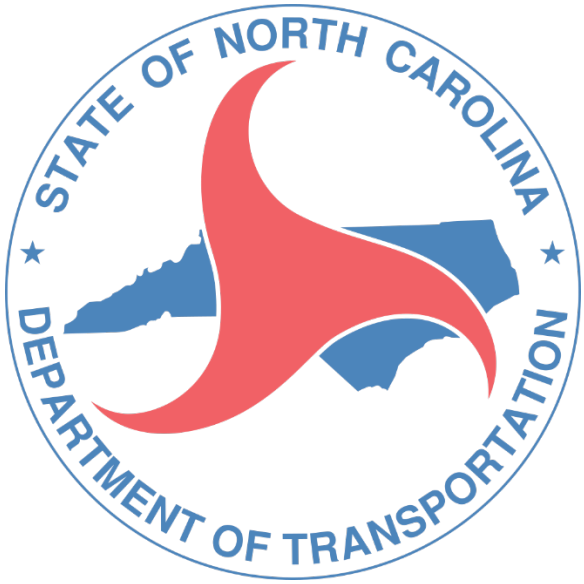
Transportation Asset Management Plan

North Carolina Department of Transportation

2022 Update



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ACRONYMS

BIL	Bipartisan Infrastructure Law (IIJA)
BMIP	Bridge Maintenance Improvement Plan
BMS	Bridge Management System
CRCP	Continuously Reinforced Concrete Pavement
FAST	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FO	Functionally Obsolete
GMR	General Maintenance Reserve
IIJA	Infrastructure Investment and Jobs Act (BIL)
IM	Interstate Maintenance
HMIP	Highway Maintenance Improvement Plan
IRI	International Roughness Index
LCC	Life Cycle Cost
MAP-21	Moving Ahead for Progress in the 21st Century Act
MOPAR	Maintenance Operations and Performance Analysis Report
NBI	National Bridge Inspection
NBIS	National Bridge Inventory System
NCGA	North Carolina General Assembly
NHS	National Highway System
PMS	Pavement Management System
PPR	Pavement Performance Rating
PCI	Pavement Condition Index
SD	Structurally Deficient
SMU	Structures Management Unit
STI	Strategic Transportation Investments
STIP	State Transportation Improvement Program
TAMP	Transportation Asset Management Plan
NCDOT	North Carolina Department of Transportation
TPM	National Transportation Performance Measures

1. ASSET MANAGEMENT OBJECTIVES

1.0 INTRODUCTION

North Carolina is a geographically diverse state which poses correspondingly diverse challenges to infrastructure. The central Piedmont is bounded by the Appalachian Mountains and the Atlantic coastal plains. The mountains contend with routine icy snowfall, and the coastal region with hurricanes and tropical storms. While predominantly regional, extreme weather less frequently extends to the entire state. Heavy rainfall events have recently increased to the level of declared disasters, exacerbating flooding along major rivers, and requiring new thinking about how to address frequently damaged sites with resilience in mind.

The North Carolina Department of Transportation (NCDOT, The Department) has long embraced data-driven asset management practices. These practices were first compiled into a single asset management document in 2014. As required by N.C.G.S 136-44.3, the MAINTENANCE OPERATIONS AND PERFORMANCE ANALYSIS REPORT (MOPAR) has been issued on every even numbered year since inception and is publicly available. It covers principles of asset management related to pavement and bridge infrastructure including inventory, condition, target performance, gap analyses, and risk. The impact of funding on current and future performance is a key output, with recommendations to the North Carolina General Assembly (NCGA) for future investment.

The MOPAR is complemented by the HIGHWAY MAINTENANCE IMPROVEMENT PLAN (HMIP). Required by law under N.C.G.S 136-44.3A, this document is a more granular five-year schedule of specific projects and activities along with their estimated costs. The schedule of projects is interactively mapped which has many benefits including the ability to optimize maintenance decisions in the vicinity of planned projects. It initially only reported on pavement assets but was expanded by S.L. 2017-57 to include bridge and general maintenance planning, beginning in the year 2020. The HMIP is also publicly available.

NCDOT GOALS:

- *MAKE TRANSPORTATION SAFER*
- *PROVIDE GREAT CUSTOMER SERVICE*
- *DELIVER AND MAINTAIN OUR INFRASTRUCTURE EFFECTIVELY AND EFFICIENTLY*
- *IMPROVE THE RELIABILITY AND CONNECTIVITY OF THE TRANSPORTATION SYSTEM*
- *PROMOTE ECONOMIC GROWTH THROUGH BETTER USE OF OUR INFRASTRUCTURE*
- *MAKE OUR ORGANIZATION A GREAT PLACE TO WORK*

Figure 1-1: NCDOT Goals

The TRANSPORTATION ASSET MANAGEMENT PLAN (TAMP) is a strategic framework for considering the full life cycle cost and performance of transportation infrastructure. Long-term cost is minimized, and overall life and system-wide performance is maximized. The TAMP documents considerations for preserving the entire network of bridge and pavement assets.

In 2012 the United States Congress passed MAP-21, which established the requirement that state DOTs meet specific performance requirements for the National Highway System (NHS). The final rules transformed the federal-aid transportation funding programs, identified national transportation goals, increased the accountability and transparency, and promoted improved project decision making through performance-based planning and programming. Seven national goal areas for performance management were established, with this document focusing on the second:

1. **Safety**
   To achieve reduction in fatalities and serious injuries
2. **Infrastructure Condition**
   Maintain highway infrastructure in a state of good repair
3. **Congestion Reduction**
   Reduce congestion on the NHS
4. **System Reliability**
   Improve the efficiency of the surface transportation system
5. **Freight Movement and Economic Vitality**
   Improve freight networks, help rural communities with access to trade markets, and support economic development
6. **Environmental Sustainability**
   Improve performance of the surface transportation system while protecting and enhancing the environment
7. **Reduce Project Delivery Delays**
   Reduce project delays and accelerate completion

The Department is headed by the Secretary of Transportation and a 19-member Board of Transportation (BOT). The BOT serves as a governing body and assists in making decisions and approving allocation of funds. The Department also includes the Governor's Highway Safety Program, Division of Motor Vehicles, Turnpike Authority, State Ports Authority, and Global TransPark.

North Carolina has major tourist destinations with heavily traveled routes from the mountains to the sea. Agriculture and manufacturing industries which are vital to the state and national economies rely on the state's transportation infrastructure. North Carolina is also home to numerous medical, educational, and military sites.

NCDOT's mission is:

> *Connecting people, products, and places safely and efficiently with customer focus, accountability, and environmental sensitivity to enhance the economy and vitality of North Carolina.*

Figure 1-2: NCDOT Mission

Six goals support this mission:

GOAL 1: Make our transportation network safer

Safety initiatives directed at meeting the first goal include the Spot Safety Program which funds small projects to improve site distance, correct road geometry, and other changes that address known areas with elevated crash rates; the intelligent transportation systems that provides advanced warning of delays or incidents along major corridors; and the Incident Management Assistance Patrol (IMAP) program that responds to motorists along major highways. Crash data is used to identify areas for potential safety improvements. A pavement friction testing program has been ongoing for over 25 years. Critical findings from bridge inspections are tracked and promptly addressed.

GOAL 2: Provide GREAT customer service

NCDOT maintains the second largest road network in the country. By state law there are no county roads, although there are municipal streets and some roads owned by other entities. Therefore, virtually every citizen is a direct customer. Most customers interact with NCDOT through the local county maintenance yards or district offices. There is a toll-free number (1-877-DOT-4YOU) for customers to call for questions or to report potholes or other infrastructure defects. Customer service also consists of attending public meetings, interacting with citizens during right-of-way acquisitions, and other situations that require sensitivity and poise.

The Department also interacts with Metropolitan Planning Organizations (MPOs) and Rural Planning Organizations (RPOs). Both MPOs and RPOs participate in the development and prioritization of projects for the Statewide Transportation Improvement Program (STIP). NCDOT has 14 geographic highway divisions, each led by a Division Engineer. One of the many responsibilities of the Division Engineer is to work with MPOs and RPOs in their area, ensuring good communication with these partners. The Division Engineer also attends city council meetings, county commissioner meetings, and other public forums to address citizen questions and concerns.

Another significant stakeholder of NCDOT is the NCGA, which guides the Department through funding and law. They are among the agency's biggest customers for asset management system analyses, and DOT personnel strive to provide reports that assist in their oversight.

GOAL 3: Deliver and maintain our infrastructure effectively and efficiently

The goal of delivering and maintaining infrastructure effectively and efficiently is directly related to asset management and the TAMP. The Department relies on Asset Management System (AMS) software which incorporates data provided by maintenance condition assessments, pavement distress assessments, and bridge inspections. This data is used to drive funding decisions in a needs-based allocation process. It also is used to identify project lists for interstate maintenance, pavement and bridge preservation, pavement and bridge rehabilitation, bridge maintenance, and bridge replacement. This data supports engineering judgement to combine pavement sections into logical contracts. Central units work with the field divisions to finalize project limits and identify appropriate treatments. The goal of maintaining the infrastructure includes:

- applied research to improve processes or materials,
- design of roads and bridges to address current and future needs,
- materials and construction controls to assure that projects are built to last for the design period,
- funding allocation to assure that levels of service goals are attained,
- central staff who coordinate the data collection and use the software systems to perform the analysis,
- field division personnel who maintain roads and bridges daily, and
- delivery of pavement and bridge projects on time and on schedule.

GOAL 4: Improve the reliability and connectivity of the transportation system

Improvements here are often the result of local input. Urban improvements include roundabouts and smart streets to reduce turning queues. Urban loops offer alternate routes that avoid signal delay in cities and towns. The BOT approved Strategic Transportation Corridors that identify key connections required for this goal as well as goals in economic development.

This goal of improving the reliability and connectivity of the transportation system is therefore directly linked to national performance goals for system reliability in terms of freight movement, and congestion mitigation.

GOAL 5: Promote economic growth through better use of our infrastructure

Infrastructure condition is frequently cited by industry in deciding where to expand. Access regional hubs, general aviation and international airports, train stations, seaports, and inland freight facilities drive economic development. Employees for these expansions must also be served by a safe and efficient transportation network.

GOAL 6: Make our organization a great place to work

NCDOT strives to be a great place to work, providing challenging and satisfying work for its employees. Camaraderie is strongest when responding to natural disasters. Employees often relocate to affected areas outside their divisions where they stay to clear debris, repair pipes, repair roads, and all other aspects of recovery. Employee safety is a high priority, with specific goals to reduce accidents, fatalities, and Worker's Compensation claims.

Department goals correlate to federal performance goals as follows:

NCDOT Goal	MAP- 21 National Performance Goal
Make transportation safer	Infrastructure Condition (Bridge and pavement condition on NHS), freight movement, and safety
Provide GREAT customer service	NA
Deliver and maintain our infrastructure effectively and efficiently	Infrastructure Condition (Bridge and pavement condition on NHS), public transportation state of good repair.
Improve the reliability and connectivity of the transportation system	System Reliability; i.e., Freight movement, Interstate and NHS performance, congestion mitigation.
Promote economic growth through better use of our infrastructure	System Reliability; i.e., Freight movement, Interstate and NHS performance, congestion mitigation.
Make our organization a great place to work	NA

Table 1-1: Relation of NCDOT to MAP-21 Goals

These goals are all important but compete for limited funding – a challenge faced by all agencies when resources are limited. Competing needs must be compared to optimize the distribution of funds. The TAMP is part of the mechanism for accomplishing this need.

1.1 The Transportation Asset Management Plan

Development of a TAMP and annual certification is required under FHWA rulemaking. This ensures states are using data-driven approaches in expending federal funds. Comparing outcomes of states with inconsistent measures was difficult. Federal performance measures apply to all states, allowing for effective comparison.

Performance measures provide an annual snapshot of infrastructure condition. The TAMP takes that snapshot with historical condition data in a strategic approach to reach targets. It is a long-term plan where each short-term program of projects fits in to incrementally sustain or improve conditions.

The TAMP will work in concert with the Department's existing asset management plans: primarily MOPAR, HMIP, and most recently the NCDOT Resilience Strategy Report. It will also incorporate components of the Statewide Long-Range Transportation Plan (SLRTP) as applicable to the performance and condition of pavements and bridges on the NHS.

This document represents the intermediate timeframe. It includes gap analyses, life cycle cost, risk, as well as an investment strategy and a 10-year financial plan. It provides a detailed analysis of the data used to describe the condition of pavements and bridges on the NHS and projects future condition based on investment strategies to maintain a state of good repair.

These interrelated plans require coordination and conversation both internally and externally. To achieve this, the development of the TAMP was coordinated by an executive committee including the Chief Engineer, Chief Operating Officer, Deputy Secretary, Chief Information Officer, Director of Performance Management, and Transportation Planning Division Branch Manager. Two subcommittees

represented the pavements and bridges asset classes. These subcommittees included representatives from an MPO and an RPO and subject matter experts from the Pavement Management Unit, Structures Management Unit, and other experts. FHWA was also represented on each of the three committees. An additional workgroup was added to address the 10-year financial plan. The office of the Chief Engineer is responsible for the development, implementation, management, and updating of the TAMP.

1.2 Organization of the Transportation Asset Management Plan

Chapter 1 – Transportation Asset Management Objectives
Describes the purpose of the TAMP and an overview of the Department's mission and goals.

Chapter 2 – Asset Inventory and Condition.
Includes a summary of assets managed by NCDOT and their condition.

Chapter 3 – Performance Goals and Targets.
Contains a description of the process and the results of the gap analyses for both pavements and bridges. It provides a system overview of the condition of NHS pavements and bridges.

Chapter 4 – Life-cycle Planning
Describes the system-wide life cycle cost analysis process. It provides a description of the process NCDOT uses to analyze the state's pavement and bridges over their whole life for minimizing cost while preserving or improving the condition.

Chapter 5 – Risk Management Analysis.
Discusses risk analyses, along with a description of the process used to identify, analyze, prioritize, evaluate, and address risks. A risk register is provided along with a mitigation plan for the top risks. A summary is provided from the evaluation that was performed of the facilities that have repeatedly been damaged by emergency events.

Chapter 6 – Financial Plan and Investment Strategies
Consists of the 10-year financial plan that identifies the sources of revenue and estimated budget allocations to major funding programs. This section also includes funding options and investment strategies and inclusion of Pavement Management System (PMS) and Bridge Management System (BMS) analysis for determining optimal asset investments.

2. INVENTORY AND CONDITION

2.0 NCDOT ASSETS

For this TAMP, "asset" is defined as in 23 CFR 515.5:

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

The scope of assets classes herein is limited to pavement and bridges both on and off the NHS. North Carolina does not have county-maintained roads, therefore NCDOT maintains most statewide highway road mileage and their associated asset subclasses. The rest are maintained by municipalities, federal agencies, and other state agencies.

NCDOT manages state funding based at the program level rather than by system. Some federal funds are required to be used on the NHS or interstate system class. Historical trends show that meeting performance targets on the entire network correlates to meeting targets on the NHS.

2.1 DATA COLLECTION METHODS

2.1.1 Pavement

NCDOT began using teams of raters to perform manual "windshield" assessments of pavement condition in 1982. Distresses evaluated include alligator cracking, transverse cracking, rutting, raveling, oxidation, bleeding, ride quality, and patching. Raters are given extensive classroom and field training and must pass a test prior to work. Each team is audited by a separate team, who is in turn audited by Department central staff to ensure statewide consistency. Details are available in the PAVEMENT CONDITION SURVEY MANUAL FOR RATERS.

Since 2012, interstate and primary system pavement condition data has been collected through automated sensors that detect a variety of distresses, as well as faulting, rutting, and IRI. Details are available in the NCDOT DIGITAL IMAGERY DISTRESS EVALUATION HANDBOOK, and the NETWORK-LEVEL PAVEMENT CONDITION DATA COLLECTION QUALITY MANAGEMENT PLAN.

In 2018, all secondary distress data was automated in the same manner as primaries. However, it was discovered that the data was inconsistent on routes with low speeds or frequent stops. Therefore, the practice of windshield surveys for the secondary system was reinstated.

2.1.2 Bridge

"Bridge" in this TAMP are synonymous with structures defined by the NBIS to include bridges, culverts, and pipe systems that span at least 20 feet. These structures are inspected on a 24-month cycle but may be inspected more frequently if warranted by poor condition ratings or other factors. Underwater inspections are performed on a 48-month cycle when underwater components cannot be assessed during an above-water inspection. Details are available in the STRUCTURES MANAGEMENT UNIT INSPECTION MANUAL.

NCDOT collects and stores bridge inspection data and reports for all state and locally owned bridges in North Carolina within the Bridge Management System. Bridge inspection data for all state and locally owned bridges on and off the NHS is collected in accordance with the requirements of NBIS. NCDOT collects data on all NHS routes regardless of owner.

2.2 Inventory and Condition

2.2.1 Pavement

The following tables show the various distributions of pavement by owner and system:

Route Class	Total State System		NHS	
	Miles	Lane-miles	Miles	Lane-miles
Interstate	1,396.9	6,684.1	1,395.2	6,677.0
Primary	13,808.3	35,191.7	4,075.0	14,221.1
Secondary	65,113.0	124,126.3	179.0	699.5
Total	**80,318.2**	**166,002.1**	**5,649.2**	**21,597.6**

Table 2-1: Total Pavement Distribution by System

System Owner	NHS Interstate		NHS Non-Interstate	
	Miles	Lane-miles	Miles	Lane-miles
NCDOT	1,395.2	6,677.0	4,254.0	14,920.6
Federal	0.0	0.0	2.3	4.6
Local	0.0	0.0	43.6	159.2
Total	**1,395.2**	**6,677.0**	**4,299.9**	**15,084.4**

Table 2-2: NHS Pavement Distribution by Owner

National performance management measures for pavements identified in 23 CFR Part 490 established four measures to assess pavement condition:

1. Percentage of pavements (lane miles) on the interstate system in “good” condition
2. Percentage of pavements (lane miles) on the interstate system in “poor” condition
3. Percentage of pavements (lane miles) on the non-interstate NHS in “good” condition
4. Percentage of pavements (lane miles) on the non-interstate NHS in “poor” condition

Historical pavement condition levels plotted against two- and four-year condition targets (*discussed in Chapter 3*) are below. Of note, condition rating values come from FHWA’s state HPMS scorecards.

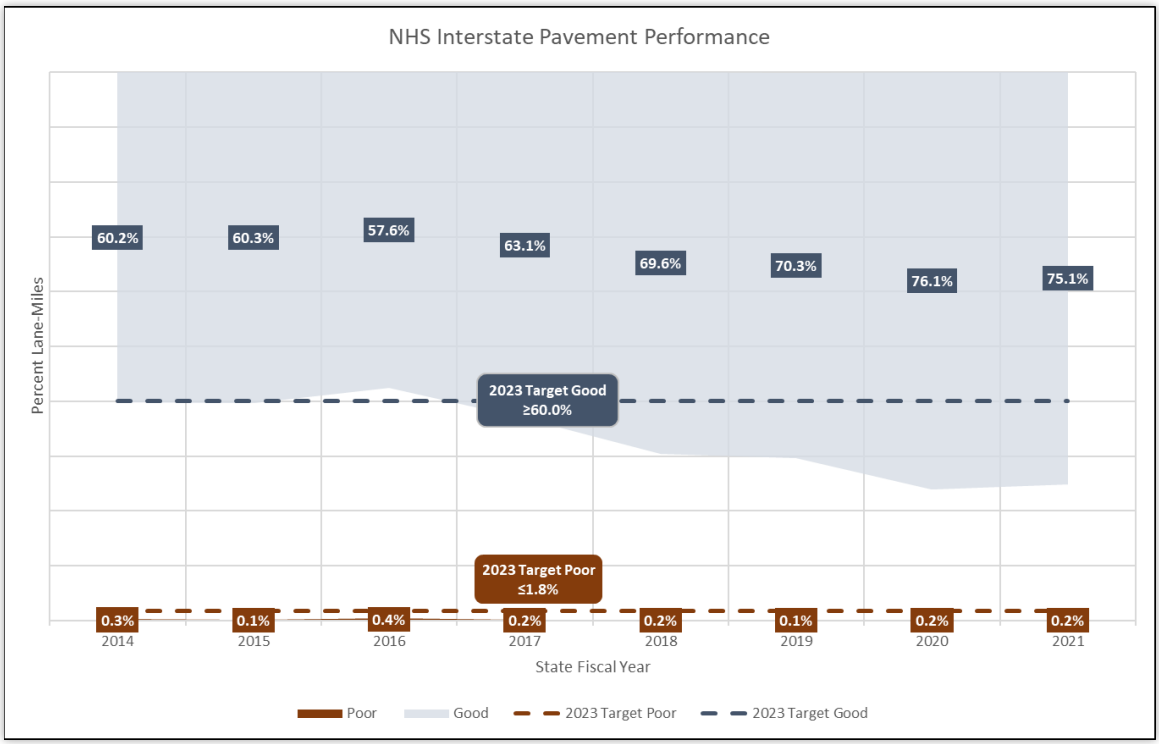


Figure 2-1: NHS Interstate Pavement Performance

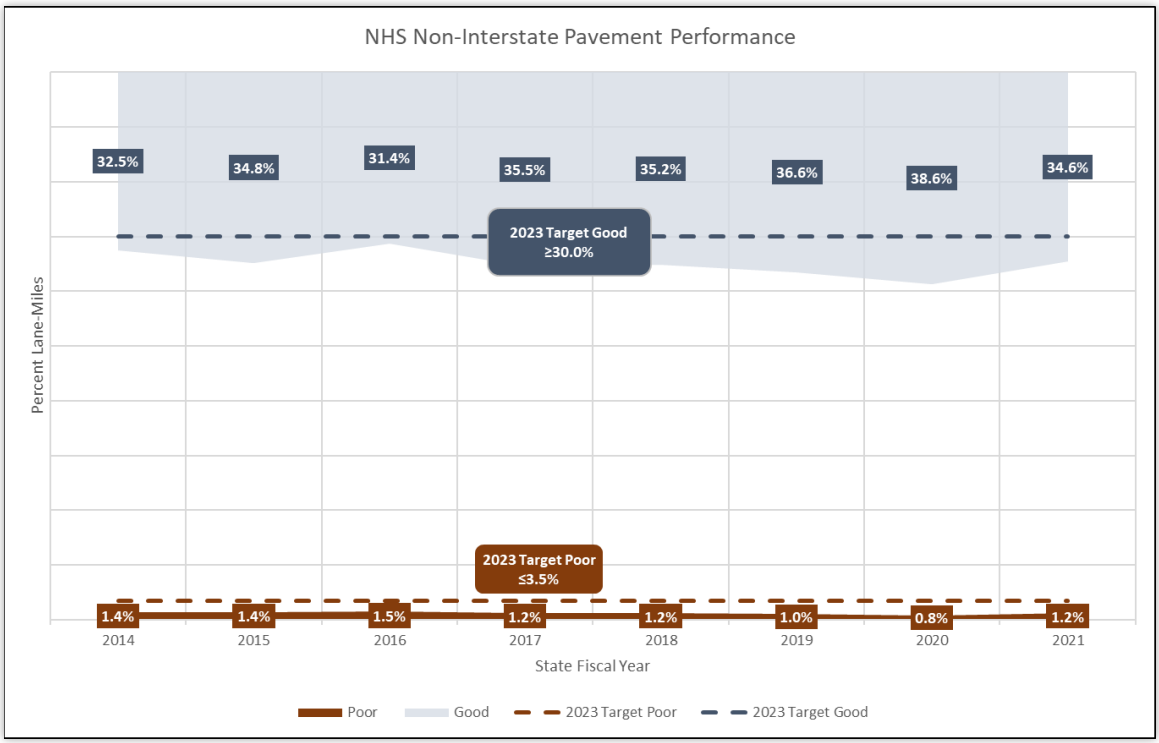


Figure 2-2: NHS Non-Interstate Pavement Performance

2.2.2 Bridge

The Department maintains 18,438 structures which include 13,647 bridges and 4,791 culverts (*as of March, 2022, submission of National Bridge Inventory data*). Of those, 3,780 bridges are on the NHS. All but 23 of them are state-owned and maintained. NHS bridges with a condition rating of poor have a total deck area of 1,556,052 square feet. Of note, one bridge makes up 30% of the square feet of those poor bridges.

As shown below, approximately 2.83% of state and locally owned NHS bridges are poor (*based on deck area*) as compared to the federal standard of no more than 10% poor. By system, 1.80% of bridges on the interstate system are poor, 3.48% on the primary system are poor, and 4.23% of the bridges on the secondary system are poor. Locally owned/maintained bridges make up 0.5% of the total NHS bridges with none of them falling into the poor category.

System	Owner	NHS Bridges & Culverts	Deck Area (SF)	Poor Deck Area (SF)	% Poor	Good Deck Area (SF)	% Good
Interstate	State	1,400	21,322,119	383,548	1.80%	10,761,860	50.47%
Primary	State	2,246	32,251,069	1,120,740	3.48%	13,871,965	43.01%
Secondary	State	111	1,223,928	51,764	4.23%	517,882	42.31%
Local GOV	Local GOV	23	210,164	0	0.00%	114,269	54.37%
Total	State	3,757	54,797,116	1,556,052	2.84%	25,151,707	45.90%
	Local	23	210,164	0	0.00%	114,269	54.37%
	Total	3,780	55,007,280	1,556,052	2.83%	25,265,976	45.93%

Table 2-3: NHS Bridge Inventory & Condition

Condition ratings for bridges were established based on a nine-point rating on each of three components: deck, superstructure, and substructure. Culverts are similarly rated on overall condition. The following table relates condition score to qualitative conditions:

Element Rating	Condition Score
Good	7 to 9
Fair	5 to 6
Poor	0 to 4

Table 2-4: Bridge Qualitative Condition Scores

The overall condition of a bridge is considered “good” only if all three components are “good”. It is considered “poor” if any one of the three components are “poor”. The bridge is otherwise considered “fair”. Culverts rated solely on their overall condition.

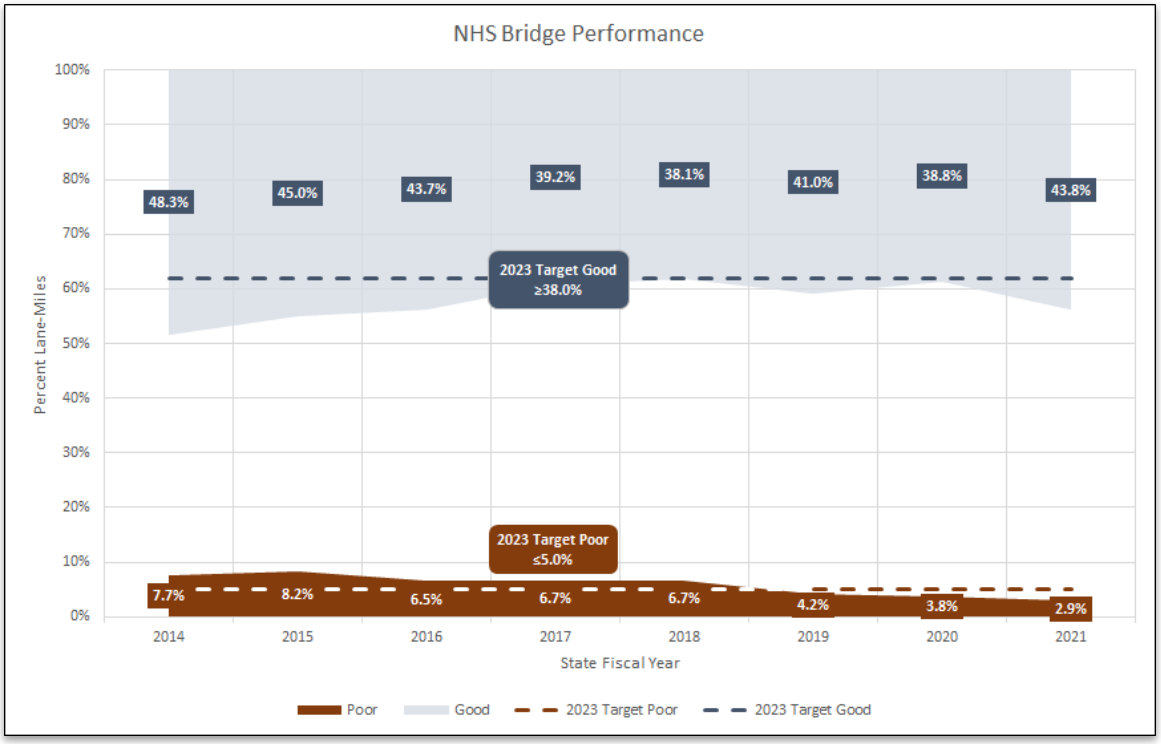


Figure 2-3: NHS Bridge Performance

3. PERFORMANCE

3.0 OVERVIEW

Establishing performance measures and targets is fundamental to an effective asset management plan. It helps in determining the success of strategic asset management initiatives and provides transparency. Condition data is managed through an asset management system (AMS) with separate modules for pavement (PMS) and bridge (BMS) assets.

NCDOT collects information on the condition of pavements and bridges throughout the state to evaluate the transportation system's performance. Performance measures and targets were established based on the operations, future conditions, and maintenance of the roadway system in conjunction with customer input. These performance measures have served as a good basis for NCDOT to determine investment strategy, funding amounts, and project identification and provide a good foundation for the TAMP.

NCDOT tracks pavement and bridge conditions in the AMS. The historic condition for each of the measurable conditions tracked are shown in Chapter 2. For pavement metrics, NCDOT collects pavement condition data through an automated process which is used to calculate a Pavement Condition Rating (PCR) for each segment of highway. The PCRs of each highway segment are used to calculate a summary score, Pavement Condition Index (PCI) for a highway or highway network which is a gauge of the overall condition of the highway. For bridges, inspectors rate the general condition of the culverts, bridge decks, bridge superstructures, bridge substructures. NCDOT stores and tracks this data, along with element level condition data, geometric data, and geographic data for each bridge. The general condition ratings are used to determine the overall condition of the bridge or culvert. For large culverts (*greater than 20' along the centerline of the highway*), NCDOT tracks the overall condition.

3.1 TARGETS

23 CFR Part 490 required state DOTs to establish performance targets for NHS pavement and bridges. Department staff developed and continue to update these targets with local stakeholders and external consultants. An update to two- and four-year targets is due in December of 2022, past the submission date of this document. Substantial efforts will continue to take place to deliver those targets by October, to include condition projection cones of probability. In the meantime, Department staff met with the consultant for an abbreviated review to set tentative targets. Those targets are listed below and will be updated in the future as warranted by the final determination in October.

2023 Target NHS Asset	Unit of Measure	2023 Target		2025 Target	
		% Good	% Poor	% Good	% Poor
Interstate	Lane-mile	≥ 60.0	≤ 1.8	≥ 62.0	≤ 1.5
Non-Interstate	Lane-mile	≥ 30.0	≤ 3.5	≥ 31.0	≤ 3.0
Bridge	Deck area (sf)	≥ 38.0	≤ 5.0	≥ 36.0	≤ 5.0

Table 3-1: NHS Condition Targets

3.1.1 Pavement

The PM2 rule specifies that state DOTs must establish pavement condition targets for the full extent of the Interstate and of the non-Interstate NHS, regardless of ownership. Subcomponents to be measured for pavement condition include IRI, cracking, rutting, and faulting as described in 23 CFR 490.313. It is important to note the IRI, Cracking percent, rutting, and faulting apply to all travel lanes, and excludes ramps, shoulders, turn lanes, crossovers, and rest areas. Per federal regulation there is a threshold for no more than 5% of Interstate pavements to be allowed to be in "Poor" condition. However, this minimum excludes bridges and invalid/missing data and non-interstate NHS pavement. If the minimum is not met for any year, the State must then obligate NHPP funds and transfer STP funds to improve pavement.

States were first required to report only full-extent distress and IRI data on the non-Interstate NHS to HPMS prior in 2021. NCDOT's 2-year and 4- year targets for non-Interstate NHS pavement condition measures are based on full-distress plus IRI data.

3.1.2 Bridge

In updating NHS performance targets for bridges, deterioration models were run through BMS to project condition in the corresponding two and four years. These deterministic models consider the condition history and deterioration rate of each component. While these models are found to be accurate in the long term, the models often over-predict deterioration in the first three years. To overcome this short-term deficiency, Department staff refine the model through manual assessment of element-level condition data. For target development, any "poor" bridge currently being replaced was removed from the overall score, and any bridge anticipated to be completed and inspected prior to the target date was projected to be in "good" condition. Culverts were incorporated by projecting a 5-year historical average of condition.

It is worth noting that several large bridges on the NHS can have a disproportionate effect on the overall bridge condition. For example, the Virginia Dare Memorial Bridge accounts for 3.5% of the total NHS deck area. It is currently listed in "good" condition with a score of "7" on each component. In accordance with the rating methodology described above, if one of these components falls to a 6, the entire deck area will fall to "fair".

3.2 CONDITION PROJECTION

3.2.1 Pavement

The following 10 year good/poor projections were developed using a combination of historic data and Pavement Management System analysis tools. This process began with running a 10-year optimization analysis on the entire North Carolina highway system to determine a projected statewide pavement rating for all systems. This analysis was based on the projected funding levels for pavement funding sources over the next decade as detailed in Chapter 6.

The NCDOT PMS optimizes benefits and costs based on North Carolina specific treatments and research-driven pavement deterioration models and decision trees. The analysis and reported results are based on NCDOT-defined management sections and for NCDOT defined metrics, such as the Pavement Condition Rating.

To connect the outputs of state-based results to the necessary Federal measures, a comparison was conducted between state and Federal data by using seven years of historical data for both the NCDOT and Federal measures. A correlation trendline was developed relating this historic data. This trendline was then used to project the future 10-year Federal results based on the NCDOT outputs for Interstate and Non-Interstate NHS routes. This analysis is fully repeatable based on the inputs such as funding level, decision trees, and road system classification.

NCDOT has partnered with a consultant and is in the process of scoping enhancements to the Pavement Management System with the overall goal of developing a more robust analysis process. One of the key improvements of this new enhanced process will allow the Department to perform the Map-21 10-year projections and target setting completely within the Department's Asset Management System. The updated analysis capability will include options to use data from and outputs for State or Federal metrics. It will include various output formats such as graphs, charts, tabular spreadsheets, and maps. This will eliminate the need for historical trend analyses for conversion between State and Federal metrics.

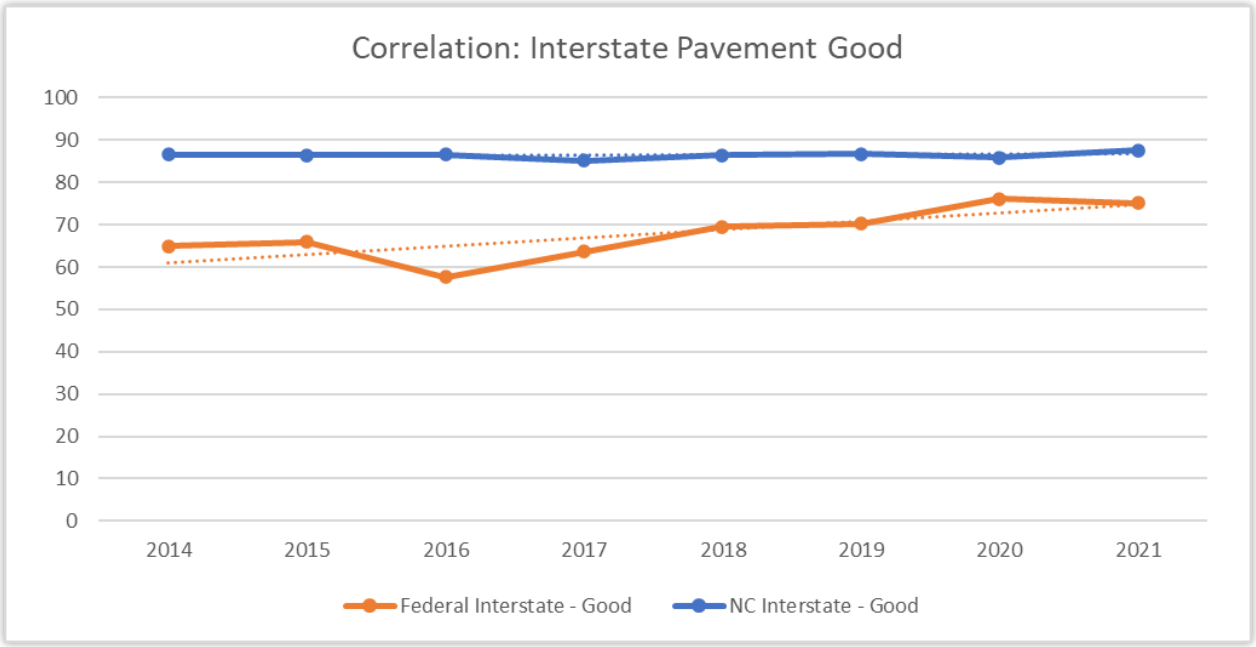


Figure 3-1: Correlation: Interstate Pavement Good

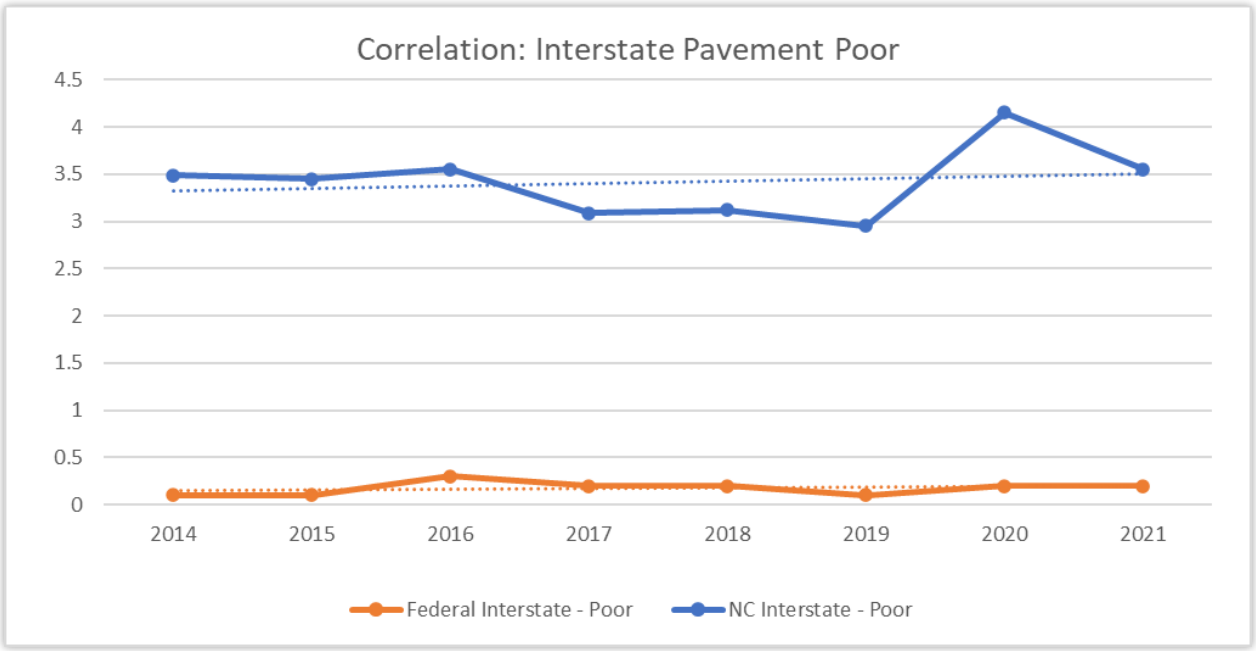


Figure 3-2: Correlation: Interstate Pavement Poor

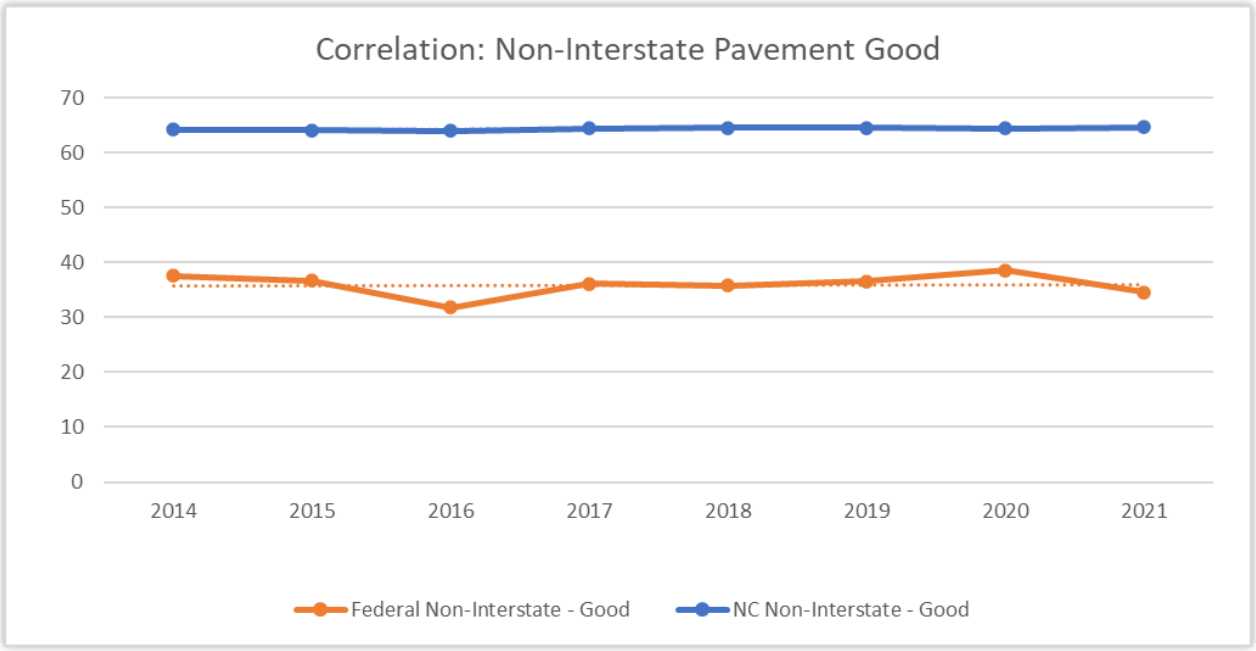


Figure 3-3: Correlation: Non-Interstate Pavement Good

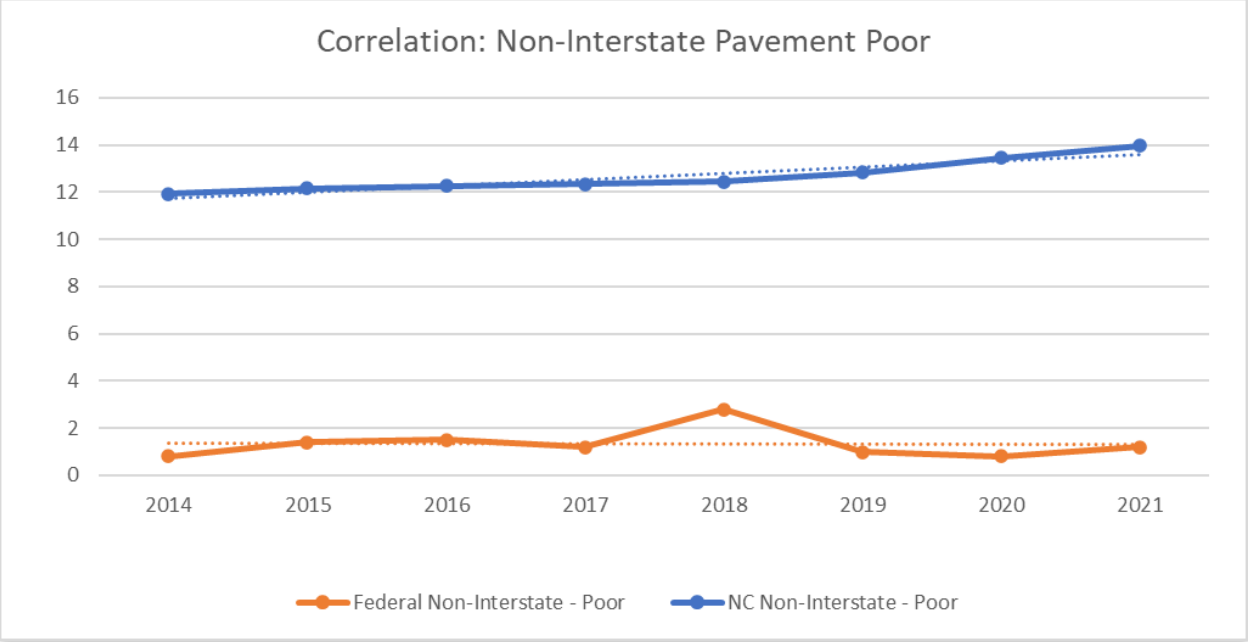


Figure 3-4: Correlation: Non-Interstate Pavement Poor

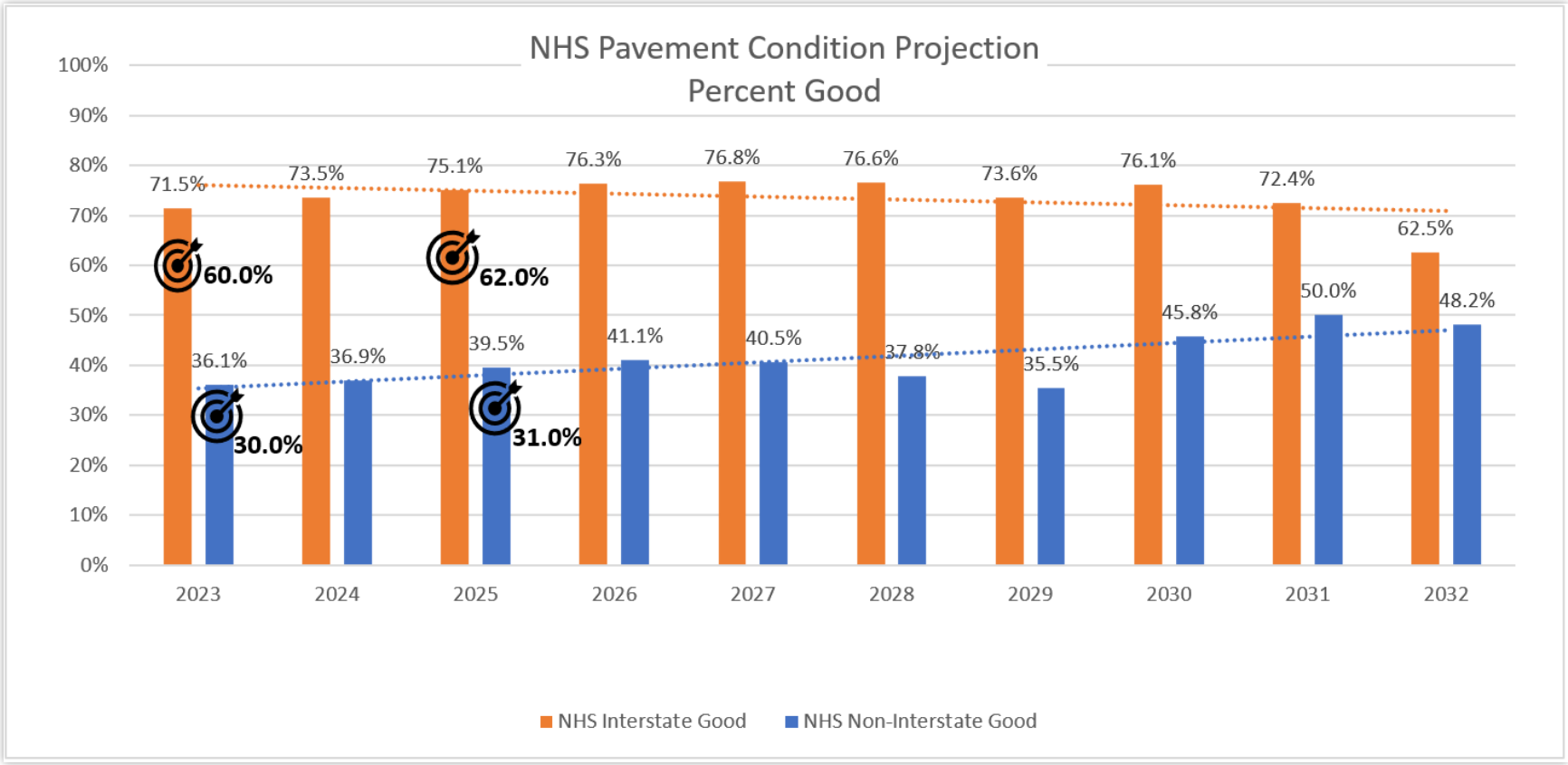


Figure 3-5: NHS Pavement Condition Projection, Good

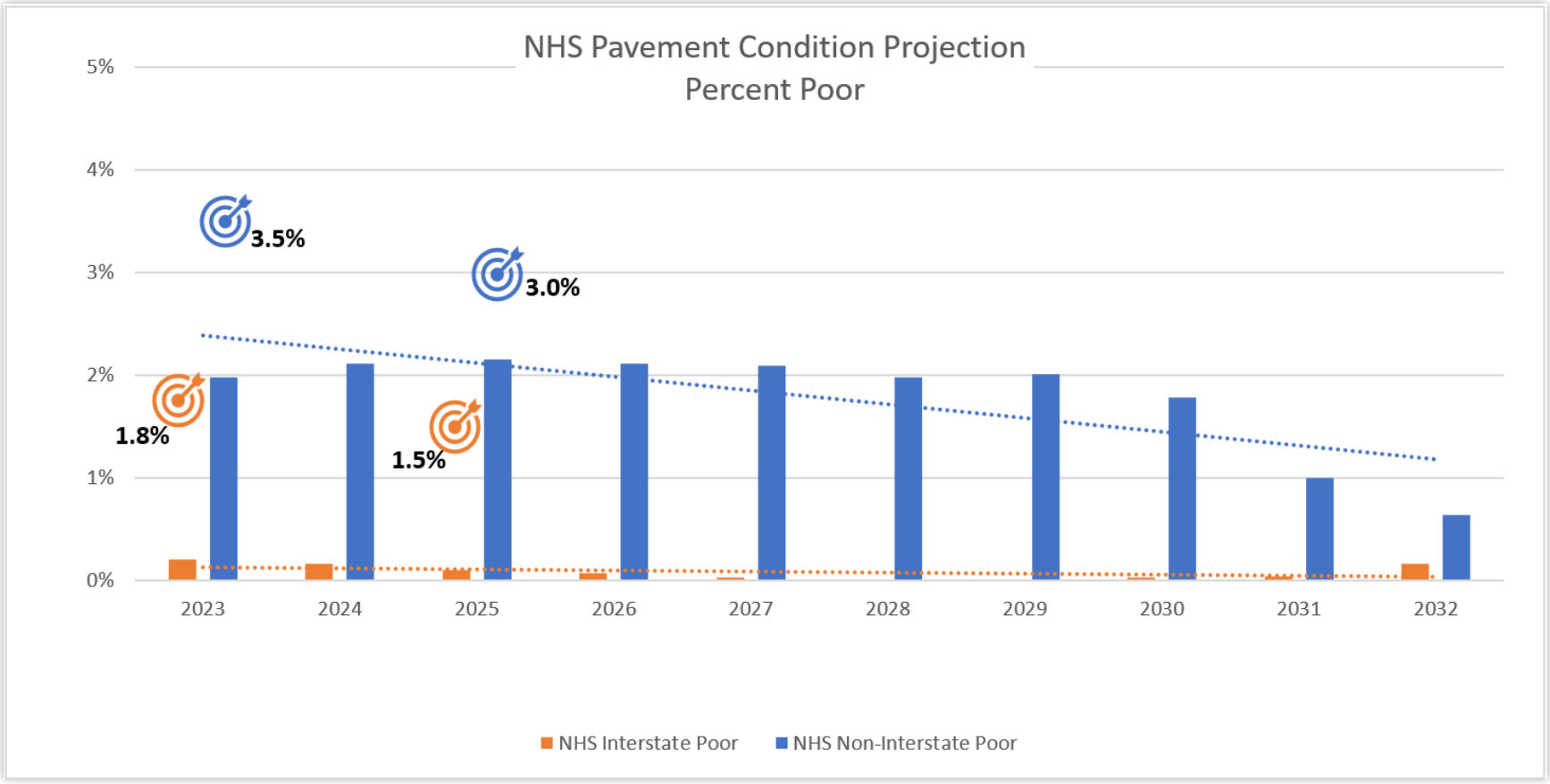


Figure 3-6: NHS Pavement Condition Projection, Poor

3.2.2 Bridge

The following 10 year good/poor projections were developed using a combination of historic data and Bridge Management System analysis tools. This process began with running a 10-year analysis for all NHS bridges to determine projected bridge condition. The analysis considered the condition history and deterioration rate of the bridge's deck, superstructure, and substructure components. Bridges currently under construction and the Department's 5-year Bridge Management Improvement Plan (BMIP) were incorporated into the analysis to determine projected NHS bridge condition needs. These needs were then compared to the projected funding levels for bridge funding sources over the next decade as detailed in Chapter 6.

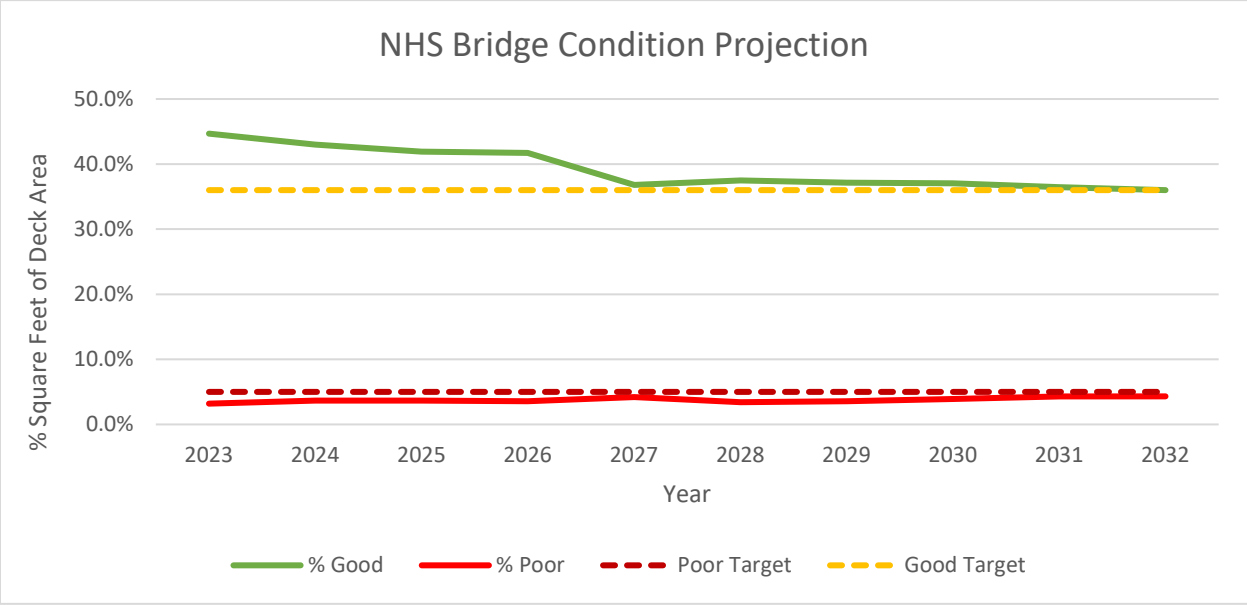


Figure 3-7: NHS Bridge Condition Projection

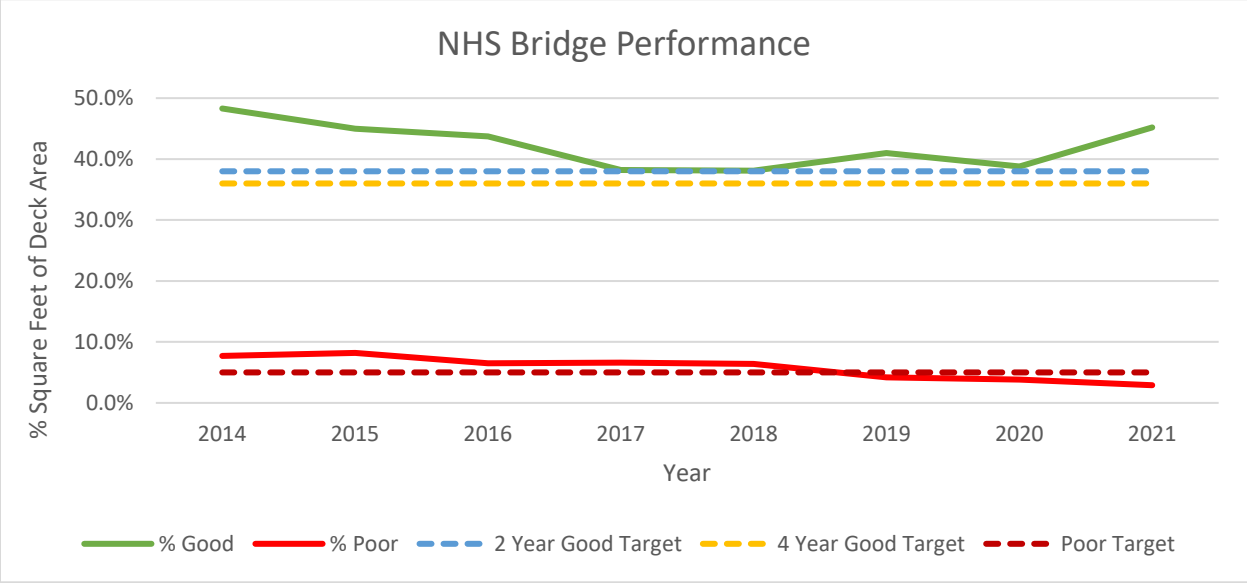


Figure 3-8: NHS Bridge Performance

4. LIFECYCLE PLANNING

4.0 REQUIREMENTS AND DEFINITIONS

23 CFR 515.7(b):

> *A State DOT shall establish a process for conducting life cycle planning for an asset class or asset sub-group at the network level (network to be defined by the State DOT). As a State DOT develops its life cycle planning process, the State DOT should include future changes in demand; information on current and future environmental conditions including extreme weather events, climate change, and seismic activity; and other factors that could impact whole of life costs of assets. The State DOT may propose excluding one or more asset sub-groups from its life cycle planning if the State DOT can demonstrate to FHWA the exclusion of the asset sub-group would have no material adverse effect on the development of sound investment strategies due to the limited number of assets in the asset sub-group, the low level of cost associated with managing the assets in that asset sub-group, or other justifiable reasons. A life cycle planning process shall, at a minimum, include the following:*
>
> 1. *The State DOT targets for asset condition for each asset class or asset sub-group;*
> 2. *Identification of deterioration models for each asset class or asset sub-group, if identification of deterioration models for assets other than NHS pavements and bridges is optional;*
> 3. *Potential work types across the whole life of each asset class or asset sub-group with their relative unit cost; and*
> 4. *A strategy for managing each asset class or asset sub-group by minimizing its life-cycle costs, while achieving the State DOT targets for asset condition for NHS pavements and bridges under 23 U.S.C. 150(d).*

23 CFR 515.5:

> *Life-cycle cost means the cost of managing an asset class or asset sub-group for its whole life, from initial construction to its replacement.*
>
> *Life-cycle planning means a process to estimate the cost of managing an asset class, or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition.*

Life Cycle Cost (LCC) refers to all costs associated with an asset over its lifetime including construction, maintenance, preservation, rehabilitation, and reconstruction. The LCC is estimated with deterioration models and unit costs. Through iterative scenario analyses, the optimal schedule recommended treatment is determined.

4.1 Life Cycle Planning Analysis

Life cycle cost (LCC) planning is used to capture likely costs of an asset over its useful life. Cost phases include initial construction, maintenance, preservation, rehabilitation, and reconstruction. LCC planning includes assessing alternatives to meet the structural and performance objectives. Deterioration models estimate an asset's condition as it ages based on factors such as environment, severe weather, and heavy vehicle loadings. A standard schedule and estimated cost of activities to maintain an asset's condition at a target performance level is defined. All these considerations facilitate selecting the most effective options to maintain a desired condition at a minimum practicable cost.

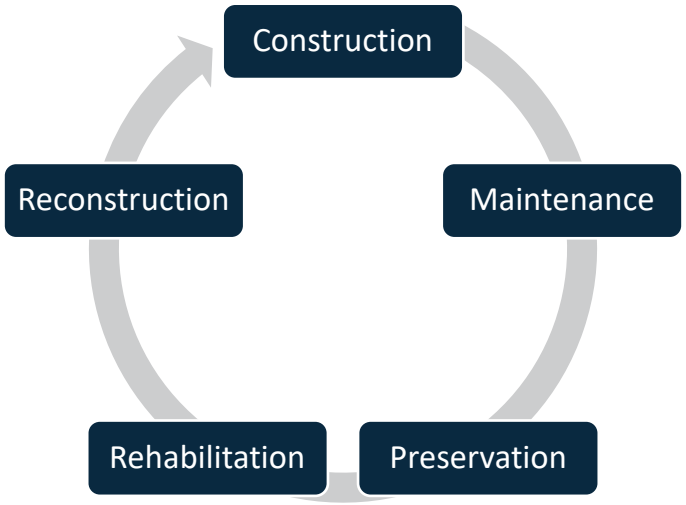


Figure 4-1: Life Cycle Phases

An example of the concept behind the benefits of implementing a lowest whole-life cost philosophy, a classic pavement deterioration curve is shown below. This curve demonstrates the goal of a preservation program. By providing less costly treatments while the pavement is in good condition, the time to costlier pavement rehabilitation is extended.

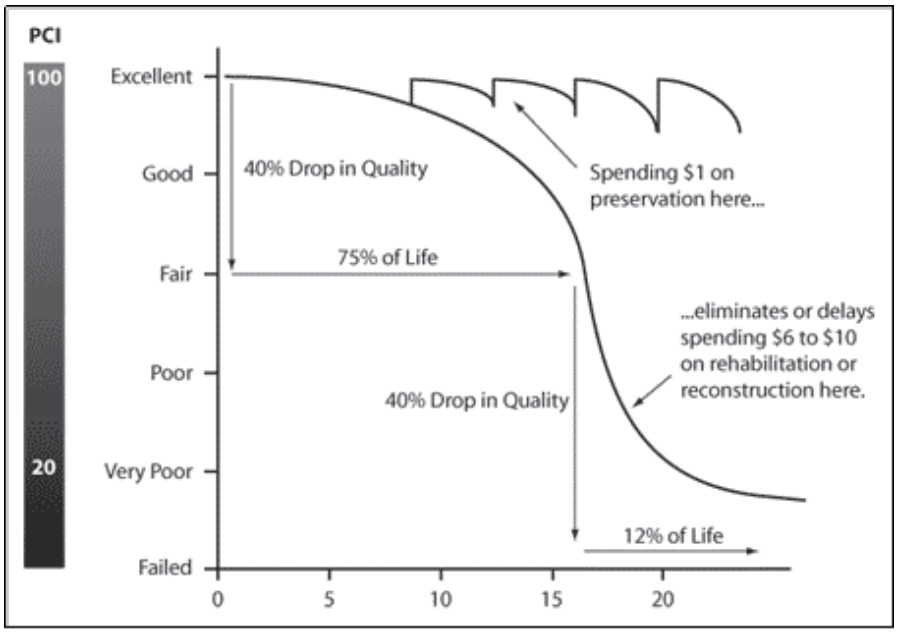


Figure 4-2: Pavement Deterioration Curve

4.2 Life Cycle Cost Process

The Department uses its AMS to perform LCC analyses on all state-owned pavement and bridge assets. The LCC analysis used performance measures and targets that NCDOT established prior to FHWA's final rule. The Department's performance measures and targets are shown below. An oversight committee consisting of key managers facilitated development of performance targets.

ASSET	SYSTEM	STATE PERFORMANCE MEASURE	STATE TARGET
Pavements (Good)	Interstate	PCI ≥ 80 (Good)	≥ 85%
	Primary	PCI ≥ 80 (Good)	≥ 80%
	Secondary	PCI ≥ 80 (Good)	≥ 70%
Pavements (Poor)	Interstate	PCI ≤ 60 (Poor)	≤ 5%
	Primary	PCI ≤ 60 (Poor)	≤ 7.5%
	Secondary	PCI ≤ 60 (Poor)	≤ 10%
Bridges	Interstate	Structural Deficiency	< 2%
	Primary	Structural Deficiency	< 6%
	Secondary	Structural Deficiency	< 15%
Culverts (NBIS)	Interstate	Condition rating ≥ 6	≥ 85%
	Primary	Condition rating ≥ 6	≥ 80%
	Secondary	Condition rating ≥ 6	≥ 75%

Table 4-1: State Asset Targets

A culture of asset management awareness is maintained through performance management. Measures and targets are linked to the overall goals and objectives of the agency considering available funds. The AMS facilitates "what-if" scenarios based on funding levels and investment strategies in the different work phases and types; it does this through iterative algorithms considering present condition, performance targets, and deterioration models.

Performance targets determine if the asset's condition is meeting expectations. The AMS provides reports at the network level to enable managers to gauge success in meeting goals and performance targets. Reports evaluated include:

- Historical expenditures, type of treatments (*work types*), and resulting performance by system
- Overall condition by system
- Estimated funding levels to achieve specified condition, by system, 10-year projection
- Estimated condition based on funding scenarios by system, 10-year projection
- Treatment work types (*preservation, maintenance, rehabilitation, reconstruction*) by highway system, 10-year cost and quantity projections

The following outline is a generalization of NCDOT's process in using LCC in the development of their annual pavement and bridge management programs. Federally owned and locally owned NHS assets are excluded from the overall LCC analysis since they represent a negligible percentage of total inventory.

4.2.1 Pavement

A condition survey is performed each year on all pavement assets as detailed in Chapter 2. The results of these surveys are used to rate the pavement condition using a Pavement Condition Index (PCI) on a scale of 0 to 100. A segment of pavement with little or no observable defects are in "good" condition. Pavements with more observable defects will trend toward "fair" or "poor".

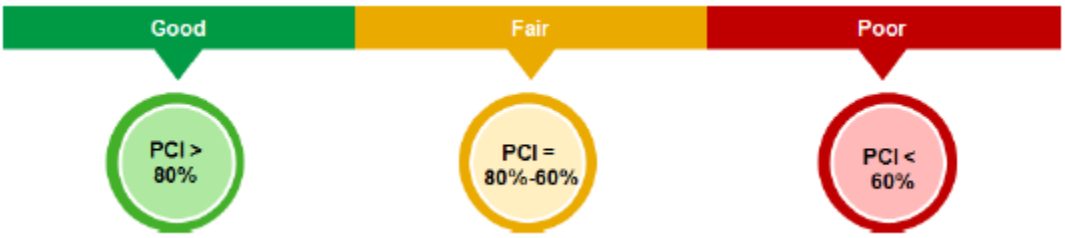


Figure 4-3: Qualitative Pavement Condition Index

Improvements in pavement condition is influenced by activities through state funded programs (*General Maintenance Reserve, Contract Resurfacing, Pavement Preservation*) and the Interstate Maintenance Program created by NCDOT after the Federal Highway Administration Federal Aid Interstate Maintenance program was merged into the National Highway Performance Program (NHPP).

Pavement life cycle planning is managed in the HMIP through the PMS which incorporates decision trees and deterioration models made in conjunction with engineering and academic consultants. Network sections are identified for treatment with the best solution for the lowest lifetime cost with work planned over five years.

By state law, HMIP planning is based on the previous fiscal year's appropriation. This is in part to allow decision makers to assess the consequences of maintaining or modifying funding levels. A list of routes and treatments is reviewed by each highway division with additional local considerations. The formula for portioning statewide appropriations to the division level is subject to change and is currently based primarily on inventory and need, where need is calculated as the expected cost to meet and sustain target conditions.

The final division plans adopted by the Board of Transportation and updated annually to reflect actual appropriations. Modifications are made beyond the first year to account for accelerated deterioration due to severe winter and hurricane conditions, or reprioritization due to local economic development.

For the interstate system, a priority list of projects is created and maintained from data out of the Pavement Management System. The projects are initialized with treatment types, limits, and cost estimates. Each Highway Division reviews projects in their area and provides recommendations based on local knowledge and engineering judgment. These recommendations can include changes to the treatment types, limits, and estimated cost. Senior management reviews the Division recommendations and selects projects from a statewide perspective within fiscal constraints.

4.2.2 Bridge

Bridge inspection results are captured within the BMS and serve as the basis for all condition data. In 2014, over 16% of bridges (*not including culverts*) managed by NCDOT were classified as structurally deficient (SD). Conditions could not be maintained – much less improved – at those staff and funding levels. A goal was established to reduce SD bridges to 10% and provide decision makers with funding options to realize that goal.

The Department has nearly 40 years of bridge condition data which are used to develop deterioration curves. In 2014, those models predicted that an additional 250 bridges would become SD each year if investment levels were maintained. Funding options would need to account closing the gap of those 250 bridges annually along with bringing SD bridges down to the new target over time.

The BMS uses condition data, deterioration curves, and decision trees to recommend optimal improvements based on unit costs. In 2014, these efforts led to the creation of the state Bridge Program for major rehabilitation and replacement. Four investment options were presented to the NCGA considering SD and functionally obsolete (FO) timelines to meet target, shown below.

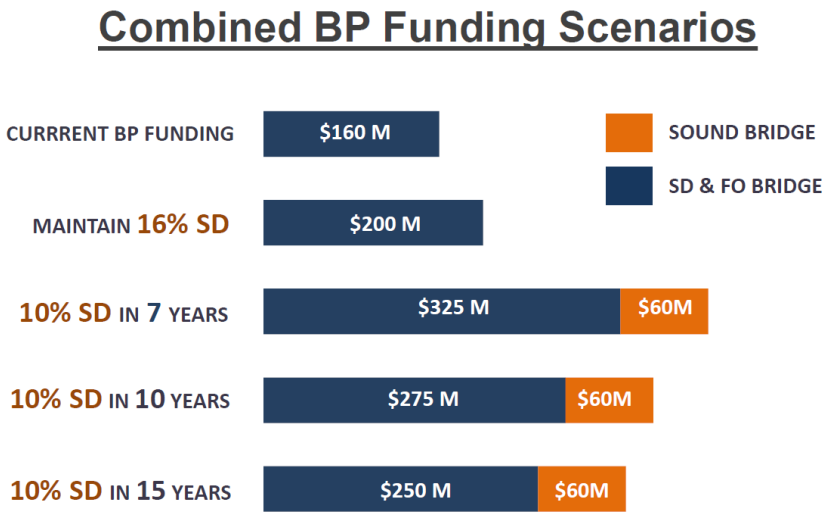


Figure 4-4: Options for 2014 Bridge Program Funding

The NCGA responded favorably and provided state funds corresponding to the 15-year option. The Department continued to work with the NCGA to improve the Bridge Preservation Program (*separate from the Bridge Program*). The Department also conveyed the need to target bridges with disproportionately high cost to replace. With this continued partnership, the state-funded bridge program now (2022) provides $273 million for reconstruction and rehabilitation, and an additional $68 million for preservation each year. Federal funds also support bridge investment, further detailed in Chapter 7.

BMS data and funding levels support a five-year Bridge Management Improvement Plan (BMIP). By state law, BMIP is now a subset of the overall HMIP, but may be referred to distinctly as "BMIP" herein. The BMIP is sectioned into central-managed projects for the interstate and primary systems, and division-managed projects for the secondary system. Overall program funds are apportioned according to a baseline equal share and need to meet the 10% SD target on schedule.

Bridges are prioritized within the BMS by a Priority Replacement Index (PRI) which serves as initial guidance to central and division bridge program managers, who may modify their plan with additional concerns based on local knowledge. The final priority list is updated in BMIP as funding becomes available.

Prioritization under Bridge Preservation is initially based on minimizing overall bridge replacement costs by extending the life of the more costly bridges to replace. Funds from the General Maintenance Reserve are also used to address critical findings and priority maintenance needs identified during NBIS inspections.

Federal Bridge Program projects are selected using NCDOT's ranking system – the Priority Replacement Index (PRI). The PRI produces a score for each structure that is intended to reflect the relative priority for replacement of bridges based on their condition and design, use, and functionality data. Municipal owned bridges are eligible for funding from the Federal Bridge Program with candidate municipal bridges prioritized by their PRI score.

The bridge life cycle planning process is revisited biannually to update budget writers on the status of the overall bridge program. Updated condition data serves to refine deterioration curves against past predictions. Unit costs due to inflation and other external factors are also revisited.

4.3 TREATMENT

4.3.1 Pavement

PMS decision trees select from a suite of work types and their unit costs in optimizing treatment plans. The many work types are broadly grouped into four categories:

1. **Maintenance**
   Routine maintenance includes daily activities that can be reactive or planned, or where timing is within the control of maintenance personnel. Examples include shallow or pothole patching, skin patching, partial-depth patching, repairing concrete corner breaks, and concrete joint repair. This work is typically performed under the state General Maintenance Reserve funding program.

2. **Preservation**
   Pavement preservation treatments prolong a pavement's state of good or fair condition. Flexible pavement treatments include crack sealing, thin overlays, and short mill-and-replace operations. They can also include microsurfacing or application of special wearing surfaces when addressing a functional need. For rigid pavements, treatments include diamond grinding, joint sealant removal and replacement, and a limited amount of full depth and partial depth concrete repairs. Preservation may also include treatment of the flexible shoulders adjacent to the concrete pavement. This work is typically performed under the state Pavement Preservation funding program.

3. **Rehabilitation**
   Pavement rehabilitation is required when condition drops into the poor category. It may also be required when there is a substantial change in road traffic and a thicker pavement section is required to meet future needs. For flexible pavements, deeper milling coupled with some full depth repairs, replacing the milled pavement and overlay with two or more layers would constitute rehabilitation. Rigid pavement rehabilitation tends to include more extensive slab replacements followed by diamond grinding. Jointed concrete pavements may include an ultra-thin bonded wearing course following slab and spall repairs. This work is typically performed under the state Contract Resurfacing funding program.

4. **Reconstruction**
   Pavement reconstruction is considered when the pavement reaches the end of its life cycle. It is typically done for rigid pavements, with flexible pavements being continuously rehabilitated. Reconstruction of continuously reinforced concrete pavements consists of unbonded jointed concrete overlays with a drainable asphalt bond breaker. Reconstruction of jointed concrete pavement could be done with either a new jointed concrete pavement or a flexible pavement sufficient for the present and future traffic projections. This work is typically performed under the state Contract Resurfacing funding program or as a capital project.

4.3.2 Bridge

BMS follows a similar method and categorization as pavements. Typical work types by category include:

1. **Maintenance**
   Spot painting, repairing structural steel, vegetation removal, sweeping/washing bridge decks, cleaning of bridge deck drains, spot deck repairs, navigation light maintenance/replacement, concrete spall repairs, timber component repairs, minor steel repairs, lubrication of bearings. This work is typically performed under the state General Maintenance Reserve funding program.

2. **Preservation**
   Repainting structural steel, deck repairs, and waterproofing deck surface with membrane (*or thin epoxy overlay, polymer modified concrete, reinforced concrete overlay*), object marker replacement, cleaning and sealing or replacement of expansion joints. This work is typically performed under the state Bridge Preservation funding program.

3. **Rehabilitation**
   Bridge deck and expansion joint replacement, scour remediation, bearing replacements, bridge deck overlays, repainting structural steel, shotcrete repairs, and structural steel repairs/strengthening. A rehabilitation project may include full replacement of the superstructure. This work is typically performed under the state Bridge Program funding program.

4. **Reconstruction**
   Include the entire replacement of either a bridge's deck, superstructure, or substructure and may also include major repairs to the deck, superstructure, or substructure. This work is typically performed under the state Bridge Program funding program.

4.4 Asset Management Strategies

A fundamental step in successful asset management is understanding the connection of funding to performance. Formal and informal practices have been implemented that rely on quality data, system processes, and analytics that complement the technical expertise of Department staff and engineering consultants.

4.4.1 Pavement

- Staff specialized in data collection, pavement design, distress analysis, and pavement management systems are responsible for designing, testing, and monitoring the health of pavements on the entire network. PMS is used to manage condition data, history of construction and maintenance, and conduct pavement analyses which assist in optimizing resources. Central staff provide guidance in the selection of candidates for maintenance, preservation, resurfacing, and rehabilitation projects for both rigid and flexible pavement with an emphasis on preventive maintenance to optimize LCC.

- Pavement Condition Index (PCI) is measured on a 100-point scale based on pavement distresses such as ride quality, cracking, rutting, patching, corner breaks, and faulting. PCI is tracked on the entire system to ensure performance goals and targets are met.

- HMIP identifies routes and optimal treatments based on anticipated funding. Results are compared to the Department's long-term "state of good repair" targets and to the targets

established as a part of 23 USC 150(d) for the NHS. Based on the results of the analysis, each division prepares a new HMIP for the next 5-year period using current budget allocations; as one year is complete, another year is added. Results of the annual pavement performance report are used to identify issues, funding needs, and other gaps. Adjustments in program strategy and funding are considered by senior management within the context of the overall vision and funding needs.

4.4.2 Bridges

- Bridge inspections are conducted on a two-year schedule and the condition information is entered into the BMS, which is used to create a prioritized list of bridges within funding sources for use in the 5-year BMIP.
- In recent years, NCDOT has placed an emphasis on reducing the number of structurally deficient bridges to no more 2% for the interstate, 6% on the primary system, and 15% on the secondary system by programming enough funds to reach these goals by 2030.
- The 5-year BMIP I used to progress toward meeting state goals for SD bridges. Performance is estimated based on current condition and budget amounts. Results are compared to long-term "state of good repair" targets, and to the targets established as a part of 23 USC 150(d) for the NHS. Based on BMS analysis, a list of bridges which meet state funding requirements are prioritized using a Priority Replacement Index (PRI). The results of the annual bridge performance report are used to identify issues, funding needs, and other gaps. Adjustments in program strategy and funding are considered by senior management within the context of the overall vision and funding needs.

4.5 Baseline Unit Cost

In December of 2015, the Department submitted its first Baseline Unit Cost (BUC) report to the NCGA as required under S.L. 2015-241 section 29.14(b). This is an annual report with data monitored quarterly that tracks actual division expenditures against established baseline costs of activities including contract resurfacing, pavement preservation, bridge replacement, and ten planned general maintenance activities. The report serves to understand and explain fluctuations in pricing, and aid in unit cost re-evaluation. Some examples of influencing factors include inflation, material cost increases including fuel, labor shortages both in Department staff and contracting partners, and supply chain disruptions. The unit costs for work functions presented in the BUC report are the same as used in AMS in LCC planning. The BUC report is not currently posted to a public forum but is available upon request.

5. Risk Management Analysis

5.0 Requirements and Definitions

23 CFR 517(c):

> *A State DOT shall establish a process for developing a risk management plan. This process shall, at a minimum, produce the following information:*
>
> *(1) Identification of risks that can affect condition of NHS pavements and bridges and the performance of the NHS, including risks associated with current and future environmental conditions, such as extreme weather events, climate change, seismic activity, and risks related to recurring damage and costs as identified through the evaluation of facilities repeated damaged by emergency events carried out under part 667 of this title. Examples of other risk categories include financial risks such as budget uncertainty; operational risks such as asset failure; and strategic risks such as environmental compliance.*
>
> *(2) An assessment of the identified risks in terms of the likelihood of their occurrence and their impact and consequence if they do occur;*
>
> *(3) An evaluation and prioritization of the identified risks;*
>
> *(4) A mitigation plan for addressing the top priority risks;*
>
> *(5) An approach for monitoring the top priority risks; and*
>
> *(6) A summary of the evaluations of facilities repeatedly damaged by emergency events carried out under part 667 of this title that discusses, at a minimum, the results relating to the State's NHS pavements and bridges.*

23 CFR 515.5:

> *Risk means the positive or negative effects of uncertainty or variability upon agency objectives.*
>
> *Risk management means the processes and framework for managing potential risks, including identifying, analyzing, evaluating, and addressing the risks to assets and system performance.*

5.1 Risk Management Framework

In 2015, NCDOT hosted a two-day National Highway Institute risk management workshop. NCDOT managers formed a workgroup to formalize risk management under a framework guided by the FHWA publication Risk-Based Transportation Asset Management Report 1: Evaluating Threats, Capitalizing on Opportunities. This framework consisted of the following steps:

1. ***ESTABLISH CONTEXT***
   Understand and document the social, cultural, legal, regulatory, economic, and natural environments to which the agency is sensitive.
2. ***IDENTIFY RISKS***
   Formally identify and document risks that could affect objectives.
3. ***ANALYZE RISKS***
   Evaluate the probability of risk with its consequence.
4. ***EVALUATE RISKS***
   Support decision making by comparing the magnitude of risks with risk tolerance.
5. ***TREAT RISKS***
   Determine option to address or mitigate top priority risks and identify responsible parties.

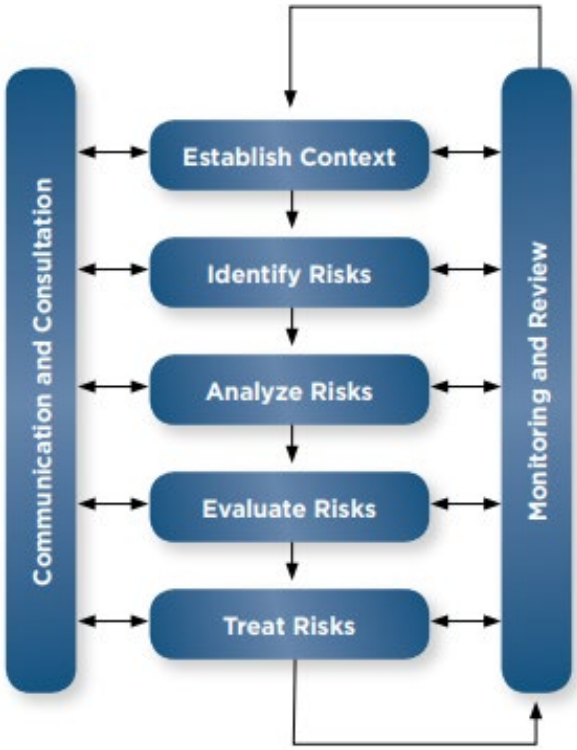


Figure 5-1: Risk Framework

The steps of this framework occur within the context of continuous communication and consultation; and continuous monitoring and review. The framework is overseen by a Senior Leadership Risk Management Committee (SLRMC) composed of the Division of Highways':

- Chief Engineer
- Western Deputy Chief Engineer
- Eastern Deputy Chief Engineer
- Central Deputy Chief Engineer
- Director of Highway Operations
- Director of Field Support

5.1.1 Risk Identification

Two subcommittees were created to initiate the risk management process: one for pavement, and one for bridge. Many risks were found to be common to both asset classes including population growth, funding uncertainty, hurricanes, flooding, and information technology. The subcommittee results were reviewed by the SLRMC.

5.1.2 Assessment of Likelihood and Consequence

The SLRMC reviewed each risk and estimated both their likelihood and consequence according to the guidance below. The scores of each member were averaged, then likelihood and consequence were multiplied for a total ranked score.

Guidance for risk likelihood:

Score	Descriptor	Description
1	Rare	*I would be very surprised to see this happen within the next 10 years.*
2	Unlikely	*I would be mildly surprised if this occurred within the next 8 years.*
3	Possible	*I think this might occur within the next 7 years.*
4	Likely	*I think this will likely occur sometime in the next 2 years.*
5	Almost Certain	*I would not be at all surprised if this happened within this year.*

Table 5-1: Guidance for Risk Likelihood

Guidance for risk consequence:

Score	Descriptor	Rank
1	Insignificant/Negligible	Low
2	Minor/Minimal	Medium Low
3	Significant/Important/Moderate	Medium
4	Major/Critical/Very Serious	Medium High
5	Catastrophic/Perilous	High

Table 5-2: Guidance for Risk Consequence

5.1.3 Evaluation and Prioritization

Each risk was evaluated by the SLRMC independent of their numerical score and grouped into the following categories:

- Funding
- Natural Disasters
- Asset Inventory
- Data Quality
- Population
- Winter Weather
- Man-Made Disasters
- Other

5.1.4 Mitigation and Monitoring

Seven high-priority risks were identified for treatment. A mitigation and monitoring plan was developed for each, and the appropriate person was identified for monitoring. The risk register, mitigation plan, and monitoring approach are detailed below:

High Priority Risk #1: Funding *Agency Level*	**Responsible**
Funding is reduced	Secretary, Deputy Secretary, Chief Operating Officer, Chief Engineer's Office, Chief Financial Officer, Communications Office
Consequences	**Mitigation**
• Number of new projects will be reduced • Capacity projects will be delayed • Program priorities could change • System performance may be degraded • Poor condition ratings leading to loss of flexibility in use of FHWA funds • Public out-cry and loss of trust • Increased cost for rehab / reconstruction • Increased potential for vehicle accidents and injuries • Large economic impact to communities • Impact on response time for emergency vehicles • Drift toward "worst first" and away from minimum whole-life cost	• Reduce STIP projects to reflect reduced budgets • Borrow funds to replenish HTF balances • Adjust performance targets • Work with NC General Assembly to improve financial position • Re-prioritize projects, programs, and services • Utilize latest preservation strategies • Coordinate bridge and pavement preservation programs to maximize efficiency • Re-emphasize existing asset management principles and avoid "worst first" approach • Manage public and stakeholder expectations through public media and social networks • Identify and prioritize critical routes and bridges and alternate routes • Monitor condition of critical bridges and highway corridors

High Priority Risk #2: Natural Disaster *Agency Level*	**Responsible**
Increased frequency and intensity of natural disasters	Secretary, Deputy Secretary, Chief Engineer's Office, Chief Financial Officer, Communications Office
Consequences	**Mitigation**
• Significant road closures and damage • Decreased mobility • Long-term impact to pavement conditions by saturation of subgrade • Injury/death • Maintenance and reconstruction costs may increase	• Identify priority routes, critical staff, resource needs, and evacuation protocols as part of an emergency response plan • Ensure a quick response by damage assessment teams • Quickly mobilize emergency response teams and bridge inspectors to impacted locations

• Increased financial obligations not covered by federal funds • Economic hardship on local businesses and residence • Short term cash flow problem pending federal reimbursement • Erosion of public confidence and trust • Increased delays in response times for emergency services	• Implement reliable emergency backup communication protocols • Hold regular practice drills to ensure preparedness of emergency response teams • Inform the public through local news media and through other established protocols • Review design standards for increased resiliency • Preform predictive analysis to identify vulnerable areas within critical corridors • Implement improved procedures from previous events to maximize and hasten federal reimbursements

High Priority Risk #3: Asset Inventory *Agency / Program Level*	**Responsible**
Asset inventory collection efforts are delayed due to lack of funding and/or resources	Secretary, Deputy Secretary, Chief Engineer's Office, Communications Office
Consequences	**Mitigation**
• Obsolete and inaccurate data sets • Impacts to maintenance and operations planning decisions • Erodes trust with decision makers • Need to substitute with subjective data • Failure to meet federal and state mandates (HPMS, NBIS, Pavement Condition, Maintenance Condition, etc.)	• Perform gap analysis and assessment of progress • Use statistical analysis to estimate inventory and condition based on current data sets • Stratify roads based on ADT and prioritize data collection • Identify other funding sources eligible for this effort • Inform decision makers of strategies • Evaluate funding of non-mandated programs areas and determine if any can be reduced or eliminated

High Priority Risk #4: Data Quality *Program Level*	**Responsible**
Poor quality data controls on cost of maintenance and operations due to inaccurate reporting or poor data quality	Chief Engineer's Office, Governance Office, Communications Office
Consequences	**Mitigation**
• Inability to project and monitor system performance	• Provide system training

• Loss of confidence from stakeholders • Inability to plan and budget accurately • Loss of data could alter program funds • Inaccurate data could cause need to substitute with subjective data	• Develop Q/C of data input procedures • Determine what data is required • Determine process for updating data • Determine options for missing data • Develop and implement Data Governance Policy

High Priority Risk #5: Population *Agency / Program Level*	**Responsible**
Population (*thus VMT/Truck volumes and freight*) increases at a faster rate than anticipated	Chief Engineer's Office, Division Engineers, Communications Office
Consequences	**Mitigation**
• Assets will deteriorate more rapidly • Increase in vehicle accidents • Reduced public confidence • Reduced system reliability in urbanized areas and major corridors • Imbalance of STIP projects to urbanized areas away from rural counties	• Identify and allocate funding for priority/critical routes • Identify sufficient preservation strategies to maximize investment • Manage public and stakeholder expectations through public media and social networks

High Priority Risk #6: Winter Weather *Program Level*	**Responsible**
More frequent and intense snow and ice events	Chief Engineer's Office, Division Engineers, Communications Office
Consequences	**Mitigation**
• Impacts to budget availability • Reduced mobility • Increased damage to pavements/bridges • Increased use of anti-icing and de-icing chemicals • Scarcity of resources for snow/ice removal, contractors, deicing and anti-icing chemicals • Erosion of public confidence • Increase in vehicle accidents and injuries • Economic impact to affected area • Hardship on secondary education school systems	• Ensure emergency response protocols are in place • Annual review of bare pavement routes • Re-assess salt storage capacity and needs • Pairing of "sister" divisions for personnel/equipment support • Ensure private trucks are under contract to assist, and hold practice runs prior to snow season • Analyze resources annually for material and equipment needs • Review and update reporting protocols annually

	• Develop "standard" press release templates prior to winter season and social networks

High Priority Risk #7: Man-Made Disaster *Program Level*	**Responsible**
Major route or bridge is closed.	Chief Engineer's Office, Division Engineers, Communications Office
Consequences	**Mitigation**
• Decreased mobility • Large economic impact to communities • Injury/death • Increased emergency response time • Increased cost and impact to NCDOT resources • Negative public perception • Negative impact on infrastructure programs • Negative and unexpected impact to the budget • Negative impact to movement of freight and goods	• Identify and prioritize critical bridges and alternate routes • Install necessary detour signage • Emergency contract procurement in place (fast-track) • Establish response protocols and train employees • Inform public through media outlets and social media • Review/establish communication coordination with other Emergency response agencies • Review/establish communication coordination with boarder/adjacent state DOTs • Develop and implement "fast-track" process for quick claim reimbursement

5.2 Facilities Repeatedly Damaged

As required by 23 CFR Part 667, NCDOT has used "reasonable efforts to obtain the data needed for the evaluation of facilities repeatedly requiring repair and reconstruction due to emergency events" by conducting an internal review and compiling a list of sites meeting the criteria put forth by FHWA using the following method:

1. Since 2003, the Department has utilized an accounting system (SAP) that assigns a unique identification number to each damaged facility caused by an emergency event.
2. A query was run on all FHWA declared events to obtain a list of facilities damaged along FHWA routes due to an emergency event.
3. "A minimum $5,000 in repair cost per site was used as a guideline for a site to be ER eligible," per the ER Manual.

4. The list of sites was expanded utilizing institutional knowledge to include additional occurrences/sites between 1997 and 2003. Each of the 14 Highway Divisions were polled to gain local historical knowledge relative to sites that would meet the criteria of this section. Divisions provided lists of potential additional sites based on historical knowledge from employees who were employed during this time, as well as through investigations into local road files or other databases that would have pre-dated the current accounting system.
5. The list of sites was then filtered using institutional knowledge and GPS mapping to include only "facilities repeatedly requiring repair and reconstruction due to emergency events".

The Department's use of institutional knowledge was due to Part 667 specifying the beginning date for the evaluation to be January 1st, 1997 whereas per 2CFR § 200.333, FHWA's record retention policy is "a period of three years from the date of submission of the final expenditure report.

5.3 Resilience Planning

5.3.1 Resilience Policy

In September 2021, NCDOT adopted an official resilience policy in response to state Executive Order 80.

> *It is the policy of the North Carolina Department of Transportation (NCDOT) to consider the resiliency of the Department's organization and the state's transportation system to support its mission of "connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina." Resiliency will be defined as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.*
>
> *NCDOT shall enhance its resilience in all day-to-day organizational activities. To develop organization-wide resilience, the Department shall deploy a coordinated approach to manage risk to business operations so it may continue to operate and provide services to our citizens and visitors to the fullest extent possible, regardless of the disruption.*
>
> *To maintain safe, reliable, and efficient transportation infrastructure, the Department shall take active steps to manage risks and strengthen transportation system resilience, considering both natural and man-made hazards. These steps shall: be based on the most up-to-date science; implement risk-based asset management and design approaches to identify threats and assess vulnerabilities; incorporate better planning to reduce disaster losses; and include processes to avoid or minimize consequences to transportation assets and the people of North Carolina.*
>
> *The Department will continue to collaborate with the appropriate state and federal agencies and organizations to ensure decisions adhere to all regulations and to facilitate information sharing and alignment of resiliency strategies. This policy will be implemented through the Department's strategic, long-range and modal plans, programming, project development, design, construction, operations, asset management, maintenance, and transportation mobility and safety.*

The Department's resilience strategies, relevant research, guidance, and procedures, will be documented annually through the "NCDOT Resilience Strategy Report."

On April 18, 2022, the Governor's Office sent a memo to the North Carolina Climate Change Interagency Council requesting that an annual report on Executive Order 80, Executive Order 246 and the CLIMATE RISK ASSESSMENT AND RESILIENCE PLAN be submitted to the Governor through the Climate Council by October 15th annually. Executive Order 80, *North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy*, was issued October 29, 2018. Executive Order 246, *North Carolina's Transformation to a Clean, Equitable Economy*, was issued January 7, 2022. The NCDOT CLIMATE STRATEGY REPORT will fulfill the agency's requirement to submit an annual status report to the Governor on the implementation of EO 80 and EO246 directives.

The 2020 CLIMATE RISK ASSESSMENT AND RESILIENCE PLAN calls for each state agency to develop an Agency Resilience Strategy report, updated annually. As described in the plan, "*each agency's Agency Resilience Strategy will build on the work that agency has completed for [the Resilience Plan], describing any changes or additions to the agency's latest understanding of its climate vulnerabilities and risks. It will also briefly outline the agency's current and planned actions to increase resilience [and] also should report progress on implementing strategies previously identified by the agency."*

The Resilience Plan acknowledges that state agencies bring a wide range of prior experience in climate adaptation and resilience planning to this effort and represent a wide array of missions, jurisdictions, and regulatory authorities. Because of this, "*these strategies will likely include a range of actions, from proposed studies and planning activities to capital projects. In some cases, an agency may already have adequate scientific and risk information to take specific action to build resilience. In other cases, where agencies have identified long term challenges needing more research and engagement before implementing a project or policy, agencies can outline their plans, funding needs, and timelines to accomplish such work*".

The NCDOT CLIMATE STRATEGY REPORT will fulfill the agency's requirement to complete an Agency Resilience Strategy report. This report is an accountability measure intended to describe how each agency is increasing its adaptation and resilience to climate impacts through changes to agency plans, policies, procedures, regulations, programs, and projects (including capital projects). What is reported through this document is expected to evolve from year to year as policies, funding availability, leadership, staff, and opportunities change.

The RESILIENCE STRATEGY REPORT serves to guide resilience awareness, potential policy amendments, practice enhancements, and investment decisions using the AREA (Absorptive, Restorative, Equitable Access, and Adaptive) framework described in detail therein.

5.3.2 Project Planning and Selection

The Technical Services Division provides project and program management, planning, design, and other preliminary engineering services to advance projects to construction in response to state and federal requirements. This group oversees hydrological design considerations and flood risk and assessment tools to enhance decision making and preparation for future events. It also interfaces with state and federal agencies to minimize and mitigate transportation impact on built and natural environments. The Technical Services Division works closely with the North Carolina Department of Emergency Management (NCEM) and NCDOT's 14 Highway Divisions to provide riverine and flood mapping data

and analysis in preparation for, and response and recovery from, storm events. The role of the Technical Services Division is to lead NCDOT's response to EO80 requirements, and position staff to coordinate resilience activities which will increasingly include other NCDOT units, tools, and data.

NCDOT's Transportation Planning Division (TPD) prepares long range transportation plans responsive to federal and state requirements and future travel demand, which in turn support traffic and design decisions in preconstruction. TPD also interfaces with local communities and agencies across the state to assess land use and travel unique to specific areas. Recently, TPD updated and incorporated new geographic information system (GIS) layers as part of its Comprehensive Transportation Planning (CTP) process to support up-to-date reviews of environmental and transportation data which enhance planning decisions. TPD's role and approach provides multiple opportunities to incorporate resilience through vulnerability assessments and modeling scenarios at network and corridor-based levels.

Efforts to maximize stakeholder engagement including MPOs, RPOs, and other state partners in both strategy and project consideration were accomplished through a series of workshops:

Workshop	Attendees	Focus Areas	Themes
Virtual Meeting #1 Leadership Meeting December 17, 2020	Project Management Team and NCDOT Leadership	Unified, coordinated vision for the department Definitions for resilience and terminology	Embed resilience into DOT practices Multimodal approach including all modes/divisions/units Framework for resilience best practices and prioritization process
Virtual Meeting #2 Workgroup Meeting January 8, 2021	Project Management Team, representatives from across the department - divisions, aviation, ferries, integrated mobility, rail, planning, maintenance, asset management, ports, Turnpike, Global TransPark, freight, and MPOs/RPOs	Historic background over last decade Need to produce a strategy document A survey and interviews to follow up the discussion and obtain more input Input on risk and resilience state of practice in North Carolina using real-time polling	Resources for pilots and studies Local/regional vulnerability assessments needed Leverage stakeholders / agency tools/data for resilience Incorporate resilience in prioritization
Virtual Meeting #3 Workgroup Meeting February 3, 2021	Project Management Team, representatives from across Department - Divisions, Aviation, Ferries, Integrated Mobility,	Discussion of "why resilience" and department-wide goal from Governor's EO 80 Strategy report will include glossary, peer	Strategies included technical assistance, vulnerability assessments, central data hub, asset

	Rail, Planning, Maintenance, Asset Management, Ports, Turnpike, Global TransPark, Freight, and MPOs/RPOs, NCDEQ	research, vision, goals and objectives and short/long term actions Cross disciplinary approach Review and input of draft strategies using real-time polling	management, and planning needs Longer term strategies: expand and deepen capacity, investigate resilience in strategic prioritization, additional STC vulnerability studies and resilience scenario planning

Table 5-3: Resilience Workshops

5.3.3 Resilience Project Examples

Numerous projects and initiatives have been undertaken to address resilience which are detailed in the RESILIENCE STRATEGY REPORT, and summarized as follows:

- **I-95/I-40 Flood Resilience Feasibility Study**
  This 2019 study addresses the vulnerability of two major Interstate corridors – I-40 and I-95 – to natural flooding disasters and develops adaptation measures to mitigate against future flooding disasters. It was conducted in response to a directive from the NCDOT Secretary of Transportation to identify improvement options and estimate costs to make sections of I-95 and I-40 more resilient to future storm events. The improvement options span from south of the I-40/I-95 interchange in central N.C. to Wilmington. Each improvement option is intended "to decrease the potential for flooding of the Interstate segments and minimize disruption to transportation during extreme weather events" and the study methodologies could be used to inform flood resilient design considerations for projects in the State Transportation Improvement Program (STIP).

- **US 70/Future I-42 Risk and Resilience Vulnerability Study**
  U.S. 70/ Future I-42 study extends from Wake/Johnston County line to MCOLF Atlantic Air Force Base. This study assesses the vulnerability of routes to airports, ports, and the NCRR rail line adjacent to the corridor. As part of the data collection effort, NCDOT is coordinating with FHWA and other state agencies. All sections of U.S. 70 will be assessed, with a focus on vulnerable areas where storm surge and floods impact U.S. 70. This study will assess infrastructure vulnerability and risk using FHWA's Vulnerability Assessment Scoring Tool (VAST), stakeholder engagement, and other agency expertise/resources. VAST is an Excel based tool that uses data and stakeholder input to create an indicator-based vulnerability assessment of transportation assets. As a part of this assessment, a gap analysis will be performed to identify missing data needed to perform a better assessment.

- **US 74 Risk and Resilience Vulnerability Study**
  U.S. 74 study area extends from I-485 in Matthews to the port in Wilmington and includes a 10-

mile buffer on either side of the corridor, using City Simulator model developed by Atkins. To understand the potential vulnerabilities that will be exposed by continued growth along with future weather challenges, a holistic assessment of the transportation corridor and its various interacting systems is required. This assessment will include people, economy, weather, and infrastructure. This assessment is taking a stakeholder-inclusive approach by including several NCDOT units, N.C. state agencies, federal partners, metropolitan planning organizations, and rural planning organizations. The objective of this pilot study is to determine goals and objectives for future U.S. 74 resiliency, identify and define any vulnerabilities of the U.S. 74 corridor to future extreme weather events – including large storms, hurricanes, and heat waves – and to develop and stress-test mitigation and adaptation scenarios against future conditions and quantify benefits relative to goals and objectives.

- **Research Project (RP) (2018-32) Flood Abatement Assessment for Neuse River Basin**
  The objectives of this 2019 research were to better understand the source(s) and nature of flooding in the Neuse River Basin and to identify and evaluate potential flood mitigation measures with a special focus on maintaining critical transportation services to eastern N.C. communities – such as Smithfield, Goldsboro, and Kinston. Hydrological modeling and community input revealed that a series of strategic transportation improvements (such as raising roadway elevations) may have a greater effect on reducing future flooding risks than simply widening bridge spans across the river basin. The NC Sea Grant and NC State University collaborated with NCDOT, NCDEM and local governments to conduct the research, which concluded in 2020.

- **United States Army Corps of Engineers Disaster Recovery 19 Flood Mitigation Studies Tar, Neuse, and Lumber River Basins**
  Under the Federal Disaster Relief Act of 2019, the United States Army Corps of Engineers (USACE) initiated three flood risk management studies for the Tar-Pamlico, Neuse, and Lumber River Basins through a cost-sharing agreement with the NCDEQ in April 2020. The purpose of these feasibility-level studies is to reduce flood risks by evaluating and recommending a potential range of structural, nonstructural and natural/nature-based mitigation measures that could minimize or even avoid future impacts of significant and extreme weather events within the river basins. The USACE is using existing floodplain and technical data from multiple sources, including state, local (counties, cities, towns) and communities impacted by prior events. The USACE has further engaged the involvement of subject matter experts from multiple state agencies including the NCDEQ, North Carolina Division of Wildlife Resources (NCDWR), NCDEM, North Carolina Office of Recovery and Resilience (NCORR) and NCDOT in multiple information gathering meetings with and without potential stakeholders. There will be opportunities to engage the public through public scoping and information meetings as these studies progress. These feasibility-level studies are scheduled to be completed by April 2023.

- **I-95 Flood Resiliency Design and Innovation through USDOT BUILD Grant**
  During Hurricane Matthew and Hurricane Florence I-95 was flooded in 10 locations between Exit 13 and Exit 76. In Lumberton, I-95 was flooded for more than seven days due to the flood waters

of the Lumber River. The NCDOT was awarded a USDOT BUILD Grant for Transportation Improvement Projects I-6064 and I-5987 to incorporate flood resilience, a flood alert network and flood vulnerability stress test. Through complex hydrological modeling, the Department will build a new highway that will withstand future extreme events and provide flood alert information that will improve safety, performance (to freight hubs, military bases, and rural access to major urban markets) and provide greater resilience to maintain the use of transportation lifelines.

- **North Carolina Future Precipitation for Resilient Design**
  The frequency and intensity of both floods and droughts are expected to increase in response to a warming climate; however, significant uncertainties remain regarding regional changes, especially for extreme rainfall. Traditional design has been based on long-term historical data that assumed that the past conditions would represent future conditions. Since this is not the case, Global Climate Models (GCM) are helping engineers and scientists predict future climate conditions. NCDOT, NCEM, the North Carolina State Climate Office and researchers will be using GCMs in this three-year study to (1) assist NCDOT with climate adaptation and resilience planning and (2) improve confidence in Flood damage along Bethlehem Church Road in Stanly County46 NCDOT | RESILIENCE STRATEGY REPORT | March 2021 16 future flood risk using existing downscaling data/methodologies and tailored high-resolution climate model projections. The study is scheduled to be completed in 2023.

- **NCHRP 20-44(23) – Pilot Test of Climate Change Design Practices Guide for Hydrology and Hydraulics**
  NCDOT staff are participating in the study with the possibility that N.C. will be one of the pilot project sites. The objective of National Cooperative Highway Research Program (NCHRP) 20-44(23) project is to conduct pilot tests in concert with several state DOTs to determine the effectiveness and ease of implementation of the Design Practices Guide produced in NCHRP Project 15-61 (Applying Climate Change Information to Hydrologic and Coastal Design of Transportation Infrastructure). The research is expected to conclude in 2022.

- **FHWA – Pooled Fund Study – Intensity-Duration-Frequency / Depth-Duration-Frequency Atlas 14 Rainfall Update**
  Rainfall data for design has not been updated in N.C. since 2004. The purpose of this study is to update precipitation frequency estimates first published in NOAA Atlas 14 Volume 2 for D.E., M.D., N.C., and V.A. The estimates and bounds of 90 percent confidence intervals will be provided at 30 arc-second durations of 5-minute through 60-day average recurrence intervals of 1- year through 1000 years. The study results will be published on the web as NOAA Atlas 14 Volume 13 through the Precipitation Frequency Data Server. The two-year study is planned to start in the summer of 2022.

- **Predicting Roadway Washout Locations During Extreme Events RP 2021-03**
  Recent extreme rainfall events have revealed the transportation network's vulnerabilities to

road washouts. Currently, NCDOT reacts to these problems as they are reported from the field. Knowing where washouts are likely to occur will lead to identifying locations for countermeasures to protect the roadway and assist with positioning of resources more efficiently. The purpose of this research project is to develop models and test several approaches for predicting crossing washouts based on forecasted rainfall. Washouts and the model predictions will be used to develop a network of "safe" routes for each watershed. The research will be completed in 2023.

- **Transportation Asset Management Program – Pipe Inventory Program**
  NCDOT's asset management practice is shifting towards a forward-looking approach to identify at-risk culverts and pipes that often meet criteria for federal funds. Knowing the location and condition of the department's drainage structures is an important component of building resilience into the state's network. Recently, NCDOT undertook a statewide inventory and condition assessment of culverts and crossline pipes that are not part of the National Bridge Inventory (NBI), coordinated closely through the Chief Engineer's office in the Division of Highways. The effort creates the first statewide comprehensive geospatial record of approximately 26,000 non-NBI structures (culverts and pipes over 48 inches) and approximately 350,000 crossline pipes (48 inches and below). The data collected as part of the pipe inventory program supports the department's lifecycle approach to asset management. The next phase of the program is to re-evaluate each asset on a cyclical basis, and to incorporate ongoing changes to the inventory.

- **N.C. 24 Causeway – White Oak River**
  N.C. 24 is a key route for community members in Cedar Point and Swansboro, providing important connectivity between Marine Corps Base Camp Lejeune, Marine Corps Auxiliary Landing Field Bogue, the Morehead City State Port and Marine Corps Air Station Cherry Point. The highway also serves as a vital evacuation route for hurricanes and a commuter road with approximately 26,000 vehicles traveling through per day. The priority sites along N.C. 24 proposed sustained damages from hurricanes Florence, Irene, and Ophelia, and are particularly vulnerable to future storm degradation. In partnership with the North Carolina Coastal Federation, the Department procured a National Fish and Wildlife Fund grant to build living shorelines and surge and wave-energy countermeasures adjacent to N.C. 24 that will have transferability for future projects. NCDOT plans to use this project to support its strategy to increase infrastructure resilience along NCDOT coastal highways.

- **N.C. 12**
  NC 12 is a critical route linking barrier islands along N.C.'s coast with resilience related improvements occurring through multiple STIP projects. The new Herbert C. Bonner bridge connecting Oregon inlet to Pea Island included design elements in its span to adapt to changing oceanic and sound tidal conditions. Specifically, four channel spans allow wave action and natural channel flow beneath the structure to migrate while simultaneously maintaining adequate access for vessels. Further south in Rodanthe the "jug handle" bridge (B-2500B) has been built on the backside of the island to provide redundant and accessible travel access if N.C.

12 is overtopped or washed out in a major event.

- **Traveler Information Systems**
  NCDOT provides real time traffic conditions and incident information through DriveNC.gov which feeds updates to navigation companies, digital message boards, 511 and the customer service center. This interconnected system alerts motorists to upcoming closed or partially closed roads due to storm events, crashes or construction zones and is linked to 511 and national traffic and road closure conditions. These systems can also direct motorists and freight operators to use coastal evacuation routes or avoid storm damaged facilities in advance of or during major storm events.

- **Active Traffic Management and Incident Management**
  NCDOT employs several strategies – working with state, local law enforcement and tow companies daily to clear disabled vehicles or efficiently address incidents. These measures take on increased significance during major weather events when increased crash potential further exacerbates critical roadway capacity. Active traffic management includes a series of emergency operational strategies at a corridor or regional network level, such as signal system synchronization or use of shoulders (and reversible lanes in extreme cases) to move large volumes of traffic from storm impact areas.

5.3.4 Flood Management Tools

North Carolina Department of Transportation maintains over 80,000 of miles of roadway in a state that has 5,200 square miles of water and 48,000 square miles of land ranging in elevation zero to 6,684. North Carolina's location on the east coast also makes it vulnerable to tropical cyclones. Since 1851, North Carolina has experienced over 387 events. Most recently however, Hurricane Matthew in 2016 and Hurricane Florence 2018 caused significant disruption of the transportation network. Hurricane Florence alone was responsible for over 31 deaths, and over 2,500 road closures. Both I-95 and I40 were closed for over a week due to flooding. Total transportation damages from Hurricane Florence which included bridge, culvert and road washouts were over $227 million. While hurricane impacts have been significant, damages from localized storm events have also been increasing. In 2020, the Department had over 500 culverts and bridges that were damaged during non-tropical cyclone events. Based on the NC Climate Assessment, it is virtually certain that sea level rise will continue, likely that annual precipitation and inland flooding will increase and likely that hurricane intensity will increase. Facing these flooding threats, NCDOT has worked with public and private partners on two three-year flood management tool pilot projects: Flood Inundation Mapping Alert Network (FIMAN) for Transportation – FIMAN-T and BridgeWatch. In September 2021, NCDOT adopted an official resilience policy in response to state Executive Order 80.

- **Flood Inundation Mapping Alert Network (FIMAN)**
  FIMAN-T was developed from FIMAN an NC Emergency Management (NCEM) product that is a sophisticated system of integrated technologies and datasets that effectively communicate flood information to emergency managers and the public. The goal of the FIMAN system is to reduce loss of life and flood-related property damage by providing emergency managers and the public with more timely, detailed, and accurate information. FIMAN integrates gages owned by

the state, USGS, and other agencies to provide a network of 400 gages. The FIMAN web application uses responsive design and modeling techniques to display real-time and forecasted flood information, accessible from any desktop, laptop, or mobile device. One of the most powerful aspects of FIMAN is its ability to not only measure and display current and forecasted stream gage information, but to analyze, map, and communicate flood risks in real-time. Every 15 minutes, the application updates with data from over 400 sites across the state. Tools inside FIMAN overlay the flood inundation boundary with existing building information to quantify buildings impacted by flooding and provide exportable damage summary statistics. The FIMAN site also integrates available flood forecast information provided by the National Weather Service for sites across North Carolina. This forecast information is displayed to FIMAN users showing the forecasted flood extent, anticipated timeline, and estimated building-level impacts. FIMAN users and emergency managers can also sign up to receive alerts from FIMAN when flood levels at chosen areas rise to certain risk thresholds.

- **Flood Inundation Mapping Alert Network for Transportation (FIMAN-T)**
  In 2020, NCDOT and NCEM partnered to develop FIMAN for Transportation (FIMAN-T), a web-based tool used to provide NCDOT officials and emergency management stakeholders with real-time and forecasted flood inundation depths along roads, bridges, and other NCDOT assets in support of risk-based decision-making during flooding events. The goal of FIMAN-T is to provide visualization and metrics for roadway inundation, bridge hydraulic performance and identify potentially impacted NCDOT assets. This has enhanced NCDOT's responsiveness during flooding events by generating data and reports for use in disaster response and planning. FIMAN-T leverages the real time, 3D inundation mapping coupled with LIDAR derived roadway elevation layers to compute flooding depths over roadways for both current and forecasted conditions. The application features an interactive dashboard allowing users to navigate between current conditions, modeled scenarios, and forecasted conditions where available. The dashboard also features different "info-widgets" that provide detailed information including stream elevation, an interactive stage hydrograph, and forecasted peak. In addition, the road affected widget gives you the option to view a summary table of all impacted roads within the inundation extent of the selected gage, or a sortable and filterable table showing all impacted roadway segments. NCDOT and NC Emergency Management are working together to expand FIMAN-T sites to include high risk transportation corridors such as I-40, I-95, NC24, US74 and other areas. In addition, new functionality has been added to FIMAN-T to include forecasted hurricane and tropical storm surge inundation and roadway impacts for the entire NC coastline allowing emergency managers and first responders to have awareness of potential roadway and evacuation impacts from an approaching storm. The partnership with Coastal Emergency Risk Assessment (CERA) has not only allowed NCDOT to map forecasted storms, but also allowed the mapping of historical storms through hindcast analysis.

- **BridgeWatch**
  In addition to piloting FIMAN-T, NCDOT is working with industry partners and NCEM to implement a three-year pilot of BridgeWatch. BridgeWatch compliments FIMAN-T by providing storm event situational awareness on 15,000 culverts and bridges. BridgeWatch is an online

bridge-monitoring application service to enable transportation professionals to proactively monitor, in real-time, valuable infrastructure to prevent and protect against hazardous conditions for private, public, and commercial transportation. BridgeWatch collects and processes real-time data at regular intervals from meteorologic, hydrologic, oceanographic, and seismologic sources, gages, and other sensing devices. Data comparisons are then performed with internal NCDOT bridge parameters such as flood impact (floodwaters reaching structure levels) or roadway overtopping. NCDOT officials and Emergency managers can customize alerts, when appropriate, via any electronic medium (cell phones, email, application dashboard, etc.) when bridges are experiencing a dangerous or critical condition. North Carolina is leveraging detailed river modeling and high-resolution LIDAR datasets to refine bridge elevations statewide for more accurate alerts. These datasets are being used to implement the following thresholds:

- **Rainfall Alerts**: The system actively monitors NEXRAD and other forecasts for thousands of bridge drainage areas statewide. Officials are notified if rainfalls (actual or forecasted) trigger predetermined thresholds.
- **Storm Surge Alerts**: National Hurricane Center advisories are monitored comparing forecasted storm surge levels to bridge elevations. Custom alerts are available for when forecasted storm surge may impact bridges.
- **Freeboard Alerts**: Officials are notified when stream levels rise close to a critical level at a bridge.
- **Low Chord Alerts**: The low chord is typically the lowest structure member (beam) above the stream or river. Officials are notified when flood waters reach these critical levels. Alerts can be used to prioritize inspections and possible road closures during a flood.
- **Road Overtopping**: Officials are also notified as sensors in the field detect water levels that could indicate that the roadway is overtopped either at the bridge or bridge approaches. This valuable information can be used for road closure, emergency response and post event inspection prioritization.

NCDOT, NCEM and the NC Department of Environmental Quality are also working together to integrate BridgeWatch and DamWatch. The hope is to inform the NCDOT of roads that may be impacted by imminent dam failure. The three-year pilots will conclude in 2022 with recommendations on how to leverage these flood management tools in the future. Years one and two of the pilot have been focused on product development and initial training. Year three will be focused on end-user training, application, reporting and interoperability with other traffic management systems.

6. FINANCIAL PLAN AND INVESTMENT STRATEGY

6.0 REQUIREMENTS AND DEFINITIONS

23 CFR 515.7(d):

> *A State DOT shall establish a process for the development of a financial plan that identifies annual costs over a minimum period of 10 years. The financial plan process shall, at a minimum, produce:*
>
> 1. *The estimated cost of expected future work to implement investment strategies contained in the asset management plan, by State fiscal year and work type;*
> 2. *The estimated funding levels that are expected to be reasonably available, by fiscal year, to address the costs of future work types. State DOTs may estimate the amount of available future funding using historical values where the future funding amount is uncertain;*
> 3. *Identification of anticipated funding sources; and*
> 4. *An estimate of the value of the agency's NHS pavement and bridge assets and the needed investment on an annual basis to maintain the value of these assets.*

23 CFR 515.5:

> *Financial plan means a long-term plan spanning 10 years or longer, presenting a State DOT's estimates of projected available financial resources and predicted expenditures in major asset categories that can be used to achieve State DOT targets for asset condition during the plan period, and highlighting how resources are expected to be allocated based on asset strategies, needs, shortfalls, and agency policies.*
>
> *Investment strategy means a set of strategies that result from evaluating various levels of funding to achieve State DOT targets for asset condition and system performance effectiveness at a minimum practicable cost while managing risks.*
>
> *Minimum practicable cost means lowest feasible cost to achieve the objective.*

6.1 REVENUE

6.1.1 Major Revenue Sources

North Carolina first imposed a gasoline tax of 1 cent per gallon on all motor fuels sold or distributed in the state in 1921, followed by traditional user fees such as vehicle and driver fees in the mid 1920's. It was not until 1989 that state got its third main source of revenue in the form of a sales tax on vehicles (*new and used*) known as the Highway Use Tax. North Carolina's total transportation funding is approximately 75% state revenues and 25% federal-aid.

- **Motor Fuel Tax** (*NCGA Chapter 105-Article 36*)
  Derived from vehicle fuel consumption and a variable state motor fuel tax rate. The variable tax

is weighted on the annual rate of change in population and the Consumer Price Index for Energy (CPI-E) adjusted annually on January 1 by the NC Department of Revenue. Fuel consumption is affected by fuel prices which are subject to world markets and economic domestic output, vehicle fuel efficiency and alternate fuel vehicles, and other disrupting variables such as e-commerce, shared mobility, micro-mobility, and other emerging technologies.

- **DMV Fees** (*NCGA Chapter 20*)
  Historically, each fee had been set by the General Assembly at infrequent time interval (*recently in 1989, 2005 and 2015*). Session Law 2015-241 added a provision for a quadrennial adjustment based on the change in Consumer Price Index (CPI) on certain fees. The first of such adjustment took place on July 1, 2020. Most fee rates apply for a one-year period but can be up to 8 years.

- **Highway Use Tax** (*NCGA Chapter 105-Article 5A*)
  Revenue is 3% of the vehicle value at the time of title issuance. Vehicle leases are subject to the Highway Use Tax at different rates. SL-2017-57 now directs $10,000,000 annually from the 8% Highway Use Tax on short-term leases for transportation uses.

- **Federal Revenues**
  Federal transportation funding is distributed by Congress based on multi-year reauthorization bills and annual appropriations. The primary source of revenue is the federal gas tax, various fees on heavy trucks, and transfers from the US General Fund. The federal motor fuel tax rate is currently 18.4 cents per gallon for gasoline and 24.4 cents per gallon for diesel.

6.1.2 Revenue Forecast

Transportation revenues are developed by a consensus forecast in which the Office of State Budget and Management, Legislative Fiscal Research Division, and NCDOT staff participate for the biennium budget. The Appropriations Act of 2015 (SL 2015-241) formalized the process requiring the Office of State Budget and Management and NCDOT to collaborate in the development of a 10-year revenue forecast. Staff from each agency use historical information, IHS Global Insight historical and forecasted data, and its own statistical models some of which are running on a SAS platform and/or using SAS software to develop the forecast. The revenue forecast is updated annually at the beginning of the calendar year and adjusted as necessary if there are legislative changes that affect the rates and/or distribution or the revenue base. In addition, revenue forecasts are also updated due to events like the Great Recession in 2008 and most recently due to the COVID-19 pandemic-induced recession in May 2020.

The 10-year revenue forecast below reflects the IIJA (BIL) funding levels and assumes federal aid revenues to remain constant at the SFY 2026 level until there is a Congressional action.

Revenue ($ millions)	State Fiscal Year									
Revenue Source	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Highway Fund	2,745	2,833	2,976	3,028	3,075	3,121	3,263	3,332	3,383	3,428
DMV Fees	874	883	1,004	1,011	1,023	1,033	1,120	1,136	1,149	1,159
Highway Use Tax	95	102	106	106	109	109	111	112	111	112
Jet Fuel	10	10	17	24	24	24	24	23	23	23
Motor Fuels	1,766	1,838	1,849	1,887	1,919	1,955	2,008	2,061	2,100	2,134
Trust Fund	1,835	1,864	1,918	2,003	2,068	2,122	2,194	2,267	2,334	2,400
DMV Fees	159	161	165	167	169	170	172	173	175	176
Highway Use Tax	1,086	1,088	1,135	1,205	1,257	1,298	1,351	1,405	1,457	1,510
Motor Fuels	590	615	618	631	642	654	671	689	702	714
Federal	1,411	1,498	1,525	1,554	1,554	1,554	1,554	1,554	1,554	1,554
FEDERAL-AID	1,411	1,498	1,525	1,554	1,554	1,554	1,554	1,554	1,554	1,554
Grand Total	**5,991**	**6,195**	**6,419**	**6,585**	**6,697**	**6,797**	**7,011**	**7,153**	**7,271**	**7,382**

Table 6-1: Revenue Forecast

6.2 Program Funding

NCDOT operates through its Highway Fund, Trust Fund, and federal funds.

- **Highway Fund**
  Used to support maintenance and operations, administration costs, multi-modal, state-aid to municipalities, state parks, and other obligations defined by law. The pavement and bridge programs that affect condition of pavements and bridges are largely supported through this fund.
- **Highway Trust Fund**
  Used for the design and construction of the projects identified in the STIP and as a state match to federal funds.
- **Federal Funds**
  Funds from Federal Highway Administration, Federal Transit Administration, and Federal Aviation Administration that support the construction and maintenance of projects that meet each agency's requirements.

The figure below details the flow of revenue to funding sources. Investments in pavement and bridge assets predominantly flow through the Highway Fund through five maintenance programs, all of which are directly appropriated funds in the state budget: General Maintenance, Contract Resurfacing, Pavement Preservation, Bridge Program, and Bridge Preservation.

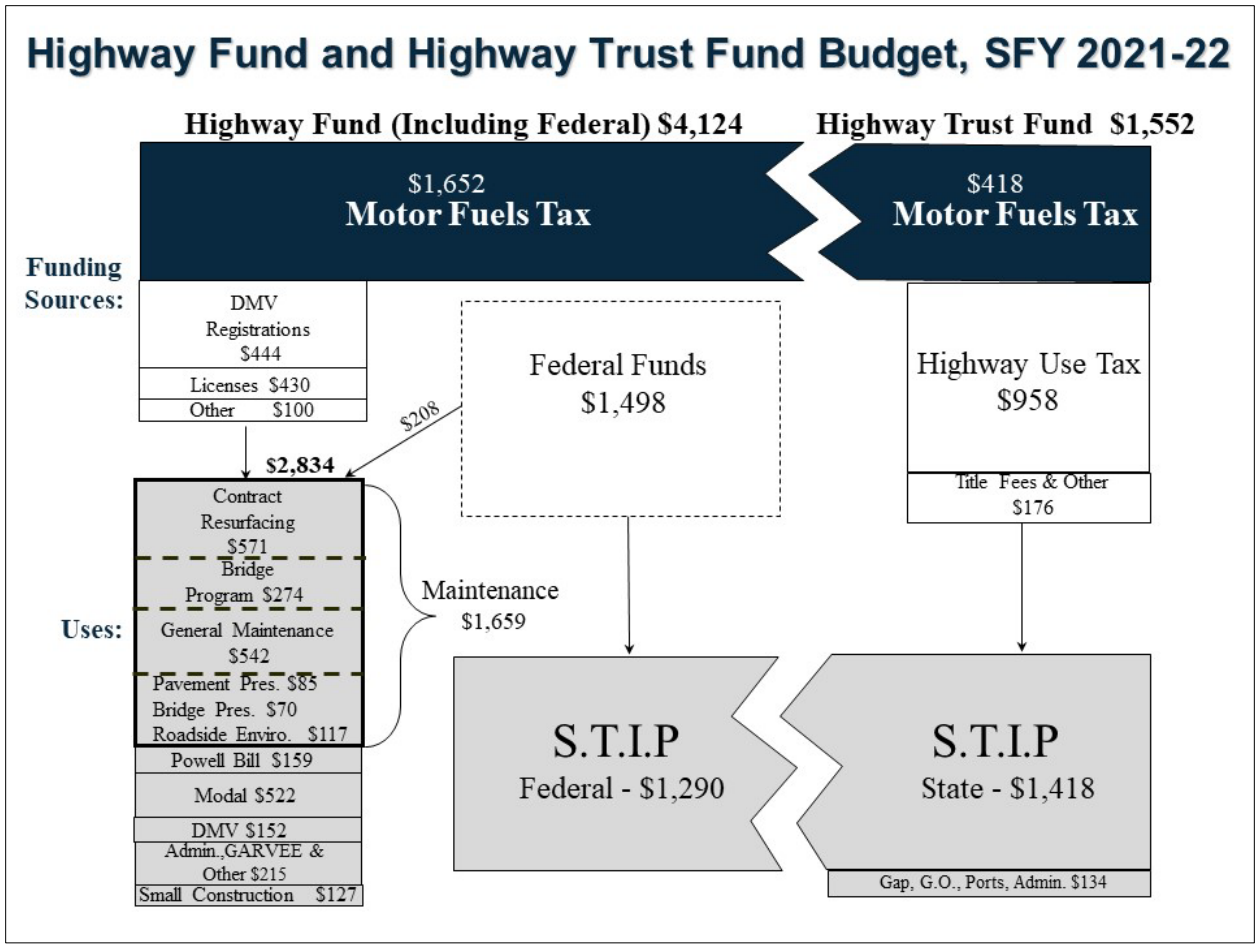


Figure 6-2: Revenue Flow

6.3 Financial Plan Development

Appropriations from the General Assembly only represent spending authority. The Department is subject to a weekly influx of funds from the various revenue sources. Revenues may come in higher or lower than projected, and the overall budget may be adjusted accordingly within a fiscal year. The Department must use annual budgets to effectively manage contracts that span and pay out over multiple years. Therefore, a cash-flow strategy is used where a portion a project's costs may be covered by future budgets. The Department is also subject to a legislative cash balance floor and ceiling and must carefully project future expenditures against projected revenues and cash on hand. To assist in this cash flow process, SAS has been employed to provide detailed projections of contracted programs. This helps the Department determine when to let contracts to maintain its cash balance.

6.4 Investment

Capital construction projects are accomplished through the Highway Trust Fund and STIP. The five primary maintenance programs through the Highway Fund are described below, covering those activities associated with the federal work types for maintenance, preservation, rehabilitation, and reconstruction.

- **Pavement Preservation**
  Activities include chip seals, slurry seals, fog seals, sand seals, scrub seals, cape seals, microsurfacing, profile milling, asphalt rejuvenators, open graded asphalt friction course treatments, overlays less than 1,000 feet in length, diamond grinding, joint sealing, dowel bar retrofit, partial or full depth repairs and reclamations, ultra-thin white topping, thin lift and sand asphalt overlays, and asphalt crack sealing.

- **Contract Resurfacing**
  Rehabilitation activities that include placement of plant mixed asphalt, extended surface treatment seals, and recycling existing pavement.

- **Bridge Preservation**
  Cost-effective activities to maximize bridge life and reduce life-cycle cost that include replacing joints, sealants, epoxy overlays, and concrete overlays.

- **Bridge Program**
  Established in 2015 by the General Assembly, intended to address structurally deficient bridges. The funds may be used on the interstate, primary and secondary systems.

- **General Maintenance Reserve**
  This program captures general routine and reactive maintenance activities not specifically covered by the other programs. Some activities are directly related to pavement and bridge condition such as pothole patching and repairing concrete decks, while other activities indirectly influence the lifespan of these assets such as shoulder maintenance and pipe replacement. This program also funds snow and ice and non-declared disaster efforts. It is often considered a "catch-all" program flexible enough to address numerous maintenance activities both planned and unplanned. Due to its reactive and miscellaneous nature, General Maintenance Reserve activities are not categorized into portions of pavement and bridge investments in this document but should be understood to support those investments directly and indirectly.

- **Federal Interstate Maintenance Funds**
  Programmatically included as part of the STIP for addressing both pavement and bridge preservation needs on the interstate system.

Investment ($ Millions)	SFY									
Asset / Program / System	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Bridge	**490**	**503**	**520**	**525**	**532**	**538**	**557**	**566**	**572**	**575**
Bridge Preservation	68	71	75	75	77	78	82	84	85	85
Interstate	8	8	9	9	9	9	10	10	10	10
Primary	39	41	43	43	44	45	47	48	49	49
Secondary	21	22	23	23	24	24	25	26	26	26
Bridge Program	272	282	295	300	305	310	325	332	337	340
Interstate	54	56	59	60	61	62	65	66	67	68
Primary	109	113	118	120	122	124	130	133	135	136
Secondary	109	113	118	120	122	124	130	133	135	136
Fed. Bridge Preservation	23	23	23	23	23	23	23	23	23	23
Interstate	23	23	23	23	23	23	23	23	23	23
Primary	-	-	-	-	-	-	-	-	-	-
Secondary	-	-	-	-	-	-	-	-	-	-
Fed. Bridge Program	127	127	127	127	127	127	127	127	127	127
Interstate	49	49	49	49	49	49	49	49	49	49
Primary	49	49	49	49	49	49	49	49	49	49
Secondary	29	29	29	29	29	29	29	29	29	29
Pavement	**759**	**782**	**815**	**828**	**839**	**850**	**884**	**901**	**913**	**924**
Contract Resurfacing	569	588	617	628	638	648	677	691	702	712
Interstate	-	-	-	-	-	-	-	-	-	-
Primary	237	245	257	262	266	270	282	288	293	297
Secondary	332	343	360	366	372	378	395	403	409	415
Pavement Preservation	83	87	91	93	94	95	100	103	104	105
Interstate	-	-	-	-	-	-	-	-	-	-
Primary	4	5	5	5	5	5	5	6	6	6
Secondary	79	82	86	88	89	90	95	97	98	99
Fed. Interstate MAINT.	107	107	107	107	107	107	107	107	107	107
Interstate	107	107	107	107	107	107	107	107	107	107
Primary	-	-	-	-	-	-	-	-	-	-
Secondary	-	-	-	-	-	-	-	-	-	-
General Maintenance	**581**	**600**	**630**	**642**	**651**	**661**	**691**	**706**	**717**	**726**
General MAINT. Reserve	581	600	630	642	651	661	691	706	717	726
Interstate	1	1	1	1	1	1	1	1	1	1
Primary	247	255	268	273	277	281	294	300	305	309
Secondary	333	344	361	368	373	379	396	405	411	416

Table 6-3: Investment Forecast

State funding is directly correlated to revenue and is expected to track closely to the revenue forecast. Investments of state funds are not made at the system level; therefore, a five-year historical expenditure was considered in predicting the apportionment of funds by system within each program. Federal funds for these asset classes are carved out of the larger federal aid program but are not expected to track as closely to that program's forecast as with state funds. These federal funds are

shown as holding steady, but any significant change to their investment will be reflected in future updates.

6.5 Asset Valuation

One method to determine if asset condition is at a steady, declining, or improving state is to chart the monetary value of the asset over time. If the value is increasing or staying the same year to year, the agency's investment is sufficient to offset condition depreciation. This strategy is consistent with maintaining targets for condition. Conversely, if the value of the asset is declining, it is depreciating faster than the agency's investment in that asset.

After reviewing the agency's readily available data, NCDOT selected the use of a modified version of the Depreciated Replacement Cost (DRC) as outlined in A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management. This approach estimates the total replacement cost of an asset and then reduces the value based on depreciation or obsolescence.

6.5.1 Pavement

The value of NHS pavements is determined based on lane-mile replacement value at the system level. This consists of the total cost to replace the full pavement structure (excluding right-of-way and grading cost) based on current construction prices. The current value (CV) is calculated by subtracting the discounted value of the surface course from the total reconstruction cost (for this calculation it is assumed that the pavement's base and any intermediate layers of pavement are adequate and hasn't lost any value). The CV of the surface course is calculated using the total surface course replacement value, discounted by the Pavement Condition Index (PCI) for each network level. The following formula is used to calculate the pavement value for one lane mile:

$$CV = Total\ Reconstruction\ Cost - New\ surface\ value\left(1 - \frac{PCI}{100}\right)$$

This method estimated that the current value of all NCDOT pavements on the NHS system is over $30 billion. The value of pavement assets has remained marginally constant each year for the past 4 years which serves as an indicator that NCDOT's Financial Plan and Investment Strategy is adequately funding pavement programs to meet their performance targets and offset any loss in value based on condition.

6.5.2 Bridge

The value of bridges is determined based on the replacement value then discounted using condition (sufficiency rating) and residual life. To account for the variety of bridge types and sizes, the replacement value (RV) is based on bridge types by to system. The RV is calculated using the area of the deck in square feet, multiplied by the current construction replacement unit cost. The current value (CV) is calculated by subtracting the discounted value using the bridge's sufficiency rating and residual life from the replacement value. The sufficiency rating is a nationally recognized numerical value from 1 to 100. According to FHWA's Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, "The sufficiency rating formula….is a method of evaluating highway bridge data…to obtain a numeric value which is indicative of bridge sufficiency to remain in service." NCDOT estimates bridges on the NHS to have a serviceable life of 75 years. The following formula is used to calculate the current bridge value.

$$CV = RV\ X\ \frac{Sufficienct\ Rating}{100}\ X\ \left(1 - 0.5\frac{\text{year today} - \text{year built}}{75}\right)$$

This method estimates the current value of all NCDOT bridges on the NHS system is over $27 billion. The value of the agency's bridge assets has marginally increased each of the past four years which serves as an indicator that NCDOT's financial plan and investment strategy is adequately funding bridge programs to meet their performance targets and offset any lost in value based on condition.

6.6 NCDOT's Investment Strategy Process

Beginning in 1998 the Department began an in-depth assessment of the condition of highway maintenance, pavement, and bridge needs and quantifying the cost to maintain these assets at an acceptable level of service to satisfy newly enacted state legislation. This effort matured over the last 20 years into the MOPAR. NCDOT is required to perform an analysis and submit a formal report to the NCGA on a biennial basis. MOPAR satisfies many national requirements by performing a gap analysis, using life-cycle planning, estimates cost to achieve state asset management targets, identifies a 5-year work program, and estimates the cost of various work types. MOPAR does not specifically address requirements of risk analysis considerations, improving the condition and performance of the NHS, achieving NCDOT targets for the NHS, and achieving the national goals.

6.7 Influencing Factors

6.7.1 Funding

Revenues are grouped into three major funds: Highway Fund, Highway Trust Fund, and federal funds. Each source has a specific purpose and contributes to initiatives that help achieve state asset management targets for pavement and bridges.

6.7.2 Revenue Forecast

Based on the revenue forecast a significant portion of the available revenue will be used to support the maintenance, pavement, and bridge programs. In the case of the pavement and bridge programs, funds will be used for a multitude of treatments including maintenance, preservation, rehabilitation, reconstruction, and replacement.

6.7.3 Risk Analysis

A comprehensive risk analysis has been completed evaluating risks the Department has faced. Examples include hurricanes, floods, snow and ice storms, rockslides, federal aid funding, revenue stagnation, economic down-turn, etc.

The majority of pavement and bridge projects on the primary and secondary system are funded through state programs. Because the Department does not have an "NHS-specific" funding program, there are two risk statements noted below:

1. **Risk**
   There is a possibility that in any given year projects may or may not be on the non-Interstate NHS. The non-interstate NHS makes up approximately 30% of the route miles of state "primary system" and about 40% of the lane miles.

2. **Opportunity**
   Pavement and bridge projects on the primary and secondary systems are state funded and the amount currently exceeds the federal aid apportionment for North Carolina. Should a need be identified for the non-interstate NHS, the Department can shift funding to the non-interstate NHS rapidly with little to no coordination needed with outside entities.

Interstate highways have a dedicated program (*NCDOT designated "Interstate Maintenance" program*) funded with federal aid to address needs on the interstate system.

(*See Chapter 5*)

6.7.4 Life-cycle planning

NCDOT advocates a holistic approach that addresses assets in poor condition while also investing in preservation strategies to keep assets in good condition. The Department has long embraced the concepts behind life cycle planning and optimization of the work program for maintenance, pavement management, and the bridge program; and has worked with the NCGA to that end.

(*See Chapter 4*)

6.7.5 Gap Analysis

The Department has long performed a condition assessment of highway assets and produced reports on actual vs. target, estimating the cost to achieve an acceptable level of service. Gaps and recommended investment are dealt with more substantially in the MOPAR. While the MOPAR does not distinguish conditions on the NHS, 95.7 % of NHS is included in either the interstate or primary highway systems, therefore their condition will be similar.

6.8 How Investment Strategies Support Performance

6.8.1 Achieving the State Asset Management Performance Targets

The MOPAR makes investment recommendations and uses a stepwise approach to reach long-term goals. The MOPAR and HMIP identify pavement and bridge projects which help the Department achieve and sustain targets.

6.8.2 Improving and Preserving the NHS

Asset management requires institutionalizing a performance management culture whereby measures and targets are linked to the goals and objectives of the agency. AMS allows performing scenario analyses on future condition of an asset based on funding levels and investment strategies. Within the core functionality of both a PMS and BMS is the presence of algorithms and deterioration models to predict the future condition of an asset based on variables such as weather, climate, environment, age, traffic loading, treatments, funding, etc. Another core function is a life cycle cost analyses whereby tailored treatments are applied to an asset based on condition. This approach minimizes whole-life cost by applying low-cost treatments early. The Department uses AMS along with the technical expertise to develop HMIP to preserve the condition and performance of the NHS.

(*See Chapter 3*)

6.8.3 Achieving NCDOT Targets on NHS

Performance targets provide the means to determine if the asset's condition is meeting expectations. Targets were established on a tiered approach based on the highway classification and its importance. At the network level, AMS provides output reports to enable NCDOT managers to gauge success in meeting the goals.

The agency established performance targets for the National Performance Management Measures identified in 23 CFR Part 490. An Oversight Committee consisting of key NCDOT managers was established to provide oversight and coordination for implementation of all MAP-21 and FAST Act final rules including development of performance targets. The Department is currently exceeding the federal minimum performance standards for NHS pavements and bridges.

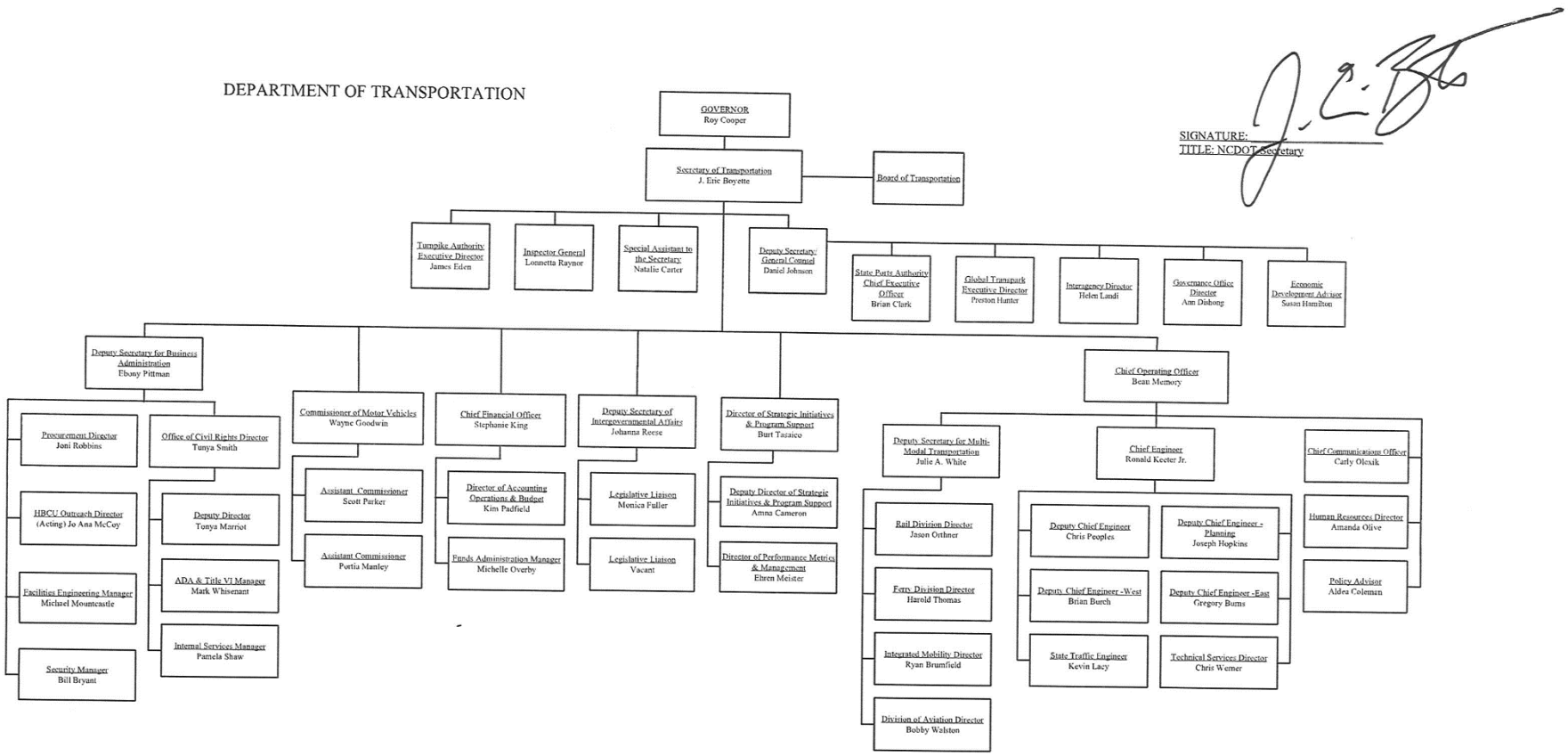
(*See Chapter 3*)

6.8.4 Achieving National Goals

NCDOT evaluates funding needs and effectiveness of the programming of projects, services, and efforts to meet the performance requirements of other sections of MAP-21 on safety, congestion reduction, system reliability, freight movement and economic vitality, environmental sustainability, and reducing project delivery delays. All these expectations are considered by senior management as annual budgets are developed in conjunction with the STIP and HMIP. Well-defined pavement and bridge programs and systems in place to evaluate the condition and future performance based on life-cycle cost planning enables NCDOT to make informed decisions based on reliable data and analyses.

APPENDIX

ORGANIZATIONAL CHART



SIGNATURE:
TITLE: NCDOT Secretary

Revised 3/4/2022

FACILITIES REPEATEDLY DAMAGED

Damaged Site Corrective Action Est. Corrective Cost	Damaging Events	Description of Damage	Est. Cost of Damage
Division 1			
NC 308 King St Signal Raise Cabinet 48" with Hand Railing OSHA (Wood Structure) $8,000	Hurricane Matthew	Signal/cabinet damage from winds/flooding	7,199
	TS Nicole	Signal damage from winds/flooding	21,208
Chowan River Bridge on US 17 No know solution, except a monolithic structure in lieu of pile and cap end bent. $1,000,000	Hurricane Irene	Undermining and end bent damage on west end bent	359,629
	Hurricane Isabel		270,500
NC 12 Canal Area Vulnerable area of NC 12 located between Bonner Bridge and the USFW parking lot. Location within Pea Island National Wildlife Refuge. Rigid structures not allowed. Nature of Barrier islands causes erosion, blowing sand, etc. The only alternative is to construct a bridge the entire length of the park, approximately 14 miles+	2021 Coastal Storm	Dune washout over a 4993' section requiring reconstruction	252,144
	Hurricane Dennis/Bonnie	Damage Resulting from blowing sand and overwash (*prior to SAP)	
	Hurricane Irene		22,603
	Hurricane Isabel	NC12 Repair Pavement and reestablish dunes (approx.8900') @ Canal Area. $75,000	303,056
	Hurricane Joaquin	Damage resulting from Ocean Overwash. Estimate: $35,000	34,233
	Hurricane Matthew	Windblown Sand on NC 12. Using force account labor as well as FOR to reestablish the dune and buffer area within the 100' ROW.	185,600
	Hurricane Ophelia	Approx. 2000' of dune repair-est. $200,000-gab add additional $55,000 to sprig/sand fence area	236,963
	Hurricane Sandy	NC-12 (Pea Island) from Bonner Bridge to USF&W Building; Remove sand; Rebuild dunes	335,684

	November 22, 2006 Floods	Inlet Bridge to Pea Island MAINT Building	351,600
	Tropical Depression Ida		60,464
NC 12 at New Inlet Area Another vulnerable area. Had been damaged multiple times. New structure recently completed that will span the potentially weak area of NC 12 known as New Inlet.	Hurricane Irene	09/06/11 - EMERGENCY PERMITS FOR IRENE DAMAGE IN DARE CTY FOR REPAIR OF NC 12 @ 2 BREACH AREAS: RODANTHE & PEA ISLAND NTL WILDLIFE REFUGE.	10,767,360
	Hurricane Matthew	NC 12 South of New Inlet. Dune has covered Roadway NC12. Return dune to pre-Matthew condition	7,660
	Hurricane Sand	NC-12 (New Inlet Bridge); Repair bridge; Repair guardrail; Repair roadway; Remove sand.	568,734
	Hurricane Sandy	NC-12 (Pea Island) from New Inlet Parking Lot to S-curves; Remove sand.	12,174
	Hurricane Sandy	NC-12 (Pea Island) from USF&W Building to New Inlet Bridge; Remove sand; Rebuild dunes; Repair roadway	35,568
NC 12 at Mirlo Beach (immediately north of Rodanthe) Mirlo Beach area. Repaired multiple time. Project now under design to bypass this area with a bridge, known as Rodanthe "Jug Handle' bridge	Beach Nourishment	Beach Nourishment	20,300,000
	Hurricane Dennis/Bonnie	Ocean Overwash	
	Hurricane Irene		3,378,596
	Hurricane Isabel	NC12 Repair Pavement & reestablish Dunes (approx. 7600') @ S Curves.	196,499
	Hurricane Matthew	Dune has covered Roadway NC12. Restore dune to pre-Matthew condition.	8,113
	Hurricane Ophelia	Pea Island-S Curves approx. 750' of dune repair@ approx. $150,000	71,240
	Hurricane Sandy	NC-12 (Pea Island) from S-curves to Rodanthe; Remove sand; Remove sand; Repair, replace, install sandbags; Repair roadway.	6,170,678
	November 22, 2006 Floods	NC S Curves 2miles north of Rodanthe to Rodanthe.	2,312,193

	Tropical Depression Ida		1,140,581
NC 12 in Kitty Hawk Protective dunes along NC 12 (Beach Road), between milepost 4 and 5. Temporary sandbags and dune construction performed multiple times. No alternative to relocate road. Sandbags installed, which represent the only permitted option. Rigid structures not allowed in the surf zone. Road relocation is not an option due to home density.	Hurricane Isabel	NC12 Re-establish Dunes at breeches throughout the Old Sandbag, Area (approx. 8500')	230,089
	Hurricane Isabel	NC12 Repair Dunes and Roadway in Kitty Hawk.	898,265
	Hurricane Joaquin	Repair/reconstruct dune, install sandbags, repair pavement, and other associated work, for approximately 1500 LF along NC 12, in Kitty Hawk. Dune, pavement, and existing sandbags damaged/destroyed by Hurricane Joaquin and associated coastal storm. Work to be accomplished by contract forces.	448,878
	Hurricane Matthew	Damage Description: Sandbags and Dunes missing. Replace sandbags and construct dune.	397,146
	Hurricane Sandy	NC-12 from US 158 (Kitty Hawk) to Sportsman (Kill Devil Hills); Repair Roadway; repair, replace, install sandbags, dune construction	883,592
NC 12 Buxton Weak area at north end of Buxton Community. Eroded dunes allow overwash and damage. Beach nourishment accomplished by Dare County, but this will be ongoing. Relocation of road is the only option to avoid encroaching dunes and surf; not feasible due to proximity of Pamlico Sound.	Hurricane Isabel	NC12 Repair Pavement & Dunes north of Buxton Village. Shape dune prior to sprigging. As of 03/25/04, all work completes except sprigging & patching, Est $15,000.	39,142
	Hurricane Ophelia	North of Buxton approx. 300' of dune repair@ approx. $50,000-gab	17,497
	November 22, 2006 Floods		17,216
NC 12 Ocracoke Protective dunes along NC 12 damaged multiple times by various storms. No alternative but to restore dune line to keep ocean overwash off NC 12. Adjacent lands all Federal Property (National Park), therefore road cannot be relocated. Dune has been reconstructed, which represented only	2021 Coastal Storm		5,471,465
	Hurricane Irene		615,098
	Hurricane Isabel	NC12 Repair Abutments Washed out.	51,306
	Hurricane Isabel	NC12 Repair Dunes and Reconstruct roadway.	3,021,696

reasonable solution. Other solution, construct bridge in sound. $250,000,000	Hurricane Joaquin	Dune damaged/destroyed by Joaquin, and coastal storm. Dune to be 10 feet in height, with a base width of 40 to 50 feet. Work to be accomplished with FOR and NCDOT forces.	467,808
	Hurricane Ophelia	Ocracoke Approx. 600' of Dune Repair	18,899
	Tropical Depression Ida		102,100
US 64, Martin County, slope failures due to heavy rains. Install freeway curb and storm drainage along entire section. Damage repair insignificant given the length of roadway section, number of storms, and minimal monetary damage. $500,000	Hurricane Joaquin	Repair washouts along US 64 which includes labor, material, riprap, & repair to concrete flume.	5,920
	Tropical Storm Nicole	Slope repair on US 64 WB Lane 0.1-mile East of US 17. Function: 3112	6,717
US 64, Alligator River Replace bridge with high h rise structure and eliminate the swing span. $175,000,000	Hurricane Isabel	Damaged motors on Alligator River Bridge	5,951
	Hurricane Matthew	Various damage. No alternative. Fender Walkway Repair	48,021
Division 2			
NC 55 @ NC 11: Lenoir Add fill to flatten slopes & install curb & gutter w/drainage structures ~5,000 lft. $500,000	Floyd		
	Matthew	NC-11 Shoulder Washout at Multiple Sites	10,000
NC 11 over Neuse River: Lenoir Add fill to flatten slopes & install curb & gutter w/drainage structures ~4,000 lft. $400,000	Floyd		
	Matthew	NC 11/55 Washouts from King Street Bridge	50,000
NC 903: Lenoir Remove box structure and replace Bridge. $750,000	Floyd		
	Matthew	NC-903 Pavement and Shoulder Repairs	125,000
US 258 @ US 70W: Lenoir Raise roadbed at this intersection approximately 2.5ft. $2,000,000	Floyd		
	Matthew	US-258 Shoulder Washouts at US-70 West	20,000

US 70 BYP: Lenoir Add fill to flatten slopes & install curb & gutter w/drainage structures ~8,200 lft. $800,000	Floyd		
	Matthew	US-70 Bypass Washouts from US 70 Business to US 258	20,000
NC 33: Pitt 35' -3" x 12'-1" Alum Box Culvert w/Head Wall or 3 @ 10' x 10' RCBC w/HW or 95' to 105' Bridge $1,000,000	Floyd		
	Matthew	NC-33 Tenth Street Washout at Culvert #2016	375,000
Division 3			
NC 130: Brunswick Raise grade up 4ft. For approximately 500ft. $296,152	Hurricane Florence	Shoulder washout on eastbound side of NC 130, undermined pavement.	
	Hurricane Floyd	Shoulder washout on eastbound side of NC 130, undermined pavement.	50,000
	TS Nicole	Shoulder washout on eastbound side of NC 130, undermined pavement.	27,158
Division 4			
(SR 1332) Lake Wilson Rd Single Span Bridge $1,000,000	Hurricane Floyd	Repaired washout across the roadway and guardrail	30,000
	Hurricane Mathew	Repaired washout to roadway at culvert	33,205
US 258 at NC 111 Princeville, NC Remove controllers from signal cabinet prior to projected flooding; this area floods up to signal heads and beyond standard cabinet risers $30,000	Hurricane Floyd	Traffic signal cabinet and components flooded and required replacement.	6,000
	Hurricane Matthew	Traffic signal cabinet and components flooded and required replacement.	7,250
US 258 at NC 33 Princeville, NC Remove controllers from signal cabinet prior to projected flooding; this area floods up to signal heads and beyond standard cabinet risers $30,000	Hurricane Floyd	Traffic signal cabinet and components flooded and required replacement.	5,800
	Hurricane Matthew	Traffic signal cabinet and components flooded and required replacement.	7,250
Forest Hills at Downing St Wilson, NC Cabinet has been raised $30,000	Hurricane Floyd	Traffic signal cabinet and components flooded and required replacement.	5,800
	Hurricane Matthew	Traffic signal cabinet and components flooded and required replacement.	7,400

Pipe 042-0042 Pipe Replaced per hydro specifications $750,000	Hurricane Floyd	Roadway and Shoulder Washed	47,700
	Hurricane Irene	Pipe Failed Replaced Pipe	203,400
	Hurricane Matthew	Pipe Failed Replaced Pipe	467,000
Division 5			
Dam spillway Increase Culvert to 3 Barrel, Homeowners Association won't cooperate with control water level of Dam $500,000	Floyd	Dam spillway does not align with culvert and washes out the embankment of NC-39	150,000
	Matthew		
Division 6			
US 701 (Bladen) NC 53 W to NC 87 Bus After the last storm (Matthew), permanent solution was implemented by installing shoulder berm gutter with drop inlets and down drains.	Matthew	Reoccurring slope failures due to top-down erosion / soil saturation.	1,100,000
	Joaquin		
	Floyd		
US 701 (Bladen) Cape Fear River Bridge 16 and 17 being replaced with a single structure with larger spans and center bents oriented with river flow 28,000,000	Matthew	River Debris Caused Damage to Fender System (Matthew) and Flow Diversions that ultimately damaged bridge (Dorian) NOTE: Estimated Amount Not Expended Due to Decision to Replace Structure	15,300,000
	Florence		
	Dorian		
NC 41 (Bladen) 1.4 Mi. N. of US 701 Permanent solution is to raise roadway elevation which will necessitate larger culvert or bridge to maintain 100-year elevation	Matthew	Overtopping During Matthew and Florence caused extensive shoulder loss with pavement loss	40,000
	Florence		
NC 53 (Bladen) 1.37 Mi. S. of SR 1332 Permanent solution implemented after	Matthew	Major Approach Failures During Matthew and Florence	19,000

Florence by accelerating replacement of bridge using Bridge funds (already programmed)	Florence		
NC 87 (Bladen) 0.2 Mi. E. of SR 1714 Permanent solution implemented after Matthew by installing junction box in pipe to dissipate velocity and align the outlet with stream.	Matthew	Reoccurring slope failure caused by pipe outlet entering 90-degree bend in stream.	150,000
	Joaquin		
	Floyd		
NC 87 (Bladen) 0.2 Mi. N. of SR 1724 Permanent solution implemented after Matthew by constructing a sheet pile retaining wall along stream bed, flattening slopes, installing shoulder berm gutter, and subsurface drainage	Matthew	Reoccurring slope failure due to saturation from top, subsurface, and stream located at and parallel to base of fill.	450,000
	Joaquin		
	Floyd		
NC 87 (Bladen) 1.0 Mi. W. of SR 1704 (Hammonds Creek) permanent solution by installing shoulder berm gutter with drop inlets and down drains.	Matthew	Reoccurring slope failures due to top-down erosion.	350,000
	Joaquin		
	Floyd		
NC 210 (Bladen) 0.9 Mi. E. of US 701 Permanent solution implemented after Florence by replacing Floyd era pipes with RCBC	Matthew	Overtopping of Roadway Causes Major Loss of Shoulders / Pavement Damage	992,000
	Florence		
US 74(Columbus) 0.7 Mi. W. of US 74 / 76 Business WB Bridge received major sheeting, approach repairs, and crutch bent after storms. Bridges need to be replaced and lengthened to accommodate 'bend' in stream channel approaching bridge $14,000,000	Matthew	Overtopping storm flows have caused major slope and bridge approach damage in Matthew and Florence	3,700,000
	Florence		
US 74(Columbus) 0.4 W. of SR 1506 (Lumber & Overflows) Bridges received additional rip rap and approach strengthening. If this does not work, next step would be to raise elevation / extend length	Matthew	Overtopping storm flows have caused major slope and bridge approach damage in Matthew and Florence	111,000
	Florence		

US 701(Columbus) 0.3 Mi. N. of SR 1333 Permanent solution is to raise roadway elevation which will necessitate larger culvert to maintain 100-year elevation $500,000	Matthew Florence	Reoccurring overtopping causes loss of shoulder and pavement but RCBC remains intact	110,000
US 701 Business (Columbus) 0.1 Mi. S. of SR 1916 After the last storm (Florence), downstream slope was armored with rip rap. Next option would be to increase bridge size to reduce overtopping exposure $1,200,000	Matthew Florence	Reoccurring overtopping causes slope failure and pavement loss on downstream side	300,000
US 74 0.25 E of NC 130 This section is being studied for resiliency efforts under upcoming project	Matthew Florence	Reoccurring overtopping causes pavement loss on downstream side	2,671,557
NC 904 from SR 2256 to Columbus Co. Permanent solution is to raise roadway elevation	Matthew Florence	Reoccurring overtopping causes pavement loss on downstream side	1,065,762
SR 2049 (Buddy Barefoot Rd) 0.37 miles N of SR 2050 (Shady Grove Rd) Construction of a rip rap lined base ditch to carry runoff to the appropriate outlet	Matthew Florence	Recurring washout at unpaved roadway where ditch overtops	100,000
Division 13			
NC 81 Repair with Shot Rock $15,000	Hurricane Frances	NC 81 FROM US 25 TO US 70 - SHOULDER WORK IN FRONT OF HAJOCA & GUARDRAIL REPLACEMENT, NC 81 & GLENDALE AVE. 200 LF GUARDRAIL REPLACEMENT, NC 81 & BEECHWOOD 200', SHOULDER REPAIR, SINKHOLE	9,901
	Hurricane Ivan	NC 81 FROM INTERSTATE 240 BRIDGE TO US 70 - WASHOUT	5,699
US 19/23 Repair with Shot Rock $16,000	Hurricane Ivan	US 19/23 - 0.40 MILES FROM SR 1140 (NORTH MORGAN BRANCH ROAD) - SLIDE	33,564
	Hurricane Ivan	US 19/23 - FROM HAYWOOD COUNTY LINE TO NC 151 - SLIDES	15,055
	July 2013 Mudslides	US 19/23 - 0.40 MILES FROM SR 1140 (NORTH MORGAN BRANCH ROAD) - SLIDE	8,178

I-40, MCDOWELL/ BUNCOMBE CO. LINE Install T-2 Barrier Wall. And Landslide Barrier! $1,340,000	Hurricane Frances	Slope Failure	275,891
	May 29, 2018 Mudslide	Slope Failure (* Cost as of July 10, 2018). Expected total costs with remediation $2 million +.	46,693
	May 6, 2013 Mudslide	Slope Failure (Non-Declared Event)	38,500
NC 181 Minor Repairs, no additional work needed	Hurricane Frances	SLIDES	58,879
	Hurricane Ivan		55,733
NC 63 Repair with Soil Nail $340,000	Hurricane Frances	Shoulder washout	7,921
	Hurricane Ivan	Shoulder washout	6,185
	Hurricane Ivan	Slide and shoulder washout	20,437
	Jan 2013 Mudslides	Rockslide	19,649
Division 14			
I-40 near mm 2.5 2009 was Permanent Solution. $17,000,000	I-40 rockslide, 10/25/2009	125 - Rockslide closed I-40 for six months	17,000,000
	I-40 rockslide, 7/1/1997	Rockslide closed I-40 for several months	5,000,000
	I-40 rockslide, 9/18/2004	112 - Hurricane Ivan - rock slide and retaining wall failure closed I-40 for several months.	1,000,000
US 276 Excavate/realign river to create a vegetated buffer between the river and highway $500,000	Hurricane Ivan	Fill Slope (riverbank) and shoulder washout	33,000
	TS Fred	Fill Slope (riverbank) and shoulder washout	20,000

Risk Identification & Evaluation

Risk ID	Risk	Average Likelihood	Average Consequence	Score
1	Major event hits NC, washouts, drainage, or pipe failures, weakened pavement structure, heavy loads immediately after event, diversion of personnel and equipment, lack of connectivity for citizens and freight, potential diversion of funds (up to 20% out of pocket), economic impacts to businesses in affected area.	4.4	4.2	18.5
2	Funding shortfall, Fewer projects, less optimal treatments, decreased pavement condition ratings, reduction in personnel, RPO's funding decreased, MPO's funding decreased	2.6	3.8	9.9
3	Route closed by rockslide, Roads blocked, Debris requires removal, lack of connectivity for citizens and freight, economic impacts for blocked businesses, structural integrity of embankment and pavement, injuries, or fatalities	3.6	3.8	13.7
4	Projected population increases occur, Increased traffic, increased freight traffic, increased pavement deterioration, decreased public satisfaction, increased treatment cost, need to increase capital program, increased tax base, more safety concerns, pavements need structural improvement, more lane miles to maintain, potentially increased urban and suburban areas.	4.8	3.0	14.4
5	IT threats to PMS- system ceases to operate, can’t produce reports, can't import data, also impacts PCS, data collection, MMS and BMS.	2.6	3.0	7.8
6	PMS must change to different vendor. Requires dollars and time to transition to new system, data integrity, users don't know the new system, programs and reports still needed.	3.6	2.8	10.1
7	Data storage amount and modernization, Loss of historical data (data used less frequently), loss of institutional knowledge	2.6	3.6	9.4
8	Data collection equipment operating system or file formats go out of date, May lack skid data on road with poor friction	2.8	2.8	7.8
9	Cement or Asphalt shortage, Delayed Construction, higher cost means less work, pavement condition declines during delay, only lower quality materials available, could change pavement type	4.0	3.4	13.6
10	Alkali Silica Reactivity, Pavement failure at Depth, Increased maintenance costs, increased ride roughness	2.6	3.4	8.8
11	Climate change raises average temperatures and level of ground water table. Asphalt used in pavement is not adequate for higher temperatures so rutting develops, higher GWT results in decreased support under pavements, increased frequency of extreme events (see hurricanes and flooding). Some roadways may be flooded in coastal plain.	2.8	3.2	9.0

12	If high priority requests for maintenance cannot be addressed, affected bridges may become closed or load restricted, resulting in increased delays and costs for the public and industry	2.6	3.8	9.9
13	If high value bridges are not preserved, Then the percent of SD deck areas on NHS will exceed 10%, resulting in a shift of funds from STI to the Bridge Program	2.4	3.8	9.1
14	Bridge Preservation Plan is not funded, Then the percentage of SD bridges will increase and will result in less bridge funds (funding capacity)	2.4	4.0	9.6
15	If bridge inspection data is not maintained at the highest level, we will have issues with reporting and will face problems demonstrating our needs	2.2	3.6	7.9
16	If there are issues with IT tools, we will have issues with reporting and will face problems demonstrating our needs	2.4	3.0	7.2
17	If enough bridge projects are not "shelf ready", Programs may not be able to be accelerated at the request of leadership	3.3	3.3	10.9
18	If a major landslide should occur along I-40, Road would be closed. Major disruptions in travel times for public and businesses	3.6	4.0	14.4
19	If flash flooding events occur, Bridges could be closed, causing delays in emergency response	3.8	3.6	13.7
20	If an interstate bridge is damaged, the bridge would need to be closed, creating traffic delays	3.4	3.6	12.2
21	Funding shortfall for bridge projects, System deterioration will increase; department will be unable to reduce or maintain current SD percentages	2.6	3.6	9.4
22	Transportation Funding, moving forward not related to motor fuels	3.3	3.5	11.6
23	Asset Inventory issues	3.8	3.0	11.4
24	HMIP, BMIP, RMIP plan issues	3.5	3.0	10.5
25	Reactive vs Planned Activities	4.3	3.0	12.9
26	Unit Cost for proper planning and needs assessment	3.7	3.0	11.1
27	Snow and Ice	5.0	3.0	15.0
28	Pavement Markers and Markings Issues	5.0	3.0	15.0

REFERENCES

A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management [Online] / auth. SpyPond Partners, KPMG, University of Texas. - https://nap.nationalacademies.org/read/25285/chapter/1.

Highway Maintenance Improvement Plan (HMIP) [Online] / auth. NCDOT. - https://connect.ncdot.gov/resources/Asset-Management/HMIP/Pages/default.aspx.

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Risk-Based Transportation Asset Managemet: Evaluating Threats, Capitalizing on Opportunities [Online] / auth. FHWA. - https://www.fhwa.dot.gov/asset/pubs/hif12035.pdf.

Structures Management Unit Inspection Manual [Online] / auth. NCDOT. - https://connect.ncdot.gov/resources/Structures/StructureResources/Inspection%20Manual.pdf.

CONSISTENCY DETERMINATION CHECKLIST

Indicators Element Meets the Requirements	How Requirements is Addressed in this Document
TAMP approved by head of State DOT (23 CFR 515.9(k))	
1. Does the TAMP bear the signature of the head of the State DOT?	Signature of NC Secretary of Transportation is on the transmittal letter to FHWA
State DOT has developed its TAMP using certified processes (23 CFR 515.13(b))	
2. Do the process descriptions align with the FHWA-certified processes for the State DOT?	NCDOT followed the requirements of 23 CFR 515.13(b) in developing the TAMP (entire document)
3. Do the TAMP analyses appear to have been prepared using the certified processes?	NCDOT followed the requirements of 23 CFR 515.13(b) in developing the TAMP (entire document)
TAMP includes the required content as described in 23 CFR 515.9(a)-(g) (23 CFR 515.13(b))	
4. Does the TAMP include a summary listing of NHS pavement and bridge assets, regardless of ownership?	Chapter 2 provides a summary listing of NHS pavement and bridge assets including federal and local government ownership.
5. Does the TAMP include a discussion of State DOT asset management objectives that meets requirements?	Chapter 1 provides a discussion on asset management objectives and measures.
6. 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?	NCDOT established national performance measurement targets and state asset management and targets for pavements and bridges in Chapter 3
7. Does the TAMP include a summary description of the condition of NHS pavements and bridges, regardless of ownership, that meets requirements?	Document discusses that >99% of the NHS pavement and bridges are state maintained, and condition of pavement and bridge assets on the NHS regardless of ownership in Chapter 2
8. Does the TAMP identify and discuss performance gaps?	Gaps affecting NCDOT's condition of NHS pavements and bridges are discussed in Chapter 3
9. Does the TAMP include a discussion of the life cycle planning that meets requirements, including results?	Discussion on life-cycle planning is described in Chapter 4. Results from analyses is described in Chapter 3.
10. Does the TAMP include a discussion of the risk management analysis that meets requirements?	Discussion on risk management process and analysis is described in Chapter 5.
11. Does the TAMP include the results of the evaluations of NHS pavements and bridges pursuant to 23 CFR part 667?	Evaluation results pursuant 23 CFR Part 667 are shown in Chapter 5.

Indicators Element Meets the Requirements	How Requirements is Addressed in this Document
12. Does the TAMP include a discussion of a 10-year Financial Plan to fund improvements to NHS pavements and bridges?	Discussion on NCDOT's 10-year Financial Plan is found in Chapter 6.
13. Does the TAMP identify and discuss investment strategies the State intends to use for their NHS pavements and bridges?	Discussion for investment strategies the State intends to use for their NHS pavements and bridges is found in Chapter 6.
14. 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?	This document shows the results of current processes and strategies in Chapter 6 for managing pavement and bridge assets that have produced a highway system meeting state asset management targets and measures described in Chapter 3.
15. 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?	This document shows historical condition data for pavements and bridges exceeding national performance goals. Chapters 2 & 3.
16. 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)?	This document shows the results of current processes and strategies for managing pavement and bridge assets that have produced a highway system that is meeting the state targets for the national performance measures as described in Chapters 2 & 3.
17. Does the TAMP include a discussion as to how the investment strategies support progress toward achieving the national goals identified in 23 USC 150(b)?	This document shows the results of current processes and strategies for managing pavement and bridge assets that have produced a highway system that is meeting the state targets for the national performance measures as described in Chapters 2 & 3.
18. 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?	NCDOT has historically had an effective process for determining allocation of funds and resources to meet the agency's objectives and measuring targets. This document outlines a summarization of NCDOT's process in the development of their annual pavement and bridge management programs. NCDOT's risk analysis has identified top priority risk strategies for mitigation.

Inclusion of Other Assets in the TAMP:	
19. If applicable, does the TAMP include a summary listing of other assets, including a description of asset condition?	Not applicable
20. If applicable, does the TAMP identify measures and State DOT targets for the condition of other assets?	Not applicable
21. If applicable, does the TAMP include a performance gap analysis for other assets?	Not applicable
22. If applicable, does the TAMP include a discussion of life cycle planning for other assets?	Not applicable
23. If applicable, does the TAMP include a discussion of a risk analysis for other assets that meets requirements in 23 CFR 515.9(l)(5)?	Not applicable
24. If applicable, does the TAMP include a financial plan to fund improvements of other assets?	Not applicable
25. If applicable, does the TAMP include investment strategies for other assets?	Not applicable