Transportation Asset Management Plan

December 2022

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STATE OF DELAWARE
DEPARTMENT OF TRANSPORTATION
800 BAY ROAD
P.O. BOX 778
DOVER, DELAWARE 19903

NICOLE MAJESKI
SECRETARY

December 1, 2022

Mr. Douglas S. Atkin
FHWA Delaware Division Administrator
1201 College Park Drive, Suite 102
Dover, Delaware 19904

Dear Mr. Atkin:

While Delaware is the second smallest state by area, the Delaware Department of Transportation (DelDOT) is responsible for managing a road network similar in size to many significantly larger states. Delaware is also the lowest lying state by average elevation which presents unique challenges in terms of managing risks to infrastructure. With these considerations in mind, DelDOT has improved and advanced asset management practices and coordination with other entities over the last few years.

In compliance with Title 23, United States Code (U.S.C.), Section 119, and with updated requirements included in the Infrastructure Investment and Jobs Act/Bipartisan Infrastructure Law (IIJA/BIL), DelDOT is proud to submit our Transportation Asset Management Plan for review and certification by the Federal Highway Administration (FHWA). We believe our TAMP aligns well with our mission to provide Excellence in Transportation for every trip, every mode, every dollar and everyone.

Should you have any questions, please let us know.

Sincerely,

Nicole Majeski
Cabinet Secretary
Delaware Department of Transportation

NM/sj
Enclosure

DelDOT

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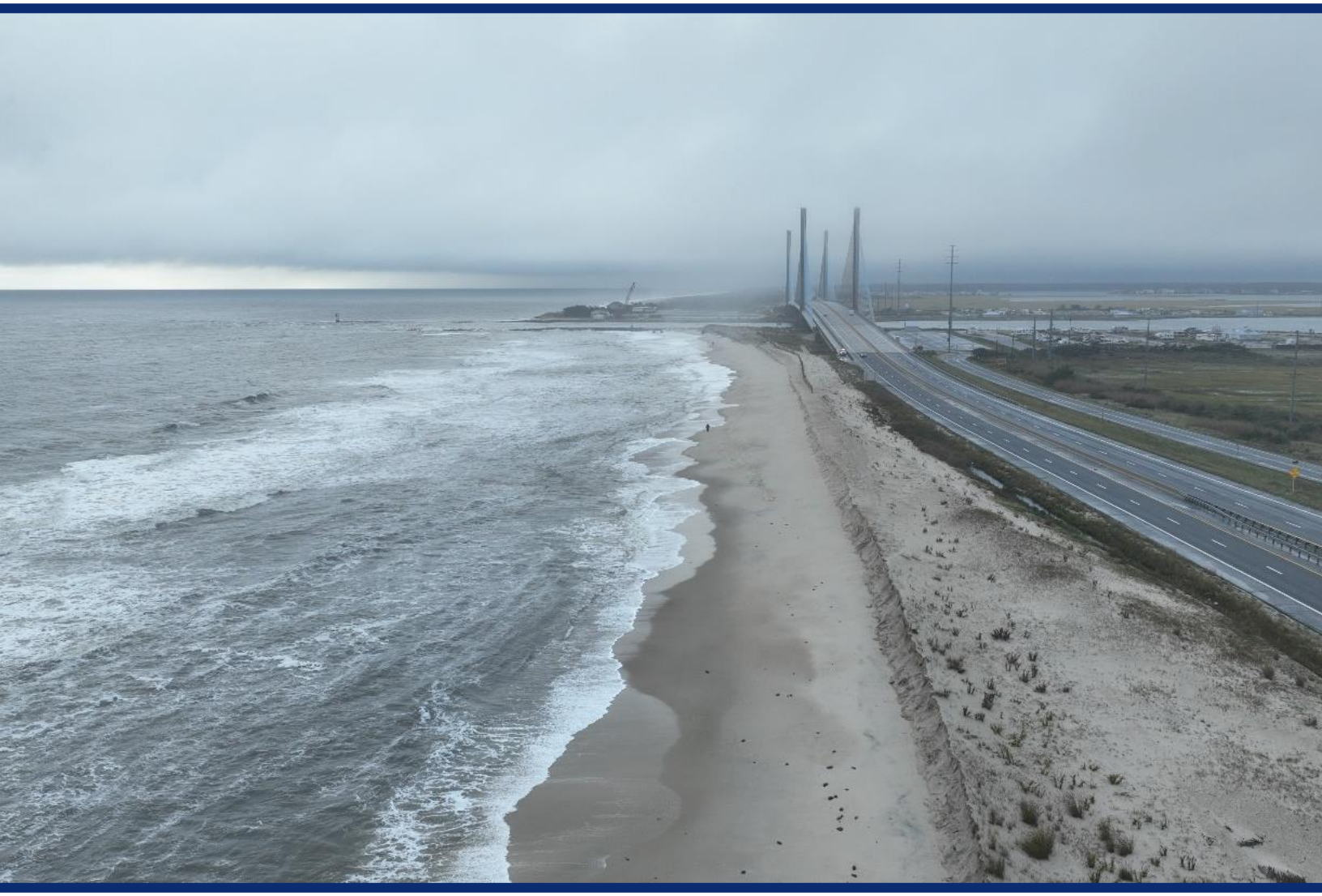
Definitions & Acronyms

Term	Definition
AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic
ADTT	Average Daily Truck Traffic
AASHTO	American Association of State Highway and Transportation Officials
B/C	Benefit Cost Ratio
BMS	Bridge Management System
BrM	AASHTO Bridge Management System
C&D	Chesapeake & Delaware
CFR	Code of Federal Regulations
COT	Council on Transportation
CTP	Capital Transportation Plan
DelDOT	Delaware Department of Transportation
DFL	Damaged Facilities List
DNREC	Department of Natural Resources and Environmental Control
DQMP	Data Quality Management Plan
DRBA	Delaware River and Bay Authority
ER	Emergency Relief
FAST Act	Fixing America's Surface Transportation Act
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FY	Fiscal Year
HPMS	Highway Performance Monitoring System
HSIP	Highway Safety Improvement Plan
IRI	International Roughness Index
LCCA	Life-Cycle Cost Analysis
LCP	Life-Cycle Planning
LRTP	Long Range Transportation Plan
MAP-21	Moving Ahead for Progress in the 21st Century Act
MDSHA	Maryland State Highway Administration
MPO	Metropolitan Planning Organization
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
OPC	Overall Pavement Condition
PMS	Pavement Management System
RDFL	Repeatedly Damaged Facilities List
SLR	Sea Level Rise

Term	Definition
SOGR	State of Good Repair
SOP	Standard Operating Procedure
STIP	State Transportation Improvement Plan
TAM	Transportation Asset Management
TAMP	Transportation Asset Management Plan
TR&S	Transportation Resiliency and Sustainability
USACE	United States Army Corps of Engineers
USC	United States Code

Chapter 1: Introduction and Purpose

Transportation Asset Management (TAM) is a relatively new but proven approach to investment decision making. This methodology continues to evolve as transportation agencies develop and implement Federally required Transportation Asset Management Plans (TAMP). The intent of this TAMP document is to extend beyond simply meeting the Federal requirements which are outlined in this section and referenced throughout the document. Instead, this document serves as a process framework to support broader, on-going efforts within the Delaware Department of Transportation (DelDOT). In turn, this allows DelDOT to manage critical assets across the entire network for which it is responsible.

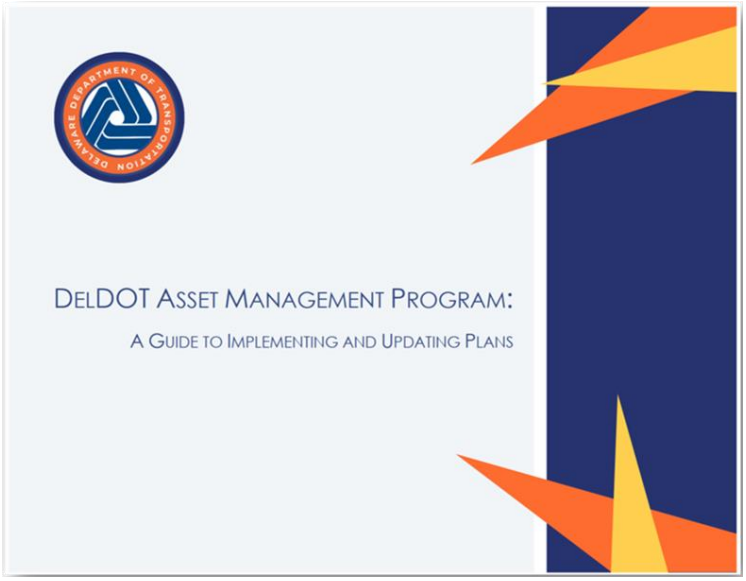


Requirements for a Transportation Asset Management Plan

Background

Asset Management is defined in Federal law[1] 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 lifecycle of the assets at minimum practicable cost." DelDOT's commitment to TAM is reflected in its Strategic Plan and by its incorporation of a mix of preservation, rehabilitation, and renewal strategies into its program development and project selection processes for pavements and bridges. This TAMP builds upon previous efforts and serves as a plan for the future. To support the annual implementation of the TAMP and other TAM efforts, the *DelDOT Asset Management Program: A Guide to Implementing and Updating Plans* (cover depicted in Figure 1) was developed following the creation of the 2019 TAMP.

Figure 1: DelDOT Asset Management Program: A Guide to Implementing and Updating Plans



Source: DelDOT TAM Guide

Evolution

Throughout the latter half of the twentieth century, the Federal Aid transportation program was principally focused on building the Interstate Highway System and expanding other US and state routes. The intent was to provide the capacity and connectivity needed to support a growing economy. However, in the 1990's much of this infrastructure began to show its age, reaching the end of its useful life in many cases. At that point new strategies began to emerge for proactively managing infrastructure assets throughout their life cycle. It was during this period that the Federal Highway Administration (FHWA) began championing the concepts and benefits of Transportation Asset Management (TAM).

Asset Management offered a new merger of economics with engineering to guide strategic infrastructure investment decisions. At the same time, rapid advancements in the field of Information Technology resulted in robust new analytical tools for managing pavement, bridge, and other asset data. These advancements better enabled agencies to forecast future needs and conditions. Like many of its peer transportation agencies, DelDOT implemented pavement and bridge management systems during this period. These systems have been continually enhanced over the years since their initial implementation. By the mid 2000's DelDOT and peer transportation agencies were increasingly subscribing to the principals of Asset Management. This involved adjusting their

[1] See 23 CFR 515.5 "Definitions"

investment strategies to focus on infrastructure preservation, safety, and mobility and to a lesser extent, on new capacity projects, using life cycle planning, prioritization, and trade-off analysis to guide these decisions.

Legislation

With the support of the American Association of State Highway and Transportation Officials (AASHTO), Transportation Funding Authorization bills passed by Congress in 2012 and 2015, respectively known as the Moving Ahead for Progress in the 21st Century (MAP-21) and Fixing America's Surface Transportation Act (FAST Act), ushered in a new era of accountability and performance reporting driven by new Asset Management related requirements. These bills established new requirements for a performance-based highway program. The overarching objective was to ensure that federal transportation funds were fully leveraged to provide the greatest benefit with respect to safety, mobility, and highway and bridge asset conditions. This legislation required each state department of transportation (DOT) to develop a risk-based TAMP that contains the following elements:

- A summary listing of the pavement and bridge assets on the National Highway System (NHS) in the State, including a description of the condition of those assets
- Asset management objectives and measures
- Performance gap identification
- Lifecycle cost and risk management analysis
- A financial plan
- Investment strategies

After the passage of the MAP 21 and FAST Act legislation, the FHWA initiated efforts to draft a series of amplifying rules governing TAMP development and Transportation Performance Management (TPM). These directives were ultimately codified in the Code of Federal Regulations (CFR). To comply with these governing rules, State DOTs were required to submit an initial TAMP to their respective FHWA Division office by April 30, 2018, with the final TAMP due by June 30, 2019. DelDOT was granted a time extension from FHWA until December 2018. The initial TAMP document was submitted by this revised deadline and certified by FHWA. This second iteration of the TAMP document constitutes the plan for the years 2022 to 2032.

With the presidential signing of the of the Infrastructure Investment and Jobs Act (IIJA) (Public Law 117-58, also known as the "Bipartisan Infrastructure Law" or BIL) on November 15, 2021[2], State DOTs are required to consider extreme weather and resilience in the life cycle planning and risk management analyses in their TAMP.[3] DelDOT has included additional discussion and processes in this TAMP to address the new requirement listed below.

Assets Covered

This TAMP document includes the performance measures for NHS pavement and bridge conditions. While State DOTs were not required to include their two and four-year performance management targets for bridge and pavement conditions in their initial TAMP submission, two and four-year targets were required in 2019 and for all subsequent performance periods.

The Delaware Department of Transportation's (DelDOT's) TAMP addresses pavements and bridges, as follows:

[2] FHWA 'one-stop shop' for the implementation of the Bipartisan Infrastructure Law: Bipartisan Infrastructure Law - FHWA | Federal Highway Administration (dot.gov)

[3] FHWA's memo discussing updated requirements for TAMPs under the IIJA: Memorandum_INFORMATION: State Asset Management PLan Under BIL (dot.gov)

- Pavements – NHS Only
- Bridges – NHS Only

DelDOT documents similar information for additional assets outside of the TAMP in the SOGR Summary Sheets described in the Overview of TAMP Process section.

State Overview and Transportation System Responsibility

State of Delaware

Delaware was the first state to ratify the Constitution in 1787 becoming the first official state of the United States. It is the nation's second smallest state in land area (just under 2000 square miles) and the lowest lying state at an average elevation of 60 feet above sea level. According to the US Census Bureau, Delaware's estimated population was 1,003,384 as of 2021. The state is comprised of three counties, New Castle, Kent, and Sussex. The largest city is Wilmington, which had an estimated population of just under 71,000 in 2020. As depicted in the NHS Map in Figure 2, the state is served by three major highway corridors, I-95, US-13, and State Route 1 along with other important modes of transportation including rail, ports, aviation, and transit.

Figure 2: DelDOT NHS Map

Source: DelDOT LRTP

Delaware Department of Transportation (DelDOT)

The DelDOT is responsible for planning, designing, constructing, and operating Delaware's statewide transportation system including roadway and bridge maintenance on nearly 90% of all roadway mileage in the State. These responsibilities also include traffic control, safety, mass transit, snow removal, vehicle and driver services, toll operations, bicycle and pedestrian facilities, airports, and operation of a ferry route. DelDOT is one of a small number of states with responsibility for maintaining secondary and suburban roads, which are most often managed by local jurisdictions, in addition to state primary or numbered routes.

DelDOT is led by a Secretary who reports to the Governor and is overseen by a nine-member Council on Transportation. DelDOT's operations are statewide, with an Administration (HQ) office in Dover, four Maintenance and Operations District Offices with twelve related Area Offices, one statewide highway maintenance facility; Delaware Transit Corporation (DTC) offices and maintenance facilities in Dover and Wilmington; Division of Motor Vehicle (DMV) facilities in Wilmington, New Castle, Dover and Georgetown; three toll plazas and a

statewide Transportation Management Center. DelDOT is also responsible for a rest area in Smyrna and a Welcome Center on I-95.

DelDOT believes that accountability and transparency in government are important and to that end publishes a report each year that details key accomplishments, statistics and trends related to all modes and aspects of transportation for which the Agency is responsible or influences.

Vision and Mission

DelDOT has adopted Strategic Mission and Vision statements along with a set of high-level agency goals which can be readily found on the Agency's website[4]. These are listed in Figure 3 for reference. The TAMP document supports the goals identified.

Figure 3: Delaware Mission and Goals

Our Mission	Our Vision	Goals
Excellence in Transportation • Every Trip • Every Mode • Every Dollar • Everyone	**Every Trip -** We strive to make every trip taken in Delaware safe, reliable and convenient for people and commerce. **Every Mode -** We provide safe choices for travelers in Delaware to access roads, rails, buses, airways, waterways, bike trails, and walking paths. **Every Dollar -** We seek the best value for every dollar spent for the benefit of all. **Everyone -** We engage our customers and employees with respect and courtesy as we deliver our services.	Minimize the number of fatalities and injuries on our system Build and maintain a nationally recognized system benefiting travelers and commerce Provide every traveler with access and choices to our transportation system Provide every customer with the best service possible Minimize the environmental impact of the state's transportation system Achieve financial sustainability through accuracy, transparency, and accountability Develop and maintain a place where talented and motivated employees love to work and can be national leaders in transportation

Source: DelDOT Website

Long Range Transportation Plan

The Map 21/FAST Act legislation included requirements for linkage between the state DOT TAMP, Long Range Transportation Plan (LRTP), and the State Transportation Improvement Program (STIP) documents. The STIP comprises the first four years of DelDOT's Capital Transportation Program (CTP) which is a six-year plan that is

[4] *About DelDOT* page: About DelDOT - Delaware Department of Transportation

updated biennially. The CTP/STIP process as it relates to the TAMP is discussed in greater detail in Chapter 6: Financial Plan of this document.

DelDOT fully updates its Statewide LRTP on a five-year cycle and published a new plan in 2019. Annually, DelDOT publishes a supplemental report to include any new initiatives not included in the full document. For instance, the 2021 Annual Supplement includes new or updated processes that address COVID-19. The new plan titled *Innovation in Motion* reflects DelDOT's belief and vision that embracing new technologies and efficiencies will help find the right solutions to meet future challenges while providing the highest level of customer service possible.

Figure 4: Long Range Goals

Innovation in Motion – Long Range Goals	
Safety & Security	Ensure the safe and secure movement of people and goods by reducing injuries and deaths on the transportation network.
Economic Vitality	Promote and strengthen the economic vitality of Delaware with an excellent transportation network that meets the needs of a diverse and growing economy.
Quality of Life	Maintain and enhance vibrant and appealing communities and support planned growth and development through a transportation network that serves the mobility needs of all Delawareans.
Connectivity	Enhance the integration and connectivity of the transportation system across and between modes throughout the state. Provide people with a choice of safe, attractive, and reliable options.
System Preservation	Preserve the transportation network to support travelers and commerce, while adapting to the future's changing needs.
System Management & Operations	Enhance system management and operations through innovative strategies and technology that increase the efficiency of the transportation system.
Resiliency & Reliability	Provide resilient and reliable transportation system that offers predictable travel times under normal conditions as well as efficient and safe use during emergency situations.
Environmental Stewardship	Protect and enhance the environment through sustainable best practices, integration of environmental considerations into planning and design, and responsible energy consumption.
Travel & Tourism	Facilitate efficient mobility options for the state's major tourist destinations that support Delaware residents, businesses and visitors.
Customer Service & Communication	Conduct the highest level of customer service possible to proactively provide information and to learn from and address our customers' needs.

Source: DelDOT 2019 Innovation in Motion: The Delaware Long Range Transportation Plan Delaware Long Range Transportation Plan - Delaware Department of Transportation (deldot.gov)

The LRTP provides a 20-year view of the principles, policies, actions, and performance measures that will shape future transportation investments in the state. The Plan includes ten guiding principles shown in Figure 4 that are used to help guide decisions on the construction and operation of the state's transportation network. It is important to note that multiple guiding principles listed align well with key objectives of the TAMP, i.e., focusing on system preservation and optimization and improving resilience and reliability of the system. The LRTP identified asset management as a key area for strategic planning, performance measures, targets, and time frames.

System Responsibility

While DelDOT is not responsible for maintaining federal or municipally owned roadways, it joins a small minority of states such as Alaska, North Carolina, Virginia, and West Virginia as an outlier compared to peer states by managing nearly 90% of all the roadways in the state. Table 1 below provides a comparison of DelDOT's total system responsibility to that of other jurisdictions within Delaware and to surrounding states in the region based on 2020 data published by FHWA.

Table 1: Delaware Public Road Mileage Comparison

State	State DOT	County	Local Government	Other Jurisdiction[5]	Federal Agency	Total
Delaware	5,466	0	860	78	122	6,526
Maryland	5,207	21,681	4,391	284	866	32,430
New Jersey	2,329	6,712	28,823	815	311	38,991
Pennsylvania	39,713	409	77,877	2,040	807	120,845

Source: https://www.fhwa.dot.gov/policyinformation/statistics/2020/hm10.cfm

National Highway System Significance

The National Highway System (NHS) comprises a network of roadways that are critically important to national security, defense, and the economy. These facilities include interstate highways, principal arterials, major strategic connectors, and intermodal connectors. Delaware's transportation network includes 749 directional centerline miles (1679 lane miles) of NHS routes. DelDOT maintains all NHS mileage with the exception of approximately 13 directional centerline miles on I-295 and SR 9 which are owned and operated by the Delaware River and Bay Authority (DRBA). Table 2 below provides an interesting comparison of NHS mileage and traffic volumes measured by Vehicle Miles Traveled (VMT) to other roadways in Delaware.

Table 2: Delaware Network Mileage and VMT

System	Directional Centerline Miles	VMT (Million)	% Total Mileage	% Total VMT
Interstate	82	1,191	1.4	14.3
Non-IS NHS	667	3,340	11.1	40.0
NHS Total	**749**	**4,531**	**12.5**	**54.3**
Other Federal Aid	1,302	2,312	21.7	27.7
Non-Federal Aid & Suburban	3,946	1,502	65.8	18.0
Totals	**5,997**	**8,345**	**100.0%**	**100%**

Source (for VMT): FHWA Highway Statistics Series 2020 https://www.fhwa.dot.gov/policyinformation/statistics/2020/vm3.cfm

While the NHS comprises just over 12% of Delaware's total network road mileage, it carries over 54% of the traffic in the state. Maintaining pavement and bridges on the NHS system in a state of good repair is critically important to national and state interests. DelDOT monitors pavement and bridge conditions as part of the asset management program and to prioritize investments in critically important infrastructure.

[5] Includes state park, state toll, other state agency, other local agency, and roadways not identified by ownership.

The NHS is strategically important to commerce and the overall economic vitality of Delaware, as is the case with other states. For example, DelDOT's section of I-95, the only interstate route located within the state, serves as the primary north-south corridor along the eastern seaboard. DelDOT has historically given priority to projects that protect the investment in NHS pavements and bridges, utilizing the best data available to drive these decisions. However, as the NHS comprises a relatively small percentage of DelDOT's overall transportation network, the Agency must consider competing needs within finite budgetary constraints.

In addition, other requirements are included within the MAP 21/FAST Act legislation for addressing safety and mobility needs which must also be considered. Accordingly, DelDOT Leadership must make investment trade-off decisions which require careful assessment and analysis of all transportation needs. As DelDOT advances this latest TAMP, it remains committed to making enhancements to its bridge and pavement management systems to better inform long-term programming decisions, ensuring that NHS infrastructure condition targets can be achieved while also addressing other transportation needs within the state.

DelDOT Asset Management Efforts

TAMP Roles & Responsibilities

The key stakeholders in DelDOT's federal TAMP efforts are DelDOT, FHWA, DRBA, and USACE. Figure 5 lists each group's main responsibilities in relation to developing and implementing the TAMP.

While there are no Metropolitan Planning Organization (MPO) owners of NHS assets, MPOs are included in the overall TAM process in Delaware. In 2021, the FHWA division office coordinated a two-day transportation performance management (TPM) workshop with DelDOT, MPOs, and other NHS owners to review progress and plans. The MPOs invited to the workshop include the Wilmington Area Planning Council (WILMAPCO), the Dover-Kent MPO, the Salisbury-Wicomico MPO, and the Delaware Valley River Planning Commission (DVRPC)[6]. The boundaries for each of these planning organizations are depicted in Figure 6 and Figure 7. The workshop included presentations of performance targets and progress against those targets for each group representing pavements, bridges, safety, reliability, and emissions. The workshop supported a transparent and collaborative TAMP effort by involving all Delaware infrastructure stakeholders.

Figure 5: TAMP Roles & Responsibilities

DelDOT	DRBA
Prepares the TAMP Coordinates collection and analysis of NHS pavement and bridge data Implements TAMP processes annually	Provides data to DelDOT for inclusion in the TAMP Reviews applicable sections of the TAMP
USACE	**FHWA**
Provides data to DelDOT for inclusion in the TAMP Reviews applicable sections of the TAMP	Provides guidance for meeting federal requirements Reviews and certifies/recertifies TAMP and development processes Reviews and approves other federal reporting

[6] CONNECTIONS 2050 Explorer (arcgis.com)

Figure 6: DVRPC Planning Area Map

Source: DVRPC Long-Range Plan

Organizational Commitment to Developing and Continuously Implementing the TAMP

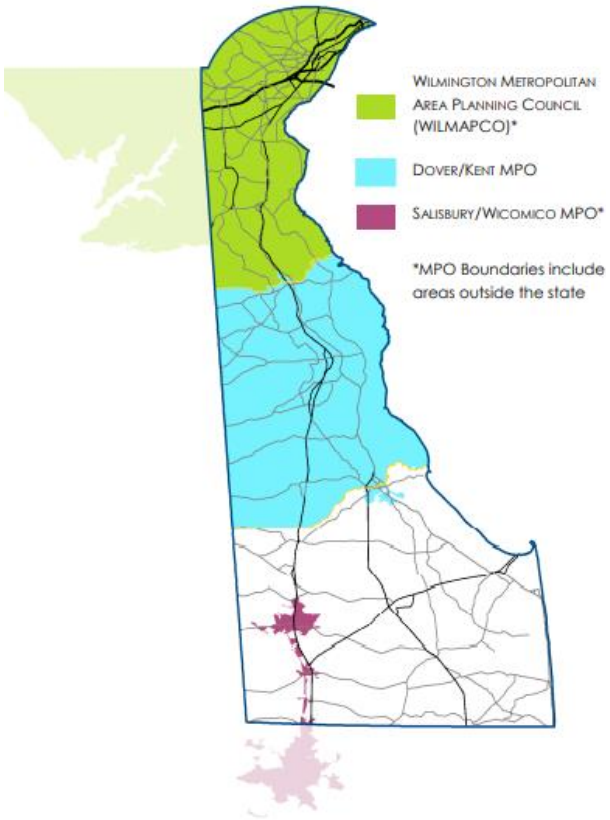
DelDOT believes that every transportation agency has stewardship responsibility for its infrastructure network, and as such, should have a plan for maintaining that network to provide an acceptable level of service. While most agencies have vision statements, mission statements, goals, and strategic plans, these may not specifically address critical infrastructure assets, their condition and service levels, forecasted performance, or the investment strategies needed to protect the investment. Accordingly, DelDOT Leadership made a firm commitment in 2012, following passage of the Map 21 Transportation Authorization bill, to develop a TAMP that would not only align with its vision, mission, goals, and strategic plan, but would also serve as a "business plan" or guide for how the organization should manage its infrastructure assets, beginning with NHS Pavements and Bridges as required by law.

Faced with budgetary constraints and an aging infrastructure, DelDOT realized that making investment decisions in "silos" and managing assets on a "worst first" approach would ultimately lead to imbalances in funding allocations. To best maintain assets, DelDOT leadership determined that Transportation Asset Management (TAM) was the most effective approach for the agency to embrace.

To effect the necessary change, DelDOT Agency Leadership proactively established an Asset Management Team that included key Agency resources from the Transportation Solutions, Maintenance and Operations, Planning, Information Technology, and Finance Divisions as well as Delaware Transit. The Asset Management Team operated under a Team Charter with team meetings held at least monthly for over a year in order to develop the initial DelDOT TAMPs in 2018 and 2019.

The asset management Steering Committee has since replaced the Asset Management Team. The Steering Committee has representatives from Management Groups (referred to as Asset Stewards), Transportation Solutions, Transportation Resiliency and Sustainability, Planning, Maintenance and Operations, Information Technology, Finance, and the University of Delaware. This committee is responsible for data analysis, needs forecasting, performance reporting, and updates to and implementation of the TAMP. The Steering Committee follows the implementation processes outlined in the

Figure 7: Delaware MPO Boundaries



Source: DelDOT LRTP

document titled *DelDOT Asset Management Program: A Guide to Implementing and Updating Plans* (referred to as the TAM Guide) including the hosting of quarterly update meetings. The TAM Guide was developed in 2020 to document DelDOT's asset management processes and provide a resource for all involved parties to use in the annual TAM implementation effort.

Asset Management continues to advance within DelDOT, with enhancements to business processes and management systems to support decision making, with an on-going commitment to focus capital and operational programs on maintaining a broad group of assets in a state of good repair. Importantly, through the development of this TAMP and other asset management documentation, DelDOT has now adopted decision making processes which are outlined in the chapters that follow. This ensures that the investment in critical pavement and bridge assets on the NHS is protected and the network operates at a satisfactory and sustainable level of service.

The TAMP is intended to function as a "living document" that will be used by decision makers, and practitioners alike, as well as DelDOT's external stakeholders. DelDOT grows and adapts to changes in legislation and new requirements, updating documentation and processes as necessary. For instance, DelDOT has improved the processes and discussion around extreme weather and resilience in the life cycle planning and risk management analyses with the passing of the IIJA.

Pavement and Bridge Data Collection and Management

Pavements

DelDOT utilizes automated data collection equipment provided by outside vendors to collect pavement distress and other roadway characteristic information such as rutting and ride quality. DelDOT has updated methods to collect and analyze roadway distress data with more detailed calibrations for different facilities, pavement types and distress conditions. Custom software is employed to provide a digitized record of roadway conditions, thereby creating a more accurate and reliable rating system.

A condition survey of every state-maintained road segment is performed biennially, although those state-maintained roads that are part of the National Highway System (NHS) are surveyed every year. This survey is a combination of various automated collection techniques and some visual inspection to determine the severity and extent of the pavement distresses present in the roadway. Automated pavement condition data is collected on NHS routes in 0.10 mile segments and the information collected includes cracking, rutting and ride quality for flexible and composite pavements and cracking, faulting and ride quality for concrete pavements. Data for NHS pavements is submitted to FHWA through the HPMS and is used for determining performance results in accordance with the Map21/FAST Act legislation. An additional requirement of the legislation was development of a pavement Data Quality Management Plan (DQMP) which DelDOT has completed, and which has been approved by FHWA. Additional details on Pavements are provided in Chapter 2: Pavements of this document.

Bridges and Structures

DRBA and USACE have their own consultants to inspect bridges within their respective jurisdictions. DelDOT performs inspections on all other bridges and structures which fall under the requirements of the National Bridge Inspection Standards (NBIS). These inspections are typically performed biennially though some structures may require more frequent and detailed inspections depending upon the design, age, and condition of the structure. Bridge inventory and condition data for all public bridges in the state is stored in the agency's AASHTOWare BrM Bridge Management System (BMS). Required bridge condition reporting is submitted to FHWA annually. The

DelDOT bridge inspection program operates under strict Federal guidelines which ensure the safety of all public bridges, and the program and audits are routinely carried out by FHWA staff in the Delaware Division office.

National Bridge Inventory (NBI) bridge condition data collected through the bridge inspection program is used for determining DelDOT's performance with respect to National metrics included in the Map21/FAST Act legislation. Additional details are provided in Chapter 3: Bridges of this document.

Management Systems

Asset management provides DelDOT with the framework for an integrated, comprehensive, and strategic approach for addressing Delaware's transportation needs. Asset management systems like the pavement and bridge management systems are an essential component of the overall process as they provide the storage, analysis, and reporting capabilities for the asset data that is used to drive program and project decision making. Recognizing the importance of these systems, DelDOT has made and continues to make significant investments to acquire, support, upgrade, and enhance the software tools needed for an effective asset management program. This includes ensuring that specific analysis capabilities required for the TAMP and associated performance reporting as outlined in this document are available to agency staff.

Pavement and bridge management systems are the most important software tools needed to support DelDOT's TAMP. However, other software applications are also necessary to support the overall TAMP business processes.

DelDOT implemented its AgileAssets pavement management system (PMS) in the late 1990's and the system has undergone numerous upgrades since that time. These include recent analysis-related enhancements to fully support the investment strategies required by the TAMP as well as the new performance metric reporting requirements covered in detail in Chapter 2: Pavements.

For managing bridge and structure assets as well as satisfying annual federal condition reporting requirements, DelDOT has relied upon software tools available through AASHTO. Like most of its peer states, DelDOT utilized the PONTIS bridge system for many years and recently began using the AASHTOWare BrM product which will ultimately provide the necessary capabilities to support the analysis and reporting requirements covered in Chapter 3: Bridges.

Other key systems and software tools used by DelDOT to support asset management at the program and project level include:

- Oracle P6 Project Management System for tracking Capital projects from inception through letting
- Decision Lens which provides a ranking matrix for prioritizing Capital Projects
- Oracle Unifier as the E-Construction program for managing projects once they have been let to contract
- TSDM7, DelDOT's Business Warehouse tool which serves as a repository for all asset management data
- Maximo supports management of assets other than pavements and bridges
- AASHTOware Project Preconstruction supports the starting processes of proposal preparation, pricing, and bid letting

Lastly, many of these systems are integrated with DelDOT's Financial system to provide necessary costing related information.

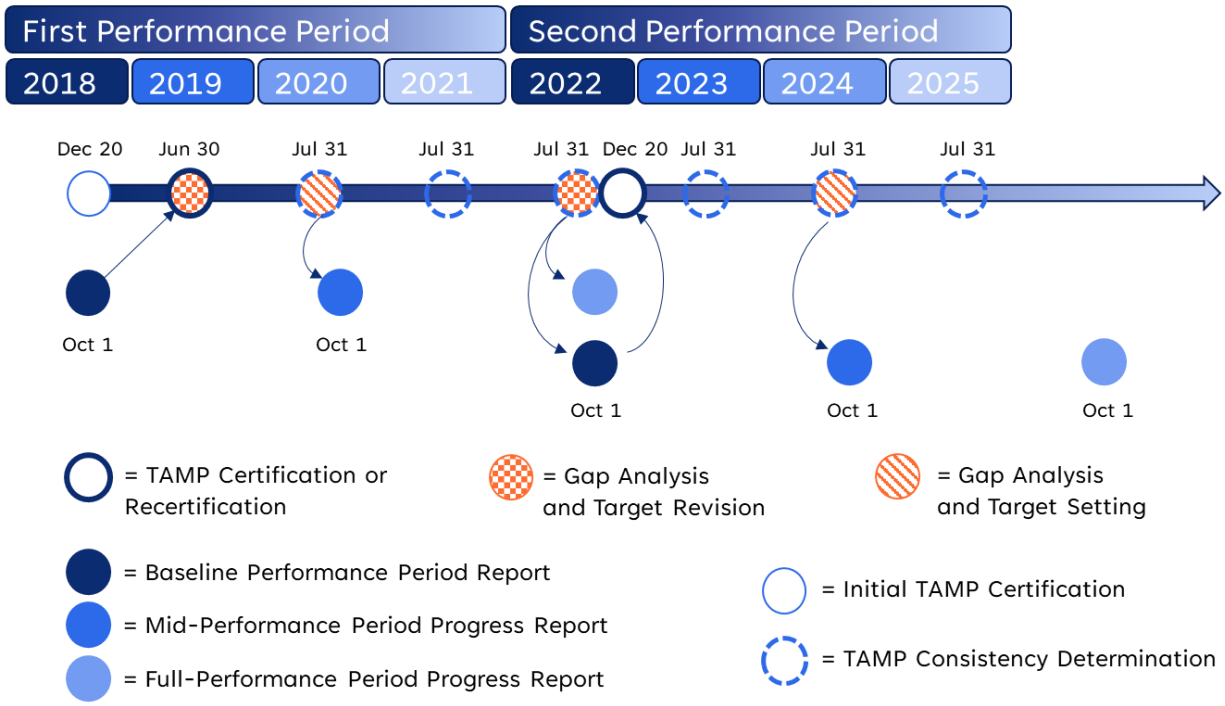
[7] Still under development

Overview of TAMP Process

Performance Periods and Milestones

Much of the TAMP process is based around the performance periods[8] defined in the legislation. These performance periods and the associated milestones relevant to the TAMP are shown in Figure 8.

Figure 8: Performance Periods and Milestones



It can be seen from the Figure 8 that there are a set of basic elements that are part of every 4-year cycle:

- TAMP Certification: DelDOT's first TAMP coincided with the beginning of a 4-year Performance Period. A new revised TAMP is required to be submitted and certified by FHWA every four years, so these have been connected to the performance period cycle. For instance, in 2022, at the start of the second performance period, this new revised TAMP will be submitted by the four-year anniversary of the initial certification date (December 20, 2018[9]).
    - Informing the TAMP is the condition data collected for bridges and pavements (due March 15, April 15, and June 15)
    - The TAMP contains new Targets and an associated Gap Analysis
    - The TAMP aligns with the Baseline Performance Period Report (due October 1, 2022)
- Gap Analysis and Target Revision or Target Setting: Initial targets are set at the beginning of the Performance Period and reported in both the TAMP and the Baseline Performance Period Report. At the mid-point of the Performance Period, a gap analysis may be conducted, and targets revised if necessary. For instance, in 2024, in the middle of the second Performance Period, a gap analysis and target revisions may

[8] 23 CFR 490.105(e)(4)(i)

[9] AASHTO TAM Portal – TAMP Certification Dates: TAMPs – The TAM Portal (tam-portal.com)

be undertaken. At the endpoint of the Performance Period, another gap analysis is completed to compare the actual 4-year conditions to the 4-year targets.

  - Initial Targets are set in the Baseline Performance Period Report
  - Any revised Targets are reported in the Mid-Performance Period Progress Report (due October 1, two years following the Baseline Report)
  - A final gap analysis is completed for the Full-Performance Period Progress Report (due October 1, four years following the Baseline Report)

- TAMP Consistency Determination: Every year of the Performance Period, DelDOT submits documentation and FHWA determines whether the State is adhering to the last certified TAMP. For instance, in 2022, at the start of the second performance period, a consistency determination was conducted to determine if the State was adhering to the plan certified in 2019.
  - The information submitted should show that the State DOT is using the investment strategies in its most recently certified TAMP to make progress toward achieving its targets for NHS asset condition and performance.

Because of the transition period, the elements and the timing in the first performance period from 2018 to 2021 are a little different from the ongoing cycle shown in the second performance period from 2022 to 2025. The cycle shown for 2022 to 2025 will be similar for future Performance Periods.

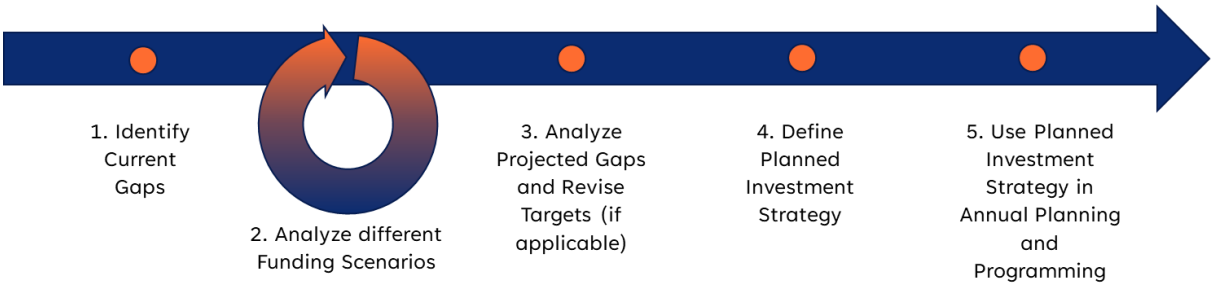
Investment Strategy Planning Process

The ultimate purpose of the TAMP is to document a planned investment strategy consisting of planned budgets per work type for each asset type, for the next 10 years. To develop and implement a new investment strategy in the TAMP every 4 years, DelDOT follows several major steps. These steps are covered in more detail in Chapter 4: Risk-Based Life Cycle Management.

- Step 1: Identify Current Gaps – Gaps between condition targets set at the beginning of the previous performance period and the actual conditions of the assets over the previous 4 years are assessed.
- Step 2: Analyze different Funding Scenarios and Project Future Network Condition – In order to confirm previous targets or set new ones for the upcoming performance period, various possible funding strategies are identified and analyzed.
- Step 3: Analyze Gaps and Revise Targets (if applicable) – Once the scenarios have been analyzed, the forecasted conditions over the next 10 years for each scenario are used to compare against the previous condition targets. Targets are revised if necessary.
- Step 4: Define Planned Investment Strategy – Based on the results of the Gap Analysis, Agency Leadership, in consultation with the Steering Committee and the individual Asset Stewards, finalize the targets and a planned investment strategy for each asset class. The adopted 10-year investment strategy consists of planned funding per work type for each asset class in each year of the TAMP period.
- Step 5: Use Planned Investment Strategy in Annual Planning and Programming – Once the planned investment strategy has been agreed by Agency Leadership and documented in the TAMP, this strategy is used by the individual Asset Stewards in their annual planning and programming process to inform the selection of projects (for instance for inclusion in the CTP/STIP).

These general steps are shown in in Figure 9 below.

Figure 9: TAMP Process for Developing and Implementing Planned Investment Strategies



To accomplish the goal of developing and documenting a planned investment strategy, the TAMP process provides analysis to support data driven decisions regarding tradeoff between long-term sustainable state of good repair and cost. DelDOT considers tradeoff between the long-term sustainable state of good repair and costs for different asset types and subtypes, for example pavement versus bridge and NHS versus non-NHS. The definition of metrics to measure current condition and track progress towards a long-term sustainable state of good repair is thus important. The specific metric definitions with respect to pavements and bridges are discussed individually in Chapter 2: Pavements and Chapter 3: Bridges. Within this document, state of good repair refers specifically to the physical condition of the assets. The analyses presented in the following chapters are undertaken with the goal of determining what long-term level of service is attainable and sustainable by adopting certain funding strategies, or conversely, what funding is needed to attain and maintain certain levels of condition.

DelDOT Transportation Asset Management Implementation Guide

To ensure effective and consistent implementation of asset management practices, DelDOT has developed the TAM Guide which outlines all asset management activities. In addition to requirements, reporting, and activities required for the federal TAMP, the TAM Guide includes general guidance for developing an asset management program for any asset class. The TAM Guide provides an annual schedule for asset management as depicted in Figure 10. This schedule includes milestones for the reporting requirements listed at the beginning of this chapter and the five steps outlined in Figure 9 above.

Note that corresponding sections of the TAM Guide are listed in the far-left column of Figure 10. Each TAM Guide section provides significant detail for each schedule task. The overarching steps of the TAM implementation align with the five steps in the life cycle management process outlined in the previous section and detailed in Chapter 4: Risk-Based Life Cycle Management.

Figure 10: DelDOT Annual TAM Implementation Calendar (Light Blue = Year 1, Medium Blue = Year 2, Dark Blue = Year 3, Yellow with Dots = Meeting, Orange = TAMP Certification)

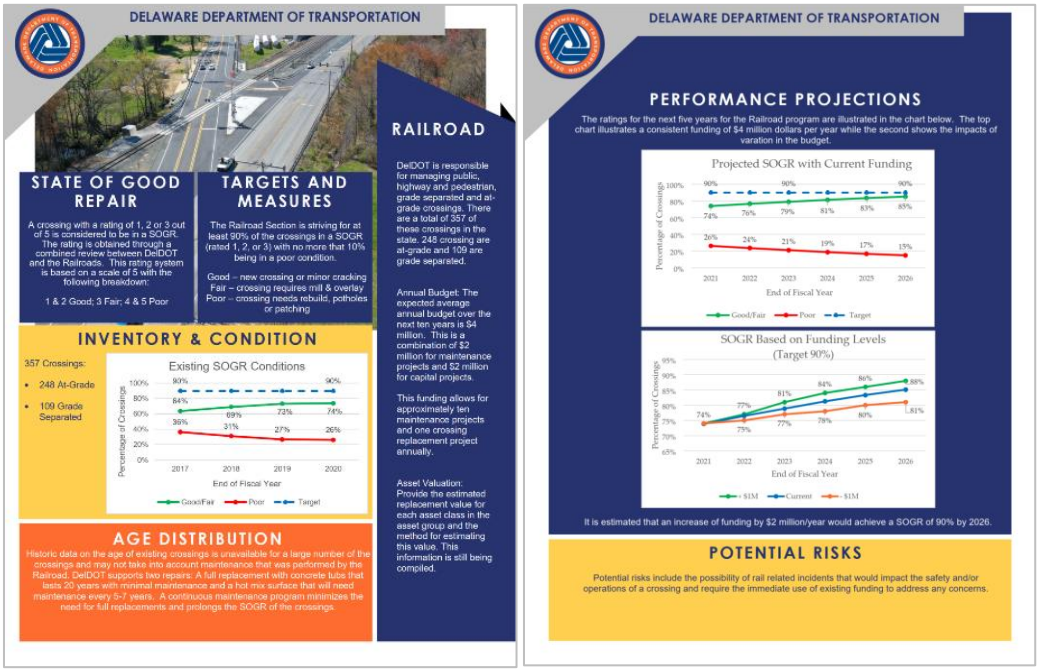
Guide Section	Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2.1.4	SC Meeting: Kickoff TAMP Process												
2.2	Update Risk Register and Part 667 Evaluations (Biannual)												
2.3	Step 1.0 Identify Current Gaps												
2.3.1	Step 1.1 Data Collection												
2.3.1, 2.3.3.3	Step 1.2 Note NHS asset condition targets												
2.3.1, 2.3.3.3	Step 1.3 Determine current condition for FHWA metrics												
2.3.1, 2.3.3.3	Step 1.4 Compare current conditions with target FHWA condition metrics												
2.3.1	Step 1.5 Compare Current State Metric Condition Values to SOGR Targets												
2.3, 2.4	Step 2.0 Analyze Different Funding Scenarios												
2.3.2.1	Step 2.1 Update inventory and condition in management system												
2.3.2.2	Step 2.2 Update analysis parameters (See TAMP)												
2.3.3.1	Step 2.3 Update Baseline Funding Scenario												
2.3.3	Step 2.4 Project Selection / Optimization												
2.3.4	Reporting: Submit NBI data on highway bridges												
2.3.4	Reporting: Submit Pavement HPMS Data (Interstate) to FHWA												
2.3.4	Reporting: Submit Pavement HPMS Data (Non-Interstate) to FHWA												
2.4.2.1	Step 2.5 Define multiple funding scenarios (10 Years)												
2.4.2.2	Step 2.6 Run life cycle optimization analysis for each scenario												
2.4.2.2	Step 2.7 Report and anlyze resulting project work plans												
2.4.2.3	Step 2.8 Submit projections for scenarios to SC with Recommendations												
2.4.2.3	SC Meeting: Review projections and recommendations from Management Groups												
2.4.3	Step 3.0 Analyze projected gaps and revise targets												
2.4.3.1	Step 3.1 Compile scenario results from asset groups												
2.4.3.2	Step 3.2 Compare projected to SoGR and FHWA targets												
2.4.4	Step 4.0 Define Planned Investment Strategy (based on funding scenarios)												
2.4.4.1	Step 4.1 Recommended adjusted scenarios to AL and revise targets if necessary												
2.4.4.2	SC/AL Meeting: Propose recommendations to AL												
2.4.4.3	Step 4.2 Approve funding scenarios and targets revisions												
4.1	Reporting: SOGR Summary Sheet Update												
2.4.5	SC Meeting: Review AL Decisions and Determine Next Steps												
2.4.4.4	Step 4.3 Appropriate Budgets												
2.4.4.5	Step 4.4 Update TAMP and Investment Strategies												
2.5.3	Step 4.5 Update Strategic Plan												
2.4.4.6	Step 4.6 Performance Period Reporting												
2.4.4.6, 2.5.1	Reporting: Performance Period Reporting												
2.5	Step 5.0 Implement Investment Strategy												
2.3.3, 2.5.2	Step 5.1 Project prioritization												
2.5.3	Step 5.2 Update CTP/STIP												
2.3.3, 2.5.2	Step 5.3 Projects selected												
2.5.6	Step 5.4 Project delivery process												
2.5.4	Step 5.5 Consistency Review												
2.5.4	Reporting: TAMP Consistency Determination												
2.5.6	SC Meeting: Review Reporting and any Feedback from FHWA												
Chapter 3	Reporting: TAMP Certification												

Source: DelDOT TAM Guide

This TAM Guide applies not only to NHS pavements and bridges, but other asset groups as well. DelDOT has added a chapter to the TAM Guide titled *Expanding the Program* which can be applied to any asset class DelDOT chooses to build into the asset management program. The ultimate goal of the process for assets not included in the TAMP is the development of a State of Good Repair (SOGR) Summary Sheet. Figure 11 presents an example SOGR Summary Sheet for Railroad Crossings. In addition to the Railroad Crossings, there are currently SOGR Summary Sheets for assets including Stormwater Best Management Practices, Pavement Long Line Striping, Overhead Signs and High Mast Lighting Structures, Pavements, and Bridges. The additional asset groups follow a similar schedule to that presented in Figure 10, though many of the reporting dates only apply to NHS pavements

and bridges. All assigned asset groups, including pavement and bridge, produce a SOGR Summary Sheet annually for the gap analysis and cross asset decision-making process.

Figure 11: Railroad Crossings SOGR Summary Sheet (2021)



Source: DelDOT TAM Guide

Chapter 2: Pavements

Out of over 5,000 miles contained within Delaware's border, 749 directional centerline miles are required to be reported on in the Federal TAMP. This chapter provides a detailed look at the NHS mileage in Delaware starting with how DelDOT defines when a pavement section is in a state of good repair. All newly constructed pavements in Delaware are in Good condition, but what happens after that? Traffic and aging both lead to deterioration of the pavement's condition. This chapter defines what makes a pavement section Good, Fair, or Poor, provides an overview of the NHS pavement inventory and current conditions, sets targets for the future pavement conditions, and examines how the conditions are expected to change over time using the life cycle analysis capabilities of the pavement management system (PMS). Based on this information, DelDOT developed an investment plan for pavement projects that supports the progress toward, and achievement of, the condition targets and extension of the life of DelDOT's pavement network.

Performance Metrics and State of Good Repair

DelDOT's TAMP is focused on maintaining critical NHS pavement and bridge assets in a state of good repair. The current state of good repair, or physical condition of Delaware's pavements, is tracked according to two sets of performance measures:

- The Overall Pavement Condition (OPC) is the State's internal performance measure which is a combination of functional, structural, and non-structural indices. This applies to all pavements.
- The FHWA condition performance measures of Percent Good and Percent Poor are derivatives of the HPMS distress measures. If two or more distress measures are Poor for a section, then the section is considered Poor overall. If all measures are Good for a section, then the section is considered Good. Any other combination of measures is considered Fair. These apply specifically to NHS pavements.

While both are important measures of physical condition for DelDOT, the primary metric that the state maximizes over time through its optimization analyses is the OPC. Therefore, the OPC is the primary metric used to track status with respect to long-term continuous targets. The resulting FHWA metrics are then tracked and forecasted within the PMS. These two sets of measures are described in more detail in the following sections.

State and Federal Performance Metrics

Internal Overall Pavement Condition (OPC)

For all pavements, separately from the FHWA required pavement condition metrics, DelDOT calculates and tracks a State-specific metric, OPC. This index is used to define the general health of a pavement section by combining individual distress indices into a calculated value.

The full definition of the OPC index for all pavement types is given in the DelDOT AgileAssets Pavement Management System Engineering Configuration Document[10]. Individual Distress Indices (IDI) are used to calculate Combined Distress Indices (CDI) which are then used to calculate the final OPC. Table 3 outlines how the individual indices are combined to calculate the OPC for Asphalt and Concrete pavements.

DelDOT's OPC includes Cracking, Rutting, IRI[11], and Faulting measurements from the HPMS condition survey. Table 3 shows that the State OPC index for Flexible (Asphalt) pavements includes Cracking, Rutting and Roughness (IRI), and for Rigid (Concrete) pavements, the OPC includes Cracking, Faulting and Roughness (IRI). The OPC is thus similar but not identical to the FHWA metrics described in the next section.

Note that the OPC calculation is currently being reviewed and may change in the next few years. For the purposes of this TAMP, the calculation stands.

[10] Source: DELDOT PMS Configuration Document-Updated June 2022 Section 3.0 – See Appendix A – Explanation of Overall Pavement Condition (OPC) Configuration.

[11] International Roughness Index (IRI) is an internationally accepted method of measuring roughness based on the longitudinal profile of the road.

Table 3: OPC Index Components

OPC Index – Pavement Type	CDI – (OPC Component Indices)	IDI – (CDI Component Indices) Note: There are also IDIs for each distress severity used to calculate the total distress IDI.				
Flexible Index	**Structural Index**	Fatigue Cracking	Patch Deterioration			
	Non-Structural Index	Transverse Cracking	Block Cracking	Surface Defects / Raveling	NWP Longitudinal Cracking	
	Functional Index	Rutting	IRI			
Composite Index	**Structural Index**	Fatigue Cracking	Patch Deterioration			
	Non-Structural Index	Reflective Cracking	Block Cracking	Surface Defects / Raveling	NWP Longitudinal Cracking	
	Functional Index	Rutting	IRI			
Surface Treated Index	**Structural Index**	Fatigue Cracking	Edge Cracking	Patch Deterioration		
	Non-Structural Index	Transverse Cracking	Block Cracking	Surface Defects / Raveling	Bleeding	NWP Longitudinal Cracking
	Functional Index	Rutting	Crown > 6%			
Concrete Index	**Slab Distress Index**	Slab Crack	Patch Deterioration	ASR		
	Joint Distress Index	Joint Seal Loss	Joint Deterioration			
	Functional Index	IRI	Faulting			

A pavement section with an OPC rating of 50 or above is defined as being in a state of good repair. The OPC ratings are determined as previously explained by combining individual distress indices into a calculated value that defines the health of a pavement section. DelDOT defines targets based on percentage of the network of pavement segments defined to be in a state of good repair.

Federal Condition Metrics

The FHWA condition metrics are based upon the percentage of tenth-mile HPMS section data that are in Good, Fair, or Poor condition. Each tenth-mile HPMS section is classified as being in Good, Fair, or Poor condition based on the definition in the code of federal regulations (CFR), specifically 23 CFR 490.313(c)[12], where:

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

[12] 23 CFR 490.313(c): https://www.ecfr.gov/current/title-23/chapter-I/subchapter-E/part-490#p-490.313(c)

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

Agencies are required to set targets for % Good and % Poor for Interstate and the non-Interstate NHS. These targets are set for each network and are currently established for the 2022-2025 Performance Period. These targets are discussed later in this section.

Inventory and Current Condition

Description of NHS Pavement Inventory

DelDOT is responsible for managing 749 directional centerline miles of NHS roadways. The pavement inventory in directional centerline miles and lane miles by functional class (regardless of owner) are shown in Table 4.

Table 4: Pavement Inventory by System

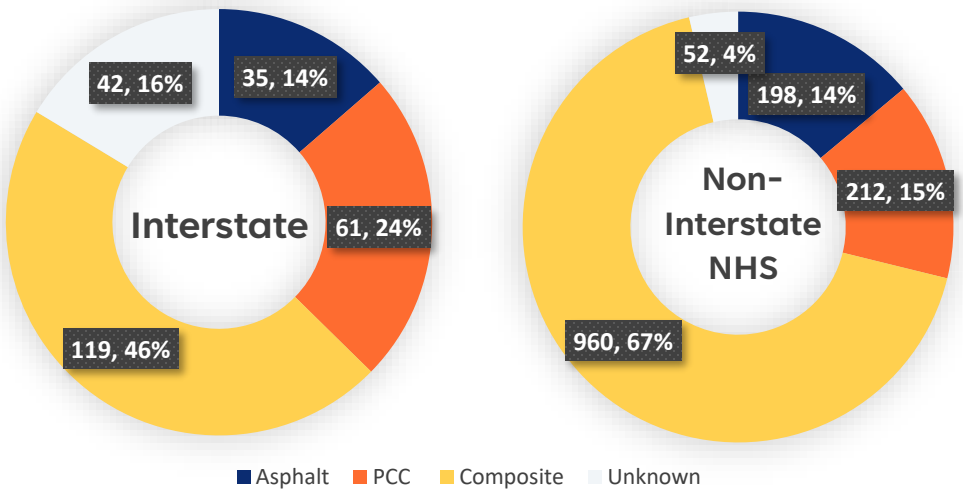
System	Directional Centerline Miles	Lane Miles	Lane Miles %
Interstate-DelDOT	82	257	2%
Non-IS NHS-DelDOT	667	1,422	12%
Other Federal Aid*	1,302	2,568	21%
Non-Federal Aid	2,387	4,765	39%
Suburban**	1,559	3,112	26%
Total System	**5,997**	**12,124**	**100%**

* Indicates non-NHS roads with a classification above minor collector. This includes interstate ramps as they are not on the NHS.

** Note that suburban routes are off the NHS and typically not included in state analysis as the funding mechanism is separate. For these reasons, this is the final mention of Suburban routes in the TAMP document.

The NHS inventory is summarized by surface type in Figure 12. Most of DelDOT's NHS pavements (46% of Interstate and 67% of Non-Interstate NHS) are composite. Some pavement surface types are undocumented at this time.

Figure 12: NHS Directional Centerline Miles by Surface Type



There are sections of the NHS located in Delaware which are owned and maintained by entities other than DelDOT. The Delaware River and Bay Authority (DRBA) owns portions of I-295 adjacent to and including the Delaware Memorial Bridge (approximately 8.5 directional centerline miles), as well as a portion of SR9 near the Cape May/Lewes Ferry (approximately 4.8 directional centerline miles). These sections of the NHS are owned and maintained solely by DRBA. However, DelDOT manages the data collection on these sections. Coordination between the DelDOT Pavement Management Group and DRBA is discussed later in this chapter.

Figure 13: Pavement Directional Centerline Miles per System

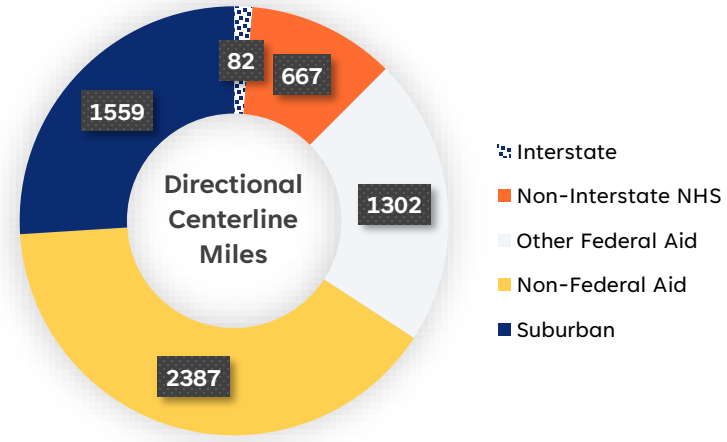


Figure 13 shows the breakdown of the pavement inventory making up Delaware's NHS roadway network.

Description of NHS Pavement Condition

Current State Internal Overall Pavement Condition (OPC)

The current condition of Delaware's NHS pavement network with respect to OPC is given in Table 5.

Table 5: NHS Pavement Inventory and Condition based on OPC

System	Directional Miles in State	% of Delaware NHS	Average OPC
Interstate Pavements – State Metrics	82	11%	93
Non-Interstate NHS Pavements – State Metrics	667	89%	86
Total NHS Network	**749**	**100%**	**90**

Current FHWA Condition Metrics

With regard to the FHWA condition metrics, Delaware pavements are generally in Good condition with 60.7% of Interstates and 40.3% of Non-Interstate NHS in Good condition, and 0.3% of Interstates and 0.7% of Non-Interstate NHS in Poor condition as shown in Table 6.

Table 6: NHS Pavement Condition – Current Baseline Values for 2022-2025 Performance Period

System	Good Condition	Poor Condition
Interstate Pavements – FHWA Metrics	The percent of Interstates in a Good condition [23 CFR 490.307(a)(1)] by tenth-mile section mileage [13] **2021 Baseline Value: 60.7%**	The percent of Interstates in a Poor condition [490.307(a)(2)] by tenth-mile section mileage **2021 Baseline Value: 0.3%**
Non-Interstate NHS Pavements – FHWA Metrics	The percent of Non-Interstate NHS in a Good condition [23 CFR 490.307(a)(3)] by tenth-mile section mileage [14] **2021 Baseline Value: 40.3%**	The percent of Non-Interstate NHS in a Poor condition [490.307(a)(4)] by tenth-mile section mileage **2021 Baseline Value: 0.7%**

Obtaining Data from other NHS Owners

As noted in Section 2.2 above, in addition to DelDOT, the Delaware River & Bay Authority (DRBA) also owns and maintains pavement on the NHS in Delaware.

Specifically, for pavements and regardless of ownership, the data collection vendor surveys inventory and condition data on all NHS road sections along with all other DelDOT owned roads. As a result, all the roadways owned and operated by DRBA are surveyed as part of the main DelDOT data collection contract and this data is imported along with all other data into the pavement management system (PMS).

DRBA does not have a formal asset management plan in place. If there are projects that DRBA lets to contract that include any DelDOT-maintained pavement sections, all expenses are initially paid by DRBA and a reimbursement agreement collects any funds from DelDOT. In addition, portions of SR54 in Delmar running along the Maryland/Delaware border are maintained either by DelDOT or the Maryland State Highway Administration (SHA) but the ownership and maintenance responsibilities are not shared. Communication is a collaborative and coordinated effort between partners when improvements or maintenance is needed on these roadways.

Committed projects for the DRBA owned pavement sections are obtained annually for inclusion in the PMS analysis of the pavement network. These projects are obtained by providing DRBA with a spreadsheet to fill out and return with the appropriate information. A review meeting is held between the DRBA and DelDOT pavement management representatives to discuss and review any questions or inconsistencies. DRBA provided their planned project list for next 15 years, which was added to the Master Work Plan (MWP) in the PMS so the analysis does not select projects using DelDOT's money. The final list of planned pavement projects from DRBA is included in Appendix C.

Objectives and Targets

The fundamental objective for pavements is that they should provide satisfactory ride quality while maximizing the pavement structure's life cycle. As noted above, the primary measure of pavement condition for Delaware is the

[13] Estimated Baseline values are taken from the PMS and are an estimate of the current baseline values using the full HPMS distresses

[14] Baseline IRI values were taken from HPMS and are for IRI only. These are reported in the 2018 Baseline Performance Report.

weighted average OPC. The State has thus historically managed their pavements using OPC targets as defined below, and these OPC targets represent the desired continuous long-term state of good repair for Delaware. As established with the TAMP requirements, FHWA's defined condition metrics are also tracked and compared to targets that align with the State's desired long-term state of good repair.

The general approach taken by DelDOT is to conduct life cycle optimization analysis to maximize weighted average OPC across the network over a long-term analysis period subject to funding constraints. Based on the recommended list of projects resulting from the analysis, the metrics for comparison with the OPC target values can then be projected as described below. In addition, these projects can then be overlaid on the tenth mile segmentation required by the FHWA to conduct the FHWA condition metric calculations. In this way FHWA metrics can also be projected and compared to the associated targets. Since the metrics measure the condition of the pavement network at any particular point in time, it should be noted that the goal is to maintain the pavement network within the desired long-term network state of good repair targets continuously if possible. In the case of the OPC metrics, the targets represent the long term sustainable desired network state of good repair. These targets are thus continuously used to measure state of good repair status and there are no specific 2, 4, or 10-year targets. However, it is recognized that one or both of the desired continuous OPC targets may not be met for short periods of time.

In the case of the FHWA condition metrics, specific point in time targets are required for performance period reporting. While these targets are set for specific years, they are aligned with the continuous OPC target network state of good repair. The targets for each of the state of good repair metrics are described below.

Internal Overall Pavement Condition (OPC) State Targets for Long Term Network State of Good Repair

By using the OPC[15] calculation for each of the different pavement types, DelDOT is able to use this normalized index to set targets for the pavement network. Delaware's pavements are maintained to meet the following targeted levels of service for long term state of good repair:

- 75% meets or exceeds an Overall Pavement Condition (OPC) rating of 60
- No more than 15% has an OPC rating below 50

These long-term state of good repair targets are shown below in Table 7.

Table 7: Pavement Condition – State Network State of Good Repair Targets

System	Good Condition	Poor Condition
All Pavements – OPC	75% meets or exceeds an OPC rating of 60.	No more than 15% has an OPC rating below 50.

Target FHWA Condition Metrics

Table 8 lists the measures and targets defined for pavements. The new performance measures as required by FHWA are incorporated into the table.

[15] For a brief description of the OPC index, see Current State Internal Overall Pavement Condition (OPC) on page 20 above.

Table 8: NHS Pavement Condition – FHWA Targets

System	Good Condition	Poor Condition
Interstate Pavements – FHWA Metrics	The percent of Interstates in a Good condition [23 CFR 490.307(a)(1)] by tenth-mile section mileage – **2023 Target: at least 50.0%.** – **2025 Target: at least 50.0%.**	The percent of Interstates in a Poor condition [490.307(a)(2)] by tenth-mile section mileage – **2023 Target: should not exceed 2.0%.** – **2025 Target: should not exceed 2.0%.**
Non-Interstate NHS Pavements – FHWA Metrics	The percent of Non-Interstate NHS in a Good condition [23 CFR 490.307(a)(3)] by tenth-mile section mileage – **2023 Target: at least 40.0%.** – **2025 Target: at least 40.0%.**	The percent of Non-Interstate NHS in a Poor condition [490.307(a)(4)] by tenth-mile section mileage – **2023 Target: should not exceed 2.0%.** – **2025 Target: should not exceed 2.0%.**

These two- and four-year targets for pavements in Good and Poor condition were based on the 2022 gap analysis process outcomes. Note that these are continuous targets, so the two- and four-year targets are the same for each category. Forecasted conditions were compared to previously set targets and adjustments were recommended based on the comparisons. The most current data from the 2021 pavement distress collection cycle was used for this determination. Agency Leadership provides the final decision on whether targets change.

The Non-Interstate NHS target for percent Good was updated from 55% to 50% since the 2019 TAMP as part of the mid-performance period reporting process in 2020 due to the optimistic initial target. Targets for Interstate % Good, Interstate % Poor, and Non-Interstate % Poor from the 2020 mid-performance period report submission were maintained for the new performance period covering 2022-2025. The Non-Interstate % Good target was lowered from 50% to 40% due to changes in the forecasted conditions. Projected conditions in terms of federal metrics are expected to dip over the next few years, coming close to the targeted % Good by the end of the 2022-2025 performance period. Therefore, the non-Interstate NHS % Good target has been lowered from the previous performance period. The lower target will allow focus on preservation of the system and provide an appropriate level of service of the full system. DelDOT optimizes the network condition using state metrics and produces projections for FHWA metrics as a subsidiary result. Thus, the federal targets for the NHS support the maintenance of DelDOT's full network to achieve an appropriate level of service. The full gap analysis process is discussed in the next section.

Gap Analysis and Condition Projections

The Pavement Management Group followed the life cycle planning process outlined in Chapter 4: Risk-Based Life Cycle Management. The outcomes of the first three of five steps are detailed below. The remaining two steps are reviewed in Chapter 6: Financial Plan.

Discussion of Gaps between Targets and Projected Condition

Step 1: Current Gaps

Based on the conditions and targets identified, the pavements in Delaware on the NHS are currently meeting targets in all categories.

For the State long term network state of good repair targets for Overall Pavement Condition (OPC), with respect to pavements in Good condition, 76.2% of the road system currently has an OPC of greater than 60. This is better than the target of 75%. With respect to pavements in Fair condition, 13.3% of the road system currently has an OPC less than 50. This is also below the maximum target of 15%.

For the FHWA condition metrics, the current baseline[16] (2021) is that 60.7% of Interstate pavements are in Good condition which is more than the target of 50.0%. For Poor pavements, it is estimated that 0.3% of pavements are in Poor condition which is better than the target of 2.0%. For Non-Interstate NHS roadways, the current estimated baseline is that 42.4% of pavements are in Good condition, which is better than the target of 40.0%. Although the percent of pavements in Poor condition, at 0.7%, is slightly more than for Interstates, this is still better than the target of 2.0%.

The gaps between the 2021 baseline conditions and the 2025 target conditions are summarized in Table 9. The 4-year targets are set in the Baseline Performance Period report and are reassessed in the Mid-Performance Period Progress report. Thus, the 4-year 2025 targets may be updated in 2024 once actual 2023 data is available and additional analysis is completed.

Table 9: NHS Pavement Condition – Gaps between 2021 Baseline and Target Values

Asset Class	Measure	Current Condition	Target	Gap
NHS Pavements	**Overall Pavement Condition (OPC)**			
	Percent ≥ 60	76.2%	≥ 75%	No Gap
	Percent < 50	13.3%	≤ 15%	No Gap
NHS Pavements	**FHWA Percent Good and Percent Poor**			
	Interstate Percent Good	2021 Baseline: 60.7%.	2023 Target: at least 50.0% 2025 Target: at least 50.0%.	No Gap
	Interstate Percent Poor	2021 Baseline: 0.3%.	2023 Target: less than 2.0% 2025 Target: less than 2.0%.	No Gap
	Non-Interstate NHS Percent Good	2021 Baseline[17]: 42.4%.	2023 Target: at least 40.0% 2025 Target: at least 40.0%.	No Gap
	Non-Interstate NHS Percent Poor	2021 Baseline[17]: 0.7%.	2023 Target: less than 2.0% 2025 Target: less than 2.0%.	No Gap

Step 2: Funding Scenario Analyses

Prior to analysis, the Pavement Management Group ensures the PMS has the inventory and condition of the pavement network regardless of ownership from the most recent annual data collection cycle. Analysis parameters including available treatment actions, deterioration models, benefit calculations, construction history, committed

[16] Estimated Baseline values are taken from the PMS and are an estimate of the current baseline values using the full HPMS distresses. Also note that these values are reported in 2022 but were measured in 2021.

[17] Estimation based on all non-interstate pavement – both NHS and non-NHS

projects, and objectives and constraints for scenarios are also updated prior to analysis. The following steps were followed for the 2022 TAMP funding scenario analyses.

1. Update inventory and condition in the PMS – This is done by initiating the annual data collection cycle with the automated data collection vendor (using the DelDOT Data Quality Management Plan certified by FHWA). As data is collected and assessed for quality, this is imported into the PMS by the Pavement Management Group. The data covers the entire state regardless of owner.
2. Update analysis parameters – This entails updating or confirming that the various inputs to the PMS are current and valid.
   2.1. Update or confirm available treatment actions - The treatments currently in use in the PMS are listed in Table 10. Treatments are added or removed from the list as applicable. The treatments and associated work types, unit costs[18], and effects on each performance index are confirmed or updated annually.

Table 10: Treatment Actions[19]

Road Structure Category (RSC)	Treatment	Federal Work Type
	Do Nothing	
Maintenance	AC Crack Seal	Maintenance
	Patch – BIT – 5%	Maintenance
	Patch – BIT – 10%	Maintenance
	Patch – BIT – 25%	Maintenance
Flexible Preservation	Fog Seal	Preservation
	Rejuvenator	Preservation
	Chipseal	Preservation
	Chipseal + Patch	Preservation
	Preservation	Preservation
	Thin Overlay	Preservation
Flexible Rehabilitation (Functional)	Rehab - Functional	Rehabilitation
Flexible Rehabilitation (Structural)	Rehab - Structural	Rehabilitation
	Cold In-place Recycling (CIR)	Rehabilitation
Flexible Reconstruction	Full Depth Reclamation (FDR)	Reconstruction
	Reconstruction – BIT	Reconstruction
Rigid Preservation	PCC Joint Repair	Preservation
	Patch PCC	Preservation
Rigid Rehabilitation (Functional)	Rehab – Functional	Rehabilitation
Rigid Rehabilitation (Structural)	Rehab – Structural	Rehabilitation
Rigid Reconstruction	Reconstruction – PCC	Reconstruction
Composite Rehabilitation (Functional)	Rehab - Functional	Rehabilitation
Composite Rehabilitation (Structural)	Rehab – Structural	Rehabilitation
Surface Treated Preservation	Chipseal	Preservation

[18] Unit costs are inclusive of 'typical' things that are included in a pavement project beyond the straight pavement portion of the project.

[19] Source: DELDOT PMS Configuration Document-Updated 20190724 – Table 8

2.2. Update or confirm deterioration models - Deterioration models are currently used for the key performance indices shown in Table 11. The Pavement Management Group also confirms or updates each of the deterioration models prior to analysis.

Table 11: Performance Indices modeled by Deterioration Models[20]

Flexible Pavement Condition Indices	Composite Pavement Condition Indices	Rigid Pavement Condition Indices	Surface Treated Pavement Condition Indices
Structural Index	Structural Index	Slab Distress Index	Structural Index
Non-Structural Index	Non-Structural Index	Joint Distress Index	Non-Structural Index
Functional Index	Functional Index	Functional Index	Functional Index
OPC	OPC	OPC	OPC

2.3. Update or confirm benefit calculations – The benefit is calculated as the area between the 'do nothing' projection of the objective function (e.g., OPC condition rating) and the projection for the proposed treatment, multiplied by various priority factors. Future updates to the benefit calculation may include more consideration of risk by, among other factors, considering the average daily traffic (ADT) on each roadway section such that the benefit (both immediate and long term) of treating sections with higher traffic are weighted higher in the benefit calculation. This step includes updates of traffic data in the system.

2.4. Update construction history – Projects that have been completed in the last year will be updated by obtaining the Construction History File and CTP/STIP Project Listing in October and updating the Construction History in the PMS.

2.5. Update committed projects (including CTP/STIP) – The list of projects that have already been committed to will be updated by obtaining the CTP/STIP Project Listing and entering these into the master work plan of the PMS.

2.6. Identify Objectives and Constraints for Scenarios – The objective function for the particular scenario will be confirmed. The objective function defines what the optimization will attempt to maximize or minimize. In addition to the objective function, the constraints for each scenario will be confirmed. Note that the main constraints will be the funding constraints obtained in Step 2 above.

3. Define analysis scenarios – Exact funding constraints are defined for input into the PMS using a funding spreadsheet developed to calculate specific funding constraints across 21 individual budgets, for each year of the analysis period.

   The funding scenarios analyzed by the Pavement Management Group included the Baseline funding scenario noted in Chapter 6: Financial Plan. The breakdown for the Baseline funding scenario is given in Table 12. It is expected that projects planned for the fiscal year will largely be executed during the 12 months preceding the end of the fiscal year such that for instance, funds allocated for FY 2022 will have partially been used on projects delivered in 2021.

[20] Source: DELDOT PMS Configuration Document-Updated 20190724 – 3.3 Combined Distress Index – See Appendix B

Table 12: Baseline Funding Scenario for Pavements (In Millions)[21]

FY	State	Federal	Total
2022	$43.0	$10.9	**$53.9**
2023	$79.2	$13.0	**$92.2**
2024	$77.0	$10.0	**$87.0**
2025	$77.0	$10.0	**$87.0**
2026	$72.0	$15.0	**$87.0**
2027	$72.0	$15.0	**$87.0**
2028	$60.0	$15.0	**$75.0**
2029	$60.0	$15.0	**$75.0**
2030	$60.0	$15.0	**$75.0**
2031	$60.0	$15.0	**$75.0**
Average Annual Investment	**$66.0**	**$13.4**	**$79.4**

In addition to the Baseline funding scenario, a scenario with a reduction in funding and a scenario where the Baseline scenario was increased by 10% was also analyzed. Life cycle optimization analysis was completed for each of the following three funding scenarios. The same objectives were set for each of these analyses while the budget constraints for the scenarios were varied. The main objective function used in the PMS Optimization Analysis is to maximize the weighted average of the OPC.

- Baseline Funding Scenario
- Baseline +10% Increased Funding
- Baseline -10% Decreased Funding

4. Run life cycle optimization analysis for each scenario – In order to perform Optimization Analysis in the PMS, the PMS is configured with Objectives and Constraints. For most analyses, the Benefit (Objective) and Treatment Cost (Constraint) are used. The main objective function used in the PMS Optimization Analysis is to maximize the weighted average of the OPC.
5. Report and analyze resulting recommended project work plans and report projected conditions for a minimum of 10-year analysis period to the Steering Committee – These reports are generated from the PMS. The resulting recommended project work plans and forecasted conditions for a 10-year analysis period were produced for each scenario. These resulting conditions were then compared to the pavement targets and analyzed as discussed in the next step.

Step 3: Analysis of Projected Gaps

Using the PMS, the Baseline and additional funding scenarios were analyzed to find the best set of recommended projects over a 10-year analysis period based on maximizing the state pavement metric OPC index across both NHS and non-NHS pavements. The results of the different scenarios are summarized in Table 13 with the baseline conditions (2021) and the conditions at the end of the 10-year analysis period (2031). Note that while the % Good decreases significantly for both Interstate and Non-Interstate NHS, the average OPC for the NHS network only decreases slightly by the end of the analysis period. The decrease in NHS % Good is largely due to a portion of pavements falling from federally defined Good to Fair. The level of service provided by Fair and Good pavements is acceptable.

[21] Baseline funding includes Federal funding associated with the IIJA.

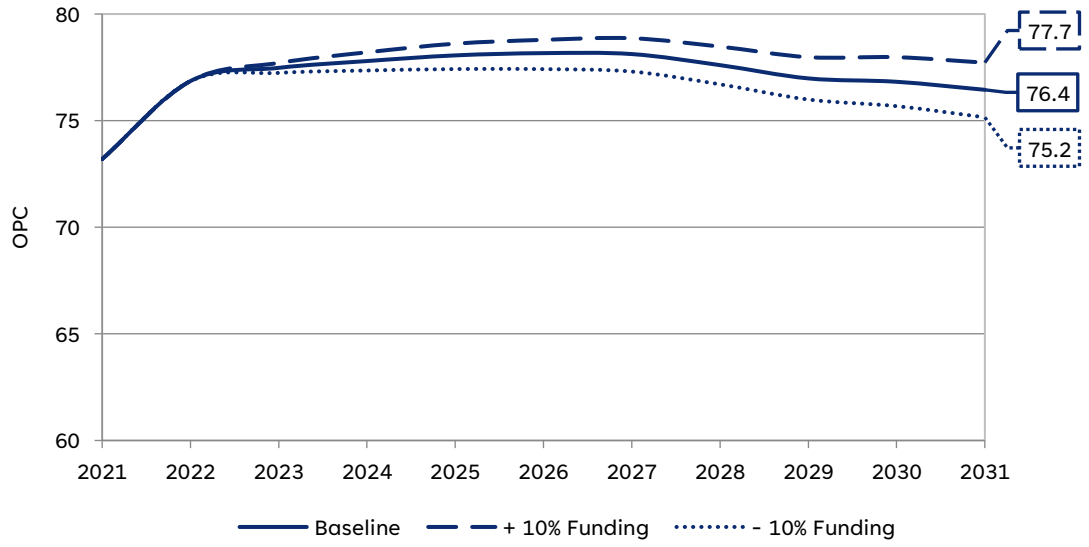
The annual average investment is the average of the funding on DelDOT's pavement network per year. It should be noted that the analyses are conducted using the baseline funding for the full network as given in Figure 38: Pavement Program Forecasted Baseline Budget Allocation and the investment strategy on the NHS is produced as a secondary output.

Table 13: Investment Scenarios Analyzed for Pavements

		FHWA Metrics				State Metrics	
Scenario	**Average Annual Investment[22]**	**Interstates % Good**	**Interstates % Poor**	**Non-Interstate NHS % Good**	**Non-Interstate NHS % Poor**	**NHS Ave. OPC**	**Whole Network Ave. OPC**
Baseline Scenario	$82.2 mil	2021: 60.7% 2031: 27.8%	2021: 0.34% 2031: 1.21%	2021: 40.3% 2031: 28.1%	2021: 0.73% 2031: 4.28%	2021: 84.2 2031: 83.3	2021: 73.2 2031: 76.4
+10% Increased Funding	$90.5 mil	2021: 60.7% 2031: 26.5%	2021: 0.34% 2031: 1.21%	2021: 40.3% 2031: 30.1%	2021: 0.73% 2031: 3.85%	2021: 84.2 2031: 83.2	2021: 73.2 2031: 77.7
-10% Decreased Funding	$74.0 mil	2021: 60.7% 2031: 30.3%	2021: 0.34% 2031: 1.21%	2021: 40.3% 2031: 28.5%	2021: 0.73% 2031: 4.25%	2021: 84.2 2031: 83.2	2021: 73.2 2031: 75.2

The projections of the OPC index summarized in Table 13 are also shown graphically in Figure 14 and Figure 15. These show that for the Baseline scenario, the weighted average OPC is maintained for the overall network with a slight decline projected for the NHS network. Based on the projections shown, the Baseline funding strategy sustains the overall network at a desired average OPC over the analysis period of 10 years. The two additional scenarios (10% increase and 10% decrease in funding) do not result in significant impacts on the final network average OPC. All three scenarios maintain or improve the 2022 OPC of 76.9 through 2027.

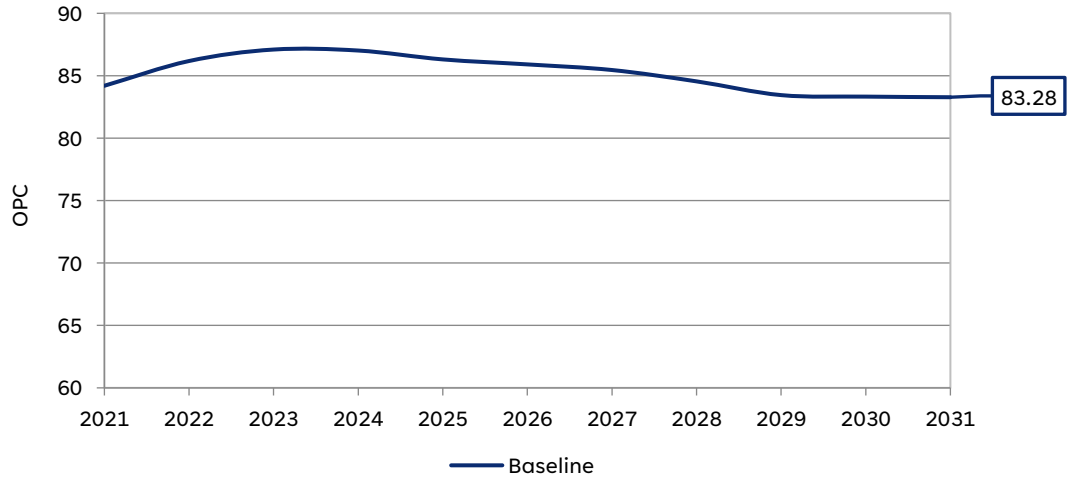
Figure 14: Overall Pavement Condition (OPC) State Optimization Analysis Results – Total Network



[22] This is the average of the projected non-initial construction project costs for the full network through 2031, not including 2022.

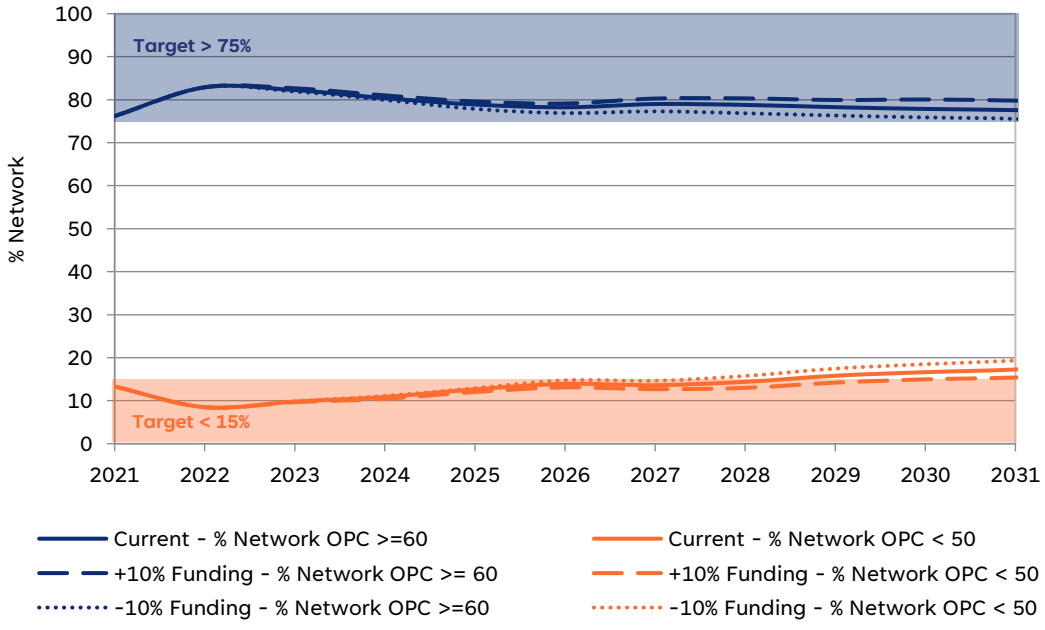
As depicted in Figure 15, the Baseline investment strategy also results in preservation of the NHS network in an acceptable level of service. There is minimal change in the network average OPC which moves from 86.2 to 83.3 over the 10-year analysis period. The NHS average OPC is maintained at or above the 2021 baseline value of 84.2 through 2025 (the end of the performance period).

Figure 15: Overall Pavement Condition (OPC) State Optimization Analysis Results – NHS



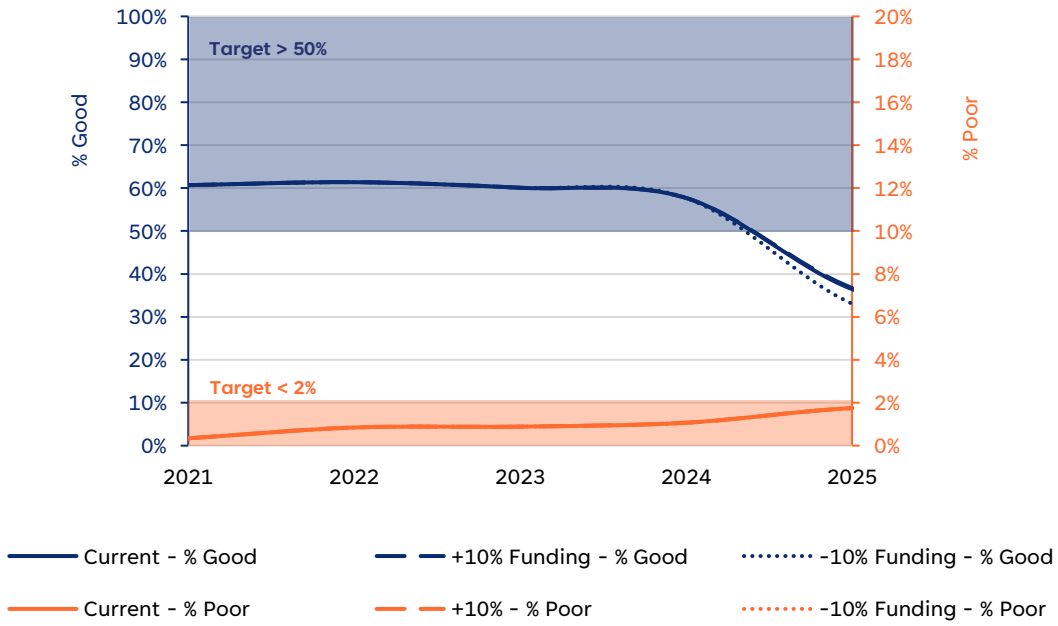
In addition to sustaining the overall network condition and the condition for the NHS with respect to weighted average of the OPC, Figure 16 shows that the Baseline funding scenario also maintains DelDOT's state of good repair target of 75% better than an OPC of 60. However, the percent of pavements below 50 are projected to not meet the target of less than 15% toward the end of the analysis period. All three funding scenarios analyzed maintain the targets through 2027. The +10% funding scenario would generally maintain all targets at the end of the scenario.

Figure 16: OPC Projections and Targets for the Total Network



The projected % Good and % Poor FHWA metrics, summarized above in Table 13, are shown graphically for the Baseline, +10% Funding, and -10% Funding scenarios in Figure 17 and Figure 18. Note that there is not a significant difference between each of the three funding scenarios for any FHWA metrics. For all three scenarios the figures show that there is a drop projected for percent Good for Interstate NHS pavements over the 4-year performance period. There is also an increase in % Poor over the performance period for the Interstate NHS in all three funding scenarios. It is intended that the 4-year 2025 targets will be re-assessed based on a revised analysis for the Mid Performance Period Progress Report in 2024 (based on 2023 data).

Figure 17: Interstate NHS Current and Projected Conditions and Targets



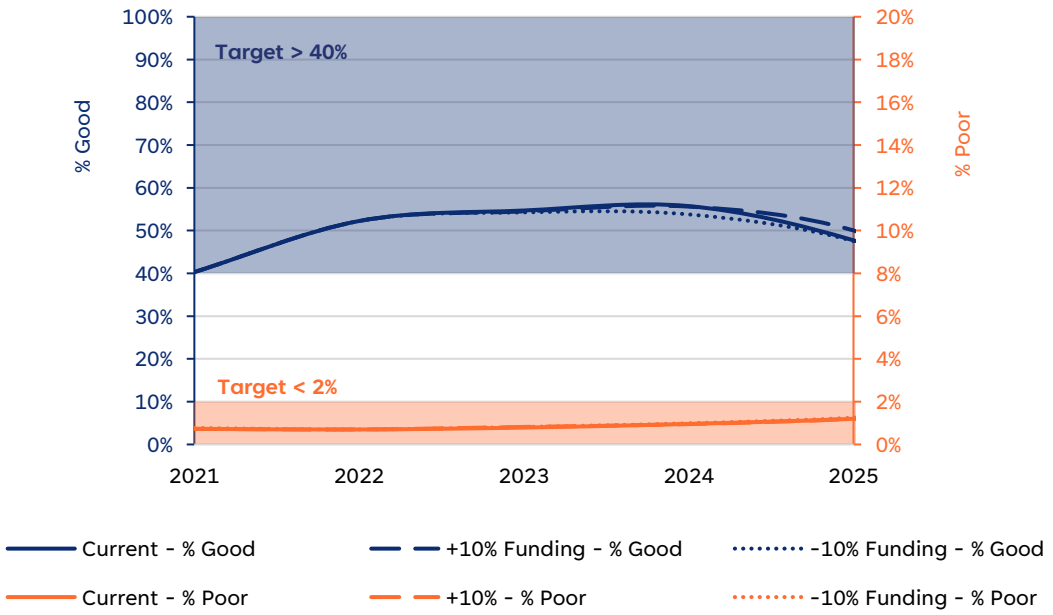
The current and forecasted conditions for the funding scenarios are compared to the targets in Figure 17 and Figure 18[23]. These forecasted conditions were presented to the Asset Management Steering Committee followed by the Agency Leadership along with recommendations from the Pavement Management Group. The Pavement Management Group recommended that the current funding level be maintained with the adjustment of the Non-Interstate NHS percent Good target from 50% down to 40%. Following analysis by the Steering Committee and Agency Leadership, it was determined that this target would be lowered from 50% to 40%. The Pavement Management Group did not recommend changes to any other Federal targets.

The federal targets, including the new Non-Interstate NHS % Good target, will be reassessed at the midpoint of the performance period[24] based on 2023 data but are adopted until then. Thus, with the targets set and the baseline funding scenario selected, the current and projected gaps can be identified. Figure 17 shows that the percent Good and Poor for Interstate NHS pavements are currently better than the target values. Figure 18 shows that the % Good for non-Interstate NHS and the % Poor are both currently better than the target values.

[23] Note that the percent Good and Poor shown for 2021 in the figures are based on data collected in 2021 (submitted to FHWA in 2022).

[24] https://www.ecfr.gov/current/title-23/section-490.105

Figure 18: Non-Interstate NHS Current and Projected Conditions and Targets



The forecasted percent of Interstate NHS pavements in Good condition decreased over the analysis period. By the end of the performance period, the gap between the projected percent of pavements in Good and the target of 50% is approximately 13% for Interstate pavements. For Non-Interstate NHS pavements, there is no gap projected by the end of the performance period. This forecasted drop in % Good is due to NHS pavements falling from Good to Fair in one of the three federal pavement rating categories. This results in pavements being classified as 'Fair' rather than 'Good' as defined by federal metrics.

Although the projected conditions fall outside of the targets later in the performance period for Interstate NHS, the conditions are expected to meet performance targets through 2024. DelDOT focuses pavement management efforts on achieving the State's state of good repair targets. The State targets ensure that the majority of DelDOT's pavement network is in a Fair to Good condition, providing an overall acceptable level of service for drivers. DelDOT plans to reassess the federal targets after two years with updated condition data and forecasts.

As previously noted, DelDOT has always prioritized state of good repair projects over capacity projects in the Capital Transportation Program (CTP). The FY 2023-2029 CTP has programmed $633 million for state of good repair projects over the 6-year period. This is 11.9% of the total CTP. DelDOT perceives this to be adequate for achieving and sustaining the state of good repair targets in the TAMP as shown in the above figures. As a result, the Baseline funding scenario was recommended as the investment strategy for pavements as further discussed in Chapter 6: Financial Plan.

Key Issues

The DelDOT Pavement Management Group faces various challenges regarding implementation of the Pavement and Rehabilitation Program. These include the following:

- Past changeover of pavement distress collection vendors and methods has caused disjointedness in the OPC scores. OPC scores have increased on some roadways that have not had rehabilitation done. There have been inconsistencies that were previously not apparent in collection methods between vendors.

- There has been a great focus on using economical preservation treatments to extend the life of Delaware's pavements. At some point in the future, these roads are all going to need more extensive treatment, and the Pavement and Rehabilitation Program budget does not account for major roadway reconstruction.
- There is a possibility of many sections of roadway falling out of Good condition and into Fair due to the rating method for federal pavement metrics. All three metrics for a pavement must be Good in order for the pavement to be categorized as such. If one distress crosses the threshold into fair, the section is categorized as fair. This combined with the fact the DelDOT optimizes to State Metrics rather than Federal increases the risk of pavement falling out of Good condition as classified by FHWA.
- With the effects of climate change, sea levels are rising, and the intensity of storm surges is increasing. Using the NOAA method, Delaware has 381 miles of coastline and is vulnerable to flooding and storms. The risk of pavement inundation is increasing which can potentially result in degradation of pavement structures.

Strategies for Managing These Issues

- The DelDOT Pavement Management Group developed a formal "Data Dictionary" which explains in detail all distresses Delaware collects, how the distress is to be collected, how it is classified, and in what unit of measure. In addition, data collection is conducted under DelDOT's new FHWA certified Data Quality Management Plan (DQMP).
- Major reconstruction projects are given to DelDOT's project development sections for design. Projects are then either fit into future years' pavement management budgets or entered into the pipeline for capital funding outside of pavement management's budget.
- Recent enhancements to DelDOT's PMS have incorporated maintenance, preservation, rehabilitation, and reconstruction treatments into the decision trees. PMS scenario analysis results can now produce an optimized program of work (project recommendations) that include a mix of all these treatment strategies and yield the best overall network level condition over the analysis period.
- Infrastructure that is vulnerable to flooding is tracked and evaluated for mitigation strategies using the Repeatedly Damaged and Vulnerable Assets process from Chapter 5: Risk Management. DelDOT's new Transportation Resiliency and Sustainability Division (TR&S) also monitors sea level rise (SLR) and develops other specific solutions as applicable. Other risks to the pavement program as a whole are tracked in the Program and Agency Risk Register.

NHS Effectiveness Performance

As defined in the MAP 21 and FAST Act legislation, the performance of Delaware's pavements and bridges is not solely measured by the physical condition of these assets; it is also measured in terms of the effectiveness of the NHS in providing safe and efficient movement of people and goods.

Projects undertaken with the objective of efficiently moving people and goods are often capacity and mobility projects that are included in the CTP/STIP. The effect that these projects have on physical condition of the pavements is included in the PMS analyses by incorporating these CTP/STIP projects as "committed projects". In this way, when these projects are modeled in the pavement management optimization analysis, the capacity and mobility project benefits of also improving the physical condition of the pavements are taken into account in the analysis.

Conversely, when major projects to restore physical condition are recommended from the pavement management optimization analysis, these projects are also analyzed to see if they can be combined with additional elements such as widening, realignment, paving of shoulders, etc. to address any safety, capacity, and mobility concerns.

In addition, it should be noted that DelDOT maintains nearly 90% of the roads in the State and the NHS only constitutes approximately 12% of the total lane miles maintained by DelDOT. Additional objectives and constraints regarding the non-NHS roadway are therefore included in the PMS which uses the OPC index to automatically trade off benefits between both the NHS and non-NHS systems within the optimization analyses.

Finally, issues and concerns with respect to current and future environmental conditions including extreme weather events, climate change, etc. are part of the Risk Management Process which includes specific assets impacted by previous emergency declarations (Part 667).

Work Planning and Programming

This process is used to disseminate the recommended workplan and target investments per work type with data collected in the future.

Once a budget has been set for the current year, it is communicated to the Pavement Management Group along with a funding scenario to be used for analysis for work planning and programming near term projects. Because the funding scenario is driven by the investment strategy identified as part of the financial plan (see Chapter 6: Financial Plan), the projected funding for each work type is defined.

The funding scenario is analyzed to generate a recommended optimum work plan over the next 10 years. From this analysis, recommended projects for the near term (over the next two to three years) are generated based on optimization and benefit-cost considerations. This recommended workplan is made available to the districts, along with summary targets for each work type. Districts and the Pavement Management Group then follow their normal programming process to define the final list of projects for the next year.

Best Use of Available Data and Management Systems for Pavements

At the start of the analysis processes described above, the most recent inventory and condition data are used as inputs to the modeling and lifecycle planning analysis performed in the PMS. The scenario analysis process described in Step 2 above includes use of a commercial PMS, AgileAssets/Trimble Pavement Analyst™, to perform life cycle optimization analyses of various scenarios. This software uses the latest available data collected by DelDOT's current automatic data collection vendor which controlled for quality using DelDOT's DQMP that has been certified by FHWA.

A fully-automated condition survey of NHS road segments is performed using a distress collection van. This survey takes roughness (IRI), rutting, cracking, and faulting measurements and these are used to calculate structural, non-structural, and functional indices. These indices will be used to help select potential project candidates for the Pavement and Rehabilitation program based on deterioration modeling of the indices over an analysis period of at least 10 years. As part of this analysis, the optimum treatments for each year will be found that maximize the long-term lifecycle benefit based on projected increased life of the pavement. The benefit is calculated based on the OPC index, which is on a scale of zero (worst condition) to 100 (best condition) and uses the combined distress indices. DelDOT's Pavement and Rehabilitation program strives to maintain the condition of Delaware's roadways

by systematically identifying candidates for rehabilitation[25] and determining the most cost-effective treatment. The program provides rehabilitation in the form of pavement preservation, rehabilitation (structural overlays), and reconstruction in the form of cold in-place recycling or full-depth reclamation, along with others.

Enhancements to the PMS are now complete, enabling full use of the system for performing analysis required for this TAMP and in the future.

The full implementation of DelDOT's pavement management software enables the following, fulfilling the requirements outlined in 23 CFR 515.17:

- Collecting, processing, storing, and updating inventory and condition data
- Forecasting deterioration
- Determining the benefit-cost over the life cycle of assets to evaluate alternative actions (including no action decisions)
- Identifying short- and long-term budget needs
- Recommending workplans and project implementation schedules
- Reporting of FHWA projected metrics for different scenarios

The process also involves using the CTP/STIP as part of the input for maintaining a list of committed projects that is used in the scenario analyses. These projects are effectively 'fixed' in the analysis so that their budget is committed and only the remaining budget is optimized. The full implementation of the PMS has enhanced the use of the PMS analysis outputs in the LCP process. The full use of the PMS in DelDOT's life cycle management process is outlined in Chapter 4: Risk-Based Life Cycle Management.

[25] Note that many of the projects included in DelDOT's Pavement and Rehabilitation program technically fall within the FHWA definition of Pavement Preservation, i.e. they are non-structural at less than 2" in overall thickness.

Chapter 3: Bridges

DelDOT maintains roughly 1,780 bridge structures. In Delaware, any structure under the public roadway with an opening greater than 20 square feet and a minimum vertical clearance of 4’ is defined as a bridge. The term “bridge” pertains to frame/box culvert and pipe culvert structures as well as traditional bridge types. All such structures are included in the bridge inventory and are subject to routine inspection. Any structure with a span of greater than 20 feet and carrying vehicular traffic is included in the National Bridge Inventory (NBI). This chapter provides a detailed look at the 340 NHS bridges in Delaware starting with what defines a “Good” bridge. It then provides an overview of the NHS bridge inventory and current conditions, sets targets for the future bridge conditions, and examines how the conditions are expected to change over time using the life cycle analysis capabilities of the bridge management system (BMS). Based on this information, DelDOT determined an investment plan for bridge projects that supports the progress toward, and achievement of, the condition targets and extension of the life of DelDOT’s bridge network.

Performance Metrics and State of Good Repair

DelDOT's TAMP is focused on maintaining critical NHS pavement and bridge assets in a state of good repair. The current state of good repair, or physical condition, of Delaware's bridges is tracked using the NBI Condition Rating performance measure. The State and Federal state of good repair definitions and targets are based on the NBI Condition Ratings. NBI Condition Ratings are determined by inspecting and rating individual bridge elements and combining those element ratings into an overall score. The NBI Condition Rating value descriptions are outlined in Table 14.

Table 14: NBI Condition Rating Descriptions

Condition Rating Value	Description
9	Excellent Condition
8	Very Good Condition – no problems noted.
7	Good Condition – some minor problems.
6	Satisfactory Condition – structural elements show some minor deterioration.
5	Fair Conditions – all primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.
4	Poor Condition – advanced section loss, deterioration, spalling, or scour.
3	Serious Condition – loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	Critical Condition – advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	'Imminent' Failure Condition – major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic, but corrective action may put back in light service.
0	Failed Condition – out of service – beyond corrective action.

State and Federal Performance Metrics

Internal State Metrics

DelDOT tracks State-specific metrics that reflect percent Good, Fair, and Poor bridges. DelDOT defines bridges with NBI condition ratings of 6 or higher as Good and NBI condition ratings less than or equal to 4 as Poor. Therefore, a single bridge is defined to be in a state of good repair if its NBI rating is 6 or greater. The DelDOT Bridge Program metrics are calculated as the *percent number of bridges* in Good and Poor condition. DelDOT manages its bridge program using the state-defined internal metrics and reports the FHWA metrics as a secondary result.

Federal Metrics

The full FHWA condition metrics are calculated as the statewide *percentage of deck area of bridges* on the NHS classified as in Good and Poor condition. The current data submitted[26] to FHWA is the condition derived from the latest data collected through the beginning date of the performance period. The data is reported to the nearest

[26] As specified in 23 CFR 490.107(b)(1)(ii)

tenth of a percent (0.1% or 0.001). Table 15 provides a comparison of the previously discussed state metrics versus the Federal metrics. Note that on top of Good and Fair having different definitions, bridges are assigned these ratings with a different method as explained below.

Table 15: Comparison of State and Federal Metrics

Condition Rating Value	Description	DelDOT Metrics	Federal Metrics
9	Excellent Condition	Good	Good
8	Very Good Condition		
7	Good Condition		
6	Satisfactory Condition		Fair
5	Fair Conditions	Fair	
4	Poor Condition	Poor	Poor
3	Serious Condition		
2	Critical Condition		
1	'Imminent' Failure Condition		
0	Failed Condition		

Bridges carrying the NHS, which includes on- and off-ramps connected to the NHS, are classified as Good, Fair, or Poor based on the following criteria in 23 CFR 490.409(b):

Good: When the lowest rating of the 3 NBI items for a bridge (Items 58—Deck, 59—Superstructure, 60—Substructure) is 7, 8, or 9, the bridge will be classified as Good. When the rating of NBI item for a culvert (Item 62—Culverts) is 7, 8, or 9, the culvert will be classified as Good.

Fair: When the lowest rating of the 3 NBI items for a bridge is 5 or 6, the bridge will be classified as Fair. When the rating of NBI item for a culvert is 5 or 6, the culvert will be classified as Fair.

Poor: When the lowest rating of the 3 NBI items for a bridge is 4, 3, 2, 1, or 0, the bridge will be classified as Poor. When the rating of NBI item for a culvert is 4, 3, 2, 1, or 0, the culvert will be classified as Poor.

Inventory and Current Condition

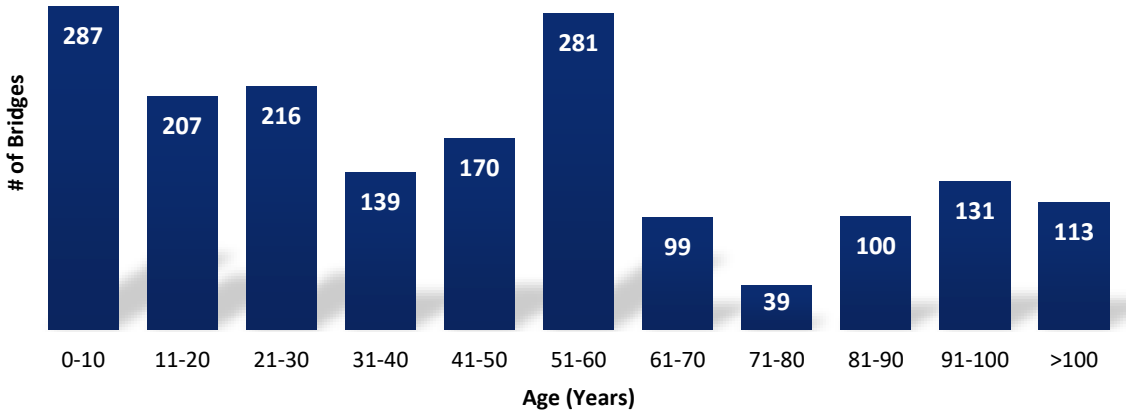
Description of DelDOT State Bridge Inventory

DelDOT maintains roughly 1,780 bridge structures. In addition to structures carrying pedestrian traffic, DelDOT considers any structure with an opening greater than 20 square feet and a minimum vertical opening of 4 feet to be a bridge. Typically, bridges are erected over a depression or an obstruction, such as water, a highway or railway.

The term "bridge" is intended to pertain to frame/box culvert and pipe culvert structures as well as traditional bridge types. All such structures are included in the bridge inventory and are subject to routine inspection. Any structure with a span of greater than 20 feet and carrying vehicular traffic is included in the NBI.

Figure 19 provides a breakdown of DelDOT's Bridge Inventory by age.

Figure 19: Bridge Age Distribution



Description of DelDOT State Bridge Condition

DelDOT measures bridge condition performance by number of bridges for the DelDOT Bridge Inventory versus square foot deck area as is required for the FHWA condition metrics for NHS bridges. In addition, DelDOT considers fair bridge condition to only include NBI condition ratings that have been assigned as a 5. Table 16 provides the number and percentage of bridges classified as Good, Fair, or Poor based on the state metrics.

Table 16: 2021 Bridge Condition Summary – State Metrics

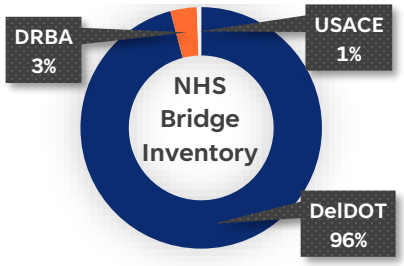
Condition Rating	All DelDOT Bridges		DelDOT NBI Bridges		DelDOT State Bridges	
	# of Bridges	% of Bridges	# of Bridges	% of Bridges	# of Bridges	% of Bridges
Poor (≤4)	29	1.6%	11	1.3%	18	1.9%
Fair = 5	255	14.3%	149	17.7%	106	11.3%
Good (≥6)	1495	84.0%	681	81.0%	814	86.8%
Total =	1,779	100.0%	841	100.0%	938	100.0%

Description of NHS Bridge Inventory

This TAMP document pertains to DelDOT, DRBA, and USACE NBI bridges on the NHS. The total number of bridges on the NHS is 340 as shown in Table 17 below.

Table 17: NHS Bridge Inventory

Description	Number of NHS Bridges
DelDOT NBI/NHS Bridges	326
DRBA NBI/NHS Bridges	12
USACE NBI/NHS Bridges	2
Total Bridges	340



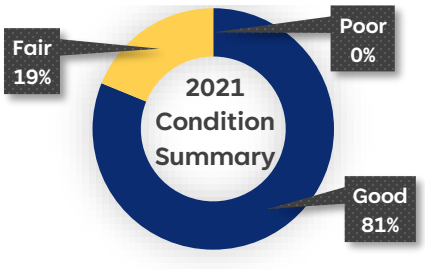
Description of NHS Bridge Condition

Current State Condition Metrics

Based on the state indices, currently DelDOT's NHS bridge network is 0% in Poor condition as given in Table 18 below. This means that no bridge is defined to be in poor condition based upon NBI data collected in 2021.

Table 18: NHS Bridge Condition Based on State Metrics

Performance Measure	Count
# of Bridges in Good Condition (6-9)	276
# of Bridges in Fair Condition (5)	64
# of Bridges in Poor Condition (≤4)	0

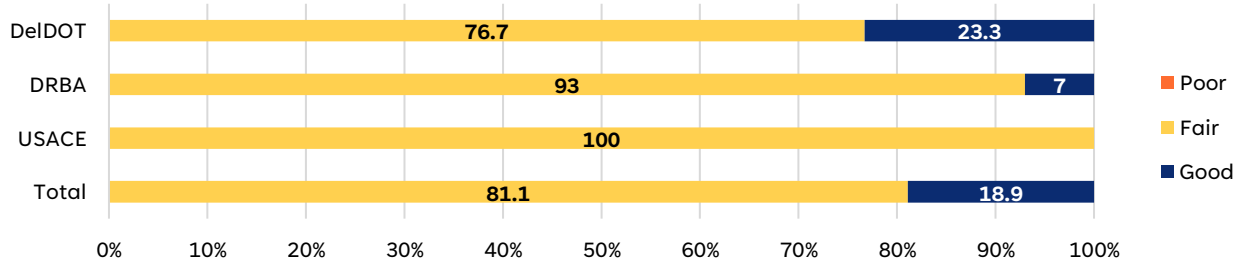


Current FHWA Condition Metrics

With regard to the FHWA condition metrics, 18.9% of the total deck area of Delaware NHS bridges are in Good condition and 0.0% in Poor condition as shown in Table 19.

Table 19: NHS Bridge Condition Based on FHWA Metrics

Condition Rating	DelDOT NBI NHS Bridges	DRBA Bridges	USACE Bridges	Total Baseline Values
	Deck Area (sq.ft.)	Deck Area (sq.ft.)	Deck Area (sq.ft.)	Deck Area (sq.ft.)
Poor (≤4)	0	0	0	**0**
Fair (= 5 & 6)	5,007,821	1,145,580	723,608	**6,877,008**
Good (≥6)	1,517,077	86,226	0	**1,603,302**
Total =	**6,524,897**	**1,231,805**	**723,608**	**8,480,310**



The summary baseline values for the 2022-2025 Performance Period are as shown in Table 20.

Table 20: NHS Bridge Condition – Baseline Values for 2022-2025 Performance Period

System	Good Condition	Poor Condition
NHS Bridges – FHWA Baseline Metrics	Statewide percentage of deck area of bridges on the NHS in Good condition. [23 CFR 490.107(b)(1)(ii)(B)] **2021 Baseline Value: 18.9%**	Statewide percentage of deck area of bridges on the NHS in Poor condition. [23 CFR 490.107(b)(1)(ii)(B)] **2021 Baseline Value: 0.0%**

Obtaining Data from other NHS Owners

The TAMP pertains to DelDOT, DRBA, and USACE NBI bridges on the NHS. As listed in Table 18, there are 2 bridges that span the Chesapeake & Delaware (C&D) Canal that are owned by the US Army Corps of Engineers (USACE) along SR896 and SR1. DelDOT's Bridge Management Section, Canal District M&O, and USACE have very open and transparent communication when performing inspections and coordinating bridge maintenance and repair activities. DRBA also maintains communication with DelDOT concerning planned projects.

Delaware River & Bay Authority (DRBA) owns all bridges located along I-295 in Delaware, the Freeman Highway bridge that carries US-9 over the Lewes & Rehoboth Canal in the Town of Lewes, and two ferry transfer bridges at the Cape May-Lewes Ferry Terminal in Lewes.

DelDOT Bridge inspectors conduct on-site bridge structure inspections to determine and report current conditions for state and municipally owned bridge structures. Bridge load rating engineers use the inspection report, plans and structural software programs to analyze the bridge structure to determine the load carrying capacity for state and municipally owned bridges. The bridge inspection data received from DRBA and the USACE is manually entered into the BrM database by DelDOT's Bridge Management Group for subsequent use in analyses.

DRBA and the USACE have their own bridge prioritization process and asset management procedures that are utilized to identify bridge work needs. DelDOT requests updates regarding planned bridge work and associated spending from DRBA and the USACE on an annual basis to update DelDOT's TAMP. DelDOT incorporates this information in the bridge modeling database. These projects are accounted for when forecasting out future NHS bridge performance measures which are used in establishing baseline conditions along with selecting future performance targets. The lists of projects are included in Appendix C.

Objectives and Targets

DelDOT's TAMP is focused on maintaining critical assets in a state of good repair. The fundamental objective for bridges is that they should be capable of safely carrying all legal, transit, permitted, and emergency vehicles.

The long-term desired network state of good repair for Delaware's bridges is defined by State targets as shown in the following sections. With the introduction of the FHWA metrics, DelDOT has also set short term targets that align with the long-term State metric goals. The long- and short-term target values for each measure are detailed below.

Internal State Targets for Long Term Network State of Good Repair

Previously, DelDOT's NHS bridges have been maintained at the following targeted level of service:

- No more than 5% of total NBI bridge deck area on the NHS classified as Poor (condition rating ≤4).

More generally, the long-term desired network state of good repair for Delaware's bridges is defined by State targets with a goal that more than 75% of bridges remain in Good condition, and no more than 2.5% of Delaware's bridges are rated as Poor. These long-term targets are shown below in Table 21.

Table 21: Bridge Condition –State Network State of Good Repair Targets

Metric	Measure	Target
Bridges - Poor	NBI Poor Condition Rating (Rating = 0-4)	≤ 2.5% of Bridges
Bridges - Good	NBI Good Condition Rating (Rating = 6-9)	> 75% of Bridges

Target FHWA Condition Metrics

Table 22 lists the federal measures and targets developed for bridges. All targets are published in the DelDOT 2022 Baseline Performance Period Report.

Table 22: NHS Bridge Condition – FHWA Targets

System	Good Condition	Poor Condition
NHS Bridges – FHWA Metrics	The percent of bridges on the NHS in a Good condition [23 CFR 490.407(c)(1)] by deck area **2023 Target: at least 15.0%** **2025 Target: at least 25.0%**	The percent of bridges on the NHS in a Poor condition [23 CFR 490.407(c)(2)] by deck area **2023 Target: should not exceed 3.0%** **2025 Target: should not exceed 3.0%**

The two- and four-year targets for bridges in Good and Poor condition were based on the outcomes from the 2022 gap analysis process. Forecasted conditions were compared to previously set targets and adjustments were recommended based on the comparisons. The most current data from the 2021 bridge inspection cycle was included in this determination. Agency Leadership provides the final decision on whether targets change. The bridge NHS two- and four-year targets are assessed and updated for each performance period. The updated targets were recommended by the Bridge Management Group and are supported by the forecasted conditions. The forecasted percent Good for NHS pavements is expected to increase by 2025, thus justifying the higher four-year target. This target will be reassessed in the 2024 mid-performance period report against updated forecasts. The full gap analysis process is discussed in the next section.

Gap Analysis and Condition Projections

The Bridge Management Group follows the life cycle planning process outlined in Chapter 4: Risk-Based Life Cycle Management. The outcomes of the five steps are detailed below.

Discussion of Gaps between Targets and Projected Condition

Step 1: Current Gaps

As shown in Table 23 and Figure 21, the 2-year target in 2023 (i.e., for data collected in 2023) for the statewide percentage of deck area of bridges on the NHS classified as in Good condition was set at a value of 15.0%. The results from the bridge modeling software show that the Good NHS bridge condition forecast for 2023 will be 18.03%. In order to account for unpredicted issues, incidents, and deterioration involving bridges such as traffic impact damage to a bridge or scour damage resulting from a major storm, a conservative cushion has been incorporated in selecting the 2 & 4-Year NHS bridge targets. Over the past 4 years, DelDOT has gained a better understanding as to the bridge modeling process and minor tweaks in element deterioration models have been made to improve the accuracy and consistency of DelDOT's bridge modeling software. Since deterioration modeling and bridge condition performance forecasting is an evolving process and DelDOT lacks extensive knowledge and expertise regarding this activity, this cushion provides some buffer when selecting future performance targets. DelDOT has incorporated the NBI 6 condition rating into the prioritization process starting in the 2020 calendar year. This will help in identifying work needs earlier and better prevent the bridge from reaching an NBI condition rating of a 5. This is also beneficial because by identifying upcoming bridge work needs sooner, this allows for a little bit of a buffer during the project design process and can help negate delays associated with the Right-of-Way, environmental permitting, utility coordination, and employee resource turnover issues.

The results from the bridge modeling software show that the Good NHS bridge condition forecast for 2023 will be 18.03%. As shown in Table 23 and Figure 21, the 2-year target in 2024 (for data collected in 2023) for the statewide percentage of deck area of bridges on the NHS classified as in Good condition has been set at a value of 15.0% for the reasons discussed above. Similarly, the bridge modeling software shows the 2-Year Poor bridge condition will be <1%, but the 2-year target for the statewide percentage of deck area of bridges on the NHS classified as in Poor condition has been set at 3%.

The bridge modeling software shows the 2025 Good bridge condition will be >28%, but the 4-year target for the statewide percentage of deck area of bridges on the NHS classified as in Good condition has been set at 25%. Similarly, the bridge modeling software shows the 2025 Poor bridge condition will be <1%, but the 4-year target for the statewide percentage of deck area of bridges on the NHS classified as in Poor condition has been set at 3%

These target value improvements have been selected due to the volume of existing projects and planned construction that DelDOT has scheduled over the next 4 years. DelDOT will re-evaluate the Good and Poor bridge condition targets at the 2-year target timeframe to see if adjustments need to be made to the 4-year targets.

Table 23: NHS Bridge Condition – Gaps between 2022 Baseline and Target Values

Asset Class	Measure	Current Condition	Target	Gap
State Bridges	**NBI Condition Rating**			
	Percent of Bridges - Good	80.9%	> 75%	No Gap
	Percent of Bridges - Poor	0.0%[27]	≤ 2.5%	No Gap
NHS Bridges	**FHWA Percent Good and Percent Poor**			
	Percent Bridge Deck Area - Good	2021 Baseline: 18.9%.	2023 Target: at least 15.0%. 2025 Target: at least 25.0%.	2023 Gap: No Gap 2025 Gap: 6.1%
	Percent Bridge Deck Area - Poor	2021 Baseline: 0.0%.	2023 Target: should not exceed 3.0%. 2025 Target: should not exceed 3.0%.	2023 Gap: No Gap 2025 Gap: No Gap

Step 2: Funding Scenario Analyses

DelDOT has fully implemented the AASHTOware BrM BMS as of 2021. The ability to analyze "what if" scenarios has allowed DelDOT to forecast the resources needed to achieve specific performance measures across the bridge inventory. This improves the link between the bridge performance goals and budgeting.

Analysis parameters used in the bridge modeling software includes various actions, deterioration models, benefit/cost calculations, committed projects, and objectives and constraints for scenarios are also updated prior to analysis. The following steps were followed for the 2022 TAMP funding scenario analyses.

1. Update bridge inventory and condition in the BMS – This is done through the Bridge Inspection Process described in more detail in DelDOT's Bridge Inspection Manual. The inspections are carried out in accordance with the National Bridge Inspection Standards (NBIS) which defines a "bridge structure" and sets minimum requirements for inspecting bridge structures. Bridge inspections are conducted using a two-part process:
    1.1. Inspection – Bridge inspectors conduct on-site bridge structure inspections to determine and report current conditions.
    1.2. Load Rating – Bridge Inspection and Load Rating engineers use the inspection report, plans and structural programs to analyze the bridge structure to determine and update the load carrying capacity of the bridge. This is described in more detail in DelDOT's Bridge Load Rating Manual.
2. Update parameters for Network Optimization analysis[28] – This entails updating or confirming that the various inputs to the BMS are current and valid.
    2.1. Update work type definitions - The current set of work type definitions is shown below in Table 24. The actions and network policies modeled in the BMS mirror these definitions. Network Level maintenance, preservation, rehabilitation, and replacement actions (also called policies) are reviewed and updated on annual basis to ensure that the BMS incorporates current Bridge Asset Management processes and procedures.

[27] Note that this is for DelDOT bridges on the NHS and does not include other bridge owners.

[28] Note that these steps will come into effect more fully with the implementation of BrM as described in more detail at the end of this section.

Table 24: Work Types and Associated Actions for Bridges

Initial Construction (IC)
- Bridge Construction on a New Roadway
- Construction of a New Bridge on an Existing Roadway
- Reconstruction of a Bridge with Additional Capacity
Reconstruction (Recon)
- Full Bridge Replacement
- Superstructure Replacement
- Bridge/Roadway Widening
- Bridge Height, Geometry or Load Path Modifications
- Bridge Removal
Preservation
Rehabilitation - Major (Rehab)
- Corrective Maintenance, Including:
- Deck Replacement
- Projects w/ Deck, Superstructure, and Substructure Repairs
Rehabilitation - Minor (Rehab)
- Smaller repairs of a few Different Bridge Elements or a project that is just addressing one of the major Deck/Super/Subcomponents
Maintenance (Maint)
Preventative Maintenance Activities
- Bridge Painting
- Bridge Joint Seal replacement
- Bridge Deck Overlay
Cyclical (non-condition based) Activities
- Recurring Deck Sealing
- Mechanical & Electrical Cyclical Movable Bridge Maintenance
Element Condition Based Repairs
- Deck Patching
- Steel Pile Jacketing
- Concrete Rail Repairs
- Minor Concrete Repairs
- Erosion Repairs
- Reapply Pourable Joint Sealer
- Fatigue Crack Repairs
- Seal Concrete Cracks

Updates of work actions are reviewed on an annual basis and includes updating the list of actions and adding or removing any as applicable. For each action, the unit cost of the action is confirmed or revised, and the effect of each action on every performance index that is being modeled is also confirmed or revised. Costs associated with each action within the BrM Program are reviewed and updated every four

years. Rehabilitation work includes a wide variety of activities as far as complexity and severity; however, the table above provides a general description.

2.2. Update deterioration models - Deterioration models for use in BrM network level optimization are defined for all bridge elements and for the general NBI bridge component condition ratings (for the Deck, Superstructure, Substructure and Culvert). These models are defined separately from the element level deterioration models and used by the NBI converter when running the Network Optimizer. Deterioration models have been developed and defined for the Component NBI Modeling section, but it is not currently used or needed as part of DelDOT's bridge modeling program since detailed element deterioration models have been developed. The bridge deterioration models can predict state and federal measures.

2.3. Update or confirm benefit calculations – The benefit is calculated as the increase in the Utility Value. Periodic review of the defined benefits for individual actions will occur to help improve the accuracy of the modeling program software.

2.3.1. Assign Network Policies – The set of network level policies (actions) have been assigned for DelDOT's modeling and forecasting program. The assigned Network Policies mirror DelDOT's current Bridge Asset Management policies and procedures.

2.4. Update construction history – When a project is completed, then the condition data is updated in the recent inspection for the bridge and the project is marked as completed or deleted since the work was completed. In addition, Maintenance fields have been created to track repair, rehabilitation, and maintenance work.

2.5. Update committed projects (including CTP/STIP) – The list of projects that have already been committed to will be updated by obtaining the CTP/STIP Project Listing and entering these into the project candidate list of the BMS and flagged as being committed projects.

2.6. Identify Objectives and Constraints for Scenarios – BrM allows for two different analyses to be run. Based on the scenario to be analyzed, one of these is chosen. If maximization of Utility is chosen, then budget constraints are also set up. DelDOT has incorporated the Maximize Utility method for use with the modeling software when running the optimizer and forecasting out bridge performance conditions.
Maximize Utility: The optimization tries to maximize the overall utility of the program within the specified performance constraints. When maximizing utility, the BMS orders strategies based on incremental utility cost ratio. The system then proceeds down the list selecting strategies until the performance and budget constraints are met.

2.6.1. Life Cycle Cost Analysis (LCCA) – The BrM software performs a LCCA as part of the Utility Value calculation when executing the optimizer to identify future bridge projects and needs. As part of this, Lifecycle Policies have been defined and are incorporated into the BrM software when running the optimizer and calculating the Utility Value.

2.6.2. Set up Program Constraints – If Maximize Utility is chosen as the analysis type, the budget constraints are set up for the chosen program.

Minimize Cost: The optimization generates a program with the minimum possible cost that meets the specified performance constraints. Utility is not factored into minimizing the cost. This method will consider increasingly expensive project alternatives until the performance constraints are met.

3. Define funding scenarios – These are prescribed by Agency Leadership as being scenarios that are to be analyzed by the Bridge Management Group. The Bridge Management Group also analyzes different scenarios to compare multiple bridge preservation strategies and to forecast out specific Bridge Preventative Maintenance Program activities such as bridge painting or pile jacketing.

The funding scenarios analyzed by the Bridge Management Group included the Baseline funding scenario noted in Chapter 6: Financial Plan. The breakdown for the Baseline funding scenario is given below in Table 25.

Table 25: Baseline Funding Scenario for Bridges (in Millions)[29]

FY	State	Federal - NHS[30]	Federal - Remaining	Total
2022	$20.27	$51.21	$24.71	$96.19
2023	$19.09	$21.16	$29.59	$69.84
2024	$14.62	$9.53	$56.32	$80.47
2025	$12.72	$67.05	$0.24	$80.01
2026	$15.20	$52.09	$3.24	$70.53
2027	$17.20	$40.57	$12.30	$70.07
2028	$18.20	$52.81	$0.06	$71.07
2029	$18.30	$51.06	$1.94	$71.30
2030	$18.30	$28.35	$24.35	$71.00
2031	$18.30	$33.41	$19.29	$71.00
Average Annual Investment	**$17.22**	**$40.72**	**$17.20**	**$75.15**

In addition to the Baseline funding scenario, two further scenarios where the Baseline scenario was decreased by 10% and increased by 10%, are also analyzed.

Three funding scenarios are therefore analyzed as shown below.

- Baseline Funding Scenario
- Baseline - 10% Decreased Funding
- Baseline + 10% Increased Funding

4. **Run Analysis**[31] – Under Program Planning in BrM, the chosen program is optimized. This generates a set of projects for each bridge over the analysis period that represent the optimal set of projects to undertake. This analysis in BrM considers benefit/cost ratio when maximizing Utility over the lifecycle of the bridge using the deterioration models and network policies discussed previously. More detail is also given on the current priority calculation (which will incorporate the BrM benefit cost output) as well as integration with the project selection in the section on Managing Asset Risks.
5. **Report and analyze** resulting recommended project work plans and report projected conditions for a minimum of 10-year analysis period to the Steering Committee – These reports will be generated from the BMS.

Step 3: Analysis of Projected Gaps

Using the BMS, the Baseline and additional funding scenarios were analyzed to find the best set of recommended projects over a 10-year analysis period based on maximizing the bridge conditions across the full DelDOT bridge

[29] Baseline funding levels include Federal funding from the IIJA.

[30] Note: The Federal – NHS values and thus the Average Annual Investments do not include spending on the I-95 Wilmington Viaduct project (~$172 Million in FY 22 and ~93 Million in FY23). This major project is not funded from the Bridge Preservation pot and would skew the values.

[31] Note that these steps will come into effect more fully with the implementation of BrM as described in more detail at the end of this section. Currently Remaining Life calculations are performed manually.

network. The results of the different scenarios are summarized in Table 26. It is important to note that the average 10% increase and decreased values used in the table were based off of the planned budget for 2026-2031 as the budgets for 2022-2025 include additional funding that DelDOT had received for a couple of larger, corridor projects that are not representative of DelDOT's Bridge Program. Also, even if DelDOT acquired additional funding to put towards the NHS bridge program, it would not be feasible to initiate and complete additional projects within the 2022-2025 timeframe. In order to be consistent with the increased/decreased funding scenarios, the 10% decrease scenario was also based off the 2026-2031 timeframe.

Table 26: Investment Scenarios Analyzed for Bridges[32]

	Average Annual Investment		State Metrics		FHWA Metrics	
Scenario	NHS	Total	% Bridges Good (6-9)	% Bridges Poor (≤4)	% Deck Area Good (7-9)	% Deck Area Poor (≤4)
Baseline Scenario[33]	$40.7 mil	$75.2 mil	2021: 84.0%	2021: 1.6%	2021: 18.9%	2021: 0.00%
			2031: 78.0%	2031: 1.7%	2031: 25.4%	2031: 0.21%
- 10% Decreased Funding	$36.7 mil	$63.9 mil	2021: 84.0%	2021: 1.6%	2021: 18.9%	2021: 0.00%
			2031: 74.5%	2031: 2.9%	2031: 25.1%	2031: 0.21%
+ 10% Increased Funding	$44.8 mil	$82.7 mil	2021: 84.0%	2021: 1.6%	2021: 18.9%	2022: 0.00%
			2031: 81.2%	2031: 1.3%	2031: 25.8%	2031: 0.17%

It can be seen from the projections above that all three strategies sustain the NHS bridges in a desired state of good repair over the analysis period of 10 years. These investment strategies all result in preservation and reconstruction projects that aim to improve the condition of the NHS network.

The projected Percent Good and Percent Poor State and FHWA metrics for the different scenarios that were analyzed are shown graphically in Figure 20 and Figure 21. Both the Baseline and +10% funding scenarios are projected to achieve all State and Federal targets over the 10-year period. The FHWA metric for percent Good grows from 18.9% to 25.4% in the Baseline scenario. A decrease of 10% annual funding for the Federal target would result in a reduced Percent Good for the 4-Year target but would result in a low-risk chance for not achieving the 25% Good target that has been selected. The -10% funding scenario for the State targets would cause DelDOT to not meet the Poor condition target toward the end of the 10-Year analysis period. The -10% funding scenario is projected to meet federal 2 & 4-Year Poor targets.

The annual average investment is the average of the funding projected for DelDOT's bridge network per year. Note that the baseline funding represents the full bridge network as given in Figure 20. The subsequent analysis resulted in the average funding projected for the NHS.

[32] Note: The Average Annual Investments do not include spending on the I-95 Wilmington Viaduct project (~$172 Million in FY 22 and ~$93 Million in FY 23). This major project is not funded from the Bridge Preservation pot and would skew the values.

[33] Baseline funding includes Federal funding associated with the IIJA.

Figure 20: 10-Year Performance Forecast – Percent Good and Poor State Metric – DelDOT Bridge Program (by % # of Bridges)

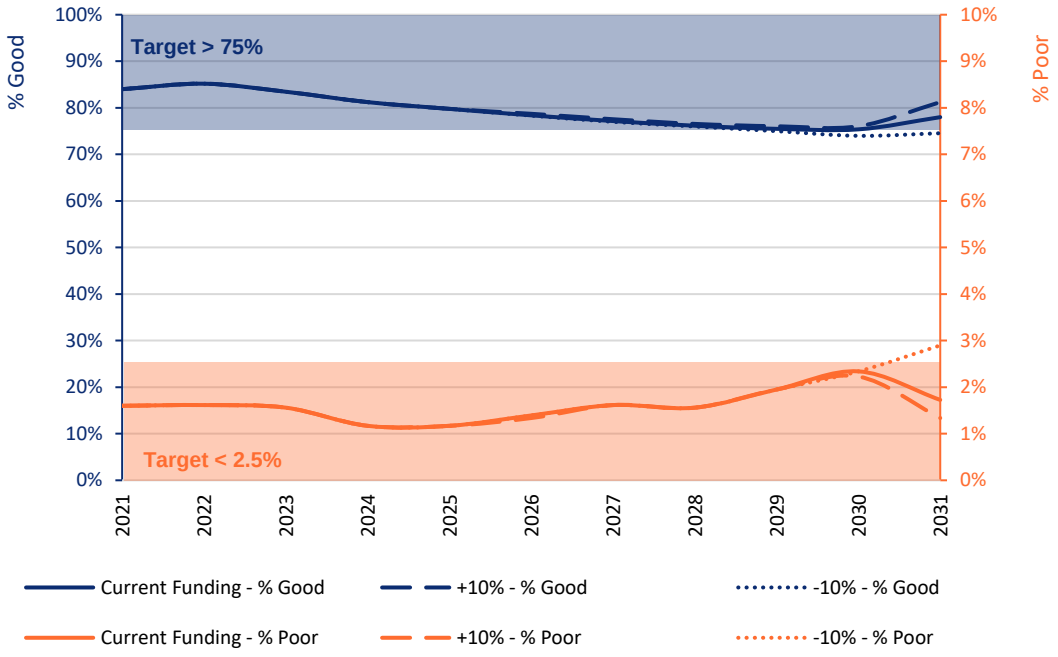
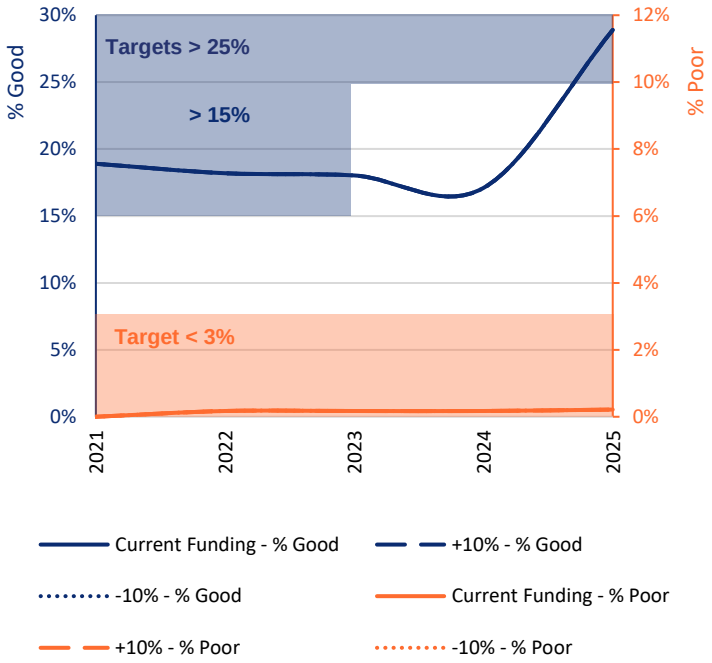


Figure 21: 10-Year Performance Forecast – Percent Good and Poor NHS FHWA Metric – NHS Bridge Program (by % Deck Area)



The projections for the Baseline funding scenario in Figure 20 and Figure 21 show that only a few new bridges are expected to move from the Good or Fair condition to Poor condition over this timeframe. These results are consistent with DelDOT's extensive historical performance and knowledge of how Delaware's bridges deteriorate, DelDOT forecasts that less than 1% of NHS bridges will be in Poor condition at the end of the performance period. However, the Agency leaned on the conservative side when setting goals for the reasons identified in Step 1 and because DelDOT does not have control over other bridge owners such as the DRBA and the USACE – both of which have some very large and complex bridges that could easily skew bridge condition performance targets. DelDOT will reevaluate at the 2-year target timeframe to see if adjustments need to be made to the 4-year targets.

Key Issues

- Interstate Bridge Decks: All of the interstate bridges received low permeability concrete overlays in the 1980s and 1990s. These overlays have a life expectancy of 30 years and continue to show signs of deterioration. This equates to over 1 million square feet of concrete bridge decks that are either already starting to show signs of deterioration or are expected to within the next 5 – 8 years.
- Major Projects: There are several major structures that have worked or are working their way up the deficiency list and will require a significant amount of money to repair. These structures include the I-495 bridge over the Christina River, bridge 1-686 & 1-684 that carry US-13 in Wilmington, and various bare deck concrete bridges with uncoated steel reinforcing.

Strategies for Managing These Issues

- Interstate Bridge Decks: The Bridge Section has implemented the use of various technologies to identify deterioration in concrete decks and has received training on the infrared camera that has been purchased. A significant number of bridge decks previously evaluated and found to have moderate deterioration have been programmed or deck work included in with other corridor projects such as the I-95/SR-896 Interchange Project. The Bridge Section will continue to develop a plan to rehabilitate additional bridges/decks based on the results of future evaluations.
- Major Projects: Since the cost for most of these will well exceed $10M, DelDOT had programmed these projects and are currently in the design phase. The I-95 Rehabilitation project, which includes major repair work to the Wilmington Viaduct and Brandywine River Bridge, is currently wrapping up and includes a significant amount of improved bridge deck area along the interstate corridor through the City of Wilmington. Replacement for bridges 1-686 and 1-684 is heavily into the design phase with construction expected in 2026. The Christina River Bridge (1-813) that carries I-495 over the Christina River is in the early stages of having a rehabilitation project initiated to bring the condition of the bridge from Fair to Good condition.

NHS Effectiveness Performance

As defined in the MAP 21 and FAST Act legislation, the performance of Delaware's bridges is not solely measured by the physical condition of these assets but is also measured in terms of the effectiveness of the NHS in providing safe and efficient movement of people and goods.

Projects undertaken with the objective of efficiently moving people and goods are often capacity and mobility projects that are included in the CTP/STIP. The effect that these projects have on physical condition of bridges will be included in the BMS analyses by incorporating these CTP/STIP projects as 'committed projects'. The physical condition of the bridge is accounted for and included when analyzing future bridge condition forecasts and funding scenarios.

Conversely, when major projects to restore physical condition are recommended for bridges, these projects are also analyzed to see if they can be combined with additional elements, such as widening, to address any capacity and mobility concerns.

In addition, it should be noted that DelDOT also has the responsibility to manage and maintain the entire network of bridges throughout the state, including non-NHS bridges. These additional objectives are included in the identification of bridge projects.

Finally, issues and concerns with respect to current and future environmental conditions including extreme weather events, climate change, etc. are part of the risk management process which includes specific assets impacted by previous emergency declarations (Part 667).

Work Planning and Programming

While the investment strategy giving approximate planned spending per work type of the next 10-years is generated by running BrM optimization analysis in the modeling software. Actual projects are identified using a combination of the annual Bridge Deficiency formula list as well as forecasted results from the BrM modeling software.

Bridge Deficiency Formula

Data for all bridges is automatically exported from BrM and imported into the Delaware Bridge Deficiency Formula spreadsheet described below using a script and a Bridge Deficiency Ranking List is produced. This list is distributed to Bridge Design by April 1 of each year. Working from the top of the list, Bridge Design and Bridge Management investigate each bridge and determine whether the deficiencies can be addressed by Maintenance Forces, Maintenance Contracts, or Bridge Design Contracts. The number of bridges selected for each group is determined by resource and budgetary constraints. Other factors that are taken into account when selecting bridges include conflicts with other upcoming construction projects, grouping of bridges with similar work needs, and monitoring/instrumentation alternatives. The list of selected bridges becomes the updated work plan for Bridge Design, Bridge Management, and the Maintenance Districts for the next 1-5 fiscal years. Additionally, Bridge Management and Bridge Design meet quarterly to discuss recent inspections, updates on the status of current projects and any potential urgent conditions that warrant immediate attention.

BrM Modeling Software

The optimizer in the BrM modeling software is performed for different bridge preventative maintenance programs to identify future bridge painting, pile jacketing, and deck overlay maintenance strategies along with other work needs so that draft cost estimates can be established, earmarked in the budget plan, and projects initiated. The 10-Year general forecast program is used to help identify larger or more expensive bridge work that will be needed in the out years. The 10-Year forecast program is also used to identify groups or clusters of bridges that have similar work needs and to evaluate the needs of bridges along a specific corridor. The results of the 10-year forecast are used to identify bridges that will most likely require replacement and this information is used when evaluating if short term work items are required or if the work items should be skipped and the funds used on other bridges.

Last, an individual bridge can have a stand-alone LCCA performed to assist with identifying the best course of action. This has been used at times to provide a more detailed analysis when evaluating multiple work actions for a particular bridge. Bridges experience a natural aging process. Each bridge is unique in the way it ages due to

varying factors including material makeup, weather and traffic loads. While there is no way to define an exact useful bridge life, for the purpose of asset management, useful life is considered to be 75 years.

Managing Asset Risks

The greatest risk associated with bridge structures is the loss of the structure for the purpose it was constructed and the potential for human loss in the event a bridge should fail. A bridge can deteriorate to the point that it loses its ability to carry full loading. When this occurs, the bridge must be posted for a lower load capacity or closed. If a route has a posted bridge, then a vehicle weighing more than the amount posted must use an alternate route. Vehicles using these alternate routes incur additional user costs due to the longer route traveled. Considering this, bridges with the greatest risk potential are those that carry the highest volume of traffic and have the longest "detour length" for alternate routes. Risk also increases as the classification of the road system increases. Interstates generally have the highest risk while Off-System routes generally have the lowest risk.

In addition to the inspection and analysis methods previously mentioned, the Bridge Deficiency formula was developed to assist in ranking the state's bridge projects. This tool concentrates DelDOT's efforts on structures with the greatest combined risk, rather than on those in the poorest condition or "worst first". The Bridge Deficiency formula is based on two principles: structural capacity and user demand. Structural capacity is based on the strength of the structure to carry vehicle loads, the condition of the different components of the bridge and the type of structure. User demand considers the amount of traffic crossing the bridge, the length of the detour if the bridge is not in service, restrictions on truck weight and classification of the roadway. Historical significance and susceptibility to scour and fracture are also factors that the formula considers to ensure that critical structures get preference. The Bridge Section uses the ranking from the Deficiency Formula to identify which bridges are candidates for rehabilitation or replacement and where these bridges need to be scheduled in the construction work program.

DelDOT currently is using the AASHTO BrM software to manage NBI and element condition data for each bridge in Delaware. The data is collected and updated by the Bridge Management Section during scheduled inspections or after a specialized event such as a large rainstorm, impact damage from vehicular traffic or observed issues identified by other entities. The BrM software uses element level inspection results to recommend preservation actions necessary for each bridge. While it has the ability to prioritize bridge work based on highest Benefit to Cost Ratio alone, the aforementioned Deficiency Formula takes into account multiple factors allowing for a more refined prioritization of bridge needs on an annual basis. They are as follows:

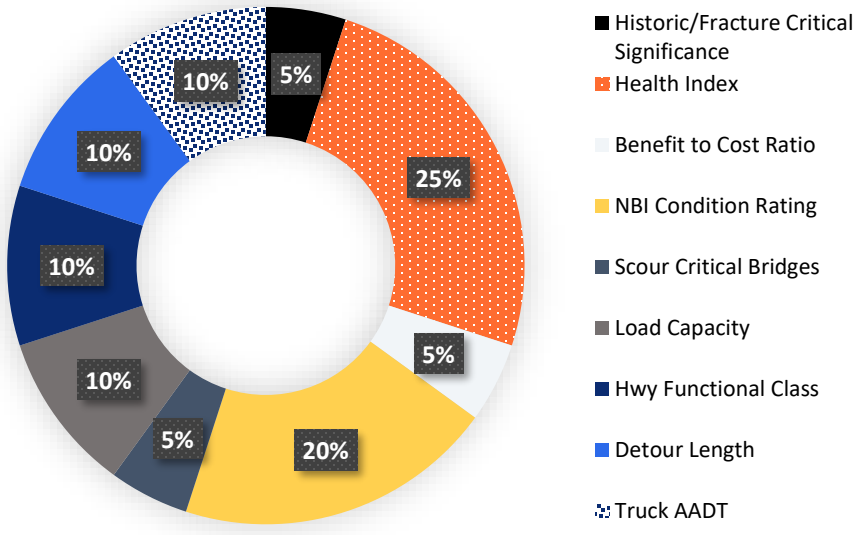
- Health Index – BrM uses Health Index as a numerical measure ranging from 0 to 100 to represent the condition of the bridge or any bridge element. The Health Index for a bridge is the sum of the quantity of each element multiplied by the condition state percentage multiplied by the element cost and relative weight, divided by the total sum of the element costs and relative weights. The Health Index is representative of the amount of work required for a given bridge.
- Benefit to Cost Ratio – Each preservation action that is recommended by BrM has an associated cost. The benefit from performing preservation work is determined by calculating the projected increase in Health Index for the bridge multiplied by the replacement cost of the bridge. BrM divides the calculated benefit by the cost to determine the Benefit to Cost Ratio.
- NBI Condition Rating – This factor assigns deficiency points to bridges that have been assigned a minimum NBI condition rating a '5' or bridges that have been identified as Structurally Deficient. A bridge is classified as "Poor" if the condition of the deck, superstructure, substructure or culvert is in poor condition as defined

by NBIS inspection guidelines. A bridge may also be considered in "Poor" condition based on load capacity or waterway adequacy.

- **Scour Critical Bridges** – A bridge is Scour Critical if the bridge foundation is determined to be unstable for the assessed or calculated scour condition. FHWA considers the completion of scour screening and evaluations of bridges over waterways and the development and implementation of Plans of Action for scour critical bridges to be high priorities in the FHWA bridge program as FHWA, in partnership with DOTs, strives to ensure safety for the users of public surface transportation.
- **Load Capacity** – All bridges have load rating calculations performed in order to determine their structural load carrying capacity. Any bridge that is not capable of carrying any of Delaware's legal load configurations must be posted as per the AASHTO Manual for Bridge Evaluation. A load posted bridge may have a significant effect on emergency services, school buses and commerce throughout the State.
- **Highway Functional Class** – Functional classification groups streets and highways according to the character of service they are intended to provide. This classification recognizes that individual roads and streets do not serve travel independently. The functional classification also gives an indication for the importance of the road. For example, the Interstate is part of the Strategic Highway Corridor Network (STRAHNET), which is important to the defense of the United States.
- **Detour Length** – This is the additional travel for a vehicle which would result from the closing of a bridge.
- **Annual Average Daily Truck Traffic (ADTT)** – The amount of truck traffic for a bridge gives an indication of the importance to commerce that a bridge may have.
- **Historic Significance** – The historic significance is determined by listing or eligibility for listing in the National Register for Historic Places. DelDOT has committed to the State Historic Preservation Office to implement a historic bridge inspection/maintenance program.
- **Fracture Critical Bridges** – Fracture Critical Bridges lack redundancy and as a result, are more susceptible to catastrophic failure, and therefore should be inspected and maintained at a higher level.

The weighting of each category in the Bridge Deficiency formula is shown in Figure 22.

Figure 22: Category Weightings in the Bridge Deficiency Formula



The BrM software forecasting scenarios are run at the beginning of each calendar year once the previous year's database has been finalized, utilizing the current bridge condition information. This generates a list of bridges based

on a prescribed cost/dollar threshold that require work according to the preservation models, defined Network Policies, and available budget. The BrM software calculates the associated costs and benefits. All other required data is queried from the current BrM database. All of the information is compiled in the Deficiency Formula spreadsheet. The deficiency points are calculated by the spreadsheet, and the bridge list is sorted by deficiency points in descending order.

Bridge work that is identified and selected from utilizing the bridge modeling software when running the optimizer for the individual bridge preventative maintenance programs and the10-Year general forecast runs are reviewed, cross-referenced, and incorporated in with the annual bridge deficiency list. Bridges and work that is identified in the modeling software for the out years (years 5-10) are not typically added to the annual bridge deficiency list but are considered for long-term planning of corridor projects and future bridge bundling projects. Even though these bridges are not added to the current annual bridge deficiency list, the total costs associated for each work type for those out years are taken into account when projecting out and planning future budget strategies. The bridges identified through the modeling software for the out years will eventually make it to the annual bridge deficiency list as the bridges further deteriorate and existing bridge projects are completed.

Best Use of Available Data and Systems for Bridges

The BrM software forecasting scenarios are run at the beginning of each calendar year, utilizing the current bridge condition information, collected using the Bridge Inspection Process outlined below. This will generate a list of bridges that require work according to the preservation models and defined parameters in the modeling software. The BrM software calculates the associated action costs, benefits, life cycle cost, and corresponding Utility Value. All other required data is queried from the current BrM database. The software then uses the analytical optimizer to forecast out and identify bridge work needs for the prescribed time period while adhering to the assigned funding constraints.

All of the necessary data required for the Bridge Deficiency Formula computations extracted out from the bridge database and is compiled in the Deficiency Formula spreadsheet. The deficiency points are calculated by the spreadsheet, and the bridge list is sorted by deficiency points in descending order.

To generate the required 10-year NHS Bridge forecast analysis using a system meeting the requirements of 23 CFR 515.17, the deterioration models and optimization analysis of BrM is used to analyze multiple funding scenarios. The process of running these analyses is described in more detail above in the Gap Analysis and Condition Projections section. The output of these analyses includes the 10-year planned expenditures by work type, as well as predicted conditions for the network over the 10-year period. This information is utilized by the Bridge Management Group for use in developing a planned investment strategy.

As described in Step 2 in the Gap Analysis and Condition Projections section above, part of this process involves updating candidate projects in the program and identifying any that are already programed in the DelDOT's Statewide Transportation Improvement Program (STIP) for instance such that these are 'frozen'. In this way, the optimization analysis will take place around any already committed projects and uses the remaining budget for any given year within the timeframe identified in the optimization run to select additional bridge work. The modeling software selects the additional bridge work while implementing prescribed Network & Life Cycle Policies.

Bridge Inspection Process

The Bridge Management Section is responsible for inspecting bridge structures and being in compliance with Code of Federal Regulations (CFR) Title 23, Part 650, Subpart C – National Bridge Inspection Standards (NBIS). The

NBIS, established by the FHWA, defines a "bridge structure" and sets minimum requirements for inspecting bridge structures. Compliance with NBIS inspection guidelines is a requirement of the law.

Bridge inspections are conducted using a two-part process:

1. Inspection – Bridge inspectors conduct on-site bridge structure inspections to determine and report current conditions.
2. Load Rating – Bridge engineers use the inspection report, plans and structural programs to analyze the bridge structure to determine the load carrying capacity. If the capacity is less than legal truck weights, the bridge structure will require posting (signs at the ends of the bridge structure detailing the maximum allowable truck weights) or closing.

A key component of compliance with NBIS requirements is to annually participate in the NBIS Metric Compliance Review with the FHWA to evaluate and document that NBIS requirements have been met.

In addition to inspecting and load rating bridge structures, the Bridge Management Group has other responsibilities including, but not limited to:

- Maintaining the AASHTO BrM software in order to effectively manage bridge assets throughout the state. Beginning in January 2015, DelDOT switched to the AASHTOware Bridge Management analytical software (the previous version was known as Pontis).
    - Working with local bridge owners to ensure that their bridge inspection program is NBIS Compliant.
- Communicating with local and other bridge owners regarding posting requirements and routine maintenance.
- Mobilizing inspection and maintenance resources to address emergency needs (flooding, bridge collisions, etc.)
    - Prioritize bridge work needs.
    - Implement Preventative Bridge Maintenance Program activities.
    - Review, evaluate, and approve superload hauling permits.

Chapter 4: Risk-Based Life Cycle Management

The AASHTO TAM Guide defines life cycle management as "an investment approach that considers maintenance, renewal, replacement, or repair options through an asset's service life with the intent to maximize the benefit provided by the asset at the minimum practicable cost."[34] This chapter describes DelDOT's process for defining a state of good repair for each asset class, establishing an appropriate network level of service based on state of good repair definitions, analyzing gaps between current conditions and identified level of service, setting targets to achieve the levels of service, and identifying and implementing life cycle strategies to achieve targets. This constitutes DelDOT's process for life cycle analysis, management, and planning.

The process described in this chapter can be applied to any asset. Multiple funding levels are analyzed across asset classes within each asset type or program to identify the resulting predicted performance over the analysis period. Once this is accomplished, cross asset tradeoff analysis can be completed by evaluating the effects of removing funding from one program and/or increasing funding in another. As the ability to project performance for different levels of funding is gained for additional asset types, these can be folded into this tradeoff analysis. The ultimate output of this process for each asset is an investment strategy based on a particular level of funding. It should be noted that the TAMP concentrates on planning for NHS pavements and bridges, but DelDOT conducts this process as part of its annual asset management cycle on various other asset groups.

DelDOT uses a condition-based life cycle management approach for both pavements and bridges. This means that the pavement and bridge assets are inspected and given a rating for their condition on a recurring schedule to provide a basis for treatment decisions. The conditions are input into the management systems and analyzed under different scenarios to determine the best mix of treatments for the condition and longevity of the pavement and bridge networks. The minimum BMS and PMS requirements include the following list as defined by 23 CFR 515.17[35].

- **"Collecting, processing, storing, and updating inventory and condition data for all NHS pavement and bridge assets;**
- **Forecasting deterioration for all NHS pavement and bridge assets;**
- **Determining the benefit-cost over the life cycle of assets to evaluate alternative actions (including no action decisions), for managing the condition of NHS pavement and bridge assets;**
- **Identifying short- and long-term budget needs for managing the condition of all NHS pavement and bridge assets;**
- **Determining the strategies for identifying potential NHS pavement and bridge projects that maximize overall program benefits within the financial constraints.; and**
- **Recommending programs and implementation schedules to manage the condition of NHS pavement and bridge assets within policy and budget constraints."**

[34] https://www.tamguide.com/section/4-1-introduction-to-life-cycle-management/

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

Five Steps of Life Cycle Management

The life cycle management process includes processes for Gap Analysis, Funding Scenario Analysis, and Target Setting, which all form part of the larger process of developing an investment strategy for the TAMP. The overall life cycle management process includes the following major steps:

Step 1: Identify Current Gaps – Current targets for % Good and % Poor metrics are discussed in each asset's chapter. To check progress against these targets, the trend of these metrics during the current performance period are plotted against the targets to identify current gaps.

Step 2: Analyze different Funding Scenarios and Project Future Network Condition – The agency uses pavement and bridge management systems[36] to forecast the condition of the assets out to the end of the analysis period[37] for each of the different funding scenarios identified in the Financial Plan. The management system analyses include life cycle cost analysis (LCCA) for each asset in the system, determining the best use of the agency's funds to achieve the desired objective. In general, the agency's objective is to provide the best network level of service possible given the available funding, thus improving asset conditions and lengthening their serviceable lives. This process is discussed in the more detailed steps below.

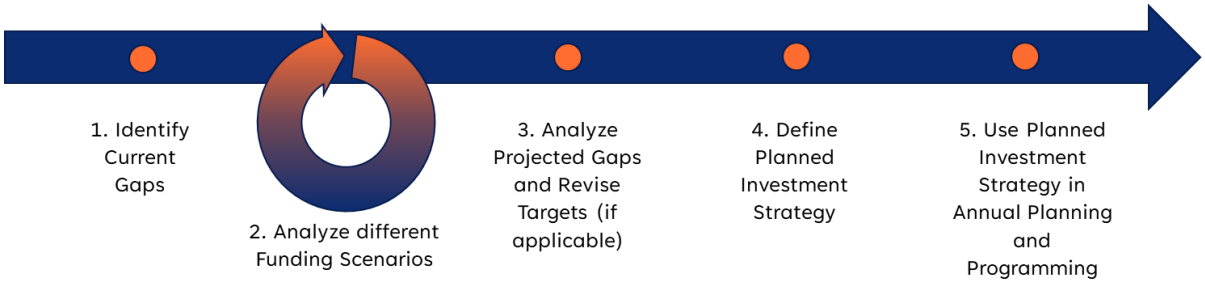
Step 3: Analyze Projected Gaps and Revise Targets (if applicable) – Once the scenarios have been analyzed, the results and resulting recommendations regarding funding needs and possibly target adjustments, are provided (from each Asset Steward) to the Steering Committee. The Steering Committee then compiles these and provides recommendations determined from the gap analysis to the Agency Leadership for consideration in the next budget cycle.

Step 4: Define Planned Investment Strategy – Based on the results of the Gap Analysis, Agency Leadership, in consultation with the Steering Committee and the individual Asset Stewards, finalizes state of good repair targets and a planned investment strategy for each asset class. The adopted 10-year investment strategy consists of planned funding per work type for each asset class in each year of the TAMP period.

Step 5: Use Planned Investment Strategy in Annual Planning and Programming – Once the planned investment strategy has been agreed upon by Agency Leadership and documented in the TAMP, this strategy is used by the individual Asset Stewards in their annual planning and programming process to inform the selection of projects.

These general steps are shown in Figure 23.

Figure 23: Gap Analysis, Scenario Analysis, and Target Setting Process



[36] Both management systems meet the federal requirements under 23 CFR 515.17 as described in the introduction to this chapter.

[37] Although the TAMP covers the plan for the next 10 years, the analysis period analyzed in the bridge or pavement systems may be much longer.

The first three major steps in the overall process are described in more detail below. The last two steps are described in more detail in Chapter 6: Financial Plan.

Step 1: Identify Current Gaps

The steps taken to identify gaps between the current condition and the targets currently adopted for the 4-year performance period are as follows:

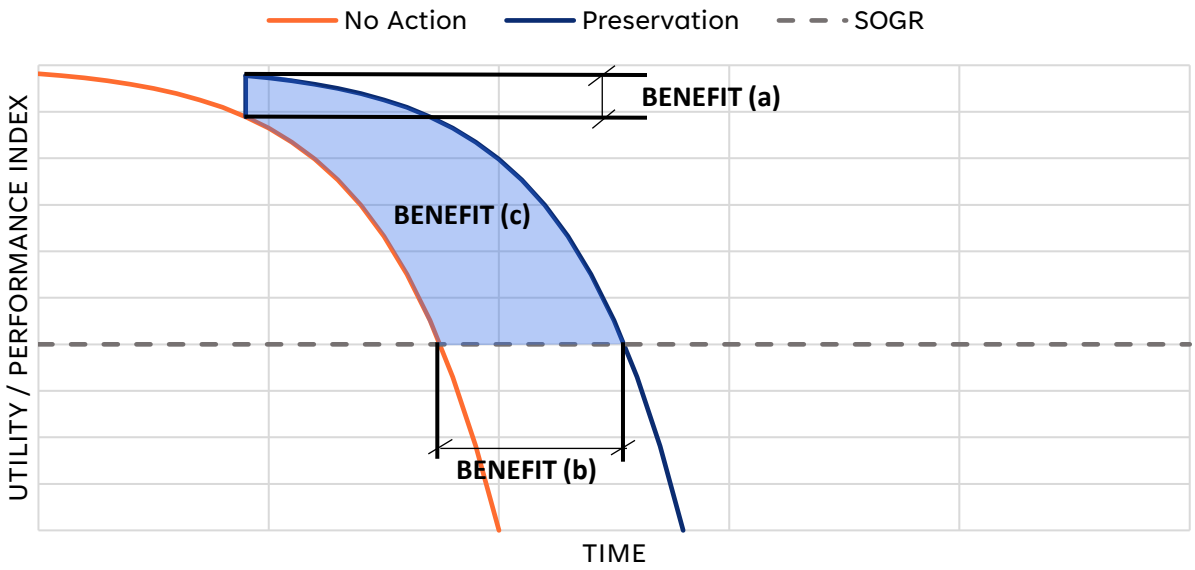
1. Note the various NHS condition targets for the FHWA metrics reported in the latest Performance Period Baseline or Progress Report, as required by 23 CFR 490.107.
2. Obtain the current condition FHWA metric values from the management system (or the latest Performance Period Baseline or Progress Report).
3. Compare the current conditions and target values for the FHWA condition metrics to identify any current gaps.
4. Obtain the current condition values in terms of the internal state index and compare these to identify any current gaps with state goals.

Step 2: Analyze different Funding Scenarios

The steps taken to analyze different funding scenarios are as follows:

1. Update asset inventory and condition in the management system – Use the most recently available data collected for each asset.
2. Update analysis parameters – This entails updating or confirming that the various inputs to the management system are current and valid.
    2.1. Update or confirm available treatment actions – Update of Treatments includes updating the list of treatments and adding or removing any as applicable. For each treatment, the unit cost of the treatment is confirmed or revised, and the effect of each treatment on every performance index that is being modeled is also confirmed or revised.
    2.2. Update or confirm deterioration models - Deterioration models are used for the key performance indices or elements for each asset.
    2.3. Update or confirm benefit calculations – The benefit is calculated as the difference between the 'do nothing' or 'no action' projection of the objective function and the projection for the proposed treatment, multiplied by various risk criticality factors. As an example, the benefit for a pavement project is calculated as the area shown shaded in Figure 24 below. This compares the original 'do nothing' condition projection over the life cycle of the asset without any action being taken to the updated condition projection over the life cycle given that an action occurs. Weighting factors can also be included in the benefit calculations. For example, average daily traffic (ADT) on the applicable roadway section is considered such that the benefit (both immediate and long term) of treating sections with higher traffic are weighted higher in the benefit calculation. This step includes updates of traffic data in the system. Future updates to the benefit calculation may include a higher consideration of risks to pavements such as flooding.

Figure 24: Benefit of a Treatment – (a) Benefit defined as the treatment's improvement to utility or performance, (b) Benefit defined as treatment's effect on the asset's useful life, and (c) Benefit defined as the area between the original deterioration curve and the updated deterioration curve.



2.4. Update construction history – Projects that have been completed in the last year are updated by obtaining the Construction History File and CTP/STIP Project Listing and updating the Construction History in the management system.

2.5. Update committed projects (including CTP/STIP) – The list of projects that have already been committed to are updated by obtaining the CTP/STIP Project Listing and entering these into the management system. The committed projects list includes many projects that are capacity or mobility projects, but also contains projects that have been identified to address threats of extreme weather and climate change and thus contribute to improving the resilience of the network. The committed projects are then 'frozen' into the benefit cost optimization analysis such that they are always included in all evaluated strategies. These risk related projects may be identified by the Districts via the Repeatedly Damaged and Vulnerable Assets (including Part 667) evaluation process or by TR&S. This is discussed in more detail in Step 5 below[38].

2.6. Identify Objectives and Constraints for Scenarios – The objective function for the particular scenario is confirmed. The objective function defines what the optimization will attempt to maximize or minimize. In addition to the objective function, the constraints for each scenario are confirmed. Note that the main constraints are the funding constraints obtained in Step 3. Typically, the main objective function used in the Optimization Analysis is to maximize the performance of the assets under a particular budget constraint.

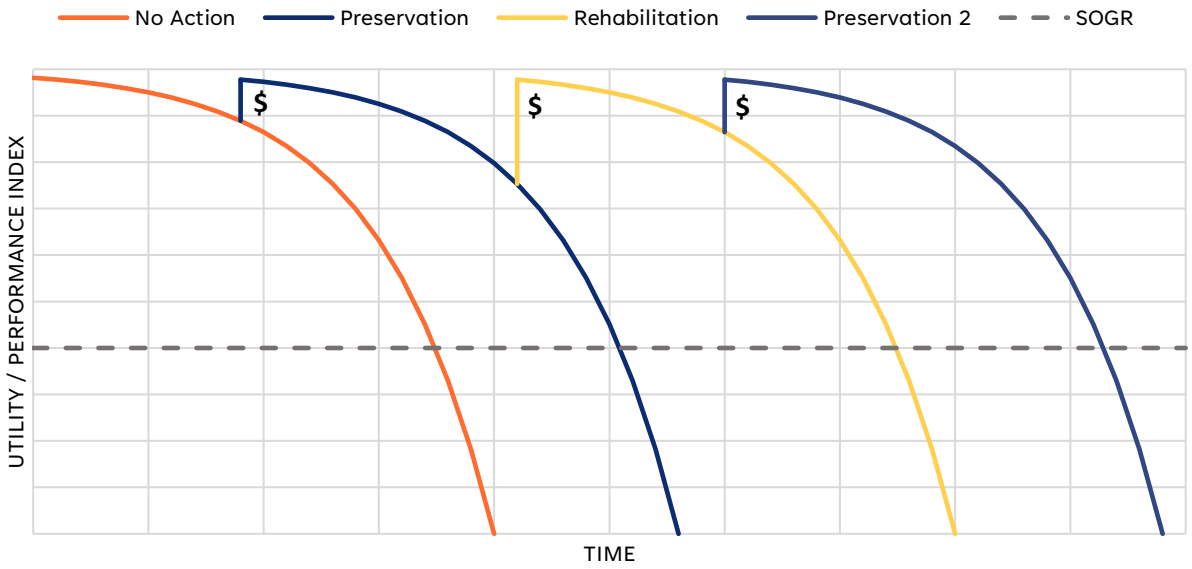
3. Define analysis scenarios – The Finance group provides the Asset Stewards with parameters for scenarios that are to be analyzed. The parameters can include things such as inflation rates, changing funding levels, percentage increase or decrease of overall funding, etc. The Asset Stewards may also choose to analyze different scenarios of their own.

4. Run life cycle optimization analysis for each scenario – Once the Objectives and Constraints have been identified for each scenario, the optimization analysis can be run. The management systems use the

[38] This ensures that projects specifically identified to address extreme weather and resilience are included in lifecycle analysis and planning.

condition information for each asset and the available treatment options to create a work plan for the network over the analysis period. For a particular asset, the resulting work plan may include multiple projects. For instance, a preservation project may be selected earlier in the asset's life cycle with a rehabilitation coming later as shown in Figure 25. Preservation treatments, when applied at the appropriate time, are typically the most cost-effective approach to maintaining an asset's condition (i.e., their benefit to cost ratio is high). Preservation maintains an appropriate level of service and increases the service life for an asset without the higher costs of a rehabilitation or reconstruction.

Figure 25: Life Cycle Analysis Example Results



5. Report and analyze results – The resulting recommended project work plans and projected conditions for a minimum of 10-year analysis period are reported to the Steering Committee. These reports are generated from the management systems. Each management group reviews the results for their asset group and determine their recommended strategy to the Steering Committee and by extension the Agency Leadership. The recommended strategies may request additional funding, changes to targets, or both depending on the assets current condition and management efforts.

Step 3: Analyze Projected Gaps and Revise Targets (if applicable)

Once the scenarios have been analyzed, the Asset Stewards provide their results and recommendations to the Steering Committee. The Steering Committee compiles these as well as recommendations and provides the gap analysis to the Agency Leadership for consideration in the next budget cycle. The following process steps are followed.

1. All scenario results from the different Asset Stewards are compiled by the Steering Committee.
2. The projected conditions over the 10-year analysis period are compared against both the State targets and the FHWA 2- and 4-year targets, and any key issues are identified that may be hindering progress toward achieving or sustaining the desired state of good repair. This includes discussing and documenting strategies for closing gaps with the asset groups.

3. If applicable, based on the results of the Gap Analysis, the Steering Committee may include recommendations for revising either the long-term State targets, or possibly short term FHWA metric targets, which must then receive approval from Agency Leadership.
4. If revised targets are adopted, one or more scenarios may need to be revised to show the budgets needed to attain the new targets. In establishing or revising targets, DelDOT considers historical levels of service, the results of customer surveys, industry practice, and any applicable laws and regulations. 2- and 4-year targets are reported and explained in both the TAMP and the performance period reporting.

Step 4: Define Planned Investment Strategy

Using the results from the Gap Analysis and the recommendations from each Asset Steward, the Steering Committee and Agency Leadership finalize targets and funding levels. The Asset Stewards take their finalized targets and funding levels and confirm the forecasted conditions determined by their management systems. Along with the conditions, the management systems produce work plans that include all treatments selected throughout the analysis period. This results in a breakdown of anticipated or planned investments on the asset network. The planned expenditures for selected treatments are then summarized into the appropriate FHWA work types listed in Figure 26.

Figure 26: FHWA Work Types

Once each treatment has been assigned an FHWA work type, the planned investment strategy, giving the planned expenditure per work type, can be determined using the work plan. The work plan for each asset group is translated into an investment strategy by summing the treatment costs for each work type per year. This final investment strategy is reported in the TAMP.

Methodology for Including the Cost of Investment Strategies in the Financial Plan

The asset management process allows for trade-off analyses between and among various asset classes. That is, DelDOT is able to forecast the performance implications of reallocating funding among asset classes. While DelDOT has the capability to analyze various scenarios within a particular asset class, conducting cross asset tradeoff is accomplished through discussion with Agency Leadership. The decision regarding whether funding should be increased or decreased over the 10-year analysis period for either the pavement or bridge programs is made by comparing the projected conditions under different funding scenarios and, based on any current or future

gaps identified, and takes into account the funding levels needed to maintain the pavement and bridge assets in a desired network state of good repair.

The existing process for funding the programs supporting the various asset classes is somewhat informal and relies on past funding levels, anecdotal knowledge of condition levels, and funding requests by the asset managers. As described, DelDOT has moved to place greater emphasis on information available from its asset management processes to play a greater role in making asset investment decisions and strategies.

The Steering Committee, in coordination with Agency Leadership, uses the asset investment scenarios provided by the Pavement and Bridge Management Groups to select one funding scenario each (from the analyzed scenarios above) for Pavement and Bridge as the Planned Investment Strategy.

In selecting the target investment strategy, multiple factors are considered. In addition to the primary focus of this plan on physical condition of the transportation infrastructure, Agency Leadership considers the other state and national goals and objectives as listed below.

- **Safety** – Projects identified through the TAMP process will be integrated with the Delaware Strategic Highway Safety Plan: Toward Zero Deaths as part of the CTP project evaluation process. DelDOT's primary traffic performance measures are related to Safety and Travel Time Reliability. This is the top priority in the CTP project evaluation process.
- **Infrastructure condition** – The focus of this TAMP document is to describe the processes and resulting plan for maximizing infrastructure condition and the asset life cycle at minimum practicable cost.
- **Congestion reduction** – Projects that are identified for maintaining infrastructure condition are combined with capacity and mobility projects and assigned scores in the CTP project evaluation procedure. This scoring system[39] assigns a weight to each project that includes the current Level of Service (LOS) and whether it is identified as a congested corridor.
- **System reliability** – One of DelDOT's long term goals is resiliency and reliability and DelDOT currently tracks a Reliability Index on Interstates (I-95, I-295 and I-495).
- **Freight movement and economic vitality** – DelDOT has identified Freight Movement as one of the eight elements of the LRTP. A primary goal under the Planning & Land Use element of the LRTP is economic vitality. Projects identified as part of the TAMP process are evaluated as part of the CTP project evaluation process based on whether they are located in a designated freight corridor[40].
- **Environmental sustainability** - Projects identified as part of the TAMP process will continue to be designed and implemented using DelDOT's environmental permitting process.
- **Reduced project delivery delays** - DelDOT has an ongoing goal to improve efficiency of project delivery. One of the goals under the Roads, Bridges and Other Assets element[41] of the LRTP is to establish a paperless project delivery system to design and procure projects using only digital files of DelDOT.

Once the overall goals of DelDOT are considered, the needs for each asset type are balanced with an emphasis on minimizing asset lifecycle ownership costs. These considerations include the probability of the respective revenue projection alternatives proving to be most accurate as well as the confidence levels associated with the projections of asset condition impacts associated with the differing levels of investment decisions. These trade-offs include

[39] Source: Long Range Transportation Plan – Part II: Implementation Strategies – Planning and Land Use

[40] Source: Long Range Transportation Plan – Part II: Implementation Strategies – Planning and Land Use

[41] Source: Long Range Transportation Plan – Part II: Implementation Strategies – Roads, Bridges and Other Assets

considering options that modify the respective investment levels between these asset classes and within work types.

The alternate asset funding scenarios provided are closely evaluated to understand the relative sensitivity of investment in these asset classes. This analysis is particularly valuable when evaluating whether to consider altering the investment ratios between asset classes.

Risk management and mitigation is considered in evaluating these options. Specifically, the Steering Committee includes a review of the risk registry as part of the evaluative process and considers whether competing investment options could have non-linear impacts on the level of risk exposure.

Based on the results of the prior steps, Agency Leadership, in consultation with the Steering Committee and the individual asset managers, finalizes the network state of good repair targets and the planned investment strategy for each asset class. The adopted 10-year investment strategy consists of planned funding per work type for each asset class in each year of the TAMP period.

The Steering Committee communicates the chosen Investment Strategy to Pavement and Bridge Groups for feedback and adjustment.

Step 5: Use Planned Investment Strategy in Annual Planning and Programming

The finalized investment strategy published in the most recent TAMP document is used as a basis for planning projects on the asset networks. The Asset Stewards use the investment strategy as a reference and guide in their annual planning and programming process. The work plans produced from the management system in the original analysis may not be followed exactly, but the magnitude of investment for each work type should be similar. Each year for the NHS pavements and bridges, the actual spending per work type is compared to the planned investment per work type for the consistency determination to confirm that the TAMP is being implemented.

Potential Projects

Condition related pavement and bridge projects are identified through the pavement and bridge management systems based on lifecycle cost analysis. In addition, a number of projects that are not directly related to condition such as mobility and capacity, and potentially risk mitigation and resilience improvement projects are continuously identified for possible inclusion in the CTP. All submitted projects for inclusion in the CTP are ranked using Decision Lens. Projects are therefore submitted to be considered in the Decision Lens process via multiple avenues including from sources such as the work plans produced from the management systems, the Repeatedly Damaged and Vulnerable Assets List, as well as the Resiliency and Sustainability Prioritization list.

- Asset Work Plans – These lists of projects are used by the Management Groups to plan work and potentially submit projects for the CTP. This process was outlined in the previous 4 steps of the LCP process.
- Repeatedly Damaged and Vulnerable Assets List – This list of assets has been developed to fulfill the requirements of 23 CFR 667. The assets that make this list are repeat issues for DelDOT that are either vulnerable to extreme weather events or other causes like high tide flooding. Each asset on the list is evaluated for mitigation options. The mitigation actions that receive a benefit cost ratio greater than 1 are submitted for consideration in the CTP. The current list is included in Appendix A – Explanation of Overall Pavement Condition (OPC) Configuration.
- Resiliency and Sustainability Prioritization List – The Frequently Flooded Roadways map is used as the starting point to determine vulnerable roadways. This map is reviewed for accuracy by the Districts, after which criticality of the roadway to the network is determined using the following factors:

- Strategic transportation network
  - Roadway link/use: evacuation route, critical asset along route (first responder location, school, hospital, freight route, etc.)
  - Roadway criticality (one-way in, one-way out roadway; redundant)
  - Roadway ADT and vehicle usage including freight (current and projected)
  - Roadway geometrics (horizontal/vertical curves)
  - Roadway pavement condition
  - Detour route if segment closed (miles/time)
  - State/federally funded roadway
  - Intermodal connector
- Impact on the public/social disruption/economic justice
  - Size of community
  - Population density (current and future)
  - Employment density (current and future)
  - Proximity to major economic and community locations
- Roadway flooding characteristics/conditions
  - Typical depth of water on roadway
  - Storm induced or "sunny day" flooding
  - Length of time water is on roadway
  - Frequency of flooding event
  - Local drainage features that could potentially reduce water on roadway

For assets owned by entities outside of DelDOT, a planned project list is obtained. DelDOT is not directly involved in other owner's project selection processes but includes their projects in the management system analysis to simulate their effects on the overall condition of the network. As there are not any MPO NHS owners, the MPOs plan work independently of DelDOT and do not submit projects for inclusion in the TAMP.

Decision Lens Prioritization Criteria

The Decision Lens Prioritization is used to generate the list of projects for DelDOT's CTP. The Approved Enhanced Project Prioritization Criteria used in Decision Lens and any changes to them are approved through the Council on Transportation (COT). The criteria and their weighting in the prioritization process are listed below.

- Safety – 35.0%
- System Operating Effectiveness – 19.1%
- Multi-Modal Mobility/Flexibility/Access – 11.9%
- Revenue Generation/Economic Development/Jobs & Commerce – 13.1%
- Impact on the Public/Social Disruption/Economic Justice[42] – 8.3%
- Environmental Impact/Stewardship – 6.6%
- State and Local Priority – 6.1%

Currently, the criteria, including Environmental Impact/Stewardship, does not account for resiliency beyond the specific projects proposed by DelDOT's TR&S division or the Repeatedly Damaged and Vulnerable Assets

[42] This criterion includes the consideration of equity in the project prioritization process.

process. However, TR&S is working on multiple initiatives to include resiliency and sustainability in the Decision Lens prioritization in the future. Other improvements in the consideration and analysis of factors relating to equity are being pursued. The initiatives related to resilience and equity are discussed in more detail in the Extreme Weather and Resilience Initiatives and Equity and Mobility Initiatives sections, respectively, in Chapter 5: Risk Management.

Inclusion of Projects in Lifecycle Planning

As noted in Step 2: Analyze different Funding Scenarios above, all of the final projects in the pavement and bridge program work plans and the CTP are included in the management systems as committed projects. Thus, the full life cycle planning process is circular.

Chapter 5: Risk Management

Risk to assets can come in many different forms ranging from natural disasters causing direct damage, to staff shortages reducing the amount of maintenance work that can be completed. As the lowest lying state by average elevation (60 ft[43]), Delaware is particularly vulnerable to flooding and sea level rise (SLR). DelDOT has developed a new division addressing risk, resilience, and sustainability; and the department implements multiple measures to identify, quantify, prioritize, and manage risks. The first section of this risk chapter presents DelDOT's ongoing and planned resilience, sustainability, and risk management initiatives. The following section covers risk management processes completed specifically as part of DelDOT's TAM processes, including the completion of an agency and program level risk register and the development and maintenance of a list of repeatedly repaired (Part 667 qualifying) assets with evaluations.

[43] https://www.statista.com/statistics/1325529/lowest-points-united-states-state/

Risk Management Initiatives

Extreme Weather and Resilience Initiatives

As of October 2021, the Infrastructure Investment and Jobs Act (also known as IIJA, Bipartisan Infrastructure Law, or BIL) updated federal regulations to require that State DOTs consider extreme weather events and infrastructure resilience in their risk management and life cycle analysis efforts. DelDOT currently has multiple efforts underway to address extreme weather and improve infrastructure resilience to factors including extreme weather and climate change. Extreme weather and climate change are intimately connected and have significant impacts on several aspects of DelDOT's NHS pavement and bridge networks from mobility to deterioration rates. This section discusses those potential impacts and DelDOT's approach for considering these in the risk management process.

CLIMATE ACTION PLAN – The Department of Natural Resources and Environmental Control (DNREC) developed a Climate Action Plan in November of 2021 for the state of Delaware. This plan lays out a roadmap for how Delaware plans to minimize greenhouse gas emissions and maximize resilience to climate change impacts. The action areas that apply to DelDOT's management of assets are as follows:

- **Update or create state regulations** that address protection and conservation of vulnerable and impacted resources.
- **Create management plans** for natural resources, emergency response, state facilities and agency equipment.
- **Update facility design and operation** that accounts for future climate conditions.
- **Promote research and monitoring** that studies the impacts of climate change and methods of adapting."[44]

The Climate Action Plan contains studies of the expected increases in temperature and sea level elevation which affect the deterioration rates of infrastructure. The plan also covers projected increases in precipitation and nor'easters which can cause road closures and washouts, culvert washouts, and bridge scour. The increase in frequency and intensity of these storms pose an increasing risk to DelDOT's infrastructure assets.

TRANSPORTATION RESILIENCY AND SUSTAINABILITY DIVISION – DelDOT's Transportation Resiliency and Sustainability Division (TR&S) was developed in May of 2021 to centralize efforts to improve the resiliency of the state's transportation network and focus on sustainability. TR&S collaborates with DNREC to implement sections of the Climate Action Plan.[45] TR&S has defined a Mission, Challenge, and Strategies to pursue the mission and address DelDOT's challenges; these are depicted in Figure 27. TR&S is primarily focused on addressing challenges associated with climate change, sea level rise (SLR), and frequently flooded roadways. TR&S coordinates with the DNREC among other organizations to investigate DelDOT's sustainability and resiliency challenges and address them appropriately.

"Sustainable transportation considerations and solutions are focused on striking a balance between economic, social, and environmental principles in a manner that supports the ongoing planning, development, operation, and maintenance of an 'enduring' transportation system."

– Climate Action Plan

[44] Delaware's Climate Action Plan - DNREC Alpha

[45] Transportation Resiliency and Sustainability - Delaware Department of Transportation (deldot.gov)

Figure 27: TR&S's Mission, Challenge, and Strategies

MISSION

- To provide the citizens of Delaware with the most resilient and sustainable transportation infrastructure through effective project planning, design, construction, and maintenance along with incorporation of innovative solutions such as alternative energy and electrification of our infrastructure to address the challenges associated with climate change and sea level rise.

CHALLENGE

- Due to the low-lying topography of the state, creating resilient infrastructure in the face of roadway flooding becomes a challenge. DelDOT has been and continues to be challenged by the effects of sea level risk (SLR) and frequently flooded roadways. It has been estimated the state has $1 Billion of infrastructure at risk assocated with these challenges.

STRATEGIES

- With so many factors, there can be no 'one size fits all' solution. DelDOT currently makes decisions about SLR on a case-by-case basis with careful considerations and unique strategies.

In addition to working on high-level resiliency and sustainability initiatives, TR&S identifies problem roadways and develops and submits projects for consideration in the CTP that improve resilience of DelDOT's vulnerable assets. TR&S considers alternative solutions to improve resilience. For instance, TR&S has considered redesigning a roadway that is frequently flooded and made impassable with porous asphalt and additional drainage protections as depicted in Figure 28. TR&S considers resilient solutions for identified vulnerable assets. To identify assets vulnerable to flooding that should be assessed for resilient solution options, TR&S has developed the Resiliency & Sustainability Prioritization Process. This process is incorporated as part of Step 5: Use Planned Investment Strategy in Annual Planning and Programming in the Life Cycle Planning process described previously.

Figure 28: Flood Resilient Pavement Design - Cross Section (Note: The picture below the cross section is the implementation of this roadway design midway through construction.)

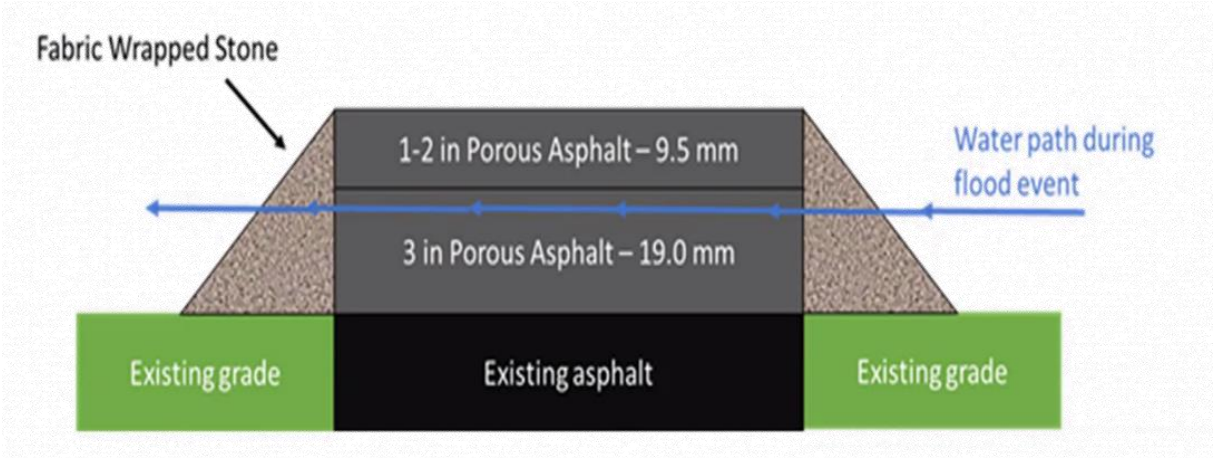


Figure 29: Map of DelDOT Pavement Management Sections and FEMA Coastal Flood Map

Source: NCHRP 08-118 Risk Assessment Techniques for Transportation Asset Management Report

TR&S is pursing the following additional initiatives to improve the resilience and sustainability of DelDOT's transportation system:

- Prioritization of frequently flooded roadways
- Roadway Flooding Matrix
- Internal/external stakeholder coordination
- Initiation and coordination of research initiatives
- Virtual Water on Road signage
- GIS/data decision making analysis
- Tide gauge/flood sensor deployment
- Maximo data utilization and/or analysis
- Green resilient infrastructure (living shorelines, pollinator sites)

UMBRELLA MITIGATION BANK INSTRUMENT (UMBI) – Due to Delaware's status as the second smallest state by square mileage (1,982 sq mi), there is low availability of land for wetland mitigation sites when required to offset project development. DelDOT has developed a tool for targeting future wetland mitigation sites. This will improve the agency's protection and enhancement of wetland resources for future project delivery.

GREEN INFRASTRUCTURE GROUP – Representatives from TR&S, Environmental Stewardship, and Water Resources make up the Green Infrastructure group. This group meets monthly to discuss green infrastructure solutions including examples such as living shorelines; wetland mitigation via the umbrella mitigation bank instrument (UMBI); increasing acreage for the pollinator program; living snow fences; etc. On a quarterly basis, DelDOT meets with DNREC to coordinate initiatives identified by the Green Infrastructure group on top of other initiatives. The purpose of DelDOT and DNREC collaboration is to determine overlap between departmental initiatives and support each other. The overlapping initiatives are largely focused on the sustainability and resilience of Delaware's infrastructure.

OTHER – In addition to DelDOT's internal initiatives, the agency has participated in regional calls and research studies that focus on developing and improving processes for inclusion of risk and resilience in State TAMP efforts. As the lowest lying state by

average elevation (60 ft[46]), Delaware is particularly interested in studies addressing flooding and SLR (see 100-year flood map in Figure 29). For instance, DelDOT participated in a National Cooperative Highway Research Program (NCHRP) funded study, titled NCHRP 08-118 Risk Assessment Techniques for Transportation Asset Management[47], that exhibited the quantification and inclusion of coastal flood risk to pavement sections in a PMS. The study was completed in the development environment of DelDOT's PMS.

Equity and Mobility Initiatives

Historically, the development of the highway system has had inequitable impacts on the US population. Collectively, highway asset managers are working toward developing equitable practices and metrics to improve the allocation of funding and projects.

DELAWARE EQUITY ANALYSIS TOOL – In coordination with WILMAPCO, the Delaware Department of Technology & Information, DNREC, the Delaware State Housing Authority, the University of Delaware, and Pennoni, TR&S has defined Disadvantaged Communities or Equity Priority Areas with the development of the Delaware Equity Analysis Tool[48]. This tool identifies Equity Focus Areas or Disadvantaged Communities throughout the state at the neighborhood block level, a more granular analysis than the census track that the US DOT and EPA tools use. The Delaware Equity Analysis Tool[49] will be used Department-wide in the decision-making process related to infrastructure investments, public outreach and engagement, and project planning. Additionally, TR&S is pursuing the inclusion of equity as a parameter in the prioritization process related to TR&S projects. The Justice40 Initiative created by the Biden-Harris Administration requires 40% of overall benefits of IIJA funding to be realized within Disadvantaged Communities.

COMPLETE STREETS – Complete streets are intended to balance needs of all travelers, regardless of ability, disability, and/or mode of transportation. DelDOT has produced the *DelDOT Complete Streets Design Guide* which guides DelDOT Design Staff through integrating complete streets design considerations into the planning stage of project development. The Complete Streets Policy along with the guide improves DelDOT's focus on mobility for all travelers.

Risk Management Process

DelDOT's annual risk-based asset management implementation effort follows the process presented in AASHTO's TAM Guide[50] and includes specific risk management activities. Figure 30[51] shows the general steps included in the risk management process. This section covers risk management processes completed specifically as part of DelDOT's TAM processes, including the completion of an agency and program level risk register and the development of a list of Part 667 qualifying assets with evaluations.

[46] https://www.statista.com/statistics/1325529/lowest-points-united-states-state/

[47] https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4556

[48] Delaware Equity Analysis Tool (arcgis.com)

[49] Delaware Equity Analysis Tool (arcgis.com)

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

[51] Adapted from AASHTO TAM Guide Figure 2.7: https://www.tamguide.com/subsection/2-2-3-risk-management/

Risk Consideration and Requirements

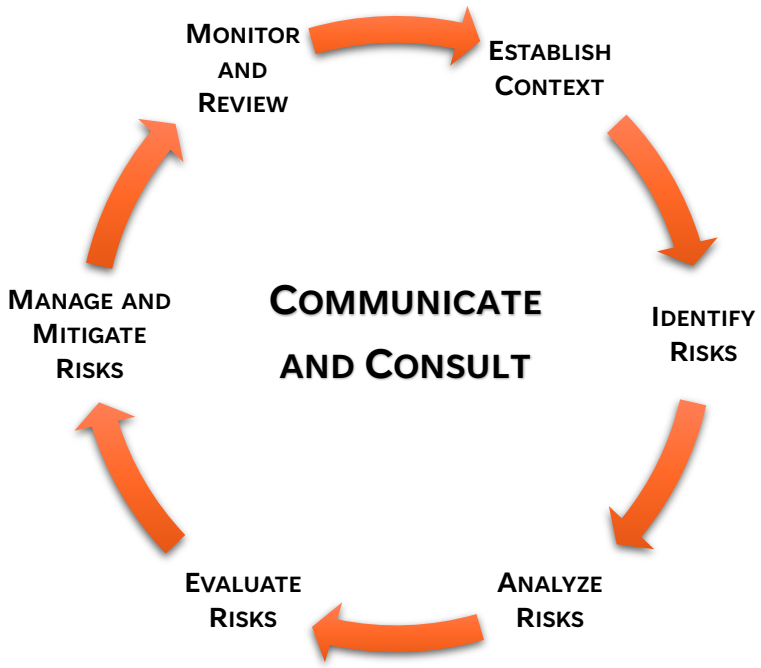
Risks can be divided into the following three levels:

- Agency Risks
- Program Risks
- Asset (project or location level) Risks

Agency risks affect more than one major program, or major objective of the organization. They tend to be external risks such as those related to budgets, legislative requirements, regulatory reforms, public sentiment, or significant personnel or managerial decisions.

Program risks affect collections of related projects or ongoing efforts to achieve specific organizational objectives. As such, a program could be a collection of construction projects, or a set of related activities such as managing pavements or bridges.

Figure 30: Risk Management Process Activities



Asset risks are assigned to individual assets, locations, or projects, such as a particular bridge, or a set of assets such as all bridges on a particular corridor.

Two sets of risks are assessed in the current process:

- High level 'agency or program' risks – these are compiled into a high-level Program Risk Register
- Asset level risks – this level of risk assessment and evaluation is required by the CFR 667 legislation to be reported on in the federal TAMP and is compiled in an Asset Risk Register called the Repeatedly Damaged Facility List (RDFL)

The agency and program risk workshop methodology is detailed in the TAM Implementation Guide while there is a dedicated SOP, 667 Repeatedly Damaged Facilities List Procedure, for updating the repeatedly damaged facilities list for 23 CFR 667[52] (referred to as Part 667). Both processes are summarized here. Each full process should be completed biennially, and the 667 list should be updated after extreme weather events. The Steering Committee is responsible for determining whether updates to either register are necessary.

The detailed requirements regarding risk for the FHWA TAMP are given in 23 CFR 515.7(c)[53]. These requirements include those for program and agency level risk identification, scoring, and management. This section of code also includes requirements to report on asset level risks including a summary of the evaluations of facilities repeatedly damaged by emergency events detailed under 23 CFR 667.

[52] 23 CFR 667: eCFR :: 23 CFR Part 667 -- Periodic Evaluation of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events

[53] 23 CFR 515.7 Process for establishing the asset management plan: https://www.ecfr.gov/current/title-23/section-515.7

Program Level Risks

The consideration of program risk is inherent in many of DelDOT's project prioritization and selection processes, as well as its operational procedures. For example, DelDOT uses a bridge deficiency formula to prioritize bridge projects. This formula includes factors not only for NBI condition rating, but also for scour susceptibility, truck traffic, AADT, and detour length, among others. Similarly, the pavement prioritization process includes consideration of such factors as AADT, access to medical facilities, and route continuity in addition to overall pavement condition.

For pavements, individual pavement and bridge projects are identified using lifecycle cost benefit analysis. In this analysis, the calculation of benefit will typically include risk mitigated by the individual projects. For instance, by weighting benefit using traffic as a factor in the pavement optimization analysis, the short and long-term benefit of treating sections with higher traffic is weighted higher in the benefit calculation for higher traffic roads.

Agency Level Risks

Because program risks are dealt with as part of the procedures described in Chapter 2: Pavements and Chapter 3: Bridges, this section focuses on agency risks. The procedure for developing and maintaining a list of agency risks is described below. The risk register identifies the primary agency and program risks, includes estimates of likelihood and consequence, and identifies mitigation strategies.

Asset Level Risks

Although states are only required to evaluate assets that have been repeatedly repaired or reconstructed due to emergency events, DelDOT manages a list of all assets that have been identified as vulnerable to risks. This list includes frequently flooded roads, assets that have been repaired or reconstructed once due to an emergency event, inoperable moveable bridges, and other vulnerable assets. The 667 list is pulled from the full list and reported on in the TAMP.

Risk Management Strategies

When determining a response to each risk identified, DelDOT considers the Five T's from the AASHTO Guide for Enterprise Risk Management[54] as follows:

- Tolerate – This option is typically chosen for low priority risks. When employing the tolerate strategy, DelDOT takes no specific action but continues to monitor the risk.
- Treat – DelDOT desires to treat and mitigate a risk if significant benefits can be attained at relatively low cost. High priority risks are often treated when possible.
- Transfer – When possible and suitable, DelDOT considers the option of transferring the risk. The most common method of transferring risk is through insurance. However, distributing risk between groups in an organization may also be considered.
- Terminate – If the risk can be removed altogether, then this option should be considered but must be weighed against cost.
- Take Advantage – In some cases, risks may be identified for a new process or policy but if the probability of considerable benefits significantly outweighs the probability of negative outcomes, it may still be desirable to adopt the process or policy.

[54] The AASHTO Guide for Enterprise Risk Management, First Edition, AASHTO 2016, available as an electronic document from the AASHTO Bookstore.

Program and Agency Risk Identification and Assessment Workshop Process

MAP-21 and FAST Act legislation requires state DOTs to develop risk-based Asset Management Plans. As part of ongoing risk identification and assessment, the Steering Committee follows the processes described below to review and update the Risk Register on a regular basis.

Workshop Frequency and Attendees

At least every other year, the Steering Committee arranges for a Risk Assessment Workshop to be conducted to update the Risk Register. The workshop attendees include a diverse group of representatives from the Districts, the Pavement and Bridge Management Groups, the Asset Management Steering Committee, and Agency Leadership. Because participants will likely differ somewhat from year to year, a refresher on the fundamentals of risk is typically covered as part of the agenda.

Workshop Scope

The workshop begins with an introduction and covers risk background including:

- Definitions and Terminology
- Risk Register Components
- Previous lessons learned

The group then participates in a facilitated exercise to identify/confirm the major risks to the Agency's goals and vision.

Risks covering a wide range of types, and the likelihood and consequences of these, are assessed. These include risks such as natural hazards, man-made or induced hazards, materials price variability, personnel or hiring issues, and other possible risk types. The process in full detail is captured in the TAM Guide.

Scoring

Risks are scored based on likelihood and consequence. Consequence and likelihood scoring guidelines are shown in Table 27 and Table 28. These include descriptions for each consequence scoring level, as well as the frequency ranges used for the likelihood or probability ratings. As part of the confirmation and update of the Risk Register, the workshop attendees should refer to these scoring guidelines as they score the risks.

The likelihood scoring guidelines are shown below.

Table 27: Likelihood Scoring Guide

Level	Descriptor	Description	Annual Probability Range	Probability
1	Low	50 years or more between events	<2%	1.0%
2	Medium Low	20 to 50 years between events	2% to 5%	3.5%
3	Medium	5 to 20 years between events	5% to 20%	12.5%
4	Medium High	1 to 5 years between events	20% to 100%	40.0%
5	High	One to several events per year	100%	99.0%

The consequences are divided into four separate impact areas: Safety, Mobility, Asset Damage, and Financial/Other Impacts. Different risks may affect these areas in different ways. The more significant risks will have high impacts in multiple areas.

Table 28: Consequence Scoring Guide

		Consequence to Public		Corridor / Region / Department	
Level	**Descriptor**	**Safety**	**Mobility**	**Asset**	**Financial Impact**
1	Negligible	Negligible safety hazard	Minimal delay	Minimal or cosmetic damage	Cost < $1M
2	Minor	Minimal safety hazard	Minor delay	Minor damage requiring repair	Cost $1M to $5M
3	Major	Likely minor injuries	Major delay	Moderate damage requiring repair	Cost $5M to $10M
4	Critical	Likely major injuries	Critical delay	Extensive damage requiring significant repair or replacement	Cost $10M to $20M
5	Catastrophic	Likely fatalities and major injuries	Catastrophic delay	Destroyed or large-scale damage requiring replacement	Cost > $20M

It should be noted that the scoring is not expected to be exact but rather to prioritize the risks in terms of their overall consequence and likelihood.

The 'raw' scores assigned based on the guidelines above are used to calculate an overall risk score for each identified risk as follows:

$$Risk\ score = \left(\sum consequence\ scores\right) \times likelihood\ score$$

Where:

- Likelihood score is the score between 1 and 5 based on the scoring guidelines (See Table 27).
- Consequence scores are the individual scores for safety, mobility, asset damage, and other financial impacts between 1 and 5 based on the scoring guidelines (See Table 28).
- Risk score is the combined effect of likelihood of the event occurring and the consequence of the event should it occur. It thus represents the overall potential impact to the Agency. The maximum score is 100.

Evaluation of Repeatedly Damaged and Vulnerable Assets

States are required to regularly evaluate facilities repeatedly requiring repair and reconstruction due to emergency events (23 CFR Part 667). In addition to the risk assessment workshop described above, as part of this requirement, DelDOT conducted a statewide evaluation to:

- Determine any emergency event as declared by the State Governor or US President since January 1, 1997
- Determine if any roads, highways, or bridges have required repair and reconstruction activities (permanent repairs) on 2 or more occasions due to emergency events
- By November 23, 2018, complete the statewide evaluation for all NHS roads, highways, and bridges – Completed
- By November 23, 2020, evaluate all roads, highways, and bridges – Completed

DelDOT initially identified facilities that were damaged and repaired or replaced due to emergency events using a designation in the project system for Emergency Repair (ER) or Federal Emergency Management Agency (FEMA) funds used. ER and FEMA funds are only used for declared emergency events, thus this was an appropriate starting point. DelDOT used this list of projects to determine whether ER or FEMA funds were used for the same location across multiple emergency events. In the future, additional fields will be added to the project system to help with tracking repeated work on the same locations. DelDOT is currently in the process of transitioning between project systems, so additional fields will be implemented in the new system. In the meantime, the initial list has been expanded to include additional vulnerable locations. The additional vulnerable locations proposed for evaluation were identified using DelDOT's list of frequently flooded roadways and known roadway washouts. While only STIP eligible locations are required for Part 667, the full list of evaluated locations is maintained by DelDOT.

The evaluation process is repeated periodically, typically at the same time as the main risk register workshop but also after declared emergency events, to continuously update the repeatedly repaired (667) facility list and risk evaluation. The detailed process for this workshop is documented in detail in an internal SOP. The evaluations for potential 667 facilities, based on the most recent risk workshop, are given in Appendix A – Explanation of Overall Pavement Condition (OPC) Configuration.

The general process for evaluating asset level risks is to evaluate possible mitigation actions, including the Do Nothing alternative. The Do Nothing option is used as a comparison point for each mitigation action as it exhibits the consequences of Tolerating the risk. Each possible mitigation action is evaluated as follows:

- Action – First evaluate Do Nothing action. Then define at least one other possible mitigation action to alleviate the consequence of a similar event to the latest event which damaged the asset.
- Cost of Action – Estimate the agency cost of the mitigation action.
- Duration of Fix – Estimate the duration before the asset will need to be repaired or replaced in years.
- Annualized Cost of Action – The Cost of Action is divided by the Duration of Fix to obtain an Annualized Cost of Action.
- Event Frequency (Likelihood) – Estimate the frequency of the event. How many years are expected between events? For example, if the event is expected to occur once every 5 years, the frequency would be 1 event / 5 years = 0.2. Or if the event is expected to occur once every month, the frequency would be 12 events / 1 year = 12.
- Cost Exposure after Action (Consequence) – Estimate the User Costs, Repair Costs, Safety Costs, and Other Costs and sum these as the consequence of the event assuming the mitigation action had been implemented. The consequence is then annualized based on the event frequency to give the annualized expected consequence.
- Risk Reduction – Calculate the risk reduction as a percentage of the expected Consequence under the Do Nothing alternative minus the remaining expected Consequence if the mitigation action was implemented.
- Benefit Cost Ratio – Calculate the benefit to cost ratio (B/C Ratio) by dividing the expected annualized consequence reduction (see Risk Reduction) by the Annualized Cost of Action (described above). If this B/C Ratio is greater than one, the mitigation action could be considered. If the ratio is less than one, the risk could be tolerated.

Regarding specific asset risks, the facilities repeatedly damaged by emergency events listed in Appendix B – Risk is regularly updated. If the B/C Ratio is less than one for a particular project, it is not likely to be selected. However, all options are reviewed as part of the annual planning and project selection process described in Step 5: Use Planned Investment Strategy in Annual Planning and Programming of the LCP process. The project Prioritization Criteria considered in the Decision Lens process (detailed in Chapter 4: Risk-Based Life Cycle Management) does

not yet include a Resilience specific criterion. However, risk mitigation projects can be weighted heavily in the System Operating Effectiveness criteria with the impacts of damage and repeat flooding. Where possible, the pavement and bridge groups consider risk mitigation actions to include in the project work plan. When selected, these projects improve the resilience of the network by mitigating the consequences of extreme weather and emergency events. Together these risks are used by DelDOT for planning projects and initiatives to mitigate the vulnerabilities of physical pavement and bridge assets.

Current Risks and Mitigation Strategies

The results of the risk workshop held in April 2022 were used to update the risk register which contains a risk score for each risk as well as the current mitigation strategy for that risk. The current risk register and the repeatedly damaged and vulnerable assets are presented in Appendix B.

Risk workshop participants identified a combined eighteen agency and program level risks to DelDOT's goals and vision. The top five agency and program level risks identified from the 2022 risk workshop are listed in Table 29. Each has an associated score, risk management approach, and mitigation strategy. The risk management approaches are one of the 5 T's defined as Treat, Tolerate, Transfer, Terminate, and Take Advantage.

The highest scored risks are both related to crashes: highway crashes and major incidents on high volume roads. Delaware is connected to the contiguous United States via upper New Castle County. All of the interstates are within this portion of the county, and when there is a major accident on any portion of these roadways, there are significant consequences to safety, mobility and the economy. Detours around Delaware are substantial either via Maryland, Pennsylvania, or New Jersey. Delaware's other roadway networks are easily overwhelmed when there is a major incident on any of the interstates. The C&D Canal separates southern New Castle, Kent, and Sussex Counties, which makes up the Delaware portion of the Delmarva Peninsula. The four bridges crossing the C&D Canal are maintained by the Army Corps of Engineers, with the SR 1 crossing being the most critical. When this one bridge is affected by an accident or planned work, the other three bridges can be overwhelmed with traffic. There is no other convenient way to get from southern Delaware to northern Delaware if there are significant issues on these crossings. One of the major interstate businesses is the chicken industry. Tractor trailers filled with chickens traverse the state from PA and MD and back, utilizing major Delaware roadways. Their economic vitality is tied into the ability to move their product between their farms in Delaware and the surrounding states.

Two of the five top risks noted above are weather related or natural hazards. Delaware is situated along the eastern seaboard and the southern portion of the state is part of the Delmarva Peninsula. While the northern part of the state is influenced more from natural events sweeping from upper elevations of Maryland and Pennsylvania, the southern portion of Delaware is influenced from the Chesapeake Bay, Delaware Bay, and Atlantic Ocean. Unanticipated occurrences of natural events (specifically extreme weather events) have increased significantly within the last few decades, resulting in safety, mobility, unanticipated asset costs, and other financial consequences. This increase in frequency of extreme weather events is largely due to climate change and sea level rise (SLR). As discussed in more detail in the Risk Management Initiatives section at the beginning of this chapter, DelDOT's TR&S division has taken the lead on researching and developing solutions for these increasing risks.

Finally, like many other agencies, DelDOT is struggling to recruit and retain employees. This is a high priority risk as the lack and loss of employees affects all activities. While DelDOT has implemented efforts to try and mitigate this risk, it is challenging to compete with consulting agencies. With fewer engineers, engineering technicians, environmental specialists, and other transportation professionals graduating, DelDOT finds it difficult to compete with private and other higher-paying agencies.

Table 29: Top 5 Agency and Program Risks Identified for 2022-25

Risk ID	Risk Level	Asset Class	Event/Occurrence	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
20	Program	Safety	Highway Crashes	**75**	DelDOT's #1 priority is to reduce fatalities and injuries.	DelDOT will continue to **Treat** this risk by continuously implementing and improving the Strategic Highway Safety Program, prioritizing safety projects in the Capital Transportation Plan, and implementing the Complete Streets program and 'safe systems' including continuing initiatives to connect trails and sidewalks and separate modes of travel.
1	Program	Safety	Major Incidents on High Volume Roadways (e.g. Interstates)	**70**	Major incidents can have major safety, mobility, and economic effects.	DelDOT is **Treating** this risk by continuing to implement the hazmat program. DelDOT has also assigned the Traffic Management Center to coordinate the emergency response. DelDOT is continuously working to improve the resilience of the network - i.e. returning to service faster.
2	Program	Culverts, Bridges, Pavement	Unanticipated Occurrence of a Natural Event/Asset Failure - Frequent Events (Localized Storms, Tornadoes)	**65**	Culverts were not designed to withstand the unanticipated storm intensities, and DelDOT cannot make all culverts larger. Typically, when an asset fails, there is not enough lead time to get permits etc. to increase culvert sizes as the roadway must be returned to service quickly.	DelDOT is currently **Tolerating** this threat with plans in place to begin **Treating** and mitigating the consequences of these events. DelDOT's recently created Transportation Resiliency and Sustainability (TR&S) Division is developing a process for prioritizing frequently flooded roadways for mitigation projects. In the future, DelDOT plans to develop inventory of pipes (and bridges) including sizes and material and locate undersized pipes. This will make risk evaluation of mitigation options possible.

Risk ID	Risk Level	Asset Class	Event/Occurrence	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
7	Agency	All	State Employee Recruitment and Retention	**60**	Staff shortages impact all activities from response time to incidents and snow events to higher project costs. Relying on contracted help increases costs and contributes to a loss of institutional knowledge. The current Low Unemployment Rate combined with salary caps affects DelDOT's ability to maintain a competitive salary for employees. DelDOT has to receive approval from the general assembly for merit salary increases.	DelDOT must **Tolerate** this risk to some extent as many factors are external. However, DelDOT is **Treating** this risk where possible by continuing to work with unions to negotiate salaries. DelDOT is also implementing the following agency initiatives to improve retention and mitigate the impacts of losses: employee moral committee, team building events, alternate work schedules, if possible, tele-working, succession planning (especially for high turnover positions), hiring consultants (in-house or external), and hiring contractors.
12	Agency	All	Anticipated Occurrence of a Natural Event/Asset Failure - Infrequent Events (Hurricanes, Nor'easters, and Tropical Storms)	**57**	The most probable destructive natural events in Delaware are hurricanes or tropical storms, Nor-easters, and flooding. As the frequency and intensity of these events is expected to increase with climate change, DelDOT will continue to emphasize and track this risk to infrastructure.	DelDOT has activities in place to **Treat** this risk and mitigate the consequences. If an event is imminent, DelDOT crews ensure that preparations, such as clearing of drainage structures, erosion control measures, etc. are performed. Post-event, DelDOT maintains a "storm" fund to expedite returning assets to a state of good repair. Federal emergency and disaster assistance funds are also used following events. In relation to other operations, DelDOT has undertaken Continuity Of Operations Planning (COOP) and provides employees with the ability to work from home. Data archives are backed up in alternate locations.

Following the 2022 risk workshops, DelDOT identified Build America, Buy America (BABA) Compliance as a risk due to possible supply chain delays, availability of materials, and cost of materials which will potentially be reflected in construction contract bid items and schedules. A sub-risk associated with the BABA requirements is the complications of requiring contractors to meet the BABA requirements, potentially causing additional delays in projects. It is DelDOT's view that requiring compliance with the proposed BABA preference on existing indefinite delivery/indefinite quantity (IDIQ) contracts may create unplanned costs and hardship on the Department and contractors working on these contracts. DelDOT has identified that some utility companies are reluctant to comply which will impact project schedules. To manage this risk, DelDOT is creating Buy America Requirements contract language, setting up a DelDOT Buy America website, using the AASHTO Portal for BABA, developing the Source of Supply Database spreadsheet, and taking advantage of the DOT proposed temporary waivers.

The evaluations for potential 667 facilities were performed at the same time as the 2022 risk workshop based on the criteria described earlier in this chapter. Not only did the participants complete a statewide evaluation for all Delaware NHS roads, highways and bridges, they also completed the evaluation of all roads, highways and bridges in Delaware. Out of the fourteen identified facilities repeatedly damaged by emergency events, there are only two on the NHS, the washout of pavement on SR 1 South of Dewey Beach near Keybox Road and another location on SR 1 South of the Indian River Inlet Bridge (IRIB). There have been several storms, most of them localized, which have covered SR 1 with either stormwater runoff or tidal waters. For the section South of Dewey, the maintenance district, after several repeated events and minor maintenance fixes, opted for a more permanent fix by adding 4" of hot-mix pavement to the top elevation of the roadway for one mile along all lane miles within this area. To date, the fix has partially mitigated this repeated damage event and the location is monitored and reevaluated biennially in the Repeatedly Damaged Facilities List (RDFL) contained in Appendix B. DelDOT is considering a similar project to raise pavement segments by 4" on SR 1 South of IRIB. An evaluation for this section is also included in the RDFL. Evaluations for each of the 14 locations are presented in the RDFL in Appendix B ranked in order of Benefit-Cost Ratio.

The risk register and the periodic evaluation of facilities repeatedly damaged due to emergency events are used for planning mitigations with regard to condition of physical pavement and bridge assets.

Chapter 6: Financial Plan

FAST Act legislation requires the inclusion of a Financial Plan as part of the Transportation Asset Management Plan (TAMP). According to the FHWA's final guidance on TAMP financial planning, *Developing TAMP Financial Plans*[55], "The key components of a TAMP financial plan include:

1. The sources and amount of revenue available to the agency for investing toward achieving asset management condition targets and managing risks.
2. The full range of funding needs to support achieving agency goals, objectives, and targets.
3. A description of the agency's investment strategy to achieve the state of good repair during the TAMP time period.
4. The estimated annual cost of implementing the agency's investment strategy during the TAMP time period.
5. An estimate of the value of the agency's NHS pavement and bridge assets and the annual cost to maintain the value of these assets."

By expanding on each of these areas in the enclosed financial plan, a realistic picture of DelDOT's projected future financial health comes into focus. In addition to highlighting the financial plan, this discussion communicates the impact of varying investment levels and predicted outcomes in the State's transportation infrastructure.

This chapter identifies the processes, documentation, and analyses that are required in an asset management financial plan. It discusses historic revenue levels and contains projections of the funding expected to be available for allocation to DelDOT's pavement and bridge assets over the next 10-years. The financial plan relies on outputs from the annual revenue forecasting and budget process, the program distribution process and the TAMP processes discussed in other chapters of this document.

Financial data for the figures in this chapter were provided by DelDOT's Finance Division in June 2022. DelDOT's Financial Division used data confirmed by the Delaware Transportation Authority in the *Official Statement* for expected revenues and spending. This chapter aligns with the State's financial goals and definitions outlined in the *Official Statement*.

[55] https://www.fhwa.dot.gov/asset/pubs/developing_tamp_fp.pdf

Revenues

Sources

DelDOT is financed by a variety of fees and taxes paid by the users of the State and national transportation systems. State revenue is generated through several sources that include motor fuel taxes, tolls, DMV Fees, and other transportation revenue. Federal funding is provided through the transportation legislation (IIJA), which is financed primarily by the Highway Trust Fund (HTF). Congress is responsible for authorizing Federal Funding, which is apportioned to states through the federal transportation legislation. DelDOT's sources of revenue include:

- **Motor fuel taxes**. The State of Delaware levies a per gallon tax on gasoline and special fuels.
- **Tolls**. DelDOT operates three toll roads: the I-95 Turnpike, State Route 1, and US 301.
- **DMV fees**. Motor vehicle document and registration fees, and driver licensing fees.
- **Federal allocations**. Funds received as a direct allocation from the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA).
- **Other**. Transit farebox revenue, state general fund transfers to DelDOT, federal discretionary grant awards, and miscellaneous revenue sources.

The base Financial Plan is a reflection of the following:

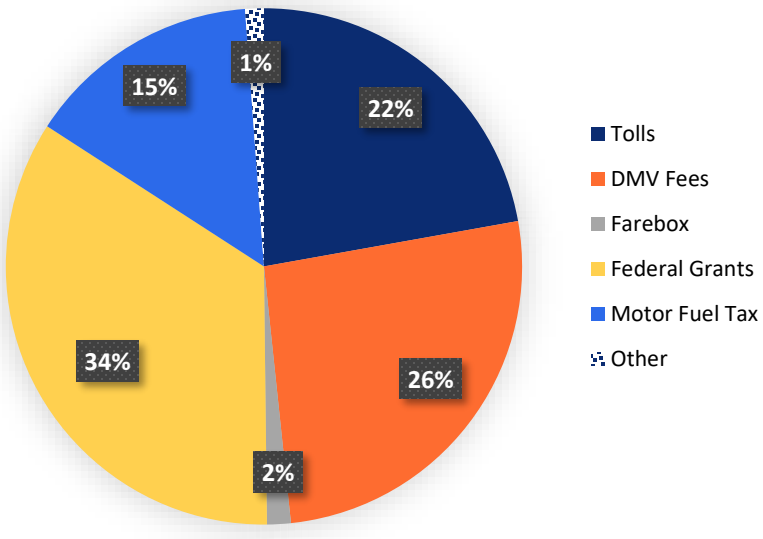
1. Sources of funds to the Transportation Trust Fund (includes both pledged and non-pledged revenue[56])
2. Debt Service Annual payments
3. Operating Budget Projections
4. Capital Program Projections - State and Federal (FHWA, FTA, FRA, FAA)

The sources and uses of funds are based on revenue projections, the 6-year Capital Transportation Plan and specific forecasts and analysis developed to support development of the TAMP. All sources and uses are based on a comprehensive cash flow plan.

Figure 34 depicts the sources of Fiscal Year 2022 revenue and their relative shares of DelDOT total revenue. This is typical for a year in which borrowing did not occur.

Tolls, fuel taxes, motor vehicle registration and license fees represent the major revenue sources for the Transportation Trust Fund, which funds

Figure 31: FY 2022 Revenue Sources



[56] Pledged versus Non-Pledged funding – Pledged revenues are revenues obligated for payment to outstanding debt of the Delaware Transportation Authority (DTA); Non-Pledged are revenues with no such obligation

the general maintenance and construction of the DelDOT roadway network. These sources also serve to match available Federal funds.

FTA and farebox funds are associated with the funding of the Delaware Transit Corporation (DTC), which provides public transportation services for the state. These revenue sources are devoted to DTC, but DelDOT also annually supplements these funds with significant operating subsidies[57]. A separate transit asset management plan covers transit assets and is submitted to the Federal Transit Authority (FTA) for approval.

Tolls:

DelDOT's Division of Motor Vehicles is responsible for providing toll services for the state's three toll roads: 1) the I-95 Turnpike, 2) State Route 1, and 3) US 301. Toll operations are supported by three main toll plazas and three automated ramps[58].

Motor Fuel Tax:

The State of Delaware levies excise taxes on gasoline, diesel fuel, and special fuels used by motor vehicles that use public highways. Likewise, the Federal government levies excise taxes on gasoline, diesel fuel, and special fuels used by motor vehicles on public highways. The excise tax rate for Motor Fuel (Gasoline, Gasohol and Aviation Gasoline) in Delaware is $0.23 per gallon[59]. The excise tax rate for Special Fuel (all other fuels placed into a licensed motor vehicle in Delaware) is $0.22 per gallon[60]. The Federal government rate is $0.184 per gallon for gasoline and $0.244 per gallon for diesel.

DMV Fees:

DMV fees include driver licenses and vehicle services (document, title, registration, inspections, motor carrier and dealer services). Driver's licenses and learner's permit fees are paid by persons licensed to operate a motor vehicle. Registration fees are based on a vehicle's classification and are renewed annually or on a multi-year basis.

Federal Aid:

DelDOT also relies on Federal funds as a source of revenue for the capital transportation program. Federal-aid is obtained in the form of reimbursable grants. Federal transportation legislation provides funds that are available for obligation for eligible projects on the Federal-aid system. DelDOT, like most other State DOTs, expects to continue obligating all available Federal funds. The current transportation legislation is the Bipartisan Infrastructure Act, also known as Infrastructure Investment and Jobs Act (IIJA). This new legislation provides $550 Billion over fiscal years 2022 through 2026 in new Federal investment in infrastructure, including in roads, bridges, and mass transit, water infrastructure, resilience, and broadband. Specifically, with regard to transportation, the IIJA will repair and rebuild our roads and bridges with a focus on climate change mitigation, resilience, equity, and safety for all users, including cyclists and pedestrians; improve the safety of our transportation system; Improve healthy, sustainable transportation options for millions of Americans; Build a network of EV chargers to facilitate long-distance travel and provide convenient charging options; Modernize and expand passenger rail and improve freight rail efficiency

[57] Delaware Transportation Authority's *Official Statement*. Published 2022.

[58] https://www.dmv.de.gov/services/toll_services/tolls.shtml

[59] Delaware Transportation Authority's *Official Statement*. Published 2022. Page 20-21.

[60] https://finance.delaware.gov/publications/tax_prefer/mtr_sp_fuel.pdf

and safety; Improve our nation's airports; and provide state and local governments with new and expanded competitive grant programs.

Based on formula funding alone, Delaware expects to receive approximately $1.4 Billion over five years in Federal highway formula funding for highways and bridges which represents a 33.4% increase in formula funding when compared to the FAST Act. Also, anticipated is approximately $225 million over five years in Federal transit formula funding for federal public transportation programs in Delaware, which is a 25% increase over current funding levels. IIJA provides funding through a wide range of competitive grant opportunities, the Department will leverage its resources to apply for applicable grant programs to potentially increase the amount of federal resources available for the capital program.

Federal law permits States with toll facilities to earn credits that can be applied towards the non-Federal share requirement on Federal-aid projects. A State may earn toll credits when a public, quasi-public, or private agency uses toll revenues to build, improve, or maintain highways, bridges, or tunnels that serve the public purpose of interstate commerce. In early 2022, DelDOT received approval of its application of toll credits valued at over $1.4 billion. Toll credits may be applied towards the non-federal share costs for which the state has not received reimbursement and must be supported by federal apportionment. While no additional apportionment is allocated for toll credits, it allows a State to complete projects as a 100% federal ratio as selected.

Other:

As indicated, FTA and farebox funds are associated with the funding of the Delaware Transit Corporation (DTC). However, other revenue sources include state general fund transfers to DelDOT as well as various miscellaneous revenue sources.

Historic Funding Levels

Table 30 depicts historical DelDOT revenues[61] by source for Fiscal years 2017 - 2021. Figure 32 illustrates this information graphically.

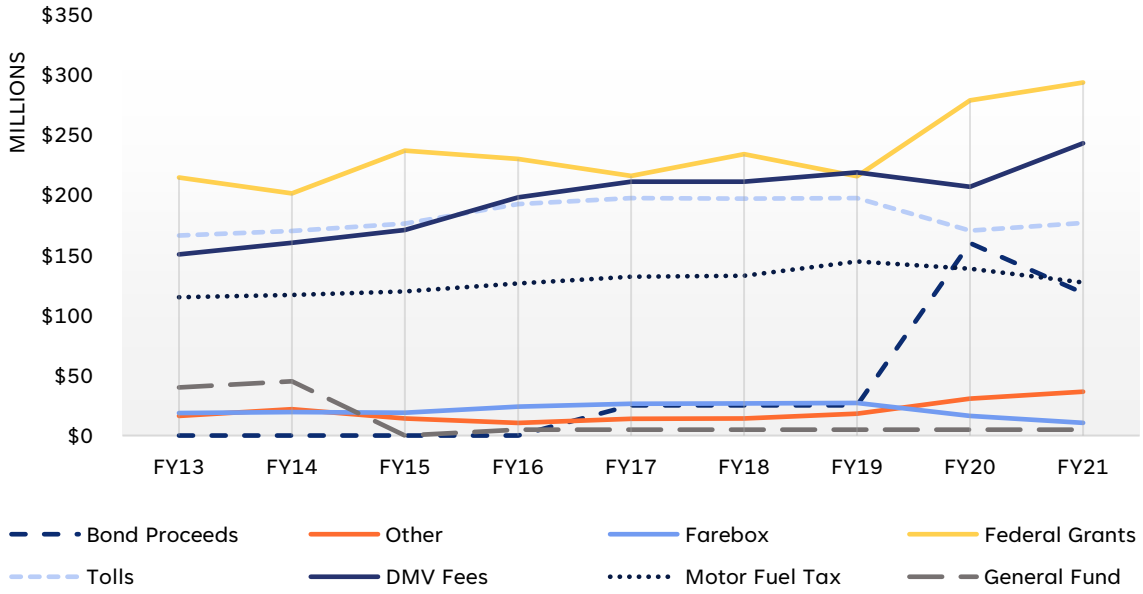
Table 30: FY17 – FY21 Revenues and Changes (in Millions)

	FY17	FY18	FY19	FY20	FY21	5-yr Annual Average	Average Annual Increase / Decrease FY17-21
Bond Proceeds	**$25.00**	**$25.00**	**$25.00**	**$160.00**	**$118.60**	**$70.72**	**$18.72**
Other	$14.00	$14.10	$18.10	$30.75	$36.44	**$22.68**	**$4.49**
Farebox	$26.40	$26.80	$27.10	$16.32	$10.55	**$21.43**	**($3.17)**
Federal Grants	$215.90	$233.90	$215.70	$278.50	$293.50	**$247.50**	**$15.52**
Tolls	$197.40	$197.00	$197.40	$170.38	$176.61	**$187.76**	**($4.16)**
DMV Fees	$211.00	$211.10	$218.80	$206.79	$242.99	**$218.14**	**$6.40**
Motor Fuel Tax	$132.10	$132.90	$144.70	$138.74	$127.20	**$135.13**	**($0.98)**
General Fund	$5.00	$5.00	$5.00	$5.00	$5.00	**$5.00**	**$0.00**
Total	$862.80	$845.80	$851.80	$1,006.48	$1,010.90	**$918.36**	**$26.82**

[61] Revenue is defined as funds made available to DelDOT during that Fiscal Year. It does not include carryover funds and does not represent funds expended in that year. Revenues from Federal sources are those apportioned in that Fiscal Year, regardless of when they are obligated or expended, and do not reflect obligation limitations (decrease) or redistribution of obligation limitations (increase), or rollover of unexpended funds from the previous year.

As can be seen in the table above and graph below, DelDOT FY 2020 revenue was bolstered by an influx of bond proceeds, which are accompanied by corresponding future liabilities in the form of bond payments. Otherwise, revenue grew by an average of 3.1 percent over the past 5-year period.

Figure 32: FY13 – FY21 Revenues and Trends



Each year the Delaware General Assembly provides DelDOT with an authorization allocation by appropriation and road classification to be used for the overall management and expenditure of state and federal dollars. These authorizations reflect the need to expend funds by project and phase. Authorization balances exceed the available cash flow due to the need to authorize the entire phase of a project in the first year of expenditure. This balance is carried throughout the duration of the project and is expended as the project phase is completed.

Financial Highlights

- DelDOT has a diverse mix of both pledged and non-pledged revenues that remain strong and have proven resilient particularly throughout the COVID-19 pandemic. DelDOT has a strong balance sheet with a continual reduction in outstanding debt across all outstanding bonds and excellent debt service coverage. Operating expenditure has been well managed, and growth has been limited. DelDOT was recently rated by both S&P Global Ratings and Moody's Investors Service Inc., both of which reaffirmed the DelDOT's high quality credit strength of AA+ and Aa1 with a stable outlook for the future.

- Financial Highlights from June 30, 2021 and 2020 Financial Statement[62] (annual) operating revenues increased by $33.1 million to $616.6 million during the Fiscal Year Ended June 30, 2021, primarily due to: 1) increased motor vehicle related revenues as a result of an increase in vehicle purchases compared to the prior year, and 2) increased toll revenue due to increased traffic volumes realized over the prior year during the height of the COVID-19 pandemic. Operating expenses decreased by $53.9 million to $821.9 million during the Fiscal Year Ended June 30, 2021. The expense fluctuation is attributed to the increased capitalization of highway infrastructure projects during the fiscal years. Total outstanding debt increased $238.3 million to $1,361.2 million during Fiscal Year 2021, primarily due to the issuance of an additional Senior Revenue Bond

[62] https://deldot.gov/Publications/reports/financial_statements_audits/pdfs/2021%20DelDOT%20Audit%20Report.pdf?cache=1669746878039

(Series 2020) of $217.3 million and GARVEE Bonds (Series 2020) of $194.5 million. The increases were offset by the refunding of Senior Bonds of $61.9 million, GARVEE Bonds of $44.0 million, and debt payments on revenue bonds of $74.2 million[63].

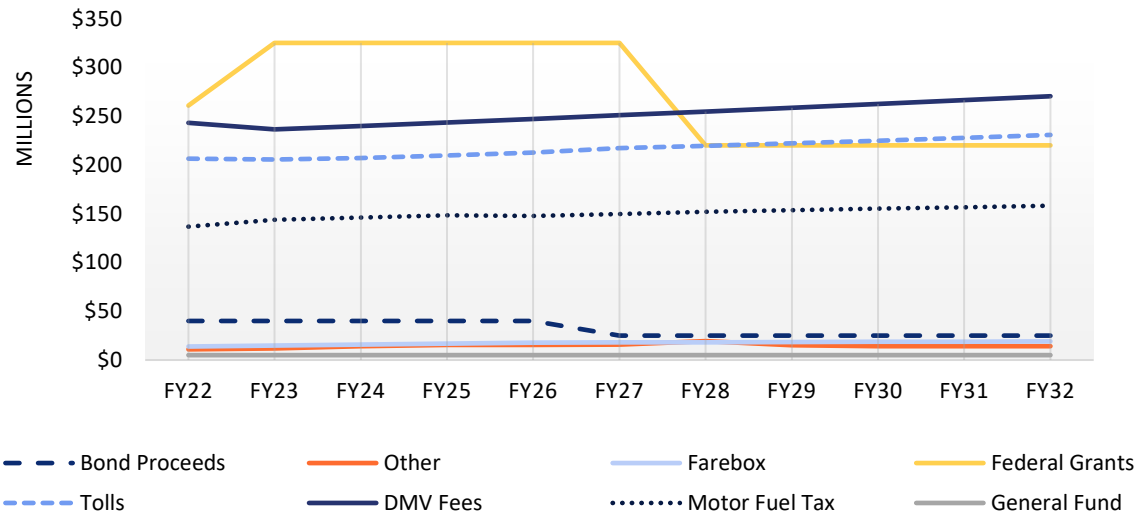
Projected Revenues

DelDOT's current baseline 10-year revenue estimate is found in Table 31 and presented graphically in Figure 33. As previously described, some of the sources (specifically Farebox revenues and FTA grants) have dedicated purposes that make them unavailable for NHS support purposes. Also as indicated, bond revenues include a future repayment liability that effectively reduces the funds available for the Capital improvement program for DelDOT.

Table 31: 10-year Revenue Projections (In Millions)

	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32
Bond Proceeds	$40.0	$40.0	$40.0	$40.0	$40.0	$25.0	$25.0	$25.0	$25.0	$25.0	$25.0
Other	$10.9	$11.7	$14.3	$15.3	$15.5	$15.8	$19.3	$15.1	$14.3	$14.3	$14.3
Farebox	$13.8	$14.8	$15.8	$16.7	$17.8	$18.0	$18.2	$18.4	$18.6	$18.9	$19.1
Federal Grants	$260.7	$325.0	$325.0	$325.0	$325.0	$325.0	$220.0	$220.0	$220.0	$220.0	$220.0
Tolls	$206.4	$205.5	$207.1	$209.5	$212.6	$217.0	$219.3	$222.2	$224.9	$227.8	$230.7
DMV Fees	$243.2	$236.4	$239.9	$243.5	$247.1	$250.9	$254.7	$258.5	$262.4	$266.3	$270.3
Motor Fuel Tax	$136.7	$143.6	$146.1	$148.3	$147.5	$149.7	$152.0	$153.5	$155.1	$156.6	$158.2
General Fund	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0
Total	**$917**	**$982**	**$993**	**$1,003**	**$1,010**	**$1,006**	**$914**	**$918**	**$925**	**$934**	**$943**

Figure 33: 10-year Revenue Projections



[63] https://auditor.delaware.gov/wp-content/uploads/sites/40/2022/01/FY20-21-DelDOT-Audit-Report_FINAL.pdf

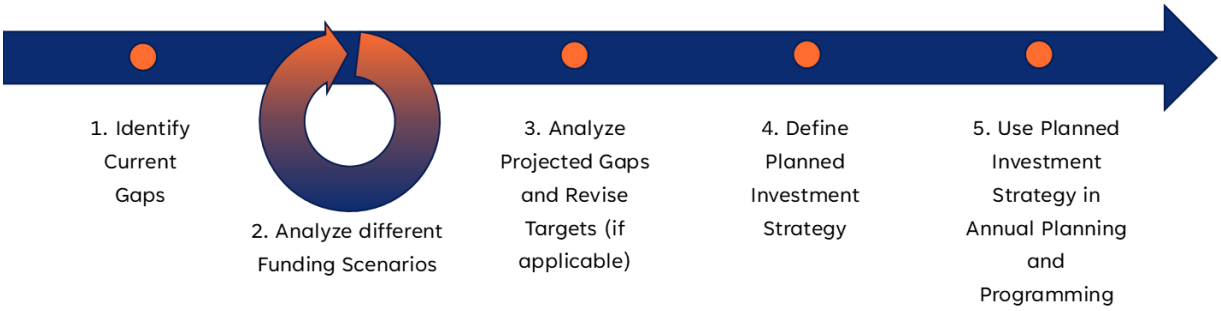
Methodology for Projecting Available Funding Levels

The process for projecting DelDOT's Transportation Trust Fund revenues is proven and consistently provides quality data. The DelDOT Finance Division starts with the market analysis, funding forecasts, trend data and Federal Highway Authorization Act, and expands those projections to 10+ years. These estimates are based on the average change in revenue over the last 5 years, projected into the future using multiple regression analysis techniques. The DelDOT Transportation Trust Fund Administration Team considers these alternative projections and in consultation with Agency Leadership, selects a baseline revenue projection as well as the alternate funding scenarios. This revenue projection process is described more holistically to include expense projections and investment rationalization in the Investment Strategy Analysis section.

Methodology for Identifying Funding Scenarios for Analysis by Pavement and Bridge Management Groups

DelDOT revenue projections feed activities that are identified as Step 2 of the LCP process. This process is described in Chapter 4: Risk-Based Life Cycle Management and illustrated below in Figure 34.

Figure 34: Gap Analysis, Scenario Analysis and Target Setting Process



As indicated, these revenue projections provide the primary constraints from which alternative bridge and pavement asset investment options are considered by those respective asset management groups. These revenue projections also feed the remaining TAMP steps and decisions.

DelDOT traditionally has projected six years beyond the current fiscal year in developing its CTP, the first four years of which represent its STIP. In developing DelDOT's TAMP, the revenue forecasts developed for the CTP/STIP provide the starting point from which the forecast is expanded to cover the 10-year planning horizon of the TAMP plan.

DelDOT begins with the departmental budget forecasts and uses historical trends to expand the CTP/STIP projections to create the TAMP revenue forecast. This budget is anticipated to be based on straight-line projections of historical trends (using regression analysis) that include appropriate adjustments around known funding initiatives and anticipated trends.

DelDOT determines the available funding levels for NHS pavements and bridges. Initially, this is based on historical percentages. However, as this process matures, there may be more movement between asset investment categories as improved asset management system analysis becomes available.

Using the information derived from the process described above, DelDOT identifies multiple funding scenarios, including some variation of the following:

- Baseline growth;
- Slight increase (e.g., 10-15%);
- Slight decrease (e.g. 10-15%);

- Variable inflation rates;
- Revenue needed to meet condition targets; and
- Trade-off between Pavements and Bridges.

For this TAMP, the selected scenarios for analysis include the Baseline, 10% Increase from Baseline, and 10% Decrease from Baseline. The two additional scenarios simulate the impacts of multiple potential changes to DelDOT's funding. For instance, an increasing inflation rate over the analysis period would have similar impacts to DelDOT's project delivery to a decrease in funding. Thus, the +/- funding scenarios are used to analyze impacts of different risks to project delivery. With the current variation in inflation rates, project delivery may be impacted significantly.

These revenue projection scenarios were shared with the Pavement and Bridge Management Groups, which used this information to inform the analysis performed by the pavement and bridge management systems. In turn, the Bridge and Pavement Management Groups provide the results of their respective impact analyses, which identify the projected impacts on asset condition given investment alternatives. The Steering Committee uses this information to feed both the Gap Analysis and LCP process described in Chapter 4: Risk-Based Life Cycle Management.

Funding Needs

Individual DelDOT Asset Stewards submit budget requests based on forecasted conditions and targets. The Agency Leadership team then approve the budgets based on such things as historical funding, asset performance/condition, and the ability to deliver the program at a specific level of funding. Adjustments may also be made throughout the year in response to quarterly revenue estimates made by the Delaware Economic and Financial Advisory Council (DEFAC).

DelDOT Pavement and Bridge Management Groups analyze multiple funding scenarios for submission to Agency Leadership via the Steering Committee. The future funding needs are investigated and the methodologies for accomplishing this are described in more detail in the Investment Strategy Analysis section.

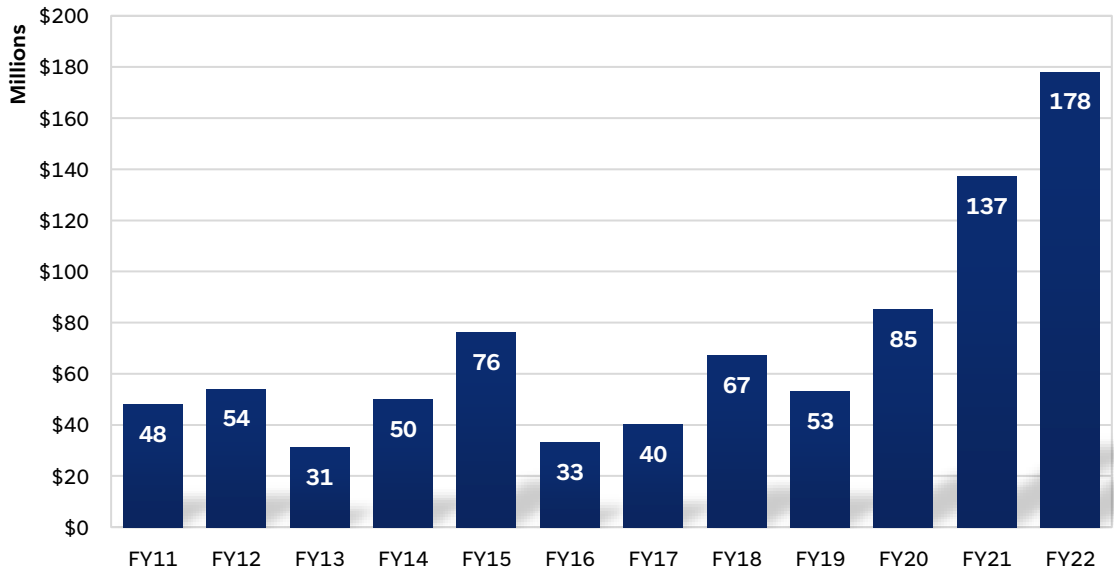
Historical Spending

Bridge

Figure 35 shows the actual bridge program expenditures for SFY 2011 through SFY 2022[64].

[64] Note that FY19-FY22 include expenditures on the I-95 Wilmington Viaduct project as follows. This project is funded through the CTP.
- FY19 = $2,634,115.79
- FY20 = $5,330,756.51
- FY21 = $64,347,990.71
- FY22 = $91,701,096.57

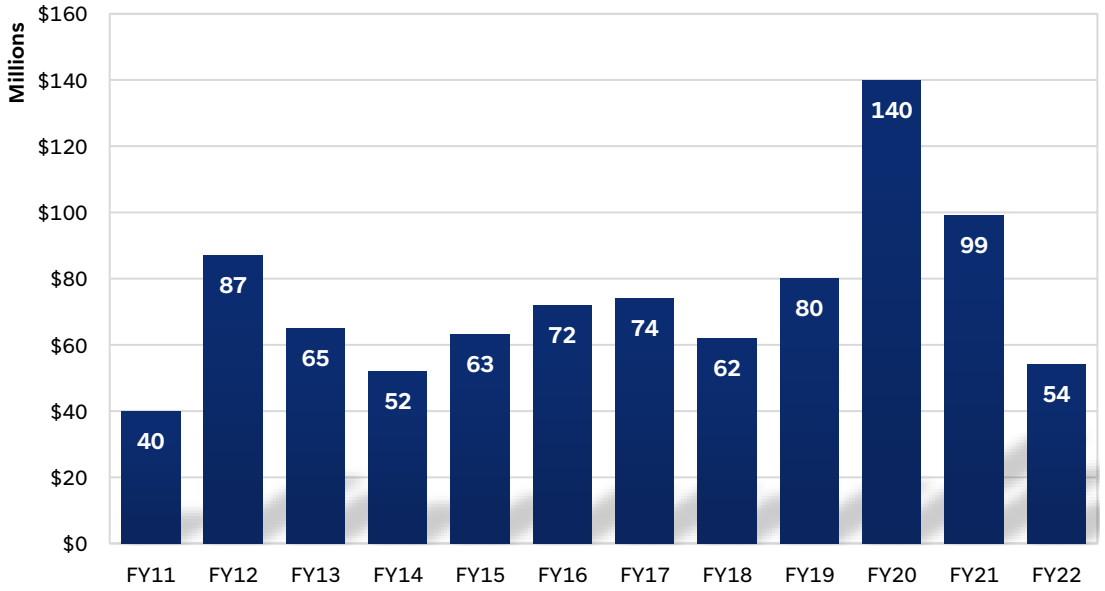
Figure 35: Bridge Program Expenditures (State and Federal)



Pavement

Figure 36 shows the actual pavement program expenditures for SFY 2011 through SFY 2022.

Figure 36: Pavement Program Expenditures (State and Federal)



DelDOT Budget Allocation Process

Typically, about 49%[65] of the State transportation budget is dedicated to capital spending, and 41% is dedicated to operations. The remaining 10% is spent on debt service.

DelDOT funds in-house routine maintenance through the operations budget while state of good repair projects are typically funded through its capital budget. DelDOT develops its annual capital budget using the following hierarchy:

1. Projects already under construction
2. State of good repair projects
3. New capital improvement (capacity) projects

DelDOT's TAMP budget process is based on and compliments its Capital Transportation Program (CTP). As described previously, the DelDOT CTP is a six-year plan, the first four years of which comprises DelDOT's STIP. However, the focus of the TAMP budget allocation process is on the NHS, achieving and maintaining a state of good repair for those assets, and covers a ten-year planning horizon.

The information developed for and included in the TAMP will be considered in determining future funding levels for the various asset classes, with the goal of achieving and sustaining the targeted levels of performance. This may result in the reallocation of resources among asset classes, and between state of good repair projects and capacity projects. This is discussed in more detail in under the Investment Strategy Analysis section.

DelDOT Forecasted Budget Allocation for All Pavements and Bridges

Budget allocation is based on processes that consider available funding, basic administrative costs such as salaries and operating expenses, maintenance and capital project needs, and debt service. For the TAMP, baseline projected bridge and pavement allocations are based on the 4-years of programed funding found in the current STIP. The baseline allocations are reviewed annually in the gap analysis process described in Chapter 4: Risk-Based Life Cycle Management. The budget allocation process then includes the 10-year projections of need from DelDOT's asset management systems (both pavement and bridge) as part of this process. This information is used along with the various revenue projection scenarios described and consider risk mitigation options as part of the investment strategies choices.

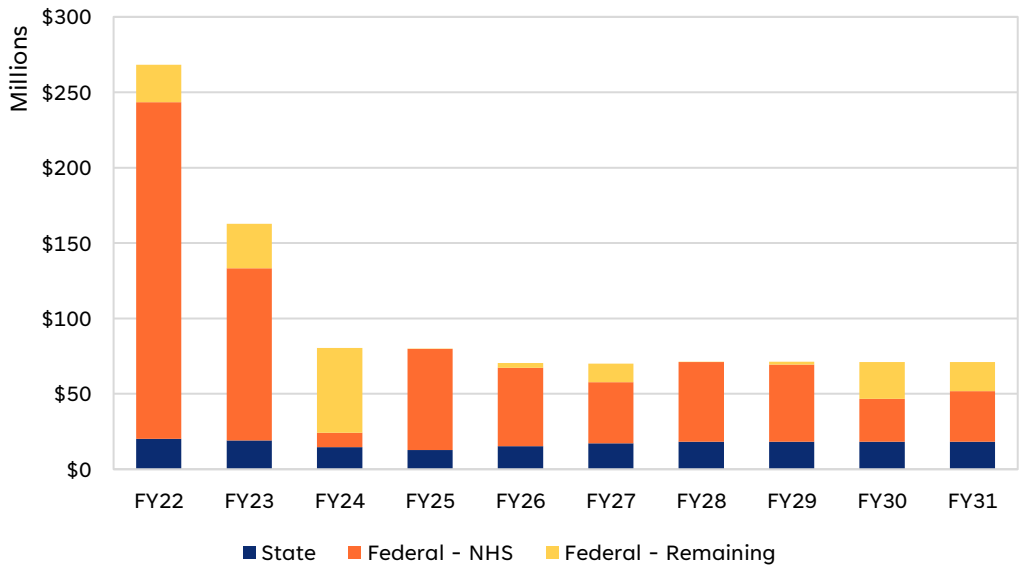
The forecasted baseline budget allocations for bridges and pavements are depicted in Figure 37 and Figure 38, respectively. The forecasted baseline budget for bridges declines significantly from FY 2022 through FY 2024, while the forecasted baseline for pavements increases in FY 2023. The reason for the funding changes in different fiscal years for bridges and pavements is due to planned on-going projects. Each funding scenario includes funding authorized by the IIJA.

Bridges

Figure 37 shows the forecasted budget allocations for the bridge program. These are the projected funds that will be available for the bridge program and are transferred to the Baseline funding scenario discussed in the Investment Strategy Analysis section. Totals include all projects authorized including both NHS and non-NHS.

[65] Determined using historical spending breakdown.

Figure 37: Bridge Program Forecasted Baseline Budget Allocation[66]



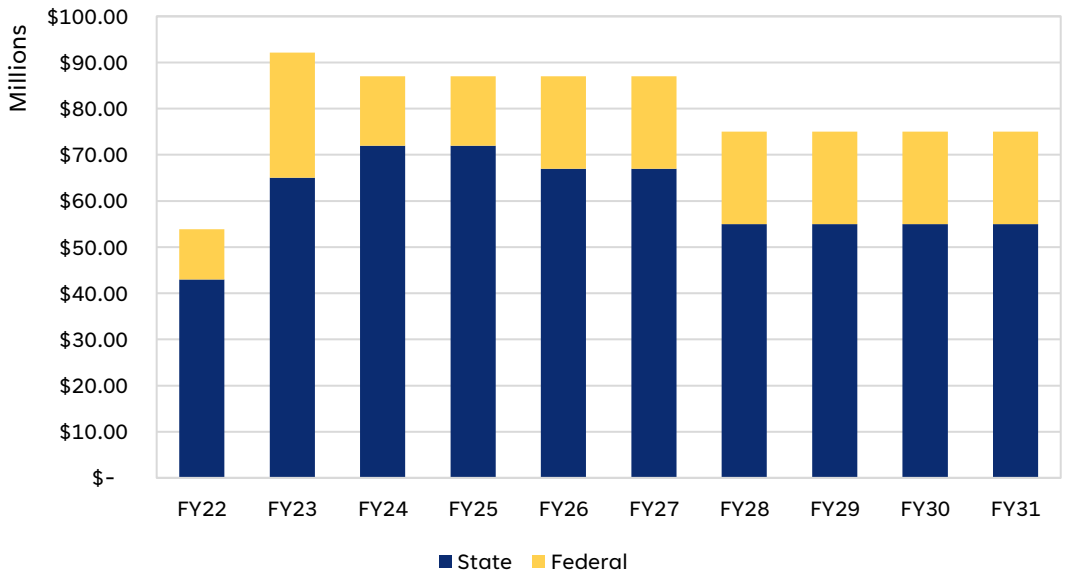
The funding spike in FY22 and FY23 is due to the additional funding received specifically for the I-95 viaduct project. This project is expected to be completed in FY23. The funding levels for FY24-31 include additional funds from the IIJA. However, DelDOT had pulled funds from other programs over the past 6-10 years to initiate various bridge maintenance and preservation strategies and programs to address the State of Good Repair and Performance Measure goals related to the Bridge Program. Now that DelDOT has received IIJA funds and made significant progress in improving bridge performance measures, DelDOT will discontinue providing those additional funds to the Bridge Program from other programs. As a result, the baseline funding trend for FY24-31 looks fairly similar to that of the funding trend prior to the distribution of IIJA funds.

Pavement

The forecasted budget allocations for the pavement program are shown in Figure 38. These are the projected funds that will be available for the pavement program and are transferred to the Baseline funding scenario discussed in the Investment Strategy Analysis section below. DelDOT uses additional funds that become available due to various delays and reasons to perform additional paving work. The result is that DelDOT's total paving program is anticipated to exceed $80M per year during the FY23-27 period. Totals include all projects authorized including both NHS and non-NHS.

[66] Includes planned expenditures for the viaduct project.

Figure 38: Pavement Program Forecasted Baseline Budget Allocation



The funding levels for FY23-31 include additional funds from the IIJA. FY22 is low as many contracts were delayed and not all planned spending occurred, thus some funds were shifted or extended into the later years, FY23-27.

Investment Strategy Analysis

In this section of the TAMP, DelDOT brings all the information gathered from the previous steps and uses this information in a rational process to make its investment decisions. The investment scenarios analyzed by the Pavement and Bridge Management Groups are discussed below. DelDOT takes all of this analysis and resulting information into account in the programming and funding of projects. First, the different scenarios that were analyzed according to the methodologies discussed in the pavement and bridge chapters are described, then the final planned investment strategy that was adopted by the DelDOT leadership is described in the Planned Investment Strategy section.

Analyzed Investment Scenarios

Figure 35, Figure 36, Figure 37, and Figure 38 above identify the historical and 10-year investment forecasts for DelDOT NHS pavements and bridges. The data is presented to provide an indication of trends over time and provide a reasonable 'baseline' assumption as to future likely investments. In addition to the financial forecasts, DelDOT asset management systems (both pavement and bridge) generate optimal simulated work plans consisting of both committed projects that are already programmed, and projected projects based on benefit cost ratio analysis, as well as the resulting condition projections. The projects that are recommended in the simulated work plan for a specific funding scenario are generated using the life cycle planning methodologies described in Chapter 4: Risk-Based Life Cycle Management and are used to both inform the CTP/STIP plan as well as evaluate alternate investment scenarios for the TAMP and DelDOT's Long Range Transportation Plan (LRTP).

Revenue projections included the 2022 TAMP are based on the best available information for revenue growth, bond issuances, administration costs, and other parts of the operating and capital budgets. Using reasonable

assumptions, a "baseline" budget scenario was developed that shows the forecasted total transportation fund revenues anticipated to be available over the 10-year TAMP horizon for both pavements and bridges. From this Baseline scenario, other scenarios were developed for the PMS and BMS to analyze projected impacts to pavement and bridge conditions.

The different scenarios analyzed by the Bridge and Pavement Management Groups are summarized below.

Pavements

Based on analysis of several different scenarios, a specific investment strategy was decided upon for pavements. The Pavement Management Group analyzed three scenarios that were defined based on available funding levels. The baseline scenario was analyzed with the current funding levels identified by the Finance team. For pavements, the baseline funding level averaged $79.4 Million annually across the full state network with an average of $15.5 Million spent on the NHS annually. The Pavement Management Group analyzed two additional scenarios for a 10% increase and 10% decrease in funding.

Ultimately, the Baseline funding scenario was selected for pavements. The full review of the funding scenarios is summarized in the following section and detailed in Chapter 2: Pavements.

Bridges

Three scenarios were also analyzed for bridges to determine the recommended investment strategy. The forecasted conditions for a baseline, 10% increase, and 10% decrease funding scenario were compared to future targets. For bridges, the baseline funding level averaged $75.1 Million annually[67] across the full state network with an average of $40.7 Million spent on the NHS annually. The Bridge Management Group analyzed two additional scenarios for a 10% increase and 10% decrease in funding.

Ultimately, the Baseline funding scenario was selected for pavements. The full review of the funding scenarios is summarized in the following section and detailed in Chapter 3: Bridges.

Funding Gap Analysis and Investment Decisions

This section discusses how the results of the asset funding scenario analyses were used to determine any gaps between desired and projected conditions, and potential solutions to those gaps. As described in Chapter 4: Risk-Based Life Cycle Management, the asset groups run analysis to determine whether the baseline funding scenario is sufficient for maintaining targets for asset conditions over a 10-year period. The results from the analysis are presented in the Gap Analysis and Condition Projections section of each asset chapter and are used for the funding gap analyses here.

Methodology for Developing a combined Gap Analysis

To identify a specific investment plan for the pavement and bridge programs, the Steering Committee works with the Pavement and Bridge Management Groups to perform the Gap Analysis effort to identify how the projected conditions under various funding scenarios compare to the State DOT's long term performance goals for a state of

[67] Note: The Average Annual spending does not include the I-95 spending (~$172 Million in FY 22 and ~$93 Million in FY 23) on the Wilmington Viaduct. This major project is not funded from the Bridge preservation pot and would skew the values.

good repair. In the TAMP process illustration in Figure 34, this step is identified as Step 3 and described in detail in Chapter 4: Risk-Based Life Cycle Management.

All scenario results and associated gap analysis from the different asset groups are compiled by the Steering Committee. This information is compiled from the various teams into a single Gap Analysis presentation for Agency Leadership.

The projected conditions and costs per work type received from the Pavement and Bridge Management Groups for each Funding Scenario are compared against the 2-, 4-, and 10-year targets. Key issues hindering progress toward achieving and sustaining the desired state of good repair and federal targets, as well as strategies to close any gaps, are discussed with the asset groups and documented.

If applicable and based on the results of the Gap Analysis, the Steering Committee may include recommendations for revising the targets which may be adopted by the Agency Leadership. If revised targets are adopted, one or more scenarios may need to be revised to show the budgets needed to attain the new targets. In establishing or revising targets, DelDOT considers historical levels of service, the results of customer surveys, industry practice, and any applicable laws and regulations.

Based on the results of the gap analysis from the Pavement and Bridge Management Groups, recommendations are identified, and a presentation is made to Agency Leadership. At this meeting, a final investment strategy is agreed upon. The gap analysis process for pavements and bridges is summarized below and described in detail in the Gap Analysis and Condition Projections section of Chapters 2 and 3, respectively.

Funding Gap Analysis for Pavements

According to Figure 14, each of the three funding scenarios (Baseline, +10%, and -10%) analyzed for the pavement network result in maintenance of the entire network average OPC. Figure 16 shows that all three funding scenarios maintained both state targets (>75% of pavements OPC > 60, <15% of pavements OPC < 50) through year 2027, where the baseline and -10% scenarios predict an increase in pavements with OPC < 50 over the target 15% starting in 2028 through the remainder of the analysis period. Figure 15 shows that the average OPC for NHS pavements is maintained for the full 10-year analysis period under the baseline scenario. Because no significant deterioration trend was observed under the Baseline funding scenario, it was determined that no significant gaps are projected for the state targets. DelDOT manages the pavement network to State metrics, thus the Baseline funding scenario was selected as the Pavement Management Group's recommendation to the Steering Committee. The impacts of this funding selection on Federal metrics are discussed below.

As depicted in Figure 17, the percent of Interstate NHS pavements in Federal Good condition is expected to decrease under the Baseline funding scenario. There is a gap projected starting in 2025 for Interstate pavements where the % Good drops below the 50% target. The percent of Good Interstate pavements is not predicted to reach the target of 50% even when funding is increased. However, the percent of Interstate pavements in Poor condition is expected to remain under the 2% target through the performance period. This indicates that more Interstate pavements are being maintained by the PMS in a Federally defined 'Fair' condition for all three analyzed funding scenarios.

For Non-Interstate NHS pavements, Figure 18 shows that there is no gap projected through the performance period. Thus, more than 40% of Non-Interstate NHS pavements are expected to remain in Federally defined Good condition through 2025. Similarly, the percent of Non-Interstate NHS pavements in Poor condition is forecasted to remain below the 2% target through 2025.

The Federal targets are reassessed biennially and may be adjusted in the Mid-Performance Period Report depending on updated forecasts. DelDOT does not expect a significant increase in Poor pavements, thus the NHS network will be maintained at an acceptable level of service with most pavements in Good or Fair condition.

Ultimately, the Pavement Management Group recommended to the Steering Committee and then to Agency Leadership that the Baseline funding scenario be adopted as the investment strategy for pavements. This investment strategy is the result of the life cycle cost benefit analysis to find the optimum mix of work types ranging from preservation to rehabilitation and reconstruction for the Baseline predicted funding for the pavement program over the next 10 years. The investment strategy also includes current STIP projects including projects that are programmed for reasons other than purely the physical condition of the pavements such as mobility, resiliency, or other functional reasons.

Final Pavement Recommendation
Use Baseline Funding Scenario

Funding Gap Analysis for Bridges

The condition projections for the Baseline funding scenario in Figure 20 show that the state targets are maintained for the full 10-year analysis period. The +10% funding scenario results in slightly better conditions by 2031, and the -10% scenario results in conditions falling outside of the State targets. Because DelDOT manages the bridge program according to the State metrics, the Bridge Management Group determined that the Baseline funding scenario is sufficient for maintaining the target level of service.

While DelDOT manages its bridge network using State metrics, Figure 21 shows that all Federal metrics are maintained at target levels for the Baseline funding scenario through the performance period. The 10% decrease in funding would not influence the Federal metrics. This along with the slight decline in bridge conditions for the Baseline scenario indicates that funding could not be re-allocated from the Bridge program without negatively impacting overall network condition.

No gaps between projected and target conditions are therefore projected and the Baseline funding scenario was selected as the Bridge Management Group's recommendation for adoption by Agency Leadership as the planned investment strategy.

Final Bridge Recommendation
Use Baseline Funding Scenario

Planned Investment Strategy

The planned investment strategy is the core objective of a TAMP. It represents DelDOT's plan for executing and measuring its progress in meeting its asset condition targets during the 2- and 4-year benchmarks for the TAMP.

The final investment strategy is the result of many factors. For this TAMP, the focus is on the physical condition of the assets. These analyses identify the desired expenditures both between pavement and bridge, and within specific work types. However, specific projects that are identified as part of the analyses undertaken by the pavement and bridge groups are combined and scored with various other projects that may have state and national objectives other than purely physical condition. The methodology is explained in more detail in the Methodology for Including the Cost of Investment Strategies in the Financial Plan section.

This information is compiled for DelDOT's pavement and bridge assets, using the analyses described in the pavement and bridge chapters, as well as for assets maintained by external entities such as DRBA and USACE. While DelDOT receives and evaluates certain information regarding pavement and bridge assets from DRBA and

USACE, this information is not enough to convert into the necessary data required for TAMP analysis. USACE does not separate their ten-year financial plan into similar work types as defined and required by the TAMP, nor do they have a matrix regarding condition projections to support the condition metrics. This information does not exist in the format needed. With DRBA, as noted in Chapter 2: Pavements, DelDOT gathers and analyzes information regarding DRBA maintained pavements. DelDOT's Bridge Management section receives current condition information regarding DRBA maintained bridge structures, however, they do not receive any information for projections to the condition metrics.

Lists of planned projects were received from both DRBA and USACE for pavements and bridges. These lists are included in Appendix C – Other Owner Planned Projects.

This section contains the planned investment strategies for DelDOT Pavements and Bridges. Specific investment strategies for Delaware's NHS are detailed as well. This information is presented as expenditures by year, by asset type (pavement versus bridge), and by work type. Because projects often move around in actual delivery and expenditures, cumulative spending is also included for ease of tracking and reporting consistency. This information is presented in both a table format as well as illustrated graphically for pavements and bridges respectively.

The investment strategy for the initial construction work type is tracked separately from the pavement and bridge investment strategies. The PMS and BMS analyses provide results in terms of treatments to existing assets; however, these management systems are not programmed to create new infrastructure. Projects that are considered to fit the 'Initial Construction' work type are typically completely new infrastructure or reconstruction projects which increase capacity of current infrastructure. These projects are also typically defined by corridor, including all assets (i.e., not broken out by pavement or bridge). Thus, the planned values are not separated into pavement and bridge categories but are tracked by work type and NHS designation. These types of projects are identified and planned in the CTP/STIP, which is the source of the planned initial construction investments.

Planned Investment Strategy for Pavements

As noted under Pavements in the Analyzed Investment Scenarios section, although multiple funding scenarios were analyzed, the Baseline funding scenario was recommended by the Pavement Management Group for adoption as the planned investment strategy for pavements. This was subsequently approved by Agency Leadership based on the methodology described in the Methodology for Including the Cost of Investment Strategies in the Financial Plan section.

The planned investment strategies for the total pavement network and specifically for the NHS network, are given below in Figure 39 and Figure 40 respectively. Figure 39 presents the investment strategy by work type for DelDOT's full pavement network. The dot above each bar represents the budget applied in the PMS for analysis. Where there is a gap between the bar and the dot, the available budget was not spent in full by the PMS.

Figure 39: Planned Investment Strategy for Pavements – State Optimization Analysis Results for Baseline Funding Scenario – Total Network

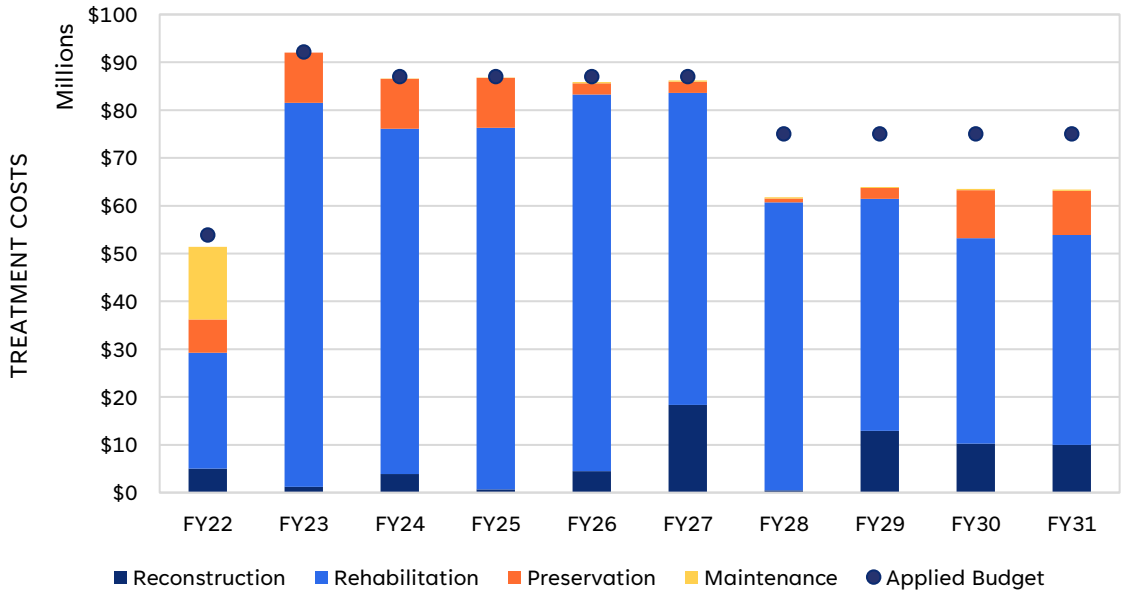
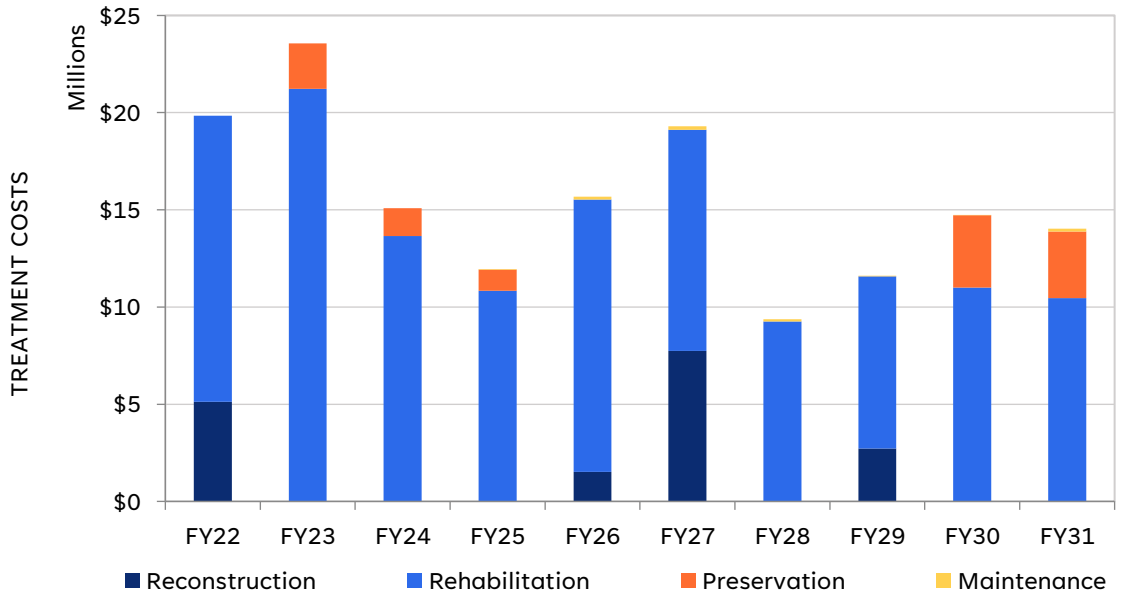


Figure 40 shows the investment strategy by work type for the NHS only. The total funding level is not consistent because the NHS does not receive a specific portion of the pavement budget. This is due to DelDOT's focus on the overall condition of the network.

Figure 40: Planned Investment Strategy for Pavements – State Optimization Analysis Results for Baseline Funding Scenario – NHS Network



The planned expenditures in the adopted pavement investment strategy are derived from projects recommended through the pavement management optimization process which is based on benefit cost lifecycle analysis projected

to sustain the overall network. The predicted NHS investments over the next 10 years are summarized below in Table 32.

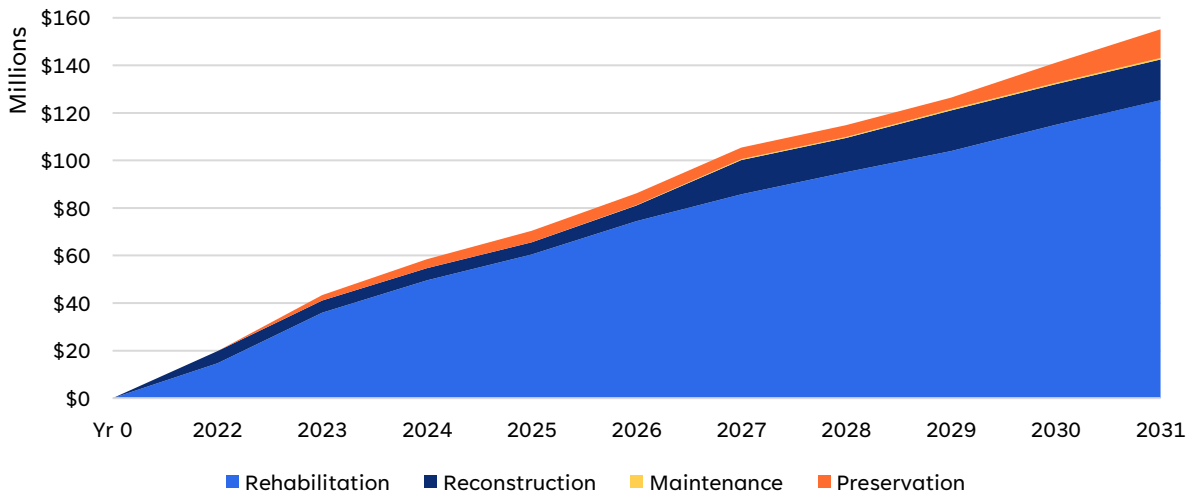
Table 32: Summarized Investment Strategy for NHS Pavements[68]

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Cumulative Total
Maintenance	$0.0	$0.0	$0.0	$0.02	$0.15	$0.19	$0.11	$0.05	$0.01	$0.15	$0.68
Preservation	$0.0	$2.3	$1.4	$1.1	$0.0	$0.0	$0.0	$0.0	$3.7	$3.4	$11.9
Rehabilitation	$14.7	$21.2	$13.7	$10.8	$14.0	$11.4	$9.3	$8.9	$11.0	$10.5	$125.5
Reconstruction	$5.1	$0.0	$0.0	$0.0	$1.5	$7.7	$0.0	$2.7	$0.0	$0.0	$17.0
Total	**$19.8**	**$23.5**	**$15.1**	**$11.9**	**$15.7**	**$19.3**	**$9.4**	**$11.7**	**$14.7**	**$14.1**	**$155.1**

The table shows very little maintenance being budgeted for the Interstate and non-Interstate NHS network because these lighter types of treatments such as Fog Seals, Chip Seals, and Patching (see Table 10) are rarely recommended for NHS pavements and are more applicable to secondary roads and streets. Similarly, Reconstruction is also avoided on NHS pavements if possible.

The forecasted investment strategy will likely not be followed exactly in practice. Projects have not been finalized, and schedules can change even when projects are programmed. Thus, DelDOT began tracking cumulative investments to account for the rate of spending. Cumulatively, DelDOT expects to spend approximately $155.1 Million total on the NHS pavements over the next 10 years. That translates to an annual average of $15.5 Million spent on the Interstate and non-Interstate NHS.

Figure 41: Cumulative Investment Strategy by Federal Work Type – NHS Pavements



It should be noted that these projected spending figures are recommended based on the optimization analyses from the PMS. These recommendations may change over time as updated condition data is received, and as the Pavement Management Group further refines the deterioration and improvement models used in the analyses.

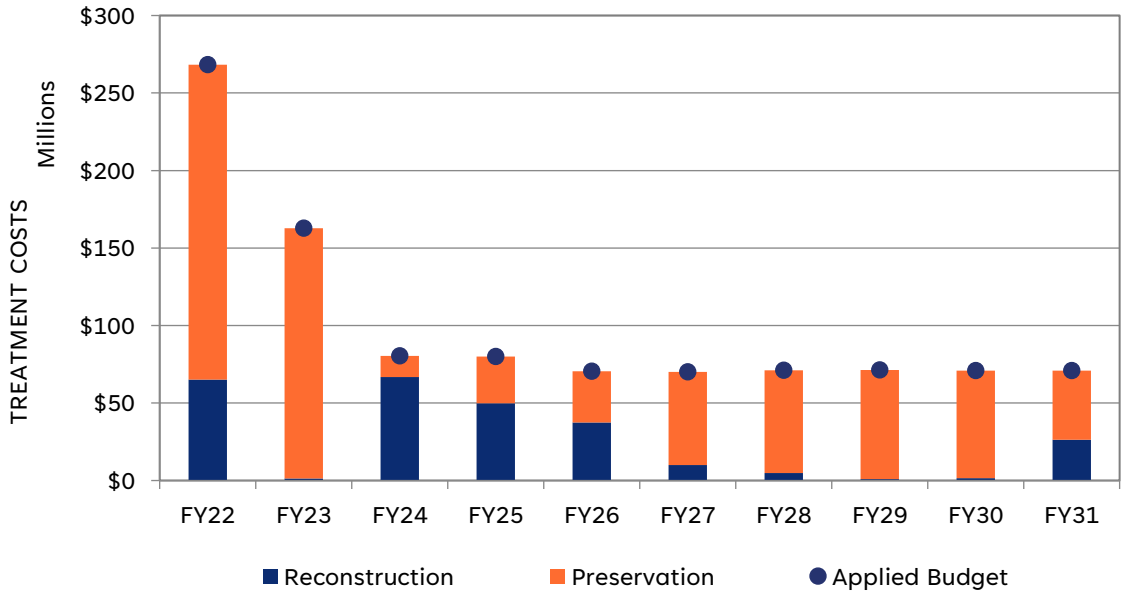
[68] All figures are in millions of dollars.

Planned Investment Strategy for Bridges

Various funding scenarios were analyzed for bridges as noted under Bridges in the Analyzed Investment Scenarios section above. The Baseline funding scenario was recommended by the Bridge Management Group for adoption as the planned investment strategy for pavements. This was approved by Agency Leadership based on the methodology described in the Methodology for Including the Cost of Investment Strategies in the Financial Plan section.

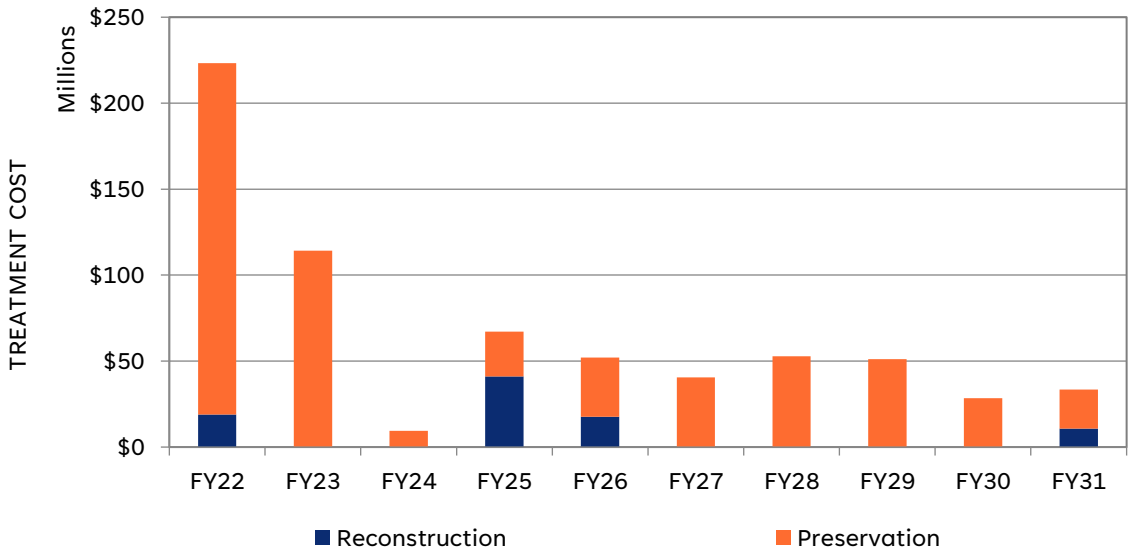
Figure 42 shows the resulting investment strategy for the full DelDOT bridge network from the BMS analysis. Compared to the available budget (the Applied Budget in the figure), most of the funds were selected for projects by the management system. The BMS does not differentiate between NHS and non-NHS when selecting projects. However, significant portions of the available budget are spent on the NHS each year as depicted in Figure 43.

Figure 42: Planned Investment Strategy for Bridges – State Optimization Analysis Results for Baseline Funding Scenario – Total Network



The planned investment strategy based on the approved Baseline funding scenario for the NHS bridges is given below in Figure 43. It should be noted that the planned investments for bridges not maintained directly by DelDOT are not included in this table. The planned projects from both DRBA and USACE can be found in Appendix C – Other Owner Planned Projects.

Figure 43: Planned Investment Strategy for Bridges – State Optimization Analysis Results for Baseline Funding Scenario – NHS Network



The bridge investment strategy is derived from projects recommended through the method described in Chapter 4: Risk-Based Life Cycle Management. These are summarized below in Table 33.

Table 33: Summarized Investment Strategy for NHS Bridges (in Millions)

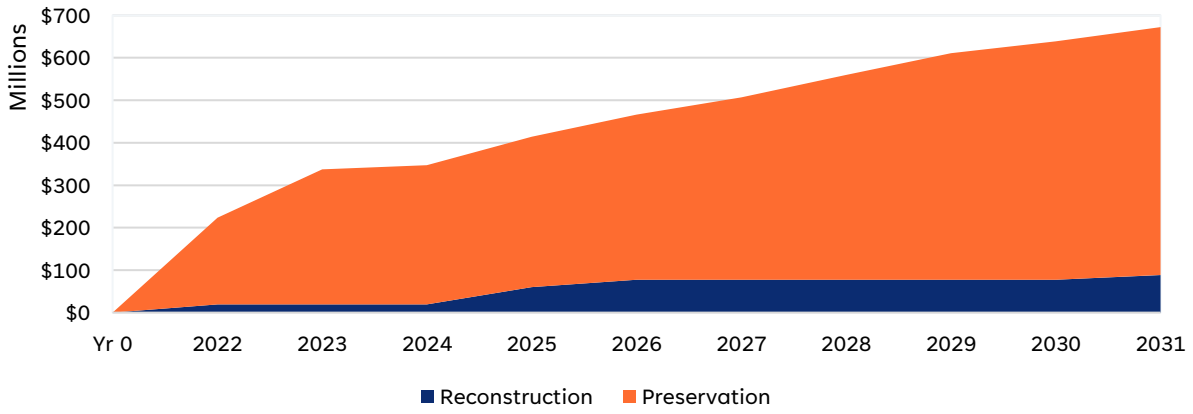
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Cumulative Total
Preservation	$204.2	$114.1	$9.5	$26.0	$34.5	$40.6	$52.8	$51.1	$28.4	$22.6	$583.8
Reconstruction	$19.0	$0.0	$0.0	$41.0	$17.6	$0.0	$0.0	$0.0	$0.0	$10.8	$88.4
Total	**$223.2**	**$114.1**	**$9.5**	**$67.0**	**$52.1**	**$40.6**	**$52.8**	**$51.1**	**$28.4**	**$33.4**	**$672.2**

Note that the values in FY 22 and FY 23 are high because of a large project on I-95. This project on the I-95 Corridor contributes over $250 Million[69] spent or planned between FY 22 and FY 23.

The forecasted investment strategy will likely not be followed exactly in practice. Projects have not been finalized, and schedules can change even when projects are programmed. Thus, DelDOT began tracking cumulative investments to account for the rate of spending. Cumulatively, DelDOT expects to spend approximately $672.2 Million total on the NHS bridges over the next 10 years. That translates to an annual average of $67.2 Million spent on the NHS bridges.

[69] Note: These funds did not come from the Bridge Preservation pot of funding. Therefore, this project is largely responsible for skewing the average annual budget over the 10-year period.

Figure 44: Cumulative Investment Strategy by Federal Work Type - NHS Bridges



Similar to pavements, it should be noted that these projected spending figures are recommended based on analyses undertaken based on current best knowledge. These recommendations may change over time as updated condition data is received, and as the Bridge Management Group further refines the inputs and methodology used in the analysis.

Planned Investment Strategy for Initial Construction

Initial construction values are tracked separately from the other work types as these are not produced by the pavement and bridge management systems. The management systems only analyze existing infrastructure and plan work on those; they are not configured to account for population growth, traffic changes, or other factors analyzed in planning studies. Thus, the initial construction values are obtained from DelDOT's CTP which is produced and updated by the Planning Division every two years. The CTP covers six years with years past FY27 in draft state, thus the projects in later years are subject to change.

Projects planned in the CTP may include several elements not limited to pavements and bridges. As these projects are not itemized by asset class in the CTP, DelDOT opts to consider each project in full. Tracking each full project on the NHS will promote more consistent and organized reporting for the annual consistency determination.

DelDOT considers projects undertaken for primarily mobility or capacity purposes as initial construction. This includes construction undertaken to produce entirely new infrastructure as well as reconstruction projects with added capacity. These projects may include other treatment types to existing adjacent infrastructure, but this cost breakdown is disregarded unless the funding comes specifically from the pavement or bridge budgets. The Pavement and Bridge Management Groups review the proposed initial construction values produced from the CTP for overlapping projects with their programs. Overlapping projects are reviewed on a case-by-case basis to determine which work type they should be classified under. The final decision is recorded. This process promotes more consistent tracking and ensures work is not counted twice under different work types.

The initial construction investment strategy is provided graphically in Figure 45. Fiscal years 2022 through 2027 are significantly higher as those projects are farther along in the planning stage and committed to in the CTP. The later years have not been finalized but will likely end up balancing with the earlier years as projects are pushed forward and delayed.

Figure 45: Planned Investment Strategy for Initial Construction - CTP - NHS Network

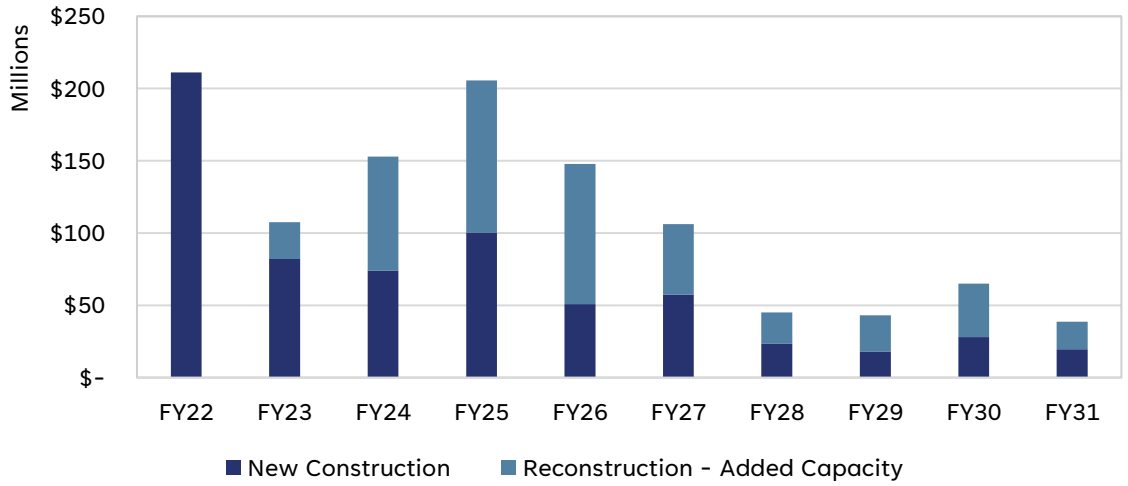


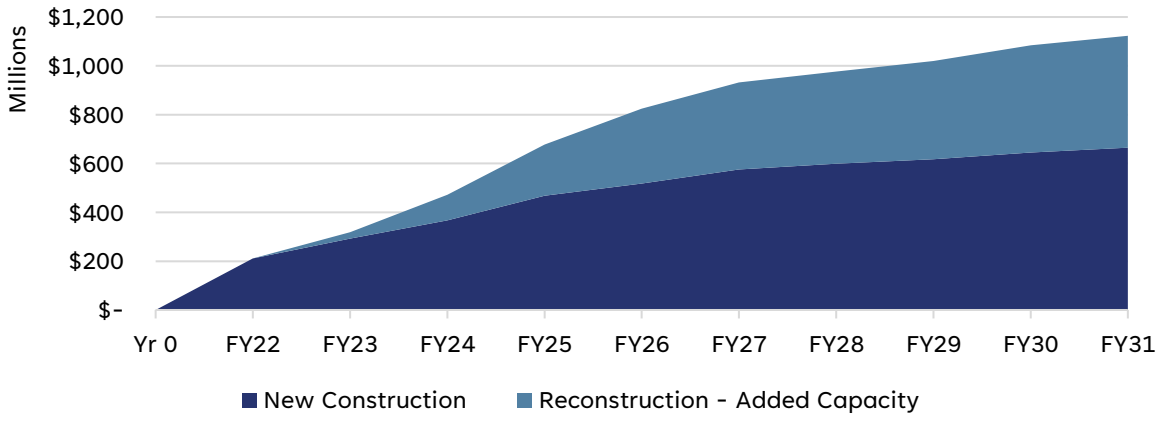
Table 34 identifies the specific values listed for each work type considered as initial construction.

Table 34: Summarized Investment Strategy for NHS Initial Construction (in Millions)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Cumulative Total
New Construction	$211.1	$82.0	$74.1	$100.5	$50.8	$57.4	$23.5	$18.0	$28.0	$19.6	**$664.9**
Reconstruction – Added Capacity	$0.0	$25.5	$78.9	$105.2	$97.2	$48.8	$21.6	$25.0	$37.0	$19.0	**$465.5**
Initial Construction	**$211.1**	**$114.8**	**$153.0**	**$205.7**	**$147.9**	**$106.2**	**$45.1**	**$43.0**	**$65.0**	**$38.6**	**$1,130.4**

The cumulative values and associated run rates in Figure 46 will be used to determine consistency of intended spending over the 10-year period in the Consistency Determination process.

Figure 46: Cumulative Investment Strategy for Initial Construction - NHS Network



Asset Valuation

Asset valuation is a required element of annual financial reporting by government agencies. The details of these requirements are included in the Government Accounting Standards Board Statement 34 (GASB 34).

DelDOT uses the "modified approach" related to depreciation on its roads and bridges. The modified approach requires that DelDOT initially set a percentage benchmark for maintaining the infrastructure in fair or better condition and report at least every three years on their condition assessment.

Pavement Asset Value

The total replacement cost for DelDOT's approximate 1,679 lane miles of NHS pavement is estimated at approximately $1.7 Billion. The estimate is based on the reconstruction costs for various pavement types used in the PMS. A weighted reconstruction unit cost per square yard (based on lane miles of each pavement type) is multiplied by the total surface area (square yards) of the pavement network. The calculation is shown in Table 35.

Table 35: NHS Pavement Value

Weighted $/Sq Yd:	$ 140.09
Total Lane Miles:	1,679
Total Sq Yds:	11,819,958
Pavement Valuation:	**$ 1,655,857,903**

Bridge Asset Value

The total value of Delaware's bridges is indicated in Table 36. The value is based on current average replacement costs. The current valuation of DelDOT's bridge assets is estimated to be $2.32 Billion with the culvert bridge population accounting for approximately 14%. The exact value of individual bridges varies.

Table 36: NHS Bridge Value

Type of Structure	Total Number of Structures	Average Health Index	Total Deck Area (Sq Ft)	Replacement Cost per Sq Ft	Total Replacement Cost
Culverts	30	0.91	74,264	$600	$40,663,996*
Bridges	310	0.91	8,406,046	$300	$2,282,241,489*
TOTAL	**340**		**8,480,310**		**$2,322,905,485**

** Total Replacement Costs were calculated by using the Health Index and Deck Area for each Individual Bridge.*

[70] The health index for a bridge is a weighted average of the individual health index for each element which is a function of the quantities of the element in each condition state.

Integration with Agency Processes

The CTP/STIP, TAMP, and LRTP have strong relationships to each other. Some differences are inevitable given the different planning horizons, frequency of preparation, and focus. However, as each document is updated, it is checked for consistency with the others. Where significant differences exist, DelDOT examines and considers the reasons for these differences and determines whether some fundamental change has occurred and how DelDOT can/should rationalize the relationships between the respective planning assumptions. DelDOT's process for comparing and aligning the plans listed here is captured in the *TAM Guide* section 2.5 titled *Implementation, Monitoring, and Planning*. This review and alignment process is completed annually and ultimately impacts project selection and delivery.

The CTP/STIP, which is revised every two years, has a much stronger tactical planning focus than the TAMP and LRTP. As such, it tends to be more reflective of near-term economic influences and financial outlook. In comparison, the TAMP and the LTRP tend to be more strategic in nature and reflective of long-term trends and changes.

The TAMP process runs parallel and complements the annual development of the six-year CTP, the MPO Transportation Plans, and the MPO Long Range Plan. These planning efforts consider revenue growth and expenditure inflation, which are included as base components of the TAMP plan. Many factors affect the revenue planning assumptions including state and national economic conditions, world events affecting availability and pricing of motor fuel, and fuel consumption rates for motor vehicles among others.

The DelDOT budget process is cyclical and continuous. DelDOT starts the process of developing the proposed STIP for any given year to begin immediately upon the passage of the bi-annual State Bond Bill, which authorizes capital allocations for the current fiscal year. DelDOT works with the MPOs to compile the list of transportation system improvements that have been identified through the creation and adoption of Regional Transportation Plans and the Statewide Transportation Plan. This is augmented with information provided through the Congestion Management Process, the Bridge Management System, and the Pavement Management System to create an initial proposed set of improvements. Since the certification of the 2019 TAMP, DelDOT has improved the integration of the TAM funding scenario analyses and with the annual budgeting process. There are now scheduled, annual presentations made by the Asset Stewards from each management group to the Steering Committee and Agency Leadership where forecasted conditions are presented for different scenarios. This process ensures that requests for changes in funding are made in a timely manner and that impacts of budget allocation changes are fully understood.

The CTP proposal is provided to the Council On Transportation (COT) for review in preparation for a series of public meetings that are jointly sponsored with the MPOs and Sussex County. Comments provided through these meetings are considered by DelDOT and the COT, and changes are made as appropriate. The entire proposal then is sent to the Governor as DelDOT's proposed STIP for the impending fiscal year.

Typically, the process continues with another public hearing and is included in the Governor's State of the State budget address. The COT considers all of the information and comments provided one last time and forwards their recommended capital budget, which includes the projects that will comprise the STIP, to the Governor. The Bond Bill Committee of the Delaware General Assembly considers the proposed capital budget through a series of public hearings each May and makes adjustments as they see fit. The final document goes through the legislative approval process toward the end of June, so that the bill is sent to the Governor for signature. This process may change as DelDOT moves to a two-year STIP process.

The TAMP process, which is described in the Overview of TAMP Process section, is based around the performance periods defined in the legislation. These performance periods and the associated milestones relevant to the TAMP are shown in Figure 8. This is a persistent, repetitive cycle that continues indefinitely until/unless legislatively superseded or the underlying requirement expires. DelDOT continues to implement asset management efforts and ensure alignment of plans and processes following its *TAM Guide*, a living document which includes all applicable review periods, meetings, milestones, and reporting requirements.

Appendix A – Explanation of Overall Pavement Condition (OPC) Configuration

(This is an extract from the DelDOT PMS Configuration Document – Updated June 2022.)

3. NETWORK MASTER AND DATA PROCESS CONFIGURATION

The Network Master File (NMF) is a calculated table within the AgileAssets database that serves as the input file to the Optimization Analysis in the AgileAssets PMS. It is a summary table of data from sources within the PMS database and relies on the most up-to-date data for accurate analysis and reporting.

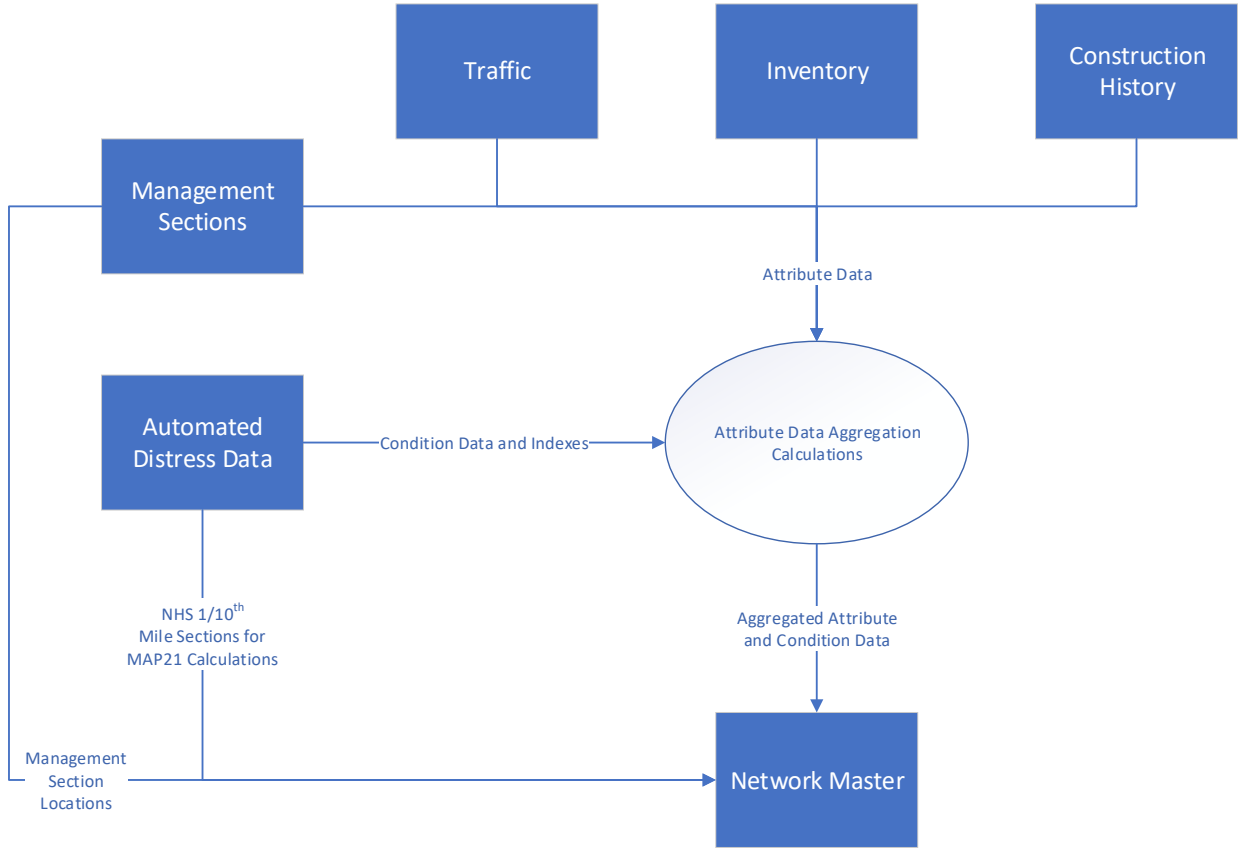


Figure 47: Conceptual Flow Diagram for Data into the Network Master Table

3.1. Pavement Types

Pavement Type is one of the most important attributes to define in a PMS. The PMS uses pavement type to define many important configuration rules including treatment selection, treatment cost, decision tree criteria, and performance modeling. The following list of Pavement Types is currently configured in the PMS.

- Flexible
- Rigid
- Composite (Flexible on Rigid)
- Surface Treated

3.2. Condition Data

The types of pavement deterioration collected and stored in the PMS are shown in *Table 37* below.

Table 37: Pavement Distresses

Flexible	*Composite*	*Surface Treated*	*Rigid*
Fatigue Cracking	Fatigue Cracking	Fatigue Cracking	Joint Deterioration
Transverse Cracking	Reflective Cracking	Transverse Cracking	Slab Cracking
NWP Longitudinal Cracking	NWP Longitudinal Cracking	NWP Longitudinal Cracking	Joint Seal Damage
Patch Deterioration	Patch Deterioration	Patch Deterioration	Faulting
Rutting	Rutting	Edge Cracking	Patch Deterioration
		Bleeding	ASR
		Crown > 6%	
		Rutting	

Note: The distresses are part of the internal configuration of the system. The addition of distresses or the elimination of any distresses in the future should involve a recalibration of the PMS to assure that the decision-making process is still valid.

For all pavement types, the rules for defining the distresses, severity levels and extent ranges are defined in DelDOT's Pavement Data Dictionary. For each survey section distress, extent data is collected for three levels of severity: Low, Medium, and High. The extent range is continuous from 0 to 100%. Based on α and β values, Individual Distress Indices (IDI) are determined for each severity level of a distress as shown in Equation *1* below.

Equation 1: Individual Distress Index Formula for Each Distress Severity Level

$$IDI^{sev} = 100e^{-\propto\beta} \quad (1)$$

Where:

IDI^{sev} = Individual Distress Index for each severity (IDI^{High}, IDI^{Med}, IDI^{Low})

α = Distress Severity Coefficient

β = % Extent of Distress

Table 38 shows values of severity (α) for each distress for Flexible, Composite, and Surface Treated pavement types.

Table 38: Individual Distress α and β Values – Flexible/Composite/Surface Treated Pavements

	Severity, α		*Extent %, β*
Fatigue Cracking	Low	0.0060	0-100
	Medium	0.0140	0-100
	High	0.0240	0-100
Transverse Cracking	Low	0.0022	0-100
	Medium	0.0046	0-100
	High	0.0075	0-100

	Severity, α		*Extent %, β*
NWP Longitudinal Cracking	Low	0.0015	0-100
	Medium	0.0035	0-100
	High	0.0055	0-100
Patch Deterioration	Low	0.0060	0-100
	Medium	0.0140	0-100
	High	0.0240	0-100
Edge Cracking	Low	0.0032	0-100
	Medium	0.0070	0-100
	High	0.0140	0-100
Bleeding		0.0040	0-100
	Medium	0.0068	0-100
	High	0.0105	0-100
Joint Reflection Cracking	Low	0.0033	0-100
	Medium	0.0057	0-100
	High	0.0086	0-100
Crown > 6%	-	0.028	0-100
Rutting	Low	0.0001	0-100
	Medium	0.007	0-100
	High	0.0105	0-100

Table 39: Individual Distress α and β Values - Rigid Pavements

	Severity, α		*Extent, β*
Joint Seal Damage	Low	0.0030	0-100
	High	0.0094	0-100
Patch Deterioration	Low	0.0033	0-100
	Medium	0.0097	0-100
	High	0.0150	0-100
Joints Deterioration	Low	0.0049	0-100
	Medium	0.0100	0-100
	High	0.0150	0-100
Slab Cracks	Low	0.0050	0-100
	Medium	0.0110	0-100
	High	0.0170	0-100
Faulting	Low	0.0049	0-100
	Medium	0.01	0-100

	Severity, α		Extent, β
	High	0.015	0-100
ASR	-	0.028	0-100

The IDI^{sev} obtained are then combined to develop a single IDI value for a distress type using the following formula.

Equation 2: Individual Distress Index Formula

$$IDI = IDI^{High} \times \frac{IDI^{Med}}{100} \times \frac{IDI^{Low}}{100}$$

or

$$IDI = IDI^{Med} \times \frac{IDI^{High}}{100} \times \frac{IDI^{Low}}{100}$$

or

$$IDI = IDI^{Low} \times \frac{IDI^{Med}}{100} \times \frac{IDI^{High}}{100} \quad (2)$$

Where:

IDI = Individual Distress Index combined for each distress type.

The Individual Distress Indices in a severity/extent matrix were originally developed to align with older pavement management processes. Now with the implementation of automated data collection of pavement distresses, data vendors can provide a level of detail necessary to use an equation to calculate the OPC based on the extent value directly in the PMS. DelDOT has implemented a change to the calculation of Individual Distress Indices in the PMS and have the data collection vendor provide the raw extent values in lieu of matrix values.

International Roughness Index (IRI) is a roughness index obtained from measured longitudinal road profiles. It is calculated using a quarter-car vehicle math model, whose response is accumulated to yield a roughness index with units of slope (in/mi, m/km, etc.). In order to convert IRI to an index (0-100), following conversion model was developed.

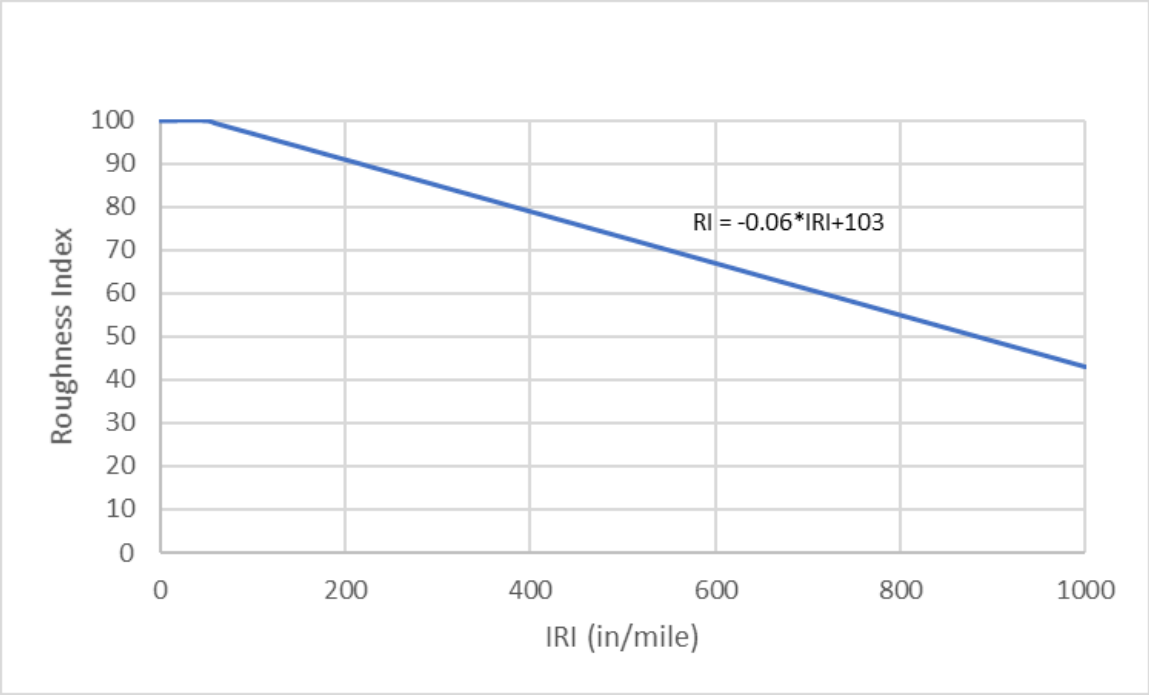


Figure 48: IRI-to-Roughness Index Conversion Models

3.3. Combined Distress Index

The Combined Distress Indices (CDI) have values ranging from 0 to 100 where 0 is the worst condition and 100 is the best condition. The Combined Distress Indices (Structural Index, Non-Structural Index, and Functional Index) are stored in the Network Master for analysis and reporting. There main function is to combine similar distress types for decision tree configuration and performance modeling.

Table 40: Combined Distress Indices - Flexible Pavements

Structural Index	*Non-Structural Index*	*Functional Index*
Fatigue Cracking	Transverse Cracking	Rutting
Patch Deterioration	NWP Longitudinal Cracking	IRI

Table 41: Combined Distress Indices – Composite Pavements

Structural Index	*Non-Structural Index*	*Functional Index*
Fatigue Cracking	Reflective Cracking	Rutting
Patch Deterioration	NWP Longitudinal Cracking	IRI

Table 42: Combined Distress Indices – Surface Treated Pavements

Structural Index	*Non-Structural Index*	*Functional Index*
Fatigue Cracking	Transverse Cracking	Rutting
Edge Cracking	NWP Longitudinal Cracking	Crown > 6%
Patch Deterioration	Bleeding	

Table 43: Combined Distress Indices – Concrete Pavements

Slab Distress Index	*Joint Distress Index*	*Functional Index*
Slab Crack	Joint Seal Loss	IRI
Patch Deterioration	Joint Deterioration	Faulting
ASR		

Equation *3* is used for calculating the Combined Distress Indices for each management section in the Network Master file.

Equation 3: Combined Distress Index Formula

$$CDI_i = \sum_{i=1}^{n} Min_i \times IDI_i - \sum_{i=1}^{n} \frac{(1 - Min_i)(100 - IDI_i)}{ni} \quad (3)$$

Where:

$$Min_i = \begin{cases} 1 & \text{if } IDI_i = \text{minimum} \\ 0 & \text{otherwise} \end{cases}$$

CDI_i = Combined Distress Index for specified Individual Distress Indices

n = number of IDIs for a combination of pavement and index type

3.4. Overall Pavement Condition (OPC) Configuration

The Overall Pavement Condition (OPC) is used to define the general health of the pavement section by combining the distress indices into a calculated value. It is also used for defining Benefit in the Optimization Analysis. An alternative approach to calculating the OPC has been configured and is a significant divergence from the old process but represents a much more realistic calculation of the OPC regardless of the number of Indices that are included in the calculation. This approach required the reconfiguration of the Distress Index equations to provide more closely matched OPC scores to the

current method. The OPC for each pavement type is computed using Equation *4* which uses CDIs instead of IDIs.

Equation 4: Overall Pavement Condition Index Formula

$$OPC = \sum_{i=1}^{n} Min_i \times CDI_i - \sum_{i=1}^{n} \frac{(1 - Min_i)(100 - CDI_i)}{ni} \quad (4)$$

Where:

OPC = Overall Pavement Condition Index

n= number of *CDI*s = 3

$$Min_i = \begin{cases} 1 & \text{if } CDI_i = \text{minimum} \\ 0 & \text{otherwise} \end{cases}$$

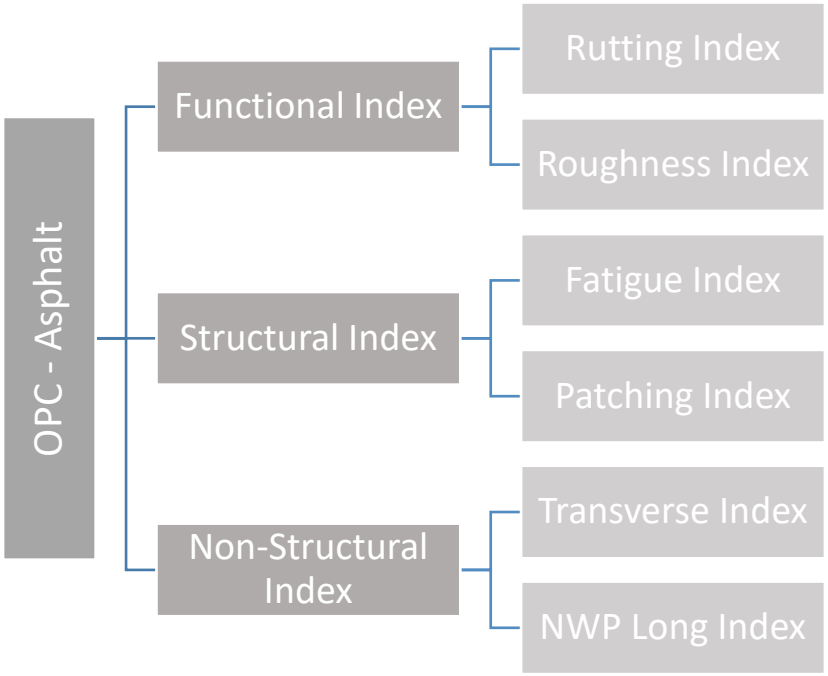


Figure 49: OPC - Asphalt

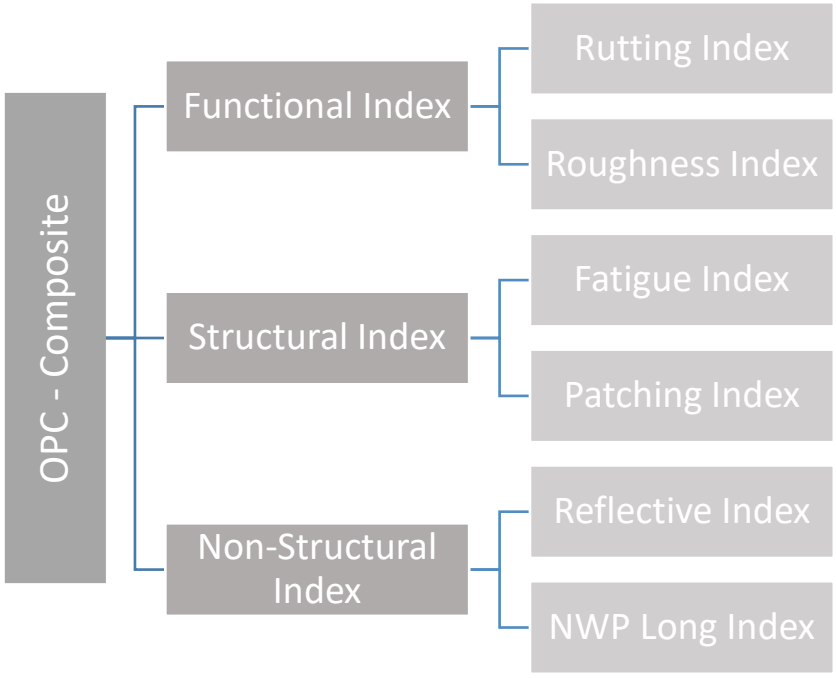


Figure 50: OPC - Composite

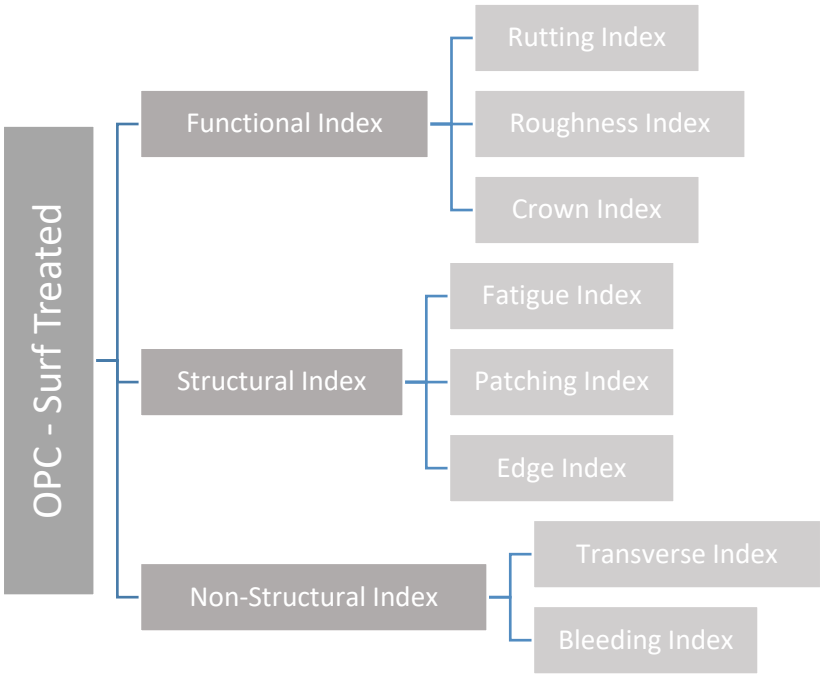


Figure 51: OPC - Surface Treated

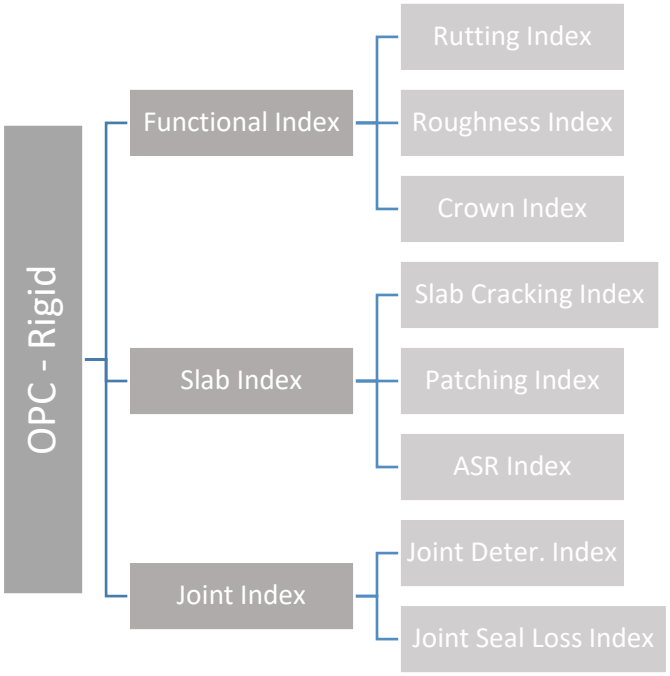


Figure 52: OPC - Concrete

Figure 7: Example of a primary arterial composite pavement in excellent condition with OPC 90.5

Figure 8: Example of major collector pavement in good condition with OPC 72.0

Figure 9: Example of major collector hot mix pavement in fair condition with OPC 58.2

Figure 10: Example of major collector composite pavement in poor condition with OPC 48.6

Figure 11: Example of local hot mix pavement in very poor condition with OPC 7.6

Appendix B – Risk

Agency & Program Level Risk Register

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
20	Program	Safety	Highway Crashes	5	5	4	2	4	**75**	DelDOT's #1 priority is to reduce fatalities and injuries.	DelDOT will continue to **Treat** this risk by continuously implementing and improving the Strategic Highway Safety Program, prioritizing safety projects in the Capital Transportation Plan, and implementing the Complete Streets program and 'safe systems' including continuing initiatives to connect trails and sidewalks and separate modes of travel.
1	Program	Safety	Major Incidents on High Volume Roadways (e.g. Interstates)	5	5	4	2	3	**70**	Major incidents can have major safety, mobility, and economic effects.	DelDOT is **Treating** this risk by continuing to implement the hazmat program. DelDOT has also assigned the Traffic Management Center to coordinate the emergency response. DelDOT is continuously working to improve the resilience of the network - i.e., returning to service faster.
2	Program	Culverts, Bridges, Pavement	Unanticipated Occurrence of a Natural Event/Asset Failure - Frequent Events (Localized Storms, Tornadoes)	5	4	3	3	3	**65**	Culverts were not designed to withstand the unanticipated storm intensities, and DelDOT cannot make all culverts larger. Typically, when an asset fails, there is not enough lead time to get permits etc. to increase culvert sizes as the roadway must be returned to service quickly.	DelDOT is currently **Tolerating** this threat with plans in place to begin **Treating** and mitigating the consequences of these events. DelDOT's recently created Transportation Resiliency and Sustainability (TR&S) Division is developing a process for prioritizing frequently flooded roadways for mitigation projects. In the future, DelDOT plans to develop inventory of pipes (and bridges) including sizes and material and locate undersized pipes. This will make risk evaluation of mitigation options possible.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
7	Agency	All	State Employee Recruitment and Retention	5	2	3	3	4	**60**	Staff shortages impact all activities from response time to incidents and snow events to higher project costs. Relying on contracted help increases costs and contributes to a loss of institutional knowledge. The current Low Unemployment Rate combined with salary caps affects DelDOT's ability to maintain a competitive salary for employees. DelDOT has to receive approval from the general assembly for merit salary increases.	DelDOT must **Tolerate** this risk to some extent as many factors are external. However, DelDOT is **Treating** this risk where possible by continuing to work with unions to negotiate salaries. DelDOT is also implementing the following agency initiatives to improve retention and mitigate the impacts of losses: employee moral committee, team building events, alternate work schedules, if possible, tele-working, succession planning (especially for high turnover positions), hiring consultants (in-house or external), and hiring contractors.
12	Agency	All	Anticipated Occurrence of a Natural Event/Asset Failure - Infrequent Events (Hurricanes, Nor'easters, and Tropical Storms)	3	5	4	5	5	**57**	The most probable destructive natural events in Delaware are hurricanes or tropical storms, Nor-easters, and flooding. As the frequency and intensity of these events is expected to increase with climate change, DelDOT will continue to emphasize and track this risk to infrastructure.	DelDOT has activities in place to **Treat** this risk and mitigate the consequences. If an event is imminent, DelDOT crews ensure that preparations, such as clearing of drainage structures, erosion control measures, etc. are performed. Post-event, DelDOT maintains a "storm" fund to expedite returning assets to a state of good repair. Federal emergency and disaster assistance funds are also used following events. In relation to other operations, DelDOT has undertaken Continuity Of Operations Planning (COOP) and provides employees with the ability to work from home. Data archives are backed up in alternate locations.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
18	Agency	All	Regulatory Controls - Fed/State Agencies, Preventing/Delaying Projects	5	2	3	2	4	**55**	Responding to changes in regulation can affect business processes and project delivery - Example changing regulations include NEPA, endangered species, IDIQ, 3R project implementation, etc. This risk has been partially mitigated since the 2019 TAMP as the specific concerns with HSIP projects have been addressed. While still considered a risk, DelDOT has lowered its priority ranking.	DelDOT has **Treated** this risk and plans to monitor changes and evaluate impacts of changes (e.g. design, permitting, project implementation). DelDOT also continues to **Tolerate**, mitigate, and address regulatory changes by coordinating to keep projects moving, emphasizing communication with FHWA, and adjusting project schedules to allow for regulatory changes (i.e., anticipate impacts of regulatory changes and add time to schedule).
29	Program	Safety	Not Meeting MASH Compliance	4	5	2	2	3	**48**	MASH requirements change frequently. The cascading effect of updated regulations are constantly a problem with federal funding at stake. Many sections of guardrail, end treatments, etc. are currently out of MASH compliance. Material shortages (specifically of steel and manufactured products) can affect DelDOT's ability to meet MASH compliance in a timely manner.	DelDOT is **Treating** this risk. A MASH Committee was formed with the goal to develop a proactive program for addressing/prioritizing MASH compliance projects. DelDOT is currently addressing non-compliance with programmatic replacement to bring assets into compliance, where possible, through pavement rehabilitation projects (though this lowers how many rehabilitation projects can be completed).

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
4	Agency	All	Anticipated Occurrence of a Natural Event/Asset Failure - Frequent Events (Rain/Flood Events)	4	2	3	3	3	**44**	Events are sustained duration, for increased frequency and intensity	DelDOT is **Treating** the risk of anticipated flooding events where possible. These events are typically anticipated and communicated to local communities early. The new Transportation Resiliency & Sustainability division is working to address flooding by identifying frequently flooded roadways, implementing virtual water on road signage, and deploying tide gauges and flood sensors.
31	Program	Bridges	Inoperable Moveable Bridges	4	2	4	3	2	**44**	Some draw bridges in Delaware become stuck either up, impacting vehicular mobility, or down, impacting marine mobility.	DelDOT is currently **Treating** this risk. DelDOT's mitigation strategy includes the creation of two types of movable bridge-specific maintenance contracts. The first addresses routine or cyclical maintenance activities for each of our 8 movable bridge. The second contract addresses specific electrical & mechanical repairs for all 8 bridges that, once completed, will reduce the likelihood of having a bridge malfunction. Last, there is a replacement project for one movable bridges (Cedar Creek Swing bridge) planned to start construction in 2024.
23	Agency	All	Technology Issues, Cyber Security and Attacks	5	2	2	2	2	**40**	Cyber attacks are a growing concern with advancements in technology and digitization of information. Additional ongoing issues include system communication, system and technology upgrades, updates to software, etc.	DelDOT currently **Treats** and **Transfers** many cyber and technological risks in coordination with Delaware's Department of Technology & Information (DTI). DTI collaborates with DelDOT "customers" (all state organizations) to implement innovative technologies and determine and deliver technological solutions. To address cyber security, DTI installs the latest firewalls, enforces DelDOT's Acceptable Use Policy, implemented Single Sign-On solution, and is continuously identifying improvement options for network security.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
30	Program	Safety	Barrier at High Crash Risk Locations	4	3	2	2	3	**40**	There is currently insufficient barrier in some high-crash risk locations.	DelDOT is working to replace insufficient barrier with heavier duty barrier (e.g. concrete barrier wall).
5	Program	Culverts, Bridges, Pavements, Drainage Systems	Catastrophic Failure - Aging Infrastructure (Pipes)	3	3	3	4	3	**39**	Aged and aging infrastructure beyond service life (e.g. corrugated metal pipes, terracotta pipes) can cause catastrophic failures (e.g. sinkholes). Initial service life expectations are often different from actual conditions. DelDOT still has an inventory of 62,000 LF terracotta pipes that need replacing.	DelDOT is currently **Tolerating** this risk at a high level and **Treating** ageing infrastructure on a case-by-case basis using High Priority Workorders where subject matter experts review the complaint and determine resolution. In the future, DelDOT plans to introduce an inventory and inspection program for pipes and develop a planned replacement program.
28	Program	Dams	Catastrophic Failure - Dams	3	4	3	4	2	**39**	The likelihood of catastrophic Dam failure is low, but the impacts would be significant. DelDOT does not own all dams in the state and thus relies on other owners to manage their risk as well.	DelDOT currently **Treats** risks to the DelDOT owned dams by maintaining an Emergency Action Plan and monitoring water levels. The responsibility for managing risks to dams owned by other entities is **Transferred** to the accountable party.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
11	Agency	All	Budget Uncertainty, Loss or Decline of Funding	3	3	2	2	5	**36**	DelDOT's current state level funding is fairly stable; however, future electrification of fuel vehicles poses a risk to consistent funding. A sustainable revenue source may be needed as an alternative to fuel tax. Federal funding is more volatile. CRs are passed every year but projects are let under the assumption that CR will be passed. Federal funding relating to TAMP and external agencies are tied to DelDOT assets where DelDOT has no control over their practices or funding. Projects may be started and not finished, or state funds would have to make up difference. Unpredictable declines of funding cause project delays or indefinite postponements and can have a major safety impact.	DelDOT must **Tolerate** some risks to funding, especially external factors. However, DelDOT's diversified revenue stream provides some protection against catastrophic revenue declines. Its three major revenue sources – motor fuel taxes, vehicle and driver fees, tolls – provide a significant portion of the revenue, with each of the three contributing between 17% and 28% of the total revenue. Where possible, DelDOT **Treats** risks to funding losses. DelDOT has an established line of credit and maintains a very high credit rating to be able to sell bonds if necessary. DelDOT also coordinates with other agencies where possible. Additionally, DelDOT's budgeting process emphasizes the maintenance of assets in a state of good repair. When revenues decline, state of good repair projects take priority over mobility projects.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
14	Program	Bridges	Catastrophic Failure - Bridges	2	5	4	5	4	**36**	Though the likelihood of a catastrophic bridge failure is unlikely, the impacts would be enormous. Thus, DelDOT tracks and manages at-risk bridges meticulously. This risk does not include bridge failure due to extreme weather.	DelDOT has always and continues to **Treat** the risk of catastrophic bridge failure. Assets susceptible to catastrophic failure, such as bridges and culverts, undergo detailed inspection at least every two years. Identified repair needs are promptly scheduled for completion. Other ongoing mitigation efforts include the NBIS inspection program, preventive maintenance, High Priority Workorders where SMEs review complaint and determine resolution, and maintaining emergency plans of action for scour critical bridges.
26	Agency	All	Workforce Safety	5	4	1	1	1	**35**	There are many risks to employees including typical risks in most workplaces such as slips, falls, workplace violence, etc. Field staff operating in ROW are at higher risk as are heavy equipment operators.	DelDOT is **Treating** this risk by improving general workplace safety. Improvement of workforce safety is accomplished through a variety of methods: reporting, tracking and investigation of incidents, development of safe operating procedures to eliminate or reduce risk (e.g. safety manual), use of engineering and/or administrative controls, training, use of personal protective equipment (PPE), and discipline.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
3	Agency	Pavement, Bridges	Climate Change Effects - Sea Level Rise	3	2	3	3	3	**33**	Sea level rise would negatively impact coastal facilities; increased rainfall amount and/or intensity could exceed drainage design capacity; and temperature extremes could cause premature pavement failures. Some roads are experiencing increased downtime from high tide inundation, which may require relocation. Additionally, increased wetlands near roadways will require more permitting and possibly delay project delivery. This trend is most likely to be mitigated through strategic planning.	DelDOT is currently **Tolerating** this risk and **Treating** vulnerable locations on a case-by-case basis. The University of Delaware is also investigating the subsidence of the state. The Governor issued an Executive Order in September 2013 creating a multi-agency committee charged with developing agency-specific plans to mitigate and adapt to climate change. DelDOT is a member of the committee and is actively developing a mitigation and adaptation plan for transportation. In the future, DelDOT expects to establish a policy for abandoning roadways and structures and addressing impacts of abandonment.
8	Program	Bridges	Bridge Strike Events	3	3	2	3	2	**30**	DelDOT has a problem with bridge hit and runs.	DelDOT is **Treating** the risk of bridge strikes by signing low clearance bridges, adding Flashing lights at some locations, implementing a program to recover repair costs from insurance companies, updating oversize/overweight permitting system, implementing High Priority Work orders where SMEs review complaint and determine resolution, and having contractors on call to make repairs in a timely manner.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
9	Program	All	Anticipated Occurrence of a Natural Event/Asset Failure - Frequent Events (Snow Events)	3	2	3	1	4	**30**	With unusually high snow years and ice storms, DelDOT is continuing to monitor and address the risk of winter events.	To **Treat** the risk of winter events, DelDOT increased the snow response budget. Major snow removal operations resources are planned and in place. DelDOT has flexibility as an agency (prior year authorization) which allows any previously unused budgets to be used for winter weather response.
24	Agency	All	Invasive Species	4	1	1	2	3	**28**	Examples of invasive species include the Spotted Lantern Fly and bamboo, which encroaches on the ROW.	DelDOT has had limited success **Treating** the risk with mitigation actions. Mitigation efforts continue and include inspecting equipment, increasing awareness and outreach to public, and removing or treating vegetation.
25	Agency	All	Barriers to Mitigating Wetland Impacts	4	1	2	2	2	**28**	The buildout of Delaware is impacting the identification of mitigation sites. Owners are unwilling to sell land and the department is unwilling to condemn properties for mitigation sites. This affects project delivery, maintenance efforts, etc.	DelDOT is **Treating** this risk by creating an umbrella mitigation bank. DelDOT is partnering with other agencies and nonprofits (DNREC, Botanical Garden) to identify and obtain wetland mitigation sites for the umbrella mitigation bank.
21	Agency	All	Global Supply Chain Issues	4	2	2	1	2	**28**	Supply chain issues result in shortages of critical materials and escalations in cost. Inflation is related and can cause additional cost increases.	DelDOT **Tolerates** supply chain risks that are out of its control and **Treats** the consequences of this risk by prioritizing projects so the next best project can be selected if a particular type of project is delayed due to material shortages. DelDOT also remains open to considering alternative materials where appropriate to continue delivering quality projects.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
17	Agency	All	Accuracy of Cost Estimates Used in Planning - Costs are Underestimated	5	1	1	2	1	**25**	The unpredictability of inflation and changes in funding levels or budget needs has impacts on many services provided by DelDOT. This affects the project pipeline.	DelDOT **Treats** this risk for Capital Improvement projects and most SOGR projects, basing the unit costs used to develop estimates on historical bid data. These estimates are typically updated annually. Estimates for paving projects also consider local market conditions and anticipated industry actions, such as raw material supplies, consolidation of suppliers, etc.
15	Agency	All	Pollution or Other Environmental Damage	3	2	1	2	3	**24**	Environmental risks will affect transportation infrastructure because DOT money may be required to fix. This could also affect permitting in the future.	DelDOT **Tolerates** and **Treats** environmental risks. DelDOT's Environmental Contingency fund covers unanticipated environmental costs. NPDES devices are inspected annually and also after major weather events. Significant deficiencies are scheduled for immediate repair. More extensive or complex deficiencies are prioritized and an action plan put in place.
27	Program	Pavement, Bridges	Blocked Access to Single Access Communities	2	3	4	3	2	**24**	Closure of road/bridge can have higher impacts on single access communities. For instance, if a road is closed due to flooding and emergency services are required in the area, risk of injury or death can increase.	DelDOT is **Treating** this risk. DelDOT's bridge group is developing mitigation plans for single access bridge failures. TR&S has an initiative to address single access communities (specifically inaccessibility due to flooded roadways).
13	Agency	All	Climate Change Effects - Increasing Temperatures	4	1	1	2	2	**24**	Climate change is causing more extreme and frequent temperatures. Pavement designs will need to change to withstand changing temperatures.	DelDOT is **Tolerating** the risk to existing infrastructure and **Treating** the risk to pavements by continuing to revise design standards.

Risk ID	Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	2022 Risk Score	Comments / Notes	Risk Management / Mitigation Description
10	Agency	All	STIP Not Approved	2	1	2	2	4	**18**	Delays in approval of DelDOT's STIP have happened in the past. This causes projects to be delayed.	DelDOT is **Tolerating** this risk and can amend or modify the existing STIP to continue work. Delaware pass a law to make STIP a biennial program to reduce delays.
16	Program	All	Accuracy of Deterioration Modeling - Budget Projections are Not Sufficient	2	1	1	3	1	**12**	Inaccurate deterioration modeling produces inaccurate condition forecasts and affects project pipeline.	DelDOT **Treats** this risk and periodically evaluates its deterioration curves for bridges, pavements, sign sheeting, etc., and updates as needed.
32	Agency	All	Pandemics	1	4	2	1	5	**12**	Pandemic (e.g., COVID-19, avian flu) can have economic fall out such as reduced traffic and therefore revenue. This can cause impacts to project delivery. Additional pandemic-related activities and risks include vaccine distributions, tele-working agreements, impacts of people working remote, PPE costs, risk of infection when in-person.	DelDOT has processes in place to **Transfer** the pandemic-related financial impacts to FHWA using contingency emergency funds and applying for federal funding to reduce economic impacts.

Asset Level Risk Register - Repeatedly Damaged (667) and Vulnerable Facilities

ID	*Facility*						
2	**Name:**	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Cedar Creek- BR3-164	Sussex	South	Y	Y	5	Y
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Bridge Structure	$279,635	Hurricane Sandy	Y	10/1/2012	100	Sea level rise and increase in abnormal tidal flooding events resulting in overtopping lead to the bridge replacement project in the STIP. The new design will account for the increased risk of flooding. Because the damage is more chronic than due to emergency events, it is not purely a 667 facility.
	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing	$0			$0		
	Already in STIP for 2022				$0		
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
		$0		$0.00		$0	
						$0	Already in STIP (approved). No further action.

8	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	South Bowers	Kent	Central	N	N	0	N
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	High tide inundation	0, under assumption this does not include removing Sand from the road.	NA	NA	NA	100	Matt Identified
	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing	$0			$20,698,049		
	1 - Raise by 5" (1 mile)	$700,000	15	$46,667	$1,338,859	94%	414.84
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
	720	$7,022	$8,000	$13,725		$28,747	
	52	$7,022	$5,000	$13,725		$25,747	B/C greater than 1. Mitigation action feasible.
9	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Woodland Beach Road	Kent	Central	N	N	0	N
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	High tide inundation	0, under assumption this does not include removing Sand from the road.	NA	NA	NA	100	Matt identified

	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing	$0			$7,196,932		
	1 - Raise by 5"	$1,000,000	15	$66,667	$0	100%	107.95
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
	180	$18,258	$8,000	$13,725		$39,983	B/C greater than 1. Mitigation action feasible.
1	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	RT 1 South of Dewey	Sussex	South	Y	N	0	N
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Added 8" pavement near Keybox Rd, doesn't completely mitigate flooding.	0, under assumption this does not include removing Sand from the road.	N/A	N	N/A	100	Alastair says pavement was raised on Route 1 in the vicinity of Keybox. Looking to raise pavement south of IRIB where there is also repeat flooding as well - potentially add as new location.
	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing	$0			$648,257		
	1 - Add 4" for one mile on all lanes	$1,200,000	15	$80,000	$129,651	80%	6.48
	2 - Permanent mitigation (e.g. causeway)						
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
	1	$613,857	$8,000	$26,400		$648,257	
	0.2	$613,857	$8,000	$26,400		$648,257	B/C greater than 1. Mitigation action feasible.

13	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	River Rd Rt 9 - south of Dobinsville	NCC	Canal	Y	Y	8/year	N
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Roadway flooding - Project to repair tide gates ($1.25M) scheduled for summer 2022 depending on permits and funding.	0	NA	NA	NA	100	Short term fix - forcing gates closed Mid-term fix - $1.25 M project to repair gates Possible capital project - will be evaluated depending on success of mid-term fix
	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing				$139,233		
	1 - Repair tide gates	$1,250,000	50	$25,000	$0	100%	5.57
	2 - Capital project						
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
	2	$63,488	$5,000	$1,129		$69,617	B/C greater than 1. Mitigation action feasible.
7	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Route 1 South of IRIB	Sussex	South	Y	N	0	N
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Repeat flooding, looking to raise pavement	0	NA	NA	NA	100	

	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing	$0			$648,257		
	1 - Raise segments by 4"	$1,200,000	15	$80,000	$321,879	50%	4.08
	2 - Permanent mitigation (e.g. causeway)						
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
	1	$613,857	$8,000	$26,400		$648,257	
	0.5	$613,857	$3,500	$26,400		$643,757	B/C greater than 1. Mitigation action feasible.
3	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Front Street- BR3-151	Sussex	South	Y	Y	2	Y
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Bridge Structure	$60,000	Storm 42-479-55	N	10/1/2021	100	
	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing				$10,000		
	1 - Replace bridge or retrofit to raise bridge	$25,000,000	100	$250,000	$0	100%	0.04
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
	0.166666667	$0	$60,000	$0		$60,000	
		$0	$0	$0		$0	B/C less than 1. Mitigation action not warranted. Tolerate Risk.

4	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	St Augustine Rt 9	NCC	Canal	<>	Y	2	N
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Roadway Washout	$64,000	42-477-55	N	10/1/2021	100	Brian says he thought "we decided that the risk is low and no further action was required". Will keep an eye on this road.
	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing				$9,659		
	1 - Raise the road 6"	$1,000,000	15	$66,667	$4,829	50%	0.07
	2 - Extend the dyke	$22,000,000	100	$220,000	$0	100%	0.04
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
	0.2	$0	$45,000	$3,294		$48,294	
	0.1	$0	$45,000	$3,294		$48,294	B/C less than 1. Mitigation action not warranted. Tolerate Risk.
		$0	$0	$0		$0	B/C less than 1. Mitigation action not warranted. Tolerate Risk.
10	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Port Mahon Road	Kent	Central	N	Y	1/MONTH	N
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Poor drainage - maintenance drains once a month.	$1.3M over 10 years	NA	NA	NA	100	Matt Identified

	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing	$0			$0		
	1 - Permanent fix not feasible. Future plan to transfer to DNREC.				$0		
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
		$0		$0		$0	Permanent fix not feasible. Transfer risk.
11	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Dutch Neck Road	NCC	Canal	N	N	1	N
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Inundation of road from the C&D Canal that adversely affects the Thousand Acre Marsh. Canal has raised a portion of this road in spring 2021.	$550,000	NA	NA	NA	10	Brian Identified - Hurricane Sandy had FEMA funding, but another storm that caused damage was funded by district operating funds. No assessment due to vulnerability = 0.
	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing	$0			$0		
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
		$0		$0		$0	Vulnerability is 10. No further action.

5	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Primehook	Sussex	South	N	Y	10	N
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Roadway Washout – DE Bay Breaches project with DNREC/F&W ($20M)	$204,697	Hurricane Sandy	Y	10/1/2012	0	Just before PS&E for T201307601, FHWA made us create a new project number (T201607303), but I cannot recall why. We did receive a $640k Public Lands Highway Discretionary grant, which basically covered about half of the construction cost. The ACOE/USFWS projects ($40M combined) fixed the breach and dredged proper channels, so the risk has been greatly reduced.
	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing (Fixed already)	$0			$222		
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
	0.005	$0	$44,405	$0		$44,405	Fixed already. No further action.
6	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Mill Creek Rd - Location 1	NCC	North	N	Y	1	Y
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Slope Stabilization	$527,401	Tropical Storm Jeanne	Y	9/1/2004	0	

	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing	$0			$5,360		
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
	0.01	$0	$527,401	$8,550		$535,951	Current vulnerability is 0. No further action.
12	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Mill Creek Rd - Location 2	NCC	North	N	N	1	NA
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**
	Slope Stabilization - tied back sheet piles	$463,874	NA	NA	1/1/2016	0	No assessment due to vulnerability = 0.
	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	0 - Do Nothing						
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**
		$0		$0			Vulnerability is 0. No further action.
14	*Facility*						
	Name:	**Location:**	**Maintenance District:**	**Federal STIP Eligible (Y/N):**	**Repeated Damage:***	**Number of Times Damaged:***	**ER/FEMA Funds Used**
	Mill Creek Rd - Full (potentially add if information found).						
	Most recent damage						
	Damage Type / Fix:	**Damage Cost:**	**Event Name:**	**Gov. Declared Event:**	**Year Month:**	**Current Vulnerability:***	**Comments (as of 2022):**

	Mitigation Actions			*Benefit Cost Ratio Calculation*			
	Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**
	Cost exposure after Action						
	Event Freq.	**User Costs**	**Repair**	**Safety**	**Other**	**Total**	**Comment:**

Appendix C – Other Owner Planned Projects

DRBA Planned Projects – NHS Pavements

Route Number	BMP	EMP	Route Description	Plan Year	Treatment	Cost Estimate
NC-00612A-F	0	0.3	DRBA Access Road	2022	Mill & Pave	$90,000
SC-00023-F	0	1.6	US 9 Freeman Memorial Hwy	2022	Mill & Pave	$960,000
SC-00023-R	1.6	3.1	US 9 Freeman Memorial Hwy	2022	Mill & Pave	$900,000
SC-00268A-F	0	0.15	US 9	2022	Mill & Pave	$100,000
SC-00019-F	0.63	0.83	Cape Henlopen Drive	2022	Mill & Pave	$120,000
NC-00056-R	16.27	20.53	I-295	2030	Mill & Pave	$3,850,000
NC-006111-F	0	0.46	Ramp	2030	Mill & Pave	$207,000
NC-006112-F	0	0.39	Ramp	2030	Mill & Pave	$175,000
NC-006113-F	0	0.33	Ramp	2030	Mill & Pave	$149,000
NC-006114-F	0	0.21	Ramp	2030	Mill & Pave	$95,000
NC-006115-F	0	0.24	Ramp	2030	Mill & Pave	$108,000
NC-006118-F	0	0.25	Ramp	2030	Mill & Pave	$113,000
NC-006121-F	0	0.25	Ramp	2030	Mill & Pave	$113,000
SC-00019A-F	0	0.14	Ferry Access Road	2030	Mill & Pave	$1,500,000
SC-00019A-R	0.14	0.28	Ferry Access Road	2030	Mill & Pave	$1,500,000
NC-00056-F	12.03	16.27	I-295	2031	Mill & Pave	$3,800,000
NC-006116-F	0	0.56	Ramp	2031	Mill & Pave	$252,000
NC-006122-F	0	0.17	Ramp	2031	Mill & Pave	$77,000
NC-006123-F	0	0.16	Ramp	2031	Mill & Pave	$72,000
NC-006124-F	0	0.21	Ramp	2031	Mill & Pave	$95,000
NC-006125-F	0	0.21	Ramp	2031	Mill & Pave	$95,000
NC-006126-F	0	0.16	Ramp	2031	Mill & Pave	$72,000
NC-006127-F	0	0.18	Ramp	2031	Mill & Pave	$81,000
NC-006128-F	0	0.16	Ramp	2031	Mill & Pave	$72,000
NC-006129-F	0	0.47	Ramp	2031	Mill & Pave	$212,000
NC-00019-F	2.17	2.57	SR 9 New Castle Ave	2036	Mill & Pave	$240,000
NC-00019-R	7.29	7.68	SR 9 New Castle Ave	2036	Mill & Pave	$240,000

DRBA Planned Projects – NHS Bridges

Bridge Number	1737A056	1737B056	3154B019A	3154C019A
Facility Carried	I 295 N & US 40 E	I 295 S & US 40 W	US 9	US 9
Feature Intersected	DELAWARE RIVER	DELAWARE RIVER	DELAWARE BAY	DELAWARE BAY
Location of Bridge	NEW CASTLE	NEW CASTLE	LEWES FERRY	LEWES FERRY
2022	$ 35,000,000	$ 20,000,000	$ -	$ -
2023	$ 57,000,000	$ 17,000,000	$ -	$ -
2024	$ 16,000,000	$ 16,000,000	$ -	$ -
2025	$ 9,000,000	$ 9,000,000	$ -	$ -
2026	$ 1,500,000	$ 3,000,000	$ -	$ -
2027	$ 3,000,000	$ 1,500,000	$ -	$ -
2028	$ 1,500,000	$ 3,000,000	$ -	$ -
2029	$ 3,000,000	$ 1,500,000	$ -	$ -
2030	$ 1,500,000	$ 3,000,000	$ -	$ -
Remarks	All rehab dollars	All rehab dollars	Bridge replaced in 2020	Bridge replaced in 2020

USACE Planned Projects – NHS Bridges

PROJECT	Bridge Number	District	FY2022	FY2023	FY2024	FY2025
IWW, DELAWARE TO CHEASAPEAKE BAY CANAL (Summit)	1494 016	NAP	Summit Bridge Substructure Concrete and Misc Steel Repairs 4.0M;	-		Summit Bridge Paint Overcoat $5.0M;
IWW, DELAWARE TO CHEASAPEAKE BAY CANAL (SR-1)	1902 082	NAP	SR-1 Deck Overlay $20.0M (Phase II);	SR-1 Concrete (sub) Repairs $1.0M		-
Planned Funding		NAP	$24,000,000	$1,000,000	$0	$5,000,000