptable condition so that it does not deteriorate unexpectedly.

Prioritization – The process of arranging work or maintenance to be done for assets in order of relative importance.

Reactive Maintenance – Activities that are done to maintain the level of service of an asset as a response to an event, such as emergency repair, routine maintenance, and corrective action.

Reconstruction – The process of rebuilding an asset after it has reached a condition where otherwise less extensive treatments would not be enough to restore it to a desired condition.

Rehabilitation – A type of corrective action that is done to restore the original condition of an asset.

Reliability – The standard deviation of origin-destination travel time.

Repair – Maintenance work that is done on an asset to improve the condition to acceptable levels.

Replacement – A type of corrective action that is done to renew an asset by completely replacing it with a new asset.

Resilience – The capacity to recover quickly from shocks and events.

Resurfacing – The process of installing a new layer of asphalt over the existing pavement, also known as an overlay.

Risk (of an asset) – The threat to transportation operations caused by extreme events, other external hazards, and from asset failure arising from any cause. Some examples of causes of asset failure are poor condition, unexpected loading, or poor work practices.

Risk Identification – The process of documenting and categorizing risks by considering its likelihood and consequences.

Risk Assessment – The process of evaluating risks that involves determining the likelihood of an extreme event occurring, the consequences to the asset if the event were to occur, and the effect on mission, life, property, and the environment of the damage to the asset or loss of function caused by the extreme event.

Risk Management – The process of identifying sources of risk, evaluating them, and integrating mitigation actions and strategies into routine business functions of the agency.

Risk Prioritization – The process of creating a list that determines the order for addressing risks, based on their potential negative impact to the agency's performance objectives.

Risk Treatment – How the agency plans to address the identified risks. This may be done through its operational program, asset preservation program, or the addition of new investments.

Risk Monitoring – Systems that are used to keep track of identified risks, residual risks, and new risks. It also monitors the execution of planned strategies for the already identified risks and evaluates their effectiveness.

Routine Maintenance – A type of reactive maintenance that is done at fixed intervals.

State Highway System (SHS) – A network of roadways and roadway assets owned and maintained by the State Department of Transportation.

State of Good Repair (SOGR) – A targeted condition state for assets, typically within an asset management program, that is designed to help an organization maximize its use of resources to pursue the condition state given a set of planning processes.

Statewide Transportation Improvement Program (STIP) – A statewide prioritized listing/program of transportation projects covering a period of four years that is consistent with the long-range statewide transportation plan, metropolitan transportation plans, and TIPS.

Strategic – The highest level of goals or objectives in an agency that affect the entire agency.

Tactical – The actions aimed at achieving a specific goal within an agency.

Targets – Predicted performance outcomes for specific measures that are typically synonymous with the goals and objectives of the TAMP.

Treatment – <See "Preservation Activities">

Utility – Establishes a unit-less common scale for each performance measure and then combines them.

Work Type – Classification of asset treatments defined by FHWA which include initial (new) construction, maintenance, preservation, rehabilitation, and reconstruction.

Appendix B: NHS Owner Outreach

This appendix summarizes the results of the outreach program undertaken by NJDOT for the New Jersey TAMP to verify inventory and condition data, and related expenditures for NHS pavement and NBIS bridge assets not owned or maintained by NJDOT. As described in *Chapter 3: TAMP Governance, Policy, and Objectives* the TAMP process conducts a data collection program to ensure the use of accurate data in its analyses. The actions and data requested from each non-NJDOT NHS owner include:

- ***Verification of Inventory:*** Review and confirmation of the accuracy of NJDOT-provided maps and data relating to the inventory of non-NJDOT NHS pavement and NBIS bridge assets, including roadway segment and bridge identifying information.
- ***Collection of Data:*** Review and/or provision of information relating to past project work, planned expenditures, and expected asset condition trends (for some owners) for non-NJDOT NHS pavement and NBIS bridge assets.

NHS Pavements

Outreach for NHS pavement data collection and verification involved 17 counties, 8 authorities/commissions, and 11 of the 54 municipalities that have responsibility for part of the NHS, as well as NJDOT's internal departments that provided data and verification for NJDOT-owned and/or maintained assets. In sum, a total of 36 out of 84 owners were contacted which represents approximately 12,177 out of 12,245 lane miles (99.5%) on the NHS. NJDOT will continue to work on improving data collection efforts to obtain best available data from the municipalities not contacted as part of the New Jersey TAMP. The results are further described in Exhibits B-1. Ultimately, data was collected and verified for approximately 89.4 percent of NHS pavements.

NHS NBIS Bridges

Outreach for NHS NBIS bridge data collection and verification involved 18 counties 8 authorities/commissions, and 1 municipality with responsibility for part of the NHS, as well as NJDOT internal departments that provided data and verification for NJDOT-owned and/or maintained assets (Note: NJ Transit and private entities were not contacted; instead, data from the NBIS database was utilized). In sum, 28 out of 30 owners were contacted which represents approximately 62,557,166 out of 62,630,377 square feet of deck area (99.9%) on the NHS. The results are further described in Exhibits B-2. Ultimately, data was collected and verified for approximately 96.8 percent of NHS NBIS bridges.

Exhibit B-1: NHS Pavement TAMP Data Collection Summary

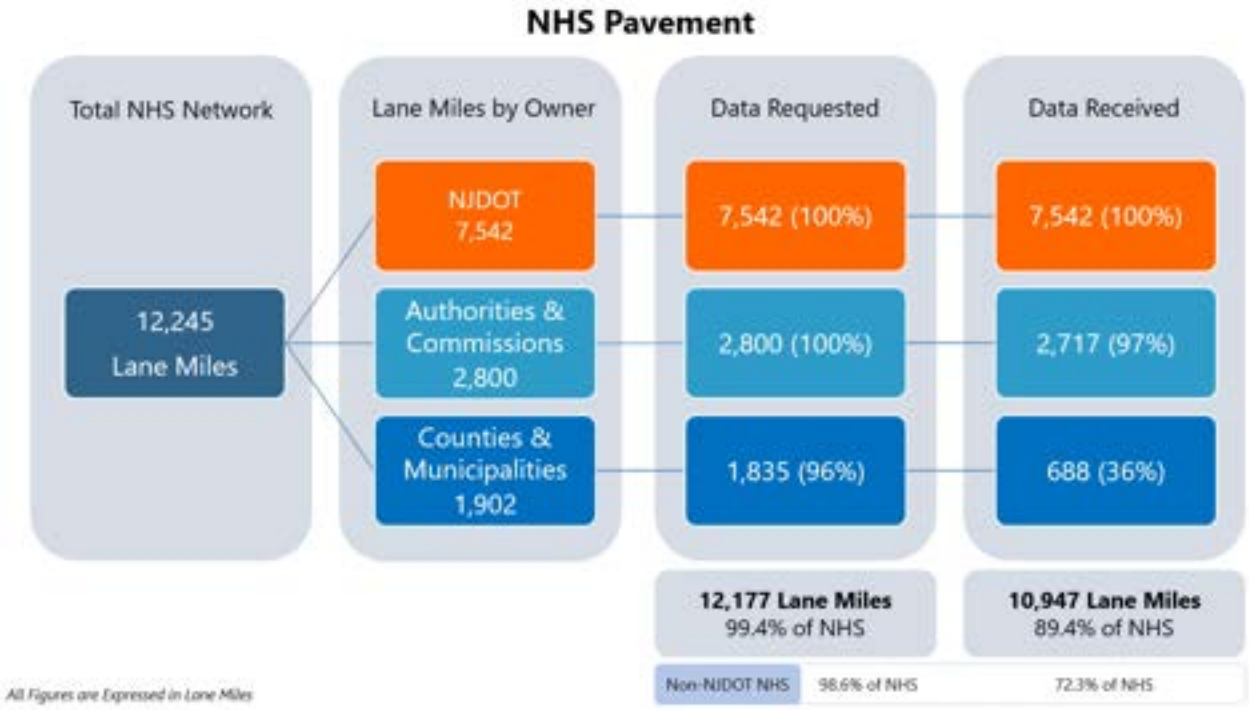
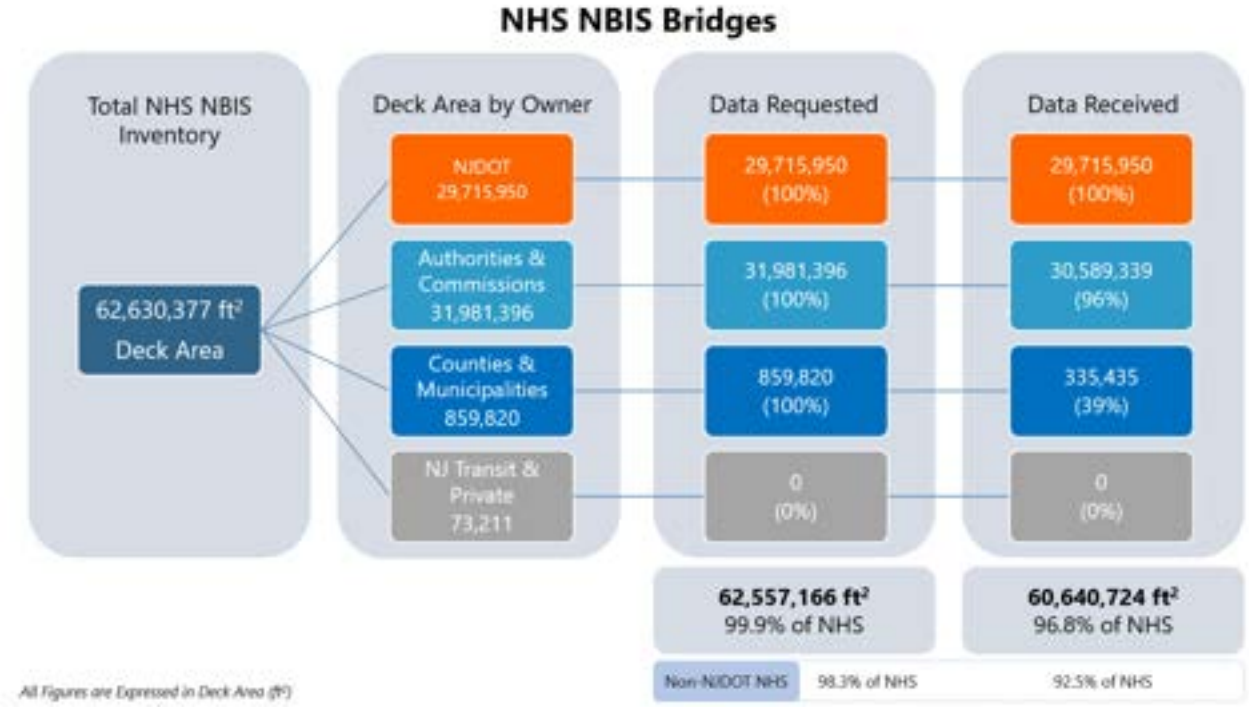


Exhibit B-2: NHS NBIS Bridge TAMP Data Collection Summary



Appendix C: NHS Pavement Gap Analysis Technical Approach

This appendix describes the process for forecasting the conditions of interstate and non-interstate National Highway System (NHS) pavements in terms of the National Highway Performance Measures, as described in *Chapter 2: Asset Inventory, Performance Measures, and Baseline Conditions*, using output from the NJDOT pavement management system.

To support target setting as required by the Performance Management Rule and performance gap analysis as required by the Asset Management Rule, NJDOT needs to forecast pavement conditions in terms of the metrics and measures defined in 23 CFR 490 Subpart C. For this reason, the following methodology was developed and used to estimate future NHS pavement conditions in terms of the NHPP measures to support two- and four-year target setting and gap analysis.

The procedures for forecasting conditions in terms of the NHPP measures are as follows:

1. NJDOT uses the pavement management database to compile an initial pavement condition data set based on condition data collected in CY's 2018, 2019, 2020, and 2021. This data set includes the NJDOT-owned and/or maintained pavements, as well as those on the Atlantic City Expressway and Palisades Interstate Parkway and includes the following data elements for each segment of pavement:
    a. NJDOT's Condition Status (Percent *Good/Fair/Poor*).
    b. International Roughness Index.
    c. Rutting
    d. Wheel Path Cracking
    e. Slab Cracking
    f. Joint Faulting

2. The data set is analyzed to determine the relationship between the NJDOT Condition Status rating of *Good/Fair/Poor*, and the NHPP measures of *Good/Fair/Poor* to determine the best means of correlating the measures.

3. A determination is made as to the statistical correlation between the measures. Exhibit C-1 shows factors used to correlate NJDOT's Condition Status to the NHPP measures in the TAMP.

Exhibit C-1: Conversion of NJDOT's Condition Status to NHPP Measures

NHPP Measure Rating	Condition Status Rating		
	Good	**Fair**	**Poor**
Good	0.89	0.24	0.06
Fair	0.11	0.76	0.86
Poor	0.00	0.00	0.08

These conversion factors provide a statistically valid correlation between the system-wide average of NJDOT's Condition Status (CS) and the system-wide average of the NHPP measures on the state-maintained system.

4. The above analysis is performed for pavement segments contained in the pavement management system and applied to outputs from the pavement management system. As described in *Chapter 4: Performance Gap Analysis*, the pavement management system only includes pavements owned and/or maintained by

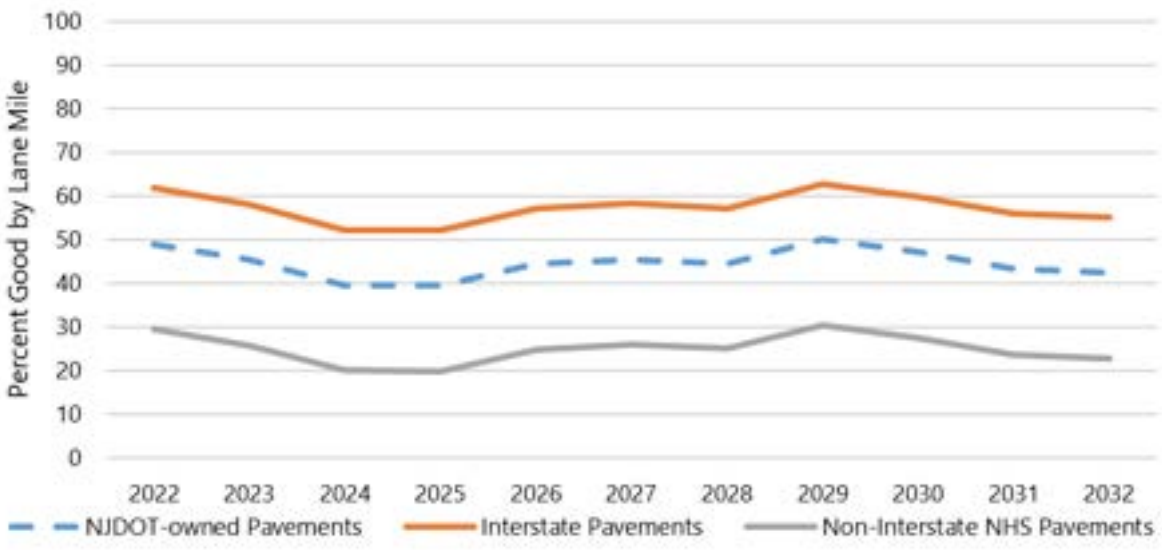
NJDOT and does not contain the entire NHS. As a result, the initial year of any prediction scenarios will not align with baseline NHS conditions, (i.e., SHS is not in the same condition as the NHS). To account for this and allow the pavement management system data to be used to estimate the condition of the NHS, the converted data must be aligned to the base year conditions for interstate and non-interstate NHS pavements. Exhibit C-2 shows the SHS-to-NHS correction factors.

Exhibit C-2: Correction Factors to Correlate NJDOT Pavement Performance with NHS Pavement Performance

Rating	Calculated NHPP Measure (SHS)	Baseline NJ Interstate NHPP Measure	Interstate Correction Factor	Baseline Non-interstate NHS NHPP Measure	Non-Interstate NHS Correction Factor
Good	45.78	75.70	29.92	41.60	-4.18
Fair	52.56	24.2	-28.36	53.60	1.04
Poor	1.65	0.10	-1.55	4.80	3.15

The correction factors, calculated on the baseline year, are added to each year of the analysis scenarios, resulting in a shifting of each predicted performance curve along the Y-axis, while preserving the shape of the performance curves in subsequent years of the analysis. Exhibit C-3 shows how the results of converting NJDOT's Condition Status percent Good to NHPP measure percent Good for Interstate and non-Interstate pavements are from a single analysis run.

Exhibit C-3: Conversion of NJDOT's Condition Status to NHPP Measures



5. For years beyond the base year, a final adjustment must be made to account for differences in the expected performance of interstate and non-interstate NHS pavements based on the investment strategies of different system owners. To support this adjustment NJDOT made the following assumptions. Exhibit C-4 shows the breakdown of the interstate and non-interstate NHS pavement inventory used for this adjustment of forecast conditions.

    - Because NJDOT does not prioritize or select pavement projects based on functional class the future performance of the NHS (interstate and non-interstate) will be the same as the performance of the SHS relative to baseline conditions.

- Investment on the non-NJDOT-owned NHS will largely follow historic trends. This is supported by *Chapter 7: Financial Plan*.
- Because the STIP indicates that NJDOT, and local owners (counties and municipalities) are largely reliant on federal aid, for preserving and improving interstate and non-interstate pavement conditions, these pavements will trend the same regardless of ownership, i.e., if NJDOT-owned pavement conditions are expected to improve from the baseline, local-owned NHS conditions will have a similar improvement.
- Because the of the current conditions, life cycle strategies, and financial resources of the New Jersey Turnpike Authority and South Jersey Transportation Authority, the performance of their pavements are expected to remain constant over the analysis period.

Exhibit C-4: Breakdown of NHS Pavements by Anticipated Performance

Owner	Interstate (Lane Miles)	Non-Interstate NHS (Lane Miles)
NJDOT & Local Owners	1,974	7,470
Authorities	1,009	1,790
Total	2,983	9,260
Percentage[1]	66.15%	80.66%

[1] Defined as the percentage of each network that we assume will perform the way NJDOT pavements will behave. Calculated as: [1,974 ÷ 2,983 = 0.6615] and [7,470 ÷ 9,260 = 0.8066]

Appendix D: Supplemental Bridge Management Information

This appendix contains additional information related to the bridge management system and process as a supplement to the content covered in the 2022 New Jersey TAMP report body. The appendix is divided into three principal sections including a review of innovative uses of materials and designs, a detailed overview of NJDOT's configuration of its bridge management software, and the inclusion of the goals and activities outlined for NJDOT's bridge management system under the 2021-2022 State Planning and Research Program.

D.1 Innovative Uses of Materials and Designs

The following sections provide a review of how the use of new materials and designs can support existing processes and augment the improvements and enhancements to bridge life cycle planning covered in *Chapter 5: Life Cycle Planning*.

Use of Improved Materials and Systems

Another strategy for improving the lifecycle of bridges is the use of improved materials and systems that are more durable, easier to install, reduce maintenance costs, and extend the useful life of the structure. NJDOT is currently identifying these material applications. Once identified, they will be added to the set of potential treatments with expected impact on future deterioration to be incorporated through a definition of action and benefit in the configuration of BrM. NJDOT continually reviews new materials and systems for potential addition to the list of treatments in BrM. A treatment is added to BrM by determining its benefit it terms of change in deterioration and the treatment's unit cost.

Examples of improved materials and systems include:

- ***Precast Concrete*** – Precast is increasingly common among the bridge industry and virtually every concrete component of a bridge can be built. Precast deck slabs, pre-fabricated superstructure units, girders, piers caps, arches, substructure units, moment slabs, approach slabs, etc. can be shipping and erected in the field within days with no curing wait time necessary. Precast pre-stressed concrete can be integrated with post-tensioned or pre-tensioned strands to increase the concrete capacity.

- ***Galvanized Steel Girders, Railings, and Rebars*** – To increase the durability of key structural components and prevent corrosion, NJDOT has employed hot dip galvanizing on steel girders, reinforcing bars, and metal railings (see Exhibits D.1-1 and D.1-2). While the steel is in the dipping kettle, the iron in the steel metallurgically reacts with the molten zinc to form a tightly-bonded alloy coating that provides superior corrosion protection to steel. The initial cost of this coating is greater than traditional painting for girders or epoxy-coating for rebar; however, the hot-dip galvanizing offers superior protection and results in an extended service life.

Exhibit D.1-1: Galvanized Reinforcing Bars – NJ Route 139

Source: Gannett Fleming Photo - NJ Route 139 Reconstruction.

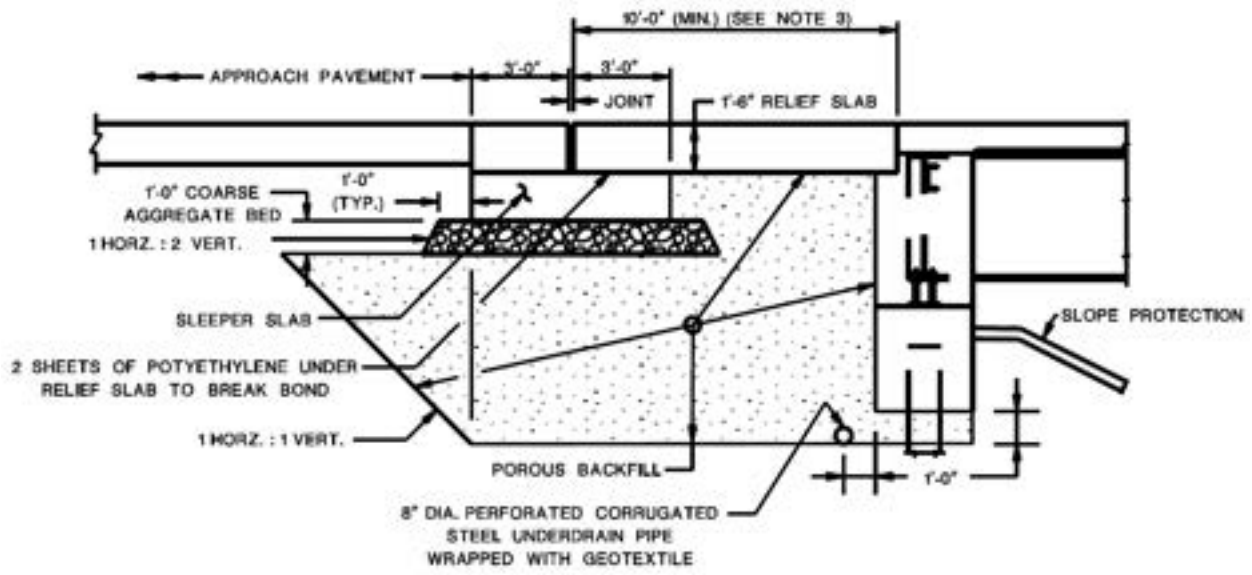
Exhibit D.1-2: Galvanized Steel Girders with Painted Overcoat (Except at faying surfaces of the connections) – NJ Route 139

Source: Gannett Fleming Photo - NJ Route 139 Reconstruction.

Adopt Better Design Details

NJDOT regularly updates its design details to extend the service life of bridges and reduce lifecycle costs. Such design details include moving joints away from bridge decks using integral abutments (Exhibit D.1-3), eliminating joints by using continuous superstructures, and introducing scour cut off walls.

Exhibit D.1-3: Integral Abutment Detail from NJDOT Standard Drawing Plate 2.5-5



Source: NJDOT Design Manual for Bridges and Structures, 6th Edition, 2016.

Incorporate Innovative Technologies

NJDOT is investing in new technologies to perform inspections more efficiently and thereby identify distresses at earlier stages of deterioration. The efforts result in the implementation of preservation measures improving the service life of bridges before significant deterioration has occurred. These methods include the use of unmanned aerial vehicles (drones) for the inspection of inaccessible areas of bridges and the use LIDAR (Light Detection and Ranging, a scanning survey technique) to map out and measure the clearances around structures and subsurface cracking. Other technologies include advanced non-destructive evaluation (NDE) techniques such as RABIT. the Robotics Assisted Bridge Inspection Tool, which includes Ground Penetrating Radar (GPR), Ultrasonic, Impact Echo, Resistivity, and High Definition Imaging applications to determine the deterioration of bridge elements before they have reached the state of advanced deterioration. Exhibit D.1-4 illustrates some non-destructive evaluation tools.

The NJDOT Bridge Resource Program investigates and implements innovative technologies. The Bridge Resource Program utilizes the extensive NJDOT laboratory and field-testing equipment and bridge engineering staff expertise to assist NJDOT. The Division of Bridge Engineering and Infrastructure Management develops: (1) lifecycle planning strategies, (2) innovative materials, (3) improved bridge design tools, (4) advanced laboratory and field data collection, (5) bridge monitoring strategies, (6) bridge inspection, (7) non-destructive evaluation, and (8) innovative technologies/equipment that enhance the conditions of NJDOT bridges by allocating available capital resources to bridges in a targeted and efficient manner.

Exhibit D.1-4: State of the Art Bridge Deck Evaluation Tools

Source: Use of Robotics in Nondestructive Evaluation and Minimally Invasive Rehabilitation of Bridge Decks, Nenad Gucunski, Rutgers University Center for Advanced Infrastructure and Transportation (CAIT).

Every Day Counts (EDC)-6 Innovation – Ultra-High Performance Concrete

NJDOT has been a leader in bridge preservation and repair nationally and participated in the FHWA Every Day Counts (EDC)-6 Ultra-High Performance Concrete (UHPC) initiative for preservation and repair projects as a participating state in the use of more durable concrete to improve life cycle cost performance and ensure bridges remain in a state of good repair. UHPC is a fiber-reinforced, cementitious composite material with mechanical and durability properties that exceed those of conventional concrete materials. Bridge preservation and repair projects are a new application of UHPC that result in a reduced need for maintenance than applications of conventional methods. A few examples of UHPC preservation and repair applications include bridge deck overlays, girder end repairs, expansion join repairs, prefabricated bridge element construction joint repairs, and column or pile jacketing. In New Jersey, UHPC projects have consisted of bridge deck overlays and connections between prefabricated elements. For more information, please visit the following websites:

- https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/uhpc_bridge_preservation.cfm
- https://highways.dot.gov/research/structures/ultra-high-performance-concrete/deployments

D.2 Supplementary Information on AASHTOWare Bridge Management Software (BrM)

Overview

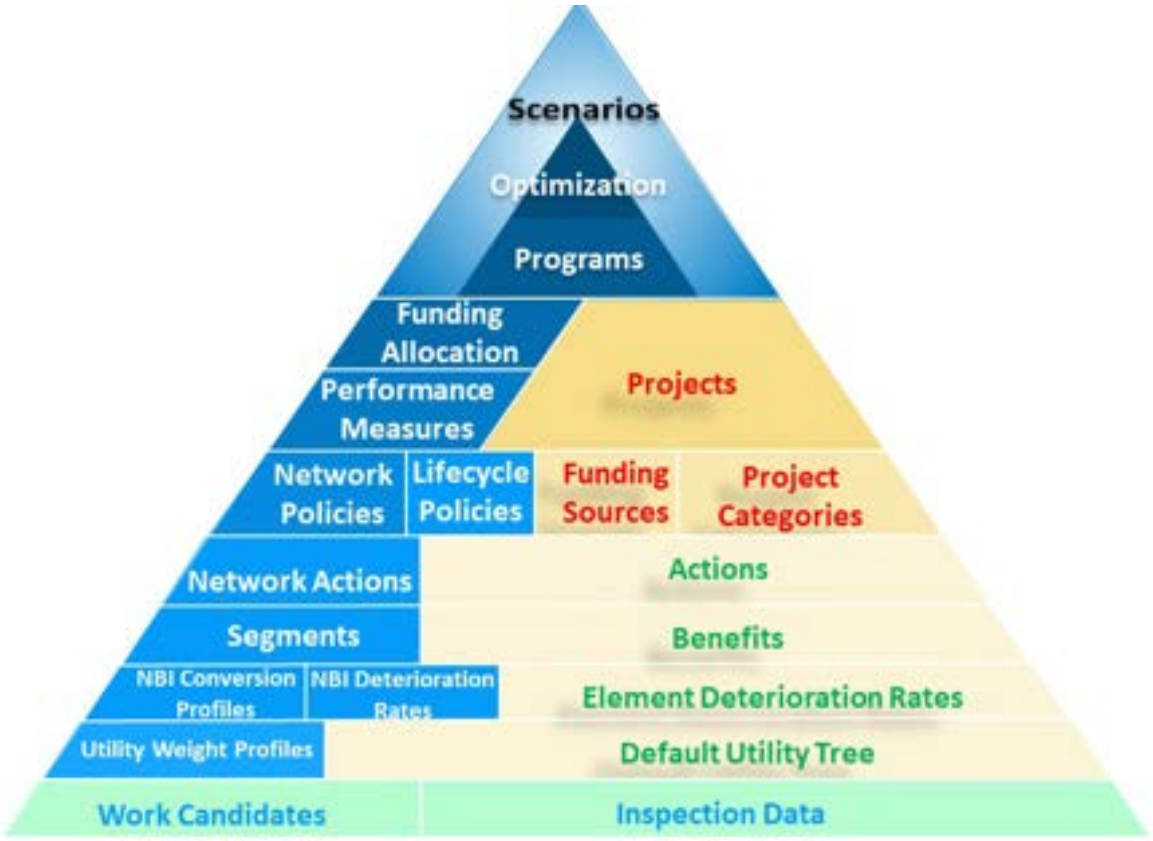
AASHTOWare Bridge Management (BrM) is a comprehensive bridge management system originally developed in 1989 (as Pontis) for the Federal Highway Administration (FHWA). The software is licensed through the American Association of State Highway and Transportation Officials (AASHTO) to over 50 State Departments of Transportation and other agencies. According to the BrM user manual, BrM specializes in:

- Allocating scarce resources to protect infrastructure investments, ensuring safety and maintaining mobility.
- Storing inventory and inspection information about an agency's bridges and other structures.
- Supplying a rich set of modeling and analysis tools to support project development, budgeting, and program development.
- Formulating network-wide preservation and improvement policies for evaluation of each structure in a network, making recommendations for the projects an agency should include in their capital plan.
- Providing the capability to analyze the impact of different project alternatives on the performance of individual structures or of an entire network of structures.
- Defining and scheduling projects for individual structures or for groups of structures.

The BrM 6 software pyramid presented in Exhibit D.2-1 displays the various modules that make up the software system. Select modules are described below, beginning with the base and working upwards. While more detailed than the description presented in *Chapter 5: Life Cycle Planning*, the description presented here is greatly simplified. The discussion below is focused on the optimization functionalities of BrM. BrM also supports storage of bridge inventory and inspection information, work records, and storage and retrieval of inspection information for tunnels, bridges, sign structures, and high mast light poles.

The Bureau of Structural Evaluation and Bridge Management (SEBM) licenses the latest releases of AASHTOWare BrM. BrM is set up to use (1) AASHTO elements inspection condition data *and/or* (2)NBI general condition ratings in deterioration modeling, action trigger rules, action effects (benefits) modeling, and utility scoring. SEBM has begun transitioning to greater emphasis on the AASHTO element condition data in all of these configuration choices.

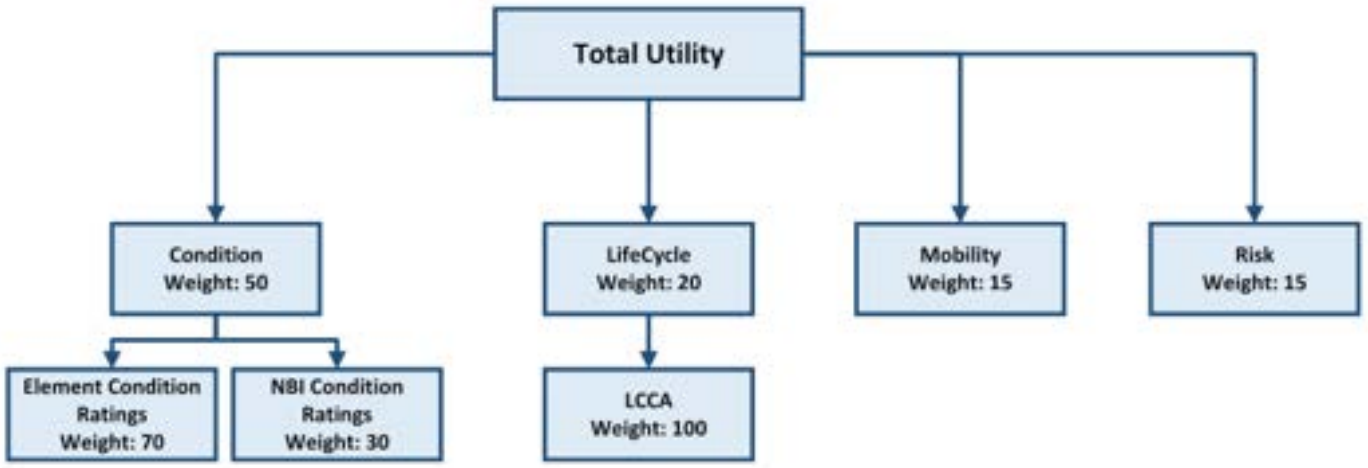
Exhibit D.2-1: AASHTOWare BrM 6.0 Pyramid



BrM Optimizer – The Utility Score

BrM 6 can be used to perform constrained optimization to recommend a set of bridge projects that maximize utility subject to a funding constraint. The utility score is the heart of this BrM optimization function. The BrM utility score can incorporate four objectives (criteria): (1) bridge condition, (2) life cycle cost, (3) mobility, and (4) risk. For each bridge work candidate, BrM calculates a score for each of the four criteria. Default Utility Tree refers to the default scheme through which a set of weights is used to compile various utility criteria scores into a single utility score. A utility score ranges from 1 to 100 and is assigned to each bridge. A utility tree (or function) is made up of four criteria: condition, life cycle cost, mobility, and risk. Exhibit D.2-2 presents an example utility tree with various Utility Weight Profiles. BrM executes an optimization algorithm that considers, for each year, all the possible work candidates and associated utility scores for each bridge and selects the work candidates that maximize the utility score within the funding constraint. This is done for each year of the TAMP analysis period.

Exhibit D.2-2: Utility Tree with Example Weight Profiles



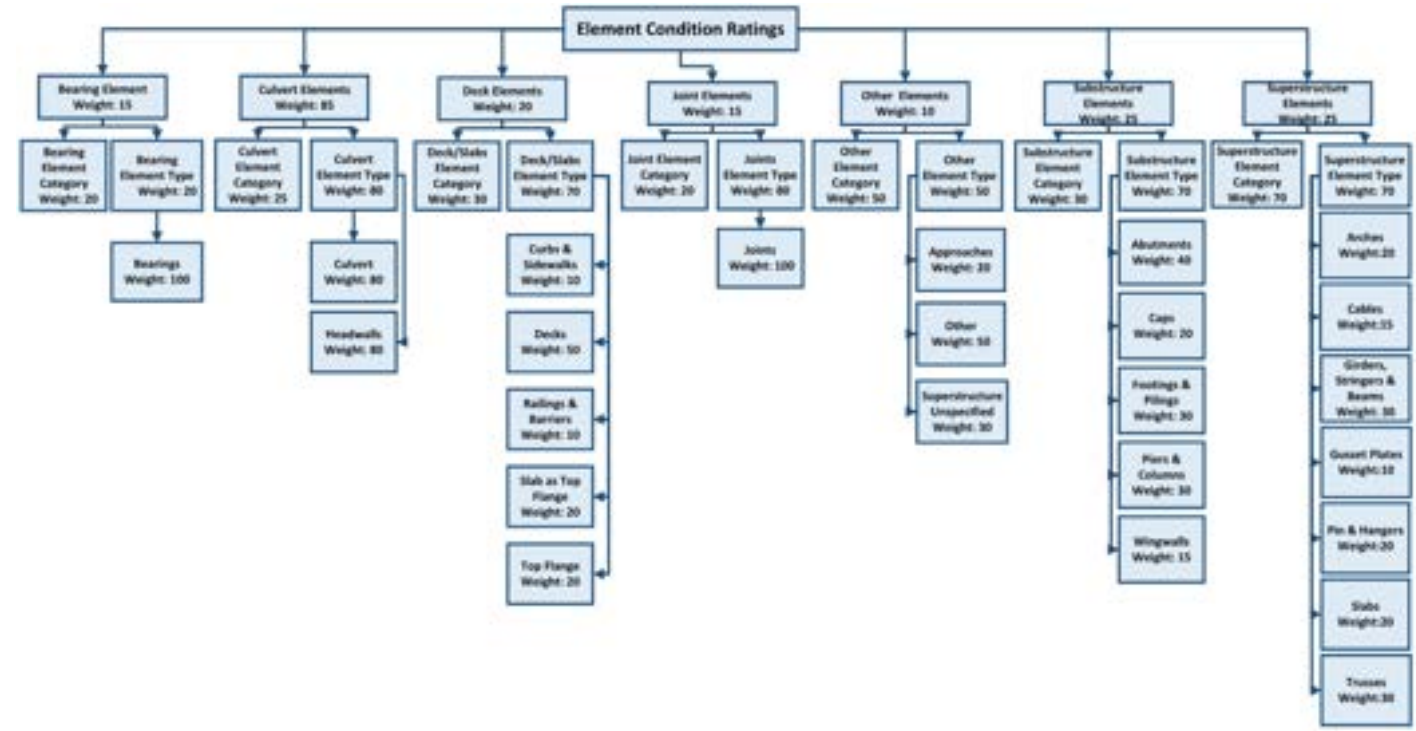
Source: NJDOT Bureau of Structural Evaluation and Bridge Management.

Exhibit D.2-2 shows a Utility Weight Profile in which the condition objective is given the highest weighting (50 out of 100 weighting points).

Detailed branches for each node (condition, life cycle, mobility, and risk) are presented in Exhibits D.2-3 through D-6.

The bridge **condition** score in this profile is a composite of the bridge "Element Ratings" (expressed as a health index) and the bridge components' National Bridge Inventory ratings. Bridge inspectors rate each bridge element (concrete deck, metal railing, steel girder, concrete column, etc.) in terms of the percentage of the element that is in each of four progressively worse Condition States (CS) from CS1 to CS4. The health index is a composite of the condition state percentages that expresses the element health on a scale from 1 to 100.

Exhibit D.2-3: Utility Tree Condition Nodes with Example Weights



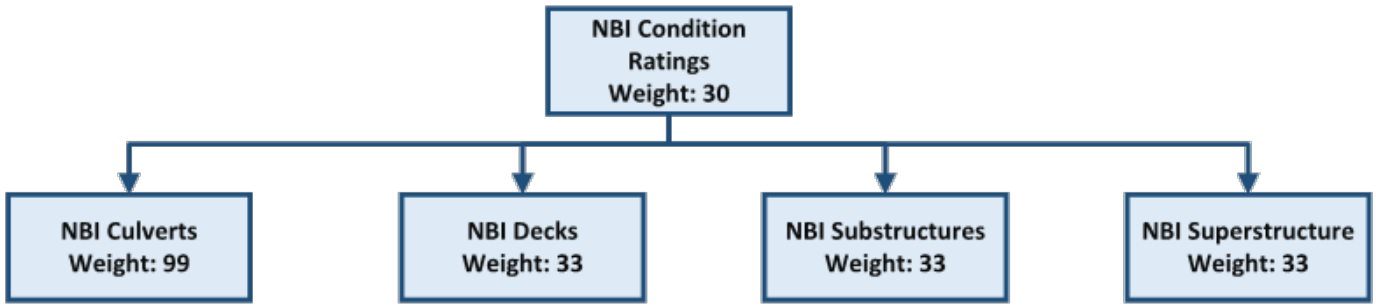


Exhibit D.2-4: Utility Tree Life Cycle Node

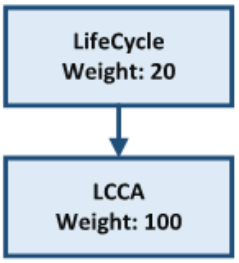


Exhibit D.2-5: Utility Tree Mobility Node with Example Weights

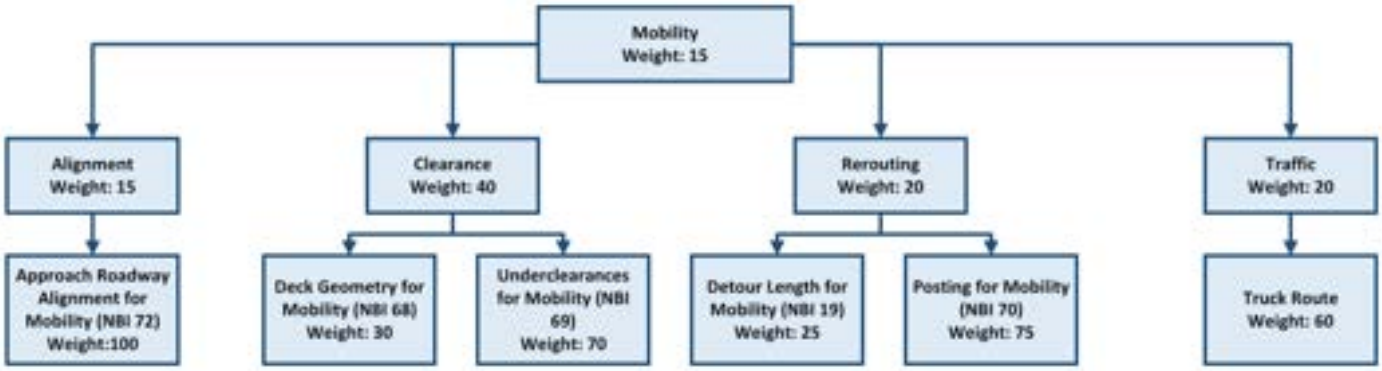


Exhibit D.2-6: Utility Tree Risk Node with Example Weights

Source: Bureau of Structural Evaluation and Bridge Management.

The **life cycle cost** score is calculated from the future stream of costs (the life cycle costs) associated with the actions being evaluated. The life cycle cost score is calculated with the following formula:

$$\left(1 - \left(\frac{Short\ Term\ Costs + Long\ Term\ Costs - Residual\ Value}{(2 \times Replacement\ Cost)}\right)\right) \times 100$$

The formula for the life cycle cost score gives a higher score to an action/bundle of actions that lowers the life cycle costs. The life cycle cost scoring uses the life cycle policies input by the user (described below). The life cycle policies are the "trigger rules" that state which treatments will be implemented under which conditions. These rules are applied over the specified period for life cycle analysis, typically some number between 50 and 75 years. The short term costs are those of the action/bundle of actions being scored. The long-term cost is the presented discounted value of the stream of costs of the actions taken over the long term analysis period as specified by the life cycle polices.

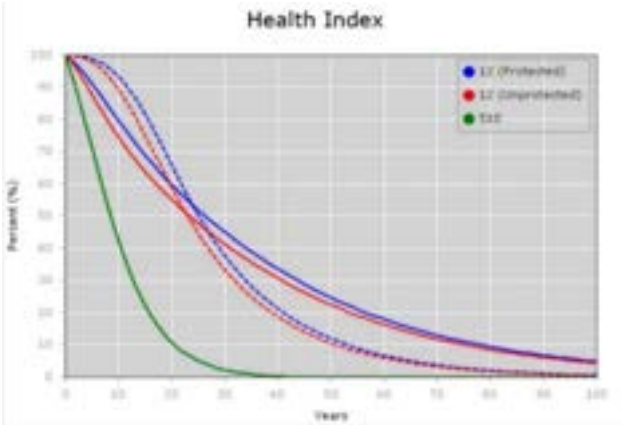
The **mobility** objective considers characteristics of the bridge that have implications for the mobility of travelers on or under the bridge. The existence of mobility restrictions lowers the score and treatments that remove an existing restriction raise the mobility score.

The **risk** objective includes several characteristics related to risk including scour critical status, vehicle collision risk, flood risks, and structural fatigue risks, among others. The lower the risk characteristics, the higher the risk score in the utility function. Treatments that lower risk will elevate the utility score for the bridge.

Deterioration Modeling

BrM projects the future health of bridge elements using probabilistic deterioration models. NJDOT's deterioration model parameters were established using expert elicitation. The NJDOT BrM model includes Element Deterioration Rates, NBI Component Deterioration Rates, and NBI Conversion Profiles that convert element ratings to NBI component ratings. on the component rating scale of one to nine. An illustrative set of deterioration curves is shown in Exhibit D.2-7. The graph shows alternative deterioration curves for Element 12 (reinforced concrete deck) with or without protective systems (Element 510) in place. Both the red (unprotected) and blue (with protective systems) lines show a decline in the health index over time, with the blue lines declining more slowly than the red lines. The solid versus dashed lines reflect different assumptions for the deterioration model parameters. The dashed lines represent a model in which the probability of deterioration from CS1 (*Good* condition) increases with the time spent in that condition. The solid lines represent a model in which there is no time component to the probability of deterioration. The green line charts the deterioration in Element 510, the protective system. As the protective system deteriorates, the difference between the protected (blue) and unprotected (red) curves narrows.

Exhibit D.2-7: Deterioration Curve for Reinforced Concrete Deck – Element 12



Source: 2018 Bridge Management Peer Exchange - Presentation by NJDOT on Initial Calibration of BrM 5.2.3 for NJDOT Initial TAMP, Bureau of Structural Evaluation and Bridge Management.

Treatments (Actions) and Their Life Cycle Benefits

BrM 6 includes actions and benefits that model the relationships between treatments and their benefits. The benefits are the changes that occur to a structure because of a treatment (action). Benefits are measured as a change in the score of one or more of the utility nodes. The actions which yield these benefits have assigned unit costs that are used in the life cycle cost analysis and in the constrained optimization modeling runs.

For the TAMP, NJDOT has run BrM 6 with the seven actions and unit cost basis presented in Exhibit D.2-8. The unit costs were developed from recorded costs for various work on previous projects in the NJDOT Bid Express System, and inflated to FY 2023 dollars. The unit costs shown are for a conventional NBIS bridge, defined as a non-movable bridge between 2,500 and 25,000 square feet deck area. Movable bridges and other size classes bridges use a multiple of these base unit costs.

Exhibit D.2-8: NJDOT Actions and Unit Costs in BrM 6 for a Conventional National Bridge Inspection Standard (NBIS) Bridge

NJDOT Actions	Unit Cost ($/SF)
Bridge Replace	$2,556
Deck Replace	$511
Superstructure Replace	$882
Bridge Preserve	$206
Deck Rehab	$ 119
Superstructure Rehab	$149
Substructure Rehab	$ 124

Source: Bureau of Structural Evaluation and Bridge Management.
Notes: Includes indirect costs (e.g., mobilization) and certain other costs not directly related to construction.

Network Policies

Within BrM 6, network policies serve as decision trees for actions or combinations of actions, along with the element and/or component conditions under which they would evaluated in the optimizer. Network policies are analogous to "trigger rules" in the NJDOT Pavement Management System. Each analysis year, the bridge's elements/NBI component ratings are deteriorated by one year, and the conditions are compared to the trigger rules for actions in the network policies. As an example, NJDOT's current Superstructure Replacement network policy in BrM is as follows:

> Evaluate the Superstructure Replacement action if:
>
> > Superstructure Category Health Index <= 60
> >
> > AND
> >
> > Substructure Category Health Index >= 65
>
> If Superstructure Replacement is triggered, then also evaluate Substructure Rehabilitation (jointly with the superstructure replacement) if:
>
> > The Substructure Category Health Index is between 65 and 90, inclusive.

For example, if both superstructure replacement and substructure rehabilitation are triggered in an analysis year, the BrM optimizer will calculate a utility score for the bridge for that year, that results from those two actions being taken. This score will be compared to the utility score for No Action and for any actions triggered for that year by any other network policies. Depending on the set of network policies, it can be possible that the optimizer will find more than one set of actions to have been triggered.

The general purpose of network policies is to limit the actions that the program will evaluate each analysis year, to only those that are appropriate for the conditions, rather than leaving the program run every possible action and combination of actions every year. In the superstructure replacement policy example above, BrM will not consider

superstructure replacement if the superstructure's health index is over 60 or if the substructure's health index is less than 65.

Life Cycle Policies

The life cycle policies are used to compute the score for the life cycle criterion of the Utility function. The life cycle policies are also used to conduct life cycle cost analysis in bridge-specific project analysis. The policies are business rules that determine the conditions under which a treatment would be applied. Life cycle policies look very much like network policies. Their uses in BrM differ, and they can have a different degree of detail from network policies. A network policy specifies an action or set of actions that, if triggered in any given year, the BrM will evaluate as an alternative to be evaluated in that year. In contrast, a life cycle policy specifies an action or set of actions that BrM will model as being taken whenever the action's life cycle trigger rules are met.

Programs

A program in BrM is a set of selected BrM specifications that is run in the BrM network optimizer to produce a set of recommended projects. A program is created by selecting the following (a partial list):

- Analysis start and end year.
- Bridge Subdivision (Segment)– a program can be run on a selected subset of the bridge network. There are many possible ways to filter the network: functional class of the road carried, District, NBI condition rating, type or scale of bridge, etc.
- Assigned Network Policies – choosing which policies are assigned is the means of limiting the treatments that BrM optimizer will consider. For example, a program aimed at determining the optimal way to invest a given preservation budget might assign only preservation network policies.
- Utility Weight Profile.
- Annual Funding Allocations for the specified period for life cycle analysis.
- Performance Constraints – targeted levels of Performance Measures such as percent *Poor* by deck area.

The user can then run the created program in the BrM optimizer. When run in utility maximization mode, the BrM optimizer selects projects that maximize utility given a funding allocation. For each bridge and each year, the optimizer will calculate an incremental benefit-cost ratio for each set of actions triggered by the network policies, where the increment in benefit is measured as the difference in utility with the set of actions compared to a "no treatment" alternative. BrM maximizes benefit by selecting projects from highest to lowest benefit-cost ratio until the funding allocation for the year is reached. The benefit cost ratio is scaled by a "structure importance factor". NJDOT's structure importance factor is bridge deck area; i.e., the benefit (change in utility) is multiplied by the bridge deck area. Without this adjustment, smaller bridges would always be selected over larger ones because their lower costs would result in a higher benefit-cost ratio.

Project Analysis ("Projects" in the BrM pyramid graphic)

Besides network optimization, BrM 6 can perform project analysis on individual bridges. For example, BrM can model the life cycle cost effects of a superstructure repair project. It will calculate the life cycle cost of the superstructure repair projects as follows:

- The cost of the repair project.
- Plus, the net present value of the stream of costs of the future projects that will be carried out on the bridge, given that the superstructure repair is undertaken (future projects are determined from the life cycle policies).
- Minus the discounted present value of the bridge's residual value at the end of the specified period for life cycle analysis (typically chosen from 50 to 75 years).

By slowing deterioration and deferring rehabilitation and replacement work further into the future, the candidate project would reduce the present value of that work and increase the residual value of the bridge.

The new analysis functionality added in Release 6.5 performs a "recursive" analysis, in which the action decision tree can branch each year, allowing for an exploration of a very large number of possible time paths of bridge work, to find the time path that yields the lowest net present value of cost. The analysis will follow the action trigger rules in any network and life cycle policies that are input for the analysis.

D.3 Goals and Activities for NJDOT's Bridge Management System in the 2021-2022 State Planning and Research Program

Content included on the following three (3) pages.

ACTIVITY: Bridge Management System – 2207185
MANAGER: Mujahid Khan, Acting Manager
Bureau: Structural Evaluation & Bridge Management

MISSION/OBJECTIVE:

The Department's overall Bridge Management System (BMS) effort directs state investment to maintain the state's bridges, and other transportation structures, in optimal condition at a minimal cost. Improve the Department's Bridge Management System to assist in developing the Statewide Transportation Asset Management Plan (TAMP), the Performance Measures and Target Setting Process (PM2), the State Transportation Improvement Program (STIP), and to enable more pro-active and cost-efficient methods of managing the State's structural assets.

GOALS/ACTIVITES:

1. Improve accuracy and quality, efficiency and timeliness of BMS data collection.
    a. Continue to develop and implement Phase 3 of the NBIS Bridge Inspection Program in CombIS and BrM, expanding the functionality to capture complete bridge inspection information for the largest and most complex NBIS bridges for all owners. This effort will also include State and County owned Minor bridges, and other State owned structural assets such as the Overhead Sign structures and High Mast Light Poles, Tunnels, Dams, and Pedestrian bridges).
        i. Develop and implement Phase 3 of the NBIS Bridge Inspection Reporting for complete inspection reports, field-by-field, for the remaining NBIS bridges within CombIS including underwater inspection reports, interim inspection reports, and possibly mechanical/electrical reports for movable structures, Tunnels, and Pedestrian Bridges.
        ii. Perform the typical cleanup effort needed at the end of any major upgrade to ensure all aspects of the system are functioning properly.
        iii. Continue to add additional fields to CombIS and/or BrM as needed to support the MAP-21 data requirements determined to be necessary for bridges and other structural asset performance measures, and asset management.
    b. Continue to improve the Federal reporting features of the SI&A, Unit Costs, National Bridge Element Data, National Tunnel Inventory Data, and Map-21 Performance Metrics
        i. Develop new reports as needed, in both CombIS and BrM to improve the data quality checking and reporting.
        ii. Develop reports to track and report on the federally mandated 23 Metrics for NBI Data Compliance, Element Level Data Compliance metrics, and 15 Metrics for NTI data Compliance.
        iii. Develop reports to support day to day Senior Management and MPO requirements.
        iv. Develop reports to support the TAMP requirements, and MAP-21 Performance Metrics.
    c. Perform all necessary actions to prepare for the federal "Tapes" for NBI and NBE compliance from **BrM650**.
    d. Continue to include data for State Border NBIS Bridges into New Jersey NBI data as per MAP-21 requirements, including State Border Tunnels in BrM and CombIS.
    e. Include bridges in New Jersey under the FHWA ownership (such as bridges within the vicinity of Defense/Military Areas) within the Historical Database.
    f. Develop and implement a plan for Risk Assessment Management tool in BMS for evaluating risk at assets level, including generating guidelines for inspectors to update/modify risk score during routine inspections. This effort will also include supporting ongoing development of the NJDOT Resilience Program by generating reports and sharing information as needed.
    g. Initiate a Standard Baseline Document Change (BDC) Process in New Jersey to incorporate updated National Bridge Inspection Standards. In addition, prepare a plan to update the New Jersey's Recording and Coding Guide for the Structure Inventory and Appraisal of NBIS Bridges based on the final approved version of the Specifications for the National Bridge Inventory (SNBI).

ACTIVITY: Bridge Management System – 2207185
MANAGER: Mujahid Khan, Acting Manager
Bureau: Structural Evaluation & Bridge Management

GOALS/ACTIVITES: (cont'd.)

2. Establish and enhance the appropriate data linkages, and/or manual methods, to enable the optimized flow of information to support the Department's decision-making. Work with the Department to adjust/refine the structural project identification and prioritization process such that, for major efforts, the right work happens at the right time. As part of this, develop appropriate project priorities and recommendations for effective Asset Management, and provide this information for use in the Capital Investment Strategy (CIS), the TAMP, the STIP, and the PM2 needs. Connect work candidates from Maintenance Work Order System (now called TAMS - Transportation Asset Management System) to CombIS and BrM to ensure that work accomplished during both major and minor preventive maintenance/preservation treatments are properly credited.
    a. Continue to develop and implement a plan to obtain and provide data to different management systems within the Department for generating an approved STIP every two years for bridge & other structural assets. Under this task, the annual consistency review for TAMP process and its implementation will be performed. Also, under the performance measures and target setting process, performance metrics will be evaluated, and state established targets may be revised if needed for mid- and full-performance period.
    b. Continue to develop and implement a plan of obtaining data on work completed on bridge and structural assets under preventive maintenance/preservation program from Maintenance Work Order System (or TAMS) into CombIS and BrM.
    c. Continue to develop and implement a plan of obtaining data on major work performed on bridges and other structural assets (major rehabilitations and replacements) from the Department's project management and construction activities. This will require working within Project Management Reporting System (PMRS), and developing a data flow process (initially manually, and later via data transfer utility) from PMRS, and possibly other data sources, to CombIS.
    d. Continue to develop and implement appropriate project priorities and recommendations using Problem Initiation (TP-1), Project Analysis, and Historical Analysis processes under Asset Management program. This prioritization process is a collaborative effort performed by the SMEs from Structural Evaluation, Asset Management, Structural Design, and Structural Value Solutions utilizing input from BMS, PMRS, Design, Value, Inspections, and other Best Practices, which helps adjusting these recommendations over time to maximize value and minimize cost.
        i. Continue to work with the Department as necessary to adjust the project development and delivery process to be more compatible with the management systems for project identification, development, and time-based (delivery-date-focused) optimization.
        ii. Based on the approved TAMP investment strategies, continue to develop and identify Project/Maintenance recommendations for the yearly Capital Program, while updating the CIS, and the STIP based on the revised bridge needs.
        iii. Develop and implement methods of tracking progress with regards to meeting established goals.

3. Maximize the effectiveness of the investment in bridge and structural asset infrastructure.
    a. Improve BrM data driven modeling capabilities.
        i. Continue to calibrate BrM deterioration models, utility value models, Action-benefit-Cost models, Lifecycle planning, and Projects & Program modeling for NJDOT.
        ii. Utilize the Bridge Resource Program and Staff Augmentation to refine various processes involved within BMS.
        iii. Develop procedures and mechanisms to enable development of projects to ensure goals are met for bridges and other structural assets in the system.
            1. Continue to develop procedures and analysis to optimize the preventive maintenance/preservation program.

ACTIVITY: Bridge Management System – 2207185
MANAGER: Mujahid Khan, Acting Manager
Bureau: Structural Evaluation & Bridge Management

GOALS/ACTIVITES: (cont'd.)

2. Continue to develop procedures and analysis to optimize major rehabilitation and replacement programs, including limited scope projects, partial replacement and widening projects, and projects due to other than bridge needs.

iv. Continue to update the override unit cost for bridge work types as per FHWA guidelines and develop methodology to estimate element level unit cost in BrM.

v. Continue to enhance the BrM functionality to support the risk-based methodology for decision making.

b. MAP-21 Implementation and data sharing/integration

i. Continue to improve integration of the BMS with the other Department management systems to ensure that projects are coordinated between disciplines.

ii. Continue to develop and provide an appropriate level of support to the MPOs and major Toll Agencies with regards to their data sharing as they endeavor to comply with the MAP-21 requirement to: *Transition to Performance Based Planning and Programming*.

iii. Implement all required aspects of the Rulemakings involving the Bridge Performance Measures and the TAMP.

c. Continue to enhance and implement a bridge preventive maintenance/preservation program, and BMS methods to support this program.

i. Continue to develop the NJDOT Bridge Preservation Section (also called "*Playbook*") as part of the NJDOT BMS Manual, that captures a task-by-task method of documenting why we chose each action we make available for a bridge, what benefit we can take credit for in BrM deterioration modeling, what the cost benefit is, and the specifics of the action.

ii. Continue to work in the preservation team, which consist of SMEs from Division of Bridge Engineering & Infrastructure Management, Bureau of Operations Support and Engineering, Moveable Bridge Engineering Group, and Asset Management, to develop, document and implement methods that provide current information on what existing maintenance contracts are being performed on State bridges and when. The team will continue to develop programming tools such as entering a list of actions in BrM that result in future bridge preservation projects.

iii. Continue to develop and document various "plays" and decision trees for determining when to implement the various alternatives listed in the Playbook.

d. Continue to enhance the BMS capabilities to deliver the TAMP, including annual consistency review, current Capital Program, the 10-year STIP, and 25-year Capital Plan, utilizing BrM directly to the extent possible and other supporting tools' capabilities where required.

i. Continue to calibrate BrM to generate the capital program and stabilize its functionality specific to New Jersey needs.

ii. Continue to adjust BrM to bring the models in alignment with our expectations, and also look for data sources and methods external to BrM for developing supporting information.

iii. Continue to develop and deliver data required for the TAMP, including PM2, Lifecycle Planning, Budgeting, and Alternate Funding Scenarios analyses.

Appendix E: Risk Register

Risks to the accomplishment of the TAMP asset management policies and State of Good Repair Objectives are described on the following pages. Exhibit E-1 presents enterprise-level risks and Exhibit E-2 presents program-level risks.

Exhibit E-1: Risk Register – Enterprise-Level Risks

Risk Identification				Risk Analysis			Risk Management	
ID	**Assistant Commiss-ioner**	**Risk Type**	**Detailed Risk Statement**	**Impact**	**Likelihood**	**Risk Rating**	**Response**	**Response Action/Strategy Description**
2	Planning, Multimodal and Grant Administration	Information	If effective mitigation strategies to protect against extreme weather hazards are not planned for and implemented, Then New Jersey's infrastructure may lack the ability to withstand extreme weather events, as well as not fulfill IIJA requirements related to improving resilience.	Very High	Medium (Possible)	30	Accept Opportunity	Continue to build upon prior Department efforts related to resiliency and further improve resiliency-related decision support tools, e.g., GIS datasets, project planning / prioritization tools, etc.
3	Planning, Multimodal and Grant Administration	External Impacts	If funding shortfalls or across the board project cost increases occur for recurring funding cycles, Then the New Jersey TAMP SOGR objectives may not be achievable.	Very High	Medium (Possible)	30	Mitigate Threat	Continue to promote NJDOT needs and possible impacts to the NHS network if objectives are not achieved through the TAMP.
4	Operations	External Impacts	If NJDOT is unable to adequately communicate the how and why of asset management, Then the overall (capital) transportation program may not be adequately funded or properly implemented; Then the bridge vs pavement (capital) transportation program may not be adequately funded or properly implemented; Then the state vs others (capital) transportation program may not be adequately funded or properly implemented.	High	High (Likely)	28	Mitigate Threat	Enhance communication with organizational units throughout the Department through the Directors group to promote awareness of asset management and the capital program.

Note: Risk "ID" numbers correspond to those in 2019 TAMP.

Risk Identification				Risk Analysis			Risk Management	
ID	**Assistant Commiss-ioner**	**Risk Type**	**Detailed Risk Statement**	**Impact**	**Likelihood**	**Risk Rating**	**Response**	**Response Action/Strategy Description**
44	Operations	Operational	If AM knowledge management/retention plans and staff succession plans are not in place, Then NJDOT risks the ability to efficiently exercise the required institutional AM knowledge and staffing allocations to support TAMP objectives.	High	High (Likely)	28	Mitigate Threat	NJDOT has identified succession planning as a key area for the Department to make progress and has participated in FHWA's Let's Go Workshop. Continued participation and involvement in succession planning is required from Department leadership and those with core responsibilities related to personnel actions. As part of its strategic workforce development program, the Department is focused on: •Formulating a Department-wide mentorship program; •Identifying emerging skillset needs with partners; •Continuing industry association outreach; and •Continuing college / university outreach.
5	Planning, Multimodal and Grant Administration	Information	If the Department continues to use metrics for the NJDOT network that are different from the metrics used for the NHS network, Then there will be inconsistencies in asset management processes across the agency.	High	Medium (Possible)	21	Mitigate Threat	A. Clearly communicate the distinction between the networks, metrics, and goals / objectives within the TAMP. B. Develop crosswalks to enable the comparison of metrics between networks and across owners so that goals / objectives can be better understood internal and external to NJDOT.
6	Planning, Multimodal and Grant Administration	Information	If project/program deliveries are not met, Then project/program costs may increase; Then maintenance requirements may change or increase; Then suboptimal treatments may be selected and potentially decrease the overall quality of the network.	High	Medium (Possible)	21	Mitigate Threat	Develop a means of capturing regular updates from the execution of STIP projects in order to provide a more accurate understanding of how other project timelines may need to be adjusted or re-prioritized.
14	Finance and Administration	External Impacts	If there is a change in federal transportation legislation requiring changes to the TAMP, Then the TAMP process will need to be re-evaluated based on any new legislation requirements; Then the cost of asset management projects may increase.	High	Medium (Possible)	21	Accept Threat	A. Continue to stay up to date on legislation changes/updates/requirements. B. Monitor the cost of AM projects as changes are published.

Risk Identification				Risk Analysis			Risk Management	
ID	**Assistant Commiss-ioner**	**Risk Type**	**Detailed Risk Statement**	**Impact**	**Likelihood**	**Risk Rating**	**Response**	**Response Action/Strategy Description**
15	Planning, Multimodal and Grant Administration	External Impacts	If there is a need to compete for limited funding, Then SOGR projects will be underfunded resulting in deterioration of the network condition and leading to increased lifecycle costs.	High	Medium (Possible)	21	Accept Threat	Continue to monitor the availability of funds, and apply AM plan for decision making regarding projects.
20	Capital Program Management	Information	If NJDOT is unable to adequately collect quality condition and performance data in a timely manner, Then this will hinder the ability to make good sound decisions regarding goals, performance measures, targets, program level prioritization, and negatively affect funding.	High	Medium (Possible)	21	Mitigate Threat	A. Continue to employ and enhance a systematic approach to data collection. B. Continue to leverage NJDOT TAMP Team meetings to discuss and share data collection best practices.
27	Planning, Multimodal and Grant Administration	Information	NJDOT manages approximately 61% of NHS pavements (lane miles) and 47% of NHS NBIS bridges (deck area sq. ft.), thus if condition and performance data are not provided by non-NJDOT NHS owners, Then TAMP data reporting may not permit the management of the entire NHS pavement and bridge infrastructure to achieve the SOGR objectives.	High	Medium (Possible)	21	Mitigate Threat	Continue to improve the means to collect the data, or with reasonable accuracy, estimate current and projected future conditions for NHS managed by other owners.
39	Operations	Operational	If there is not continued support for the AM governance structure and dedicated resources within NHS owners, Then the ability to carry out, improve upon, and manage AM process related to the TAMP (as well as achievement of the TAMP objectives) may be diminished.	High	Medium (Possible)	21	Enhance Opportunity	NJDOT leadership is committed to supporting the AM governance structure and the Department's AM Program. Dedicated resource(s) within the Department for AM is a future consideration. The Department will continue to engage other NHS owners and their respective AM dedicated resources.
40	Operations	Operational	If organizational units and other contributors supporting the TAMP fail to continue to collaborate on planning efforts and avoid obstacles, Then planning efforts including the development of lifecycle strategies, risk management, and investment strategies may not be ideal or effectively implemented.	High	Medium (Possible)	21	Enhance Opportunity	Continue to leverage NJDOT's AM governance structure to promote collaboration and planning across organizational units. Utilize the Department's AM resources as appropriate.

Risk Identification				Risk Analysis			Risk Management	
ID	**Assistant Commiss-ioner**	**Risk Type**	**Detailed Risk Statement**	**Impact**	**Likelihood**	**Risk Rating**	**Response**	**Response Action/Strategy Description**
43	Planning, Multimodal and Grant Administration	Asset Failure	If non-pavement/bridge assets are not adequately maintained, Then they may present risks to the safety, condition, and/or resiliency of NHS pavement and bridge assets.	High	Medium (Possible)	21	Mitigate Threat	NJDOT has committed to developing asset management programs for assets beyond pavements and bridges, reducing the risk for Department-owned assets. The Department will need to continue to engage the other NHS owners regarding non-Department-owned, non-pavement and bridge assets.
8	Finance and Administration	External Impacts	If other jurisdictions do not complete impactful actions to implement processes outlined in the TAMP, Then the targets will not be met which will affect future funding needs.	Moderate	Very High (Almost Certain)	20	Accept Threat	Communicate the importance of the processes outlined in the TAMP with other agencies/jurisdictions.
16	Capital Program Management	External Impacts	If a new administration (federal/state/local) is elected and/or new policies enacted, Then New Jersey's TAM priorities may shift.	Moderate	Very High (Almost Certain)	20	Accept Threat	Monitor any changes in administration and respective change of policies.
17	Planning, Multimodal and Grant Administration	Operational	If costs escalate and cost estimating fluctuate, Then different agencies will determine costs in different ways, leading to inconsistent estimation; Then prices go up; Then cost estimating package accuracy will affect this risk differently; Then longer projections will lead to higher uncertainty; Then there is a risk of projects not being delivered, negatively affecting program objectives.	Moderate	Very High (Almost Certain)	20	Accept Threat	A. Continue to monitor/document any changes of costs. B. Consider best alternative to establish a reasonable consistent approach.
1	Operations	External Impacts	If other types of transportation assets are incorporated into the TAMP and/or AM processes, Then a more holistic understanding of investment needs over the lifecycle of assets, and trade-offs between asset types can be achieved.	Moderate	High (Likely)	16	Exploit Opportunity	A. Develop programs for other assets and establish lifecycle plans for other assets that inform investment strategies. B. Consider inclusion of additional asset types in future TAMP efforts.

Risk Identification				Risk Analysis			Risk Management	
ID	**Assistant Commiss-ioner**	**Risk Type**	**Detailed Risk Statement**	**Impact**	**Likelihood**	**Risk Rating**	**Response**	**Response Action/Strategy Description**
9	Capital Program Management	Operational	If NJDOT is unable to adequately collect a complete set of financial data, Then this will hinder the ability to make sound decisions regarding goals, performance measures, targets, and program level prioritization; consistency reviews will not be representative of the actual realities and future funding will suffer.	Moderate	High (Likely)	16	Mitigate Threat	Continue the periodic administration of a survey developed to collect qualitative data on anticipated pavement funding and condition from other NHS pavement owners. For planned projects using funding from Bridge Assets, the BMS will be kept in sync with the approved STIP. Anytime there is an update to the STIP (every 2 years), it will be reflected in the BMS, and project information will be revised. A survey will be regularly administered to collect planned information from other NHS NBIS bridge asset owners. For future projects, the anticipated funding and the condition information will be calculated based on current NJDOT predictive capabilities, and a survey will be regularly administered to collect future projects by other NHS NBIS bridge assets owners.
11	Capital Program Management	Information	If NJDOT geospatial modeling is based on the outdated information, Then this will obstruct the Department's ability to make data-driven decisions due to its lack of ability to understand the interconnected geospatial relationships (GIS intersection analysis) over the lifecycle of each respective asset class.	Moderate	High (Likely)	16	Mitigate Threat	Continue enhancements to the data warehouse and automatically update asset class data Department-wide to help address concerns of outdated geospatial data.
12	Finance and Administration	Information	If there is no systematic prioritization process for all NHS owners/maintainers in NJ, Then NJDOT cannot effectively achieve its obligation to meet its set targets for the NHS.	Moderate	High (Likely)	16	Mitigate Threat	Share NJDOT prioritization strategies with others and highlight the importance of applying a consistent method for the maintenance of NJ's transportation network.
19	Planning, Multimodal and Grant Administration	Information	If NJDOT lacks or has inadequate tools for lifecycle modeling, Then forecasts and expectations are going to be ineffective towards vital agency planning processes.	Moderate	High (Likely)	16	Mitigate Threat	A. Improve lifecycle modeling tools for asset classes and for managing across assets. B. Through regular NJDOT TAMP Team meetings, continue to discuss, and share lifecycle modeling and tool utilization best practices, including for asset types beyond bridges and pavements.

Risk Identification				Risk Analysis			Risk Management	
ID	**Assistant Commiss-ioner**	**Risk Type**	**Detailed Risk Statement**	**Impact**	**Likelihood**	**Risk Rating**	**Response**	**Response Action/Strategy Description**
42	Capital Program Management	External Impacts	If there is insufficient industry and NHS owner capacity to deliver increased volumes of work due to increases in funding to existing programs, funding for new programs, and additional planning funding, Then NHS owners may be unable to leverage additional funds to deliver an increased volume of work in a timely manner.	Moderate	High (Likely)	16	Accept Threat	Continue to: A. Monitor industry capacity and capability to deliver increased volumes of work; B. Conduct outreach with industry groups; and C. Engage and coordinate with other NHS owners accordingly to reduce impacts of potential industry capacity constraints to the extent practical.
13	Planning, Multimodal and Grant Administration	External Impacts	If human intentional threats and their impact on the NJDOT system are not accounted for, Then New Jersey may lack the ability to respond in a timely manner to mitigate the effects of human intentional threats.	High	Low (Unlikely)	14	Mitigate Threat	Prepare for human intentional threats by developing scenarios, mitigation strategies, and improving security measures that would minimize these threats.
21	Finance and Administration	Information	If datasets across the Department and among agencies are not standardized for practical compatibility, Then communication of data between internal and external stakeholders will suffer as silos.	Moderate	Medium (Possible)	12	Mitigate Threat	Enforce standardize schemas as a requirement to submit data into the NJDOT data warehouse.
41	Transportation Systems Management	External Impacts	If changes in travel patterns resulting from ecommerce truck activity (e.g., new warehouses) and shifting commuting patterns (e.g., tele-working, co-working spaces) cannot be reliably predicted with respect to the NHS, Then New Jersey will be unable to determine the impacts on currently established deterioration models and design standards for NHS assets.	Moderate	Medium (Possible)	12	Accept Threat	Monitor future truck travel and commute patterns. As updated data is collected, adjust deterioration models and design standards accordingly if new truck travel and commute patterns are established.

Risk Identification				Risk Analysis			Risk Management	
ID	**Assistant Commiss-ioner**	**Risk Type**	**Detailed Risk Statement**	**Impact**	**Likelihood**	**Risk Rating**	**Response**	**Response Action/Strategy Description**
45	Capital Program Management	Information	If the Part 667 database is not updated, managed, and integrated into the Department's project delivery process, Then screening for and analyzing reasonable preferred alternatives that will mitigate or partially or fully resolve the root cause of recurring damage may not be considered.	Moderate	Medium (Possible)	12	Mitigate Threat	Enhance the capabilities of the Part 667 database in order to improve the Department's ability to identify potential locations / events of repeat repair / reconstruction.
18	Capital Program Management	Operational	If New Jersey experiences a significant cyber incident, such as a malware attack, Then data maybe lost or unavailable which will cause cascading effects in the prioritization of funding and other resources.	Moderate	Low (Unlikely)	8	Mitigate Threat	A. Include cybersecurity as part of the developmental process of all technological advances / implementation in NJDOT system to avoid dealing with these situations as an after-thought. B. Develop strategies, plans, and any training necessary to incorporate addressing technological threats as part of NJDOT's TAMP.
24	Planning, Multimodal and Grant Administration	Information	If NJDOT's management systems do not have the ability to identify roadway type (NHS vs. non-NHS), Then reporting on total expenditures for the entirety of the NHS requires additional efforts and the identification of correlation methodology.	Moderate	Low (Unlikely)	8	Mitigate Threat	Continue to improve the means through which assets can be identified relative to the NHS network.
26	Planning, Multimodal and Grant Administration	Operational	If a future TAMP submission is not certified or an annual consistency determination is not issued, Then NJDOT will have to incur costs of data collection or there will be gaps in reported condition data; Then NJDOT may incur substantial financial penalties, which will impact NJDOT's programming capabilities and progress toward TAMP objectives.	High	Very Low (Rare)	7	Accept Threat	Continue regular two-way dialogue with local FHWA District Office staff to help ensure TAMP requirements are well understood and to promote continued compliance. Continue to leverage the Directors Group to communicate compliance requirements and promote ongoing dialogue as it relates to Federal requirements.

Exhibit E-2: Risk Register – Program-Level Risks

Risk Identification				Risk Analysis			Risk Management	
ID	**Assistant Commiss-ioner**	**Risk Type**	**Detailed Risk Statement**	**Impact**	**Likelihood**	**Risk Rating**	**Response**	**Response Action/Strategy Description**
28	Finance and Administration	Operational	If AM-supporting software and equipment is not properly maintained or upgraded due to a lack of adequate resources, Then data required for HPMS and AM and PM regulations could be insufficient and/or incorrect leading to penalties for non-compliance.	High	High (Likely)	28	Enhance Opportunity	A. Implement management systems and strategies to maintain equipment and software needed for compliance. B. Develop contingency plan.
29	Capital Program Management	Asset Failure	If we continue to see deterioration in asphalt binder as industry does not improve the refinement process effectively enough Then treatment life/performance would stay a challenge, resulting in pre-mature deterioration of the network.	High	High (Likely)	28	Mitigate Threat	Improve materials specifications.
30	Capital Program Management	Operational	If critical staff are lost or there is an obstacle to onboarding new staff due to the constraints of the civil service system, Then data required for HPMS and AM and PM regulations could be insufficient and/or incorrect leading to penalties for non-compliance.	High	Medium (Possible)	21	Mitigate Threat	Continue to train and grow expertise within the unit.
31	Capital Program Management	External Impacts	If we experience poor construction quality, Then treatment life/performance will be greatly reduced resulting in pre-mature deterioration of the network.	High	Medium (Possible)	21	Mitigate Threat	A. Improve construction inspection process and specifications. B. Provide training to the industry and in-house staff.
32	Capital Program Management	External Impacts	If the number of contractors who can/will do pavement preservation treatments does not increase, Then preservation program cannot grow, and project costs are not optimized.	Moderate	Very High (Almost Certain)	20	Accept Threat	A. Continue to encourage competition within the industry through outreach and training. B. Demonstrate that the department is increasing funding for its preservation program. C. Continue to explore alternate treatments that maybe more suitable for more contractors.

Risk Identification				Risk Analysis			Risk Management	
ID	**Assistant Commiss -ioner**	**Risk Type**	**Detailed Risk Statement**	**Impact**	**Likelihood**	**Risk Rating**	**Response**	**Response Action/Strategy Description**
33	Capital Program Manage ment	Informa tion	If The Pavement Management System cannot accurately predict when major rehab and reconstruction is required. If a large number of pavement projects require more costly treatments, Then the network pavement conditions predicted by the modeling software will not be correct and the recommended funding level will not be sufficient.	Very High	Low (Unlikely)	20	Mitigate Threat	Investigate new technology to perform structural evaluation at the network level.
34	Capital Program Manage ment	Operati onal	If critical staff are lost or there is an obstacle to onboarding new staff due to the constraints of the civil service system, Then subject matter expertise required to effectively produce asset management requirements could become insufficient and produce inaccurate results.	High	Medium (Possible)	21	Mitigate Threat	SEBM will continue to utilize staff augmentation services to enhance bridge asset management practices and work with internal and external partners on the improvement of tools used. The initial models will be validated by our research partners. Any recommendation to calibrate/tweak such models in order to improve the efficiency of the models, specific to New jersey needs, will be considered. We will continue to train our BMS staff by using AASHTOWare's BrM service units agreements, peer exchange meetings, and internal entities.
35	Capital Program Manage ment	External Impacts	If the deterioration model is not configured accurately, or if the amount of benefit or credit for each treatment is not taken timely and accurately, Then future projects may not reflect the optimal treatment to be performed on the bridge assets in the given target year, resulting in BrM creating projects in the future that may not happen at all in the given year (target year may get delayed).	Moder ate	High (Likely)	16	Mitigate Threat	Use consultant support services through joint staff augmentation contracts for SEBM and TOSS (Transportation Operations Systems and Support), as well as research partners to continuously improve on the configuration of the models. Continue to improve the communication plan between Bridge Maintenance (custodian of Bridge Preventive Maintenance and Bridge Preservation) and Bridge Management System.

Appendix F: Part 667 Events

FHWA Final Rule 23 CFR 667 requires State DOTs to conduct a statewide evaluation 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 since January 1, 1997.

The statewide evaluation must include identification and consideration of any alternative that will mitigate, or partially or fully resolve, the root cause of the recurring damage, the costs of achieving the solution, and the likely duration of the solution. The evaluations must consider the risk of recurring damage and the cost of future repair under current and future environmental conditions.

As part of the most recently completed evaluation in 2020 for all public roadways (as of the prior 2019 TAMP, the evaluation had only been completed for the NHS, which was in 2018), NJDOT conducted an analysis of the following:

- 8 Federal Emergency Declarations
- 23 Major Disaster Declarations
- 51 State of Emergency Declarations

The majority of damages and repairs to NHS infrastructure in the state of New Jersey identified during this analysis and data collection phase have been attributed to six (6) main events including:

- Hurricane Floyd (September 1999)
- Tropical Depression Ivan (September 2004)
- Nor'easter (April 2007)
- Hurricane Irene (August 2011)
- Tropical Storm Lee (September 2011)
- Hurricane Sandy (October 2012)

Based on the analysis performed as part of the 2020 evaluation, NJDOT has not identified any locations experiencing repeated damages to pavement or bridge assets (i.e., requiring repair or reconstruction activities on two or more occasions) due to emergency events since January 1, 1997. The following exhibits list the identified Federal and State Emergency Declarations analyzed for this evaluation.

Exhibit F-1: Federal Emergency Declarations for New Jersey from January 1, 1997 to September 2, 2021

ID	Event	Incident Period	Date Declared
1	New Jersey Remnants of Hurricane Ida (EM-3573)	September 01, 2021 to September 03, 2021	September 02, 2021
2	New Jersey Hurricane Sandy (EM-3354)	October 26, 2012 to November 08, 2012	October 28, 2012
3	New Jersey Hurricane Irene (EM-3332)	August 26, 2011 to September 05, 2011	August 27, 2011
4	New Jersey Hurricane Katrina Evacuation (EM-3257)	August 29, 2005 to October 01, 2005	September 19, 2005

ID	Event	Incident Period	Date Declared
5	New Jersey Power Outage (EM-3188)	August 14, 2003 to August 16, 2003	September 23, 2003
6	New Jersey Snowstorm (EM-3181)	February 16, 2003 to February 17, 2003	March 20, 2003
7	New Jersey Terrorist Attack Emergency Declaration (EM-3169)	September 11, 2001	September 19, 2001
8	New Jersey Virus Threat (EM-3156)	May 30, 2000 to November 01, 2000	November 01, 2000
9	New Jersey Hurricane Floyd (EM-3148)	September 16, 1999 to September 18, 1999	September 17, 1999

Exhibit F-2: Federal Major Disaster Declarations for New Jersey from January 1, 1997 to September 5, 2021

ID	Event	Incident Period	Date Declared
1	New Jersey Remnants of Hurricane Ida	September 01, 2021 to September 03, 2021	September 05, 2021
2	New Jersey Severe Winter Storm and Snowstorm	January 31, 2021 to February 02, 2021	April 28, 2021
3	New Jersey Tropical Storm Isaias	August 04, 2020 to August 04, 2020	December 11, 2020
4	New Jersey Severe Winter Storm and Snowstorm (DR-4368-NJ)	March 6, 2018 to March 7, 2018	June 8, 2018
5	New Jersey Severe Winter Storm and Snowstorm (DR-4264)	January 22, 2016 to January 24, 2016	March 14, 2016
6	New Jersey Severe Storm (DR-4231)	June 23, 2015	July 22, 2015
7	New Jersey Hurricane Sandy (DR-4086)	October 26, 2012 to November 08, 2012	October 30, 2012
8	New Jersey Severe Storms and Straight-Line Winds (DR-4070)	June 30, 2012	July 19, 2012
9	New Jersey Severe Storm (DR-4048)	October 29, 2011	November 30, 2011
10	New Jersey Remnants of Tropical Storm Lee (DR-4039)	September 28, 2011 to October 06, 2011	October 14, 2011
11	New Jersey Severe Storms and Flooding (DR-4033)	August 13, 2011 to August 15, 2011	September 15, 2011
12	New Jersey Hurricane Irene (DR-4021)	August 27, 2011 to September 05, 2011	August 31, 2011
13	New Jersey Severe Winter Storm and Snowstorm (DR-1954)	December 26, 2010 to December 27, 2010	February 04, 2011

ID	Event	Incident Period	Date Declared
14	New Jersey Severe Storms and Flooding (DR-1897)	March 12, 2010 to April 15, 2010	April 02, 2010
15	New Jersey Severe Winter Storm and Snowstorm (DR-1889)	February 05, 2010 to February 06, 2010	March 23, 2010
16	New Jersey Snowstorm (DR-1873)	December 19, 2009 to December 20, 2009	February 05, 2010
17	New Jersey Severe Storms and Flooding Associated with Tropical Depression Ida and a Nor'easter (DR-1867)	November 11, 2009 to November 15, 2009	December 22, 2009
18	New Jersey Severe Storms and Inland and Coastal Flooding (DR-1694)	April 14, 2007 to April 20, 2007	April 26, 2007
19	New Jersey Severe Storms and Flooding (DR-1653)	June 23, 2006 to July 10, 2006	July 07, 2006
20	New Jersey Severe Storms and Flooding (DR-1588)	April 01, 2005 to April 03, 2005	April 19, 2005
21	New Jersey Tropical Depression Ivan (DR-1563)	September 18, 2004 to October 01, 2004	October 01, 2004
22	New Jersey Severe Storms and Flooding (DR-1530)	July 12, 2004 to July 23, 2004	July 16, 2004
23	New Jersey Severe Storms, Flooding and Mudslides (DR-1337)	August 12, 2000 to August 21, 2000	August 17, 2000
24	New Jersey Hurricane Floyd (DR-1295)	September 16, 1999 to September 18, 1999	September 18, 1999
25	New Jersey Coastal Storm (DR-1206)	February 04, 1998 to February 08, 1998	March 03, 1998
26	New Jersey Flooding (DR-1189)	August 20, 1997 to August 21, 1997	September 23, 1997

Exhibit F-3: State of Emergency Declarations for New Jersey from January 1, 1997 to January 28, 2022

EO	Date	Governor	Explanation
73	8/22/97	Whitman	Declares State of Emergency due to torrential rainfall and resultant flooding and damages, etc., in counties of Atlantic, Burlington, Cape May, Cumberland and Ocean.
78	2/6/98	Whitman	Declares state of emergency existed and presently exists in Atlantic, Cape May, Monmouth and Ocean Counties.
98	8/5/99	Whitman	Declares state of water emergency exists throughout New Jersey.
101	9/15/99	Whitman	Declares a State of Emergency in the State of New Jersey due to flooding from Hurricane Floyd.
117	8/14/00	Whitman	Declares State of Emergency exists in Morris and Sussex Counties.

EO	Date	Governor	Explanation
120	12/30/00	Whitman	Declares State of Emergency exists in New Jersey due to severe weather conditions caused by snow and blizzard conditions, including hazardous road conditions, high tides and coastal flooding.
124	3/4/01	DiFrancesco	Declares State if Emergency exists in New Jersey – Severe Winter Weather
130	7/3/01	DiFrancesco	Declares State of Emergency exists in Morris County – Accident leading to Bridge being unsound I-80
131	9/11/01	DiFrancesco	Declares State of Emergency in the State of New Jersey due to the Terroristic Attacks on the World Trade Center and the Pentagon.
11	3/4/02	McGreevey	Declares Water Emergency – Drought
27	8/14/02	McGreevey	Declares a state of emergency in Monmouth County – severe weather
28	8/28/02	McGreevey	Declares a state of emergency in Camden and Gloucester Counties – severe weather
48	2/16/02	McGreevey	Declares State of Emergency – severe winter weather
63	8/14/02	McGreevey	Declares State of Emergency – widespread power outages
68	9/18/03	McGreevey	Declares State of Emergency – Hurricane Isabel
121	7/13/04	McGreevey	Declares that a State of Emergency presently exists in Burlington and Camden Counties – flooding and power outages.
15	1/22/05	Codey	Declares a State of Emergency presently exists throughout the State of New Jersey – Winter weather
59	10/14/05	Codey	Declares a State of Emergency presently exists throughout the State of New Jersey – severe weather
16	6/28/06	Corzine	Declares a State of Emergency presently exists throughout the State of New Jersey – severe weather
64	4/16/07	Corzine	Declares a State of Emergency presently exists throughout the State of New Jersey – Nor'easter
160	11/12/09	Corzine	Declares a State of Emergency for the counties of Cape May, Atlantic, Cumberland, Burlington, Ocean and Monmouth – Nor'easter
13	2/9/10	Christie	Declares and proclaim that a State of Emergency has existed in the aforesaid counties since 2/5/10 – Severe Winter Weather
18	3/12/10	Christie	Declares and proclaims that a State of Emergency exists – flooding and storm
55	1/25/11	Christie	Declare and proclaim that a State of Emergency exists within the Passaic Valley Sewerage District
57	3/9/11	Christie	Declares a Weather-Related State of Emergency – Flooding
73	8/25/11	Christie	Declare and proclaim that a State of Emergency exists in the State of New Jersey – Hurricane Irene
80	10/30/11	Christie	Declare and proclaim that a State of Emergency exists in the State of New Jersey – Strong winter-type storm
104	10/27/12	Christie	Proclaim that a State of Emergency exists in the State of New Jersey – Hurricane Sandy
106	11/1/12	Christie	Declares State of Water Emergency, Authorizes DEP to take steps to prevent water shortage
108	11/2/12	Christie	Declares a limited State of energy emergency with regard to the supply of motor fuel and implementing odd-even rationing for gasoline purchases in 12 New Jersey counties.

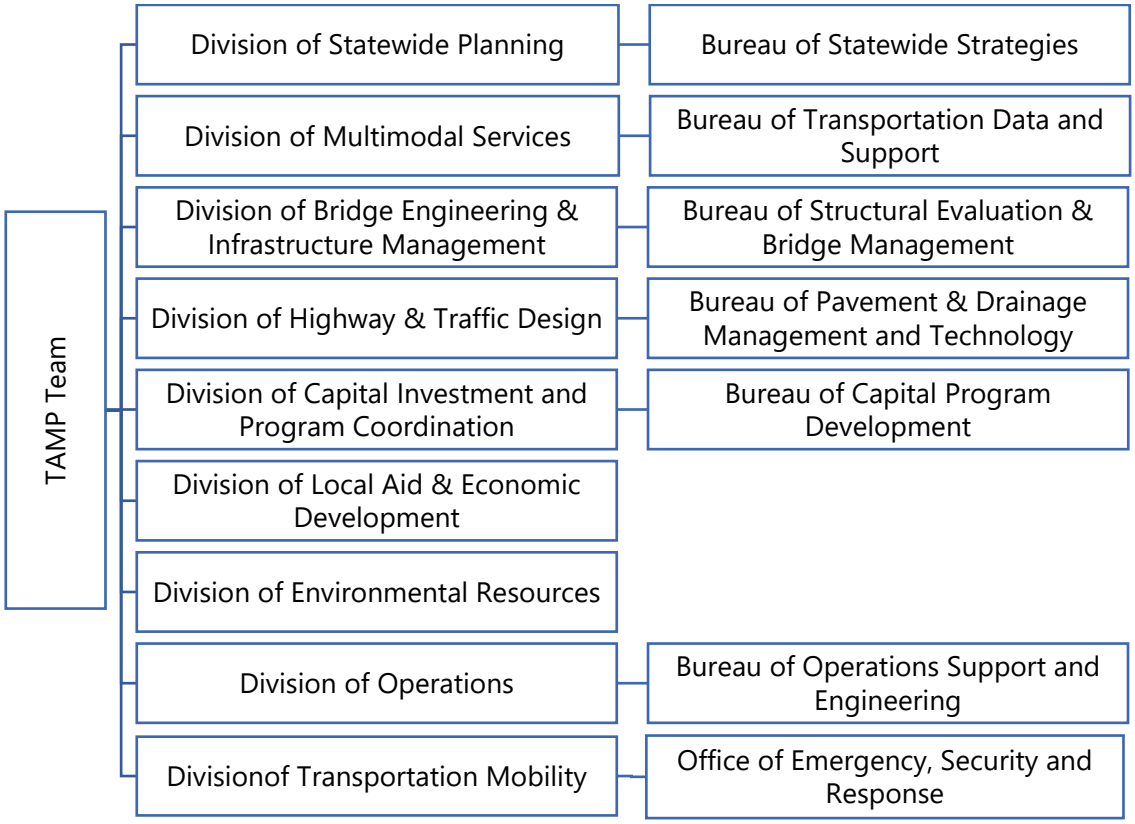
EO	Date	Governor	Explanation
146	1/2/14	Christie	Declares a State of Emergency, authorizing the State Director of Emergency Management to active and coordinate the preparation, response and recovery efforts for the storm with all county and municipal emergency operations and governmental agencies. Governor Christie authorized the closing of state offices on Friday, January 3 for all non-essential personnel.
147	1/21/14	Christie	Declares a State of Emergency, authorizing the State Director of Emergency Management to active and coordinate the preparation, response and recovery efforts for the storm with all county and municipal emergency operations and governmental agencies. – Winter storm
148	2/3/14	Christie	Declares a State of Emergency, authorizing the State Director of Emergency Management to active and coordinate the preparation, response and recovery efforts for the storm with all county and municipal emergency operations and governmental agencies. – Winter Storm
149	2/4/14	Christie	Governor Christie Declares State of Emergency in Preparation for Tuesday Night's Severe Winter Weather
150	2/12/14	Christie	Governor Christie Declares State of Emergency in Preparation for Wednesday Night's Severe Winter Weather
153	3/2/14	Christie	Governor Christie Declares State of Emergency in Preparation for Monday Morning's Severe Winter Weather
167	11/26/14	Christie	Governor Chris Christie today declared a State of Emergency, authorizing the State Director of Emergency Management to activate and coordinate the preparation, response and recovery efforts for the storm with all county and municipal emergency operations and governmental agencies. Commuters are asked to use extreme caution while traveling across the state. - Winter Weather
172	1/26/15	Christie	Declares and proclaims that a State of Emergency exists – Severe Winter Weather
175	3/4/15	Christie	Authorizes the State Director of Emergency Management to activate and coordinate the preparation, response and recovery efforts for the storm with all county and municipal emergency operations and governmental agencies. - Winter Weather
186	10/1/15	Christie	Governor Chris Christie today declared a state of emergency throughout the state as a result of severe weather conditions expected in the coming days. – Winds and Flooding
202	1/22/16	Christie	Governor Christie Declares State of Emergency Ahead of Arrival of Winter Storm
214	9/3/16	Christie	Governor Chris Christie Declares A State of Emergency for Ocean, Atlantic and Cape May Counties in Preparation for Tropical Storm Hermine
221	3/13/17	Christie	Governor Chris Christie declared a State of Emergency, authorizing the State Director of Emergency Management to activate and coordinate the preparation, response and recovery efforts for the storm with all county and municipal emergency operations and governmental agencies in preparation for Winter Storm Stella
14	3/6/18	Murphy	Declares the state emergency across all 21 counties in the state and allows for the extension of resources into other parts of the state as the storm continues to impact New Jersey. – Nor'easter

EO	Date	Governor	Explanation
17	3/20/18	Murphy	Declares a State of Emergency exists throughout the State of New Jersey, effective at 7:00 p.m., Eastern Daylight Time, on March 20, 2018 – Nor'easter
33	2018-08-14	Murphy	Governor Murphy Signs Executive Order Declaring State of Emergency in Flood-Impacted Counties – Flooding
50	2019-01-18	Murphy	Declares a State of Emergency beginning at noon on Saturday ahead of Winter Storm Harper – Major winter storm
55	2019-02-11	Murphy	Gov. Phil Murphy declares state of emergency for NJ for Tuesday February 12 – Winter storm causing
57	2019-02-20	Murphy	Governor Murphy Declares State of Emergency Effective at 5:00 a.m. on February 20, 2019 – Significant winter storm
59	2019-03-03	Murphy	Declares a state of emergency across all 21 counties in New Jersey, allowing resources to be deployed throughout the state during the duration of the storm – Major winter storm
70	2019-06-20	Murphy	Governor Murphy Declares a State of Emergency in Burlington, Camden, and Gloucester Counties – Severe weather conditions
174	2020-08-03	Murphy	Response to Hurricane Isaias
208	2020-12-16	Murphy	Response to Expected Winter Storm
218	2021-01-31	Murphy	Response to Expected Winter Storm
259	2021-09-01	Murphy	Response to Tropical Storm Ida
272	2021-10-25	Murphy	In Preparation for Nor'easter Storm
278	2021-01-02	Murphy	In Preparation for Expected Winter Storm in Atlantic, Burlington, Cape May, Cumberland, and Ocean Counties
279	2022-01-06	Murphy	In Preparation for Expected Winter Storm
285	2022-01-28	Murphy	In Preparation for Expected Winter Storm

Appendix G: TAMP Team Member Responsibilities

This appendix reviews the specifics responsibilities by TAMP Team member. First the constitution of the TAMP Team and its key responsibilities are reviewed from *Chapter 3: TAMP Governance, Policy*. After, the responsibilities by TAMP Team member are presented.

Exhibit 3-2: TAMP Team



Key Responsibilities

- Manage the TAMP process to meet federal and NJDOT business requirements.
- Propose, adopt, and manage technical procedures for the TAMP process.
- Evaluate investment scenarios to support the Transportation Asset Management Steering Committee in investment decisions for asset management in New Jersey's Transportation Capital Program and STIP development processes.
- Ensure that NJDOT asset managers are adopting and utilizing life cycle planning and life cycle planning strategies.
- Coordinate and collaborate with all non-NJDOT NHS owners and the MPOs.
- Manage the implementation of TAMP strategies and actions.
- Manage and maintain the TAMP risk register and risk management process.

Specific Responsibilities by Team Members

Division of Statewide Planning - Bureau of Statewide Strategies

The Bureau of Statewide Strategies provides overall project management for the TAMP process, including the work of the TAMP Team and the management of compliance with federal requirements.

Key Responsibilities

- Manage TAMP Team work required for compliance with federal TAMP requirements.
- Develop and deliver work required for compliance with federal TAMP requirements.
- Assist NJDOT pavement and bridge Subject Matter Experts (SME) with engagement of all non-NJDOT NHS owners and MPOs related to the process for establishing targets in conjunction with the other NHPP performance measures and targets.
- Report all statewide NHPP performance measures and targets established by NJDOT to the Federal Highway Administration (FHWA).
- Communicate and collaborate with all jurisdictions that own NHS assets and MPOs regarding the TAMP process.
- Incorporate asset management into the overall statewide performance-based planning and programming process and transportation performance management framework.

Division of Multimodal Services - Bureau of Transportation Data and Support

The Bureau of Transportation Data and Support is responsible for the management of data collection and completion of the NHS asset inventory.

Key Responsibilities

- Maintain the New Jersey transportation network definition and linear referencing system.
- Manage collection of pavement asset and roadway data from the county and municipal NHS owners.
- Collect and provide NHS pavement condition data for all jurisdictions other than NJDOT and the New Jersey Turnpike Authority.
- Coordinate data collection from the New Jersey Turnpike Authority.
- Ensure the completeness of the NHS and SHS roadway system attributes and pavement data quality compliance in accordance with FHWA requirements.
- Submit the Highway Performance Monitoring System/NHS data to FHWA.

Division of Bridge Engineering and Infrastructure Management - Bureau of Structural Evaluation and Bridge Management

The Bureau of Structural Evaluation and Bridge Management provides technical leadership for the management of bridge and structural assets in New Jersey and establishes the technical policies, procedures, and business practices for life cycle planning of bridge and structural assets.

Key Responsibilities

- Provide all relevant National Bridge Inspection Standard (NBIS) bridge inventory data for the NHS and SHS for all jurisdictions.
- Monitor the condition of bridge and structural assets and conduct performance gap analysis to evaluate alternative investment and policy scenarios to support performance-based capital planning, program development, and performance target setting.
- Develop and manage the Bridge Management System (BMS) analytical procedures to enable analyses of investment scenarios and to optimize investments.
- Provide technical leadership to identify and drive implementation of business practices that increase the durability and remaining service life of New Jersey's bridge and structural assets.
- Conduct life cycle planning and implement life cycle planning strategies.

- Manage implementation of enhancements to asset management capabilities for bridge and structural assets.
- Identify and manage risks associated with the management of bridge and structural assets.

Division of Highway and Traffic Design - Bureau Pavement and Drainage Management and Technology

The Bureau of Pavement and Drainage Management and Technology provides technical leadership for the management of pavement assets in New Jersey and establishes the technical policies, procedures, and business practices for life cycle management of pavement.

Key Responsibilities

- Monitor the condition of pavement and conduct performance gap analysis to evaluate alternative investment and policy scenarios to support performance-based capital planning, program development, and performance target setting.
- Develop and manage the Pavement Management System (PMS) and analytical procedures to optimize investments.
- Provide technical leadership to identify and drive implementation of business practices that increase the durability and remaining service life of New Jersey's pavement assets.
- Conduct life cycle planning and implement life cycle planning strategies.
- Manage implementation of enhancements to asset management capabilities for pavement.
- Identify and manage risks associated with the management of pavement assets.

Division of Capital Investment and Program Coordination - Bureau of Capital Program Development

The Division of Capital Investment and Program Coordination uses the TAMP process analyses to consider the impact of alternative investment scenarios on the TAMP state of good repair objectives in the capital investment planning process.

Key Responsibilities

- Provide data on sources and uses of transportation funds for the TAMP financial plan.
- Conduct New Jersey's Transportation Capital Program development process. The Capital Program details the set of projects, which will be authorized by NJDOT in the given year, along with each project's funding source(s).
- Prepare the STIP on a biennial basis.
- Advance new projects into the project delivery process.

Division of Local Aid & Economic Development

The Division of Local Aid and Economic Development works with county and municipal government officials to improve the efficiency and effectiveness of the New Jersey's transportation system.

Key Responsibilities

- "Cradle to grave" administration and management of Local Public Agency projects funded under the Federal-aid and state aid programs.
- Provide technical leadership to identify and drive implementation of business practices that increase the durability and remaining service life of the local transportation system while providing technical guidance to Local Public Agencies.
- Facilitate federal and state programs including: management of solicitations, development of program criteria, as well as provision of project selection oversight, and grant announcements.
- Provide program-level quality assurance to ensure there is a unified approach to program administration of grants throughout the Division.

Division of Environmental Resources

The Division of Environmental Resources works to ensure that roadway projects comply with all environmental policies, State and federal environmental regulations, and commitments stemming from coordination with regulatory agencies and consultation with cultural resource agencies.

Key Responsibilities

- Perform and oversee the preparation of National Environmental Policy Act (NEPA) documents.
- Facilitate permit applications, soil erosion and sediment control certifications.
- Perform cultural resource studies.
- Monitor construction, wetland mitigation plans, and hazardous waste in New Jersey.
- Identify and manage external risks to mitigate extreme weather and climate change impacts on New Jersey's transportation system.

Division of Operations - Bureau of Operations Support and Engineering

The Division of Operations - Bureau of Operations Support and Engineering provides data on preventive maintenance and preservation projects for roadway and bridge assets in the State of New Jersey.

Key Responsibilities

- Support preventive maintenance and infrastructure preservation for roadway and bridge assets to achieve the state of good repair objectives.
- Implement life cycle planning strategies for management of roadways and bridges.
- Implement asset management TAMP Policy and state of good repair objectives.
- Monitor the condition of pavement and bridge assets in New Jersey.
- Identify and manage performance risks within the framework of available funding associated with the management of roadways and bridges.

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NJDOT Asset Management Steering Committee

Diane Gutierrez-Scaccetti
Joseph Bertoni
Lewis Daidone
Snehal Patel (Retired)
Michael Russo
Andrew Tunnard

NJDOT TAMP Directors Group

Salvatore Cowan
Christopher Feinthel
Elkins Green
John Longworth
Charles Maciejunes
Robert Marshall
Nicole Minutoli
Eric Powers
Laine Rankin
Atul Shah
Andrew Swords
Eric Yermack
Gary Zayas

NJDOT TAMP Team

Nazhat Aboobaker
Shukri Abuhuzeima
Sabah-Norri AlSabbagh
Harjit Bal
Sutapa Bandyopadhyay (FHWA)
David A. Bishay
Robert Blight
David Bruccoleri
Peter Brzostowski
Robert Burd
Glenn Catana
Danielle Calcagni
Andrew Clark
Rickie Clark (FHWA)
Fady Daoud
Mohammad Falamarz-Sheikhabadi
Zenobia Fields
Smruti Gariwala
Thomas Houck
Mohab Hussein
Brian Jackson
Sudhir Joshi
Muhammad A. Khan
Mahmood Khandakar
Narinder Kohli
Raymond Maiorano
Nipa Maniar
Amanda McElwain
John Micikas
Veronica Murphy
Atta Najem
Simon Nwachukwu
Bassey Onyile
Bhaveshkumar Patel
Deven Patel
Pankesh Patel
Amy Polachak
Pritesh Prajapati
Sharad Rana
John Riggi
Helene Roberts (FHWA)
Gina Rossi
Vijay Sampat
Stephen Schapiro
Julie Seaman
Kumar Selvakumar
Aakash Shah
Bharat Shah
Chandrahas Shah
Muhanad Shalchi
Kimberly Sharp
Ramesh Suvagiya
Touraj Tayebi
Jonathan Trauger
John Williams

2022 NJ TAMP Consultant & Support Teams

Eric Adams, GF
Brad Allen, APT
Abhik Borthakur, APT
Michael Boxer, CAIT
Lori Flint, SC
Patti Gibson, SC
Sue Gresavage, APT
John Hencken, CAIT
Kathryn R. Malarich, GF
Ister Morales, GF
John P. O'Har, GF
Nicole Pace-Addeo, SC
Maria Pena, GF
David C. Rose, GF
Charles J. Smith, GF

Abbreviations

APT: Applied Pavement Technology
CAIT: Rutgers, Center for Advanced Infrastructure & Transportation
FHWA: Federal Highway Administration, New Jersey Division Office
GF: Gannett Fleming
SC: Stokes Creative Group

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DEPARTMENT OF TRANSPORTATION
THE STATE OF NEW JERSEY