TRANSPORTATION ASSET MANAGEMENT PLAN

June
2019

Delaware Department of Transportation

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STATE OF DELAWARE
DEPARTMENT OF TRANSPORTATION
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JENNIFER COHAN
SECRETARY

June 20, 2019

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

Dear Mr. Atkin:

In compliance with the Moving Ahead for Progress in the 21st Century Act (MAP-21), codified in 23 U.S.C. 119, the Delaware Department of Transportation (DelDOT) is proud to submit our Transportation Asset Management Plan (TAMP) 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,

Jennifer Cohan
Secretary

JC:mkd
Enclosure

DelDOT

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CHAPTER 1: INTRODUCTION AND PURPOSE

1.1 REQUIREMENTS FOR A TRANSPORTATION ASSET MANAGEMENT PLAN

Background

Transportation Asset Management is a relatively new but proven approach to investment decision making. This methodology continues to evolve as transportation agencies develop and implement 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, it is intended to serve as a process framework to support broader, on-going efforts within the Delaware Department of Transportation (DelDOT). In turn, this will allow DelDOT to manage critical assets across the entire network for which it is responsible.

Asset Management is defined in Federal law[1] as "a strategic systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the lifecycle of the assets at minimum practicable cost." DelDOT has subscribed to an Asset Management philosophy for several years. This is reflected in DelDOT's 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 will build upon previous efforts and serve as a guide for the future.

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 or improving other important 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 began championing the concepts and benefits of Transportation Asset Management. 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, the Delaware Department of Transportation (DelDOT) implemented pavement and bridge asset management systems during this period and these systems have continued to be enhanced over the years since their initial implementation. By the end of the early 2000's DelDOT and peer transportation agencies were increasingly subscribing to the principals of Asset Management. This involved adjusting their investment strategies to focus on infrastructure preservation, safety and mobility and to a lesser extent, on new capacity projects, using prioritization and trade-off analysis to guide these decisions.

[1] See 23 CFR 515.5 "Definitions"

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 condition. A key element of this legislation was a requirement for each state department of transportation (DOT) to develop a risk-based Transportation Asset Management Plan (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

Subsequent to the passage of the MAP 21 and FAST Act legislation, the Federal Highway Administration initiated efforts to draft a series of amplifying rules governing TAMP development and Transportation Performance Management. These directives were subjected to an established vetting process and 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 Federal Highway Administration (FHWA) Division office by April 30, 2018 with the final TAMP due by June 30, 2019. DelDOT was ultimately granted a time extension from FHWA until December 2018. The initial TAMP document was submitted by this revised deadline and certified by FHWA. This final TAMP document has been developed to fully comply with all federal requirements and will subsequently be submitted by the June 30, 2019 deadline for approval.

Mandatory Requirements

This TAMP document includes the performance measures for National Highway System (NHS) pavement and bridge conditions. State DOTs were not required to include their two and four-year performance management targets for bridge and pavement conditions in their initial 2018 TAMP submission. This one-time exclusion applied because the deadline for state DOTs to set those targets was less than 6 months before the deadlines for submission of the initial TAMP. States were however encouraged by FHWA to include the targets if available. DelDOT, however did include good and poor targets for its NHS bridges and pavements in their initial TAMP document and no further changes have been made to these targets for this submission.

Assets Covered

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

- Pavements – NHS Only

- Bridges – NHS Only

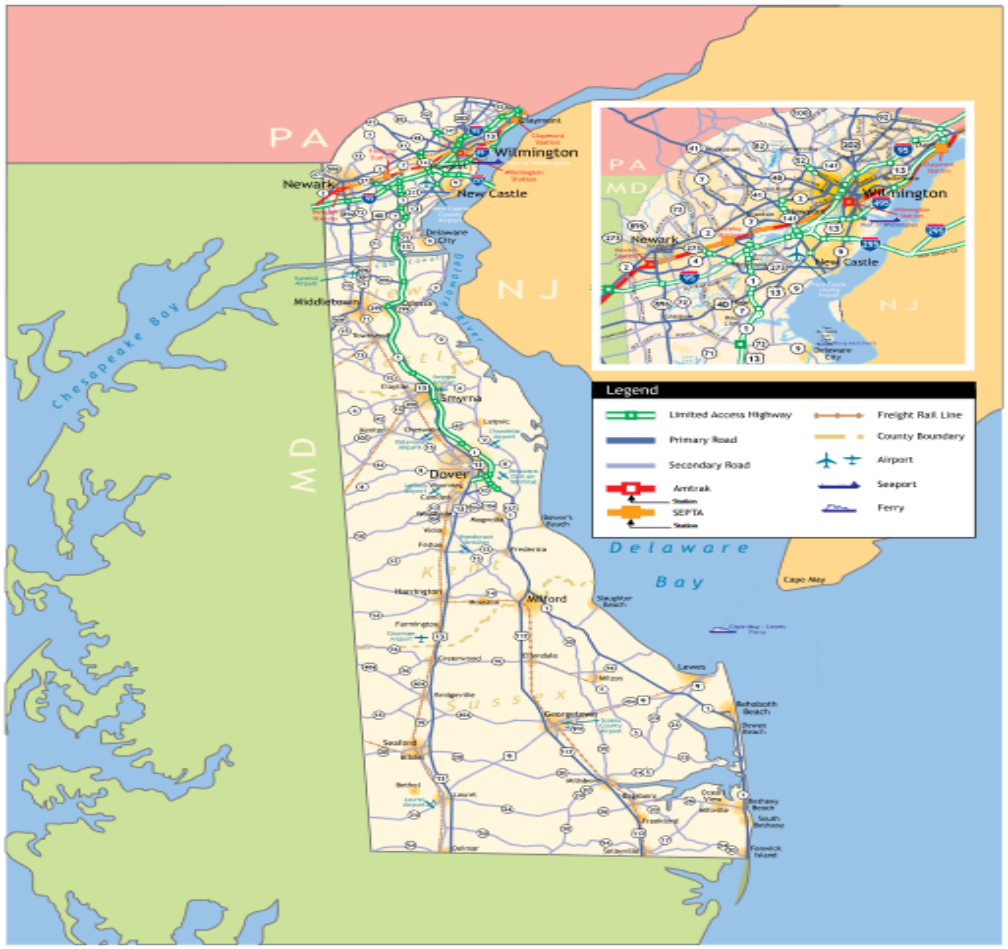
Additional assets may be added in future versions of the TAMP.

1.2 State Overview and Transportation System Responsibility

State of Delaware

Delaware has the unique distinction of being the first state to ratify the Constitution in 1787 making it 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 according to data published by the US Census Bureau had an estimated population of 961,939 in 2017. 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 72,000 in 2017.

Figure 1: DelDOT Transportation Map



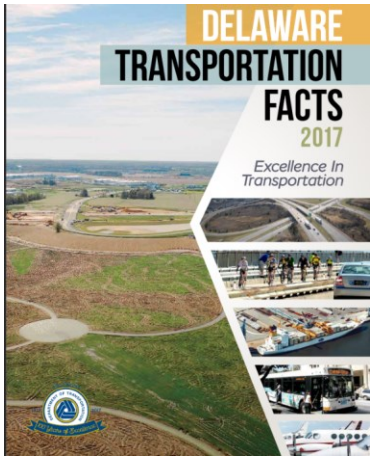
Source: https://www.deldot.gov/Publications/reports/ fact_book/pdfs/2017/DelDOTFactBook.pdf

As depicted in the Transportation Map above taken from DelDOT's Annual Report, 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.

Delaware Department of Transportation (DelDOT)

The Delaware Department of Transportation (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, and even 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.

FIGURE 2: DELAWARE TRANSPORTATION FACTS



Source: https://www.deldot.gov/Publications/reports/fact_book/pdfs/2017/DelDOTFactBook.pdf

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, twelve 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. These goals which are outlined below, are also included in DelDOT's 2017 Annual Report and Transportation Facts publication.

FIGURE 3: DELAWARE MISSION AND GOALS

OUR MISSION

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.

OUR GOALS

1. Minimize the number of fatalities and injuries on our roadways.
2. Build and maintain a nationally-recognized system benefiting travelers and commerce.
3. Provide every traveler with access and choices to our transportation system.
4. Provide every customer with the best service possible.
5. Minimize the environmental impact of the state's transportation system.
6. Achieve financial sustainability through accuracy, transparency and accountability.
7. Develop and maintain a place where talented and motivated employees love to work and can be national leaders in transportation.

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 updated bi-annually. The CTP/STIP process as it relates to the TAMP is discussed in greater detail in Chapter 5 of this document.

DelDOT updates its Statewide Long-Range Transportation Plan on a five-year cycle and expects to publish a new plan in 2019. The new plan entitled ***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 TRANSPORTATION PLAN POLICY PRINCIPLES

1. System Preservation/Optimization Maintenance first	Focus on maintenance and operations and optimization of the Transportation System.
2. Development Direct programs, services and facilities to support smart growth and smart transportation initiatives	Coordinate land use and transportation in a manner that promotes long-term transportation efficiency.
3. Travel Opportunities and Choices Maximize transportation choices for residents and visitors	Promote expansion of a variety of travel opportunities with connections to workplaces, services, residences and recreation for those with limited mobility options and the general public.
4. Cost-Effectiveness Use cost-effectiveness as the fundamental principle	Use cost-effectiveness indicators when prioritizing projects. Maintain and use existing resources and equipment. Use technology to improve service.

Source: https://www.deldot.gov/Publications/reports/fact_book/pdfs/2017/DelDOTFactBook.pdf

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 four guiding principles shown in Figure 4 above that are used to help guide decisions on the construction and operation of the state's transportation network. It is important to note that the first guiding principle listed aligns well with key objectives of the TAMP, i.e. focusing on system preservation and optimization. The new plan is centered around the topics listed below that have been identified as key areas for strategic planning, performance measures, targets, and time frames. Responsible parties for each area are being identified as the Long-Range Plan is finalized.

- Asset Management
- Traffic Management
- Bicycling
- Pedestrian
- Freight
- Aeronautics
- Transit
- Planning and Land use

System Responsibility

While DelDOT is not responsible for maintaining federal or municipally owned roadways, it joins 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 2017 Highway Performance Monitoring System (HPMS) data published by FHWA.

TABLE 1: DELAWARE PUBLIC ROAD MILEAGE COMPARISON

State	State DOT	County	Local Government	Other Jurisdiction[2]	Federal Agency	TOTAL
Delaware	**5,425**	**0**	**828**	**78**	**122**	**6,452**
Maryland	5,155	21,561	4,317	292	886	32,211
New Jersey	2,322	6,662	28,790	814	308	38,896
Pennsylvania	39,733	409	77,641	1,922	816	120,521

Source: https://www.fhwa.dot.gov/policyinformation/statistics/2017/hm10.cfm

Lane mileage can offer additional insights into system responsibilities for operations, maintenance and capital improvements as all roadway miles are not equal. Table 2 from DelDOT's 2017 Annual Report and Transportation Facts publication provides a network lane mileage breakdown by functional classification and county for years 2016 and 2017.

TABLE 2: DELDOT LANE MILEAGE BY COUNTY

Lane Miles in Delaware, 2016-2017

	New Castle '16	New Castle '17	Kent '16	Kent '17	Sussex '16	Sussex '17
Interstate	253	257	0	0	0	0
Other Freeways & Expressways	132	132	114	110	0	0
Other Principal Arterial	554	555	120	120	488	497
Minor Arterial	406	396	288	292	113	115
Major Collector	525	521	372	376	733	732
Minor Collector	151	150	246	246	265	265
Local	3,644	3,675	2,155	2,164	3,348	3,352
Total Lane Miles	**5,665**	**5,686**	**3,295**	**3,308**	**4,947**	**4,961**

Source: https://www.deldot.gov/Publications/reports/fact_book/pdfs/2017/DelDOTFactBook.pdf

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,

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

and intermodal connectors. Delaware's transportation network includes 424 miles (1695 Lane Miles) which are located on the NHS[3]. DelDOT maintains all NHS mileage with the exception of approximately 39 lane miles on I-295 and SR 9 which are owned and operated by the Delaware River and Bay Authority. Table 3 below provides an interesting comparison of NHS mileage and traffic volumes measured by Daily Vehicle Miles traveled to other roadways maintained by DelDOT.

TABLE 3: DELDOT NETWORK MILEAGE AND VMT

System	Miles	DVMT (M)	% Total Mileage	%Total VMT
Interstate	40.61	4.2	0.63	14.63
Non-IS NHS	383.39	11.5	5.94	40.21
NHS Total	**424.0**	**15.7**	**6.57**	**54.84**
Other Federal Aid	1103.64	8.3	17.10	29.11
Non-Federal Aid	4924.81	4.6	76.32	16.05
Totals	**6452.45**	**28.7**	**100%**	**100%**

While the NHS comprises just under 7% of DelDOT's total network road mileage, it carries nearly 55% 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.

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. Understanding the significance of the NHS led Congress to include requirements within the MAP 21 and FAST Act legislation for ensuring that state of good repair standards were instituted for maintaining this critical network. 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, it is important to understand that with the NHS comprising a relatively small percentage of DelDOT's overall transportation network, the Agency must also 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 TAMP, it is also 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.

[3] This figure does not include US 301.

1.3 DelDOT Asset Management Efforts

Organizational Commitment to Developing 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 in a state of good repair. 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 not only aligned with its vision, mission, goals, and strategic plan, but also would serve as a "business plan" or guide for how the organization as a whole 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 and require a larger overall allocation of funds due to the need to completely replace assets. 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 Senior 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 was chaired by the Chief of Performance Management and operated under a Team Charter with team meetings held at least monthly for over a year with a directive to accomplish the following initial objectives:

- Define the scope of an agency Asset Management System and Plan
- Establish performance measures and associated targets for each asset group
- Work with Divisions within DelDOT to perform gap analyses and identify gap closing strategies
- Assess alternative scenarios based on funding and levels of service
- Create an Asset Management Plan to meet federal requirements

The initial work of the Asset Management Team focused on establishing "State of Good Repair" performance standards and targets for a set of assets deemed to be of high importance to the Agency. With consultant support, the Asset Management Team followed published guidance from AASHTO for developing and implementing an Asset Management Plan, conducting self-assessment surveys, performing gap analyses and working toward aligning planning and programming policies and processes.

As the Federal rule making process and associated guidance from FHWA evolved over a period of several years, DelDOT made corresponding changes to its Asset Management approach. The Asset Management Team completed its initial mission while responsibility for guiding the Agency's Asset and Performance Management efforts was formally transferred to the Office of Performance Management. Today, the Office of Performance Management, working collaboratively with the Pavement, Bridge, Planning and Finance groups, serves as the Agency Asset Management Team. As such, this team has responsibility for implementation of the TAMP, data analysis, needs forecasting and performance reporting.

Asset Management continues to advance within DelDOT, with enhancements to business processes and management systems to support decision making, and 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 document, 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 operated 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 the Department's external stakeholders.

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 Highway Performance Monitoring System (HPMS) and will be 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 which DelDOT has completed and which has been accepted by FHWA. Additional details on Pavements are provided in Chapter 2 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 and 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 will be 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 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 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 obviously the most important software tools needed to support DelDOT's TAMP. However, an array of other software applications also is necessary to support the overall TAMP business processes.

DelDOT implemented its AgileAssets Pavement Management system 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.

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 transitioning to the new AASHTOWare BrM product which will ultimately provide the necessary analysis capabilities to support the analysis and reporting requirements covered in Chapter 3.

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
- E-Construction for managing projects once they have been let to contract
- TSDM[4], 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

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

1.4 Overview of TAMP Process

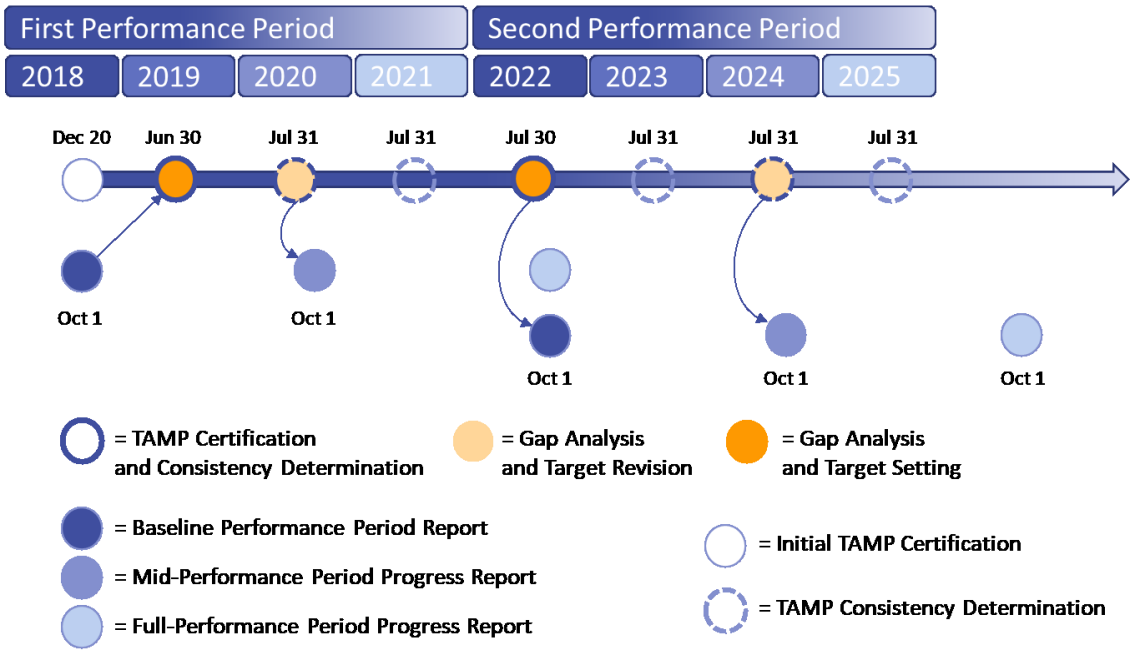
Performance Periods and Milestones

Much of the TAMP process is based around the performance periods[5] defined in the legislation. These performance periods and the associated milestones relevant to the TAMP are shown in Figure 5.

[4] Still under development

[5] 23 CFR 490.105(e)(4)(i)

FIGURE 5: PERFORMANCE PERIODS AND MILESTONES



It can be seen from the Figure 5 that there are a set of basic elements that are part of every 4-year cycle:

- TAMP Certification: At the beginning of each 4 year Performance Period, a new revised TAMP is required to be submitted and certified by FHWA. For instance, in 2022, at the start of the second performance period, the new revised TAMP will be submitted July 30.
    - Informing the TAMP will be the condition data collected for pavements (due April 15 and June 15)
    - The TAMP will contain new Targets and an associated Gap Analysis
    - The TAMP will inform the Baseline Performance Period Report (due October 1)
- Gap Analysis and Target Revision or Target Setting: At the mid-point of the Performance Period, a gap analysis may be conducted, and targets revised. For instance, in 2024, in the middle of the second performance period, gap analysis and target revisions may be undertaken.
    - Any revised Targets will be reported in the Mid-Performance Period Progress Report (due October 1)
- TAMP Consistency Determination: Every year of the Performance Period, DelDOT will submit documentation and FHWA will determine if the State is adhering to the last certified plan. For instance, in 2022, at the start of the second performance period, a consistency determination will be conducted to determine if the State is 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 submitted TAMP to make progress toward achievement of 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 to the ongoing cycle shown in the second performance period from 2022 to 2025.

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 will follow several major steps.

Step 1: Identify Current Gaps – Gaps between condition targets set at the beginning of the previous performance period and the actual condition trends of the assets over the previous 4 years will be 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 will be identified and analyzed.

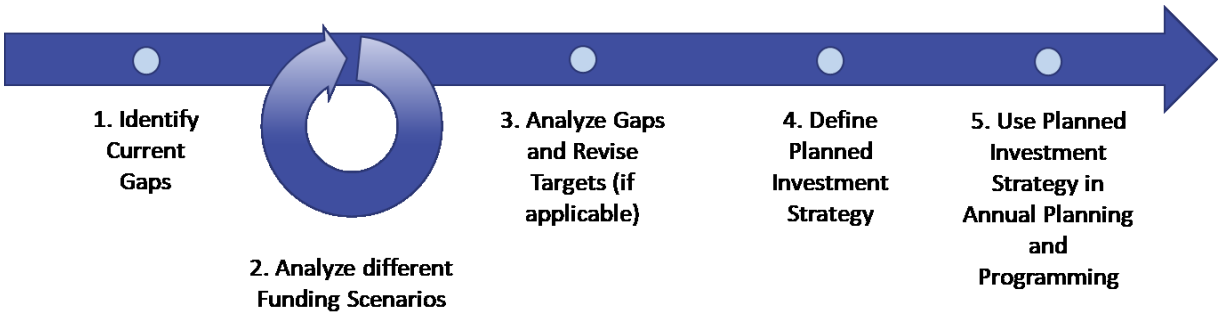
Step 3: Analyze Gaps and Revise Targets (if applicable) – Once the scenarios have been analyzed, the projected conditions over the next 10 years for each scenario will be used to compare against the previous condition targets. Targets will be revised if necessary.

Step 4: Define Planned Investment Strategy – Based on the results of the Gap Analysis, Agency Leadership, in consultation with the Asset Management Team and the individual asset managers, will finalize the targets and a planned investment strategy for each asset class. The adopted 10-year investment strategy will consist 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 will be used by the individual asset managers in their annual planning and programming process to inform the choice of projects (for instance for inclusion in the CTP/STIP).

These general steps are shown in in Figure 6 below.

FIGURE 6: TAMP PROCESS FOR DEVELOPING AND IMPLEMENTING PLANNED INVESTMENT STRATEGIES



The first three major steps in the overall process are mostly accomplished by the specific asset groups (for example pavement or bridge management groups) and are described in more detail in Chapter 2: Pavements and Chapter 3: Bridges. The last two steps are described in more detail in Chapter 5: Financial Plan.

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. In turn there needs to be tradeoff between the long-term sustainable state of good repair and costs for different asset types, for example pavement and bridge; as well as between the state of good repair of different tiers of roadways, for instance the NHS and the non-NHS portions of the network. The definition of metrics to measure current

condition and track progress towards a long term sustainable state of good repair is thus important and 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 (SoGR) refers specifically to the physical condition of the assets. The analyses presented in the following chapters is therefore undertaken with the goal of determining what long-term physical condition is attainable by adopting certain funding strategies, or conversely, what funding is needed to attain and maintain certain levels of condition.

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CHAPTER 2: PAVEMENTS

2.1 INVENTORY AND CONDITION

Description of NHS Pavement Inventory

DelDOT is responsible for managing 756 directional centerline miles of NHS roadways. Centerline miles by functional class (regardless of owner) are shown in Table 4 below.

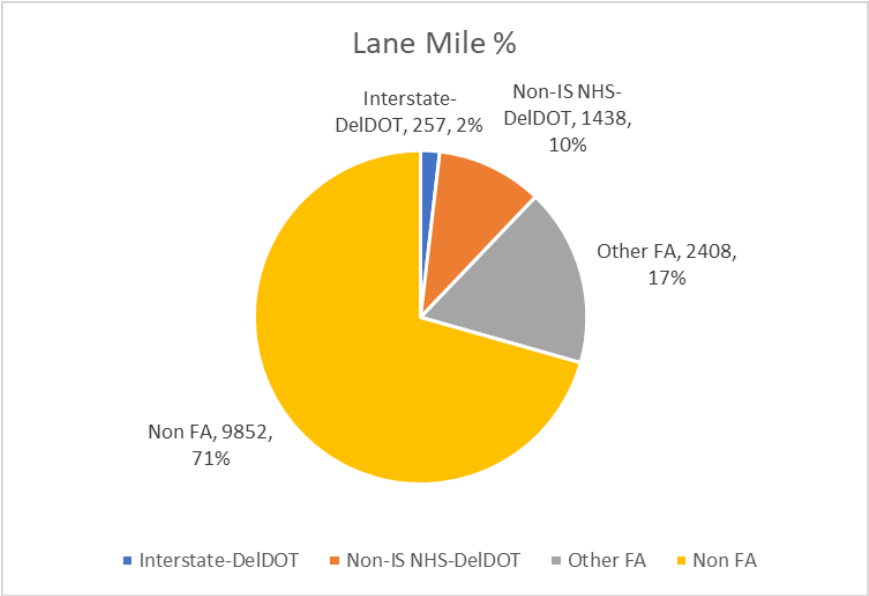
TABLE 4: PAVEMENT CENTERLINE AND LANE MILES PER SYSTEM

System	Centerline Miles	Lane Miles	Lane Miles %
Interstate-DelDOT	40.61	257	**2%**
Non-IS NHS-DelDOT	383.39	1438	**10%**
Other Federal Aid	1,103.64	2408	**17%**
Non-Federal Aid	4,924.81	9852	**71%**
Total System	6,452.45	13954	**100%**

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 35 lane miles), as well as a portion of SR9 near the Cape May/Lewes Ferry (approximately 3.5 lane miles). These sections of the NHS are owned and maintained solely by DRBA. However, DelDOT manages the data collection on these sections.

Figure 7 below shows the breakdown of the pavement inventory making up Delaware's NHS roadway network.

FIGURE 7: PAVEMENT CENTERLINE AND LANE MILES PER SYSTEM



Description of NHS Pavement Condition

The current state of good repair (SoGR), 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.
- The FHWA condition performance measures of Percent Good and Percent Poor, derivatives of the HPMS distress measures, where if two or more distress measures are Poor for a section, then the section is considered Poor overall, and if all measures are Good for a section, then the section is considered Good.

While both are important measures of physical condition for DelDOT, the primary metric that the state maximizes over time in its optimization analyses is the state metric, OPC. The OPC metric is therefore the primary metric used to track status with respect to its long-term continuous targets.

These two measures are described in more detail in the following sections.

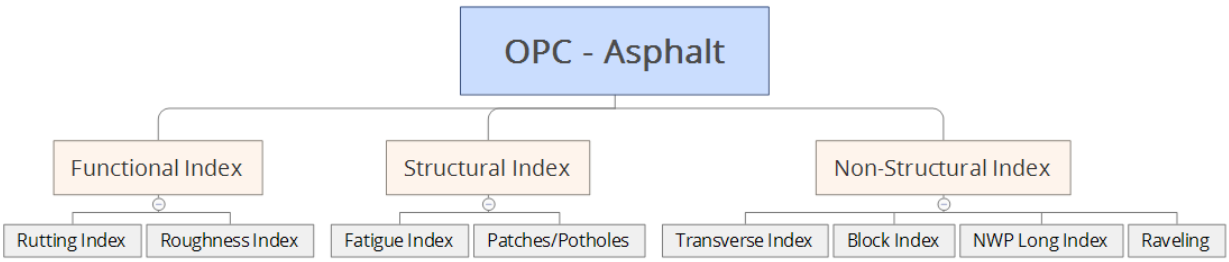
Current State Internal Overall Pavement Condition (OPC)

For pavements, separately from and in addition to the FHWA required pavement condition metrics, DelDOT calculates and tracks a State-specific metric called the Overall Pavement Condition (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[6]. Examples of the individual indices that are combined to calculate the OPC are given for Asphalt and Concrete pavements below in Figure 8 and Figure 9.

DelDOT recently updated the OPC to include Cracking, Rutting, IRI[7] and Faulting measurements from the HPMS condition survey.

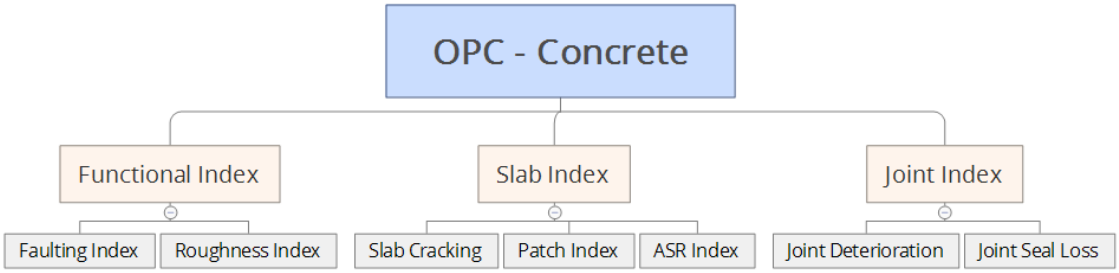
FIGURE 8: OPC INDEX COMPONENTS FOR ASPHALT



[6] Source: DELDOT PMS Configuration Document-Updated 20190724 Section 3.0 – See Appendix B

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

FIGURE 9: OPC INDEX COMPONENTS FOR CONCRETE



The Function, Structural and Non-Structural combined distress indices for Asphalt are shown below in Table 5.

TABLE 5: COMBINED DISTRESS INDICES – FLEXIBLE PAVEMENTS

Structural Index	Non-Structural Index	Functional Index
Fatigue Cracking	Transverse Cracking	Rutting
Patch Deterioration	Block Cracking	IRI
	Surface Defects/Ravelling	
	NWP Longitudinal Cracking	

The individual Slab Distress, Joint Distress and Functional combined distress indices for Concrete are shown below in Table 6.

TABLE 6: COMBINED DISTRESS INDICES – RIGID PAVEMENTS

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

From the Tables above it can be seen that the State OPC index for Flexible (Asphalt) includes Cracking, Rutting and Roughness (IRI), and for Rigid (Concrete), the OPC includes Cracking, Faulting and Roughness (IRI). The OPC is thus similar, but not exactly the same, as the FHWA metrics described in the next section. The current condition of Delaware's NHS pavement network with respect to OPC is given in Table 7 below.

TABLE 7: NHS PAVEMENT INVENTORY AND CONDITION BASED ON OPC

Surface Type	Directional Miles in State	% of Delaware Roads	% meeting goal of OPC >50
Asphalt	102.1	14%	90%
Portland Cement Concrete	139.7	18%	88%
Composite	513.9	68%	95%

Current FHWA Condition Metrics

The FHWA condition metrics are based upon the percentage of tenth-mile Highway Performance Monitoring System (HPMS) section data that are in Good, Fair, or Poor condition. Each tenth-mile HPMS section is classified as being in Good, Fair, or Poor condition based on the 23 CFR 490.313(c) where:

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

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

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

Agencies are required to set targets for % Good and % Poor for Interstate and the non-Interstate NHS. These targets are set for each of Interstate and Non-Interstate NHS roadways, and are currently established for the 2018-2021 Performance Period.

With regard to the FHWA condition metrics, Delaware pavements are generally in Good condition with 54.7% of Interstates and 59.7% of Non-Interstate NHS in Good condition, and 0.8% of Interstates and 1.2% of Non-Interstate NHS in Poor condition as shown in Table 8 below.

TABLE 8: NHS PAVEMENT CONDITION – CURRENT BASELINE VALUES FOR 2018-2021 PERFORMANCE PERIOD

	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 **[8]Estimated Baseline Value: 54.7%**	The percent of Interstates in a Poor condition [490.307(a)(2)] by tenth-mile section mileage **Estimated Baseline Value: 0.8%**
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 **[9]Baseline IRI Value: 67.5%**	The percent of Non-Interstate NHS in a Poor condition [490.307(a)(4)] by tenth-mile section mileage **Baseline IRI Value: 6.9%**

The baseline information reported in the Baseline Performance Period report submitted to FHWA was taken from HPMS and is IRI only. However, the Delaware DOT used full distress values to set targets for both Interstate and Non-Interstate pavements. Per FHWA's 9/27/18 memo, for Non-Interstate NHS, Delaware will review significant progress based on (1) IRI data reported to HPMS in 2020 or 2022, compared to the baseline condition (based on IRI data reported to HPMS in 2018); or (2) whether the actual condition level (based on "full-distress distress plus IRI data" reported to HPMS in 2020 or 2022) is equal to or better than the established target (established based on "full-distress plus IRI data").

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

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

2.2 Obtaining Data from other NHS Owners

As noted in Section 2.1 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 DelDOT 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.

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.

2.3 Objectives and Targets

DelDOT's TAMP is focused on maintaining critical NHS pavement and bridge assets in a state of good repair (SoGR). The fundamental objective for pavements is that they should provide satisfactory ride quality while also maximizing the pavement structure's life cycle. As noted above, the primary measure of pavement condition for Delaware is the 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. However, with the introduction of the condition metrics defined by the FHWA, these 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 state of good repair targets continuously if possible. In the case of the OPC metrics, the targets represent the long term sustainable desired 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 other 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 (for example short term targets for the end of the FHWA performance period) are required. While these targets are set for specific years, they are aligned with the continuous OPC target 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 State of Good Repair (SoGR)

By using the OPC[10] 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 SoGR targets are shown below in Table 9.

TABLE 9: PAVEMENT CONDITION – STATE SOGR TARGETS

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

Target FHWA Condition Metrics

Table 10 lists the measures and targets defined for pavements. The new performance measures as required by FHWA are incorporated into the table.

TABLE 10: NHS PAVEMENT CONDITION – FHWA TARGETS

	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 **2021 Target: at least 50.0%.**	The percent of Interstates in a Poor condition [490.307(a)(2)] by tenth-mile section mileage **2021 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 **2021 Target: at least 55.0%.**	The percent of Non-Interstate NHS in a Poor condition [490.307(a)(4)] by tenth-mile section mileage **2021 Target: should not exceed 2.0%.**

These four-year targets for pavements in Good and Poor condition were based on historical data and trends for funding and condition ratings. The most current data from the 2017 pavement distress collection cycle was included in this determination. Some engineering judgement was used as DelDOT changed the process for rating roadways during the latest collection cycle.

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

2.4 Gap Analysis and Condition Projections

Discussion of Gaps between Targets and Projected Condition

Current Gaps

Based on the conditions and targets identified above, the pavements in Delaware on the national highway system (NHS) are currently meeting targets in all categories.

For the State long term state of good repair targets for Overall Pavement Condition (OPC), with respect to pavements in Good condition, 93% of the road system currently has an OPC of greater than 50. This is considerably better than the target of 85%. With respect to pavements in Fair condition, 9% of the road system currently has an OPC between 50 and 60. This is also below the maximum target of 10%.

For the FHWA condition metrics, the current estimated[11] baseline (2018) is that 54.7% of Interstate pavements are in Good condition which is more than the target of 50.0%. For Poor pavements, it is estimated that 0.8% 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 59.7% of pavements are in Good condition, which is better than the target of 55.0%. Although the percent of pavements in Poor condition, at 1.2%, is slightly more than for Interstates, this is still better than the target of 2.0%.

The gaps between the 2018 baseline conditions and the 2021 target conditions is summarized in Table 11.

Table 11: NHS Pavement Condition – Gaps between 2018 Baseline and Target Values

Asset Class	Measure	Current Condition	Target	Gap
NHS Pavements	Overall Pavement Condition (OPC)			
	Percent ≥ 50	**93%**	**≥ 85%**	No Gap
	Percent 50-60	**9%**	**≤ 10%**	No Gap
NHS Pavements	FHWA Percent Good and Percent Poor			
	Interstate Percent Good	**2018 Estimated Baseline: 54.7%.**	**2021 Target: at least 50.0%.**	No Gap
	Interstate Percent Poor	**2018 Estimated Baseline: 0.8%.**	**2021 Target: should not exceed 2.0%.**	No Gap
	Non-Interstate NHS Percent Good	**2018 Estimated Baseline[12]: 59.7%.**	**2021 Target: at least 55.0%.**	No Gap
	Non-Interstate NHS Percent Poor	**2018 Estimated Baseline[12]: 1.2%.**	**2021 Target: should not exceed 2.0%.**	No Gap

[11] 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 2018 but were actually measured in 2017.

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

Projected Gaps

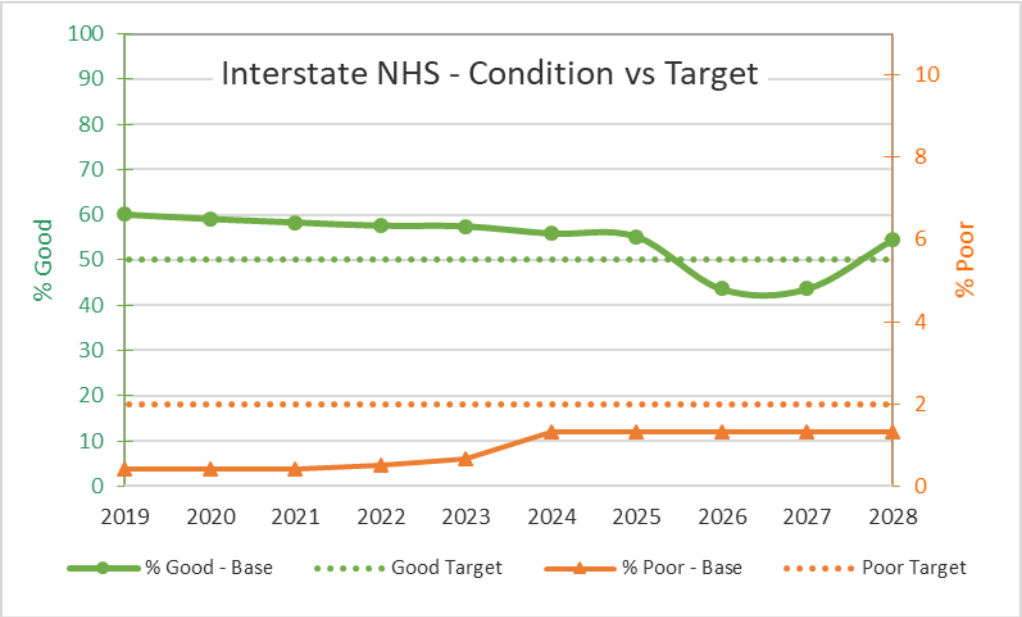
As noted in the financial analysis discussion in Chapter 5: Financial Plan, a number of different scenarios were analyzed and based on these analyses, a specific investment strategy was decided upon. The current conditions, and those projected for the planned investment strategy, are compared to the targets below in Figure 10 and Figure 11[13].

While no historical trend information is available yet because DelDOT has only recently started collecting the full set of HPMS distresses on the whole network, the figures show that the percent Good and Poor for both Interstate and Non-Interstate NHS pavements are currently better than the target values.

With respect to the FHWA metrics and targets, the projections of condition over the 10-year analysis period show that the percent of Poor pavements remain below the targets for the 10-year analysis period. While the percent in Poor condition does not remain steady, the general trend is that there is a small increase in the percent Poor by the end of the 10-year analysis period for both Interstate pavements, and for Non-Interstate NHS pavements.

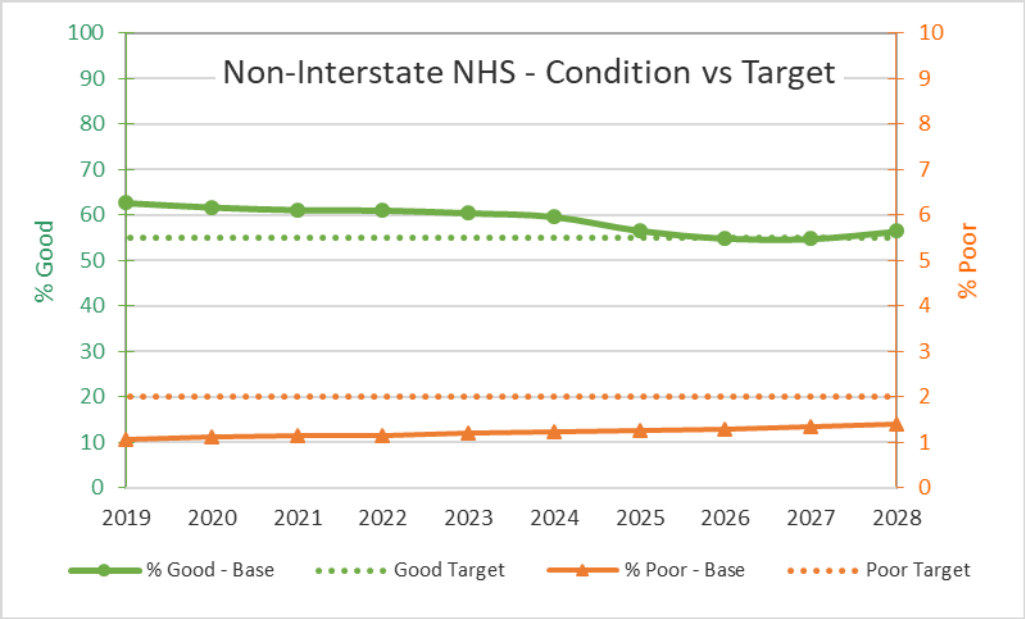
The projections of percent of pavements in Good condition show a slight decrease over the 10-year analysis period. There is a slight gap projected in 2026 and 2027 for Interstate pavements where the percent Good drops below the target by approximately 5%. However, in 2028 the percent of Good pavements is again predicted to be above the target of 50%. For Non-Interstate NHS pavements, there is also a slight gap projected in 2026 and 2027 where the percent Good drops below the target. However, in 2028 the percent of Good Non-Interstate NHS pavements is again predicted to be above the target of 55%. These apparent temporary drops in percent Good appear to be the result of a cohort or 'wave' of NHS pavements becoming due for rehabilitation around the same timeframe.

FIGURE 10: INTERSTATE CURRENT AND PROJECTED CONDITIONS AND TARGETS



[13] Note that the percent Good and Poor shown for 2018 in the figures are based on deteriorating the condition from 2017 (submitted to FHWA in 2018) and also modeling any improvements. As a result, these figures are not directly comparable with those submitted as the baseline report in Table 11.

FIGURE 11: NON-INTERSTATE NHS CURRENT AND PROJECTED CONDITIONS AND TARGETS



Key Issues

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

- 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 inconsistences 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.

Strategies for Managing These Issues

- The DelDOT Pavement Management Team has worked with the most recent collection vendor to create 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 will in the future be 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 and to be entered into the pipeline for capital funding outside of pavement management's budget.
- Recent enhancements to DelDOT's Pavement Management System 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 of these treatment strategies and yield the best overall network level condition over the analysis period.

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 pavement management system 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 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 pavement management system which uses the Overall Pavement Condition 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. will become part of the risk management process which includes specific assets related to previous emergency declarations (Part 667).

2.5 Gap and Scenario Analysis Process for Pavements

DelDOT's Pavement and Rehabilitation program strives to maintain the condition of Delaware's roadways by systematically identifying candidates for rehabilitation[14] 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.

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 Overall Pavement Condition (OPC) index, which is on a scale of zero (worst condition) to 100 (best condition) and uses the combined distress indices.

[14] 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.

The Gap Analysis, Funding Scenario Analysis, and Target Setting processes all form part of the larger process of developing an investment strategy for the TAMP. These processes together include the following major steps:

Step 1: Identify Current Gaps – Targets for % Good and % Poor metrics are discussed in the previous section. To check progress against these targets, the trend of these metrics during the current performance period will be plotted against the targets to identify current gaps.

Step 2: Analyze different Funding Scenarios and Project Future Network Condition – The agency uses the pavement management system, to project the condition of NHS pavements out to the end of the current PMS performance period for each of the different funding scenarios identified in the Financial Plan. This process is discussed in the more detailed steps below regarding the life cycle planning process.

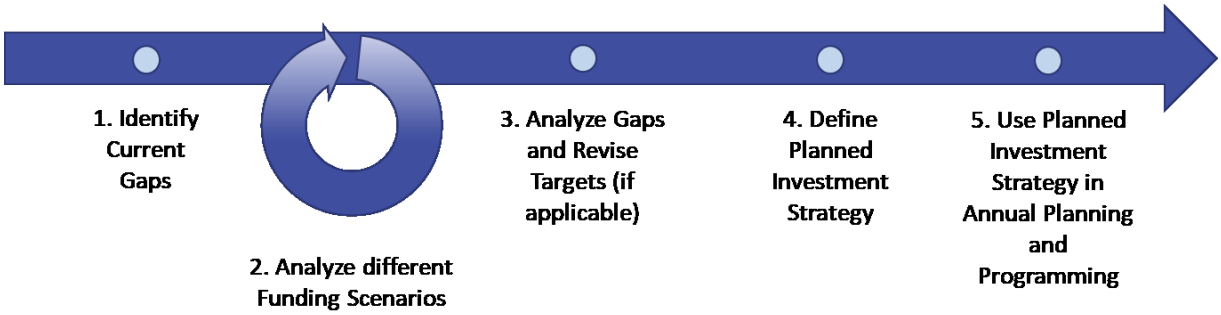
Step 3: Analyze Projected Gaps and Revise Targets (if applicable) – Once the scenarios have been analyzed, the results are provided to the Asset Management Team (from each asset management group). The Asset Management Team will then compile these and provide the gap analysis to the Agency Leadership 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 Asset Management Team and the individual asset managers, finalizes state of good repair (SoGR) 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 will be used by the individual asset managers in their annual planning and programming process to inform the choice of projects.

These general steps are shown in in Figure 12 below.

FIGURE 12: GAP ANALYSIS, SCENARIO ANALYSIS AND TARGET SETTING PROCESS



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 5.

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 pavement 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 PMS (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 OPC index and compare these to identify any current gaps.

Step 2: Analyze different Funding Scenarios

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

1. Update Inventory and condition in the pavement management system – 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 pavement management system by the Pavement Management Group. The data covers the entire state regardless of owner.
2. Define funding scenarios – These are obtained from Agency Leadership as being scenarios that are to be analyzed by the Pavement Management Group. The Pavement Management Group may also choose to analyze different scenarios of their own. 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.
3. Update analysis parameters – This entails updating or confirming that the various inputs to the pavement management system are current and valid.
   3.1. Update or confirm available treatment actions - The treatments currently in use in the pavement management system are shown in Table 12. The work type (budget category) is also updated.

TABLE 12: TREATMENT ACTIONS[15]

Road Structure Category (RSC)	Treatment	Work Type
	Do Nothing	
Seals	AC Crack Seal	Maintenance
	Fog Seal	Maintenance
	Chipseal	Preservation
	Chipseal + Patch	Preservation
Patching	Patch - BIT - 5%	Maintenance
	Patch - BIT - 10%	Maintenance
	Patch - BIT - 25%	Maintenance
Flexible Preservation	Microsurfacing	Preservation
Flexible Rehabilitation (Functional)	Rehab – Functional (<2” Mill and Overlay)	Rehabilitation
Flexible Rehabilitation (Structural)	Rehab – Structural (>2” Mill and Overlay)	Rehabilitation

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

Road Structure Category (RSC)	Treatment	Work Type
	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

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.

3.2. Update or confirm deterioration models - Deterioration models are currently used for the key performance indices shown below in Table 13.

TABLE 13: PERFORMANCE INDICES MODELED BY DETERIORATION MODELS[16]

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

3.3. Update or confirm benefit calculations – The benefit will be 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 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.

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

3.4. 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 pavement management system.

3.5. 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 pavement management system.

3.6. 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.

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 Asset Management Team – These reports are generated from the PMS.

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

Once the scenarios have been analyzed, the results are provided to the Asset Management Team (from each asset management group). The Asset Management Team will then compile these and provide 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 groups are compiled by the Asset Management Team.

2. The projected conditions over the 10-year analysis period are compared against both the State OPC state of good repair 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 Asset Management Team may include recommendations for revising either the long term OPC state of good repair targets, or possibly short term FHWA metric targets, which may then be adopted by the 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.

Recent Pavement Management Enhancements

The Pavement Management Configuration Document has been updated to reflect changes made to the program to incorporate the modeling and projection of the FHWA metrics.

DelDOT has also updated the Pavement Performance Models based on Delaware's historical data and validating field data with calculated OPC values. This will improve the forecasting and budget analysis within the Pavement Management Program.

2.6 Work Planning and Programming

This process is used to disseminate the recommended workplan and target budgets 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 5), 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) is 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.

2.7 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 pavement management system. The scenario analysis process described in Step 2 above includes use of a commercial pavement management system, AgileAssets 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 Data Quality Management Plan (DQMP) that has been certified by FHWA.

Recent 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:

- 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.

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CHAPTER 3: BRIDGES

3.1 INVENTORY AND CONDITION

Description of NHS Bridge Inventory

DelDOT maintains roughly 1,722 bridge structures. Any structure under the public roadway with a hydraulic opening of greater than 20 square feet and a minimum vertical clearance of 4' is considered 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 culvert and pipe 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).

In addition, there are 4 bridges that span the C&D Canal that are owned by the US Army Corps of Engineers (USACE) along 4 roadways: SR896, SR1, US13, and SR9 and. DelDOT's Bridge Management Section, Canal District M&O, and USACE have very open and transparent communication when performing any inspections and small-scale maintenance. Delaware River & Bay Authority (DRBA) owns all bridges located along I-295 in Delaware, the Freeman Highway bridge that carries US9 over the Lewes & Rehoboth Canal in the Town of Lewes, and two ferry transfer bridges at the Cape May-Lewes Ferry Terminal in Lewes.

This TAMP document pertains to DelDOT, DRBA, and USACE NBI bridges on the NHS. The total number for bridges on the NHS is 339 as shown in Table 14 below.

TABLE 14: NHS BRIDGE INVENTORY

Description	Number of NHS Bridges
DelDOT NBI/NHS Bridges	323
DRBA NBI/NHS Bridges	12
USACE NBI/NHS Bridges	4
Total Bridges	**339**

Description of NHS Bridge Condition

Current State Condition Metrics

In addition to the FHWA required bridge condition metrics, DelDOT tracks State-specific metrics that reflect percent of Good, Fair and Poor bridges. These indexes are calculated as the percent of bridges where the NBI rating for the bridge is less than or equal to 4 for Poor, the NBI rating is 5 for Fair, and the NBI rating is 6 or higher for Good.

Based on these indexes, currently DelDOT's NHS bridge network is 0.3% in Poor condition as given in Table 15 below.

TABLE 15: NHS BRIDGE CONDITION BASED ON STATE METRICS

Performance Measure	Count	2019 Condition Summary
# of Bridges in Good Condition (6-9)	252	78.0%
# of Bridges in Fair Condition (5)	70	21.7%
# of Bridges in Poor Condition (≤4)	1	0.3%

Current FHWA Condition 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[17] 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 tenth of a percent (0.1% or 0.001).

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):

(1) 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.

(2) 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.

(3) 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.

With regard to the FHWA condition metrics, 17.4% of the total deck area of Delaware NHS bridges are in Good condition and 5.4% in Poor condition as shown in Table 16 below.

TABLE 16: NHS BRIDGE CONDITION BASED ON FHWA METRICS

	DelDOT NBI NHS Bridges		DRBA Bridges		USACE Bridges		Total Baseline Values	
Condition Rating	**Deck Area (sq.ft.)**	**% Deck Area**	**Deck Area (sq.ft.)**	**% Deck Area**	**Deck Area (sq.ft.)**	**% Deck Area**	**Deck Area (sq.ft.)**	**% Deck Area**
Poor (≤4)	234,198	3.9%	1,519	0.1%	227,832.6	18.7%	**463,566**	**5.4%**
Fair (= 5 & 6)	4,315,344	72.7%	1,286,615	93.0%	991,804.2	81.3%	**6,593,763**	**77.2%**
Good (≥6)	1,389,613	23.4%	95,320	6.9%	0.0	0.0%	**1,484,933**	**17.4%**
Total =	**5,939,155**	**100.0%**	**1,383,454**	**100.0%**	**1,219,636.8**	**100.0%**	**8,542,262**	**100.0%**

The summary baseline values are as shown in Table 17 below.

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

TABLE 17: NHS BRIDGE CONDITION – BASELINE VALUES FOR 2018-2021 PERFORMANCE PERIOD

	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)] **2018 Baseline Value: 17.4%**	Statewide percentage of deck area of bridges on the NHS in Poor condition. [23 CFR 490.107(b)(1)(ii)(B)] **2018 Baseline Value: 5.4%**

3.2 OBTAINING DATA FROM OTHER NHS OWNERS

The TAMP discussed in this document pertains to DelDOT, DRBA, and USACE NBI bridges on the NHS.

DRBA and USACE have their own consultants that inspect their bridges. Both, DRBA and USACE, will provide DelDOT with the NBI data (SI&A forms) within 180 days of the inspection date or by December 1st. DRBA also submits their element level inspection data within the 180-day window. However, DelDOT currently does not receive element level data from the USACE as State DOT's are not required to collect, store, and report this data to the FHWA. The data received from DRBA and the USACE is typically submitted in spreadsheet form and is manually entered into the BrM database by DelDOT's Bridge Inspection Engineer.

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 programs to analyze the bridge structure to determine the load carrying capacity for State and Municipally owned bridges. DRBA and USACE perform load rating analyses with their in-house or consultant staff.

3.3 OBJECTIVES AND TARGETS

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

The long-term desired 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 current conditions are given above in section 3.1. The long and short-term target values for each measure follow.

Internal State Targets for Long Term State of Good Repair (SoGR)

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

- No more than 10% of total NBI bridge deck area on the NHS classified as Poor (condition rating ≤4).

More generally, the long-term desired 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 5% of Delaware's bridges are rated as Poor. These long term SoGR targets are shown below in Table 18.

TABLE 18: BRIDGE CONDITION –STATE SOGR TARGETS

	Measure	Target
Bridges - Poor	NBI Poor Condition Rating (Rating = 0-4)	≤5% of Bridges.
Bridges - Good	NBI Good Condition Rating (Rating = 6-9)	>75% of Bridges.

Target FHWA Condition Metrics

Table 19 lists the measures and targets developed for bridges.

DelDOT has established the following targets:

- 2-year Target: The percent of bridges on the NHS in a Good condition [23 CFR 490.407(c)(1)] by deck area should be at least 13.4%.
- 4-year Target: The percent of bridges on the NHS in a Good condition [23 CFR 490.407(c)(1)] by deck area should be at least 20.0%.
- 2-year Target: The percent of bridges on the NHS in a Poor condition [23 CFR 490.407(c)(2)] by deck area should not exceed 4.0%.
- 4-year Target: The percent of bridges on the NHS in a Poor condition [23 CFR 490.407(c)(2)] by deck area should not exceed 2.0%.

These are shown below in Table 19. All targets are published in the DelDOT 2018 Baseline Performance Period Report.

TABLE 19: NHS BRIDGE CONDITION – FHWA TARGETS

	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 **2018 Target: at least 13.4%.** **2020 Target: at least 20.0%.**	The percent of bridges on the NHS in a Poor condition [23 CFR 490.407(c)(2)] by deck area **2018 Target: should not exceed 4.0%.** **2020 Target: should not exceed 2.0%.**

3.4 GAP ANALYSIS AND CONDITION PROJECTIONS

Discussion of Gaps between Targets and Projected Condition

Current Gaps

As shown in Table 20 and Figure 13, the 2-year target in 2020 for the statewide percentage of deck area of bridges on the NHS classified as in Good condition was set at a value of 13.4%. The reason for this is two-fold; first, this is the first year that DelDOT is reporting Fair condition bridges as a 5 and 6 for the lowest NBI Condition Ratings for deck,

superstructure, substructure, and culverts. As such, most of the projects that are already planned over the next two years are primarily addressing bridges that meet the previous definition of Fair condition (NBI Condition Rating = 5) and Poor condition. Second, while DelDOT has a fairly good understanding as to how many bridges will have a condition rating drop from a 6 to a 5 from one inspection to the next, DelDOT has less confidence in the Agency's ability to predict how many bridges will have a condition rating drop from a 7 to a 6. A bridge can more easily become a 6 versus a bridge that is already 6 dropping to a 5.

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 20%. This target value has been selected due to the volume of existing projects and planned construction that DelDOT has scheduled over the next 4 years.

DelDOT also plans to have a better understanding as to the rate at which bridges that will move from Good condition to Fair condition (7 to 6) by that time. DelDOT also plan to incorporate the NBI 6 condition rating into the prioritization process starting in the 2019 calendar year. This will help in identifying work needs earlier and prevent the bridge from reaching an NBI condition rating of a 5. DelDOT will re-evaluate at the 2-year target timeframe to see if adjustments need to be made to the 4-year targets.

TABLE 20: NHS BRIDGE CONDITION – GAPS BETWEEN 2018 BASELINE AND TARGET VALUES

Asset Class	Measure	Current Condition	Target	Gap
State Bridges	NBI Condition Rating			
	Poor Condition Percent of Bridges	**0.3%**[18]	**≤ 5%**	No Gap
	Good Condition Percent of Bridges	**78%**	**> 75%**	No Gap
NHS Bridges	FHWA Percent Good and Percent Poor			
	Percent Good	**2018 Baseline: 17.4%.**	**2020 Target: at least 13.4%.** **2022 Target: at least 20.0%.**	2020 Gap: No Gap 2022 Gap: 2.6%
	Percent Poor	**2018 Baseline: 5.4%.**	**2020 Target: should not exceed 4.0%.** **2022 Target: should not exceed 2.0%.**	2020 Gap: 1.4% 2022 Gap: 3.4%

Projected Gaps

As noted in the financial analysis discussion in Chapter 5: Financial Plan, a number of different scenarios were analyzed and based on these analyses, the Baseline investment strategy was decided upon. The current conditions compared to future targets are shown in Table 20. Targets and conditions projected for the Baseline investment strategy are shown in Figure 13 and Figure 14. The 2 and 4-year targets for the statewide percentage of deck area of bridges on the NHS in Poor condition has been set at 4% and 2%. The baseline 2018 percent in Poor condition was 5.4%.

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

As can be seen from the projections for the Baseline funding scenario in Figure 13 and Figure 14, based on DelDOT's extensive historical performance and knowledge of how Delaware's bridges deteriorate, the Agency expects only a few new bridges moving from the Good or Fair condition to that of a Poor condition over this timeframe. DelDOT projects that the metrics will be less than 2% at the 4-year target timeframe, however, the Agency leaned on the conservative side when setting goals as it does not have control over other bridge owners such as the DRBA and the USACE – both of which have some very large 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.

FIGURE 13: PERCENT GOOD AND POOR NHS FHWA METRIC PROJECTIONS FOR BRIDGES – BASELINE SCENARIO

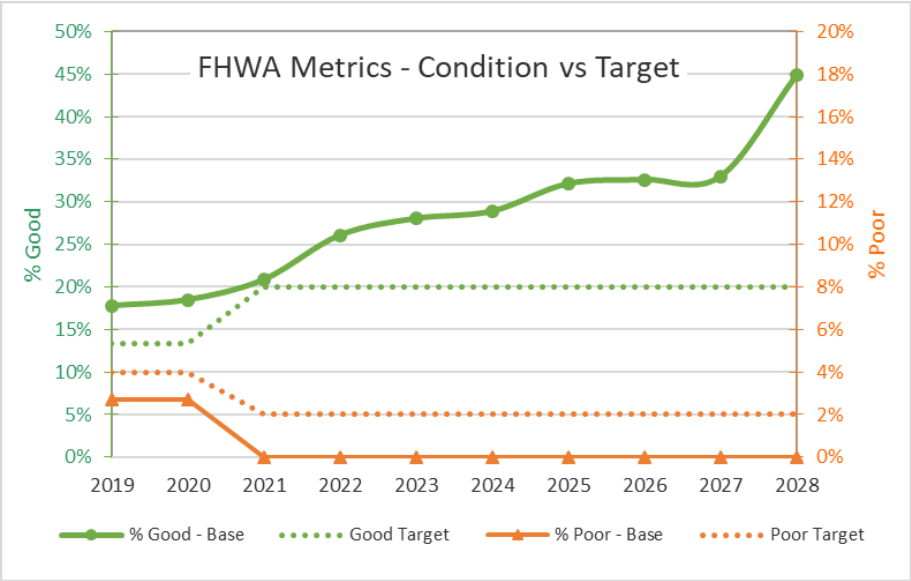
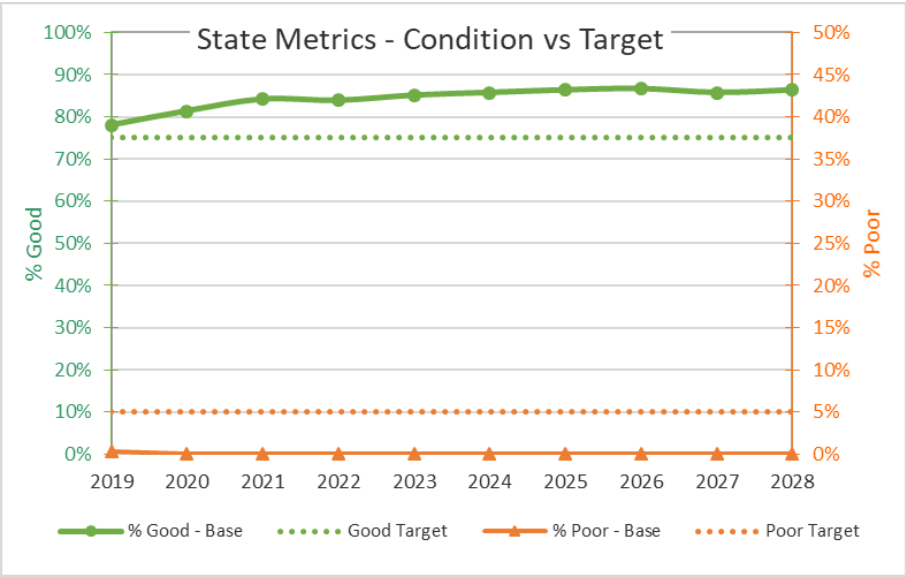


FIGURE 14: PERCENT GOOD AND POOR NHS STATE METRIC PROJECTIONS FOR BRIDGES – BASELINE SCENARIO



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 are starting 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 – 10 years.

- Major Projects: There are several major structures that are working their way up the deficiency list and will require a significant amount of money to repair. These structures include the I-95 Viaduct, I-95 over the Brandywine, and various bare deck concrete bridges with uncoated steel reinforcing.

Strategies for Managing These Issues

- Interstate Bridge Decks: The Bridge Management Section has evaluated different nondestructive methods (infrared cameras, impact echo, and ground penetrating radar) to determine the condition of the deck overlays and how much life they have left in them. The Bridge Section has implemented the use of impact echo to identify deterioration in bare concrete decks with uncoated steel reinforcing and has recently worked with a consultant to receive training on the infrared camera that has been purchased. The Bridge Section has developed a plan to rehabilitate those decks based on the results of the evaluations.

- Major Projects: Since the cost for each of these will well exceed $10M, DelDOT had programmed these projects back in 2013/2014. The I-95 Rehabilitation project, which includes major repair work to the Wilmington Viaduct and Brandywine River Bridge, has been planned for FY21-FY24 and is currently programmed in the Capital Transportation Program.

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 bridge management system analyses by incorporating these CTP/STIP projects as 'committed projects'. The physical condition of the bridge can be 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. will become part of the risk management process which includes specific assets related to previous emergency declarations (Part 667).

3.5 Gap and Scenario Analysis Process for Bridges

DelDOT is committed to keeping the Bridge Inventory in satisfactory condition as bridges are vital links to keep its infrastructure operating as planned. This includes replacing deficient bridges that are at the end of their useful service life as well as providing bridge maintenance and preservation in a timely fashion. Also, deferring maintenance repairs and preservation increases the risk of greater life cycle costs. Failure to perform required maintenance and preservation will result in more costly repairs.

In 2011, DelDOT reorganized and combined Bridge Design and Bridge Maintenance into a single Bridge Section. Through this comprehensive lens, this section can address all bridge maintenance, replacement and project activities in a more efficient and effective manner.

The Gap Analysis, Funding Scenario Analysis, and Target Setting processes all form part of the larger process of developing an investment strategy for the TAMP. These processes together include the following major steps:

Step 1: Identify Current Gaps – Targets for % Good and % Poor metrics are discussed in the previous section. To check progress against these targets, the trend of these metrics during the current performance period will be plotted against the targets to identify current gaps.

Step 2: Analyze different Funding Scenarios and Project Future Network Condition – Currently, DelDOT does not have Bridge Management System software in place to perform this analysis. Therefore, everything in this TAMP has been analyzed and completed manually (spreadsheet based). In the future, the agency will use the BrM Bridge Management System, to analyze the effects of different funding scenarios. The section Future Bridge Management Enhancements below discusses this in detail and provides expected goals and associated timelines for developing and implementing BrM into DelDOT's Bridge Asset Management Program.

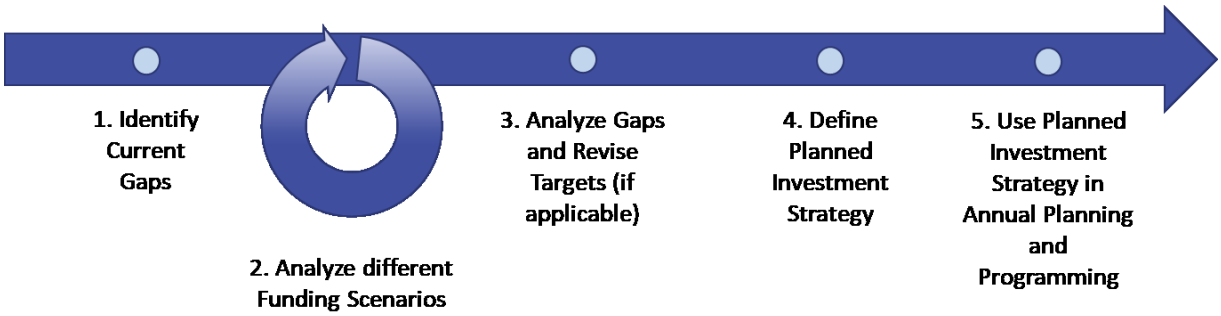
Step 3: Analyze Projected Gaps and Revise Targets (if applicable) – Once the scenarios have been analyzed, the results are provided to the Asset Management Team (from each asset management group). The Asset Management Team will then compile these and provide the gap analysis to the Agency Leadership 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 Asset Management Team and the individual asset managers, 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 will be used by the individual asset managers in their annual planning and programming process to assist in the selection of bridge rehabilitation and replacement projects.

These general steps are shown in in Figure 15 below.

FIGURE 15: GAP ANALYSIS, SCENARIO ANALYSIS AND TARGET SETTING PROCESS



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 5.

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 bridge 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 BMS (or the latest Performance Period Baseline or Progress Report). For a more detailed explanation of the process for bridge inspection, please see Bridge Inspection Process below on page 46.
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

DelDOT will review options and alternatives to best leverage its AASHTOware BrM System. The ability to analyze "what if" scenarios would allow DelDOT to forecast the resources needed to achieve specific NBI condition ratings across the bridge inventory. This would improve the link between the bridge performance goals and budgeting.

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

1. Update inventory and condition in the Bridge Management System (BMS) – This is done through the Bridge Inspection Process described in more detail below under the section "Bridge Inspection Process". 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 the load carrying capacity. This is described in more detail below under the section "Bridge Inspection Process".

2. Define funding scenarios – These are obtained from Agency Leadership as being scenarios that are to be analyzed by the Bridge Management Group. The Bridge Management Group may also choose to analyze different scenarios of their own.

3. Update parameters for Network Optimization analysis[19] – This entails updating or confirming that the various inputs to the BMS are current and valid.

   3.1. Update or confirm available Network Level maintenance, preservation, rehabilitation and replacement actions (also called policies) - The actions modeled in the bridge management system will be confirmed or updated. The current set of work type definitions is shown below in Table 21

TABLE 21: WORK TYPES AND ASSOCIATED ACTIONS FOR BRIDGES

Initial Construction (IC)
- Bridge Construction on a New Roadway
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)
- Repair of 3-5 Different Bridge Elements
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

[19] 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.

- Reapply Pourable Joint Sealer
- Fatigue Crack Repairs
- Seal Concrete Cracks

Update of work actions 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.

3.2. Update or confirm deterioration models - Deterioration models for use in BrM network level optimization will be defined for the general NBI bridge component condition ratings (for the Deck, Superstructure, Substructure and Culvert). These models will be defined separately from the element level deterioration models and the NBI converter will not be used. The models are defined and used according to the Component NBI Modeling section in the BrM documentation[20].

3.3. Update or confirm benefit calculations – The benefit will be calculated as the increase in the Utility Value.

3.4. Select Program and 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 bridge management system and flagged as being committed projects.

3.5. Assign Network Policies – The set of network level policies (actions) will be assigned for the program.

3.6. Identify Objectives – BrM allows for two different analyses to be run. Based on the scenario to be analyzed, one of these will be chosen. If maximization of Utility is chosen, then the budget constraints will also be set up.

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 can then go down the list selecting strategies until the performance and budget constraints are met.

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.

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

4. Run Analysis[21] – Under Program Planning in BrM, the chosen program will be 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 takes into account benefit cost when maximizing Utility over the lifecycle of the bridge using the deterioration models and network policies set up in steps 3.2 and 3.5 above. Because BrM is not implemented at this time, more detail is given regarding some current remaining life considerations (which will be incorporated into the BrM deterioration modeling and trigger rules) below in the section on Remaining Life on page 47. More

[20] See Component NBI Modeling section on p49 of the BrM document FDS 523 – Deterioration Modeling_updated.pdf, titled "AASHTOWare Bridge Management - Functional Design Specification - Deterioration Modeling Enhancements: Draft October 5, 2016.

[21] 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.

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 on page 48.

5. Report and analyze resulting recommended project work plans and report projected conditions for a minimum of 10-year analysis period to the Asset Management Team – These reports will be generated from the BMS.

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

Once the scenarios have been analyzed, the results are provided to the Asset Management Team (from each asset management group). The Asset Management Team will then compile these and provide 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 groups are compiled by the Asset Management Team.
2. The projected conditions are compared against the 2- and 4-year targets and key issues hindering progress toward achieving and sustaining the desired state of good repair, as well as strategies to close any gaps are discussed with the asset groups and documented.
3. If applicable, based on the results of the Gap Analysis, the Asset Management Team may include recommendations for revising the targets which may be adopted by the 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.

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 Federal Highway Administration (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 Section 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.

Remaining Life

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. Table 22: shows the existing age of bridges in the state and their current condition.

TABLE 22: DELDOT NHS BRIDGE AGE AND CONDITION (NBI BRIDGES ONLY)

Road Type	NBI Condition Rating	Bridge Age In Years												
		0 -10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	>100	Total	Ave. Age
Inter-state	7 - 9	6											6	5.5
	5 – 6	1			2	30	43						76	49.6
	0 – 4												0	
	Total	**7**	**0**	**0**	**2**	**30**	**43**	**0**	**0**	**0**	**0**	**0**	**82**	**46.3**
Arterial	7 - 9	31	15	22	3		1		2		1	1	76	18.4
	5 - 6		19	48	11	20	27	18	5	4	7	3	162	45
	0 - 4					2						1	3	62
	Total	**31**	**34**	**70**	**14**	**22**	**28**	**18**	**7**	**4**	**8**	**5**	**241**	**36.8**
Totals =		**38**	**34**	**70**	**16**	**52**	**71**	**18**	**7**	**4**	**8**	**5**	**323**	**41.6**

In future TAMPs, DelDOT's bridge management system (BrM) will provide specific results from its asset management system rather than the general planning information that follows. That said, it can be useful to consider that if bridges are assumed to have a 75-year useful life, DelDOT would need to replace approximately 4 bridges annually. Additionally, in order to reach a 75-year service life, DelDOT has identified the following maintenance cycles for select bridge components.

TABLE 23: LIFE EXPECTANCY OF BRIDGE COMPONENTS

Component	Life Expectancy (Years)
Bridge Deck Overlay	30
Bridge Joint	30
Paint	30
Bearings	40

Total replacement and maintenance costs for DelDOT owned NBI/NHS bridges equates to approximately $35 million annually.

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 rain storm, impact damage from vehicular traffic or observed issues identified by other entities. Once implemented, the BrM software will use 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. 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.

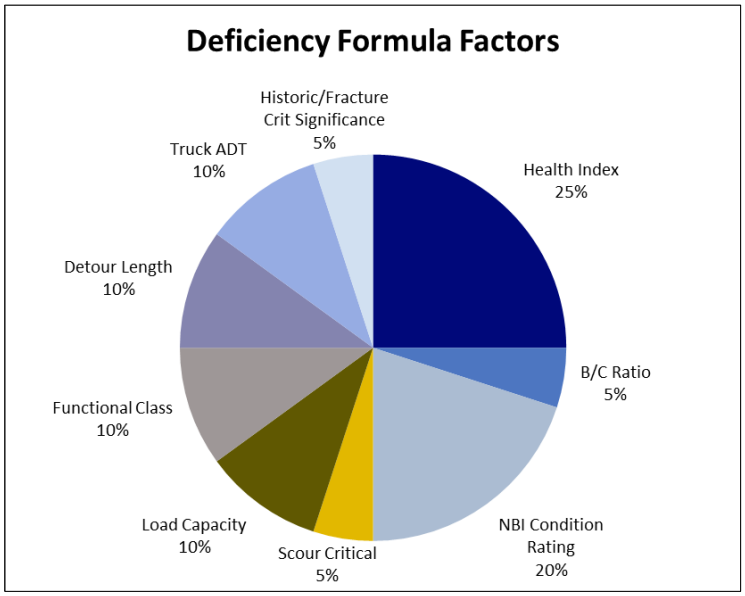
- Benefit to Cost Ratio – Each preservation action that is recommended by BrM has an associated cost. The benefit from performing preservation work is determined by calculating the projected increase in Health Index for the bridge multiplied by the replacement cost of the bridge. BrM divides the calculated 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 of 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.
- Truck AADT – 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 16.

FIGURE 16: CATEGORY WEIGHTINGS IN THE BRIDGE DEFICIENCY FORMULA



The BrM software scenarios will be run at the beginning of each calendar year, utilizing the current bridge condition information. This will generate a list of bridges based on a prescribed cost/dollar threshold that require work according to the preservation models. The BrM software will calculate 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.

Future Bridge Management Enhancements

As noted, DelDOT is currently developing the bridge management system modeling software. As a result, the 10-Year work plan, spend, and condition performance forecasts were completed manually. This involved evaluating the current condition, history, age, and applying typical preventative maintenance, rehab, and repair activities and associated frequencies. From there, future bridge conditions, expected work needs and associated costs were identified. Since DelDOT's Bridge Management Section is actively working on developing the BrM software much of the logic, generalized element deterioration, and cost data that went into this manual analysis is also being incorporated into the BrM simultaneously. The manual analysis allowed for optimization of grouping adjacent bridges or multiple bridges along a portion of a specific highway corridor in each year that will require similar work.

DelDOT strongly feels that this methodology used for the initial 10-year TAMP analysis is adequate and substantial enough based on the small size, age, and complexity level of Delaware's NHS bridge inventory. In addition, DelDOT has a significant amount of newer or younger bridges that are 15-20 years old and would not be expected to require any repairs, maintenance, or rehab type of work activity within the next 10 years. There are 72 DelDOT bridges out of 323 (22.3%) that fall into this category. An additional 70 (21.7%) bridges are already currently planned for work meaning that a project has been initiated or funding has been set aside for work within the next 6 years. While the manual analysis didn't specifically incorporate the lowest long-term cost evaluation, roughly 90% of Delaware's bridges have a significant amount of life left in them – well past the 10-year forecast timeframe that the initial TAMP addresses.

As noted earlier, DelDOT is actively developing the BrM software. In order to successfully accomplish this task, DelDOT has brought on a consultant with experience in developing bridge element deterioration models, associated work actions & benefits, and repair costs. In addition, reassignment of one of DelDOT's well experienced and knowledgeable Bridge Management employees was adopted to have this individual solely focus on working with the BrM software and take the lead on developing DelDOT's bridge modeling program. Last, overtime approval for DelDOT's Bridge Management Engineer has been obtained to allow for sufficient review time, assist with data query and analysis activities, and to keep the project on track. This shows DelDOT's commitment and seriousness to comply with recent federal legislation and to establish an effective, systematic, and comprehensive Bridge Asset Management Program.

Table 24 displays the goals and associated expected timeframes for completion and implementation of the BrM software into DelDOT's Bridge Management and Bridge Asset Management Programs.

TABLE 24: DELDOT BRIDGE MANAGEMENT SYSTEM DEVELOPMENT AND IMPLEMENTATION PLAN

Goal/Activity	Timeframe	Expected Completion (Implementation) Date	Actual Completion Date
Develop Element Deterioration Models	June of 2018 - May of 2019	May 17, 2019	May 21, 2019
Develop NBI Deterioration Models	June of 2018 - July of 2019	July 12, 2019	--
Develop NBI Conversion Profiles	June of 2018 - July of 2019	July 12, 2019	--
Develop Work Actions for Each Element	February of 2019 - August of 2019	August 2, 2019	--
Develop Benefits and Benefit Groups for Work Actions	March of 2019 - August of 2019	August 2, 2019	--
Revise the Utility Function	June 2018 - August of 2019	August 16, 2019	--
Develop & Assign Network Policies	August of 2019 - October of 2019	November 1, 2019	--
Develop Life Cycle Cost Analysis (LCCA) Rules	August of 2019 - November of 2019	February 1, 2020	--
Develop & Assign LCCA Policies	October of 2019 - November of 2019	February 1, 2020	--
Develop Preservation & Replacement Policies	October of 2019 - December of 2019	March 1, 2020	--
Test BrM Software	December of 2019 - February of 2020	June 1, 2020	--
Run Different Forecasting Scenarios	February of 2020 - March of 2020	August 1, 2020	--
Implement into Annual Bridge Prioritization Process	March of 2020 - April of 2020	April 3, 2021	--

3.6 WORK PLANNING AND PROGRAMMING

While the investment strategy giving approximate planned spending per work type of the next 10-years will be generated by running BrM optimization analysis, the actual projects will be identified using the Bridge Deficiency formula.

Data for all bridges is automatically exported from BrM and imported into the Delaware Bridge Deficiency Formula spreadsheet described above 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 work plan for Bridge Design and the Maintenance Districts for the next fiscal year. 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.

3.7 Best Use of Available Data and Systems for Bridges

The BrM software scenarios will be run at the beginning of each calendar year, utilizing the current bridge condition information. This will generate a list of bridges that require work according to the preservation models. 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.

To generate the required 10-year analysis using a system meeting the requirements of 23 CFR 515.17, the optimization analysis of BrM will be used to analyze one or more funding scenarios. The process of running these analyses is described in more detail above in section 3.5. The output of these analyses will be 10-year planned expenditures by work type, as well as predicted conditions for the network over the 10-year period. This information will be made available to the Asset Management Team for use in developing a planned investment strategy.

As described in Step 2 in section 3.5 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.

CHAPTER 4: RISK MANAGEMENT

4.1 Risk Management Process

Risk Consideration and Background

Risks can be divided into the following three levels:

- Agency Risks
- Program Risks
- Project 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.

Project risks are assigned to individual projects, such as a construction project, or creation of a new product such as new information system application.

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, as noted under section 2.5 Gap and Scenario Analysis Process previously, using the inspection data, 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 sections 2.5 and 3.5, this section, therefore, will focus on agency risks. The procedure for developing and maintaining a list of agency risks is described below. The risk register identifies the primary agency risks and mitigation strategies.

Risk Identification and Assessment Workshop Process

MAP -21 and FAST Act legislation requires state DOT's to develop risk-based Asset Management Plans. As part of ongoing risk identification and assessment, the Asset Management Team will follow 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 Asset Management Team will arrange for a Risk Assessment Workshop to be conducted to update the Risk Register. The workshop will be attended by a diverse group of representatives from the Districts, the Pavement and Bridge Management Groups, the Asset Management Team, and Agency Leadership. Because participants will likely differ somewhat from year to year, a refresher on the fundamentals of risk will typically be covered as part of the agenda.

Workshop Scope

The workshop will begin with an introduction and will cover risk background including:

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

The group will then participate 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, will be assessed such as natural hazards, man-made or induced hazards, materials price variability, personnel or hiring issues, and other possible risk types.

Scoring

Risks will be scored based on likelihood and consequence. Example consequence and likelihood scoring guidelines are shown in Table 25 and Table 26. These include the dollar ranges for each consequence scoring level, as well as the frequency ranges used for the likelihood/probability ratings. As part of the development/confirmation of the Risk Register, the workshop attendees will refer to these scoring guidelines as they score the risks.

To simplify scoring the overall consequence in terms of an anticipated dollar value, the consequences may be divided into separate areas such as:

- Safety
- Mobility
- Asset Damage
- Other Financial Impact

The example consequence and likelihood scoring guidelines are shown below.

TABLE 25: EXAMPLE CONSEQUENCE TERMINOLOGY

		Consequence to Public			Corridor / Region / Department	
Level	**Descriptor**	**Safety**	**Conveyance**	**Asset**	**Financial**	**Other Impacts**
1	Negligible	Negligible safety hazard	Minimal delay	Minimal or cosmetic damage	Cost < $1M	Consider negative impacts to: future funding, insurance costs, regulatory compliance, political issues, and public reputation
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	

TABLE 26: EXAMPLE LIKELIHOOD TERMINOLOGY

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 Low	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%

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 will be used to calculate an overall risk score for each identified risk as follows:

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

Where:

- Risk score is the combined effect of likelihood of the event occurring and the consequence of the event should it occur. It thus represents the overall potential impact to the Agency. The maximum score is 100.
- Consequence scores are the individual scores for safety, mobility, asset damage, and other financial impacts between 1 and 5 based on the scoring guidelines (See Table 25).
- Likelihood score is the score between 1 and 5 based on the scoring guidelines (See Table 26)

Evaluation of Facilities Repeatedly Damaged due to Emergency Events

States are required to regularly evaluate facilities repeatedly requiring repair and reconstruction due to emergency events (23CFR Part 667). In addition to the risk assessment workshop described above, as part of this requirement, DelDOT will conduct 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
- Review and update the entire evaluation every 4 years
- By November 23, 2018, complete the statewide evaluation for all NHS roads, highways and bridges
- By November 23, 2020, evaluate all roads, highways and bridges

The evaluation described above is repeated periodically, typically at the same time as the main risk register workshop described above, to continuously update the 667 facility list and risk evaluation. The evaluations for potential 667 facilities, based on the most recent risk workshop, are given in Appendix A.

The process for evaluating asset level risks is to evaluate possible mitigation actions, including the Do Nothing alternative. Each possible mitigation action was 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 the action is divided by the duration of the fix to obtain an annualized cost.
- Event Frequency (Likelihood) – Estimate the frequency of the event.
- 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 the action (described above). If this B/C ratio is greater than one, the mitigation action could be considered. If the ratio is less than one, the risk could be tolerated.

With regard to specific asset risks, the facilities repeatedly damaged by emergency events listed in Appendix A will be regularly updated. Together these risks will be used by DelDOT with regard to planning concerning the condition of physical pavement and bridge assets.

4.2 Current Risks and Mitigation Strategies

Risks to individual pavements and bridges are assessed and analyzed on a continuous basis as part of the pavement and bridge inspection processes discussed in 2.5 Gap and Scenario Analysis Process and 3.5 Gap and Scenario Analysis Process for Bridges above.

In addition to individual asset risks, the results of the risk workshop held in April 2019 were used to update the risk register which contains a risk score for each risk as well as the current mitigation strategy. The current risk register is shown in Table 37: Agency and Program Level Risk Register in Appendix A. In addition, the facilities repeatedly damaged by emergency events are listed in Table 38: Risk Evaluation of Possible Mitigation Strategies for Facilities Recently Damaged in Emergency Events in Appendix A.

Risk workshop participants identified a combined eighteen agency and program major risks to DelDOT's goals and vision. The top five agency and program level risks identified from the 2019 risk workshop are:

1. Regulatory Controls – Federal/State agencies, preventing/delaying projects (risk score: 80)
2. Major accidents on high volume roadways (e.g. interstates) (risk score: 70)
3. Unanticipated occurrence of a natural event/asset failure – frequent events (localized storms/tornadoes) (risk score: 60)
4. Anticipated occurrence of a natural event/asset failure – infrequent events (hurricanes and tropical storms) (risk score: 60)
5. Unanticipated occurrence of a natural event/asset failure – frequent events (rain/flood events) (risk score: 55)

Prevention and delay of projects due to regulatory controls ranked first on the risk register with participants citing the high likelihood of this occurring, along with the catastrophic safety and mobility consequences. This risk could result in targeted HSIP and SoGR projects being delayed significantly such that LRTP, TAMP, and overall DelDOT goals are not met and cause effects in Delaware's economic vitality. The example cited is from a 1998 HSIP project that is currently in construction and still not finished yet. Major delays are attributed to regulatory controls, outside the control of DelDOT.

The second highest scored risk is major accidents 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 Chesapeake & Delaware (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 SR 1 crossing being the most critical. When this one bridge is affect by an accident, 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.

The last three 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 have increased significantly within the last few decades, resulting in safety, mobility, unanticipated asset costs, and other financial consequences.

The evaluations for potential 667 facilities were performed at the same time as the 2019 risk workshop based on the criteria described above. 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 six identified facilities repeatedly damaged by emergency events, there was only one on the NHS, the washout of pavement on SR 1 South of Dewey Beach near Keybox Road. There have been several storms, most of them localized, which have covered SR 1, at one of the narrowest widths of SR 1 between Dewey Beach and Fenwick Island, with either stormwater runoff or tidal waters. The maintenance district, after several repeated events and minor maintenance fixes, decided 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. The cost of the fix was approximately $1million with a risk reduction of 100% resulting in a B/C ratio of 2.84. To date, the fix has addressed this repeated damage event.

The risk register and the periodic evaluation of facilities repeatedly damaged due to emergency events will be used as the risk plan for DelDOT with regard to condition of physical pavement and bridge assets.

CHAPTER 5: 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 Asset Management Financial Report Series, Report 2, Components of a Financial Plan[22], "a comprehensive financial plan that supports long-term transportation asset management (TAM) will at a minimum include the following primary components:

1. The various uses of funds based on forecasted system conditions and performance targets. It will include assumptions related to future projections.
2. Projected revenues from all available and anticipated sources of funds including related assumptions.
3. Projected gaps or surpluses based on the above.
4. Scenarios reflecting adjustments necessary to address gaps, if any, along with related consequences.
5. Final proposed financial plan to support the agency's asset management plan."

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 in the State's transportation infrastructure.

This chapter identifies the processes, documentation, and analysis 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 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 April 2019.

5.1 REVENUES

Sources

DelDOT is financed by a variety of fees and taxes paid by the users of the State and national transportation systems. Sources of FY 2019 revenue include:

- *State motor fuel taxes.* The State of Delaware levies a per gallon tax on motor fuels.
- *Tolls*. DelDOT operated three toll roads: the I-95 Turnpike, State Route 1, and US 301.
- *Motor vehicle registration and titling fees, and driver licensing fees* (DMV fees).
- *Federal allocations.* Funds provided are by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA).
- *Other.* Transit farebox revenue, state general fund transfers to DelDOT, and miscellaneous revenue sources.

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

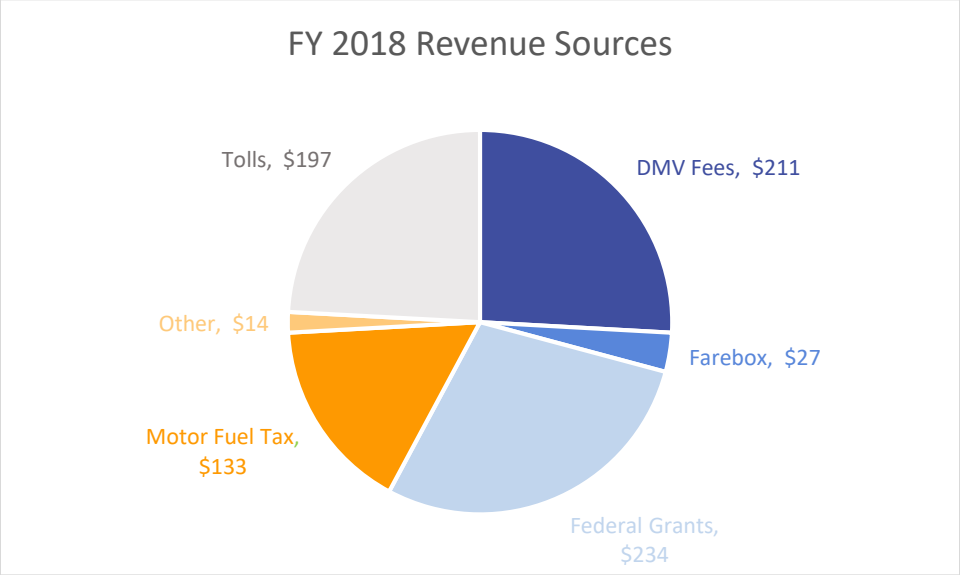
The base Financial Plan is a reflection of the following:

- Sources of funds to the Transportation Trust Fund (Includes both pledged and non-pledged revenue)
- Debt Service Projections
- Operating Budget Projections
- 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 17 depicts the sources and of Fiscal Year 2018 revenue and their relative shares of DelDOT total revenue. This is typical for a year in which borrowing did not occur.

FIGURE 17: FY 2018 REVENUE SOURCES



Tolls, fuel taxes, automobile privilege taxes, motor vehicle registration and license fees represent the major revenue sources for the Transportation Trust Fund, which funds 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 operational subsidies[23]. A separate transit asset management (TAM) plan covers transit assets and is submitted to the Federal Transit Authority (FTA) for approval.

[23] State of Delaware Department of Transportation, Financial Statement June 30, 2017 and 2016, page 19.

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[24].

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[25]. The excise tax rate for Special Fuel (all other fuels placed into a licensed motor vehicle in Delaware) is $0.22 per gallon[26]. 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 (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.

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 27 depicts historical DelDOT revenues* by source for Fiscal years 2013 - 2017.

Figure 18 illustrates this information graphically.

* *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.*

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

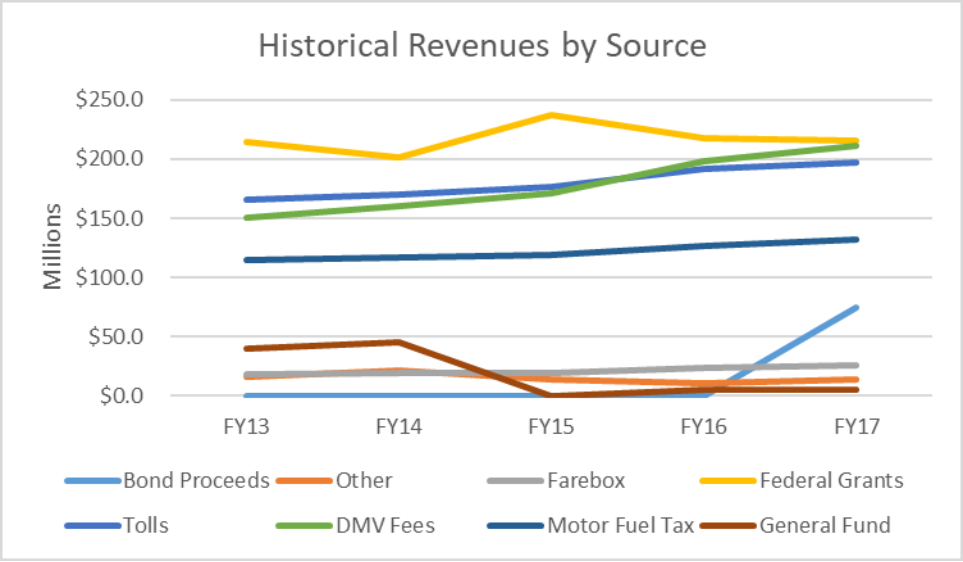
[25] https://finance.delaware.gov/publications/tax_prefer/mtr_sp_fuel.pdf

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

TABLE 27: FY13 - FY18 REVENUES AND CHANGES

*in Millions	FY13	FY14	FY15	FY16	FY17	FY18	5-yr Annual Average	Average Annual Increase / Decrease FY13-17
Bond Proceeds	$0.0	$0.0	$0.0	$0.0	$75.0	$0.0	$15.0	NA
Other	$16.3	$21.9	$14.3	$10.5	$14.0	$14.1	$15.4	-3%
Farebox	$18.8	$19.4	$19.1	$24.1	$26.4	$26.8	$21.6	8%
Federal Grants	$214.5	$201.3	$236.9	$217.7	$215.9	$233.9	$217.3	0%
Tolls	$166.3	$170.0	$176.1	$192.3	$197.4	$197.0	$180.4	4%
DMV Fees	$150.6	$160.3	$171.0	$198.1	$211.0	$211.1	$178.2	8%
Motor Fuel Tax	$115.0	$116.9	$119.7	$126.5	$132.1	$132.9	$122.0	3%
General Fund	$40.0	$45.1	$0.0	$5.0	$5.0	$0.0	$19.0	-18%
Total	$721.5	$734.9	$737.1	$774.2	$876.8	$0.0	$768.9	4%

FIGURE 18: FY13-17 REVENUES AND TRENDS



As can be seen in the above table and graph, DelDOT FY 2017 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 at a compound annual growth rate of slightly less than 2.1 percent.

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

- Operating revenues increased by $7.1 million to $579.6 million during the Fiscal Year Ended June 30, 2017, primarily due to:

    1) Increased motor vehicle related revenues as a result of new fee increases that became effective in October 2015;
    2) Increases in toll revenues due to continued low fuel prices; and
    3) Increased motor fuel taxes as a result of increased travelers due to lower fuel prices.

- Operating expenses decreased by $3.3 million to $651.6 million during the Fiscal Year Ended June 30, 2017, primarily due to an increase in capitalized infrastructure projects such as the Route 301 and the West Dover Connector projects that were partially offset by other post-employment benefit plans and pension expense included in payroll costs.

- Total capital assets (net of depreciation) increased $193.3 million to $4,596.0 million during Fiscal Year 2017, primarily as a result of the following spending: US 301 - $123.2 million; SR-1 - $26.4 million; West Dover Connector - $17.5 million; Wilmington Riverfront/Christina River Bridge - $5.8 million; building and land improvements - $17.4 million; and truck, tractor, and equipment purchases - $25.2 million[27].

Projected Revenues

DelDOT's current baseline 10-year revenue estimate is found in Table 28 and presented graphically in Figure 19. 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 to fund future NHS state of good repair projects.

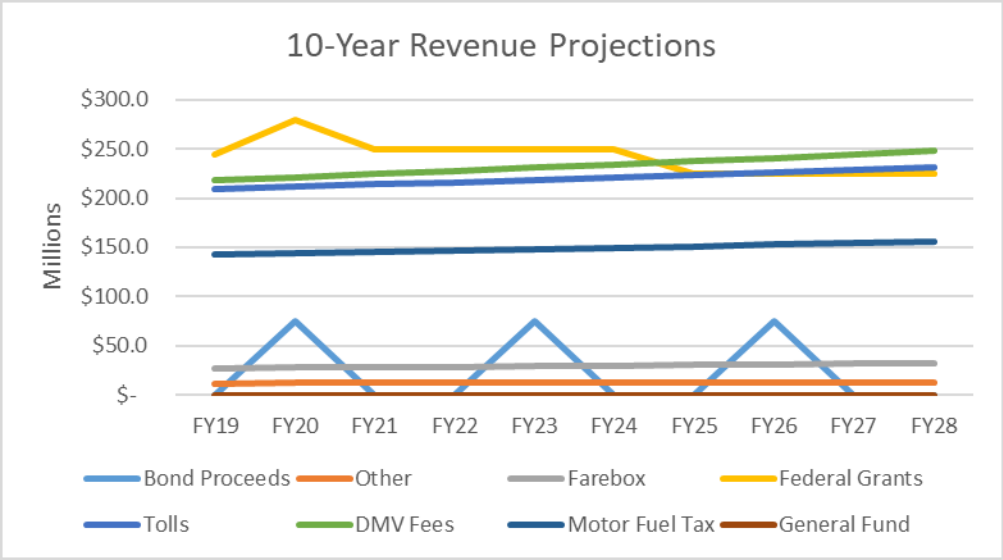
TABLE 28: 10-YEAR REVENUE PROJECTIONS

	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28
Bond Proceeds	$-	$75.0	$-	$-	$75.0	$-	$-	$75.0	$-	$-
Other	$11.2	$12.2	$12.5	$12.5	$11.9	$12.3	$12.3	$12.3	$12.4	$12.5
Farebox	$27.1	$27.5	$28.0	$28.5	$28.9	$29.5	$30.1	$30.7	$31.3	$31.9
Federal Grants	$245.0	$280.0	$250.0	$250.0	$250.0	$250.0	$225.0	$225.0	$225.0	$225.0
Tolls	$208.9	$211.4	$213.8	$216.4	$218.9	$221.2	$223.5	$226.4	$229.0	$231.6
DMV Fees	$218.0	$221.2	$224.4	$227.7	$231.0	$234.4	$237.7	$241.0	$244.4	$247.8
Motor Fuel Tax	$142.4	$143.8	$145.2	$146.7	$148.2	$149.7	$151.2	$152.7	$154.2	$155.8
General Fund	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-

*In millions

[27] Delaware-Department-of-Transportation-Financial-Statement-Audit-June-30-2017

FIGURE 19: 10-YEAR REVENUE PROJECTIONS



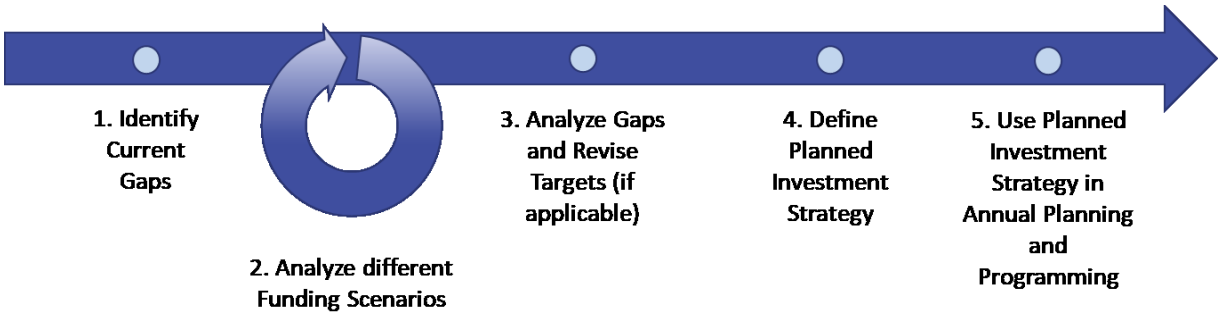
Methodology for Projecting Available Funding Levels

The process for projecting DelDOT's Transportation Trust Fund revenues is anticipated to evolve over time. The DelDOT Finance Division will start with the market analysis, funding forecasts, trend data and Federal Highway Authorization Act and expand those projections to 10+ years. These estimates will be based on the average change in revenue over the last 5 years, projected into the future using multiple regression analysis techniques. The DelDOT Asset Management Team will consider these alternative projections and in consultation with DelDOT leadership, will select 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 Section 5.4 Investment Strategies.

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 TAMP process. This process was previously described in sections 2.5 Gap and Scenario Analysis Process for Pavements and 3.5 Gap and Scenario Analysis Process for Bridges of this document and illustrated below in Figure 20.

FIGURE 20: 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 will provide the starting point from which the forecast will be expanded to cover the 10-year planning horizon of the TAMP plan.

DelDOT will begin with the departmental budget forecasts and use 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 will determine the available funding levels for NHS pavements and bridges. Initially, this likely will be 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 will create multiple funding scenarios, including some variation of the following:

- Baseline growth;
- Slight increase (e.g., 10-15%);
- Slight decrease (e.g. 10-15%);
- Revenue needed to meet condition targets; and
- Trade-off between Pavements and Bridges.

These revenue projection scenarios will be shared with the Pavement and Bridge Management Groups, which will use 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 alternate investment alternatives. These asset management team will use this information to feed both the Gap Analysis process described in 5.3 Funding Gap Analysis and the Investment Analysis process described in 5.4 Investment Strategies.

5.2 Funding Needs

Individual DelDOT project managers submit state of good repair budget requests based on needs. The executive 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.

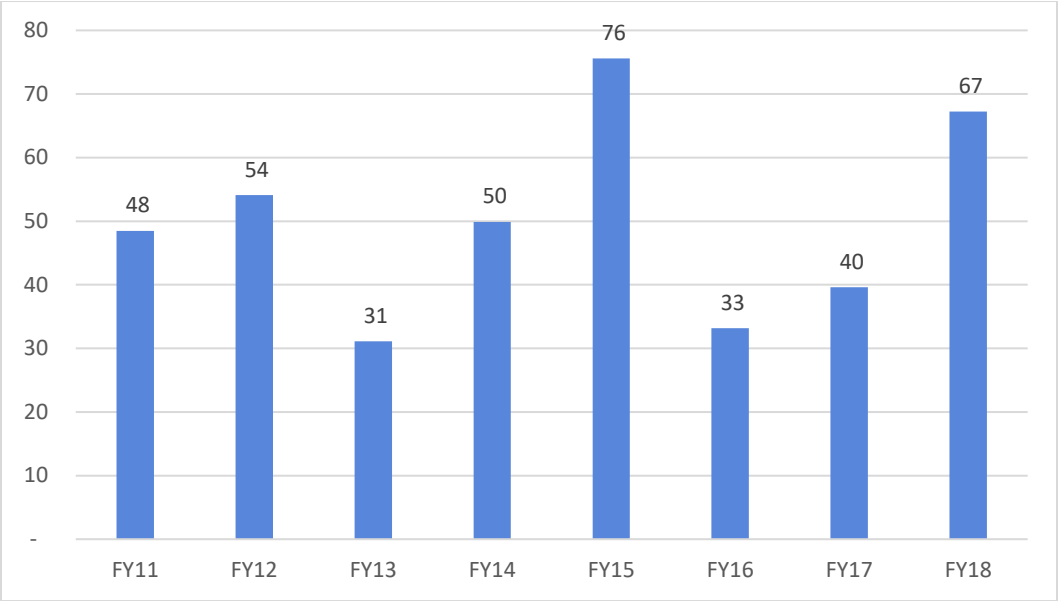
This basic process will continue but in the future DelDOT Pavement and Bridge Management Groups will analyze multiple funding scenarios for submission to Agency Leadership via the Asset Management Team. The methodologies for accomplishing this are described in more detail in section5.4 Investment Strategies.

Historical Spending

Bridge

Figure 21 shows actual bridge funds expended from FY 2010 through FY 2018.

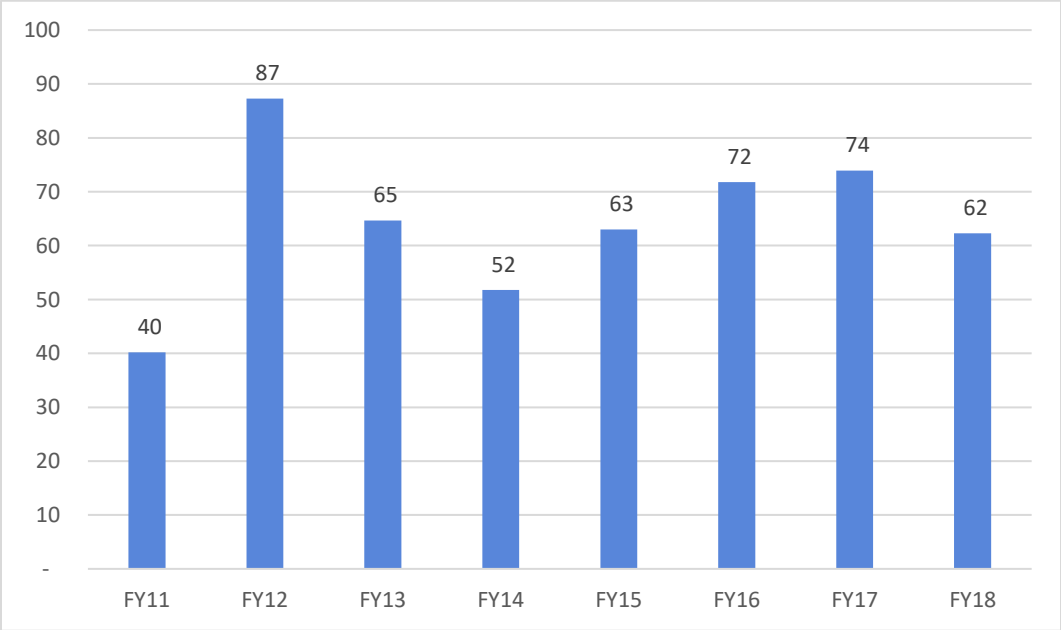
FIGURE 21: BRIDGE PROGRAMS EXPENDITURES



Pavement

Figure 22 shows the actual pavement program expenditures for FY2010-2018.

FIGURE 22: PAVEMENT PROGRAM EXPENDITURES



DelDOT maintains the condition of Delaware's roadways by systematically identifying candidates for rehabilitation and determining the most cost-effective treatment. The program provides rehabilitation in the form of pavement preservation, replacement, and reconstruction using a variety of techniques. The inventory, including pavement condition, is maintained through its active pavement management system.

DelDOT Budget Allocation Process

Typically, about 36%[28] of the State transportation budget is dedicated to capital spending, and 46% is dedicated to operations. The remaining 18% is spent on debt service.

DelDOT funds in-house routine maintenance through the operations budget while state of good repair projects typically are 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 TAMP budget allocation process is on the NHS system, 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 Section 5.4 Investment Strategies.

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 (which is a subset of the CTP). The budget allocation process then includes the 10-year projections of need from DelDOT's asset management systems 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 allocation for bridges and pavements (shown in Figure 23 and 24, respectively) shows a slight decline in funding initially after which the funding remains relatively stable for the out years. The forecasted baseline budget for bridges dips through FY 2022, while the forecasted baseline for pavements declines in FY 2021. The reason for the funding decrease is in a different fiscal year for bridges and pavements is due to planned on-going projects; DelDOT had to maintain bridge funding in FY 2021 for certain on-going projects and thus reduced pavement funding in FY 2021. In the following fiscal year, pavement funding was increased to account for the previous fiscal year reduction and the bridge funding was decreased.

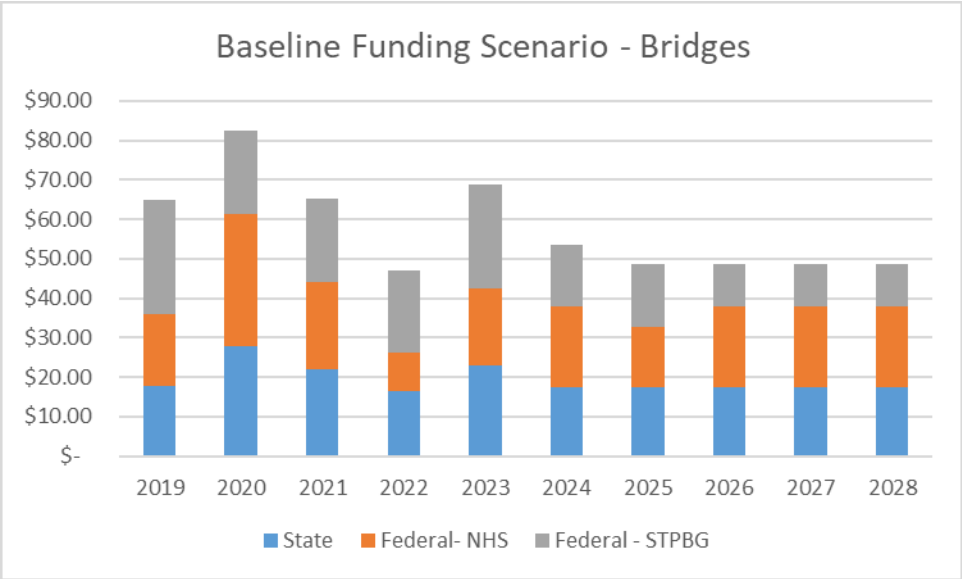
[28] Identified budget allocation percentages come from "DRAFT ROADS, BRIDGES, & OTHER ASSETS", Part II-24, provided by DelDOT.

The overall funding decrease in FY 2021 and FY 2022 is in anticipation of the FAST Act ending in 2020. If a continuing resolution is passed, DelDOT will reassess funding levels and defer back to the FY 2019 funding levels.

Bridges

Figure 23 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 5.4 Investment Strategies. Totals include all projects authorized including both NHS and non-NHS.

FIGURE 23: BRIDGE PROGRAM FORECASTED BASELINE BUDGET ALLOCATION[29]

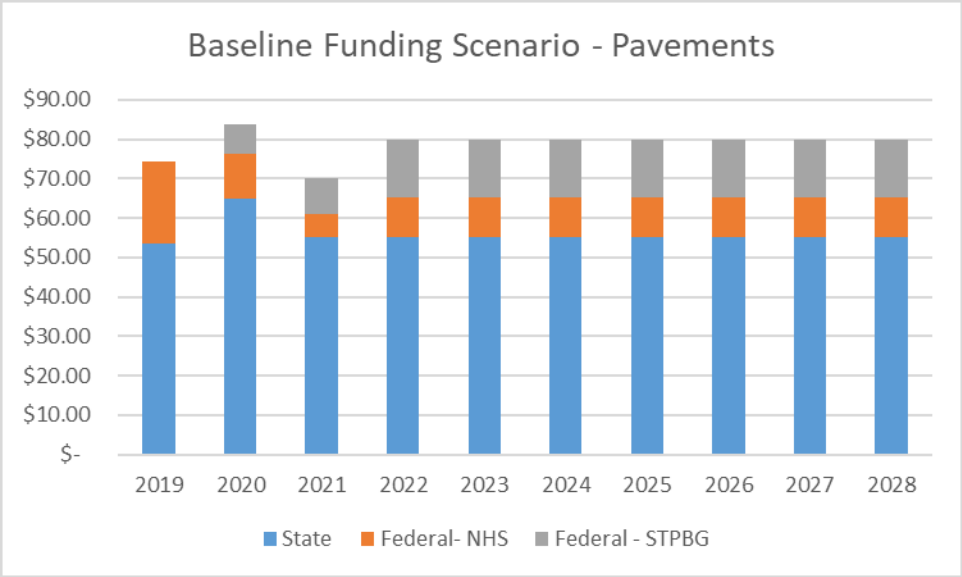


Pavement

The forecasted budget allocations for the pavement program are shown in Figure 24. These are the projected funds that will be available for the pavement program, and are transferred to the Baseline funding scenario discussed in 5.4 Investment Strategies. DelDOT uses additional funds that become available due to various delays and reasons to perform additional paving work with those funds. The result is that DelDOT's total paving program is anticipated to exceed $80M per year during the FY19-22. Totals include all projects authorized including both NHS and non-NHS. For the 2019 forecasted baseline year, Federal STPBG funding was planned for other eligible non-pavement projects and therefore, none was planned for pavements.

[29] All figures are in millions of dollars.

FIGURE 24: PAVEMENT PROGRAM FORECASTED BASELINE BUDGET ALLOCATION[30]



5.3 FUNDING GAP ANALYSIS

Funding Gap Analysis for Pavements

Based on the condition projections for the Baseline funding scenario analyzed and discussed in 2.4 Gap Analysis and Condition Projections, the projections of condition over the 10-year analysis period show that the percent of Poor pavements remains below the targets for the 10-year analysis period.

As further discussed in 2.4 Gap Analysis and Condition Projections, the projections for the Baseline funding scenario of percent of pavements in Good condition show a slight decrease over the 10-year analysis period and there is a slight gap projected in 2026 and 2027 for Interstate pavements where the percent Good drops below the target by approximately 5%. However, in 2028 the percent of Good pavements is again predicted to be at the target of 50%. For Non-Interstate NHS pavements, there is also a slight gap projected in 2026 and 2027 where the percent Good drops below the target by approximately 2%. However, in 2028 the percent of Good Non-Interstate NHS pavements is again predicted to be at the target of 55%. These apparently temporary drops in percent Good appear to be the result of a cohort or 'wave' of NHS pavements becoming due for rehabilitation around the same timeframe.

Because no significant deterioration trend was observed in the analyses discussed above under the Baseline funding scenario, and because the state OPC metrics stayed relatively steady, it was determined that no significant gaps are projected. As a result, it was recommended to senior 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, through 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 or other functional reasons.

Funding Gap Analysis for Bridges

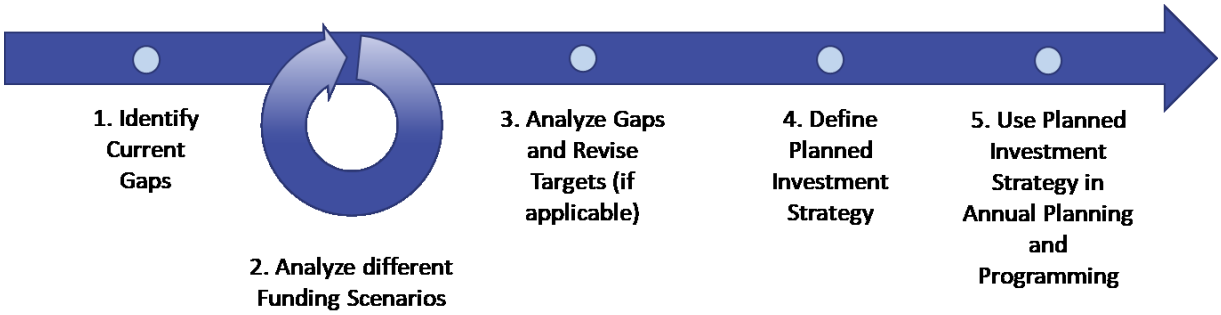
The 10-year condition projections discussed in 3.4 Gap Analysis and Condition Projections, and summarized for the Baseline funding scenario in 5.4 Investment Strategies, show that the percent of Poor bridges remains below the targets for the 10-year analysis period for both the State and the FHWA metrics. Similarly, the projections for the Baseline funding scenario show that percent Good for both State and FHWA metrics are also expected to exceed target levels for the 10-year analysis period.

No gaps between projected and target conditions are therefore projected and the Baseline funding scenario was recommended for adoption by senior leadership as the planned investment strategy. More details of the planned investment strategy are shown in 5.4 Investment Strategies in the Bridges section under Analyzed Investment Scenarios.

Methodology for Developing a combined Gap Analysis

To identify a specific investment plan for the pavement and bridge programs, the Asset Management Team 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-good-repair. In the TAMP process illustration in Figure 25, this step is identified as Step 3.

FIGURE 25: GAP ANALYSIS, SCENARIO ANALYSIS AND TARGET SETTING PROCESS



All scenario results and associated gap analysis from the different asset groups are compiled by the Asset Management Team. This information is compiled from the various teams into a single Gap Analysis presentation for senior 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- and 4-year targets. Key issues hindering progress toward achieving and sustaining the desired state of good repair, 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 Asset Management Team 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 senior leadership. At this meeting, a final investment strategy is agreed.

5.4 Investment Strategies and Life Cycle Plans

In this section of the TAMP, DelDOT brings all the information gathered from the previous steps and goes through the process of rationalizing this information and making investment decisions. The investment scenarios analyzed by the Pavement and Bridge Management Groups will be discussed below. First, the different scenarios that were analyzed by the pavement and bridge groups according to the methodologies discussed in the pavement and bridge chapters are described, then the final planned investment strategy (also known as a life cycle plan) that was adopted by the DelDOT leadership is described in 5.5 Planned Investment Strategy and Life Cycle Plan.

Analyzed Investment Scenarios

Figure 21, Figure 22, Figure 23 and Figure 24 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 provide the projections in the form of a simulated work plan consisting of both committed projects that are already programmed and projected projects based on benefit cost ratio analysis results from the management systems. These 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 2: Pavements and Chapter 3: Bridges earlier 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 2019 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 systems to analyze projected pavement and bridge conditions under these funding scenarios.

The different scenarios analyzed by the bridge and pavement management groups are summarized below.

Pavements

The funding scenarios analyzed by the Pavement Management Group included the Baseline funding scenario noted under section 5.2 Funding Needs previously. The breakdown for the Baseline funding scenario is given below in Table 29. It is expected that projects planned for the fiscal year will be largely be executed during the 12 months preceding the end of the fiscal year such that for instance, funds allocated for FY 2020 will have partially been used on projects delivered in 2019.

Table 29: Baseline Funding Scenario for Pavements[31]

FY	State	Federal- NHS	Federal - STPBG	Total
2019	$53.55	$20.80	$-	**$74.35**
2020	$65.00	$11.14	$7.46	**$83.60**

[31] All figures are in millions of dollars.

FY	State	Federal- NHS	Federal - STPBG	Total
2021	$55.20	$5.80	$9.00	**$70.00**
2022	$55.20	$10.00	$14.80	**$80.00**
2023	$55.20	$10.00	$14.80	**$80.00**
2024	$55.20	$10.00	$14.80	**$80.00**
2025	$55.20	$10.00	$14.80	**$80.00**
2026	$55.20	$10.00	$14.80	**$80.00**
2027	$55.20	$10.00	$14.80	**$80.00**
2028	$55.20	$10.00	$14.80	**$80.00**

It can be seen from Figure 26 and Figure 28, the analysis of the Baseline funding scenario showed that for the total network, there could be no drop in funding since the condition metrics were already projected to fall below desired levels briefly during the 10 year analysis period. As a result, a scenario with a reduction in funding was not desirable. In addition to the Baseline funding scenario, a scenario where the Baseline scenario was increased by 10% was also analyzed. Two funding scenarios were therefore analyzed in total as shown below.

1. Baseline Funding Scenario
2. Baseline +10% Increased Funding

Using the pavement management system, the Baseline funding scenario discussed above, as well as the additional scenarios that were identified by the pavement management group, were analyzed to find the best set of recommended projects over a 10-year analysis period based on maximizing the state pavement metric Overall Pavement Condition (OPC) index across both NHS and non-NHS pavements. The analysis was conducted using the pavement management system software using the process described in section 2.5 Gap and Scenario Analysis Process for Pavements. The results of the different scenarios are summarized in Table 30 below.

TABLE 30: INVESTMENT SCENARIOS ANALYZED FOR PAVEMENTS

		FHWA Metrics				State Metrics	
Scenario	Average Annual Investment[32]	Interstates % Good	Interstates % Poor	Non-Interstate NHS % Good	Non-Interstate NHS % Poor	NHS Ave. OPC	Whole Network Ave. OPI
Baseline Scenario	$20.9 mil	2019: 60.3% 2028: 54.4%	2019: 1.0% 2028: 1.3%	2019: 60.9% 2028: 56.4%	2019: 1.2% 2028: 1.4%	2019: 82.3% 2028: 88.5%	2019: 71.3% 2028: 76.3%
+ 10% Increased Funding	$22.99 mil	2019: 60.3% 2028: 55.1%	2019: 1.0% 2028: 1.0%	2019: 60.9% 2028: 57.6%	2019: 1.2% 2028: 1.4%	2019: 82.3% 2028: 89.4%	2019: 71.3% 2025: 77.5%

[32] This is the average of the projected NHS non-initial construction project costs through 2028 including 2019

The projected Overall Pavement Condition (OPC) index summarized above in Table 30 above, are also shown graphically specifically for the Baseline scenario in Figure 26 and Figure 27. These show that for the Baseline scenario, the weighted average OPC is maintained for the overall network, and improvement is projected for the NHS network.

Based on the projections shown, it can be seen that using the Baseline scenario, this funding strategy sustains the overall network in a desired state of good repair over the analysis period of 10 years. This investment strategy also results in preservation and improvement of the NHS network.

The annual average investment is the average of the funding on the NHS per year. It should be noted that the analyses are conducted using the baseline funding for the full network as given in Figure 24 and these figures represent the resulting funding on the NHS.

FIGURE 26: OVERALL PAVEMENT INDEX (OPC) PROJECTIONS FOR THE TOTAL NETWORK – BASELINE SCENARIO

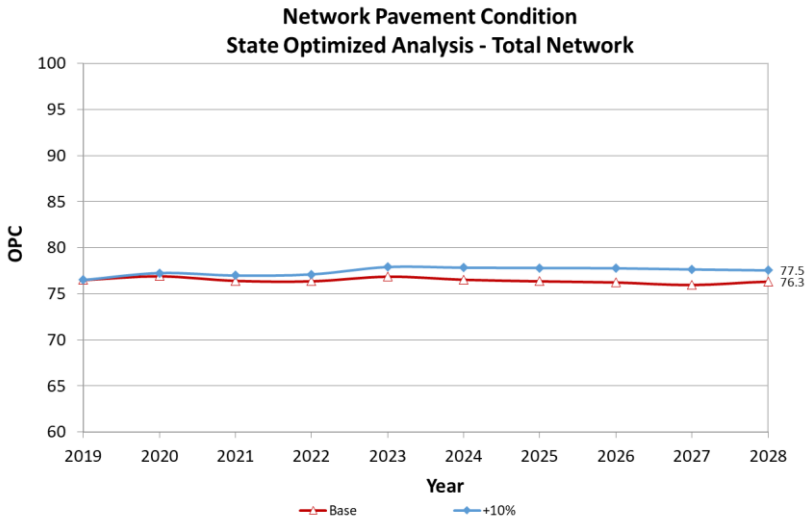
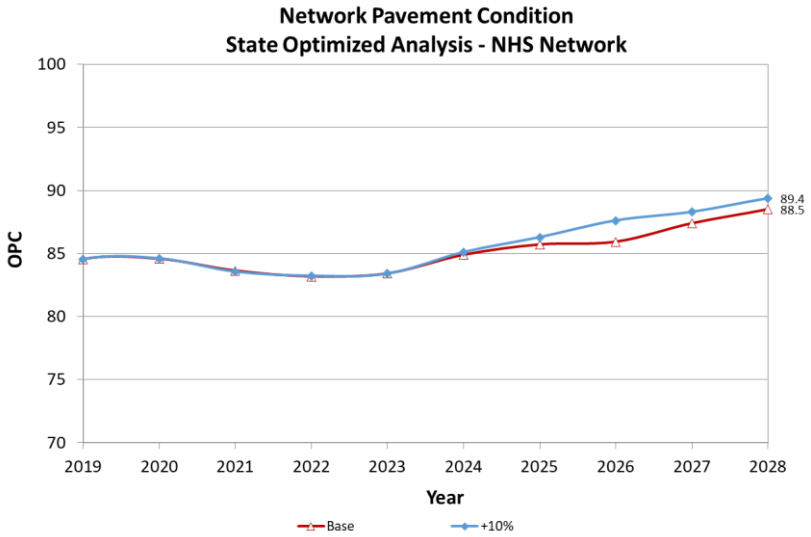
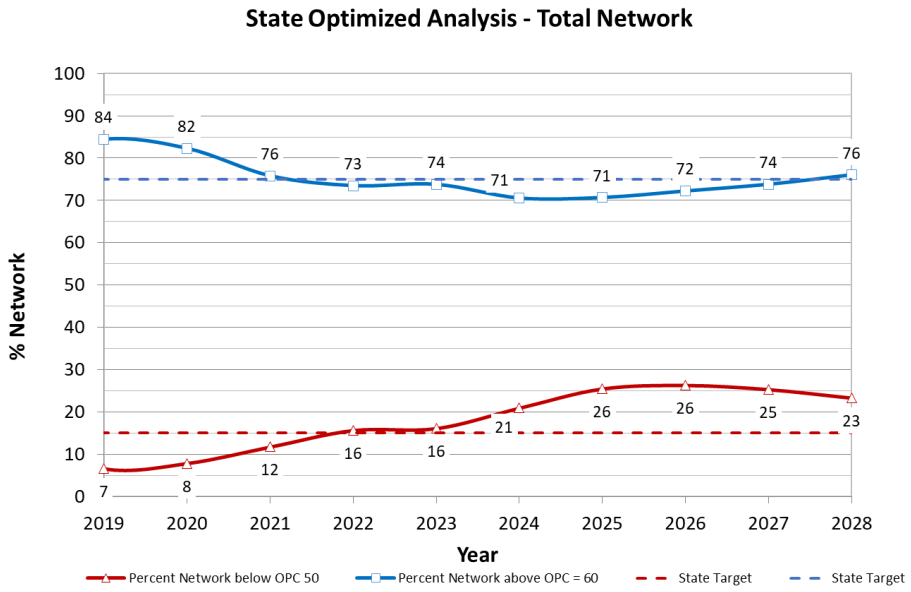


FIGURE 27: OVERALL PAVEMENT INDEX (OPC) PROJECTIONS FOR THE NHS NETWORK – BASELINE SCENARIO



In addition to sustaining the overall network condition and improving the condition for the NHS with respect to weighted average of the OPC, it can also be seen from Figure 28 below that although the Baseline funding scenario allows the overall network to drop below the DelDOT goals of 75% better than an OPC of 60, both this metric and the percent of pavements below 50 start to trend in the right direction in the second half of the analysis period.

FIGURE 28: OPC PROJECTIONS AND TARGETS FOR THE TOTAL NETWORK – BASELINE SCENARIO



The projected Percent Good and Percent Poor FHWA metrics that are summarized above in Table 30, are shown graphically specifically for the Baseline scenario in Figure 29 and Figure 30. These show that for NHS pavements, there is a slight drop projected for percent Good for both Interstate pavements and non-Interstate NHS. There is also a slight increase in percent Poor over the analysis period. However, although the percent Good is projected to drop below the targets for a short time, the trend is back up to the targets of 50% and 55% in Good condition. The percent poor remains well within the target of no more than 2% Poor for both Interstate and non-Interstate NHS pavements.

FIGURE 29: PERCENT GOOD AND POOR METRIC PROJECTIONS FOR INTERSTATE NHS – BASELINE SCENARIO

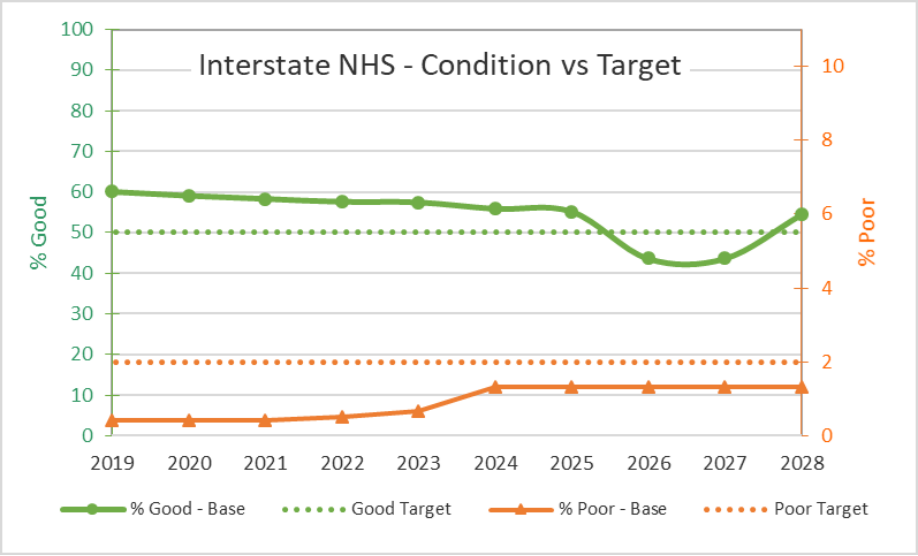
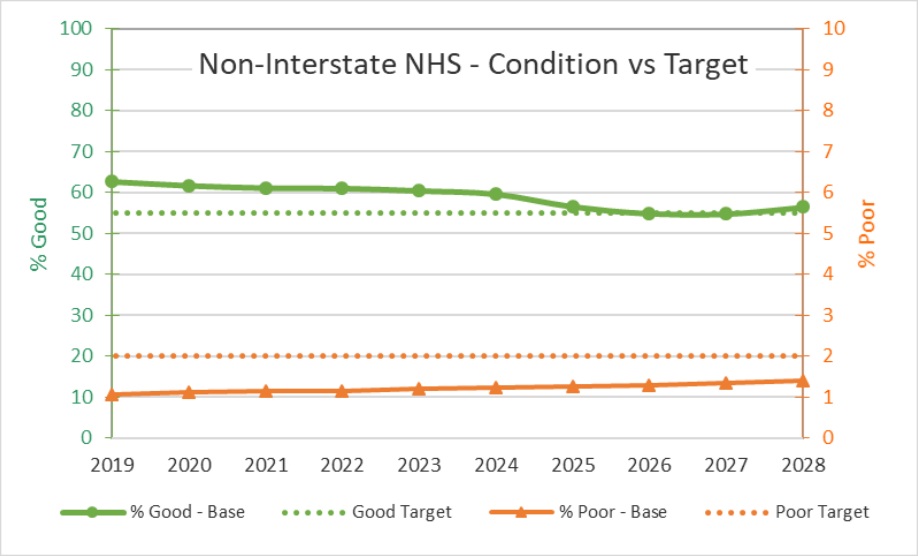


FIGURE 30: PERCENT GOOD AND POOR METRIC PROJECTIONS FOR NON-INTERSTATE NHS – BASELINE SCENARIO



As previously noted, state of good repair projects are given priority over Capacity projects in the Capital Transportation Program (CTP). The FY 2018-2024 CTP has programmed $2.05 billion for state of good repair projects over the 6-year period. This is 49.9% 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 the 5.5 Planned Investment Strategy and Life Cycle Plan section below.

Bridges

The funding scenarios analyzed by the Bridge Management Group included the Baseline funding scenario noted under section 5.2 Funding Needs previously. The breakdown for the Baseline funding scenario is given below in Table 31.

TABLE 31: BASELINE FUNDING SCENARIO FOR BRIDGES[33]

FY	State	Federal- NHS	Federal - STPBG	Total
2019	$17.76	$18.12	$29.14	**$65.02**
2020	$27.86	$33.52	$21.06	**$82.45**
2021	$22.01	$22.23	$21.10	**$65.34**
2022	$16.31	$9.81	$21.08	**$47.20**
2023	$23.06	$19.28	$26.62	**$68.96**
2024	$17.37	$20.45	$15.81	**$53.63**
2025	$17.37	$15.45	$15.81	**$48.63**
2026	$17.37	$20.45	$10.81	**$48.63**
2027	$17.37	$20.45	$10.81	**$48.63**
2028	$17.37	$20.45	$10.81	**$48.63**

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

Three funding scenarios were therefore analyzed in total as shown below.

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

To analyze the projected conditions for the three finding scenarios, the analysis methodology described previously in section 3.5 Gap and Scenario Analysis Process for Bridges was used to project the conditions over 10 years. The results for the funding scenarios are summarized below in Table 32.

TABLE 32: INVESTMENT SCENARIOS ANALYZED FOR BRIDGES

		State Metrics		FHWA Metrics	
Scenario	Average Annual Investment[34]	% Bridges Good (6-9)	% Bridges Poor (≤4)	% Deck Area Good (7-9)	% Deck Area Poor (≤4)
Baseline Scenario	$35.5 mil	2019: 78.0% 2028: 86.3%	2019: 0.3% 2028: 0.0%	2019: 17.8% 2028: 44.8%	2019: 2.7% 2028: 0.0%
- 10% Decreased Funding	$31.9mil	2019: 78.0% 2028: 85.1%	2019: 0.3% 2028: 0.0%	2019: 17.8% 2028: 42.1%	2019: 2.7% 2028: 0.0%
+ 10% Increased Funding	$39.0 mil	2019: 78.0% 2028: 86.3%	2019: 0.3% 2028: 0.0%	2019: 17.8% 2028: 47.5%	2019: 2.7% 2028: 0.0%

[33] All figures are in millions of dollars.

[34] This is the average of the projected NHS project costs through 2029 excluding 2019

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 improvement of the NHS network.

The projected Percent Good and Percent Poor State and FHWA metrics for the different scenarios that were analyzed are summarized above in Table 32. , are shown graphically specifically for the Baseline scenario in Figure 31 and Figure 32. These show that for NHS bridges, all scenarios show the percent Poor bridges, using both the State and FHWA metric definitions, drops to zero early in the analysis period. With regard to percent Good, the State metric shows some improvement over the 10-year analysis period rising from 78.0% to 86.3%. The FHWA metric for percent Good grows from 17.8% to 44.8%.

FIGURE 31: PERCENT GOOD AND POOR NHS STATE METRIC PROJECTIONS FOR BRIDGES – BASELINE SCENARIO

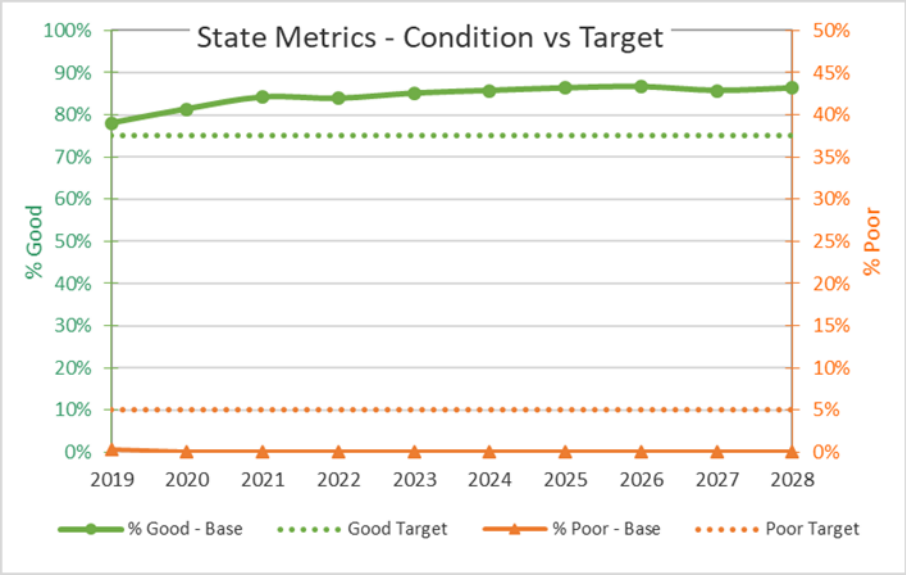
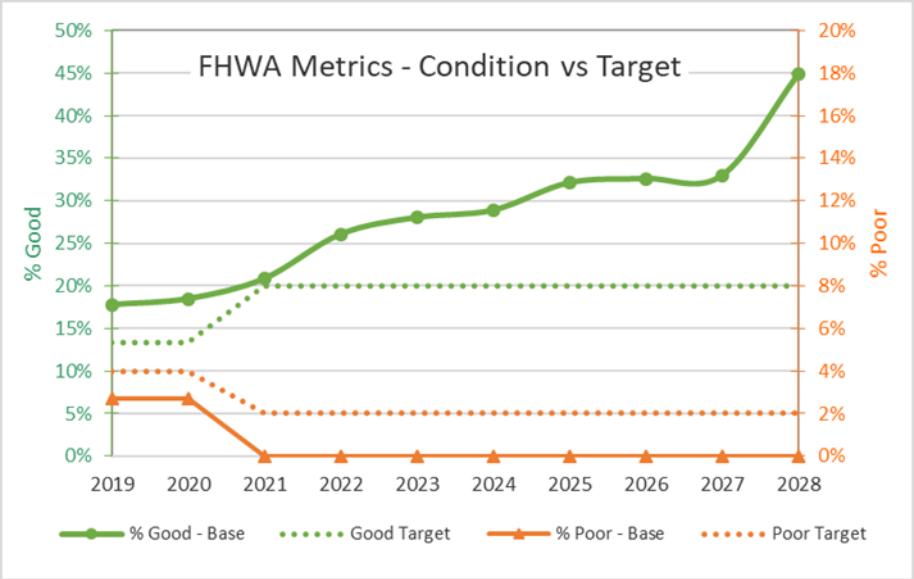


FIGURE 32: PERCENT GOOD AND POOR NHS FHWA METRIC PROJECTIONS FOR BRIDGES – BASELINE SCENARIO



The annual average investment given in Table 32: Investment Scenarios Analyzed for Bridges is the average of the funding projected for NHS bridges per year. Note that the baseline funding represents the full bridge network as given in Figure 23 and Table 31 previously. The subsequent analysis resulted in this average funding projected for the NHS based on need.

5.5 Planned Investment Strategy and Life Cycle Plan

The planned investment strategy section is the core objective of a TAMP. It represents the DOT'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 asset management plan, the focus is on the physical condition of the assets. These analyses identify the desired expenditures both between pavement and bridge, and also within specific work types. However, for specific projects that are identified as part of the analyses undertaken by the pavement and bridge groups, these projects 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 section Methodology for Including the Cost of Investment Strategies in the Financial Plan below.

This information is compiled for DelDOT's pavement and bridge assets, using the analyses described in the pavement and bridge chapters earlier, 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 nearly 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, DelDOT gathers and analyzes information regarding DRBA maintained pavement. 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. Repeated attempts were made at contacting DRBA requesting this additional information, however, DelDOT was not able to ascertain any response, and thus no additional information was made available.

This section contains the planned investment strategies for NHS Pavement and Bridge. This information is presented in a way that details the expenditures by year, by asset type (pavement versus bridge), and by work type. This information is presented in both a table format as well as illustrated graphically for pavements and bridges respectively.

Planned Investment Strategy for Pavements

As noted under Pavements in the Analyzed Investment Scenarios section above, 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 senior leadership based on the methodology described in the Methodology for Including the Cost of Investment Strategies in the Financial Plan section below.

The planned investment strategy for the total pavement network, and then specifically for the NHS network, is given below in Figure 33 and Figure 34 respectively.

FIGURE 33: PLANNED INVESTMENT STRATEGY FOR PAVEMENTS (BASELINE FUNDING SCENARIO – TOTAL NETWORK)

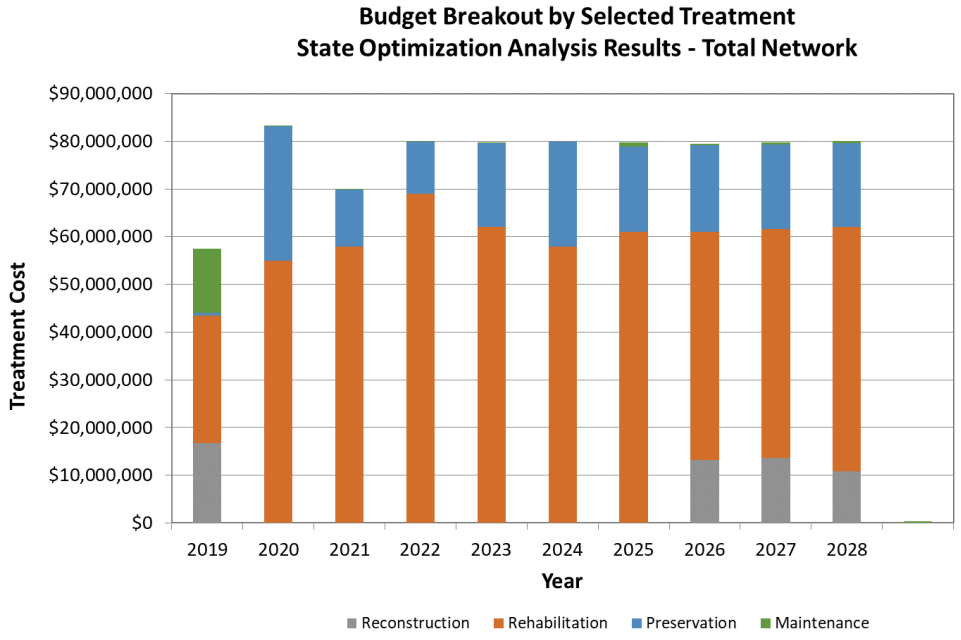
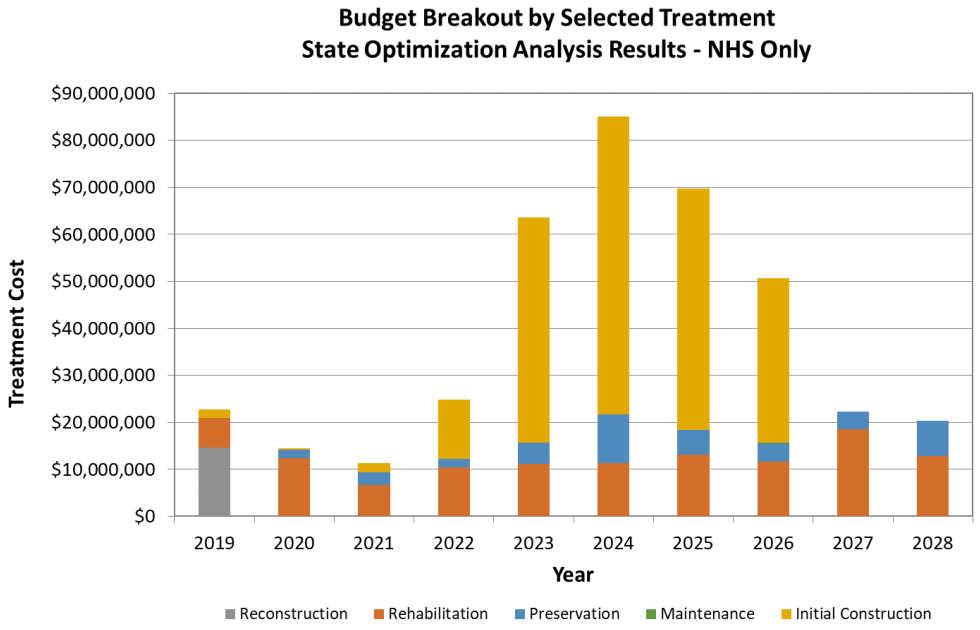


FIGURE 34: PLANNED INVESTMENT STRATEGY FOR PAVEMENTS (BASELINE FUNDING SCENARIO – NHS NETWORK)



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 and improve the NHS network. These are summarized below in Table 33.

TABLE 33: SUMMARIZED INVESTMENT STRATEGY FOR NHS PAVEMENTS[35]

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Maintenance	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.1	$0.0	$0.0
Preservation	$0.0	$1.8	$2.7	$1.8	$4.4	$10.3	$5.2	$4.0	$3.8	$7.5
Rehabilitation	$6.3	$12.4	$6.7	$10.5	$11.2	$11.3	$13.1	$11.6	$18.6	$12.8
Reconstruction	$14.7	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Initial Construction[36]	$1.8	$0.40	$2.00	$12.50	$48.00	$63.50	$51.50	$35.00	$0.0	$0.0
Total	$22.8	**$14.1**	**$9.4**	**$12.3**	**$15.6**	**$21.6**	**$18.3**	**$15.7**	**$22.4**	**$20.3**

The investment plan in Figure 34 and Table 33 shows considerable planned spending on Initial Construction. These totals are for State and Federal funds and are largely the result of planned funding on two projects to increase mobility. These projects are the HEP, KC, US13, Lochmeath Way to Puncheon Run Connector project, and the North Millsboro Bypass, US 113 to SR24 project. This may change once the projects are better defined (regarding major bridge structures, etc.) but for planning purposes, these are classified as Pavements projects.

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 12) 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 investment plan for Reconstruction is planned only in 2019 due to several larger projects scheduled to be completed. The two major projects out of approximately a half dozen are the three miles of reconstruction on southbound Rt. 113 in Sussex County and the one mile northbound and southbound on Rt. 141 in New Castle County.

It should be noted that these projected spending figures are recommended based on the optimization analyses from the pavement management system and that 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.

Planned Investment Strategy for Bridges

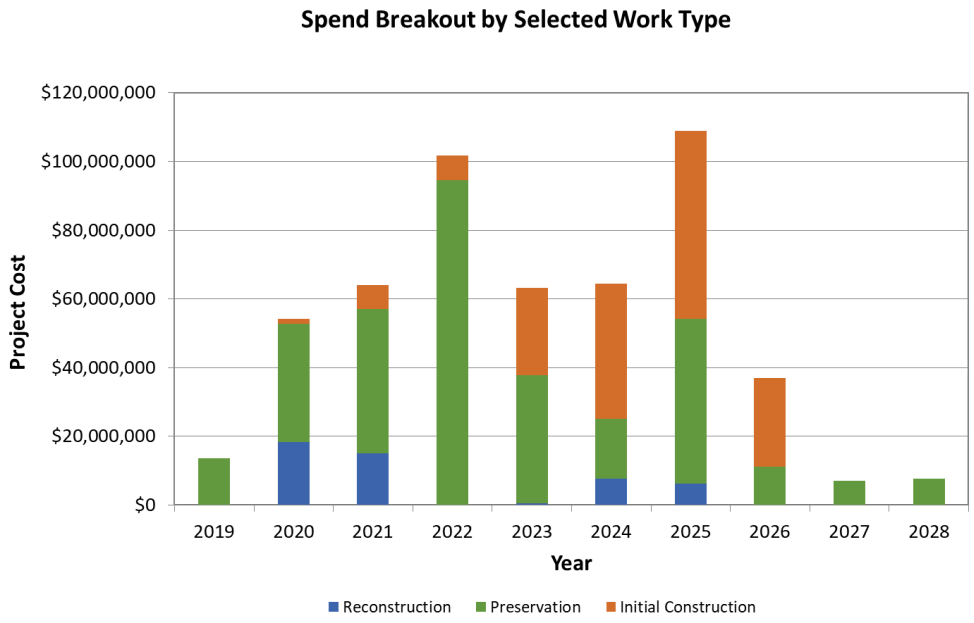
Various funding scenarios were analyzed for bridges as noted under Bridges in the Analyzed Investment Scenarios section above. The Baseline funding scenario was recommended by the bridge management group for adoption as the planned investment strategy for pavements. This was approved by senior leadership based on the methodology described in the Methodology for Including the Cost of Investment Strategies in the Financial Plan section below.

The planned investment strategy based on the approved Baseline funding scenario for the NHS bridges is given below in Figure 35. It should be noted that no planned investment strategy is available for bridges not maintained directly by DelDOT.

[35] All figures are in millions of dollars.

[36] Note that Initial Construction expenditures are from the CTP and are not available beyond this timeframe.

FIGURE 35: PLANNED INVESTMENT STRATEGY FOR BRIDGES (BASELINE FUNDING SCENARIO – NHS NETWORK)



The bridge investment strategy is derived from projects recommended through the method described in 3.5 Gap and Scenario Analysis Process for Bridges. These are summarized below in Table 34.

TABLE 34: SUMMARIZED INVESTMENT STRATEGY FOR NHS BRIDGES[37]

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Preservation	$13.7	$34.5	$42.1	$94.6	$37.2	$17.4	$47.9	$11.2	$7.0	$7.8
Reconstruction	$0.0	$18.3	$15.0	$0.0	$0.6	$7.8	$6.3	$0.0	$0.0	$0.0
Initial Construction[38]	$0.0	$1.4	$7.0	$7.0	$25.5	$39.3	$25.8	$0.0	$0.0	$0.0
Total	**$13.7**	**$54.2**	**$64.1**	**$101.6**	**$63.3**	**$64.4**	**$108.9**	**$36.9**	**$7.0**	**$7.8**

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. Again similar to pavements, Initial Construction projected funding is based on CTP projects to advance goals other than purely physical condition such safety and mobility.

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

[37] All figures are in millions of dollars.

[38] Note that Initial Construction expenditures are from the CTP and are not available beyond this timeframe.

accomplished through discussion with senior 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 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 is moving 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 Asset Management Team, in coordination with senior 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, senior leadership considers the other state and national goals and objectives as listed below.

(1) 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.

(2) Infrastructure condition – The focus of this Transportation Asset Management Plan (TAMP) document is to describe the processes and resulting plan for maximizing infrastructure condition and the asset life cycle at minimum practicable cost.

(3) 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.

(4) 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).

(5) 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].

(6) Environmental sustainability - Projects identified as part of the TAMP process will continue to be designed and implemented using DelDOT's environmental permitting process.

(7) 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 the department are considered, the needs for each asset type is balanced with an emphasis on minimizing asset lifecycle ownership costs. These considerations include considering the probability of the

[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

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 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 Asset Management Team 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 Asset Management Team and the individual asset managers, finalizes the 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 Asset Management Team communicates the chosen Investment Strategy to Pavement and Bridge Groups for feedback and adjustment.

5.6 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 the Department 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 1695 lane miles of NHS pavement is estimated at approximately $920 million. The estimate is based on the reconstruction costs for various pavement types used in the Pavement Management System. The calculation is shown in Table 35.

Table 35 NHS Pavement Value

Weighted $/Sq Yd:	$ 77.02
Total Lane Miles:	1,695
Total Sq Yds:	11,930,688
Pavement Valuation:	**$ 918,921,478**

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 exact value of individual bridges varies.

TABLE 36 NHS BRIDGE VALUE

Type of Structure	Total Number of Structures	Average Health Index[42]	Total Deck Area (Sq Ft)	Replacement Cost per Sq Ft	Total Replacement Cost
Culverts	31	0.87	117,346	$600	$70,407,600*
Bridges	292	0.91	5,821,809	$300	$1,746,542,700*
TOTAL	**323**		**5,939,155**		**$1,816,950,300**

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

5.7 INTEGRATION WITH AGENCY PROCESSES

The CTP/STIP, TAMP and LRTP should have strong relationships to each other. Some differences are inevitable given the differing planning horizons, frequency of preparation and focus; however, as each document is updated, it should be checked for consistency with the others. Where significant differences exist, the Agency should consider the reasons for these differences and determine whether some fundamental change has occurred and how DelDOT can/should rationalize the relationships between the respective planning assumptions.

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 somewhat 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 Capital Transportation Program, the Metropolitan Planning Organization 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. The Department 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.

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 the Department and the COT and changes are made as appropriate. The entire proposal then is sent to the Governor as the Department'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

[42] 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.

Committee of the Delaware General Assembly considers the proposed capital budget through a series of public hearings in 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 section 1.4 Overview of TAMP Process, 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 5. This is a persistent, repetitive cycle that continues indefinitely until/unless legislatively superseded of the underlying requirement expires.

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APPENDIX A

AGENCY AND PROGRAM LEVEL RISK REGISTER

Table 37 is the current set of agency and program level risks identified and scored using the process described in Chapter 4: Risk Management.

TABLE 37: AGENCY AND PROGRAM LEVEL RISK REGISTER

Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety Consequence	Mobility Consequence	Asset Costs Consequence	Other Financial Consequence	Risk Score	Comments / Notes	Mitigation Description
Agency	All	Regulatory Controls - Fed/State agencies, preventing/delay projects	5	5	5	2	4	80.0	HSIP project at 141/95 identified in 1998, project is still in construction in 2019 and not yet complete	Target delays so that DelDOT can re-allocate funding to other HSIP or SoGR projects and not delay/push money from year to year.
Program	Safety	Major accidents on high volume roadways (e.g. Interstates)	5	4	4	2	4	70.0	Major accidents can have major safety, mobility, and economic effects.	Hazmat program. Emergency coordination. Traffic Management Center to coordinate.
Program	Culverts, Bridges, Pavement	Unanticipated Occurrence of a Natural Event/Asset Failure - Frequent Events (Localized Storms/tornadoes)	5	4	3	3	2	60.0	Problem is that don't have the luxury of making culverts larger. Do not have time to get permits etc.; example: Seaford	Future: Get inventory of pipes (and bridges) including sizes and perform an exercise to find undersized pipes so that program of risk evaluation and possible replacement can be implemented.
Agency	All	Anticipated Occurrence of a Natural Event/Asset Failure - Infrequent Events (Hurricanes and Tropical Storms)	3	5	5	5	5	60.0		The most probable destructive natural events in Delaware are hurricanes or tropical storms, and flooding. 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. Have undertaken some COOP planning and have ability to work from home. Data

Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety Consequence	Mobility Consequence	Asset Costs Consequence	Other Financial Consequence	Risk Score	Comments / Notes	Mitigation Description
										archives are backed up in alternate locations.
Agency	All	Unanticipated Occurrence of a Natural Event/Asset Failure - Frequent Events (Rain/Flood Events)	5	2	2	3	4	55.0	Events are sustained duration, for increased frequency and intensity	Anticipated and communicated to local communities early.
Agency	All	State Employee Retention	3	3	3	4	5	45.0	Low Unemployment Rate combined with salary caps Affects ability for DOT to maintain a competitive salary for employees. Fewer projects being delivered. Cannot respond to incidents and snow events as quickly. Results in increasing costs of projects because cannot be competitive internally. Relying on contracted help increases costs	General assembly would have to approve salary increases.
Program	Culverts, Bridges, Pavement	Catastrophic Failure - Pipes	5	1	2	4	1	40.0	Bridges less of a problem. However, corrugated metal pipes can be a problem (e.g. sinkholes) since not being inspected regularly. Pavements, typically not as much of a problem here.	High Priority Workorders where SMEs review complaint and determine resolution. Future: Introduce inspection program for pipes (including inventory). Planned replacement program.
Agency	All	Budget Uncertainty/Loss of federal funding	5	1	1	1	5	40.0	State level funding fairly stable. Federal funding is more volatile. CRs are passed every year but projects let under assumption that CR will be passed. Projects may be started and not finished, or state funds would have to make up difference. Fed funding tied to TAMP and external agencies are tied to DelDOT assets where we have no control over their practices or funding	Established line of credit. Maintain a very high credit rating to be able to sell bonds if necessary.

Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety Consequence	Mobility Consequence	Asset Costs Consequence	Other Financial Consequence	Risk Score	Comments / Notes	Mitigation Description
Agency	Bridges, Pavements, and Safety	Decline of Funding	2	5	4	5	5	38.0	Unpredictable decline of funding. Projects may be delayed. Some projects postponed indefinitely. Can have a major safety impact.	DelDOT's diversified revenue stream provides some protection against catastrophic revenue declines. Its four major revenue sources – motor fuel taxes, vehicle and driver fees, tolls, and Federal funding – provide over 95% of revenue, with each of the four contributing between 17% and 28% of the total revenue. DelDOT's budget 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.
Program	Bridges	Bridge strike events	5	2	2	2	1	35.0	Hit and runs is a problem.	Signed low clearance bridges. Flashing lights at some locations. Program to recover repair costs from insurance companies. Updating oversize/overweight permitting system. High Priority Workorders where SMEs review complaint and determine resolution. Have contractors on call to make repairs in a timely manner.
Program	All	Anticipated Occurrence of a Natural Event/Asset Failure - Frequent Events (Snow Events)	3	2	3	1	5	33.0	Unusually high snow years, ice storms.	Increased budget recently. Major snow removal operations resources planned and in place. Have flexibility as an agency (prior year authorization) which allows any previously unused budgets to be used.
Agency	Pavement, Bridges	Climate Change Effects - sea level rise	2	4	2	4	4	28.0	May need to move some roads. Also increased wetlands near roadways will require more permitting and possibly delay project delivery. This is more of a trend to be mitigated through strategic planning.	Potential climate change effects include sea level rise, increased rainfall amounts and/or intensity, and more frequent temperature extremes. 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. The

Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety Consequence	Mobility Consequence	Asset Costs Consequence	Other Financial Consequence	Risk Score	Comments / Notes	Mitigation Description
										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. Continue to monitor and plan in advance. Future: Policy should be established about when to abandon roadways and structures.
Agency	All	STIP not approved	3	2	2	2	2	24.0	Delays in approval of STIP have happened in the past. This causes projects to be delayed.	Can amend or modify existing STIP and continue work. Law passed recently to make STIP a bi-ennial program.
Agency	All	Climate Change Effects - increasing temperatures	5	1	1	1	1	20.0	Increased rainfall (reduction in snow events). Pavement designs will need to change.	Continue to revise design standards
Program	Bridges	Catastrophic Failure - Bridges	1	5	5	5	5	20.0		Assets susceptible to catastrophic failure, such as bridges and culverts, undergo detailed inspection at a minimum every two years. Identified repair needs are promptly scheduled for completion. NBIS Inspection program. Preventive maintenance. High Priority Workorders where SMEs review complaint and determine resolution.
Agency	All	Pollution or other environmental damage	1	1	1	3	3	8.0	Will affect transportation infrastructure because will require money to fix which will come out of DOT budget. Also could affect permitting in the future.	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.

Risk Level	Asset Class	Event/Occurrence	Likelihood	Safety Consequence	Mobility Consequence	Asset Costs Consequence	Other Financial Consequence	Risk Score	Comments / Notes	Mitigation Description
Program	All	Accuracy of deterioration modeling - budget projections are not sufficient	1	1	1	3	1	6.0	Also project pipeline	DelDOT periodically evaluates its deterioration curves for bridges, pavements, sign sheeting, etc., and updates as needed.
Agency	All	Accuracy of Cost Estimates used in planning - costs are underestimated	1	1	1	3	1	6.0	Also project pipeline	For Capital Improvement projects and most SoGR projects, DelDOT bases 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.

Risk Register of Facilities Repeatedly Damaged by Emergency Events

Table 38 is the current record of historical damage events available from the DelDOT Division of Maintenance and Operations. This list contains facilities damaged in recent events. Various mitigation actions were considered by DelDOT staff for each facility and the benefit cost ratios were calculated.

Table 38: Risk Evaluation of Possible Mitigation Strategies for Facilities Recently Damaged in Emergency Events

Facility				*Most recent damage*			
Name:	**Location:**	**NHS (Y/N):**	**Repeated Damage:**	**Damage Type / Fix:**	**Damage Cost:**	**Event Name:**	**Year Month:**
RT 1 South of Dewey	0	Y	Y	Adding 8" pavement near Keybox Rd	$ -		
Mitigation Actions			*Benefit Cost Ratio Calculation*				
Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**	**Comment:**
0 - Do Nothing	$0	0	$0	$189,584	0%	-	
1 - Add 4" for one mile on all lanes	$1,000,000	15	$66,667	$0	100%	2.84	B/C greater than 1. Mitigation action feasible.
Facility				*Most recent damage*			
Name:	**Location:**	**NHS (Y/N):**	**Repeated Damage:**	**Damage Type / Fix:**	**Damage Cost:**	**Event Name:**	**Year Month:**
Cedar Creek- BR3-164	Sussex	N	Y	Bridge Structure	$ 279,635.12	Hurricane Sandy	12-Oct
Mitigation Actions			*Benefit Cost Ratio Calculation*				
Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**	**Comment:**
0 - Do Nothing	$0	0	$0	$0	0%	-	
Already in STIP (approved)	$0	0	$0	$0	0%	-	Already in STIP (approved). No further action.
Facility				*Most recent damage*			
Name:	**Location:**	**NHS (Y/N):**	**Repeated Damage:**	**Damage Type / Fix:**	**Damage Cost:**	**Event Name:**	**Year Month:**
Front Street- BR3-151	Sussex	N	Y	Bridge Structure	$ 526,887.00	Hurricane Sandy	12-Oct
Mitigation Actions			*Benefit Cost Ratio Calculation*				
Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**	**Comment:**
0 - Do Nothing	$0	0	$0	$65,000	0%	-	
1 - Replace bridge or retrofit to raise bridge	$25,000,000	100	$250,000	$0	100%	0.26	B/C less than 1. Mitigation action not warranted. Tolerate Risk.
Facility				*Most recent damage*			
Name:	**Location:**	**NHS (Y/N):**	**Repeated Damage:**	**Damage Type / Fix:**	**Damage Cost:**	**Event Name:**	**Year Month:**
St Augustine	NCC	N	Y	Roadway Washout	$ 68,032.78	Hurricane Sandy	12-Oct
Mitigation Actions			*Benefit Cost Ratio Calculation*				

Action:	Cost of Action:	Duration of Fix (Yrs):	Annualized Cost of Action:	Consequence:	Risk Reduction:	B/C Ratio:	Comment:
0 - Do Nothing	$0	0	$0	$8,039	0%	-	
1 - Raise the road 6"	$750,000	15	$50,000	$0	100%	0.16	B/C less than 1. Mitigation action not warranted. Tolerate Risk.
2 - Extend the dyke	$20,000,000	100	$200,000	$0	100%	0.04	B/C less than 1. Mitigation action not warranted. Tolerate Risk.
Facility				*Most recent damage*			
Name:	**Location:**	**NHS (Y/N):**	**Repeated Damage:**	**Damage Type / Fix:**	**Damage Cost:**	**Event Name:**	**Year Month:**
Primehook	Sussex	N	Y	Roadway Washout – DE Bay Breaches project with DNREC/F&W ($20M)	$ 204,696.75	Hurricane Sandy	12-Oct
Mitigation Actions			*Benefit Cost Ratio Calculation*				
Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**	**Comment:**
0 - Do Nothing (Fixed already)	$0	0	$0	$222	0%	-	Fixed already. No further action.
Facility				*Most recent damage*			
Name:	**Location:**	**NHS (Y/N):**	**Repeated Damage:**	**Damage Type / Fix:**	**Damage Cost:**	**Event Name:**	**Year Month:**
Mill Creek Rd	NCC	N	Y	Slope Stabilization	$ 527,401.00	Tropical Storm Jeanne	4-Sep
Mitigation Actions			*Benefit Cost Ratio Calculation*				
Action:	**Cost of Action:**	**Duration of Fix (Yrs):**	**Annualized Cost of Action:**	**Consequence:**	**Risk Reduction:**	**B/C Ratio:**	**Comment:**
0 - Do Nothing	$0	0	$0	$110,805	0%	-	
1 - Slope stabilization	$5,000,000	50	$100,000	$0	100%	1.11	B/C greater than 1. Mitigation action feasible.

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APPENDIX B

EXPLANATION OF OVERALL PAVEMENT CONDITION (OPC) CONFIGURATION

(This is an extract from the DelDOT PMS Configuration Document – Updated 20190724.)

3.0 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.

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 following types of pavement deterioration are collected and stored in the PMS.

Table 1: Pavement Distresses

Flexible	Composite	Surface Treated	Rigid
Fatigue Cracking	Fatigue Cracking	Fatigue Cracking	Joint Deterioration
Transverse Cracking	Reflective Cracking	Transverse Cracking	Slab Cracking

Block Cracking	Block Cracking	Block Cracking	Joint Seal Damage
NWP Longitudinal Cracking	NWP Longitudinal Cracking	NWP Longitudinal Cracking	Faulting
Patch Deterioration	Patch Deterioration	Patch Deterioration	Patch Deterioration
Surface Defects	Surface Defects	Surface Defects	ASR
Rutting	Rutting	Edge Cracking	
		Bleeding	
		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 and extent ranges are determined by DelDOT for field data collection. 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 below.

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

$$IDI^{sev} = 100e^{-\propto\beta} \tag{1}$$

Where:

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

α = Distress Severity Coefficient

β = % Extent of Distress

Table 3 shows values of severity (α) for each distress for Flexible, Composite, and Surface Treated pavement types.

Table 2: 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
Block Cracking	Low	0.0051	0-100
	Medium	0.0090	0-100
	High	0.01450	0-100
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
Surface Defects	Low	0.0022	0-100
	Medium	0.0045	0-100
	High	0.0070	0-100
Edge Cracking	Low	0.0032	0-100
	Medium	0.0070	0-100
	High	0.0140	0-100
Bleeding	Low	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 3: 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
	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

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

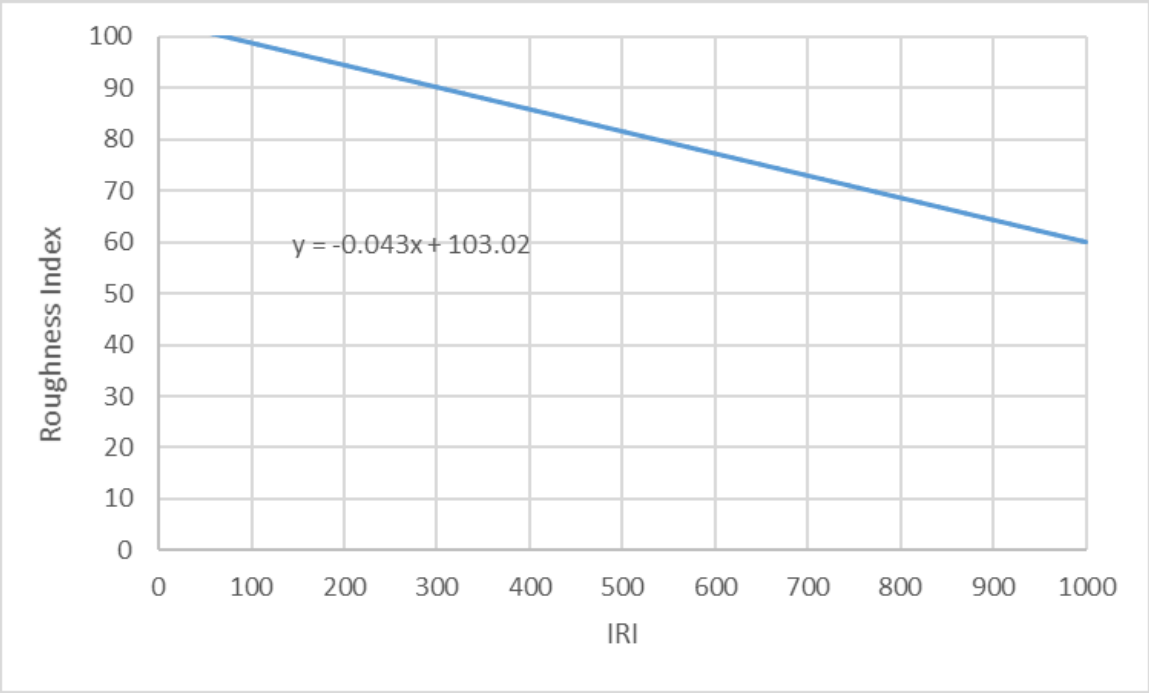
Where:

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 PMS software limitations. Now with the latest version of PMS software as well as the implementation of automated data collection of pavement distresses, data vendors can provide a level of detail necessary to use an equation to accurately calculate the OPC based on the extent value directly in the PMS. KEI recommended that PMG implement 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. This will allow the PMS to be configured to calculate a more accurate OPC.

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 for Rural and Urban roads.

Figure 1: 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.

Table 4: Combined Distress Indices - Flexible Pavements

Structural Index	*Non-Structural Index*	*Functional Index*
Fatigue Cracking	Transverse Cracking	Rutting

Patch Deterioration	Block Cracking	IRI
	Surface Defects/Raveling	
	NWP Longitudinal Cracking	

Table 5: Combined Distress Indices – Composite Pavements

Structural Index	*Non-Structural Index*	*Functional Index*
Fatigue Cracking	Reflective Cracking	Rutting
Patch Deterioration	Block Cracking	IRI
	Surface Defects/Raveling	
	NWP Longitudinal Cracking	

Table 6: Combined Distress Indices – Surface Treated Pavements

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

Table 7: 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		

The newly defined Combined Distress Indices will also be added to the Network Master file and the existing individual distress indices will be removed from the Network Master file. Following equation is used for calculating the Combined Distress Indices for each management section in the Network Master file.

Equation 3: Combined Distress Index Formula

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

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

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

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 2: OPC - Asphalt

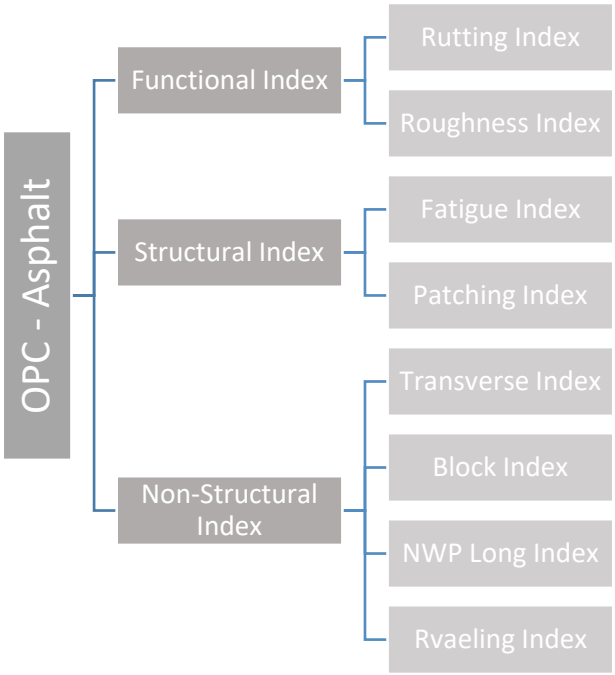


Figure 3: OPC - Composite

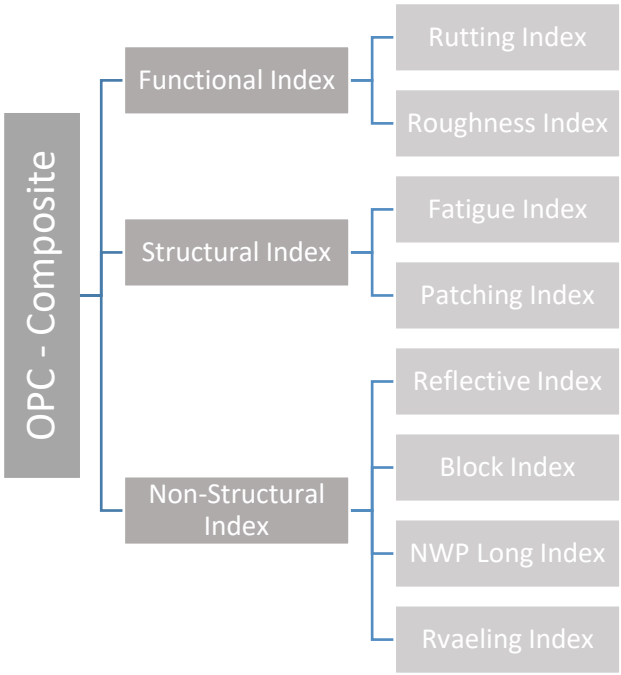


Figure 4: OPC - Surface Treated

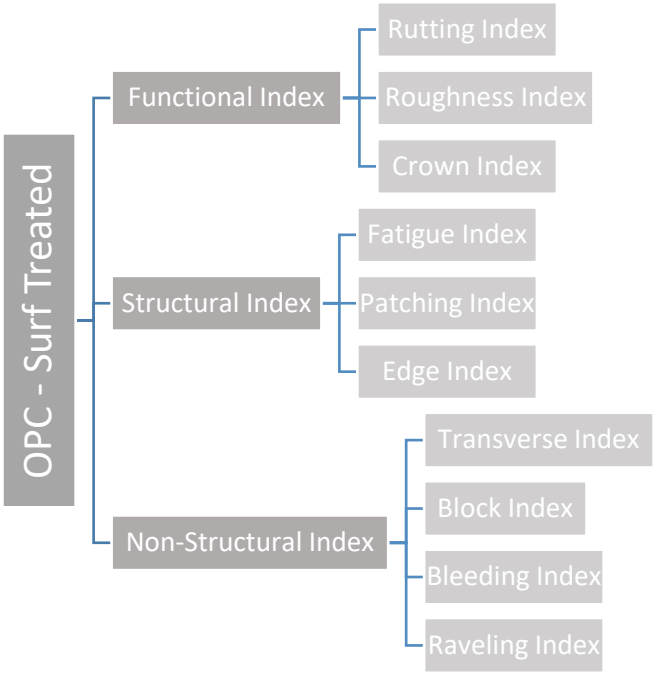
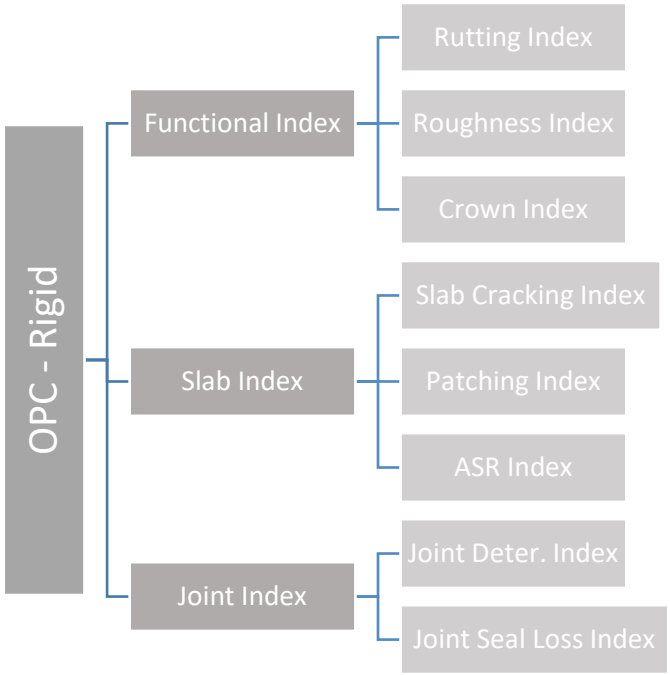


Figure 5: OPC - Concrete



In general, the OPC ranges from 100 which is considered excellent, to zero which is considered very poor. For reference purposes, a number of photographs are included below to illustrate different levels of OPC. DelDOT is in the process of conducting a study to redefine the OPC ranges for good/fair/poor to better reflect field conditions. However this study is not yet complete.

Figure 6: Example of a primary arterial composite pavement in excellent condition with OPC 90.5

Figure 7: Example of major collector pavement in good condition with OPC 72.0

Figure 8: Example of major collector hot mix pavement in fair condition with OPC 58.2

Figure 9: Example of major collector composite pavement in poor condition with OPC 48.6

Figure 10: Example of local hot mix pavement in very poor condition with OPC 7.6

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APPENDIX C

CERTIFICATION CHARTS

TABLE 39: PLAN DEVELOPMENT AND CONTENT CHECKLIST

Required Elements	Indicators the TAMP Meets Element Requirements in 23 U.S.C. 119(e) and 23 CFR part 515	Location Addressed in TAMP
TAMP approved by head of State DOT (23 CFR 515.9(k))		
	Does the TAMP bear the signature of the head of the State DOT?	Signed by the Delaware Secretary of Transportation.
State DOT has developed its TAMP using certified processes (23 CFR 515.13(b))		
	Do the process descriptions align with the FHWA-certified processes for the State DOT? [If the process descriptions do not align with the FHWA-certified processes, the State DOT must request recertification of the new processes as amendments unless the changes are minor technical corrections or revisions with no foreseeable material impact on the accuracy and validity of the processes, analyses, or investment strategies. State DOTs must request recertification of TAMP development processes at least 30 days prior to the deadline for the next FHWA TAMP consistency determination as provided in 23 CFR 515.13(c).]	The processes used for pavement analysis are the FHWA-certified processes for the State DOT from the Initial TAMP. These processes are described in *2.5 Gap and Scenario Analysis Process for Pavements* and elsewhere in *Chapter 2: Pavements*. The processes used for bridge analysis are the FHWA-certified processes for the State DOT from the Initial TAMP although the final software tools are still in the process of being implemented. These processes are described in *3.5 Gap and Scenario Analysis Process for Bridges* and elsewhere in *Chapter* 3: Bridges. The processes used for risk analysis are the FHWA-certified processes for the State DOT from the Initial TAMP. These processes are described in *4.1Risk Management Process*. The processes used for financial analysis and investment strategy development are the FHWA-certified processes for the State DOT from the Initial TAMP. These processes are described in the Methodology sections and elsewhere in *5.4 Investment Strategies*.
	Do the TAMP analyses appear to have been prepared using the certified processes?	See explanation above.

Required Elements	Indicators the TAMP Meets Element Requirements in 23 U.S.C. 119(e) and 23 CFR part 515	Location Addressed in TAMP
TAMP includes the required content as described in 23 CFR 515.9(a)-(g) (23 CFR 515.13(b))		
	Does the TAMP include a summary listing of NHS pavement and bridge assets, regardless of ownership?	This is contained in section *2.1 Inventory and Condition* for pavements and in section *3.1 Inventory and Condition* for bridges.
	Does the TAMP include a discussion of State DOT asset management objectives that meets requirements?	This is contained in section *2.3 Objectives and Targets* for pavements and in section *3.3 Objectives and Targets* for bridges.
	Does the TAMP include a discussion of State DOT measures and targets for asset condition, including those established pursuant to 23 U.S.C. 150, for NHS pavements and bridges, that meets requirements?	This is contained in section *2.3 Objectives and Targets* for pavements and in section *3.3 Objectives and Targets* for bridges.
	Does the TAMP include a summary description of the condition of NHS pavements and bridges, regardless of ownership, that meets requirements?	This is contained in section *2.1 Inventory and Condition* for pavements and in section *3.1 Inventory and Condition* for bridges.
	Does the TAMP identify and discuss performance gaps?	This is contained in section *2.4 Gap Analysis and Condition Projections* for pavements and in section *3.4 Gap Analysis and Condition Projections* for bridges.
	Does the TAMP include a discussion of the lifecycle planning that meets requirements, including results?	A description of the lifecycle planning process is contained in *2.5 Gap and Scenario Analysis Process for Pavements* for pavements and in *3.5 Gap and Scenario Analysis Process for Bridges* . Results are given in *2.4 Gap Analysis and Condition Projections* and *3.4 Gap Analysis and Condition Projections* respectively.
	Does the TAMP include a discussion of the risk management analysis that meets requirements?	Discussion of the risk management process and results is contained in *Chapter 4: Risk Management*.
	Does the TAMP include the results of the evaluations of NHS pavements and bridges pursuant to 23 CFR part 667?	Discussion of evaluations of NHS pavements and bridges pursuant to 23 CFR part 667 are contained in Evaluation of Facilities Repeatedly Damaged due to Emergency Events. Results are contained in 4.2 Current Risks and Mitigation Strategies.

Required Elements	Indicators the TAMP Meets Element Requirements in 23 U.S.C. 119(e) and 23 CFR part 515	Location Addressed in TAMP
	Does the TAMP include a discussion of a 10-year Financial Plan to fund improvements to NHS pavements and bridges?	A discussion of a 10-year Financial Plan to fund improvements to NHS pavements and bridges is contained in *5.4 Investment Strategies*
	Does the TAMP identify and discuss investment strategies the State intends to use for their NHS pavements and bridges?	The TAMP identifies and discusses investment strategies the State intends to use for their NHS pavements and bridges in *5.4 Investment Strategies*.
	Does the TAMP include a discussion as to how the investment strategies make or support progress toward achieving and sustaining a desired state of good repair over the life cycle of the assets?	Discussion on how the planned investment strategy supports progress toward achieving and sustaining a desired state of good repair over the life cycle of the assets is included in section *5.4 Investment Strategies*.
	Does the TAMP include a discussion as to how the investment strategies make or support progress toward improving or preserving the condition of the assets and the performance of the NHS related to physical assets?	Discussion as to how the planned investment strategy supports progress toward improving or preserving the condition of the assets and the performance of the NHS related to physical assets is contained in section *5.4 Investment Strategies*.
	Does the TAMP include a discussion as to how the investment strategies make or support progress toward achieving the State's targets for asset condition and performance of the NHS in accordance with 23 USC 150(d)?	Discussion as to how the planned investment strategy supports progress toward achieving the State's targets for asset condition and performance of the NHS in accordance with 23 USC 150(d) is included in section *5.4 Investment Strategies*.
	Does the TAMP include a discussion as to how the investment strategies make or support progress toward achieving the national goals identified in 23 USC 150(b)?	Discussion as to how the planned investment strategy supports progress toward achieving the national goals identified in 23 USC 150(b) is included in section *5.4 Investment Strategies*.
	Does the TAMP include a discussion as to how the TAMP's life-cycle planning, performance gap analysis, and risk analysis support the State DOT's TAMP investment strategies?	Discussion as to how the TAMP's life-cycle planning, performance gap analysis, and risk analysis support the State DOT's TAMP investment strategy is included in section *5.4 Investment Strategies*. More detailed discussion is included in *2.5 Gap and Scenario Analysis Process for Pavements* and *3.5 Gap and Scenario Analysis Process for Bridges.*
Inclusion of Other Assets in the TAMP in 23 CFR 515.9 (l):		Not applicable.

TABLE 40: TAMP IMPLEMENTATION CHECKLIST

Required Elements	Indicators the TAMP Meets Element Requirements in 23 U.S.C. 119(e) and 23 CFR part 515	Location Addressed in TAMP
Integration of TAMP into transportation planning processes that lead to the Statewide Transportation Improvement Program (STIP) (23 CFR 515.9(h))		
	Do State DOT planning documents or records of planning activities show that the TAMP was integrated into its transportation planning processes that lead to the STIP?	Discussion of the planning process for pavements in contained in *2.6 Work Planning and Programming* . Discussion of the planning process for bridges in contained in *3.6 Work Planning and Programming*.
TAMP available to the public (23 CFR 515.9(i))		
	Has the State DOT made its TAMP available to the public by posting on its website, or distributing in public meetings, or by some other means?	Complete TAMP will be posted on the DelDOT website at https://deldot.gov/Publications/tamp/pdfs/DelDOT-Transportation-Asset-Management-Plan-2019.pdf .
State DOT demonstrates through current and verifiable documentation that it has implemented a TAMP meeting requirements of 23 U.S.C. 119 and 23 CFR part 515 and that the State DOT is following the investment strategies in the TAMP (23 CFR 515.13(b)(2)).		
	Has the State DOT documented evidence that the State DOT is using the TAMP investment strategies? (23 CFR 515.13(b)(2)). The best evidence is that, for the 12 months preceding the consistency determination, there was alignment between the actual and planned levels of investment (in the TAMP) for various work types as defined in 23 CFR 515.5 (i.e., initial construction, maintenance, preservation, rehabilitation and reconstruction) (23 CFR 515.13(b)(2)(i))?	Documentation will be contained in annual Consistency submission letter to FHWA.
	If the State DOT deviated from the TAMP investment strategies, did they document reasons the deviation(s) were necessary due to extenuating circumstances beyond the State DOT's reasonable control (23 CFR 515.13(b)(2)(ii)).	Documentation of any deviations will be contained in annual Consistency submission letter to FHWA.