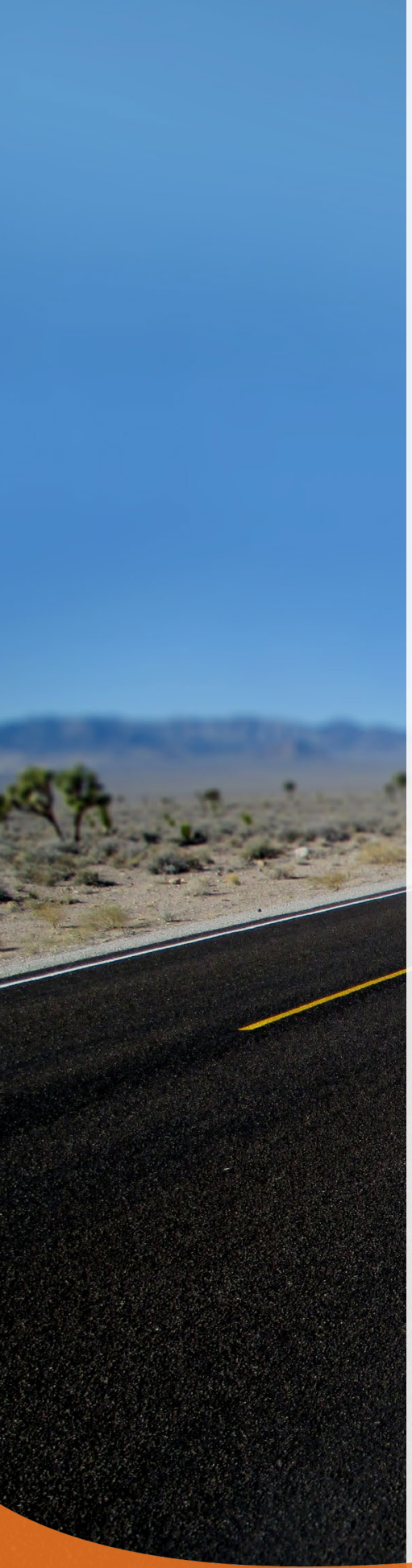
FULLY-COMPLIANT TRANSPORTATION ASSET MANAGEMENT PLAN

April 10, 2019

NEVADA DOT



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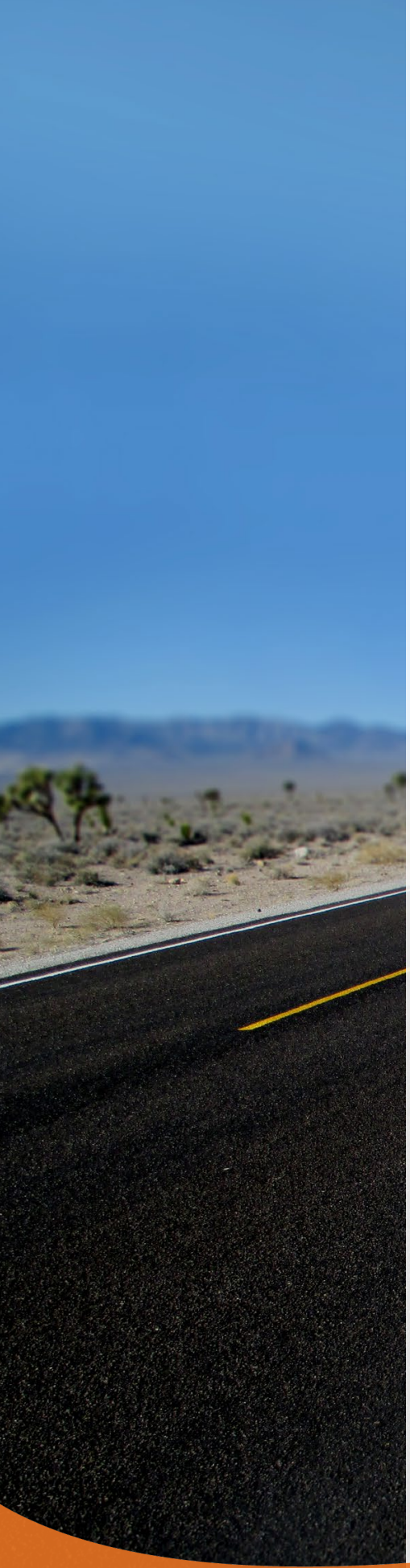
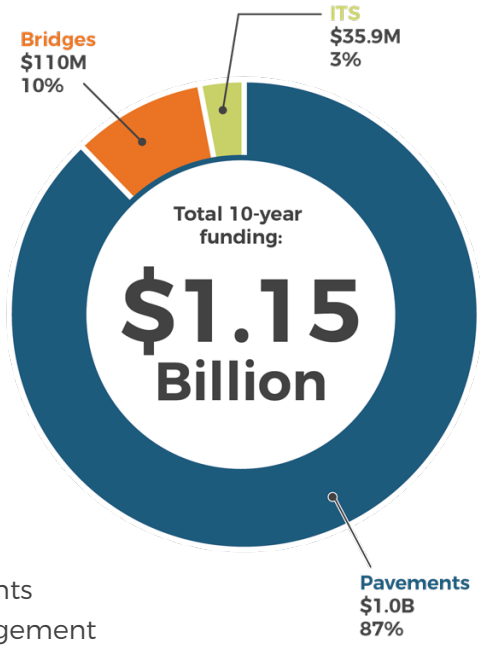


Executive Summary

Overview

NDOT's overarching mission is to "provide a better transportation system for Nevada through unified and dedicated efforts." Nevada's Statewide Transportation Plan establishes the critical role that the state's transportation infrastructure system plays in supporting a growing economy and a high quality of life for its residents.

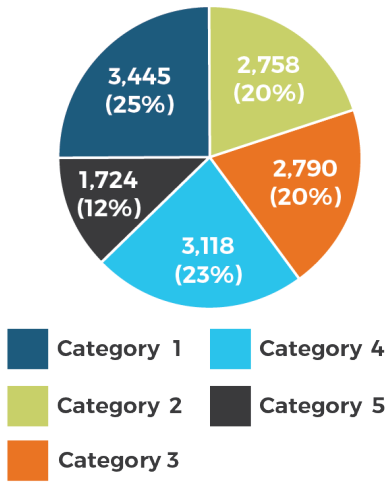


The Nevada Department of Transportation (NDOT) is responsible for designing, constructing, maintaining, and operating this transportation system, which includes 13,835 lane miles of rural and urban highways, 1,284 bridges, and many other assets required to keep the transportation system operating smoothly, safely, and efficiently. To help plan investments in its transportation assets, NDOT prepared a Transportation Asset Management Plan (TAMP) that summarizes the condition of certain assets and the agency's plans for managing these assets for the next 10 years.

NDOT has made a significant investment in its transportation system, with a replacement value of nearly $23 billion for pavements, bridges, and ITS assets. To help extend the service lives of these assets, NDOT is proposing, in this TAMP, a proactive preservation strategy that increases the amount of preservation activities, especially on bridges. Between 2017 and 2027, NDOT will be investing $1.15 billion in maintaining and managing its pavement, bridge, and intelligent transportation (ITS) assets.

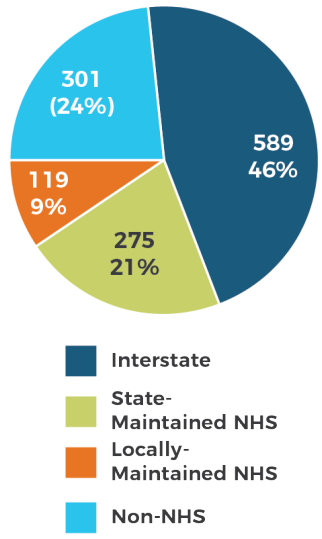
PAVEMENTS

Inventory by Road Category (Lane-Mile)



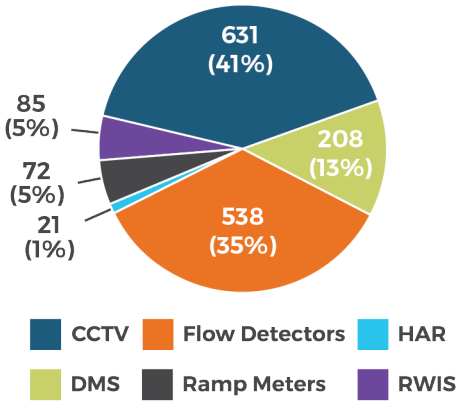
BRIDGES

Inventory (Count)



ITS ASSETS

Inventory Count by Asset Type



Whole-Life Management

When NDOT considers all the costs that are incurred over the life of an asset, the planned use of low-cost treatments while the assets are still in relatively good condition is significantly more cost effective than other strategies that defer treatment until significant amounts of deterioration are present. This strategy is similar to the type of routine maintenance you apply to your car to make it last as long as possible.

Over 60 years, NDOT's pavement preservation approach is expected to result in a savings of approximately $8.7 billion over a worst-first approach

Approximate average annual savings: $145 million

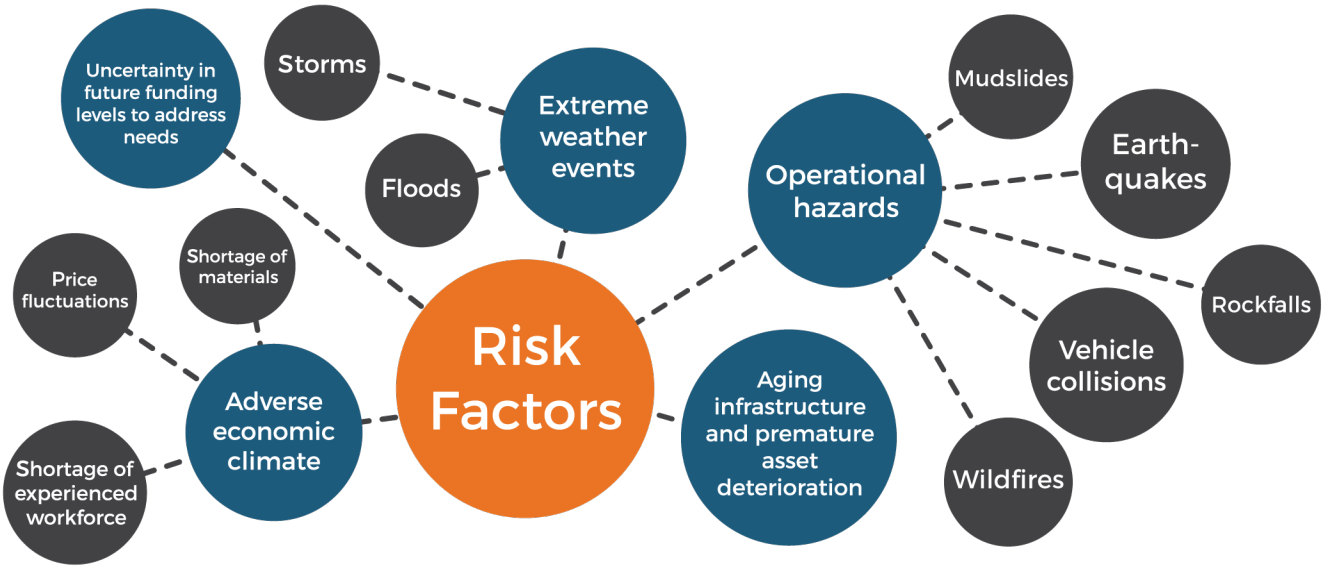
Bridge preservation activities performed on a 15–25 year cycle can significantly increase the life of the bridge

An increase in preservation to 64% of current capital spending would yield a nearly 10x return on investment by postponing bridge replacement.

NDOT's current ITS asset management strategy results in a savings of approximately $1.1 million over 20 years

Risk Management

NDOT strives to provide a safe, functional transportation system that provides the highest possible level of service within funding constraints. However, unexpected or unplanned events, such as adverse economic climate and external hazards (such as floods or storms), can prevent an agency from meeting its goals. Other factors for some assets, such as the lack of reliable performance data or forced workforce reductions, will impact an agency's ability to anticipate and plan for risks. NDOT considered these factors in developing its Investment Plan.

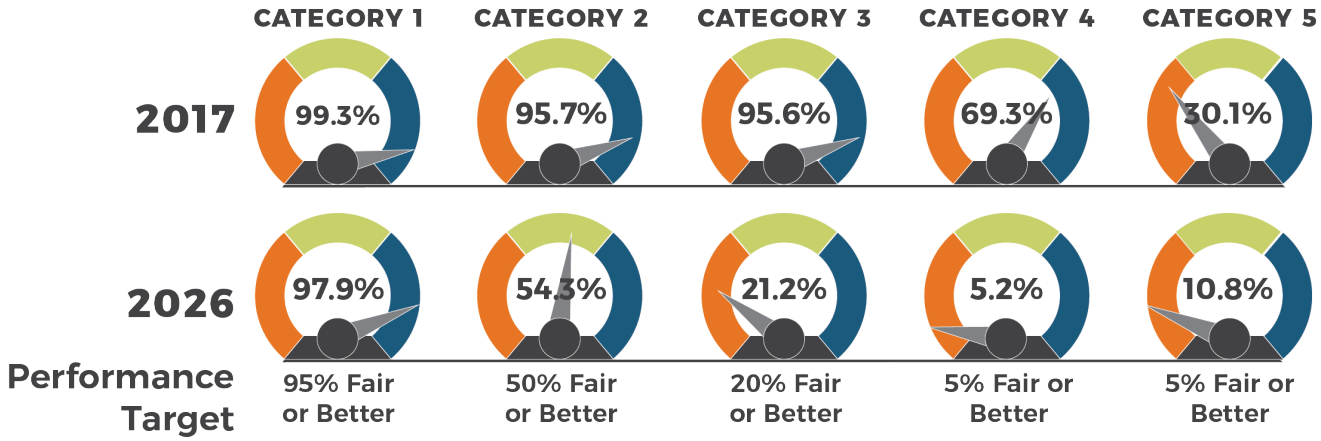


Investment Plan

PAVEMENTS

The projected annual level of investment of $100 million per year ($75 million for preservation, rehabilitation, and reconstruction and $25 million for maintenance) over the next decade will result in steeply declining pavement conditions. At that funding level, the overall network condition is expected to drop from the current level of 71 percent of the network in Fair or Better condition to approximately 25 percent of the network in Fair or Better condition.

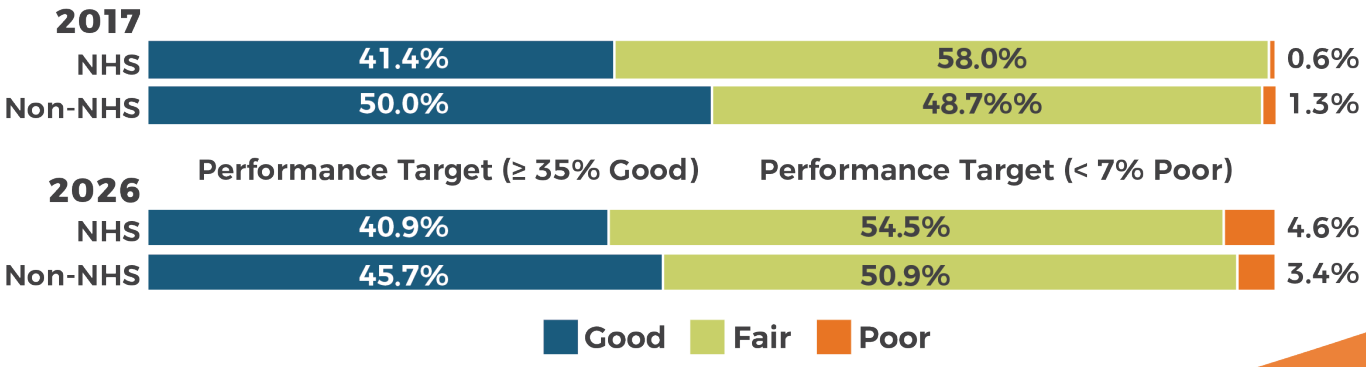
Predicted pavement conditions (% Fair or Better) 2017 vs. 2026



BRIDGES

NDOT will invest $11 million per year ($10.45 million for preservation, rehabilitation, and reconstruction, and $0.55 million for maintenance) in its bridge program between 2017 and 2026 in order to meet the established performance targets. Preservation needs will continue to increase because of the aging of the bridge inventory. Hence, NDOT is proposing to allocate a greater share of resources to preservation activities as a means of prolonging bridge life as much as possible.

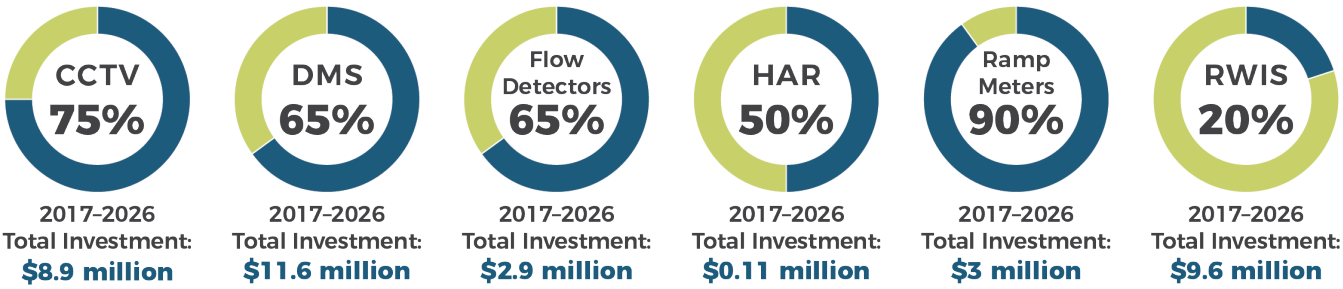
Predicted bridge conditions 2017 vs. 2026



ITS ASSETS

The investment strategy for ITS assets included in the TAMP focused on maintaining the current levels of service over the next 10-years. This will require an average annual investment of approximately $3.6 million without accounting for new ITS assets that are added to the system.

Current ITS asset conditions (devices with at least 80% of manufacturer-recommended service life remaining)



CCTV	DMS	Flow Detectors	HAR	Ramp Meters	RWIS
2017–2026 Total Investment: **$8.9 million**	2017–2026 Total Investment: **$11.6 million**	2017–2026 Total Investment: **$2.9 million**	2017–2026 Total Investment: **$0.11 million**	2017–2026 Total Investment: **$3 million**	2017–2026 Total Investment: **$9.6 million**

Moving Forward

Achieving the goals outlined in the TAMP requires that NDOT continue to take steps to improve its use of performance data to allocate resources in a way that achieves its strategic objectives and manages risks. Moving forward, NDOT has established an Asset Management Oversight Committee (AMOC) to provide guidance and direction on the development and maintenance of the TAMP. In addition to having primary responsibility for governing the TAMP update process, the AMOC will also be responsible for ensuring that sound asset management principles are promoted and embraced at all levels within NDOT.

The AMOC will guide NDOT's initiatives, ensure that the Department stays on track to improve the condition of its transportation assets, and strive to achieve the agency's vision of becoming the "nation's leader in delivering transportation solutions and improving Nevada's quality of life." ■

MAJOR SHORT-TERM ASSET MANAGEMENT IMPROVEMENT INITIATIVES

1. **Implement an Enterprise Asset Management System (EAMS)**
2. **Develop and implement protocols to monitor and assess maintenance of ITS assets**
3. **Implement a statewide enterprise GIS system**

Chapter 1. Introduction

Overview

Nevada's Statewide Transportation Plan establishes the critical role that the state's transportation infrastructure system plays in supporting a growing economy and a high quality of life for its residents. The Nevada Department of Transportation (NDOT) is responsible for designing, constructing, maintaining, and operating this transportation system, which includes 13,835 lane miles of rural and urban highways, 1,284 bridges (including non-state maintained NHS bridges), and many other assets required to keep the transportation system operating smoothly, safely, and efficiently. Although the road network maintained by NDOT represents only 20 percent of all the roads in the State of Nevada, this network carries 52 percent of all automobile traffic and 65 percent of the truck traffic (based on 2014 data).

The Department takes pride in maintaining one of the nation's highest levels of pavement and bridge condition, while also recognizing the top priority of preserving this valuable investment. At the same time, Nevada's infrastructure is aging. For example, 464 of NDOT's bridges (36 percent) have exceeded the 50 year lifespan for which most were designed. The Department's current goal has been to replace one structurally deficient bridge per year, but would need to replace 26 bridges per year over the long term to keep up with expected deterioration rates. Over the past biennium the Department has spent just over $300 million to preserve its existing pavements and bridges, but this current level has not been sufficient to maintain steady conditions across the network. Over the next 10 years, system conditions are projected to deteriorate drastically, especially on the lower volume road systems, and the unfunded needs are projected to grow substantially.

To help preserve the investment that has been made in the transportation system, NDOT has adopted asset management principles that provide a framework for making cost-effective decisions that reflect agency priorities and demonstrate fiscally-responsible investment choices. This Transportation Asset Management Plan (TAMP) documents the asset management framework and outlines NDOT's plans for preserving its existing transportation system over the next 10 years. The contents of the TAMP have been developed through the efforts of an Asset Management Team that represents a broad cross section of the Department and operates under the direction of the NDOT Director and the Transportation Board.

According to the 21st Annual Report on the Performance of State Highway Systems, Nevada ranks ...

24th in Overall Highway Performance

29th in Rural Interstate Pavement Condition

3rd in Rural Arterial Pavement Condition

26th in Urban Interstate Pavement Condition

3rd in Bridge Conditions

http://reason.org/files/21st_annual_highway_report.pdf

Purpose and Requirements

On July 6, 2012, President Obama signed into law highway legislation commonly known as Moving Ahead for Progress in the 21st Century Act, or MAP-21. This legislation established a performance-based Federal highway program that funded transportation programs focused on national transportation goals and increased accountability and transparency. One of the requirements of the legislation was the development of a risk- based asset management plan for pavement and bridge assets on the National Highway System (NHS). States were encouraged to expand their TAMP to include all state-maintained pavements and bridges, and to include other infrastructure assets within the highway right-of-way. The plan is expected to include a 10-year investment strategy that enables states to make progress towards state performance targets and national goals. The most recent legislation, known as Fixing America's Surface Transportation Act (or FAST), further supports the MAP-21 requirements for a TAMP.

NDOT has embraced the principles of asset management as the basis for its performance management process to ensure that system preservation investments are aligned with agency priorities. An asset management framework considers factors such as current and projected conditions, costs over the life of an asset, available funding, and risks in evaluating investment options. Ultimately, asset management practices reduce preservation costs while maximizing performance across the transportation network. With inadequate funding levels on the horizon, asset management strategies are increasingly important to NDOT. Some of the characteristics and benefits of an asset management program are presented in Figure 1-1.

Since NDOT had begun the implementation of asset management principles prior to the MAP-21 legislation, the agency was in a good position to expand the scope of the TAMP beyond the minimum requirements outlined in the law. The Department evaluated the data availability and maturity level for its assets. The Department elected to include all state-maintained roads and bridges in the TAMP. In addition, NDOT elected to include certain Intelligent Transportation System (ITS) assets since an objective assessment concluded that data on ITS assets was available and they were a high priority to the Department in managing traffic operations. There were other high priority items such as hydraulic infrastructure, sign structures, slopes, and guard rails; however, NDOT decided to include these assets in future TAMPs when the inventory and condition information for these assets is more complete. In future years, when the TAMP is updated, additional assets, such as guardrail, barriers, slopes, and culverts, may be added to the TAMP.

Characteristics of an Asset Management Program	Benefits of Applying Transportation Asset Management Principles
• Track system condition, needs, and performance. • Consider public expectations and desires when setting strategic objectives. • Align agency investment decisions to achieve strategic goals. • Use an objective process to maintain and manage assets; manage assets, considering needs, available funding, risks, operational constraints, and maintenance costs over the life of the assets. • Determine the optimal time to improve assets based on performance data.	• Optimize and improve transportation system performance. • Improve customer satisfaction. • Minimize life cycle costs. • Match level of service provided to public expectations. • Make more informed, cost-effective program decisions and better utilize existing assets. • Develop an objective method for balancing tradeoffs between competing objectives.

Figure 1–1. Characteristics and benefits of a transportation asset management program.

TAMP Content

In addition to satisfying a Federal requirement, this TAMP serves as an important communication and accountability tool that will guide NDOT's investments in pavement, bridge, and ITS preservation over the next 10 years. The TAMP content has been developed using processes certified by the Federal Highway Administration (FHWA) on May 30, 2018. The TAMP is required to be updated on a regular basis, with no more than 4 years passing between updates.

The TAMP summarizes the pavement, bridge, and ITS assets that NDOT maintains, providing information about the number and condition of these assets. In addition, the document describes the performance metrics that are used to monitor the performance of these assets. Using life-cycle planning, the TAMP illustrates the cost-effectiveness of timely preservation activities and the costly consequences if these activities are deferred.

In addition to costs, the TAMP considers the potential risks that NDOT faces while managing assets that continue to age and deteriorate in an unpredictable environment. A formal risk analysis allows NDOT to analyze and prioritize problem areas before unexpected events occur, rather than

The NDOT Transportation Asset Management Plan:

Summarizes the number and condition of pavement, bridge, and ITS assets NDOT maintains.

Quantifies the widening gap between targeted and expected performance due to funding constraints.

Illustrates the cost-effectiveness of the preservation strategies NDOT is currently using.

Identifies, evaluates, and prioritizes risks that may impact NDOT's ability to achieve its goals.

Describes expected funding levels and recommends 10-year investment strategies for pavements, bridges, and ITS assets.

Documents future enhancements that NDOT will undertake to improve its practices.

wait and react to the resulting damage. As a result, future improvements can be planned and prioritized within the highway construction program to address high-risk areas.

The TAMP also includes a 10-year financial plan based on projected revenue and forecasted conditions. Planned investment strategies place a high priority on preserving the performance of the State's high-volume facilities, and recognize that funding is inadequate to preserve the medium- and low-volume systems. The expected conditions are presented and the gaps between forecasted and desired conditions are detailed. The planned investment strategies will guide future expenditures through a systematic process that is aligned with agency goals and priorities.

The TAMP content is presented in the seven chapters and four appendices listed below.

- **Chapter 1, Introduction**—Introduces the TAMP and its content.
- **Chapter 2, Asset Management Objectives**—Introduces NDOT's asset management program and the business processes that support these efforts, including current performance measures and targets.
- **Chapter 3, Asset Inventory and Performance**—Summarizes information about the pavement, bridge, and ITS assets included in the TAMP, including the size of the inventory, the condition of the assets, and their replacement value.
- **Chapter 4, Life-Cycle Planning Considerations**—Describes the life-cycle planning that was conducted to evaluate the cost-effectiveness of NDOT's current treatment strategies and outlines strategies for reducing life cycle costs.
- **Chapter 5, Risk Management**—Identifies the risks that may hinder NDOT's ability to achieve its performance targets and establishes priorities for managing them.
- **Chapter 6, Financial Plan and Investment Strategies**—Presents a financial outlook for 10-year revenue projections based on recent trends and assumptions and describes how available funds will be invested in pavements, bridges, and ITS assets over the 10-year planning horizon.
- **Chapter 7, Asset Management Process Enhancements**—Describes NDOT's plans for asset management governance and enhancements that are expected to be made over the next several years.

- **Appendix A. MAP-21 Compliance Checklist**—Summarizes MAP-21 requirements and the sections of the TAMP that address those requirements.
- **Appendix B. Assumptions Used in Life-Cycle Planning Analysis for ITS Assets**—Documents key assumptions used in modeling the life cycle performance and investment needs for the ITS assets addressed in this TAMP.
- **Appendix C. FHWA TAMP Certification Guidance**—Provides a framework for undertaking and completing process certifications/re-certifications for a State DOT's TAMP development processes as outlined in 23 CFR 515.13
- **Appendix D. Nevada NHS Roadway Listing**—Provides a summary listing of the NHS routes in Nevada. ■

Chapter 2. Asset Management Objectives

Overview

To manage the state's highway system effectively, NDOT has established a strategic performance management process that relies on measurable performance indicators for monitoring progress toward strategic targets. The targets, which are guided by input from the traveling public, the State Legislature, the Transportation Board, NDOT leadership, and NDOT Division offices, drive investment decisions and the allocation of resources. The results of this effort are monitored regularly and published in the annual *Performance Management Report.* The process is illustrated in Figure 2-1.

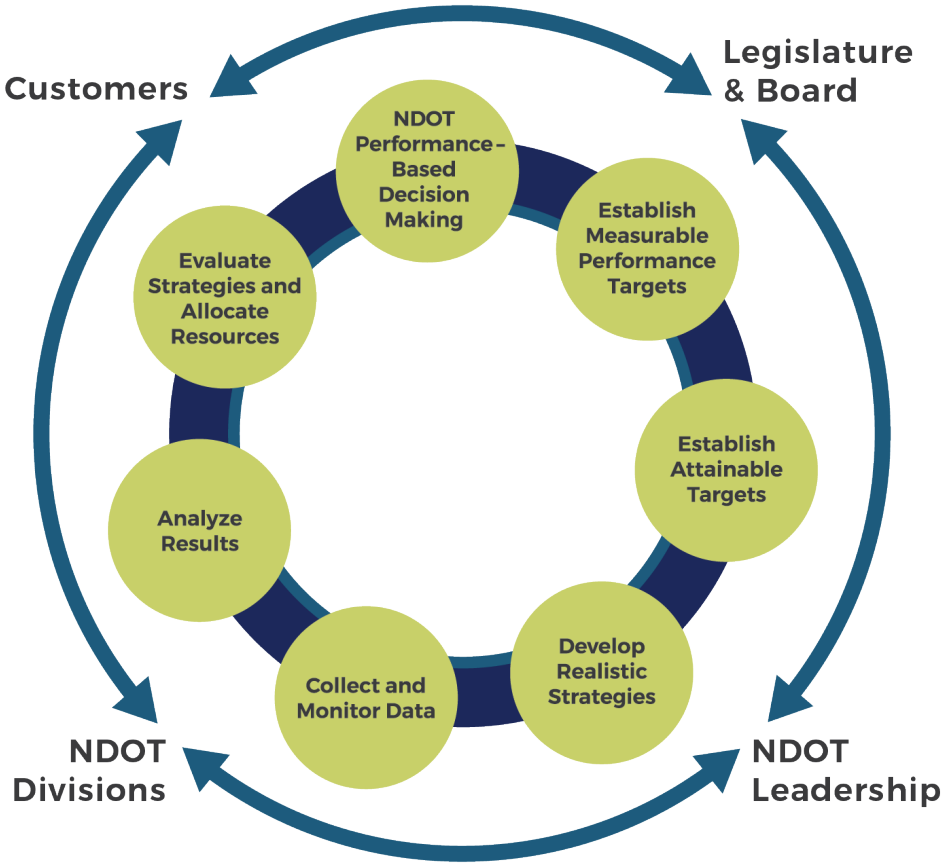


Figure 2-1. Overview of NDOT's strategic performance management process.

Nevada's Strategic Planning Framework to Ensure a Safe and Reliable Transportation System (2016-2020)

- Reduce congestion on state highways
- Improve the condition of the state's bridges and reduce the anticipated backlog of bridge preservation work
- Support expanded, affordable, and reliable public transportation options across all geographic regions within the state, especially for individuals with disabilities
- Reduce the incidents of animal / car collisions along state highways statewide

Given the continuing scarcity of resources, the Department has focused on developing better methods to prolong the service lives of its assets and maintain their performance as cost-effectively as possible. The techniques of Transportation Asset Management (TAM) will be fundamental to achieving this.

TAM starts with identifying and measuring the Department objectives for quality of service and carefully evaluating every proposed investment for its ability to improve performance. Every time the Department builds new infrastructure, it commits to a stream of future costs to keep the assets in service and performing as intended. Investment decisions consider all of the initial and future costs, to find the solutions that keep costs low in the long run. This strategic approach to performance and costs is supported in state law. For example, Nevada Revised Statutes (NRS) 408.133 calls on the Department to measure and report on system performance and NRS 408.3195 requires an analysis of long-term costs and benefits of proposed highway projects.

Goals and Objectives

The NDOT *Statewide Transportation Plan* establishes a list of key performance objectives, or Guiding Principles, which guide the Department's construction and maintenance decisions. These include:

- **Safety**—Improve safety for all modes of our transportation system.
- **Customer Service**—Improve internal and external customer service and satisfaction.
- **Fiscal Responsibility**—Secure the highest amount of funding possible for our state and ensure that it is invested responsibly and properly.
- **Asset Management**—Protect the public's investment in our transportation system.
- **Mobility/Accessibility**—Provide a statewide, multimodal, interconnected, efficient transportation system that enhances Nevada's economic competitiveness.
- **Freight Movement**—Improve the safety and mobility of freight movers.
- **Environmental Stewardship**—Ensure the human and natural environments are considered when developing the transportation system.

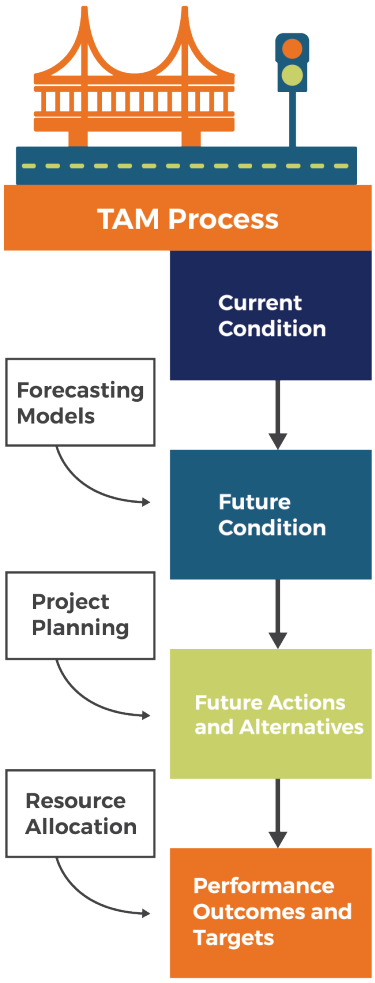


Figure 2-2. Transportation Asset Management (TAM) process.

A very similar list is provided in federal law (23 USC 150(b)) to summarize goals for the National Highway System (NHS). In addition to these concerns about long-term costs and system performance, the Statewide Transportation Plan also devotes considerable emphasis to risk management, especially the risk of service disruption posed by natural and man-made hazards.

Linking the TAMP to Existing Business Practices

The Department's TAM process is presented in Figure 2-2. It reflects activities that ensure that the Department is continuously measuring its performance and programming investments that are most cost effective to improve performance. It is based on the principle that what gets measured gets done. Key features include:

- **A clear relationship between investment decisions and agency objectives that use performance measures** designed to provide an indication of how well each asset and project satisfies agency goals and policies.
- **Maintenance of an asset inventory** listing all of the significant pavements, bridges, and certain additional asset classes.
- **Periodic inspection of assets** to update the inventory and performance measures. This information serves as the basis for project identification. Forecasting models estimate future changes in performance and future needs, providing an opportunity for the Department to anticipate and avoid or delay future costs.
- **Consideration of program alternatives** to account for uncertainty in funding, costs, conditions, and hazards.
- **Development of short-range and long-range plans, programs, and targets** culminating in updates to this TAMP and projects in the *State Transportation Improvement Plan (STIP).*

As optimized investments are delivered, their effectiveness is measured, to ensure that Department objectives are achieved and to further improve the forecasting and delivery capability. In this way, the Department engages in a process of continuous improvement, using its ability to measure performance in order to identify ways of improving. All of the ingredients in the process work together to help the Department keep its long-term costs lower and manage risk at acceptable levels.

For many years NDOT has had in place a set of procedures and systems for monitoring the condition of its infrastructure, focused on pavements and bridges. These systems include an up-to-date inventory and a variety of data items related to physical deterioration, traffic, safety, mobility, risk,

and costs. These processes comply with federal requirements and are subject to uniform national quality assurance processes. NDOT has also developed a data quality management plan that is in accordance with the FHWA requirements and the new Enterprise Asset Management System (EAMS) being implemented is in accordance with the requirements specified under 23 CFR 515.17.

For pavements, NDOT has adopted systems to forecast future conditions and needs, allowing the Department to develop, compare, and optimize program alternatives according to future cost savings and performance. In the coming years, this capability will be extended to other asset classes.

Within the next year, new analysis methods will be implemented for bridges to meet federal requirements. There is considerable potential for long-term cost savings from taking a more developed approach to bridge preservation when making decisions.

The TAMP reflects NDOT's commitment to asset management and the Department's efforts to integrate asset management into planning and programming activities. As shown in Figure 2-3, the TAMP links high-level, long-term transportation plans (such as the Statewide Transportation Plan and the One Nevada Plan) with both capital and maintenance improvement programs.

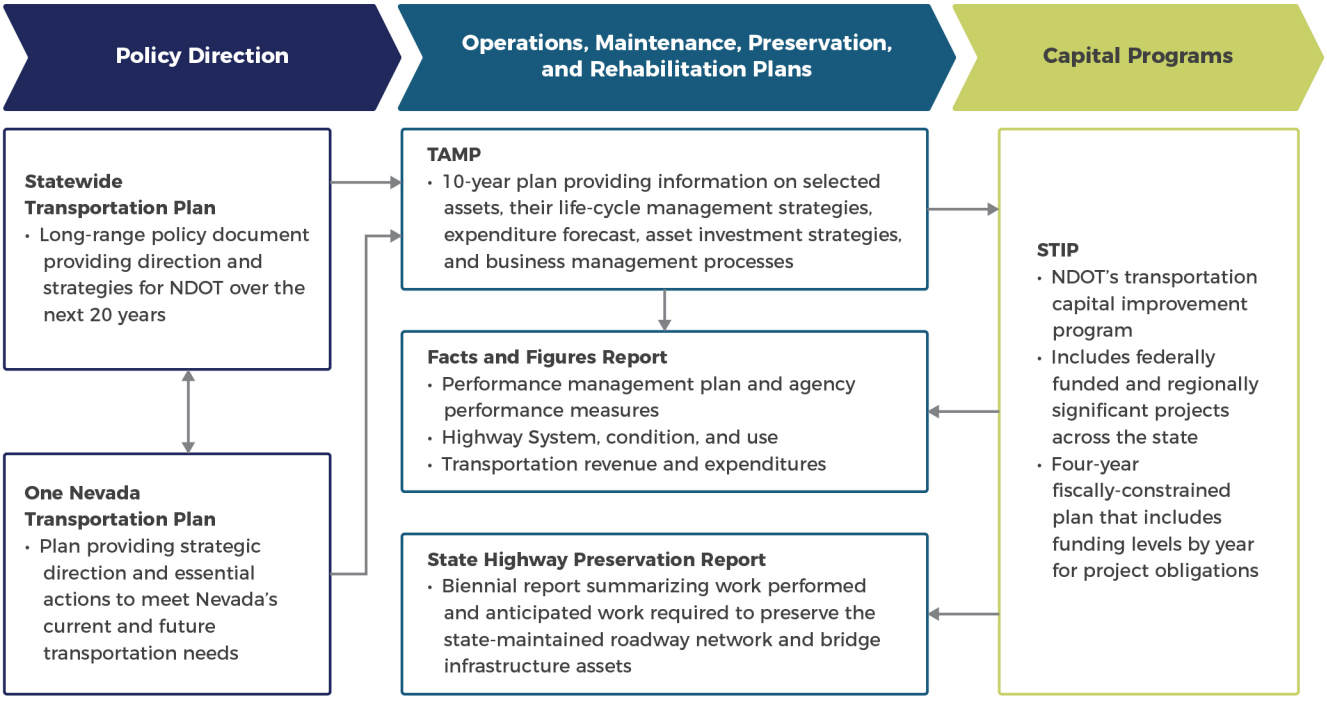


Figure 2-3. The TAMP's link to NDOT policies, plans, and programs.

Additional information about asset management within NDOT can be found in the documents shown in Figure 2-3. These include: the *Statewide Transportation Plan*, the *One Nevada Plan*, the *State Highway Preservation Report*, and the *Facts and Figures* report. ■

Figure 2-4. Guiding documents for TAMP development.

Chapter 3. Asset Inventory and Performance

Overview

Nevada's state highway system includes 13,835 lane-miles of roadways and 1,284 bridges. Collectively, the replacement value of these assets is roughly $23 billion. In addition to roadways and bridges, numerous other transportation assets are maintained by NDOT as shown in Table 3-1.

Table 3-1. Examples of assets managed by NDOT.

Asset Category	Asset Type
Pavements	Mainline pavements
	Shoulders
Bridges	Bridges and Bridge Culverts
Hydraulic Infrastructure	Drainage culverts
	Pipes
	Other Drainage Structures [drop inlets, manholes, basins, and channels (ditches and irrigation)]
Other Roadside Assets	Pavement Striping and Marking
	Curb and Gutter
	Guard Rails, Barriers, and Impact Attenuators
	Slopes and Embankments
	Retaining Walls
	Noise Barrier Walls
	Rest Areas, Salt-Sand Storage Areas, Weigh Stations
	Maintenance Depots, Pump Houses, Communication Buildings
	Lighting Structures
	Landscape Features
Traffic Assets	Intelligent Transportation Systems (ITS)
	Signs and Support Structures
	Traffic Signals
Multimodal Assets	Americans with Disabilities Act (ADA) features
	Bike paths
	Sidewalks

NDOT routinely collects asset performance data on its highway system to evaluate the effectiveness of its investments and determine future maintenance needs. Maintaining transportation assets in good condition and investing in preserving their condition is key to reducing life cycle costs and providing a safe transportation system for Nevada's citizens. NDOT

uses a standardized approach, which has continuously been improved over the years, to evaluate, maintain, and manage asset performance data.

Asset Inventory

PAVEMENTS

NDOT's road network is divided into five road prioritization categories (as shown in Figure 3-1) based on heavy truck traffic loads (in terms of Equivalent Single Axle Loads or ESALs) and average daily traffic (ADT). Local roads maintained by cities and counties, and roads on federal lands, are not included in the state-maintained road network. Brief descriptions of the five road prioritization categories are provided below:

- **Category 1: Controlled Access Roads.** These roads include interstates, freeways, and expressways with limited access and high traffic speeds such as Interstate 15: (Clark County), Interstate 580 (Washoe County) and Interstate 80 (Elko County).
- **Category 2: ESALs > 540 or ADT > 10,000.** These roads have high traffic volumes and heavy truck loads, but are not considered controlled-access roads. Examples include SR146, St. Rose Parkway (Clark County), US 050, Lincoln Highway (Carson City), SR227, Fifth Street (Elko County).
- **Category 3: 540 ≥ ESALs > 405 or 1,600 < ADT ≤ 10,000.** These roads have relatively high traffic and truck loads. These are generally considered to be state routes (SR) such as SR157, Kyle Canyon Road (Clark County), SR028, Lake Tahoe Area (Douglas County), and SR225, West Urban Limits of Elko (Elko County).
- **Category 4: 405 ≥ ESALs > 270 or 400 < ADT ≤ 1,600.** These roads include the lower volume state routes such as SR158, Deer Creek Road (Clark County), SR206, Foothill Road/Genoa Lane (Douglas County), and SR228, and Jiggs Road (Elko County).
- **Category 5: ADT ≤ 400.** These roads have the lowest traffic volumes in the state. Examples include SR 156, Lee Canyon Road (Clark County), SR121, Dixie Valley Road (Churchill County), and SR229, and Secret Pass Road (Elko County).

A portion of the network is included in the National Highway System (NHS), which is a network of strategic highways identified by the U.S. Department of Transportation in cooperation with states, local officials, and metropolitan planning organizations (MPOs) and approved by the

U.S. Congress. NHS routes include the Interstate Highway System and additional roads that serve major airports, ports, and other strategic transport facilities. Although most of the NHS routes are managed by NDOT, there are approximately 150 centerline miles (415 lane miles, about 3 percent of the total pavement mileage) that are managed by local agencies in the state. A summary listing of the NHS routes in Nevada is available in Appendix D. NDOT collects cracking, roughness, rutting, and faulting data on all NHS routes as part of its pavement management practices in compliance with the Highway Performance Monitoring System (HPMS) reporting requirements. The mileage summaries included in this section include all of the NHS routes, including those managed by local agencies. The performance targets established for the state-maintained NHS pavements also apply to the NHS pavements maintained by local agencies (discussed in Chapter 6).

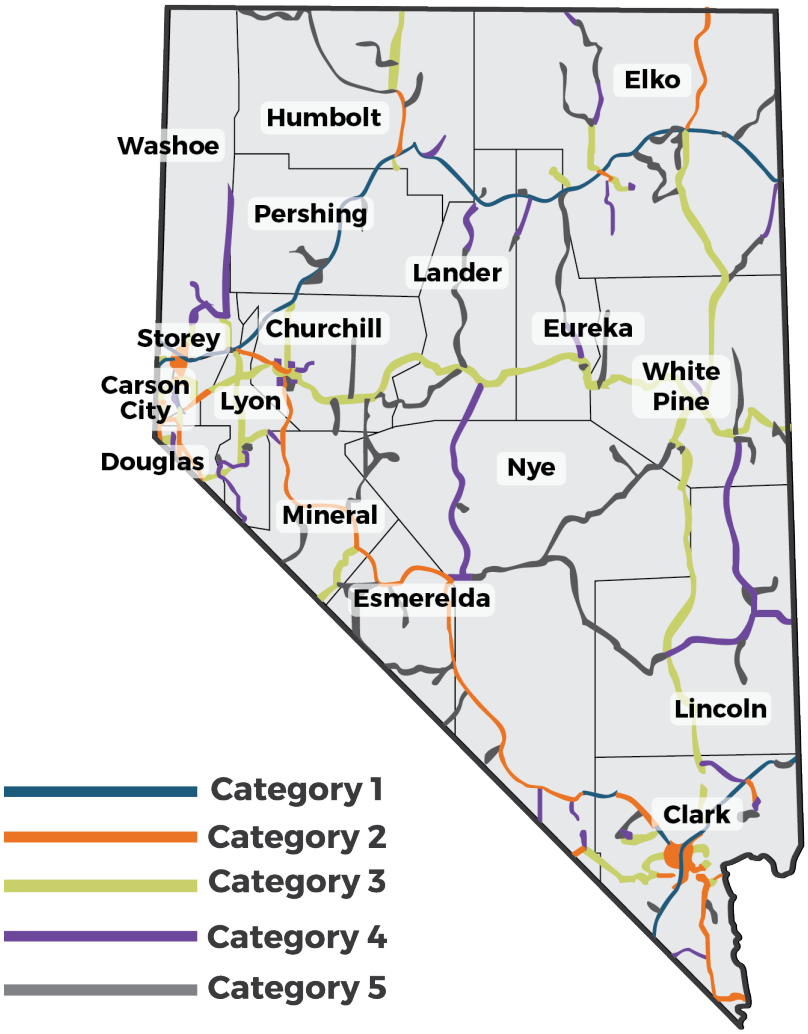


Figure 3-1. Nevada's state-maintained roadway network identified by prioritization categories.

Figure 3-2 shows the distribution of the pavement inventory by system (National Highway System [NHS] vs. non-NHS), pavement type (the type of road surface, such as asphalt surfaced or concrete surfaced), and prioritization category.

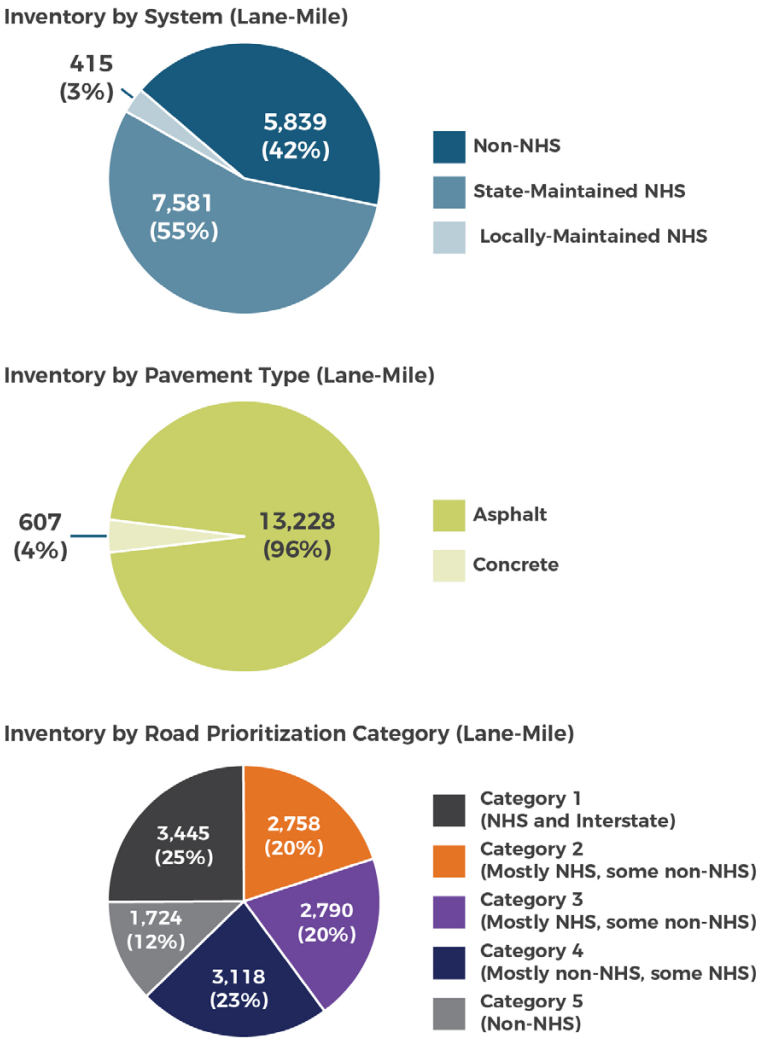


Figure 3-2. Distribution of NDOT's state maintained road network inventory. (Based on 2017 HPMS submittal and NDOT PMS data)

BRIDGES

NDOT maintains 1,165 bridges across the state. In addition to the state-maintained bridges, there are 119 additional bridges on the NHS that are maintained by local agencies. Figure 3-3 shows the distribution of NDOT's state and locally maintained bridge inventory by system (Interstate, NHS, non-NHS).

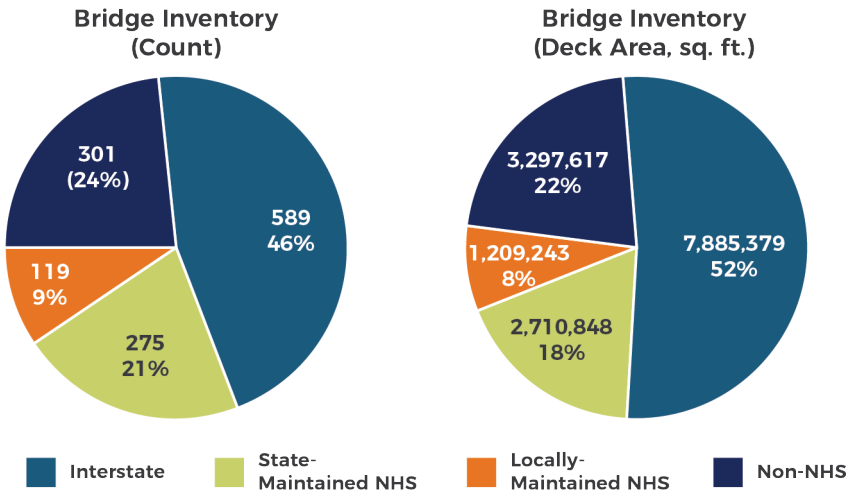


Figure 3-3. NDOT's state maintained bridge inventory.

INTELLIGENT TRANSPORTATION SYSTEM (ITS) ASSETS

NDOT's Traffic Operations Division maintains and manages several types of ITS assets to address highway safety and mobility needs. The following ITS assets are addressed in this TAMP: Closed Circuit Television Camera (CCTV) devices, Dynamic Message Signs (DMS), Flow Detectors, Highway Activity Radios (HAR), Ramp Meters, and Road Weather Information Systems (RWIS).

It should be noted the ITS asset maintenance and management strategies discussed in this TAMP cover only the devices and not the supporting structures and other secondary devices that make up the equipment. Figure 3-4 shows a summary of the ITS asset inventory included in this TAMP.

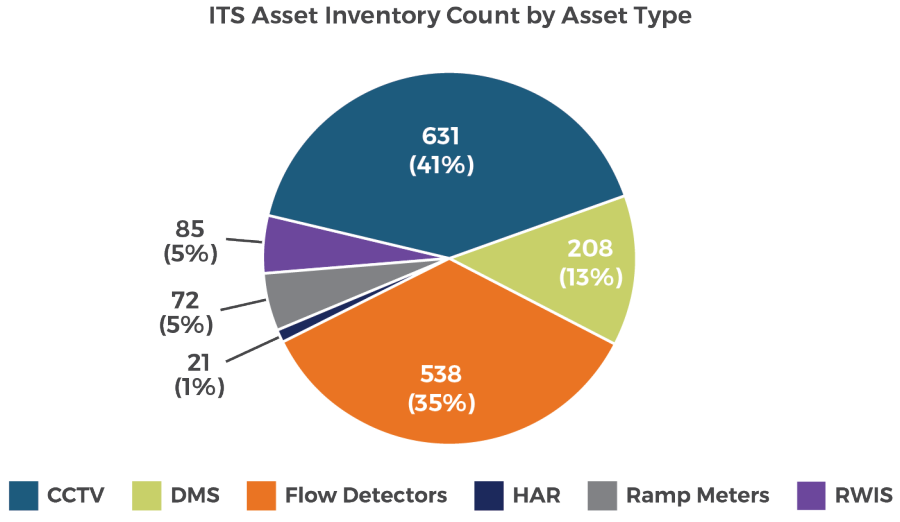


Figure 3-4. ITS asset inventory.

Factors Influencing Asset Condition and Performance

Asset age is one of the key factors influencing performance. As assets age, they require more maintenance and rehabilitation in order to ensure acceptable performance. Figure 3-5 and Figure 3-6 show the age profile of NDOT's pavements and bridges, respectively. About 40 percent of the state-maintained pavements have a surface that is less than 10 years old. These pavements represent either newly constructed pavements or, more typically, pavements that have recently been resurfaced. They require maintenance and preservation treatments to maintain or improve their conditions and delay the need for major rehabilitation or reconstruction.

More than 53 percent of the state maintained bridges are over 40 years old. Most of these bridges have already or will soon exceed their design life of 50 years. As with pavements, routine maintenance and preservation are key to ensuring good bridge performance. A more detailed discussion on life-cycle planning strategies is presented in Chapter 4.

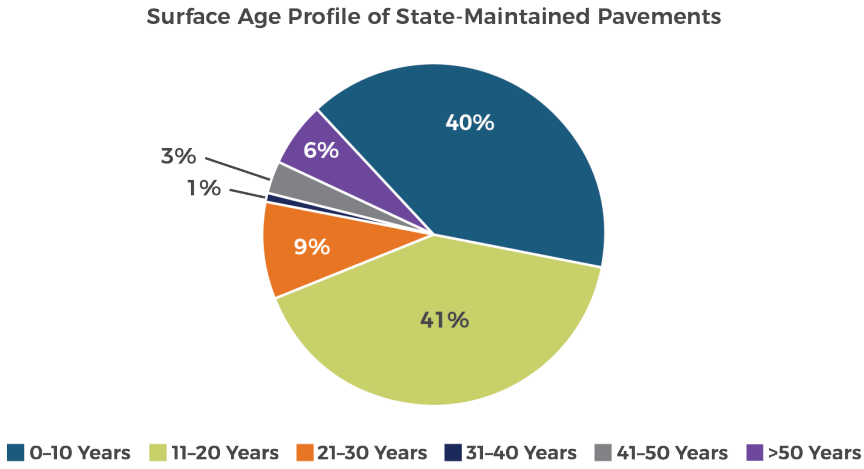


Figure 3-5. Age profile of state-maintained pavements.

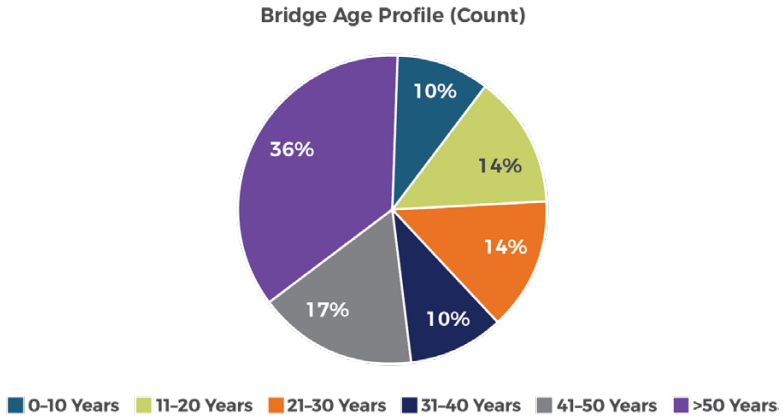


Figure 3-6. Age profile of state-maintained and NHS bridges.

In addition to age, asset conditions are also influenced by a host of other factors such as construction type and quality, climatic and operating conditions, traffic loading, and human factors. Some of the main factors influencing the condition and performance of the assets included in the TAMP are highlighted in Table 3-2.

Table 3-2: Significant factors influencing asset conditions.

Pavements	Bridges	ITS Assets
Pavement type	Bridge type	Fabrication quality
Traffic volumes	Usage of deicing chemicals	Installation quality
Traffic weight	Presence of water	Traffic hits
Environmental factors	Traffic volumes	Strong winds
Material properties	Traffic weight	Firmware issues
Type of underlying material	Environmental factors	Obsolescence
Maintenance frequency	Material properties	
Construction quality	Maintenance frequency	
	Construction quality	

Performance Measures

NATIONAL PERFORMANCE MEASURES FOR PAVEMENTS AND BRIDGES

The Federal Highway Administration (FHWA) recently issued a rule that includes measures to assess the condition of pavements and bridges on the NHS. The pavement and bridge condition thresholds and performance measures are summarized in Table 3-3 and Table 3-4, respectively.

Table 3-3. Summary of condition thresholds and performance measures for pavements.

Pavements			
Condition Thresholds			
Metric as defined in HPMS	**Good**	**Fair**	**Poor**
IRI (in/mile)	<95	95–170	>170
Asphalt Concrete Cracking (%)	<5	5–20	>20
Jointed Plain Concrete (JPC) Cracking (% slabs)	<5	5–15	>15
Continuously Reinforced Concrete (CRC) Pavement Cracking (%)	<5	5–10	>10
Rutting (in) [asphalt-surfaced pavements only]	<0.20	0.20–0.40	>0.40
Faulting (in) [concrete-surfaced pavements only]	<0.10	0.10–0.15	>0.15

Performance Measures[1]	
Good	**Poor**
Asphalt Pavements: Pavement section is rated as "Good" if all three metrics (IRI, Asphalt Cracking, and Rutting) are rated to be "Good"	**Asphalt Pavements:** Pavement section is rated as "Poor" if two or more of the three condition metrics (IRI, Asphalt Cracking, and Rutting) are rated to be "Poor"
JPC Pavements: Pavement section is rated as "Good" if all three metrics (IRI, JPC Cracking, and Faulting) are rated to be "Good"	**JPC Pavements:** Pavement section is rated as "Poor" if two or more of the three condition metrics (IRI, Jointed Plain Cracking, and Faulting) are rated to be "Poor"
CRC Pavements: Pavement section is rated as "Good" if both metrics (IRI and CRC Pavement Cracking) are rated to be "Good"	**CRC Pavements:** Pavement section is rated as "Poor" if both condition metrics (IRI and CRC Pavement Cracking) are rated to be "Poor"

Performance measures are calculated for pavements in the Highway Performance Monitoring System (HPMS). Pavement conditions on the NHS are reported as:

- Percentage of pavements on the Interstate System in Good condition.
- Percentage of pavements on the Interstate System in Poor condition.
- Percentage of pavements on the NHS (excluding the Interstate System) in Good condition.
- Percentage of pavements on the NHS (excluding the Interstate System) in Poor condition.

To meet federal minimum condition requirements, no more than 5% of the Interstate pavement may be in Poor condition.

1 23 CFR Part 490 National Performance Management Measures – Provides guidance on assessing pavement and bridge conditions, including national performance measures to assess the performance of the NHS.

NDOT has adjusted its pavement management system reporting capabilities to enable the reporting of pavement conditions in accordance with the national performance measures.

Table 3-4. Summary of condition thresholds and performance measures for bridges.

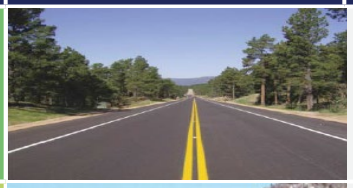
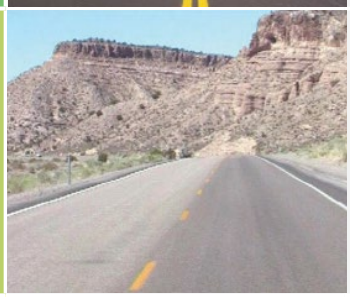
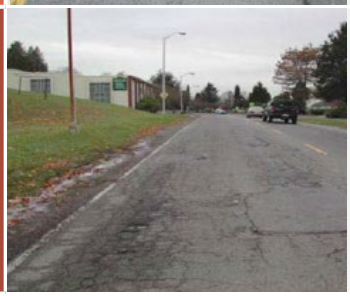
Bridges		
Condition Thresholds and Performance Measures		
Item	**Good**	**Poor**
Bridges—Lowest of: • Deck (NBI item 58) • Superstructure (NBI item 59) • Substructure (NBI item 60)	7–9	0–4
Culverts (NBI item 62)	7–9	0–4
Performance measures for bridges and culverts are based on the National Bridge Inventory (NBI) rating. NHS bridge conditions are reported in terms of: • Percentage of NHS bridges classified in Good condition. • Percentage of NHS bridges classified in Poor condition.		

For bridges, NDOT is already using the required national performance measures in accordance with 23 CFR 490.

PAVEMENTS

NDOT uses the Present Serviceability Index (PSI) condition rating method that measures the pavement condition attributes that are important to the traveling public. The PSI is computed using pavement condition measurements (such as smoothness and safety) and distresses such as cracking, raveling, rutting, and patching. The raw distress data is combined to calculate a 5-point PSI rating scale with 5 representing a brand new pavement and 0 representing a pavement in failed condition. Table 3-5 describes the PSI categories that correspond to pavements in *Very Good, Good, Fair, Mediocre, Poor, Very Poor,* and *Failed* conditions. NDOT considers pavement in *Fair* or better condition, which is indicated by a PSI ≥3.0 to be in a State of Good Repair (SOGR). Pavements in a SOGR have little structural deterioration present and can be preserved very cost-effectively. The PSI distress data satisfies the HPMS requirements and serves as the basis for federal performance reporting and target setting.

Table 3-5. PSI rating scale categories.

	PSI Range & Condition Category	Example Photo	Description
STATE OF GOOD REPAIR	**Very Good 5.00 to 4.00**		• Very smooth ride quality with very little to no pavement distress. • Pavement is in like-new condition.
	Good 3.99 to 3.50		• Very smooth ride quality with minor distresses that are typically environmental rather than load related. • Distresses include minor non-wheel path longitudinal and transverse cracks as well as minor surface raveling. • Candidate for preventive maintenance such as crack sealing and surface treatments such as chip, slurry, and scrub seals. • Surface treatments reduce pavement deterioration and protect the pavement structure from water infiltration and weathering.
	Fair 3.49 to 3.00		• Good ride quality except noticeable environmental distress such as longitudinal and transverse cracks, light surface oxidation and weathering. • Structural distress in the form of ruts and fatigue cracks begin to occur. • Candidate for a surface treatment such as microsurfacing or double chip seal, and possibly a two inch overlay.
	Mediocre 2.99 to 2.50		• Barely acceptable ride quality and significant environmental and structural distresses have accumulated. • Pavement has non-wheel path longitudinal cracking and transverse cracks so closely spaced that block cracks develop. Ruts and fatigue cracks are present. • Pavement structural deterioration is evident. • Candidate for three inch or thicker overlays and may require patching before the new overlay is placed.
	Poor 2.49 to 2.00		• Poor ride quality and large amounts of environmental and structural related distresses have accumulated. • Non-wheel path longitudinal and transverse cracks are severe. The surface is weathered, rutted, and fatigue cracks are widespread. • Lower volume roads are candidates for thick overlays or cold in-place recycling (CIR) and overlay repair. Higher volume roads will require reconstruction such as a full depth recycling and overlay repair.
	Very Poor or Failed < 2.00		• Very poor ride quality and significant environmental and structural distresses have accumulated. • The surface is pitted and there are wide non-wheel path longitudinal and transverse cracks. Networked, spalled fatigue cracks, deep ruts, and potholes are prevalent. • Requires constant maintenance activity such as patching and filling potholes. • Requires full-depth reconstruction and recycling the road may not be an option.

BRIDGES

The NDOT bridge inventory includes all the NHS bridges within Nevada. NDOT manages the inspections and collects all the data for all of these bridges and provides the data to the bridge owners. The data in the NDOT bridge inventory is collected in accordance with the National Bridge Inspection Standards (NBIS) and is reported to the National Bridge Inventory (NBI).

The NDOT BMS is part of a new Enterprise Management System (EAMS) that is currently undergoing development and configuration. The BMS is expected to be functioning by mid-2020. The BMS will use the NBI items and element data to assess current bridge conditions and forecast future bridge conditions. Once fully implemented, EAMS will satisfy all the 23 CFR 515.17 requirements for a BMS.

Bridge inspectors rate condition on the NBI scale of 0 to 9 as shown in Table 3-6. The deck, superstructure, and substructure of each bridge are rated separately. For the purposes of this TAMP, and for developing performance targets, the three bridge ratings are combined by selecting the worst of the assessed ratings. Then, the 0-9 scale is collapsed into just three classes with ratings of 7 or better representing bridges in Good condition, ratings of 5 or 6 representing bridges in Fair condition, and ratings of 4 or lower represent bridges in Poor condition (also shown in Table 3-6).

When any of the NBI condition ratings fall to 4 or below, the bridge is considered structurally deficient (SD). For National Highway System bridges, federal law specifies a penalty for states that have more than 10 percent of their deck area on structurally deficient bridges. Nevada currently has only 0.6 percent in this category, and is not at risk of failing the federal criterion in the next 10 years.

NDOT considers a bridge to be in a State of Good Repair when the primary NBI Condition Ratings (Items 58, 59, 60, and 62) are 5 or higher. Therefore, bridges that are in Good or Fair condition are also considered to be in a State of Good Repair. The percentage of bridges in a State of Good Repair has experienced a minor amount of fluctuation over the last 20 years, but has gradually increased from 95 percent in 1999 to 99 percent in 2017.

Table 3-6. Bridge condition rating scale.

		NBI Rating	Condition	Condition Description
STATE OF GOOD REPAIR	Good	9	Excellent	Like new condition
		8	Very Good	No problems noted
		7	Good	Some minor problems
	Fair	6	Satisfactory	Structural elements show minor deterioration
		5	Fair	All primary structural elements are sound but may have minor section loss, cracking, spalling or scour
	Poor	4	Poor	Advanced section loss, deterioration, spalling or scour
		3	Serious	Loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present
		2	Critical	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken
		1	Imminent Failure	Major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service
		0	Failed	Out of service—beyond corrective action
		N		Not Applicable

ITS ASSETS

Unlike pavements and bridges, ITS assets do not have a formally-established performance metric for condition. For the purposes of the TAMP, a simplified subjective performance metric based on the manufacturers' recommended service life for each device was established as shown in Table 3-7.

Table 3-7. ITS condition rating scale.

Condition Category	Condition Description
Good	Age of the device is less than 80 percent of the manufacturers' recommended service life.
Low Risk	Age of the device is between 80 and 100 percent of the manufacturers' recommended service life.
Medium Risk	Age of the device is between 100 and 125 percent of the manufacturers' recommended service life.
High Risk	Age of the device is greater than 125 percent of the manufacturers' recommended service life.

The Low Risk, Medium Risk, and High Risk categories are based on the likelihood of a device failure as determined from subjective assessments of NDOT's historical experience.

Asset Performance

PERFORMANCE TRENDS

Historical pavement performance trends are illustrated in Figure 3-7. It is apparent that the pavement conditions have been slowly declining over the past 15 years. The conditions of Category 1 pavements (which includes all the interstate pavements) have remained fairly stable over the past 15 years, which shows that these pavements have been a clear priority for NDOT. The condition of pavements in Categories 4 and 5 have been declining at a much faster rate, which is testimony to the fact that current funding levels are inadequate to maintain lower priority pavements (to be further discussed in Chapter 6).

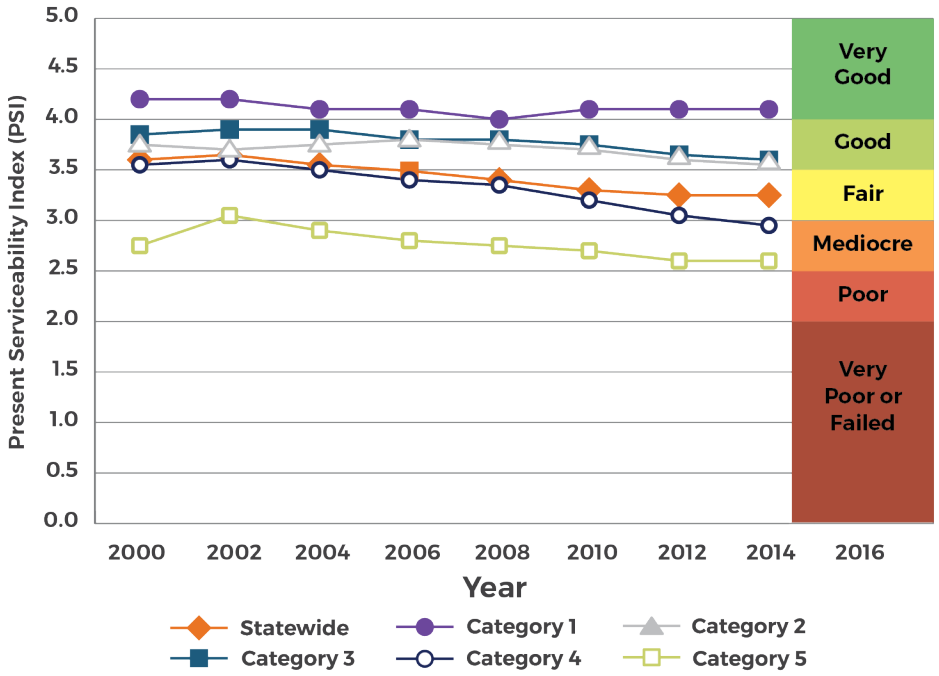


Figure 3-7. Pavement performance trends.

Figure 3-8 illustrates historical bridge condition trends. Bridge condition was fairly stable from 1998 to 2013, but the percent in Good condition has declined recently due to a reduction in the Department's preservation funding and the continuing aging of the inventory. The investment plan in Chapter 6 shows NDOT's proposal to increase the preservation emphasis over coming years to counteract this.

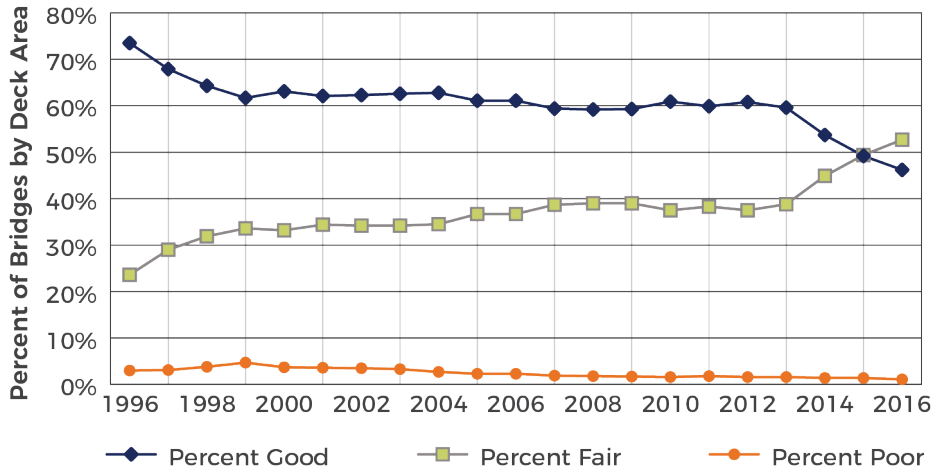


Figure 3-8. Bridge performance trends.

CURRENT CONDITIONS

Table 3-8 summarizes the current conditions of pavements, bridges, and ITS assets.

Table 3-8. Current asset conditions.

Pavements			
NDOT Performance Measures			
Prioritization Category	**% Fair or Better**		
1	99.3%		
2	95.7%		
3	95.6%		
4	69.3%		
5	30.1%		
National Performance Measures			
System	**% Good**	**% Poor**	
Interstate	78%	1%	
Non-Interstate NHS	93%	0%	
Bridges			
National Performance Measures			
System	**% Good**	**% Poor**	
NHS	41.4%	0.6%	
Non-NHS	50.0%	1.3%	
ITS Assets			
Asset Type	**Estimated Condition (Based on % of total asset count)**		
	Good	**Low Risk**	**Medium Risk**	**High Risk**
CCTV	55%	20%	20%	5%
DMS	45%	20%	20%	15%
Flow Detectors	50%	15%	10%	25%
HAR	40%	10%	20%	30%
Ramp Meters	70%	20%	5%	5%
RWIS	5%	15%	10%	70%

The condition of the ITS assets reported in Table 3-8 were estimated based on input from NDOT subject matter experts. NDOT has not formally adopted the ITS performance measures reported in the TAMP; however, NDOT is looking to adopt a performance-based approach for ITS assets in the near future and is actively working on implementing a subset of its EAMS to monitor the inventory, performance, and investments in ITS assets.

FEDERAL PERFORMANCE TARGETS AND PERFORMANCE GAPS

To drive the investments outlined in Chapter 6, NDOT established the performance goals shown in Table 3-9 for pavements and bridges. In addition to establishing these targets to drive NDOT investments, these targets were submitted to the FHWA as NDOT's 2- and 4-year targets as required under the Transportation Performance Management rules and regulations. No performance targets were established for ITS assets at this time. As part of the TAMP process, NDOT evaluated whether there would be any performance gaps at the end of the 10-year period covered in the TAMP. A performance gap is defined as the gap between actual conditions or performance and the targeted performance. As shown in Table 3-9, NDOT does not anticipate any performance gaps on the NHS over the 10-year period covered in the TAMP In addition, NDOT expects to satisfy the minimum condition requirements for pavements and bridges over the next 10 years.

Table 3-9. Targeted 10-year performance results for the NHS.

Pavements			
Performance Goal		**Current Condition**	**Performance Gap**
NDOT Performance Goal	≥75% of Interstate Pavements and ≥40% of Non-Interstate NHS Pavements in Good Condition ≤5% of Interstate and Non-Interstate NHS Pavements in Poor Condition	78% of Interstate Pavements in Good Condition 93% of Non-Interstate NHS Pavements in Good Condition	No Gap
Federally-Mandated Performance Requirement	≤5% of Interstate Pavements in Poor Condition	1% of Interstate pavements and 0% of Non-Interstate NHS Pavements in Poor Condition	No Gap
Bridges			
Performance Goal		**Current Condition**	**Performance Gap**
NDOT Performance Goal	NHS Bridges by Deck Area: ≥35% in Good Condition <7% in Poor Condition	NHS Bridges by Deck Area: 41.4% in Good Condition 0.6% in Poor Condition	No Gap
Federally-Mandated Performance Requirement	NHS Bridges by Deck Area: ≤10% Structurally Deficient	NHS Bridges by Deck Area: 0.6% Structurally Deficient	No Gap

As shown in Table 3-9, in addition to meeting federally-mandated performance requirements for pavements and bridges on the NHS, NDOT also meets the performance goals set internally by the Department. The expected levels of funding and investment strategies that will enable NDOT to achieve its goals are discussed in Chapter 6.

NDOT is in a position where pavements and bridges conditions are favorable and there are no performance gaps. NDOT will continue refining processes and monitoring conditions to meet the goal of maintaining pavement and bridge conditions above the target values.

Asset Value

NDOT has made significant investments to enable transportation of people and goods in a safe and efficient manner. Transportation assets are crucial to the economic vitality of the state. It is critical that NDOT invests in preserving the value of these assets through a whole-life management strategy that extends the service life of these assets. A summary of the current replacement values of the assets included in the TAMP is provided in Table 3-10.

Table 3-10. Summary of current replacement value of assets.

Asset	Current Replacement Value (Approx.)
Pavements	$17.4 Billion
State-Maintained Bridges	$5.4 Billion
ITS Assets (CCTV, DMS, Flow Detectors, HAR, Ramp Meters, RWIS)	$42.2 Million
Total	**$22.84 Billion**

Pavement replacement value based on $1.8 Million per centerline mile for Category 1 and $0.5 Million per centerline-mile for Categories 2-5.

Bridge replacement value based on $400 per sq. ft. and bridge culvert replacement costs are based on $200 per sq. ft.

ITS asset replacement values based on average replacement cost per device: CCTV: $11,500/device; DMS: $95,000/device; Flow Detector: $9,500/device; HAR: $25,000/device; Ramp Meter: $52,500/device; RWIS: $75,000/device.

As an asset ages, its value and functionality gradually decline. In accounting terms, this decrease in value is referred to as depreciation. Monitoring the change in asset value over time is one way of determining whether investment levels in transportation assets are financially sustainable. If an agency is not investing at least as much as its assets are depreciating each year, the assets are losing value and the program is not financially sustainable. The use of value to monitor financial sustainability is gaining momentum nationally. Therefore future NDOT TAMPs may include a comparison between estimated asset depreciation and anticipated investment. ■

Chapter 4. Life-Cycle Planning Considerations

NDOT's goal is to **manage its transportation assets** in a **strategic** and **proactive** manner using the following approaches:

- Designing and constructing durable, long-life assets by applying smart decisions during the planning and design phases.
- Adopting sound maintenance and preservation practices and deploying well-trained maintenance staff to apply the necessary maintenance actions at the right places at the right times.
- Monitoring asset conditions using a performance-based approach to determine preservation needs.
- Taking advantage of proactive preservation opportunities when they arise.
- Minimizing the impact of work zones on the traveling public.

Overview

NDOT's transportation infrastructure is constantly under attack from physical and chemical deterioration; the damaging impact of floods, earthquakes and other hazards; and the normal wear and tear caused by traffic. Infrastructure assets are managed using a whole-life approach that includes planned maintenance and rehabilitation activities to preserve overall performance, to keep the system operating, and to lower costs. Similar to fleet vehicle maintenance through planned oil changes and maintenance that can prevent or reduce severe engine damage, Nevada's transportation assets must be addressed periodically to offset the various forms of deterioration that occur each year.

MANAGING THE INFRASTRUCTURE LIFE CYCLE

Asset management practices help to preserve asset value and minimize the total costs attributable to NDOT's transportation assets by recommending effective treatment strategies for each phase of an asset's whole life cycle (illustrated in Figure 4-1).

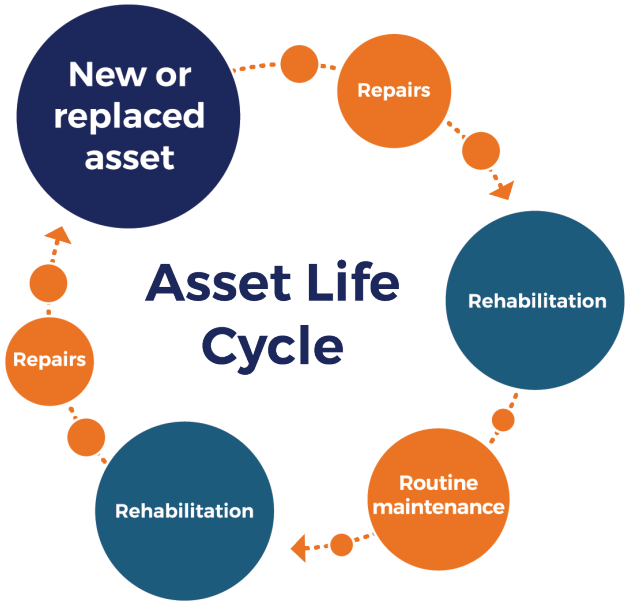


Figure 4–1: Typical asset life cycle phases.

As shown in the figure, each new or replaced asset can require planned activities to extend the life cycle as long as possible. Transportation agencies

often do not have the money to replace assets, therefore, preservation activities to prevent or slow the rate of deterioration are effective ways to lower costs and keep operation of the transportation system at an acceptable level.

This chapter documents the results of the network-level life-cycle planning analysis performed for pavements, bridges and ITS assets. Two strategies were compared: (a) NDOT's existing strategy for maintaining and managing its assets and (b) a worst-first strategy where assets would be replaced as they deteriorate to a Poor condition. NDOT's existing plan for managing pavements, bridges, and ITS assets has been effective in the past; however, anticipated funding levels and an aging system require an increased focus on preservation strategies, especially on the bridge network.

Life-Cycle Planning Analysis

The analysis of different treatment strategies was conducted using a life-cycle planning (LCP) analysis, which considers numerous costs incurred over the service life of an asset. For a comparable basis, the LCP analysis takes into account the numerous costs associated with construction, inspection, maintenance, rehabilitation, and disposal (or retirement) once the service life of the asset has ended. This type of analysis is important because each time NDOT invests in constructing a new road or bridge, or installing a new ITS device, NDOT not only commits to the initial construction costs, but also to the future costs of maintaining and operating that asset over its service life. Over numerous years of the asset's service life, the future maintenance and operational expenditures can be much greater than the initial investment made in the asset. Therefore, it is important to consider current and future costs when planning and budgeting for investment strategies.

In an LCP analysis, the near-term cost of timely preservation, repair, or maintenance action is balanced against the benefit of delaying larger costs farther into the future. This benefit is quantified as a discount rate. All results in this chapter use a discount rate of 2 percent. This is based on 10-year average data from the Bureau of Labor Statistics. The outcome when using the discount rate is to divide rehabilitation costs by a factor of 1+discount rate (e.g., 1.02) for each year that the rehabilitation cost will be delayed. Although it is attractive to delay costs as much as possible and take advantage of the discount rate, there are practical limits. When preservation is delayed, the condition of the system deteriorates each year, eventually having an effect on the serviceability or even the safety of the infrastructure, and necessitating more expensive premature replacement activities.

Certain kinds of preservation actions have higher cost savings, but only when performed at the optimal time. Examples of highly-effective activities that prolong asset life are:

a) Painting a steel bridge before any significant material is lost to corrosion.

b) Applying a chip seal treatment to a pavement in Fair to Good condition.

Delaying the bridge painting and chip seal application activities at some point will result in: (a) too much of the steel rusting, thereby rendering the painting activity ineffective, and (b) the pavement will eventually develop structural distresses and will no longer be suitable for a preventive maintenance treatment. Eventually, a more expensive treatment, such as major rehabilitation or replacement, will be required.

A key goal of an LCP analysis is to find the optimal level of preservation where life cycle costs are kept to an absolute minimum. Conceptually, this "happy medium" point (illustrated in Figure 4-2) exists where maintenance expenditures are neither too frequent nor delayed too long. Typically, a properly maintained pavement or bridge, when maintained at a level that minimizes costs in the long term, is continuously kept in relatively good condition. Over the life of these assets, preservation activities that are optimally timed are estimated to cut life cycle costs roughly in half, compared to a policy where no preservation activities are performed at all.

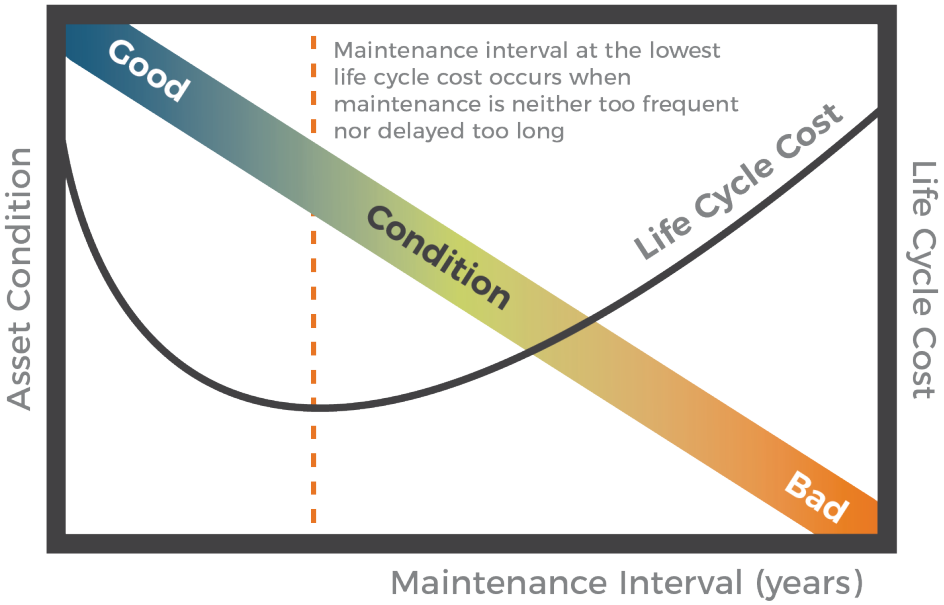


Figure 4-2. Illustration of the life-cycle cost analysis concept.

Figure 4-3. Example of a deteriorated asphalt pavement.

Figure 4-4. Example of deteriorated steel on a bridge girder.

FORECASTING DETERIORATION

All transportation assets deteriorate over time. For example, pavements are damaged by traffic, heavy trucks, freeze and thaw cycles, extreme heat, and moisture in the underlying layers (Figure 4-3). Pavement materials can crack or shrink as they age, thus weakening their structural strength and providing a pathway for water damage. Similarly, bridges are also degraded by corrosion, chemical activity, collisions, metal fatigue, increasing traffic loading, and earthquakes (Figure 4-4).

The causes of deterioration can vary drastically from one site to another and from year to year. To quantify and predict deterioration, engineers use mathematical models. In Nevada, it takes about 25 years for half of any set of bridges to deteriorate from Good condition to Fair condition under normal maintenance. Generally, each year approximately 2.85 percent of bridges transition from Good to Fair condition. Pavements typically transition from Good to Fair condition in approximately 10 to 20 years, depending on the road prioritization category[2].

Figure 4-5 shows a conceptual illustration on how preventive maintenance activities help extend asset life at a fraction of the cost of more extensive treatments by keeping assets in Good condition.

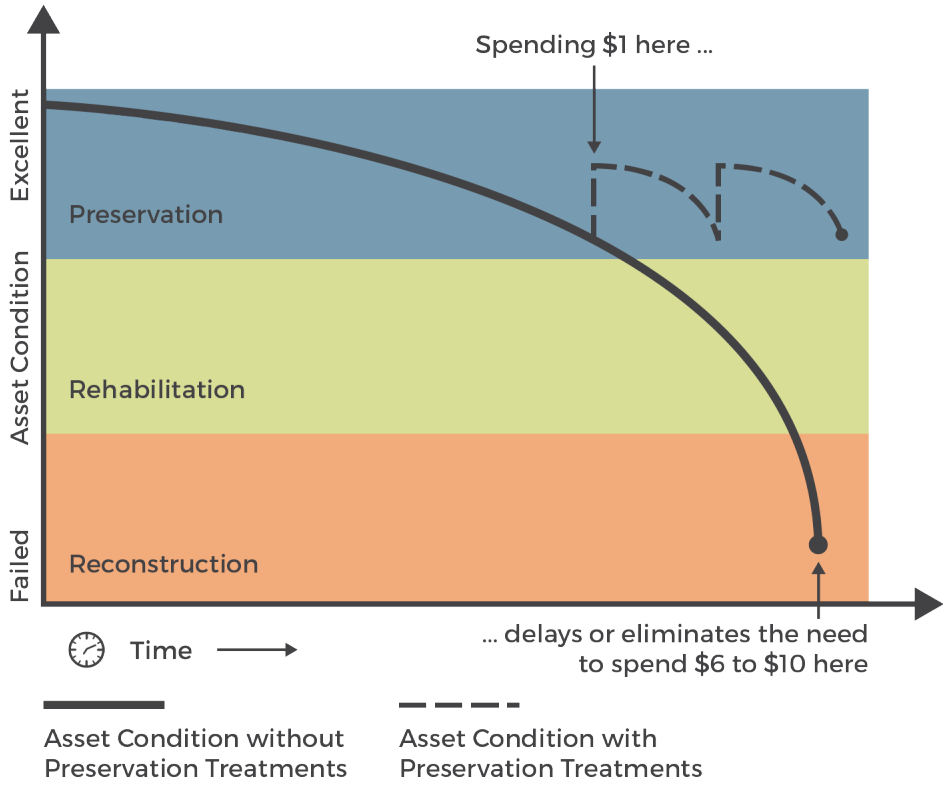


Figure 4-5. Conceptual model of asset deterioration and treatment strategies.

2 Definitions of Good, Fair, and Poor conditions for pavements and bridges are provided in Chapter 3.

NDOT has been improving its ability to forecast asset deterioration rates and developing processes to determine the effectiveness of its maintenance and rehabilitation activities in order to improve its ability to manage assets from a whole-life perspective. Pavement deterioration models have been developed by analyzing historical pavement conditions with pavement age for each road prioritization category. The pavement condition forecasting models used by NDOT's pavement management system are shown in figure 4-6. These models have been developed using historical pavement condition data stored in the PMS. The models use data from pavement segments with ages ranging from 0 to 35 years. NDOT periodically reviews and updates its performance models to improve the accuracy of the pavement condition forecasts.

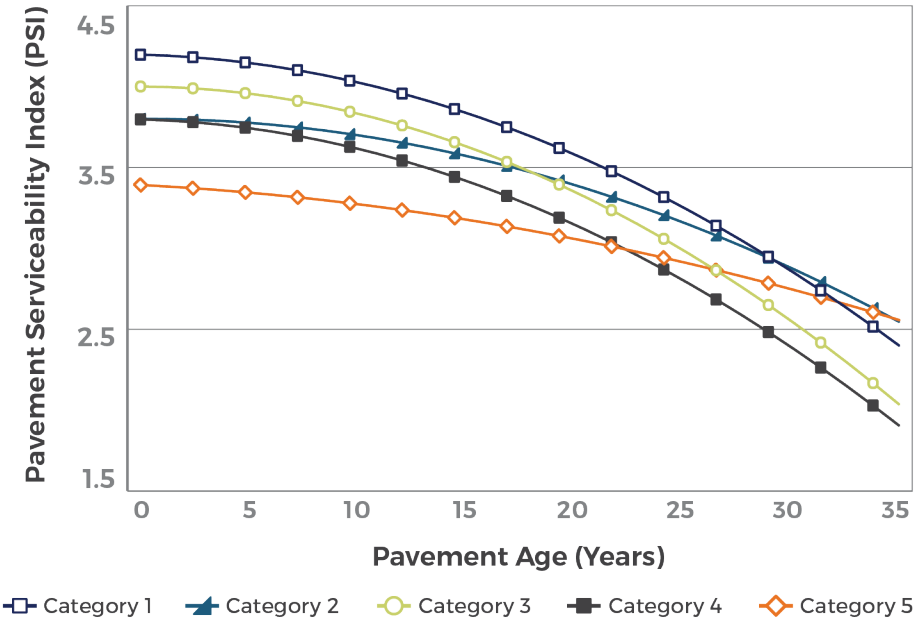


Figure 4-6. Pavement condition deterioration models used by NDOT.

NDOT is currently contracted with Agile Assets to implement new EAMS software. The new asset management system should be implemented in 2020. The ability to forecast bridge deterioration is one of the requirements of this new system. In the absence of an operational BMS, probabilistic deterioration models were developed for use in a spreadsheet tool for analyzing the long-term impacts of different investment options. The models were developed by NDOT's bridge technical experts, based on their experience and judgment, for each class of structures. Transitions in bridge conditions were modeled for four condition states, with and without desired maintenance, orver a 200-year period.

Life-Cycle Management of Pavements

Pavement performance is a function of several parameters, as discussed in Chapter 3. As pavement ages, the ride quality gradually deteriorates and surface conditions exhibit distress in need of repair. Different types of pavement distresses require different types of repair. For instance, some distresses don't change significantly over time and can be addressed with relatively minor repair strategies. Pavements with more significant distress, or distress types that show signs of structural damage, indicate the need for more substantial rehabilitation actions due to increased traffic volumes, heavy trucks, or inadequate thickness.

NDOT uses many types of treatments to address pavement performance issues and the various distresses. These treatments fall under the general FHWA descriptions of Maintenance, Preservation, Rehabilitation, and Reconstruction, as listed below:

- **Maintenance:** Maintenance describes work that is performed to maintain the condition of the transportation system or to respond to specific conditions or events that restore the highway system to a functional state of operation. Maintenance is a critical component of an agency's asset management plan that is comprised of both routine and preventive maintenance. Preventive maintenance is a cost-effective means of extending the useful life of the Federal-aid highway.
- **Preservation:** Preservation consists of work that is planned and performed to improve or sustain the condition of the transportation facility in a state of good repair. Preservation activities generally do not add capacity or structural value, but do restore the overall condition of the transportation facility.
- **Rehabilitation:** Rehabilitation includes more substantial repairs that are applied when the pavement in is Fair or Poor condition to repair the structurally- or functionally-deficient section and provide a new surface that improves the pavement's ability to carry traffic loads
- **Reconstruction:** Reconstruction includes any pavement repair that completely disturbs the top surface of the pavement and reaches or penetrates to the aggregate base surface.

Table 4-1 summarizes the types of treatments used on various road categories along with their costs.

NDOT uses maintenance and preservation strategies **to extend a pavement's service life** to defer the need for rehabilitation.

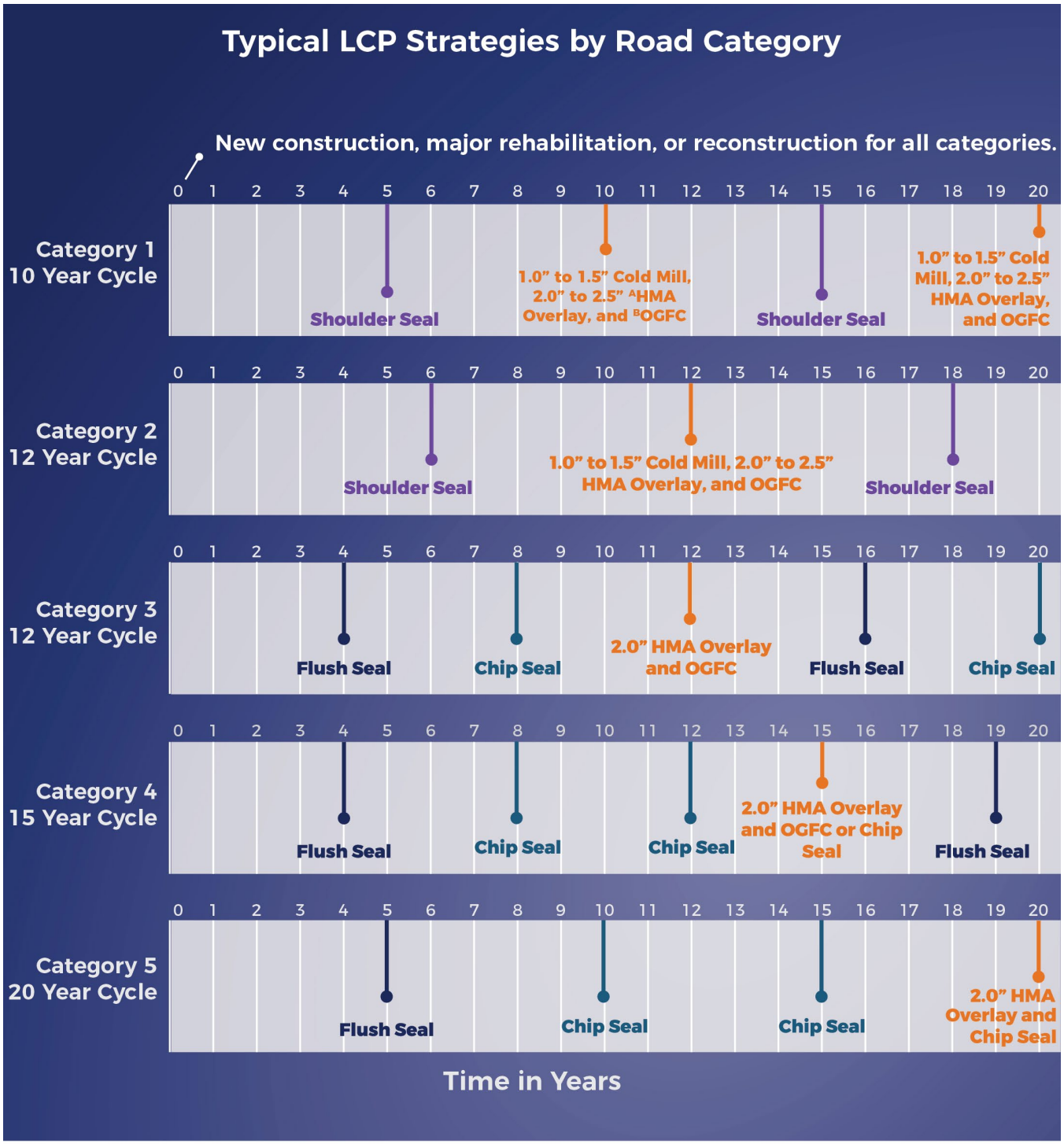
This cost-effective strategy reduces the overall cost of maintaining the road network and demonstrates the Department's efforts to use taxpayer money wisely.

Table 4-1. Treatments used by NDOT.

Treatment Types	Road Category	Cost ($/lane-mile)
Crack Seal[1]	3, 4, 5	$100,000 to $300,000
Scrub Seal[1]	3, 4, 5	$100,000 to $300,000
Chip Seal[1]	3, 4, 5	$100,000 to $300,000
Microsurfacing[1]	2	$200,000 to $400,000
Asphalt Mill and Overlay (1–2 in)[1]	1	$900,000 to $1.3 million
	2	$800,000 to $900,000
	3, 4, 5	$200,000 to $500,000
Diamond Grinding, Spall Repairs[2]	1	$400,000 to $800,000
Asphalt Mill and Overlay (3–5 in)[1]	1	$1.9 to $2.3 million
	2	$1.4 to $1.8 million
	3	$800,00 to $1.2 million
	4	$800,000 to $1.2 million
	5	$600,000 to $800,000
Slab Repairs, Dowel Bar Retrofit[2]	1	$1.2 to $1.8 million

1 Treatments on asphalt-surfaced pavements
2 Treatments on concrete-surfaced pavements

Figure 4-7 summarizes the typical treatment cycles for the pavements maintained by NDOT. It is to be noted that the treatment types shown in the figure are purely for illustrating typical practices. While the average treatment timing is expected to be the same as indicated in the figure, the treatment types may vary based on pavement type and roadway category.



[A] HMA Overlay = Hot Mix Asphalt Overlay

[B] OGFC = Open-graded Friction Course

Figure 4–7. Illustration of treatment scenarios over a 20-year period for each road category.

NDOT uses a pavement management system (PMS) to program appropriate pavement maintenance and rehabilitation treatments based on the distresses observed and the overall pavement condition in terms of PSI. Pavements with a PSI rating of 3.5 or more (on a 5-point scale) are typically suited for maintenance and preservation activities. Pavements with a PSI rating of less than 3.5 are suited for structural overlays or other rehabilitation activities (illustrated in Figure 4-8).

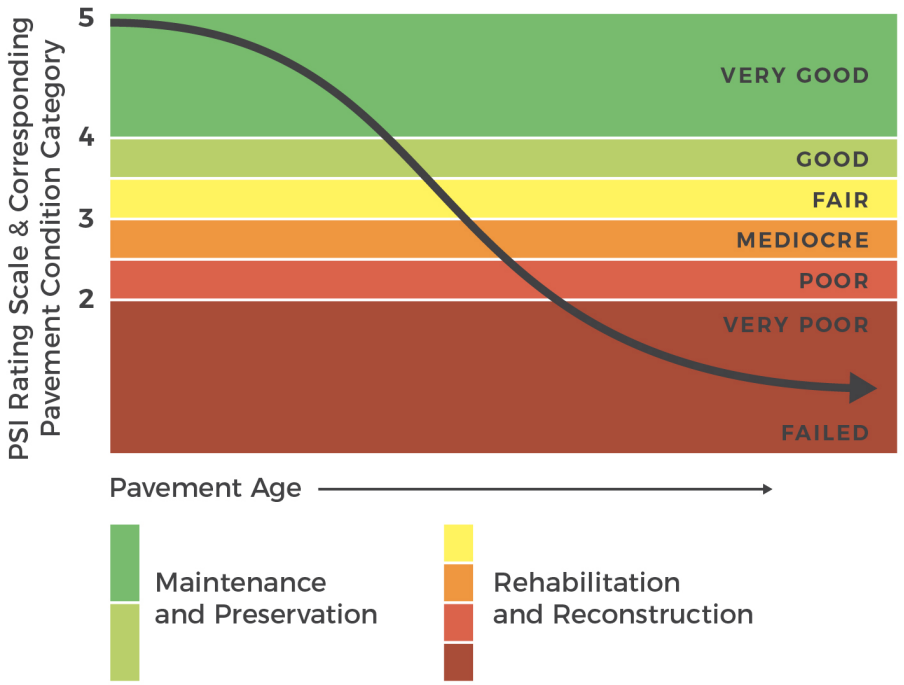


Figure 4-8. Illustration of a typical pavement deterioration curve and selection of repair strategies based on the PSI Rating.

For the LCP analysis, the two scenarios listed below were analyzed using actual data and NDOT's pavement management models.

- **Scenario One:** The fundamental repair strategy illustrated in Figure 4-7 was applied. This strategy includes maintenance and preservation activities for pavements in Good or Better condition and rehabilitation activities for pavements in Fair or Worse condition. To determine the amount of work conducted each year, the average annual maintenance or repair work typically performed by NDOT was applied to current and projected conditions within each road category (using the performance models shown earlier in Figure 4-6).

The projections were provided by the pavement management system.

- **Scenario Two:** A "worst-first" strategy in which pavements are not repaired until they reach a Poor condition was applied. In this scenario, current and projected pavement conditions were used to determine when rehabilitation activities would be needed. For both scenarios, a 60-year analysis period and a 2 percent discount rate were used in the analysis.

A comparison of the results for the two life-cycle management strategies is presented in Figure 4-9. As the figure illustrates, it is much more cost effective to continue using NDOT's current preservation strategy than to defer treatment until more substantial repairs are needed. The Department's current preservation strategy enables the agency to keep its roads in the best condition possible for the available funding. Over a 60-year period, it is estimated that NDOT's preservation strategy will have reduced life cycle costs by approximately $8.7 billion dollars over the "worst-first" strategy[3].

The preservation approach adopted by NDOT is expected to result in a life-cycle savings (based on a 60-year analysis period) of approximately $8.7 billion over a worst-first approach.

This translates to an average **annual savings of approximately $145 million.**

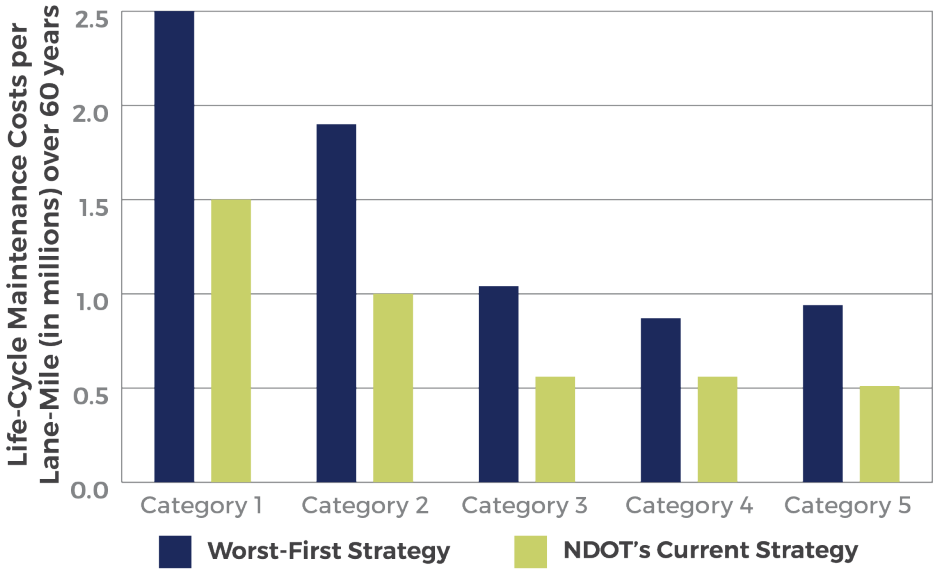


Figure 4-9. Summary of pavement life-cycle planning analysis results.

It should be noted that the existing financial environment at NDOT will affect the proactive policy of applying maintenance preservation activities for pavements in a Good or Better condition. Due to financial constraints, a combination of proactive and "worst-first" strategies may have to be employed. This is discussed in more detail in Chapter 6.

3 The number of lane-miles of pavement in each road prioritization category used in the LCP analysis are as follows: Category 1: 3445; Category 2: 2758; Category 3: 2790; Category 4: 3118; Category 5: 1724. These lane-mile figures were multiplied by the life-cycle costs for each of the respective roadway categories (shown in Table 4-1) to compute the total life-cycle cost (for a 60-year analysis period) for the entire pavement inventory for both the strategies evaluated. For the worst-first strategy, the total life-cycle costs add up to $20.1 billion dollars. For NDOT's current strategy, the total life-cycle costs add up to $11.4 billion dollars. Hence, the net savings of using the preservation scenario over the worst is approximately $8.7 billion dollars.

Bridge preservation activities, performed on a 15-25 year interval, can postpone the much larger $4.6 million that it typically costs to replace a bridge, potentially **doubling its life** based on industry experience.

An increase in preservation to 64% of current bridge capital spending would yield a 10 time return on investment by postponing bridge replacement, according to the life-cycle planning analysis.

Life-Cycle Management of Bridges

Bridges are subject to corrosion, cracking, and other damage caused by weather, traffic, and age, so they require regular corrective action to keep them in a state of good repair. Bridge repair needs are identified by inspectors in the field and documented as a part of each bridge's biennial inspection report. Each district compiles its program of capital projects from the inspection results.

In most cases currently, the programming of bridge work has been "worst first" based on condition ratings. As the average age of bridges in the NDOT inventory approaches 50 years, the percentage of the inventory in Good condition has recently been declining, signaling the need for more emphasis on preservation to extend bridge lifespans. By means of its district forces and contractors, NDOT has a variety of bridge preservation capabilities at its disposal:

- Patching of concrete.
- Repair of corroded steel.
- Spray liners and paving of culverts.
- Replacement of bridge decks.
- Installation or replacement of deck waterproofing systems.
- Replacement or patching of deck wearing surfaces.
- Spot painting or total repainting.
- Sealing and repair of expansion joints.
- Repair or replacement of bridge bearings.
- Placement of rip rap or other slope and stream bank protection.

To analyze the potential size and benefit of a more comprehensive preservation program, NDOT conducted a network-level LCP analysis. The analysis was conducted using a sophisticated spreadsheet tool that uses a model of bridge deterioration, preservation unit costs, and preservation effectiveness developed by NDOT's bridge technical experts, based on their experience and judgment, for each class of structures. Starting with current bridge inventory conditions, the model is able to forecast future conditions and evaluate the cost and benefit of each work type across the whole life of the bridge population, to quantify the amount of preservation and replacement work required at each condition level.

The life cycle cost and investment model allows NDOT to forecast bridge conditions 10 years in the future under fiscal constraints, and to design a preservation program that can meet 10-year targets. All of the bridges in

NDOT's bridge inventory (both state-maintained and locally maintained) are included in the analysis.

Across the Nevada bridge inventory, and if no maintenance is performed, the model estimates that the median time from new to Poor condition is about 51 years. NDOT currently experiences a median lifespan of 62 years for bridges as currently constructed and maintained. The model estimates that a median life of 70 years or more may be possible under an expanded preservation program. Figure 4-10 compares these scenarios. Each bridge receives preservation work on average once each 20 years, and this causes a significant improvement in condition, especially to protective systems such as expansion joint seals, deck wearing surfaces, and coatings. These help the structural components of the bridge to last longer.

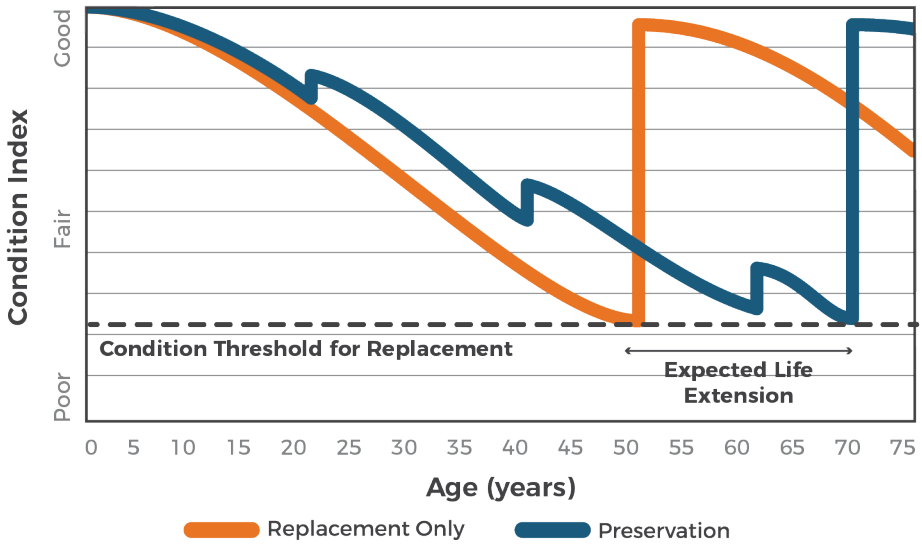


Figure 4-10. Bridge life extension achievable with increased emphasis on preservation.

Chapter 6 provides detail on the Department's financial forecasts and the condition levels that the model found to be achievable under the proposed preservation program.

In the future, bridge LCP will be performed with the BMS included in the new EAMS software. The new BMS will model deterioration of the individual bridge elements of the bridges in the NDOT inventory, and compute life cycle cost of alternative strategies. The new BMS will use the cost and effectiveness data of various maintenance and repair strategies to develop an optimized bridge preservation plan. NDOT will be able to analyze various groups of bridges, time frames, and investment scenarios

to forecast the resulting future bridge conditions for each scenario. The new BMS will allow NDOT to develop specific projects and maintenance activities to meet the Department's performance targets at the lowest cost.

Over a 20-year period, NDOT's current strategy for maintaining and managing ITS assets results in an average savings of approximately **$1.1 million (56 percent)** over a "worst-first" strategy.

Life-Cycle Management of ITS Assets

As described in Chapter 3, ITS assets do not have performance measures that have been formally adopted by NDOT. For the purposes of the TAMP, the conditions of the ITS assets were based on the device manufacturer's recommended service life as described below:

- **Good:** Age of the device is less than 80 percent of the manufacturers' recommended service life.
- **Low Risk:** Age of the device is between 80 to 100 percent of the manufacturers' recommended service life.
- **Medium Risk:** Age of the device is between 100 to 125 percent of the manufacturers' recommended service life.
- **High Risk:** Age of the device is greater than 125 percent of the manufacturers' recommended service life.

A simple condition transition probability matrix was developed for each ITS device included in the TAMP (discussed in Appendix B). These transition matrices were used to model the deterioration of ITS assets based on expert opinion provided by NDOT. The matrices describe the time required for the device to deteriorate from one condition state to another (e.g., Good to Low Risk), with an inherent assumption that there is a 50 percent probability that devices would deteriorate to the lower condition categories after the time period established in the transition matrix. Two separate transition probability matrices were developed:

a) Using the preservation approach adopted by NDOT.

b) Using the "worst-first" strategy (purely for comparison purposes).

Detailed descriptions specific to each ITS device discussed in the TAMP are included in Appendix B. Brief descriptions of the inspection and maintenance activities performed on ITS devices are provided on the following page.

- **Inspection:** Involves routine maintenance of the device or asset by NDOT typically performed annually or biannually based on type of device.
- **Minor Repairs:** Typically performed on site and these include activities such as adjusting loose cables, battery replacement, firmware upgrades.

- **Major Repairs:** Typically requires the device to be sent back to the maintenance shop or factory for repairs and involves the replacement of one or more key parts to ensure satisfactory device functioning.
- **Replacement:** Involves complete removal and replacement of the device.

The impact of the type of maintenance activity on the existing condition states are shown in Table 4-2. For instance, an ITS asset in Good condition requires only periodic inspection. If the results of the inspection indicate that the asset is a Low Risk, minor repairs could be applied to bring that asset back up to Good condition. Similarly, if an ITS asset is a Medium Risk, major repairs could improve the status to Low Risk. Finally, an asset that is High Risk can either be converted to a Medium Risk with major repairs or could be returned to Good condition if replaced.

Table 4-2. Maintenance activity impact matrix.

Current Condition	Resulting Condition After			
	Inspection	Minor Repair	Major Repair	Replacement
Good	Good			
Low Risk	Low Risk	Good		
Medium Risk	Medium Risk	Medium Risk	Low Risk	
High Risk	High Risk	High Risk	Medium Risk	Good

An LCP analysis was conducted to determine the effectiveness of NDOT's current ITS asset maintenance strategy over a "worst-first" approach where the devices would receive no minor repairs or maintenance and would simply be replaced after they fail. A 20-year analysis period and a 2 percent discount rate were used in the analysis. A comparison of the two life cycle management strategies shows the annual maintenance cost per device (in 2015 dollars, excluding initial installation costs) as presented in Figure 4-11. As in the previous examples, NDOT's maintenance strategy costs considerably less than the worst-first strategy.

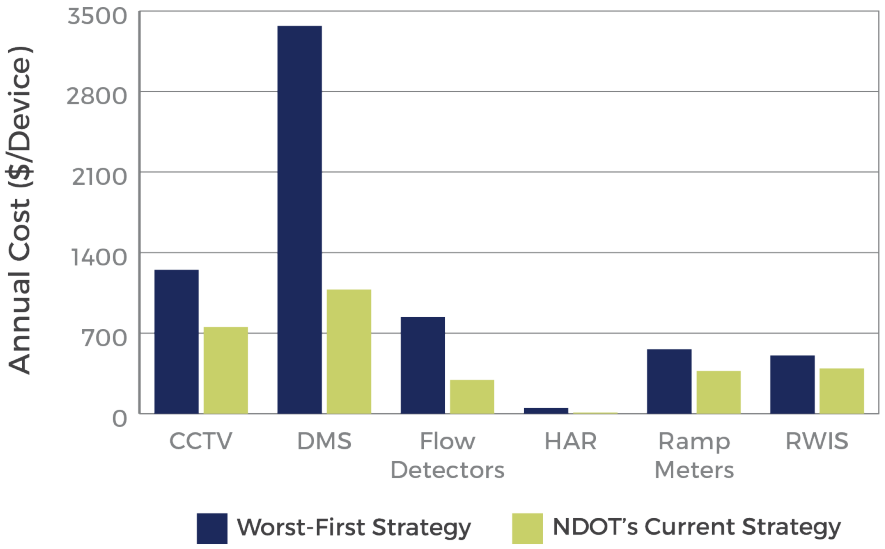


Figure 4-11. Summary of ITS asset life-cycle planning analysis results.

Summary

The overarching purpose of conducting a network-level LCP analysis is to explore the most cost-effective, long-term investment strategies to keep the infrastructure in serviceable condition. As shown in the analysis presented in this chapter, the planned use of preventive maintenance or preservation treatments on assets that are in relatively good condition is significantly more cost effective than other strategies that defer treatment until significant amounts of deterioration are present. NDOT has employed a preservation strategy for maintaining its pavement assets for years and is proposing to increase the allocation of available funds to bridge preservation to slow the observed decline in the percentage of Good condition bridges and minimize life cycle costs. For ITS assets, there have been efforts to inspect and repair or replace; however, the strategy is not fully developed. NDOT will continue with its proactive preservation strategies for the 10-year period addressed in this TAMP.

The LCP analysis also provided an opportunity to explore the future maintenance costs of new roads, bridges, or ITS assets when added to the system. The expenditure of $1M towards a new road carries with it a commitment of approximately $200,000 to $460,000 in future discounted costs. A $1M expenditure for new bridges will require a future expenditure of $7000/year to maintain the bridge ($20,000/year to maintain and replace in the future.) ■

Chapter 5. Risk Management

Overview

Risk is typically defined as the "effect of uncertainty on objectives."[4] Risks can have positive or negative effects on agency objectives and they are more than just threats to the effective functioning of an organization. Acknowledging, understanding, and managing risks associated with transportation assets can help agencies plan for potential system disruptions, manage and mitigate impacts and consequences, and improve the resilience of the overall system. Risk Management is the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events.[5]

Because of the importance of understanding risks to the organization and the services it provides, the development of a TAMP typically involves an assessment of key risks that could impact the Department's ability to achieve the 10-year performance outcomes that have been established (discussed in Chapter 6). The primary objectives of the risk management analysis conducted by NDOT were to:

- Articulate the story behind what does, or what could, potentially impede NDOT's asset management objectives.
- Illustrate uncertainties that NDOT must address to achieve its long-term goals.
- Identify decisions that could potentially damage the public's perception of NDOT.
- Prioritize investments to mitigate risks.

RISKS ASSOCIATED WITH TRANSPORTATION ASSETS

NDOT strives to provide a safe, functional transportation system that provides the highest possible level of service within funding constraints. However, unexpected or unplanned events, such as an adverse economic climate and external hazards (such as floods, storms), can prevent an agency from meeting its goals. Other factors for some assets, such as the lack of reliable performance data or forced workforce reductions, will impact an agency's ability to anticipate and plan for risks. Some examples of the types of factors that impact risks of particular concern to transportation agencies are shown in Figure 5-1.

Some risk factors can be managed by analyzing historical records, monitoring changes, and improving the quality of the data used to predict their likelihood. However, the data can be unduly expensive to monitor or may require technology that is not readily available. Even so, risk management strategies can be identified to:

Build staff and public awareness.

Align investments with risk-mitigation techniques.

Prioritize risk-prone assets for replacement or mitigation.

Collaborate with partners and stakeholders on ways to reduce or jointly manage risks.

4 International Organization for Standardization (ISO). 2009. Risk Management. ISO Standard 31000. International Organization for Standardization, Geneva, Switzerland.

5 Hubbard, D. W. 2009. The Failure of Risk Management: Why It's Broken and How to Fix It. John Wiley and Sons, Hoboken, NJ.

Figure 5-1. Transportation-related risk factors.

These factors, and the risks that result, can have significant consequences to an agency, including:

- Personal injury
- Loss of life
- Private property damage
- Infrastructure damage
- Harm to public health
- Harm to agency reputation
- Traffic congestion
- Loss of access, detours, delays
- Loss of economic activity
- Harm to the environment
- Litigation and liability loss
- Resource wastage

Risk Management Analysis

A comprehensive risk analysis considers risks at all levels of the organization. As shown in Figure 5-2, risks can be broadly classified into three levels: agency, program, and project. Agency risks (e.g., funding issues and climate change impacts) refer to the risks at the highest level within the organization that impact the DOT's ability to accomplish its strategic goals and objectives. Program risks (e.g., shortage of workforce) affect a group of similar projects to address pavement needs. Project risks (e.g., premature asset failure or poor contract execution) are specific to individual projects.

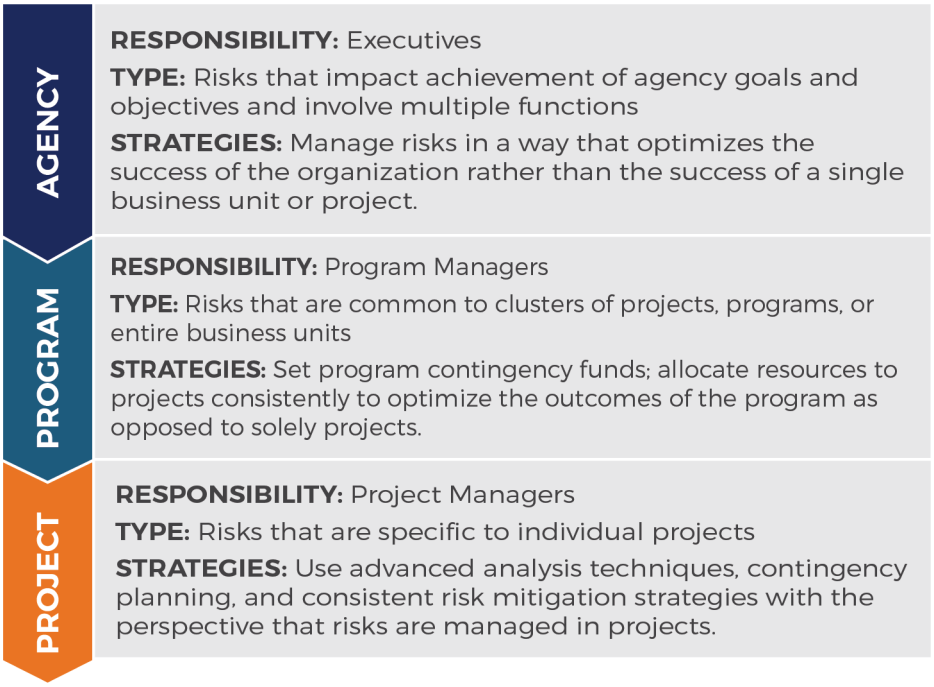


Figure 5-2. Types of risks.[6]

The analysis conducted as a part of the TAMP development efforts focused on agency and program risks because NDOT handles project-level risks separately. Guidelines for managing project-level risks and for estimating risk-based construction costs have already been developed.[7] NDOT is currently in the process of developing a formal Enterprise Risk Management (ERM) program that builds on the risk assessment conducted as part of the TAMP development and further emphasizes the importance of a structured, disciplined, and consistent approach to risk management that facilitates risk-informed decision-making throughout the agency.

Both the risk assessment conducted for the TAMP and the proposed ERM program follow the risk management process developed by the International Organization on Standards (ISO), shown in Figure 5-3. The steps that were taken for the TAMP risk are listed in Figure 5-4 and the results of the analysis are described in this chapter. Additional information on the ERM framework is also provided.

6 Federal Highway Administration (FHWA). 2012. Risk-based Asset Management: Examining Risk-based Approaches to Transportation Asset Management: Report 2: Managing Asset Risks at Multiple Levels in a Transportation Agency. FHWA-HIF-12-050. Federal Highway Administration, Washington, DC.

7 Nevada Department of Transportation (NDOT). 2012. Risk Management and Risk-Based Cost Estimation Guidelines. Nevada Department of Transportation, Carson City, NV.

Figure 5-3. Risk management process (ISO 31000:2009).

Set Context	Identify asset management goals, objectives and risks Develop likelihood and consequence ratings
Identify Risks	Identify risks
Analyze Risks	Rank and prioritize risks and assign likelihood and consequence ratings
Evaluate Risks	Develop risk management strategy Identify costs involved, time frame for implementation, responsibilities
Treat Risks	Act and communicate plan
Monitor	Update and improve

Figure 5-4. NDOT's risk management analysis framework.

RISK TYPES AND MITIGATION STRATEGIES

During the risk analysis process, NDOT representatives were asked to identify the various types of risks that could impact their program. For each risk, potential areas of concern were identified and possible mitigation strategies were developed. The results of this process are presented in Table 5-1.

Table 5-1. Types of risks and mitigation strategies.

Risk Type	Areas of Concern	Possible Mitigation Strategies
Financial	Is future funding adequate to achieve targets? What is the impact of inflation on purchasing power?	Demonstrate funding shortfalls Communicate uncertainty in achieving targets due to funding fluctuations Emphasize trade-offs, such as lower levels of service to be accepted Justify and seek additional funding
Information	Do we have tools to predict and manage asset conditions for next 10 years?	Fill data gaps Improve tools and management systems
Asset	Are key assets such as poor performing pavements or bridges a continuing risk to asset management targets? Are specific functional classes particularly vulnerable?	Prioritize assets for funding, treatment, and monitoring using an objective, data-driven approach
Program	Is our project delivery mechanism reliable enough to meet condition targets? Do we have a sound preventive maintenance program? Do we have sound contracting mechanisms to ensure material and construction quality?	Improve internal processes
Decision	Does our project selection process identify appropriate candidates and treatments?	Improve project selection approach and adopt a whole-life approach to preserve, maintain, and manage assets
Climate	Will increased climate-related events have a noticeable impact on asset conditions or level of service?	Conduct climate vulnerability and impact studies Emphasize robustness, resiliency, redundancy

There are several different approaches that can be taken to address risk that vary in terms of cost and the amount of residual risk that remains. In general, risk mitigation strategies can be classified into the following categories:

- **Terminate:** Eliminate threat posed by the risk.
- **Transfer:** Shift risk to third party.
- **Treat:** Take steps to reduce probability and/or impact of risk.
- **Tolerate:** Deal with the risk and monitor it for changes.
- **Take Advantage:** Use it as an opportunity to seek external funding or partnership.

RISK RATINGS

NDOT developed likelihood and impact ratings to rate and prioritize each risk identified (shown in Table 5-2 and Table 5-3).

Table 5-2. Risk likelihood ratings.

Ranking	Likelihood	Frequency	Score
Almost Certain	Near Certainty (90-100%)	Likely to occur within the year	5
Likely	Highly Likely (70-90%)	Likely to occur within two years	4
Moderate	Likely (30-70%)	Likely to occur within 3 to 5 years	3
Unlikely	Unlikely (10–30%)	Likely to occur within 6—10 years	2
Rare	Remote (<10%)	Not likely to occur for 10 or more years	1

Table 5-3. Risk impact ratings.

Impact	Score
Catastrophic Impact on System Performance	5
Major Impact on System Performance	4
Moderate Impact on System Performance	3
Minor Impact on System Performance	2
Insignificant Impact on System Performance	1

BRIDGE RISKS

The BMS currently in development as part of new Enterprise Asset Management software will quantify the risk to each bridge in the inventory under they five key areas of risk. The new BMS will estimate the annual risk value due to earthquake, flood, steel fatigue and overload, concrete overload, and vehicular collision. The estimated risk value from the five types of events will be combined to provide an estimated value of annual risk for each bridge and the entire inventory. The value of the individual risks will be evaluated against possible mitigation strategies to make cost-benefit comparisons. The value of the total risk will be included in bridge replacement evaluations.

Risks to Nevada's Transportation Assets

The primary risks to Nevada's transportation assets were identified through a collaborative process involving Front Office personnel and representatives from the pavement, bridge, and ITS asset work groups.

A risk heat map (shown in Table 5-4) was used to assign an overall risk rating based on the likelihood of that event occurring and the magnitude of its impact. One or more risk management/mitigation strategies were developed for each risk to help reduce NDOT's potential exposure.

Table 5-4. Risk heat map.

Likelihood Ratings and Risk Levels					
Impact Ratings	**Rare (1)**	**Unlikely (2)**	**Moderate (3)**	**Likely (5)**	**Almost Certain (5)**
Catastrophic (5)	Low	Medium	High	Extreme	Extreme
Major (4)	Low	Medium	High	High	Extreme
Moderate (3)	Low	Low	Medium	High	High
Minor (2)	Very Low	Low	Low	Medium	Medium
Insignificant (1)	Very Low	Very Low	Low	Low	Low

The results of the risk management analysis are presented in the risk register shown in Table 5-5. These risks will be monitored on a regular basis as part of the ERM program and the risk register will be updated periodically to help ensure that the significant risks are mitigated or managed.

Table 5-5. NDOT's asset management risk register.

What is the Risk?	Risk Rating			What are Likely Causes?	What are the Consequences?	How Will NDOT Deal With It?
	Likelihood	Impact	Overall Risk Rating			
Increase in regulations could result in increased investment needs	5	3	High	Federal and State policy changes or mandates such as: · Installation of assets on historical lands · Air and water quality considerations	· A significant increase in investment needs on individual projects · Increase in staff time commitment to address issues	· Monitor regulation changes and determine impacts on project selection and funding · Participate in national organizations such as AASHTO to stay informed on regulatory issues
Volatility in material and construction prices could reduce the accuracy of NDOT's needs estimates	3	3	Medium	· Economic inflation · Political or economic changes · Uncertainties in cement and asphalt production quantities and costs	· Fewer projects being funded · Increasing complaints from the traveling public	· Prioritize projects within available funding based on agency goals · Monitor prices regularly and revise condition projections and performance targets accordingly
Lack of data and analytical tools	3	2	Medium	· Failure to implement an asset management system · Uncertainty in asset performance and service life	· Inability to prioritize and deliver projects · Inability to maintain assets at lowest life cycle cost	· Develop a process to prioritize projects within available funding based on agency goals · Implement asset management software to improve the decision process and better understand investment options
Loss of experienced workers	3	3	Medium	· Staff retirements · Staff moving to new positions within the Department · Issues with hiring and/or training staff · Demand on staff time	· Loss of institutional knowledge · Lack of experienced personnel to assess work quality · Inability to collect and process asset performance data · Inadequate resources to address all NDOT needs	· Conduct succession planning · Identify and conduct training for current NDOT staff · Develop and maintain documents describing procedures and practices · Improve quality management skills of current NDOT staff
Leadership, organizational changes, and restructuring within NDOT could result in a drastic change to current goals and priorities	3	3	Medium	· Fiscal shortages · Political factors	· Significant changes to existing goals and priorities · Need to revisit current procedures and protocols for data collection, processing, and analysis · Need to develop new prioritization strategies to program projects	· Eliminate subjectivity in decisions by improving transparency

Table 5-5. NDOT's asset management risk register (continued).

What is the Risk?	Risk Rating			What are Likely Causes?	What are the Consequences?	How Will NDOT Deal With It?
	Likelihood	Impact	Overall Risk Rating			
Increase in extreme weather, and other natural events will result in significant asset damage	2	3	Low	· Changes in weather and climate patterns	· Asset damage and mobility issues · More frequent asset repairs or replacement needs · Reduction in funding available for other planned activities · Reduction in staff available to perform other daily activities due to utilization of resources in emergency response · Data sharing and connectivity issues	· Maintain emergency response plans · Conduct flood and earthquake vulnerability assessment study to identify and prioritize specific locations · Monitor asset deterioration rates over a long time period
Increase in man-made hazards (such as overloads, overheight truck collisions, and tanker truck fires) will contribute to asset damage or failures	3	2	Low	· General increase in truck traffic volumes · Vandalism and theft	· Increase in asset condition deterioration rates · Significant increase in investment needs impacting specific projects	· Monitor and assess additional needs annually · Maintain emergency response plans and ability to reprioritize quickly · Increase security by installing more CCTV cameras
NDOT's transportation assets will deteriorate prematurely	2	3	Low	· Missing or unreliable condition prediction models · Inadequate oversight during construction · Poor material quality · Lack of preventive maintenance at appropriate times	· A significant increase in investment needs to stretch projects · Substandard performance not meeting NDOT and customer requirements · Safety issues due to the lower level of service provided · Increasing complaints from the traveling public · Degradation of NDOT's reputation	· Adopt performance-based specifications · Increase accountability · Develop asset condition prediction models (where needed) and periodically evaluate the accuracy of models and adjust (as required)

SPECIAL REQUIREMENTS FOR PERIODIC EVALUATION OF FACILITIES REPEATEDLY REQUIRING REPAIR AND RECONSTRUCTION DUE TO EMERGENCY EVENTS

One of the requirements under 23 CFR Part 667, *Periodic Evaluation of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events*, necessitates the conduct of a periodic statewide evaluation of the State's existing roads, highways, and bridges on the NHS that have repeatedly required repair or reconstruction on two or more occasions from emergency events declared by the Governor or the President of the United States.

In response to this provision, NDOT has completed an evaluation of the repair and reconstruction events that have been undertaken as a result of emergency events that have occurred since January 1, 1997. It has been determined that, to the best of their knowledge, no road, highway, or bridge on the NHS has required repair or reconstruction on two or more occasions due to emergency events. Moving forward, NDOT will adopt the process outlined in Figure 5-5 to support the 23 CFR Part 667 requirements.

Documentation	After an emergency event has been declared, the NDOT Operations Division will assess the situation and evaluate the damage on roads, highways, and bridges on the National Highway System. Once the situation has been assessed, a Detailed Damage Inspection Report (DDIR) will be completed and submitted to the FHWA. The DDIRs will be input into a GIS system for documenting the location, asset(s) damaged, and extent of damage.
Evaluation	NDOT will check for recurring events at a particular location using the GIS database. If recurring events (more than two events at a given location) are identified, NDOT will develop an action plan for addressing the issue.
Implementation	Asset managers will meet with subject matter experts to evaluate the most suitable repair and rehabilitation strategies. A funding request will be submitted to the appropriate authorities. The selected repair and rehabilitation strategy will be communicated to the responsible parties. The permanent repairs will be documented in the GIS database for future assessments.

Figure 5-5. Business process to support 23 CFR Part 667 requirements.

NDOT will actively monitor the spending due to emergency events and determine if a statewide vulnerability assessment study is required to identify assets and locations that are more prone to damage due to these events in order to develop a long-term strategy for improving the resilience and sustainability of its transportation infrastructure. If a vulnerability assessment is determined to be required, the Operations Division will lead this effort and coordinate with other divisions within NDOT to initiate and execute the effort.

NDOT DIVISIONS RISK OWNERS

- Accounting
- Administrative Services
- Agency Risk Management
- Audit Services
- Civil Rights—External
- Civil Rights—Internal
- Construction Division
- Design Division
- Director's Office
- District 1
- District 2
- District 3
- Environmental Services
- Equipment Division
- Financial Management
- Flight Operations
- Human Resources
- Information Technology
- Location
- Maintenance and Asset Management
- Materials Division
- Performance Analysis
- Program Development
- Project Management
- Public Information Office
- Research
- Right Of Way
- Roadway Systems
- Safety and Loss Control
- Safety Engineering
- Stormwater
- Structures Division
- Traffic Information
- Traffic Operations
- Training
- Transportation and Multimodal Planning

CONSIDERING RISKS AT THE ENTERPRISE LEVEL

NDOT recognizes the importance of evaluating and managing uncertainties that could impact its ability to execute its mission. To ensure that risks are considered consistently throughout the agency, and to ensure that risks are monitored regularly, NDOT has embarked on the implementation of an ERM program that extends the risk analysis conducted for the TAMP to a broader array of strategic, program, project, and activity risks. Risk registers are developed by risk owners at each level and reviewed quarterly so changes are monitored. Risk owners are responsible for reporting upward to senior management and laterally to peers if risks to his or her area could affect other objectives, programs, projects, or activities. Communication is expected to be both continuous and effective. A summary of risk owners at the Division and Delivery Program levels are shown in Figure 5-6.

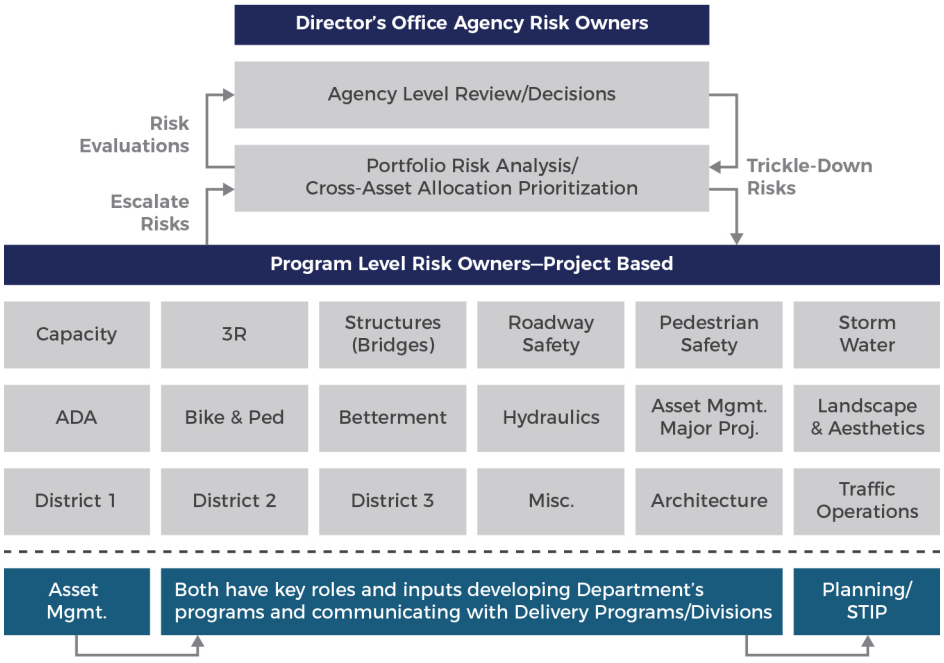


Figure 5-6. Summary of risk owners at the Division and Delivery Program levels

NDOT's planning documents, including the TAMP, inform the risk management strategies that are considered as part of NDOT's delivery programs, as shown in Figure 5-7.

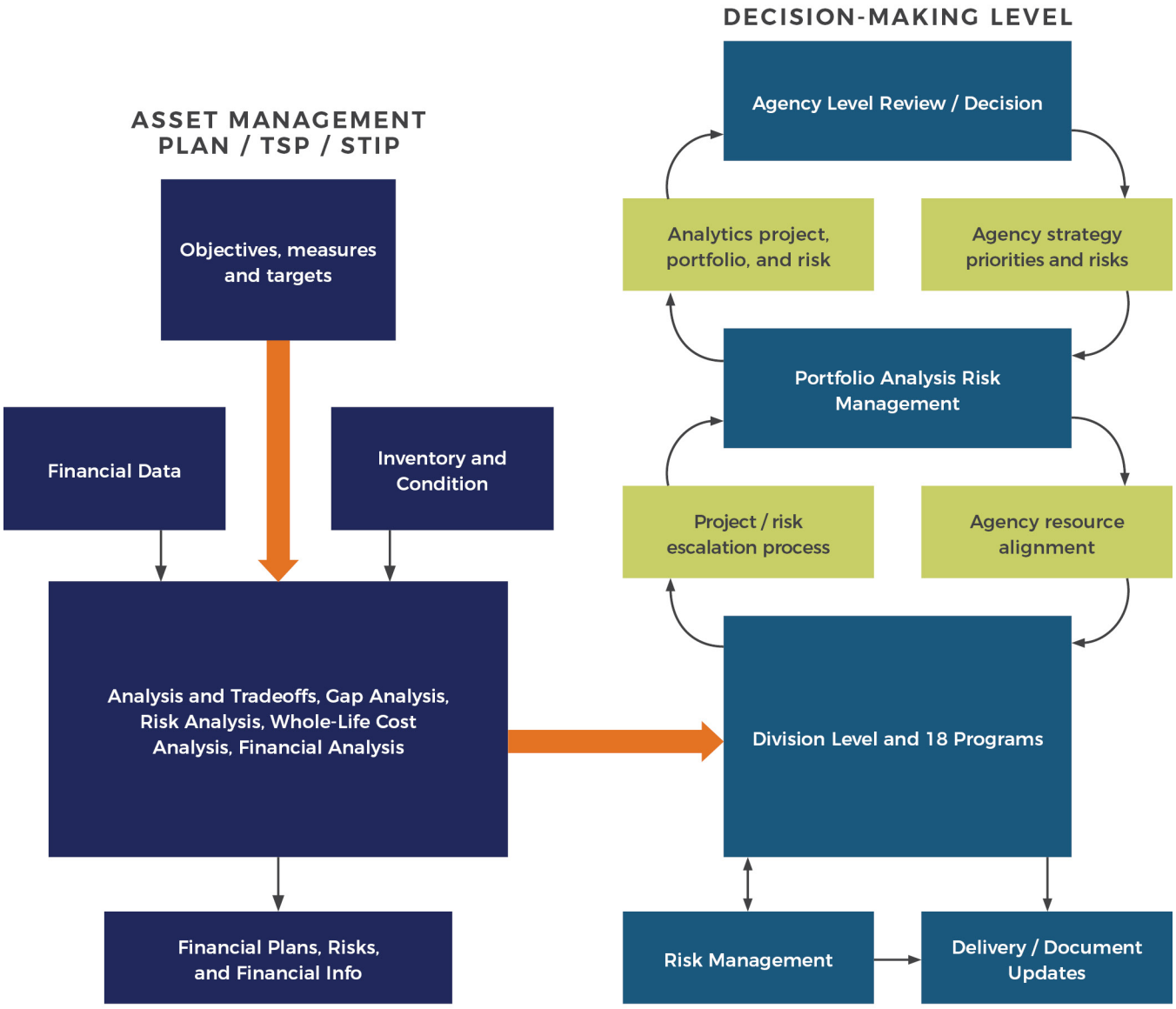


Figure 5-7. Risk management strategies as part of NDOT's delivery programs. ■

Chapter 6. Financial Plan and Investment Strategies

Overview

NDOT's principal source of funding for highway construction, maintenance, and repair is the State Highway Fund, which is a dedicated source of funding established by the Nevada State Constitution expressly for this purpose and appropriated by the legislature. State Highway Fund revenue (excluding NDOT and Las Vegas Convention and Visitors Authority [LVCVA] bond proceeds) totaled approximately $7.6 billion and averaged approximately $955 million per year in fiscal years 2010 through 2017. The majority of this revenue is provided by Federal Aid and state resources, such as the State gasoline and special fuel taxes, vehicle registration fees, commercial carrier fees, and driver's license fees. This revenue is sometimes bolstered with the sale of bonds to finance construction projects, and NDOT and LVCVA bonds sold during the fiscal year 2010 through 2017 period totaled $773 million. In addition to NDOT, the Department of Motor Vehicles and the Department of Public Safety receive a significant amount of state user fee funding from the State Highway Fund. The various funding sources that contribute to the State Highway Fund are shown in Figure 6-1.

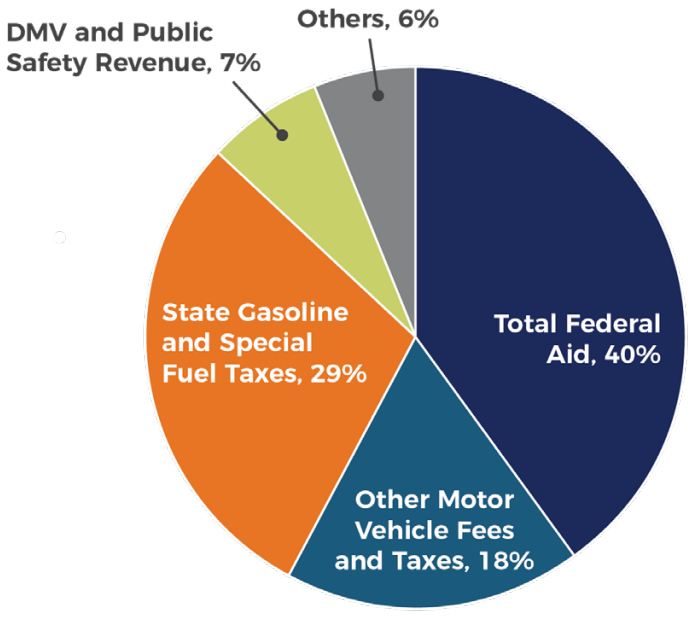


Figure 6-1. Funding sources for the Nevada State Highway Fund (2010 to 2017).

Figure 6-2 shows the total State Highway Fund revenue between fiscal years 2010 and 2017 by source and a summary of the key financial information for this 8-year period is summarized below.

- Average Annual NDOT's Share of Total State Highway Fund Expenditures (including bond repayment): $834 million
- Average Annual State Gas and Motor Vehicle Taxes: $444 million
- Average Annual Federal Aid Revenue: $380 million
- Average Annual Bond and Other Revenue: $157 million

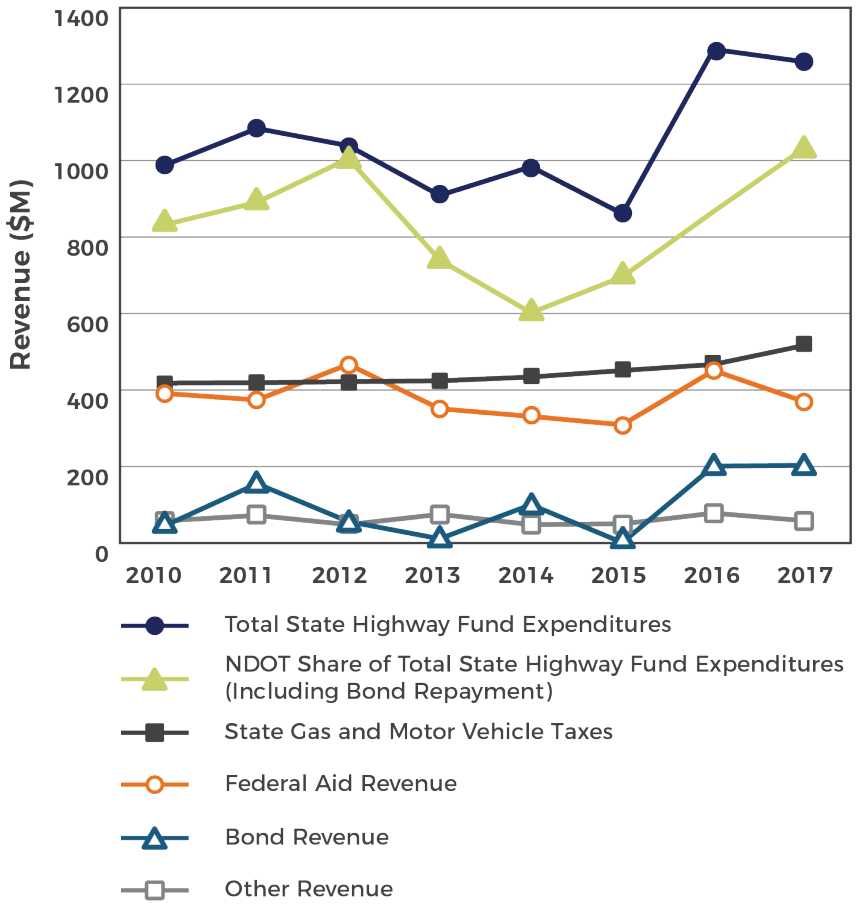


Figure 6-2. Historical State Highway Fund revenue (2010 to 2017).

Revenue Projections

Recent trends in State Highway Fund revenue show that the overall State Highway Fund revenue has varied between a high of $1,291 million in fiscal year 2016 and a low of $861 million in fiscal year 2015. Over the next decade, the average annual State Highway Fund revenue is projected to include modest growth. The State Highway Fund is also benefiting from the addition of Government Services Tax (GST) revenue beginning in state fiscal

year 2017. This additional revenue is partially offset by increases in the DMV system enhancement budget. Excluding possible bond sales, State Highway Fund revenue is projected at approximately $1.06 billion while NDOT's portion of that revenue (excluding bond revenue and bond debt repayment) is expected to be approximately $770 Million annually. NDOT expects to spend approximately $630 million annually (about 82 percent of the net revenue to NDOT) on new construction and non-maintenance related activities (such as operations, payroll, administrative support and services) and the remaining $140 million (about 18 percent of the net revenue to NDOT) for maintenance and asset management activities. Maintenance and asset management activities include: maintenance, preservation, rehabilitation, and reconstruction.

Figure 6-3 shows the portion of the anticipated revenue that will be allocated to: (a) new construction and other non-maintenance activities and (b) maintenance and asset management.

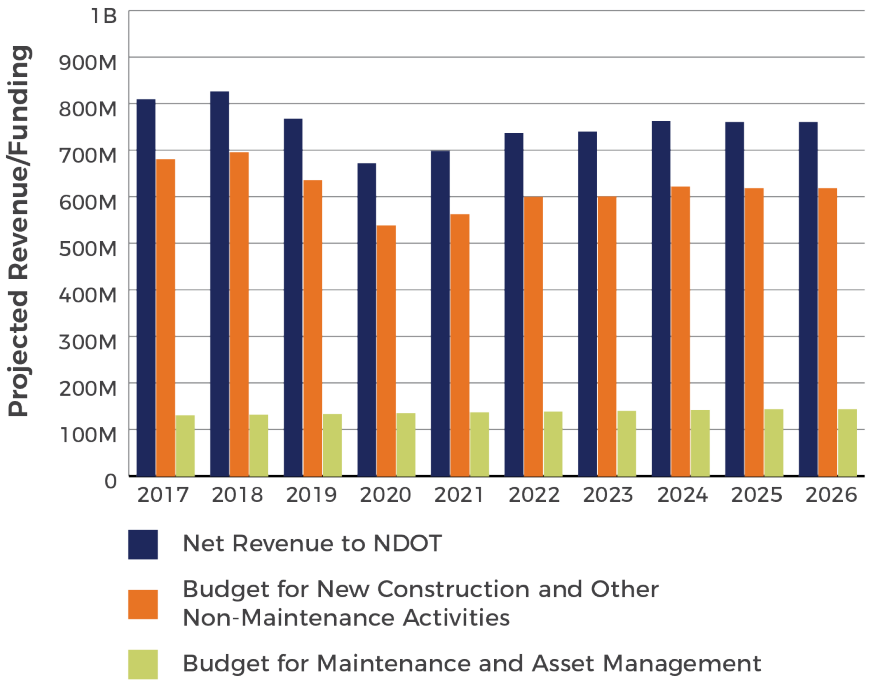


Figure 6-3. Net revenue and budgets (2017 to 2026).

Table 6-1 shows the expected annual investments in new construction and asset management activities over the next 10 years. Of the $630 million spent on non-maintenance activities annually, $400 million is expected to be spent on operations, district offices, and other administrative and support services. Of the remaining $230 million, approximately $170 million is expected to be budgeted for new pavement construction and $17 million for new bridge construction activities. The remaining $43 million will be

While the annual budget for the next 10 years is constant, NDOT's purchasing power is expected to **decline due to inflation.**

budgeted for addressing emergency needs and other work activities. The annual expenditures for pavement, bridge, and ITS asset management activities (i.e., Maintenance, Preservation, Rehabilitation, and Reconstruction) are explained in the remainder of the chapter. Over the next ten years, the annual investments in pavements, bridges, and ITS assets are expected to remain steady. However, the costs to address needs are expected to increase each year due to inflation. Therefore, a 2 percent inflation rate (based on 10-year average data from Bureau of Labor statistics) has been applied to the future maintenance and preservation costs. While the annual budget for the next 10 years is constant, NDOT's purchasing power is expected to decline due to inflation. This is directly reflected in the asset conditions that are achievable at the end of the 10-year period, reported later in this chapter.

Table 6-1. Expected annual budget for new construction, maintenance, and asset management activities.

	Work Type	Budget ($, Million)										
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-26
Pavements	Initial Construction	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	**$1,700.00**
	Maintenance	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	**$250.00**
	Preservation	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	**$350.00**
	Rehabilitation	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	**$350.00**
	Reconstruction	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	**$50.00**
	Subtotal	**$270.00**	**$270.00**	**$270.00**	**$270.00**	**$270.00**	**$270.00**	**$270.00**	**$270.00**	**$270.00**	**$270.00**	**$2,700.00**
Bridges	Initial Construction	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	**$170.00**
	Maintenance	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	**$5.50**
	Preservation	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	**$32.4**
	Rehabilitation	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	**$31.3**
	Reconstruction	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	**$40.8**
	Subtotal	**$28.00**	**$28.00**	**$28.00**	**$28.00**	**$28.00**	**$28.00**	**$28.00**	**$28.00**	**$28.00**	**$28.00**	**$280.00**
ITS	Maintenance	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	**$35.90**
Grand Total		**$301.59**	**$301.59**	**$301.59**	**$301.59**	**$301.59**	**$301.59**	**$301.59**	**$301.59**	**$301.59**	**$301.59**	**$3015.90**

Figure 6-4 shows the expected distribution of maintenance and asset management funding for pavements, bridges, and ITS assets. The numbers shown in Figure 6-4 include only contract costs associated with maintenance, preservation, rehabilitation, and reconstruction activities. Additional costs incurred in designing and administering contracts are not included. The numbers **do not** include new construction costs.

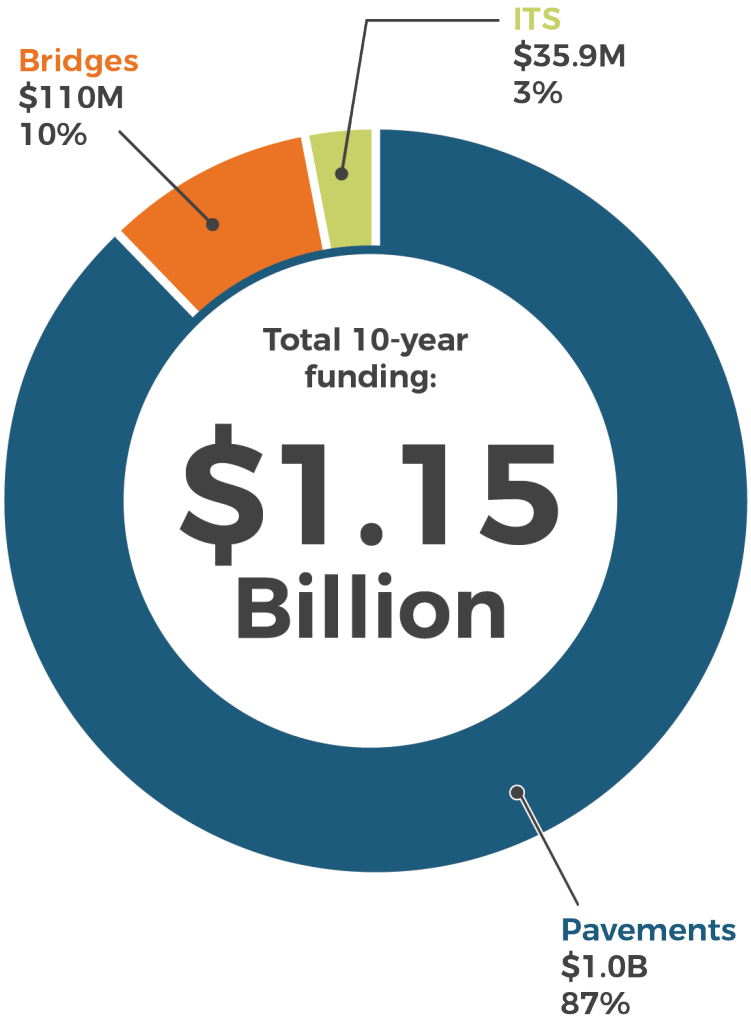


Figure 6-4. Expected budget for pavement, bridge, and ITS maintenance and asset management activities between 2017 and 2026 (costs exclude initial construction).

Figure 6-5 shows the expected budget for pavements and bridges. It should be noted that NDOT does not make a clear distinction between preservation and rehabilitation for pavements and bridges in the *STIP*. The percentages shown are approximate estimates based on historical data.

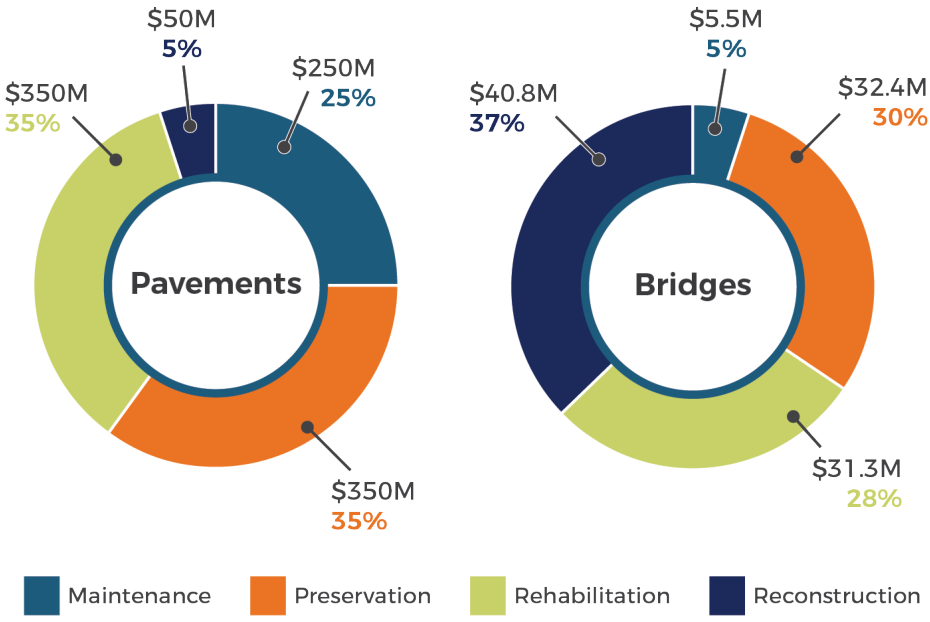


Figure 6-5. 10-year total budget by work type for pavements and bridges (costs exclude initial construction).

Revenue Trends in Nevada

The financial risks that could impact the asset management revenue can potentially be attributed to the factors described below.

Improvements in Vehicle Fuel Efficiency and Other Automobile Technologies: Increased fuel efficiency (see Figure 6-6) has been required by the federal government through the Corporate Average Fuel Economy (CAFE) program. While lowered emissions have a positive impact on the environment, the increased efficiency results in fewer dollars spent fueling the more efficient vehicles. This, in turn, results in less funding availability because the gas tax is one of the major sources of both federal and state revenue. Additionally, electric and hybrid vehicles are gaining in popularity and becoming more affordable, leading to more conversions from gasoline-based automobiles to alternatives that offer a more economical and environmentally sustainable solution.

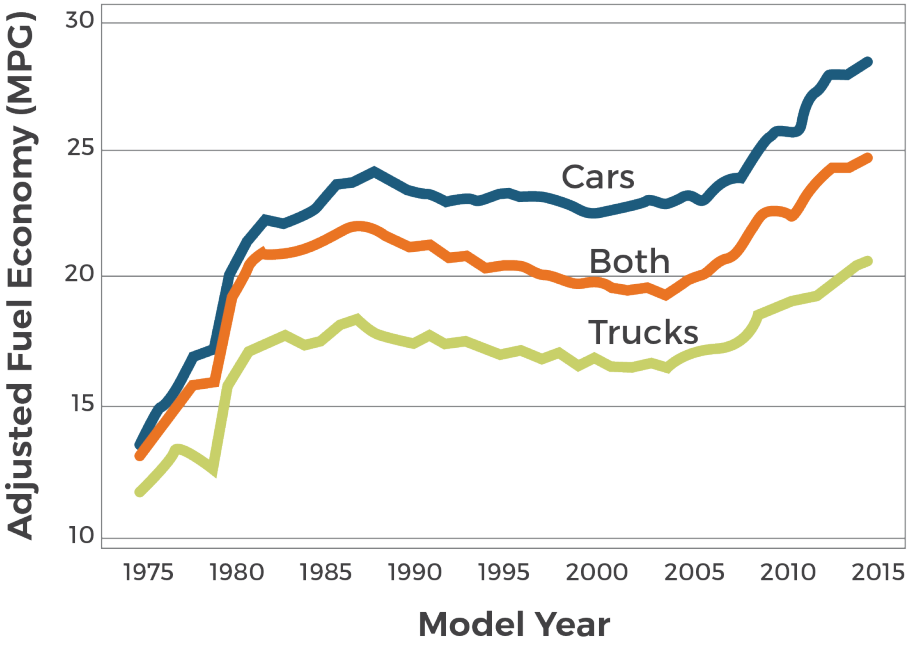


Figure 6-6. Average fuel economy (Miles Per Gallon) by model year, 1975–2015 (Source: EPA Website)

Reduction in Vehicle Sales and Registration/Renewal Revenue: Consumers are keeping their vehicles longer thereby decreasing the revenue generated from the number of vehicles sold and the associated initial vehicle registration fees and taxes. Additionally, vehicle registration renewal fees decline with each subsequent year of ownership over the life of the vehicle. It is anticipated that this trend of consumers keeping their vehicles longer will result in declining revenues from vehicle registration renewals.

Highway Fund Revenue Legislation

The Nevada State Legislature has provided some additional revenue sources in recent years to bolster funding available to NDOT.

Assembly Bill 595 (2007)

This legislation requires counties with a population of 100,000 or more (Clark and Washoe Counties) to allocate a portion of ad valorem tax for capital projects into the State Highway Fund. These funds are to be used for the construction and maintenance of public highways, with property taxes raised in Clark and Washoe counties to be spent only in the county where the taxes were collected. This revenue source contributed $99 million to the State Highway Fund between FY 2010 and FY 2015, averaging $16.5 million per fiscal year.

Senate Bill 5 (2009 – 26th Special Session)

This legislation requires any amount of the Fund for Cleaning Up Discharges of Petroleum which exceeds $7,500,000 at the end of any fiscal year to a special account in the Highway Fund. The money distributed from the account must only be used for construction, reconstruction, improvement and maintenance of public roads and is allocated 70% to projects in Clark County, 20% to projects in Washoe County, and 10% to projects in other counties. This revenue source contributed $19 million to the State Highway Fund between FY 2011 and FY 2015, averaging approximately $4 million per fiscal year.

Senate Bill 483 (2015)

This legislation modified the distribution of the basic governmental services tax authorized by Senate Bill 429, 2009. The bill allocates this revenue solely to the General Fund in FY 2016, 50 percent to the General Fund and 50 percent to the State Highway Fund in FY 2017. State Highway Fund revenue received as a result of this legislation was $38.6 million in state fiscal year 2017.

Senate Bill 486 (2015)

This legislation modifies the distribution of the basic governmental services tax authorized by SB 429, 2009. The bill allocates this revenue 25 percent to the General Fund and 75 percent to the State Highway Fund in fiscal years 2018 and 2019, with 100 percent of the revenue to the state Highway Fund thereafter. Revenue estimates for FY 2018 and FY 2019 are approximately $60 million per fiscal year.

Investment Strategies

Several cities in Nevada are among the fastest-growing in the nation, thus increasing the overall vehicle traffic on roadways. Heavy trucks contribute to deterioration on Nevada's transportation infrastructure.

Over the past eight years, NDOT has spent an average of $158 million per year on maintenance (including corrective and preventive actions) and rehabilitation (including replacement) to partially offset deterioration. As the state's infrastructure ages, the need for reinvestment increases. NDOT has been working to increase its use of preventive maintenance and repair strategies for extending the life of its assets. During fiscal years 2007 to 2010, NDOT spent approximately 17 percent of its pavement reinvestment funds on low-cost preventive and repair actions. Between 2011 and 2015, this percentage dropped to approximately 9 percent.

NDOT increased the allocation of funds for pavement preventive and corrective actions in FY14, increasing the percentage from 9 percent to 19 percent. Bridge preservation funding increased gradually up to 2013, keeping pace with the increasing needs of an aging inventory. However, starting in 2013 the Department's preservation funding declined while preservation needs continued to increase. This led to a decline in the percent of the inventory in Good condition as discussed in chapter 3.

As illustrated in Figure 6-7, there are several trends in funding for preventive and corrective actions that impact asset conditions: a) annual expenditures for pavements were returned to 2007 levels, b) annual expenditures on pavements and bridges fluctuate regularly, and c) pavements receive more funding than bridges.

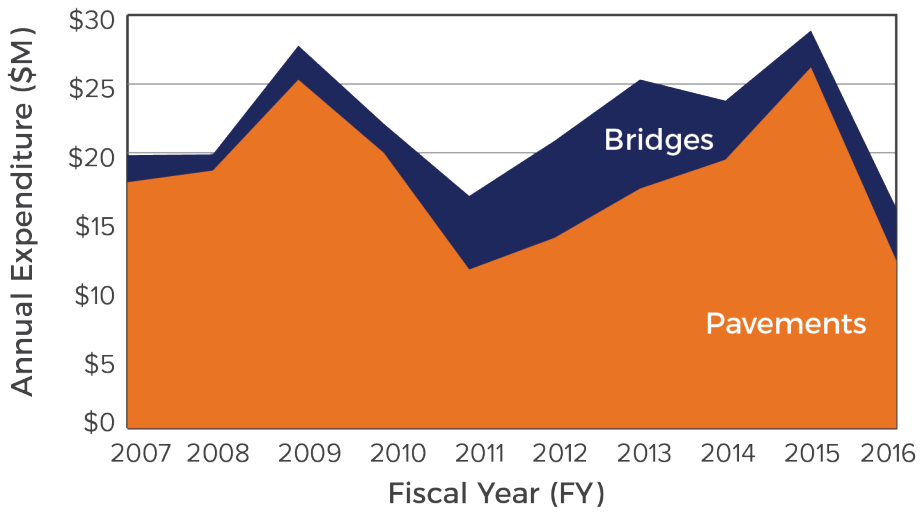


Figure 6-7. NDOT expenditures for preventive and corrective actions (2007 to 2016).

PAVEMENT INVESTMENT STRATEGIES

NDOT uses a financial consequence-based project prioritization process for its pavement management practices. Roadways with the most important financial consequence, such as interstates and non-interstate principal arterials, are kept at a higher level-of-service than low-volume roads. Projects are prioritized based on the proactive strategy of maintaining pavements in Fair or Better condition rather than waiting until pavements deteriorate to Poor conditions when rehabilitation costs can be up to six times higher than repairs to pavements in Fair or Better condition. The following priorities have been implemented as the NDOT long term action plan for project selection:

- **Maintaining the Interstate highways and Non-interstate Principal Arterial roads (Category 1)** at a high level of service by constructing proactive, thin asphalt overlays at the right time, as funding allows.
- **Managing the non-Interstate National Highway System (NHS) (Categories 1 and 2)** routes at a higher priority than other roadways in need of rehabilitation. This is due to higher standards and expectations for the NHS.
- **Preserving Major Collectors and other roads with moderate traffic (Categories 3 and 4)** at a good level of service by constructing proactive, thin plant-mix overlays at the right time, as funding allows.
- **Managing the low volume roads (Category 5)** at an acceptable level of service through the limited use of State Force Maintenance and District contract funds.

Predicting the optimal timing for programming rehabilitation projects for different road prioritization categories can be challenging. Projects can be deferred or canceled if the total project cost is too high in relation to the size of the overall program budget. When funding amounts are limited, some projects are not funded. Frequently, the Category 5 projects are deferred or canceled first because these projects have the smallest financial consequence to the agency if rehabilitation is not performed. If further funding reductions are required, then Category 4 projects are deferred or canceled, and so forth. Occasionally, the available revenue allows for rehabilitation on Category 1 roadways only.

Pavement Data Analysis Process Enhancements

NDOT has recently implemented the following activities to help analyze the condition of its pavements and to assist in predicting future pavement conditions:

- Began the use of Oracle Business Intelligence (BI) software to simplify the data processing in the pavement management database system. BI can process data and facilitate the conversion of the data into charts and tables that are used in reports, such as the State Highway Preservation Report.
- Compiled information for the TAMP using traditional methods outside of the BI; however, future versions could possibly benefit from a robust BI application.
- Developed pavement deterioration models for each Roadway Prioritization Category. These prediction models are used

to forecast future pavement conditions over time, thereby improving NDOT's planning and programming capabilities. This enables the analysis of the system both as an overall network and on a specific project level. By analyzing the pavements at the network level, NDOT can estimate the overall condition of its pavements, determine backlog costs, and calculate costs to maintain the system at any given condition level. The models are also valuable on a project level by indicating when future maintenance or rehabilitation work should be completed on a specific section of roadway in order to prevent the pavement from deteriorating into Poor condition when expensive major rehabilitation or reconstruction would otherwise be required.

Pavement Condition and Investment History

Historical pavement condition investment trends were analyzed to determine if the investments in pavement maintenance and rehabilitation activities were adequate to maintain or improve the average condition of the roadway network. Figure 6-8 shows the average PSI trends and historical investments in pavement maintenance (which includes preventive maintenance and corrective actions to preserve the structural integrity of the pavements and maintain them in Fair or Better conditions) and rehabilitation activities (which include structural overlays and other substantial repairs to restore the structural capacity of the pavements that are in Mediocre or worse condition). While the average condition of the Category 1 pavements (which include the interstates and other NHS routes) have remained fairly stable over the past fifteen years, the condition of the pavements in the rest of the roadway categories has been deteriorating, especially in Categories 4 and 5. Although significant funding (nearly $300 million) was invested in 2011 for rehabilitation activities, the overall average network conditions were not visibly improved by this investment. A sustained higher level of funding is needed to improve the average PSI. Given that the level of investment in pavements is unlikely to increase in the near future, it is anticipated that the overall network conditions will continue to decline.

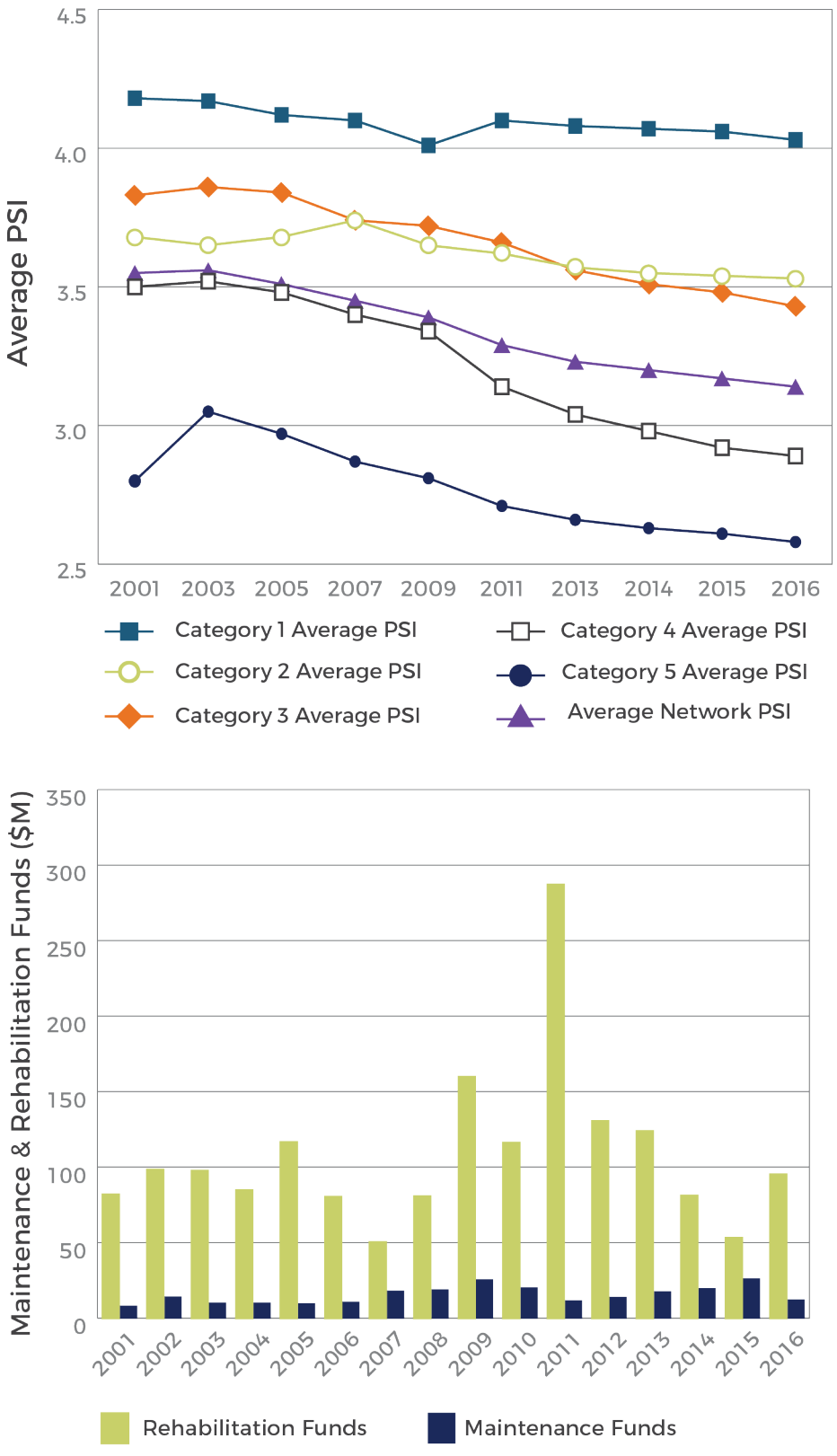


Figure 6-8. Average investment and Pavement Serviceability Index (PSI) trends.

NDOT's projected funding level for pavements is not expected to be sufficient to maintain current conditions over the next ten years. Overall, the pavement conditions are expected to decline steeply from the current level of 71 percent of the network in Fair or Better condition to only 25 percent of the network in Fair or Better condition by 2026. Since NDOT's strategy is to preserve the condition of the Category 1 through 3 roads, the majority of the deterioration will be on the Category 4 and 5 roads.

Due to lack of adequate funding, NDOT's investments have focused on maintaining and preserving the structural condition of pavements in Categories 1 through 3 since these are higher priority routes and carry higher traffic volumes. There is often little or no funding available to address the maintenance and rehabilitation needs of pavements in Categories 4 and 5. NDOT has had to resort to stopgap repairs in order to keep these roads in operable conditions. While none of the pavements in Categories 1 through 3 are in need of any major rehabilitation work, the estimated cost of the major rehabilitation activities necessary to restore the structural integrity of pavements in Categories 4 and 5 has grown substantially over the past five years. Without any additional funding dedicated to major rehabilitation, these pavements will continue to deteriorate to a condition level where complete reconstruction may be the only viable alternative.

Investment Scenarios Investigated

As discussed in Chapter 4, NDOT utilizes a proactive pavement preservation strategy that includes the application of treatments like fog seals, crack sealing, and chip seals to maintain and preserve the condition of pavements that are in Good or Better condition (PSI > 3.5). Pavements that have a PSI rating of less than 3.5 are better suited for structural overlays or other rehabilitation activities. NDOT's pavement investment strategy is summarized in Figure 6-9.

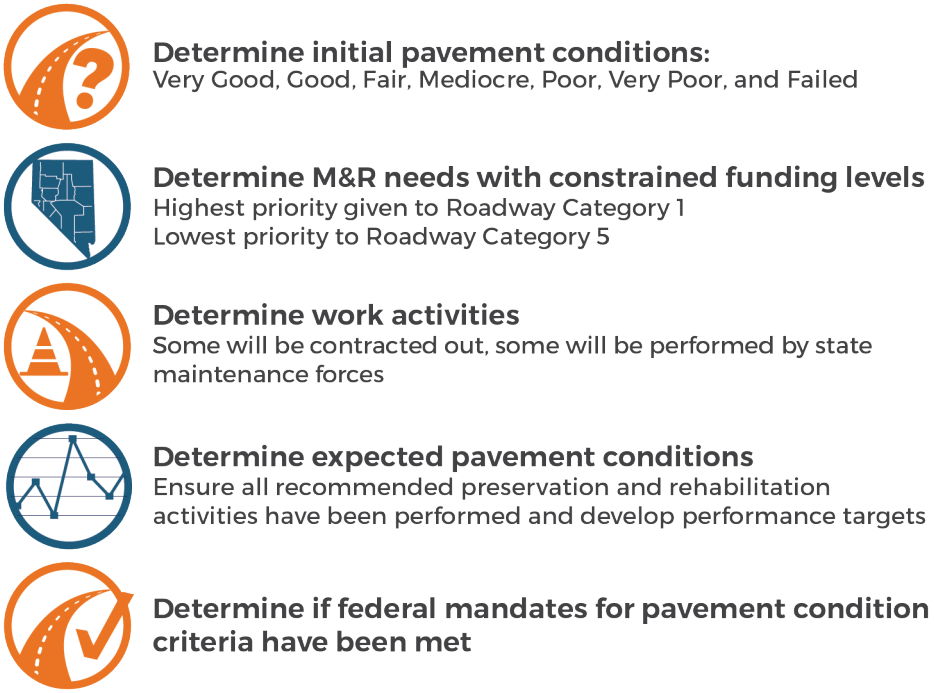


Figure 6-9. NDOT's pavement investment strategy.

Using the life-cycle planning strategy discussed in chapter 4, NDOT investigated the impact of four investment scenarios on future pavement conditions:

- $100 million per year (baseline scenario, lowest funding expected to be available for maintenance and preservation between 2017 and 2026).
- $127 million per year (current average annual investment).
- $264 million per year (funding needed to maintain current conditions).
- $309 million per year (funding needed to achieve the aspirational state of good repair of 95 percent of the pavements in all roadway categories in Fair or Better condition).

Figure 6-10 shows the impact of the various investment scenarios investigated.

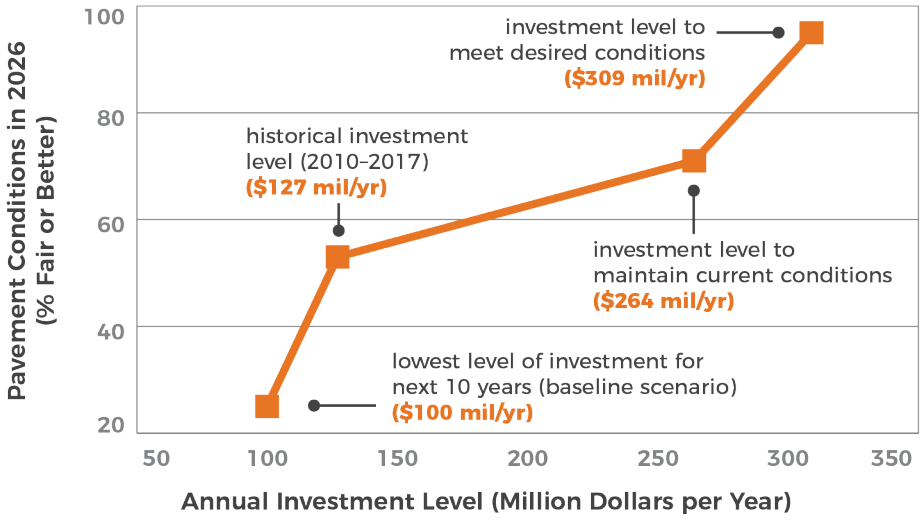


Figure 6-10. Comparison of various pavement investment scenarios.

Figure 6-10 shows that the projected annual level of investment of $100 million per year over the next 10 years will result in steeply declining pavement conditions. At that funding level, the overall network condition is expected to drop from the current level of 71 percent of the network in Fair or Better condition to approximately 25 percent of the network in Fair or Better condition. To meet the aspirational state of good repair of 95 percent Fair or Better, an annual investment of $309 million each year is required between 2017 and 2026. After the 95 percent Fair or Better has been achieved, approximately $264 million annual investment will be required to maintain the goal.

Performance Targets

Pavement performance targets have been established to measure the effectiveness of the maintenance and rehabilitation work performed on the state-maintained roadway system. Careful consideration was given to balance the cost of rehabilitation at varying pavement condition levels with the availability of funds. Other criteria used in the process included pavement deterioration rates, the effectiveness of maintenance repair work, traffic volume, the number of heavy trucks, and the cost to repair or replace roads in each Roadway Prioritization Category.

Because a portion of the pavement network (approximately 150 centerline miles, around 3 percent of the total network) is maintained by the Local Public Agencies (LPAs) rather than state maintained, NDOT has been working with its regional planning partners to establish common goals for the entire NHS within the state. To facilitate this activity, a Performance Management Working Group was established under the Planning Executive Group at NDOT. This group meets regularly to discuss the pavement condition data reporting requirements for HPMS and national performance management (23 CFR 490). Based on the discussions during the Performance Management Working Group meetings, the LPAs decided to adopt the state targets established by NDOT and are currently working on common, statewide targets.

The group meets monthly and is actively working towards establishing common performance targets that can be used to manage pavements and bridges on the NHS and fulfill FHWA reporting requirements.

If adequate funding levels were available, the pavement performance target would be to maintain the entire network to a minimum of 95 percent of the roads in Fair or Better condition. However, since funding levels are not expected to be adequate to achieve this performance target, it is referred to as an “aspirational” or “desirable” goal. In reality, the expected funding level of $100 million per year between 2017 and 2026 is only adequate to achieve the aspirational performance target for Category 1 pavements. No funding is anticipated to be available for the roads in any of the other categories. Therefore, NDOT set a more realistic target for its pavement conditions, which is referred to as a "constrained" or "realistic" target for managing the pavement network. NDOT's aspirational and constrained 10-year targets are presented in Table 6-2, along with the pavement conditions that are expected to be achieved at the end of the 10-year period. NDOT does not expect any performance gaps to occur with either the constrained targets or the federal targets. As stated earlier, it would cost an estimate of $309 million per year to achieve the aspirational targets.

In addition to NDOT's performance targets, 2- and 4-year targets were required to be reported to the FHWA using federally-established metrics that differ from the PSI. Using the federal metrics, NDOT established the targets shown in Table 6-3.

Table 6-2. Predicted pavement conditions and performance targets.

2026 Predicted Condition							
Condition	PSI Rating Scale	PSI Condition by Road Prioritization Category Percentage (%) and Number of Miles					
		Road Category 1	Road Category 2	Road Category 3	Road Category 4	Road Category 5	Roadway Network Totals
Very Good	5.00 to 4.00	55.8% 281	0.0% 0	0.0% 0	0.0% 0	0.0% 0	5.5% 281
Good	3.99 to 3.50	39.5% 199	1.2% 11	3.8% 46	0.0% 0	0.0% 0	5.0% 256
Fair	3.49 to 3.00	2.6% 13	53.1% 492	17.3% 207	5.3% 45	10.8% 177	18.2% 934
Mediocre	2.99 to 2.50	1.0% 5	37.8% 350	19.6% 235	16.9% 145	36.4% 597	26.0% 1,332
Poor	2.49 to 2.00	0.8% 4	6.4% 59	43.7% 524	36.8% 315	25.4% 416	25.7% 1,318
Very Poor	< 2.00	0.0% 2	1.5% 14	15.5% 186	41.1% 352	27.4% 448	19.6% 1,002
Total Miles:		**504**	**926**	**1,198**	**857**	**1,638**	**5,123**
Aspirational Goal: Min. Percentage of Roads in Fair or Better Condition (Aspirational SOGR)		95%	95%	95%	95%	95%	—
2026 Predicted Condition: Percentage of Roads in Fair or Better Condition		97.9%	54.3%	21.2%	5.2%	10.8%	—
Financially Constrained Goal (Constrained SOGR): Percentage of Roads in Fair or Better Condition		95%	50%	20%	5%	5%	—

Table 6-3. Federal pavement targets.

System	2- and 4-Year Targets	
	%Good	%Poor
Interstate	≥ 75%	≤ 5%
Non-Interstate NHS	≥ 40%	≤ 5%

BRIDGE INVESTMENT STRATEGIES

Nearly all of Nevada's bridges were designed for a 50-year lifespan, and 36 percent have already exceeded this age. With 1,284 bridges in the inventory (includes all NHS bridges and state-maintained non-NHS bridges), approximately 2 percent of them (26 bridges) would have to be replaced each year in order to sustain the bridges on the state highway system over the long term without accounting for growth. At current prices this would cost $115 million per year. NDOT currently spends less than $12 million each year to sustain its bridges. Most state transportation agencies reinvest 1 to 2 percent of the value of their bridge inventory each year in preservation and replacement strategies, but Nevada only spends 0.2 percent. Currently 0.8 percent of state-maintained bridges are in Poor condition, but this low percentage is not sustainable and is expected to increase under any investment level because of the advanced age of the inventory. To maintain relatively good bridge conditions at modest investment levels, NDOT recognizes there is a need to extend the average lifespan of each bridge well beyond the intended 50-years by including preservation activities, as well as to gradually increase the level of reinvestment.

An analysis of bridge deterioration and costs over the next 10 years reveals a range of possible futures for Nevada's state-maintained bridge inventory. NDOT is expected to expand its use of inexpensive preventive maintenance and corrective actions to extend bridge service life and implement a bridge management system to find the most attractive strategic investments. As shown in the planned investment scenario, bridge expenditures will remain fairly constant at $10.45 million per year (excluding routine maintenance expenditures) between 2017 and 2026. Bridge replacement funding is expected to decline, reflecting the very small percentage of bridges now in Poor condition.

Investment Scenarios Investigated

A set of fiscal scenarios explore a range of alternatives for future total bridge reinvestment funding (includes bridge replacement expenditures, excludes routine maintenance costs):

NDOT's current funding level for bridges is **not expected to be sufficient** to maintain existing conditions over the next twelve years.

- **Anticipated Investment Level.** Over 10 years, including bridge replacement projects, this scenario has a capital cost of $104.5 Million (without routine maintenance expenditures) and results in 4.3 percent of bridges falling into a category of Poor Condition and 42.0 percent Good.
- **Optimistic Investment Levels.** The total 10-year capital cost, including bridge replacement projects, is $204.1 million (excluding routine maintenance expenditures). This results in approximately 3.2 percent of bridge infrastructure falling into a category of Poor Condition and 43.2 percent Good.
- **Pessimistic Investment Levels.** The total 10-year capital cost, including bridge replacement projects is $59 million (excluding routine maintenance expenditures). This results in approximately 6.7 percent of bridge infrastructure falling into a category of Poor Condition and 38.4 percent Good.

This information is summarized in Figure 6-11, in terms of the percent of NHS and state-maintained bridge deck area on bridges in a weighted average of Fair or Better condition. The annual investment levels are computed by dividing the 10-year total cost (excluding routine maintenance expenditures) by 10. These scenarios use the same deterioration rates and costs as in the life-cycle planning analysis (discussed in Chapter 4).

Includes all NHS and state-maintained non-NHS bridges, and is a 10-year average.

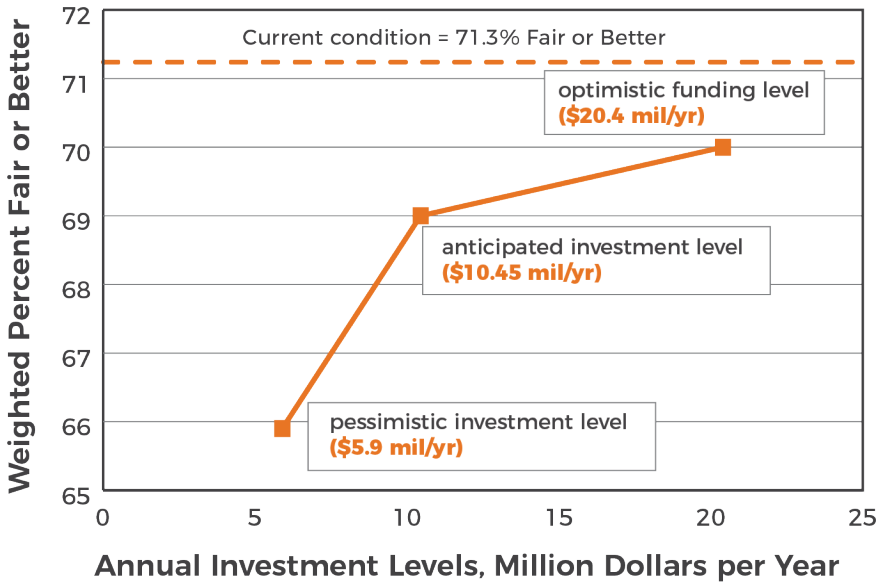


Figure 6-11. Comparison of various bridge investment scenarios (excludes routine maintenance expenditures).

Performance Targets

Table 6-4 summarizes the percent of total deck area on bridges in Good and Poor condition for NHS and non-NHS state-maintained bridges, using the three scenarios investigated. The financially constrained performance target, acknowledged as the constrained SOGR for bridges, is to:

a) Improve bridge conditions and maintain at least 35 percent of deck area on NHS and state-maintained bridges in Good condition and,

b) Minimize the fraction of bridges in Poor condition by allowing no more than 7 percent of deck area on NHS and state-maintained bridges to fall below this threshold.

Table 6-4. Ten-year cost (excluding routine maintenance costs) and forecasted bridge condition outcomes in 2026 by fiscal scenario.

Scenario	National Highway System			Non-NHS			Total Cost ($M)
	Cost ($M)	Percent Poor	Percent Good	Cost ($M)	Percent Poor	Percent Good	
Anticipated	81.7	4.6%	40.9%	22.8	3.4%	45.7%	104.5
Optimistic	159.5	3.4%	42.1%	44.6	2.2%	47.0%	204.1
Pessimistic	46.1	7.0%	37.2%	12.9	5.5%	42.4%	59.0

The Anticipated scenario is viewed as most likely, while the Optimistic scenario is desired if the corresponding funding level can be attained. The Pessimistic scenario is shown purely for comparison purposes to illustrate the impacts of sharp decline in funding for bridges.

Based on the predicted conditions, NDOT expects to be able to achieve its 10-year constrained targets at the end of the analysis period. Therefore, no performance gap is expected.

As with pavements, 2- and 4-year targets were reported to the FHWA for NHS bridges. The targets were established using federal definitions for Good, Fair, and Poor. NDOT's bridge targets are presented in table 6-5.

Table 6-5. Federal bridge targets.

System	2- and 4-Year Targets	
	%Good	%Poor
NHS	≥ 35%	< 7%

INTELLIGENT TRANSPORTATION SYSTEM (ITS) ASSETS

As described in Chapter 3, ITS assets do not have performance measures that have been formally adopted by NDOT. For the purposes of the TAMP, the condition of the ITS assets were based on the device manufacturer's recommended service life.

The ITS asset investment strategies developed as a part of the TAMP address the following devices: Closed Circuit Television Camera (CCTV) devices, Dynamic Message Signs (DMS), Flow Detectors, Highway Activity Radios (HAR), Ramp Meters, and Road Weather Information Systems (RWIS). However, the budget allocated for ITS assets in the financial plan includes other ITS devices being maintained and managed by NDOT.

The investment strategy used by NDOT was obtained during meetings with the ITS asset workgroup to understand general steps for identification and response to aging equipment and devices. A simple MS-Excel-based spreadsheet tool was developed by NDOT to forecast deterioration of the devices and determine the 10-year investment needs (using the approach described in Figure 6-12) to maintain current levels of service. As NDOT expands its TAMP to include other ITS assets in future years, a similar process for developing investment strategies could be adopted.

Determine initial device conditions
- Good, Low Risk, Medium Risk, and High Risk (conditions based on NDOT staff expert opinion)

Define general procedures and protocols
- Inspections, minor repairs, and replacement activities
- Unit costs for each activity

Identify appropriate activities
- Best practices for device management
- How activities impact the condition of each device
- Indicate percentage of devices that require annual activities

Determine maintenance and repair activities
- Simple, expert-judgement based deterioration models
- Indicate level of investment needed to maintain current level-of-service over the next 10-year period

Figure 6-12. ITS asset investment strategy.

The average annual investment needs by device type and district are summarized in Table 6-6. An average annual investment of approximately $3.6 million is required to maintain the current level-of-service for the ITS assets. District 1 will need 57 percent of the total investment because it maintains and manages the largest number of ITS devices in the state. District 2 will need 27 percent and District 3, the remaining 16 percent.

Table 6-6. Average annual investment needs for ITS assets (2017-2026).

ITS Asset	District 1	District 2	District 3	Statewide
CCTV	$765,000	$79,000	$24,000	$868,000
DMS	$656,000	$358,000	$147,000	$1,161,000
Flow Detectors	$240,000	$48,000	$4,000	$292,000
HAR	$2,000	$3,000	$6,000	$11,000
Ramp Meters	$284,000	$15,000	$0	$300,000
RWIS	$103,000	$481,000	$373,000	$957,000
Totals	**$2,050,000**	**$984,000**	**$554,000**	**$3,589,000**

To help ensure the operation and maintenance of its ITS assets, NDOT has entered into an Interlocal Agreement with the Regional Transportation Commission of Southern Nevada (RTC) to provide funding to the RTC for the operations and maintenance of ITS devices for the controlled access freeways located in southern Nevada. This agreement has helped to ensure that ITS devices are maintained in working condition as outlined in this investment plan.

Addressing System Performance

The management of NDOT's transportation system requires the agency to balance asset condition needs with other system priorities, such as ensuring safe travel, providing an efficient system that addresses mobility goals, and addressing demands for system expansion. To help achieve this balance, NDOT has incorporated asset management objectives into its Statewide Transportation Plan, which guides the Department's construction and maintenance decisions. This emphasis on system per-

formance drives strategic investments at all levels of the organization. For instance, NDOT's emphasis on reducing congestion on state highways was influential in the Department's decision to include ITS assets in its TAMP since ITS devices have a significant role in relieving congestion in urbanized areas and enabling users to make better informed and safer use of the state-maintained highways.

In addition, NDOT is implementing a statewide Transportation System Management and Operations (TSMO) program that optimizes system performance of existing infrastructure through integrated, multimodal, and cross-jurisdictional projects that maintain capacity while improving security, safety, and reliability. TSMO is being implemented because NDOT is facing a severe funding shortfall while the state is seeing dramatic increases in population and traffic volumes. TSMO is aimed at helping NDOT find ways to make the existing transportation system work better.

The TSMO program objectives address several of NDOT's strategic goals, including enhancing safety, optimizing mobility, fostering sustainability, enhancing reliability, optimizing customer service, and enhancing collaboration. Preserving the existing infrastructure is another goal that has been established, including the maintenance of TSMO assets (such as ITS) and preserving the transportation system (including pavements and bridges). The TSMO implementation includes the development of an Investment Prioritization Tool (IPT) that allows the Department to prioritize projects efficiently, allocate resources, and ensure alignment between planned investments and NDOT's strategic goals. The IPT considers factors such as goals, project drivers, strategic value, return on investment, available research, business risks, and value to establish project priorities.

As shown in Figure 6-13, TSMO links all aspects of performance and investment to help NDOT realize the greatest possible value from each planned investment, enabling the Department to stretch its limited funding as much as possible using integrated solutions.

Figure 6-13. Links between TSMO and existing NDOT plans and programs.

Investment Summary

Table 6-7 summarizes the planned budget to achieve both short- and long-term pavement performance targets. The expected budget for pavements between 2017 and 2026 will only be adequate to maintain the condition of Category 1 pavements. The pavements in Categories 2–5 will only receive localized maintenance to keep them in safe and operable condition levels and the average conditions of these pavements are expected to decline steeply over the next 10 years if additional funding is not provided for needed capital improvements, however, the constrained performance targets will be met.

Table 6-7. Planned budgets and performance targets for pavements.

Category / Functional Class	Current Condition	Expected Budget (2017–2026)	2026 Predicted Conditions	Constrained Performance Target
NDOT Performance Measures				
Category 1	99.3% Fair or Better	$1.0 Billion for Categories 1 through 5	97.9% Fair or Better	≥95% Fair or Better
Category 2	95.7% Fair or Better		54.3% Fair or Better	50% Fair or Better
Category 3	95.6% Fair or Better		21.2% Fair or Better	20% Fair or Better
Category 4	69.3% Fair or Better		5.2% Fair or Better	5% Fair or Better
Category 5	30.1% Fair or Better		10.8% Fair or Better	5% Fair or Better
Federal Performance Measures				
Interstate	78% Good 1% Poor	$1.0 Billion for Interstate and Non-Interstate NHS pavements	75% Good 2% Poor	≥75% Good ≤5% Poor
Non-Interstate NHS*	93% Good 0% Poor		40% Good 4% Poor	≥40% Good ≤5% Poor
*Includes both State and Locally-Maintained NHS				

Table 6-8 summarizes the planned budget to achieve bridge performance targets. Bridge conditions are expected to decline under all realistic fiscal scenarios, but additional funding will reduce the rate of deterioration over the next ten years. All scenarios anticipate an increase in preservation activity, a program which NDOT will be developing as it implements its new Enterprise Asset Management System, due to be completed in Spring 2019. For this plan, the targets were developed using the network-level model described in Chapter 4, based on anticipated funding and allowing for current uncertainty in funding levels, costs, and deterioration rates.

Table 6-8. Planned budgets and performance targets for bridges (2017-2026).

Category / Functional Class	Current Condition	Expected Budget (2017–2026)*	2026 Predicted Conditions	Constrained Performance Target
NHS	41.4% Good 0.6% Poor	$86 Million	40.9% Good 4.6% Poor	≥35% Good <7% Poor
Non-NHS	50.0% Good 1.3% Poor	$24 Million	45.7% Good 3.4% Poor	≥35% Good <7% Poor
*Includes routine maintenance investments				

The planned budget needed to maintain the current level-of-service for ITS assets are summarized in Table 6-9. Since performance measures have not been formally established and approved by NDOT for ITS assets, targets have not been established.

Table 6-9. Budget to maintain current conditions of ITS assets (2017–2026).

ITS Assets		
Asset	**Current Condition**	**Investment**
CCTV	75% — Low Risk or Better	$8.7 Million
DMS	65% — Low Risk or Better	$11.6 Million
Flow Detectors	65% — Low Risk or Better	$2.9 Million
HAR	50% — Low Risk or Better	$0.11 Million
Ramp Meters	90% — Low Risk or Better	$3 Million
RWIS	20% — Low Risk or Better	$9.6 Million
	Total	**$35.9 Million**

A more detailed summary of the investment strategies for pavements, bridges, and ITS assets was provided earlier in Table 6–1, which summarizes the annual budgets by treatment category. The table is reprinted here as Table 6-10.

Table 6-10. Expected annual budget for new construction, maintenance, and asset management activities.

	Work Type	Budget ($, Million)										
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-26
Pavements	Initial Construction	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	$170.00	$1,700.00
	Maintenance	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$250.00
	Preservation	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$350.00
	Rehabilitation	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$350.00
	Reconstruction	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$50.00
	Subtotal	$270.00	$270.00	$270.00	$270.00	$270.00	$270.00	$270.00	$270.00	$270.00	$270.00	$2,700.00
Bridges	Initial Construction	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	$17.00	$170.00
	Maintenance	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55	$5.50
	Preservation	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	$3.24	$32.4
	Rehabilitation	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	$3.13	$31.3
	Reconstruction	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$40.8
	Subtotal	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$280.00
ITS	Maintenance	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	$3.59	$35.90
Grand Total		$301.59	$301.59	$301.59	$301.59	$301.59	$301.59	$301.59	$301.59	$301.59	$301.59	$3015.90

Chapter 7. Asset Management Governance and Enhancements

Overview

An effective Transportation Asset Management Plan is a dynamic document that must be updated periodically to reflect the changing environment in which asset investment decisions are made. As evidenced by the way NDOT has sought to achieve its strategic objectives over the years, an even stronger commitment to applying asset management principles is expected to continue to enable NDOT to operate effectively.

As reflected in the previous chapters, there are improvements that could be made to existing business practices to better support asset management. This chapter outlines NDOT's plans for administering and updating the TAMP as well as the enhancements that will be made to improve the Department's future asset management practices.

TAMP Governance

This document represents NDOT's second TAMP. The first TAMP, which documented NDOT's TAM processes, was certified by the FHWA on May 30, 2018. This TAMP expands on the content included in the initial TAMP, including analysis results that were generated using the processes certified by FHWA. In the future, the TAMP is required to be updated and recertified at least every four years. A list of the requirements for TAMP certification is presented in Appendix A, along with information showing where each requirement is addressed in the TAMP. Appendix C presents the criteria used by FHWA for TAMP certification.

As shown in Figure 7–1, the TAMP will be developed and maintained under the direction of an Asset Management Oversight Committee (AMOC). The AMOC meets on a regular basis to:

- Monitor TAMP updates to reflect key changes and improvements within NDOT or Federal requirements.
- Determine additional asset classes to be included in future TAMPs.
- Monitor progress towards the performance targets established and recommend adjustments (if needed).
- Conduct dialogue between various asset groups and program areas within NDOT to establish a process for allocating funds and resources.

- Inform NDOT Executive Leadership on asset management activities within the Department and promote asset management policies within the agency.
- Review the use of funding received by each program area within NDOT and determine the proportion of the funding being dedicated to maintaining and preserving the existing assets versus capital expansion and improvement projects.

Figure 7-1. Composition of the Asset Management Oversight Committee (AMOC).

In addition to having primary responsibility for governing the TAMP update process, the AMOC will also be responsible for ensuring that sound asset management principles are promoted and embraced at all levels within NDOT.

Asset Management Enhancements

Table 7-1 summarizes the major short-term asset management improvement initiatives that are being advanced by NDOT along with the expected outcome and the timeframe for implementation.

Table 7-1. Asset Management Improvement Initiatives.

Motivation/ Driver	Improvement Initiative	Expected Outcome	Time-frame
Assets are being managed in silos and there is no structured system to link data from various programs.	NDOT is in the process of implementing an Enterprise Asset Management System (EAMS) that will have the ability to manage the vast majority of assets that NDOT is responsible for maintaining.	Asset inventory and performance data housed within a single system. Cross-asset trade-off decisions will be easier to make.	Mid-2020
The bridge management system is not capable of modeling deterioration and analyzing life cycle strategies.	The Bridge Management System implemented as a part of the EAMS will be able to support deterioration modeling and life-cycle cost analysis.	Bridge investment decisions can be made using a data-driven approach. Analysis of life-cycle performance data will help NDOT improve bridge maintenance and preservation strategies.	Early 2020
Maintenance activities performed by in-house maintenance forces are not tracked adequately.	The Maintenance Management System implemented as a part of the EAMS will help track both in-house and contract maintenance activities in a more stream-lined manner.	Data on maintenance activity by asset type and condition can be extracted quickly to help in planning future maintenance needs and also refining existing maintenance protocols and strategies.	Goes live May 2019
Need for a robust asset management planning and programming framework to ensure better coordination between various plans developed within NDOT	NDOT will establish an Asset Management Oversight Committee (AMOC) to help synchronize various activities and initiatives within NDOT.	A strong alignment between planning and programming activities at the policy and operational levels.	Completed

Motivation/ Driver	Improvement Initiative	Expected Outcome	Time-frame
Maintenance and management of ITS assets needs a more structured approach.	NDOT will provide the Districts with more autonomy in managing the ITS assets within their jurisdiction. To help support the process, NDOT will provide maintenance agreements and funding for Districts I, II, and III. NDOT will also develop and implement protocols to regularly monitor and assess the maintenance agreements.	Improved financial assessment of ITS needs and maintenance strategies.	Mid-2020
Need for a robust data visualization platform to view inventory, condition, and maintenance data and make more informed decisions.	NDOT will implement a statewide Enterprise GIS system with a consistent linear referencing system to help monitor inventory, performance, and maintenance data for various assets and program areas.	A visual approach will provide the ability to consider multiple issues and trade-offs during the decision making process. Improvements to analysis and reporting capabilities. Helps identify issues isolated to a specific geographic location.	2019

The asset management improvement initiatives summarized in Table 7-1 are described in more detail below.

- **Implement an Enterprise Asset Management System (EAMS).** NDOT's asset information was historically stored in separate databases that were not accessible department-wide. Additionally, asset inventories for some assets are not complete. To address these and other issues, NDOT's Information Technology (IT) Division is working on implementing the Agile Assets infrastructure asset management software. NDOT plans to establish, implement, and start using the EAMS software over the next 6 to 18 months. Pavements, bridges, and hydraulic structures will be the first three assets to be included in the EAMS. Other assets will then be integrated into the EAMS one at a time. NDOT

also plans to conduct training programs internally within the Department to ensure a smooth transition from the existing system to the new EAMS platform.

- **Improve bridge management tools.** NDOT's current bridge management software is limited in its ability to predict changes in bridge conditions with time and to analyze the consequences of different life cycle strategies on future bridge conditions. To address this issue, NDOT will use the bridge management system (BMS) in the EAMS software. The objective is to have new bridge management system in place by mid-2020 to meet Federal requirements.
- **Improve tracking of contracted maintenance activities.** During the development of the TAMP, it was difficult to extract information related to maintenance activities performed by external contractors. This issue is expected to be addressed when the maintenance management module within the EAMS software replaces the existing Maintenance Management System (MMS).
- **Develop a process to synchronize the TAMP with other NDOT plans.** To continue to be effective, it is important that the TAMP aligns with other NDOT planning and programming documents. This synchronization will be one of the responsibilities of the Asset Management Oversight Committee discussed earlier in this chapter.
- **Develop protocols to ensure consistency in maintenance and management of ITS assets.** NDOT has recently made a change in the management process for ITS assets. Each District has been given more autonomy and responsibility in maintaining and managing the ITS assets within their jurisdiction. NDOT will allocate funding based on the number of devices being maintained by each District. In order to ensure consistency in inspection methods, maintenance protocols, and management strategies between the Districts, NDOT has developed maintenance agreements that each District is required to adopt when using the allocated funding to maintain its ITS assets. To help ensure that funds are being spent appropriately, NDOT will also develop and implement a process to verify that each district is adhering to the maintenance agreements. The process is also expected to provide input to the Central Office to determine whether any adjustments are required to the maintenance agreements.

- **Establish a statewide GIS database.** NDOT has already invested significant resources into implementing a statewide enterprise GIS database in an effort to facilitate access to statewide asset inventory and condition data. NDOT expects the implementation to be completed in 2019 and in-house training to begin thereafter. The training will enable NDOT personnel to use the new system to improve the existing management and reporting processes.

Future TAMP Enhancements

In addition to the software and business process enhancements described previously, NDOT has identified several additional enhancements that will be considered in future versions of the TAMP. These enhancements are described below.

- **Expand the TAMP to include additional assets.** The first action item for NDOT is to determine the list of assets (in addition to those included in this TAMP) to be considered for the next TAMP. Hydraulic infrastructure assets have already been looked at as one of the high priority assets that could potentially be included in the next TAMP. Decisions on the additional assets to be included will be based on the recommendations provided by the AMOC.
- **Improve and embrace decision-making based on long-term life-cycle cost considerations.** The TAMP has demonstrated the value of life-cycle costing to help formulate a suitable investment strategy for pavements, bridges, and ITS assets. NDOT will embrace the results of this analysis and continue to identify strategies that reduce the overall life cycle cost of asset preservation. For instance, the bridge investment strategies reflect an increased investment in bridge preservation over the next 10 years to extend bridge service life.
- **Assess trade-offs between different asset classes and programs and improve processes to determine cross-asset funding allocation priorities.** NDOT is already in the process of implementing a TSMO program to help the agency determine funding allocation priorities across various asset classes and programs using a data-driven approach.
- **Investigate the use of measures and metrics that provide a leading indication of asset performance.** As part of its ongoing evaluation of its performance measurement program, NDOT will consider the future use of performance

measures and metrics that consider more than just asset condition. Condition-based metrics are typically considered to be "lag" indicators because they monitor the resulting effect of investment decisions. Lag indicators are easy to measure but hard to use to achieve goals. Additionally, lag indicators often take time to see significant changes in performance. Ideally, new leading performance indicators could be developed for assets to help drive cost-effective investment decisions to help achieve performance targets. Transportation agencies in Europe, Australia and New Zealand have recognized the drawbacks of using condition-based indicators and are starting to embrace some lead metrics. These lead metrics monitor the process used to obtain the results rather than the result itself. One example of such a lead indicator for assets is the Asset Sustainability Index (ASI) that measures the asset preservation budget relative to the budget needed based on the estimates determined by the asset management system. Time-series trends of ASI would enable NDOT to determine the adequacy of its investments and re-formulate its investment strategies.

- **Develop a communication plan.** An effective communication plan that documents and communicates the significance and importance of the efforts undertaken during the TAMP development effort is a key step in ensuring that asset management practices are embraced at all levels within the Department. Therefore, a communication plan will be developed to promote the TAMP and explain its role in supporting asset investment decisions both internally and externally. ■

Appendix A. TAMP Certification Requirement Checklist

March 27,2018

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
Asset Inventory, Performance Measures, and Condition				
1	23 CFR 515.9 (b)	An asset management plan shall include, at a minimum, a summary listing of all NHS pavement and bridge assets, regardless of ownership	The inventory and condition information for all NHS pavements and bridges has been included in Chapter 3.	3–4, 3–5 Appendix D
2	23 CFR 515.9 (d) U.S.C 150(c)(3)(A)(ii)	The Plan must include measures and associated targets the State DOT can use in assessing the condition of the assets and performance of the highway system as it relates to those assets.	Measures and targets used by NDOT has been included in Chapter 3.	3–7 to 3–16
3	23 CFR 515.9 (d) U.S.C 150(c)(3)(A)(ii)	The measures and targets must be consistent with the State DOT's asset management objectives	NDOT's asset management objectives are summarized in Chapter 2. The measures are targets summarized in Chapter 3 clearly show how they are related to NDOT's overall asset management objectives.	3–7 to 3–16
4	23 CFR 515.9 (d) U.S.C 150(c)(3)(A)(ii)	Bridge Performance Measures determined according to 23 CFR 490.409: • Percentage of NHS bridges in Good condition • Percentage of NHS bridges in Poor condition	Bridge performance measures have been determined according to 23 CFR 490.409 and the data is summarized in Chapter 3.	3–11, 3–12, 3–15
5	23 CFR 515.9 (d) U.S.C 150(c)(3)(A)(ii)	Pavement Performance Measures determined according to 23 CFR 490.313: • Percentage on Interstate pavements in Good condition • Percentage of Interstate pavements in Poor Condition • Percentage of non-Interstate NHS in Good condition • Percentage of non-Interstate NHS in Poor condition	Pavement performance measures have been determined according to 23 CFR 490.313 and the data is summarized in Chapter 3.	3–8, 3–10, 3–15
6	23 CFR 490.315	Minimum condition level for pavements: • Percentage of lane-miles of interstate pavement shall not exceed 5% Poor condition as computed per 23 CFR 490.313(e)(3) except as noted below	NDOT will meet the meet minimum condition level for pavements. 2027 predicted conditions for interstate pavements: 75% Good, 23% Fair, 2% Poor	3–16

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
7	23 CFR 490.411	Minimum Condition level for bridges: • Percentage of deck area of Structurally Deficient bridges does not exceed 10 percent • Includes bridges carrying NHS, including on- and off-ramps connected to NHS within a state and bridges carrying NHS that cross a state border	NDOT will meet the meet minimum condition level for bridges. 2027 predicted conditions for NHS bridges: 40.9% Good, 54.5% Fair, 4.6% Poor	3–16
8	23 CFR 515.9 (d)	Document performance measures used by state for NHS pavements and bridges that were established through pre-existing management efforts and/or additional performance measures developed to supplement pavement and bridge measures required under 23 U.S.C. 150	For bridges, NDOT has been using performance measures that use consistent with the 23 CFR 490.313 requirements. For pavements, NDOT uses a PSI rating scale and this is discussed in Chapter 3.	3–9 to 3–13
Asset Management Objectives				
1	23 CFR 515.9	Align asset management objectives with agency's mission	NDOT's asset management objectives and the relationship between the TAMP and existing business processes are clearly documented in Chapter 2.	2–4 to 2–5
2	23 CFR 515.9	Objectives consistent with purpose of asset management, which is to achieve and sustain the desired state of good repair over the life cycle of the assets at a minimum practicable cost		
3	23 CFR 490 Subpart C, D	State DOT targets for NHS pavements and bridge asset conditions based on National Performance Management Measures for Pavements and Bridges	State DOT targets for NHS pavements and bridges are documented in Chapter 3.	3–16
Performance Gap Analysis				
1	23 CFR 515.7(a) 23 U.S.C. 150(d)	Establish a process for conducting a performance gap analysis	The process is described in Chapter 3.	3–16
2	23 CFR 515.7(a) 23 U.S.C. 150(d)	Long-term vision (performance goals and targets) of a state of good repair (SOGR)	The performance goals for NHS pavement sand bridges are summarized in Chapter 3.	3–16, 6-16, 6-19

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
3	23 CFR 515.7(a) 23 U.S.C. 150(d)	Identify deficiencies hindering progress towards achieving and sustaining desired SOGR as defined by the state DOT	NDOT does not have any performance gaps. In addition to meeting federally-mandated performance requirements for pavements and bridges on the NHS, NDOT also meets the performance goals set internally by the Department. The expected levels of funding and investment strategies that will enable NDOT to achieve its goals	3–15 to 3–17
4	23 CFR 515.7(a) 23 U.S.C. 150(d)	Comparison between current condition and short-term performance targets		
5	23 CFR 515.7(a) 23 U.S.C. 150(d)	Gaps in the performance of NHS that affect NHS pavements and bridges regardless of their physical condition in their ability to provide safe and efficient movement of people and goods		
6	23 CFR 515.7(a) 23 U.S.C. 150(d)	Strategies to close or address the gaps identified		
Life-Cycle Planning (LCP)				
1	23 CFR 515.7 (b) 23 USC 119(e)(4)(D)	Process for conducting a life-cycle planning (LCP) analysis for an asset class or asset sub group at network level	Chapter 6 documents the results of the network-level life-cycle planning analysis performed for pavements, bridges and ITS assets. Two strategies were compared: (a) NDOT's existing strategy for maintaining and managing its assets and (b) a worst-first strategy where assets would be replaced as they deteriorate to a Poor condition.	4–1 to 4–15
2	23 CFR 515.7 (b) 23 USC 119(e)(4)(D)	Factors that could impact whole life cost of assets (e.g., changes in demand, environmental condition, climate change, seismic activity etc.)	NDOT has identified factors that influence asset conditions and whole-life costs. These have been during the LCP Analysis.	4–1 to 4–5
3	23 CFR 515.7 (b) 23 USC 119(e)(4)(D)	State DOT targets for asset condition for each asset class or asset sub-group	NDOT's road network is divided into five road prioritization categories based on heavy truck traffic loads (in terms of Equivalent Single Axle Loads or ESALs) and average daily traffic (ADT). In addition to establishing performance targets for NHS pavements, performance targets have also been established for each of these five categories. Performance targets have been established for both NHS and non-NHS bridges.	3–16

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
4	23 CFR 515.7 (b) 23 USC 119(e)(4)(D)	Deterioration models for each asset class or asset subgroup	Pavement deterioration models have been developed by analyzing historical pavement conditions with pavement age for each road prioritization category. To analyze the potential size and benefit of a more comprehensive preservation program, NDOT has developed a network-level life-cycle cost analysis. The analysis uses a model of bridge deterioration, preservation unit costs, and preservation effectiveness developed by a group of experts, based on their experience and judgment, for each class of structures.	4–4, 4–5, 4–12
5	23 CFR 515.7 (b) 23 USC 119(e)(4)(D)	Potential work types for the whole life of each asset class or asset subgroup and their relative unit costs	Treatments used on pavements and bridges has been summarized in Chapter 4.	4–7, 4–11
6	23 CFR 515.7 (b) 23 USC 119(e)(4)(D)	Strategies to manage asset class/subgroup by minimizing life-cycle cost while achieving State DOT targets for condition of NHS pavements and bridges	NDOT's current pavement preservation strategy enables the agency to keep its roads in the best condition possible for the available funding. Over a 60-year period, it is estimated that NDOT's preservation strategy will have reduced life cycle costs by approximately $8.7 billion dollars over the "worst-first" strategy. Starting with current bridge inventory conditions, the bridge analysis model is able to forecast future conditions and evaluate the cost and benefit of each work type across the whole life of the bridge population, to quantify the amount of preservation and replacement work required at each condition level. This approach leads then to a management strategy whose near-term costs and outcomes during the next 10 years can be estimated. The life cycle cost and investment model allows NDOT to forecast bridge conditions ten years in the future under fiscal constraints, and to design a preservation program that can meet ten-year targets.	4–5 to 4–15

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
Risk Management Plan				
1	23 CFR 515.7 (c)	Process for developing a risk management plan: • Risk identification process • People involved in the process	The analysis conducted as a part of the TAMP development efforts focused on agency and program risks because NDOT handles project-level risks separately. During the risk analysis process, NDOT representatives were asked to identify the various types of risks that could impact their program. For each risk, potential areas of concern were identified, and possible mitigation strategies were developed.	5–1 to 5–7
2	23 CFR 515.7 (c)	Identify risks that can affect condition of NHS pavements and bridges such as: • Risks associated with current and future environmental conditions, such as extreme weather events, climate change, and seismic activity • Financial risks • Operational risks such as asset failure • Strategic risks such as environmental compliance	The risks identified during the risk management analysis effort has been summarized in a risk register.	5–8, 5–9
3	23 CFR 515.7 (c)	Assess risks in terms of likelihood of their occurrence and their impact and consequence of they do occur.	NDOT developed likelihood and impact ratings to rate and prioritize each risk identified.	5–8, 5–9
4	23 CFR 515.7 (c)	Describe process for evaluation and prioritization of identified risks	A risk heat map was used to assign an overall risk rating based on the likelihood of that event occurring and the magnitude of its impact. One or more risk management/mitigation strategies were developed for each risk to help reduce NDOT's potential exposure.	5–6 to 5–9
5	23 CFR 515.7 (c)	Identify top priority risks, develop and document a mitigation plan for addressing top priority risks including steps for implementation (scope, duration, funding)	The causes, consequences, and mitigation/adaptation strategies have been documented in the risk register.	5–8, 5–9
6	23 CFR 515.7 (c)	Process for monitoring risks and personnel responsibilities	The process for monitoring risks identified have been documented in the risk register.	5–8, 5–9

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
7	23 CFR 667	Describe process for periodic evaluation of facilities (on the NHS at a minimum) requiring repair and rehabilitation due to emergency events	NDOT has completed an evaluation of the repair and reconstruction events that have been undertaken as a result of emergency events that have occurred since January 1, 1997. NDOT has been determined that, to the best of their knowledge, no road, highway, or bridge on the NHS has required repair or reconstruction on two or more occasions due to emergency events.	5–10, 5–11, 5-12
8	23 CFR 667	Determine if there are roads, highways, or bridges (on the NHS at a minimum) that have required repair and reconstruction due to emergency events on two or more occasions		
9	23 CFR 667	Conduct statewide evaluation to determine if there are reasonable alternatives to roads, highways, and bridges that have required repair and reconstruction on two or more occasions due to emergency events		
10	23 CFR 667	Describe how the DOT considers the results when developing projects.	Moving forward, NDOT has developed a process to support the 23 CFR Part 667 requirements.	
Financial Plan				
1	23 CFR 515.7 (d)	Process for developing a 10-year financial plan Consider strategies from gap analysis, LCP, and risk management analysis in developing financial plan Process for determining funding sources and expected funding levels for NHS pavement and bridges	The process for developing a financial plan including revenue sources, revenue projections, revenue trends, and financial risks are documented in the first half of Chapter 6.	6–1 to 6–8
2	23 CFR 515.7 (d)	Funding sources and amount of funding available from each source for the 10-year financial plan		6–1 to 6–3
3	23 CFR 515.7 (d)	Forecasted available funding levels for NHS pavements and bridges by fiscal year	Expected annual investments in new construction and asset management activities over the next 10 years is summarized in Chapter 6.	6–4, 6–5
4	23 CFR 515.7 (d)	Elaboration of financial risks influencing success of financial plan	NDOT considered two financial risks that could potentially impact the asset management revenue: (a) improvements in vehicle fuel Efficiency and other automobile technologies, and (b) reduction in vehicle sales and registration/renewal revenue.	6–6 to 6–9

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
5	23 CFR 515.7 (d)	Trade-off analysis in prioritizing funding strategies using result of performance gap analysis, LCP, and risk management analysis	For pavements, available funding is only adequate to address needs of Category 1 pavements (that includes the interstates and NHS pavements). NDOT has determined that the risks and long-term costs associated with not maintaining Category 1 pavements are much higher than similar risks associated with pavements in Categories 2-5. Given the constrained fiscal scenario, NDOT will maintain the high priority pavements in better conditions and use the maintenance dollars to keep the roads in other categories in safe operable conditions. To maintain relatively good bridge conditions at modest investment levels, NDOT recognizes there is a need to extend the average lifespan of each bridge well beyond the intended 50-years by including preservation activities, as well as to gradually increase the level of reinvestment. NDOT is expected to expand its use of inexpensive preventive maintenance and corrective actions to extend bridge service life and implement a bridge management system to find the most attractive strategic investments	6–9 to 6–23
6	23 CFR 515.7 (d)	Asset valuation for NHS pavements and bridges including annual investment needs to maintain asset value	NDOT invests in preserving the value of its transportation assets through a whole-life management strategy that extends the service life of these assets. A summary of the current replacement values of the assets included in Chapter 3.	3–17
Investment Strategies				
1	23 CFR 515.7 (e) 515.7 (f)	How investment strategies were influenced by financial plan, performance gap analysis, LCP, and risk management analysis	Investment strategies were primarily driven by the fiscal constraints. The LCP analysis clearly showed great benefits of increase preservation actions on both pavements and bridges. The risk analysis showed the importance of prioritizing investments to achieve agency goals. These factors organically drove the development of the investment strategies given the fiscal constraints. The available funding will be used in the most judicious manner while considering trade-offs.	6–9 to 6–23

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
2	23 CFR 515.7 (e) 515.7 (f)	Methodology for developing investment strategies that support progress toward: • Achieving and sustaining desired SOGR over life cycle of asset • Improving or preserving condition of NHS pavements and bridges • Achieving state DOT targets for NHS pavements and bridges • Achieving national goals identified in 23 USC 150(b): (safety, infrastructure condition, congestion reduction, system reliability, freight movement and economic vitality, environmental sustainability, reduced project delivery delays)	The investment strategies developed have placed an emphasis on preserving the condition of interstate and other NHS pavements and bridges. Safety and infrastructure condition have been utmost importance during the development of the plan. The expected level of funding for pavements between 2017 and 2026 will only be adequate to maintain the condition of Category 1 pavements. The pavements in Categories 2–5 will only receive localized maintenance to keep them in safe and operable condition levels and the average conditions of these pavements are expected to decline steeply over the next 10 years if additional funding is not provided for needed capital improvements, however, the established performance targets will be met. Bridge conditions are expected to decline under all realistic fiscal scenarios, but additional funding will reduce the rate of deterioration over the next ten years. However, performance targets will be met.	6-9 to 6-23
Obtaining Data from Other NHS Owners				
1	23 CFR 515.7(f)	Methodology for obtaining necessary data from other NHS owners in a collaborative and coordinated effort	Because a portion of the pavement network (approximately 150 centerline miles) is maintained by the Local Public Agencies (LPAs) NDOT has been working with its regional planning partners to establish common goals for the entire NHS within the state.	3-2, 3-3, 6-15
Ensuring Use of Best Available Data and Use of Pavement and Bridge Management Systems				
1	23 CFR 515.7(g)	Ensure use of best available data for development of TAMP	NDOT has had in place a set of procedures and systems for monitoring the condition of its infrastructure, focused on pavements and bridges. These systems include an up-to-date inventory and a variety of data items related to physical deterioration, traffic, safety, mobility, risk, and costs. These processes comply with federal requirements and are subject to uniform national quality assurance processes. NDOT has also developed a data quality management plan that is in accordance with the FHWA requirements and the new Enterprise Asset Management System (EAMS) being implemented is in accordance with the requirements specified under 23 CFR 515.17	2-4

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
2	23 CFR 515.7(g)	Develop TAMP using PMS and BMS that meet 23 CFR 515.17 requirements	NDOT is in the process of implementing the EAMS system which will meet all requirements under 23 CFR 515.17. The Bridge Management System implemented as a part of the EAMS will be able to support deterioration modeling and life-cycle planning analysis. The maintenance management system module of the EAMS will help track both in-house and contract maintenance activities in a more stream- lined manner. The EAMS implementation is expected to be completed in early 2019.	7–3, 7–4
3	23 CFR 515.7(g)	If state DOT does not have PMS and BMS that meet 23 CFR 515.17 requirements for first certification, document process used for analysis and steps that DOT is taking to meet requirements • Plans to improve efficiency and functionality of PMS and BMS • Timeframe		
4	23 CFR 515.7(g)	Ensure process for using information from Statewide Transportation Improvement Program (STIP) in the TAMP is consistent with TAMP process and data requirements	The results from the PMS and BMS analysis will be used to determine the projects for the STIP moving forward. The projects already included in the STIP have been accounted for during the development of the investment strategies for this TAMP.	2–3 to 2-4, 3–11, 6–5
5	23 CFR 515.7(g)	Ensure accuracy and consistency in data and data collection methodology amongst NHS owners	Although most of the NHS routes are managed by NDOT, there are approximately 150 miles that are managed by local agencies in the state. NDOT collects roughness, rutting, and faulting data on all NHS routes as part of its pavement management practices.	3–2, 3–3, 6–15
6	23 CFR 515.7(g)	Document assumptions made to complete analyses in the absence of PMS and/or BMS	NDOT currently does not have a BMS in place. As noted earlier, the BMS will be implemented as a part of the EAMS and is expected to be operational in early 2019. In the absence of a BMS, all the analysis for the TAMP was conducted using spreadsheet tools using data and input from the NDOT asset management group.	4–11 to 4–15, 7–3, 7–4
7	23 CFR 515.7(g)	Detailed action plan including timeframes to address issues related to data unavailability	The major short-term asset management improvement initiatives that are being advanced by NDOT along with the expected outcome and the timeframe for implementation have been documented in Chapter 7.	7–3, 7–4

Item	Reference	TAMP Certification Requirement	How it is Addressed in the TAMP	Where it is Addressed (page number)
Minimum Standards for PMS and BMS				
1	23 CFR 515.17	Documented procedures for collecting, storing, and updating inventory and condition data	As discussed earlier, once the new EAMS is implemented, NDOT will meet all the minimum standards for PMS and BMS.	N/A
2	23 CFR 515.17	Forecasting deterioration for NHS pavements and bridges		N/A
3	23 CFR 515.17	Determine benefit-cost over life cycle to evaluate alternative actions (including no action) for managing NHS pavement and bridge condition		N/A
4	23 CFR 515.17	Identify short- and long-term budget needs for managing NHS pavements and bridges		N/A
5	23 CFR 515.17	Determine strategies identifying NHS pavement and bridge projects that will maximize overall program benefits within financial constraints		N/A
6	23 CFR 515.17	Recommend programs and implementation schedules to manage NHS pavement and bridge condition within policy and budget constraints		N/A

Appendix B. Assumptions Used in the Life-Cycle Planning Analysis for ITS Assets

This appendix documents the key assumptions used in modeling the life cycle performance of the ITS assets addressed in this TAMP: Closed Circuit Television camera devices (CCTV), Dynamic Message Signs (DMS), Flow Detectors, Highway Activity Reporting (HAR) devices, Ramp Meters, and Road Weather Information System (RWIS) devices.

Deterioration Models

The deterioration of ITS assets is based on models developed using expert judgment provided by NDOT staff. The models are based on a "Health Index", which is a measure that has been developed purely for the purposes of illustrating asset performance over time. The Health Index is based on a 0 to 100 scale. Values of 75 to 100 correspond to "Good" condition, values of 50 to 75 correspond to "Low Risk" condition, values of 25 to 50 correspond to "Medium Risk" condition and values below 25 represent a "High Risk" condition. It is to be noted that these values are subjective estimates based on expert judgment.

Asset performance was modeled for two scenarios: (a) a preservation scenario where proactive maintenance activities are applied and (b) a worst-first scenario where assets are replaced when they reach a Medium to High Risk condition. The network-level deterioration models developed for each of the ITS assets included in the TAMP are shown in Figures B-1 through B-6.

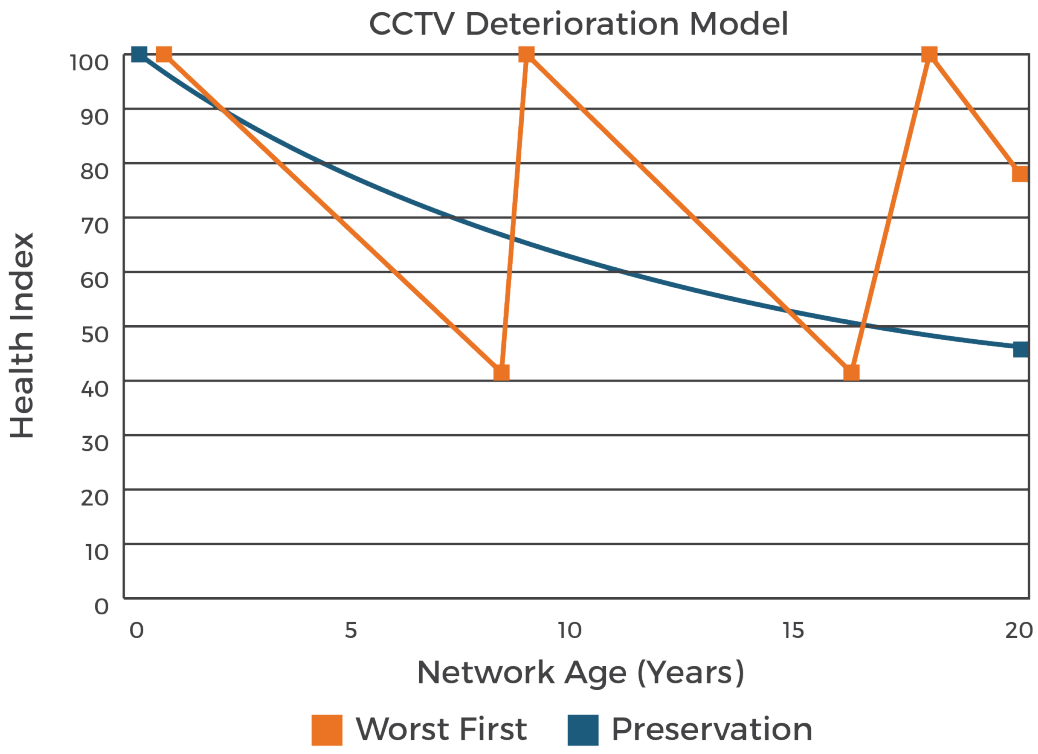


Figure B-1. Deterioration Model for CCTV Devices.

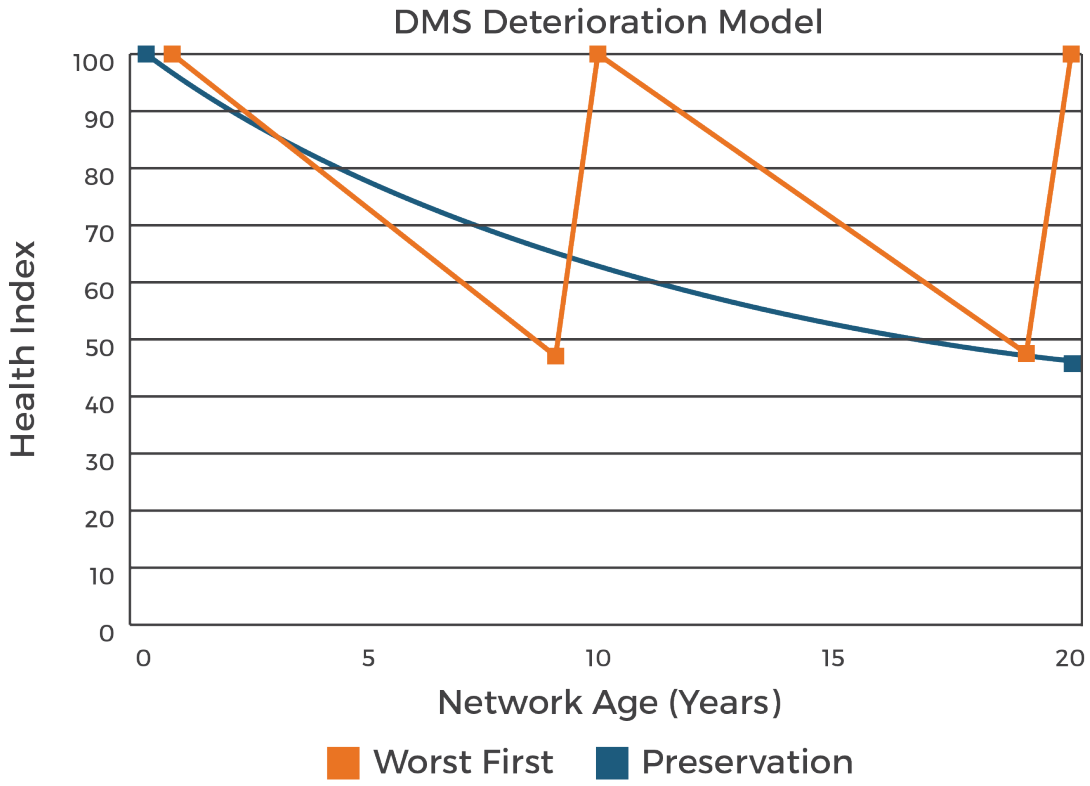


Figure B-2. Deterioration Model for DMS Devices.

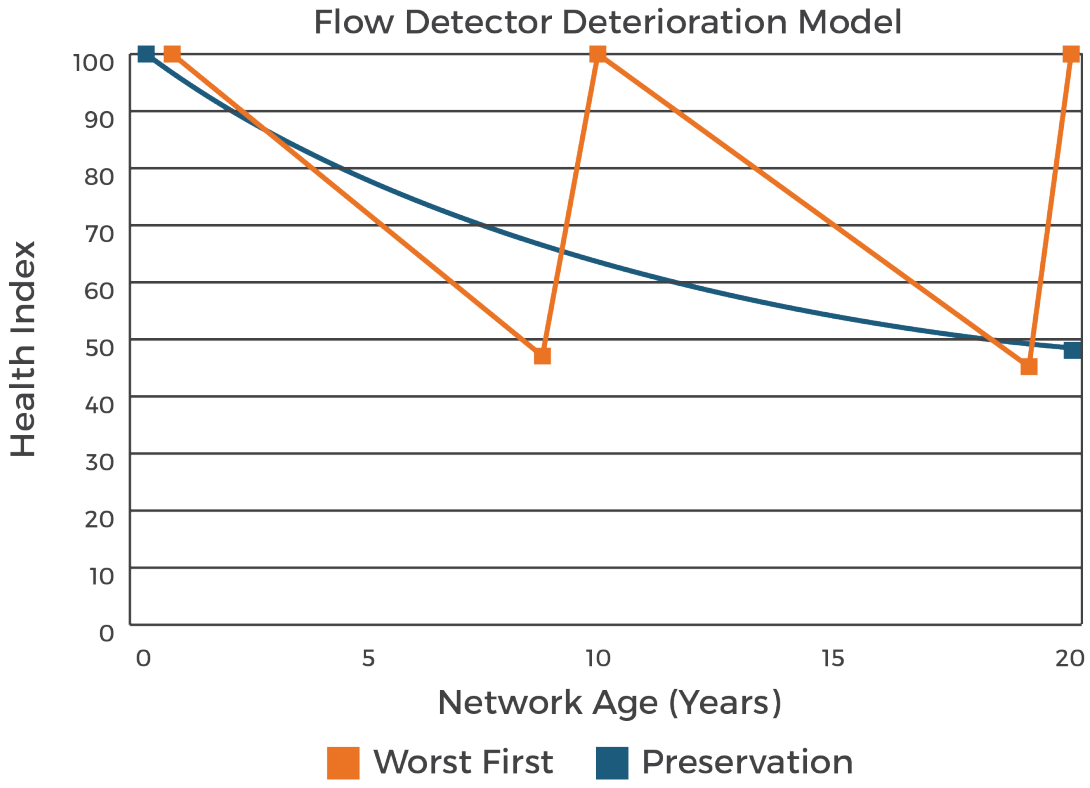


Figure B-3. Deterioration Model for Flow Detectors.

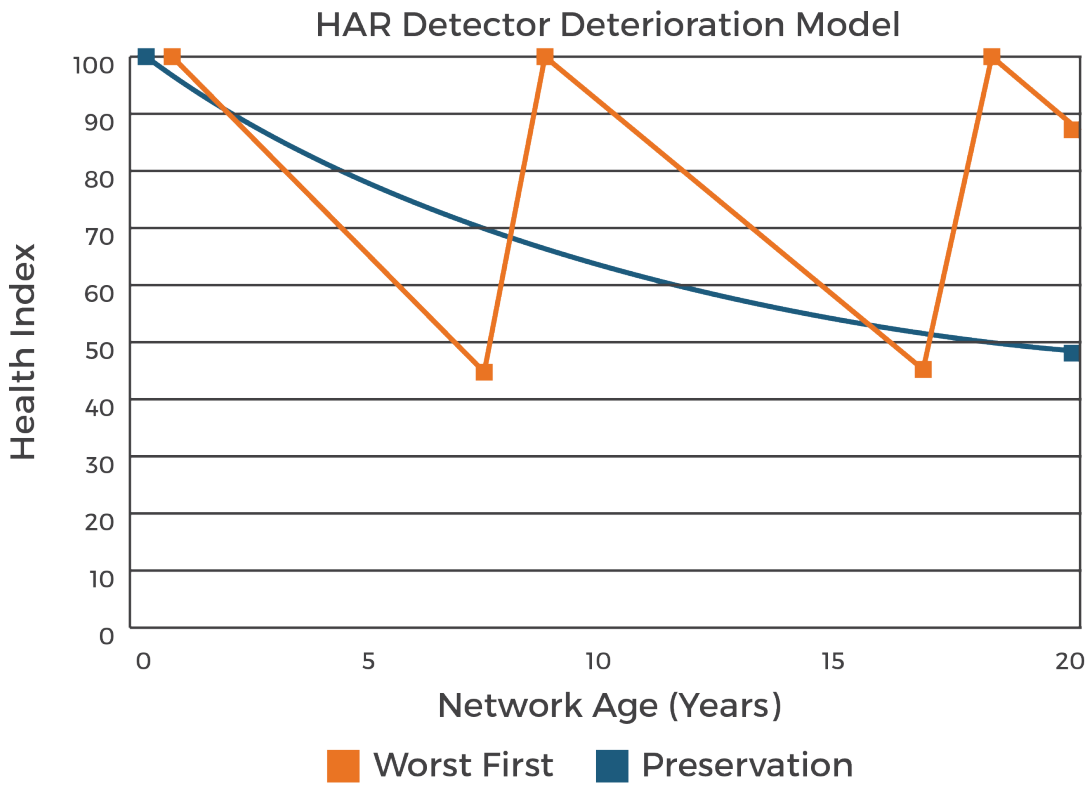


Figure B-4. Deterioration Model for HAR Devices.

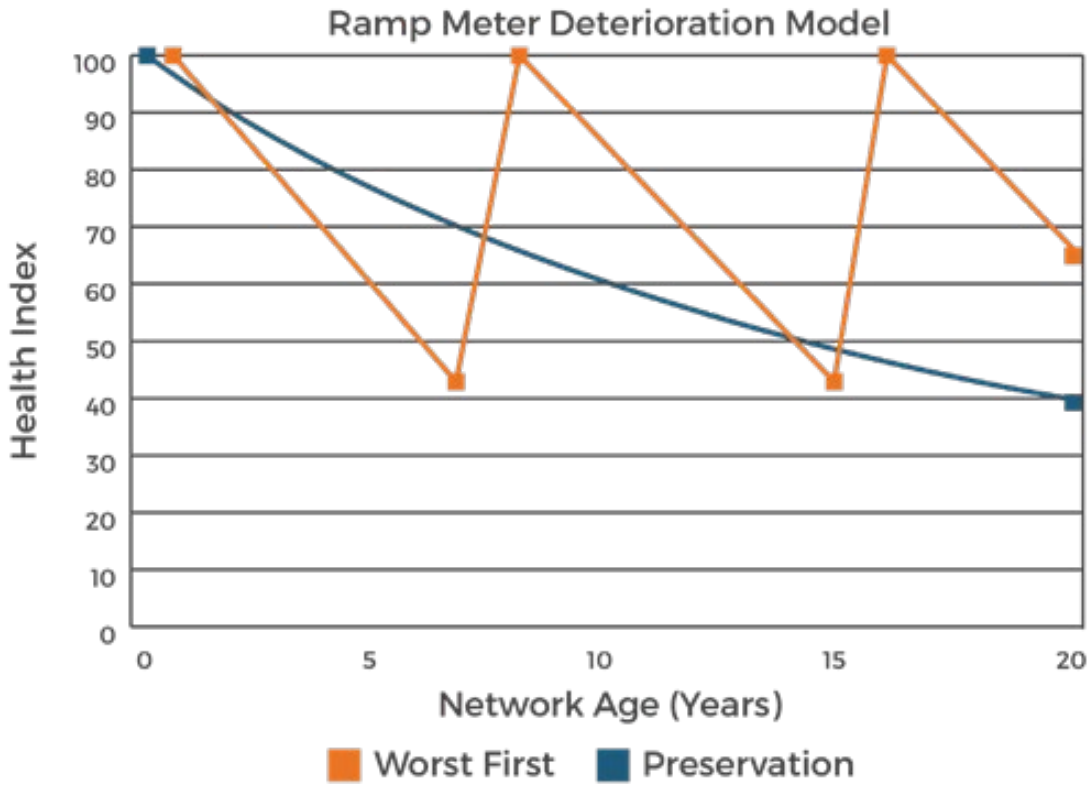


Figure B-5. Deterioration Model for Ramp Meters.

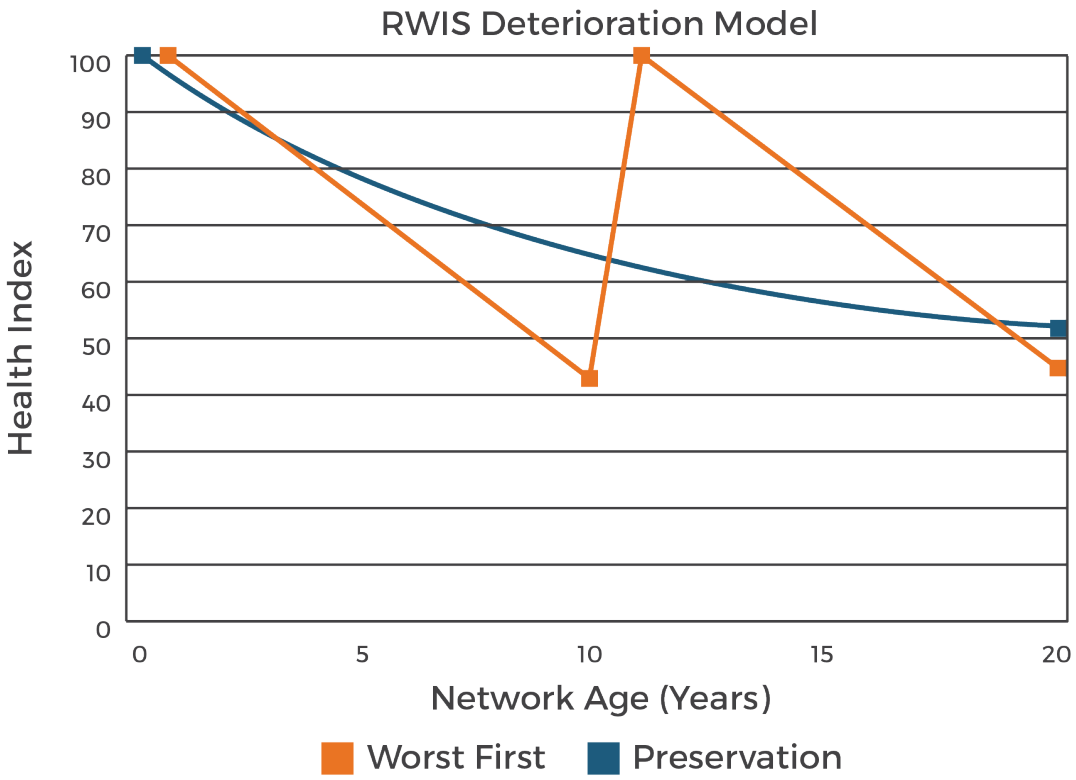


Figure B-6. Deterioration Model for RWIS devices.

ITS Asset Maintenance

The four types of inspection and maintenance activities performed on ITS devices are provided below.

- **Inspection:** involves routine maintenance of the device/asset by NDOT typically performed annually or bi-annually based on type of device.
- **Minor Repairs:** Typically performed on site and these include activities such as adjusting loose cables, battery replacement, firmware upgrades.
- **Major Repairs:** Typically requires the device to be sent back to the maintenance shop or factory for repairs and involves the replacement of one or more key parts to ensure satisfactory device functioning.
- **Replacement:** Involves complete removal and replacement of the device.

The impact of the type of maintenance activity on the existing conditions state are shown in Table B-1. For instance, an ITS asset in good condition requires only periodic inspection. If the results of the inspection indicate that the asset is a Low Risk, minor repairs could be applied to bring that asset back up to Good condition. Similarly, if an ITS asset is a Medium Risk, major repairs could improve the status to Low Risk. Finally, a High Risk asset can either be converted to a Medium Risk with major repairs or could be returned to Good condition if replaced.

Table B-1. Maintenance activity impact matrix.

Current Condition	Resulting Condition After:			
	Inspection	Minor Repair	Major Repair	Replacement
Good	Good			
Low Risk	Low Risk	Good		
Medium Risk	Medium Risk	Medium Risk	Low Risk	
High Risk	High Risk	High Risk	Medium Risk	Good

Detailed descriptions of the inspection and maintenance activities by ITS asset type are summarized in Table B-2.

Table B-2. Descriptions of Inspection and Maintenance Activities by ITS Device Type.

Device	Inspection	Minor Repairs	Major Repairs	Replacement
CCTV	Performed twice a year. Standard factory recommended preventive maintenance (PM) performed on all devices. PM activities include: cleaning cabinet and device, changing filters, checking connections, ensuring proper functionality, run manufacturer recommended tests. One to two person crew required for inspection which takes about 2 hours per device.	Repairs typically performed on site, takes 4 to 8 hours. Typical repairs include: adjusting loose camera and cables, repairing camera lowering device, encoder programming, and configuring devices.	Repairs typically require device to be sent back to shop or factory for major repairs. Typical repairs include: zoom repair, camera features repair, gyro and motor repair, CCTV and lowering device cable repairs. Repairs can take anywhere from 1 day to 1 week.	Replacement is typically required when the device/ parts are no longer serviceable or become obsolete. Typical parts needing replacement include: camera, encoding device, cabinet. Replacement can take anywhere between 3 to 6 weeks.
DMS	Performed once a year. Standard factory recommended PM performed on all devices. PM Activities include: replacing filters and lamps, checking interior lighting, checking visible damage to sign structures and electrical connections, checking functionality of cooling fan, backup UPS, and lubricating engines in cabinet. Inspection takes 2 hours per device, one person crew.	Repairs typically performed on site, takes 4 to 8 hours. Typical repairs include: replacement of power supply box, changing batteries.	Repairs typically require device to be sent back to shop or factory for major repairs. Typical repairs include: changing LED boards (for new signs), controller replacement. Signs will be down when repairs are being performed. Repairs can take anywhere from 1 day to 1 week.	Replacement is typically required when the device/ parts are no longer serviceable or become obsolete. Replacement is usually required when the sign/cabinet is damaged after accidents. Replacement can take anywhere between 3 to 6 weeks.

Device	Inspection	Minor Repairs	Major Repairs	Replacement
Flow Detectors	Performed once a year. Standard factory recommended PM performed on all devices. PM Activities include: fine-tuning configurations, calibration, checking connections, verifying device functionality. Inspection takes 2 hours per device, one person crew	Repairs typically performed on site, takes 4 to 8 hours. Typical repairs include: wire repairs, re-aiming, unit reconfiguration, and surge protection.	Repairs typically require device to be sent back to shop or factory for major repairs. When unit goes down, some parts will need to be replaced as required. Repairs can take anywhere from 1 day to 1 week.	Replacement is typically required when the device/ parts are no longer serviceable or become obsolete. Typically involves replacement of accompanying devices (as needed). Replacement can take anywhere between 3 to 6 weeks.
HAR	Performed once a year. Standard factory recommended PM performed on all devices. PM Activities include: device cleaning and testing connections. Inspection takes 2 hours per device, one person crew.	Repairs typically performed on site, takes 4 to 8 hours. Typical repairs include: replacing card and motors, firmware upgrades.	Repairs typically require device to be sent back to shop or factory for major repairs. When unit goes down, the entire system needs to be taken out for repair. Repairs can take anywhere from 1 day to 1 week.	Replacement is typically required when the device/ parts are no longer serviceable or become obsolete. Typically involves replacement of accompanying devices (as needed). Replacement can take anywhere between 3 to 6 weeks.
Ramp Meters	Performed once a year. Standard factory recommended PM performed on all devices. Inspection takes 2 hours per device, one person crew.	Repairs typically performed on site, takes 4 to 8 hours. Typical repairs include: controller replacement, load bay replacement, lamp replacement.	Repairs typically require device to be sent back to shop or factory for major repairs. Typical repairs include: cabinet replacement, pole repair, detection system repair. Repairs can take anywhere from 1 day to 1 week.	Replacement is typically required when the device/ parts are no longer serviceable or become obsolete. Replacement is usually required when intersection designs are updated (freeway widening, ramp reconfiguration etc.) Replacement can take anywhere between 3 to 6 weeks.
RWIS	Performed once a year. Standard factory recommended PM performed on all devices. PM Activities include: device cleaning and testing connections. Inspection takes 2 hours per device, one person crew.	Repairs typically performed on site, takes 4 to 8 hours. Typical repairs include: replacing card and motors, firmware upgrades.	Repairs typically require device to be sent back to shop or factory for major repairs. When unit goes down, the entire system needs to be taken out for repair. Repairs can take anywhere from 1 day to 1 week.	Replacement is typically required when the device/ parts are no longer serviceable or become obsolete. Typically involves replacement of accompanying devices (as needed). Replacement can take anywhere between 3 to 6 weeks.

The average inspection and maintenance costs for each ITS asset is shown in Table B-3.

Table B-3. Average Maintenance Cost by ITS Device Type.

Average Maintenance Cost/Unit				
Device	**Inspection**	**Minor**	**Major**	**Replacement**
CCTV	$300	$1,150	$4,600	$11,500
DMS	$1,000	$9,500	$23,750	$95,000
Flow Detectors	$300	$1,200	$1,200	$9,500
HAR	$300	$2,500	$10,00	$25,000
Ramp Meters	$300	$3,500	$15,000	$52,500
RWIS	$1,000	$5,000	$15,000	$75,000

The fraction of the network inspected or receiving a particular type of maintenance activity annually is shown in Table B-4.

Table B-4. Average Annual Inspection and Maintenance Fractions.

Device	**Maintenance Type**	**Asset Condition**			
		Good	**Low Risk**	**Medium Risk**	**High Risk**
CCTV	Inspection	133%	133%	133%	133%
	Minor		10%	30%	10%
	Major			10%	25%
	Replacement				10%
DMS	Inspection	133%	133%	133%	100%
	Minor		10%	20%	10%
	Major			10%	15%
	Replacement				10%
Flow Detectors	Inspection	100%	100%	100%	100%
	Minor		5%	5%	5%
	Major			5%	5%
	Replacement				20%

Device	Maintenance Type	Asset Condition			
		Good	Low Risk	Medium Risk	High Risk
HAR	Inspection	100%	100%	100%	100%
	Minor		10%	50%	0%
	Major			10%	0%
	Replacement				0%
Ramp Meters	Inspection	133%	133%	133%	133%
	Minor		20%	30%	10%
	Major			10%	50%
	Replacement				0%
RWIS	Inspection	100%	100%	100%	100%
	Minor		10%	50%	10%
	Major			10%	75%
	Replacement				1%

Appendix C: FHWA TAMP Certification Guidance

Transportation Asset Management Plan Development Processes Certification and Recertification Guidance

Introduction

Asset management provisions enacted in the Moving Ahead for Progress in the 21st Century Act (MAP-21) require a State Department of Transportation (DOT) to develop and implement a risk-based asset management plan in accordance with 23 U.S.C. 119, to achieve and sustain a state of good repair over the life cycle of the assets and to improve or preserve the condition of the National Highway System (NHS). Pursuant to 23 U.S.C. 119(e)(4)(A), the State DOT must include all NHS highway pavements and bridges in its transportation asset management plan (TAMP) regardless of the ownership of the relevant NHS facility. Note that 23 U.S.C. 103(a) defines NHS as including the Interstate Highway System. The Federal Highway Administration (FHWA) adopted the asset management rule, 23 CFR Part 515, to implement the asset management requirements. The statute does not provide any authority for FHWA to grant a waiver to a State DOT from the requirements to develop and implement a TAMP.

Under the statute, FHWA must take two actions with respect to State DOT asset management activities. The first is FHWA's TAMP *development process certification/recertification*. Under 23 U.S.C. 119(e)(6), FHWA must certify at least every 4 years that the State DOT's processes for developing its TAMP meet applicable requirements (23 CFR 515.13(a)). The FHWA must also recertify whenever the State DOT amends its TAMP development processes (23 CFR 515.13(c)). The second FHWA action is an *annual consistency determination,* which evaluates whether the State DOT has developed and implemented a TAMP that is consistent with the requirements of 23 U.S.C. 119.

1 The FHWA will make the first process certification decisions in 2018. State DOTs must submit an initial TAMP to their FHWA divisions not later than **April 30, 2018** (23 CFR 515.11(a)(1)). Requirements for the initial plan are discussed in FHWA's "Asset Management Initial Plan Guidance," available on FHWA's Asset Management Web Page (https://www.fhwa.dot.gov/asset/). Within 90 days, FHWA will review the initial TAMP for two purposes. First, FHWA will make its first process certification decision based on the TAMP development methodologies described in the initial TAMP (23 CFR 515.11(a)). Second, FHWA will provide feedback to the State DOTs on the alignment of the initial TAMP with regulatory requirements. The goal of this feedback is to help ensure that State DOTs' TAMPs will meet applicable requirements by the time State DOTs submit their complete TAMPs, which are due not later than **June 30, 2019** (23 CFR 515.11(a)(2)).

This document provides a framework for undertaking and completing *process certifications/recertifications* for a State DOT's TAMP development processes as outlined in 23 CFR 515.13. Best practices in this Guidance may be revised as the state of asset management practices advance and the asset management rule is further implemented. The FHWA Division Offices (Divisions) will receive separate guidance on making *consistency determinations* under 23 CFR 515.13(b).

Certification Process and Possible Outcomes of the Certification Review

The FHWA Division Offices are responsible for certification and recertification of the State DOT processes for development of the TAMP. The TAMP Certification and Recertification Guidance provides a tool to help FHWA Divisions assess the elements and completeness of a State DOT's TAMP development processes. The asset management statute provides, in 23 U.S.C. 119(e)(6)(A), that -

Not later than 90 days after the date on which a State submits a request for approval of the process used by the State to develop the State asset management plan for the NHS, the Secretary shall –
(i) review the process; and
(ii)(I) certify that the process meets the requirements established by the Secretary; or
(II) deny certification and specify actions necessary for the State to take to correct deficiencies in the State process.

Additionally, 23 U.S.C.119(e)(6)(B) requires a State DOT to update its TAMP development processes at least every 4 years and submit the processes to FHWA for recertification. Also, whenever the State DOT updates or otherwise amends its TAMP or its TAMP development processes, the State DOT must submit the amended plan or processes to the FHWA for a new process certification and consistency determination at least 30 days prior to the deadline for the next FHWA consistency determination under 23 CFR 515.13(b). Minor technical corrections and revisions with no foreseeable material impact on the accuracy and validity of the processes, analyses, or investment strategies in the plan do not constitute amendments and do not require submission to FHWA (23 CFR 515.13(c)).

Below is a summary of the certification process included in 23 CFR Part 515.

- On or before April 30, 2018, the State DOT must submit its first State-approved TAMP. The FHWA will use this document for certification of the State DOT's processes (23 CFR 515.11(a)(1)). The certification decision is based on whether the TAMP development processes described in the TAMP meet the process requirements described in 23 CFR 515.7.

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- The State DOT must update and resubmit its TAMP development processes to FHWA for a new process certification at least every 4 years (23 CFR 515.13(a)).

- Whenever the State DOT updates or otherwise amends its TAMP or its TAMP development processes, the State DOT must submit the amended plan or processes to FHWA for a new process certification (23 CFR 515.13(c)).

- Not later than 90 days after the date on which FHWA receives a State DOT's processes and request for certification or recertification, FHWA will decide whether the State DOT's processes meet the requirements (23 CFR 515.13(a)).

- A certification review could lead to one of three outcomes:
  - Certified Processes: TAMP processes meet the requirements of 23 CFR 515.7 (23 CFR 515.13(a)(1)).
  - Conditionally Certified Processes: TAMP processes substantially meet the requirements of 23 CFR 515.7 except for minor deficiencies (23 CFR 515.13(a)(3)).
    - The FHWA may certify the State DOT's processes as being in compliance, but the State DOT must take actions to correct the minor deficiencies within 90 days of receipt of the notification of conditional certification.
    - Minor deficiencies are deficiencies where a portion of the information or process is slightly incomplete, as compared to regulatory requirements. A conditional certification cannot be given for deficiencies that are more than minor, including any case where the State DOT fails to address any of the required processes.
    - The State must notify FHWA, in writing, when corrective actions are completed.
    - Once the Division Office verifies the corrections, it will issue a letter of full certification to the State DOT.
  - Denial of Certification: TAMP processes do not meet the requirements of 23 CFR 515.7 (23 CFR 515.13(a)(2)).
    - The FHWA will send the State DOT a written notice of the denial of certification or recertification, including a listing of the specific deficiencies.
    - The State DOT will have 90 days from receipt of the notice to address the deficiencies and resubmit its processes to FHWA.
    - Upon request, FHWA may extend the State DOT's 90-day period to cure deficiencies.
    - During the cure period, all penalties and other legal impacts of a denial of certification will be stayed as provided in 23 U.S.C. 119(e)(6)(C)(i).

A State DOT's process certification or recertification submission must demonstrate that the State DOT's TAMP development processes meet the minimum requirements contained in 23 CFR 515.7.

In making a determination whether the State DOT's submission is adequate, Divisions should consider whether the submission describes the processes in enough detail and with sufficient clarity so that the Division can make a reasoned decision whether (1) each process meets the requirements in the regulation and will produce the information required for the TAMP; and (2) the submission includes all required processes. A submission likely is incomplete if the submission substitutes references to websites or vendor publications for adequately detailed process descriptions.

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Consider the following examples:

State A notes in its risk analysis process that the final decision regarding risk prioritization will be made by the Office of XX, and that the Office can override the risk prioritization list. In this case, the process is not certifiable because it is not clear what criteria or process this Office may use to modify the initial list as part of the evaluation and prioritization process required under 23 CFR 515.7(c)(3).

State B notes in its TAMP that the vendor's pavement management systems manual explains the State DOT's process for life cycle planning for pavements. Generally, the management systems manuals are technical documents that provide extensive technical information pertaining to analyses, but are not customized to provide a clear description of the process that is adopted by the State DOT. Therefore, State B must include a life cycle development process specific to its life cycle plan approach in order to satisfy 23 CFR 515.7(b). However, the State DOT may attach the vendor document, if it believes that document provides further understanding.

The overall context of the TAMP is important when evaluating the adequacy of the State DOT's TAMP development processes. Divisions should consider how State DOT's objectives for the State DOT risk-based TAMP, performance measures and State DOT targets, and asset conditions may affect the design of TAMP development processes. That information can help Divisions decide whether the State DOT's proposed processes can

produce the required analyses that the State DOT will consider when deciding how the State DOT can achieve asset management outcomes such as improving or preserving the condition of assets, and making progress toward achievement of the State DOT's objectives.

For example, consider a State DOT with objectives and the related targets. The State DOT's targets (which must be consistent with the TAMP's objectives (23 CFR 515.9(d)(2)) focus on managing its pavements and bridges for their whole life, rather than using a worst–first approach. The State DOT's life cycle planning process should reflect this focus by including the use of deterioration models that addresses changes in the condition of assets with time and usage. If the process description does not identify a deterioration model that can analyze changes in condition with time and usage, then the process does not meet the requirements under 23 CFR 515.7(b). This is because the process will not produce the information needed to evaluate strategies for achieving the State DOT's whole life targets for the assets.

Division Certification Review Framework

To assist Divisions with their certification reviews, please use the following evaluation matrix for each required TAMP development process.

The matrix for each required TAMP development process has three columns:

- **Process:** Identifies the TAMP development process that the row of the matrix discusses.
- **Required Elements:** A brief summary of the key elements for the particular TAMP development process. A State DOT's TAMP development process must satisfy each of these regulatory requirements.
- **Examples of Good Practices:** Describes voluntary enhancements to the basic requirements. State DOTs are at various maturity levels with their asset management programs. Therefore, how each State DOT addresses and enhances its processes depends on the maturity level of a State DOT regarding its asset management program. For example, State A with a mature asset management program most likely has already developed a process for determining how to maintain an asset over its life cycle whereas State B, which is at a lower maturity level with its asset management program, may need to develop a basic life cycle planning process and build upon it in the future. The FHWA encourages State DOTs to adopt more sophisticated approaches to asset management, but as long as the State DOT's processes satisfy the required elements, FHWA will certify the processes. Further information on TAMP practices can be found in the preamble to the final rule and the Q&A's found at www.fhwa.dot.gov/asset/.
- **Division Assessment**: The last row in each section is for the Division to indicate if the State DOT has met the requirements discussed in the Required Elements column, and how the State DOT has demonstrated compliance. Utilizing the Required Elements, the Division can document if the individual process has deficiencies, make recommendations, and point out notable practices.

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Required TAMP Processes

Under 23 CFR 515.7, the State DOT must have the following TAMP processes:

1. Process to complete a performance gap analysis and to identify strategies to close gaps
2. Process to complete life cycle planning
3. Process to complete a risk analysis and develop a risk management plan
4. Process to develop a financial plan covering at least a 10-year period
5. Process to develop investment strategies
6. Process for obtaining necessary data from NHS owners other than the State DOT
7. Process for ensuring the TAMP is developed with the best available data and that the State DOT uses bridge and pavement management systems meeting the requirement s in 23 CFR 515.17 to analyze NHS bridge and pavement conditions

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1. Performance Gap Analysis Process

A State DOT must establish a process for conducting a performance gap analysis that, at a minimum, will identify alternative strategies to close the gaps between the current asset condition and (1) State DOT 23 U.S.C. 150(d) targets for asset condition for the NHS, and (2) the gaps in the performance of the NHS that affect NHS pavements and bridges (23 CFR 515.7(a)).

Sample questions to ask as the FHWA Division Office reviews the TAMP development processes:

- Does the process have a method for identifying gaps affecting the State DOT targets for the condition of NHS pavements and bridges as established pursuant to 23 U.S.C. 150(d)?
- Does the process describe how the State DOT will identify deficiencies hindering progress toward achieving and sustaining the desired state of good repair (as defined by the State DOT)?
- Does the process describe how alternative strategies will be developed that will close or address the identified gaps in the physical condition of the assets?
- Does the process describe how the State DOT will identify gaps in the performance of the NHS (as defined in 23 CFR 515.5)?
- Does the process describe a methodology for identifying gaps in the performance of the NHS that affect NHS bridges and pavements regardless of their physical condition?
- Does the process describe how alternate strategies will be developed that will close or address the identified gaps in the performance of the NHS that affect NHS bridges and pavements regardless of their physical condition?

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Process	Required Elements	Examples of Good Practices
Performance Gap Analysis (23 CFR 515.7(a))	**Physical Condition of Assets** The TAMP must describe a methodology, with regard to the physical condition of the assets, for: • Identifying gaps affecting the State DOT targets for the condition of NHS pavements and bridges as established pursuant to 23 U.S.C. 150(d). • Identifying deficiencies hindering progress toward achieving and sustaining the desired state of good repair (as defined by the State DOT). • Developing alternative strategies that will close or address the identified gaps.	**Physical Condition of Assets** The State DOT's process includes the following elements: • The State DOT's long-term vision (targets and long-term performance goals) of a state of good repair for assets. • A summary of data items that are needed for analysis, but not available or accessible. • Assumptions that must be made in order to complete data analyses. The State DOT's process includes methods to: • Compare the existing condition to the short-term targets required by 23 U.S.C. 150(d). • Compare the long-term performance of the assets in terms of achieving and sustaining a state of good repair to the existing condition of the assets. • Describe how the State DOT will identify strategies to close the gap between the existing condition and projected condition for achieving and sustaining a state of good repair. • Describe how alternative strategies will be compared.
	NHS Effectiveness Performance: The TAMP must describe a methodology for analyzing gaps in the performance of the NHS that affect NHS bridges and pavements regardless of their physical condition, that will: • Identify gaps in the effectiveness of the NHS in providing safe and	**NHS Effectiveness Performance:** The State DOT's process includes methods to: • Consider roadway uses, performance impacts, and changes in assets due to programs (e.g., freight, safety, congestion) and other factors (e.g., climate change, extreme weather). • Incorporate the upcoming changes in assets due to programs (e.g., freight, safety, congestion) and other

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Process	Required Elements	Examples of Good Practices
	efficient movement of people and goods. (23 CFR 515.7(a)(2)). • Identify strategies to close or address the identified gaps affecting the physical assets. (23 CFR 515.7(a)(3)).	factors (e.g., climate change, extreme weather) into the TAMP performance gap analysis. • Identify strategies to address gaps identified by programs (e.g., freight, safety, congestion) and other factors (e.g., climate change, extreme weather) and incorporate the strategies into the TAMP performance gap analysis.
Division Assessment	• Each element is met. • Each element is substantially met; deficiencies are minor. • One or more elements not met.	Comments – document major and/or minor deficiencies, recommendations, and notable practices.

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2. Process for Life Cycle Planning

Life cycle planning directly addresses the very definition of asset management as "a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the lifecycle of the assets at minimum practicable cost" (23 U.S.C. 101(a)(2), 23 CFR 515.5). A State DOT must establish a process to estimate the cost of managing an asset class at the network level (network to be defined by the State DOT) over its whole life with consideration for minimizing cost while preserving or improving the asset condition (23 CFR 515.7(b)). "Asset class" refers to assets with the same characteristics and function (e.g., bridges, culverts, tunnels, pavements, or guardrail) that are a subset of a group or collection of assets that serve a common function (e.g., roadway system, safety, IT, signs, or lighting) or asset sub-group (i.e., a specialized group of assets within an asset class with the same characteristics and function (e.g., concrete pavements or asphalt pavements)). As a State DOT develops its process for life cycle planning, the State DOT should include process elements that will address 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 the whole life costs of assets. The State DOT may propose excluding one or more asset sub-groups from its life cycle planning if the State DOT can demonstrate to FHWA that the exclusion of the sub-group would have no material adverse effect on the development of sound investment strategies due to the limited number of assets in the sub-group, the level of cost impacts associated with managing the assets in the sub-group, or other supportable grounds (23 CFR 515.7(b)). A life cycle planning process must, at a minimum, include the following: the State DOT targets, deterioration models, work types that should be undertaken to preserve or improve assets, and strategies that lead to the managing of assets while minimizing costs during the whole life of assets.

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Sample questions to ask as the FHWA Division Office reviews the TAMP development processes:

- Does the process describe how the State DOT will incorporate the State DOT targets for asset condition for each asset class or asset sub-group into the analysis?
- Does the process describe the deterioration modeling for NHS bridges and pavements for each asset class or asset sub-group?
- Does the process require inclusion of the State DOT's description of the work types (i.e., what work activities are included in each work type)?
- Does the process include the analysis of potential work types across the whole life of each asset class or asset sub-group, with the general unit costs identified?
- Does the process require the State DOT to identify management strategies for each asset class or asset sub-group? Does the process describe a method for determining which management strategies will minimize life cycle costs while achieving the 23 U.S.C. 150(d) performance targets for asset condition?
- Does the process require the State DOT to identify any subgroups that have been excluded from the life-cycle planning analysis, with justification for their exclusion?

Process	Required Elements	Examples of Good Practices
Life Cycle Planning Analysis (23 CFR 515.7(b))	The TAMP must describe a methodology for: • Incorporating the State DOT targets for asset condition for each asset class or asset sub-group into the analysis. • Modeling deterioration for NHS bridges and pavements for each asset class or asset sub-group. • Analyzing potential work types across the whole life of each asset class or asset sub-group with the general unit costs identified. • Identifying management strategies for each asset class or asset sub-group to minimize the life cycle costs while achieving the 23 U.S.C. 150(d) performance targets for asset condition. • Identifying any subgroups that have been excluded, with justification for their exclusion.	The State DOT's Process includes methods to: • Describe how the State DOT determined its long-term vision (targets or long-term performance goals) of a state of good repair. • Describe how the State DOT used its pavement and bridge management systems to set short-term targets and long-term performance goals for a state of good repair for assets. • Consider an appropriate range of factors in analyzing life cycle costs during the whole life of assets. • Consider different life cycle plans for different types of asset sub-groups. • Consider a tiered system to prioritize highways by factors important to the State DOT. • Address future changes in demand, regional differences, environmental conditions, and financial factors. Consider the following as examples where the approach to analysis may be affected by applicable conditions: ○ Regions prone to frost heave versus regions that experience more moderate climate. ○ Assets located within areas prone to flooding events. ○ Costs of treatments influence and drive the whole life management strategies. ○ Assets within regions prone to extreme weather events might require different types of life cycle planning not applicable to the same assets located in other regions. • Does the process include consideration of risks that could affect assets (by asset class or subgroup) over their full life cycle?

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Process	Required Elements	Examples of Good Practices
		• Does the process require the State DOT to include the costs of addressing those risks as part of the work type cost evaluation? Describe how the unit cost of various work types was incorporated into life cycle planning.
Division Assessment	• Each element is met. • Each element is substantially met; deficiencies are minor. • One or more elements not met.	Comments – document major and/or minor deficiencies, recommendations, and notable practices.

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3. Process for Developing a Risk Management Plan

A State DOT must establish a process for developing a risk management plan (23 CFR 515.7(c)). This process must identify risks that can affect the NHS condition and performance, including risks associated with current and future environmental conditions, such as extreme weather events, climate change, seismic activity, and a summary of the evaluations of facilities repeatedly damaged by emergency events, as defined in 23 CFR Part 667. The summary must discuss, at a minimum, the results relating to the existing pavements and bridges on the NHS in the State, and (if available) results for any other pavement or bridge included in the TAMP at the option of the State DOT. 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). In addition, this process should include, at a minimum, an explanation of how risks are assessed, evaluated, and prioritized. The top priority risks must be identified along with a mitigation plan and monitoring approach. For additional information regarding risk management, please refer to http://www.fhwa.dot.gov/asset/.

Sample questions to ask as the FHWA Division Office reviews the TAMP development processes:

- Does the process describe how the State DOT will identify risks that can affect the condition of NHS pavements and bridges, including the risks listed in 23 CFR 515.7(c)?
- Does the process describe how the State DOT will identify risks that can affect the performance of the NHS pavements and bridges, including the risks listed in 23 CFR 515.7(c)?
- Does the process require the State DOT to assess the identified risks in terms of the likelihood of their occurrence and their impact and consequence if they do occur?
- Does the process describe how the State DOT will evaluate and prioritize identified risks?
- Does the process describe how the State DOT will develop a mitigation plan for addressing top priority risks?
- Does the process require the State DOT to describe how it will monitor top priority risks?
- Does the process require the State DOT to include the results of the 23 CFR part 667 evaluations for facilities in the State repeatedly damaged by emergency events, including at a minimum the results relating to NHS pavements and bridges? Does the process describe how the State will use the Part 667 information in its evaluations?

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Process	Required Elements	Examples of Good Practices
Risk Management Analysis (23 CFR 515.7(c))	The TAMP must describe a methodology for: • Identifying risks that can affect the condition of NHS pavements and bridges, and the performance of the NHS, including the risks listed in 23 CFR 515.7(c)(1). • Assessing the identified risks in terms of the likelihood of their occurrence and their impact and consequence if they do occur.	The State DOT's process includes methods to: • Explain how the risks were identified. • Describe what issues were considered for risk identification. There could be multiple areas to consider, such as infrastructure condition, finance, environment, geotechnical circumstances, staffing and expertise, hazards, etc.

Process	Required Elements	Examples of Good Practices
	• Evaluating and prioritizing the identified risks. • Developing a mitigation plan for addressing the top priority risks that involve potentially negative consequences. • Developing an approach for monitoring top priority risks. • Including in the analysis, and considering, a summary of the results of the 23 CFR Part 667 evaluations of facilities in the State repeatedly damaged by emergency events, including at a minimum the results relating to NHS pavements and bridges.	• Describe the methods used to determine the likelihood and impact/consequences of the risks on asset classes or sub groups. • Describe how the high-priority risks were determined and what criteria were used for this determination. • Describe risks resulting from current and future environmental conditions contained in State vulnerability/resilience assessments. • Identify who was involved in prioritization, including whether other NHS owners were consulted. • Identify whose responsibility it is to monitor the identified risk(s), and how monitoring is done. • Identify how many ER events have happened in the past several years, what types of damage happened, and at what cost. • Produce a detailed mitigation plan, including all necessary steps for implementation. A mitigation plan for high priority threats (risks with potential negative impact) should include the scope of activities the State should be undertaking to mitigate those risks, including information about the anticipated activity duration, start and end dates for each activity, and required funding for implementation. • Produce a report/map/spreadsheet that identifies areas prone to damage from current and future environmental conditions. • Include consideration of changes in assets due to programs (e.g., freight, safety, congestion) and other factors (e.g., climate change,

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Process	Required Elements	Examples of Good Practices
		extreme weather) where the changes may trigger new threats (risks with negative impacts) or opportunities (risks with positive impacts). • Describe what risks has the state identified that could affect assets (by asset class or asset sub-group) over their full life cycle? • Calculate the costs of addressing those risks, the costs of keeping them in a state of good repair, given the identified risks. • Estimate the benefits (i.e., the avoided costs) of addressing those risks. • Develop actions to address vulnerabilities and risks identified in the Part 667 analyses.

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Process	Required Elements	Examples of Good Practices
Division Assessment	• Each element is met. • Each element is substantially met; deficiencies are minor. • One or more elements not met.	• Comments – document major and/or minor deficiencies, recommendations, and notable practices.

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4. Process for Developing a Financial Plan

A State DOT must establish a process for the development of a financial plan (23 CFR 515.7(d)). A financial plan within the context of asset management means a plan spanning 10 years or longer that presents a State DOT's estimates of projected available financial resources and predicted expenditures in major asset categories;[1] can be used to achieve State DOT targets for asset condition during the plan period; and highlights how resources are expected to be allocated based on asset strategies, needs, shortfalls, and agency policies (23 CFR 515.5). For information regarding financial planning for asset sustainability as used in the examples of good practices below, please refer to: http://www.fhwa.dot.gov/planning/processes/statewide/practices/asset_sustainability_index/page01.cfm

Sample questions to ask as the FHWA Division Office reviews the TAMP development processes:

- Does the process describe how the State DOT will develop a TAMP financial plan that covers a period of at least 10 years?
- Does the process include a method for estimating the cost to implement the adopted investment strategies, by State fiscal year and work type?
- Does the process include a method for determining the estimated funding levels that will be reasonably available, by fiscal year, to address the costs of implementing the strategies, by work type?[2]
- Does the process address sources of anticipated funding?
- Does the process require the State DOT to develop a summary asset valuation for the State's NHS pavement and bridges, including the investment needed on an annual basis to maintain the asset value?

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Process	Required Elements	Examples of Good Practices
Financial Plan Development (23 CFR 515.7(d))	The TAMP must describe a methodology for producing a financial plan that: • Covers at least a 10-year period. • Includes the estimated cost to implement the investment strategies by State fiscal year and work type. • Includes the estimated funding levels that are expected to be reasonably available, by fiscal year, to address the costs of implementing the investment strategies, by work type.	The State DOT's process includes methods to: • Address financial needs and consequences associated with achieving and sustaining the State DOT's vision of what constitutes a "state of good repair." • Consider all strategies that resulted from performance gap analysis, life cycle analysis, and risk analysis in developing the State DOT's financial plan. • Describe how the State determines the funding sources and expected funding levels for NHS pavements and bridges.

[1] The FHWA encourages State DOTs to express expenditures in "year of expenditure" dollars. Use of year-of-expenditure dollars would be consistent with the treatment of expenditures in transportation planning.
[2] The FHWA gives the term "reasonably available" in this context the same meaning as the term has in transportation planning.

Process	Required Elements	Examples of Good Practices
	• Identifies anticipated sources of available funding. • Includes a summary asset valuation for the State's NHS pavement and bridges, including the investment needed on an annual basis to maintain the asset value.	• Identify the assumptions used when calculating the projected revenue and costs by work type. • Elaborate on the financial risk(s) influencing the success of the financial plan. • Include the development of scenarios, using bridge and pavement management systems, for various funding strategies and their impact on asset condition. • Describe how trade-offs are made when prioritizing strategies for funding based on the results of the performance gap analysis, life cycle planning analysis, and risk analysis (including mitigation strategies). • Produce the estimated future annual investment needed to maintain the condition of State's NHS pavement and bridges. • Identify the methodology and assumptions used for the asset valuation. • Consider loss/gains in asset values when evaluating alternative investment scenarios. • Identify financial indicator(s) such as an asset sustainability index as a measure of performance.

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Process	Required Elements	Examples of Good Practices
Division Assessment	• Each element is met. • Each element is substantially met; deficiencies are minor. • One or more elements not met.	Comments – document major and/or minor deficiencies, recommendations, and notable practices.

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5. Process for Developing Investment Strategies

A State DOT must establish a process for developing investment strategies meeting the requirements in 23 CFR 515.9(f) (23 CFR 515.7(e)-(f)). Investment strategies are not developed in isolation. State DOT decisions about TAMP investment strategies will involve trade-offs amongst TAMP assets based on the results of the required TAMP analyses (such as performance gap, life cycle plan, and risk management analyses) (23 CFR 515.7(e) and 515.9(g)). A State DOT must clearly demonstrate how its selected investment strategies were influenced by the analyses done using TAMP processes. Any adjustment to the selected strategies, or rebalancing funds amongst strategies, is an amendment to the TAMP that is subject to the same requirement (23 CFR 515.13(c)).

Sample questions to ask as the FHWA Division Office reviews the TAMP development processes:

- Does the process describe how the State DOT will develop investment strategies that collectively make or support progress toward achieving and sustaining a state of good repair; improving or preserving the condition of NHS assets and performance of the system; and achieving State DOT and 23 U.S.C.150(b) targets?
- Does the process require the State DOT to describe how investment strategies are influenced by anticipated available funding to implement strategies and estimated future costs?
- Does the process require the State DOT to describe how the State considered the results of the life-cycle planning, performance gap analysis, and risk analysis?

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Process	Required Elements	Examples of Good Practices

Investment Strategies (23 CFR 515.7(e) and 515.9(f))	The TAMP must describe a methodology for:
	• Producing investment strategies that collectively make or support progress toward:
	  ○ Achieving and sustaining a desired state of good repair over the life cycle of the assets,
	  ○ Improving or preserving the condition of the assets and the performance of the NHS relating to physical assets,
	  ○ Achieving the State DOT targets for asset condition and performance of the NHS in accordance with 23 U.S.C. 150(d), and
	  ○ Achieving the national goals identified in 23 U.S.C. 150(b).
		The State DOT's process includes methods to:
		• Identify the strategies that are not being implemented because of funding limitations, and explain how this affects achieving the state of good repair.
		• Describe how the investment strategies will be implemented and provide a schedule for implementation.
		• Explain the reasons for inclusion of any "worst-first" investment strategies, including whether such strategy is justified based on the results of TAMP analyses.
		• Demonstrate the process is designed in a way that a reviewer can easily see the connection between the investment

Process	Required Elements	Examples of Good Practices
	• Identifying and describing how the investment strategies are influenced by: ○ Anticipated available funding to implement strategies and estimated cost of future work types associated with investment strategies being considered, based on the TAMP financial plan. ○ Results of the TAMP risk, management, life cycle planning, and performance gap analyses.	strategies and making or supporting progress toward the four areas required by 23 CFR 515.9(f).
Division Assessment	• Each element is met. • Each element is substantially met; deficiencies are minor. • One or more elements not met.	Comments – document major and/or minor deficiencies, recommendations, and notable practices.

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6. Process for Obtaining Data from Other NHS Owners

The processes established by State DOTs shall include a provision for the State DOT to obtain necessary data from other NHS owners in a collaborative and coordinated effort (23 CFR 515.7(f)). State DOTs must use the best available data to develop their TAMPs (23 CFR 515.7(g)), as discussed in the next section.

Sample questions to ask as the FHWA Division Office reviews the TAMP development processes:

- Does the process describe how the State DOT will obtain data from other NHS asset owners?
- Does the process require the State DOT to describe how the State DOT worked with other NHS asset owners in a collaborative and coordinated manner?

Process	Required Elements	Examples of Good Practices
Obtaining Data from Other NHS Owners (23 CFR 515.7(f))	The TAMP must describe a methodology for obtaining necessary data from other NHS owners in a collaborative and coordinated effort.	The State DOT's process includes methods to: • Identify all NHS owners. • Develop a coordination plan for collecting and sharing data in conjunction with all NHS owners. • Reduce duplication by utilizing data produced through the planning process under 23 CFR 450.314(h)(1) ("The MPO(s), State(s), and the providers of public transportation shall jointly agree upon and develop specific written provisions for cooperatively developing and sharing information related to transportation performance data.")

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Process	Required Elements	Examples of Good Practices
Division Assessment	• Each element is met. • Each element is substantially met; deficiencies are minor. • One or more elements not met.	Comments – document major and/or minor deficiencies, recommendations, and notable practices.

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7. Process for Ensuring Use of Best Available Data and Use of Bridge and Pavement Management Systems

State DOTs must use the best available data to develop their TAMPs and must analyze the condition of NHS pavements and bridges for developing the TAMP by using bridge and pavement management systems that meet the requirements in 23 CFR 515.17 (23 CFR 515.7(g)).

Sample questions to ask as the FHWA Division Office reviews the TAMP development processes:

- Does the process describe the State DOT's methodology for ensuring it is using the best available data to develop its TAMP?
- Does the process require the State DOT to describe the analysis undertaken using its pavement and bridge management systems?
- Does the process require the State DOT to use bridge and pavement management systems that comply with 23 CFR 515.17 to analyze the condition of NHS pavements and bridges? If the State DOT does not have fully compliant bridge and pavement management systems at the time of the first process certification, does the State DOT process identify the additional means the State DOT will use to provide the same data and analyses that compliant systems would produce?[3]
- Is the process for using information from the State DOT's Statewide Transportation Improvement Program (STIP) in the development of the State DOT's TAMP consistent with TAMP process and data requirements (meaning the STIP does not over-ride the TAMP requirements)?

Process	Required Elements	Examples of Good Practices
Use of best available data and bridge and pavement management systems to develop TAMP (23 CFR 515.7(g))	The TAMP must describe a methodology for • Ensuring that the State DOT uses the best available data for development of the TAMP. • Ensuring that the TAMP is developed using bridge and pavement management systems that meet the requirements of 23 CFR 515.17. If, at the time of the first certification, the State DOT does not have bridge and pavement management systems that fully comply with 23 CFR 515.17 standards, the State DOT process identifies additional means it will use to provide analyses or other information needed to meet all of the requirements in 23 CFR 515.17. • Ensuring the process for using information from the State DOT's Statewide Transportation Improvement Program (STIP) in the development of the State DOT's TAMP is	The State DOT process includes methods to: • Create and maintain a current and complete inventory of all NHS bridges and pavements, regardless of ownership. • Ensure that data obtained from other NHS owners are accurate. • Ensure that there is consistency in data collection methodology amongst NHS data owners. • If the State DOT does not have bridge and pavement management systems that fully comply with 23 CFR 515.17 requirements, the State DOT identifies in its TAMP the enhancements needed and outlines an action plan (with milestones and dates) that the State DOT plans to take to improve the efficiency and functionality of its bridge and pavement

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[3] When doing the TAMP development process certification review, FHWA does not determine whether the State DOT's systems comply with 23 CFR 515.17. Systems compliance is a question for general oversight, not something to be addressed directly during TAMP process certification.

Process	Required Elements	Examples of Good Practices
	consistent with TAMP process and data requirements. This means that the STIP may be used to provide background information, but cannot be used as a substitute for carrying out the required analyses, or be used to override the results of the required independent analyses of relevant data when developing investment strategies.	management systems (e.g., procuring software, developing decision trees, calculating benefit values, etc.). The TAMP also describes the expected timeframes to achieve the enhancements to the bridge and pavement management systems. • Describe data available or collected to analyze for future risks, including data developed in vulnerability assessments. • Describe any assumptions made in order to complete analyses with the bridge and pavement management systems where needed data is unavailable. • Describe a detailed action plan including corresponding timeframes for completing each action item to address and resolve issues pertaining to data unavailability.
Division Assessment	• Each element is met. • Each element is substantially met; deficiencies are minor. • One or more elements not met.	Comments – document major and/or minor deficiencies, recommendations, and notable practices.

Division Certification Decision and Notice to the State DOT

Once the FHWA Division has reviewed the State DOT's TAMP development processes and determined whether they comply with applicable requirements, the FHWA Division Administrator will issue a letter to the State DOT advising the State DOT of the results (for possible outcomes, see section above titled "Certification Process and Possible Outcomes of the Certification"). The FHWA Division should send a copy of the letter to the FHWA Office of Infrastructure in Headquarters, together with a copy of the TAMP that describes the certified processes.

Appendix D. Nevada NHS Roadway Listing

Nevada's National Highway System (NHS)

AUGUST 2017

Not owned or maintained by NDOT

in centerline miles

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
IR15	1	CL	CA state line to AZ state line	80.333	35.610	7.820	123.763
IR215	2	CL	IR515 to Stephanie Ln and Warm Springs to IR15		4.268		4.268
IR215	2	CL	S. Valley View to I15		0.548		0.548
IR215	2	CL	Warm Springs to Stephanie Ln		6.894		6.894
CC215	107810	CL	IR15 South to IR15 North		38.561		38.561
CC215 (SO1509)	1509	CL	CC215 to Ramps 1 and 2 IR15		0.086		0.086
IR515	3	CL	US93/US95 @ Wagonwheel Intg to IR15		20.010		20.010
Summerlin Pkwy	191864 10177 10907	CL	CC215 to US95 includes connecting ramps		6.557		6.557
IR80	5	WA	CA stateline to WA/ST county line	21.873	22.590		44.463
	5	ST	WA/ST county line to ST/LY county line	0.605			0.605
	5	LY	ST/LY county line to LY/CH county line	8.711		7.197	15.908
	5	CH	LY/CH county line to CH/PE county line	27.710			27.710
	5	PE	CH/PE county line to PE/HY county line	75.091			75.091
	5	HU	PE/HU county line HU/LA county line				
	5	LA	HU/LA county line to LA/EU county line	26.856			26.856
	5	EU	LA/EU county line to EU/EL county line	25.815			25.815
	5	EL	EU/EL county line to UT state line	117.671		15.004	132.675
IR580	4	CC	From US50/US395 JCT to Fairview Intg		3.146		3.146
	4	CC	Fairview Intg to the CC/WA county line	0.264	5.880		6.144
	4	WA	CC/WA county line to IR80	9.832	15.927		25.759
US6	9	MI	CA state line to Mina/Basalt (SR360) cutoff	11.952			11.952
	9	ES	JCT W/US95 Coaldale to ES/NY county line	38.904			38.904
	9	NY	ES/NY county line to the JCT of SR376 E of Tonopah	7.187			7.187
	9	WP	Sunnyside RD SR318 to UT state line	86.686			86.686
US50	7	DO	CA state line to DO/CC county line	13.168		1.433	14.601
	7	CC	DO/CC county line to JCT of IR580/US395	6.609	0.965		7.574
	7	CC	Williams St/US50 Intg IR580 to CC/LY county line		4.129		4.129
	7	LY	CC/LY county line to LY/CH county line	24.320	1.221	9.847	35.388
	7	CH	LY/CH county line to CH/LA county line	98.072		8.891	106.963
	7	LA	CH/LA county line to LA/EU county line	56.738			56.738
	7	EU	LA/EU county line to EU/WP county line	47.338			47.338

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
	7	WP	EU/WP county line to the JCT of US6 in Ely	68.290			68.290
US50ALT	8	LY	US95A at roundabout to LY/CH county line	0.974		6.842	7.816
	8	CH	LY/CH county line to US50	9.096			9.096
US93	10	CL	AZ state line to IR515 & Garnet Intg ramps 1 & 2 to the CL/LN county line	40.727	2.275	4.837	47.839
	10	LN	CL/LN county line to Sunnyside Rd SR318	50.601			50.601
	10	WP	JCT W/US50 in Ely to WP/EL county line	63.267			63.267
	10	EL	WP/EL county line to ID state line	141.760			141.760
US95	12	CL	CA state line to JCT with US93 @ Railroad Pass & from IR15 @ downtown Expwy Intg to the CL/NY county line	91.342	21.344		112.686
	12	NY	CL/NY county line to NY/ES county line & ES/NY county line to the JCT W/US6 in Tonopah	108.454			108.454
	12	ES	NY/ES county line to ES/NY county line and from the JCT with US6 @ Coaldale to the ES/MI county line	57.827			57.827
	12	MI	ES/MI county line to MI/LY county line	92.168			92.168
	12	LY	MI/LY county line to LY/CH county line	2.822			2.822
	12	CH	LY/CH county line to the JCT W/US50 in Fallon and from US50 to IR80	52.804		6.123	58.927
	12	HU	IR80 Winnemucca West downtown exit to NV/OR state line	69.743		5.620	75.363
US95ALT	13	LY	JCT with US50A @ Fernley Roundabout to IR80 @ E. Fernley Intg			0.928	0.928
US395	6	DO	CA state line to DO/CC county line	20.076	2.962	10.941	33.979
	6	CC	DO/CC county line to JCT with IR580/US/50		0.531		0.531
	6	WA	Ir80 to NV/CA state line		15.896		15.896
US395 ALT	11257	WA	Mt Rose Hwy to Patriot Blvd		3.808		3.808
Williams St (FRCC11)	11189	CC	From Russell Wy to IR580		0.123		0.123
Woodfords Rd (SR88)	195	DO	CA state line to US395	1.367		6.503	7.870
St Rose Pkwy (SR146)	23	CL	IR15 Southern Highlands Pkwy Intg Ramps 3 & 4 to IR215 Pecos Intg Ramps 1 & 2		6.594		6.594
Lake Mead Blvd (FRCL57)	10192	CL	US95 Ramp 3 to Rainbow Blvd		0.177		0.177
E Lake Mead Blvd (SR147)	24	CL	Losee Rd to Civic Center Dr/Eastern Ave		1.482		1.482
Lake Mead Blvd	119856	CL	Rainbow Blvd to Losee Rd		5.724		5.724
Charleston Blvd (SR159)	28	CL	Rainbow Blvd to I15		4.671		4.671
Charleston Blvd (SR159)	28	CL	Main St to SR582 Boulder Hwy		2.071		2.071
Blue Diamond/ Pahrump RD (SR160)	29	CL	Las Vegas Blvd to CL/NY county line	32.293	10.987		43.280
	29	NY	CL/NY county line to Boothill Dr in Pahrump			11.086	11.086
Laughlin Hwy (SR163)	31	CL	Casino Dr to AZ state line			0.107	0.107

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
Mountain City Hwy (SR225)	43	EL	IR80 W Elko Intg Ramps 3 & 4 to SR535 Idaho St			0.982	0.982
E Winnemucca Blvd (SR289)	58	HU	US95 at Melarkey St to IR80 Ramps 3 & 4			0.749	0.749
Sunnyside Rd (SR318)	67	LN	US93 to LN/NY county line	49.113			49.113
	67	NY	LN/NY county line to NY/WP county line	38.912			38.912
	67	WP	NY/WP county line to US6	22.712			22.712
Mina/Basalt Cutoff (SR360)	78	MI	US6 to US95	23.229			23.229
Tonopah/Austin Hwy (SR376)	85	NY	US6 E of Tonopah to NY/LA county line	81.680			81.680
	85	LA	NY/LA county line to US50	18.048			18.048
S Virginia St	138887	WA	Patriot Blvd to SO11049		1.856		1.856
S Virginia St (SO11049)	11049	WA	0.064 S. of IR580 to 0.087 N. of IR580		0.151		0.151
S Virginia St	138887	WA	SO11049 to SO11050 at I-80		4.014		4.014
FRWA66	11268	WA	SR659 to Neil Rd		0.664		0.664
FRWA67	11269	WA	Neil Rd to SR659		0.660		0.660
N Virginia St (SR430)	98	WA	N McCarran Blvd to US395		3.158		3.158
USA Parkway (SR439)	11048	LY	US50 @ Opal Ave to LY/ST county line	8.554			8.554
USA Parkway (SR439)	11048	ST	LY county line to WA county line	10.434			10.434
USA Parkway (SR439)	11048	WA	WA/ST county line to IR80, Ramps 3 & 4	0.116			0.116
Pyramid Wy (SR445)	101	WA	Nugget Ave to Descanso Ln		12.762		12.762
E Jennings Wy (FREL17)	1510	EL	Idaho St to IR80 E. Elko Intg Ramps 3 & 4			0.197	0.197
Idaho St (SR535)	117	EL	W Elko Intg to the W city limits and SR225 to SR 227			3.199	3.199
Idaho St	117680	EL	W. City Limits of Elko to SR225			0.570	0.570
Idaho St	117680	EL	SR227 to E Jennings Wy			1.570	1.570
Lake Mead Pkwy (SR564)	119	CL	IR515 to Lake Las Vegas Pkwy		6.602		6.602
Boulder Hwy (SR582)	124	CL	IR515 Wagonwheel Intg Ramps 3 & 4 to Shahra Ave		14.159		14.159
Craig Rd (SR573)	120	CL	US95 to Decatur Blvd and Frehner Rd to Las Vegas Blvd		5.283		5.283
Craig Rd	109265	CL	Decatur Blvd to Frehner Rd		5.482		5.482
Sahara Ave (SR589)	125	CL	Rainbow Blvd to Boulder Hwy SR582		7.953		7.953
Tropicana Ave	137611	CL	Dean Martin Dr to SR582 Boulder Hwy		7.415		7.415
Tropicana Ave	137611	CL	Rainbow Blvd to Dean Martin Dr		3.358		3.358
Rainbow Blvd (SR595)	130	CL	Tropicana Ave (SR593) to Ramp 2 @ US95		5.366		5.366
Rainbow Blvd	129234	CL	SR160 Blue Diamond to Tropicana Ave		5.335		5.335
Rancho Rd (SR599)	132	CL	Redondo Ave to 0.28 miles N of N Rainbow Blvd		6.947		6.947
Rancho Rd (RM1007, RM1009)	10007 10009	CL	Connecting ramps to US 95		1.238		1.238

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
Rancho Rd	129569	CL	Sahara Ave to Redondo Ave		1.856		1.856
Nellis Blvd (SR612)	138	CL	Tropicana Ave to Las Vegas Blvd		9.400		9.400
Nellis Blvd	124639	CL	Las Vegas Blvd to Craig Rd		0.303		0.303
5th St	100257	CL	SR147 Lake Mead Blvd to CC215		6.604		6.604
Eastern Ave/Civic Center	111773 107766	CL	St Rose Pkwy SR146 to Lake Mead Blvd SR147		13.011		13.011
Eastern Ave/Civic Center (FRCL53)	11152	CL	Ramps 1 & 2 to Ramps 3 & 4 IR515		0.170		0.170
Casino Dr	106625	CL	JCT of Thomas Edison Dr to SR163 Laughlin Hwy			1.879	1.879
4th St	178854	WA	W McCarran Blvd to Virginia St and Center St to FRWA62		4.123		4.123
4th St (FRWA62)	11200	WA	0.028 W of IR580 to 0.030 E of IR580		0.058		0.058
4th St	178854	WA	FRWA62 to Galetti Wy		0.353		0.353
Prater Way (SR647)	140	WA	Galetti Wy to E ROW of IR80 near View St		0.182		0.182
Prater Way	128585	WA	E ROW of IR80 near View St to Vista Blvd		4.000		4.000
2nd St	100170	WA	S Virginia St to Keitzke Ln		1.303		1.303
Glendale Ave (SR648)	141	WA	Kietzke Ln to McCarran Blvd (SR659)		2.651		2.651
Plumb Ln	128211	WA	W McCarran Blvd to Kietzke Ln		3.775		3.775
Plumb Ln (SR653)	144	WA	Kietzke Ln to Terminal Wy		0.588		0.588
McCarran Blvd (SR659)	11119	WA	McCarran, from IR580, clockwise W, N, E, S, back to IR580		23.031		23.031
Kietzke Ln	119228	WA	Neil Rd to S Virginia St		1.066		1.066
Kietzke Ln (SR667)	149	WA	S Virginia St to Kuenzli St		3.314		3.314
Vista Blvd (FRWA08)	294	WA	IR80 to 0.030 miles N of Ramps 3 & 4		0.127		0.127
Vista Blvd	138907	WA	0.030 miles N of Ramps 3 & 4 to Los Altos Pkwy		4.612		4.612
Neil Rd	124629	WA	Kietzke Ln to FRWA44		0.060		0.060
Neil Rd (FRWA44)	376	WA	W IR580 ROW to the E IR580 ROW		0.188		0.188
Neil Rd	124629	WA	E IR580 ROW to S Virginia St		0.107		0.107
Damonte Ranch Pkwy (SO11039)	11039	WA	N Virginia St to W ROW of IR580		0.311		0.311
Damonte Ranch Pkwy (FRWA49)	10384	WA	W ROW of IR580 to the E ROW of IR580		0.162		0.162
Damonte Ranch Pkwy	109904	WA	E ROW of IR580 to Double R Blvd		0.104		0.104
Sparks Blvd	155556	WA	Greg St to FRWA53 0.037 S of Ramps 1 & 2		0.104		0.104
Sparks Blvd (FRWA53)	10432	WA	0.037 miles S of Ramps 1 & 2 Sparks Intg to N ROW fence		0.211		0.211
Sparks Blvd	155556	WA	N ROW fence Sparks Intg to Pyramid Hwy SR445		5.851		5.851
Wells Ave	139542	WA	2nd St to FRWA54		0.596		0.596
Wells Ave (FRWA54)	10410	WA	S of IR80 Ramps 1 & 2 to N of IR80 Ramps 3 & 4		0.125		0.125

Route	RMID	County	Description (From & To)	Rural	Urban	Small Urban	Total
Wells Ave	139542	WA	FRWA54 to Sutro St		0.698		0.698
Oddie Blvd	190000	WA	Sutro St to FRWA58 and from FRWA58 to Pyramid Hwy SR445		2.327		2.327
Oddie Blvd (FRWA58)	1520	WA	W of US395 Ramp 4 to E of US395 Ramp 1		0.165		0.165
Stead Blvd (SR673)	152	WA	Ramps 3 & 4 to 0.230 N		0.230		0.230
Stead Blvd	135171	WA	0.230 N of Ramps 3 & 4 to Lear Blvd		1.446		1.446
Union Ln (SR720)	157	CH	US95 to Pasture Rd	3.010			3.010
Los Altos Pkwy	121256	WA	Sparks Blvd to Vista Blvd		0.549		0.549
Baring Blvd	102730	WA	McCarran Blvd to Vista Blvd		1.646		1.646
Kuenzli St	119569	WA	E 2nd St to Kietzke Ln		1.047		1.047
Moana Ln	123531	WA	Virginia St to E Ramps 3 & 4 of IR580		0.603		0.603
Moana Ln (SO10392)	10392	WA	Ramps 3 & 4 to Ramps 1 & 2 of IR580		0.078		0.078
Longley Ln	121178	WA	S Virginia St to S Rock Blvd		3.352		3.352
Double R Blvd	111188	WA	Damonte Ranch Pkwy to Longley Ln		3.456		3.456
Pasture Rd	127088	CH	Union Ln to Churchill Ave	0.247			0.247
Intermodal Connectors							
McCarran Inter. Airport Connector (SR171)	37	CL	McCarran Inter. Airport to IR215		0.693		0.693
McCarran Inter. Airport Connector 5	100594	CL	SR171 to Paradise Rd		1.276		1.276
McCarran Inter. Airport Paradise Rd	126845	CL	Sahara Ave to SR171 Airport Connector - I Wy Southbound only from E Harmon Ave to Airport Connector		4.424		4.424
McCarran Inter. Airport Kittyhawk Wy	119440	CL	Paradise Rd to JCT of Wayne Newton Blvd and Swenson St		0.152		0.152
McCarran Inter. Airport Wayne Newton Blvd	129347 139447	CL	E Russel Rd to JCT of Kittyhawk Wy and Swenson St		0.327		0.327
McCarran Inter. Airport Swenson St	136195	CL	JCT of Kittyhawk Wy and Wayne Newton Blvd to Thomas Mack Dr - I Wy Northbound		0.602		0.602
Las Vegas Amtrak Station Main St	189177 28	CL	Amtrak Station to Charleston on Main St and Main St to IR15 on Charleston		1.537		1.537
Downtown Transit Station Stewart St	135271 189603 1693	CL	Downtown Transit Station to Las Vegas Blvd on Stewart and Stewart to IR515 on Las Vegas Blvd including SO1693		0.549		0.549
FRWA51	10394	WA	Plumb Ln to Villanova Dr		0.243		0.243
Reno Amtrak Station Lake St	119886	WA	Amtrak Station to 4th St		0.122		0.122
Reno Greyhound Terminal 2nd St	100170	WA	Stevenson to Virginia St		0.287		0.287
Reno Greyhound Terminal 2nd St	100170 119208 10413	WA	Bus Terminal to Keystone on 2nd St and 2nd to IR80 on Keystone incl. FRWA55		0.838		0.838
Reno Transit Station 4th St	178854	WA	Reno Transit Station at Center St to Virginia St on 4th St		0.072		0.072
			Totals	1998.180	454.107	120.904	2573.191

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