North Carolina Department of Transportation
Transportation Asset Management Plan
2019 Final Report

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Acronyms

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
IM	Interstate Maintenance
HMIP	Highway Maintenance Improvement Plans
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
SAT	State Asset Targets
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

Chapter 1 Transportation Asset Management Objectives

1.1 Introduction

The North Carolina Department of Transportation (NCDOT) has been practicing asset management principles for years using a data-driven process to guide the Department in meeting the expectations of its senior leadership and the multitude of stakeholders that support surface transportation in the state. This Transportation Asset Management Plan (TAMP) highlights the work the Department has accomplished over the last decade to establish a data-driven culture within the organization to achieve agency goals and to demonstrate how the Department will meet the goals and objectives of the Moving Ahead for Progress in the 21st Century Act (MAP-21) and the Fixing America's Surface Transportation (FAST) Act.

In general terms, the TAMP is a strategic framework that positions agencies to consider the full life-cycle cost when evaluating, managing, and investing in transportation assets and infrastructure. It establishes a business-like approach within an agency that looks to limit long-term costs while extending the overall lifecycle and boost the system-wide performance of the transportation network. The purpose of the TAMP is to document the transportation assets that fully encompass NCDOT's transportation network in order to maintain and preserve that network.

In 2012 the United States Congress passed MAP-21, groundbreaking legislation which for the first time established an expectation and requirement that state Departments of Transportation meet specific performance requirements for the nation's most heavily traveled highways – the National Highway System (NHS). The legislation and final rules transformed 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 as follow:

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

While this document will focus on national goal number 2. Infrastructure Condition, NCDOT has developed other documents to meet the requirements of the remaining six national goal areas.

The Department is led by the Secretary of Transportation and a 19-member Board of Transportation. The Board serves as the Department's 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 (DMV), Turnpike Authority, State Ports Authority, and Global TransPark. An organization chart can be found in the appendix.

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." North Carolina has major tourist destinations from the mountains to the sea and one aspect of the Department's mission is to bring those tourists to and from their homes with a pleasant, safe, and efficient driving experience. Many of the state's agricultural and manufacturing businesses rely on NCDOT facilities in transporting goods to market which is vital to the state and national economies. North Carolina is also home to numerous medical, educational, and military sites and as host to these sites, transportation is key. NCDOT's mission is to serve all these customers who use the transportation system at the highest level possible within available funding.

NCDOT has developed goals that support the Department's mission. They are:

- Make our transportation network 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

Among the initiatives that are directed at making transportation safer is the Spot Safety Program (SPOT), which provides funding for small projects to improve site distance, correct road geometry, address areas with elevated crash rates, support intelligent transportation systems that provide advance warning of delays or incidents along major corridors, and the NCDOT Incident Management Assistance Patrol (IMAP) program that provides assistance to motorists along major highways. In addition, data concerning crashes and crash locations is tracked and used to identify areas where safety improvements may be needed. NCDOT has had a pavement friction testing program for more than 20 years. Due to the high quality of aggregates, surface friction is rarely the issue causing wet weather accidents, but this program assures that this remains the case. Critical findings from bridge inspections are tracked and scheduled to reduce safety impacts. The (DMV) also plays a significant role in making transportation safer by licensing qualified drivers and instructing them on the importance of seat belts, controlling speed, proper driving around schools and school buses, and numerous other safety-related topics.

NCDOT owns and maintains the second largest road network in the country. By state statute there are no county-owned roads, and most public roads – other than municipal streets and federal roads – are state-owned. As a result, virtually every citizen is a customer. Most of these customers interact with NCDOT through the local county maintenance yards or district offices. Additionally, the Department has a toll-free number (1-877-DOT-4YOU) for customers to call with questions or to report potholes or other infrastructure defects. Sometimes items are reported to personnel in central office units, and these are

transmitted to the appropriate location for response. The goal is to listen to the issue and provide a response to the citizen in a manner that is helpful and courteous. Customer service also consists of attending public meetings, interacting with citizens during right-of-way acquisitions, and numerous other situations that require tact and clear heads.

In addition to direct citizen interactions, NCDOT also interacts with Metropolitan Planning Organizations (MPOs) and Rural Planning Organizations (RPOs). Within North Carolina, both MPOs and RPOs participate in the development and prioritization of projects for the Statewide Transportation Improvement Program (STIP). NCDOT has 14 geographic 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 North Carolina General Assembly (NCGA), which guides NCDOT's activities through statute and funding. They are among the agency's biggest customers for asset management system analyses, and NCDOT personnel strive to provide reports that assist the members in their oversight functions.

The goal of delivering and maintaining the state's infrastructure effectively and efficiently is directly related to asset management and the TAMP. To assist with the accomplishment of this goal, the Department relies on complex computer software systems such as the Maintenance Management System (MMS), Pavement Management System (PMS), Bridge Management System (BMS) and other systems to manage equipment, signs, signal systems, and other asset types. It also includes the data required to use these systems: maintenance condition assessments, automated pavement distress data collection for the NHS (automated data collection for the entire network began in 2018), and the regular program of bridge inspections. The data supplied by these condition assessments is used to drive funding decisions in the 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. Management systems provide key input into the development of projects to be included in these programs. Engineering judgement is required to combine pavement management sections into usable construction sections. Central units work with the field divisions to finalize project limits and identify appropriate treatments. The goal of maintaining infrastructure cuts across all areas of the Division of Highways and 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,

- division field personnel who maintain roads and bridges daily,
- delivery of pavement and bridge projects on time and on schedule, and
- many others.

In summary, the NCDOT goal of delivering and maintaining the agency's infrastructure effectively and efficiently is directly related to the MAP-21 national goal area for bridge and pavement condition on the NHS.

Another goal is to improve the reliability and connectivity of the transportation system. Many improvements in this area are the result of local identification of problem areas and potential solutions. Urban improvements have included roundabouts and smart streets to eliminate or reduce turning queues. An ongoing effort to provide urban loops also serves to address system reliability by offering alternate routes that do not include the signalized intersections common in cities and towns. The Board of Transportation approved the Strategic Transportation Corridors initiative that identifies key connections required for this goal as well as goals in economic development.

The goal of improving the reliability and connectivity of the transportation system is therefore directly linked to the MAP-21 national performance goal for system reliability in terms of freight movement and congestion mitigation.

As previously mentioned, promotion of economic growth through better use of the agency's infrastructure is a department goal. Infrastructure condition is one of the key factors used by industry in deciding where to locate future plants or offices. Access to ports and airports as well as stable delivery systems for materials aid in attracting industry and promote economic growth. Connections with regional hubs, general aviation and international airports, train stations, ports, and inland freight facilities are maintained as part of this goal area. In addition, it is important that workers be able to get to and from work safely and efficiently. These components are directly tied to infrastructure condition and system reliability.

NCDOT strives to be a great place to work and provide challenging and satisfying work for employees. At no time is the spirit of the agency stronger than when dealing with natural disasters. Agency employees pull together and move to affected areas where they stay as long as needed to clear debris, repair pipes, repair roads, and perform all other aspects of recovery. It is a great place to work because of the great employees who are dedicated to public service. As part of the great place goal, employee safety is a high priority, with specific goals to reduce accidents, reduce fatalities, and reduce Worker's Compensation claims. While somewhat tied to the MAP-21 national performance goals for safety, this goal is more internally focused and not directly linked to the MAP-21 performance targets. The correspondence between NCDOT goals and MAP-21 program performance goals is summarized in Table 1-1.

Table 1-1: Correlation between NCDOT Goals and MAP-21 National Performance Goals

NCDOT Goal	MAP- 21 National Performance Goal
Make transportation safer	Infrastructure Condition (Bridge and pavement condition on interstates and non-interstate NHS), freight movement, and safety
Provide GREAT customer service	NA
Deliver and maintain our infrastructure effectively and efficiently	Infrastructure Condition (Bridge condition on NHS, pavement condition on interstates and non-interstate 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

All the goals described here are commendable, but they share limited funding. This is the challenge faced by all agencies when resources are limited. Competing needs must be compared and evaluated so that the available funds are used to their best advantage. The TAMP is part of the mechanism for accomplishing this need.

1.2 The Transportation Asset Management Plan and NCDOT's Goals

Development and annual certification of a TAMP is required under the FHWA rulemaking associated with MAP-21. The goal of the rulemaking is to ensure that states are using data-driven approaches in the expenditure of federal funds and to facilitate the reporting to Congress in this regard. The development of the TAMP is occurring at the same time as reporting on performance measures regarding safety, infrastructure health (bridges and pavements), system reliability, congestion, freight movement, and project delivery. Up until now, each state may have developed their own performance measures in several of these areas. Comparing outcomes across states was tenuous because the measures were different, and the methods used to obtain them were not consistent. The performance measures identified in MAP-21 and subsequent rulemaking applies to all states. In the area of pavements, the measures are consistent with the federal reporting requirements of the Highway Performance Monitoring System (HPMS); bridge condition will be reported in conformance with the federal National Bridge Inspection Standards (NBIS) program.

The performance measures provide an annual snapshot of the condition of the state's infrastructure. The TAMP takes that snapshot in conjunction with preceding condition information to identify a strategic approach to reach state targets regarding infrastructure condition. The TAMP is not a short-term planning document. It is a long-term plan where each short-term program of projects fits into the overall plan to incrementally maintain or improve conditions.

The TAMP will be evolutionary. This is NCDOT's first TAMP and it represents the current state of practice and understanding. As the plan is used, the Department anticipates processes will be identified that will require adjustment. With the transition to an increased level of outsourcing, adjustments to the TAMP may be required to reflect this shift in the delivery of some programs. Future levels of department funding are unknown and will affect the ability of the Department to deliver a program of projects based on the 10-year financial plan. As a result, the financial estimates are just that and it is expected that these numbers will change over time.

Some components of the TAMP will be relatively constant. The agency mission and goals have had modest tweaking, but the focus has remained the same: to provide a safe, well-maintained and reliable transportation system. It is anticipated that the process for identifying gaps and conducting system-wide Life Cycle Cost (LCC) analyses may change some in the first few plans as the methodology for doing these is refined. Similarly, the process for identifying and analyzing risks will evolve, especially the evaluation of facilities that have required repeated emergency repairs. Over time, the process for conducting these analyses should become relatively constant. The NHS has gotten larger over time and this is especially true for bridges. In the pavement area, NCDOT has constructed numerous loop roads in the last 15 years. Each of these limited-access facilities require interchanges that add bridges to the system.

The intent is that the TAMP will work in concert with several existing plans or ones being created by NCDOT such as the Maintenance Operations and Performance Analysis Report (MOPAR), Highway Maintenance Improvement Plans (HMIP), and Bridge Management Improvement Program (BMIP). It will also incorporate components of the Department's Statewide Long-range Transportation Plan (SLRTP) as applicable to the performance and condition of pavements and bridges on the NHS.

This TAMP represents the intermediate timeframe. It includes a gap analysis, life-cycle cost analysis of the system, risk analysis, as well as an investment strategy and a 10-year financial plan. The SLRTP and the TAMP should speak to the same vision and priorities. The TAMP 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 the Department's investment strategy to maintain these assets in a state of good repair.

The various programs must be consistent with and support the long-term vision and targets of the SLRTP through a shorter-term list of projects in goal areas including pavements, bridges, ports, aviation facilities, and other assets.

These interrelated plans require coordination and conversation both internally and externally, i.e. within the agency along with MPOs and RPOs. The performance targets must support the MAP-21 National

performance goals, the SLRTP, the TAMP, and be tracked in a way that supports agency mission and goals.

To achieve this level of interdepartmental communication, the development of the TAMP has been coordinated by an Executive Committee consisting of the following: Chief Engineer, Chief Operating Officer, Deputy Secretary, Chief Information Officer, Director of Performance Management, and Transportation Planning Division Branch Manager, among others. Two subcommittees represented the two initial asset classes that will be included in the TAMP: pavements and bridges. These two working committees included representatives from an MPO and an RPO as well as subject matter experts from the Pavement Management Unit, Structures Management Unit, and several other units from NCDOT. The Federal Highway Administration (FHWA) was also represented on each of the three committees. An additional workgroup was added to address the 10-year financial plan. The NCDOT Chief Engineer and their staff will be responsible for the development, implementation, management, and updating of the TAMP for the Department with assistance from appropriate units and staff.

1.3 Organization of the Transportation Asset Management Plan

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

Chapter 2 – Asset Inventory and Condition. This section of the plan includes a summary of assets managed by NCDOT and their condition. It includes an asset register for both pavements and bridges.

Chapter 3 – Performance Goals and Targets. This section 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. This section describes the system wide LCC 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. This section discusses risk analyses, along with a description of the process used to identify, analyze, prioritize, and evaluate and address risks. A risk register is provided along with a mitigation plan for the top risks. Additionally, a summary is provided from the evaluation that was performed on the facilities that have repeatedly been damaged by emergency events.

Chapter 6 – Financial Plan and Investment Strategies. This section consists of the 10-year Financial Plan that identifies the sources of revenue and estimated budget allocations to major NCDOT programs. This section also covers funding options and investment strategies, including PMS and BMS analyses for determining optimal asset investments.

Chapter 2 Asset Inventory & Conditions

2.1 NCDOT Assets

As mentioned, this is the first TAMP developed by NCDOT. Any State Transportation Agency has a variety of assets including pavements, bridges, retaining walls, noise walls, pipes, signs, traffic signals, and intelligent transportation devices. In addition, NCDOT has over 100 equipment shops, 97 county maintenance yards, 14 division offices and provides oversight to 72 general aviation airports. The DMV – which is part of NCDOT – has more than 300 facilities. Each facility has both parking and buildings to maintain, although some DMV facilities are in county government offices or shopping centers. NCDOT also owns and operates 22 ferries which have docks and vessels to be maintained. The Rail Division has more than 3,300 miles of railroad tracks, rolling stock, and facilities to be maintained. The NCDOT fleet has more than 18,000 pieces of equipment and 3,430 pickup trucks and work vans. Trying to include this vast array of assets in the initial TAMP would be a huge undertaking.

NCDOT will initially focus on the NHS pavements and bridges as required by MAP-21. However, because North Carolina's non-NHS road system is so large and all pavement and bridge assets are included in the pavement and bridge management systems, those assets are in the analysis so a more complete picture of needs, funding issues, and priorities is portrayed which will support the Department's process for achieving goals. NCDOT manages and prioritizes program funding based on conditions of the interstate, primary, and secondary road networks. Historical condition data trends demonstrate that by meeting state targets on these three systems, the MAP-21 requirements are met for the NHS network.

2.2 Data Collection Methods

2.2.1 Data Collection Methods – Pavements

In 2012 NCDOT began collecting pavement condition information through an automated system for all interstate and primary highways. In 2018, the annual Pavement Condition Survey (PCS) was conducted for all state-maintained routes and non-state-maintained NHS routes using an automated data collection process. Both NHS and non-NHS routes will be evaluated by the automated survey using high definition images for automated crack detection. Line-scan sensors provide faulting and rutting measurements as well as International Roughness Indices (IRI). The contract to collect these data elements was developed to meet HPMS reporting requirements and will satisfy the requirements of MAP-21.

2.2.2 Data Collection Methods – Bridges

Structures as defined by the NBIS are bridges, culverts, and pipe systems that span 20 feet or greater. Inspection of these assets is a primary function of the Structures Management Unit (SMU). A combination of Initial, Routine, In-Depth, Damage, Special, and Fracture Critical Inspections are carried out by NCDOT inspection teams, as well as by private engineering firms by contract. Bridge inspections are performed by small, hands-on teams to document the existing physical and functional conditions of each structure in accordance to FHWA's National Bridge Inspection (NBI) program. The

inspection report for these bridges includes condition ratings, photographs, maintenance needs, and recommendations for major improvements.

Routine Inspections, Fracture Critical Member Inspections, and Movable Span and Machinery Inspections occur on a 24-month cycle for all bridges. Inspections occurring less than 24 months are determined on a case by case basis, such as when a condition rating of 3 or less exists for one of the following: Deck, Substructure, Superstructure, or Culvert. Consideration is given to the presence of temporary repairs and other relevant factors. Underwater inspections occur on a 48-month cycle for all bridges over water when structural members underwater cannot be evaluated during the routine above-water inspection. Underwater inspections may be performed more frequently than every 48 months on a case by case basis. Damage inspections due to vehicle or vessel collisions are also performed as needed.

2.3 Inventory and Condition

The NHS includes interstate highways, interstate business routes; US, NC, and selected secondary routes, and ramps connecting to an NHS route. Routes may be owned and maintained by the state, municipality, or federal agency. Tables 2-1 and 2-2 show the distribution of state and federal designated routes and mileage correlation of the NHS and the state's interstate, primary, and secondary routes.

Table 2-1: Mileage Correlation by Category in North Carolina

Route Designation	Route Miles	Lane Miles	NHS Route Miles	NHS Lane Miles	NHS by Route Miles	NHS by Lane Miles
Interstate*	1,366.6	6,472.8	1,364.9	6,466.0	99.88%	99.89%
Primary	13,775.5	34,994.3	4,076.2	14115.2	29.59%	40.34%
Secondary	64,901.1	131,612.4	197.1	762.9	0.30%	0.58%
Total State-Maint.	80,043.2	173,079.5	5,6838.2	21,334.1	7.02%	12.33%

*Includes interstate designated business loops and other interstate business routes

Table 2-2: NHS Mileage by System and Owner

Route Designation	NHS Route Miles	NHS Lane Miles	NHS by System Route Miles	NHS by System Lane Miles
Interstate*	1,364.9	6,466.0	24.02%	30.05%
Primary	4,076.2	14,115.2	71.73%	65.59%
Secondary	197.1	762.9	3.47%	3.55%
Total State Maintained	5,638.2	21,344.1	99.22%	99.19%
Federal	2.3	4.5	0.04%	0.02%
Local Government	42.0	170.7	0.74%	0.79%
Total NHS	**5,682.5**	**21,519.3**	**100.00%**	**100.00%**

*Includes interstate designated business loops and other interstate business routes

The NHS in North Carolina makes up about 12% of the 173,079 lanes miles of state-maintained highways; 96% of the NHS is on the interstate and primary systems. Additionally, there are 175.2 lane miles of the NHS maintained by other agencies. NCDOT collects pavement and bridge condition data for the NHS maintained by local governments. These routes will be excluded from the LCC analysis since the low inventory will have negligible impact.

2.4 National Performance Measures and Minimum Standards

Through MAP-21, national performance goals have been established for pavements and bridges to maintain the condition of these assets in a state of good repair. The National Performance Management Measures for pavements identified in 23 CFR Part 490 have 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 NHS (excluding the interstate system) in good condition, and
4. Percentage of pavements (lane miles) on the NHS (excluding the interstate system) in poor condition.

Within the national rule, condition ratings of good, fair, and poor for pavements have been established by FHWA based on a combination of several metrics collected by every state DOT in accordance with HPMS. FHWA will use these metrics to quantify the condition of pavements in terms of roughness (IRI), cracking, rutting (asphalt), and faulting (concrete). The following Table 2-3 summarizes the metrics and performance ratings.

Table 2-3: MAP-21 Pavement Metrics and Performance Ratings

METRIC	PAVEMENT TYPE	GOOD	FAIR	POOR
IRI	All	< 95	95 to 170	> 170
Cracking	Asphalt	< 5%	5% to 20%	> 20%
Cracking	Jointed Concrete	< 5%	5% to 15%	> 15%
Cracking	CRCP	< 5%	5% to 10%	> 10%
Rutting	Asphalt	< 0.20"	0.20" to 0.40"	> 0.40"
Faulting	Jointed Concrete	< 0.10"	0.10" to 0.15"	> 0.15"

Using this criteria, an asphalt pavement is considered to be in good condition only if all three metrics (IRI, percent cracking, and rutting) meet the criteria for good. The pavement is considered to be in poor condition if any two of the three metrics (IRI, percent cracking, and rutting) meet the criteria for poor. Finally, the pavement is classified as fair if it doesn't meet the criteria of the good or poor conditions. Similarly, a jointed concrete pavement is considered to be in good condition only if all three metrics (IRI, percent cracking, and faulting) meet the criteria for good. The pavement is considered to be in poor condition if any two of the three metrics (IRI, percent cracking, and faulting) are determined to be in poor condition. Finally, the pavement is classified as fair if it does not meet the criteria of the good or poor

classification. Continuously Reinforced Concrete Pavement (CRCP) is evaluated only on two metrics: IRI and cracking. CRCP is considered to be in good condition if both metrics of IRI and cracking are determined to meet the criteria for good. It is considered to be in poor condition if both IRI and cracking are determined to meet the criteria for poor. It is considered to be in fair condition if it does not meet the criteria of the good or poor classification. The following Table 2-4 provides a summary of this information along with the applicable federal rule and the minimum standard for interstate pavements.

Table 2-4: MAP-21 Good/Fair/Poor Determination for Pavements and Minimum Standard

RULE	23 CFR Part 490.313 (c)				23 CFR Part 490.315(a) (Interstate only)
PAVEMENT TYPE	**METRICS**	**GOOD**	**POOR**	**FAIR**	**MINIMUM STANDARD (Interstate only)**
Asphalt	IRI, Cracking, Rutting	All 3 = Good	2 of 3 = Poor	All other combinations	< 5% in Poor condition
Jointed Concrete	IRI, Cracking, Faulting	All 3 = Good	2 of 3 = Poor	All other combinations	< 5% in Poor condition
CRCP	IRI, Cracking	All 2 = Good	2 of 2 = Poor	All other combinations	< 5% in Poor condition

In order to give state and local agencies time to modify the way they collect pavement condition data to meet these collection standards, the national rule provides for a transition period. Data collected between January 1st, 2018 and December 31st, 2018 will be used for all data items on Interstate routes in the Calendar Year 2019 HPMS submittal. The data collected between January 1st, 2019 and December 31st, 2019 will be used for all items on both the Interstates and NHS in the Calendar 2020 HPMS submittal. State DOTs will only be measured based on IRI rating after the data collection cycle ending December 31st, 2018 for interstate highways and December 31st, 2020 for the non-interstate NHS system. After these dates, state DOTs will be evaluated based on the metrics identified in Table 2-4 and will also be required to limit the portion of their inventory data that is missing, invalid, or unresolved to no more than 5%.

The process for determining the condition of bridges is similar in concept to that for pavements. The national performance management measures for bridges identified in 23 CFR Part 490 have established three classifications for the purpose of assessing bridge condition (based on square foot of deck area):

1. Percent of NHS bridges classified as in good condition,
2. Percent of NHS bridges classified as in fair condition, and
3. Percent of NHS bridges classified as in poor condition.

Within the national rule, performance ratings of good, fair, and poor condition for bridges have been established by FHWA based on a combination of three metrics that are collected by every state DOT including NCDOT. These metrics, based on a 0 to 9 condition scale, will be used to quantify the condition of bridges in terms of bridge deck, superstructure, and substructure. Culverts will be evaluated based on their overall condition. The following Table 2-5 summarizes the metrics and the performance ratings.

Table 2-5: MAP-21 Bridge Components and Performance Ratings

COMPONENT	GOOD	FAIR	POOR
Deck	7 to 9	5 to 6	0 to 4
Superstructure	7 to 9	5 to 6	0 to 4
Substructure	7 to 9	5 to 6	0 to 4
Culverts	7 to 9	5 to 6	0 to 4

Using this criterion, a bridge is considered to be in good condition only if all three metrics for the deck, superstructure, and substructure meet the criteria for good. The bridge is considered to be in poor condition if any of the three metrics are determined to be in poor condition. Finally, the bridge is classified as fair if it doesn't meet the criteria of the good or poor conditions. Similarly, for a NBI culvert, it is considered to be in good condition only if its overall condition is rated as good. It is considered to be in poor condition if its overall condition is determined to be in poor condition. Finally, it is classified as fair if its overall condition is determined to be in fair condition. The following Table 2-6 provides a summarization of this information along with the applicable federal rule, and the minimum standard for all bridges on the NHS.

Table 2-6: MAP-21 Good/Fair/Poor Determination for Bridges and Minimum Standard

RULE	23 CFR Part 490.409 (b)				23 CFR Part 490.411(a)
STRUCTURE TYPE	**COMPONENT**	**GOOD**	**FAIR**	**POOR**	**MINIMUM STANDARD**
Bridge	Deck, Superstructure, Substructure	All Components = Good	No Components = Poor, 1 or more = Fair	1 or more Components = Poor	No more than 10% rated as POOR
Culvert	Overall Condition Rating	Rating = Good	Rating = Fair	Rating = Poor	

*Based on square feet of bridge deck

2.4.1 Interstate Pavements

Based on the MAP-21 performance standards for pavements, Figures 2-1 and 2-2 show the estimated good, fair, and poor metrics of the Interstate system for years 2013-2018. The pavement section condition entries in percent good have all three of the MAP-21 performance metrics meeting the good threshold. Entries in percent poor have two or more of the MAP-21 performance metrics meeting the poor threshold. Missing and invalid data constitutes no more than 1.1% of the total mileage which is below the 5% cap requirements of 23 CFR 490.109(e)(4)(iii). Figure 2-2 shows trends with a slight decrease for percent good and conversely a slight increase for percent poor from 2013 to 2018.

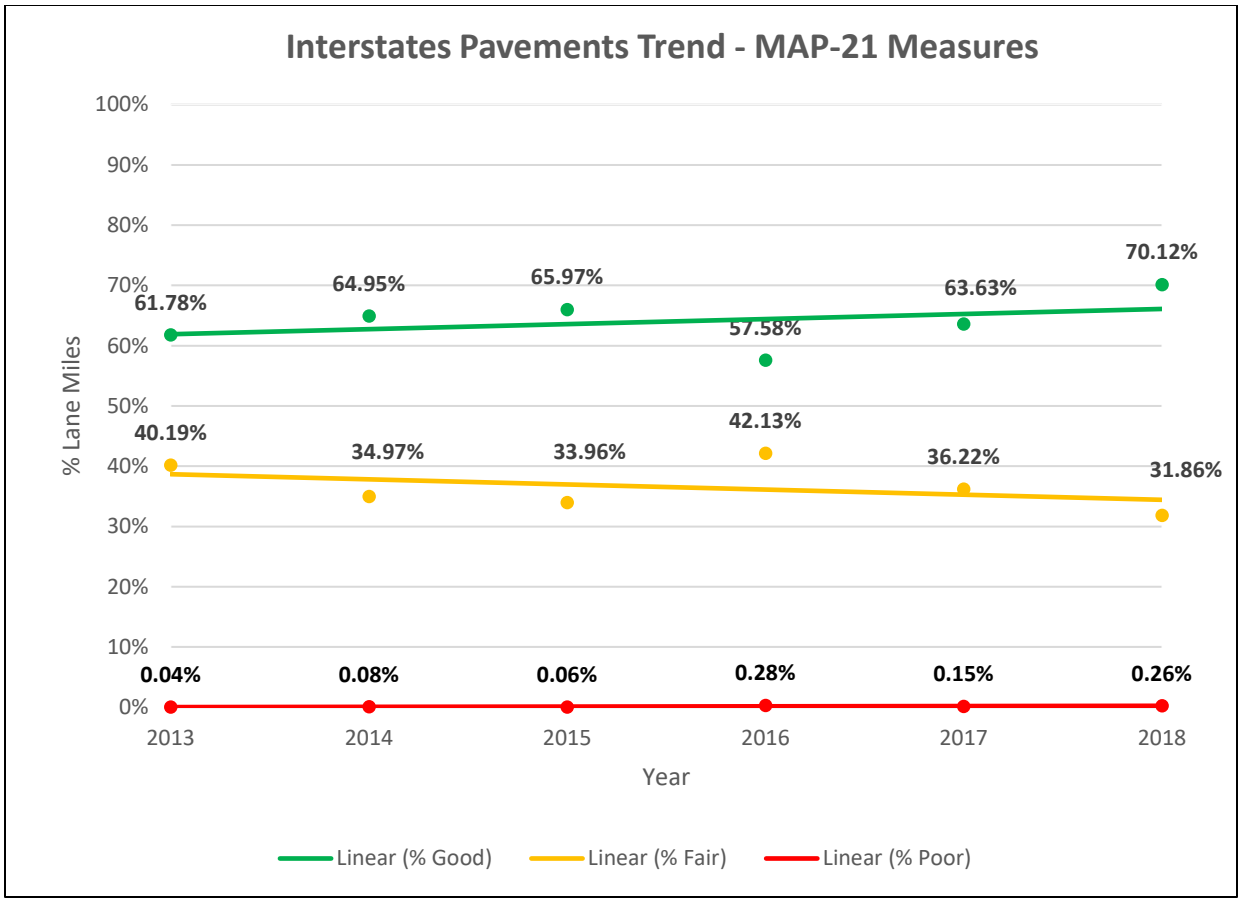


Figure 2-1: Interstate Pavement % Good, Fair, Poor Trends (MAP-21 Measures)

2.4.2 Non-Interstate NHS Pavements

Figure 2-2 shows the estimated percentage of pavements in good, fair, and poor categories for the non-interstate NHS using the MAP-21 performance measures. There are 1,394.7 miles (2.6%) of missing and invalid Non-Interstates NHS for year 2017 of which 735.5 miles are secondary roads that were surveyed with a windshield survey method (used prior to 2018) and does not conform to the FHWA rules. In addition, there are 170.7 miles of local government roads (generally municipal streets) and 4.5 miles of Federal Roads. Modification of the contract with the automated distress survey vendor to collect the complete inventory of previously uncollected NHS in accordance with FHWA rules will result in a significant reduction in missing lane miles. Figure 2-2 shows estimated condition trends having 4.79% decrease for percent good and a 2.06% increase for percent poor from 2013 to 2018.

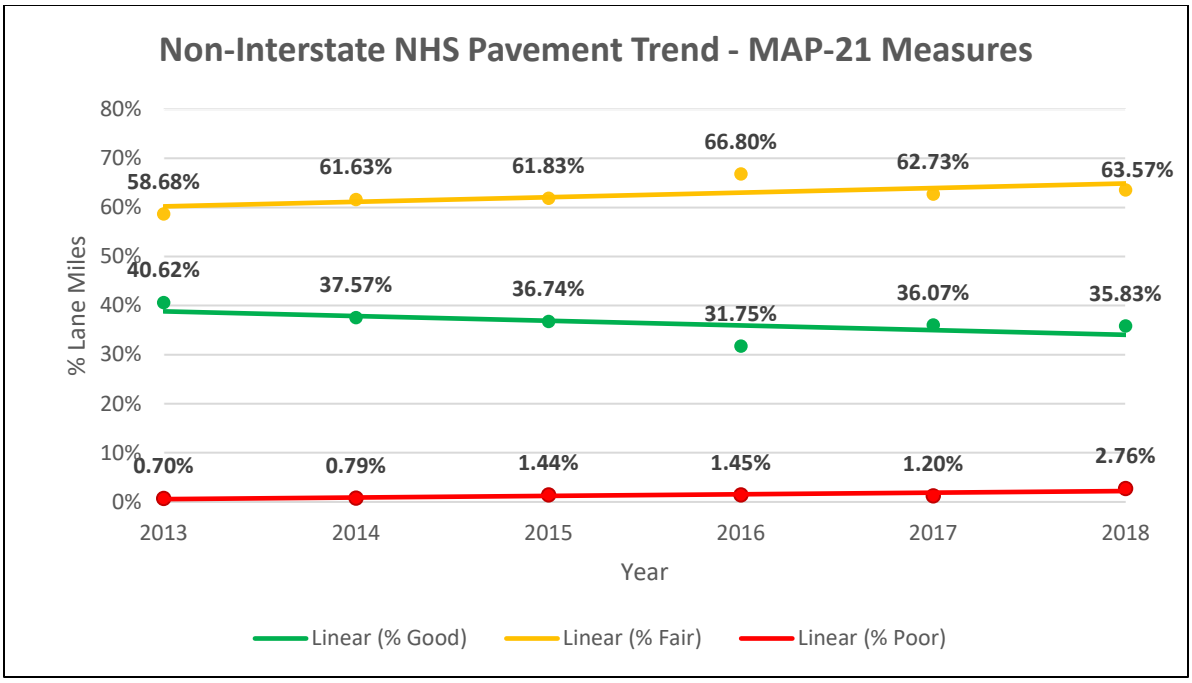


Figure 2-2: NHS Non-Interstate % Good, Fair, Poor Trends (MAP-21 Measures)

2.4.3 NHS Bridge Conditions

There are 3,713 bridges on the NHS in North Carolina including 1,268 that are on the interstate system. All but 24 of them are state owned and state maintained. The NHS bridges have condition rating of poor have a total deck area of 2,984,213 square feet. Two large bridges make up one third of the square footage of bridges rated as poor.

As shown in Table 2-7, in accordance with MAP-21 performance standards approximately 6.15% 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, 2.85% of the bridges on the Interstate system are poor, 8.15% on the primary system are poor, and 4.62% of the bridges on the secondary system are classified as poor. Locally owned/maintained bridges make up 0.6% of the total NHS bridges with none of them falling into the poor category and are excluded from the Life Cycle Cost analysis due to negligible impact.

Table 2-7: Current Inventory and Condition of NHS Bridges & Culverts

System	Owner	Number of Bridges & Culverts	Deck Area (SF)	MAP-21 Poor Deck Area (SF)	MAP-21 Poor	MAP-21 Good Deck Area (SF)	Good
Interstate	State	1,268	17,282,685	492,958	2.85%	7,428,396	42.98%
Primary	State	2,282	29,738,971	2,423,598	8.15%	10,770,146	36.22%
Secondary	State	139	1,463,619	67,655.80	4.62%	879,210	60.07%
Local government	Local government	24	254,220	0	0.00%	163,362	64.26%
Total	State	3,689	48,485,275	2,984,213	6.15%	19,077,752	39.35%
	Local	24	254,220	0	0.00%	163,363	64.26%
	Total	3,713	48,739,495	2,984,213	6.12%	19,241,115	39.48%

Based on the MAP-21 performance standards for bridges, Figure 2-3 shows the good, fair, and poor performance of the NHS bridges for years 2013-2018. The bridge condition entries in percent good have all three of the MAP-21 performance measures meeting the good threshold. Entries in percent poor have one or more of the MAP-21 performance measures meeting the poor threshold. Figures 2-3 shows trends with a slight decrease for percent good and percent poor from 2013 to 2018.

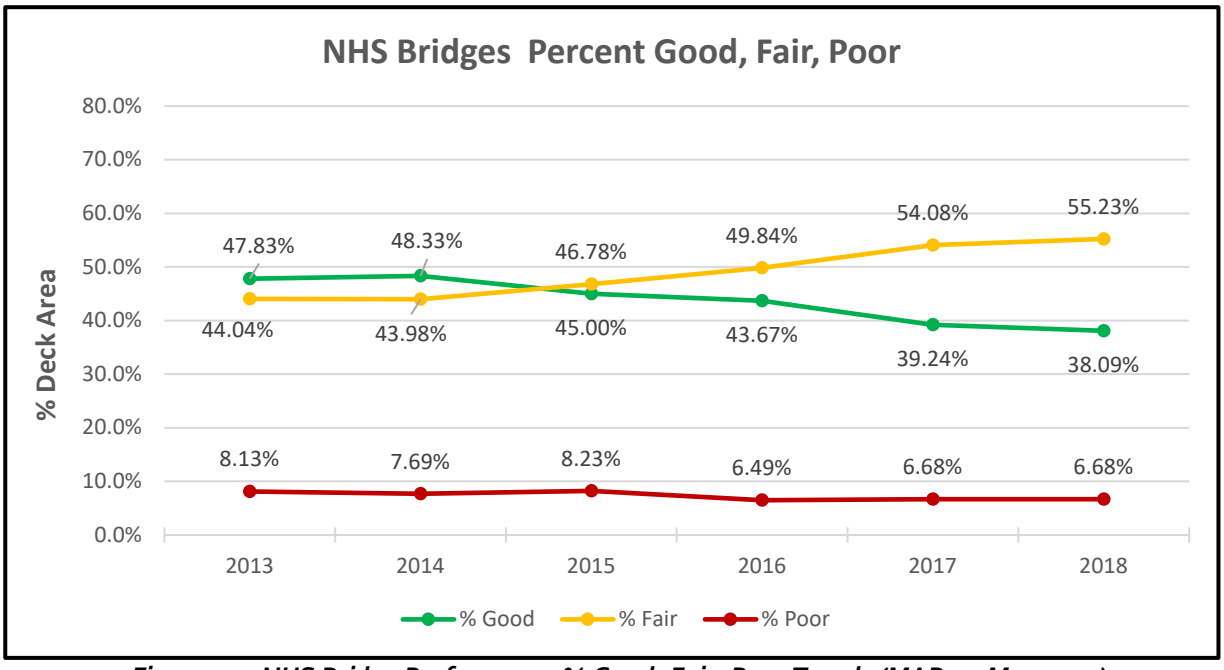


Figure 2-3: NHS Bridge Performance % Good, Fair, Poor Trends (MAP-21 Measures)

Chapter 3 Performance Goals, Targets, & Gaps

3.1 Performance Goals and Targets Overview

NCDOT collects information on the condition of pavements and bridges throughout the state in order 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.

The national performance management measures and targets required by MAP-21 – to address the condition of pavements and bridges on both the interstate system and the NHS system – are discussed in this chapter. In addition to the national performance measures, NCDOT has defined state specific asset management measures and targets for pavement and bridges on the interstate and primary systems.

Establishing performance measures and targets is fundamental to creating an asset management plan that supports the management and performance of the NHS, as well as to identify the need for preservation, maintenance, rehabilitation, or construction of new facilities. Tracking measurable conditions for pavements and bridges in relation to targets is a useful tool for NCDOT to determine if the agency's goals for performance are being achieved at a network level as well as at a division or a local level. It is also a transparent tool for NCDOT to identify where funds benefit the various highway systems both on and off interstates.

NCDOT tracks pavement and bridge conditions in a pavement management system and a bridge management system. 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, and 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.

It is important to note that NCDOT historically meets or exceeds the national performance minimum standards established by MAP-21 for the pavement and bridge conditions, as will be shown in the following sections of this chapter.

3.2 NCDOT Targets for the National Performance Management Measures for Pavements and Bridges

NCDOT has established performance targets for the National Performance Management Measures identified in 23 CFR Part 490 as indicated in Table 3-1. In October 2017, NCDOT Transportation Planning Division (TPD) started to compile data and organize internal and external partners to address the TPM requirements. The process included regular coordination with a work group and subject matter experts as well as collaboration with FHWA to confirm requirements and with Metropolitan Planning Organizations to ensure their role within the process. This integrated approach helped develop targets based on the latest available data and federal guidance to support a technical and business process. NCDOT leadership provided strategic direction to staff at key milestones.

Table 3-1: NCDOT National Performance Management Targets

ASSET	SYSTEM	GOOD	POOR
PAVEMENTS (Based on Lane-miles)	Interstate (4 year)	>37.0%	<2.2%
	Non-Interstate NHS (2 Year)	>27.0%	<4.2%
	Non-Interstate NHS (4 Year)	>21.0%	<4.7%
BRIDGES (Based on square feet of deck area)	NHS (Interstate and Non-Interstate) (2 Year)	> 33.0%	<8%
	NHS (Interstate and Non-Interstate) (4 Year)	> 30.0%	<9%

3.3 How NCDOT Compares to National Performance Standards

NCDOT is currently meeting or exceeding the federal minimum performance standards for NHS pavements and bridges as shown in Figures 3-1 thru 3-3 below. For NCDOT to maintain this high standard of bridge conditions that have been historically established, the bridge management system (BMS) is used to assist NCDOT in predicting the future needs to preserve the system and maximize the use of their assets at minimum cost. The BMS is used to track the metrics of the bridges and culverts as described in Chapter 2. This same system can be used to evaluate future needs through life cycle analysis. Similarly, the Pavement Management System (PMS) is the engine that stores the results of the pavement condition survey and provides the analysis to assist NCDOT managers with the information and data to develop pavement management programs to meet NCDOT's goals and objectives using life cycle cost processes discussed in more detail in Chapter 4.

The Department has been practicing asset management for over a decade resulting in longer term data availability for state defined performance metrics. In addition, the Department has established state funding programs and asset management targets built around state metrics. For those reasons, and due to limited historical performance data needed to accurately predict future performance against Map-21 metrics, the Department will continue to measure NHS pavement and bridge performance against established state performance targets. For future performance – if projected funding levels hold – the Department does not anticipate any problems meeting the established federal performance targets.

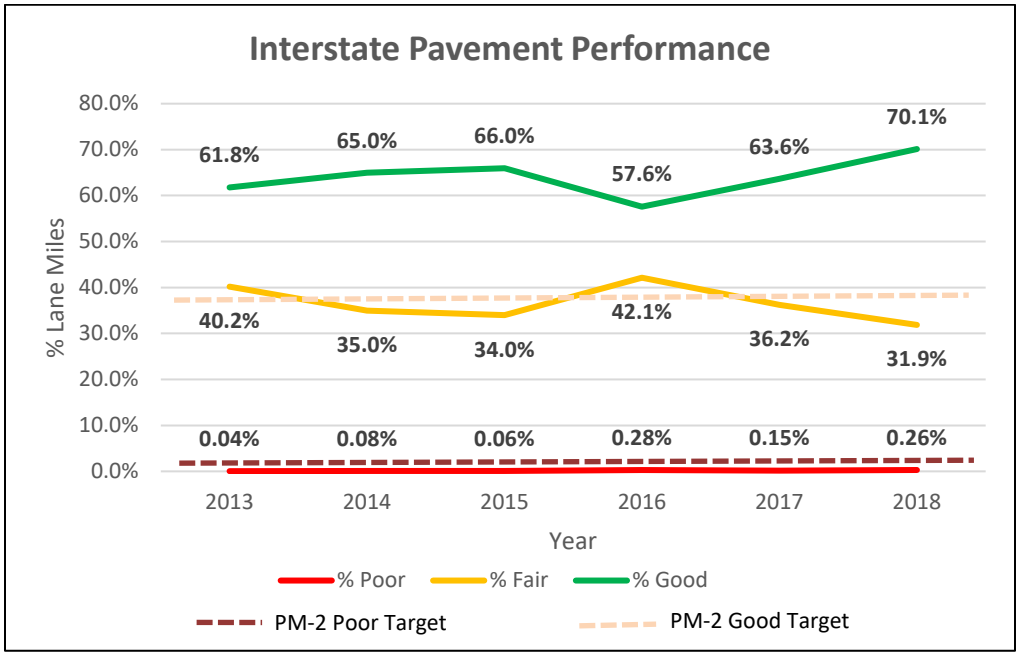


Figure 3-1: NHS Interstate Pavement Performance (MAP-21 Measures)

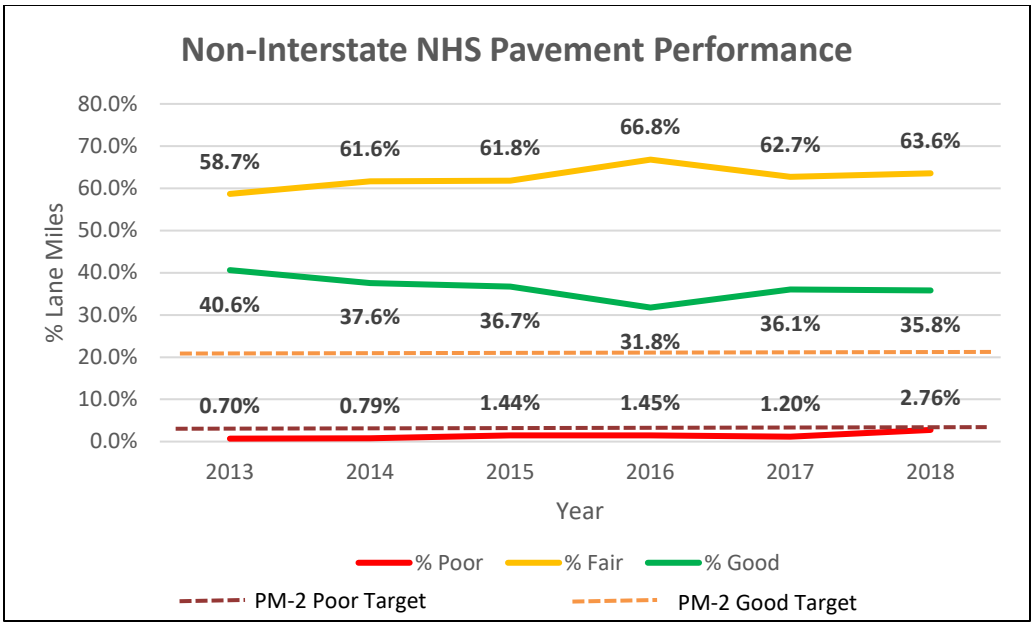


Figure 3-2: NHS Non-Interstate Pavement Performance (MAP-21 Measures)

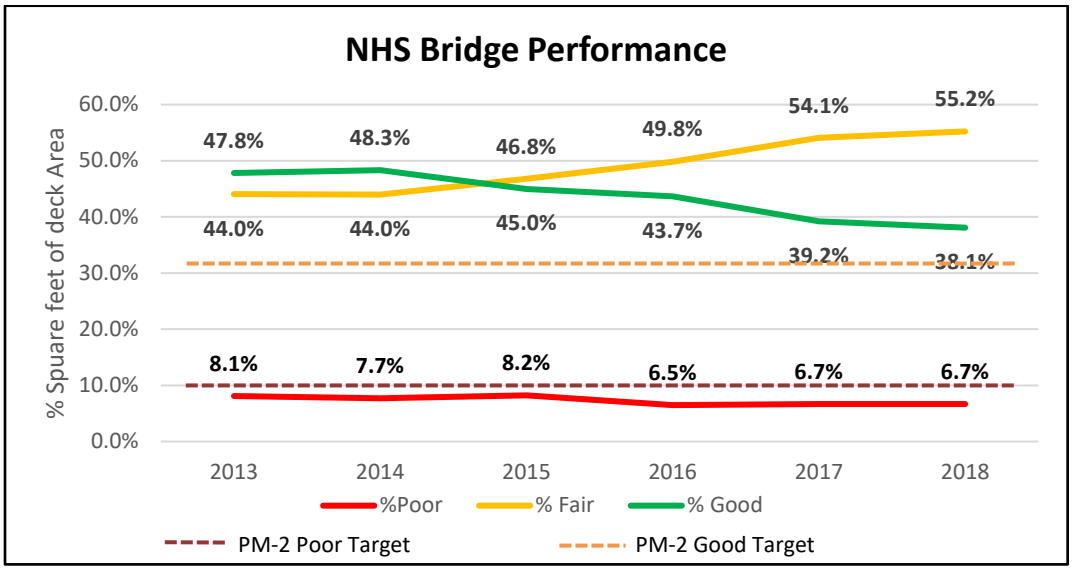


Figure 3-3: NHS Bridge Performance (MAP-21 Measures)

3.4 NCDOT State Asset Targets for Pavement and Bridges

NCDOT has a long-standing history of maintaining the state's pavement and bridges in good condition and serviceable to the traffic they serve. The agency's long-term goals are to maintain pavement and bridges to meet performance expectations throughout the asset's life at the lowest possible cost.

NCDOT has established long-term performance targets for pavements and bridges based on their importance and functional need in accordance with the highway system designation of interstate, primary, and secondary. For example, interstate highways are the most important facilities since they provide the backbone for the movement of people, freight, and commerce within and through the state as well as provide access for the majority movement of people and goods into and out of the state. The next most important highways are the primary routes, and lastly the secondary roads. It should be noted that NCDOT's highway system designation of interstate, primary, and secondary does not fully match the state's NHS, however, the interstate and primary system comprises 95.7% of all NHS lane miles. The following Table 3-2 provides the state asset performance measures and targets for the agency's pavements and bridges based on highway system.

Bridge performance is determined based on the NBIS rating codes identified in Table 3-3. NCDOT uses these condition ratings for managing the bridge program and considers a bridge to be Structurally Deficient (SD) if any one of the three components of bridge deck, superstructure, or substructure is rated a 4 or less. The Department's state asset targets (SAT) for SD bridges on the interstate and systems are <2% and <6%, respectively. It should be noted that NCDOT's performance measure for NBIS culverts is slightly different from the MAP-21 rules. The Department uses the NBIS condition code for the overall condition of the culvert, however, the performance standard is based on a minimum condition rating of 6 or better to be consider in good condition, whereas, MAP-21 rules specifies that in order to be considered in good condition the condition rating has to be 7 or higher. This is reflected in the following tables and charts as indicated.

Table 3-2: State Asset Targets

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

* MAP-21 specifies a condition rating of 7 or higher to be considered good

Every even-numbered year the Department provides a report, "Maintenance Operations and Performance Analysis Report" (MOPAR), to the North Carolina General Assembly on the condition of the state highway system and the maintenance funding needs. Within this report the Department identifies the funding needed to achieve its performance goals for pavements, bridges, and maintenance.

3.5 Gap Between Pavement Performance and State Asset Targets

As described previously, NCDOT tracks the pavement condition index (PCI) for asphalt and concrete highways. The PCI is a composite index number measured on a 0 to 100 scale based on pavement

distresses such as cracking, rutting, patching, corner breaks, and faulting. A pavement with a PCI of 80 to 100 is in good to very good condition, while a pavement with a PCI of less than 60 is in poor condition. Using these characteristics, performance is calculated and reported per number of lane miles. These results are used to assist the Department in determining funding amounts, allocations to the 14 divisions, and choosing the appropriate work types to minimize whole-life cost; i.e. combination of maintenance, preservation, rehabilitation, or reconstruction needed for the pavements. The following Figure 3-4 shows the PCI rating from 2016 to 2018 for the interstate and primary road systems. As shown in 2018, only 1.85% of the interstate is rated poor, which is within the state asset target range of no more than 5%. For the primary system, only 3.7% are rated poor, which is within the target range of no more than 7.5% poor.

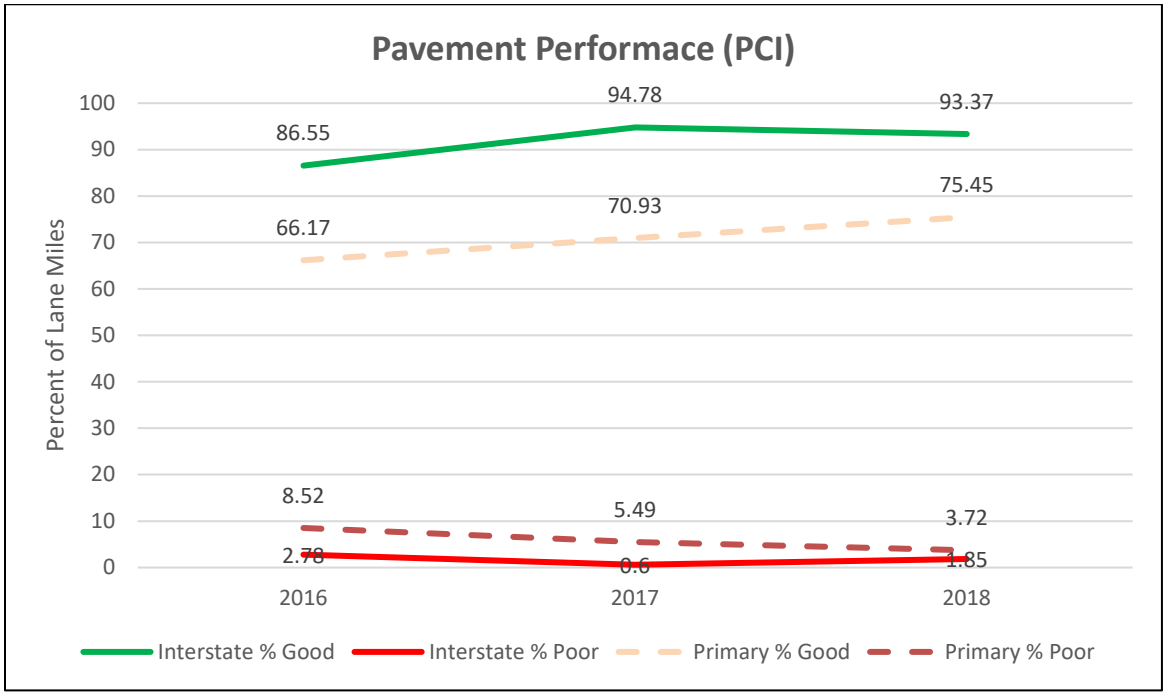


Figure 3-4: Pavement Performance (NCDOT Measures)

3.6 Gap Between Bridge Performance and State Asset Targets

Since NCDOT has established a dependable bridge management process using the NBIS inspection reports to determine program and project needs, the Department will be able to make a smooth transition to the TAMP requirements. The inspection program requires an in-depth evaluation of the deck, substructure, and superstructure for bridges, and key features of culverts based on the NBIS. The results of the inspection are used to determine the type of work activity required for the bridge or culvert, i.e. maintenance, preservation, rehabilitation, or replacement.

Based on NCDOT's state asset management targets listed in Table 3-2, the following Figure 3-5 shows the percent of bridges in poor condition based on bridge data for years 2014-2018. Bridges in poor condition fall into a structurally deficient (SD) category and include those with advanced section loss,

deterioration or spalling, or insufficient load carrying capacity. In 2018 there were 3.5% of the bridges rated as SD on the interstate system and 8.7% SD on the primary system. While the existing conditions are not meeting the state asset targets, the Department is committed to improve the performance of bridges and that commitment is reflected in the decline of the percent of SD over the past five years as depicted in Figure 3-5.

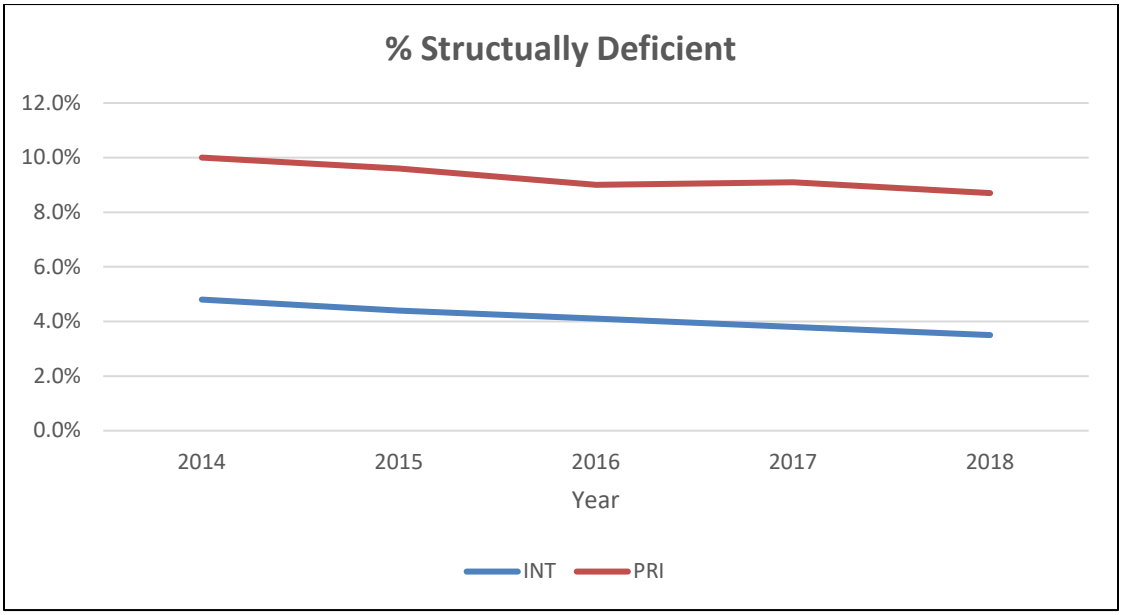


Figure 3-5: Percent of Deficient Bridges by System (NCDOT Measures)

3.7 NCDOT's Predicted Pavement Condition vs. State Asset Targets

The following Figures 3-6 and 3-7 from the PMS analysis show the pavement condition (using PCI) expected between years 2018-2027 for the interstate, and primary systems. The analysis excludes known capital projects. It should be noted that performing a 10-year analysis is dependent on assumptions that can fluctuate over time and vulnerable to conditions that can change drastically, especially in the latter half of the 10-year period. The longer the period of analysis, the greater the uncertainty becomes in the out years. A review of Figure 3-6 indicates that the PCI for interstate pavements will remain within state asset target value through year 2025 and fall slightly below the target for year 2026 and 2027. The primary system, shown in Figure 3-7, struggles to meet the state asset target for the duration of the 10-year analysis period. The Department has identified this as a gap in the MOPAR and identified strategies to overcome this deficiency. The Department will continue to monitor the performance of all the paved highway system to identify performance gaps and problems and develop additional strategies to modify programs or amend funding recommendations to the NC General Assembly as budgets are discussed. The results of the analysis are broken down for each facility type in the following graphs:

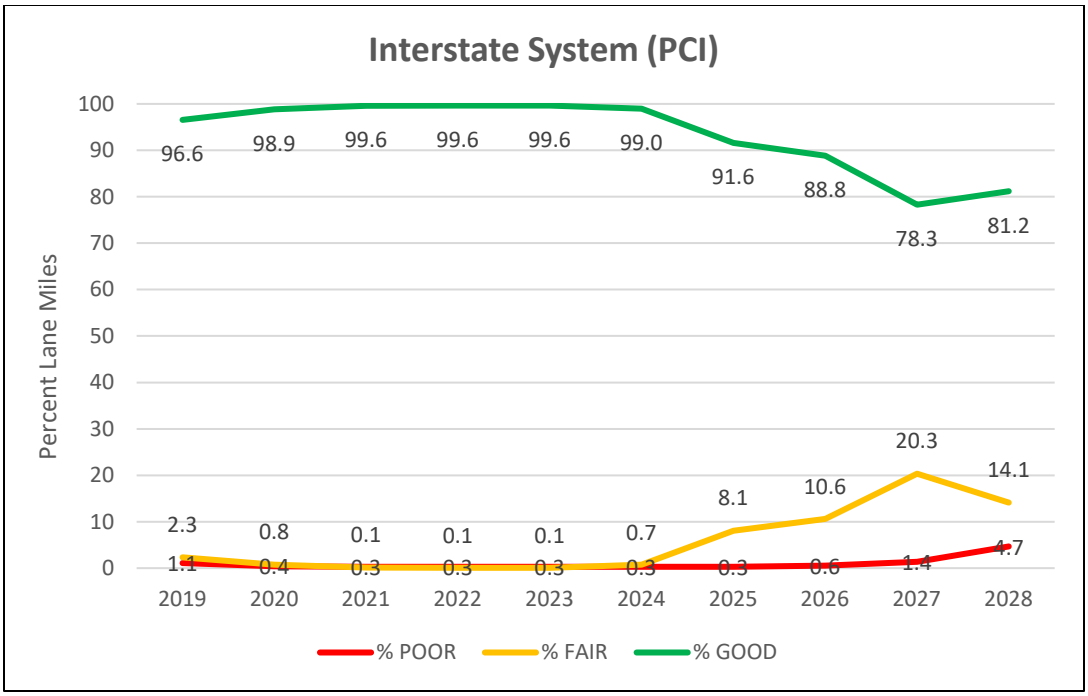


Figure 3-6: Predicted Pavement Performance – Interstate (NCDOT Measures)

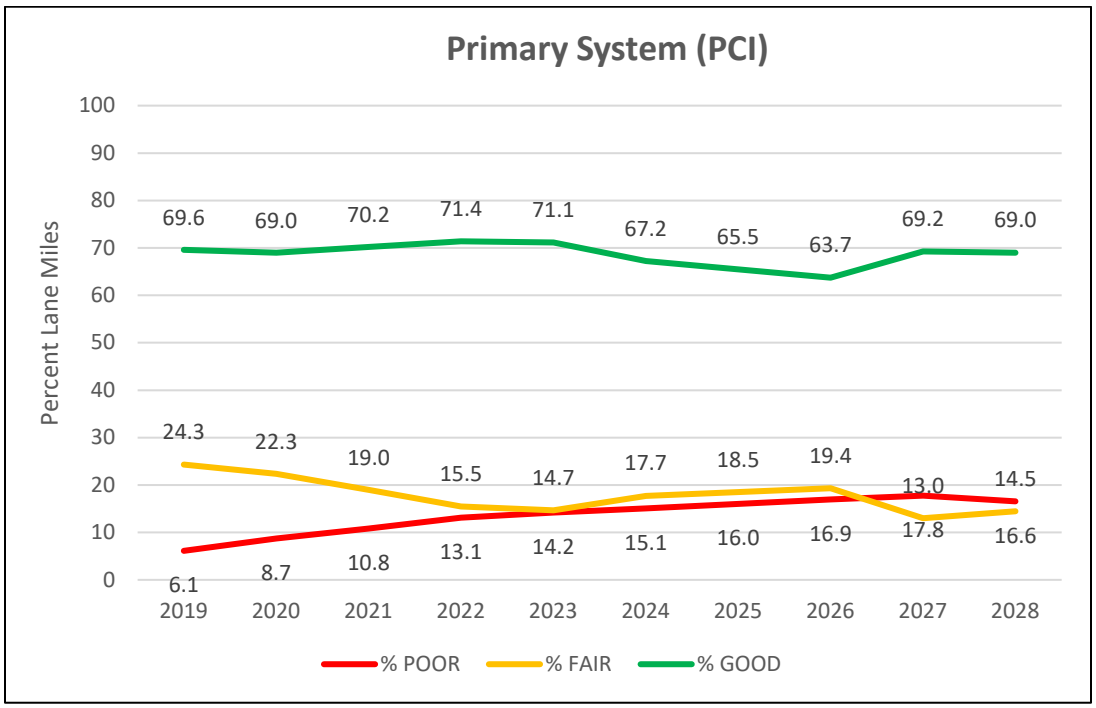


Figure 3-7: Predicted Pavement Performance – Primary (NCDOT Measures)

3.8 NCDOT's Predicted Bridge Condition vs. State Asset Targets

The following figure shows the bridge condition expected in future years. The results of the analysis are broken down for each system type. Figure 3-8 shows the Department's expected overall trends and the plan to reach the state asset target for percentages of SD bridges (excluding culverts) on the interstate and primary road networks by 2030. NBIS Culverts are not tracked through the Department's bridge measures, but through the MCAP program. Currently the Department does not have a process in place to perform a needs analysis to achieve state asset targets on culverts and has identified this as a gap.

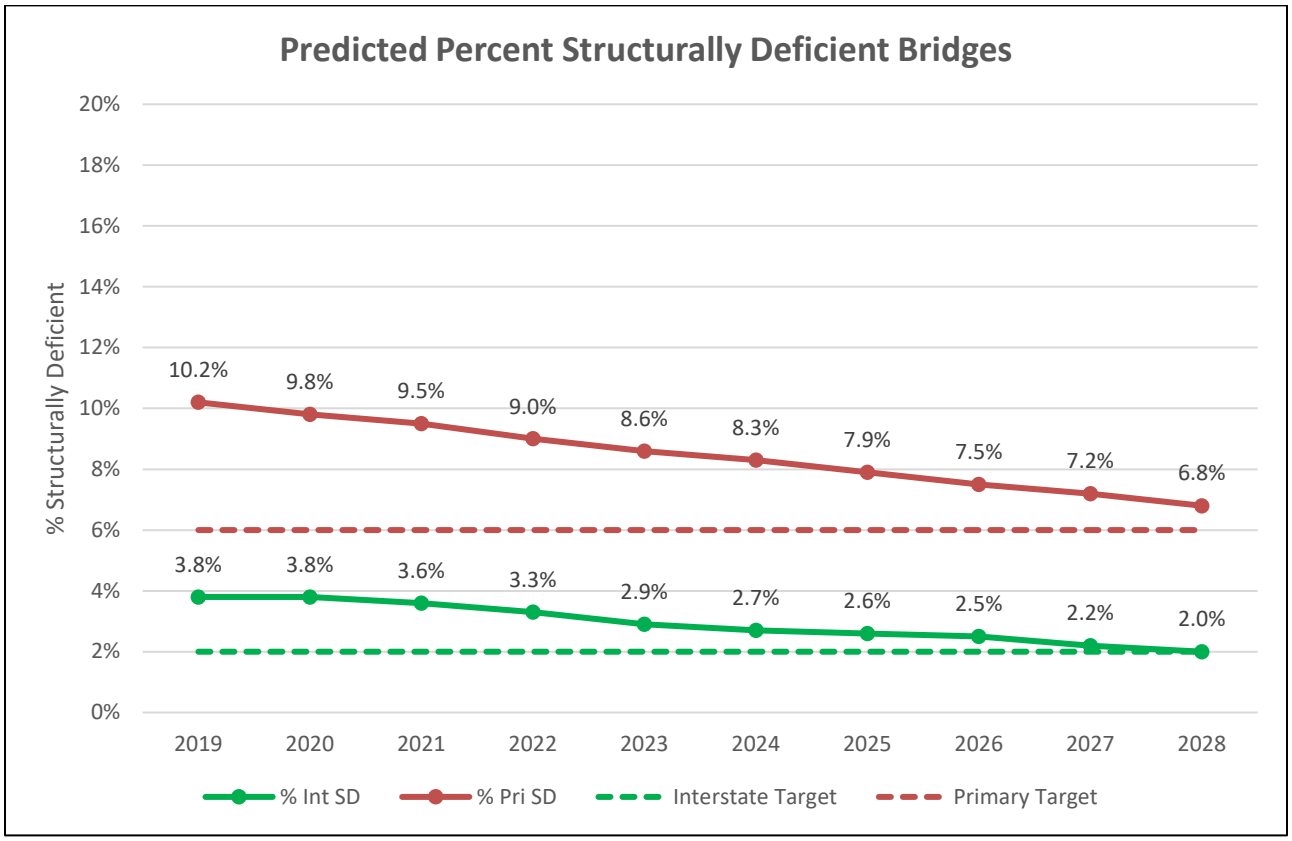


Figure 3-8: Predicted Percent Structurally Deficient Bridges on Interstate and Primary Routes (does not include NBIS culverts)

3.9 Correlation Between MAP-21 and State Asset Condition Measures and Targets

Historical condition reports show that meeting goals of the state asset targets for pavements and bridges on both the interstate and primary systems indicate a similar trend of meeting the MAP-21 goals for the NHS. Figures 3-9 and 3-10 show the correlating historical condition measures for pavements and bridges. The Department will continue investment strategies for the interstate and primary system to ensure condition goals are met for pavement and bridge assets on the NHS.

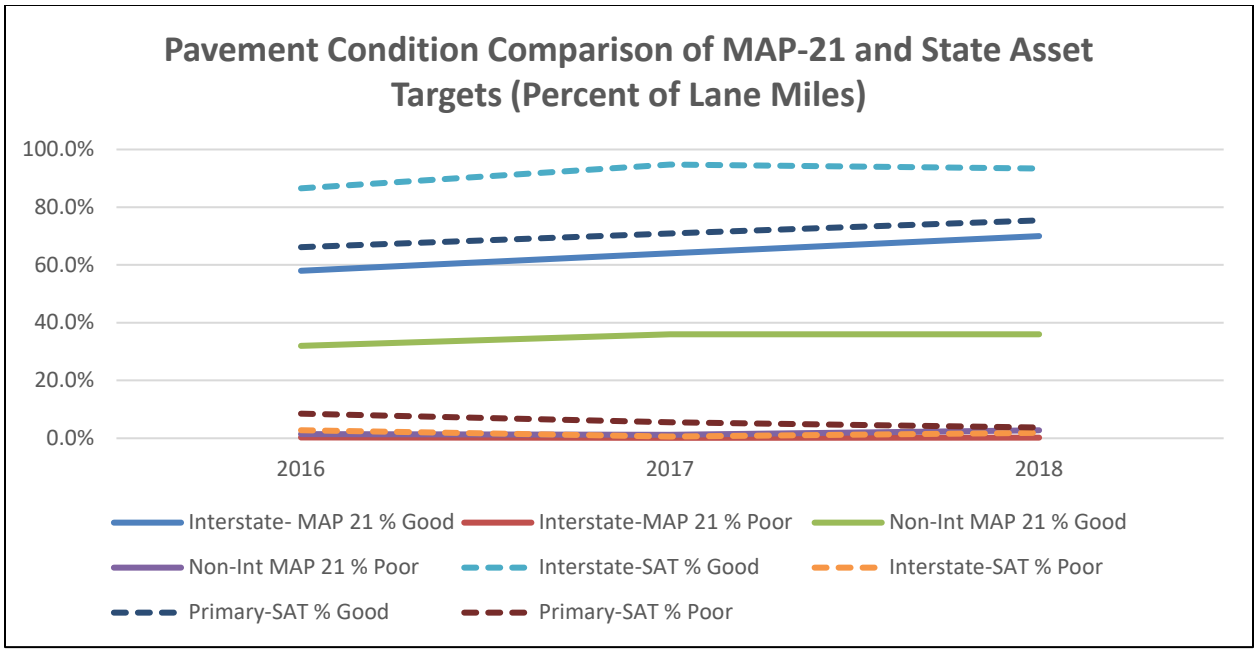


Figure 3-9: MAP-21 and State Asset Pavement Condition Measures Comparison

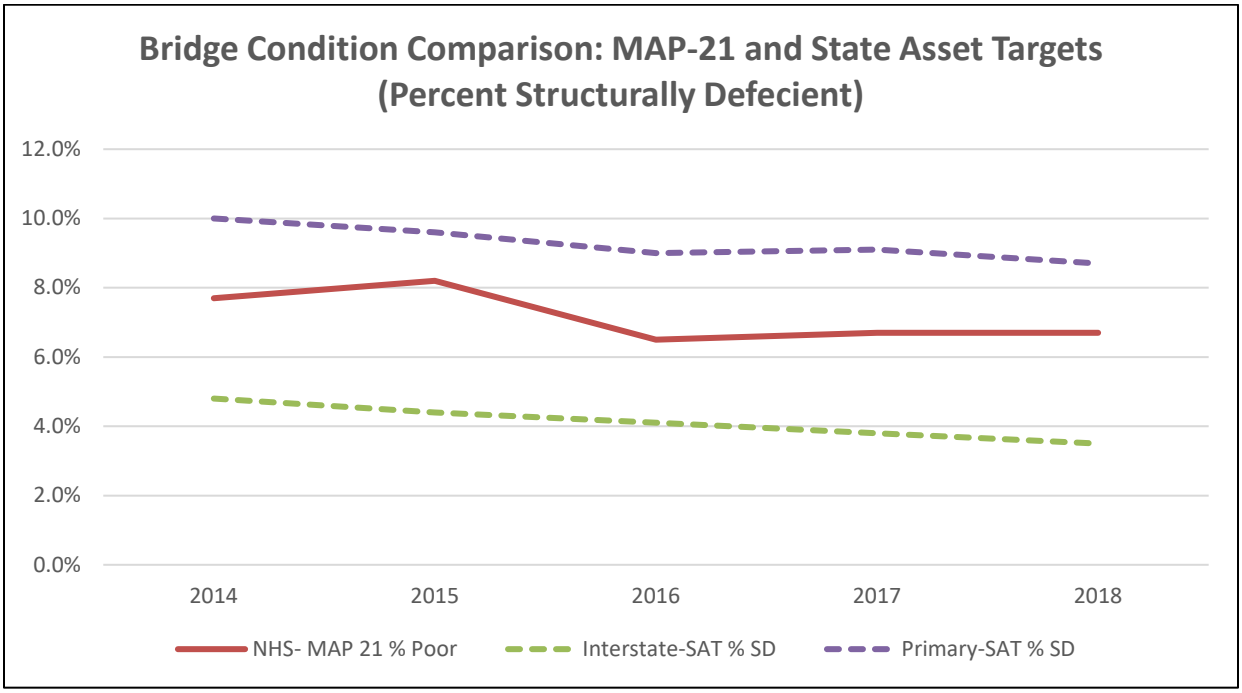


Figure 3-10: MAP-21 and State Asset Management Bridge Condition Measures Comparison

3.10 Factors Hindering Progress and Strategies to Address the Gap

NCDOT faces a number of challenges in meeting the transportation needs of the state's growing population. The Department is responsible for all modes of transportation in the state including highways, ferries, aviation, rail, public transit, bicycle, and pedestrian, all of which share limited funding. With a diverse portfolio of transportation assets, NCDOT has developed a strategic, data-driven decision-making process relying on performance, transparency, and accountability to ensure informed investment decisions are being made across all modes of transportation.

Deficiencies in the various programs are identified in the Department's MOPAR, and recommendations are listed to meet the performance targets. For pavements, the 2018 report compares cycle time (the interval between each treatment activity) to identify the number of miles needed to reach state asset management goals. The industry recommends average cycle time of 12 to 15 years for resurfacing treatments and 4 to 7 years for preservation treatments. The department's cycle time for Contract Resurfacing program noted in the 2018 MOPAR is 16 years on the primary system and 31 years on the secondary system. Pavement Preservation program accomplishments notes a cycle time of 19 years.

3.11 Monitoring the Performance of Pavement and Bridges

As explained in earlier portions of this section NCDOT has a number of processes in place to monitor the condition of pavements and bridges to determine if the investment strategy and program of projects are in line with the objectives of the agency and the long-term state asset targets. Below is a summary of NCDOT processes to identify potential problems, gaps, and development of strategies to head-off issues.

- Pavement Program – The Department implemented the Highway Maintenance Improvement Plans (HMIP) in 2015 which started out as a 3-year program but has evolved to a 5-year work plan that identifies routes and optimal pavement treatments based on anticipated funding. Each of the 14 highway divisions prepare a plan for their area for adoption by the Board of Transportation. On an annual basis pavement condition results are gleaned from the pavement condition survey, provided to each division, and are reported to NCDOT senior management. Additionally, pavement condition performance is estimated based on current condition and budgetary amounts. Results are compared to NCDOT's long-term state asset targets and to the targets NCDOT has 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 based on constant dollars; as one year is complete, another year is added. As described in the chapter on Investment Strategy, the results of the annual pavement performance report will be used to identify issues in NCDOT's pavement management program, determination of funding needs, or other gaps. Adjustments in program strategy and funding will be considered by senior management within the context of the overall vision and funding needs of the Department.

- Bridge Program – Similar to the HMIP, the Department develops a 5-year Bridge Management Improvement Program (BMIP) to make progress towards reaching the state goals for SD bridges. The Structures Management Unit (SMU) and the Divisions work cooperatively to develop the BMIP. Generally, SMU develops initial recommendations for interstate and primary system

bridges and the Divisions develops recommendations for secondary road bridges. On an annual basis bridge condition results are gleaned from the BMS, provided to each Division, and reported to NCDOT senior management. Additionally, bridge performance is estimated based on current condition and budgetary amounts. Results are compared to NCDOT's long-term state asset targets and the targets NCDOT establish as a part of 23 USC 150(d) for the NHS. Based on the BMS analysis a list of bridges which meet state funding requirements are prioritized using a Priority Replacement Index (PRI). Division and SMU program managers use this list as they develop their BMIP. As described in the chapter on Investment Strategy, the results of the annual bridge performance report will be used to identify issues in NCDOT's bridge management program, determination of funding needs, or other gaps. Adjustments in program strategy and funding will be considered by senior management within the context of the overall vision and funding needs of the Department.

- NCDOT will also evaluate 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, system performance/congestion, freight movement, and congestion mitigation and air quality. All these various performance expectations will be considered by NCDOT's senior management as annual budgets are developed. With well-defined pavement and bridge programs and systems in place to evaluate the condition and future performance based on life-cycle cost planning, NCDOT will be able to make informed decisions based on reliable data and state-of-the practice analysis.

- NCDOT will continue to program pavement and bridge resources to meet the State's measures and targets and continue to monitor the National Performance Measure's targets. Based on historical trends, NCDOT expects the Federal Measures to follow the same trend as NCDOT's State Asset measures and meet the MAP-21 requirements.

Chapter 4 Life Cycle Planning

4.1 Life Cycle Planning Analysis

A life cycle cost (LCC) analysis is used to give a picture of the likely costs of an asset from construction to the end of the analysis period. The LCC analysis considers all the relevant cost incurred throughout the whole life of an asset. Those costs begin with the initial construction and include maintenance, preservation, rehabilitation, and reconstruction. In order to keep an asset functioning adequately, achieve the performance targets established by the agency, and provide users with the level of service that meets their expectation, there are certain actions that must be performed throughout its life. The LCC process begins with the development of different alternatives to fulfill the structural and performance objectives of an asset. A key component of this analysis is the use of deterioration modeling tools that estimate an asset's condition as it ages. This estimation is based on factors such as environment, weather, and in the case of pavements and bridges, heavy vehicle loadings. The schedule of initial and future activities to maintain an asset's condition at a predetermined performance level is defined and the costs of these activities are estimated. Direct expenditures (i.e. construction, reconstruction, maintenance, preservation, and rehabilitation activities) are typically included. The predicted schedule of activities and their associated agency costs form the projected LCC. Considering all these costs during the service life of an asset helps the agency to select the lowest cost options to maintain a desired condition at a minimum practicable cost. Figure 4-1 shows a series of phases that could make up the life cycle of an asset.

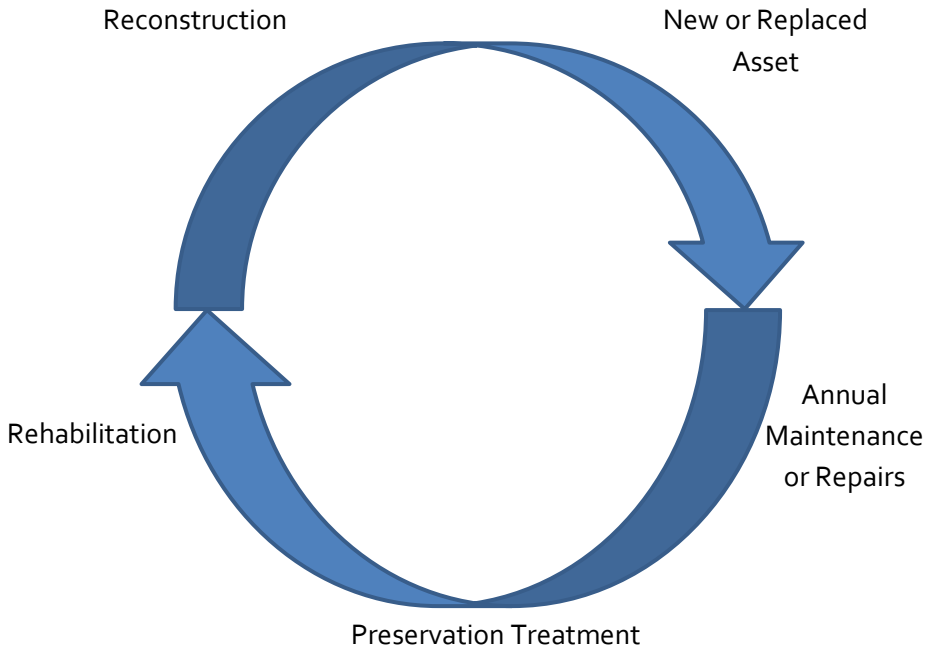


Figure 4-1: Phases in the Life Cycle of an Asset

An example of the concept behind the benefits of implementing a lowest whole-life cost philosophy, a classic pavement deterioration curve is shown in Figure 4-2. 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.

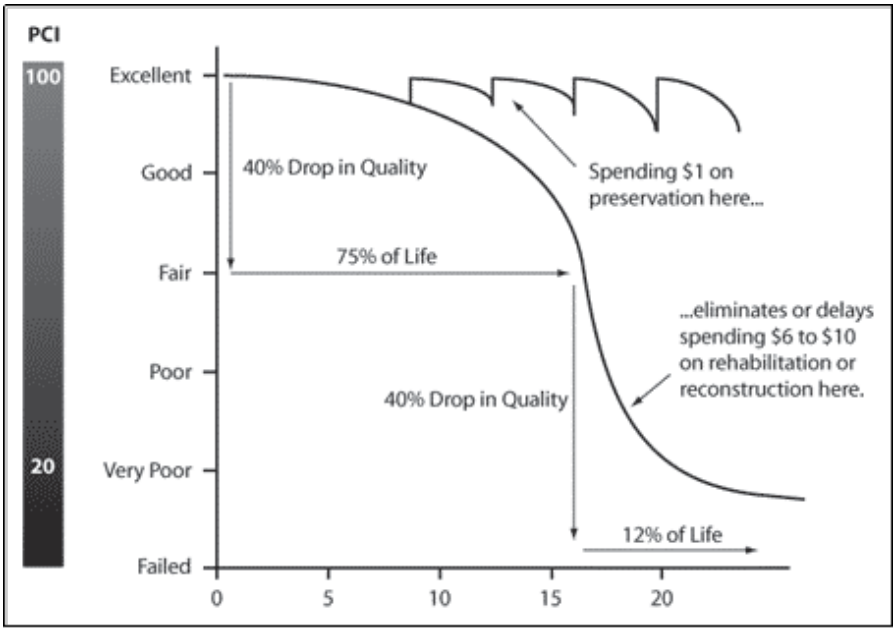


Figure 4-2: Pavement Deterioration Curve

4.2 MAP-21 and Final Rule Requirements

Life cycle cost and life cycle planning is defined in 23 CFR Part 515.5 as follows:

- Life Cycle Cost - The cost of managing an asset class or asset sub-group for its whole life, from initial construction to its replacement.
- Life Cycle Planning - A process to estimate the cost of managing an asset class, or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition.

And in 23 CFR Part 515.7, state DOTs are required to develop a risk-based asset management plan to include specific minimum processes including the following section on life cycle planning identified in subsection (b):

- A state DOT shall establish a process for conducting life cycle planning for an asset class or asset subgroup 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-life costs of assets. The State DOT may propose excluding one or more asset sub-groups from its lifecycle 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, provided that 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).

4.3 NCDOT's Process for Performing Life Cycle Cost Analysis

NCDOT performs a thorough and systematic LCC analysis on all state-owned pavement and bridge assets, regardless of highway system class, using the agency's PMS and BMS. NCDOT's performance targets – established to meet requirements in 23 CFR Part 490 – are shown in Table 4-1.

Table 4-1: NCDOT National Performance Management Targets*

ASSET	SYSTEM	2-YEAR TARGET	4-YEAR TARGET
Pavements	Interstate	N/A	≥ 37.0% Good condition
	Interstate	N/A	≤ 2.2% Poor condition
	Non-Interstate NHS	≥ 27.0% Good condition	≥ 21.0% Good condition
	Non-Interstate NHS	≤ 4.2% Poor condition	≤ 4.7% Poor condition
Bridges	NHS Bridges	≥ 33.0% Good condition	≥ 30.0% Good condition
	NHS Bridges	≤ 8.0% Poor condition	≤ 9.0% Poor condition

*See Chapter 3 for National Performance Measure Descriptions

NCDOT has little experience using the performance measures established in 23 CFR Part 490. Therefore, NCDOT's life cycle planning analysis used performance measures and targets that NCDOT has established prior to FHWA's final rule. NCDOT's state asset performance measures and targets are shown in Table 4-2. An Oversight Committee consisting of key NCDOT managers provided oversight and coordination for implementation of all MAP-21 and FAST Act final rules including development of performance targets.

Table 4-2: NCDOT State Asset Targets

ASSET	SYSTEM	PERFORMANCE MEASURE	TARGET
Pavements	Interstate	PCI ≥ 80 (Good)	≥ 85%
	Primary	PCI ≥ 80 (Good)	≥ 80%
	Secondary	PCI ≥ 80 (Good)	≥ 70%
Pavements	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%

*MAP-21 specifies a condition rating of 7 or higher to be considered good

A key component of asset management is creating and instituting a performance management culture within all levels of an organization. Within the performance management framework, performance measures and targets are created to link the overall goals and objectives of the agency to the available funds. Modern computerized management systems allow agencies to perform multiple "what-if" scenarios to analyze the future condition of an asset. These scenarios are based on different funding levels and investment strategies, i.e. strategies based on preservation, maintenance, rehabilitation, reconstruction, or a combination of all work types. Within the core functionality of both a PMS and BMS is the presence of complex computer algorithms, deterioration models, and the ability to predict the future condition of a pavement or bridge based on a number of variables such as weather, climate, environment, age, traffic loading, treatments, funding, etc. Another core function is an LCC analysis component whereby tailored treatments are applied to a pavement section or bridge based on their condition. The concept behind this approach is to minimize whole-life cost by applying low cost treatments to an asset early in its life and extending the service life while minimizing investments.

Performance targets provide the measuring stick to determine if the asset's condition is meeting the expectations of NCDOT. With the establishment of state asset performance measures and targets for pavements and bridges, NCDOT performs an evaluation using the results from the PMS and BMS. At the network level, the PMS and BMS provide several output reports to enable NCDOT managers to gauge

success in meeting the agency's goals and performance targets. Examples of the type of reports evaluated are:

- Historical reports of expenditures, type of treatments (work types), and resulting performance by highway system (interstate, primary, secondary)
- Condition by highway system (interstate, primary, secondary)
- Estimated funding levels to achieve specific condition, by highway system, 10-year projection
- Estimated condition based on various funding scenarios by highway 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. It should be noted that federally owned and locally owned pavement and bridges are excluded from the Department's LCC analysis since they represent such as small percentage of the total inventory (0.86% of pavement lane miles and 0.52% of square feet of bridge decks).

4.3.1 Pavement Management Program

Each year, the Department performs a pavement condition survey of all agency pavement assets on the interstate, primary, and secondary systems. These surveys provide a point-in-time snapshot of the condition based on observed defects in the pavement such as cracking, patching, rutting, raveling, corner breaks, seal breaks, and faulting. The results of these surveys are used to rate the pavement condition using a Pavement Condition Index (PCI) on a rating scale of 0 to 100. A segment of pavement with little or no observable defects will score above 80 and considered to be in "good" condition. Pavements with more observable defects will score lower on the PCI scale and trend towards the "fair" or "poor" category, see Figure 4-3.

Pavements deteriorate over time due to the effects of weather, traffic, and truck traffic. Improvement in pavement condition is influenced primarily by activities funded through state funded programs from General Maintenance Reserve (GMR), contract resurfacing, and 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).

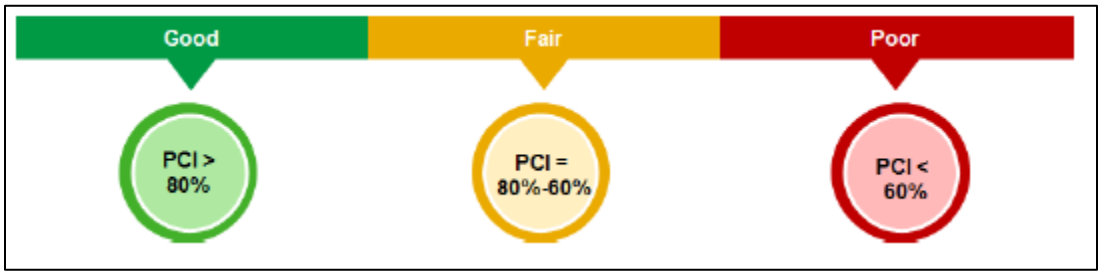


Figure 4-3: Pavement Condition Index

Pursuant to North Carolina General Statutes (N.C.G.S.) 136-44.3A NCDOT produces a Highway Maintenance Improvement Plan (HMIP) outlining a 5-year work plan based on annual funding appropriations. The first step in developing the plan is to load the most recent pavement condition data into the Pavement Management System (PMS). The PMS is used to identify sections to treat to achieve the best pavement condition rating at the lowest cost, i.e. life cycle cost analysis for a 5-year horizon. The PMS incorporates decision trees and deterioration modeling within the analysis to project future condition and optimized treatments for each pavement segment. The decision trees and deterioration modeling consider the entire life of a pavement from initial construction to the end of its useful life and these models are used to develop the 5-year program for the HMIP. For the primary and secondary systems, the budget used in the PMS optimization is based on the previous fiscal year's allocation of the pavement treatment programs previously mentioned (State Highway Funds only, no federal funds included). The HMIP is developed using the data collected for PCI to identify routes and optimal treatments to reach state asset management targets. A list of routes and recommended treatments is created and provided to each of the 14 Divisions for review and consideration as they develop their annual programs for treatment. Division budget allocations (state funds only) for the pavement management program are calculated based on the respective inventory (by lane miles) and needs in each division. These Division plans, pursuant to legislation, are adopted by the Board and updated annually to reflect actual budget allocations. It is anticipated that annual modifications and additions will be made to the plan to adjust years 2 through 5 to changing conditions, funding, and needs. For example, an unusually cold and wet winter may cause roads in western NC to deteriorate faster than usual. Similarly, flooding due to a hurricane can also cause rapid road deterioration. Additionally, the division may become aware of local economic development planned along one or more roadways that makes strengthening those roadways a division priority.

For the interstate system, the output from the PMS is provided to the divisions for their review as they develop their candidate list of projects for funding consideration within the NCDOT Interstate Maintenance Program using Federal Funds. Divisions submit their candidate projects, with recommended treatment and estimated cost, to the Department's senior management for consideration. Projects are selected based on a statewide basis with the goal to improve the overall network condition at the most optimized cost.

4.3.2 Structures Management Program

In 2014, NCDOT compared poorly to other states in terms of percent of bridges that were structurally deficient (SD). Over 16% of the bridges (not including culverts) were considered SD. These SD bridges are in poor condition and generally require high maintenance effort of funds to assure they remain safe for their posted load. The high percentage of these high maintenance bridges raised concerns that at current staff and budget levels NCDOT's bridge maintenance crews may be pressed to address the increasing demand. The Department began an effort to establish new goals to reduce the percent of SD from over 16% to 10% and provide budget makers with funding options to realize them.

Bridge inspections are performed in accordance with the federal National Bridge Inspection Standards (NBIS) and results are uploaded to the bridge management system (BMS) upon

completion of each bridge inspection. As discussed in Chapter 2, the data collected from bridge inspections is the basis for the determining the condition of bridges. Bridge inspection condition data is available for the 30-plus year history of the bridge inspection program and is used to build a history of bridge condition. The condition history has been used to model the deterioration over the life of a bridge. These deterioration models have been integrated in the BMS and were used in 2014 to predict that an additional 250 bridges would become SD each year given current bridge maintenance funding. Therefore, in order to achieve its goal of 10% SD, the initial 6% gap would need be closed and 250 additional bridges would need to be improved each year.

NCDOT has a long history of valuing sound bridge management practices, including maintenance and preservation. Agency experience, in combination with national best practices, are used to determine feasible actions that can be performed for a given bridge condition. Both state and national experience are also used to track and predict the cost and benefit of bridge improvements. Section 4.4.2 provides examples of the work types NCDOT utilizes to restore the condition of its bridges.

This combined experience is integrated into the BMS to allow the system to recommend improvements for a given bridge condition and provide the cost benefit data. The deterioration models can be combined with decision rules to provide recommendations for network level programs associated with bridge work types. In 2014, this process was used to provide state Bridge Program (BP) and funding recommendations shown in Figure 4-4.

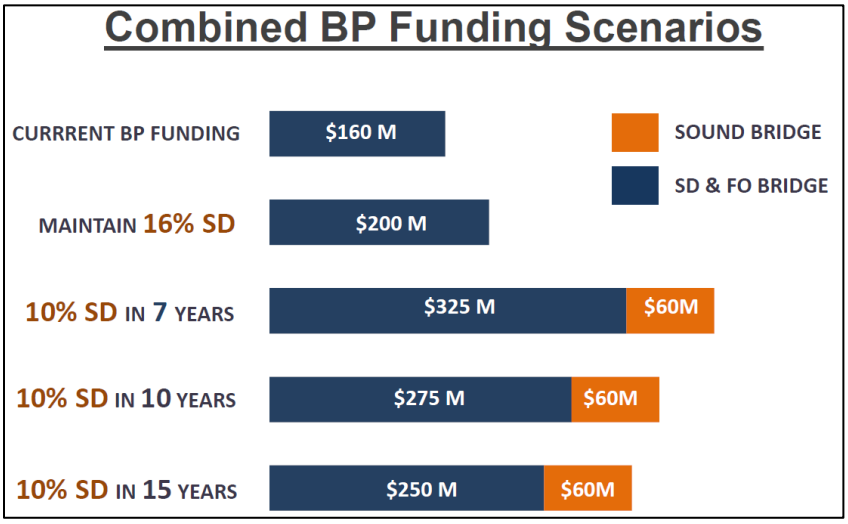


Figure 4-4: 2014 Initial Recommendations for State Bridge Program Funding

As shown in Figure 4-4, the Department provided four options for the bridge program if funding to bridge maintenance crews remained constant ("SD & FO Bridge" refers to Structural Deficient and Functional Obsolete Bridges.). The four options provided the need for a program of projects to rehabilitate or

reconstruct unsound bridges. To reduce costs associated with deterioration the options also included recommended programs for preserving sound bridges.

The NC General Assembly (NCGA) responded favorably and initially provided state funds corresponding to the 15-year option for the reconstruction and rehabilitation of unsound bridges. Over the next two years, the Department continued to work with the NCGA to establish a state funded bridge preservation program. Additionally, the Department recognized risks associated with the costs of bridges with disproportional high costs to replace, over $20M. Because of this continued cooperation, the state funded bridge program now provides $272M for the reconstruction and rehabilitation of deficient bridges, and an additional $80M for the preservation of sound bridges. These funds are combined with federal funds to provide the following five funding sources that make up NCDOT's bridge program:

- Strategic Transportation Investments (STI) program (Federal Funded)
- Interstate Maintenance Program (IM) (Federal Funded)
- Bridge Program (State Funded)
- Bridge Preservation Program (State Funded)
- General Maintenance Reserve (State Funded)

These funding sources are combined to develop a program of projects and fund maintenance activities necessary to achieve NCDOT's goal of 10% SD no later than 2030.

The combined STI, and State Funded Bridge Program are used to create a 5-year Bridge Management Improvement Plan (BMIP). The BMIP is made up of two portions: Centrally (Structures Management Unit) funded projects to address needs on the interstate and primary systems, and a Division managed program to address needs on the secondary system. Funds are apportioned to both the Central and Division programs in proportion with the needs to achieve Structural Deficient (SD) goals in each county for the interstate, primary, and secondary systems identified in Table 4-1.

The division funded program is allocated in two parts:

- An equal share is allocated to each division to address deficient bridges within the respective division.
- Remaining balance is allocated to each division based upon the proportionate need to achieve statewide goals.

The (BMS) is used to create a list of bridges that qualify for the state funded bridge program. The list of qualified bridges is prioritized within the BMS by the Priority Replacement Index (PRI) and serves as an initial guidance for bridge program managers. Division and Central bridge program managers review the recommended prioritized list of candidates and make adjustments to reflect additional concerns based on local knowledge. The final prioritized bridge improvements are then entered in the BMIP as funding becomes available.

Project prioritization for the Bridge Preservation program is initially based on replacement value of bridges as identified in the BMS. This initiative supports extending the service life of bridges identified by NCDOT as high value bridges for which replacement may not be financially feasible. In addition, the Department provides funds from the General Maintenance Reserve to support bridge maintenance

activities in each of its 14 divisions. These funds and the activities it support are key to the overall bridge management program as they are used to perform maintenance and repairs to critical findings and priority maintenance needs identified during NBIS inspections. This allows the Department to limit restrictive weight limits on bridges and maintain them until time for rehabilitation or replacement. The funds are also essential to maintaining historical network level deterioration curves that are used in the BMS.

Finally, as improvement projects are completed and as bridge conditions improve, the above-mentioned life cycle planning process is revisited every two years to update budget writers on the status of the bridge program. The continued reevaluation is critical to confirming predictions related to deterioration, update costs due to inflation, and incorporate benefits of advancements in the management of bridges.

An example of NCDOT doing a lifecycle analysis using performance targets is with the establishment of the state's Interstate Maintenance Program. In 2013, NCDOT performed an analysis of the interstate system for pavement, bridge, and roadway needs. Historical expenditures were charted against the Pavement Condition Index (PCI). Next, the PMS ran a series of scenarios starting with $45.4 million (the amount programed in 2013) and in $20-million increments from $60 to $140 million. The optimal amount needed to reach and maintain NCDOT's PCI target was $80-$100. Since there were bridges on the interstate system that needed attention, the Structures Management Unit analyzed the typical mix of pavement projects done on the interstate in a given year and estimated a need of $20-25 million in bridge preservation and rehabilitation work within those project limits. The Maintenance Management system identified another $10-$15 million in annual ancillary interstate work. As a result, NCDOT leadership worked with the North Carolina General Assembly to establish an Interstate Maintenance Program funded out of the federal Nation Highway Performance Program (NHPP).

4.4 Treatments for Pavements and Bridges

4.4.1 Pavement Work Types

NCDOT uses a systematic approach in developing the annual pavement management program consisting of a multitude of treatments (work types). The suite of work types are key inputs into the PMS's optimization program using life cycle cost analysis. Table 4-3 provides a list of typical work types and their unit cost. Typical work types can be classified into four major categories; Maintenance, Preservations, Rehabilitation, Reconstruction as follows:

- Maintenance – Routine maintenance is the day-to-day pavement maintenance activities that are both reactive or scheduled, or whose timing is within the control of maintenance personnel. Some examples are:
  - Shallow or Pothole Patching
  - Skin Patching
  - Partial-depth patching
  - Repair concrete corner breaks
  - Concrete joint repairs

- Preservation – Preservation treatments prolong the period during which the pavement remains in good to fair condition. Preservation of pavements includes timely application of treatments including crack sealing, surface treatments, thin overlays, and mill and replace treatments. They can also include microsurfacing or the application of special wearing surfaces when addressing a functional need. For rigid pavements, preservation 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.

- Rehabilitation – Rehabilitation of pavements is required when the pavement condition drops below fair 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 2 or more layers would constitute rehabilitation. Rigid pavement rehabilitation tends to include more extensive slab replacements followed by diamond grinding. Jointed concrete pavements in North Carolina have also performed for 10 years or more with an ultra-thin bonded wearing course following slab and spall repairs.

Reconstruction – Reconstruction should be considered when the pavement structure reaches the end of its life cycle. While NCDOT has historically performed reconstruction for rigid pavements, that is not the case with flexible pavements. Instead the practice has been to perform repeated rehabilitation. Reconstruction of continuously reinforced concrete pavements has consisted 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.

Table 4-3: Typical Pavement Work Types and Unit Cost

WORK TYPE	TREATMENT	UNIT COST ($/ Lane Mile)
Maintenance	Wheel-path Patching	17,229
	Interstate - Patching	46,513
Preservation	Seal Cracks	6,009
	Microsurfacing	29,247
	1.25" Overlay (A Level)	52,933
	1.5" Overlay (A Level)	62,031
	2.0" Overlay (A Level)	80,197
	Minor Concrete Rehab / Diamond Grinding	218,996
	Interstate - Slurry Seal	62,286
	Interstate - Microsurfacing	62,286
	Interstate - 1.5" Overlay (D Level)	110,746
	Mill 1.5" & Replace (A Level)	750,705
	Interstate - Mill 1.5" & Replace (D Level)	127,140
	Mill 1.25" & Replace (A Level)	66,607
Rehabilitation	Mill 3.0" & Replace (B Level)	129,976
	Mill 4.0" & Replace (A Level)	159,715
	Mill 2.5" & Replace / 1.5" Overlay (B Level)	162,489
	Moderate Concrete Rehab / Overlay	365,897
	Major Concrete Rehab / Overlay	747,463
	Interstate - Mill 3.0" & Replace (D Level)	219,870
	Interstate - Mill 2.5" & Replace / 1.5" Overlay (D Level)	247,212
	Interstate - Moderate Concrete Rehab / Overlay	365,897
	Interstate - Major Concrete Rehab / Overlay	747,463
Reconstruction	AC Reconstruction - 5000<= AADT <15000	694,992
	AC Reconstruction - AADT>15000	723,136

4.4.2 Bridge Work Types

Similar to pavement management, NCDOT uses a systematic approach in developing the annual structures management program consisting of a multitude of treatments (work types). The suite of work types are key inputs into the BMS's optimization program using life cycle cost analysis. Table 4-4 provides a list of typical work types and their unit costs. Typical work types can be classified into four major categories; Maintenance, Preservation, Rehabilitation, or Reconstruction as follows:

- 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.
- Preservation – Repainting structural steel, deck repairs and waterproofing deck surface (with membrane, thin epoxy overlay, polymer modified concrete, or a reinforced concrete overlay), object marker replacement, cleaning and sealing or replacement of expansion joints.
- Rehabilitation – Bridge deck and expansion joint replacement, scour remediation, bearing replacements, and bridge deck overlays, repainting structural steel, concrete shotcrete repairs, and structural steel repairs/strengthening. A repair project may also include the replacement of the full superstructures of bridges.
- Reconstruction – Typically, projects 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.

Table 4-4: Typical Bridge Work Types and Unit Cost

Work Type	Element	Material	Treatment	Unit Cost ($/SF deck)
Preservation	Deck	Concrete	Light LMC	25.00
	Deck	Concrete	Epoxy Overlay	7.00
	Superstructure	Concrete	Light Girder Repairs	1.50
	Superstructure	Steel	Light Girder Repairs	7.00
	Substructure	Concrete	Light Sub Repairs	4.85
	Substructure	Steel	Light Sub Repairs	5.00
Rehabilitation	Deck	Concrete	Latex Modified Conc	30.00
	Superstructure	Concrete	Girder Repairs	4.75
	Superstructure	Concrete	Heavy Girder Repairs	12.00
	Superstructure	Steel	Girder Repairs	35.00
	Superstructure	Steel	Heavy Girder Repairs	38.00
	Substructure	Concrete	Sub Repairs	8.00
	Substructure	Steel	Sub Repairs	8.60
Reconstruction	Deck	Concrete	Replace Deck	68.00
	Superstructure	Concrete	Replace Super	122.00
	Superstructure	Steel	Replace Super	116.00
	Substructure	Concrete	Heavy Sub Repairs	15.50
	Substructure	Steel	Heavy Sub Repairs	19.00

4.5 Strategies to Manage Assets

NCDOT has a long history of effectively managing state-owned assets to extend service life, especially pavement and bridges. A key feature of the success of using asset management principles is understanding the connection between funding and maintaining asset performance at an established target. In order to successfully manage the agency's assets, formal and informal practices have been implemented that rely on quality data, systematic processes, and analytical evaluation that complement the technical expertise in the State Pavement Management and Structures Management Unit. Below are examples of strategies NCDOT uses to effectively manage the pavement and bridge assets:

4.5.1 Pavement

NCDOT Pavement Management work units of Data Collection, Pavement Design & Distress Analysis, and Pavement Management Systems are responsible for designing, testing, and monitoring the health of pavements on the 80,000-mile NCDOT network. They provide the technical knowledge for the vision, objectives, and procedures for managing the agency's pavements. The PMS is used to manage pavement condition data, maintain a history of road construction and maintenance treatments, and conduct pavement analyses which assist the Department in optimizing limited funding resources. The Pavement Management unit provides guidance in the selection of candidates for maintenance, preservation, resurfacing, and rehabilitation projects for both rigid (concrete) and

flexible (asphalt) pavement with an emphasis on employing preventive maintenance treatments until repair costs exceed the benefit, i.e. using LCC concepts.

Pavement Condition Index (PCI) – The PCI is a composite index number measured on a 0 to 100 scale based on pavement distresses such as ride quality, cracking, rutting, patching, corner breaks and faulting. NCDOT tracks this number for the Interstate, Primary and Secondary network to monitor the health of the system and to ensure the Department is meeting its performance goals and targets discussed in Chapter 3.

The Department has implemented a 5-year work plan – the Highway Maintenance Improvement Plan (HMIP) – which identifies routes and optimal pavement treatments based on anticipated funding. Pavement condition performance is estimated based on current condition and budgetary amounts. Results are compared to NCDOT's long-term state of good repair targets and are compared to the targets NCDOT has 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. The results of the annual pavement performance report are used to identify issues in NCDOT's pavement management program, determination of funding needs, or other gaps. Adjustments in program strategy and funding are considered by senior management within the context of the overall vision and funding needs of the Department.

4.5.2 Bridges

The Structures Management Unit conducts bridge inspections on all the bridges in the state except the federally owned bridges on a two-year schedule and the condition information is entered into the BMS. The BMS is used to create a prioritized list of bridges that qualify for bridge fund sources and prepare 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. Approximately 78% of the budget for Structure Management is allocated to replacement of structural deficient bridges, while the remaining 22% is allocated to preservation.

Similar to the HMIP, the Department develops a 5-year Bridge Management Improvement Program (BMIP) to make progress towards reaching the state goals for SD bridges. On an annual basis bridge condition results are gleaned from the BMS and reported to NCDOT senior management. Bridge performance is estimated based on current condition and budgetary amounts. Results are compared to NCDOT's long-term state of good repair targets and the targets NCDOT has established as a part of 23 USC 150(d) for the NHS. Based on the BMS analysis a list of bridges which meet state funding requirements are prioritized using a Priority Replacement Index (PRI). Division and SMU program managers use this list as they develop their BMIP. The results of the annual bridge performance report are used to identify issues in NCDOT's bridge management program, determination of

funding needs, or other gaps. Adjustments in program strategy and funding are considered by senior management within the context of the overall vision and funding needs of the Department.

Chapter 5 Risk Management Analysis

5.1 NCDOT's Plan for Risk Management Analysis

NCDOT's Risk Management Analysis process will be discussed in this chapter. It will describe requirements of the final rule and identify the iterative process NCDOT used to satisfy the requirements of MAP-21 for risk management analysis.

5.2 MAP-21 and Final Rule Requirements

Risk Management Analysis requirements are identified in 23 CFR Part 515.7 (c) as follows:

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 repeatedly 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.

5.3 Risk Management Definitions

For the purposes of this section, the following definitions are listed to provide the framework and context for the discussion of Risk and Risk Management, as it applies to the TAMP at NCDOT.

Risk – The impact of uncertainty upon NCDOT's ability to deliver its programs, projects, and services. Risk is an event that is a deviation from the expected outcome. Risk can either be positive or negative and is measured in terms of a combination of the likelihood of an event occurring and the consequence if the event did occur.

Risk Management – A systematic process of identifying, analyzing, and prioritizing risks with the development of strategies to respond to potential threats and opportunities.

Risk Identification – The process of finding, recognizing, and describing risks.

Risk Register – A formal listing of risks identified by the Department, which may include such information as priority, type, likelihood, consequence, impact, and mitigating actions.

Risk Context – The social, cultural, legal, regulatory, economic, and natural environment in which an entity operates that is unique to the Department.

Risk Analysis – A process to understand the potential impact of various risks, in terms of likelihood and consequence.

Risk Assessment – The process of identifying risks, analyzing risks, and evaluating risk.

Risk Evaluation – The process of reviewing the results from the Risk Analysis and comparing the impact with the Department's risk tolerance.

Risk Tolerance – The capacity of the Department to accept or tolerate risk.

Risk Treatment – A process to determine how a Department will respond to an identified risk.

Likelihood – The probability that a specific event might occur.

Consequence – The outcome of an event impacting the Department's objectives.

Mitigation – Actions taken to address or reduce risk. Generally, it refers to the entire process of responding to risks.

Risk Levels – The different levels of risk which can be categorized into three major risk areas: Agency/Enterprise, Programmatic, and Project/Asset. They can be distinct or overlapping from one level to the next.

Agency/Enterprise Risk – Risks that are high-level issues and can impact the achievement of the agency's goals and objectives involving a multitude of issues, i.e. budgets, legislative requirements, regulatory reforms, public sentiment, broad managerial and personnel decisions.

Programmatic Risk – Risks that are typically a collection of related projects or program delivery issues that may be attributed to an entire sub-unit or business unit, e.g., bridge program, preservation program, maintenance program, program budgets.

Project/Asset Risk – Risks that are associated with an individual project, location, or individual asset class; can be associated with providing continuity of service of a bridge or highway and system resilience and asset failure.

5.4 Steps NCDOT has Taken Towards Risk Management

With the passage of MAP-21, NCDOT has taken this opportunity to initialize a more comprehensive approach to assess risk across the agency in accordance with asset management concepts. In October of 2015, NCDOT hosted the National Highway Institute (NHI) risk management workshop. Several NCDOT

managers came together for a two-day workshop to kick-off the formal risk management effort and establish processes for identifying, evaluating and analyzing risks.

As part of the two-day workshop, the workgroup was guided by the framework identified in the NHI course and FHWA publication, "Risk-Based Transportation Asset Management Report 1: Evaluating Threats, Capitalizing on Opportunities." Based on these two documents, the risk management process framework consists of a five-step methodology, as follows:

- **Step 1: Establishing context** – In this step, the Department's social, cultural, legal, regulatory, economic, and natural environment in which it operates are identified. This can be thought of as the Department's DNA and its purpose for existence.
- **Step 2: Identify Risk** – In this step, the Department formally identifies and document risks that could prohibit it from meeting the requirements of MAP-21.
- **Step 3: Analyze Risk** – In this step, for each of the risks identified in Step 2, the Department determines the likelihood of the event happening and its consequence based on expert judgment. This provides a method to quantify the importance and initial priority of each risk.
- **Step 4: Evaluate Risk** – The purpose of this step is to (1) evaluate the identified risks based on their importance and (2) make decisions, based on the outcome of the risk analysis. This includes a review of which risk needs treatment and its priority. The top priority risks are identified during this step.
- **Step 5: Treat Risk** - In this step the Department determines option(s) to address or mitigate the top priority risks as well as who is responsible for each one.

Two additional components are identified as a part of the framework: 1) **Monitoring and Review**, and 2) **Communication and Consultation**. Monitoring and Review is a planned part of the process that is accomplished on an established frequency, as determined by the Risk Management Committee and identification of who is responsible for monitoring each risk. Communication and Consultation provides an avenue to keep internal and external stakeholders abreast of the issues where risk problems and events are known throughout the Department. This information is then shared with the public, legislature, media, and oversight bodies. The five-step process, as depicted in ISO literature, is illustrated in Figure 5-1.

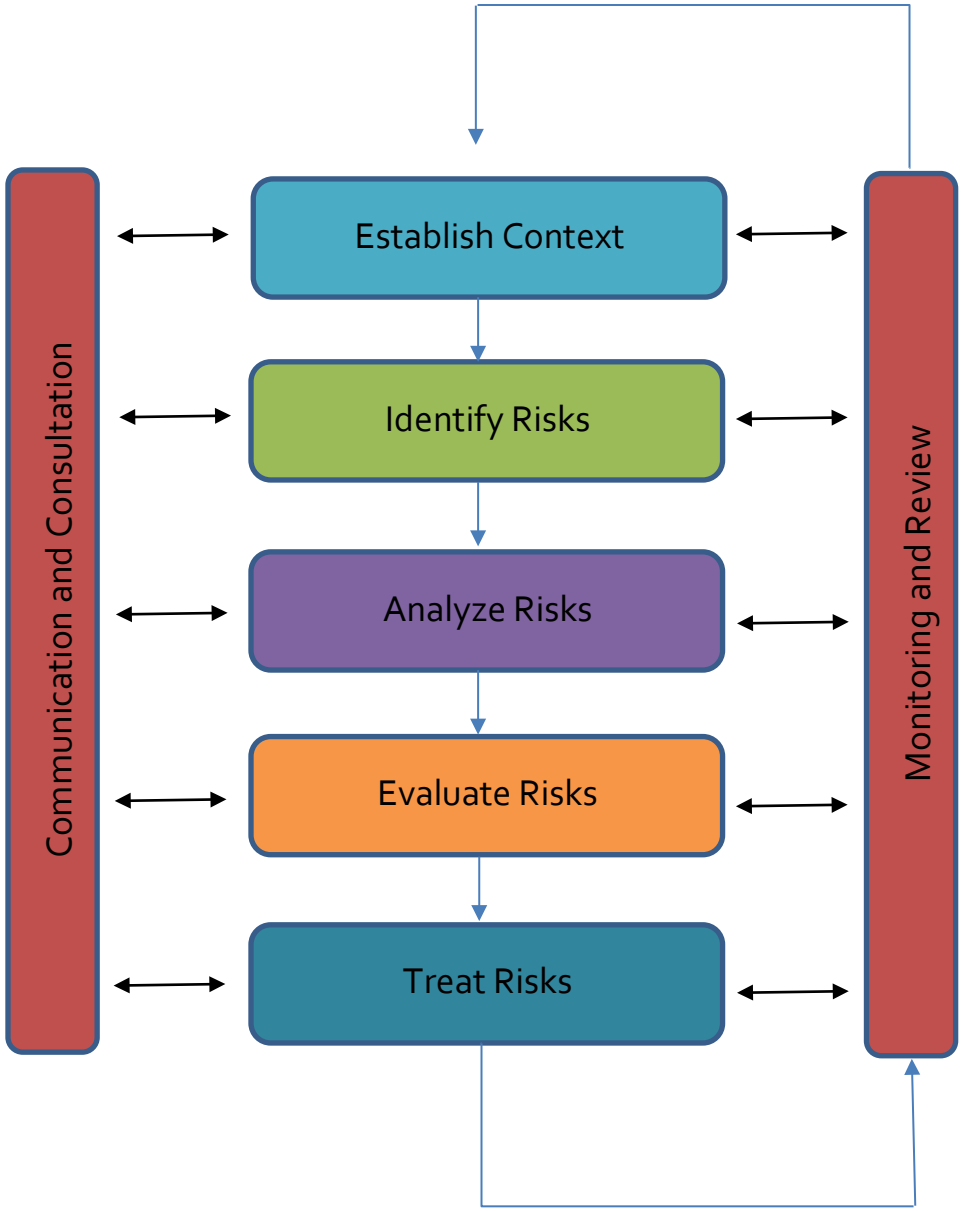


Figure 5-1: Risk Management Framework, ISO 31000:2009

5.5 Risk Identification

Following the workshop mentioned earlier two subcommittees were established to initiate the risk management process for the Department, one for pavements and another for bridges. Initially, risks were identified by the pavement and bridge work committees independently, and after comparing the two lists it became apparent that many of the identified threats are common to both pavement and bridge. These include the impacts of population growth, funding level uncertainty, and hurricanes and/or flooding. Additional risks associated with Information Technology (IT) were also identified. The work of the two subcommittees was combined into a single list of risks for potential inclusion in the final TAMP, (see Appendix) and reviewed by the Senior Leadership Risk Management Committee.

The Senior Leadership Risk Management Committee (SLRMC) is a broad-based group of managers who represent each of the major business units within the Department that contribute to the vision and guiding principles of the asset management plan for pavement and bridges. The core members are listed below, but additional members may be added to the committee, based on the needs of the Department or to address additional areas of risk on an as-needed basis.

Chief Engineer	Deputy Chief Engineer
Director of Highway Operations	Director of Field Support
Easter Deputy Chief Engineer	Western Deputy Chief Engineer

5.6 Risk Analysis

For each risk identified the Senior Leadership Risk Management Committee reviewed each one and using their knowledge and experience, estimated the Likelihood of the risk happening and the Consequence if the risk should occur. Each committee member ranked the risks individually based on the following Risk Analysis Guidance listed in Figure 5-1. The resulting scores were averaged and collapsed into a single score for Likelihood and Consequence, then the average scores were multiplied to calculate a total score for each risk and ranked based on their score (see Appendix).

RISK ANALYSIS GUIDANCE

The Likelihood of a risk occurring are ranked by the following:		
Score	Descriptor	Description
1	Rare	I would be very surprised to see this happen, but cannot entirely rule out the possibility of it happening beyond the next 10 years
2	Unlikely	I would be mildly surprised if this occurred, but cannot entirely rule out the possibility of it happening within the next 8 to 10
3	Possible	I think this could maybe occur at some point within the next 3 to 7 years
4	Likely	I think this could occur sometime in the next couple of years
5	Almost Certain	I would not be at all surprised if this happened within this year

The Consequences of a risk occurring are ranked by the following:		
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

Figure 5-2: Risk Analysis Guidance

5.7 Risk Evaluation

Each risk was reviewed and evaluated from a senior management perspective based on their importance, independent of the numerical score. Some of the individual risk were similar in nature and were combined into a single risk statement. Additionally, they were grouped into eight broad categories of: Funding, Natural Disasters, Asset Inventory, Data Quality, Population, Winter Weather, Man-Made Disasters, and Other (see Appendix). Seven high priority risk were identified for treatment.

5.8 Risk Treatment

A mitigation plan and monitoring approach was developed for each top priority risk along with the appropriate responsible person at the Department who is responsible for monitoring the risk. The following tables represents the Department's risk register, mitigation plan, monitoring approach.

Table 5-1: Funding Risk

RISK	TYPE	IF	THEN	MITIGATION STRATEGY	WHO
Decrease in funding levels due to various reasons at the state or federal level	Agency	Funding is reduced	1. Number of new projects will be reduced 2. Capacity projects will be delayed 3. Program priorities could change 4. System performance may be degraded 5. Poor condition ratings leading to loss of flexibility in use of FHWA funds 6. Public out-cry and loss of trust 7. Increased cost for rehab/reconstruction 8. Increased potential for vehicle accidents and injuries 9. Large economic impact to communities 10. Impact on response time for emergency vehicles 11. Drift toward "worst first" and away from minimum whole life cost	1. Reduce STIP projects to reflect reduced budgets 2. Borrow funds to replenish HTF balances 3. Adjust performance targets 4. Work with NC General Assembly to improve financial position 5. Re-prioritize projects, programs, and services 6. Utilize latest preservation strategies 7. Coordinate bridge and pavement preservation programs to maximize efficiency 8. Re-emphasize existing asset management principles and avoid "worst first" approach 9. Manage Public and Stakeholder expectations thru public media and social networks 10. Identify and prioritize critical routes and bridges and alternate routes 11. Monitor condition of critical bridges and highway corridors	NCDOT Secretary, Deputy Secretary, Chief Financial Officer, PIO office

Table 5-2: Natural Disaster Risk

RISK	TYPE	IF	THEN	MITIGATION STRATEGY	WHO
Increased frequency and intensity of natural disasters due to climate change or other environmental factors	Agency	The frequency and intensity of natural disasters occurs (hurricanes, major flooding, tornadoes, etc.)	1. Significant road closures and damage may occur 2. Decreased mobility is likely 3. Long-term impact to pavement conditions by saturation of subgrade 4. Injury/Death may occur 5. Maintenance & reconstruction costs may increase 6. Increased financial obligations not covered by federal funds 7. Economic hardship on local businesses and residence 8. Create short term cash flow problem until federal reimbursements 9. Erosion of public confidence and trust 10. Increased delays in response times for emergency services	1. Identify priority routes, critical staff, resource needs, and evacuation protocols as part of an Emergency Response Plan 2. Ensure a quick response by damage assessment teams 3. Quickly mobilize Emergency Response Teams and bridge inspectors to impacted locations to determine the affected structures 4. Implement emergency backup communication protocols which will be most reliable during an emergency situation 5. Hold regular practice drills to ensure preparedness of emergency response teams 6. Inform the public through local news media and through other established communication protocols 7. Review Design Standards for increased resiliency 8. Preform predictive analysis to identify vulnerable areas within critical corridors 9. Identify and implement new/improved procedures from previous events to maximize and speed up federal reimbursements	NCDOT Secretary, Deputy Secretary, Chief Engineer's Office, Chief Financial Officer, PIO office

Table 5-3: Asset Inventory Risk

RISK	TYPE	IF	THEN	MITIGATION STRATEGY	WHO
Asset inventory collection efforts are delayed due to lack of funding or other resources	Agency or Program	Asset inventory collection efforts are delayed due to lack of funding and/or resources	1. Possible increased amount of obsolete and inaccurate data sets 2. Potential Impacts to maintenance and operations planning decisions 3. Erodes trust with decision makers 4. Insufficient data collection could cause need to substitute with subjective data 5. Failure to meet federal and state mandates on data information (HPMS, NBIS, Pavement Condition, Maintenance Condition, etc.)	1. Perform Gap analysis and assessment of progress 2. Use statistical analysis to estimate inventory and condition based on current data sets 3. Stratify roads based on ADT and prioritize data collection based on route prioritization 4. Look for other funding sources under the FHWA program area which is eligible for this effort 5. Inform decision makers of strategies to prevent erosion of confidence 6. Evaluate funding of non-mandated programs areas and determine if any can be reduced or eliminated	NCDOT Secretary, Deputy Secretary, Chief Engineer's Office, PIO office

Table 5-4: Data Quality Risk

RISK	TYPE	IF	THEN	MITIGATION STRATEGY	WHO
Poor quality data controls on cost of operations and maintenance activities due to inaccurate reporting, poor data quality, and/or data governance issues	Program	Data is inaccurate	1. Inability to project/monitor system performance 2. Loss of confidence from stakeholders 3. Inability to plan/budget accurately 4. Loss of data could alter program funds 5. Inaccurate data could cause need to substitute with subjective data	1. Preform system training 2. Develop and implement quality control of data input procedures 3. Determine what data is required 4. Determine the process for generating replacement data 5. Determine options if specific information is missing 6. Develop and implement Data Governance Policy	Chief Engineer's Office, Governance Office, PIO office

Table 5-5: Population Risk

RISK	TYPE	IF	THEN	MITIGATION STRATEGY	WHO
Population (and VMT/Truck volumes and freight) increases at a faster rate than anticipated	Agency or Program	VMT increases and weights of vehicles on the NHS continues to grow	1. Pavements and bridges will deteriorate more rapidly 2. Increase in vehicle accidents and injuries 3. Erosion of public confidence 4. System reliability issues, i.e. congestion issues in urbanized areas and major corridors 5. Migration of STIP projects to urbanized areas away from rural counties	1. Identify priority routes and allocate funding for critical routes 2. Identify sufficient preservation strategies to maximize investment and avoid "worst first" 3. Manage public and stakeholder expectations thru public media and social networks	Chief Engineer's Office, PIO office

Table 5-6: Winter Weather Risk

RISK	TYPE	IF	THEN	MITIGATION STRATEGY	WHO
More frequent occurrence or increased intensity of snow and ice events	Program	More frequent occurrence and/or intensity of snow and ice events occur	1. Negative impacts to budget availability 2. Reduces mobility 3. Increases damage to pavements/bridges 4. Increase use of anti-icing and deicing chemicals 5. Scarcity of resources for snow/ice removal, i.e. contractors, deicing and anti-icing chemicals 6. Erosion of public confidence 7. Increase in vehicle accidents and injuries 8. Economic impact to effected area 9. Hardship on secondary education school systems	1. Ensure Emergency response protocols are in place 2. Annual review of Bare Pavement Routes 3. Analyze Salt storage capacity base on BPR and storm frequency 4. Identification of 'Sister' division and personnel/equipment that will be available to help affected division 5. Ensure private trucks are under contract to assist, and hold practice runs prior to snow season 6. Analyze resources annually for material and equipment needs 7. Review Reporting protocols annually and update/modify as necessary 8. Develop "Standard" press release templates prior to winter season	Chief Engineer's Office, Division Engineers, PIO office

Table 5-7: Man-Made Disaster Risk

RISK	TYPE	IF	THEN	MITIGATION STRATEGY	WHO
Interstate or critical route/bridge is closed due to damage from vehicle accident, act of terror, or some other human cause	Program	A major route or bridge on a major route is closed	1. Decreased mobility due to detours (sometimes significant) 2. Large economic impact to communities 3. Injury/Death 4. Impact on response time for emergency vehicles 5. Increased cost and impact to NCDOT resources 6. Negative public perception 7. Negative impact on infrastructure programs 8. Negative and unexpected impact to the budget 9. Negative impact to movement of freight and goods	1. Identify and prioritize critical bridges and alternate routes 2. Install necessary detour signage 3. Emergency contract procurement in place (fast-track) 4. Establish response protocols and train employees 5. Inform public through media outlets and social media 6. Review/establish communication coordination with other Emergency response agencies 7. Review/establish communication coordination with boarder/adjacent state DOTs 8. Develop and implement “Fast-track” process for quick claim reimbursement	Chief Engineer’s Office, Division Engineers, PIO office

5.9 Evaluation of Facilities Repeatedly Damaged by Emergency Events

As required by part 23 CFR § 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 procedures below. This information was provided to the North Carolina Federal Highway Administration office in November 2018 and is included in the Appendix.

- 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.
- A query was run on all FHWA declared events to obtain a list of facilities damaged along FHWA routes due to an emergency event.
- "A minimum $5,000 in repair cost per site was used as a guideline for a site to be ER eligible", per the Emergency Relief (ER) Manual.
- The list of sites was expanded using 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 period, as well as through investigations into local road files or other databases that would have pre-dated the current accounting system.
- 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."

Chapter 6 Financial Plan and Investment Strategy

6.1 Introduction

The North Carolina Department of Transportation has its own budget separate from the state's General Fund. North Carolina's annual state budget identifies sources of revenue and estimated amounts to contribute to NCDOT's Highway Fund and Highway Trust Fund. Budgetary control is maintained by the Department, working in conjunction with the Office of State Budget and Management.

NCDOT's process for developing a financial plan and an investment strategy will be covered in this chapter. It includes a discussion on how the agency takes a holistic approach by reviewing and analyzing historical performance based on expenditures to determine future funding needs and projected performance of all modes of transportation that fall under NCDOT's purview. The discussion will review how NCDOT uses historical data and information to develop an investment strategy that meets their needs and sustains the agency's state targets for pavement and bridge assets.

As required by the final rule, the following section identifies the process NCDOT will use to satisfy the requirements of MAP-21 for the financial plan and investment strategy.

6.2 MAP-21 and Final Rule Requirements

Definitions as they apply to this section are found in 23 CFR Part 515.5 and repeated here as follows:

- ***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 risk.
- ***Work type*** includes construction, maintenance, preservation, rehabilitation, and reconstruction.

Federal Regulation 23 CFR Part 515.7, states DOTs are required to develop a risk-based asset management plan to include specific minimum processes. The following section on financial plan is identified in subsection (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:
  (5) The estimated cost of expected future work to implement investment strategies contained in the asset management plan, by State fiscal year and work type;
  (6) 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;

(7) Identification of anticipated funding sources; and
(8) 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.

And in 23 CFR Parts 515.7(e) and 515.9(f), state DOTs are required to develop a risk-based asset management plan to included specific minimum processes for developing an investment strategy as listed in the following subsections:

- 515.7(e) A State DOT shall establish a process for developing investment strategies meeting the requirements in § 515.9(f). This process must result in a description of how the investment strategies are influenced, at a minimum, by the following:
  (1) Performance gap analysis required under paragraph (a) of this section;
  (2) Life-cycle planning for asset classes or asset sub-groups resulting from the process required under paragraph (b) of this section;
  (3) Risk management analysis resulting from the process required under paragraph (c) of this section; and
  (4) Anticipated available funding and estimated cost of expected future work types associated with various candidate strategies based on the financial plan required by paragraph (d) of this section.

- 515.9(f) An asset management plan shall discuss how the plan's investment strategies collectively would make or support progress toward:
  (1) Achieving and sustaining a desired state of good repair over the life cycle of the assets,
  (2) Improving or preserving the condition of the assets and the performance of the NHS relating to physical assets
  (3) Achieving the State DOT targets for asset condition and performance of the NHS in accordance with 23 U.S.C. 150(d), and
  (4) Achieving the national goals identified in 23 U.S.C. 150(b).

6.3 NCDOT's Process for Developing a Financial Plan

The State of North Carolina is a fiscally conservative state where annual budgets are prepared based on cash-flow. The Governor is required to present a proposed budget to the North Carolina General Assembly (NCGA) on a biennial basis. The General Assembly, in consideration of the Governor's recommendations, passes an appropriation act which is the financial plan for all state agencies. The annual fiscal year budget begins on July 1st and ends on June 30th.

NCDOT's revenues are grouped into three major fund categories: Highway Fund, Highway Trust Fund, and Federal Funds. Both the Highway Fund and Highway Trust Fund are from state revenues that make up approximately 75% of the Department's transportation funding. The Federal Fund makes up approximately 25%. Each revenue source and the program it generally supports is summarized as follows:

- Highway Fund – Highway funds are generated by highway user fees such as the state's registration fees, driver license fees, truck license plate fees, other user fees, and 71% of the

revenue generated from motor fuel tax. These funds are used to support the maintenance and upkeep of the state's 80,000-mile system, administration cost of NCDOT and DMV, the multi-modal programs including public transportation, aviation, ferries, rail, and bicycle and pedestrian program, state-aid to municipalities for road maintenance, state park road maintenance, and other general obligations as defined by law. The pavement and bridge programs that affect condition of pavements and bridges are predominantly supported by highway funds. Projects that are funded from these funds are prioritized through processes outside the State Transportation Improvement Program (STIP).

- Highway Trust Fund – Highway Trust funds are generated by similar highway user fees such as, tax on motor vehicle sales and title transfers, title and registration fees, and 29% of the revenue generated from motor fuel taxes. These funds are used for the design and construction of the projects identified in the State Transportation Improvement Program (STIP) and used to match the funds North Carolina receives from the Federal Highway Trust fund.

- Federal Funds – These are federal funds that come to North Carolina through three federal agencies, Federal Highway Administration, Federal Transit Administration, and Federal Aviation Administration that support the construction and maintenance of projects that meet each federal agency's requirements.

Figure 6-1 below provides a general overview of funds that support the Department's operations and how they are distributed to the various programs. The portions that fund the pavement and bridge programs are described in more detail later in this chapter.

The state budget appropriates funds to the Department from the Highway Fund and the Highway Trust Fund to accomplish its mission. The Appropriations Act of 2017 provided revenue projections for the two years of the biennium budget and in 2018 the NCGA adjusted those revenue projections and establish a budget for fiscal year 2018-19. NCDOT employs a cash-flow budgeting practice to maximize use of funds to deliver its various programs therefore it is critical to ensure revenue projections are as accurate as possible. The Department in collaboration with the Office of State Budget and Management develops a revenue forecast that is used to:

- Develop a four-year cash flow estimate,
- Develop the Strategic Transportation Improvement Program, and
- Compute debt capacity by the State Treasurer.

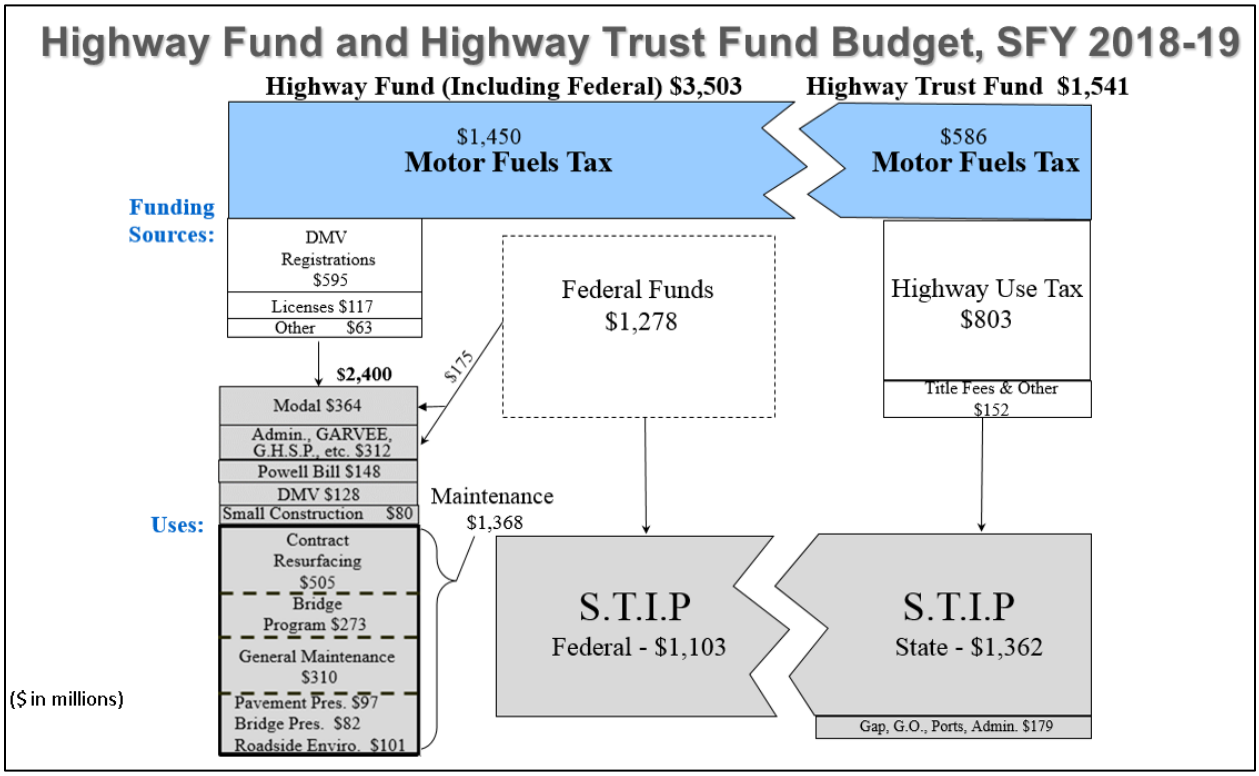


Figure 6-1: Highway and Highway Trust Funds Budget (Millions of Dollars)

Source: Chief Financial Officer's Report to NC Board of Transportation

Based on these considerations the following 10-year forecast in Table 6-1 provides the Highway Fund and Highway Trust Fund budget for fiscal year 2018-19, and estimates the state revenues expected to be generated by the Highway Fund and Highway Trust Fund for the state fiscal year 2019-20 to state fiscal year 2027-28 time frame. Federal funds and the Highway Trust funds are predominately used for funding State Transportation Improvement Program (STIP). Federal funds are conservatively estimated to remain about the same due to the uncertainty at the federal level.

Table 6-1: NCDOT 10-Year Revenue Forecast (Millions of Dollars)

Fiscal Year	Highway Fund	Highway Trust Fund	Federal Funds	Total NCDOT Funds
2018-19	2,225.0	1,541.0	1,278.0	5,044.0
2019-20	2,298.0	1,576.4	1,289.0	5,163.4
2020-21	2,387.0	1,604.2	1,289.0	5,280.2
2021-22	2,426.0	1,631.5	1,289.0	5,346.5
2022-23	2,460.0	1,669.4	1,289.0	5,418.4
2023-24	2,490.0	1,711.9	1,289.0	5,490.9
2024-25	2,588.0	1,768.0	1,289.0	5,645.0
2025-26	2,610.0	1,804.8	1,289.0	5,703.8
2026-27	2,635.0	1,842.7	1,289.0	5,766.7
2027-28	2,662.0	1,885.3	1,289.0	5,836.3
Total	**24,791.0**	**17,045.2**	**12,862.0**	**54,698.2**

NCDOT's investment strategy for pavements and bridges reflect projected budgets based on most recent revenue forecasts. NCDOT estimates that 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 activities including maintenance, preservation, rehabilitation, reconstruction, and replacement. The following Table 6-2 provides an estimate of the funds to support these programs over the next ten years.

Table 6-2: Estimated Funds for Highway Maintenance, Pavement Program, and Bridge Program (Millions of Dollars)

Fiscal Year	Highway Maintenance	Pavement Program*	Bridge Program**	Total Funds
2018-19	424.7	715.0	450.1	1,589.8
2019-20	436.7	732.1	460.4	1,629.1
2020-21	453.6	756.1	474.9	1,684.6
2021-22	461.0	766.7	481.3	1,708.9
2022-23	467.4	775.9	486.8	1,730.2
2023-24	473.1	784.0	491.7	1,748.9
2024-25	491.8	810.6	507.7	1,810.0
2025-26	496.0	816.5	511.3	1,823.8
2026-27	500.7	823.3	515.4	1,839.4
2027-28	505.8	830.6	519.8	1,856.2
Total	**4,710.8**	**7,810.7**	**4,899.3**	**17,420.9**

**Pavement program includes $110 million (annual average) of Federal funds to be used for pavement preservation on the Interstates*

***Bridge program includes Federal funds in the amount of $20 million (annual average) for bridge preservation projects on the Interstates, and $65 million for bridge replacements on the interstate, primary and secondary systems*

As alluded to earlier, most initial construction of pavements and bridges are accomplished through the STIP. Below is a listing of the Highway funded programs directly related to work types for maintenance, preservation, rehabilitation and reconstruction:

- General Maintenance Reserve (GMR) funds are utilized for the purposes of continuing routine maintenance activities including, but not limited to, pavement patching, pavement markings, markers, signs, symbols, roadside vegetation management, drainage, unpaved shoulders, litter pickup, and other similar maintenance activities. Bridge related activities include, but are not limited to, repairing concrete bridge decks, girder painting, emergency bridge repair or replacement, foundation repair, installation of support bents, and deck and rail repair. Replacing small critical bridges and pipes are also eligible activities. The GMR funds may be used on the interstate, primary, and secondary systems.

- Pavement Preservations funds are allocated to address preservation activities or treatments for pavements. Eligible activities include chip seals, slurry seals, fog seals, sand seals, scrub seals, and cape seals. Microsurfacing, profile milling, asphalt rejuvenators, and open graded asphalt friction course treatments are also eligible. Additional preservation activities include overlays less than 1,000 feet in length, diamond grinding, joint sealing, dowel bar retrofit, and partial or full depth repairs and reclamations. Ultra-thin whitetopping, thin lift and sand asphalt overlays, and asphalt crack sealing are also eligible pavement preservation activities. Pavement

Preservation funds may be used on the interstate, primary, and secondary systems, but are predominately used on the primary and secondary systems.

- Bridge Preservation funds are used to employ cost effective solutions to maximize bridge life and lower whole-life cost. It should be noted that nearly 50% of these funds will initially be allocated for high value bridge preservation projects. Bridge Preservation funds may be used on the interstate, primary, and secondary systems, but are predominately used on the primary and secondary systems.

- Contract Resurfacing fund activities include placement of plant mixed asphalt, surface treatment seals, and recycling existing pavement. The Contract Resurfacing funds may be used on the interstate, primary, and secondary systems, but are predominately used on the primary and secondary systems.

- Bridge Program funds, established in 2015 by the North Carolina General Assembly, are intended to address structurally deficient bridges. Funds may be utilized on the interstate, primary, and secondary systems. Currently, 60% are programmed for bridges on the primary system and 40% for bridges on the secondary system.

- Interstate Maintenance funds are programmatically included as part of the STIP for addressing pavement and bridge preservation needs on the interstate system.

Tables 6-3 through 6-6 list the total estimated 10-year investment of the STIP and Highway Fund programs associated with pavements and bridges, and the investments by interstate, primary and secondary systems. Note the fund amounts listed for "GMR – Pavement" include maintenance of other assets in addition to pavement related activities but are available to address pavement needs.

Table 6-3: Total 10-Year Investments for Pavements and Bridges (Millions of Dollars)

	* Interstate Maintenance		GMR		Preservation		Contract Resurfacing	**Bridge Program
Fiscal Year	Pavement	Bridge	Pavement	Bridge	Pavement	Bridge	Pavement	Bridge
2018-19	110.00	20.00	286.19	37.18	97.83	82.33	507.17	347.73
2019-20	110.00	20.00	294.25	38.23	100.58	84.65	521.47	355.70
2020-21	110.00	20.00	305.65	39.71	104.48	87.93	541.66	366.96
2021-22	110.00	20.00	310.65	40.35	106.19	89.36	550.51	371.90
2022-23	110.00	20.00	315.00	40.92	107.68	90.62	558.23	376.20
2023-24	110.00	20.00	318.84	41.42	108.99	91.72	565.04	379.99
2024-25	110.00	20.00	331.39	43.05	113.28	95.33	587.27	392.39
2025-26	110.00	20.00	334.21	43.42	114.24	96.14	592.27	395.17
2026-27	110.00	20.00	337.41	43.83	115.34	97.06	597.94	398.33
2027-28	110.00	20.00	340.86	44.28	116.52	98.06	604.07	401.75

* Interstate Maintenance represent annual average amounts

** Includes Highway Fund Bridge Program plus annual $65M federal funds

Table 6-4: Investments for Pavements and Bridges on the Interstate (Millions of Dollars)

	* Interstate Maintenance		GMR		Preservation		Contract Resurfacing
Fiscal Year	Pavement	Bridge	Pavement	Bridge	Pavement	Bridge	Pavement
2018-19	110.00	20.00	26.13	0.97	0.26	9.35	1.37
2019-20	110.00	20.00	26.87	0.99	0.27	9.62	1.41
2020-21	110.00	20.00	27.91	1.03	0.28	9.99	1.46
2021-22	110.00	20.00	28.36	1.05	0.29	10.15	1.49
2022-23	110.00	20.00	28.76	1.06	0.29	10.29	1.51
2023-24	110.00	20.00	29.11	1.08	0.29	10.42	1.53
2024-25	110.00	20.00	30.26	1.12	0.31	10.83	1.59
2025-26	110.00	20.00	30.51	1.13	0.31	10.92	1.60
2026-27	110.00	20.00	30.81	1.14	0.31	11.03	1.61
2027-28	110.00	20.00	31.12	1.15	0.31	11.14	1.63

*Interstate Maintenance represent annual average amounts

Table 6-5: Investments for Pavements and Bridges Primary System (Millions of Dollars)

	GMR		Preservation		Contract Resurfacing	Bridge Program
Fiscal Year	Pavement	Bridge	Pavement	Bridge	Pavement	Bridge
2018-19	79.59	12.01	33.23	50.00	172.29	208.64
2019-20	81.83	12.35	34.17	51.41	177.14	213.42
2020-21	85.00	12.83	35.49	53.40	184.00	220.18
2021-22	86.39	13.03	36.07	54.27	187.01	223.14
2022-23	87.60	13.22	36.58	55.03	189.63	225.72
2023-24	88.67	13.38	37.02	55.70	191.94	228.00
2024-25	92.16	13.91	38.48	57.90	199.50	235.43
2025-26	92.94	14.02	38.81	58.39	201.19	237.10
2026-27	93.83	14.16	39.18	58.95	203.12	239.00
2027-28	94.79	14.30	39.58	59.55	205.20	241.05

Table 6-6: Investments for Pavements and Bridges Secondary System (Millions of Dollars)

	GMR		Preservation		Contract Resurfacing	Bridge Program
Fiscal Year	Pavement	Bridge	Pavement	Bridge	Pavement	Bridge
2018-19	180.44	24.20	64.33	22.98	333.52	139.09
2019-20	185.53	24.88	66.14	23.63	342.92	142.28
2020-21	192.71	25.85	68.71	24.54	356.20	146.78
2021-22	195.86	26.27	69.83	24.94	362.02	148.76
2022-23	198.61	26.64	70.81	25.29	367.09	150.48
2023-24	201.03	26.96	71.67	25.60	371.57	152.00
2024-25	208.94	28.03	74.49	26.61	386.19	156.96
2025-26	210.72	28.26	75.13	26.83	389.47	158.07
2026-27	212.74	28.53	75.84	27.09	393.20	159.33
2027-28	214.92	28.83	76.62	27.37	397.23	160.70

6.4 NCDOT's Asset Valuation for Pavements and Bridges

A quick gauge to determine if an agency is maintaining an asset at steady, declining, or improving state is to look at the monetary value of the asset over a defined time frame. If the value of the asset is increasing or staying the same year to year, the agency's investment in the asset is large enough to offset any decline in condition, i.e. depreciation. This type of strategy is typically consistent with maintaining

the state asset management 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" (Re: Spy Pond Partners, LLC, KPMG, and University of Texas at Austin. NCHRP 19-12: A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management. TRB, 2018). The basic approach in using this method is to estimate the total replacement cost of an asset in current dollars and then reduce the value based on depreciation or lost value due to use or obsolescence. This approach is used to estimate the value of NCDOT's pavement and bridge assets on the NHS as follows.

6.4.1 Pavement Valuation

The value of NCDOT's NHS pavements is determined based on the per-lane mile replacement value in current dollars for each of the network levels (interstate, primary, and secondary) that make up the NHS system. The replacement value consists of the total value to replace the pavement structure (base, intermediate, and surface courses), not including right-of-way nor grading cost, based on current construction dollars. The Current Value (CV) is calculated by subtracting the discounted value of the surface course, based on condition, 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 current value of the surface course is calculated using the total surface course replacement value, discounted by the Pavement Condition Index (PCI) for each network levels. The following formula is used to calculate the pavement value for one lane mile:

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

Using this methodology, it is estimated that the current value of all NCDOT pavements on the NHS system is $29.4 billion. The value of the agency's pavement assets has remained relatively constant each year for the past four 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.

6.4.2 Bridge Valuation

The value of NCDOT's bridges is determined based on the replacement value in current dollars, then discounted using the bridge's condition (sufficiency rating) and residual life. To account for the variety of bridge types and sizes, the replacement value is based on bridge types according to system served (interstate, primary, secondary). The replacement value (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, where 100 is the best condition rating. 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." For NCDOT bridges on the NHS system it is estimated they have a serviceable life of 75 years. The following formula is used to calculate the current bridge value.

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

Using this methodology, it is estimated that the current value of all NCDOT bridges on the NHS system is $26.65 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.

6.5 NCDOT's Investment Strategy Process

Beginning in 1998 the Department began taking an in-depth look at the condition of the state's highway maintenance, pavement, and bridge needs and quantifying the cost to maintain these assets at an acceptable level of service in order to satisfy newly enacted legislation by the North Carolina General Assembly (NCGA). This effort has matured and evolved over the last 20 years into the Maintenance Operations and Performance Analysis Report (MOPAR). NCDOT is required to perform an analysis and submit a formal report to the NCGA on a biennial basis. The report satisfies many of the requirements of MAP-21 Investment Strategy by performing a gap analysis, using life-cycle planning, estimates cost to achieve state asset management targets, identifies a 5-year work program, and estimated cost of various work types. The MOPAR does not specifically address MAP-21 requirements of risk analysis considerations, improving the condition and performance of the NHS, achieving NCDOT targets for the NHS, and achieving the national goals; these items will be discussed in greater detail in this section.

6.6 Influencing Factors

6.6.1 Funding

As stated earlier in this chapter, NCDOT's revenues are grouped into three major funds, Highway Fund, Highway Trust Fund, and Federal Funds. Each funding source has a specific purpose in funding NCDOT's programs, but at the same time contribute to projects and initiatives that helps the Department achieve their state asset management targets for pavement and bridges.

6.6.2 Revenue Forecast

Revenue forecasting is discussed in section 6.3. Based on the revenue forecast identified in Table 6-1 NCDOT estimates that 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.

6.6.3 Risk Analysis

Risk Analysis – A comprehensive risk analysis has been completed evaluating a number of risks the Department has faced over the years and will continue to address as the need arises. Some examples are: hurricanes, floods, snow and ice storms, rockslides, federal aid funding, revenue stagnation, economic down-turn, etc. The process and results are discussed in Chapter 5.

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

- 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 NCDOT's "Primary System" and about 40% of the Lane Miles.

- Opportunity: Because the 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, NCDOT has the ability to shift focus and funding to more projects on the Non-Interstate NHS rapidly with little to no coordination needed with outside entities.

Interstate highways have a dedicated program (an NCDOT-designated "Interstate Maintenance" program) funded with Federal Aid dollars to address needs on the interstate system.

6.6.4 Life-Cycle Planning

Life-cycle planning – NCDOT has been a national leader in advocating for a holistic approach in managing and sustaining pavements and bridges through an active comprehensive program to not only address assets in poor condition, but to also invest in maintenance and preservation strategies to keep good pavements and bridges in good condition. The Department has historically 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 identify funds for these purposes as indicated in the 2018 Appropriations Act and identified in the 2018 MOPAR. More details on this subject are covered in the life-cycle planning section, Chapter 4.

6.6.5 Gap Analysis

Gap analysis – The Department has performed an in-depth assessment of the condition of the state's highway assets for a number of years and has produced reports on the actual condition versus agency targets and estimated the cost to achieve an acceptable level of service. Figure 6-2 provides the most recent information identifying the condition and targets for the agency's pavements and bridges by highway system. While the chart does not specifically identify pavement and bridge conditions on the NHS, it should be noted that 95.7 % of NHS is included in either the interstate or primary highway systems, therefore, their condition will be similar to those reported in Figure 6.2 for the interstate and primary systems.

Asset	Condition Element	Performance Measure	Highway System	Target	Actual Condition*
Pavement	Minimum Pavement % Good	Pavement Condition Rating ≥ 80	Interstate	86	**95**
Pavement	Minimum Pavement % Good	Pavement Condition Rating ≥ 80	Primary	80	**71**
Pavement	Maximum Pavement % Poor	Pavement Condition Rating < 60	Interstate	5	**2**
Pavement	Maximum Pavement % Poor	Pavement Condition Rating < 60	Primary	7.5	**5**
Bridges	Percent of Structural Deficient Bridges	Percent of SD bridges by system and statewide target of 10% by 2030	Interstate	2	**3**
Bridges	Percent of Structural Deficient Bridges	Percent of SD bridges by system and statewide target of 10% by 2030	Primary	6	**8**
Culverts	NBIS Culverts	Percent Condition Rating ≥ 6	Interstate	85	**67****
Culverts	NBIS Culverts	Percent Condition Rating ≥ 6	Primary	80	**67****

* Source: 2018 Maintenance Operations and Performance Report (MOPAR), December 2018

**The percent condition ratings shown for NBIS Culverts reflect most recent data

Figure 6-2: Statewide Asset Condition from 2018 Maintenance Operations and Performance Analysis Report

6.7 How Investment Strategies Support Condition Performance

6.7.1 Achieving the State Asset Management Performance Targets

As mentioned earlier the Department takes an in-depth look at the condition of the state's highway maintenance, pavement, and bridge needs and quantifies the cost to maintain these assets at an acceptable level of service.

The 2018 MOPAR lists investment recommendations based on improvement plans for pavements, bridges, highway assets and workforce, and uses a stepwise approach to reach long-term level of service goals. The MOPAR, and companion Highway Maintenance Improvement Plans (HMIP) and Bridge Maintenance Improvement Plans (BMIP), are formalized reports that identify pavement and bridge projects which are intended to help the Department sustain and make progress toward meeting their state asset management targets. Figure 6-2 provides a summary of the condition of pavements and bridges on the interstate, primary, and secondary highway systems. As indicated by the green colored boxes, the Department is meeting its targets for three of the twelve performance measures and close to meeting it targets in five other areas as represented by the yellow colored boxes. Only two of the four areas that are severely deficient are on the interstate and primary systems, identified as red-colored boxes.

6.7.2 Improving and Preserving Condition and Performance of NHS

A key component of asset management is the creation and institutionalizing of a performance management culture within all levels of an organization whereby performance measures and performance targets are linked to the overall goals and objectives of the agency. Modern computerized management systems allow agencies to perform multiple "what-if" scenarios to analyze the future condition of an asset based on different funding levels and investment strategies, i.e. strategies based on preservation, maintenance, rehabilitation, reconstruction, or a combination of all work types. Within the core functionality of both a PMS and BMS is the presence of complex computer algorithms, deterioration models, to predict the future condition of a pavement or bridge based on a number of variables such as weather, climate, environment, age, traffic loading, treatments, funding, etc. Another core function is a life cycle cost analysis component whereby tailored treatments are applied to a pavement or bridge based on their condition. The concept behind this approach is to minimize whole-life cost by applying low cost treatments to an asset early in its life. NCDOT uses the power of its management systems along with the technical expertise in the central units and divisions to develop HMIP and BMIP plans to preserve the condition and performance of the NHS as shown in Figure 6-2 and covered in Chapter 3.

6.7.3 Achieving NCDOT Targets on NHS in Accordance with 23 U.S.C 150(d)

Performance targets provide the measuring stick to determine if the asset's condition is meeting the expectations of NCDOT. Performance targets for pavements and bridges on were established on a tiered approach based on the highway classification and its' importance. At the network level the PMS and BMS provides output reports to enable NCDOT managers to gage success in meeting the agency's 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. These targets are identified in chapter 3. NCDOT is currently meeting and exceeding the federal minimum performance standards for NHS pavements and bridges as depicted in Figures 3-1 through 3-3 in Chapter 3.

6.7.4 Achieving National Goals Identified in 23 U.S.C. 150(b)

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 various performance expectations are considered by NCDOT's senior management as annual budgets are developed in conjunction with the STIP, HMIP, and BMIP programs. 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 state-of-the practice analysis.

References

TAMP Federal Ruling, 23 CFR Part 515, https://www.gpo.gov/fdsys/pkg/CFR-2017-title23-vol1/xml/CFR-2017-title23-vol1-part515.xml

NBIS Regulations, https://www.gpo.gov/fdsys/pkg/FR-2004-12-14/pdf/04-27355.pdf

Strategic Transportation Investments, https://www.ncdot.gov/initiatives-policies/Transportation/stip/Pages/strategic-transportation-investments.aspx

10-year State Transportation Improvement Plan, https://connect.ncdot.gov/projects/planning/pages/state-transportation-improvement-program.aspx

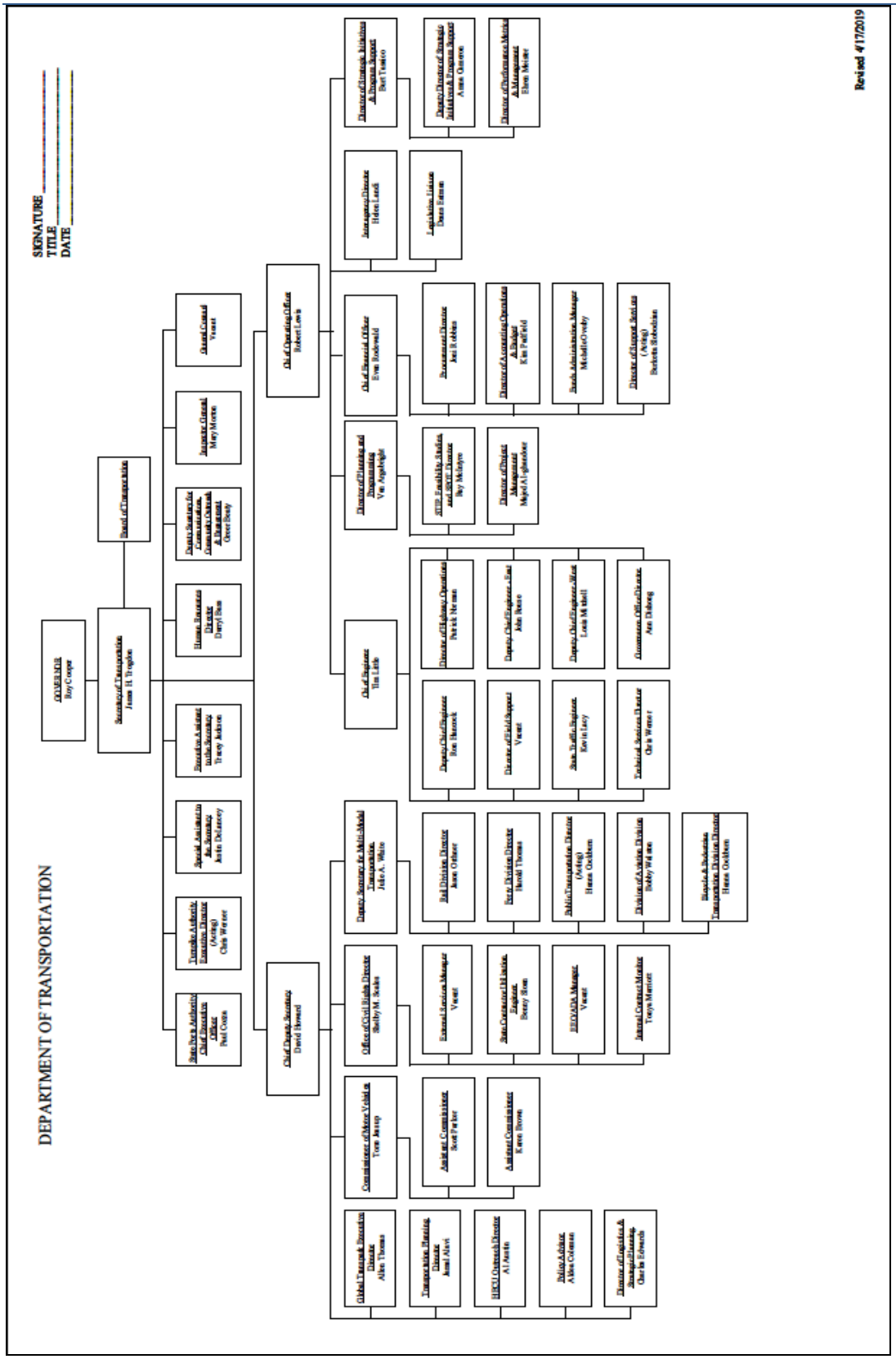
Maintenance Operations and Performance Analysis Report, https://www.ncdot.gov/about-us/how-we-operate/finance-budget/nc-first/Documents/mopar.pdf

NCDOT Transportation Asset Management Plan (TAMP) 2018 Interim Report, http://www.tamptemplate.org/wp-content/uploads/tamps/056_northcarolinadot.pdf

"A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management," Spy Pond Partners, LLC, KPMG, and University of Texas at Austin. NCHRP 19-12: A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management. TRB, 2018

Appendix

NCDOT Organization Chart



Risk Identification List

Risk ID	Risk
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
2	Funding shortfall, fewer projects, less optimal treatments, decreased pavement condition ratings, reduction in personnel, RPO's funding decreased, MPO's funding decreased
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
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
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
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
7	Data storage amount and modernization, loss of historical data (data used less frequently), loss of institutional knowledge
8	Data collection equipment operating system or file formats go out of date, May lack skid data on road with poor friction
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
10	Alkali Silica Reactivity, pavement failure at depth, increased maintenance costs, increased ride roughness
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
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
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
14	Bridge Preservation Plan is not funded, then the percentage of SD bridges will increase and will result in less bridge funds (funding capacity)
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
16	If there are issues with IT tools, we will have issues with reporting and will face problems demonstrating our needs

17	If a sufficient number of bridge projects are not "shelf ready", programs may not be able to be accelerated at the request of leadership
18	If a major landslide should occur along I-40, road would be closed and major disruptions in travel times for public and businesses
19	If flash flooding events occur, bridges could be closed, causing delays in emergency response
20	If an interstate bridge is damaged, the bridge would need to be closed, creating traffic delays
21	Funding shortfall for bridge projects, system deterioration will increase; department will be unable to reduce or maintain current SD percentages
22	*Transportation Funding, moving forward not related to motor fuels
23	*Asset Inventory issues
24	*HMIP, BMIP, RMIP plan issues
25	*Reactive vs Planned Activities
26	*Unit Cost for proper planning and needs assessment
27	*Snow and Ice
28	*Pavement Markers and Markings

*Risks identified by Senior Leadership Management Committee

Risk Evaluation

Risk ID	Risk	Type	Average Likelihood	Average Consequence	Total Score	Category	Comments
28	Condition of pavement markings and markers will deteriorate more quickly due to increase in VMT, lack of contractors available to complete work needed, and increases snow & ice events resulting in increased snow plowing which damages markings/markers	Program	5	4	20	Population	Risk ID 28 and 4 combined into one Risk on Population increases
1	Hurricanes or other major storm event(s) hits North Carolina causing significant infrastructure damage to pavements & bridges. Complete washouts of pavements and bridges or significant undermining of facilities causing weakness in pavement and bridge structures.	Agency	3.8	4.3	16.6	Natural Disaster	Risk ID 1, 3, 18, 19, and 11 combined into one Risk on Natural Disasters
4	Population increases (and VMT/Truck volumes and freight) at a faster rate than anticipated resulting in increased demand on highway infrastructure and accelerated deterioration of infrastructure assets.	Program	4.7	3.5	16.3	Population	Risk ID 28 and 4 combined into one Risk on Population increases
22	Funding levels will decrease as a result of current dependency on motor fuels tax.	Agency	4	4	16	Funding	Risk ID 22, 13, 2, 12, 21, and 14 combined into one Risk on Funding
27	More frequent occurrence or increased intensity of snow and ice events resulting in faster deterioration of pavements due to increased moisture, freeze/thaw cycles, and increased usage of anti-icing and de-icing materials	Program	5	3	15	Winter Weather	Winter Weather events
26	Poor quality data controls on cost of operations and maintenance activities due to inaccurate reporting, poor data quality, and/or data governance issues, resulting in inaccuracies of work plans. Building distrust with decision makers	Program	5	3	15	Data Quality	Risk ID 26, 24, 7, 5, and 16 combined into one Risk on Data Quality

23	Asset inventory collection efforts are delayed due to lack of funding or resources resulting in obsolete data sets, impacting maintenance and operations planning decisions and impacting trust with decision makers	Agency or Program	5	3	15	Asset Inventory	Risk ID 23, 15, and 8 combined into one Risk on Asset Inventory Data
3	Major rain/flooding event impacting western NC resulting in major routes closed by rock/land slide, low-water roads and bridges blocked, debris requires removal resulting in impacts to emergency response efforts, lack of connectivity for citizens and freight, economic impacts for blocked businesses, structural integrity of embankment and pavement, and possible injuries or fatalities	Agency	3.8	3.8	14.7	Natural Disaster	Risk ID 1, 3, 18, and 19 combined into one Risk on Natural Disasters
18	If a major landslide should occur along I-40, Road would be closed. Major disruptions in travel times for public and businesses	Project	3.3	4.3	14.4	Natural Disaster	Risk ID 1, 3, 18, and 19 combined into one Risk on Natural Disasters
19	If flash flooding events occur, Bridges could be closed, causing delays in emergency response	Project	3.5	3.5	12.3	Natural Disaster	Risk ID 1, 3, 18, and 19 combined into one Risk on Natural Disasters
20	Interstate or critical route/bridge is closed due to damage from vehicle accident, act of terror, or some other human cause, resulting in closure of the road, implementation of detours (sometimes significant), causing delays in emergency response, impacts to goods and freight movement, and overall traffic delays	Program	3.2	3.7	11.6	Man-made Disaster	Man-made Disaster
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	Program	3.2	3.5	11.1	Funding	Risk ID 22, 13, 2, 12, 21, and 14 combined into one Risk on Funding
2	Funding shortfall, Fewer projects, less optimal treatments, decreased pavement condition ratings, reduction in personnel,	Agency	2.8	3.8	10.9	Funding	Risk ID 22, 13, 2, 12, 21, and 14 combined into one Risk on Funding

	RPO's funding decreased, MPO's funding decreased						
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	Program	3.0	3.3	10.0	Funding	Risk ID 22, 13, 2, 12, 21, and 14 combined into one Risk on Funding
14	Bridge Preservation Plan is not funded, Then the percentage of SD bridges will increase and will result in less bridge funds (funding capacity)	Program	2.5	4.0	10.0	Funding	Risk ID 22, 13, 2, 12, 21, and 14 combined into one Risk on Funding
24	HMIP, BMIP, RMIP plan issues	Agency or Program	5	2	10	Data Quality	Risk ID 26, 24, 7, 5, and 16 combined into one Risk on Data Quality
25	Reactive vs Planned Activities	Program	5	2	10	Other	
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	Program	2.8	3.2	9.0	Asset Inventory	Risk ID 23, 15, and 8 combined into one Risk on Asset Inventory Data
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.	Program	2.8	2.8	8.0	Asset Inventory	Risk ID 23, 15, and 8 combined into one Risk on Asset Inventory Data
7	Data storage amount and modernization, Loss of historical data (data used less frequently), loss of institutional knowledge	Program	2.8	2.8	8.0	Data Quality	Risk ID 26, 24, 7, 5, and 16 combined into one Risk on Data Quality
17	If a sufficient number of bridge projects are not "shelf ready", Programs may not be able to be accelerated at the request of leadership	Program	2.8	2.7	7.6	Other	
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.	Agency or Program	2.5	2.8	7.1	Data Quality	Risk ID 26, 24, 7, 5, and 16 combined into one Risk on Data Quality
21	Funding shortfall for bridge projects, System deterioration will increase; Department will be unable	Agency or Program	2.0	3.2	6.4	Funding	Risk ID 22, 13, 2, 12, 21, and 14 combined into

	to reduce or maintain current SD percentages						one Risk on Funding
10	Alkali Silica Reactivity, Pavement failure at Depth, Increased maintenance costs, increased ride roughness	Project	2.0	3.2	6.3	Other	
8	Data collection equipment operating system or file formats go out of date, May lack skid data on road with poor friction	Program	2.7	2.2	5.8	Asset Inventory	Risk ID 23, 15, and 8 combined into one Risk on Asset Inventory Data
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	Agency or Program	2.0	2.7	5.3	Other	
16	If there are issues with IT tools, we will have issues with reporting and will face problems demonstrating our needs	Agency or Program	2.0	2.7	5.3	Data Quality	Risk ID 26, 24, 7, 5, and 16 combined into one Risk on Data Quality
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.	Agency or Program	1.8	2.3	4.3	Natural Disaster	Risk ID 1, 3, 18, 19, and 11 combined into one Risk on Natural Disasters

Evaluation of Facilities Repeatedly Damaged by Emergency Events

Sites Damaged on 2 or more FHWA Declared Events from January 1, 1997 to Present						
Division	**Site/Name**	**Event Names (2 or more)**	**Cost Approximation**	**Brief Description of Damage**	**Corrective Action**	**Estimated Cost**
1	NC 308 King St Signal	TS Nicole	$21,208.00	Signal damage from winds/flooding	Raise Cabinet 48" with Hand Railing OSHA (Wood Structure)	$8,000 25% more to Contract Work
		Hurricane Matthew	$7,199.00	Signal/cabinet damage from winds/flooding		
1	Chowan River Bridge on US 17	Hurricane Irene	$359,629.00	Undermining and end bent damage on west end bent	No know solution, except a monolithic structure in lieu of pile and cap end bent.	$1,000,000?
		Hurricane Isabel	$270,500.00			
1	NC 12 Canal Area	Hurricane Joaquin	$34,233.30	Damage resulting from Ocean Overwash. Estimate: $35,000	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+	Cost prohibitive $
		Hurricane Matthew, N 35.765 W75.52	$185,599.63	Windblown Sand on NC 12. Using force account labor as well as Fully Operated Rental to reestablish the dune and buffer area within the 100' right of way.		
		Hurricane Irene	$22,602.59			
		Tropical Depression Ida	$60,464.45			
		November 22, 2006 Floods	$351,600.44	Inlet Bridge to Pea Island Maint Building		
		Hurricane Isabel	$303,056.14	NC12 Repair Pavement and reestablish dunes (approx.8900') @ Canal Area. $75,000		
		Hurricane Ophelia	$236,963.24	Approx. 2000' of dune repair-est. $200,000-gab add additional $55,000 to sprig/sand fence area		
		Hurricane Sandy	$335,684.12	NC-12 (Pea Island) from Bonner Bridge to USF&W Building; Remove sand; Rebuild dunes		
1	NC 12 at New Inlet Area	Hurricane Matthew	$7,659.77	NC 12 South of New Inlet. Dune has covered Roadway NC12. Return dune to pre-Matthew condition	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.	N/A
		Hurricane Sand	$568,733.97	NC-12 (New Inlet Bridge); Repair bridge; Repair guardrail; Repair roadway; Remove sand.		
		Hurricane Sandy	$12,174.05	NC-12 (Pea Island) from New Inlet Parking Lot to S-curves; Remove sand.		
		Hurricane Sandy	$35,567.87	NC-12 (Pea Island) from USF&W Building to New Inlet Bridge; Remove sand; Rebuild dunes; Repair roadway		
		Hurricane Irene	$10,767,359.59	09/06/11 - EMERGENCY PERMITS FOR HURRICANE IRENE DAMAGE IN DARE COUNTY FOR REPAIR OF NC 12 @ 2 BREACH AREAS: RODANTHE & PEA ISLAND NATIONAL WILDLIFE REFUGE.		
1	NC 12 at Mirlo Beach (immediately north of Rodanthe)	Hurricane Matthew	$8,113.01	Dune has covered Roadway NC12. Restore dune to pre-Matthew condition.	Mirlo Beach area. Repaired multiple time. Project now under design to bypass this area with a bridge, known as Rodanthe "Jug Handle' bridge	N/A
		Tropical Depression Ida	$694,220.33			
		Hurricane Sandy	$6,170,677.95	NC-12 (Pea Island) from S-curves to Rodanthe; Remove sand; Remove sand; Repair, replace, install sandbags; Repair roadway.		
		Hurricane Ophelia	$71,239.84	Pea Island-S Curves approx. 750' of dune repair@ approx. $150,000		
		Hurricane Isabel	$196,498.54	NC12 Repair Pavement & reestablish Dunes (approx. 7600') @ S Curves.		
		November 22, 2006 Floods	$2,312,193.35	NC S Curves 2miles north of Rodanthe to Rodanthe.		
		Tropical Depression Ida	$446,360.86			
		Hurricane Irene	$3,378,595.67			
1	NC 12 in Kitty Hawk	Hurricane Matthew	$397,145.92	Damage Description: Sandbags and Dunes missing. Replace sand bags and construct dune. Estimate: $300,000	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.	Unable to determine $
		Hurricane Joaquin	$448,877.63	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		

Sites Damaged on 2 or more FHWA Declared Events from January 1, 1997 to Present						
				coastal storm. Work to be accomplished by contract forces.		
		Hurricane Sandy	$883,592.35	NC-12 from US 158 (Kitty Hawk) to Sportsman (Kill Devil Hills); Repair Roadway; repair, replace, install sandbags, dune construction		
		Hurricane Isabel	$898,265.34	NC12 Repair Dunes and Roadway in Kitty Hawk.		
		Hurricane Isabel	$230,088.59	NC12 Re-establish Dunes at breeches throughout the Old Sandbag, Area (approx. 8500')		
1	NC 12 Buxton	November 22, 2006 Floods	$17,215.88		Weak area at north end of Buxton Community. Eroded protective dunes allow overwash and damage to roadway. 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 likely feasible due to proximity of Pamlico Sound.	Unable to determine $
		Hurricane Ophelia	$17,496.60	North of Buxton approx. 300' of dune repair@ approx. $50,000-gab		
		Hurricane Isabel	$39,141.93	NC12 Repair Pavement & Dunes north of Buxton Village. As a result of storms, we will need to shape the dune prior to sprigging. As of 03/25/04, all work is complete except sprigging & patching, which is estimated to cost $15,000.		
1	NC 12 Ocracoke	Hurricane Joaquin, Repair/reconstruct protective dune along NC 12, on Ocracoke Island, for approximately 1 mile.	$467,807.58	Dune damaged/destroyed by Hurricane Joaquin, and associated coastal storm. Dune to be 10 feet in height, with a base width of 40 to 50 feet. Work to be accomplished with a combination of fully operated rental equipment and NCDOT Maintenance forces and equipment.	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 reasonable solution. Other solution, construct bridge in sound.	$250,000,000
		Tropical Depression Ida	$102,100.14			
		Hurricane Irene	$615,098.49			
		Hurricane Ophelia, Ocracoke Approx. 600' of Dune Repair	$18,898.80			
		Hurricane Isabel, NC12 Repair Abutments Washed out.	$51,306.39			
		Hurricane Isabel, NC12 Repair Dunes and Reconstruct roadway.	$3,021,695.83			
1	US 64, Martin County, miscellaneous slope failures	Tropical Storm Nicole	$6,716.61	Slope repair on US 64 WB Lane 0.1 mile East of US 17. Function: 3112	Various slope washed 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	$5,920.24	Repair washouts along US 64 which includes labor, material, rip-rap, & repair to concrete flume.		
1	US 64, Alligator River	Hurricane Matthew, Fender Walkway Repair	$48,021.25	Various damage. No alternative	Replace bridge with high rise structure, and eliminate the swing span.	$175,000,000
		Hurricane Isabel, damaged motors on Alligator River Bridge	$5,951.30			
2	NC 55 @ NC 11: Lenoir	Matthew	$10,000.00	NC-11 Shoulder Washout at Multiple Sites	Add fill material to flatten slopes & install curb & gutter w/drainage structures approximately 5,000 ft.	$500,000
		Floyd				
2	NC 11 over Neuse River: Lenoir	Matthew	$50,000.00	NC 11/55 Washouts from King Street Bridge	Add fill material to flatten slopes & install curb & gutter w/drainage structures approximately 4,000 ft.	$400,000
		Floyd				
2	NC 903: Lenoir	Matthew	$125,000.00	NC-903 Pavement and Shoulder Repairs	Remove box structure and replace Bridge.	$750,000
		Floyd				
2	US 258 @ US 70W: Lenoir	Matthew	$20,000.00	US-258 Shoulder Washouts at US-70 West	Raise roadbed at this intersection approximately 2.5ft.	$2,000,000
		Floyd				
2	US 70 BYP: Lenoir	Matthew	$20,000.00	US-70 Bypass Washouts from US 70 Business to US 258	Add fill material to flatten slopes & install curb & gutter w/drainage structures approximately 8,200 ft.	$800,000
		Floyd				
2	NC 33: Pitt	Matthew	$375,000.00	NC-33 Tenth Street Washout at Culvert #2016	35' -3" x 12'-1" Alum Box Culvert w/Head Wall or	$600,000
		&			3 @ 10' x 10' RCBC w/Head Wall or	$1,000,000
		Floyd			95' to 105' Bridge	$2,000,000
3	NC 130: Brunswick	TS Nicole	$27,157.70	Shoulder washout on eastbound side of NC 130, undermined pavement.	Raise grade up 4ft. For approximately 500ft.	$296,152
		Hurricane Floyd	$50,000.00	Shoulder washout on eastbound side of NC 130, undermined pavement.		
4	(SR 1332) Lake Wilson Rd	Hurricane Floyd	~$30,000.00	Repaired washout across the roadway and guardrail	Single Span Bridge	$1,000,000
		Hurricane Mathew	$33,204.90	Repaired washout to roadway at culvert	As Per: Hydro last repair should be Permanent fix	

Sites Damaged on 2 or more FHWA Declared Events from January 1, 1997 to Present						
4	US 258 at NC 111 Princeville, NC	Hurricane Floyd	$6,000.00	Traffic signal cabinet and components flooded and required replacement.	Raise Cabinet 48" with Hand Railing OSHA	$30,000
		Hurricane Matthew	$7,250.00	Traffic signal cabinet and components flooded and required replacement.		
4	US 258 at NC 33 Princeville, NC	Hurricane Floyd	$5,800.00	Traffic signal cabinet and components flooded and required replacement.	Raise Cabinet 48" with Hand Railing OSHA	$30,000
		Hurricane Matthew	$7,250.00	Traffic signal cabinet and components flooded and required replacement.		
4	Forest Hills at Downing St Wilson, NC	Hurricane Floyd	$5,800.00	Traffic signal cabinet and components flooded and required replacement.	Raise Cabinet 48" with Hand Railing OSHA	$30,000
		Hurricane Matthew	$7,400.00	Traffic signal cabinet and components flooded and required replacement.		
4	Pipe 042-0042	Hurricane Floyd	$47,700.00	Roadway and Shoulder Washed	Single Span Bridge	$750,000
		Hurricane Irene	$203,400.31	Pipe Failed Replaced Pipe		
		Hurricane Matthew	$467,000.00	Pipe Failed Replaced Pipe		
4	Pipe 042-0042	Hurricane Floyd	$47,700.00	Roadway and Shoulder Washed	Single Span Bridge	$750,000
		Hurricane Irene	$203,400.31	Pipe Failed Replaced Pipe		
		Hurricane Matthew	$467,000.00	Pipe Failed Replaced Pipe		
5	Dam spillway	Floyd, Matthew	$150,000.00	Dam spillway does not align with culvert and washes out the embankment of NC-39	Increase Culvert to 3 Barrel Home Owners Association won't cooperate with control water level of Dam	$500,000
6	US 701 (Bladen) NC 53 W to NC 87 Bus (Cape Fear River)	Matthew, Joaquin, Floyd (Matthew Site 009-123)	$1,100,000.00	Reoccurring slope failures due to top down erosion / soil saturation.	After the last storm (Matthew), permanent solution was implemented by installing shoulder berm gutter with drop inlets and down drains.	N/A
6	NC 87 (Bladen) 0.2 Mi. E. of SR 1714	Matthew, Joaquin, Floyd (Matthew Site 009-055)	$150,000.00	Reoccurring slope failure caused by pipe outlet entering 90-degree bend in stream.	Permanent solution implemented after Matthew by installing junction box in pipe to dissipate velocity and align the outlet with stream.	N/A
6	NC 87 (Bladen) 0.2 Mi. N. of SR 1724	Matthew, Joaquin, Floyd (Matthew Site 009-110)	$450,000.00	Reoccurring slope failure due to saturation from top, subsurface, and stream located at and parallel to base of fill.	Permanent solution implemented after Matthew by constructing a sheet pile retaining wall along stream bed, flattening slopes, installing shoulder berm gutter, and subsurface drainage	N/A
6	NC 87 (Bladen) 1.0 Mi. W. of SR 1704 (Hammonds Creek)	Matthew, Joaquin, Floyd (Matthew Site 009-168)	$350,000.00	Reoccurring slope failures due to top down erosion.	After the last storm (Matthew), permanent solution was implemented by installing shoulder berm gutter with drop inlets and down drains.	N/A
13	NC 81	Hurricane Frances	$9,901.03	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	Repair with Shot Rock	$15,000
		Hurricane Ivan	$5,699.23	NC 81 FROM INTERSTATE 240 BRIDGE TO US 70 - WASHOUT		
13	US 19/23	July 2013 Mudslides	$8,177.74	US 19/23 - 0.40 MILES FROM SR 1140 (NORTH MORGAN BRANCH ROAD) - SLIDE	Repair with Shot Rock	$16,000
		Hurricane Ivan	$33,563.89	US 19/23 - 0.40 MILES FROM SR 1140 (NORTH MORGAN BRANCH ROAD) - SLIDE		
		Hurricane Ivan	$15,054.93	US 19/23 - FROM HAYWOOD COUNTY LINE TO NC 151 - SLIDES		
13	I-40, McDOWELL/ BUNCOMBE CO. LINE	Hurricane Frances	$275,890.58	Slope Failure	Install T-2 Barrier Wall. And Landslide Barrier!	$1,340,000
		May 6, 2013 Mudslide	$38,500.00	Slope Failure (Non-Declared Event)		
		May 29, 2018 Mudslide	* $46,692.70	Slope Failure (* Cost as of July 10, 2018). Expected total costs with remediation $2 million +.		
13	NC 181	Hurricane Frances	$58,879.31	SLIDES	Minor Repairs, no additional work needed	N/A
		Hurricane Ivan	$55,732.55			
13	NC 63	Jan 2013 Mudslides	$19,649.49	Rock Slide	Repair with Soil Nail	$340,000
		Hurricane Frances	$7,920.99	Shoulder washout		
		Hurricane Ivan	$6,184.60	Shoulder washout		
		Hurricane Ivan	$20,436.68	Slide and shoulder washout		
14	I-40 near mm 2.5	I-40 rock slide, 7/1/1997	$5,000,000.00	Rock slide closed I-40 for several months	2009 was Permanent Solution.	$17,000,000

Required Elements	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 North Carolina 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? [If the process descriptions do not align with the FHWA-certified processes, the State DOT must request recertification of the new processes as amendments unless the changes are minor technical corrections or revisions with no foreseeable material impact on the accuracy and validity of the processes, analyses, or investment strategies. State DOTs must request recertification of TAMP development processes at least 30 days prior to the deadline for the next FHWA TAMP consistency determination as provided in 23 CFR 515.13(c).]	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, Section 2.3 provides a summary listing of NHS pavement and bridge assets Tables 2-1 and Table 2-2 in including Federal and Local Government ownership.
	5. Does the TAMP include a discussion of State DOT asset management objectives that meets requirements?	Chapter 1, Sections 1.1 and 1.2 provide 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, Sections 3.2 and 3.4

Required Elements	Indicators Element Meets the Requirements	How Requirements is Addressed in this Document
	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 99.2% of the NHS pavement is state maintained and 99.4% of NHS bridges are state maintained, and condition of pavement and bridge assets on the NHS regardless of ownership in Chapter 2, Sections 2.3, 2.4.2 and 2.4.3
	8. Does the TAMP identify and discuss performance gaps?	Gaps affecting NCDOT's condition of NHS pavements and bridges are discussed in Chapter 3, Sections 3.5 and 3.6
	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, Sections 4.1 to 4.5. Results from analysis is described in Chapter 3, Sections 3.7 and 3.8
	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, Section 5.1 to 5.8
	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, Section 5.9
	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, Section 6.3
	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 Sections 6.5, 6.6 and 6.7
	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 Performance Goals & Targets.
	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. (Chapter 3, Section 3.2)

Required Elements	Indicators Element Meets the Requirements	How Requirements is Addressed in this Document
	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

Required Elements	Indicators Element Meets the Requirements	How Requirements is Addressed in this Document
	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