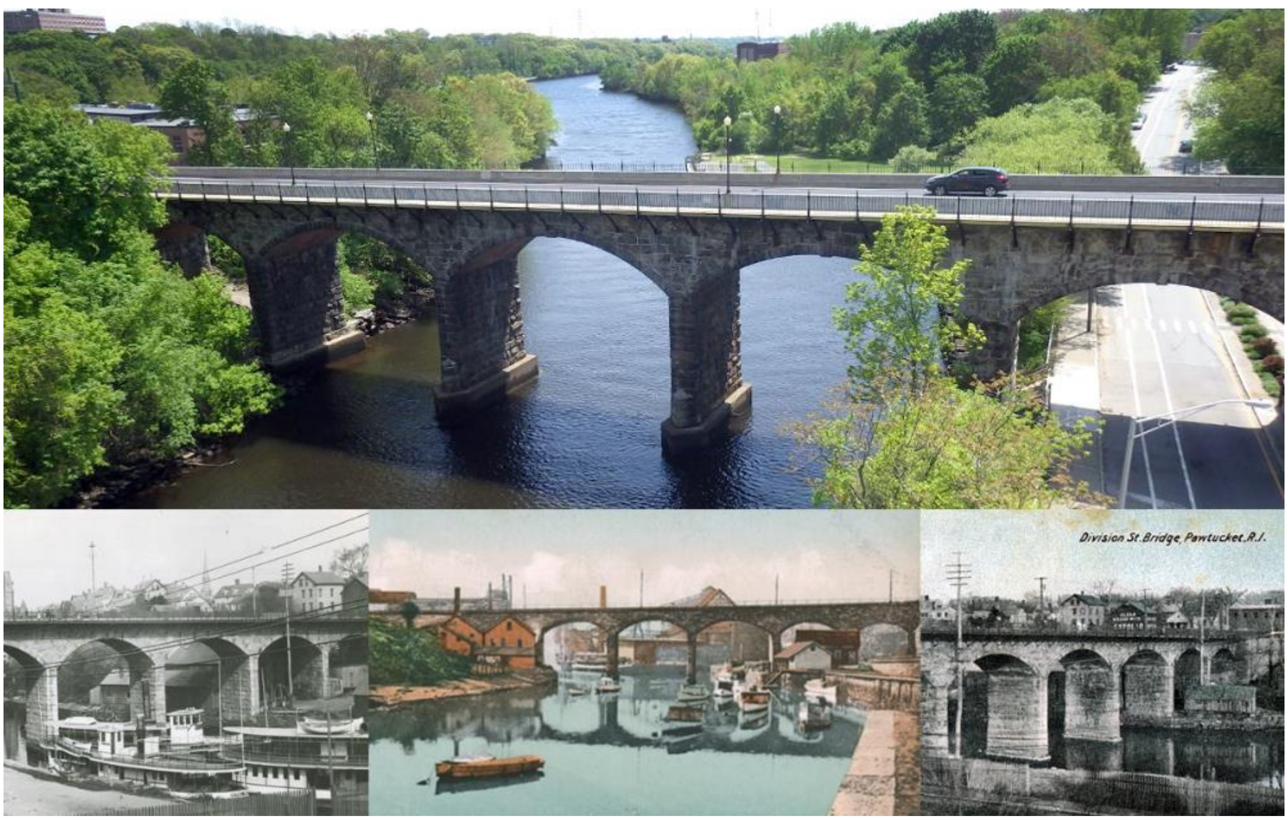
TRANSPORTATION ASSET MANAGEMENT PLAN

Rhode Island Department of Transportation

August 28, 2019



Peter Alviti Jr, P.E.

Director, Rhode Island Department of Transportation

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Executive Summary

For decades, Rhode Island's roads and bridges have been ranked among the worst in the United States. In 2015, 178 of the state's 766 National Bridge Inventory (NBI) bridges were rated Poor, with many exhibiting dangerous signs of deterioration due to neglect. Rhode Island Department of Transportation (RIDOT), along with legislators and key decision makers, for years struggled with insufficient capital funding for transportation infrastructure. Within the last decade alone, there have been no fewer than three groups empaneled to examine transportation needs and recommend future funding sources, with an emphasis on sustainability.

To address and reverse the deteriorating condition of RIDOT's assets, including those listed on the National Highway System (NHS), Governor Gina Raimondo in 2016 signed into law RhodeWorks (An Act Relating to State Affair and Government – Rhode Island Bridge Replacement, Reconstruction, and Maintenance Fund – Tolls"), overhauling how RIDOT manages and develops assets. The legislation has three central components:

1. It allows Rhode Island Department of Transportation (RIDOT) to charge tolls on large commercial trucks to provide for the replacement, reconstruction, maintenance, and operation of Rhode Island bridges. Once fully operating, these tolls are expected to generate approximately $40 million in net revenue, annually;

2. It allows RIDOT to refinance existing Grant Anticipation Revenue Vehicle (GARVEE) bonds to shift payments into future years, freeing up to $129 million in additional federal funds to Federal Fiscal Years (FFY) 2016, 2017, and 2018; and

3. It allows RIDOT to move forward with additional GARVEE bonds to help fund the surge of financing necessary to bring Rhode Island's bridges into a State of Good Repair and to meet the federally-mandated minimum of 90% bridge sufficiency by 2025.

RhodeWorks also mandates RIDOT's Strategic Transportation Improvement Plan ([S]TIP) to address a 10-year period, exceeding the federal mandate of just 4 years. This Ten-Year Plan provides an opportunity to help facilitate and implement asset management goals outlined throughout this document. It also aids RIDOT staff in identifying departmental strengths and shortfalls, as outlined in this document.

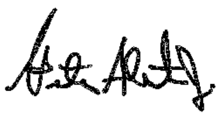
This document's strategic and departmental significance builds upon the new organizational approaches compelled by RhodeWorks. In addition to meeting federal standards, RIDOT's Transportation Asset Management Plan (TAMP) will serve to guide operations and will help develop implementation guidance to further RIDOT's strategic goals. These goals include delivering on RhodeWorks' promise of strategic, efficient asset management and utilizing state-of-the-art infrastructure preservation practices to maintain and preserve good conditions of assets while limiting future costs.

This TAMP provides an overview of NHS bridge and pavement assets regardless of ownership, as well as assets owned, operated, and maintained by RIDOT along with an assessment of future goals, risks, and implementation strategies to navigate the foreseeable life cycles of those assets. While this TAMP is fully compliant with federal regulations, including 23 U.S.C. 119 (National highway performance program), 23 CFR 515, and MAP-21 (Moving Ahead for Progress in the 21st Century Act), it also goes beyond the minimum requirements, including detailed summaries of non-NHS assets.

This document is intended to be a readable, concise guide for implementing asset management methods and measures in development of the STIP and other necessary plans. This TAMP communicates RIDOT’s asset management processes, providing a roadmap for further progress.

Thank you for your consideration,

Peter Alviti, Jr., P.E.



Director, Rhode Island Department of Transportation

Title VI, ADA, and Additional Information

Title VI Notice to Public

It is the Rhode Island Department of Transportation's (RIDOT) policy that no person shall, on the ground of race, color, national origin or sex, as provided by Title VI of the Civil Rights Act of 1964, be excluded from participation in, be denied the benefits of, or be otherwise discriminated against under any of its federally funded programs and activities.

All claims and requests for information should be forwarded to:

Rhode Island Department of Transportation
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Providence, RI 02902
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Tel: 401-222-2481
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Questions Regarding RIDOT's Transportation Asset Management Plan

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Chapter 1: Introduction

The Rhode Island Department of Transportation (RIDOT) is faced with the difficult task of maintaining, preserving, replacing, and improving transportation assets throughout Rhode Island. Operating in the second-most densely populated state in the country, RIDOT manages 1,176 bridges and more than 2,900 lane miles of roadway. This network is a crucial component of Rhode Island's economy and provides significant support to the region.

Like many state DOTs, RIDOT must contend with aging assets, rising maintenance costs, and fiscal constraints. Until recently, the state's assets had been neglected for decades, and investment was lagging. As a result, the quality of Rhode Island's roads and bridges have deteriorated to historic national lows. In 2016, RIDOT was empowered by the new vision of RhodeWorks, state legislation which both mandated the implementation of an asset management approach to infrastructure investment and provided capital funds to support that mandate.

Since then, RIDOT has worked at an unprecedented pace to repair the state's infrastructure, getting projects out the door and shovels in the ground. Public safety has improved, and infrastructure investment has stimulated economic growth beyond initial estimates. Three years after RhodeWorks was enacted, the Department remains focused on fulfilling the law's core promise: ensuring that less than 10 percent of all state bridges are in Poor condition by 2025.

The passage of RhodeWorks has ushered in an era of data-driven asset management at RIDOT, prioritizing the efficient preservation of assets to minimize future costs. RIDOT's TAMP, detailed in this guidebook and appendices, codifies the asset management principles and processes through which the Department monitors its assets and programs projects in Rhode Island's Statewide Transportation Improvement Program (STIP).

The processes documented here are facilitate decisions about where and when to invest limited transportation funds throughout Rhode Island, to bring the state's assets up to a State of Good Repair.

Asset Management Goals

To facilitate the safe and efficient movement of people and goods through Rhode Island, the Department's primary objective is achieving and maintaining a State of Good Repair for its network of roads and bridges. RIDOT's asset management goals and its organization framework are laid out in state law, most notably RhodeWorks. For additional information regarding RIDOT's asset management objectives, see Chapter 2: Objectives and Measures.

Purpose of the TAMP

This initial Transportation Asset Management Plan (TAMP) complies with all federal requirements for TAMP development under 23 CFR 515, and describes the processes through which sound principles of asset management and lifecycle cost analysis are implemented at RIDOT for bridges and pavement, especially those on the National Highway System (NHS). The objectives, measures, asset inventories, life cycle plans, and risk management strategies described here support asset-level investment strategies and a comprehensive financial plan codified in corresponding and collaborative documents including Rhode Island's Statewide Transportation Improvement Program (STIP) and Long-Range Transportation Plan (LRTP).

The guiding principles of this TAMP work to facilitate smart, efficient investment and project prioritization. The focus of extending asset life cycles to prevent or defer deterioration and costly rehabilitation helps RIDOT prevent unnecessary expenditures of limited capital funds. The strategies outlined in this document will help sustain and strengthen Rhode Island's infrastructure so that it may achieve and maintain the desired State of Good Repair by favoring preservation, maintenance, and small repairs over costly reconstruction. Pursuant to guidance from FHWA, this document represents a significant revision and reorganization of RIDOT's original April 2018 TAMP.

Please note that all pavement condition projections presented in this TAMP are based on uniform construction segments, not one-tenth mile segments. Construction segments are sections of road that generally exhibit similar pavement conditions along their length and are bounded by the limits of a previous construction contract. When RIDOT collects pavement distress information as part of the annual survey, road conditions are collected and recorded in 1/10-mile intervals. These 1/10-mile intervals are then aggregated to an average condition (PSHI) over the length of the construction segment. This approach allows RIDOT to present the vendor survey information in a more useable manner (see Figure 16) than the tens of thousands of 1/10 mile segments.

A good analogy for the construction segments would be viewing an impressionist painting. The 0.1-mile segments are akin to the individual dots of colored paint in the painting. If you look at the painting from up close all you see are thousands of dots of differently colored paint that do not form any type of discernable object. If you step back, the painting comes into focus and the dots form objects. The construction segments are akin to the objects in the painting. This approach allows pavement planners to get a good picture of current conditions on the network without getting lost in the 0.1-mile segments.

There are roughly 1,200 construction segments on the RIDOT owned network municipally owned portion of the NHS. The construction segments vary in length from 0.1 miles to nearly 10 miles. On average, they are about 1 mile long.

Agency Overview and Project Prioritization Process

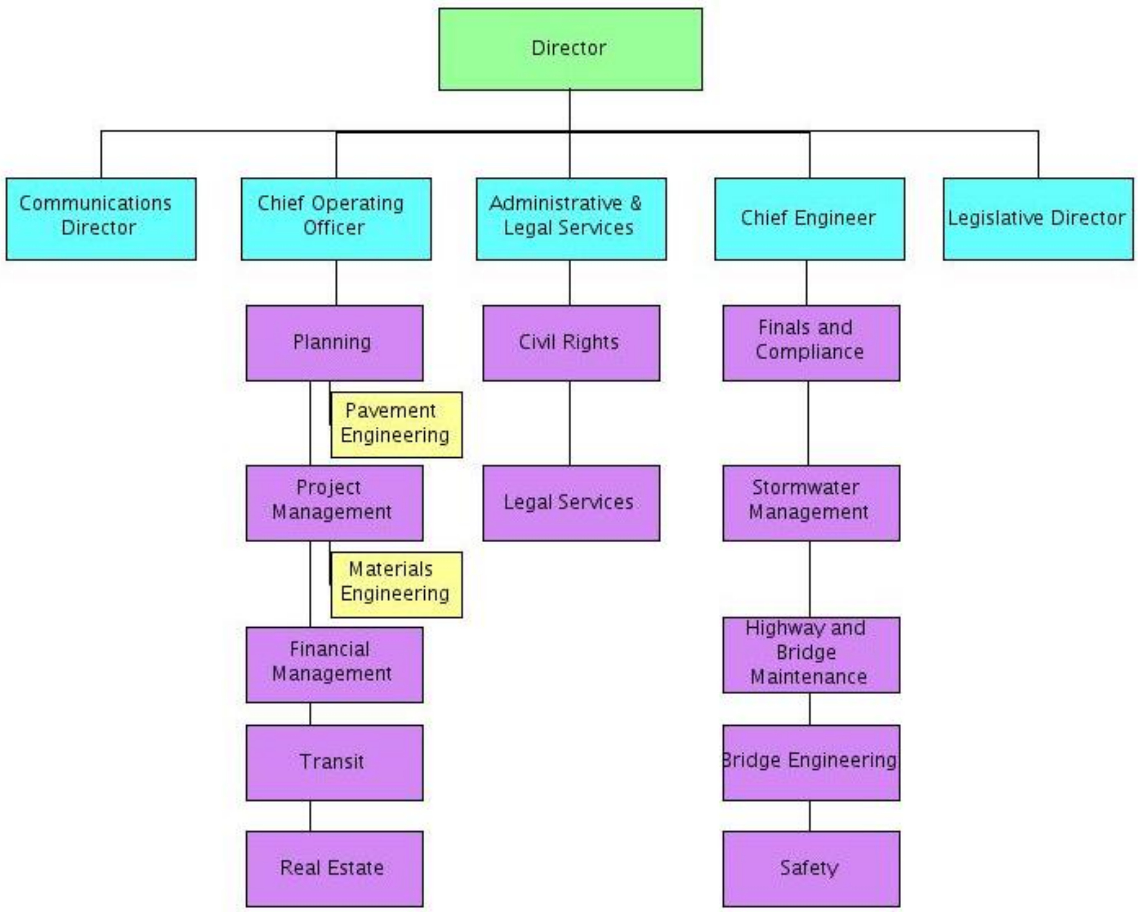
The Asset Management Process at RIDOT flows primarily through the Division of Planning, the Division of Project Management, and the Division of Highway and Bridge Maintenance, with support from other divisions within the Department.

Using inputs from the Divisions of Transit, Real Estate, Stormwater Management, Bridge Engineering, and Safety, Pavement Engineering and Materials, the Division of Planning collects, analyzes, and synthesizes a wide range of information about transportation assets, from data systems to community inputs, and from projected lifecycle to identified risks. The primary considerations in the project prioritization process are aligned with RIDOT's TAMP objectives. The Division of Planning considers:

- Whether a project will help the Department achieve its RhodeWorks-mandated goal of less than 10 percent Poor bridge condition by 2025; and
- Whether a project will improve public safety.

These objectives are evaluated alongside asset data, and all four levels of risk—detailed in Chapter 5—are also considered prior to project programming. Following project initiation and evaluation – RIDOT's asset management team, within the Planning Division, assesses each project and programs it into the STIP, including information about the project and its readiness.

Figure 1 -- RIDOT Organizational Structure



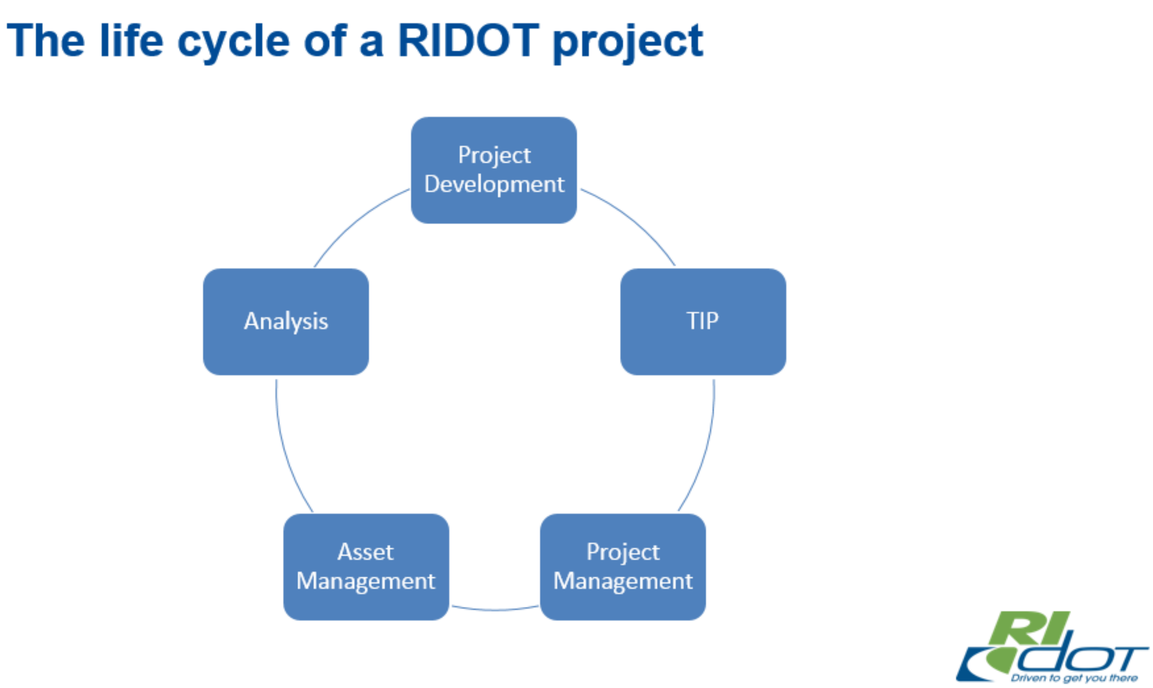
Following project initiation and evaluation – RIDOT's asset management team, within the Planning Division, assesses each project and programs it into the STIP, including basic information about project readiness and a project description. Then, the scoping team within the Project Management Division defines the project's parameters (including what is/is not in the project) and identifies potential project risks, constraints, stakeholders, and innovations.

Each project is assigned to its own project manager, an individual trained to coordinate all aspects of project delivery including scheduling, design, risk mitigation, construction, and final inspections. The project manager uses the Scoping Document to procure a consultant who designs the project and creates a construction bid package. The project managers coordinate with contractors, consultants, cultural and environmental resource managers, communications staff, construction managers, and maintenance field operators to ensure that each project is completed on time and on budget.

This process also requires interfacing with stakeholders, including but not limited to state partners in the Department of Environmental Management (RIDEM), the Coastal Resources Management Council (CRMC), and the Historical Preservation and Heritage Commission (RIHPHC), as well as federal partners at the Environmental Protection Agency (EPA), Federal Highway Administration (FHWA), and Federal Transit Administration (FTA).

Once construction on an asset is complete, the Division of Highway and Bridge Maintenance takes over, making repairs and minor improvements as needed. This cradle-to-grave look at each of the state's valuable assets then cycles back to Planning, where assets are re-assessed for new transportation projects, as shown in Figure 2.

Figure 2 -- RIDOT Asset Management Cycle



Working with Other NHS Owners and Stakeholders

Along with the RIDOT, other entities own and control a portion of the non-Interstate NHS roadway network in Rhode Island. These entities include numerous municipalities, the Rhode Island Turnpike and Bridge Authority, and the Quonset Development Corporation. A summary of the total number of non-Interstate NHS roadway assets, along with their owners and current

HPMS condition ratings is shown below and summarized in Chapter 3. **The entirety of Interstate NHS pavement in Rhode Island is owned and controlled by the RIDOT.** In total, **43.04 centerline miles of Non-Interstate NHS roads are owned and controlled by the non-RIDOT entities. This represents about 7% of the total 600.7 centerline miles of NHS roads in the state.**

Figure 3 -- Summary Table of Other-Owned NHS Pavements

Municipality	Number of Roads	Total Lane Mileage
Cranston	6	5
East Providence	1	0.1
Jamestown (RI Turnpike and Bridge Authority)	5	7.6
N. Kingstown (RI Turnpike and Bridge Authority)	2	1.4
Newport	4	1.5
Newport (RI Turnpike and Bridge Authority)	1	2.2
North Kingstown (Quonset Development Corporation)	1	3.1
Pawtucket & Central Falls	1	1.4
Pawtucket	17	5
Providence	34	13.1
Westerly	2	0.6
Woonsocket	5	1.5
East Providence	1	0.5
Grand Total	**80**	**43.038**

The Pavement Capital and Pavement Maintenance programs in the STIP are designed to preserve and maintain pavement segments throughout RI, using both data inputs maintained by RIDOT and direct input from cities and towns about their pavement needs. When the need arises, additional communication and coordination with municipalities and other NHS roadway owners regarding system condition, immediate needs, future treatment planning, and pavement asset management is handled by the Division of Planning on a case-by-case basis.

RIDOT also manages the majority of NHS bridges in Rhode Island, but there are 36 NHS bridges in the state managed by other entities, including towns, cities, other state agencies, private companies, and the Rhode Island Bridge and Turnpike Authority (RITBA).

The RITBA-managed bridges include the Mount Hope Bridge, the Jamestown Verrazano Bridge, and the Claiborne Pell Bridge—also known as the “Newport Bridge”—and the Sakonnet River Bridge. These bridges effectively link Aquidneck Island to the rest of Rhode Island. These and other non-RIDOT-owned NHS bridges are summarized in the figure below.

Figure 4 -- Summary of Other-Owned NHS Bridges

Owner and Municipality	Number of Bridges	Total Deck Area (Sq. Ft.)
Towns and Local Highway Agencies		
Johnston	1	143.00
Cities and Municipal Highway Agencies		
Pawtucket	4	23,736.82
Providence	11	131,911.10
Woonsocket	2	29,372.94
Other State Agencies		
North Kingstown	1	4,336.50
Warwick	2	18,143.75
Private Non-Railroad Entities		
East Providence	1	2,088.46
Rhode Island Turnpike & Bridge Authority (RITBA)		
Bristol	1	154,484.40
Jamestown	9	1,179,946.00
North Kingstown	1	5,096.64
Portsmouth	2	219,192.20
Tiverton	1	9,724.00
Grand Total	**36**	**1,778,175.81**

TAMP Reporting

Under federal MAP-21 requirements, all states are required to develop and submit a TAMP document in order to define, address, and codify various asset management approaches, especially with regards to managing assets that are part of the NHS. Following the initial submission and review, state DOTs have until June 30, 2019 to submit an asset management plan that complies with federal code 23 U.S.C. 119.

Penalties may result from an incomplete TAMP, including reduced federal funding through the National Highway Performance Program. Processes described within the TAMP will be subject to recertification at least every four years and whenever there is a non-trivial change in asset management processes

Initial and Future Scope

This initial TAMP focuses almost exclusively on NHS bridge and pavement assets, as required by MAP-21, including all state-owned pavement and bridge assets. RIDOT hopes that this model will serve as a foundation for an extension of the TAMP to additional assets in the future. At this time, RIDOT lacks the data required to augment this TAMP with all of inputs required by MAP-21 and 23 U.S.C. 119, but the Department hopes to include Storm water, Signs, Guardrail, ITS assets, and more in its future TAMPs.

TAMP Content

This initial TAMP includes each of the following elements, as they apply to NHS pavement and bridge assets in Rhode Island:

- Processes to complete a performance gap analysis and to identify strategies to close gaps;
- Processes to complete life cycle planning;
- Processes to complete a risk analysis and develop a risk management plan;
- Processes to develop a financial plan covering at least a 10-year period;
- Processes to develop investment strategies;
- Processes for obtaining necessary data from NHS owners other than RIDOT; and
- Processes for ensuring the TAMP is developed with the best available data and that RIDOT uses bridge and pavement management systems meeting the requirements in 23 CFR 515.17 to analyze NHS bridge and pavement conditions.

The table below summarizes the contents of each chapter in this initial TAMP.

Figure 5 -- Initial TAMP Chapter Overviews

Chapter	Description of Contents
2—Objectives and Measures	Federal and state requirements impacting the contents of this initial TAMP; description of measures used to track asset performance; discussion of the use of measures and targets in developing asset management objectives
3—Asset Inventory and Condition	Description of Rhode Island's NHS assets; federal and state requirements impacting asset conditions; summary of asset inventory, condition, and performance trends.
4—Life Cycle Planning (LCP)	Summary of RIDOT's approach to life-cycle planning; comparison of treatment options and associated costs for NHS pavement and bridges.
5—Risk Management	RIDOT's risk assessment and management strategy; federal and state requirements impacting risk management and mitigation; summary of transportation risks in RI; TAMP risk management next steps.
6—Revenues and Financial Plan	Description of RIDOT's approach to financial planning; federal and state requirements and constraints; revenue sources and uses reflected in the 2018-2027 RI STIP.
7—Performance Gap Analysis	Analysis of existing performance gaps; process for identifying and addressing future performance gaps.
8—Investment Strategies	Discussion of investment prioritization strategies; guiding principles of the Statewide Transportation Improvement Plan (STIP); summary of state's unfunded priority list.
9—Implementation and Systems	Description of RIDOT's planned self-assessment methods; future asset management systems and strategies in development.

Chapter 2: Objectives and Measures

RIDOT has identified **four guiding principles and objectives** to define the scope and content of this Transportation Asset Management Plan (TAMP). Aligned with the Department's goals and asset-level measures and targets, the objectives below are applied throughout this document in (1) as guiding principles of asset management, and (2) as long-term goals for the Department.

Figure 6 -- RIDOT Asset Management Objectives

Objective	Description
Achieve and Maintain a State of Good Repair	RIDOT's #1 priority is achieving and maintaining a state of good repair for all of Rhode Island's transportation assets, beginning with NHS bridges and pavement. Under **RhodeWorks**, RIDOT has pledged that 90% of its bridges will be in fair or good condition by 2025. In addition, RIDOT's ongoing pavement objective is to ensure that no more than 20% of the non-interstate NHS pavement network is in poor condition by 2022, and no more than 4% of the Interstate NHS pavement network is in poor condition by 2022. The pursuit of this objective is the single largest influence on the Department's investment strategies and long-term financial planning.
Improve Public Safety	RIDOT is committed to improving public safety throughout Rhode Island by making safety improvements on state bridges and roadways wherever and whenever possible. The **RI Strategic Highway Safety Plan (SHSP)** supports this objective, outlining a five-year transportation safety plan to engage key safety stakeholders and a ten-year plan to work toward zero transportation-related deaths.
Coordinate Effectively Across Divisions and Agencies	RIDOT is continuously working to improving inter- and intradepartmental communication to service the needs of Rhode Island's transportation assets. The Department is continuing to develop and streamline workflows to establish clear links between asset managers, project managers, and maintenance personnel.
Improve Technological Capabilities	RIDOT strives to use reliable, recent data to inform its asset management decisions. In service of that aim, the Department is working to improve and integrate its asset management systems. Over the next several years, RIDOT hopes to employ a comprehensive Asset Management System.

These objectives build on one another to form a comprehensive approach to developing RIDOT's asset management capabilities. In sum, to achieve a state of good repair, RIDOT must improve public safety, continue to coordinate effectively across divisions and agencies, all while improving the asset management tools available to the Department.

Federal and State Requirements

Federal Requirements

Both MAP-21 (P.L. 112-141) and the FAST Act (P.L. 114-94) mandate performance management for federal highway programs. The acts also established the National Highway Performance Program (23 U.S.C. § 119) in order to improve how federal transportation funds are allocated among states. In addition, each state DOT is mandated to develop a risk-based TAMP with regard to NHS assets in order to preserve and strengthen the state of NHS infrastructure and to meet the National Goals and Performance Management Measures (23 U.S.C. § 150(b)).

Both pavement and bridge assets within the NHS must be addressed, though the inclusion of other assets is encouraged. Due to the inclusion of assets not listed on the NHS in this document, they are subsequently required to be managed under the same provisions.

State Requirements

MAP-21 requires State Departments of Transportation (DOTs) 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 their assets and to improve or preserve the condition of the National Highway System (NHS). The state of Rhode Island, in RhodeWorks, codified its standards to align with federal expectations.

As part of RIDOT's comprehensive strategic plan, the TAMP provides standards and practices to guide RIDOT's management of NHS and other state infrastructure. The guidelines within this document also inform RIDOT's STIP, a 10-year plan which plans and prioritizes capital projects.

Asset Management Objectives, Performance Measures, and Targets

In the development of this TAMP and the execution of its day-to-day operations, RIDOT's principal objective is to achieve a state of good repair for all of Rhode Island's transportation assets, including 1,176 bridges (with 766 catalogued as part of the National Bridge Inventory (NBI)) and more than 2,800 lane miles of roadway. Despite the transportation system's vital role in supporting the state's $50 billion economy, Rhode Island's transportation assets have been plagued by underinvestment for decades. As a result, the state reported the worst bridge conditions in the country. According to 2016 Federal bridge data, the state has 97 Poor NHS bridges and 192 Poor bridges overall.

RhodeWorks establishes an ambitious program that will rehabilitate or replace more than 150 bridges and preserve and repair another 500 by 2025. The goal of this cohesive bridge program is to reduce the percentage of bridge deck area rated as deficient from today's 23 percent to no more than 10 percent deficient by 2025.

State of Good Repair

While there is no national standard for a State of Good Repair, RIDOT has developed asset-specific definitions in coordination with FHWA. For this initial TAMP, RIDOT is using the MAP-21 condition assessment to assign whether a specific asset is in a State of Good Repair. A State of Good Repair for a specific asset is defined as a section of pavement or bridge in fair or good condition. For an inventory of assets to be considered in a State of Good Repair, RIDOT must meet its targets for network condition for the network to achieve a State of Good Repair.

Figure 7 -- State of Good Repair Criteria, Asset- and Class-Level

Asset Class	State of Good Repair Criteria Individual Asset Level	State of Good Repair Criteria Asset Class Inventory Level
Bridge	"Good" rating (7 or higher) for all bridge components	No more than 10% of bridges rated "Poor."
Pavement	PSHI rating of 70 or higher, which is an HPMS rating of "Fair."[1]	No more than 20% of all non-Interstate NHS pavement rated "Poor" by HPMS. Less than 4% of all Interstate NHS rated poor by HPMS

Pavement Objectives, Performance Measures and Targets

RIDOT's pavement-specific asset management objective is to maximize the usable life of pavement structures through innovative design, timely preservation, and regular maintenance.

Designing, preserving, and maintaining long-lasting pavement structures is an essential component of life cycle cost minimization. The near-term focus of the Pavement Capital Program is to bring the pavement assets to a condition where they can reasonably be preserved. Through 2027, the program will transition from replacing poor and failed pavements through reconstruction, or rehabilitation, to one that utilizes data to apply the correct treatments to preserve assets. Pavement maintenance and preservation activities are an integral part of the Department's pavement management approach to asset management in the near term, but they are expected to take on a much larger role in out years beyond the four-year fiscally constrained period of the current STIP.

Focusing on extended life cycles by repairing before rehabilitation becomes necessary is a crucial strategy to help achieve these goals and reach a State of Good Repair. Pavement performance is measured annually in two ways:

1. **The Pavement Structural Health Index (PSHI),** a RIDOT index which weights various pavement distresses including cracking, rutting, International Roughness Index (IRI), patching, and other distresses to arrive at an index value between 0 and 100. The PSHI is calculated for all state roadways – NHS Interstate, Other NHS (including NHS roads with non-state owners), and Other State roads.
2. **The Highway Performance Monitoring System (HPMS),** a Federal Highway Administration system which uses a more generalized set of pavement distresses to rank pavement condition according to a broad, three-tiered system – Good, Fair, and Poor. The HPMS system is only used to rank the Interstate NHS and Other NHS roads. The "Other State roads" are not ranked in the HPMS.

[1] Please see figure 12 on page 20 for a conversion between PSHI and HPMS ratings.

While these methodologies use similar weights and inputs, they are distinct enough to warrant individual explanation, and they have distinct uses. RIDOT will work to unify condition assessment and reporting in the future, but for the time being, the table below details the applications of each measure and the performance targets associated with each pavement type.

Figure 8 -- Pavement Conditions and Targets[2]

	Measure	Pavement Condition	Baseline (% in 2018)	2-Year Target (% in 2020)	4-Year Target (% in 2022)	Gap
All State-Owned Pavement	HPMS	Good	22.00%	24.10%	23.20%	No
		Fair	66.90%	64.80%	65.50%	N/A
		Poor	11.10%	11.10%	11.30%	Yes
Interstate NHS	HPMS	Good	55.05%	-	55.00%	Yes
		Fair	44.95%	-	41.00%	N/A
		Poor	0.00%	-	4.00%	Yes
Non-Interstate NHS	HPMS	Good	18.01%	10.00%	10.00%	Yes
		Fair	62.08%	70.00%	70.00%	N/A
		Poor	19.91%	20.00%	20.00%	Yes
All Other NHS Owners3	HPMS	Good	4.39%	0.00%	0.00%	Yes
		Fair	72.74%	40.00%	30.00%	N/A
		Poor	22.87%	60.00%	70.00%	Yes

Pavement Performance Measurement Process

Pavement distress data is gathered annually for roadways and entered into RIDOT's Pavement Management System (PMS). A Pavement Structural Health Index (PSHI) is then calculated for each 1/10th of a mile segment of road. The data is also processed and entered in to the HPMS,

[2] For the purposes of this table, the focus remains on pavement in "Good" and "Poor" condition. Fair is therefore a redundant measure, so gaps are not applicable.

[3] Two- and four-year targets in this category assume that the non-state entities that control these NHS assets do not implement any improvements of any type during the performance period and that the 2018 (measured) PSHI of these assets deteriorate linearly at a rate of 1.5 points per year. *Based on HPMS rating system

which establishes a Good, Fair, or Poor ranking for each 1/10th mile section of NHS Interstate and Other NHS roads. PSHI is calculated by assuming the pavement is perfect (PSHI = 100) and applying a series of weighted deductions for various distresses as shown in below:

Figure 9 -- PSHI Weighted Deductions

PSHI Element	Weighted Deduction
Alligator Cracking	16%
Block Cracking	10%
Longitudinal Cracking	7%
Transverse Cracking	7%
Patching	20%
Rutting	10%
International Roughness Index (IRI)	30%

The appropriate deductions are applied to the "perfect" score of 100 to arrive at the final PSHI for a segment of road, broken into lengths of 1/10th mile. PSHI ratings are as follows:

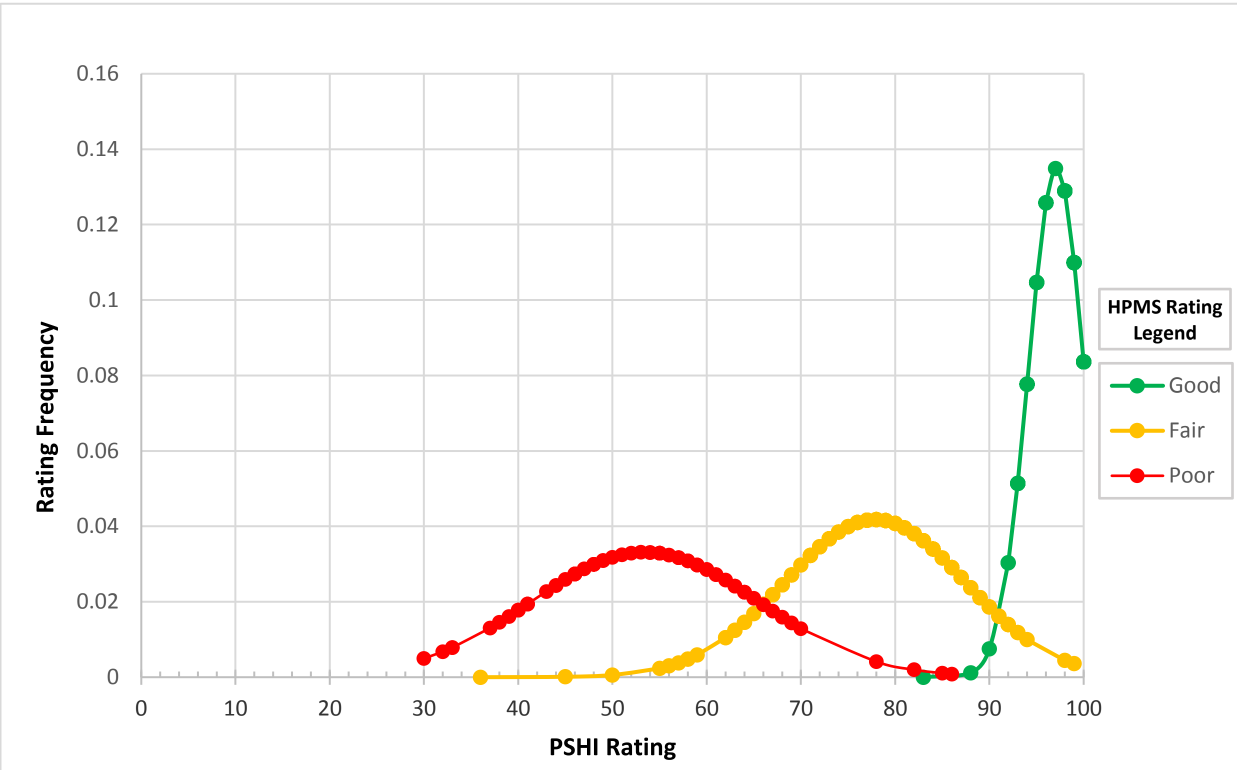
Figure 10 -- PSHI Ranges and Condition Ratings

PSHI Range	Pavement Condition Ranking
≥ 90	Excellent
80-89	Good
70-79	Fair
60-69	Poor
≤59	Failed

Chapter 2: Objectives and Measures

RIDOT has developed a system to convert PSHI to an HPMS ranking to align pavement performance targets with federal requirements. Pavement Engineering staff developed a histogram illustrating the frequency of PSHI rankings over 1/10th mile sections of road, pulling samples of Good, Fair, and Poor segments rated by HPMS. Roughly 400 data points were used to develop the histogram below, which was then plotted as a series of three normalized curves, each representing one of the HPMS ranking categories.

Figure 11 -- HPMS Conditions Relative to PSHI Measures



The points of intersection of the three curves (Good, Fair, Poor) were used to define the expected PSHI range for each HPMS ranking. This is not a perfect conversion, however; the likelihood of HPMS rankings falling into the defined PSHI range fluctuates between 80 and 98 percent. The figure presented below is hereafter referred to as the "Rosetta Stone."

Figure 12 -- PSHI to HPMS Conversion

PSHI Range	HPMS Ranking	Likelihood of Exact Match
>91	Good	98 %
66 - <91	Fair	80%
<66	Poor	86%

RIDOT's pavement management team is working to refine the conversion between these two measures, but for the time being, RIDOT tracks pavement conditions using both metrics to inform asset management decisions.

Chapter 2: Objectives and Measures

Bridge Objectives, Performance Measures and Targets

RIDOT's Office of Bridge Planning has identified the following objective to preserve and improve the state's bridges:

- Design, preserve, and maintain resilient bridges and culverts;
- Minimize the number of load-posted, load-restricted, and closed bridges; and
- Reduce the percentage of NHS bridges in Poor condition to 10 percent by the end of 2025.

RIDOT currently designs its new bridges for 75-year service lives. While the Department is currently focused on achieving and maintaining a system-wide state of good repair, RIDOT considers exposure to sea-level rise and other environmental risk in the development of its bridge project. Additional asset information on RIDOT's bridges can be found in Chapter 3: Asset Inventory and Condition, while information on environmental resiliency strategies can be found in Chapter 5: Risk Management.

Efficient preservation and maintenance service minimize the need to post load limits or close bridges. RIDOT is currently working to reopen 11 closed bridges and repair 107 posted bridges (30 are NHS bridges) as part of its effort to bring bridges up to a state of good repair by 2025.

In October 2018, RIDOT established performance targets for bridges on the NHS classified in Good and Poor condition, as required under MAP-21. Those targets are reported below, along with additional information for all RIDOT bridges.

Figure 13 -- Bridge Condition Classifications by Group

	Bridge Condition Classification	Baseline (% as of 2018)	2-Year Target (% in 2020)	4-Year Target (% in 2022)	Gap
NBI-NHS	Good	13.10%	14.00%	16.00%	No
	Fair	63.00%	60.00%	63.00%	N/A
	Poor	24.00%	26.00%	21.00%	No
All RIDOT Bridges	Good	22.21%	Not Available		N/A
	Fair	58.21%			N/A
	Poor	19.57%			N/A

Bridge Performance Measurement Process

Bridge condition classifications are determined by the lowest rating of the deck, superstructure, substructure, or culvert, rated on a 0 to 9 scale. If *any* component of a bridge is in "Poor" condition—designated by a classification of 4 or lower—the entire bridge is assigned a rating of "Poor." Maintaining a state of good repair for Rhode Island bridges, then, means maintaining all aspects of every bridge using a holistic approach.

To facilitate that process, RIDOT inspects its National Bridge Inventory (NBI) assets on a regular basis according to its rating. The Department's preventative maintenance schedule is discussed in detail in Chapter 4: Life Cycle Planning.

Setting Performance Targets

Targets were required to be set for the Map-21 Pavement and Bridge condition performance measures by May 2018 and reported in the Baseline Performance Report by October 1, 2018. RIDOT submitted this report on time, and the performance targets established in that document are reflected throughout this TAMP.

To ensure that these targets are met, RIDOT's Division of Planning is working to establish a Project Intake and Asset Management Council, which will have three core functions:

- Collect and review asset-level data to ensure that performance targets are reasonable and accurate;
- Assess proposed projects to determine their impact on asset performance; and
- Ensure that changes to the Statewide Transportation Improvement Plan (STIP) further the Department's asset management objectives.

Chapter 3: Asset Inventory and Condition

Rhode Island's infrastructure is composed of a diverse array of assets, including Interstate assets on the NHS, non-Interstate assets on the NHS, and additional state-managed assets. This includes over 2,800 miles of roadway and 1,176 bridges.

National Highway System (NHS)

Rhode Island's National Highway System (NHS) assets include 1,856 lane-miles of highway and 766 bridges. 419 of the Department's NBI bridges are located on the NHS.

Federal and State Requirements

Federal

Under MAP-21, each state must manage an inventory of pavement and bridge assets on the National Highway System. Additional information regarding asset inventories is requires to be reported in accordance with the HPMS Field Manual.

State

While no specific state requirements exist regarding inventory of assets, RIDOT does maintain and manage inventories of its NHS assets to fulfill its asset management duties and meet federal reporting requirements.

Pavement Asset Inventories and Condition

Pavement assets are an integral component of the state surface transportation network and have an outsize role in serving the public. It is important that pavement assets are maintained in serviceable condition to reduce travel times, minimize wear and tear on vehicles, and provide a safe and pleasant travel experience to those using Rhode Island roadways. Pavement quality is perhaps the most noticeable, appreciable, and public-facing transportation asset. Pavement condition is arguably the most common metric employed by the public to judge the performance of the Department.

As described in this chapter, the RIDOT pavement inventory distinguishes between three types of roads, for those roads within agency jurisdiction, and projects their current and future conditions under the current ten-year plan. These include:

- Interstate roads that are part of the national highway system;
- Non-interstate roads that are part of the national highway system; and
- Other state roads that are within RIDOT jurisdiction; and
- NHS roads that are outside of RIDOT's jurisdiction but within state boundaries

The ownership of the state's pavement inventory is summarized in the figure below.

Chapter 3: Asset Inventory and Condition

Figure 13 -- Pavements Inventory Summary

Highway System	RIDOT Lane-Miles	Others' Lane-Miles	Subtotal Lane-Miles
Interstate NHS	378.15	0.00	378.15
Non-Interstate NHS	1,357.92	119.93	1,477.85
Total NHS	**1,736.07**	**119.93**	**1,856.00**
Non-NHS Federal Aid Highways	993.07	1,360.02	2,353.09
Total Federal Aid Eligible	**2,729.14**	**1,479.95**	**4,209.09**
Non-Federal Aid Highways	127.43	8,404.68	8,532.11
Total Statewide	**2,856.57**	**9,884.63**	**12,741.20**

RIDOT controls and maintains the entirety of the Interstate NHS network in the state, as well as most other pavement types. As discussed in Chapter 2, pavement asset condition is measured and reported in two ways: HPMS and PSHI. The figures below report the state's pavement asset conditions using both methods as of July 2017.

Figure 14 -- Current Pavement Condition (HPMS)

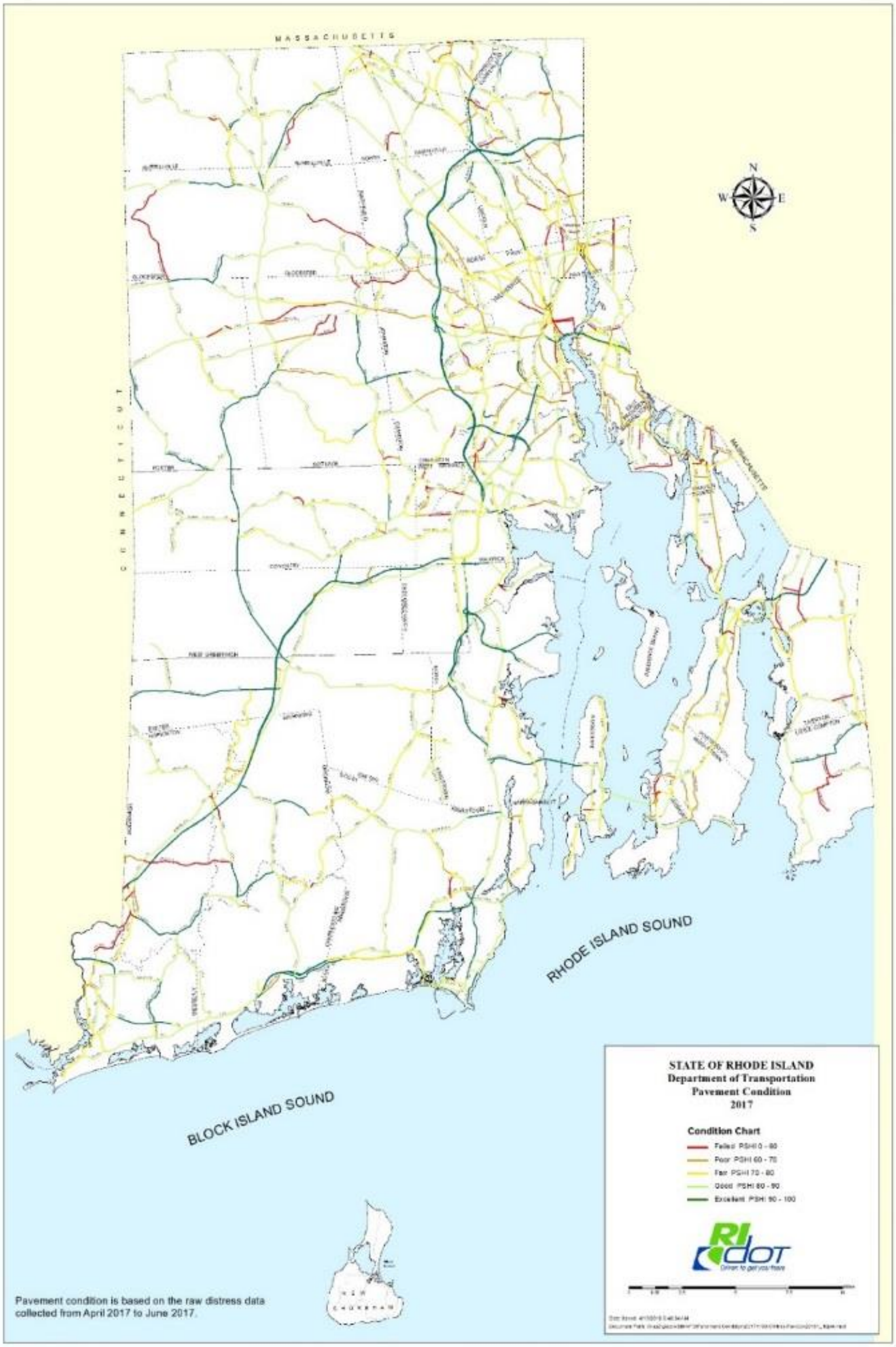
	RIDOT Owned & Maintained			Other Owned & Maintained		
Highway System	**% Good**	**% Fair**	**% Poor**	**% Good**	**% Fair**	**% Poor**
Interstate NHS	55.05	44.95	0	0	0	0
Non-Interstate NHS	18.01	62.08	19.91	4.39	72.74	22.87

Figure 15 -- Current Pavement Conditions (PSHI)

	RIDOT Owned & Maintained					Other Owned & Maintained				
Highway System	% Excellent	% Good	% Fair	% Poor	% Failed	% Excellent	% Good	% Fair	% Poor	% Failed
Interstate NHS	79.60	16.60	3.80	0.00	0.00	Not Applicable				
Non-Interstate NHS	26.20	30.20	24.60	15.60	3.40	30.40	17.30	24.20	19.90	8.20
Non-NHS Federal-Aid Eligible State	TBD	TBD	TBD	TBD	TBD	Not Applicable				
Non-Federal-Aid Eligible State	TBD	TBD	TBD	TBD	TBD					

RIDOT is responsible for the maintenance of over 2,800 lane miles of roadway throughout Rhode Island, the current conditions of which are indicated in the map below.

Figure 16 -- Current Pavement Conditions in Rhode Island



Rhode Island's roadway pavement structures are comprised of several elements:

1. The native subsoil specific to the location on which the road was built;

2. A gravel borrow subbase, which is a free draining layer of high-quality granular soil that provides a firm foundation and permeable layer to transmit water; and

3. A concrete (or bound) pavement structure that forms the road base and riding surface.

In Rhode Island, most pavement assets are asphalt roadways; the bound component of the structure consists entirely of asphalt concrete. A smaller percentage of the system is comprised of composite pavement, where the bound component of the pavement consists of a Portland cement concrete (PCC) base, overlain with asphalt concrete, which forms the riding surface. Finally, less than 3½ total miles of the state roadway pavement is PCC, where the PCC forms the base and riding surface.

The RIDOT pavement inventory distinguishes between the same three road types identified above: Interstate-NHS, Non-Interstate NHS, and Other State Roads. The current and project future conditions of each road type are summarized in the table below:

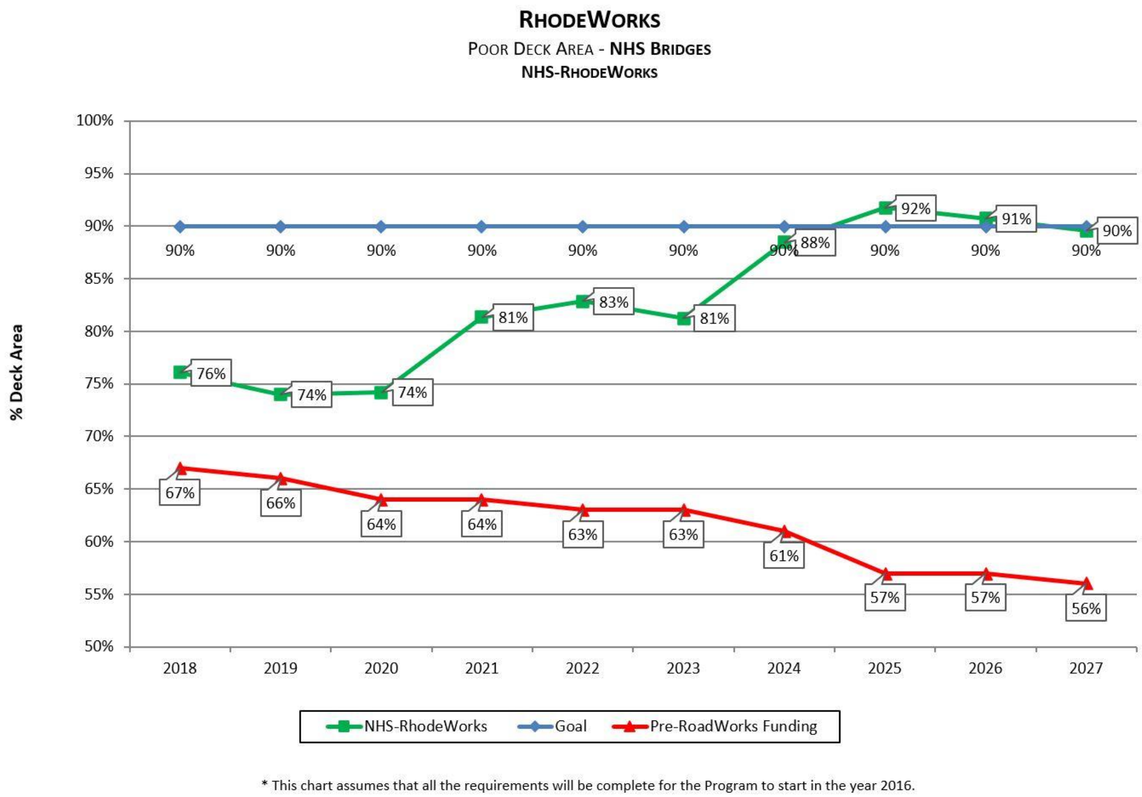
Figure 17 – Projected Pavement Structural Health Index (PSHI) Rating by Highway System

	Interstate NHS				Non-Interstate NHS				Other State Roads			
PSHI	**Actual**	**2019**	**2021**	**2027**	**Actual**	**2019**	**2021**	**2027**	**Actual**	**2019**	**2021**	**2027**
Excellent	78.7	83.9	83.4	49.6	24.7	24.6	25.5	36.2	8.9	6.7	8.1	8.0
Good	18.6	13.4	16.6	48.2	32.5	36.8	29.2	29.9	45.6	45.9	40.0	18.9
Fair	2.7	2.7	0.0	2.2	26.1	23.7	29.2	22.3	25.3	27.7	33.0	46.5
Poor	0.0	0.0	0.0	0.0	12.6	11.0	12.7	8.2	10.0	9.8	11.2	20.1
Failed	0.0	0.0	0.0	0.0	4.1	3.9	3.4	3.4	10.2	9.9	7.7	6.5

Bridge Asset Inventories and Condition

According to FHWA, Rhode Island's bridges rank worst in the nation. Of the state's 1,162 bridges, 22.21 percent are Poor, including 24 percent of bridges on the 419 NBI bridges on the NHS. (See Figure 19.) For this reason, the central focus of the RhodeWorks program is to use a data-driven, asset management-based protocol to update the Department's entire bridge inventory to a state of good repair. By increasing up-front investment, the State of Rhode Island is on track to achieve the minimum standard of 90 percent bridge sufficiency by 2025. Effective, efficient asset management of the bridges that RIDOT has already repaired—and all those that remain in poor condition—is a central priority for RIDOT. Bridge reconstruction can be as much as six times as expensive as rehabilitation, and therefore it is imperative that the state manage its bridges carefully. While bridge condition is more difficult for the public to discern, bridge sufficiency is perhaps the most important component of highway safety. Roads with perfect pavement surfaces are useless if they link crumbling bridges that are weight-restricted or closed. Safe bridges make for safe roads, safe drivers, and safe commerce. The figure below reports the projected condition of RIDOT's bridges over the next decade.

Figure 18 -- Projected Bridge Conditions Pre- and Post-RhodeWorks Funding



As described in Chapter 2, RIDOT has adopted the standard of no more that 10 percent deficiency for all its bridges, meaning that at least 90 percent of the state's NHS bridges must be maintained in Fair or Good condition.

Bridge condition measures are based on deck area, and determined by the rating of the deck, superstructure, substructure, or culvert. Each element is rated on a 0 to 9 scale in which ratings of 7 or greater correspond to "Good" condition, 5 and 6 indicate "Fair" condition, and 0 to 4 indicate "Poor" condition.

Overall bridge condition ratings are taken from the lowest individual component condition. A bridge with a deck rating of 8, a substructure rating of 9, and a deck rating of 3 would therefore be classified as a bridge in "Poor" condition. The tables below provide summaries of the current inventory and condition of Rhode Island's bridge assets by Highway System.[4] The list of "other"

[4] The bridge information shown in the tables throughout this TAMP was initially reported by RIDOT in March 2018. That reporting reflects prior-year information. Therefore, 2018 information will be available following RIDOT's March 2019 reporting.

asset owners can be found in the "Working with Other NHS Owners and Stakeholders" section of Chapter 1.

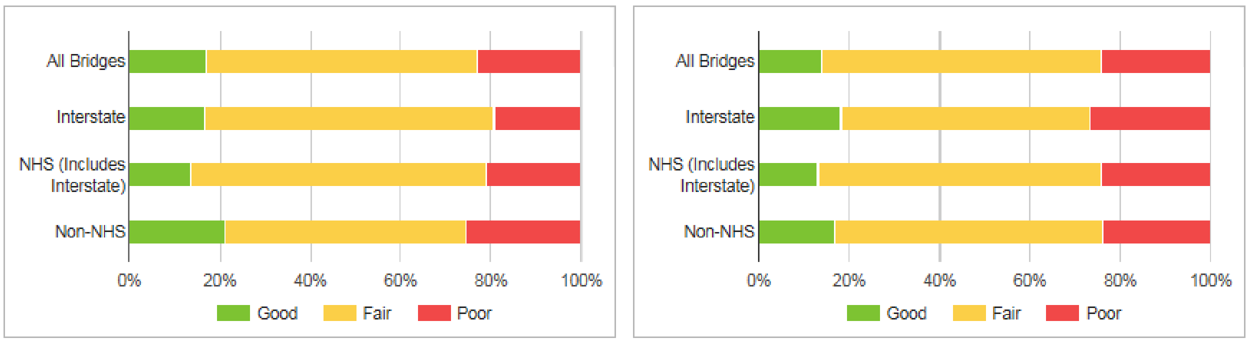
Replacement value is based on inspections that were reported in the 2018 submission. The value is based on the LCCA of the bridge and where it lies in that analysis, remaining life value of the bridge is then computed with present dollars. Condition is viewed on where it remains on its life-cycle curve.

Figure 19 -- Bridge Inventory

Bridge Performance Measures for Selected Bridges

Percentages by Bridge Count

Percentages by Bridge Deck Area



	Good	Fair	Poor
All Bridges	134 (17.18%)	466 (59.74%)	180 (23.08%)
	Total: 780		
Interstate	21 (16.94%)	79 (63.71%)	24 (19.35%)
	Total: 124 % of Total: 15.90%		
NHS (Includes Interstate)	57 (13.60%)	274 (65.39%)	88 (21.00%)
	Total: 419 % of Total: 53.72%		
Non-NHS	77 (21.33%)	192 (53.19%)	92 (25.48%)
	Total: 361 % of Total: 46.28%		

	Good	Fair	Poor
All Bridges	1,182,898 (13.85%)	5,316,014 (62.24%)	2,042,609 (23.91%)
	Total (sq. ft.): 8,541,521		
Interstate	404,398 (18.07%)	1,239,432 (55.39%)	593,698 (26.53%)
	Total (sq. ft.): 2,237,528 % of Total: 26.20%		
NHS (Includes Interstate)	888,515 (13.09%)	4,272,694 (62.95%)	1,626,052 (23.96%)
	Total (sq. ft.): 6,787,261 % of Total: 79.46%		
Non-NHS	294,383 (16.78%)	1,043,320 (59.47%)	416,556 (23.75%)
	Total (sq. ft.): 1,754,259 % of Total: 20.54%		

Figure 20 -- Bridge Inventory by Owner

	Deck Area (Feet^2)					Count				
Owner	**Good**	**Fair**	**Poor**	**SD**	**All**	**Good**	**Fair**	**Poor**	**SD**	**All**
State	1,044,797	3,277,972	1,860,310	1,860,310	6,183,078	86	366	137	137	**589**
City	58,492	424,080	96,284	96,284	578,845	12	49	17	17	**78**
Town	60,408	51,829	31,678	31,678	143,915	24	30	23	23	**77**
State Toll	226,066	1,345,306	0	0	1,571,372	5	9	0	0	**14**
State Park	2,734	2,303	1,012	1,012	6,049	3	3	2	2	**8**
Local Park	0	4,198	3,477	3,477	7,675	0	3	2	2	**5**
Other State Agency	10,775	61,193	0	0	71,968	1	2	0	0	**3**
Federally Owned	0	39,106	0	0	39,106	0	2	0	0	**2**
Other Local Agency	0	2,659	0	0	2,659	0	1	0	0	**1**
Private	0	2,088	0	0	2,088	0	1	0	0	**1**

Using bridge condition reports, replacement costs, and lifecycle forecasting calculations, the Department determines the value of its bridge assets, reporting the value of each bridge to FHWA annually. The table below, and Figure 49, provides a summary of the total value of the Department's bridges and how conditions are valued:

Figure 21 -- Bridge Conditions (FHWA Measures)

ALL NBI BRIDGES							
Deck Area (Feet^2)				Count			
Good	**Fair**	**Poor**	**Subtotal**	**Good**	**Fair**	**Poor**	**Subtotal**
1,403,281	5,210,745	1,992,750	**8,606,765**	131	466	181	**778**
16.30%	60.54%	23.15%	**100%**	16.84%	59.90%	23.26%	**100%**
ALL NBI-NHS BRIDGES							
Good	**Fair**	**Poor**	**Subtotal**	**Good**	**Fair**	**Poor**	**Subtotal**
888,515	4,272,694	1,626,052	**6,787,261**	57	274	88	**419**
13.09%	62.95%	23.96%	**100%**	13.60%	65.39%	21.00%	**100%**

Figure 22 -- Statewide Estimated Replacement Value of Bridge Assets

Bridges & Structures	Quantity	Units	Average Unit Replacement Value	Replacement Value ($M)
Vehicular Bridges	778	Each	Variable – Based on Structure Size and Type	$5,437
Small Structures	363	Each	Variable – Based on Structure Size and Type	$111
Pedestrian Structures	70	Each	Variable – Based on Structure Size and Type	$48
Total	**1,211**			**$5,596**

Figure 23 -- Estimated NHS Bridge Replacement Value (Local and State Agencies)

State-Owned Bridges on the NHS	Quantity	Units	Average Unit Replacement Value	Replacement Value ($M)
Vehicular Bridges	394	Each	Variable – Based on Structure Size and Type	4,348
Culverts	24	Each	Variable – Based on Structure Size and Type	$33
Total	**418**			**$4,381**
Locally-Owned Bridges on the NHS	**Quantity**	**Units**	**Average Unit Replacement Value**	**Replacement Value ($M)**
Vehicular Bridges	17	Each	Variable – Based on Structure Size and Type	$121
Total	**435**			**$4,512**

Using the data available from Amendment 10 to the 2018-2027 STIP, RIDOT has also evaluated the condition of its bridge assets on the NBI, anticipating the next ten years of deterioration along with development, replacement, and preservation work programmed in the STIP. The table below provides an overview of current and anticipated future bridge conditions.

Figure 24 -- NBI-NHS Bridge Condition Forecast

Year	Good		Fair		Poor	
	NBI	NHS	NBI	NHS	NBI	NHS
2018	16.3%	16.6%	60.5%	59.8%	23.2%	23.6%
2019	16.3%	16.7%	59.5%	58.8%	24.2%	24.5%
2020	17.6%	15.8%	57.0%	58.2%	25.4%	26.0%
2021	18.0%	18.0%	60.0%	60.0%	22.0%	22.0%
2022	20.0%	20.0%	60.0%	60.0%	19.0%	21.0%
2023	22.0%	22.0%	62.0%	62.0%	16.0%	16.0%
2024	24.0%	24.0%	64.0%	64.0%	11.0%	11.0%
2025	25.0%	25.0%	65.0%	65.0%	10.0%	10.0%
2026	25.0%	25.0%	67.0%	67.0%	8.0%	8.0%
2027	25.0%	25.0%	66.0%	66.0%	9.0%	9.0%
2028	25.0%	25.0%	65.0%	65.0%	10.0%	10.0%

Pursuant to FHWA requests, the Department has also included an estimate of the cost of total replacement for bridges according to two sets of criteria. According to FHWA guidelines, the anticipated cost of total bridge replacement is approximately $360 per square foot for all bridges. BrM can and does use both square-foot and element-based estimates for costs.

RIDOT's Project Management Portal (PMP) contains some historical weighted-average-unit costs (WAUPs) for various bridge elements, but lump-sum project WAUPs are simply calculated on a per-square foot basis.

Chapter 4—Life Cycle Planning

By maintaining transportation assets on a clearly-defined schedule, Rhode Island can greatly reduce overall life-cycle maintenance costs. Cost data shows that maintenance and preservation work are considerably cheaper than rehabilitation, reclamation, and reconstruction.

RIDOT is mandated by the RhodeWorks legislation to prioritize the repair and replacement of bridges throughout the state, and therefore the state's pavement resurfacing, and rehabilitation needs will stretch beyond the first four, fiscally constrained years of the STIP up until 2022, gradually picking up in volume throughout the rest of the 10-year-plan to 2027. Once that state is reached, preservation and maintenance work can become a larger portion of the program. Using this timeline, RIDOT's asset management policy states that the agency will work towards a fully implemented "preservation first" approach, using regular maintenance activities, and planned rehabilitation projects.

RIDOT Pavement Lifecycle Planning and Treatment Strategies

Pavement lifecycle management at RIDOT is currently conducted through two interrelated processes: [1] preventative pavement maintenance, and [2] pavement resurfacing and rehabilitation. These two activities are generally reflected in the Pavement Maintenance and Pavement Capital Programs of the STIP, respectively. In the recent past, preventative pavement maintenance functioned largely independently of pavement resurfacing and rehabilitation.

RIDOT is taking steps to link these processes into a comprehensive pavement lifecycle management approach. This section outlines the two processes as they are currently managed and identifies a path towards preventative maintenance and resurfacing integration.

Preventative Pavement Maintenance

Most preventative pavement maintenance work in the state has been managed in recent years by the Department's Office of Materials. Historically, road segments have been identified as candidates for pavement preservation in two ways:

1. Materials personnel monitor the completion of pavement resurfacing projects and set alerts within ArcMap for five years from the date of resurfacing and rehabilitation project completion. At that point, Materials personnel compare the condition of the subject roadway to the information contain in RIDOT's pavement management system, dTIMS, to confirm whether the expected deterioration has taken place. If a road segment is still in "excellent" condition, then an alert is set for a future year based on PSHI measurements. If not, observational surveys are conducted to evaluate the need for crack sealing, PPEST, chip sealing, or other treatments. This portion of the preservation selection process is therefore driven by the pavement resurfacing and rehabilitation work that is completed each year. The projects completed in 2013, for example, were inspected and addressed in 2018.

2. Staff also use day-to-day experience of driving throughout Rhode Island to identify other pavement segments which may be eligible for preservation treatments. This portion of the preservation process is driven by the experience of Materials personnel, as well as commentary from residents and other RIDOT staff.

Ideal candidates for preventative maintenance are typically long stretches of road in “fair” or better condition on PSHI scales. Once preventative maintenance candidates are identified, Staff select pavement segments for treatment based on several considerations:

1. Which combination of preventative maintenance project(s) will maximize the utility of that available funding, with geographic considerations in mind;

2. The pavement condition in the area, as indicated by PSHI and HPMS measures housed in dTIMS (described in the next section); and

3. The prescribed treatment for each segment, based on the needs of the pavement. Preventative maintenance treatments may include:

    a. Crack sealing;
    b. Chip sealing;
    c. Paver Placed Elastomeric Surface Treatment (PPEST), also commonly referred to as “thin overlays;” and
    d. Other miscellaneous treatments, including fog seals.

In RIDOT’s experience, crack seals tend to last three to five years, on average. Chip seals last a bit longer—10 years on average—while PPEST, designed for 10-year lifespans, typically last only six years. Based on these expectations, all preventative maintenance work is inspected within a five-year window to evaluate the viability and utility of additional preventative maintenance treatments. The Department considers” mill and fill” pavement rehabilitation, not preservation (i.e. preventative maintenance.)

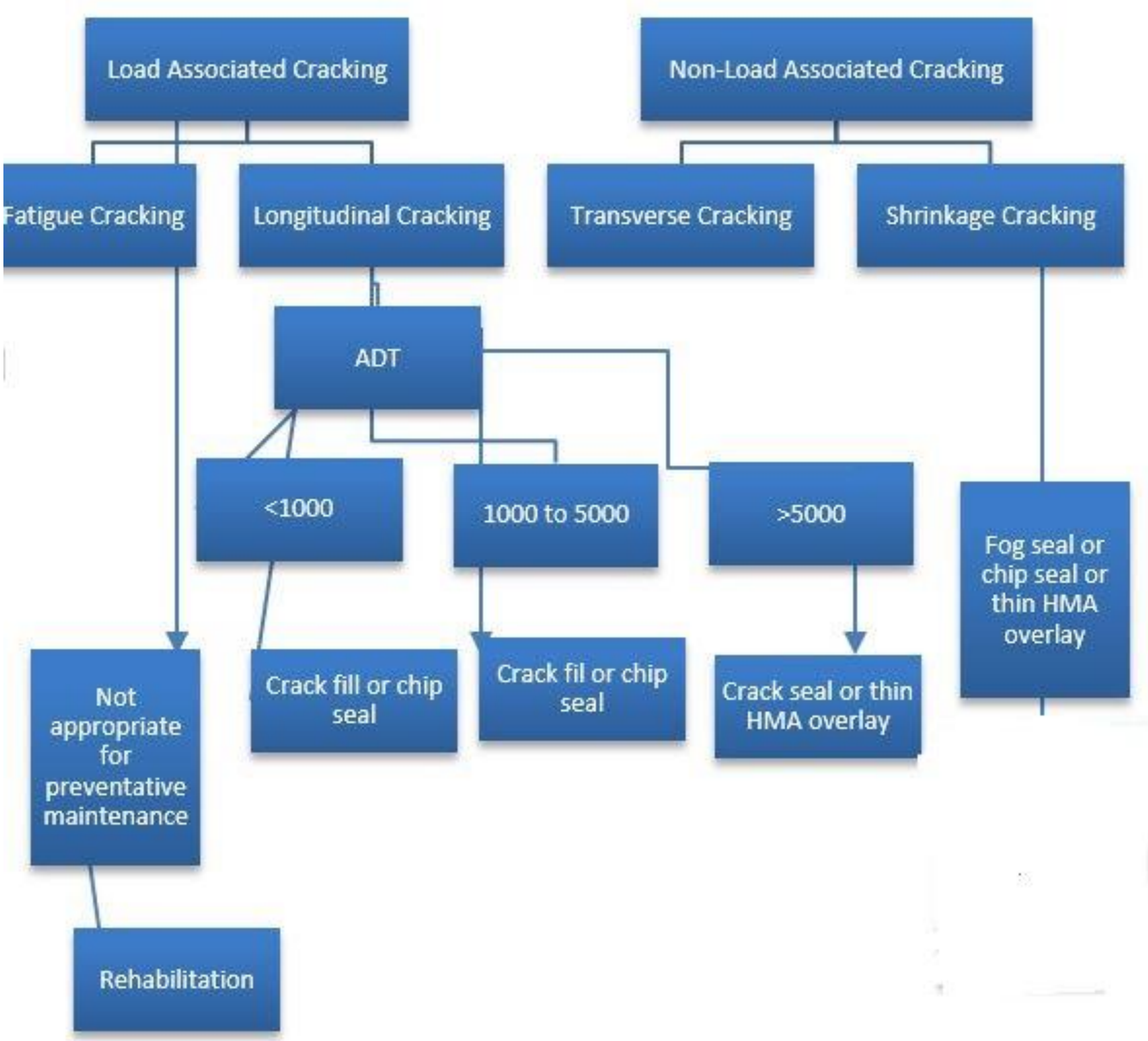
The identification of which treatment to use is typically governed by an analysis of the observational survey data. Figure 25 below provides a sample decision tree which summarizes a typical set of considerations involved in distinguishing between treatment options including crack fills, chip seals, crack seals, thin overlays, and foregoing preventative maintenance altogether.

The figure below offers only an approximation of the Department’s decision-making process, as preventative maintenance activities shift from year to year. In addition, the limits of preventative maintenance projects are established on a case-by-case basis.

On average between 2008 and 2018, RIDOT has applied crack seal treatments to 198 lane miles of road per year. Chip seals and overlays are more varied year to year. The attached exhibit reports the total lane mileage, expenditure, and cost per mile of pavement preservation activity since 2008.

Analysis shows that there is enough need for preventative maintenance in the state that an additional $10M per year could be well spent extending pavement lifecycles. Road segments to which preventative maintenance treatments are not or cannot be applied—either because they are too large or small to be economically viable, or too damaged to be preserved—will continue to deteriorate and eventually fail. Failed pavements will eventually be addressed through pavement reclamation or reconstruction.

Figure 25 -- Sample Decision Tree for Cracking



Pavement Resurfacing and Rehabilitation

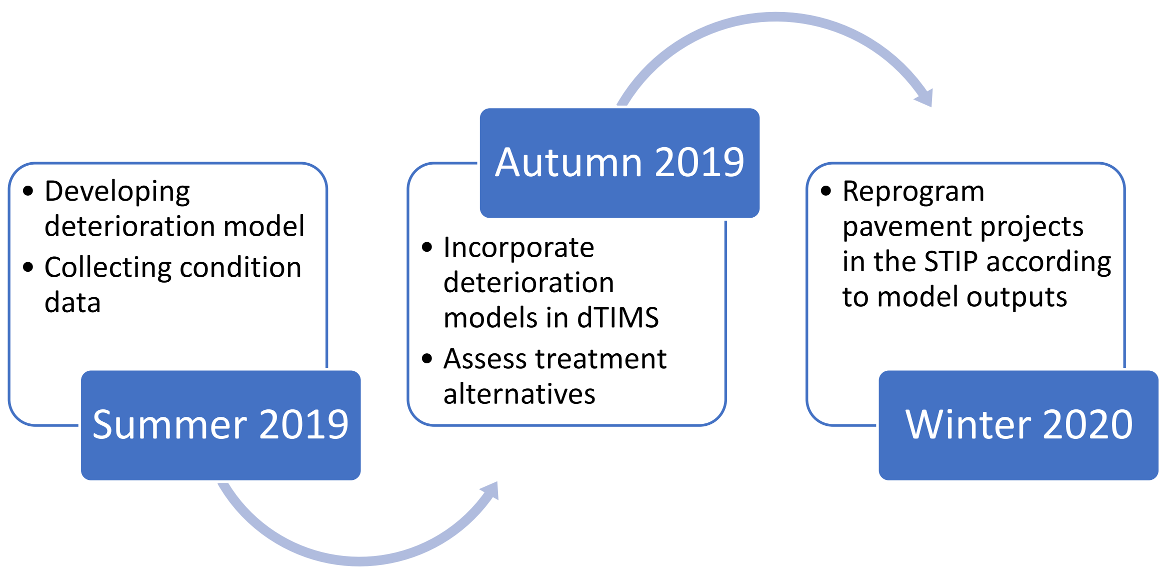
RIDOT's pavement resurfacing and rehabilitation work is driven by pavement condition data managed through RIDOT's pavement management system, Deighton Total Infrastructure Management Systems (dTIMS).

Pavement condition/distress data including cracking, rutting, rideability, and patching is collected annually through contracted vendor services. Distresses are ranked by severity, illustrated on color-coded plan view photos, and quantified in tabular format. Mainline data for both NHS and "other" state roads is collected annually. Limited access ramp data is collected bi-annually.

This data is loaded into dTIMS and recorded in 0.1-mile increments based on route and mile point. The data is then processed to calculate a Pavement Structural Health Index (PSHI) for all state and non-state NHS roads. Pavement deterioration is currently modeled within dTIMS using a standardized rate of deterioration of the entire network, freeways excluded.

RIDOT's Pavement engineering team is developing a more refined set of deterioration models that may include road type, road location, traffic volume, work type performance, and climactic (thermal) zone. The refined deterioration models, expected in the fall of 2019, will be incorporated into dTIMS to improve future predictions of pavement conditions under various treatment alternatives.

Figure 26 -- Preliminary Pavement Program Improvements Timeline



These projections allow RIDOT to identify anticipated treatment needs of road segments within the 10-Year Plan, subject to funding constraints. In addition to modeling how various work types affect future pavement conditions over time, RIDOT is in the process of updating the "cost expressions" within dTIMS. The cost expressions update, expected to commence in the fall of 2019, is intended to help refine the project cost predictions for each work type. The updated cost expressions, combined with the anticipated life expectancy of the various treatment types, will form the basis for the Department's life-cycle cost analyses and projections.

There are currently 352 pavements resurfacing and rehabilitation projects programmed in the STIP's Pavement Capital Program. Under ideal circumstances, the Pavement Capital Program would be entirely shaped by the comprehensive data modelling managed through dTIMS**.**

Cost data shows that maintenance and preservation work are considerably cheaper than rehabilitation, reclamation, and reconstruction. In the near-term, because RIDOT is mandated by the RhodeWorks legislation to prioritize the repair and replacement of bridges throughout the state, the state's pavement resurfacing, and rehabilitation needs will stretch beyond the first four, fiscally constrained years of the STIP, gradually picking up in volume throughout the rest of the 10-year-plan. Once that state is reached, preservation and maintenance work can become a larger portion of the program. By the end of the 10-year plan in 2027, the Department will integrate its pavement preservation and resurfacing processes to create a comprehensive pavement lifecycle management strategy.

Linking Pavement Preservation and Rehabilitation

RIDOT is taking two major steps to integrate its pavement processes and improve its comprehensive pavement lifecycle management strategy.

First, the Department has moved the pavement preservation program into its Project Management Division, where it will be administered alongside rehabilitation projects daily. This streamlines communication surrounding pavement work because both activities will be supervised and executed by the same division.

Second, the Department is working to eliminate pavement data governance and sharing issues. In the recent past, most of the data managed in dTIMS has not fully influenced preservation activities, but rather, served only as a comparative data point. Similarly, the data collected and maintained by Materials staff has not fully impacted the treatment triggers in dTIMS. RIDOT's goal is integrate the data which dictates *preventative maintenance* treatments with the data dictating pavement *resurfacing and rehabilitation* treatments before the start of 2020.

The Department is in the process of linking those two data inputs to feed a comprehensive model, managed through dTIMS. The purpose of the resulting model will be to identify the optimal use of available funds to achieve the desired state of repair of the road network, while meeting or exceeding the stated performance goals for each of the 3 categories of roads – Interstate NHS, Non-Interstate NHS, and Other State Roads.

The dTIMS system will continue to be used to help pavement managers identify the best overall pavement management strategy to meet or exceed stated, or even changing goals. This program management strategy will define which treatments are applied to specific roads, and at which time, based on the revamped data model. This, in turn, will form the basis of the Pavement Maintenance and Pavement Capital Programs in the STIP. To fully transition the Pavement program to a life-cycle based analysis, the Department will fully implement the steps by 2027.

Figure 27 -- Pavement Preservation by Lane Mile and Total Cost, 2008-2018

PROJECT	LANE MILES	BID AMOUNT	COST PER LANE MILE
2008			
CRACK SEAL	349	$1,157,977.46	$3,317.99
CHIP SEAL	40	$1,810,389.55	$45,259.74
THIN OVERLAY	16	$881,946.76	$55,121.67
2009			
CRACK SEAL	287	$1,099,840	$3,832.20
CHIP SEAL	46	$2,177,404.18	$47,334.87
THIN OVERLAY	16	$1,272,021.74	$79,501.36
2010			
NO CONTRACTS			
2011			
CRACK SEAL	233.4	$1,033,882.88	$4,429.66
CHIP SEAL	29.4	$1,296,324.31	$44,092.66
THIN OVERLAY	13.7	$1,896,873.98	$138,457.95
2012			
CRACK SEAL	53.7	$186,905.00	$3,480.54
CHIP SEAL	24.3	$1,496,376.04	$61,579.26
THIN OVERLAY	14.1	$1,454,312.53	$103,142.73
2013			
CRACK SEAL	160.3	$751,929.40	$4,690.76
CHIP SEAL	46.8	$1,963,766.02	$41,960.81
2014			
CRACK SEAL	166.6	$709,169.60	$4,256.72
CHIP SEAL	30.9	$1,627,051.12	$52,655.38
THIN OVERLAY	14.5	$1,849,739.50	$127,568.24
2015			
CRACK SEAL	178.7	$631,342.50	$3,532.97
CHIP SEAL	13.5	$454,322.00	$33,653.48
THIN OVERLAY	14.1	$1,683,408.54	$119,390.68

PROJECT	LANE MILES	BID AMOUNT	COST PER LANE MILE
2016			
CRACK SEAL	168.9	$598,672.33	$3,544.54
CHIP SEAL	62.8	$3,550,316.87	$56,533.71
THIN OVERLAY	7.9	$633,062.04	$80,134.44
Mill & Overlay	**16.47**	**$9,419,952.87**	**$586,182.51**
2017			
CRACK SEAL	274	$1,622,534.84	$5,921.66
CHIP SEAL	34.7	$1,842,837.81	$53,107.72
THIN OVERLAY	13.6	$1,182,258.58	$86,930.78
Mill & Overlay	**23.8**	**$17,160,396.74**	**$721,025.71**
2018			
CRACK SEAL	303.5	$1,753,650.00	$5,778.09
CHIP SEAL	86.6	$4,082,612.69*	$47,143.33*
THIN OVERLAY	66.4	$7,153,123.44*	$107,727.76*
Mill & Overlay	**49.1**	**$44,567,861.50**	**$907,695.75**

* Unofficial estimates; total combined expenditure estimated to be $6M in 2018.

Approach to Life Cycle Planning (LCP)

Life Cycle Planning for Pavement

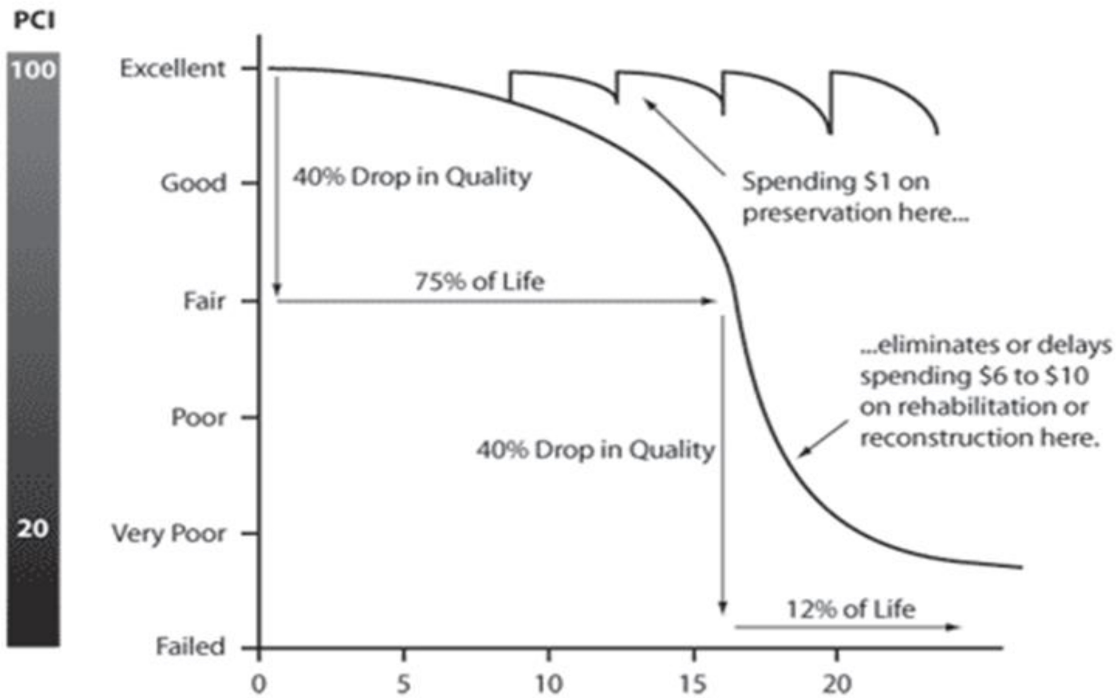
Pavement management and lifecycle planning involves utilizing rehabilitation and preservation treatments to delay major capital expenditures and maintain pavement in at least "serviceable condition," generally analogous to "Fair" or better condition on the PSHI and HPMS scales. Periodic preservation techniques, like crack and surface sealing, generally lower overall pavement lifecycle costs by extending the usable life of pavement asset, increasing the frequency of minor maintenance expenditures to decrease the frequency of major capital expenditures. The figure below provides a visual representation of this principle at work.

As described in Chapters 2 and 3, the state's pavement assets are inventoried and assessed annually. For the past 20 years, the RIDOT Highway Design Manual has guided this process, as good asset management begins with design. Section 620, "Design of Pavement Structures," notes:

> *Design of pavement structures will be based on design-year traffic projections including truck percentages. For reconstruction projects, RIDOT materials section will perform pavement cores to determine the existing pavement makeup. Sieve analyses will be*

performed on the gravel samples retrieved from the cores to determine if the existing gravel base meets the specification.

Figure 28 -- Pavement Life Cycle Management in Practice



Using this condition data, RIDOT examines the need for pavement rehabilitation and preservation programs projects at the appropriate time, and in consideration of fiscal constraints and asset needs.

Planning-level cost estimates are calculated by determining the area of pavement to be improved and establishing the proposed improvement type (i.e. reconstruction, mill and overlay, overlay, chip seal, etc.) and applying cost/area figures derived from past project bids. The base pavement management cost is then defined, and the costs of other elements such as wheelchair ramp improvements and stormwater structural treatment units are added in to produce a final base cost. Finally, contingency factors are applied to arrive at the final planning level cost estimate, which is factored for inflation and programmed in the STIP in the appropriate year.

Pavement typically last anywhere from 15 years on the interstate, to 25 or 30 years on minor arterial roadways with minimal truck traffic and some level of preservation during their lifetimes. The primary factors affecting pavement lifecycle (i.e. rate of deterioration) are:

- Historical pavement maintenance and preservation work;
- Overall traffic volumes, with consideration of heavy truck volumes; and
- Environmental factors such as
  - Freeze/thaw cycles; and
  - Sun exposure.

RIDOT categorizes its pavement as a Tier 1 asset. Tier 1 assets are managed at each stage of their lifecycle, and they benefit from regular preservation and maintenance to improve their condition and minimize their life-cycle costs. Accordingly, RIDOT inspects its pavement assets on an annual basis, and evaluates them using PSHI and HPMS metrics.

Future Performance Measures

Performance measures related to condition do not capture a portion of RIDOT's commitment to achieving a State of Good Repair at a minimum practicable cost. To measure the Department's progress in fulfilling the cost-facing component of that objective, RIDOT is evaluating the inclusion of additional performance measures as part of the final TAMP. These performance measures are *Remaining Service Life,* and *Asset Sustainability Ratio*.

Both performance measures have established purposes and inputs. Incorporating them for RIDOT's NHS bridge and pavement assets will require additional analysis, but RIDOT is planning to develop these metrics in preparation for future TAMP updates.

Remaining Service Life

Remaining Service Life (RSL) may be measured and reported as either [1] the percentage of remaining useful life of an asset relative to its anticipated service life, or [2] as the remaining useful service life of an asset measured in years. RIDOT currently maintains this data for bridges, and pavement deterioration curves may be developed for individual segments of road.

To successfully capture and report Remaining Service Life as TAMP performance measure, RIDOT is working to establish standards, targets, and deterioration model inputs for NHS assets.

Asset Sustainability Ratio

Asset Sustainability Ratio (ASR) is a measure of useful life restoration relative to deterioration. A new bridge might add 75 years of useful life, for example, while maintenance activity may provide 3 years of useful life. While RIDOT strives to time lowest life cycle activities based on condition and age, the maturity of NHS pavement and bridge inventories would tend to require approximately an equal number of life-years replenished to consumed, or an ASR between 0.9 and 1.1, to manage the network sustainably.

The Asset Sustainability Ratio can also be expressed as the dollar amount invested to the total depreciated value over a period. To successfully implement the ASR, RIDOT and NHS stakeholders will work to establish standards regarding estimated life replenished by activity and/or depreciation, while also agreeing on the proper timeframe(s) to report the ASR over.

According to FHWA-HIF-19-006, asset management is "a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair (SOGR) over the life cycle of the assets at minimum practicable cost (23 CFR 515.5)."

RIDOT is therefore undertaking an action plan for further developing/refining and implementing the LCP process to include the component of LCCA. According to FHWA, "Life-Cycle Cost Analysis (LCCA) is an engineering economic analysis tool that allows transportation officials to quantify the differential costs of alternative investment options for a given project. LCCA can be used to study either new construction projects or to examine preservation strategies for existing transportation assets."

Pavement Life Cycle Management Strategies

The figure below shows RIDOT's typical pavement treatment options including management strategies, types of work, service life extension, and costs. Cost and life values represent generalized averages used at RIDOT for program analyses, project cost projections, and asset service life evaluations. The annual costs are costs needed to keep the pavement performance at an acceptable level, which is established by condition index thresholds for cracking, rutting, roughness, and friction and captured in both HPMS and PSHI ratings.

As the average cost data shows, maintenance and preservation work are considerably cheaper than rehabilitation, reclamation, and reconstruction. However, RIDOT primarily engages in the latter forms of work as it continues to bring its pavement assets up to a state of good repair. Once that state is reached, preservation and maintenance work can become a larger portion of the capital program.

Figure 29 – Pavement Cost Data[5]

Management Strategy	Description	Work Type	Typical Life Extension (Years)	Approx. Agency Cost ($/ Lane Mile) *	Average Cost ($/Lane Mile/Year)	Equivalent Uniform Cost ($/Lane Mile/Year)
Maintenance	Maintains roads in serviceable condition during its lifetime.	Pothole Filling, Patching	N/A	N/A	N/A	N/A
Preservation	Properly timed treatments intended to seal the pavement surface from water intrusion, reduce reflective cracking, and/or improve ride quality.	Crack Sealing, Chip Sealing, Paver Placed Elastomeric Surface Treatment (PPEST), Stress Absorbing Membrane Interlayer (SAMI - chip seal & overlay)	Crack Sealing: 3 years	$4,200	$1,400	$1,345
			Chip Sealing: 8 years	$65,000	$8,100	$7,055
			PPEST: 9 years	$95,000	$10,500	$8,975
			SAMI: 15 years	$140,000	$9,500	$6,990

[5] Discount Rate of 4% used to calculate Equivalent Uniform Cost column.

Management Strategy	Description	Work Type	Typical Life Extension (Years)	Approx. Agency Cost ($/ Lane Mile) *	Average Cost ($/Lane Mile/Year)	Equivalent Uniform Cost ($/Lane Mile/Year)
Rehabilitation	Properly timed resurfacing treatments intended to preserve pavement structure and improve ride quality.	Level & overlay, mill & overlay	Level & Overlay: 15 years	$170,000	$11,500	$8,490
			Mill & Overlay: 15 years	$170,000	$11,500	$8,490
Reclamation	Form of limited reconstruction that recycles a portion of the gravel borrow subbase and improves it with asphalt millings, then replaces the entire asphalt pavement structure.	Reclamation	20 years	$440,000	$22,000	$14,775
Reconstruction	Replaces entire road structure from the gravel borrow subbase to the asphalt surface. Typically, also includes other elements such as sidewalk replacement and drainage system repair or replacement.	Reconstruction	20 years	$1,300,000	$65,000	$43,655

*** Assume one average lane consists of a 12' travel lane and 4' shoulder; total width = 16'. So, 1 lane mile = 9,387 SY.**

Deterioration Modeling

RIDOT is in the process of developing deterioration models for our roadways using historical condition information collected by way of RIDOT's Automated Pavement Condition Data Collection Survey vendor contract. The current vendor contract started in 2016, and only data from that contract is being used to construct the deterioration models to ensure that condition information is consistent. Using that data, Pavement Management staff evaluated Pavement

Structural Health Index (PSHI) ratings for 1/10-mile segments of road on various classes of roadways. These classes include Limited Access; Urban Principal Arterial; Rural Principal Arterial; Urban Collector; Rural Collector; and, Local.

The listed classes of roadway were chosen to act as surrogates to stratify according traffic volume, pavement structure, and the presence of utility structures. Using these classes of road as surrogates allows staff to stratify the roads and customize the deterioration model for like roadways.

Pavement Engineering staff also worked with the RIDOT meteorologist to evaluate the need to stratify the state into climate zones to address potential variation in the number of freeze/thaw cycles and/or extreme temperature cycles. That exercise, which relied on extensive historical pavement temperature data from sensors embedded in pavement around the state, showed that the number of freeze/thaw cycles and extreme temperature cycles varied only minimally throughout the state. As a result, RIDOT determined that the entire state is one climatic zone, and that geographic location (i.e. coastal or inland) need not be considered as a variable in pavement deterioration.

Starting with baseline data from 2016, RIDOT forensically constructed curves by determining the age of the pavement and it's corresponding PSHI rating at a given age. For example, if a road was resurfaced in 2010, and the 2018 PSHI for the road was calculated at 86.3, the data point was plotted as (x-axis) age = 8 years; (y-axis) PSHI = 86.3.

Using this approach, RIDOT constructed a series of curves to model the real-world deterioration of these classes of roads over time. RIDOT will improve these curves over time by adding more roadway data to the deterioration model.

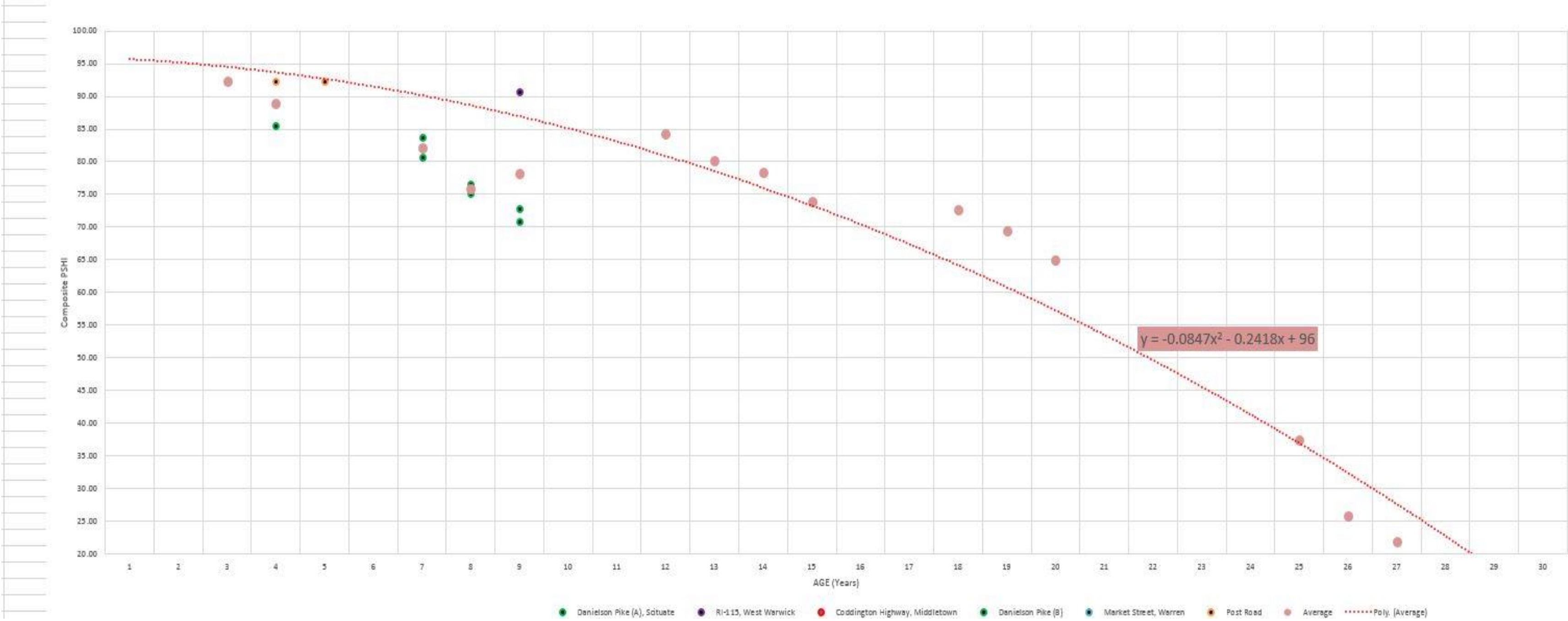
When possible, RIDOT selects roads that were resurfaced and then allowed to deteriorate without any type of preservation treatment other than pothole patching. This is intended to help model the influence of preservation treatments in the next stage of deterioration modeling development.

Unfortunately, it is difficult to find roads that have had no preservation treatments over their life, particularly in the Limited Access class, so the Limited Access deterioration model consists almost entirely of roads that have been crack sealed. An example deterioration curve for Urban Collectors is shown in Figure 30.

Figure 30 -- Example Deterioration Model

DETERIORATION CURVE - Urban Collectors

Age (Years)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Danielson Pike (A)				85.50			83.80	76.65	72.80																					
Danielson Pike (B)							80.65	75.10	70.90																					
RI-115									90.70			84.30	80.25	78.45																
Coddington															73.85			72.60	69.50	65.00										
Market Street, Warren																									37.5	25.85	22			
Post Road, Warwick			92.3	92.3	92.3																									
Sum Total			92.30	177.80	92.30		164.45	151.75	234.40			84.30	80.25	78.45	73.85			72.60	69.50	65.00					37.50	25.85	22.00			
Average			92.30	88.90			82.23	75.88	78.13			84.30	80.25	78.45	73.85			72.60	69.50	65.00					37.5	25.85	22			



Cost-Benefit Analysis

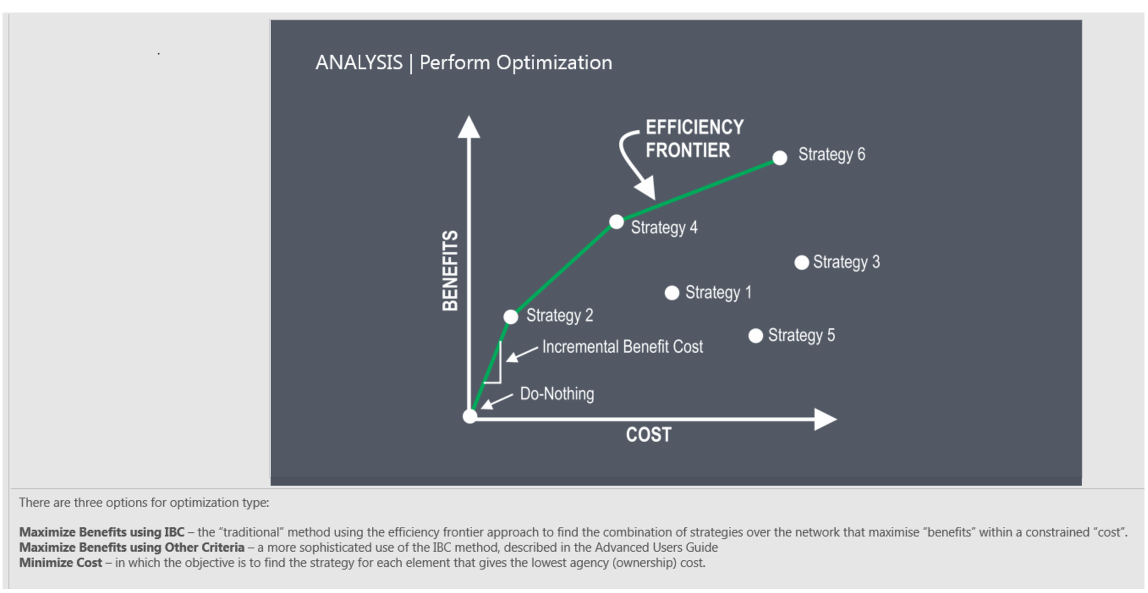
RIDOT's pavement management software (currently dTIMS) facilitates life cycle cost analysis (LCCA) for its pavements. The deterioration models described above form the basis of LCCAs. LCCAs are used to compare different strategies for building, preserving or improving pavement assets by estimating the future costs and projected pavement conditions resulting from alternative strategies. LCCA determines cost-effective rehabilitation, preservation and reclamation/reconstruction decisions by weighing the costs and benefits of these alternative strategies against one-another over time.

The aim of LCP using network-level LCCA is to identify the most cost-effective investment strategies for achieving targets. Treatments for each segment of the pavement asset network will be selected from the many that will be defined within this system. This is done using an optimization procedure in which two primary elements are considered:

- The objective, or desired outcome, and;
- The resource constraint, or available funding

Using the pavement management software, RIDOT can run multiple analyses to evaluate the impact of different funding levels by adjusting the objective or resource constraint in the analysis configuration. Strategies are selected from a roster of available treatments and will be applied when projected pavement conditions trigger a treatment that is appropriate for that level of distress. The system quantifies the benefit of the strategies it generates using projected condition and roadway class (acting as a surrogate for AADT), along with other variables such as discount rate, rate of inflation, etc. Using treatment cost data that will be updated within the system, the software generates a plot of benefit v. costs. This incremental benefit cost chart will then be used to select strategies that fall along the envelope of the highest benefit to cost ratio.

Figure 31 -- Deterioration Modeling and Cost-Benefit Analysis



Life Cycle Planning for Bridges

To plan its investments according to the life-cycle changes of its bridges, RIDOT looks at both the cost of new bridge construction and the long-term maintenance and rehabilitation costs of each new bridge.

Most bridges in the inventory are not in new condition, so it is essential that bridge inspections help to provide an accurate sense of the structure's condition to determine its current life-cycle point. As with the identification of performance gaps, the first step in the bridge life-cycle planning process is bridge inspection.

RIDOT is responsible for reviewing the condition of all NBI bridges classified as "Fair" or better on a 2-year schedule, while bridges classified "Poor" are inspected yearly, as are bridges featuring posted weight limits. Non-NBI structures or inspected on 2 to 4-year schedules, or more frequently as needed.

All inspections are done "hands-on" and at the element-level. All inspection Data is stored and used by the Bridge Management system (AASHTOWare BrM). From there, BrM is utilized to account for the changes that result in each bridges' life-cycle because of all bridge treatments. All activity—Maintenance, Rehabilitation or Replacement of bridges—has a unique cost and impact on the life of the asset.

Over the years, the Department has developed methods to assess different treatment combinations—and the timing thereof—to minimize the cost and maximize the benefits of prolonged service life of its bridges. These Network Policies have been programmed into BrM and then are run on any or any part of the bridge network, an exercise which allows the Department to anticipate life-cycle fluctuations and track important changes over time.

The NBI condition rating is generally used for reporting the bridge condition, and BrM is capable of predicting future bridge conditions, but RIDOT uses element-level deterioration for calculating the LCCA. The element conditions then can be put into their NBI component groups to give an NBI condition rating.

The figure below provides an example of element deterioration at Bridge 054851 in 2017. This approach differentiates between deck, girders, patched areas, wearing surfaces, and more.

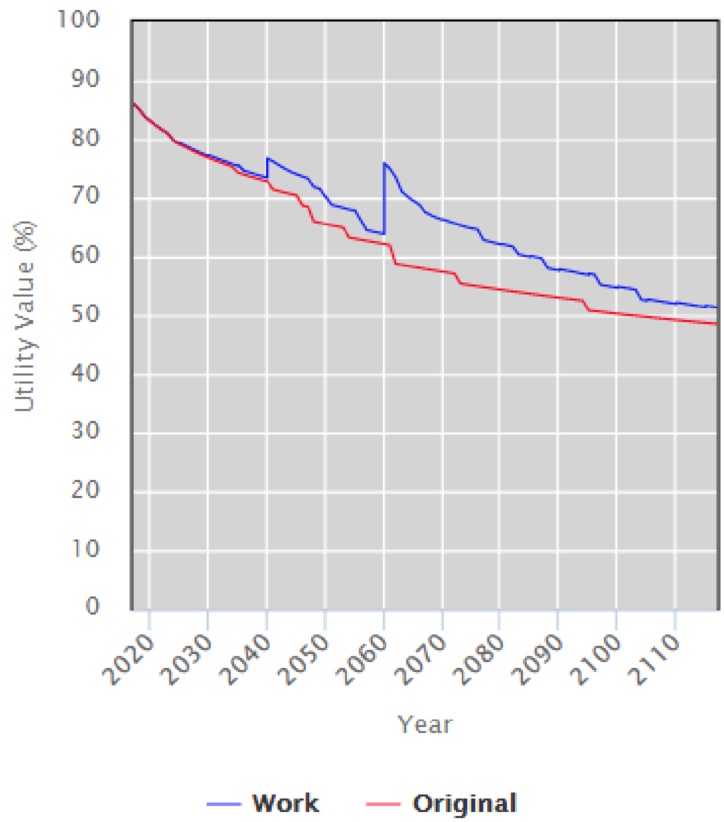
Figure 32 -- Example of Deterioration of Element at Bridge 054851 in 2017

Year: 2027

Element	Str. Unit	Env.	Quantity	Units	Starting Conditions	Effect	Ending Conditions
(12) Re Concrete Deck	1	Mod.(3)	8,343.00	sq.ft			
(510) Wearing Surfaces	1		6,180.00	sq.ft			
(1130) Cracking (RC and Other)	1		5.00	sq.ft			
(107) Steel Opn Girder/Beam	1	Mod.(3)	2,124.00	ft			
(515) Steel Protective Coating	1		15,783.00	ft			
(205) Re Conc Column	1	Mod.(3)	4.00	each			
(215) Re Conc Abutment	1	Mod.(3)	109.00	ft			
(1080) Delamination/Spall/Patched Area	1		2.00	ft			
(220) Re Conc Pile Cap/Ftg	1	Mod.(3)	129.00	ft			
(234) Re Conc Pier Cap	1	Mod.(3)	54.00	ft			
(301) Pourable Joint Seal	1	Mod.(3)	78.00	ft			
(310) Elastomeric Bearing	1	Mod.(3)	56.00	each			
(1020) Connection	1		1.00	each			
(321) Re Conc Approach Slab	1	Mod.(3)	1,226.00	sq.ft			
(510) Wearing Surfaces	1		1,226.00	sq.ft			
(8213) R/C Return Wall	1	Mod.(3)	132.00	(LF)			
(8218) Backwall, All Types	1	Mod.(3)	109.00	(LF)			
(8305) Asphaltic Joint Material	1	Mod.(3)	80.00	(LF)			
(8335) Guardrail, Vehicular	1	Mod.(3)	1.00	(LF)			
(8336) Conc Bridge Parapet	1	Mod.(3)	312.00	(LF)			
(8367) Slope Blocks	1	Mod.(3)	1,851.00	sq.ft			
(8370) Steel Diaphragms	1	Mod.(3)	130.00	(EA)			
(515) Steel Protective Coating	1		1,046.00	(EA)			
(8398) Curb/sidewalks - Con	1	Mod.(3)	312.00	ft			
(8425) Pro Screen Type1	1	Mod.(3)	312.00	ft			
(1020) Connection	1		1.00	ft			

The figure below illustrates the general life cycle of a new bridge, constructed in 2018.

Figure 33 -- Typical Lifecycle of a New Bridge



New bridges are designed to conform with AASTHO standards, which establish a 75-year lifecycle. To maintain the bridge over its lifetime, the Department uses a set of standard cyclical maintenance actions, implemented according to time or condition, which is tracked and reported by bridge inspectors and by deterioration modeling, based on component condition ratings or element-level conditions, in the AASHTOWare BrM management system.

It is not an error that the lifecycle appears to “begin” at 87 percent utility value. No new bridge is truly perfect; any cracks or deeper deficiencies must be addressed.

Bridge Life Cycle Management Strategies

The figure below provides a summary of the cyclical maintenance activities undertaken by RIDOT and the frequency with which they occur. These strategies have been programmed into AASHTOWare BrM and utilizing its deterioration modeling, Benefit-Cost Analysis, and Work candidates both inspector-created, and program-generated.

All bridges are Tier 1 assets, but investment priorities are identified through evaluation of bridge conditions**. The figure below provides the base average treatment cost estimates per square foot of bridge deck by size.**

Figure 34 -- Average Bridge Treatment Costs per Square Foot of Deck Area[6]

Management Strategy	Description	Work Type	Average Cost (<2000 sq. ft. of Deck Area)	Average Cost	Average Cost (>23000 sq. ft. of Deck Area)
Maintenance	Maintenance describes work that is performed to maintain the condition of the transportation system or respond to specific conditions or events that restore the highway system to a functional state of operations. Maintenance is a critical component of an agency's asset management plan that includes both routine and preventive maintenance.	Remove Brush, Maintain Stream Channels, Maintain Bank Protection & Walls, Clean Substructure, Seal Substructure, Lubricate Bearings, Clean Super & Deck, Repair Joints, Remove Wearing Surface, Place Wearing Surface, Place Membrane (as needed), Seal Deck, Seal Curb, Sidewalk, Fascia, Fill Cracks & Joints, Clean Drainage System, Spot Painting, Maintain Electrical & Mechanical Equip.	$4	$3	$3
Preservation	Bridge preservation is defined as actions or strategies that prevent, delay, or reduce deterioration of bridges or bridge elements; restore the function of existing keep bridges in good or fair condition; and extend their service life. Preservation actions may be cyclic or condition-driven.		$350	$250	$225
Rehabilitation	Rehabilitation involves major work required to restore the structural integrity of abridge, as well as work necessary	Re concrete Deck, Pre Concrete Deck, Pre Concrete Top Flange, Steel Deck – Open Grid, Steel Deck – Conc Fill Grid, Steel Deck –	$525	$400	$375

[6] Figure 34 breaks down cost by square foot of deck area. For cost breakdown by unit, see Figure 49.

Management Strategy	Description	Work Type	Average Cost (<2000 sq. ft. of Deck Area)	Average Cost	Average Cost (>23000 sq. ft. of Deck Area)
	to correct major safety defects	Orthotropic, Re Concrete Slab, Timber Slab, Pre Conc Appr Slab, Re Conc Approach Slab, Metal Bridge Railing, Re conc Bridge Railing, Timber Bridge Railing, Other Bridge Railing, Masonry Bridge Railing, Asphaltic Joint Material, Sliding Plate Joints, Bridge Joint Other			
Replacement	Total replacement of an existing bridge with a new facility constructed in the same general traffic corridor.	*Joints:* Strip Seal Exp. Joint, Pourable Joint Seal, Compression Joint Seal, Assembly Joint with Seal, Open Expansion Joint, Assembly Joint without Seal, Other Joint *Misc.:* Wearing Surfaces, Asphaltic Joint Material	$700	$600	$550

RhodeWorks places an emphasis on reaching a state of good repair for bridges. Goals include:

- Designing, preserving, and maintaining resilient bridges and culverts;
- Minimizing the number of load-posted, load-restricted and closed bridges; and
- Reducing the percentage of NHS bridges in Poor condition to 10 percent by the end of 2025.

RIDOT will continue to rehabilitate, preserve, and replace Poor bridges until there is less than 10 percent deck area on bridges classified in Poor condition. However, the long-term result of the RhodeWorks approach will be cost savings over time, which will free up resources to improve the condition of state roads and other assets. Because weight limit postings can impede commerce and signal structural sufficiency concerns to the public, "Poor" and posted bridges may receive additional consideration for accelerated repair. Reducing load-posted bridge, and tracking and measuring NHS bridge performance are all important steps in this process.

Chapter 5—Risk Management

The application of risk management within a transportation agency supports effective decision making for future investments and the ability to plan for possible negative impacts to the transportation network. For the purposes of this TAMP, RIDOT also considers and monitors bridge- and pavement-specific asset-level risks, which include **scour** and **lifecycle variability**.

At RIDOT, four principal risks are described and evaluated:

1. Funding Availability;
2. Environmental Changes;
3. Political Will; and
4. Price Variability.

While financial risk creates the largest exposure, for this TAMP specifically, RIDOT is also monitoring an additional risk factor: **the impact of an upcoming Major Amendment to the FFY2018-2027 Rhode Island Statewide Transportation Improvement Program (STIP) on the performance metrics, gap analyses, and financial considerations outlined in this TAMP.** The Department will be submitting a Major Amendment to the Division of Statewide Planning for processing in late Spring 2019. Thereafter, the Amendment will be subject to public comment, a process which will last approximately three months and extend beyond the June 30, 2019 deadline for final TAMP submission. At this time, RIDOT does not consider the upcoming Major Amendment to be a **principal** risk factor because the Amendment is still subject to public hearing processes which will ultimately determine its final contents. RIDOT will develop a more formal risk mitigation strategy once the final contents of the Major Amendment are known and made publicly available.

Although the content outlined throughout this TAMP corresponds to the STIP as of Amendment 16, the adoption of future amendments will likely impact the revenue and financials, performance gaps, and investment strategies outlined in the ensuing chapters. Like the STIP, RIDOT views this TAMP to be a living document subject to amendment and adjustment. Pursuant to federal requirements, RIDOT will provide the documentation required to explain how its STIP amendment complies with the asset management strategies outlined in this document. RIDOT will also update the TAMP as required to reflect the latest available information on performance gaps and investment strategies.

Another specific financial risk to this TAMP is the beginning of Rhode Island's first-ever truck-only tolling program, a unique approach to repairing bridges by tolling only specific types of tractor trailers. The tolls collected at each location in Rhode Island will go to repair the bridge or bridge group associated with that toll location. As of May 2019, two active gantries are collecting revenues, and the contractor has been issued the notice to proceed for construction of the next ten locations, which will be completed in May 2020.

While the tolling program to date has functioned as expected, the fact that it is a new program presents some risk factors, including revenues falling short due to delays or possible diversion from the routes. Thus far, there has not been noticeable diversion, as the program has tolled 1,120,190 verified vehicles. However, RIDOT continues to monitor the tolling program, as revenues have been projected to provide 10 percent of the annual $4.9 billion RhodeWorks 10-year plan.

At this time, RIDOT does not consider the tolling program to be a **principal** risk factor because the continued development of the toll program is projected to benefit the Department overall. Current revenue projections align with the anticipated uses and availability of toll revenue. In general, if revenues meet projections, there will be no impact on the Department's performance gap analyses or investment scenarios. If revenues fall short, **bridge** performance gaps may become more pronounced, and investment strategies will need to be adjusted. If revenues exceed projections, investment strategies will be revised, and bridge performance may ultimately improve depending upon the amount of additional funding available.

Federal Requirements

Under MAP-21, the FHWA defines risk as the "positive or negative effects of uncertainty or variability upon agency objectives." Risk management is defined as "the processes and framework for identifying, evaluating and managing potential risks." Under 23 CFT 515.7.c 1-6, FHWA mandates that states establish a process with which they will develop a risk management plan. This process must include:

- Identification of risks affecting NHS pavement and bridge asset conditions and performance of the NHS (addressed in "RIDOT TAMP Risk Assessment"), such as:
    - Risks associated with current and future environmental conditions;
    - Financial risks (e.g. budget uncertainty);
    - Operational risks (e.g. asset failure); and
    - Strategic risks (e.g. environmental compliance).
- Risk assessments considering likelihood of occurrence, impact, and consequence (addressed in "Transportation Risks in Rhode Island");
- Risk evaluation and prioritization (addressed in "Transportation Risks in Rhode Island");
- Mitigation plans for addressing top priority risks (addressed in "RIDOT Principal Risk Management Strategies");
- Risk monitoring approach for top priority risks (addressed in "RIDOT Principal Risk Management Strategies"); and
- Summary of the evaluations for NHS pavements and bridges and facilities repeatedly damaged by emergency events (23 CFR Part 667) (addressed in "RIDOT Principal Risk Management Strategies").

RIDOT's risk management processes outlined in this chapter are specifically designed to conform with federal regulations and inform asset management decisions at the enterprise, program, project, and asset levels.

RIDOT TAMP Risk Assessment

The TAMP risk assessment is focused on reducing potential consequences to goals outlined in the RhodeWorks legislation, which is the centerpiece of RIDOT's strategic mission. Investment strategies are subject to risk impact, as accounted for in RIDOT's TAMP risk assessment process. Risks that directly impact the availability of funding and the ability of the department to deliver funding strategies can potentially affect the viability of these investments. To monitor this affect, RIDOT's process incorporates five distinct phases:

1. Risk identification
2. Qualitative evaluation of the risk
3. Risk analysis
4. Risk response planning and implementation, and
5. Monitoring and control

This approach provides opportunities for the agency to relate potential risks across all levels of the agency, executive leadership to individual asset groups. Additionally, these activities also encourage enterprise-level discussion among different groups at the program level to determine whether any potential risks are shared by others. For bridge and pavement risks specifically, regular inspections and data tools including BrM and dTIMs help identify issues and evaluate asset-level risks. Bridge and pavement planning staff perform risk analyses based on real-time data and subject-matter expertise.

Transportation Risks in Rhode Island

Utilizing a standard risk analysis matrix like the one below, along with expert elicitation and historic records, RIDOT identified prioritized four principal risks listed below.

Figure 35 -- RIDOT Risk Matrix

RISK MATRIX							
Risk Matrix with Impact and Likelihood Definitions			Likelihood				
			Rare	Unlikely	Likely	Very Likely	Almost Certain
			Less than once every 10 years	Once in more than 3 but less than 10 years	Once between 1-3 years	Once a year	Several times a year
Impact	Catastrophic	Potential for multiple deaths & injuries, substantial public & private cost.	Medium	Medium	High	Very High	Unacceptable
	Major	Potential for multiple injuries, substantial public or private cost and/or foils agency objectives.	Low	Medium	Medium	High	Very High
	Moderate	Potential for injury, property damage, increased agency cost and/or impedes agency objectives.	Low	Medium	Medium	Medium	High
	Minor	Potential for moderate agency cost and impact to agency objectives.	Low	Low	Low	Medium	Medium
	Insignificant	Potential impact low and manageable with normal agency practices.	Low	Low	Low	Low	Medium

Chapter 5—Risk Management

RIDOT has prioritized the Department's four principal risks according to their potential consequence, as determined in accordance with the risk matrix above. The figure below provides a summary of these principal risk categories, the likelihood of their occurrence, the scale of their potential impact, and the exposure to the entire Department associated with each risk.

Figure 36 -- RIDOT Principal Risks, Impacts, and Exposure

Risk Factor	Likelihood	Impact	Exposure
1 Funding Constraints	Almost Certain	Major	**Very High**
2 Environmental	Very Likely	Major	**High**
3 Political Will	Likely	Moderate	**Medium**
4 Price Variability	Likely	Moderate	**Medium**

RIDOT Principal Risk Management Strategies

RIDOT actively monitors the four principal risks above and works to implement both short- and long-term risk mitigation strategies to address them.

Principal Risk 1 - Funding Constraint Risk Mitigation

Funding constraints are the most critical risk to RIDOT, at both the enterprise- and program-levels. Decades of underfunding and insufficient planning left the state's roads and bridges in the state of disrepair that necessitated RhodeWorks. In general, RIDOT must monitor developments impacting the major sources of funding for the Department (both federal and state). Without adequate funding, RIDOT cannot fulfill its responsibility to maintain Rhode Island's transportation infrastructure in a state of good repair. In collaboration with the state legislature, the Department made significant progress by developing, as a part of RhodeWorks, a comprehensive funding approach that included:

1. Developing a Ten-Year Plan to establish a project pipeline and maximize the utility of available funding;
2. Providing data-and testimony to the General Assembly that led to the establishment of the Rhode Island Highway Maintenance Account (RIHMA);
3. Refinancing debt, freeing up about $129 million over a three-year period;
4. Erecting all-electronic truck-only tolling gantries; and
5. Proposing cooperative, public-private partnership project delivery models.

Even with these improvements in place, RIDOT must continue to manage risks that may impact both federal and state funding sources.

Federal Funding Risks
Like all states, Rhode Island is dependent upon federal funds to support the state's highways and bridges. RIDOT continues to monitor reports concerning the fluctuation of federal funding and work closely with regional and national partners to lobby for positive long-term solutions to potential funding shortfalls. In addition, RIDOT works to maximize its share of federal funding by:

1. Maintaining a pipeline of under-funded, grant-eligible projects to ease the application process for discretionary funding when a Notice of Funding Opportunity (NOFO) is issued;

2. Preparing executable projects to maximize the utility of August Redistribution funds; and

3. Closing out projects to free up federal funds when projects are completed under budget.

State Funding Risks
To obtain federal funds for transportation, states must make some of their own funds available as a match. For most federally supported projects, at least 20 percent of the total cost must be covered by state funds to secure the remaining 80 percent from federal sources. Now, the state legislature appropriates funding for transportation on an annual basis. RIDOT must continue to work closely with the state legislature to secure state match funding for capital projects and agency operations.

Principal Risk 2 - Environmental Risk Mitigation
In Rhode Island, the Ocean State, there are numerous environmental and natural threats to RIDOT's assets. With 400 miles of coastline and large inland watersheds, the state's infrastructure (roads, bridges, buildings, culverts, etc.), employees, and systems are all vulnerable. From a transportation perspective, coastal hazards like riverine flooding, sea level rise and storm surge pose serious threats to the efficient management of key assets' life cycles.

In the past five years, numerous studies and resources have been developed in Rhode Island to assist environmental resiliency efforts. Two are crucial to RIDOT's environmental risk mitigation:

1. The study, "Vulnerability of Statewide Transportation Assets to Sea Level Rise;" and

2. The development of STORMTOOLS.

STORMTOOLS is an ongoing project developed through the RI Coastal Resources Management Council (CRMC) and its partners, including the University of Rhode Island. The models and maps developed as a part of STORMTOOLS have been adopted by the State for short- and long-term planning, illustrating what coastal flooding could look like in the future under different sea level rise and storm scenarios. These maps allow Rhode Island's residents, municipal officials and decision-makers to better understand the risks of coastal inundation for the Ocean State, which will pose serious challenges in terms of transportation asset management, particularly because of the expected lifespan of roads and bridges constructed today.

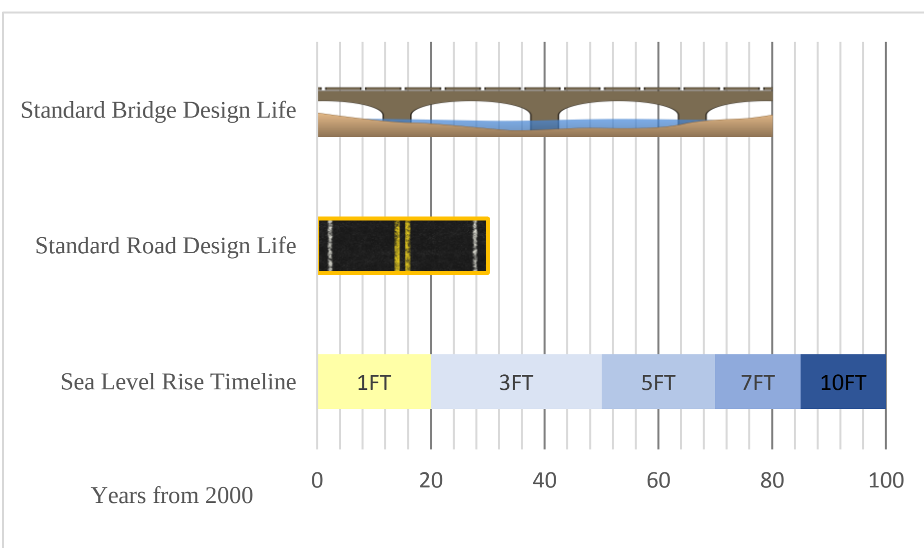
The figures below illustrate the extent of this challenge, which will worsen over time. For coastal roads and bridges, even a foot of sea level rise could result in flooding or structural problems. The impact of sea level rise on Rhode Island's roadway and bridge drainage systems is even more pressing given the nature of how the state's drainage systems were designed and where the outfalls are located. By 2050, a point at which the new bridges of today will be about halfway through their lifecycles, sea levels may have risen 3 feet or more. The development of an environmental resiliency tool will allow RIDOT to plan and design for this risk.

In addition, Rhode Island has done the reporting required by a related rule (23 CFR Part 667) to conduct a statewide evaluation of existing roads, highways and bridges eligible for federal-aid funding that have needed repair and/or reconstruction on two or more occasions because of emergency events. Evaluations started with 1997 data, and there have been no repeat emergency events. RIDOT continues to monitor its most vulnerable assets.

Figure 37 -- Sea Level Rise Scenarios, Newport, RI

Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.03	0.16	0.20	0.30	0.39	0.46	0.49
2020	0.06	0.33	0.39	0.59	0.75	0.95	0.92
2030	0.10	0.49	0.59	0.89	1.21	1.48	1.57
2040	0.13	0.66	0.79	1.25	1.71	2.20	2.43
2050	0.16	0.82	1.02	1.64	2.26	3.02	3.41
2060	0.19	0.98	1.21	2.07	2.92	4.00	4.63
2070	0.23	1.15	1.41	2.56	3.64	5.02	6.00
2080	0.26	1.25	1.57	3.08	4.49	6.14	7.48
2090	0.29	1.38	1.74	3.64	5.38	7.55	9.28
2100	0.32	1.44	1.90	4.17	6.36	8.99	11.15

Figure 38 -- Asset Design Lifecycles vs. Sea Level Rise



Principal Risk 3 - Political Will Risk Mitigation

RIDOT's political risk management strategy is centered on education and communication. Education can take the form of documents like this TAMP. By outlining what happens when a political request -- such as swapping out a pavement project for a much-needed bridge replacement – the Department can deter requests or legislative changes that may potentially compromise asset management. Communication works best through the Office of Legislative Affairs, the Department maintains regular contact with state legislators, the Office of the Governor, and local stakeholders to update them on transportation projects, articulate additional funding needs, and communicate policy priorities. Data-driven analysis of transportation infrastructure needs are the best tools to mitigate this potential risk.

Principal Risk 4 - Price Variability Risk Mitigation

RIDOT must monitor the cost fluctuation of construction inputs and maintenance materials. Three inputs are particularly important: [1] steel, [2] asphalt, and [3] diesel fuel. Through the Department's Project Management Portal (PMP), weighted-average unit prices (WAUP) of key project inputs are tracked over time. The Department will coordinate the use of WAUP data to update and improve project scoping tools and estimates to anticipate financial difficulties brought on by price variability.

In addition, the sheer volume of active construction projects – more than $715 million in 2019 alone – means procurement pricing is not optimal.

While these 77 currently active projects – more than any other in the state's history --include a combination of bridge repair, replacement, and preservation activities on 177 bridges, Rhode Island's limited geography raises the possibility of maxing out available contractors for the needed work, making those contracts expensive

The pool of available contractors in Rhode Island has historically been relatively small, ranging from 3-5 bidders for most projects. In addition, non-Rhode Island based contractors have had a difficult time breaking into and establishing themselves in the Rhode Island market. During the recession, RIDOT witnessed increased competition with not only more than 5 contractors bidding on projects, but also a higher number of outside contractors, primarily Massachusetts-based ones bidding on Rhode Island projects.

Similarly, to what was happening in Rhode Island with RhodeWorks, Massachusetts also went out earlier with its own initiative to bring their bridges into a state of good repair. That has essentially reduced the pool of available contractors that are interested in working in Rhode Island apart from the ones that are looking for mega projects.

Combining projects to achieve economies of scale and lower administrative costs for RIDOT also has a side effect in that less contractors are now able to bid and perform that work.

The combination of these factors described above typically results in less competition, witnessed in most cases through higher prices and a reduction in the number of bidders for each project.

To mitigate these risks, RIDOT is considering alternate project staging strategies and bundling for future STIPS.

Asset-Level Risk Management Strategies

BRIDGE: Scour Mitigation

To mitigate the bridge asset-level risk of scour, RIDOT develop its Bridge Scour Management System (BSMS). The BSMS is a real-time monitor of steam and river water flows and levels at all RIDOT Scour-Critical bridges. It also contains the Plans of Action (POA) for each bridge and reporting tools. All bridge scoping processes evaluate existing scour mitigation POAs to account for the impact of a bridge's scour-critical status on the treatment proscribed to that bridge. RIDOT is monitoring these bridges for safety purposes and will adjust STIP project scopes and schedules involving scour-critical bridges as needed, but the Department's ability to include the needs of scour-critical bridges in performance gap evaluations is currently limited. The system is set with an email notification system that alerts inspection teams at the time of any events.[7]

This is part of the bridge asset check required in rule (23 CFR Part 667) to conduct a statewide evaluation of bridges eligible for federal-aid funding that have needed repair and/or reconstruction on two or more occasions due to emergency events. The evaluation determines whether reasonable alternatives to any of the bridges exist and consider the risk of recurring damage and cost of future repairs given current and future environmental conditions. In addition, the State has performed an environmental consideration check for sea-level rise, noted by bridge in the STIP.

PAVEMENT: Lifecycle Variability

Pavement segment lifecycles are not perfectly predictable; even the most advance models cannot anticipate the development of premature surface deterioration or extreme weather events that result in destabilized pavement assets. To mitigate the impact of this issue, RIDOT deploys the pavement preservation strategy outlined in Chapter 4. In addition, the Department carefully tracks calls from constituents that note unsafe or unstable roadways, working to rectify critical problems as quickly as possible.

TAMP Risk Management Next Steps

Effective, efficient asset management requires detailed, accessible data. To monitor risks, track asset lifecycles, and program project updates in real time, RIDOT is in the process of implementing a comprehensive data management solution incorporating geospatial registration, cross-asset analysis, and regular maintenance updates. The Department already relies on several data management systems, but they are disjointed, and cross-platform communication is limited.

To improve efficiency, organization, and data management, RIDOT is in the process of implementing a set of coordinated new technology platforms intended to improve storage and utilization of asset data and provide RIDOT staff with better tools to manage process flow. For

[7] A link to the Bridge Inspection Manual can be found here.

example, RIDOT is expanding its use of the Falcon Document Management System to archive and track project documents. The document management system is being updated in 2019, and RIDOT will continue to invest in other data-management systems throughout the following decade, as it works to develop a 10-year data plan.

The Department will be linking Falcon and other systems to a GIS database through an E-Construction Pilot using tools based on Headlight computer software and Bluebeam Revu Extreme. At a cost of $140,000, the E-Construction Pilot gauged the Department's success in integrating on-site, digital data management technology with internal databases, including the Project Management Portal (PMP) and VueWorks.

Chapter 6—Revenues and Financial Plan

Every year, RIDOT updates the STIP to reflect changes in funding availability. Due to changes in local and national political priorities, revenue projections, or other factors that may influence available revenue, the Department may need to develop strategies to replace revenue or make choices to align project schedules with the cash flow available.

As the Department has moved toward a ten-year STIP with annual updates and frequent adjustments, the process for weighing asset needs against available funds continues to be refined and developed. **As noted in the previous chapter, RIDOT is in the process of implementing a major amendment to the 2018-2027 STIP. This amendment will impact the data reported in this TAMP, particularly in this chapter and Chapter 8. The data included in this TAMP is accurate as of STIP Amendment 16, made available publicly on April 30, 2019.**

Federal and State Requirements

Federal

Under MAP-21, a TAMP document is mandated to contain a financial plan. In 23 CFR 515.5, the Federal Highway Administration defined a TAMP financial plan as "a long-term plan spanning 10 years or longer, presenting a state DOT's estimates of projected available financial resources and predicted expenditures in major asset categories. Key components of this financial plan include:

- Sources and amounts of revenue available to the agency for investing towards achieving asset management condition targets and managing risks;
- Full range of funding needs to support achieving agency goals, objectives, and targets;
- Description of the agency's investment strategy to achieve State of Good Repair during the TAMP timeline;
- Estimated annual cost of implementing the agency's investment strategy during the TAMP timeline; and
- Estimate of the value of the agency's NHS pavement and bridge assets and the annual cost to maintain the value of these assets.

State

RhodeWorks, enacted February 12, 2016, developed sustainable transportation infrastructure funding in Rhode Island. The central components of the RhodeWorks program included refinancing the state's existing Grant Anticipation Revenue Vehicle (GARVEE) bonds, reducing payments in the first three years of the program to interest only and making an additional $129 million in federal funding available to advance bridge projects; issuance of up to $300 million in new GARVEE bonds to fund the Route 6/10 Interchange project; and the all-electronic, truck-only tolling that is expected to generate a net of approximately $40 million annually for preventive maintenance, rehabilitation, and reconstruction of bridges. RhodeWorks also mandated that

RIDOT develop a 10-Year STIP, which serves as a living financial planning document involving major RIDOT projects.

Financial Plan Revenue Sources

Rhode Island's STIP is supported by a variety of funding source, but the majority of RIDOT's funding comes from federal formula funds, GARVEE bonds repaid by federal formula funds, and

Figure 39 -- RIDOT STIP Funding Sources FFY2018-2021 ($ Millions)

Highway - State	FY 2018	FY 2019	FY 2020	FY 2021	4-Yr Totals
GasTax	$85.56	$91.44	$90.08	$90.20	$357.28
RICAPfunds	$30.60	$30.60	$30.60	$30.60	$122.40
RIHMA	$78.10	$85.35	$87.50	$87.70	$338.65
RICAPfacilities	$4.80	$4.20	$4.30	$4.30	$17.60
ProjectCloseouts	$8.00	$5.00	$5.00	$5.00	$23.00
LandSales	$4.03	$2.87	$1.00	$1.00	$8.90
GARVEE	$85.00	$77.00	$45.00	-	$207.00
TransitBond	$5.00	$20.00	$7.00	$3.00	$35.00
RICAPpavement	-	$20.00	$20.00	$20.00	$60.00
Third Party Funding	$1.00	$3.50	$1.00	$1.00	$6.50
TollRevenue	$19.00	$44.80	$44.80	$44.80	$153.40
Prior Year Funds	$4.00	$3.00	-	-	$7.00
Total RIDOT State Sources	**$325.09**	**$387.76**	**$336.28**	**$287.60**	**$1,336.73**
Highway- Federal	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**4-Yr Totals**
NEW TIGER	-	$1.48	$9.68	$8.84	$20.00
RailwayProgram	$1.20	$1.20	$1.20	$1.20	$4.80
HSIP	$18.00	$18.20	$18.50	$18.50	$73.20
TAP	$3.30	$3.30	$3.30	$3.30	$13.20
NHPP	$128.60	$131.40	$134.40	$134.40	$528.80
CMAQ	$10.80	$10.90	$11.10	$11.10	$43.90
Inflation	-	-	-	$6.00	$6.00
Planning	$6.30	$6.30	$6.40	$6.40	$25.40
STBG	$61.10	$62.20	$63.70	$63.70	$250.70
NationalFreight	$6.60	$7.50	$8.30	$8.30	$30.70
OLD TIGER Grant	-	$13.10	-	-	$13.10
OtherFederal	$25.64	$25.64	$25.64	$25.64	$102.56
Federal Budgetary Holdback	($6.40)	($6.50)	($6.60)	($6.60)	($26.10)
Total Federal Highway Funding Sources	**$255.14**	**$274.72**	**$275.62**	**$280.78**	**$1,086.26**
Non Highway Revenue	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**4-Yr Totals**
NHTSA	$3.00	$3.00	$3.00	$3.00	$12.00
GEB	$6.50	$2.70	-	-	$9.20
FTA	$0.92	$13.14	$5.39	$5.15	$24.60
FerryBoatCap		$0.50	$0.50	$0.50	$1.50
FTA5307		$0.40	$0.40	$0.40	$1.20
Total Non-Highway Funding Sources	**$10.42**	**$19.74**	**$9.29**	**$9.05**	**$48.50**
Total RIDOT Funding Sources	**$590.65**	**$682.22**	**$621.19**	**$577.43**	**$2,471.49**

state revenue. The current STIP only shows funding sources in the constrained period, which ends in FFY2021. The following sections summarize the primary state and federal funding sources identified in the figure above. A more detailed discussion of RIDOT's revenue sources can be found in the FFY2018-2027 STIP.

Primary State Funding Sources

1. **Gas Tax:** Rhode Island's gas tax was $0.34 per gallon in FY2019, with an additional penny assessed to fund the Underground Storage Tank (UST) fund, for a total of $0.35 cents. This amount is scheduled to increase in even calendar years based on indexing for inflation. The distribution of the gas tax is set by statute and cannot be diverted to the General Fund, or for other purposes. Projections of gas tax revenue are revised semi-annually at the Revenue Estimating Conference.
2. **RICAP Funds:** The Rhode Island Capital Plan (RICAP) fund is an account that receives any revenues more than the 95% of state revenue upon which the Governor is required to build the annual budget. RICAP funds are restricted to capital projects only and are constitutionally prohibited from use for debt service payments.
3. **RI Highway Maintenance Account:** Initially created in 2011 as an account to hold the funds from dedicated registration and license fee increases, along with the RICAP funds intended to replace the annual $40 million in state match borrowing, the RIHMA has been amended by statute several times and now is the repository for all transportation-related funds formerly allocated to the General Fund and now directed to "programs that are designed to eliminate structural deficiencies of the state's bridge, road, and maintenance systems and infrastructure" (RIGL § 39-18.1-5(b).
4. **Toll Revenue:** A central component of RhodeWorks, all-electronic, truck-only tolling is anticipated to provide approximately $44 million annually once all gantry locations are in place and active. Tolling at the first two locations is began in 2018. Revenues are being revised and will be adjusted accordingly as the STIP is amended.

Primary Federal Funding Sources

1. **National Highway Performance Program (NHPP)** - The National Highway Performance Program (NHPP) is a broad category of funding which allows expenditures on a wide range of programs and projects. The State Planning and Research (SPR) programs receives a 2% set-aside from this category, which is detailed under Planning funding. Expenditures must support progress toward achievement of national performance goals for improving infrastructure condition, safety, mobility, or freight movement on the NHS.
2. **Surface Transportation Block Grant (STBG) -** The Surface Transportation Block Grant (STBG) program has the most flexible eligibilities among all federal aid highway programs. Eligible activities include most items eligible under NHPP.
3. **Highway Safety Improvement Program (HSIP) -** Projects funded under the Highway Safety Improvement Program (HSIP) strive to achieve a reduction in traffic fatalities and serious injuries on public roads. The HSIP requires a data-driven, strategic approach to improving highway safety on all public roads that focuses on performance.
4. **Congestion Mitigation Air Quality (CMAQ) -** The CMAQ program provides a flexible funding source to state and local governments for transportation projects and programs that help

meet the requirements of the Clean Air Act. Funding is available to reduce congestion and improve air quality for areas that do not meet the National Ambient Air Quality Standards (NAAQS) for ozone, carbon monoxide, or particulate matter (non-attainment areas) and for former non-attainment areas that are now in compliance (maintenance areas). On March 1, 2019, the Environmental Protection Agency's Region I supported USDOT's positive conformity determination for the Providence (all of Rhode Island) RI non-attainment area under the 1997 8-hour ozone National Ambient Air Quality Standard (NAAQS).

5. **Discretionary Grants** – These discretionary (nonformula) federal funds are awarded though a competitive grant process. Under MAP-21 and the FAST Act, there have been annual competitive processes for the award of these funds. In recent years, RIDOT has received $13.1M from the TIGER program to fund the Pawtucket/Central Falls Transit Center, $20M from the TIGER program to support the Route 37 Corridor Safety Sweep, and $20M from the BUILD program to support the reconstruction of the Pell Bridge Ramp approaches.
6. **Other Federal Non-Formula Distribution/ Redistribution** - This category includes non-formula funding received by RIDOT including old earmark funds, August Redistribution funds, and federal funds secured from closing out old projects.

GARVEE Sources

In 2016, RIDOT secured $300M in Grant Anticipation Revenue Vehicle (GARVEE) bonds to finance a surge of capital projects. $207M are currently shown in the FFY2018-2027 STIP under state funding sources. In future iterations of the STIP, RIDOT will shift the GARVEE funding to the federal funding sources side of the table because the GARVEE bonds are being repaid with federal formula funds.

As of May 2019, RIDOT is currently in the process of securing an additional $200M in GARVEE bonds to support additional capital projects in need of funds, most notably including the Providence Northbound Viaduct Project. If the Department secures that additional $200M, RIDOT will amend the STIP accordingly to include the new source of funding and its usage within the STIP's capital programs. Like the 2016 issuance, the new GARVEE bonds will be repaid with federal formula funds.

Financial Plan Revenue Expenditures

While available funding is one central component of RIDOT's financial plan, the constrained uses, or how available funds are allocated across asset pipelines, provides a snapshot of how RIDOT spends available funding.

The figure below shows all expenditures, as projected for the ten years of the STIP. The focus of the discussion in this section will be on the expenditures for capital purposes, but it is important to note that all funds expended by RIDOT are driven by the goals and objectives of the TAMP.

Figure 40 -- RIDOT Program Allocation Summary from the 2018-2027 STIP ($ Millions)

TIP PROGRAM ALLOCATION SUMMARY

Updated - April 30, 2019

RIDOT TIP PROGRAMS	FY 2018	FY 2019	FY 2020	FY 2021	SUBTOTAL	% OF TOTAL	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	TOTAL	% OF TOTAL
6/10 PROJECT	$77.00	$70.00	$92.20	$60.36	$299.56	10.75%	$38.34	$28.74	$23.36	$0.00	$0.00	$0.00	$390.00	5.86%
BRIDGE CAPITAL PROGRAM	$195.75	$212.74	$174.87	$149.85	$733.21	26.30%	$182.98	$171.98	$143.01	$130.05	$128.86	$130.58	$1,620.67	24.36%
BRIDGE MAINTENANCE	$15.23	$17.30	$16.38	$17.40	$66.31	2.38%	$17.40	$17.40	$17.40	$16.42	$16.40	$16.40	$167.73	2.52%
CONTINGENCY - INFLATION	$0.00	$0.00	$0.41	$0.50	$0.91	0.03%	$0.70	$4.30	$0.50	$0.50	$9.00	$9.40	$25.31	0.38%
DEBT SERVICE	$69.82	$102.72	$99.19	$106.32	$378.04	13.56%	$102.24	$101.64	$96.41	$77.40	$76.85	$67.57	$900.16	13.53%
DRAINAGE CAPITAL PROGRAM	$1.75	$1.20	$2.70	$5.15	$10.80	0.39%	$9.65	$10.65	$10.15	$7.95	$11.00	$12.00	$72.20	1.09%
DRAINAGE MAINTENANCE	$7.20	$5.40	$6.90	$5.90	$25.40	0.91%	$7.15	$5.15	$5.95	$4.95	$6.00	$6.00	$60.60	0.91%
HEADQUARTERS OPERATIONS	$15.97	$17.64	$16.67	$15.73	$66.01	2.37%	$17.20	$18.00	$17.90	$17.40	$18.00	$19.00	$173.51	2.61%
MAINTENANCE CAPITAL PROGRAM	$5.46	$6.12	$4.25	$4.25	$20.08	0.72%	$14.70	$10.20	$10.20	$9.10	$10.00	$10.00	$84.28	1.27%
MAINTENANCE OPERATIONS	$40.43	$44.10	$45.79	$42.38	$172.70	6.20%	$46.67	$49.31	$58.11	$61.61	$62.60	$62.60	$513.59	7.72%
PASS THRU	$8.08	$8.09	$8.10	$8.05	$32.32	1.16%	$8.70	$8.67	$8.76	$8.76	$8.76	$8.76	$84.73	1.27%
PAVEMENT CAPITAL PROGRAM	$46.68	$60.44	$67.72	$61.16	$235.99	8.47%	$74.10	$78.78	$92.24	$130.95	$125.71	$126.00	$863.77	12.98%
PAVEMENT MAINTENANCE	$7.14	$7.16	$7.18	$7.20	$28.68	1.03%	$7.22	$7.24	$7.26	$7.28	$7.90	$8.30	$73.88	1.11%
PLANNING - PROGRAM DEVELOPMENT	$17.30	$15.83	$17.30	$17.20	$67.64	2.43%	$17.30	$17.20	$17.20	$17.20	$17.20	$17.20	$170.94	2.57%
TOLL OPERATIONS	$1.90	$2.20	$2.20	$2.20	$8.50	0.30%	$2.20	$2.20	$2.20	$2.20	$2.20	$2.20	$21.70	0.33%
TRAFFIC MAINTENANCE	$7.69	$7.30	$7.25	$6.30	$28.54	1.02%	$6.25	$6.40	$6.25	$6.15	$6.20	$6.20	$65.99	0.99%
TRAFFIC SAFETY CAPITAL PROGRAM	$27.56	$20.24	$22.28	$29.07	$99.15	3.56%	$29.61	$24.44	$41.22	$23.41	$27.02	$30.02	$274.88	4.13%
TRANSIT CAPITAL PROGRAM - RIDOT	$5.90	$54.14	$15.63	$13.02	$88.68	3.18%	$9.65	$14.53	$14.53	$15.13	$16.73	$20.73	$179.95	2.71%
TRANSIT OPERATIONS - RIDOT	$8.23	$7.24	$7.28	$7.31	$30.06	1.08%	$8.58	$8.71	$8.83	$8.96	$9.40	$9.90	$84.44	1.27%
TRANSPORTATION ALTERNATIVES	$18.92	$18.89	$5.95	$16.50	$60.26	2.16%	$16.50	$16.75	$14.90	$19.90	$14.29	$15.00	$157.59	2.37%
SUBTOTAL RIDOT	$578.01	$678.75	$620.22	$575.84	$2,452.82	88.0%	$617.14	$602.28	$596.38	$565.32	$574.12	$577.86	$5,985.92	90.0%

At this time, RIDOT does not differentiate between operating and capital expenditures in the STIP. Future iterations of the STIP may delineate between expenditure types in multiple new ways, including distinctions between design versus construction expenditures, capital versus operating expenditures, and current- versus prior-year expenditures.

10-Year Needs, Planned Bridge and Pavement Spending vs. Needs

As Chapter 8 will detail, RIDOT's expenditures in the current STIP are guided by RhodeWorks, which prioritizes reducing the state's Poor bridge deck area to no more than 10 percent by 2025. However, bridge and pavement conditions change every day, often in unforeseen ways. To assist in the asset management process, bridge and pavement planning personnel estimate the total funding needed over ten years to meet the Department's ideal performance targets.

The ten-year need shown below is therefore the amount of funding necessary to achieve and sustain a state of good repair for Rhode Island's bridge and pavement networks under ideal circumstances in which funding is unconstrained. The planned spending reflected in the figures below is taken from the most recent iteration of the FFY2018-2027 STIP, last updated April 30, 2019.[8] The estimated needs shown in the figures below represent the level of investment required to ensure that less than 10 percent of all bridges in RI are in poor condition by 2025, and no more than 20 percent of all non-interstate NHS pavements, and no more than 4 percent of Interstate NHS pavements are in poor condition by 2022.[9]

Figure 41 -- RIDOT's Planned Pavement Expenditures ($ Millions)[10]

Federal Fiscal Year (FFY)	2018	2019	2020	2021	2022-27	Total
Pavement Maintenance and Preservation Spending	$7.14	$7.16	$7.18	$7.20	$45.20	**$73.88**
Pavement Rehabilitation and Reconstruction Spending	$46.68	$60.44	$67.72	$61.16	$627.77	**$863.77**
Total Planned Pavement Spending	**$53.82**	**$67.60**	**$74.90**	**$68.36**	**$672.97**	**$937.65**

[8] The expenditures shown in this section align with the 2018-2027 STIP inclusive of Amendment 16. As previously stated in Chapter 5, there will be an Amendment 17 to follow at some point in the near future, which may meaningfully alter the expenditure levels shown here. Pursuant to federal requirements, RIDOT will update both the STIP and TAMP accordingly

[9] While the TAMP and STIP both examine the ten-year period between FFY2018 and FFY2027, RhodeWorks' goals are tied to 2025, so for the purposes of this need assessment, the 2025 target end date is used for both bridge and pavement assets.

[10] The expenditures in the pavement tables below include both NHS and non-NHS pavement investments. RIDOT's pavement programs in the STIP include a variety of roads and projects, all of which contribute to the ongoing state-of-good repair goals outlined in previous chapters. For this reason, RIDOT is currently unable to distinguish between NHS and non-NHS investment levels

Figure 42 -- RIDOT's Estimated Pavement Needs ($ Millions)

Federal Fiscal Year (FFY)	2018	2019	2020	2021	2022-27	Total
Pavement Maintenance and Preservation Need	$10.00	$10.50	$10.50	$11.00	$60.00	**$102.00**
Pavement Rehabilitation and Reconstruction Need	$81.68	$95.44	$102.72	$96.16	$837.77	**$1,213.77**
Total Planned Pavement Need	**$91.68**	**$105.94**	**$113.22**	**$107.16**	**$897.77**	**$1,315.77**
Pavement Investment Gap	**($37.86)**	**($38.14)**	**($38.62)**	**($38.80)**	**($224.80)**	**($378.22)**

Figure 43 -- RIDOT's Planned Bridge Expenditures[11] ($ Millions)

Federal Fiscal Year (FFY)	2018	2019	2020	2021	2022-27	Total
Total Bridge Capital Program Spending	$195.76	$206.79	$174.87	$149.85	$887.46	**$1,620.67**
Preservation	*$64.13*	*$77.10*	*$71.69*	*$48.58*	*$354.89*	*$616.39*
Rehabilitation	*$109.48*	*$111.71*	*$77.21*	*$74.83*	*$331.36*	*$704.59*
Replacement	*$13.45*	*$9.65*	*$15.89*	*$17.53*	*$101.55*	*$158.07*
Other/Immediate Needs	*$8.70*	*$8.33*	*$10.08*	*$8.91*	*$99.66*	*$135.68*
Bridge Maintenance Program Spending	$15.23	$17.30	$16.38	$17.40	$101.42	**$167.73**
6/10 Project Spending	$77.00	$70.00	$92.20	$60.36	$90.44	**$390.00**
Total Planned Spending	**$287.99**	**$294.09**	**$283.45**	**$227.61**	**$1,079.32**	**$2,172.46**

[11] At this time, RIDOT is unable to differentiate between NHS expenditures and non-NHS expenditures because the Department groups NHS and non-NHS bridges togethers in "bridge groups" to achieve economies of scale in design and construction. For this reason, the planned expenditure of RIDOT revenue includes NHS and non-NHS bridges combined. RIDOT has also included the cost of the 6/10 Project, a major highway interchange reconstruction which includes predominately bridge work.

Figure 44 – RIDOT's Estimated Bridge Needs ($ Millions)

Federal Fiscal Year (FFY)	2018	2019	2020	2021	2022-27	Total
Total Bridge Capital Program Need	$195.75	$233.34	$226.44	$221.35	$1,150.00	**$2,026.88**
Preservation	*$64.13*	*$87.00*	*$92.83*	*$71.76*	*$459.88*	*$775.60*
Rehabilitation	*$109.48*	*$126.05*	*$99.98*	*$110.53*	*$429.39*	*$875.43*
Replacement	*$13.45*	*$10.89*	*$20.58*	*$25.89*	*$131.59*	*$202.40*
Other/Immediate Needs	$8.70	$9.40	$13.05	$13.16	$129.14	**$173.46**
Bridge Maintenance Need	$15.23	$19.52	$21.21	$25.70	$131.42	$213.09
6/10 Project Need	$77.00	$70.00	$92.20	$60.36	$90.44	$390.00
Total Need	**$287.99**	**$322.86**	**$339.85**	**$307.41**	**$1,371.86**	**$2,629.97**
Bridge Investment Gap	**$0.00**	**($28.77)**	**($56.40)**	**($79.80)**	**($292.54)**	**($457.51)**

Asset Replacement and Treatment Values

This section identifies the total value of RIDOT's bridge and pavement assets, as well as RIDOT's estimated treatment costs for pavement and bridge projects by element. The Department's bridge and pavement planners employ the charts below in planning and pre-scoping projects to develop cost estimates which are then incorporated into the STIP.

Pavement Asset Values

Using data from the 2018 pavement condition survey, RIDOT has estimated the total replacement value and remaining value of all NHS pavement assets shown in the figure below. The calculations assume an average replacement cost of $140/sq. yd, and that pavement segments in Excellent condition have, on average, 95 percent replacement value.

Figure 45 -- Estimated NHS Pavement Asset Value

Total Replacement Value	Current Remaining Value	Percent Value Remaining
$2,731,122,240	**$2,301,067,358**	**84.3%**

Pavement Treatment Values

The estimated pavement treatment values reported in the figure below are derived from historical data on pavement maintenance, rehabilitation, and replacement. The treatment values shown do not consider the impact of pavement condition, deterioration, or project-level needs, but the estimated average values shown below can be used to estimate the cost of pavement maintenance, preservation, rehabilitation, reclamation, and reconstruction at the project-level.

Figure 46 -- Estimated Average Pavement Treatment Cost Values

Treatment	Cost	Unit	Life Expectancy
Crack Seal	$0.32	Linear Foot	~3-5 Years
Chip Seal	$6.89	Square Yard	~10 Years
PPEST	$9.99	Square Yard	~6-9 Years
SAMI (Chip Seal & Overlay)	$14.65	Square Yard	15 Years
Level & Overlay	$18.00	Square Yard	15 Years
Mill & Overlay	$44.19	Square Yard	15 Years
Mill & Overlay (w/ Sidewalks)	$56.22	Square Yard	15 Years
Mill & Overlay (Limited Access)	$19.77	Square Yard	15 Years
Reclamation	$46.98	Square Yard	20-25 Years
Reconstruction (w/ Sidewalks)	$139.52	Square Yard	20-25 Years
Sidewalks Only (No Pavement)	$101.65	Linear Foot	30+ Years

Bridge Asset Values

To establish a total bridge asset value, RIDOT calculates replacement costs (square foot of deck area multiplied by average historical cost for bridge replacement). Then, that number is multiplied by a percentage of the expected remaining useful life of the bridge. This method establishes an overall value for the bridge network. The figure below reports the estimated replacement cost and remaining value of bridge assets by type (all state-owned, NBI, and NHS).

Figure 47 -- Estimated Bridge Asset Value

Bridge Type	Total Replacement Value	Current Remaining Value
All State-Owned	$4,200,000,000	$1,477,000,000
National Bridge Inventory (NBI)	$3,990,000,000	$1,482,000,000
National Highway System (NHS)	$3,254,000,000	$1,256,000,000

Bridge Treatment Values

The estimated bridge treatment values in the figure below are housed within BrM and used to calculate estimated construction costs for RIDOT's bridges. The software allows the user to select which treatment elements are relevant to a given bridge, and the inputs below are then used to calculate the cost of a given treatment. User inputs allow for customization of construction cost estimates to identify the most likely estimate based on the scope of work required and/or assigned to a particular bridge or group of bridges.

To develop cost estimates at the project-level, RIDOT applies this procedure to all the bridges in a given group. Bridge project cost estimates may then be determined by applying cost inflation factors to the combined construction value of the bridges using the Department's "Green Sheet Tool," which relies on historical project cost data to assign dollar values to various project elements based on the size of the project. This method allows RIDOT to reestablish project cost estimates when individual bridges are added to or removed from bridge groups. Distinctions among bridges in type, need, condition, and treatment complicate macro-level cost estimates by increasing the number of variables that the model must consider. For this reason, individual bridge construction cost estimates are used to derive project cost estimates. That process allows for the consideration of unique structural elements in each bridge, which then move along with it as project groupings or implementation schedules shift throughout the STIP.

The figure below provides a sample of element-level treatment cost values for bridges.

Figure 48 -- Estimated Average Bridge Treatment Cost Values[12]

Element Name	Treatment	Cost Per Unit	Unit
Re Concrete Deck	Condition Improved	$ 25	Square Foot
Pre Concrete Deck	Condition Improved	$ 25	Square Foot
Pre Concrete Top Flange	Condition Improved	$ 25	Square Foot
Re Conc Top Flange	Condition Improved	$ 25	Square Foot
Steel Deck - Open Grid	Condition Improved	$ 100	Square Foot
Steel Deck - Conc Fill Grid	Condition Improved	$ 100	Square Foot
Steel Deck - Orthotropic	Condition Improved	$ 100	Square Foot
Re Concrete Slab	Condition Improved	$ 35	Square Foot
Timber Slab	Condition Improved	$ 120	Square Foot
Strip Seal Exp Joint	Replacement	$ 65	Linear Foot
Pourable Joint Seal	Replacement	$ 19	Linear Foot
Compression Joint Seal	Replacement	$ 70	Linear Foot
Assembly Joint With Seal	Replacement	$ 1,175	Linear Foot
Open Expansion Joint	Replacement	$ 25	Linear Foot
Assembly Joint Without Seal	Replacement	$ 1,175	Linear Foot
Other Joint	Replacement	$ 1,175	Linear Foot

[12] RIDOT calculates the remaining asset value of a bridge by first calculating a simple square foot replacement value, then multiplying replacement value by the percentage from the remaining projected useful life of the bridge. The present bridge condition is considered by an addition or subtraction of 10% due to its condition compared to its age. Where if a bridge is in good condition and is over 10 years old it will receive a 10% bonus to the percentage of its remaining life. If a bridge is in poor condition and is less than 60 years old, it will receive a negative 10% to the percentage of its remaining life.

Element Name	Treatment	Cost Per Unit	Unit
Pre Conc Appr Slab	Condition Improved	$ 45	Square Foot
Re Conc Approach Slab	Condition Improved	$ 45	Square Foot
Metal Bridge Railing	Condition Improved	$ 140	Linear Foot
Re Conc Bridge Railing	Condition Improved	$ 45	Linear Foot
Timber Bridge Railing	Condition Improved	$ 95	Linear Foot
Other Bridge Railing	Condition Improved	$ 95	Linear Foot
Masonry Bridge Railing	Condition Improved	$ 175	Linear Foot
Wearing Surfaces	Replacement	$ 57	Square Foot
Asphaltic Joint Material	Condition Improved	$ 55	Linear Foot
Asphaltic Joint Material	Replacement	$ 55	Linear Foot
Sliding Plate Joints	Condition Improved	$ 55	Linear Foot
Bridge Joint Other	Condition Improved	$ 55	Linear Foot

Chapter 7—Performance Gap Analysis

The evaluation of gaps in NHS performance is a critical step in RIDOT's asset management process. This chapter summarizes RIDOT's processes for developing asset performance scenarios and evaluating performance gap analyses. As required under MAP-21, performance gap analysis is the process of identifying deficiencies hindering progress towards preserving or improving the NHS and achieving the desired State of Good Repair. Following the identification of the deficiencies in NHS performance, RIDOT develops strategies to address those performance gaps.

This chapter outlines the ways in which RIDOT evaluates two forms of performance gaps— [1] Target-Based Performance Gaps, and [2] Plan-Based Performance Gaps—for both pavement and bridge assets. Then, three target-based performance scenarios are discussed. Finally, this chapter concludes with a discussion of the Department's use of cross-asset resource allocation. RIDOT's ability to analyze cross-asset performance scenarios is limited for the time being. However, this chapter includes a discussion of the Department's long-term plans to improve those capabilities.

Performance Gap Analysis Processes

RIDOT evaluates three types of performance gaps:

1. **Target-Based Performance Gaps,** the difference between current asset conditions and formally established asset condition *targets*;
2. **Program-Based Performance Gaps,** the difference between programmed asset treatments and the needs of those assets in both the short- and long-term; and
3. **Plan-Based Performance Gaps**, which arise when external planning efforts recommend changes to existing pavements, bridges, or other physical assets. An example of this is the assessment of mobility in Rhode Island's freight plan**, "Freight Forward: State of Rhode Island Freight and Goods Movement Plan,"** resulting in recommendations for additional capacity.

Pavement Performance Gap Analysis Process

For pavement assets, RIDOT identifies deficiencies in two ways:

1. **By manually collecting** and analyzing current pavement distress data; and
2. **By leveraging that data** to develop models of future pavement conditions.

These processes allow RIDOT to identify both current and future performance gaps and assess whether existing investment strategies will allow the Department to meet its established targets. As stated in Chapter 4, RIDOT will rely on its pavement management software (currently dTIMS) to facilitate LCCA for its pavements, using deterioration models shown in Figure 31. The aim of a LCCA is to identify the single most cost-effective strategy of pavement treatments to maintain a desired condition level. As with Bridge infrastructure, rate of deterioration based on historical Rhode Island models. The cost of doing the work is based on a weighted average price index published by RIDOT or by lump sum pricing by pavement type.

Chapter 7—Performance Gap Analysis

RIDOT maintains detailed pavement data measured according to Pavement Structural Health Index (PSHI) and Highway Performance Monitoring System (HPMS) standards. FHWA has established pavement system performance requirements for the NHS Interstate system indicating that no more than 5% of the NHS interstate system can be in "Poor" condition according to the HPMS ranking system. FHWA has left it to RIDOT to set the HPMS targets for the remainder of the NHS system, and RIDOT has set the 2019 and 2021 pavement performance targets at no more than 20% "Poor," respectively, according to the HPMS rating system. Additional information about performance measures and processes can be found in Chapter 2.

In both cases, alternative strategies are developed through a collaborative process involving pavement engineers and planners, financial management, project managers, and all other key stakeholders.[13] The implementation of gap-targeting strategies works in concert with the state's TIP. Though the next decade of projects is always outlined in the TIP, RIDOT's Division of Planning is careful to update the TIP to accommodate gap-targeting strategies whenever necessary. Accordingly, the most recent version of the TIP reflects the investment strategies identified as the resource-maximizing, performance gap-targeting treatments for every asset class, including pavement.

Bridge Performance Gap Analysis Process

Through RhodeWorks, RIDOT is working to repair its Poor bridges to meet FHWA standards. As of March 2018, however, the Department is still dealing with an elevated number of "Poor" assets. The conditions of Rhode Island's bridges are summarized in the table below.

Figure 49 -- Bridge Conditions by Classification

Bridge Type	Bridge Condition Rating	Bridge Condition 2018 (%)	Two-Year Condition Estimate, 2020 (%)	Four-Year Condition Estimate, 2022 (%)
NBI-NHS	Good	13.09	14.00	16.00
	Fair	62.95	60.00	63.00
	Poor	23.96	26.00	21.00
ALL RIDOT BRIDGES	Good	22.21	N/A	N/A
	Fair	58.21	N/A	N/A
	Poor	19.57	N/A	N/A

[13] Other key stakeholders may include but are not limited to internal RIDOT staff from the Office of Performance Management or the Office of Transportation Information Systems, in addition to external stakeholders from Rhode Island's Division of Statewide Planning (RIDSP), municipal planners and engineers, and elected officials.

Chapter 7—Performance Gap Analysis

The notable **target-based performance gap** between the federal sufficiency target of 90 percent and the condition of RIDOT's bridges is the most significant performance gap for RIDOT. To address this gap, the Department must be cognizant of bridge deterioration—particularly of assets in Fair condition—as it repairs and replaces bridges in Poor condition. While the share of sufficient bridge deck area will increase as each major bridge project is completed, it may decrease as other bridges age. This is precisely the reason why RhodeWorks does *not* rely on a "worst first" approach to fixing bridges. Those assets deemed - Poor may be strategically prioritized, but the Department must also determine which bridge projects will generate the greatest public good and have the most significant impact on the state's bridge sufficiency rating overall.

The RhodeWorks plan was developed in response to performance gap analyses which identified the scope of RIDOT's bridge sufficiency problem. RhodeWorks prioritizes the Department's investments according to an asset management strategy utilizing maintenance, preservation, rehabilitation, or replacement when appropriate. Pursuant to RhodeWorks' philosophy, RIDOT utilizes a three-step method for identifying, analyzing, and addressing bridge performance gaps, whether they are target-, program-, or plan-based performance gaps.

First, RIDOT bridge inspectors conduct a thorough analysis of each NBI bridge. These inspections are conducted on a regular basis, with the frequency of inspections increasing as bridge condition deteriorates. All bridges classified as "Good" or "Fair" as inspected every two years. "Poor" bridges and bridges with posted weight limits are inspected yearly. Non-NBI structures or inspected on 2 to 4-year schedules, or more frequently as needed. All inspections are done "hands-on" at the element-level, allowing RIDOT to identify performance gaps in the bridge system. All inspection Data is stored in the Bridge Management system (AASHTOWare BrM).

Second, AASHTOWare BrM is used to analyze each performance gap by predicting the ways in which each performance gap will develop over time. RIDOT uses BrM to predict the future condition of the NHS and all its bridge assets by utilizing a Benefit-Cost Analysis (BCA) and a predicted budget to reach a set goal. If BrM cannot reach the set goal using the initial constraints, bridge planning personnel can then use BrM to run different budget scenarios to close each Performance Gap as effectively as possible. Each of these scenario analyses provides useful insight for RIDOT's long-term bridge planning because it illustrates potential differences in costs

Third, the gap analysis process described above is conducted on RIDOT's entire bridge system to address its performance gaps, identifying the most efficient investment strategies to address performance gaps system-wide. Bridge planning and engineering personnel run multiple detailed scenarios through the BrM program using different budgets and altering the scope of work to be performed on the bridge network to identify the most impactful resource allocation strategy to guide investments in Rhode Island's bridges. When each project is approved, it can then can be locked into the State's STIP in the Bridge Capital Program, so that future analyses and budgetary changes will take the costs of each bridge project into account.

Performance Scenarios

RIDOT utilizes the processes described in this chapter to conduct performance-based scenario analyses in which the Department's models are utilized to produce outputs designed around one or more critical assumptions or goals. The Revenue Expenditures section of Chapter 6 includes the outputs of a **program-based** performance gap analysis, reporting the gulf between the planned investments and a performance scenario in which RIDOT maintains its pavement and bridges in a state of good repair without regard for funding constraints. The figures below present three additional **target-based** performance scenarios:

1. **Optimal Performance,** a scenario which prioritizes achieving and maintaining a state of good repair for **all** bridge assets, and **only NHS** pavement assets;

2. **Planned Performance,** a scenario which reflects the Department's currently planned and projected investment levels between 2018 and 2027; and

3. **Deteriorating Performance,** a scenario which reflects an investment level that would allow the conditions of the state's bridge and pavement network to deteriorate so rapidly that RIDOT's investments do not meaningfully impact network-level asset conditions.

Pavement Performance Scenarios

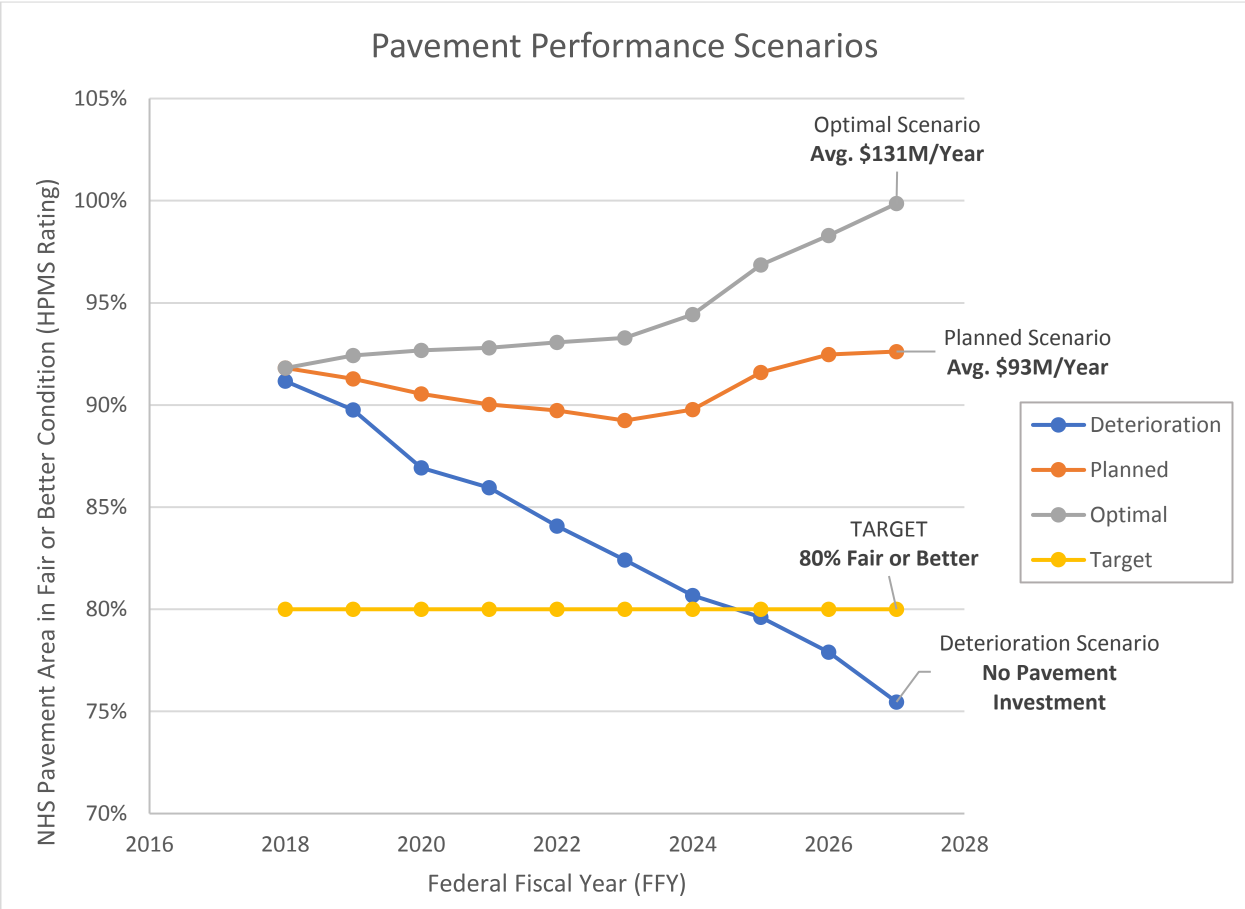
The figure below shows projected NHS pavement conditions under all three scenarios. The "Planned" baseline assumes implementation of the pavement capital program as programmed in the current STIP. Projections were developed in dTIMS in the RIDOT PSHI system, then converted to the HPMS rating scale using the Rosetta Stone (see Figures 11 and 12, in chapter 2 Objectives and Measures).

The "Optimal" scenario shows projected NHS pavement conditions with an additional $38 million per year added to the existing proposed capital program in the current STIP. Similar to the baseline, this scenario assumes implementation of the pavement capital program as programmed in the current STIP and allows the dTIMS pavement management software spend an additional $38 million per year on pavement capital projects as it sees fit. As with the baseline, projections were developed in dTIMS in the RIDOT PSHI system, then converted to the HPMS rating scale using the Rosetta Stone. This scenario projects that RIDOT could essentially eliminate poor-rated pavements altogether by 2027 and achieve over 70 percent Good rated pavements by that same year by increasing annual investment by $35 million over the 10-year plan. This scenario is intended to represent the idealized model requested by FHWA.

Finally, the "Deterioration" line shows projected NHS pavement conditions with zero investment ($0) in pavement capital projects over the next 10 years. As with the first two scenarios, pavement condition projections were developed in the dTIMS software in the PSHI system, then converted to the HPMS rating system using the Rosetta Stone. This scenario predicted roughly 25 percent Poor pavements with the remainder of the network in Fair condition.

Given the way pavements deteriorate, the percentage of pavements in Poor condition would be expected to increase rapidly in the years following the forecasted period. In addition, because of the broad nature of the HPMS rating system, it would be expected that the bulk of the pavements projected to be in poor condition would be associated with failed roads that require costly reconstruction or reclamation. This scenario is intended to represent the point of no return model requested by FHWA.

Figure 50 -- Pavement Performance Scenarios



Bridge Performance Scenarios

Pursuant to 23 C.F.R. § 490.11(a), the total percentage of bridge deck areas classified as Structurally Deficient must not exceed 10 percent. In alignment with these national goals and standards, Rhode Island has established RhodeWorks to achieve this goal by 2025. The following scenarios have been created around these standards.

The figure below shows the trajectory of bridge ratings under all three scenarios. Following the pavement graph above, the "Planned" line represents the spending in the current 10-year-plan, set to achieve the state of good repair goal of less than 10 percent Poor bridges[14] by <u>2027</u>,

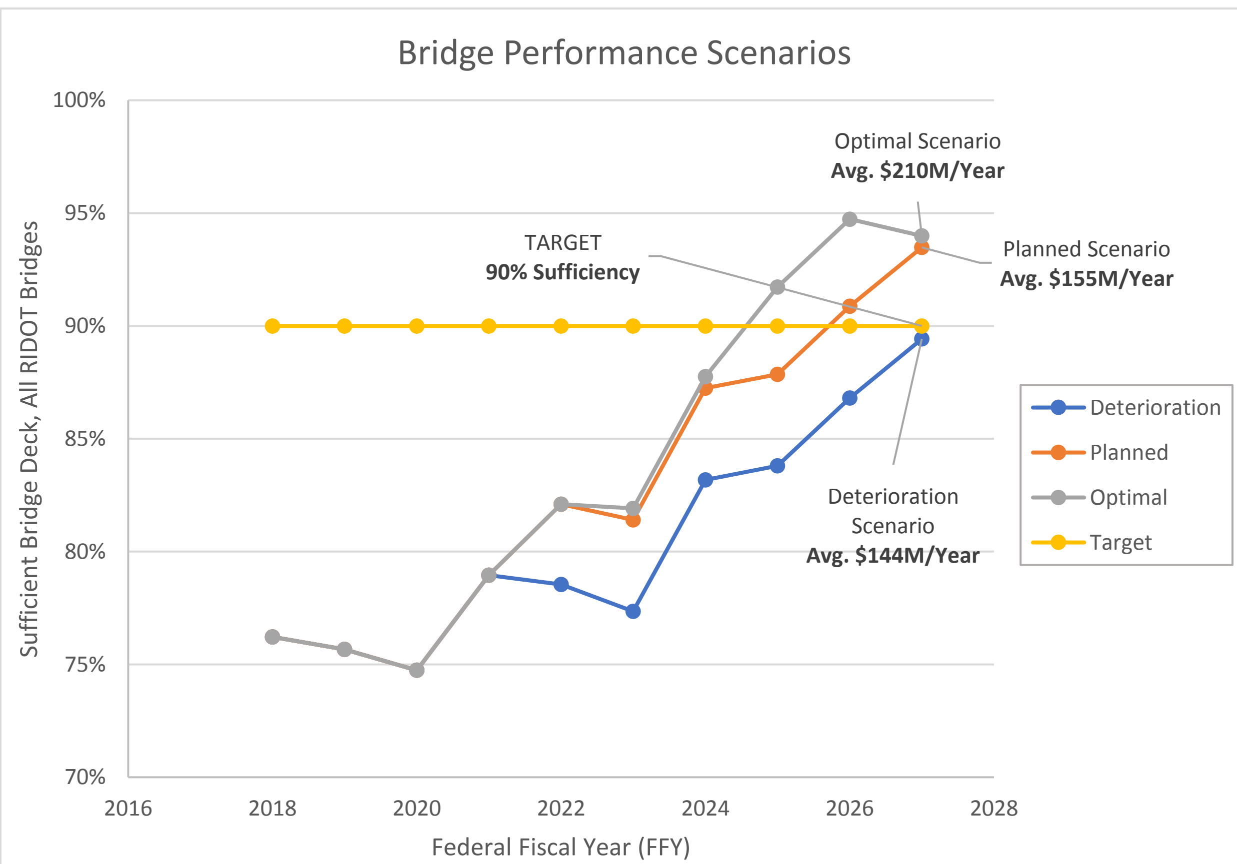
[14] This goal is intended to comply with 23 U.S.C., specifically to avoid the penalties outlined in 23 U.S.C. 119(f)(2).

specifically some time before the end of FFY2026. Under the current scenario, the Providence Viaduct Northbound project is scheduled for substantial completion by 2027 and the Henderson Bridge, spanning Providence and East Providence, is scheduled for substantial completion 2030.

The "Optimal" scenario, which would achieve the RhodeWorks goal of 90 percent deck area sufficiency for all bridges by 2025, would require approximately $55M more per year in bridge funding. That scenario would accelerate the completion of both the Viaduct and Henderson Bridge projects, allowing them both to achieve substantial completion before the end of FFY2025. As the figure below indicates, the acceleration of these two projects is effectively the key difference between the "Planned" and "Optimal" investment scenarios. Completing Henderson and the Viaduct by 2025 ensures that RIDOT reaches 90 percent sufficiency by 2025 as opposed to 2026 (Planned Scenario) or not at all (Deterioration Scenario).

RIDOT is working to secure funds that will allow the Department to act on that scenario. However, even a small drop in funding below current planned levels would be very problematic. The "Deterioration" line below shows the consequences of a 7 percent drop in funding. At an annual investment level of $144M would lead to long-term deterioration of the state's bridges, such that 90 percent sufficiency would be permanently out of reach. The 2027 sufficiency rating of 89 percent shown below ultimately becomes the high point, and thereafter, bridge conditions deteriorate rapidly beyond the point of recovery.

Figure 51 -- Bridge Performance Scenarios



The lines nearly overlap through 2021, as changes in investment level will not immediately translate into significant system-wide condition improvements. Thereafter, however, investment level changes produce significant variation in overall bridge condition across the state. As the following chapter will detail, the analyses presented here directly inform the Department's investment strategies and decisions.

Cross-Asset Resource Allocation Framework

Developing performance scenarios is an important part of cross-asset decision making. In Rhode Island, cross-asset resource allocation decisions are a goal, but due to the RhodeWorks law that requires bridge conditions to be the immediate priority, the state is focused on a state of good repair goal with efforts to ramp up to better assess cross-asset resource allocation as the Department moves through its 10-year plan.

RIDOT's goal is to develop a cross-asset resource allocation framework similar to what is proposed in NCHRP Report 806: Guide to Cross-Asset Resource Allocation and the Impact on Transportation System Performance.

The Department has engaged in discussions with project prioritization software vendors such as Decision Lens to learn how best to invest in the data solutions needed for proper cross-asset resource allocations, for both pavement and bridge assets.

Due to the data-intensive nature and technical requirements for sophisticated asset deterioration and performance modelling, this effort is a long-term goal. Further inroads will be made as the state ramps up its data-modeling investments in FFY20.

Chapter 8—Investment Strategies

Rhode Island's financial plan dovetails with the State Transportation Improvement Program (STIP/TIP). The state's shift toward an asset management-based system of programming available resources to meet critical infrastructure needs has allowed RIDOT to develop a ten-year STIP, in conjunction with the RhodeWorks initiative, and to implement investment strategies developed through a collaborative process within the department. Together, the STIP and RhodeWorks legislation allow RIDOT to aggressively design targeted projects and implement specific maintenance practices to achieve a state of good repair.

Changes in investments to Rhode Island's State Transportation Improvement Program can greatly affect RIDOT'S state of good repair objectives outlined in both federal performance rules and the state's RhodeWorks law. This chapter discusses the constraints governing the Department's investment decisions and the ways in which the analyses presented in the Risk Management, Revenue, and Performance Gap Analysis chapters of this TAMP feed the Department's final investment strategies.

As illustrated in both the Revenue and Financial Plan chapter and the Life Cycle Planning chapter of this document, RIDOT's investment strategies are developed with consideration to alternative approaches and the long-term goals of RIDOT.

Programming Constraints: Prioritization of Bridge and Pavement Projects

To achieve and maintain a state of good repair, the Department organizes its investment strategies around four dimensions of analysis, ordered by weight:

1. Funding available for future work and the estimated cost of potential projects;
2. The notable gaps in asset performance identified by asset owners;
3. Analysis of the critical risks associated with each asset; and
4. The lifecycle of each asset impacted by future projects.

These selection criteria provide the framework within which RIDOT evaluates each potential asset for replacement, repair, or rehabilitation. This section outlines the unique ways in which these considerations collectively form the Department's investment strategy for asset management.

Pavement Prioritization

Using the tools and analyses identified throughout this TAMP, RIDOT assesses pavement needs by evaluating:

1. The objective, or desired outcome for each asset; and
2. The resource constraints—primarily the funding available—to support the needs of that pavement asset.

Chapter 8—Investment Strategies

Using the pavement management software (dTIMs), RIDOT will run multiple analyses to evaluate the impact of different funding levels by adjusting the objective or resource constraint in the analysis configuration. The outputs of these analyses were shown in the previous chapter.

Strategies will be selected from a roster of available treatments and will be applied when projected pavement conditions trigger a treatment that is appropriate for that level of distress. The system will quantify the benefit of the strategies it generates using projected condition and roadway class (acting as a surrogate for AADT), along with other variables such as discount rate, rate of inflation, etc.

Using the treatment cost data shown in Chapter 6, the software generates an incremental benefit-cost chart (IBC), will then be used to select strategies that fall along the envelope of the highest benefit to cost ratio. In summary, the system will evaluate all appropriate treatments each year over the defined analysis period and select the series of treatments that offers the greatest benefit to cost ratio.

As an example of the above, take a road that was resurfaced this year. The objective of an analysis may be defined as: maintain a minimum PSHI of 70 for that class of roadway. For this example, the budget will be unlimited. The system will evaluate all options for that roadway (and the entire network or defined subset of the network) over a period of 30 years. Those options may vary from simply resurface in Year 16 to crack seal in Years 5, 8, and 11; surface seal in Year 15, and mill and overlay in Year 26. The system will generate a recommendation to implement the option with the highest benefit to cost ratio, which in this case, would be the crack seal, surface seal, resurface option.

There are three options for optimization type:

1. Maximize Benefits using IBC – the "traditional" method using the efficiency frontier approach to find the combination of strategies over the network that maximize "benefits" within a constrained "cost." IBC calculations are based on:
    a. The suite of treatments available to the system, defined in previous figures;
    b. The traffic volumes in the area (AADT); and
    c. The expected pavement structural health index (PSHI) improvement that is realized by the proposed treatment.
2. Maximize Benefits using Other Criteria – a more sophisticated use of the IBC method, described in the Advanced Users Guide
3. Minimize Cost – in which the objective is to find the strategy for each element that gives the lowest agency (ownership) cost.

Using these evaluation criteria along with considerations of fiscal constraint, RIDOT has arrived at the current planned funding scenario in the STIP. As discussed in the previous chapter, that scenario keeps the Department is on track to gradually reduce the share of Poor NHS pavements over time, but not without small upticks in Poor NHS pavement between now and 2025, the end of the RhodeWorks analysis period, as well as the wider window of 2017 to 2029 shown below.

The figure below presents a condition distribution for the Department's planned investment scenario for pavements, as defined by the most current STIP. As previously stated in Chapter 5, the STIP will be amended in the near term, which will alter the outputs of the analysis shown below for both pavement and bridge assets.

Figure 53 – NHS Pavement Condition Projections, Planned Investment Level

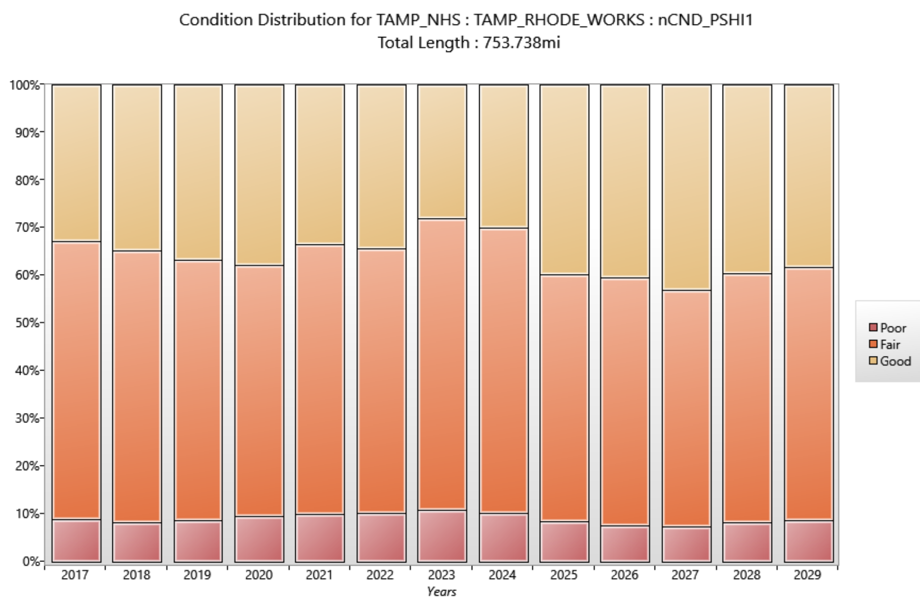
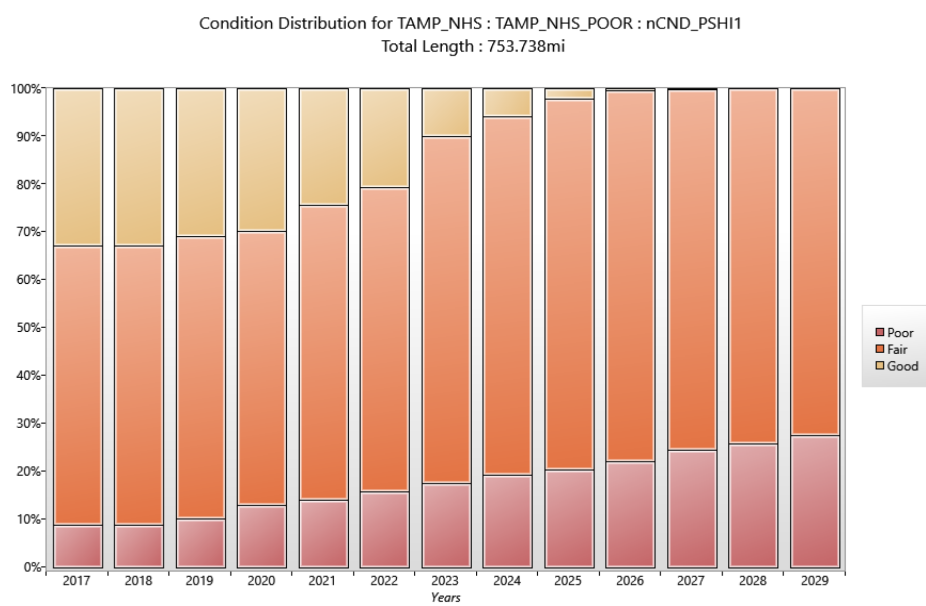


Figure 52 – NHS Pavement Condition Projections, Deterioration Scenario



While the needs of the state's bridges are urgent, RIDOT is working to be mindful of the potential repercussions of under-investment in the NHS pavement system. The figure below shows the most extreme case, in which NHS pavement investment is simply zeroed out. Predictably, conditions deteriorate rapidly, a trend which would require significant investment to reverse.

Bridge Prioritization

As with pavement assets, RIDOT utilizes the tools and analyses identified throughout this TAMP to evaluate and program bridge projects by considering:

1. The current and projected future condition of each bridge

2. The requirements associated with treating each bridge, including permitting, historic, and right-of-way coordination issues, environmental conditions including noise, air quality, wetlands, water quality, utilities, etc; and

3. Whether economies of scale might be achieved by grouping bridges with similar needs together (or by separating bridges with distinct needs and timelines).

To begin this process, within BrM, a bridge is selected and then assigned the LCCA policy rules for that type of structure. The rules determine what work will be done to the bridge when it reaches a certain condition or age. The program deteriorates the bridge while using these policy rules determine when and what work will be done on the bridge, using a cost-benefit ratio generate the greatest return to the bridge's health.

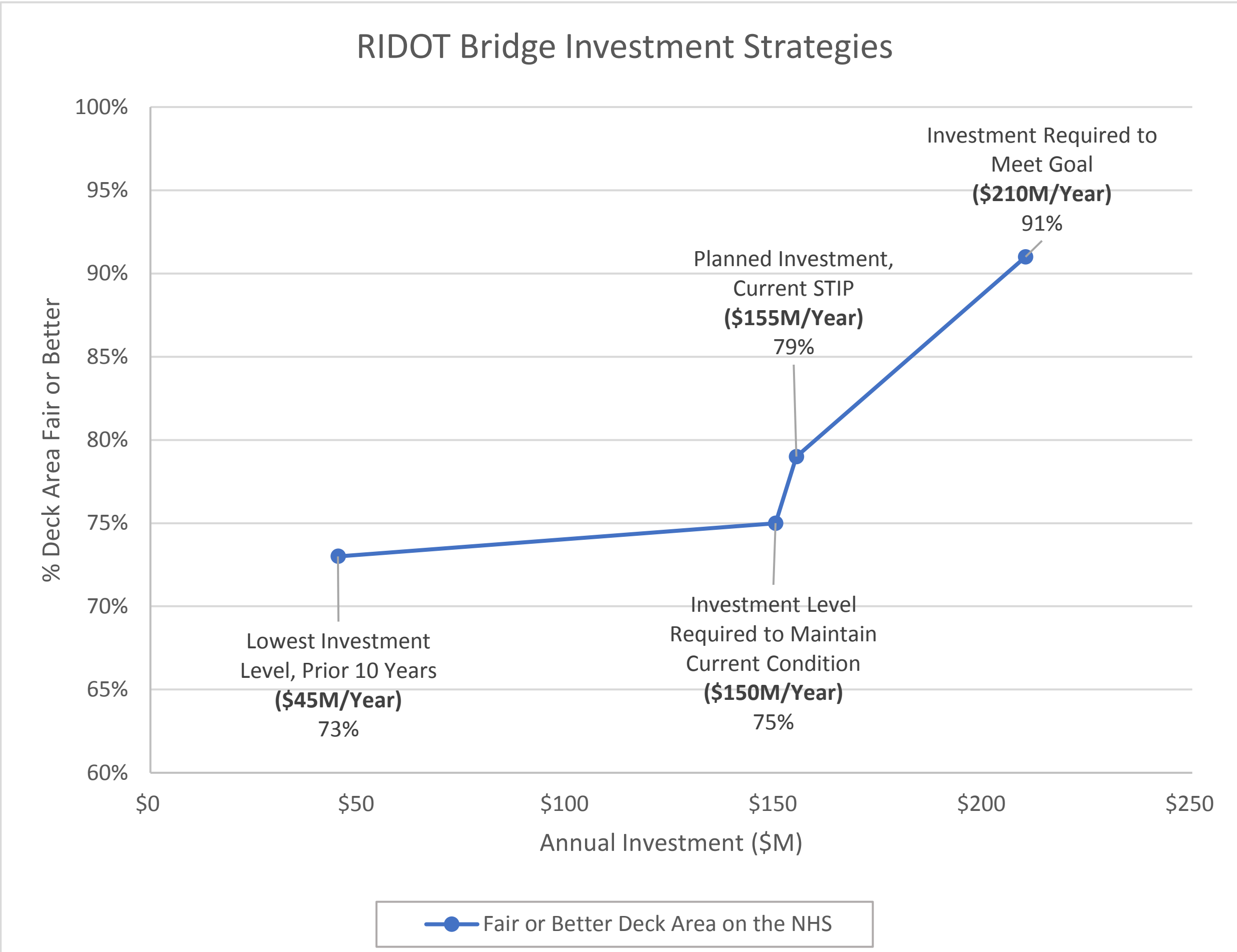
The deterioration rate is based on historic Rhode Island deterioration models. The cost of treatment is based on a weighted average price index published by RIDOT or by lump-sum pricing by work type. The LCCA rules differ by bridge type and are not set to a budget.

RIDOT then relies on BrM to produce estimates of bridge condition over time, which are compared against the Department's goals. As discussed in Chapter 7, the current planned investment scenario leaves RIDOT just short of its goal, and results in a long-term average sufficiency rating of 79 percent as shown below. The Department is working to secure additional funding as detailed in the next section, which will facilitate the completion of additional major projects. This investment will not only allow the Department to reach its sufficiency goal by 2025, it will ensure that the long-term needs of the bridge network are met.

Consider the graph below, which shows four possible investment strategies. The first shows estimated **current NHS bridge conditions** if investment had stayed at its lowest level in recent history, approximately $45M/year. The second shows estimated conditions at a maintenance-only level, the investment required to ensure that bridge conditions simply do not worsen ($150M/year). The third shows the outcome of RIDOT's current planned investment level ($155M/year), and the fourth shows the investment required to meet 90 percent sufficiency by 2025 as required under RhodeWorks.

Since the passage of RhodeWorks, refinements in project cost estimates and unforeseen bridge deterioration have increased the financial needs of the bridge network. While this development has resulted in a clear investment gap between the planned and required investment scenarios shown below, RIDOT is in the process of securing the funding required to meet the Department's RhodeWorks goal.

Figure 54 -- RIDOT Bridge Condition Projections by Investment Strategy



Reaching Required Investment Levels: Efforts to Secure Additional Funding

As described in previous chapters, RIDOT's efforts to mitigate exposure to financial has included and will continue to include the pursuit of additional revenues. In addition to the $53.1M secured through TIGER and BUILD programs since 2016, three other developments in process may help RIDOT reach its desired levels of investment over 10 years.

New Federal Funding

With the approval of a March 2019 THUD Appropriations bill, led by U.S. Senator Jack Reed, Rhode Island received $236 million in contract authority from federal highway programs under the FAST Act, plus an additional $69.7 million in general fund appropriation increases. This new federal funding will allow RIDOT to accelerate the replacement of Bridge 060001 (known locally as the Henderson or Red Bridge) from a substantial completion date of 2030 to substantial completion by 2022.

New GARVEE Bonds

In the spring of 2019, RIDOT began seeking state approvals for $200 million in Grant Anticipation Revenue Vehicle (GARVEE) funds to help replace the dangerous and crumbling northbound portion of the I-95 Viaduct in Providence. The project will cost an estimated $250 million, but under the present planned investment scenario, only $120 million is available.

The borrowing would have a minimal impact on paying for the rest of the 10-year bridge-repair plan, with the cost of the extra debt service covered by the $120 million currently allocated to the Viaduct. If the GARVEE bond is approved, the state will reach its bridge ratings goals about six months early, with the Viaduct NB Substantially complete in 2025 and Henderson Bridge Substantially complete in 2022.

If the GARVEE bond is not approved, RIDOT will need to reevaluate its strategy for financing the I-95 Viaduct, balancing the needs of the project against the needs of the entire Bridge Capital Program.

INFRA Grant

In addition to the GARVEE proposal, RIDOT has also requested $75M from the INFRA program to support the construction of the Viaduct. If RIDOT secures that funding, $75M of GARVEE bonds can be "displaced" to service other needs throughout the program.

If RIDOT secures INFRA funding but does not secure the GARVEE bond, RIDOT will likely be able to finance the Viaduct, but the rest of the bridge program will still require additional funding to meet its needs. If RIDOT is unable to secure the INFRA grant *and* the GARVEE bonds, investment levels will remain at the "Planned Scenario" level shown in the figures above.

Collectively, these three efforts will allow RIDOT to approach its required investment levels while staying true to the asset management principles and priorities outlined in this TAMP. As new revenues and expenditures are confirmed, the STIP and the TAMP will be updated in accordance with state and federal requirements.

Chapter 9—Implementation and Systems

To improve the status of Rhode Island's infrastructure and achieve a state of good repair, the processes identified in this TAMP will need to be supported with sufficient data systems to help facilitate and organize progress and sustainability on all fronts.

Thanks to the new approaches both outlined in this document and mandated by RhodeWorks, RIDOT's path towards its stated objectives, including zero deaths, are well underway.

Asset Management Systems

RIDOT uses a technology-focused approach to asset management, which seeks to adapt existing software systems to incorporate new information from communities, asset owners, and contractors. The result of this process will be a full suite of tools designed to update and process asset information on a geospatial basis in real time.

The data management systems that assist in tracking roads, bridges, pathways, storm drains, and sidewalks form the digital core of RIDOT's asset management capabilities. Personnel in every division depend upon software operations to facilitate their daily workload, allowing them to update and maintain asset information, condition reports, and expenditures.

Currently, RIDOT manages several databases in support of safety analysis, including statewide crash data, the newly expanded statewide inventory data, and traffic data. RIDOT also uses the Rhode Island GIS (RIGIS) to support spatial analysis and serve as a resource for data management and analysis. In future TAMPs, RIDOT would like to provide a complete summary of these systems and their capabilities. For the purposes of this TAMP, however, only the Pavement Management System (dTIMS) and Bridge Management System (BrM) are discussed in detail.

Pavement Management System Implementation and Utilization

RIDOT's pavement management system is administered using the Deighton Total Infrastructure Management System (dTIMS) software developed by Deighton Associates.

Collecting, Processing, Storing, and Updating Inventory Condition Data

Pavement condition/distress data including cracking, rutting, rideability, and patching is collected annually through contracted vendor services. Distresses are ranked by severity, illustrated on color-coded plan view photos, and quantified in tabular format. Mainline data for both NHS and "other" state roads is collected annually. Limited access ramp data is collected bi-annually.

This data is loaded into the dTIMS software and recorded in 1/10-mile increments based on route and mile point. The data is processed to calculate a Pavement Structural Health Index (PSHI) for all RIDOT and NHS roads as described in Chapter 2. A PSHI score is calculated annually for both the individual 1/10-mile segments and aggregate construction segments. dTIMS provides RIDOT with the ability to forecast the condition of roadways and identify possible treatments. Critical roadway information from the MIRE road inventory will be shared with the PMS and the MIRE pavement condition elements will be shared by the PMS.

Forecasting Deterioration of NHS Assets

Pavement deterioration is currently modeled within dTIMS using a standardized rate of deterioration of the entire network, freeways excluded. The RIDOT Pavement Management team is in the process of developing a more refined set of deterioration models that may include such variables as road type, road location, traffic volume, work type performance, and climactic (thermal) zone. If the effort proves practical, the refined deterioration models will be incorporated into the dTIMS to help more accurately predict future pavement conditions under various treatment alternatives. To the extent possible, all deterioration models are proposed to be developed using historic condition information from past annual pavement condition assessments. The deterioration modeling effort is intended to be dynamic and constantly improving over time as additional condition information becomes available.

Determining the Benefit-Cost Over the Lifecycle of Assets to Evaluate Alternative Actions

In addition to modeling how various work types affect future pavement conditions over time, the RIDOT is in the process of updating the "cost expressions" within dTIMS. The cost expressions update is intended to help refine the project cost predictions for each work type. RIDOT is also evaluating working group scenarios to help capture and define other non-pavement project costs such as ADA and stormwater improvements, utility, soft costs, etc. The intent of this effort is to improve cost projections for future projects and the RIDOT program. RIDOT will also update the "trigger expressions" within the dTIMS that define which treatments are appropriate based on projected pavement conditions. For example, a limited amount of cracking may trigger the need for a crack seal preservation treatment whereas a significant amount of cracking and rutting, and poor rideability, may trigger a mill and overlay restoration treatment.

The dTIMS software optimizes pavement treatment strategies over a defined period by comparing different strategies using the cost and trigger expressions to run an incremental benefit-cost analysis. The incremental benefit-cost analysis involves the theoretical application of all available treatments to each road in the database over the defined time. The software is utilized to determine which series of treatments provides the highest benefit to cost ratio to that road within the budget that is available to maintain the entire system. In this way, the treatment regimen for each construction section is optimized to available resources.

Identifying Short- and Long-Term Budget Needs for Managing NHS Asset Condition

To maximize the capacity of dTIMS, RIDOT needs to improve the cost and trigger expressions for all pavement preservation, rehabilitation and reconstruction treatments so the system can compare them more objectively as part of the incremental benefit-cost analysis.

Utilizing the dTIMS software as described in the section on Benefit-Cost above, RIDOT will not only be able to determine the fiscal resources needed to reach a desired condition state, but also the best means to utilize limited capital resources to optimize the condition of its pavements. Given the state and federal mandates regarding bridges, and the reality of the need to maintain other transportation asset classes outside of bridges and pavements, the ability to optimize the effectiveness of our pavement treatments is of paramount importance.

Utilization of the dTIMS software in the manner described above will allow RIDOT to integrate more creative analyses of pavement treatment scenarios to identify the most beneficial road treatment plan for the State, thus maximizing the "right treatment to the right road at the right time" philosophy or approach to pavement management. The Department rarely does any pavement preservation work on roadways that require permitting or periphery work such as stormwater treatment, sidewalk replacement, or traffic signal improvements. Allowing the system to compare pavement preservation more objectively (Life Cycle Planning with Life Cycle Cost Analysis) against pavement rehabilitation and reconstruction may enable an expansion of pavement treatments and encourage preservation projects that may *seem* expensive or complex but ultimately save money in the long run.

Determining Strategies for Identifying Projects that Maximize Program Benefits
The sections on Benefit-Cost and Budget Needs above describe how the RIDOT intends to expand and refine the capacity of the dTIMS system. The ability to maximize the effectiveness of the limited resources made available to the pavement program will, in turn, allow RIDOT to identify a system-wide strategy to maximize program benefits.

Recommending Programs and Implementation Schedules
The intent of all the aforementioned dTIMS improvements is to refine the system used to find the best balance of use of available funds to achieve the desired state of repair of the road network as a whole, while meeting or exceeding the stated performance goals for each of the 3 categories of roads – Interstate NHS, Non-Interstate NHS, and Other State Roads. The dTIMS system is and will be used to help pavement managers identify the best overall pavement management strategy to achieve or exceed stated, or even changing goals. This program management strategy will define what treatments are applied to what roads at what time. This, in turn, will form the basis of RIDOT's 10-year plan pavement capital and preservation programs.

Improving the Pavement Management System

RIDOT is working to improve its pavement management system capabilities by addressing the following needs:

1. Pavement conditions continue to deteriorate around the state, but funds are not available to implement large-scale pavement reconstruction efforts. RIDOT must find ways to extend the life of "healthy" pavement.

Proposed Action: Evaluate the creation and implementation of a more robust preventative pavement maintenance program on state roads and highways. This programmatic adjustment will be evaluated during the drafting process for the next STIP, which will likely begin some time in late FFY2019 or early FFY2020.

2. Changes in pavement condition are not currently captured in real-time in the STIP, so if a pavement segment scheduled for reconstruction in 2025 is critically damaged by an unforeseen weather event or other sudden disruption, there is limited flexibility for RIDOT to address the problem immediately.

Proposed Action: Develop and maintain a list of the "worst" pavement segments, and cross-check future adjustments to the pavement capital program in the STIP against the needs of the most critically damaged pavement assets in the state.

Bridge Management System Implementation and Utilization

RIDOT manages and tracks its bridge infrastructure using AASHTOWare Bridge Management software (BrM). BrM provides RIDOT a means to manage its bridge inventory and inspections following AASHTO's Guide Manual for Bridge Element Inspection. The bridge inventory data is integrated with VUEWorks and is the authoritative source for bridge data for the GIS.

RIDOT will continue to be an active participant in discussions about the future of bridge management software, and work to integrate the latest technology into its bridge planning processes. For the time being, BrM will remain the primary source of bridge data for the Department, and all future connections between data management systems will work to maximize the technological capabilities of BrM.

Collecting, Processing, Storing, and Updating Inventory Condition Data

BrM is an AASHTOWare product that provides the Department with the ability to track the current condition of all state-owned or maintained bridges and all bridges on the National Highway System. BrM is also the tool utilized to complete NBI reporting to FHWA on an annual basis pursuant to 23 CFR 650. Bridge inspections, which determine the condition ratings for each bridge, are also managed and tracked within BrM.

In recent years, BrM has moved to a web-based architecture, which affords RIDOT and its consultants the opportunity to access and update BrM data more frequently than ever before. In the past year, the introduction of VueWorks for maintenance operations have allowed RIDOT to submit and track internal bridge work. For bridge work that is managed by consultants, however, it is more difficult to track progress in BrM.

Forecasting Deterioration of NHS Assets

Utilizing AASHTOWare 's advanced deterioration modeling and life-cycle cost analysis, RIDOT can now forecast future conditions of bridges, and identify which preservation and maintenance treatments would be best to perform on an individual bridge or on entire bridge networks, to keep them in a state of good repair for the longest amount of time at the least cost.

Determining the Benefit-Cost Over the Lifecycle of Assets to Evaluate Alternative Actions

As bridge inspection reports are updated, RIDOT can refine its BrM-based projections of lifecycle estimates for individual bridges, as well as replacement, preservation, and maintenance costs. As bridge conditions change, RIDOT may find it valuable to alter bridge groupings to pair like-work types or alter project schedules to address bridges sooner or later. BrM provides the Department with the ability to perform scenario analyses at the bridge- or program-level to determine which programmatic options will maximize lifecycle benefits and minimize costs.

Identifying Short- and Long-Term Budget Needs for Managing NHS Asset Condition
RIDOT uses BrM to project bridge-level construction cost estimates based on deck area, bridge component condition, and the projected needs of the bridge. Combining this process with the benefit-cost analyses and forecasting deterioration described above, RIDOT can develop rough cost estimates for bridges in both the short- and long-term.

Determining Strategies for Identifying Projects that Maximize Program Benefits
Using bridge costs, bridge condition ratings, and deterioration modeling the bridge management system can determine the different scenarios for maximizing the condition of the bridge over its lifecycle. This is done by using a cost benefit analyst on each bridge and or network of bridges. The different scenarios can then be analyzed with budgetary constraints.

Recommending Programs and Implementation Schedules
Program strategies with cyclical maintenance can be than analyzed to see the long-term lifecycle effects on the network of bridge structures. These strategies can then be compared against each other to see which one or combination will best fit RIDOT's long term goals.

Improving the Bridge Management System
RIDOT is working to improve its bridge management system capabilities by addressing the following needs:

1. In the past, it has been difficult to track which bridge projects are completed, and while BrM technology has improved this issue, some problems remain. The current BrM and VueWorks systems do not communicate automatically, so when a maintenance work order is filled through VueWorks, Bridge personnel must manually enter that information into the BrM system after the fact.

Proposed Action: The Bridge group is working with Maintenance to establish an automatic, electronic link between these systems, which will reduce the need for redundant data entry in multiple systems.

2. As RIDOT continues to implement and update its ten-year plan through the STIP, bridge-level cost projections have become increasingly valuable.

Proposed Action: RIDOT will continue to be an active participant in discussions about the future of bridge management software, and work to integrate the latest technology into its bridge planning processes to strengthen its cost estimation capabilities.

Other Data Management Systems

Maintenance Tracking
RIDOT has been utilizing VUEWorks software for approximately two (2) years for maintenance management and processing of work order requests. All customer service, maintenance, and Transportation Management Center (TMC) calls are entered as service requests related to a

location or an asset. Service requests are routed internally based on the type of issue and the location. Once reviewed, service requests may become work orders where the work activity, personnel, and equipment used is recorded. As part of the ESRI Roads & Highways implementation, VUEWorks will be connected to the Roads & Highways enterprise linear referencing system through web service connections, resulting in the location of work against the LRS. RIDOT recently procured additional modules associated with VUEWorks including project, condition, risk, budget, forecasting, and mobile. With these additional modules VUEWorks can now be configured as a full Asset Management System. There is also an on-going effort to obtain mobile devices such as tablets and other smart devices to allow for the completion of work orders in the field. VUEWorks is acritical system for the tracking of changes to RIDOT's assets through maintenance operations and projects.

Crash Data

RIDOT stores their crash data in a centralized Crash Data Repository System (CDRS) and has developed an Online Crash Analysis and Reporting (OSCAR) application. Currently about 20-30% of all crashes are referenced with latitude/longitude coordinates. Approximately 30-40% of the crashes are referenced to a street address. These crashes are primary located in urban areas. The remaining crash locations are referenced to an intersection or an intersection with an offset mile post. With the implementation of ESRI Roads & Highways, RIDOT plans to update the crash database and populate latitude/longitude coordinate values for all crash locations.

The crash database will be registered with the enterprise geodatabase developed for ESRI Roads & Highways, resulting in a common LRS for all crash records. Additionally, once the crash database is registered with ESRI Roads and Highways, the crash database will be made available to other platforms such as VUEWorks.

Rhodeways Incident Management System

Rhodeways is RIDOT's incident management system. Operators from RIDOT's Transportation Management Center (TMC) locate incidents through a mapping interface that utilizes RIDOT's ArcGIS services. The application stores incident locations with latitude/longitude coordinates. Incidents are made available through RIDOT's website and callers' reports. Integration with VUEWorks allows for the viewing of active incidents. Future enhancements, including the integration with ESRI Roads & Highways, will allow for location referencing in the LRS.

Traffic Volume Database

Traffic data is collected through continuous, seasonal, and short-term counting stations. RIDOT Traffic section collects, processes, and analyzes the data using various applications. The final published data is managed in an Access database where the ADT and AADTT (Average Annual Daily Truck Traffic) are stored. This information is shared through the GIS and linked to the location based on the Traffic Station ID. RIDOT plans on replacing the existing system with an off the shelf enterprise traffic data management system.

Chapter 9—Implementation and Systems

RIDOT is in the process of implementing the MS2 software to calculate AADTT. The system calculates AADTT using count station data and seasonal factors, when applicable. The seasonal factors are developed for roads classes or sites displaying similar seasonal traffic patterns.

Improving Asset and Data Management System

RIDOT's collective efforts to build out a comprehensive data management solution will ideally culminate in the integration of new platforms capable of doing several things:

- Linking all activities—maintenance, construction, weight posting, design updates, and more—to each asset within a geospatially registered data management system;
- Connect digital versions of all architecture and design documents to each asset through cross-system integration with asset management systems like BrM and dTIMS;
- Establish connections between financial and construction management systems so that every transaction can be traced back to an individual asset; and
- Provide a single, comprehensive portal for all project development, project management, construction, maintenance, and contracting staff to examine, update, and download data on projects, assets, maintenance activities, and more.

To realize this vision, RIDOT has three broad options. The first and most likely option is to continue expanding the Department's VueWorks licenses to integrate all the modules necessary to allow the sort of cross-system communication envisioned here. A second option would be to expand dTIMS instead, which also has some of the asset management capabilities of VueWorks. Finally, RIDOT could procure an alternate application. However, given the Department's success in integrating the work order components of VueWorks for maintenance purposes, it remains the most reasonable option.

Proposed Action: RIDOT is currently working with ESRI to develop a comprehensive, integrated data management system linking asset-level information to financial, planning, maintenance, traffic, and GIS systems. The ESRI coordination process has already resulted in the production of a Project Scoping App, which RIDOT is in the process of implementing Department-wide. Over the next year, RIDOT expects to have a more detailed plan in place to transition to the next phase of data management integration.

Conclusion

RIDOT has developed this TAMP to fulfill both federal and state legislative requirements to keep Rhode Island's roads and bridges in a state of good repair. The Department has analyzed the process and cost of operating, maintaining and upgrading all the state transportation system's physical assets throughout their life cycle. This strategic and systematic approach clearly indicates where resources should be allocated and helps prevent the unnecessary expenditures of capital funds.

The cost of failure to adhere to asset management principles is high, leading to sharply escalating costs, poor road and bridge conditions and a high percentage of Poor infrastructure.

Asset management is the driver for the STIP, which is reviewed annually, replacing a planning process that was only reviewed once every four years.

Properly focusing on preservation, maintenance and repairs over costly reconstruction can lead to dramatic savings. RIDOT expects to save $950 million over the first 10 years of RhodeWorks by making preservation-level repairs to 500 bridges – nearly half of all the bridges in Rhode Island – to avoid costly bridge rehabilitation or reconstruction projects that otherwise would be three to four times more expensive.

This TAMP is intended to be a living document that will help RIDOT to track and update the asset management processes, objectives, and investment strategies that will facilitate the Department's pursuit of a State of Good Repair for its bridge and pavement assets.