



TRANSPORTATION ASSET MANAGEMENT PLAN

Right Investment, Right Asset, Right Time

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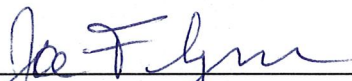
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ORGANIZATIONAL COMMITMENT

The Vermont Agency of Transportation (VTrans) is a performance-driven organization that focuses on continuous improvement to maximize transportation benefits for all Vermonters. We manage opportunities, threats and vulnerabilities across our organization, and at all levels within the organization, through effective and efficient asset management practices. We collectively strive to generate positive, long-lasting, and sustainable outcomes through fiscally responsible and proactive investment strategies.

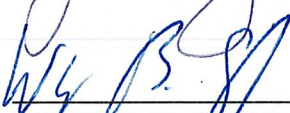
This Transportation Asset Management Plan provides the foundation for ensuring that the right treatment is made on the right asset and at the right time. This plan provides synergy with our strategic goals and objectives and it provides structure and support towards implementing our mission and vision communicated in our 2040 Long-Range Transportation Plan.

We, the undersigned, are the leadership team charged with implementation of asset management within VTrans. We support the efforts of the multi-disciplinary team tasked with developing this plan. We will dedicate our efforts to providing our teams with the resources, guidance and tools necessary to sustain our infrastructure in a state of good repair.



Joe Flynn, Secretary

06/17/2019
Date



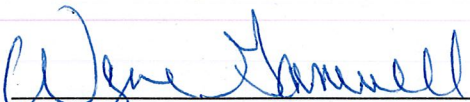
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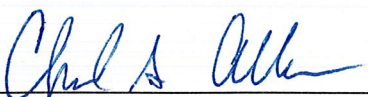
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Lenny Leblanc, Chief Financial Officer

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Chad Allen, Director
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6/17/19
Date

Executive Summary

How Does Transportation Asset Management Help Vermont?

- Ensures that VTrans is making the right level of investment in the right asset at the right time.
- Makes preventive maintenance a priority.
- Integrates efforts throughout the Vermont Agency of Transportation (VTrans), including communication, business practices, and projects—from development through maintenance.
- Focuses investment on an efficient, cost-effective, sustainable transportation system.

How Does Asset Management Help Me?

Asset management helps VTrans maintain its roads, bridges, sidewalks, bike paths, and other transportation facilities in a cost-effective way. This is coordinated with efforts to support mobility, connectivity, safety, economic access, resiliency, communities, environment, and health access.



Figure 1: Why are Roads and Bridges Important to Me?

What is in the Transportation Asset Management Plan (TAMP)?

- Current and future issues related to asset condition.
- Key risks to the transportation network and how they are managed
- Action plan to fix issues.
- To read the TAMP brochure or report, search on TAMP at vtrans.vermont.gov/docs

VTrans only has 70% of funds it needs to maintain the transportation system.

What Outcomes Could Vermonters Expect?

- More bang for the buck.
- More choices in a long-lasting, coordinated transportation system.
- Fewer impacts from events such as severe storms.
- Better-coordinated decisions made with communities that benefit current and future generations.

VTrans fixes roads the same way you may fix your house...a little preventive maintenance now will save a lot of money later.



Figure 2: Example of How VTrans is Implementing Asset Management

1. INTRODUCTION

How VTrans Does Transportation Asset Management

The Vermont Agency of Transportation (VTrans) takes a strategic approach to maintaining Vermont’s roads, bridges, and other infrastructure guided by its mission and vision. The purpose is to achieve and sustain the desired state of good repair, over the life of each asset, at a minimum practical cost. A “state of good repair” is a condition in which physical assets provide the service for which they were designed and built. VTrans strives to keep as many assets in this condition state while minimizing the asset improvement costs across the entire network and balancing these costs across various asset classes. Specific asset performance measures and targets are addresses later in this report.

Assets are the physical elements of the transportation system, such as pavements, bridges, culverts, guard rail, signs, traffic signals, trails/paths, buses, railroads, and airports.

Some of the specific benefits of asset management for Vermont are

- maximum value through enhanced use of data and preventive maintenance;
- better management of risks;
- more efficiency by planning for the entire **life cycle** of an asset;
- optimized investment across assets.

VTrans has used asset management since the mid-1990s. In 2014, VTrans adopted an Asset Management Policy Statement with four goals:

- Meet the minimum federal and state legislative requirements regarding asset management implementation.
- Develop factual, risk-based, and data-driven asset management processes.
- Use asset management to manage the Agency’s physical infrastructure, drive the budget development process, and support the Agency’s Strategic Plan.
- Integrate asset management principles into VTrans culture.

What is in the TAMP?

Federal regulations require the development of a TAMP. While meeting the regulations, VTrans views the TAMP as part of aligning its plans, processes, and activities to support asset management.

Federal regulations require State Departments of Transportation to prepare a TAMP that includes

- asset management objectives and measures;
- condition of National Highway System (NHS) pavements and bridges, regardless of ownership;
- performance targets and issue analyses for NHS pavements and bridges;
- risk analyses and strategies to manage or mitigate them;
- life-cycle planning;
- strategies to address issues and close gaps;
- 10-year financial plan, including asset investment strategies.

What is the Life Cycle of a Transportation Project?

Projects go through phases handled by different experts. Coordination by these experts cuts costs and provides better service. At VTrans, the phases can be summarized as

- *Budgeting, Planning, and Programming*
- *Design*
- *Construction*
- *Maintenance and Operations*

This TAMP covers the federal minimum of NHS bridges and pavement. As processes and data mature other assets will be incorporated into a holistic approach to asset management.

A diverse group of VTrans asset stewards have been collaborating as the TAMP Working Group (TAMP-WG) since 2014. This group developed the Asset Management Policy Statement, supports the current TAMP efforts, and continues to guide asset management implementation. TAMP-WG members are listed in Appendix C.

The TAMP-WG guided development of three products to maximize the benefits of asset management to all Vermonters.

Vermont spends approximately one-third of its budget managing pavement and bridge conditions so implementing best management practice approaches for these assets are a priority.

1. A brochure entitled, “Why Should We Care About Roads” – The key audience for this brochure is legislators, regional planning commissions (RPCs), RPC Transportation Advisory Committee (TAC) members, municipal officials and board members, and everyone who will help make decisions that affect transportation assets. A brief, visually interesting brochure was the appropriate format to engage people in reading about this technical topic.
2. This TAMP – The key audience for this plan is professionals whose work intersects with transportation asset management. People whose work contributes to, or is guided by, asset management can do a better job if they understand how the pieces fit together. This plan also explains how VTrans is meeting FHWA requirements. It is essential that this plan be clear and relatively brief for a range of VTrans staff and other partners to read it and implement it.
3. The VTrans Asset Management Practitioners’ Guide – this is a more in-depth supplemental document for a smaller, more technical audience of transportation professionals conducting asset management and includes assets that are not yet part of the TAMP. This guide also represents VTrans’ enhanced efforts to document institutional knowledge and processes as staff members change positions or retire.

This TAMP is organized in chapters that build on each other to support a range of uses. For this reason, Appendix D is a correspondence table of federal requirements and TAMP contents to facilitate the formal review process. Each chapter purposefully brings together assets to provide a foundation for cross-asset discussions. Appendix A defines important acronyms. Appendix B is the Financial Plan. Appendix C recognizes members of the TAMP-WG.

- Chapter 2 orients readers to the history and use of asset management at VTrans;
- Chapter 3 covers VTrans performance measures, current condition of transportation assets, and current funding, issues, and fixes;
- Chapter 4 discusses future conditions related to assets and funding, including issues and fixes;
- Chapter 5 introduces risk management at three levels: agency-wide (enterprise), program, and project, with short-term issues and fixes;
- Chapter 6 describes and provides examples of the strategies VTrans uses to address issues; and
- Chapter 7 builds on all the other chapters with a communication plan, specific actions table, and exploration of potential future enhancements.

An important takeaway from the TAMP is the Risk Action Plan depicted in Table 27 (Chapter 7).

2. PAST, PRESENT, AND FUTURE ASSET MANAGEMENT IN VERMONT

Vermonters value a high quality of life, which includes strong communities and a pristine environment in which to work and play. This desire to protect the environment is balanced with other transportation values such as safety, regional, economic access, asset condition, mobility/connectivity, resiliency, and health access. These qualities have been and will continue to be supported in essential ways by the state’s transportation system. However, it has become increasingly difficult to meet capital and operating needs within current and projected funding constraints. This is exactly the atmosphere that initiated and supported the start of asset management in Vermont in the 1990s. This chapter describes and illustrates VTrans’ asset management experiences – the past, present, and future.

Asset Management at VTrans Started in the 1990s

Asset management was underway in Vermont by 1995 with the introduction of a pavement management system (PMS). This has remained a priority for VTrans since it effectively balances risks, needs, and resources. The federal Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law in 2012 and established national transportation performance goals to guide planning and programming decisions by state DOTs towards more efficient investments while increasing accountability and transparency. The Fixing America’s Surface Transportation Act (FAST Act) was signed into law in 2015 and continues the MAP-21 performance management approach, in which states invest resources in projects that collectively make progress toward national goals.¹ These acts have made asset management a requirement, including the development of a TAMP.

Shifting Business Model in the early 2000s

The *VTrans Asset Management Vision and Work Plan* was completed in 2002. This was part of the background to a change in the VTrans business model summarized in a 2006 policy, “The Road to Affordability.” This policy relied on the principles of asset management to schedule lower-cost preventive maintenance treatments that would extend useful asset life, resulting in future savings which would accumulate over time, increasing the Agency’s financial sustainability. Prior to this policy, preventive maintenance projects had to compete with new infrastructure projects for limited available funds. Justification for the “Road to Affordability” was founded on the premise that a commitment to preventive maintenance would provide significant long-term savings, exemplified and communicated as

- A \$100,000 investment in a culvert under 20 feet of fill on the Interstate today saves over \$1 million in traffic impacts and replacement costs tomorrow.
- A \$100,000 investment in a new bridge membrane today saves over \$1 million in deck replacement costs tomorrow.
- A \$1 million investment in pavement substructure today will save over \$5 million in reconstruction costs tomorrow.²

Integration of Asset Management in the Current Decade

Implementation of asset management has been maturing at VTrans in recent years. In 2014 VTrans reorganized to create the Asset Management and Performance Bureau (AMP). It included sections for

¹ www.fhwa.dot.gov/fastact/summary.cfm

² vtrans.vermont.gov/sites/aot/files/portal/documents/aboutus/capprog/09/2BACKGROUNDINFORMATIONANDEMPHASISAREAS.pdf

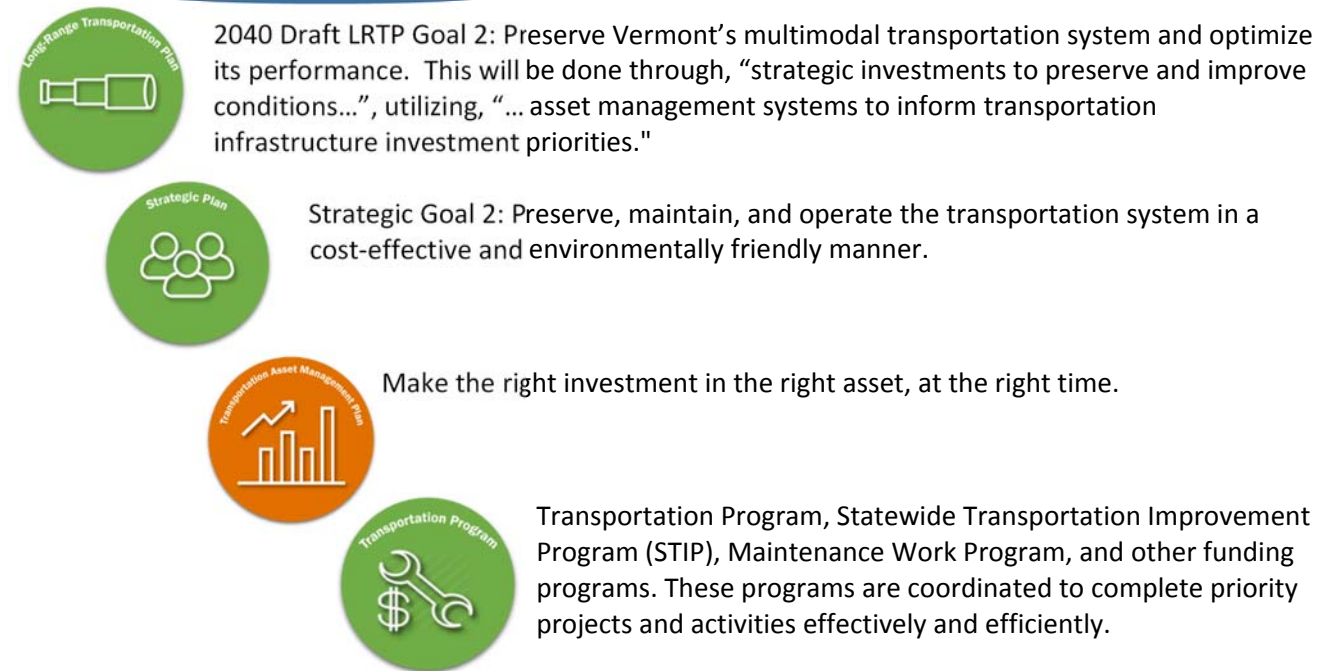
data management, performance and risk, and budget and programming. As transportation performance has continued to grow in importance, VTrans created a new agency-wide performance group in 2017 and the AMP is now referred to simply as the Asset Management Bureau (AMB). This team focuses on high-level enterprise-wide performance and coordinates with the AMB, which retains responsibilities for asset-level performance. VTrans worked with a FHWA Consultant in 2014 to prepare a *Transportation Asset Management Implementation Plan* that identified further opportunities for improvement.

This TAMP is an integrated effort with Vermont’s policy goals as well as the closely related fields of performance and risk management. It is consistent with the vision expressed by Vermont’s governor and legislature and summarized in the recently published 2040 VTrans Long-Range Transportation Plan (LRTP).

Figure 3: Aligning Efforts at VTrans - Connected Plans, Shared Vision, Empowered Professionals

Mission: Provide for the safe and efficient movement of people and goods.

Vision: A safe, reliable, and multimodal transportation system that promotes Vermont’s quality of life and economic wellbeing.



As VTrans discusses asset management in increasingly diverse settings, it needs brief, clear communication pieces. The TAMP brochure was developed for a broad audience, and Figures 4 and 5 on the pages that end this chapter can be used as handouts. Additional discussion of two-way communication, outreach, training, and education can be found in Chapter 7.

Setting the Financial Stage

VTrans has a reliable history of “taking care of what it has”. Most of the highway network in Vermont has been built which has resulted in limited new construction. Tables 1 and 2 below provide introductory information on the past and current expenditure levels pertaining to the Agency’s pavement and bridge investments on the National Highway System (NHS) and compares these investments to the total pavement and bridge budgets for the current (SFY2020) and past five (5) fiscal years. The analysis segregates investments into four (4) major work types; maintenance, preservation, rehabilitation, and reconstruction. For NHS pavements, preservation includes monies spent on maintenance as well as preservation activities. VTrans is not reporting any new construction, or construction work types, because most of Vermont’s NHS network has already been constructed and VTrans’ current focus is on “taking care of what we have”. Appendix B provides a financial plan pertaining to the management of VTrans’ transportation assets and future NHS investment levels.

Table 1: NHS Pavement Investment Levels

		SFY 2015	SFY 2016	SFY 2017	SFY 2018	SFY 2019	5-yr Average	SFY 2020
Paving Program	Total Program Budget	\$ 115,830,703	\$ 84,592,201	\$ 111,084,559	\$ 112,841,555	\$ 104,199,583	\$ 105,709,720	\$ 100,682,429
	Preservation	\$ 29,764,747	\$ 14,693,500	\$ 12,120,000	\$ 19,574,484	\$ 19,575,109	\$ 19,145,568	\$ 15,253,676
	Rehabilitation	\$ 3,106,266	\$ 6,200,000	\$ 11,745,345	\$ 18,737,246	\$ 9,501,821	\$ 9,858,136	\$ 7,073,518
		\$ 32,871,013	\$ 20,893,500	\$ 23,865,345	\$ 38,311,730	\$ 29,076,930	\$ 29,003,704	\$ 22,327,194
Roadway Program	Total Program Budget	\$ 50,036,081	\$ 43,407,714	\$ 31,143,236	\$ 39,649,087	\$ 51,972,218	\$ 43,241,667	\$ 48,779,614
	Rehabilitation	\$ 4,011,963	\$ 3,688,218	\$ 5,395,000	\$ 6,100,000	\$ 652,617	\$ 3,969,560	\$ -
	Reconstruction	\$ 3,832,770	\$ 7,625,146	\$ 6,287,758	\$ 10,468,838	\$ 21,470,817	\$ 9,937,066	\$ 21,916,482
		\$ 7,844,733	\$ 11,313,364	\$ 11,682,758	\$ 16,568,838	\$ 22,123,434	\$ 13,906,625	\$ 21,916,482
Total NHS Pavement Investments		\$ 40,715,746	\$ 32,206,864	\$ 35,548,103	\$ 54,880,568	\$ 51,200,364	\$ 42,910,329	\$ 44,243,676

Table 2: NHS Bridge Investment Levels

		SFY 2015	SFY 2016	SFY 2017	SFY 2018	SFY 2019	5-yr Average	SFY 2020
Interstate Bridges	Total Program Budget	\$ 54,653,015	\$ 44,010,852	\$ 52,785,722	\$ 36,599,190	\$ 24,543,000	\$ 42,518,356	\$ 30,831,313
	Preservation	\$ 5,635,000	\$ 5,386,992	\$ 6,504,000	\$ 4,161,071	\$ 112,117	\$ 4,359,836	\$ 1,500,000
	Rehabilitation	\$ 4,526,170	\$ 4,795,000	\$ 9,828,672	\$ 9,232,947	\$ 20,818,191	\$ 9,840,196	\$ 16,611,313
	Reconstruction	\$ 44,491,845	\$ 33,828,860	\$ 36,453,050	\$ 23,205,172	\$ 3,612,692	\$ 28,318,324	\$ 13,270,000
		\$ 54,653,015	\$ 44,010,852	\$ 52,785,722	\$ 36,599,190	\$ 24,543,000	\$ 42,518,356	\$ 31,381,313
State Bridges	Total Program Budget	\$ 71,810,914	\$ 49,164,341	\$ 32,251,548	\$ 31,403,328	\$ 57,636,326	\$ 48,453,291	\$ 54,100,006
	Preservation	\$ 5,866,000	\$ 5,284,312	\$ 900,000	\$ -	\$ -	\$ 2,410,062	\$ 800,000
	Rehabilitation	\$ 110,000	\$ 110,000	\$ 149,583	\$ 122,094	\$ 1,605,108	\$ 419,357	\$ 879,272
	Reconstruction	\$ 1,574,516	\$ 1,661,353	\$ 1,361,857	\$ 504,276	\$ 108,000	\$ 1,042,000	\$ 1,670,389
		\$ 7,550,516	\$ 7,055,665	\$ 2,411,440	\$ 626,370	\$ 1,713,108	\$ 3,871,420	\$ 3,349,661
Town Highway Bridges¹	Total Program Budget	\$ 16,482,361	\$ 22,956,001	\$ 20,021,730	\$ 16,524,009	\$ 13,324,994	\$ 17,861,819	\$ 13,833,851
	Rehabilitation	\$ 150,000	\$ 125,000	\$ 41,066	\$ 100,000	\$ 1,460,000	\$ 375,213	\$ -
	Reconstruction	\$ 496,000	\$ 298,085	\$ 234,174	\$ 4,112,611	\$ 2,128,715	\$ 1,453,917	\$ 3,244,225
		\$ 646,000	\$ 423,085	\$ 275,240	\$ 4,212,611	\$ 3,588,715	\$ 1,829,130	\$ 3,244,225
Routine Bridge Maintenance								
	Statewide Total	\$ 5,916,989	\$ 6,657,873	\$ 9,752,466	\$ 4,675,974	\$ 5,324,117	\$ 6,465,484	
	NHS ²	\$ 1,065,058	\$ 1,198,417	\$ 1,755,444	\$ 841,675	\$ 958,341	\$ 1,163,787	\$ 1,270,000
Total NHS Bridge Investments		\$ 63,914,589	\$ 52,688,019	\$ 57,227,846	\$ 42,279,846	\$ 30,803,164	\$ 49,382,693	\$ 39,245,199

¹ - Preservation and maintenance type activities for Town Highway Bridges are performed and paid for by each Town.

² - Routine Maintenance Investment is based on the assumption that dollars were evenly spent across the entire bridge network.

Related Current Efforts

The following VTrans initiatives are underway to support growth towards full asset management implementation.

- *Project Selection and Prioritization:* An example of VTrans' commitment to an integrated approach is its *Project Selection and Prioritization Process (VPSP2)* project. The TAMP provides most of the contents described in the regulations about developing an optimized transportation program, but at the later stages it intertwines with VPSP2. Starting in 2020-2021 (FY22 Budget), VPSP2 may be used to select multimodal projects. It communicates the value that projects provide to Vermonters using eight criteria: safety, asset condition, mobility/connectivity, economic access, resiliency, environment, health access, and regional (priority).
- *Data Integration and Information Sharing:* A key initiative by VTrans to enhance data integration and information sharing is the *Vermont Asset Management Information System (VAMIS)*. VAMIS will support the analysis of different investment scenarios across multiple asset types. VAMIS is a collection of hardware, software, data, and processes that support asset management business processes. It will gather data from various sources, process, store, and analyze it. It will be used for budget and planning to implement sound maintenance, rehabilitation and replacement strategies and to schedule, track, and manage work. VAMIS is anticipated to be available online in 2020. Full implementation of VAMIS is expected to be completed 18 to 24 months once the project begins in the summer/fall of 2019. Statewide entities have expressed interest in using VAMIS to manage their assets. State governmental entities include the Department of Buildings and General Services, the Agency of Natural Resources, and the Agency of Human Services.

Future of Asset Management at VTrans

VTrans is committed to continually improving how it advances healthy, safe, and efficient transportation options for future generations. The action plan in Chapter 7 has important next steps that VTrans will invest in and monitor for completion. Asset management will continue to be used to make risk-based, performance-based, and data-driven decisions.

Figure 4: Benefits of Transportation Asset Management in Vermont

1. Maximize transportation value in the short- and long-term

Use data and best practices to squeeze the most value and life from transportation assets, while leaving them in better condition for future generations. An important element is being more proactive; shifting from fixing big problems in an isolated manner to emphasizing more frequent preventive maintenance activities with consideration of the whole network of transportation infrastructure.



2. Reduced emergency repairs, crashes, and traffic by reducing risk

Identifying and managing risks saves resources and provides better customer service. For example, imagine how much traveler time and taxpayer resources can be saved by preventing a few major road washouts or bridge closures each year.



3. Efficiency through planning for the life of a project

Working together down through the phases of a project (planning, budgeting, programming, design, construction, operation, and maintenance) is more efficient than a traditional approach in which groups working on different phases of the life of an asset don't coordinate. Collaboration is a major part of life-cycle planning.



4. Effective use of funding by optimizing investments across assets

Working together horizontally across assets to best invest limited resources increases asset and organizational performance. Cross-asset allocation is more difficult than it may sound, but offers a high rate of return over time, resulting in a more sustainable transportation system.



I will have safe access to doctor appointments and healthy food options.

I will be able to do my job more easily and effectively.

My business will reliably receive goods and provide services.

I will have various convenient ways to get places.

I will be able to go to fun places more easily.

More people in my communities will be able to get to good jobs.

Figure 5: History of Asset Management in Vermont



Then

Built new highways. Fixed the worst roads and bridges with low priority on maintenance.

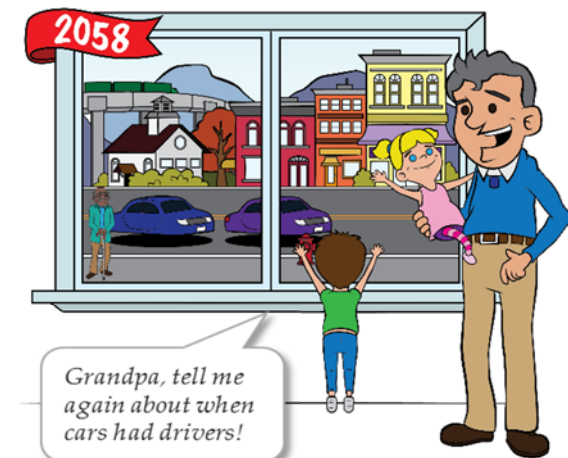
If there had been more focus on the whole transportation system rather than just stretches of road, Vermont could have saved a lot of money!



Now

Transportation asset management helps VTrans invest efficiently in a mix of maintenance and other projects.

This focus provides choices that improve mobility and connectivity, safety, economic access, resiliency, communities, environment, and health access.



Future

Transportation asset management helps Vermont be prepared to meet transportation goals and needs in a rapidly changing world.

This focus will help VTrans engage even more with you and your community's needs and vision.

3. EXISTING TRANSPORTATION NETWORK AND SHORT-TERM ISSUES

How does VTrans decide which short-term issues are most important to fix?

- It gathers data, conducts analyses, and leverages its knowledge.
- It sets performance objectives and measures informed by its customers.
- It proactively explores pavement and bridge needs and opportunities for improvement.
- It identifies existing performance issues for action with consideration of future needs and broader risk management objectives.
- It determines how to reduce issues in a coordinated, efficient manner.

This chapter builds from the description of asset management in Chapter 2 that highlighted the interrelated efforts that establish overall asset management goals. It introduces the objectives and measures for bridges and pavement used to understand their current performance. A summary of the existing inventory and asset conditions is provided for context with links to more information. An important element is identifying a few important, existing gaps or issues for bridges and pavement. These issues are combined through the next chapters with consideration of funding, risks, long-term issues, and knowledge of what can be done to identify next steps. Consideration of how to manage assets is not confined to their specific subject area, but rather is done in a comprehensive manner; for example, managing road and bridge assets includes engaging with those responsible for transportation safety and mobility planning. After actions are completed, the management system cycles back with evaluation processes and recommendations to guide continuous improvement efforts. Figure 6 shows the ongoing process of continuous improvement.

Figure 6: TAMP Asset Management Framework



Objectives, Measures, and Targets

VTrans uses its asset management goals, objectives, measures, and targets to help decide how to invest its limited resources. VTrans has followed this approach for many years. As a result, the TAMP complements existing efforts rather than being a new undertaking.

The TAMP is consistent with national performance goals and the 2040 Vermont Long Range Transportation Plan. The vision, goals, and objectives of the LRTP guide both the Agency’s Strategic Plan and the TAMP. While the TAMP helps make progress on all the goals, the most relevant one is “Goal 2 - Preserve Vermont's multimodal transportation system and optimize its performance.” Within that, the most relevant objective is “1) Make strategic investments to preserve and improve conditions of highways, railways, airports, and public transit facilities.” Asset management is coordinated with the long -range transportation plan, the strategic plan, and other internal policy and planning efforts.

Definition:

Asset Management

The purpose of asset management is to achieve and sustain the desired state of good repair over the life cycle of the assets at a minimum practicable cost. (23 CFR Part 515)

Bridge Condition Measures and Targets

VTrans uses the National Bridge Inspection Standards (NBIS) to assess the condition of its structures. Bridge conditions in Vermont are evaluated in four ways:

1. **Past National Practice:** Maintaining compliance with the long-term federal requirement to report on structurally deficient and functionally obsolete bridges.
2. **Current Vermont Practice:** VTrans has historically established performance limits based on the maximum percentage of structurally deficient bridges, excluding border bridges, allowed for the Interstate, State, and Town Highway systems (Table 3). These measures will remain in use.

Table 3: VTrans Structurally Deficient Performance Limits

System	Maximum Limit	
	Percent	Number
Interstate	6%	18
State	10%	81
Town Highway	12%	198

3. **Current (New) National Practice:** MAP-21 requires states to report on two performance measures for bridge condition. VTrans has started tracking these measures for all its bridges, including NHS border bridges. They are
 - a. Percentage of NHS bridges classified in Good condition
 - b. Percentage of NHS bridges classified in Poor condition

Definition:

Bridge Structural Deficiency

A highway bridge is classified as structurally deficient if the deck, substructure, or superstructure is rated in "poor" condition (4 or less on the NBI rating scale). A bridge can also be classified as structurally deficient if its load carrying capacity is significantly below current design standards or if a waterway below the bridge frequently overtops during flood events. The fact that a bridge is structurally deficient does not mean the bridge is inherently unsafe.

MAP-21 regulations require that no more than 10% of Vermont’s NHS bridge deck area be structurally deficient. Condition is determined by the lowest rating of deck, superstructure, substructure, or culvert. If the lowest NBI rating is greater than or equal to 7, the bridge is classified as good; if it is less than or equal to 4, the classification is considered poor. The MAP-21 targets in Table 4 were developed in coordination with the lone metropolitan planning organization (MPO) in Vermont, the Chittenden County Regional Planning Commission (CCRPC) and were due to FHWA for review in May 2018. On October 18, 2018 the CCRPC Board of Directors adopted the bridge and pavement performance measures developed by VTrans.

Table 4: VTrans MAP-21 Performance Targets for Bridges by Percent Deck Area

<i>NHS Bridge Condition Measures and Targets</i>	<i>Federal Performance Targets</i>
NHS Bridges classified as in Good Condition:	35.0% Minimum
NHS Bridges classified as in Poor Condition:	6.0% Maximum

* Baseline Statewide Performance Data (Submitted to FHWA 9/30/2018)

4. **Current Regional Practice:** The Vermont, Maine, and New Hampshire Departments of Transportation established the “Tri-State” cooperative agreement pledging to work together to further develop regional standardized performance measures for assets and business practices. The Annual Tri-State Report compares performance measures on bridge condition, pavement condition, sign performance, safety, and project delivery. The bridge, pavement, and safety measures are consistent with MAP-21 reporting requirements. The NBI rating is used by the three states as guidance to determine system-wide needs in three categories:
 - Cyclic maintenance needs (includes routine maintenance) = NBI 7-9,
 - Preventive maintenance needs (includes minor rehabilitation) = NBI 5-6,
 - Replacement or rehabilitation needs (includes major rehabilitation) = NBI 0-4.

Pavement Condition Measures and Targets

VTrans has been using two statewide performance measures to manage its pavement investments for more than 20 years. These measures, listed below, have guided VTrans investments in a manner that has placed it in a position to immediately comply with the MAP-21 pavement performance measures. The existing measures will continue to be used in combination with the new federal measures.

1. **Current State Practice**
 - a. Overall Network Pavement Condition – Maximum of 25% Very Poor pavement across the entire VTrans managed network. This measure helps VTrans manage the state-maintained pavement condition for transportation users across its entire network, including those roadways in the more rural areas with lower traffic volumes.
 - b. Travel Weighted Average Condition – Maintain a minimum pavement condition index of 70 across the entire VTrans managed network. (0-100 statewide index score) This measure evaluates the pavement condition for each 0.1-mile segment on all state and interstate highways and is “weighted” by traffic volume into a pavement condition index between 0-100. This measure balances the risks and needs of the state-maintained pavement system so that investments benefit as many transportation users as possible.

2. **Current (New) Federal Practice**

- a. Percentage of Interstate pavements in Good condition
- b. Percentage of Interstate pavements in Poor condition
- c. Percentage of Non-Interstate NHS pavements in Good condition
- d. Percentage of Non-Interstate NHS pavements in Poor condition

The targets for the MAP-21 measures are outlined in Table 5. They were developed in coordination with the CCRPC (MPO) and have been finalized and submitted to FHWA. MAP-21 rules established minimum thresholds for pavement condition on the interstate (no more than 5% Poor) and non-Interstate NHS (no more than 10% Poor).

Table 5: VTrans MAP-21 Performance Targets for Pavements

Asset Category	Measure	State Target		Federal Maximum	
NHS-Interstate	Good Condition	Minimum	35%	-----	
	Poor Condition	Maximum	4.9%	Maximum	5%
NHS-Non-Interstate	Good Condition	Minimum	30.0%	-----	
	Poor Condition	Maximum	9.9%	Maximum	10%

How Do All These Measures Come Together?

To pull the discussion of measures into tighter focus, Table 6 summarizes the required MAP-21 measures, the minimum targets set by FHWA, and the performance targets adopted by VTrans.

Table 6: Summary of Federal Asset Performance Measures and Targets

Federal Measure	Federal Targets	VTrans Adopted Targets
NHS bridges in Good condition (% deck area)	N/A	35.0%
NHS bridges in Poor condition (% deck area)	≤ 10%	6.0%
Interstate pavements in Good condition (% miles)	N/A	35.0%
Interstate pavements in Poor condition (% miles)	≤ 5%	4.9%
Non-Interstate NHS pavements in Good condition (% miles)	N/A	30.0%
Non-Interstate NHS pavements in Poor condition (% miles)	≤ 10%	9.9%

Current Condition of Bridge and Pavement Assets

This section presents an overview of the bridges and pavements in Vermont and their conditions. There are 1,141 miles of roads on the NHS and 483 bridges on the NHS in Vermont, see Table 7 for a breakdown of interstate and non-interstate highways. This table includes assets owned or maintained by VTrans and local municipalities, as well as NHS border bridges owned and maintained by New York and New Hampshire. Analyses in the TAMP covers all the roads and bridges on the NHS regardless of who owns or maintains them. For instance, VTrans is responsible for the maintenance of 467 of the 483 NHS bridges.

VTrans collects pavement data on the entire NHS. The 1,141 miles of NHS in Vermont includes 64 miles of ramps, spurs, and approaches. The NHS mileage used to calculate federal performance measures doesn't include them per regulations. This leaves 1,077 through-lane miles of NHS. VTrans owns or maintains 1,106 (97%) of these miles and municipalities are responsible for 35 (3%) of the through-lane miles. Of the 35 miles owned or managed by municipalities, 13 (37%) miles lie within the Chittenden County Metropolitan Area. VTrans coordinates with CCRPC and the municipalities to manage assets in the only metropolitan area of the state.

Figure 7: NHS Roads by Entity That Owns or Maintains Them

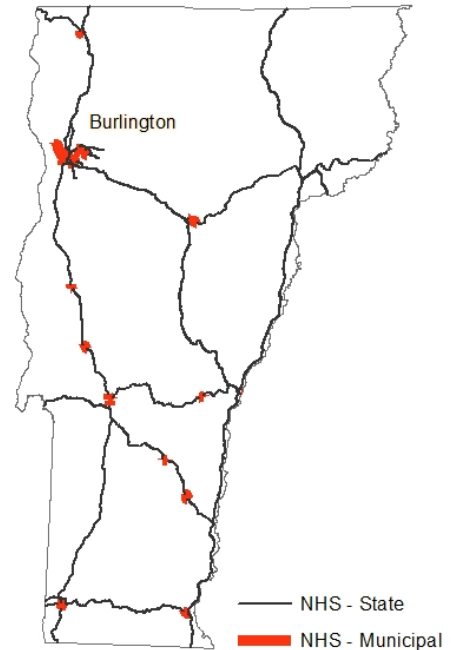


Table 7: Summary of VTrans' NHS Pavement & Bridge Inventory

NHS Pavement & Bridge System (Owner)	NHS Bridges (Number)	NHS Pavement (Miles)
Interstate (State)	313	699
Non-Interstate (State)	154	407
Non-Interstate (Municipality)	16	35
Total	483	1,141

Bridge Information

Bridge Data and Tools

VTrans inspects each bridge every two years unless there is increased risk, in which case the bridge is inspected more frequently. The Agency uses decades of component-level data. It is in its second cycle of gathering the element-level data for NHS bridges that is now required by FHWA. Bridge data has been managed in a Microsoft Access database. It is being transitioned to the database in the AASHTO BrM software.



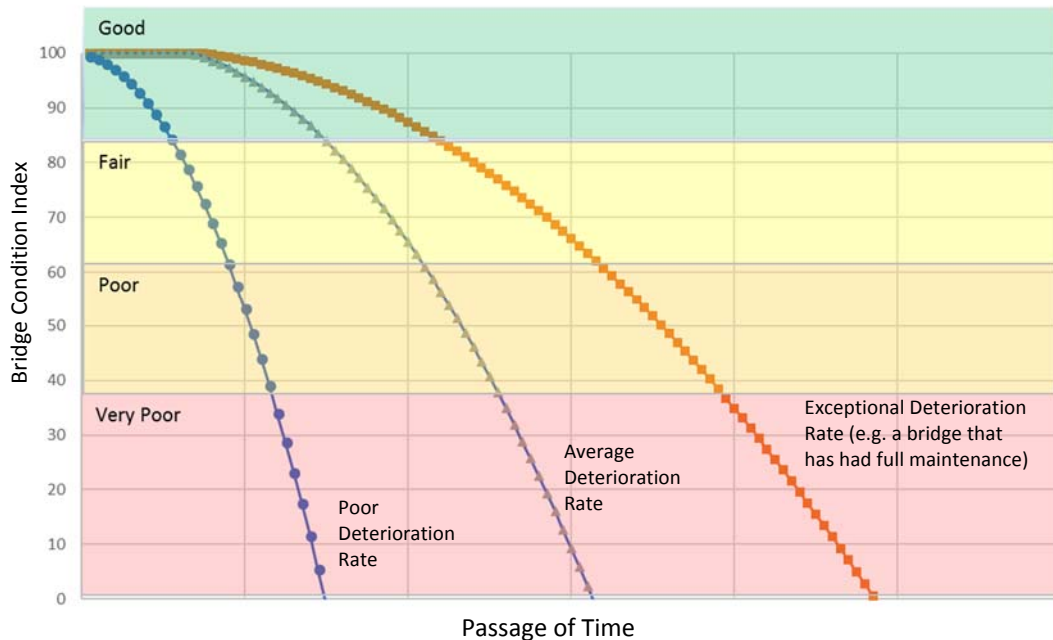
VTrans bridge inspectors at work.

VTrans has developed a bridge management system (BMS). In general, the BMS includes the items listed below. The location of information relative to each item in the TAMP is in parentheses.

- inventory of bridges and their characteristics (Chapter 2: Bridge Inventory)
- condition data from regular field inspections (Chapter 2: Bridge Inventory)
- methodology that forecasts deterioration over time (follows in this section)
- treatment costs (follows in this section)
- systematic process to identify the right asset treatment at the right time based on the current and forecasted condition to maximize the benefits at the lowest practical cost (follows)
- other factors and elements as useful (multiple chapters, including discussion of Life Cycle Planning in Chapter 6)

An integral part of managing any asset is understanding how its condition changes over time. Deterioration rates are commonly shown as curved lines that start almost flat and then curve down rapidly. Figure 8 depicts treatment costs at different condition levels and demonstrates how an asset ages—slowly when it is kept in good condition but rapidly if not adequately maintained. Performing preventive maintenance to keep an asset in good or fair condition is the most cost-efficient life-cycle planning strategy.

Figure 8: Typical Vermont Interstate Bridge Deterioration Curves



Source: Preliminary results from VTrans Bridge Deterioration Curves Project (April 2018)

To accompany the figure of bridge deterioration curves, Table 8 shows usual costs for different bridge treatments based on actual VTrans construction cost data. Deck treatments are an important element of bridge management, though analysis for superstructure and substructures is available as well. The table reinforces the efficiency of preventive treatments rather than allowing bridges to deteriorate to the point of need for early rehabilitation or replacement.

Table 8: Bridge Project Costs based on Work Type, reported in cost per SF (2017)

Treatment	NHS		Non-NHS	
	Interstate	Non-Interstate	State Highway	Town Highway
Replace	\$592	\$666	\$798	\$929
Major Rehab	\$445	\$535	\$607	\$878
Deck Rehab	\$232	\$328	\$453	\$740

Source: VTrans, 2018

The bridge deterioration curves and costs are examples of results flowing from the recent investments VTrans has made into research. VTrans currently uses a Markov-based approach to forecast long-term bridge needs and a step function process to calculate bridge deterioration over a shorter time span. These processes are being refined and updated.

Bridge Inventory

VTrans uses the term “long structures” to identify bridges with spans greater than 20 feet. There are 2,781 long structures in Vermont (including border bridges). Of these, 504 of the bridges are on the NHS, and additional 577 bridges are on non-NHS state highways, and 1,700 are on town highways. This inventory includes 33 border bridges. Of the 504 NHS bridges, 372 bridges are on the Interstate System.

While the number of bridges in Vermont is small compared to larger states, the ratio of bridges to people is unusually high. In Vermont, there are approximately 4.4 bridges per 1,000 people. This is the eleventh-highest number of bridges per capita in the United States.³

Bridge Conditions

VTrans evaluates bridge condition by asset class: Interstate, State Highway, and Town Highway bridges. In 2006, 11% of Vermont’s Interstate highway bridges were rated as structurally deficient and as a result there was a focus on investing in bridges. By 2016, this number had been reduced to 2%. All the bridge programs have met their performance targets since 2011. VTrans started measuring and tracking its performance for MAP-21 performance measures in 2017. Figure 9 shows the results using the 2016 data used for the 2017 submittal to FHWA.

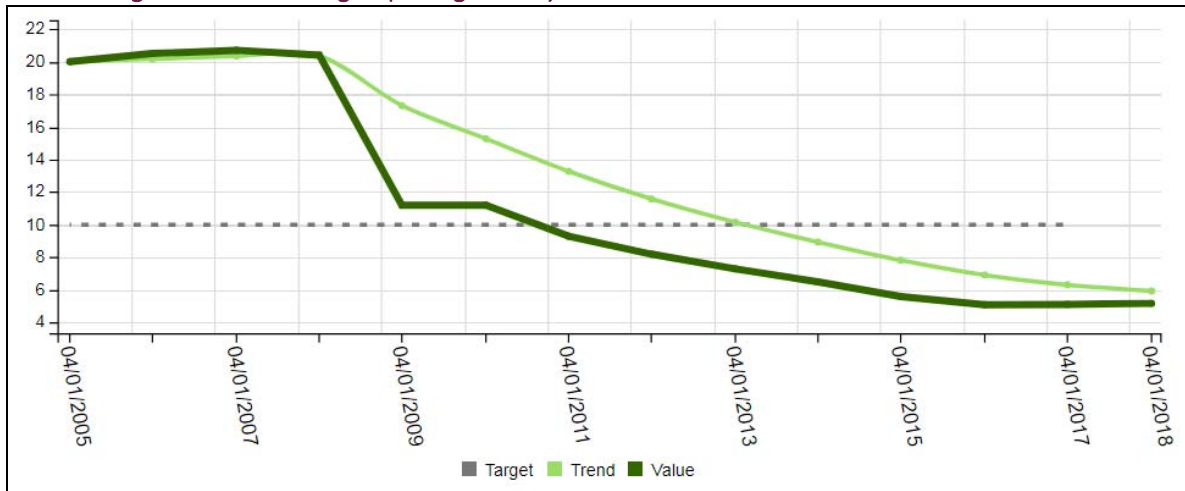
³ www.statemaster.com/graph/trn_bri_tot_num_percap-bridges-total-number-per-capita.

Figure 9: Percent Bridge Structural Deficiency by Asset Class

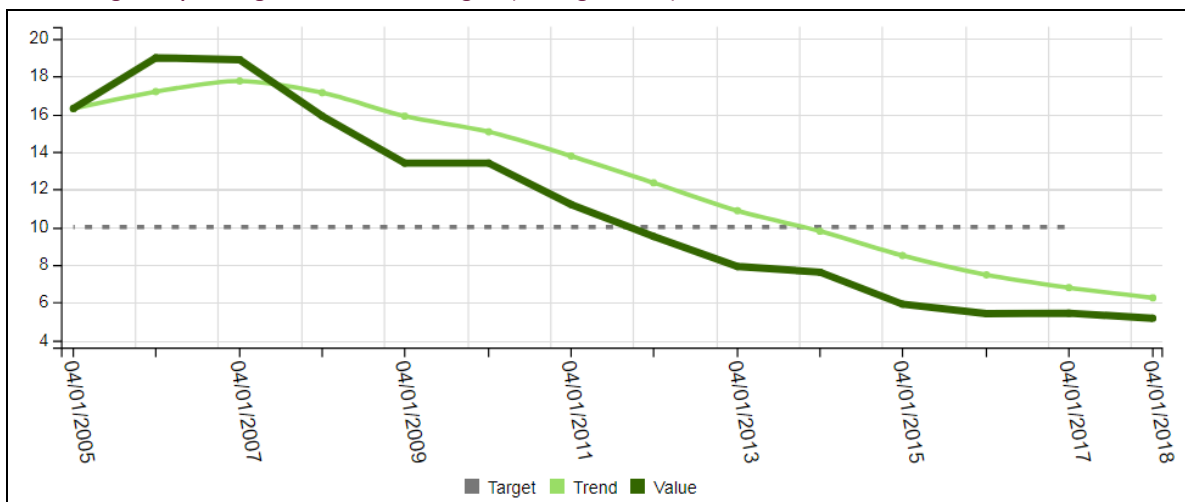
Interstate Bridge Data and Target (straight line)



State Bridge Data and Target (straight line)



Town Highway Bridge Data and Target (straight line)



Source for these figures and updates: <http://ootapps/tachometer/factsheet.html#33>

Current Process Issues for Bridge Assets

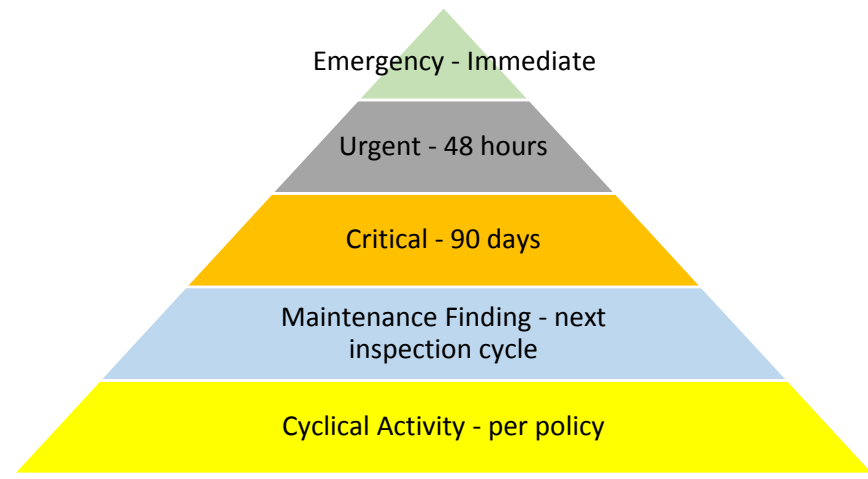
VTrans is satisfying all performance targets related to condition of NHS bridges. However, there is room for improvement in the processes the Agency uses for asset management. Some of the most important issues for bridge assets have been improving processes to address non-emergency problems when they are identified during inspections and advancing the BMS. VTrans is actively managing these issues. Broader challenges are covered in Chapter 5: Risk Management.

Issue 1: Communication and Prompt Action After Bridge Inspections

When a bridge inspector is in the field and identifies a problem, currently he or she notifies the district maintenance office. This notification is intended to result in an action to correct the issue but at times non-emergency items have gone into a long list subject to funding and staffing. The Districts, operating within these constraints, sometimes make reactive maintenance decisions that aren't consistent with the most effective long-term strategy. The loop of communication does not consistently get closed in a prompt and efficient manner.

- **Fix - Underway:** Starting as early as 2020, the bridge inspection team will enter bridge findings into VAMIS (described at end of Chapter 2). VTrans will use VAMIS to automate the process of issuing a work order, which will streamline the process and facilitate the communication of the issue in a timely manner. Automating the workflow will reduce delays, add accountability, and allow the repair cost to be linked to the correct expenditure account.
- **Fix – Underway:** During 2019 the bridge inspection team has been used to develop the summer 2019 Bridge Maintenance Work Plan. Part of this process is to define the risk level associated with a necessary repair. Work is defined as Emergency, Urgent, Critical, Maintenance Finding or Cyclical Activity. Each definition has a specified time frame within which the deficiency must be corrected.

Figure 10: Bridge Finding Classification



Issue 2: Bridge Data is a Bottleneck for Cross-Asset Optimization Processes

VTrans is working on its BMS but it has been challenging. Although additional development opportunities exist a network level analysis has been achieved. Further development will facilitate cross-asset optimization efforts.

- **Fix - Underway:** VTrans has completed the initial development of a network level bridge management system. In 2019 and expanding into 2020 VTrans will be implementing is VAMIS

solution. This solution will utilize and leverage the PMS and BMS to conduct trade-off analyses and cross-asset reallocation analyses over a 10 to 20-year time period to optimize VTrans' pavement and bridge investments. In 2020 and 2021 VTrans will add other assets into VAMIS to explore expanding the cross-asset optimization processes beyond pavement and bridge assets.

Issue 3: Lack of Commitment to Finalizing and Using Mature BMS

In the 1990s, Vermont ranked poorly in national bridge condition comparisons. Since then, VTrans has invested heavily in its bridges and has brought conditions to among some of the best in the nation. Investing in correct strategies to protect this investment while bringing other assets up to desired standards requires a BMS in full use and abilities to conduct cross-asset analyses.

- **Fix-Underway:** Since 2014, VTrans has made significant investments in developing its BMS. Currently the BMS utilizes the same software as the PMS. The project team took a step back to simplify the input and output to provide a reliable network level analysis. The BMS was trending toward a very complex system, however, a course correction resulted in a simplification of the system. This has been instrumental in developing the foundation of a reliable, trustworthy initial management system. VTrans will add complexity and customizations as it matures in this area. As of June 2019 VTrans, has achieved a valid output based on a network level analysis. This output can be used to program short-term bridge investments and to determine future asset needs. Some of the additional follow-up actions that are underway and will continue to be supported are listed below.
 - Use preliminary elements of the BMS even while some other elements remain in development to test it and build it into other processes.
 - Allocate enough staff time and resources to complete the BMS and institutionalize it.
 - Connect BMS output to internal and external performance measures.
 - Have a BMS champion tasked with communicating to senior management and outside decision-makers.
 - Roll out electronic tablets to bridge inspection staff to increase accuracy and efficiency in summer 2019.
 - Add elements to State Highway bridge inspections in 2020-2021; the elements will be selected to support specific data-driven investment decisions.
 - Continue to update FHWA's Local Division about the BMS and how VTrans is meeting the six BMS system requirements, in accordance with Section 515.17 of the Federal regulations as was done in May 2019.

Pavement Information

Pavement Data and Tools

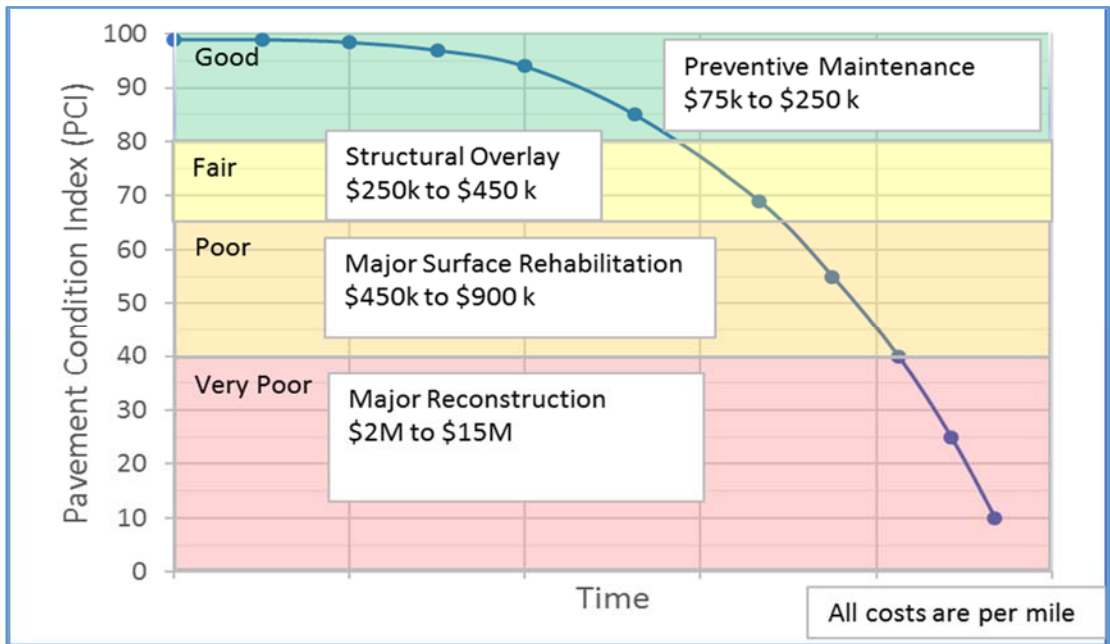
VTrans collects and updates network-level pavement data on the entire NHS system on an annual basis, including mileage managed by municipalities and the MPO. VTrans uses consultants to collect pavement data in tenth-of-a-mile (0.1 mile) segments. Each segment is assigned a Pavement Condition Index (PCI) rating of 1 to 100 based on rutting, cracking, and roughness parameters. This translates into Good, Fair, Poor, and Very Poor ratings. VTrans uses various control protocols to ensure the quality of the data.

The PMS has multiple components that function together to develop paving projects and support life-cycle planning. It uses dTIMS, an asset database and analysis tool. This software was developed by the Deighton company and implemented at VTrans in 1994. The database contains pavement condition and characteristics, project treatment history, traffic, and network definitions. Treatment families, triggers, and deterioration models all specific to Vermont have been developed, implemented, and refined over time. The analysis is configured to optimize the benefit to the network based on a given budget and allows for selection of project candidates and network condition forecasting.

Innovative Application:
Artificial Neural Network (ANN)
 These are computational models based on the structure of biological neural networks. Information that flows through the network affects the structure of the ANN because a neural network changes - or learns - based on it. VTrans is exploring the use of ANNs to compute bridge and pavement deterioration models.

Pavement deteriorates at different rates based on variables such as materials, treatments, freeze-thaw cycles, and use. Anticipated conditions are forecasted using evaluation of past trends in dTIMS.

Figure 11: Typical Vermont Pavement Deterioration Curve



Source: VTrans, 2018

Pavement Inventory

VTrans has categorized the highway network into customer service level tiers shown in Table 9. The service levels are related to vehicle miles traveled (VMT) and the annual average daily traffic (AADT). The CSL tiers may be used by the Agency in the future as the basis for different performance targets to determine different investment and corridor management strategies.

Table 9: Customer Service Levels of Roads (2017)

CSL Tier	CSL Description	Miles	% Miles	VMT	%VMT	AADT
1	Interstates & Divided Highways (NHS-Interstate)	719	23%	5,463,927	39%	7,600
2	Arterial Highways (NHS-Non-Interstate)	442	14%	3,392,912	24%	7,680
3	SHS-Regional Corridor	710	23%	2,546,362	18%	3,590
4	SHS-Local Connector	1,175	37%	2,177,286	15%	1,850
5	TH-Class 1 (non-NHS Class 1s)	100	3%	567,507	4%	5,660
Totals:		3146	100%	14,147,994	100%	

Source: VTrans, 2019

In 2019, CCRPC completed an update of highway functional class in the metropolitan area. This added key intermodal connectors and correcting inaccuracies, such as from when all arterials were placed on the NHS in 2012.

Table 10: NHS Mileage by System

Total	NHS – Total (Centerline Miles)		NHS – Interstate (Centerline Miles)		NHS - Non-Interstate (Centerline Miles)	
	Miles	%	Miles	%	Miles	%
	1141	100%	699	61%	442	39%

Source: 2019 – VTrans HPMS Data Submittal

Pavement Conditions

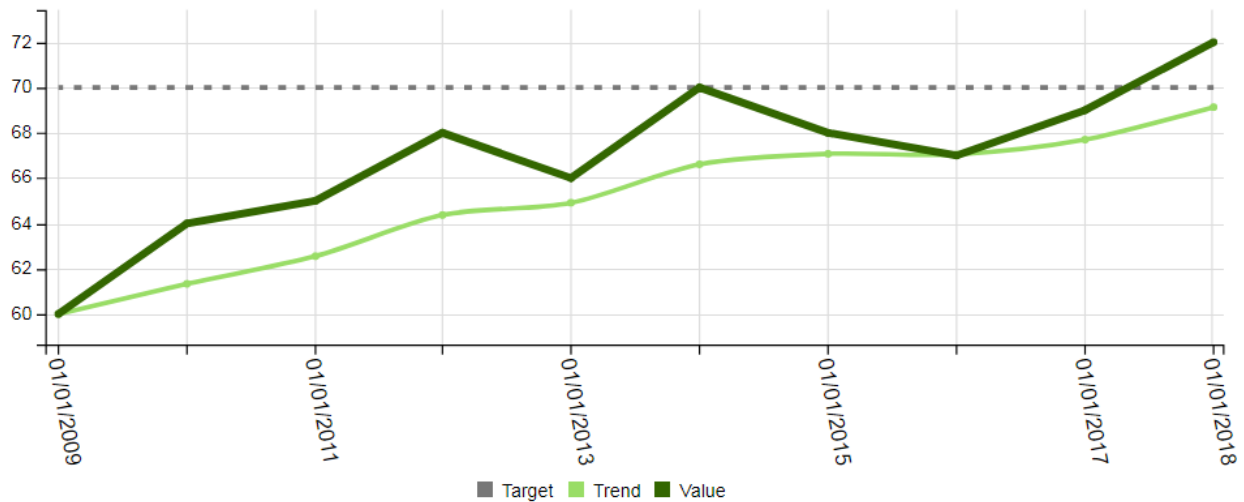
VTrans has used two pavement condition performance measures for years as described in the Objectives, Measures, and Targets section. The condition of the state-maintained road network using these measures is shown in Figures 12 and 13. Tracking the percent Very Poor network pavement condition shows Vermont has achieved its targets. It also shows that overall pavement condition can change quickly so it needs ongoing commitment. Achieving the target for the travel-weighted average network condition has been more challenging, but the measures are trending in a positive direction.

Figure 12: Pavement Condition Percent Very Poor



Source: <http://aotapps/tachometer/factsheet.html#1>

Figure 13: Travel-Weighted Average Network Condition

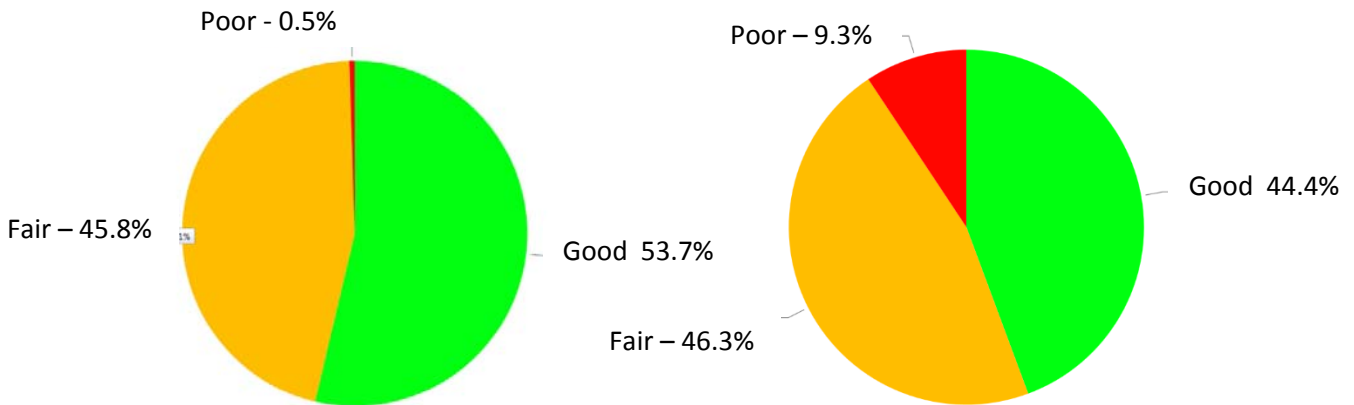


Source: <http://aotapps/tachometer/factsheet.html#1>

Years of using these two performance measures prepared VTrans to meet MAP-21 pavement management requirements. VTrans has started to use the MAP-21 performance measures for pavement. They are shown in Figures 14 and 15. The figures show that percent of pavement in poor condition (0.5%) on the NHS Interstate system is below our target of 4.9% in poor condition.

Figure 15: NHS - Interstate Pavement

Figure 14: Non-Interstate NHS Pavement Conditions



Source for both figures: 2018 Pavement Condition Data - VTrans TAMP, 2019

Overall, interstate pavement in Vermont is in good shape. The non-interstate NHS is more challenging. The non-interstate NHS has slower speeds and can accommodate greater rutting depths than the NHS-Interstate pavements. While the measures are the same as for the interstate system, targets and allowable thresholds are different.

Current Process Issues for Pavement Assets

VTrans is satisfying all the “Poor” performance targets related to pavement condition, however, there is room for improvement in the processes the Agency uses. Some of the more important short-term issues relate to keeping essential tools current and retaining institutional knowledge.

Issue 1: Pavement Deterioration Curves Require Updating and Validation Review

Current pavement deterioration curves are from 2008 and are being considered for updating. Treatment methods are being updated with materials or strategies that have come into use since the previous pavement deterioration curves were developed. Additional factors being improved for accurate predictive modeling include improving base and subbase materials information.

- **Fix-Underway:** VTrans has been investigating the adjustment of historic deterioration curves for the full range of investment strategies. Deterioration curves may be developed for new materials where such development is statistically relevant. In 2019 VTrans will acquire pavement base and subbase data along its Interstate mileage using a rolling weight deflectometer (RWD). Pending successful implementation, it is anticipated that the RWD will be expanded to the State Highway System where the RWD information would be employed to develop long-term, network strategies for both engineered and non-engineered pavements.

Issue 2: Inability to Retain Institutional Knowledge

Documenting and handing down institutional knowledge is important, especially with employees who are responsible for pavement management roles as they are spread across the Agency. VTrans has lost over 150 years of pavement management experience in the last two years and little of this knowledge was transferred in a proactive manner.

- **Fix – Underway:** Use the TAMP Practitioner Guide for asset stewards and managers to develop a common level of understanding and to transfer knowledge. In 2014, VTrans established two working groups, a Pavement Working Group and a Structures Working Group. Benefits of these teams include the interactions between asset subject matter experts (SMEs) that help form shared institutional knowledge. The meeting minutes provide written history of each group’s activities. Structure continues to be defined for an oversight team that includes Division and Bureau Directors that provides tasks to the working groups. A deliverable from each working group will be defined roles and improved processes for asset management across the Agency. Another deliverable is to understand how the Agency will select and deliver the next generation of employees who will commit themselves to managing Vermont’s pavements and bridges.

More Inventory Analysis

VTransparency provides public access to a range of contents such as bridge inspection reports and how pavement segments are deteriorating. It is available at <http://vtransparency.vermont.gov>. For additional information, see the *2019 VTrans Fact Book*.

Project Selection and Prioritization

VTrans invests in transportation improvements in a variety of ways such as maintenance activities, capital improvement projects, capital line items, and grant programs. Specific capital improvement projects are documented in the Agency’s annual Transportation Program. Projects proposed for federal funding are also included in the State Transportation Improvement Program (STIP). The status of VTrans’ construction projects is available through VTransparency. VTrans is currently working to link projected performance to investment dollars to provide justification for setting and maintaining asset investment levels, an approach cited by FHWA as the best evidence of TAMP implementation.

VTrans has been using a project prioritization process to manage its 400-plus projects with a variety of competing priorities. The existing project prioritization system is being replaced with a more-comprehensive approach: VPSP2 (discussed in Chapter 2).

Bridge Project Selection

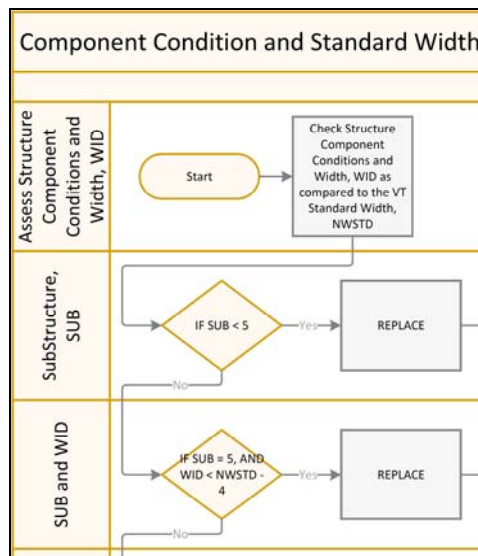
VTrans uses procedures to estimate short- and long-term budget needs for managing the condition of its bridges, however this process is less mature than the processes employed for managing pavements. As of 2019, funding decisions for bridge projects are based on

- asset condition;
- performance measures and targets;
- safety needs;
- regional priorities developed by the RPCs and VTrans district offices (15% weight).

Bridge SMEs refine the set of projects based on anticipated resources (staffing and funding). The BMS will help improve and mature this process with tools such as the treatment decision tree, internally developed cost estimator, and enhanced deterioration curves.

One tool in development is a bridge decision tree. It will suggest short-term and long-term approximate treatment decisions that can then be verified or enhanced with scoping tasks. It summarizes the long-structure inventory needs at a network level. The decision tree is a logic system that triggers or evaluates treatments depending upon the condition of current components. A small segment is shown in Figure 16 to illustrate how this works.

Figure 16: Sample of Bridge Decision Tree



Source: Component Condition and Standard Width Triggers from Page 10 of the Decision Tree Rough Draft Dated 02/16/2018.

Pavement Project Selection

As of 2019, funding decisions for paving projects are based on several considerations:

- analysis of pavement condition along each 0.1-mile pavement segment;
- benefit/cost ratios;
- investment levels intended to maximize pavement service life across the entire network;
- performance measures and targets– currently for the two state measures but MAP-21 measures are being added;
- improving safety;
- regional priorities developed by the RPCs and VTrans district offices (20% weight).

The PMS maximizes increase in service life; thus, priority is given to preventive treatments. The result is analyses and estimated costs for both short-term and long-term investment scenarios. SMEs review the range of considerations and then recommend projects for inclusion into the Transportation Program.

Statewide Transportation Improvement Plan

The Agency's **Statewide Transportation Improvement Program (STIP)** is a staged, multi-year, statewide, intermodal program of transportation projects funded by the Federal Highway Administration or the Federal Transit Administration. Projects listed on the STIP are consistent with the Statewide Long-Range Transportation Plan produced by the Vermont Agency of Transportation as part of a planning process that involves the Chittenden County Metropolitan Planning Organization. In general, the STIP covers a time period that is not less than 4 years. It is fiscally constrained by year and includes financial information that demonstrates which projects and project phases are to be implemented using current and projected revenues.

The STIP contains both capital and non-capital projects. The Agency's Asset Management Bureau develops a 5-year capital improvement plan for pavements and bridges that is fiscally constrained. This plan is developed using the data and information provided by the pavement and bridge management systems based on asset condition, most cost-effective treatment type, and maximized network benefits. The system output is validated by teams of subject matter experts. The resulting capital improvement plan is then integrated into the budget process where project schedules are adjusted, and costs are fiscally constrained. Once the fiscal year budget has been approved by the Budget Committee the Agency's STIP Coordinator incorporates the asset level improvements into the STIP.

Current Funding Gaps

Current funding provides approximately 70% of the monetary resources needed to maintain Vermont's transportation system in a state of good repair. In 2019, the gap is approximately \$250 million. The analysis for the short- and long-term is in the next chapter, Table 13: VTrans Funding Availability and Needs Analysis (2019).

Some of strategies that could be considered to help close the short- and long-term funding gaps are

- Increase gas tax and "purchase and use" revenue.
- Generate new revenue sources.
- Reduce customer service levels (winter maintenance).
- Reduce asset performance targets.
- Consider strategic disinvestment strategies so there would be fewer assets to maintain.

At a more specific and short-term scale, there is room for improvement in Agency decision-making processes. Some of the more important short-term issues relate to preparing data necessary for funding discussions and ways to encourage discussion by high-level decision-makers on how to address funding shortfalls.

Issue 1: Incomplete Data and Tools for Cross-Asset Allocation Analyses

For bridges, pavement, and the other assets that VTrans plans to incorporate into its future TAMPs, there is a need for detailed data prepared in a parallel way for each asset. Investment strategies will be generated based on current and predicted asset performance. The performance of the assets will be

linked to levels of investment so that VTrans can make informed decisions on where its limited funds may be best spent.

- **Fix – Underway:** Complete series of Asset Fact Sheets; these fact sheets flow from a spreadsheet-based approach to help bring a range of assets to a level where cross-asset allocation discussions can be done. The spreadsheet includes necessary items such as whether there is a GIS-based inventory, what is the quality of data, how is useful life modeled, and whether performance measures and targets have been developed.

Issue 2: Limited Discussion to Maximize Funding Across Assets

Given that VTrans only has approximately 70% of funding needed to maintain its transportation system in the short term, there are some discussions underway of how to maximize the benefit-cost ratio off agency investment decisions. However, VTrans will use this opportunity to conduct more in-depth discussion using what asset data is available utilizing a risk-based cross-asset allocation approach.

- **Fix – Underway:** An internal exercise is being organized for September 2019 to balance short-term asset needs with revenue. A spreadsheet-based tool with sliders for different asset funding levels and the resulting impacts on all assets has been drafted. These efforts are the beginning of a process to link investment dollars to asset performance. This will provide the Executive Team and taxpayers with a clearer picture of what the “budget is buying us.”

Summary of Existing Performance Gaps and Issues

This chapter has provided background about a range of current gaps or issues for asset management. These are specific process items, and all are being addressed with near-term fixes. These issues are combined with those identified in the next chapters on future performance issues and risk management. The risk management chapter addresses some of the larger and more complex challenges for asset management. It is followed by chapters that describe the categories of strategies and then next steps.

Table 11: Short-Term Process Issues

Context	Issue	Fix	Category of Strategy*
Bridge Issue 1	Communication and Prompt Action After Bridge Inspections	In 2020, have bridge inspection team enter bridge findings into VAMIS. Transfer to using VAMIS to issue work orders and otherwise improve processes.	Life-Cycle Planning
Bridge Issue 2	Bridge Data is a Bottleneck for Cross-Asset Optimization	Define a realistic interim point with timeframe for BMS to provide necessary data for bridge projects and cross-asset optimization.	Financial Planning and Benefit/Cost Analysis
Bridge Issue 3	Lack of Commitment to Finalizing and Using Mature BMS	Use preliminary elements of the BMS even while some elements remain in development. Allocate enough staff time to complete the BMS and institutionalize it. Include BMS in internal performance measures. Have a BMS champion tasked with communicating to senior management and outside decision-makers.	Life-Cycle Planning

Pavement Issue 1	Pavement Deterioration Curves Require Updating and Validation	Deterioration curves and range of strategies are being updated and then validated. VTrans is investigating the economic feasibility of acquiring pavement base and subbase data.	Data, Information, and Performance Management
Pavement Issue 2	Inability to Retain Institutional Knowledge	Use the TAMP Practitioner Guide to gather important knowledge. Develop asset centric working groups to share information and transfer knowledge. Become more proactive in workforce planning efforts.	Risk Management
Short-Term Funding Issue 1	Incomplete Data and Tools for Cross-Asset Allocation	Complete series of individual asset management plans in the Practitioner’s Guide. Continue spreadsheet-based approach to help bring a wide range of assets to a level where cross-asset allocation discussions can be done.	Data, Information, and Performance Management
Short-Term Funding Issue 2	Limited Discussion to Maximize Funding Across Assets	An internal exercise is being organized for mid-2019 that will be performance-based and risk-based to balance the short-term financial needs of assets with the available revenue. This is the start of an ongoing process.	Financial Planning and Benefit/Cost Analysis

**Category of strategies that best describes the main approach to fixing this gap or issue, recognizing that real fixes include multiple strategies. For more information on each category of strategies, see Chapter 6: How VTrans Improves Assets.*

Source: VTrans TAMP, 2018

4. FUTURE PERFORMANCE ISSUES (10-YEAR HORIZON)

Transportation Trends

The future holds many challenges for managing Vermont’s roads, bridges, and other assets. The TAMP focuses on a 10-year horizon but needs to consider trends further out to prepare efficiently. Nine foreseeable trends are described in this section. The first two are so important that they each have their own section later in the document.

1. *Asset Needs are Increasing* – Asset needs are increasing at an accelerated pace, in part because bridges built after the 1927 flood and sections of the Interstate system are reaching the end of their useful life. There was major expansion of the Interstate highway system in Vermont between 1958 and 1978. Population in Vermont grew at its highest rate at that timeframe, so many other roads were built or expanded then too. Customers are requesting smoother pavements and fewer potholes, but there is limited funding to support these increased services.
2. *Transportation Revenues are Decreasing* – Revenue is not increasing at the same rate as the assets are deteriorating, resulting in an asset sustainability index (ASI) that continues to decline. Limited support for tax increases makes that an unlikely solution.

3. *Sprawl and Vehicle Miles Travelled (VMT) Growth* - Land development and transportation investments that are not coordinated and well-planned drive up infrastructure costs. While Vermont has made important efforts to focus growth in centers where transportation and other assets can be provided efficiently, sprawl is a continuing trend. Sprawl is associated with needing to travel outside of city or town growth centers and as a result, transportation users drive more miles, often alone, and with fewer transportation options. In the last 50 years, VMT in Vermont has tripled. It has increased more than twice as fast as the Vermont population. Although the rate of increase slowed during the recent national recession and period of high gas prices, VMT is once again on the rise.
4. *Aging Population* - Vermont has the second oldest population of all the states, with only Maine having an older median age. In addition, population growth between 2010 and 2017 was the 49th slowest among the 50 states. Some potential implications for asset management are
 - Need to modify design standards and retrofit existing assets to better accommodate drivers with slower reaction times and less visual acuity, who may make shorter trips, and who may come to rely on a broader range of transportation options.
 - Potential for fewer people to fill jobs and pay taxes that support transportation investments.
5. *Water Quality Impacts of Transportation* - VTrans needs to reduce the impacts of transportation on water quality. The water quality improvement efforts are mandatory under Vermont's Clean Water Act (Act 64 of 2015), Statewide Transportation Separate Storm Sewer System (TS4) permit, and Lake Champlain Total Maximum Daily Load (TMDL) of phosphorous. This is anticipated to involve new costs to VTrans on the order of \$50 to \$90 million over 20 years.
6. *Safety Downtrend* – Crashes and fatalities in Vermont have been trending up since 2014 after over 40 years of trending down. Similar trends are being reported across the nation. For further analysis see <http://vermonthighwaysafety.org/data>. For Vermont's safety strategy commitments, see <http://vermonthighwaysafety.org/about-us/strategic-highway-safety-plan/>.
7. *Impacts of Changed in Freight Movement* – The size and weight of trucks is increasing. Truck volumes continues to grow with changes in how businesses and people expect to receive goods, including just-in-time requirements. Interstate vehicle size and weights in Vermont have increased beyond the federal bridge formula and may significantly impact durability and life cycle cost for pavements and bridges.⁴
8. *Changing Technology* – Technology will continue to change rapidly, with significant impacts to transportation infrastructure. In Vermont, Transportation System Management and Operations (TSMO) is leading the way to manage mobility rather than building new lane miles. There is hope that connected and autonomous vehicles will improve safety, mobility, and accessibility. However, much is unknown about intended and unintended consequences. Technology that allows vehicles to communicate with infrastructure will likely become more prevalent. This would increase the demand for an asset class in the early stages of deployment. This technology also creates an opportunity to incorporate more efficient, automated tracking and management of asset condition. Data has become an asset that will requires management and is why the Agency created a Data Management Section in 2014.

⁴ Vermont Pilot Program Report - Chapter 8 - https://ops.fhwa.dot.gov/freight/sw/reports/vt_pilot_2012/index.htm

9. *Increase in Extreme Weather* - The Northeast has experienced a greater increase in extreme precipitation than any other region. Between 1958 and 2012, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (the heaviest one percent) according to the National Climate Assessment. Climate changes including larger temperature swings and more freeze-thaw cycles which increase asset life-cycle costs and the risk of bridge and pavement failure.

Bending Trends Toward Policy Goals

It can be tempting to use asset management analyses in a vacuum, but to be effective it is important to consider a bigger picture of trends and policy goals. The policy considerations described in this section draw from Vermont's Long-Range Transportation Plan, VPSP2, Governor Scott's strategic goals (Executive Order 01-17), national goals identified in 23 U.S.C. 150(b), and additional VTrans efforts.

1. *Improve safety and security across all transportation modes.* Improving safety for the public includes protecting those that are most vulnerable such as bicyclists and pedestrians. Similarly, protecting infrastructure also includes protecting the most vulnerable assets from climatic events. While considering resiliency is a safety priority so is ensuring preparedness for technological changes such as automated vehicles.
2. *Preserve Vermont's multimodal transportation system and optimize its performance.* This is the long-range transportation plan goal that most relates to asset management. Elements include keeping the transportation system in a state of good repair, managing congestion, increasing reliability, keeping costs down, and being innovative.
3. *Provide transportation choices and accessibility for everyone.* An interconnected, multimodal system keeps people and goods moving where they need to go.
4. *Leverage transportation investments to increase Vermont's economic vitality.* This includes considering whether transportation projects increase access to jobs as well as various ways the projects themselves benefit the economy. Efficient processes, such as minimizing project delivery delay and focusing investments to contribute towards Vermont's economic vitality. Focusing investments includes coordinated engagement in town centers and growth areas.
5. *Practice environmental stewardship.* VTrans values the scenic and mostly pristine environment that envelops much of our transportation infrastructure. One of the eight evaluation criteria proposed for future projects is environmental protection and preservation. This is a policy trend that will be continued and driven by regulations such as the Clean Water Act and the stormwater regulations, and the desire to reduce the amount of pollutant flowing into Lake Champlain from or via our transportation system. The need to enhance how transportation investments can protect and improve water quality is one of the many areas for attention.
6. *Support livable, healthy communities.* Vibrant communities advance efficient use of transportation assets. They increase access to health services and recreation opportunities that improve overall health and wellness. Efficient and thoughtful development coordinated with transportation investments is a proven path to sustainable economic growth. A source for more information is [Strengthening Vermont's Economy by Integrating Transportation and Smart Growth Policy](#) (Smart Growth America and VTrans, 2013)

Future Bridge and Pavement Asset Conditions

This section includes analysis of the anticipated future condition of bridge and pavement asset conditions, focusing on the next 10 years. This work needs to recognize that there are many unknowns that will shape future asset conditions and expectations including, but are not limited to

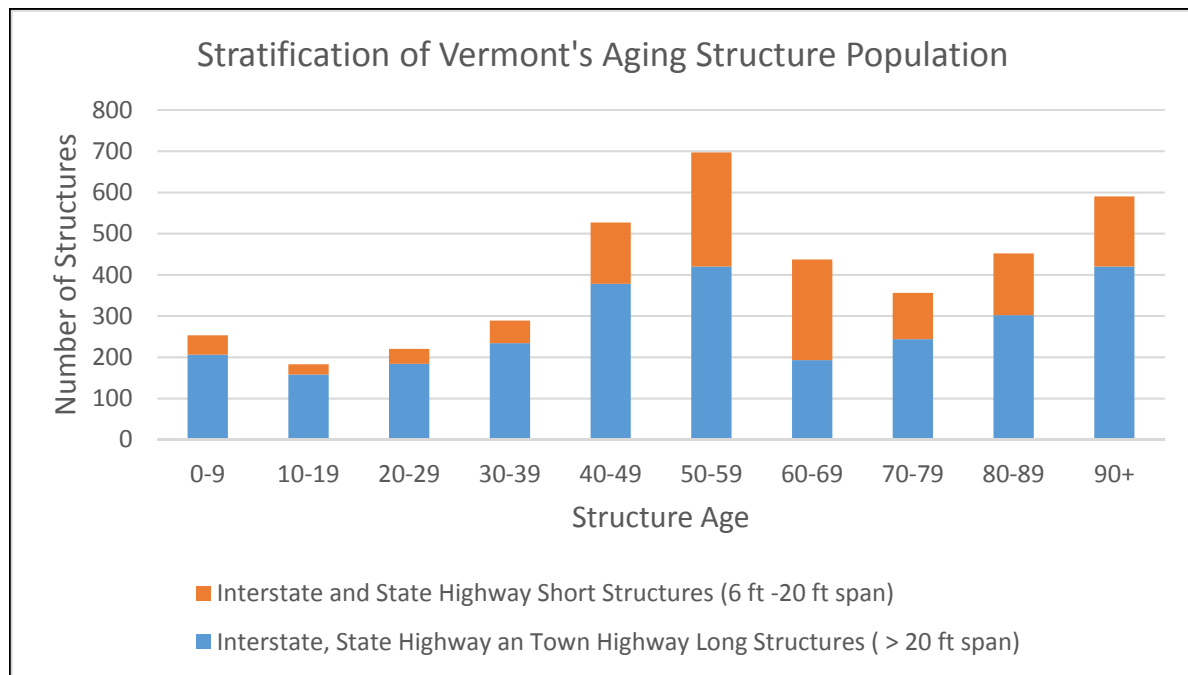
- accuracy of predictive deterioration models;
- control that the right treatment is completed at the right time;
- material quality and performance;
- availability of high-quality workmanship;
- changing technologies and engineering approaches;
- shifting policies and regulations that call for changes in investment level or type.

Anticipated Bridge Conditions

It is more difficult to anticipate the future condition of bridges than many other assets because of their longer lifespans and structural complexities. For example, VTrans may have details about the last few projects constructed to maintain the pavement of a road, but it may have limited design drawings with no supporting documentation for bridges built in the 1920s. Without good historical data it is more difficult to anticipate future needs.

There have been periods of concentrated bridge investment in Vermont. Some examples are after the 1927 flood, during the expansion of the interstate system between 1958 through 1978, and after Tropical Storm Irene in 2011. Almost 60% of the bridges in Vermont were built 50 or more years ago. This combination creates investment risk related to the “humps” of need that may arise during concentrated periods of time as the structures reach the end of their lifespans, as shown in Figure 17.

Figure 17: Structure Count by Age in Years



Source: Data from VTrans 2018 Fact Book and Annual Report p. 27

VTrans has been able to keep up with its increasing bridge demands, primarily because it has increased its investments levels. They have grown from \$20-30 million per year during 1995 to 2000, \$40 to \$65 million per year during 2001 to 2009, and from \$80 to \$110 million per year during 2010 to 2015, with a spike of \$140 million in 2015. This is partially because several large, complex bridges recently needed replacement. Such large investments in asset renewal presents a risk to addressing annual maintenance needs. If VTrans is investing heavily in bridge reconstruction what preventive maintenance items aren't getting done?

The future needs for bridges will be shaped by changing policies. VTrans has recently been applying a back-to-basics approach in keeping with national best practices. Back-to-basics emphasizes cyclical and preventive maintenance needs. Additional policy-related matters that affect future needs include

- preparing for uncertain funding and other risks;
- how bridge priorities are set, for example the importance of AADT, length of detour, and local input;
- how much time is invested in building internal expertise and how many projects should be contracted out to consultants;
- level of commitment to providing pedestrian and bicyclist access across bridges.

Medium-Term and Future Bridge Management Issues

Continuing adoption of preventive maintenance and finalizing the BMS will continue. Some longer-term issues for bridge assets are making the “humps” of bridge needs more manageable and making Vermont’s bridges more resilient. Issues are relatively specific items while broader challenges, including more on resiliency, are covered in Chapter 5: Risk Management.

Issue 1: Large Amount of Bridge Needs Concentrated within a Few Distinct Time Spans

Periods of focused bridge investment in the past are creating “humps” of future needs that must be managed proactively. VTrans is working in several ways to manage these future demands.

- **Fix – Underway:** Use institutional knowledge and analysis to schedule rehabilitation or replacement projects to “flatten out” or spread the bridge needs out over longer time periods. Enhance coordination with internal (Maintenance and Operations) and external partners (consultants, contractors, permitting staff) to ensure resource availability.

Issue 2: Statewide Bridge System is Not Prepared for Climate Change

Climate change is bringing more extreme weather to Vermont. The high temperatures, freeze-thaw cycle frequency, and severe storm frequency create stresses on bridges that shorten their life span. The extent of extreme weather risks for bridges is not known and documenting them is a first step toward managing them. See the risk chapter for additional background.

- **Fix – Underway:** Identify bridges at risk due to extreme weather, in part by using the Transportation Flood Resilience Planning Tool and Part 667 tasks to reduce repeat damages. Revise standards to become more prepared for climate change and seismic activity.

Issue 3: Inconsistent Funding and Prioritization of Preventive Bridge Treatments

It takes time and attention to shift to a focus on preventive bridge treatments. This includes shifts in budgeting, planning, programming, engineering, and maintenance. In past budget crises, a reaction was to rescind state-funded projects such as Statewide Bridge Maintenance. VTrans must identify the right amount of preventive maintenance for its bridges and ensure these activities are completed.

- **Fix – Underway:** Continue to evaluate effective preventive maintenance, schedule it on a regular cycle, and communicate why it is important inside and outside of VTrans. Run analyses to determine the amount of preventive maintenance that maximizes asset service life.

Anticipated Pavement Conditions

VTrans has been developing its PMS since 1995. It is a mature system that supports forecasting pavement needs and evaluating scenarios of how to best meet short- and long-term targets.

VTrans conducts statewide transportation public opinion surveys that inform the long-range transportation plan, the strategic plan and this TAMP. The 2016 results were like those from 2006 and 2000. The most important services and issues continue to be winter snow and ice removal, ensuring the safety of the traveling public, and bridge and pavement conditions. A related survey was conducted in 2017 on how customers rate different conditions of pavement. This work may result in revisions to pavement condition categories or performance targets. The research may help answer the questions; “How are we doing?” and “How do we know?”

Some long-term pavement needs are known, and some are not, for example

- On the State Highway System there is a lack of information on the condition of the pavement base and subbase materials. Roads with a stable engineered sub-base have a longer life.
- Some state highways were built with concrete pavement that was later removed and replaced with bituminous concrete. Removal of remaining slabs is a long-term undertaking included in the TAMP Financial Plan.
- Recent pavement condition data suggests that just surface treatments on the ageing interstate system are not going to be the cost-effective much longer. One strategy under consideration is to rehabilitate and reconstruct approximately 50% of the interstate network over the next 40 years. Costs for the range of strategies are included in Table 12.

Table 12: Cost by Pavement Investment Strategy

Pavement Investment Strategy	Investment Period (years)	Annualized Cost per Year (millions)
Removal of Concrete Slabs under State Highway System and full depth reconstruction	20	\$109
Reconstruction of State Routes: Assume 20% Rehabilitation and 5% Reconstruction	20	\$67
Rehabilitate and Reconstruct Interstate Routes: Assume treating 50% of Interstate in next 40 years (75% rehab and 25% reconstruction)	40	\$38
	Total:	\$214

Source: VTrans, 2018

Medium-Term and Future Pavement Management Issues

Issues are relatively specific items while broader challenges are covered in Chapter 5: Risk Management. The issues include preparing for an increase in pavement segments reaching the end of their life and for the effects of climate change. The following priority process issues are being actively managed.

Issue 1: Lack of Strategic Planning for Where to Invest in Aging Pavement

An increasing percentage of pavement segments will be reaching the extent of their design life in the next 10 years.

- **Fix – Underway:** Provide enough personnel and train them for strategic consideration of where and how to invest limited resources. Follow up customer pavement condition perception survey results to use knowledge gained. Coordinate with the CCRPC, the State’s lone Metropolitan Planning Organization (MPO), as a significant amount of the NHS pavement that will reach the end of service life are in the Chittenden County metropolitan area. Develop a 10-year pavement asset management plan to assist with corridor management planning, resource planning, and investment analyses.

Issue 2: Lack of Preparedness for Climate Change Effects on Roads

As noted for bridges, Vermont’s climate is changing and stressing pavements and associated elements of roads in ways that decrease their lifespans.

- **Fix – Underway:** Expand Transportation Flood Resilience Planning Tool from test locations to statewide. Identify a champion to incorporate resilience in pavement asset management. Identify strategies to mitigate the effects of climate change on pavement performance. Prepare GIS database of pavements damaged by extreme weather events and participate in repeatedly damaged facilities task.

Funding Levels and Needs Over Next 10 Years

A pressing question across all assets is how to provide desired results within available funding. To answer this question, it is necessary to explore

- How much money will be available in the analysis period?
- What revenue or resources would be needed to achieve desired asset conditions and goals—and do any of those need adjusting?
- How do the needs compare to the existing revenue—what is the gap?

A summary of the results of exploring these questions is provided in this section, there is more detail available in the VTrans TAMP Financial Plan.

Vermont Transportation Revenue Sources

Vermont has two primary transportation revenue sources: federal funds that make up approximately 52% of the VTrans budget, and state funds. State funds come from sources including fuel taxes, fines, motor vehicle registration, and other vehicle purchase and use fees. The most significant is purchase and use taxes which provide on the order of 33% of state transportation funding. There are also one-time federal funding infusions such as emergency funds after emergency declarations or through grant programs.

The discussion of VTrans future funding levels started with examining current funding sources. Matters explored include projecting future funding levels and examining what other funding sources are likely in the future. After an evaluation of the historic consumer price index and through discussions with the Agency’s Chief Financial Officer, a two-percent growth rate was assumed early in the development of the Financial Plan. Estimated funding levels for FFY2020 through FFY2030 started with developing 20-year projections and then refining those back to more-certain 10-year values. These projections for all VTrans funding sources are included in Table 13. A financial risk for Vermont, like other rural states with

small populations, is that it continues to rely heavily on federal funds to meet its transportation needs. Since the inception of the Financial Plan, tables of anticipated funding levels have been revised approximately once per year.

Anticipated Transportation Asset Financial Needs

VTrans projected its funding needs for 20 years based on

- historic expenditures,
- system and asset conditions;
- future asset deterioration based on management systems;
- life-cycle planning investments necessary to maintain or improve assets;
- implementation of current policy requirements (e.g. for stormwater management).

As with anticipated funding, only the first ten years are included because they are the most reliable. The estimates include minor capacity additions but no major ones. VTrans estimated annualized funding needs are included in Table 13. It is important to also consider the risks covered in Chapter 5.

Table 13: VTrans Funding Availability and Needs Analysis (2019)

	FFY2020	FFY2021	FFY2022	FFY2023	FFY2024	FFY2025	FFY2026	FFY2027	FFY2028	FFY2029	FFY2030
Available Funding (millions, by SFY, assumes 2% growth):											
FHWA annual formula	\$216.8	\$220.9	\$225.1	\$229.4	\$233.8	\$238.3	\$242.9	\$247.5	\$252.3	\$257.1	\$262.1
Federal discretionary	\$12.0	\$12.0	\$12.0	\$12.0	\$12.0	\$12.0	\$12.0	\$12.0	\$12.0	\$12.0	\$12.0
FHWA other: obligated unspent from prior years, etc.	\$46.5	\$46.5	\$46.5	\$46.5	\$46.5	\$46.5	\$46.5	\$46.5	\$46.5	\$46.5	\$46.5
Total FHWA	\$275.3	\$279.4	\$283.6	\$287.9	\$292.3	\$296.8	\$301.4	\$306.0	\$310.8	\$315.6	\$320.6
FTA	\$21.6	\$22.1	\$22.5	\$23.0	\$23.4	\$23.9	\$24.4	\$24.9	\$25.4	\$25.9	\$26.4
FAA	\$9.4	\$9.5	\$9.7	\$9.9	\$10.1	\$10.3	\$10.5	\$10.7	\$11.0	\$11.2	\$11.4
FRA	\$7.8	\$8.0	\$8.1	\$8.3	\$8.4	\$8.6	\$8.8	\$9.0	\$9.1	\$9.3	\$9.5
Other federal	\$5.5	\$5.7	\$5.8	\$5.9	\$6.0	\$6.1	\$6.2	\$6.4	\$6.5	\$6.6	\$6.8
Total Federal	\$319.6	\$324.7	\$329.8	\$335.0	\$340.3	\$345.8	\$351.3	\$357.0	\$362.7	\$368.6	\$374.6
Local/Other (VTrans managed budget)	\$4.7	\$4.8	\$4.9	\$5.0	\$5.1	\$5.2	\$5.3	\$5.4	\$5.6	\$5.7	\$5.8
State Transportation Fund	\$263.1	\$268.4	\$273.7	\$286.2	\$291.9	\$297.8	\$310.7	\$316.9	\$323.3	\$336.7	\$343.5
State TIB Fund	\$13.5	\$13.7	\$14.0	\$14.3	\$14.6	\$14.9	\$15.2	\$15.5	\$15.8	\$16.1	\$16.4
State Bonds	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
Total Available Funding	\$600.9	\$611.6	\$622.4	\$640.5	\$652.0	\$663.6	\$682.5	\$694.8	\$707.3	\$727.1	\$740.3
Needs (millions):											
Department of Motor Vehicles	\$33.1	\$34.0	\$34.8	\$35.7	\$36.6	\$37.5	\$38.4	\$39.4	\$40.4	\$41.4	\$42.4
Finance & Administration	\$15.5	\$15.9	\$16.3	\$16.7	\$17.1	\$17.5	\$18.0	\$18.4	\$18.9	\$19.4	\$19.8
Paving	\$101.8	\$104.4	\$107.0	\$109.7	\$112.4	\$115.2	\$118.1	\$121.1	\$124.1	\$127.2	\$130.4
Bridges	\$99.5	\$102.0	\$104.6	\$107.2	\$109.9	\$112.6	\$115.4	\$118.3	\$121.3	\$124.3	\$127.4
Roadway	\$221.0	\$226.6	\$232.2	\$238.8	\$245.9	\$252.1	\$258.5	\$265.1	\$271.8	\$278.7	\$285.8
Traffic & Safety	\$21.9	\$22.5	\$23.0	\$23.6	\$24.2	\$24.8	\$25.4	\$26.1	\$26.7	\$27.4	\$28.1
Park & Rides	\$3.2	\$3.3	\$3.4	\$3.5	\$3.6	\$3.7	\$3.7	\$3.8	\$3.9	\$4.0	\$4.1
Bike & Ped Facilities	\$11.9	\$12.3	\$12.6	\$12.9	\$13.2	\$13.5	\$13.9	\$14.2	\$14.6	\$14.9	\$15.3
Transportation Alternatives	\$3.4	\$3.5	\$3.6	\$3.7	\$3.8	\$3.9	\$4.0	\$4.1	\$4.2	\$4.3	\$4.4
Program Development Administration	\$23.8	\$24.4	\$25.0	\$25.6	\$26.3	\$26.9	\$27.6	\$28.3	\$29.0	\$29.7	\$30.5
Rest Areas	\$0.7	\$0.7	\$0.7	\$0.8	\$0.8	\$0.8	\$0.8	\$0.8	\$0.9	\$0.9	\$0.9
Policy & Planning	\$11.2	\$11.5	\$11.8	\$12.1	\$12.4	\$12.7	\$13.0	\$13.3	\$13.6	\$14.0	\$14.3
Maintenance	\$105.6	\$108.3	\$111.0	\$113.7	\$116.6	\$119.5	\$122.5	\$125.6	\$128.7	\$131.9	\$135.2
Public Transit	\$34.0	\$34.9	\$35.7	\$36.6	\$37.6	\$38.5	\$39.5	\$40.4	\$41.5	\$42.5	\$43.6
Aviation	\$7.4	\$7.6	\$7.8	\$8.0	\$8.2	\$8.4	\$8.6	\$8.8	\$9.0	\$9.3	\$9.5
Rail	\$37.8	\$38.8	\$39.8	\$40.7	\$41.8	\$42.8	\$43.9	\$45.0	\$46.1	\$47.3	\$48.4
Central Garage	\$20.1	\$20.7	\$21.2	\$21.7	\$22.2	\$22.8	\$23.4	\$24.0	\$24.6	\$25.2	\$25.8
Transportation Buildings	\$2.9	\$3.0	\$3.1	\$3.2	\$3.3	\$3.3	\$1.7	\$1.7	\$1.8	\$1.8	\$1.9
Transportation Board	\$0.3	\$0.3	\$0.3	\$0.3	\$0.3	\$0.3	\$0.3	\$0.3	\$0.3	\$0.4	\$0.4
Town Programs	\$98.7	\$101.2	\$103.7	\$106.3	\$109.0	\$111.7	\$114.5	\$117.4	\$120.3	\$123.3	\$126.4
Total Needs	\$853.9	\$875.8	\$895.6	\$925.8	\$948.9	\$972.7	\$995.3	\$1,020.2	\$1,045.7	\$1,071.8	\$1,098.6
Available Funding - Need (millions):	(\$253.0)	(\$264.2)	(\$273.1)	(\$285.3)	(\$297.0)	(\$309.0)	(\$312.7)	(\$325.3)	(\$338.3)	(\$344.7)	(\$358.3)

Source: 2019 VTrans TAM Financial Plan

Bridge Investment Levels and Needs

Bridge investment needs are high due to the large number, age, and condition of bridge assets. This is a significant risk particularly with limited revenue growth. Funding for bridges includes budgets for interstate, state highway, and town highway bridges.

In 2013, the Agency issued “Vermont Transportation Funding Options Section 40 Act 153,” (the Section 40 Report). This report formed the basis for the establishment of a \$152 million need. The ASI analysis in it remains accurate about bridge funding gaps. When examining the current level of bridge funding, the annualized ASI would trend between 0.6 and 0.7 which corroborates the agency-level ASI in Table 14.

Table 14: VTrans Asset Sustainability Index (ASI)

Budget Year	2% Budget Growth	Anticipated Need	Infrastructure Gap	ASI
2020	\$600.9	\$853.9	(\$253.0)	0.70
2021	\$611.6	\$875.8	(\$264.2)	0.70
2022	\$622.4	\$895.6	(\$273.1)	0.70
2023	\$640.5	\$925.8	(\$285.3)	0.69
2024	\$652.0	\$948.9	(\$297.0)	0.69
2025	\$663.6	\$972.7	(\$309.0)	0.68
2026	\$682.5	\$995.3	(\$312.7)	0.69
2027	\$694.8	\$1,020.2	(\$325.3)	0.68
2028	\$707.3	\$1,045.7	(\$338.3)	0.68
2029	\$727.1	\$1,071.8	(\$344.7)	0.68
2030	\$740.3	\$1,098.6	(\$358.3)	0.67

Note: Dollar values are in millions

Source: VTrans, 2019

The estimate of bridge needs in the Section 40 report was based on when work will be required on each bridge included in the inventory estimated by age and asset condition. Table 15 describes a schedule for different improvements over the lifecycle of a typical bridge.

Table 15: Assumed Life-Cycle Improvements for Long Structures

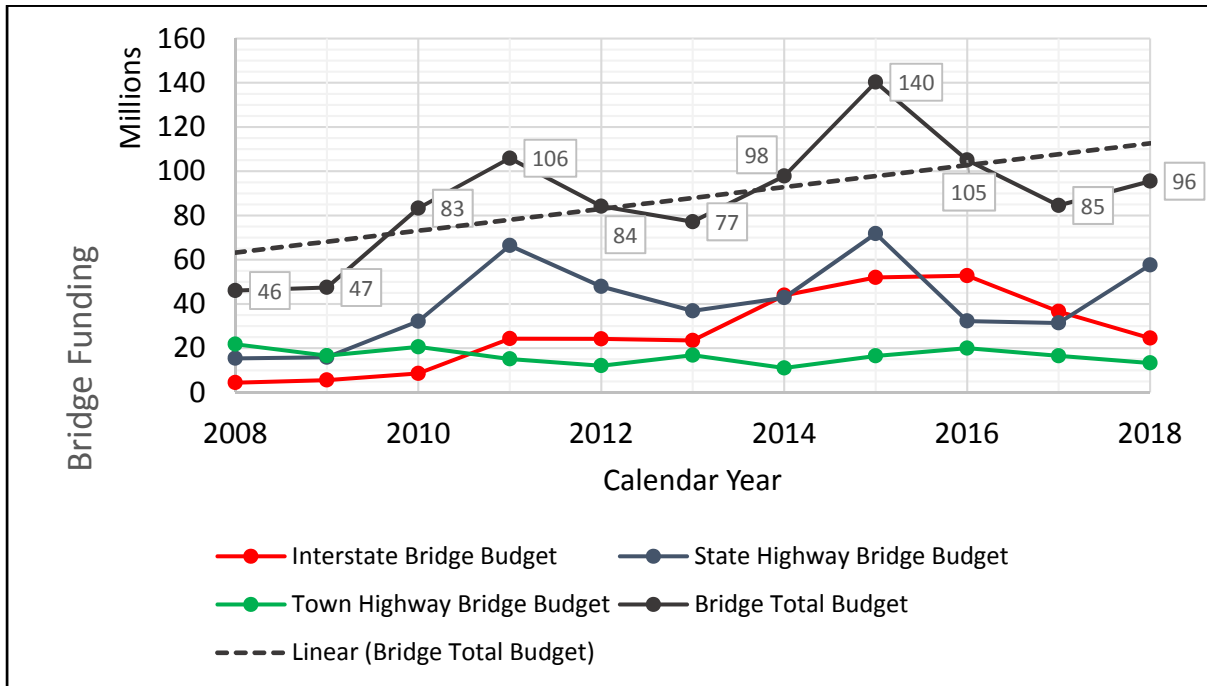
Stage	Improvement Category	Examples of Improvements
15, 30, and 45 years	Major Preventive Maintenance	Deck or deck membrane replacement, grinding and painting steel, minor patching to the concrete deck and repaving
60 Years	Rehabilitation	Replacing the deck and steel and rebuilding the substructure unit. At least one component of the original structure must remain in use to be classified as a rehabilitation project.
80 Years	Reconstruction	Removal and rebuilding of a bridge. May include alignment changes, widening or other changes for consistency.

Source: VTrans, 2018

Costs for each improvement category were estimated based on historical project cost records converted into average costs per bridge deck area. For more information see Table 8: Bridge Project Costs based on Work Type.

Bridge funding for the Interstate, State, and Town Highway Programs is in Figure 18. The trend line shows bridge funding levels of \$100 million and needs of \$152 million. This results in the ASI for VTrans bridge assets of approximately 0.66.

Figure 18: Vermont Bridge Funding by Calendar Year



Source: VTrans TAMP, 2018

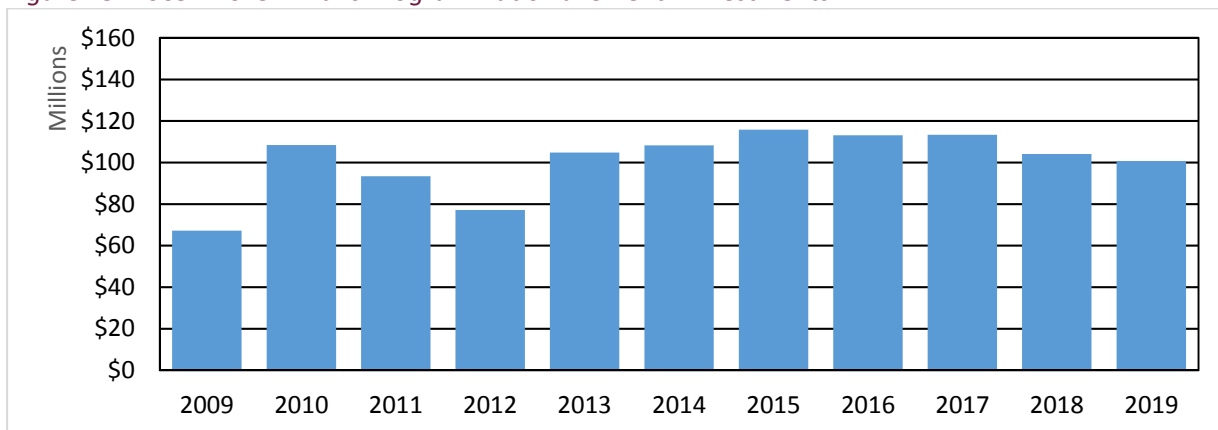
Gap between Bridge Funding and Needs

The projected gap between VTrans bridge funding and long-term bridge needs is approximately \$52 million. This gap has decreased over the years due to increased investment. While bridge needs are seemingly plateauing, they are expected to climb significantly.

Pavement Investment Levels and Needs

VTrans has been successful in securing funding that addresses a large amount of its surficial pavement needs. Based on a \$128 million dollar need VTrans’ pavement sustainability index has ranged anywhere from 0.87 to 0.97 over the last five years. The current trend is that pavement funding has flat lined since 2013. Reasons for this have been attainment of the “percent network pavement in very poor condition” goal and a desire not to over-spend on any one asset.

Figure 19: 2009 - 2019 VTrans Programmatic Pavement* Investments



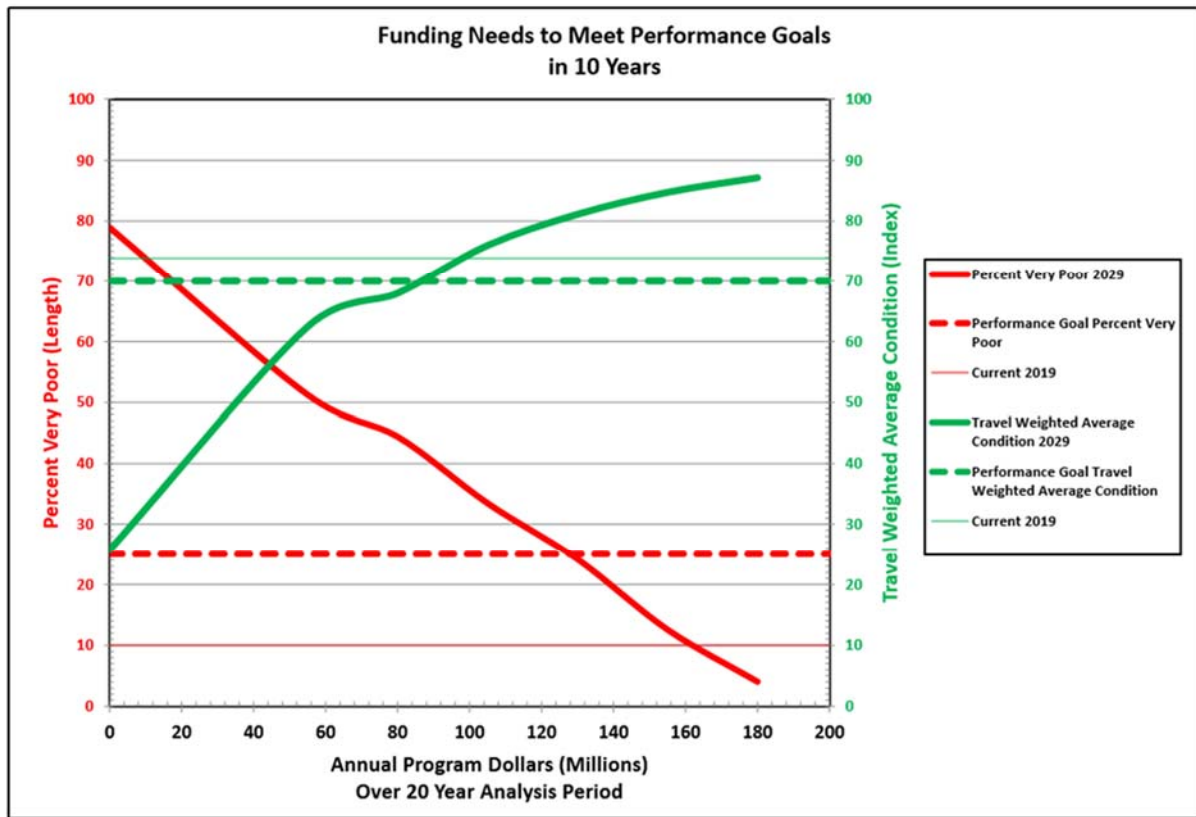
*Doesn't include the total amount of monies spent on rehabilitation and reconstruction activities

Source: VTrans TAMP, 2018

Gap between Pavement Funding and Needs

VTrans conducts an annual 20-year analysis that computes the travel weighted average condition and percent network pavement in very poor condition based on funding for each year. For example, if VTrans invests \$80 million per year, the percent network pavement in very poor condition at the end of the 20 years would be approximately 43% and the travel weight average pavement condition would be about 68. The 20-year analysis uses a discount rate of 4%. The analysis is run at intervals of approximately \$10 million, intentionally exceeding anticipated funding levels. The results are in Figure 20. This analysis leads to the conclusion that VTrans needs approximately \$128 million annually to meet both of its pavement targets in 20 years.

Figure 20: Pavement Needs Analysis to Meet VTrans Performance Objectives



Source: VTrans Performance Measures (2016 presentation)

While the gap between anticipated short-term needs and current funding levels is relatively small, the long-term need versus future funding levels is concerning. VTrans must resist pressures to reduce funding for pavements (and bridges) at times when the agency may be meeting its performance measures because short-term performance doesn't guarantee long-term performance.

Medium- to Long-Term Funding Issues for Transportation Assets

Some of the most important issues for long-term funding of transportation assets are reaching consensus on what Vermonters agree are desired, reasonable conditions for their assets and how to provide that funding in a stable manner. Issues are relatively specific items; broader challenges are covered in Chapter 5. Risk Management.

Issue 1: Lack of Internal Engagement and Agreement on Desired Objectives and Outcomes

The discussion of what Vermont’s transportation assets should be like in ten or twenty years occurs at many levels and in many ways. Elements include discussions with elected officials and the expectations of customers—the people who use transportation assets. Many of these discussions will be led outside of asset management, such as within the Vermont Legislature and updates of the VTrans Long-Range Transportation Plan, but participation by asset management staff provides essential information.

- **Fix - Underway:** Continue to lead and participate in a variety of discussions across sections within VTrans and outside of VTrans with partners. Provide analysis of needs and effects of different funding scenarios.

Issue 2: Inadequate and Unstable Funding Levels to Meet Objectives

While reaching agreement on reasonable outcomes includes discussion of funding, the funding side will likely be somewhat general. Once there is agreement on how to proceed, it can be expected that there will be significant follow-up. VTrans staff will continue to need to participate in how assets will be funded. While much of the decision-making may be outside of VTrans, staff will need to be engaged to provide analysis and answer questions.

- **Fix - Underway:** Participate in discussions, provide analysis, continue to explore how to be most efficient and effective at meeting transportation asset objectives.

Summary of Medium- to Long-Term Performance Issues

This chapter has provided background about medium- to long-term gaps and issues for asset management. These are specific process items, and all are being addressed with near-term fixes. For a summary of these issues see Table 16, these issues are combined with those identified in the previous and next chapters. The next chapter on risk management also addresses some of the larger and more complex challenges for asset management. It is followed by chapters that describe the categories of strategies and then next steps.

Table 16: Medium-Term Asset Management Performance Issues

Context	Issue	Fix	Category of Strategies*
Bridge Issue 1	Large Amounts of Bridge Needs Concentrated within a Few Distinct Time Spans	Use institutional knowledge and analysis to schedule rehabilitation or replacement projects to “flatten” or spread the bridge needs out over longer time periods. Enhance coordination with external partners (consultants, contractors, permitting staff) to ensure resource availability.	Life-Cycle Planning
Bridge Issue 2	Bridge System is Not Prepared for Climate Change	Identify bridges at risk due to extreme weather, in part by using methodology from Transportation Flood Resilience Planning Tool. Participate in planned task to evaluate facilities repeatedly damaged by major events. Revise standards to become more resilient in the face of climate change and chance of seismic activity.	Risk Management
Bridge Issue 3	Inconsistent Funding and Prioritization of Preventive Bridge Treatments	Continue to evaluate effective preventive maintenance, schedule it on a regular cycle, and communicate why it is important inside and outside of VTrans.	Life-Cycle Planning
Funding Issue 1	Lack of Internal Engagement and Agreement on Future Objectives and Outcomes	Continue to lead and participate in a variety of discussions across sections within VTrans and outside of VTrans. Provide analysis of needs and effects of different funding scenarios.	Strengthening Alignments Within VTrans, and with its Partners and Stakeholders
Funding Issue 2	Inadequate and Unstable Funding to Meet Objectives	Participate in discussions, provide analysis, continue to explore how to be most efficient and effective at meeting objectives.	Financial Planning and Benefit/Cost Analysis
Pavement Issue 1	Lack of Strategic Planning for Where to Invest in Aging Pavements	Fully staff teams and train for strategic consideration of where and how to invest limited resources. Incorporate knowledge gained from customer pavement condition perception survey. Coordinate with the MPO as a significant amount of the pavement that will reach practical life will be in the Burlington metropolitan area.	Strengthening Alignments Within VTrans, and with its Partners and Stakeholders
Pavement Issue 2	Lack of Preparedness for Climate Change Effects on Pavements	Expand 2018 Transportation Flood Resilience Planning Tool from test locations to statewide. Identify a champion to incorporate resilience in pavement asset management. Participate in repeatedly damaged facilities task.	Risk Management

*Category of strategies that best describes the main approach to fixing this gap or issue, recognizing that real fixes include multiple strategies. For more information on each category of strategies, see Chapter 6: How VTrans Improves Assets.

Source: VTrans TAMP, 2018

5. RISK MANAGEMENT – REDUCING RISK IMPROVES PERFORMANCE

All undertakings consider risks, whether they are called by that term or not. *Is there enough funding? What if tasks get delayed? Who should be engaged so unexpected problems don't come up later? How do we manage our infrastructure to minimize flood damage?* Considering questions like these early, often, and thoughtfully makes a big difference in achieving effective results. Answering them make an agency's various initiatives more efficient, transparent, and credible.

Just as there are categories of transportation projects and programs, there are categories of risks:

- **Activity** – risks assigned to activity owners, such as those who manage the individual preventive maintenance activities at a district level, or the pavement data collection activities or the bridge deterioration modeling activities.
- **Project** – risks assigned to project managers who identify, prioritize, and mitigate issues during the development, construction and operation of a project,
- **Program** – risks assigned to a mid- to high-level manager, that impede program effectiveness. Programs generally are collections of related projects or on-going efforts to ensure achievement of specific organizational objectives. Breakdowns in information systems or data quality can threaten the quality of an entire program.
- **Enterprise** – risks or risk focus areas assigned to senior and executive staff that have widespread interest and impact because they impact an agency's ability to achieve its objectives

Enterprise-Level Bridge and Pavement Risk Focus Areas

VTrans addresses each of the four risk categories (enterprise, program, project, and activity), however enterprise-level risk areas will be a focus in the TAMP for two reasons. One is that enterprise risk is an area where the TAMP-WG was able to add value—the high-level thinking for the TAMP filled a gap in agency's risk management portfolio, which has been more focused on activity and project level risks. Another is that enterprise-level risk must be managed systematically to ensure organizational performance necessary to achieve the agency's mission, goals and asset management objectives.

Six important enterprise-level risk focus areas for bridges and pavement are identified in Table 17. These high-level risk focus areas build on the specific evaluation of likelihood and impact in the bridge and pavement registers covered in the next section. These risk focus areas also have applicability to other transportation assets.

VTrans developed mitigation strategies for each of the enterprise-level risk areas. Table 18 identifies general strategies linked to more-specific strategies in the asset register work for tracking.

Table 17: Risk Focus Areas for Bridge and Pavement Assets

Focus Area	Risk Event	Primary Impacts
Safety	If bridge or pavement-condition declines below acceptable levels,	then deficiencies could lead to increased crashes, decreasing safety and service.
Funding	If funding for pavements and bridges declines below minimum acceptable levels,	then asset conditions will deteriorate prematurely, leading to increased total lifecycle costs and decreased cost effectiveness.
Workforce	If VTrans continues to lose institutional knowledge regarding the management of its pavements and bridges,	then poor decisions and lower quality work products will result from inception through construction and maintenance resulting in a reduction of useful life, service life, and safety.
Tools and Resources	If pavement and bridge data is unavailable or not integrated or models are not reliable,	then asset management strategies may be flawed, and treatments performed on the wrong pavements or bridges at the wrong time or place.
Asset Sustainability	If best practices* are not steadily used to make cost-effective pavement and bridge management decisions with consistent leadership support,	then the agency’s decision-making effectiveness will decline, and program and maintenance costs will increase resulting in lower quality, less life span, and customer confidence in VTrans will decrease.
Extreme Weather	If Vermont continues to experience extreme weather events due to climate change,	then pavement and bridge damage will increase; lowering service life expectancies and increasing the demand for future maintenance activities.

*asset management, risk management, data management, performance management

Source: VTrans TAMP (2019)

Table 18: Risk Response Strategies by Risk Focus Area

Focus Area	Risk Response Strategies
Safety	<ol style="list-style-type: none"> 1. Provide education and notice of deficient assets to stakeholders 2. Research and use emerging technologies to improve performance 3. Perform emergency maintenance as required
Funding	<ol style="list-style-type: none"> 4. Reallocate funds from less strategic assets 5. Consider strategic disinvestment / reinvestment 6. Optimize and prioritize preventive maintenance efforts
Workforce	<ol style="list-style-type: none"> 7. Implement succession planning 8. Expand education and training 9. Produce predictable amount of work for consultants and contractors
Tools and Resources	<ol style="list-style-type: none"> 10. Keep data and metadata current 11. Enhance access and ability to view all information about a facility (capital investments, completed maintenance, priority risks, other) 12. Validate and calibrate analysis tools regularly based on best practices
Asset Sustainability	<ol style="list-style-type: none"> 13. Define life expectancy, remaining service life and asset valuation for pavement, bridge and large culvert assets 14. Optimize and prioritize preventive maintenance treatment selection 15. Coordinate with a wide range of partners; communicate why asset management is important and that it requires long-term commitment for best results
Extreme Weather	<ol style="list-style-type: none"> 16. Develop transportation resilience plans for vulnerable assets and watersheds 17. Incorporate resilience into the project selection and prioritization process 18. Monitor for when climate change seems to call for changes in standard practices, e.g. due to more-frequent freeze-thaw cycles, higher or colder temperatures, or severe storms 19. Enhance how asset management incorporates resilience planning into key program areas

Source: VTrans TAMP (2018)

Data Management was the leading tactical priority in the 2014 VTrans Transportation Asset Management Implementation Plan. The focus was on information integration and access. Its recommendations are incorporated in the Tools and Resources strategies.

Bridges and Pavement Program Risks from Registers

As noted, there are four categories of risk. Enterprise-level risk areas are the broadest. The next level includes risks grouped by program area. These risks are identified and managed through risk registers.

Developing risk registers for each major asset class has been an important undertaking at VTrans. These registers identify risks for an asset, assess likelihood and impacts, and result in priority setting activities. Risk management includes recommending strategies to avoid, accept, transfer, or mitigate negative risks or take advantage of opportunities. The recommended strategies are linked to the enterprise-level risk so that progress can be tracked at both levels.

Each risk was identified by a SME and then rated by a group of peers regarding the risk’s likelihood and impact. These are rated on a scale from one to five, with five being the most likely and impactful. The two ratings are then multiplied, resulting in a risk value rating ranging from 1 to 25. The top five resulting risks for bridges are summarized in Table 19 and for pavement in Table 20. See the individual risk registers for the strategies to minimize, mitigate, or act on these risks.

Table 19: Top Five Risks for Bridge Assets

Risk Event	Primary Impact	Asset Risk Focus Area	Likelihood Rating (1-5)	Impact Rating (1-5)	Risk Value* (1-25)
If bridges deteriorate prematurely	then major rehabilitation or replacement will be needed, increasing the life-cycle cost	Sustainability	3.4	4.5	15.0
If there is not enough planned bridge maintenance funding	then bridges will deteriorate prematurely	Funding	3.5	4.0	14.2
If flooding increases	then transportation system resiliency may decrease	Environmental Conditions	3.3	3.7	12.2
If funding is reduced to the bridge program	then the number of deficient bridges may increase	Funding	3.1	3.9	12.1
If our bridges experience early onset cracking	then the asset life-cycle cost may increase	Sustainability	3.1	3.5	10.9

Note: Numbers are rounded.

Source: BridgeRiskRegister.xlsx (accessed March 14,2018)

Table 20: Top Five Risks for Pavement Assets

Risk Event	Primary Impact	Asset Risk Focus Area	Likelihood Rating (1-5)	Impact Rating (1-5)	Risk Value (1-25)
If funding declines below minimal acceptable levels,	then pavement conditions will decline.	Funding	3.6	4.3	15.4
If politics are too heavily involved in decision-making,	then the Agency may be forced to perform projects that go against ideal treatment principles.	Sustainability	3.6	3.8	13.5
If greater amounts and types of recycled materials are mandated to be used in pavement,	then lower quality pavements and shorter life cycles could result.	Tools and Resources	3.7	3.6	13.3
If district leveling funds decrease,	then the overall VTrans network condition may decrease and public complaints will increase.	Funding	3.6	3.5	12.9
If Vermont experiences an increase in intense precipitation and storm events,	then culverts will be exceeding capacity more frequently leading to pavement damage. *	Environmental Conditions	3.4	3.7	12.6

Note: Numbers are rounded.

Source: PavementRiskRegister.xlsx (accessed March 14,2018)

*Other risks from climate change (e.g. impacts of increased freeze-thaw cycles) are addressed in full registers.

The completed registers will be included in the TAMP Practitioners’ Guide. Maintaining current registers is part of how VTrans monitors and actively manages its risks.

Resilience and Repeatedly Damaged Facilities

To improve system resilience and reliability, limit reconstruction costs and lower operating and user costs, and to provide better customer service VTrans is working to reduce the number of transportation infrastructure locations vulnerable to damage by floods, erosion, wind, and other extreme weather events. In addition to advancing agency objectives, this effort will meet and exceed 23 CFR Part 667 requirements for periodic evaluation of facilities repeatedly requiring repair and reconstruction due to emergency events.

Part 667 includes two immediate deadlines: one in 2018 to reduce repeat damage on the NHS network and one in 2020 for the full Federal Aid system. VTrans completed a thorough first product on time and is working on the 2020 requirements.

The 2018 work used data from all available Detailed Damage Inspection Reports (DDIRs) prepared for FHWA. It also used other sources such as a statewide assessment of bridges, culverts, and road segments that are vulnerable to damage from inundation, erosion, and deposition. This work is part of the VTrans Methods and Tools for Resilience Planning.

VTrans staff gathered, cleaned, and analyzed DDIRs from Governor-declared emergencies between 2004 through the end of 2017. Staff explored “if there are reasonable alternatives to [NHS] roads, highways,

and bridges that have required repair and reconstruction activities on two or more occasions due to emergency events.” (*Federal Register*, 81 No. 95 October 24, 2018: Sec 661.1).

The analysis started with over 1,000 DDIRs and resulted in five locations for further exploration and action. Interestingly, this data-driven process identified one corridor as head-and-shoulders most important: US 4 in the Hartford area. The analysis was verified by a range of VTrans bureau and district staff. The locations with multiple DDIRs from different emergencies in the same location or nearby are

1. US 4 in the Hartford area
2. US 2 in St. Johnsbury
3. VT 9 in Brattleboro
4. VT 9 in Woodford
5. VT 15 in Essex.

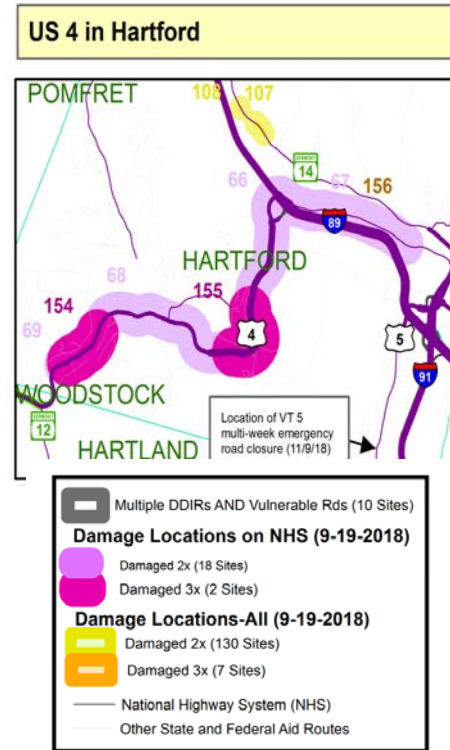
Part 667 efforts have been purposefully multi-disciplinary. Results include

- Formed and use VTrans Risk Management Leadership Team of bureau chiefs from Asset Management, Emergency Management, Maintenance, and Planning and Policy.
- Discussed Part 667 efforts with RPCs at TPI meeting, VTrans districts at Project Managers’ meeting, municipal representatives at Central Vermont Regional Planning Commission (CVRPC) Technical Advisory Committee meeting and mix of road foremen and emergency managers at their joint Central Vermont meeting.
- Preparing for field views and next steps on the priority locations that will likely include exploration of a substantial US 4 project.
- Proposing a VTrans policy on risk coordinated with asset management and performance management.
- Ongoing coordination, such as with ANR-VTrans Coordination group.
- A related result is funding through the FEMA Pre-Disaster Mitigation program to increase resilience in the vicinity of the VT 9 Brattleboro site.

VTrans plans to enhance the current efforts into a more comprehensive approach that will include

- Basic web map of DDIR analysis on Federal Aid System for expanded work with VTrans districts and other partners; this work will inform a future business process in VAMIS.
- Completing the Part 667 requirements for the full Federal Aid System by November 23, 2020.
- Updating damaged asset inventory after Governor-declared emergency events.
- Reviewing and evaluating the current damaged asset inventory at least every four years.

Figure 21: Most-Important Area of NHS to Reduce Repeat Damage (from Part 667 Analysis)



Source: *Reducing Repeat Damage of Vermont's Roads & Structures* (Vermont Agency of Transportation, November 19, 2018)

Additional Risk Management Activities

VTrans manages risk in a variety of additional ways:

- Risk assessments as part of scoping and identifying preferred design alternatives during project development.
- All staff are required to regularly complete an appropriate level of federal Incident Command System (ICS) training. ICS is a management structure that VTrans deploys to manage the response and recovery from a disaster or other disruptive event.
- Risk is the defining attribute in the rock ledge management system, one of the next systems that may be incorporated into the TAMP and into the asset management system, dTIMS.
- Considerations of risk has been incorporated into the VPSP2 framework, thus elements of risk assessment, risk management and performance will be part of future project selection and prioritization processes.
- In 2017, VTrans completed research on seismic activity risk assessments to its bridge inventory, “Quantifying the Vulnerability of Vermont Bridges to Seismic Loading.”

Issues and Short-Term Opportunities in Risk Management

While risk management is an overarching approach there are some aspects of it that could benefit from specific, short-term efforts. These are identified in the TAMP as issues. Some important issues are continuing to build risk management into VTrans culture, to improve access to information and to take a multi-disciplinary approach. Acting on these issues helps address risks across focus areas.

Short-Term Risk Issues

Risk Issue 1: Continue to Build Risk Management into VTrans’ Culture

Risk management needs ongoing support at a variety of levels within VTrans to be effective. Some of the efforts to do this have existed for years but there is more that should be done.

- **Fix - Underway:** Continue and enhance efforts underway that include
 - Holding trainings on how to incorporate risk management into various VTrans processes;
 - Holding multidisciplinary meeting of VTrans asset risk managers to review and reassess performance of strategies and changing threat levels (likelihood and impact);
 - Emphasizing an integrated approach among agency goals and objectives, asset management; risk management, and performance management;
 - Completing risk registers for all reasonable assets and using the results to improve decision-making;
 - Monitoring new risks and evaluating whether strategies to mitigate or minimize known risks are working as hoped.

Risk Issue 2: Continue to Improve Access and Integration of Data and Information

Continue to enhance metadata to support proper use. Improve the ease of access to asset data required for risk management. This includes establishing data standards for consistent asset evaluation and easy-to-use maps showing needs, analysis results, risks, and projects.

- **Fixes - Underway:** Complete and communicate work on the following underway efforts:
 - Developing asset management data standards, such as in the VTrans Asset Registry Lifecycle Matrix, and associated efforts;

- Providing access to key asset data and information, such as in VTransparency, internal GIS tools such as “Steak Knife 1” (SK1) and VAMIS;
- Integrating risk management into processes such as VPSP2 and expanding resiliency planning statewide with RPCs.

Risk Issue 3: Collaborate to be Effective in this Multidisciplinary Challenge

Not only does effective risk management require integration within VTrans, it also requires collaborating more with partners. While it may take time for these partnerships to develop and show results, building them now is an essential and productive step to managing risk focus areas.

- **Fixes - Underway:** Enhance collaboration with internal and external partners by
 - Coordinating multidisciplinary VTrans meetings to assess progress and set next steps to implement multi-level risk management (enterprise, program, project, activity);
 - Establishing and maintaining relationships with key stakeholders, including traditional (e.g. public safety) and non-traditional groups (e.g. resource agencies, non-profit organizations) to minimize or mitigate identified risks.

Summary of Risk Management Issues

This chapter has provided background about asset risk management and how it relates to asset management. It has identified some specific process gaps or issues, and all are being addressed with near-term fixes. These issues are combined with those identified in the previous chapters. The next chapters describe the categories of strategies and then next steps.

Table 21: Short-Term Risk Issues

Context	Issue	Fix	Category of Strategy*
Risk Issue 1	Continue to Build Risk Management into VTrans Culture	Hold periodic trainings on how to incorporate risk management into various VTrans processes. Emphasize an integrated approach. Complete risk registers, use, and update them. Identify a risk management champion for each key asset group. Monitor new risks. Evaluate whether strategies are working.	Strengthening Alignments Within VTrans, and with its Partners and Stakeholders
Risk Issue 2	Continue to Improve Access and Integration of Data and Information	Complete and communicate work on asset management data standards; access to information; and integrating risk management in processes	Data, Information, and Performance Management

*Category of strategies that best describes the main approach to fixing this gap or issue, recognizing that real fixes include multiple strategies. For more information on each category of strategies, see Chapter 6: How VTrans Improves Assets.

Source: VTrans TAMP, 2018

6. HOW VTRANS IMPROVES ASSETS

VTrans provides for the safe and efficient movement of people and goods. Asset management helps with a focus on achieving and sustaining the desired state of good repair over the life cycle of assets at a minimum practicable cost.

*Today's Decisions
Impact Tomorrow's
Performance.*

There are four cornerstones of how VTrans does asset management, and they all build on high-quality data and analysis.

1. Vertical coordination of the stages of a project, such as development, construction, and maintenance as part of a long-term focus on improving and maintaining assets.
2. Horizontal integration of VTrans processes across its divisions and bureaus so all parts of the Agency communicate efficiently for the short- and long-term.
3. Fuller use of preventive maintenance to sustain performance.
4. Managing risks at the project, program, and enterprise levels.

VTrans pursues continuous improvement as an agency and in how it manages the State's transportation assets. It uses many strategies to do this, which may be grouped into categories for ease of reference. This section describes five categories. The first two, performance management and risk management, are so central that they have been covered as individual chapters (Chapters 3 and 5). The categories are

1. Data, information;
2. Performance management;
3. Risk management;
4. Life-cycle planning;
5. Financial planning and benefit/cost analysis;
6. Strengthening alignments within VTrans, and with its partners and stakeholders.

Data, Information, and Performance Management

VTrans has been known for its innovative, collaborative approach to paving new roads and building new bridges. As the highway systems in Vermont are mostly built, VTrans has shifted to managing data and assets. The ways in which VTrans gathers, manages, and uses data are covered throughout the TAMP. Well-managed data is also integral to performance and risk management.

Analyses are only as good as their data. Therefore, VTrans has focused effort on increasing access to data, improving data quality, and supporting consumption of information based on the users' preferences. VTrans has committed to sharing information in a transparent, efficient, and effective manner. Appendix A includes a table of key VTrans management systems.

Risk Management

The AMB led the way within VTrans at adopting risk management in a formal manner and it has since been incorporated in many processes. The TAMP has been a tool to elevate the visibility of risk management and stress its importance in achieving overall performance. VTrans is conducting risk-based, performance-based work at the project, program, and enterprise levels. Improvements are underway through documenting those efforts, sharing them, and committing to using risk management principles in a reliable, transparent framework to make better decisions.

Life-Cycle Planning

Life-cycle planning is so broad that it can be difficult to differentiate it from overall asset management. FHWA defines it as

... a process to estimate the cost of managing an asset class... over its whole life with consideration for minimizing cost while preserving or improving the condition.

Source: 23 CFR Part 515 Definitions

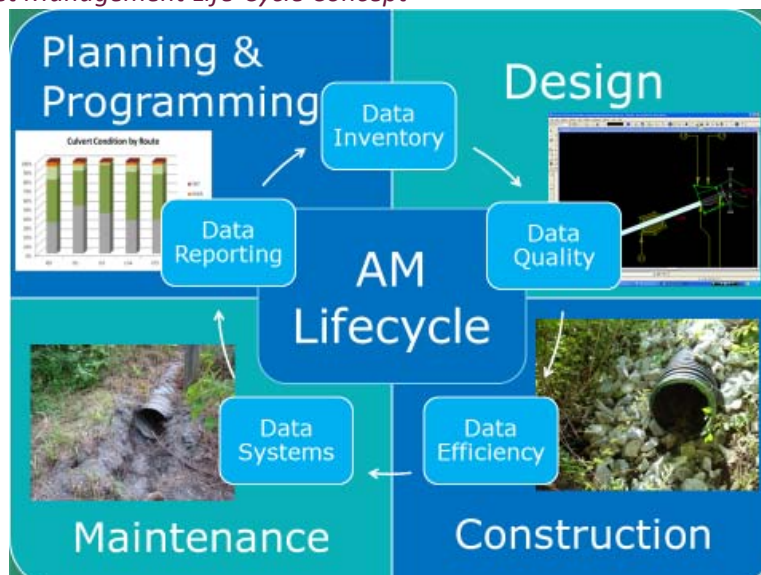
The value of a strong life-cycle planning process is to help DOTs

- establish a long-term focus for improving and preserving the system;
- develop maintenance strategies that consider long-term investment needs;
- determine the funding needed to achieve the desired state of good repair (SOGR);
- determine the conditions that can be achieved for different levels off funding;
- reduce the annual cost of system preservation without impacting asset conditions;
- provide objective data to support investment decisions;
- eliminate existing performance gaps; and
- demonstrate good stewardship to internal and external stakeholders.

Source: Using a Life Cycle Planning Process to Support Asset Management (FHWA, 2017)

An asset with a long useful life will require multiple treatments across key work types throughout its lifetime. As illustrated in Figure 22, having good data plays an essential role in being able to perform the right treatment at the right time for the right asset. Key work types include maintenance, preservation, rehabilitation, reconstruction and new construction. Maintenance activities are routine or cyclical activities completed to maintain or improve current service levels, while preservation activities are condition based treatments meant to sustain current asset conditions and extending service life. Rehabilitation activities are condition based activities to improve current asset conditions while extending service life. Reconstruction activities are completed at the end of an asset’s viable service life to renew the asset life to the maximum service level. Strategic timing of treatments minimizes total cost of ownership. New construction is not often relative as most of Vermont’s highway network is already constructed, however, sometimes improvements are made to increase capacity. Lifecycle planning also considers changing demand; information on current and future environmental conditions including extreme weather events and seismic activity; and other factors that could impact life cycle costs.

Figure 22: Asset Management Life-Cycle Concept



Life Cycle Planning includes the processes listed below. The first three have been largely covered in Chapter 3. The sections that follow focus on the fourth element of this list.

1. Set targets for asset condition for each asset class.
2. Develop deterioration models for each asset class.
3. Identify potential work types across the whole life of each asset class with relative unit costs.
4. Use strategies to manage each asset class that minimizes its life cycle costs while achieving the State’s targets and goals.

Bridge Life-Cycle Planning at VTrans

In 2014, VTrans created the Structures Steering Committee and the Structures Working Group (names have shifted over time) that decide strategies to manage structure assets. These committees bring together bridge experts from budgeting, planning, programming, design, construction and maintenance. Together these groups have explored alternative contracting procedures, evaluated preventive maintenance strategies, and communicated future asset directions. The Steering Committee is mainly Division and Bureau Directors, while the Working Groups are predominantly SMEs. The Structures Working Group develops responses to risks and issues. VTrans is reviewing the functions of these teams to align with broader organizational structure while defining more proactive strategies for bridge issues.

How Much Can Life-Cycle Planning Save VTrans?

At this point the amount of potential savings for VTrans has not been calculated precisely, however Table 22 is a general estimate. By maximizing and prioritizing investments in life-cycle bridge preventive maintenance, VTrans could potentially save 30% per year.

Table 22: General Potential Savings from Life-Cycle Preventive Maintenance (PM)

Bridge Class	No PM	High Level of PM	Percent Increase in Cost if No PM
NHS-Interstate	\$ 51,767,700	\$ 38,396,000	135%
NHS-Non-Interstate	\$ 30,945,800	\$ 22,996,900	135%
State	\$ 57,556,300	\$ 45,684,000	126%
Town	\$ 86,827,500	\$ 69,200,000	125%

Assumptions:

- With no preventive maintenance, one deck rehabilitation, and one major rehabilitation, a bridge will last 70 years, before needing replacement.
- With 70 years of high preventive maintenance, three deck rehabilitations, and one major rehabilitation, a bridge will last 125 years, before needing replacement.

Source: VTrans Life-cycle Cost Analysis for Bridges

Pavement Life-Cycle Planning at VTrans

VTrans has mature strategies in place to manage pavement asset classes in ways that minimizes life cycle costs while achieving the State’s targets and goals. A refinement underway is more thoroughly incorporating risk management. A risk that has impacted these efforts is a loss of institutional knowledge due to retirements. A Pavement Steering Committee and a Pavement Working Group exists for this asset class. The challenge of losing SMEs was treated as opportunity to review and refine roles and responsibilities of members and subcommittee structure.

Financial Planning and Benefit/Cost Analysis

The VTrans Transportation Program includes the upcoming budget year plus the three fiscally constrained planning years. This is consistent with the STIP timeframe as required by 19 VSA Section 10g and federal transportation regulations.

The first planning year after the budget is considered very reliable in terms of timing and costs. The second planning year data has become increasingly reliable and accurate. Asset management has been particularly helpful in developing future years budget targets for individual programs. Improving knowledge of the asset needs coming in the next five, 10 and 20 years improves efficiency in budgeting, planning and programming. This knowledge ensures that personnel and resources are being focused in the appropriate areas.

Three areas of effort are covered in this section. They are covered in order of broadness from project-specific benefit/cost analysis through financial planning to long-term asset valuation. These transportation financial planning elements also help integrate accounting-oriented staff members with staff more focused on engineering or planning.

More Fully Use Benefit/Cost Analysis

Benefit/cost analysis can be used in various ways. VTrans is considering or currently using it to

- compare alternatives when developing a project – this tends to use relatively few criteria in each, benefits and costs;
- prioritize or refine a program of established projects – this may use more criteria such as emissions or community considerations;
- allocate funds across programs - once all projects are going through VPSP2 analysis for key criteria it will be possible to use the concepts of benefit/cost analysis to consider how to allocate limited funding across program areas for the greatest benefit to Vermont.

Benefit/cost analysis requires high-quality, consistent data. The TAMP has identified fixes to be better able to isolate costs of elements and stages of projects.

Pavement is the asset class with the most suitable data currently available for benefit/cost analysis. VTrans used dTIMS software to evaluate how to maintain assets over a 10-year period to ensure that VTrans meets or exceeds state and federal performance targets given anticipated funding levels. The savings are then reinvested in the renewal of transportation assets.

Definitions:

VTrans Transportation Program

- **Budget** - Each year, VTrans prepares a request of funds from the Legislature for the coming state fiscal year, which starts July 1st. For example, the approved request to fund capital projects, operations, payroll, etc. starting July 1, 2019 is in the FY20 Transportation Program (“The White Book”)
- **Projected Spending Levels** – There are also three years of projected spending needs for all Agency projects and supporting activities.

Statewide Transportation Improvement Program (STIP)

This is a subset of projects that VTrans and its partners propose to do that are eligible for partial or full federal funding. The STIP functions on the federal fiscal year which starts October 1st. Projects from the FY20 and FY21 Transportation Program become part of the FFY21 STIP.

Bridge management will follow an approach like pavement management once work is refined. VTrans will then use dTIMS to conduct a resource allocation analysis between pavement and bridge assets. Different funding sources are also a consideration, for example, the interstate and state highway bridge programs are part of the larger highway appropriation while the town highway bridge program is its own appropriation. The planned trade-off analysis approach will result in a more efficient, balanced program of projects.

Maintain TAMP Financial Plan and Enhance Financial Planning

In 2016 VTrans prepared a financial plan in keeping with regulations. It was recognized by FHWA and published as *The Vermont Experience: A Case Study* (FHWA Asset Management Financial Report Series Report 6 (FHWA-HIF-17-033)).

The financial plan was updated in 2019 and is the primary source of reference for all financial analyses throughout the TAMP, including the following sections of Chapter 4

- estimated costs to implement the investment strategies by state fiscal year and work type for bridges and pavements;
- estimated future funding levels by fiscal year to address needs by work type;
- anticipated sources of available funding.

VTrans' 2019 Financial Plan is included as Appendix B. It will, at a minimum, be updated every two years or whenever there is a significant change to the revenue stream, funding sources, asset needs, or other new information. For example, new spending profiles and anticipated schedule of needs were prepared in early 2018 that resulted in an update to the Agency's projected needs. VTrans maintains a spreadsheet-based 20-year analysis of needs for its assets. The needs are documented in various levels of maturity, but this analysis forms the basis for communicating the Agency's financial health. Additional uses of this analysis are described in the next section on asset valuation.

VTrans is employing two short-term strategic actions:

1. Start using cross-asset optimization - AMB staff will facilitate VTrans Executive Team use of a spreadsheet-based budget balancing exercise based on the principles of cross-asset optimization: "If you had one more dollar to spend, where would you spend it and why?"
2. Use asset class level analysis - development of the VAMIS and construction management system (CMS) will allow the Agency to track investment levels at the asset class level. This will allow for a more accurate understanding of life-cycle costs, but more importantly will clarify how much money is being spent on which assets. This will enable VTrans to examine whether strategies it has employed to close infrastructure gaps are performing as expected.

In addition to these short-term actions, there are additional strategies for decision-makers to discuss as noted in short-term funding issues. One of the strategies is strategic disinvestment. VTrans has received verbal support of both the Vermont House and Senate Transportation Committees to explore reducing the number of bridges. This can be done in a reasonable manner that lowers costs while not jeopardizing public health and safety.

The Financial Plan is being used in additional ways than the TAMP, including

- more accurate project costs to budget projected spending and for better project management;
- more efficient development of asset projects by developing 10-year needs analysis.

Use a Systematic Approach to Increase the Value of Vermont’s Assets

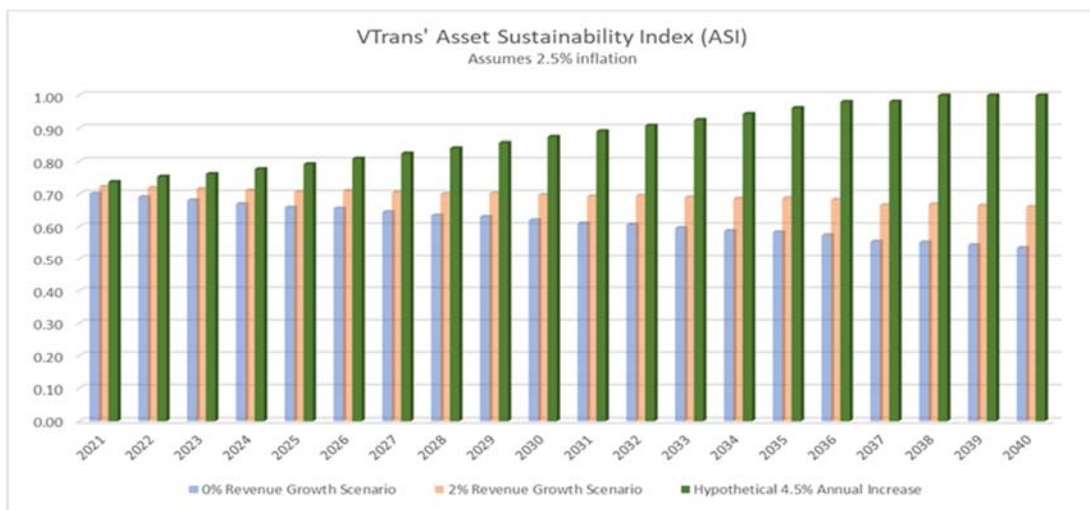
Asset valuation will help VTrans track the return on its investments for each asset. In an adequately funded, well-maintained transportation system the trend would be for the value to track upwards. VTrans has developed four financial performance measures to evaluate the sustainability of its pavement and bridge assets and to evaluate overall financial health of its infrastructure. The sustainability indices (the first three measures) are discussed as a set. The fourth one is explained next.

1. Pavement sustainability index (PSI)
2. Bridge sustainability index (BSI)
3. Overall Asset Sustainability Index (ASI)
4. Asset Consumption Ratio (ACR)

ASI

ASI is based on infrastructure needs and revenue projections (see Table 13). The ratio of anticipated needs to anticipated revenues yields the ASI. VTrans’ current ASI is approximately 0.7, meaning that we currently have about 70% of what is necessary to maintain our transportation assets in a state of good repair. With anticipated needs growing faster than anticipated resources, the ASI is anticipated to decline in the future (Figure 23). Annual revenue growth of approximately 4.5% would be necessary to achieve an ASI of 1.0 in 20 years.

Figure 23: VTrans Asset Sustainability Index (ASI)



ACR

Asset Consumption Ratio is the newest measure. It is a ratio of the current value of the asset to its replacement cost. The resulting percentage is in the far-right column of Tables 23 and 24. ACR is used to demonstrate the impact of infrastructure investment decisions on the Agency’s overall asset value. It provides a balance sheet perspective on the impact of Agency investments and reflects the decision-making processes used to make those decisions.

Table 23 shows that there are 1,700 bridges on Town Highways (CSL 5). Their current value (\$399 million) is less than what it would cost to replace them (\$811 million). The ratio of the current value divided by the replacement value is 49.2%. This can be reported as the percent of remaining life; it is also communicated as the ACR.

The resulting ACR provides an indication of the aged condition of physical assets; typical values are between 40% and 80%. An ACR is specific to an asset class, examination of the ACR value helps VTrans answer questions such as “Are the current funding and strategies doing what is desired?” or “What work should we be doing in the future?”

ACR is used to demonstrate the impact of previous infrastructure investment decisions on the Agency’s overall asset value. It provides a balance sheet perspective on the impact of past Agency investment decisions and can provide insight into where future monies may need to be spent to maintain a minimum asset value. It can be used to determine how balanced each asset’s investment plan is over the Agency’s entire asset portfolio

Table 23: VTrans Bridge Asset Valuation

Asset Valuation of VTrans Bridges						
CSL Designation	Number Bridges	Deck Area	Replacement Value (rv)	Current Value (cv)	% Remaining	
			\$ (in millions)	\$ (in millions)		
CSL1	372	3,295,041	\$ 1,064	\$ 620	58.2%	
CSL2	132	1,116,946	\$ 361	\$ 215	59.6%	
CSL3	247	1,102,132	\$ 325	\$ 182	56.1%	
CSL4	330	1,062,173	\$ 313	\$ 174	55.6%	
CSL5	1700	2,747,876	\$ 811	\$ 399	49.2%	
Totals	2781	9,324,168	\$ 2,874	\$ 1,590	55.3%	

Source: VTrans TAMP, 2019

Table 24: VTrans Pavement Asset Valuation

Asset Valuation of VTrans Pavements					
CSL Designation	Lane Miles	Replacement Value (rv)	Current Value (cv)	% Remaining	
		\$ (in millions)	\$ (in millions)		
CSL1	1443.2	\$ 10,522	\$ 10,204	97.0%	
CSL2	887.8	\$ 6,659	\$ 6,334	95.1%	
CSL3	1386.9	\$ 5,599	\$ 5,257	93.9%	
CSL4	2284.2	\$ 9,181	\$ 8,593	93.6%	
CSL5	199.1	\$ 3,104	\$ 2,967	95.6%	
Blank	61.2	\$ 319	\$ 300	94.0%	
Totals	6262.4	\$ 35,066	\$ 33,354	95.1%	

Source: VTrans TAMP, 2019

One might next ask how the values in Tables 23 and 24 are calculated. VTrans has a Fixed Asset Accounting team that reports on asset value with the simplified method provided by the Government Accounting Standards Board (GASB) Statement 34, or GASB-34. These computations and selected depreciation schedules do not accurately represent asset value from an asset management, long-term, perspective. Why not? For instance, a bridge that has been completely depreciated since it was built in 1928 could have zero “book” value, while most would argue that a bridge still carrying traffic has tremendous value. While the GASB-34 method is acceptable from an accounting perspective, there are methodologies that have demonstrated a more realistic snapshot of asset value. VTrans evaluated methodologies from academia, other DOTs, Australia and the United Kingdom. As a result, it adopted a methodology developed by Colorado DOT (CDOT).

The CDOT methodology uses **depreciated replacement cost (DRC)**. DRC is based on the current replacement cost of an asset. The CDOT methodology was modified slightly to align with VTrans' processes.

The **current asset value** is based on current bid prices to replace it. The value of each CSL class of pavements is the sum of all 0.1-mile segments in it. The value for bridges is the sum of the asset value of each bridge in its class.

The **depreciated replacement cost** is developed based on depreciable and non-depreciable costs. An example of a non-depreciable cost is the underlying earthworks. The remaining depreciable costs for a segment of pavement were then reduced based on the pavement condition.

The current asset value divided by its depreciated replacement cost is the **asset consumption ratio (ACR)**. For example, if a bridge currently valued at \$10 million would cost \$20 million to replace even considering the non-depreciable parts that can be reused, then the ACR would be 0.5.

VTrans will monitor ASI and ACR values for bridges and pavement on an annual basis. VTrans primary asset (financial) goal is to increase or maintain current performance levels by making the right treatment on the right asset, at the right time. This will extend each asset's service life for the minimum practical cost.

Strengthen Alignments within VTrans and with Related Efforts

VTrans has exciting efforts underway and more planned to strengthen alignments within the Agency, with partner agencies, and with stakeholders. Alignment is comprehensive, cooperative, continuing, and based on two-way communication.

Alignment is a big subject that many processes seek to improve, among them the TAMP. Three ways the TAMP strengthens alignment are

- Further coordinating processes and procedures;
- New corridor planning and project harmonization efforts;
- Improving communication, outreach, training, and education.

Figure 24: Coordination of Processes



Source: VTrans TAMP, 2018

Coordinate Processes and Procedures Across VTrans

One can think of further coordinating processes within VTrans as building horizontal alignment to complement the vertical alignment described in life-cycle planning. This is the work conducted across traditional “silos” to make VTrans into a more cohesive and effective whole.

The TAMP started with improving coordination among the long-range transportation plan, strategic plan, and transportation program/STIP. Even before this first TAMP was completed, VTrans has seen improvement in coordination of contents and visual communication, such as covers that display the relationship on each of these related plans. The LRTP and strategic plan coordinate with the TAMP, and all these efforts build on a foundation of risk management and performance management.

The shift toward cross-asset optimization at VTrans is an example of commitment to continuous improvement. It calls for changes in processes, roles, and responsibilities. A way that VTrans makes these changes is by training leaders on LEAN process management. VTrans recognizes it needs to pursue improvement not just internally but in its collaboration with other agencies, organizations, and stakeholders. There are many ways this is supported by the AMB. These include developing new public-facing tools (e.g. VTransparency) and changing how VTrans conducts its business (e.g. VPSP2). In addition, VTrans has elected to follow the ADKAR (awareness, desire, knowledge, ability and reinforcement) methodology to implementing change management around many of the various improvements underway.

Innovation:

Expediting Project Delivery

In 2013, VTrans received a grant from the Strategic Highway Research Program 2 (SHRP2) program to apply strategies to expedite project delivery. It has been applied to both the Project Initiation and Innovation Team (PIIT) and Accelerated Bridge Program (ABP) This multifaceted initiative included over 100 participants from within and outside of VTrans including three neighboring DOTs. It enhanced:

- team approach to delivering projects
- public engagement
- transfer of knowledge
- standardized project delivery
- project scheduling.

(Source: 2018 VTrans Fact Book)

Figure 25: Ongoing Integration of a Range of Partners

Corridor Planning and Project Harmonization

In 2017, VTrans launched an effort at efficient, coordinated work focused on corridor management. It builds on previous efforts that created a shared GIS map of needs identified by asset analyses and VTrans maintenance teams. The first of a series of corridor plans was completed in 2018. It combines asset needs, stakeholder recommendations, and information on planned projects to become more efficient in investments. It also enhances how VTrans conceives corridor management and corridor management’s role in asset management working in partnership with RPCs, municipalities, and stakeholders. This shift in thinking is summarized in Figure 25.



Harmonization is a concept flowing from corridor planning, VPSP2, and other VTrans initiatives. It brings together asset needs, stakeholder requests, and projects under development. Doing this helps VTrans capture opportunities to make strategic investments and improve coordination with partners. It also is a way for smaller requests or needs that might not reach the priority to become stand-alone projects to be accomplished as part of larger projects. Examples might be building a short sidewalk connection or making proactive drainage improvements.

Communication, Outreach, Training, and Education

In the face of shrinking funding, growing asset needs, and people busier all the time, how can a transportation agency strengthen alignment? In addition to all the fixes described in this TAMP, ongoing commitment to communication, outreach, training, and education are essential. Some techniques VTrans will use are

- Ongoing trainings on life-cycle planning, risk management, financial planning, asset management, and performance planning to build knowledge and engagement.
- Two-way communication with users of the transportation system and partners, such as through participating in outside meetings, and sharing survey results.
- Education efforts, both traditional and cutting edge, so that everyone interested in asset management has the knowledge to participate in decision-making at an appropriate level.

Innovation:

Story Maps

VTrans is exploring use of ESRI story maps to better communicate with stakeholders. A first effort is underway for the VT 100/108 corridor study that is expected to be a template for future corridor studies.

What Outcomes Could Vermonters Expect?

What would Vermonters get from VTrans better understanding needs and risks for its transportation assets and then acting on them to develop efficient projects? More than the sum of those parts! This integrated approach will help achieve a state of good repair of assets, increase the efficiency of projects, and increase the reliability of the transportation system. Meshing the gears of various related efforts make the whole engine work efficiently, as illustrated in Figure 26.

Figure 26: Meshing Gears of Asset Management, Risk Management, and Innovation



Source: VTrans TAMP, 2018

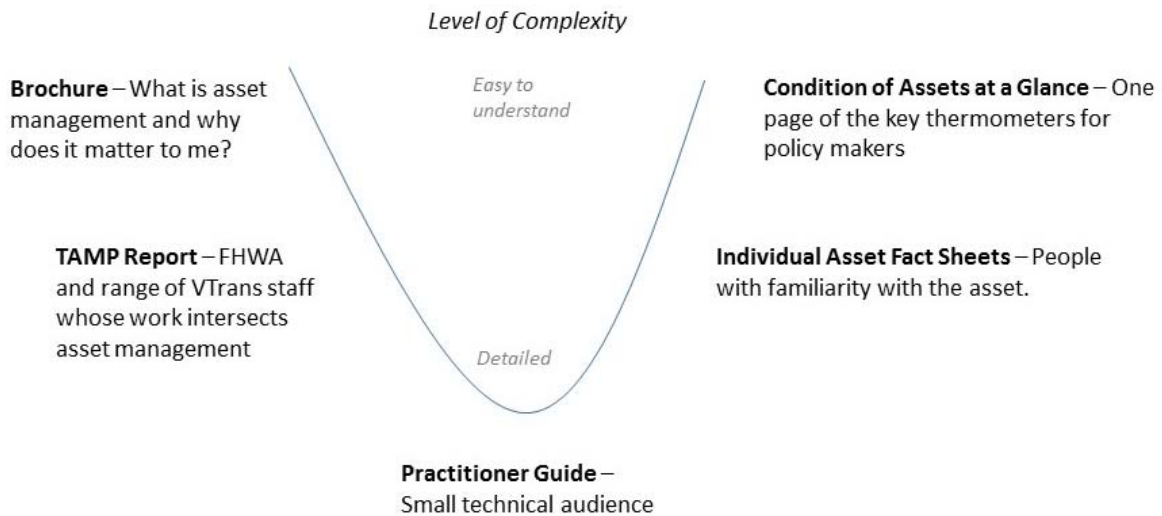
7. NEXT STEPS AND POTENTIAL ENHANCEMENTS

Asset management is an ongoing process. This TAMP was developed for action. This chapter includes the communication plan, action plan, and potential enhancements.

Communication Plan

An objective of the TAMP has been to create an engaging and effective story. VTrans has pursued this in a variety of ways. The range of communication pieces and their purposes is shown in Figure 27. Most of these items will be available online, some tailored to interactive presentation as resources allow.

Figure 27: Vision for Asset Management Communication Products



As of April 2019, hundreds of copies of the TAMP brochure have been requested by legislators and by the MPO and RPCs, which are distributing the brochure to their TACs. Copies of this TAMP report or a shortened version of it will be distributed widely within VTrans as part of an education effort. A key audience is the staff members whose work intersects asset management, but who have not been directly involved. The effort to explain why each person’s work matters and how their collective efforts fit together has asset management benefits but also enhances the overall VTrans organization.

VTrans has spent considerable effort on the AM Practitioners’ Guide; this work will continue in 2020. Highlights include having short informational “pull-outs” that provide key asset information referred to as I-AMPS or individual asset management plans. These IAMPs can be used by asset stewards to quickly and efficiently provide background asset information to a diverse audience. The Practitioner Guide will document VTrans efforts, support continuous improvement, and capture institutional knowledge.

Action Plan

The TAMP has identified short-term process issues and fixes for asset management in Chapter 3 and medium-term ones in Chapter 4, followed by issues within risk management in Chapter 5. This section brings the work together for action and tracking. VTrans will use best management practices and strategies and manage its resources to advance the action plan in a timely, efficient, coordinated manner. It will manage the risk of insufficient resources to complete items as well as agency-wide (enterprise) risk focus areas. These risk focus areas were described in Chapter 5 and are summarized in Table 25.

Table 25: Risk Focus Areas – Summary of Potential Impact

Risk Focus Area	Summary of Potential Impacts
Safety	Safety – Crashes and injuries
Funding	Funding - Premature asset deterioration with increased lifecycle costs
Knowledge Transfer and Future Workforce	Loss of institutional knowledge to do high-quality work or insufficient future workforce
Information Management	Lower-quality decision-making due to lack of good information
Sustainable Asset Management	Manage assets for best value now in a manner that leaves them in better condition for future generations
Extreme Weather Impacts	Costs and delays due to increased asset damage from effects of climate change: more-extreme temperatures, bigger and more frequent storms, and other impacts

Source: VTrans TAMP (2018)

The major strategies VTrans uses to fix issues in asset management were described in Chapter 6 and are summarized in Table 26. Each action item in Table 27 on the next pages uses at least one of these best-practice strategies. See the tables at the end of chapters 3, 4, and 5 for more detail.

Table 26: Strategies to Continuously Improve VTrans and its Assets

Strategy	Summary Definition
Data, Information, and Performance Management	Ensure data is fully available and of high quality, then generate valuable information and use it to make proactive, performance-based decisions.
Risk management	Focusing resources to efficiently manage programs and advance objectives through a consistent approach to identify and prioritize program and project needs.
Life-Cycle Planning	Coordinated vertical planning for the stages in the life of a road and across assets to manage a facility at the least cost
Financial Planning and Benefit/Cost Analysis	<ul style="list-style-type: none"> • Benefit/cost analysis of projects and program areas and across assets for trade-off analysis • Financial Planning • Asset Valuation
Strengthening Alignments Within VTrans, and with its Partners and Stakeholders	<ul style="list-style-type: none"> • Coordinated processes and procedures • Corridor planning and project harmonization • Communication, outreach, training, and education

Table 27: How VTrans is Fixing Asset Management Issues (Action Plan Table)

Green shading indicates short-term issues with fixes expected to start to show results within a year or two.							
Blue shading indicates medium-term issues with fixes being discussed, but that may take three to five years to have results.							
ID	Risk Focus Area	Issue	Fix	VTrans Action Lead (P – Primary, S - Secondary)	Description of On-going Efforts	Timeline	Reference in TAMP
TAMP1	Extreme Weather Impacts	Risk Management Not Yet Embedded into VTrans Culture	Identify a risk management champion for each asset group. Train how to incorporate risk management in VTrans processes emphasizing an integrated approach. Implement strategies from asset risk registers. Monitor new risks. Evaluate strategies.	Emergency Management Director (P) Bureau Directors (S) [VTrans' Team: Todd Sears, Chad Allen]	Agency hired Todd Sears on 3/5/2018 as the Emergency Management Director. This position is a Risk SME and is teaming with the Asset Management Bureau Director to investigate the effectiveness of Agency led internal trainings on how to conduct risk assessments, the benefit of risk assessments and how to operationalize them into its business processes.	Training of VTrans employees or teams is yet to be developed. Focus has been on developing and maintaining emergency management (ICS) training and skills.	Risk 1 for Next 1-2 Years (p. 44)
TAMP2	Extreme Weather Impacts	Bridge System is Not Prepared for Climate Change	Identify bridges at risk due to extreme weather, in part using VTrans Transportation Resilience Planning Tool (TRPT). Participate in an evaluation of facilities repeatedly damaged by major events. Revise standards to become more resilient in the face of climate change and chance of seismic activity.	Emergency Management Director (P) Project Delivery Bureau Director (S) [Joe Segale, Todd Sears, Zoe Neaderland]	Continue Part 667 risk analysis, VTrans has identified those facilities damaged two or more times on the State Highway System. Conducting field site visits to the sites that have been impacted most frequently.	On-going; work underway on 2020 full Federal Aid System report. Site Evaluations to be conducted in July/August 2019	Bridge 2 for Next 3-4 Years (p. 29)
TAMP3	Extreme Weather Impacts	Lack of Preparedness for Climate Change Effects on Roads	Expand TRPT from three test watersheds to statewide. Use complete but less-detailed statewide flooding vulnerability layer. Participate in repeatedly damaged facilities task.	Planning Bureau Director (P) Emergency Mgmt Director (S) AMB Director (S) [Todd Sears, Joe Segale, Chad Allen]	The TRPT is being applied in six more watersheds and RPC staff are being trained to apply further. The lessons learned have been utilized to characterize the effects of climate change beyond the test watersheds.	Expansion to six more watersheds will be completed in 2020. Efforts will continue to scale the proof of concept statewide.	Pavement 2 for Next 3-4 Years (p. 30)
TAMP4	Funding	Limited Discussion to Maximize Funding Across Assets	An internal exercise is being organized for mid-2019 to balance short-term needs of assets with revenue. It will be followed-up annually.	AMB Director (P) Executive Team (S) [Chad Allen, Ken Valentine, Wayne Symonds]	This event was delayed but anticipate a late summer exercise to engage Executive Team on balancing the Agency's budget to address its asset needs to influence a positive trend on its asset sustainability index (ASI).	September 2019	Funding 2 for Next 1-2 Years (p. 23)
TAMP5	Funding	Lack of Engagement and Agreement on Future Objectives and Outcomes	Continue to lead and participate in a variety of discussions across sections within VTrans and outside of VTrans with partners. Provide analysis of needs and effects of different funding scenarios.	AMB Director (P) AM Engineer (S) Planning Bureau Director (S) Asset Stewards (S) [Ken Valentine, Chad Allen, Joe Segale]	Asset Management has hired an Asset Management Engineer who is working with asset stewards to develop individual asset management plans for their assets. These plans will assess the overall need and roll up into the Agency's TAM Financial Plan. VTrans efforts to revamp its project selection and prioritization processes (VPSP2) project, providing insight into its current and future transportation needs.	On-going, initial drafts of the key assets to be developed in time to support September 2019 ASI / budget exercise. VPSP2 is to be completed in time for the FY22 budget development.	Funding 1 for Next 3-4 Years (p. 36)
TAMP6	Funding	Inadequate and Unstable Funding Levels to Meet Objectives	Participate in discussions, provide analysis, continue to explore how to be most efficient and effective at meeting transportation asset objectives.	AMB Director (P) AM Engineer (S) VTrans Asset Stewards (S) [Chad Allen, Ken Valentine, Kevin Marshia]	The AM Bureau continues to raise overall awareness by discussing budget issues, trade-off analyses, strategic disinvestment, ASI, the need for additional revenue and cost savings attained by being more proactive and less reactive.	On-going - Investigating impacts of current snow and ice control policy changes on overall budget, safety, and performance.	Funding 2 for Next 3-4 Years (p. 37)
TAMP7	Information Management	Communication and Prompt Action After Bridge Inspections	Have bridge inspection team enter bridge findings into VAMIS. Transfer to using VAMIS to issue work orders and otherwise improve processes.	AMB Director (P) AM Data Management Director (S) [Chad Allen, Dan Schall, Pam Thurber, Kevin Marshia]	Implementation of VAMIS will help facilitate efficient and effective communication of bridge needs. In winter 2018-19 the bridge inspection team reviewed all bridge inspection findings and helped develop a proposed Bridge Maintenance Work Plan (BMWP). Prior to this year the work plans were developed without the team's input and several bridge inspection findings would go unaddressed until the next inspection.	VAMIS implementation will begin on July 1, 2019, a 24-month implementation period is expected. Bridge inspectors' involvement in the BMWP will continue.	Bridge 1 for Next 1-2 Years (p. 15)

Action Table, continued

ID	Risk Focus Area	Issue	Fix	VTrans Action Lead (P – Primary, S - Secondary)	Description of On-going Efforts	Timeline	Reference in TAMP
TAMP8	Information Management	Bridge Data is a Bottleneck for Cross-Asset Optimization	Define a realistic interim point with timeframe for BMS to provide necessary data for bridge projects and cross-asset allocation analyses.	Data Mgmt Systems Engr (P) Data Administration Director (S) [Reid Kiniry, Dan Schall]	Continue building on work of last three years to develop a state-of-the-practice BMS. Network-level output has been confirmed. VAMIS implementation starts with the incorporation of pavement then bridge assets. Pavement and bridge data and system analysis parameters will be leveraged within VAMIS. This will make it possible to use the strategic asset module of VAMIS to do cross-asset allocation analysis.	For TAMP actions 8 and 9: follow-up internal VTrans presentation and external presentation to FHWA on BMS. Sprints to place pavement and bridge data into VAMIS will occur beginning in July 2019. 23 two-week sprints are anticipated, resulting in a one-year implementation period.	Bridge 2 for Next 1-2 Years (p. 16)
TAMP9	Information Management	Lack of Commitment to Finalizing and Using BMS	Use preliminary parts of BMS. Commit necessary staff time and resources to complete it.	Data Mgmt Systems Engr (P) Data Administration Director (S) AMB Director (S) [Reid Kiniry, Dan Schall]	Completing BMS. Held internal VTrans presentation April 23, 2019 and presentation for FHWA- Local Division Office on May 8, 2019. BMS and its parameters to be downloaded into VAMIS.		Bridge 3 for Next 1-2 Years (p. 16)
TAMP10	Information Management	Incomplete Data and Tools for Cross-Asset Allocation	Communicate work on asset management data standards. Complete and use spreadsheet-based approach to help bring a range of assets to a level for cross-asset allocation discussions.	Data Administration Director (P) AMB Director (P) GIS Professional IV (S) [Dan Schall, Chad Allen]	VAMIS has a 27-month implementation which currently has many asset classes being incorporated into the tool. This effort will support cross-asset analyses. In addition, direction from the Management team on balancing the Agency's asset needs is anticipated for some time in September 2019. Data Governance is recognized as a future area of concern and interest.	July 2019: VAMIS Implementation September 2019: Executive Team ASI Budget Discussion	Funding 1 for Next 1-2 Years (p. 23)
TAMP11	Information Management	Limited Access and Integration of Risk Data and Information	Improve access to risk management data and information; widely communicate availability and how to use it.	F&A Performance Section Manager (P) Data Administration Director (S) [Dan Schall, Adrienne Gil – Acting Performance Chief]	Risk Management Engineer left for another internal position and management decided not to hire another position to focus on risk management. The F&A Performance Section business model is to assist with performance but lacks a risk focus. AM Bureau will work with its Data Mgmt Team to develop a risk database, however, due to VAMIS implementation, this effort will be tertiary at best. F&A Performance Manager has recently left the position and a new manager will soon be hired. There may be opportunity to pursue risk management integration into the Agency's cycle of continuous improvement.	Undetermined, pending replacement of F&A Performance Section Manager.	Risk 2 for Next 1-2 Years (p. 44)
TAMP12	Knowledge Transfer and Future Workforce	Inability to Retain Institutional Knowledge	Use the TAMP Practitioner Guide to gather important knowledge. Hold "VTrans World of Pavement" exercise. Become more proactive in workforce planning efforts. Institutionalize a Pavement Working Group to facilitate knowledge transfer, share experiences, and increase communication across teams with different responsibilities and focus.	Pavement Working Group (PWG) [Kevin Marshia, PWG Members]	Held two meetings (April 18, 2018 and May 1, 2018) with senior pavement experts. Mapped existing pavement processes. Developed charter for Pavement Working Group (PWG) while consolidating different pavement "committees". 4/25/19: PWG taking lead on risk mitigation plan on known pavement defect on I-89 which occurred during construction in September 2018.	On-going activity. The PWG is quickly becoming the "knowledge hub" for all pavement issues; making connections between asset management, construction, design and maintenance. The PWG is now holding regularly scheduled meetings.	Pavement 2 for Next 1-2 Years (p. 20)
TAMP13	Knowledge Transfer and Future Workforce	Large Amount of Bridge Needs Concentrated within a Few Distinct Time Spans	Use institutional knowledge and analysis to schedule rehabilitation or replacement projects to "flatten" or spread the bridge needs out over longer time periods. Enhance coordination with external partners to ensure resource availability.	AMB Budget & Programming Mgr. (P) AMB Director (S) [Chad Allen, Kevin Marshia, Pam Thurber]	As part of the continued development of the TAM Financial Plan the Agency is sharpening its pencil on quantifying its bridge needs. The Agency has developed a draft 10-yr plan of pavement investments and expects to begin to move forward to develop a 10-yr plan for bridge investments (including maintenance).	Anticipate a revised dollar figure of bridge needs in May 2019. March 2020 is the due date for an initial draft of a 10-yr bridge investment plan.	Bridge 1 for Next 3-4 Years (p. 29)

Action Table, continued

VTrans Transportation Asset Management Plan – June 2019

ID	Risk Focus Area	Issue	Fix	VTrans Action Lead (P – Primary, S - Secondary)	Description of On-going Efforts	Timeline	Reference in TAMP
TAMP14	Safety	Pavement Deterioration Curves Require Updating	Pavement deterioration curves and range of strategies are being updated in 2018-19. These curves require validating and updating.	AMB Pavement Mgmt. System Engr (P) <i>[Reid Kiniry]</i>	Curves did not get updated in 2019 but remain a key work item to be completed to further the development and maturity of VTrans' Pavement Management System. This work item will be considered during the upcoming implementation of VTrans' asset management information system (VAMIS).	Not clear, earliest start date is likely summer 2020.	Pavement 1 for Next 1-2 Years (p. 20)
TAMP15	Sustainable Transportation	Inconsistent Funding and Prioritization of Preventive Bridge Treatments	Continue to evaluate effective preventive maintenance, schedule it on a regular cycle, and communicate why it is important inside and outside of VTrans.	AMB Budget & Programming Mgr. (P) AMB Director (S) <i>[Chad Allen, Kevin Marshia, Matt Joy, Pam Thurber]</i>	Significant effort has been expended to engage bridge inspection team in developing the annual bridge maintenance work plan (BMWP). Bridge inspectors reviewed past inspections and identified which bridges needed what level of maintenance. This information was shared with the Bridge Working Group which determines who will be performing bridge work, funding levels, roles, and responsibilities. Developed a new project in the Capital Program for State Highway Bridge called "Emergent Needs". This project was funded at \$1 million and can be used to react to emerging bridge needs. This will help to preserve the dedicated bridge maintenance funds to help ensure that the Agency can perform necessary bridge maintenance. Once VAMIS is on-line the establishment of Bridge Maintenance Work Orders.	Start use in summer 2019 Bridge Maintenance Plan. FY20 Budget – to be in the implemented as part of the "As Passed" budget on July 1, 2019.	Bridge 3 for Next 3-4 Years (p. 29)
TAMP16	Sustainable Transportation	Ineffective Collaboration in Enterprise-Level Risk Management	Facilitate and coordinate annual meeting focused on the management of enterprise level risk. First steps include the establishment of a multidisciplinary team composed of experienced transportation professionals. VTrans to establish communication protocols and processes to address enterprise level risks.	Emergency Management Director (P) AMB Director (P) Planning Bureau Director (P) <i>[Todd Sears, Joe Segale, Chad Allen]</i>	Held Meeting on "Coordinated Risk Management on August 7, 2018"; Including preparedness and resilience in corridor management planning work (Transportation Resiliency Tool) and coordination with VPSP2. Exploring developing a risk management/performance management/asset management policy statement. Reviewed Facilities Requiring Repeated Repairs due to Governor-declared states of emergency.	Training of VTrans employees or teams is yet to be developed. Focus has been on developing and maintaining emergency management (ICS) training and skills. 2019-2020 Development of Transportation Resiliency Tool continues from proof of concept stage to implementation across the network level. 2018-2020.	Risk 3 for Next 1-2 Years (p. 45)
TAMP17	Sustainable Transportation	Lack of Planning for Where to Invest in Aging Pavements	Fully staff teams and train for strategic consideration of where and how to invest limited resources. Provide education of key asset management performance metrics. Track investment dollars down to the asset level.	AMB Budget & Programming Mgr. (P) AMB Director (S) Pavement Mgmt. System Engr. (S) <i>[Kevin Marshia, Reid Kiniry, Chad Allen, Dan Schall (VAMIS), Molly Perrigo (CMS)]</i>	Engaging front line staff in the decision-making process; for instance, bridge inspectors are working with the Bridge Working Group to define locations for minor maintenance investments. Asset valuation is in the second cycle, asset management performance metrics are taking small footholds. The Agency Secretary frequently communicates that the ASI is .7. The Agency has committed to the modernization of its management systems, specifically the CMS and VAMIS. These systems are anticipated to track investments, or dollars expended, by asset level.	Bridge Inspectors participation level began in 2018-19 and is expected to continue as a new Agency process. The CMS began implementation in 2018. The VAMIS will begin implementation in July 2019.	Pavement 1 for Next 3-4 Years (p. 30)

Source: VTrans TAMP (2019)

Potential Future Enhancements

For every step that VTrans expects to do (as listed in the Action Plan), there are many more that would be productive and desirable. A priority is to add more assets to the TAMP. Some of the most likely are

- Culverts – probably next to be included in an integrated software management system, perhaps distinguishing between large and small culverts.
- Rock Slopes – staff are working on making risk-based decisions from the data, and asset performance can already be tied to investment levels.
- Traffic Signals – an asset management system has been developed and is being tested. Investment levels for the next 10 years have been developed.
- Stormwater Management – data is in a GIS environment and staff are exploring how to use it. Anticipated funding levels have been linked to new environment policy requirements.
- Signs – have initial, but aging, database and ten-year individual asset management plan based on spatial programming.

If resources allow, some of the additional potential steps are listed below. These are not commitments but rather possibilities.

- Safety – more closely integrate safety planning into asset management to bend the trend of crashes and fatalities back into the desired direction.
- Sustainable Asset Management - continue to explore how to balance transportation investments to meet conflicting enterprise objectives while moving the needle on the Agency's ASI towards 1.0.
- Funding – continue to explore conversations with Legislature to increase potential earnings from current funding sources. Examine potential for new funding sources.
- Knowledge Transfer and Future Workforce – plan for future SMEs, establish foundational knowledge surrounding asset management objectives.
- Data and Information Management – Develop a data governance manual to ensure uniformity in asset data collection, inventory and databases.
- Extreme Weather Impacts – Coordinate with RPCs and municipalities to help better prepare non-state assets for extreme weather or seismic activity.

VTrans will continue to improve the TAMP and the asset management efforts the TAMP supports. Future enhancements will be shaped by experiences implementing asset management in Vermont, changing conditions, and the best practices that emerge as states across the nation implement their first formal TAMP reports.

Appendices

- Appendix A: Acronyms and Key Management Systems
- Appendix B: TAM Financial Plan
- Appendix C: TAMP-WG Participants
- Appendix D: Correspondence Table to FHWA Requirements

APPENDIX A: ACRONYMS AND KEY MANAGEMENT SYSTEMS

AADT – Average Annualized Daily Traffic
ACR Asset Consumption Ratio
AMB – VTrans Asset Management Bureau
ANN – Artificial Neural Network
ASI – Asset Sustainability Index
BMS – Bridge Management System
CAV – Connected and Autonomous Vehicle
CCRPC – Chittenden County Regional Planning Commission
CMS – Construction Management System
CSL – Customer Service Level
DDIR – Detailed Damage Inspection Report prepared by VTrans for FHWA
dTIMS - Deighton Total Infrastructure Management System
FAST Act - Fixing America's Surface Transportation Act (FAST Act), federal transportation act signed into law in 2015
FFY – Federal Fiscal Year (October 1 to September 30)
FY – State Fiscal Year (July 1 to June 30)
GASB-34 – Government Accounting Standards Board Statement 34
ICS – Incident Command Structure
LRTP – Long-Range Transportation Plan
MAP-21 - Moving Ahead for Progress in the 21st Century Act (MAP-21), federal transportation act signed into law in 2012
MPO – Metropolitan Planning Organization
NBIS – National Bridge Inspection Standards
NHS – National Highway System
PCI – Pavement Condition Index
PMS – Pavement Management System
RPC – Regional Planning Commission
RWD – Rolling Weight Deflectometer
SK1 – VTrans Steak Knife 1 internal data analysis and visualization system that compliments VTransparency, the more-general outward facing web interface
SME – Subject Matter Expert
STIP – State Transportation Improvement Program
TAC – Transportation Advisory Committee, e.g. of an RPC
TAMP – Transportation Asset Management Plan
TMDL - Lake Champlain Total Maximum Daily Load (of phosphorous)
TS4 – Vermont Statewide Transportation Separate Storm Sewer System
TSMO – Transportation System Management and Operations
V2I – Vehicle-to-Infrastructure Technology
VAMIS - Vermont Asset Management Information System, started as TAMIS – Transportation Asset Management Information System
VMT – Vehicle Miles Travelled
VPSP2 – Vermont Project Selection and Prioritization Process

Key VTrans Management Systems

System Name / Acronym	System Description
<p>Bridge Management System / BMS</p>	<p>Bridge data has been, and continues to be, managed in a Microsoft Access database. VTrans is evaluating the AASHTO BrM module to allow bridge inspectors to "check-in /check-out" bridge data and to update the inventory and condition data post inspection. The long-term vision is for the bridge inventory to reside in the State's Enterprise Data Environment (EDE), but it may need to reside temporarily within the Microsoft SQL database environment hosted within the VAMIS solution; the Deighton dTIMS environment. VTrans will utilize dTIMS to analyze strategies based on different investment levels as part of a series of long-term financial analyses coordinated to maximize system benefits across the entire bridge network.</p>
<p>Construction Management System / CMS</p>	<p>VTrans is replacing its existing AASHTOware software. Key components being replaced include the TRANSPORT suite of products and SITE MANAGER. New user stories ensure that the system will be able to track costs at the asset level and allow VAMIS to access key asset attributes such as materials used, disposition of materials, material certifications, etc. This information will be critical in understanding how much VTrans is spending on its assets and will offer insights into why an asset may experience a favorable or unfavorable deterioration curve.</p>
<p>Pavement Management System / PMS</p>	<p>VTrans uses the Deighton dTIMS software application for its PMS. The platform is an SQL database that allows for data storage and user-defined life-cycle analysis. It is the source for the highway network needs analysis, condition reporting, and paving program development.</p>
<p>Vermont Asset Management Information System / VAMIS</p>	<p>VAMIS will be the brains of future VTrans operations and activities. It integrates data from multiple sources (CMS, BMS, PMS, etc.) for ease of use. It will have the ability to track maintenance activities down to the asset level. It is envisioned that VAMIS will have various modules such as planning, budgeting, programming, maintenance, and performance and risk management. It provides users with asset data and information, inspections, GIS data resources, and access to open data sources.</p>

APPENDIX B: TAM FINANCIAL PLAN

TRANSPORTATION ASSET MANAGEMENT PLAN



FINANCIAL PLAN

*Resources Needed to Preserve Vermont's
Transportation Assets*

Introduction

This report serves as the Financial Plan for Vermont's Transportation Asset Management Plan (TAMP). This Financial Plan describes and assesses all of Vermont's transportation funding trends and system needs. Existing and projected conditions specific to the National Highway System (NHS) pavements and bridges are broken out at the end of the report, to facilitate the review of those elements required by the Federal Highway Administration (FHWA).

Funding Sources and Trends

Funding Sources

Vermont's transportation system is funded using a combination of sources, including:

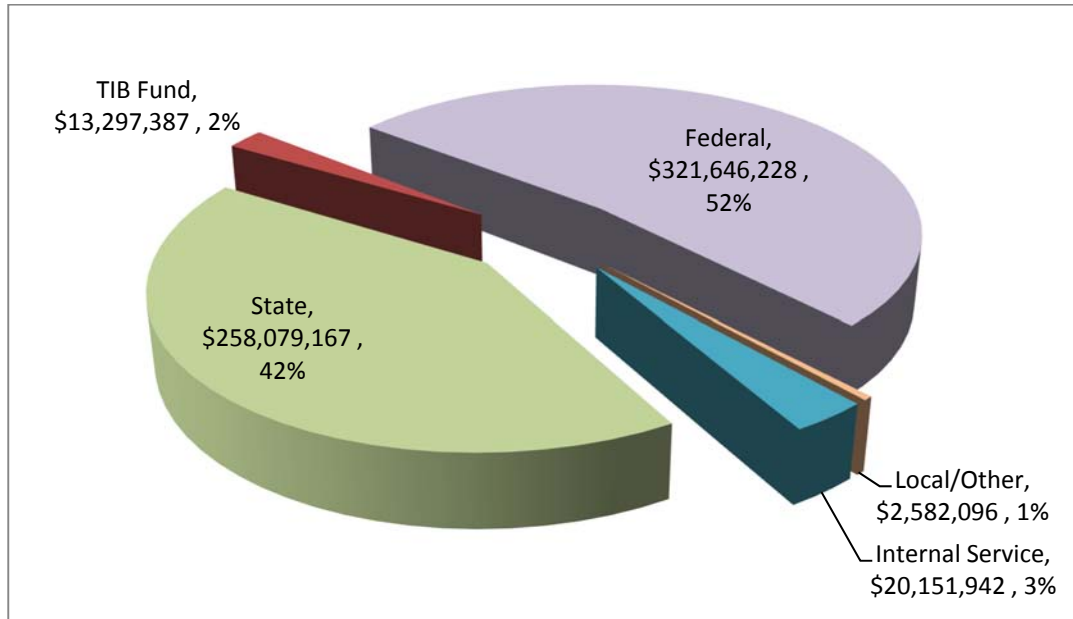
- Federal transportation funds (all major modal administrations)
- State fuel taxes (gasoline and diesel taxes, and assessments)
- State Department of Motor Vehicles (DMV) registration and other fees
- State vehicle purchase and use taxes

For State Fiscal Year (SFY) 2020, approximately 52% of VTrans' \$617.5 million transportation budget (Governor's recommended, referenced hereafter simply as SFY '20) is derived from federal funding sources, including the Federal Highway Administration (FHWA), Federal Transit Administration (FTA), Federal Aviation Administration (FAA), Federal Railroad Administration (FRA), and the National Highway Traffic Safety Administration (NHTSA) (Figure 1). In addition, Vermont receives federal discretionary funding, as well disaster funding through the FHWA Emergency Repair program, and Federal Emergency Management Administration (FEMA) disaster funding.

The State Transportation Fund (T-Fund) accounts for the second largest funding source at 42%. The T-Fund includes revenue from gas and diesel taxes, purchase and use tax, and DMV fees.

Vermont also levies a Transportation Infrastructure Bond (TIB) assessment on gas and diesel fuel which is dedicated to paying the debt service on TIB bonds issued; and to the extent the assessment revenue is not needed to pay debt service, it be expended on certain transportation infrastructure projects. TIB funding has effectively increased the amount of state funding available and allowed VTrans to complete more projects by providing matching funds for federal-eligible projects.

Figure 1: VTrans by Major Funding Sources, SFY 20

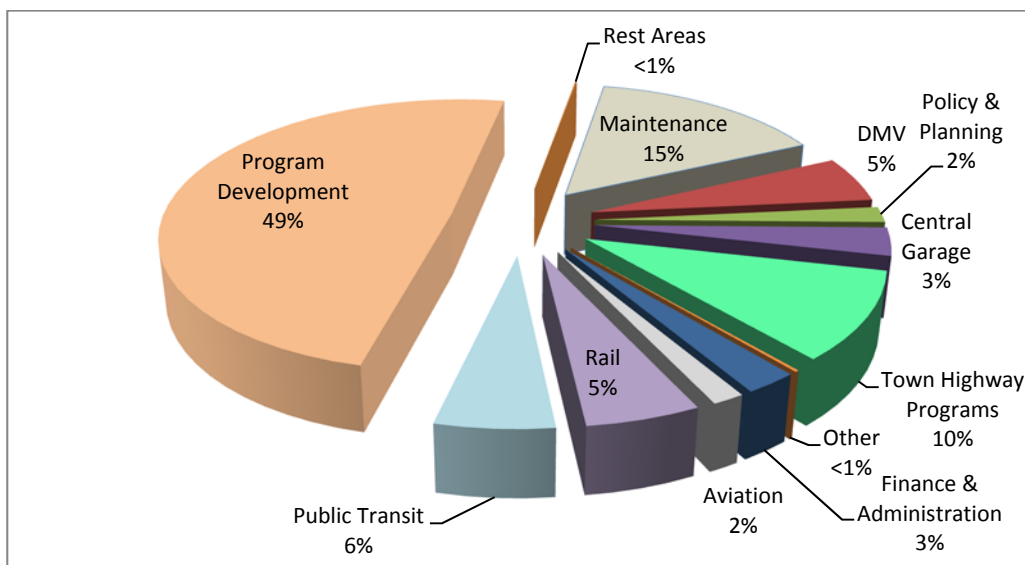


Source: VTrans Budget & Fiscal Management Section

Budget Allocation

Approximately 49% of the Agency’s proposed \$617.5 million SFY budget is expended on program development activities, including state bridges, pavement, and safety programs. The Maintenance programs follow at 15%, and Town Highway programs is the third largest budgeted category at 10% (Figure 2).

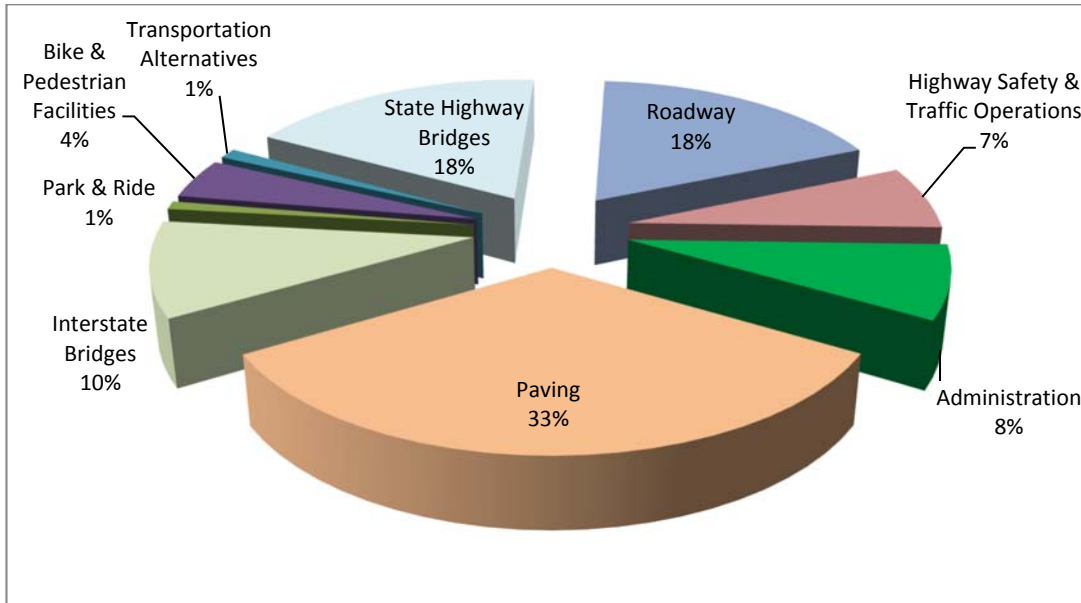
Figure 2: SFY 20 Budget, by Program Area



Source: VTrans Budget & Fiscal Management Section

Within the program development budget, paving, roadways, and bridges account for approximately 79% of expenditures (Figure 3).

Figure 3: SFY 20 Program Development Budget by Program Area

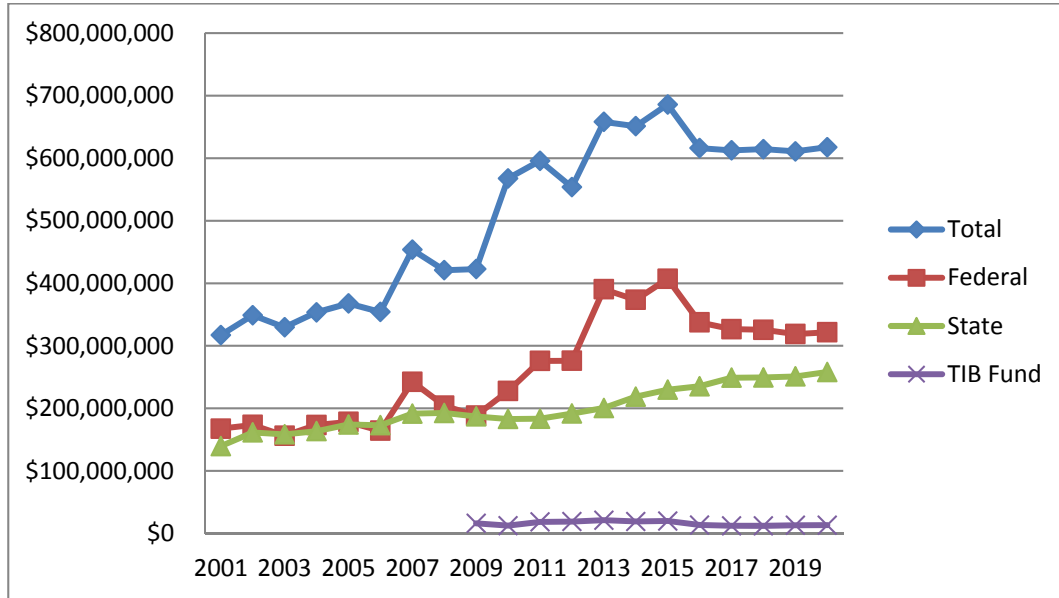


Source: VTrans Budget & Fiscal Management Section

Federal Funding Trends

Vermont relies heavily on federal funding to maintain and operate its transportation system. For SFY 2020, Vermont anticipates expending \$321,646,228 in federal funds (Figure 4). Federal funding levels have declined from the 2013 - 2015 levels which peaked due to the funding of several FHWA Emergency Relief and FEMA projects related to Tropical Storm Irene, as well as American Recovery and Reinvestment Act (ARRA) projects. This additional funding enabled VTrans to accelerate the schedule of dozens of projects and implement projects that would not have been possible without additional federal assistance.

Figure 4: Major Sources of Transportation Funding in Vermont



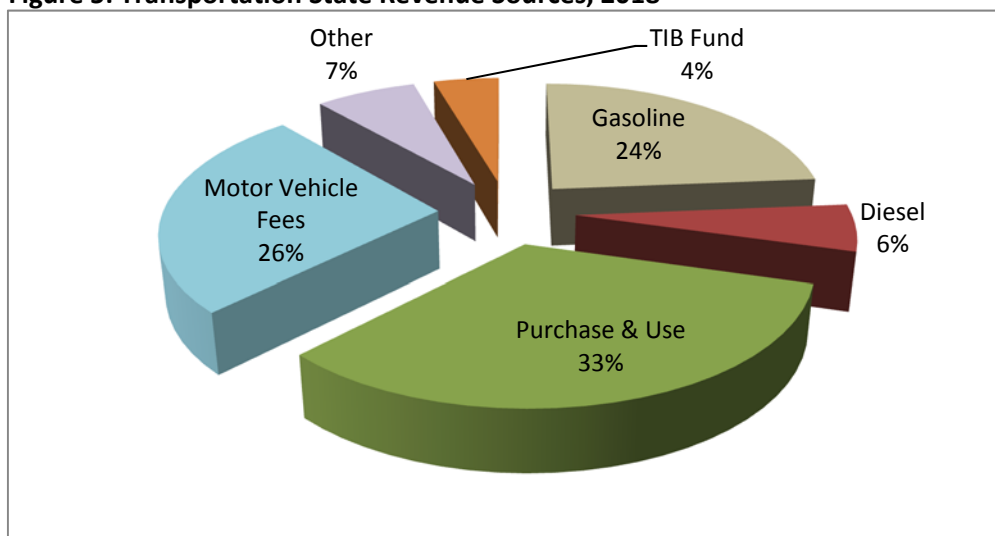
Source: VTrans Budget & Fiscal Management Section

State Funding Trends

State revenues account for the second largest share of transportation revenues. The Governor’s recommended SFY 20 budget includes approximately \$258 million in state funds, and \$13.3 million in Transportation Infrastructure Bonds (TIB) funds.

State revenues encompass a diverse combination of gas and diesel taxes, purchase & use taxes, motor vehicle fees, and TIB funding (Figure 5). Purchase & Use fees account for 33% of revenue, followed by gas and diesel taxes (30%), and by Department of Motor Vehicle (DMV) fees (26%).

Figure 5: Transportation State Revenue Sources, 2018

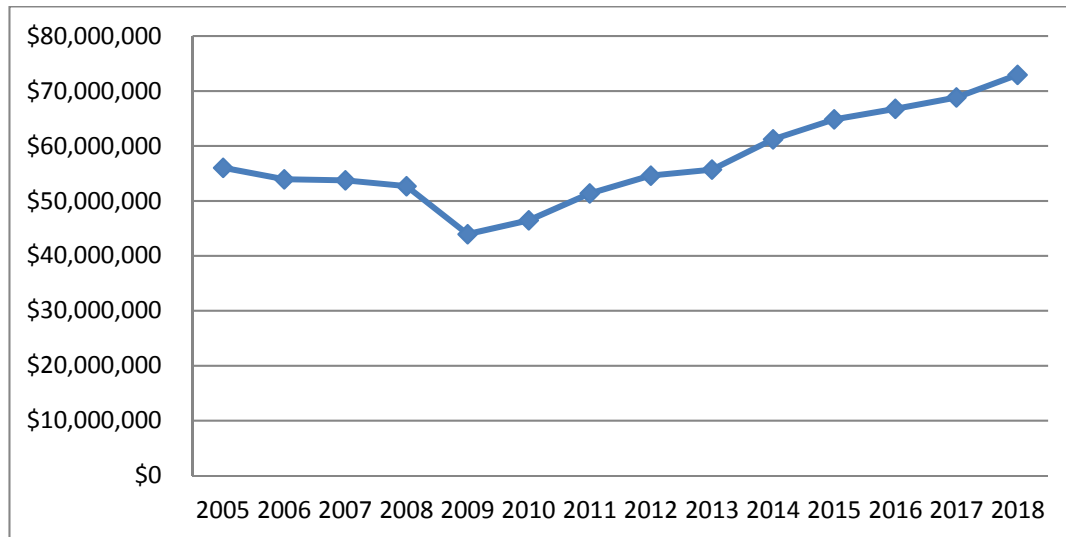


Source: https://aoa.vermont.gov/sites/aoa/files/revenue-economy/EboardRpts/EPRForecastUpdateReport_FINAL_01.17.2019.pdf

1. Purchase & Use Fees

The purchase and use tax (P&U) is 6% of the cost of a vehicle; 4% is allocated to the Transportation Fund and 2% to the Education Fund. P&U taxes contribute 33% of state transportation fund revenues, accounting for the highest share of state revenues. P&U revenues have consistently increased since the recession of 2008-2009 (Figure 6).

Figure 6: State Transportation Fund Revenue from Purchase & Use Fees



Source: Vermont Joint Fiscal Office – Transportation Fund Revenue Report <http://www.leg.state.vt.us/jfo/transportation.aspx>

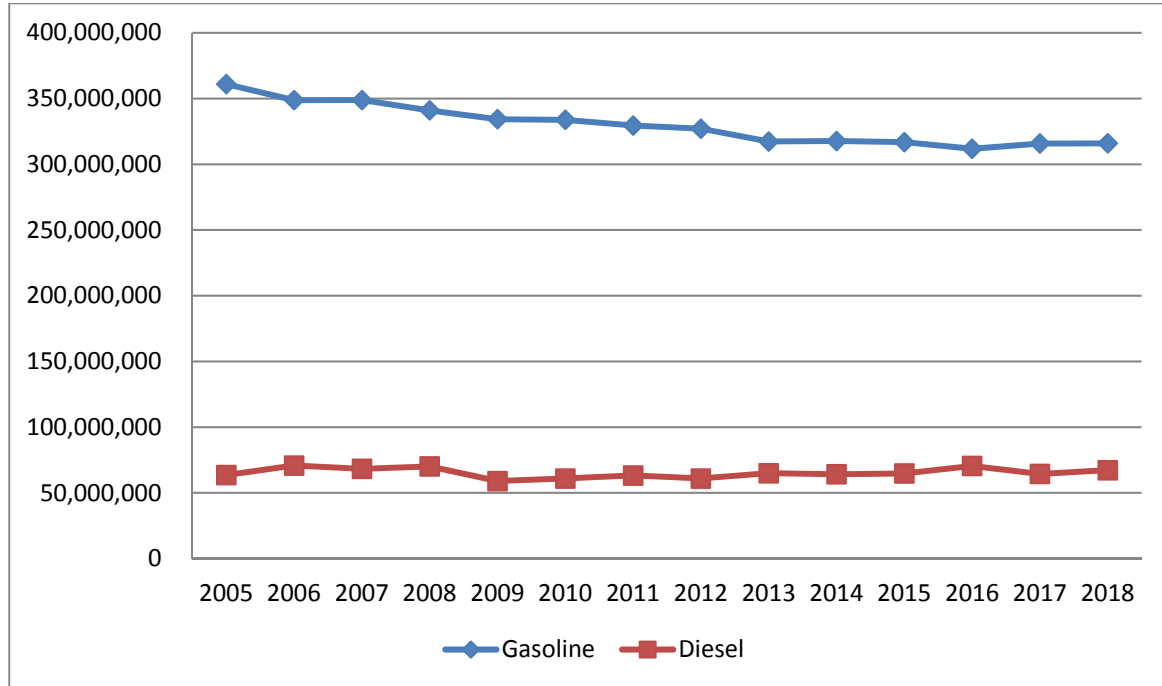
2. Gasoline and Diesel Fuel Taxes

Vermont’s gas tax is 13.1 cents-per-gallon, which includes a 1 cent-per-gallon petroleum cleanup fee. In addition, there is a 2% TIB assessment levied to the retail price of gasoline, and a T-Fund assessment of 4% of the retail price with a minimum tax of 13.4 cents-per-gallon and maximum of 18 cents-per-gallon. Prior to SFY 13, the gas tax was 20 cents-per-gallon – 19 cents were allocated to the transportation fund and 1 cent to the petroleum clean-up fund, with a 2% TIB assessment levied on the retail price of gasoline.

Gasoline revenue to the T-Fund declined steadily between 2005 and 2013 as improvements to fuel economy and fewer vehicles miles traveled (VMT) resulted in lower gasoline consumption rates (Figure 7). Since 2013, gasoline revenues rose as a result of the change in the gas tax (Figure 8). However, revenues have been flat from 2014 to 2018, and will likely not keep pace with inflation without a significant increase in consumption.

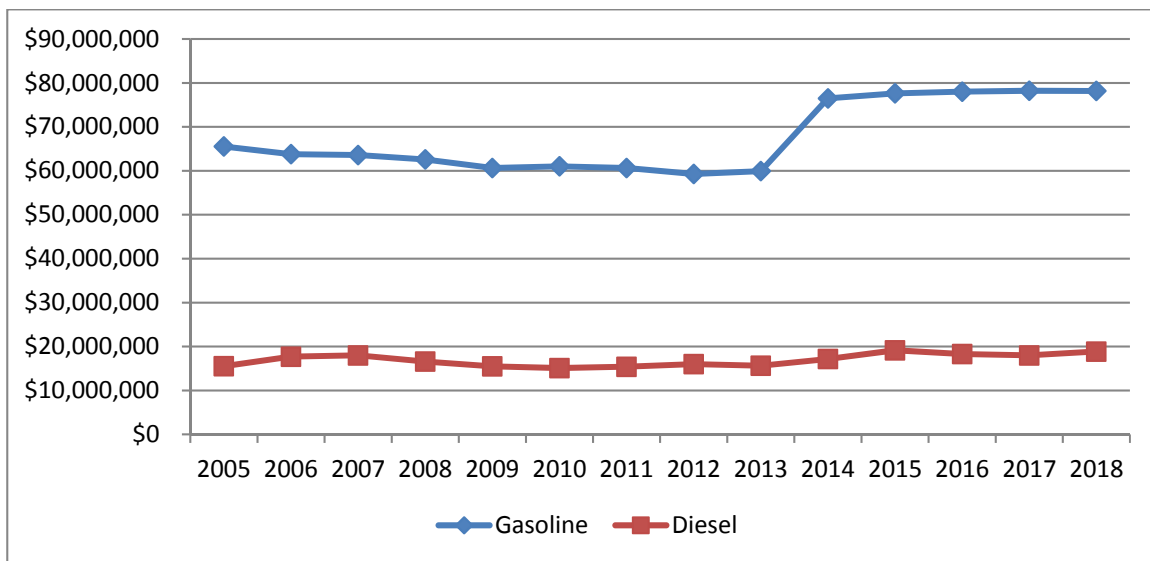
In SFY 2013, Vermont’s diesel tax was raised from 25 cents-per-gallon to 27 cents-per-gallon. In SFY 2014, it was raised again to 28 cents-per-gallon. Consumption and the associated revenues have remained essentially steady.

Figure 7: Gasoline and Diesel Consumption by SFY



Source: Vermont JFO – Gasoline & Diesel Revenues Report <http://www.leg.state.vt.us/jfo/transportation.aspx>

Figure 8: Gasoline and Diesel Revenue in Vermont by SFY

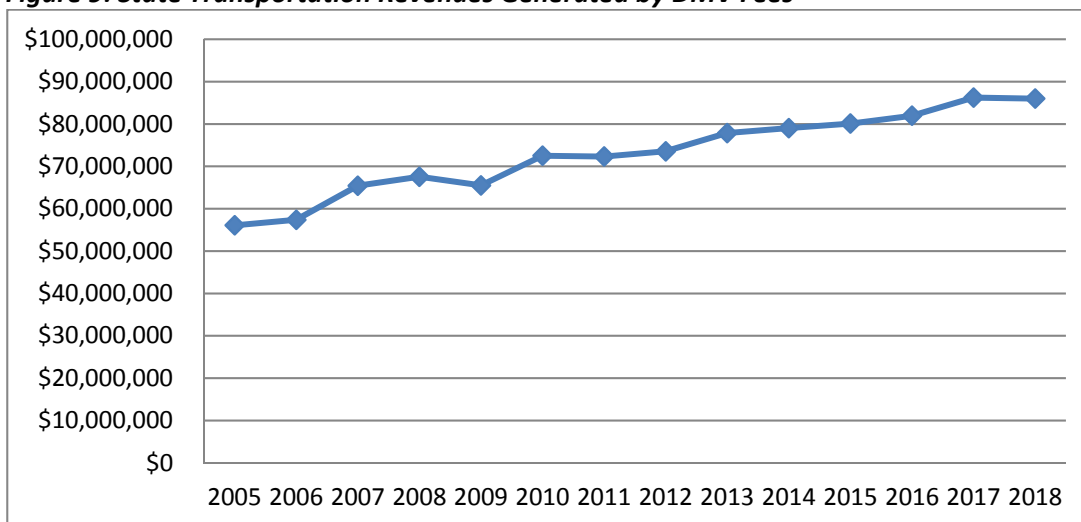


Source: Vermont Joint Fiscal Office – Gasoline & Diesel Revenues Report <http://www.leg.state.vt.us/jfo/transportation.aspx>

3. DMV Motor Vehicle Fees

DMV motor vehicle fees account for the third highest share of state transportation revenues at 26%. DMV fees consist of a variety of fees for vehicle registrations, licenses, permits and endorsements. In contrast to gasoline revenues, DMV fee revenue has steadily increased over the past decade with the help of three fee adjustments which ensured that they kept pace with inflation (Figure 9).

Figure 9: State Transportation Revenues Generated by DMV Fees



Source: Vermont Joint Fiscal Office – Transportation Fund Revenue Report
<http://www.leg.state.vt.us/jfo/transportation.aspx>

Funding Risks

Federal Funding

Federal funding risks center on transportation reauthorization and Highway Trust Fund (HTF) revenues. The vast majority of Vermont’s \$321,646,228 federal funds are derived from the HTF account.

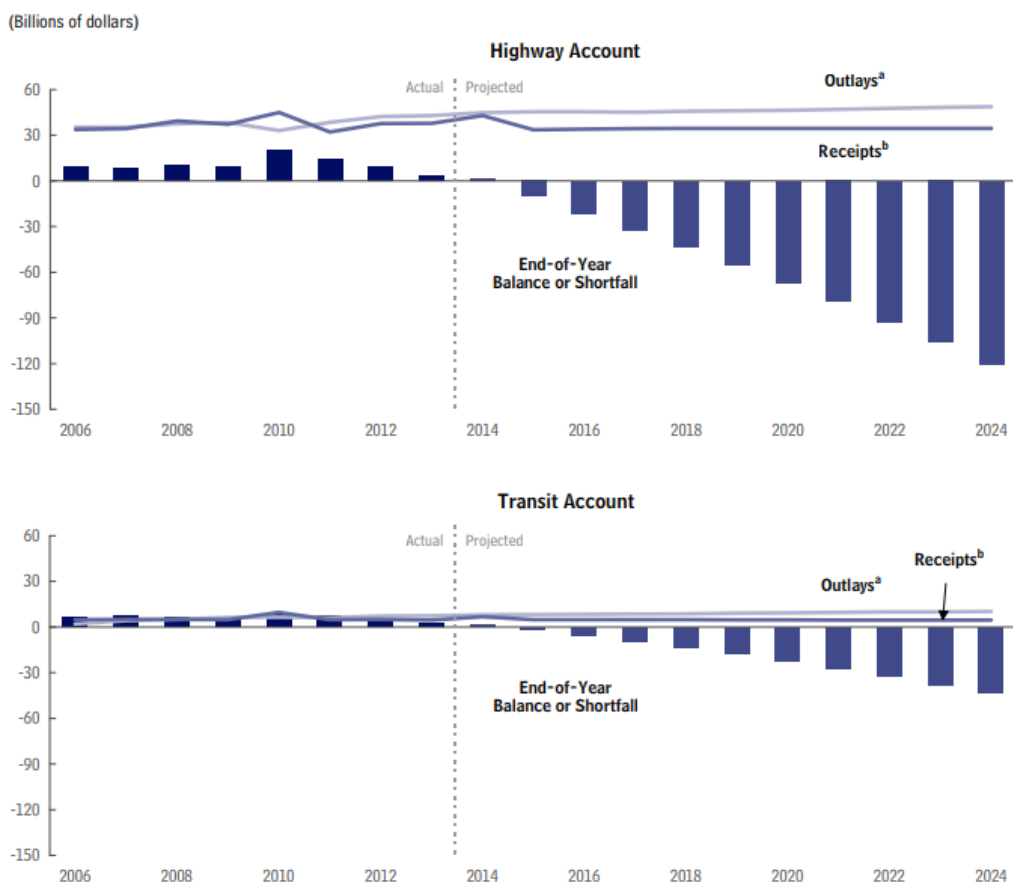
The current federal surface transportation authorization bill – Fixing America’s Surface Transportation (FAST) – is a 5-year, \$305 billion authorization that covers highway, transit, and rail programs. Prior to FAST, VTrans was operating under a series of extensions to the previous authorization, making it difficult for the agency to plan long-term for projects, a critical component of asset management.

FAST does not provide sufficient long-term funding for Vermont’s transportation needs. Although funded at slightly higher levels than the previous authorization, funding levels are insufficient to

reduce the backlog of VTrans’ needs or keep up with the inflation associated with capital and operating costs.

The HTF, which collects taxes on gasoline and diesel sales, is the primary federal mechanism to fund highway and transit programs. Approximately one-quarter of FAST apportionments are based on funding sources other than the HTF. The fund is intended to be self-sustaining. In recent years, however, Congress has approved multi-billion-dollar transfers from the General Fund to the HTF to cover shortfalls. The HTF’s long-term solvency continues to be threatened by lower than anticipated revenues and the impact of inflation – the federal gasoline tax (18.4-cents per gallons) has not been increased since 1993 (Figure 10).

Figure 10: Receipts, Outlays, and Balance or Shortfall for the Highway Trust Fund (April 2014 Baseline)



Source: Congressional Budget Office.

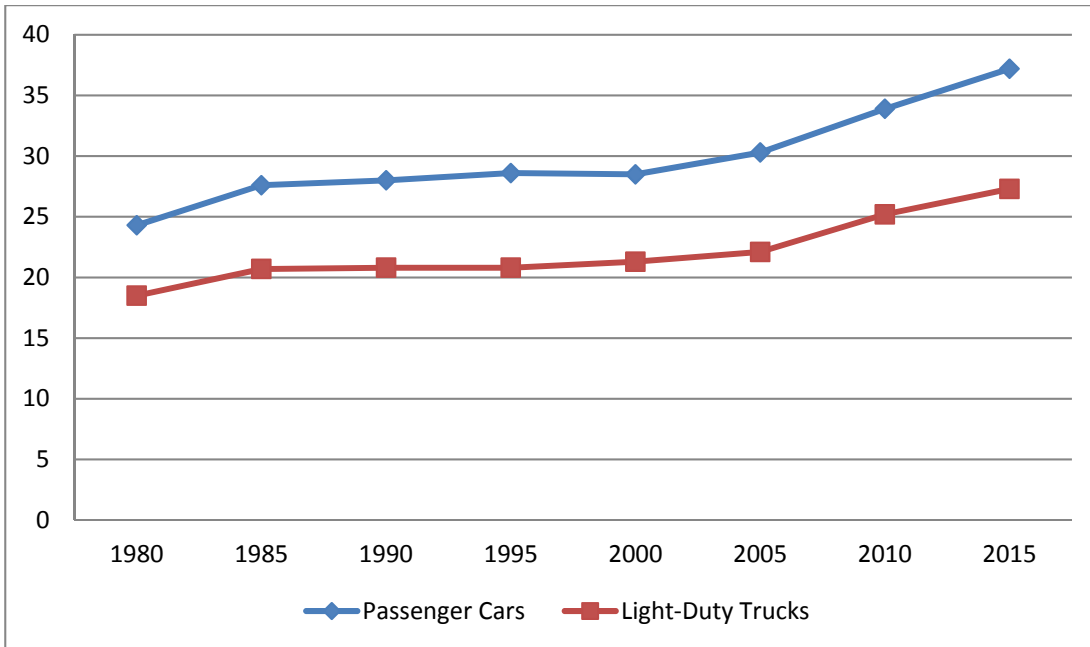
Note: Under current law, the Highway Trust Fund cannot incur negative balances, nor is it permitted to borrow to cover unmet obligations presented to the fund. Under the Balanced Budget and Emergency Deficit Control Act of 1985, however, CBO’s baseline for highway spending must incorporate the assumption that obligations incurred by the Highway Trust Fund will be paid in full.

- a. Projections of outlays are calculated by adjusting the obligation limitations set for the current year to account for projected inflation.
- b. Projections of receipts are based on market conditions, and they incorporate an assumption under CBO’s April 2014 baseline that some taxes (including taxes on certain heavy vehicles and tires and all but 4.3 cents of the federal tax on motor fuels) that are credited to the Highway Trust Fund but scheduled to expire on September 30, 2016, would be extended.

The receipts line includes revenues credited to the Highway Trust Fund and intragovernmental transfers, mostly from the U.S. Treasury’s general fund. Since 2008, those transfers (including amounts transferred in fiscal year 2014) have totaled about \$54 billion.

The long-term HTF forecast signals continuing problems. The Congressional Budget Office (CBO) projects that the fund will pay out \$465 billion to states from 2015 through 2024, but will only take in \$343 billion¹. A 2012 CBO report notes that higher fuel economy standards for all cars and light trucks which started in 2016 will reduce gasoline consumption and associated revenues.²

Figure 11: Average Fuel Economy (Miles Per Gallon) by Model Year, 1980-2015



Source: Bureau of Transportation Statistics – Table 4-23: Average Fuel Efficiency of U.S. Light Duty Vehicles
<https://www.bts.gov/content/average-fuel-efficiency-us-light-duty-vehicles>

Due to the increased dependence on general fund revenues, there are risks associated with appropriations. While FAST includes authorized funding levels, the appropriations process ultimately sets funding amounts. In the first year of FAST, several authorized rail capital assistance programs failed to receive appropriations. The risk that that this will affect highway programs increases the more these programs rely on general funds.

In addition, due to advances in engine and battery technologies, a greater proportion of vehicles are using electric and hybrid energy sources. This transition will ultimately result in a loss of transportation revenue, as these vehicles consume less or no fuel and thus contribute less revenue to the HTF.

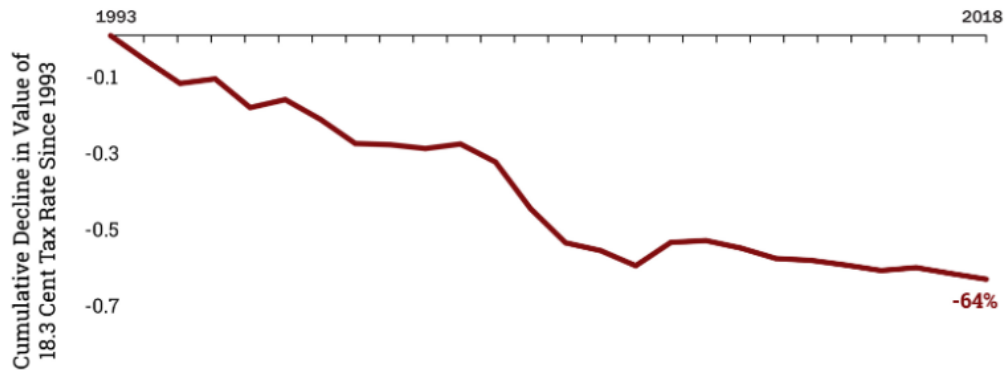
The inability of the HTF to keep up with authorized funding has also resulted in inflation diminishing the HTF’s buying power. At 18.4¢ per gallon, the gasoline tax is the highest it has ever been in nominal dollars, yet its buying power is significantly diminished.

¹ <https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/45416-TransportationScoring.pdf>

² https://www.cbo.gov/sites/default/files/112th-congress-2011-2012/reports/05-02-CAFE_brief.pdf

After adjusting for both inflation and fuel-efficiency gains, the purchasing power of the Federal gas tax has decreased by 64% since 1993. (Figure 12).

Figure 12: Purchasing Power of the Federal Gas Tax due to Inflation and Fuel-Efficiency Gains



Source: Institute on Taxation and Economic Policy (ITEP) analysis of data from the Federal Highway Administration (FHWA), Energy Information Administration (EIA), and Congressional Budget Office (CBO).

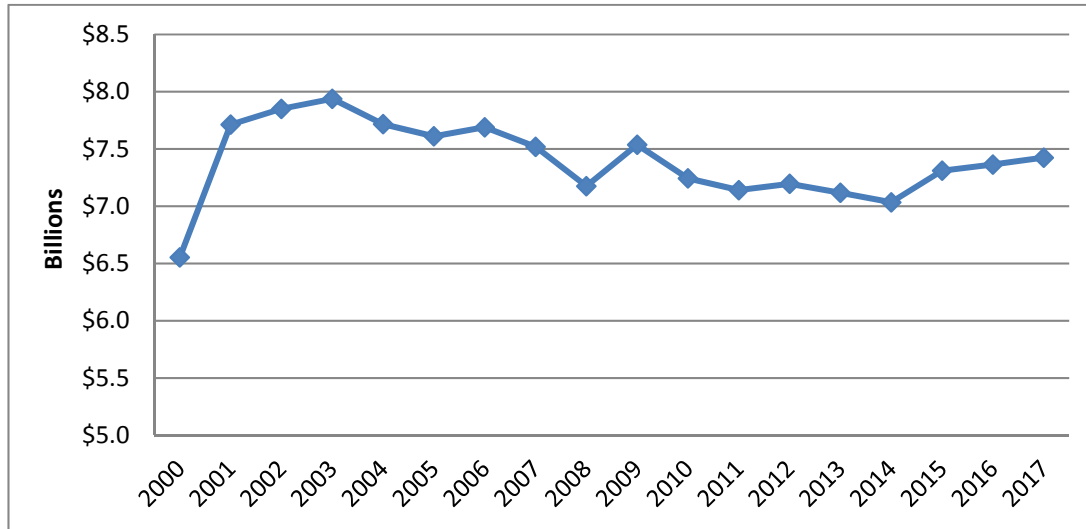
Source: Institute on Taxation and Economic Policy – “An Unhappy Anniversary: Federal Gas Tax Reaches 25 Years of Stagnation” (2018): <https://itep.org/an-unhappy-anniversary-federal-gas-tax-reaches-25-years-of-stagnation/>

State Funding

The gasoline tax risks associated with federal funding are also applicable to state funding. Mirroring national trends, Vermont has witnessed a decline in gasoline consumption – an important source of revenue accounting for close to a quarter of state transportation revenues as residents drive less and shift to more fuel efficient vehicles. Since 2005, gasoline consumption has declined by more than 45 million gallons (12%).

Throughout the 1990s and early 2000s, VMT in Vermont increased an average of 2% annually, peaking in 2003 at 7.9 billion. Since then, VMT has generally stabilized at approximately 7.2 billion miles (Figure 13).

Figure 13: Vehicle Miles Traveled in Vermont, 2000-2017



Source: VTrans Highway Research Section – Vehicle Miles Traveled, 2003-2014
<http://vtransplanning.vermont.gov/research/highway/publications>

While VMT is expected to increase with a stronger economy, steady improvements in vehicle efficiency along with greater use of alternative fuels and electric vehicles are likely to offset future fuel consumption from increases in VMT—particularly as the federal government has increased automobile fuel economy standards (Corporate Average Fuel Economy) through 2025 (Table 1).

Table 1: Estimated Average Required Fleet-Wide Fuel Economy (mpg) under Footprint Based CAFE Standards

	MY	2017	2018	2019	2020	2021	2022	2023	2024	2025
	Baseline									
Passenger cars	2008	40.1 –	41.6 –	43.1 –	44.8 –	46.8 –	49.0 –	51.2 –	53.6 –	56.2 –
	2010	39.6	41.1	42.5	44.2	46.1	48.2	50.5	52.9	55.3
Light trucks	2008	29.4 –	30.0 –	30.6 –	31.2 –	33.3 –	34.9 –	36.6 –	38.5 –	40.3 –
	2010	29.1	29.6	30.0	30.6	32.6	34.2	35.8	37.5	39.3
Combined	2008	35.4 –	36.5 –	37.7 –	38.9 –	41.0 –	43.0 –	45.1 –	47.4 –	49.7 –
	2010	35.1	36.1	37.1	38.3	40.3	42.3	44.3	46.5	48.7

Federal Register / Vol. 77, No. 199 / Monday, October 15, 2012 / Rules and Regulations, page 62640
<https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy#corporate-average-fuel-economy-light-duty-vehicles>

As noted previously, Vermont is very dependent on Federal funding to maintain its transportation infrastructure. For most programs, State matching funds are required to leverage federal funds. Recent increases to Federal funds are at risk of outpacing the State funds necessary to fully access them. Increased Federal funds, while welcome, may force the State's hand to increase its own revenue sources. VTrans has a long-standing practice of obligating all its federal funds. VTrans is committed to maintaining this practice into the foreseeable future. VTrans' approach towards mitigating this risk is to propose a fee bill every three (3) years to increase State revenue that ensures that VTrans has the State funds to match the federal funds which it receives. VTrans next fee bill proposal is scheduled for submission in January 2020.

Transportation Funding Forecast

Forecasts for anticipated gasoline revenue continue to point to flat returns. The Consensus Forecast projects virtually flat gasoline revenue of \$77.6 million through 2021¹. Long-range transportation budget forecasts of 0% and 2% growth are presented in Tables 2 and 3.

¹ https://aoa.vermont.gov/sites/aoa/files/revenue-economy/EboardRpts/EPRForecastUpdateReport_FINAL_01.17.2019.pdf

Table 2: Vermont Transportation Funding Projections at 0% Budget Growth (assumes 2% growth in Federal funds, 0% growth in State funds, \$7M increase in fees every three years)

	Current Year											
	FFY2020	FFY2021	FFY2022	FFY2023	FFY2024	FFY2025	FFY2026	FFY2027	FFY2028	FFY2029	FFY2030	
Funding Projection @ 0% Growth Update provided by Lenny Leblanc (CFO) on September 5, 2018 Vermont Estimated Apportionment (excluding high priority earmarks, assumes 2% growth after FFY18)												
National Highway Performance Program	125,359,554	127,866,746	130,424,080	133,032,562	135,693,213	138,407,078	141,175,219	143,998,724	146,878,698	149,816,272	152,812,597	
Surface Transportation Program	62,715,175	63,969,479	65,248,868	66,553,846	67,884,923	69,242,621	70,627,474	72,040,023	73,480,823	74,950,440	76,449,449	
Highway Safety Improvement Program	12,502,161	12,752,205	13,007,249	13,267,394	13,532,742	13,803,396	14,079,464	14,361,054	14,648,275	14,941,240	15,240,065	
Railway-Highway Crossings Program	1,224,000	1,248,480	1,273,450	1,298,919	1,324,897	1,351,395	1,378,423	1,405,991	1,434,111	1,462,793	1,492,049	
Congestion Mitigation & Air Quality Improvement Program	12,766,621	13,021,953	13,282,392	13,548,040	13,819,001	14,095,381	14,377,289	14,664,834	14,958,131	15,257,294	15,562,440	
Metropolitan Planning Program	2,265,800	2,311,116	2,357,339	2,404,486	2,452,575	2,501,627	2,551,659	2,602,693	2,654,746	2,707,841	2,761,998	
National Highway Freight Program	7,062,236	7,203,481	7,347,551	7,494,502	7,644,392	7,797,279	7,953,225	8,112,290	8,274,535	8,440,026	8,608,827	
Total Apportionments	223,895,549	228,373,460	232,940,929	237,599,748	242,351,743	247,198,777	252,142,753	257,185,608	262,329,320	267,575,907	272,927,425	
Obligation Limitation	215,983,905	220,103,583	224,305,655	228,591,768	232,963,603	237,422,875	241,971,333	246,610,759	251,342,975	256,169,834	261,093,231	
	Beyond the Fast Act in FY20 assuming 2% growth in federal funds, but 0% growth											
Available Funding (by SFY):												
FHWA annual formula	215,983,905	220,103,583	224,305,655	228,591,768	232,963,603	237,422,875	241,971,333	246,610,759	251,342,975	256,169,834	261,093,231	
Federal discretionary	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	
FHWA other: obligated unspent from prior years, etc	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	
Total FHWA	274,483,905	278,603,583	282,805,655	287,091,768	291,463,603	295,922,875	300,471,333	305,110,759	309,842,975	314,669,834	319,593,231	
FTA	21,225,000	21,225,000	21,225,000	21,225,000	21,225,000	21,225,000	21,225,000	21,225,000	21,225,000	21,225,000	21,225,000	
FAA	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	
FRA	7,650,000	7,650,000	7,650,000	7,650,000	7,650,000	7,650,000	7,650,000	7,650,000	7,650,000	7,650,000	7,650,000	
Other federal	5,440,000	5,440,000	5,440,000	5,440,000	5,440,000	5,440,000	5,440,000	5,440,000	5,440,000	5,440,000	5,440,000	
Total Federal	312,798,905	316,918,583	321,120,655	325,406,768	329,778,603	334,237,875	338,786,333	343,425,759	348,157,975	352,986,834	357,908,231	
Local/Other (VTrans managed budget)	4,650,000	4,650,000	4,650,000	4,650,000	4,650,000	4,650,000	4,650,000	4,650,000	4,650,000	4,650,000	4,650,000	
State Transportation Fund (\$7M every 3 years for a fee bill)	258,073,000	258,073,000	258,073,000	265,073,000	265,073,000	265,073,000	272,073,000	272,073,000	272,073,000	279,073,000	279,073,000	
State TIB Fund	13,200,000	13,200,000	13,200,000	13,200,000	13,200,000	13,200,000	13,200,000	13,200,000	13,200,000	13,200,000	13,200,000	
Total Available Funding	588,721,905	592,841,583	597,043,655	606,529,768	612,701,603	617,160,875	626,709,333	633,348,759	638,080,975	649,907,834	654,831,231	

Source: VTrans Budget & Fiscal Management Section

Table 3: Vermont Transportation Funding Projections at 2% Budget Growth (assumes 2% growth in Federal funds, 2% growth in State funds, \$7M increase in fees every three years)

	Current Year											
	FFY2020	FFY2021	FFY2022	FFY2023	FFY2024	FFY2025	FFY2026	FFY2027	FFY2028	FFY2029	FFY2030	
Funding Projection @ 2% Growth												
Update provided by Lenny Labianc (CFO) on September 5, 2018												
Vermont Estimated Apportionment (excluding high priority earmarks; assumes 2% growth after FFY18)												
National Highway Performance Program	125,460,076	127,969,278	130,528,663	133,139,236	135,802,021	138,518,061	141,288,423	144,114,191	146,996,475	149,936,404	152,935,133	
Surface Transportation Block Grant Program	62,833,048	64,091,749	65,373,584	66,681,056	68,014,677	69,374,970	70,762,470	72,177,719	73,621,273	75,093,699	76,595,473	
Highway Safety Improvement Program	12,505,708	12,795,822	13,010,939	13,271,157	13,536,581	13,807,312	14,083,458	14,365,128	14,652,430	14,945,479	15,244,388	
Railway-Highway Crossings Program	1,225,000	1,249,500	1,274,490	1,299,980	1,325,979	1,352,489	1,379,549	1,407,140	1,435,283	1,463,988	1,493,268	
Congestion Mitigation & Air Quality Improvement Program	12,770,507	13,025,917	13,286,435	13,552,164	13,823,207	14,099,672	14,381,665	14,669,298	14,962,684	15,261,938	15,567,177	
Metropolitan Planning Program	2,273,079	2,318,941	2,364,911	2,412,210	2,460,454	2,509,663	2,559,856	2,611,053	2,663,274	2,716,540	2,770,871	
National Highway Freight Program	7,693,067	7,846,928	8,003,867	8,163,944	8,327,223	8,493,768	8,663,643	8,836,916	9,013,654	9,193,927	9,377,806	
Total Apportionments	224,762,485	229,257,735	233,842,889	238,519,747	243,290,142	248,155,945	253,119,064	258,181,445	263,345,074	268,611,976	273,984,215	
Obligation Limitation	216,781,486	220,917,116	225,135,458	229,438,167	233,826,931	238,303,469	242,869,539	247,526,930	252,277,468	257,123,017	262,065,478	
Available Funding (by SFY):												
FHWA annual formula	216,781,486	220,917,116	225,135,458	229,438,167	233,826,931	238,303,469	242,869,539	247,526,930	252,277,468	257,123,017	262,065,478	
Federal discretionary	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	12,000,000	
FHWA other; obligated unspent from prior years, misc., etc	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	46,500,000	
Total FHWA	275,281,486	279,417,116	283,635,458	287,938,167	292,326,931	296,803,469	301,369,539	306,026,930	310,777,468	315,623,017	320,565,478	
FTA	21,602,900	22,082,900	22,524,140	22,974,623	23,434,115	23,902,797	24,380,853	24,868,470	25,365,840	25,873,157	26,390,620	
FAA	9,353,400	9,540,468	9,731,277	9,925,903	10,124,421	10,326,909	10,533,448	10,744,117	10,958,999	11,178,179	11,401,742	
FRA	7,803,000	7,959,060	8,118,241	8,280,606	8,446,218	8,615,443	8,787,445	8,963,194	9,142,458	9,325,307	9,511,813	
Other federal	5,548,800	5,659,776	5,772,972	5,888,431	6,006,200	6,126,324	6,248,850	6,373,827	6,501,304	6,631,330	6,763,856	
Total Federal	319,636,186	324,638,910	329,782,068	335,007,790	340,337,884	345,774,642	351,320,135	356,976,538	362,746,068	368,639,990	374,633,610	
Local/Other (VTrans managed budget)	4,743,000	4,837,860	4,934,617	5,033,310	5,133,976	5,236,655	5,341,388	5,448,216	5,557,180	5,668,324	5,781,691	
State Transportation Fund (\$7M every 3 years - orange columns - for a fee bill)	263,094,460	268,356,349	273,723,476	279,197,946	284,781,905	290,479,343	296,295,161	302,231,359	308,291,046	314,468,327	320,765,603	
State TIB Fund	13,464,000	13,733,280	14,007,946	14,288,105	14,573,867	14,865,344	15,162,651	15,465,904	15,775,222	16,090,726	16,412,541	
State Bonds												
Total Available Funding	600,937,646	611,586,399	622,448,127	640,827,090	651,967,631	663,636,884	682,539,724	694,820,518	707,346,929	727,123,867	740,296,346	

Source: VTrans Budget & Fiscal Management Section

Transportation Needs

This section presents a preliminary estimate of the cost to maintain, operate, build and administer Vermont's transportation system for the ten-year period between 2021 and 2030. Needs estimates are provided for a "basic needs" scenario.

For the purposes of this report, "basic needs" means the cost to preserve the state's existing transportation system in a state of good repair. It assumes that preserving the functionality of the road network is fundamental to meeting basic travel needs of people and goods and therefore includes the necessary funding to preserve bridges and roads. It does not include expansion of rail or transit beyond existing levels of service and does not include any major roadway expansion beyond projects already in the project development "pipeline".

In all cases, these are estimates and are subject to change as assumptions and methods are refined throughout the study process or as VTrans improves its asset management systems. Out-year needs are increased for inflation at an estimated rate of 2.5%.

In some cases, particularly administrative programs such as DMV, Policy and Planning, and PDD Admin, future needs are estimated simply by scaling up by recent expenditures by the inflation rate to reflect anticipated salary increases. For some programs, such as Roadway, Rail, and Transit, future needs are estimated based on the informed opinions of subject matter experts. Some programs, particularly Paving and Bridges, have or are developing sophisticated analyses of conditions, predicted deterioration, and optimized spending plans to meet target conditions.

More detailed information on the funding needs of four major (\$100 million+) program elements (Paving, Bridges, Roadway, and Maintenance) are provided.

Table 4: Vermont Transportation Funding “Basic Needs” Forecast

SFY	2020 (Current)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
DMV	\$ 33,150,701	\$ 33,979,469	\$ 34,828,955	\$ 35,699,679	\$ 36,592,171	\$ 37,506,975	\$ 38,444,650	\$ 39,405,766	\$ 40,390,910	\$ 41,400,683	\$ 42,435,700
F&A	\$ 15,497,069	\$ 15,884,496	\$ 16,281,608	\$ 16,688,648	\$ 17,105,865	\$ 17,533,511	\$ 17,971,849	\$ 18,421,145	\$ 18,881,674	\$ 19,353,716	\$ 19,837,559
Paving	\$ 100,682,429	\$ 104,395,297	\$ 107,005,179	\$ 109,680,309	\$ 112,422,317	\$ 115,232,875	\$ 118,113,696	\$ 121,066,539	\$ 124,093,202	\$ 127,195,532	\$ 130,375,421
Bridges	\$ 84,931,319	\$ 102,032,105	\$ 104,582,907	\$ 107,197,480	\$ 109,877,417	\$ 112,624,352	\$ 115,439,961	\$ 118,325,960	\$ 121,284,109	\$ 124,316,212	\$ 127,424,117
Roadway	\$ 53,679,614	\$ 226,645,954	\$ 230,177,453	\$ 243,776,946	\$ 249,871,370	\$ 256,118,154	\$ 262,521,108	\$ 269,084,136	\$ 275,811,239	\$ 282,706,520	\$ 289,774,183
T&S	\$ 20,745,379	\$ 22,481,729	\$ 23,043,772	\$ 23,619,867	\$ 24,210,363	\$ 24,815,622	\$ 25,436,013	\$ 26,071,913	\$ 26,723,711	\$ 27,391,804	\$ 28,076,599
P&R	\$ 2,651,588	\$ 3,310,311	\$ 3,393,069	\$ 3,477,896	\$ 3,564,843	\$ 3,653,964	\$ 3,745,313	\$ 3,838,946	\$ 3,934,920	\$ 4,033,293	\$ 4,134,125
Bike & Ped	\$ 13,040,923	\$ 12,252,323	\$ 12,558,631	\$ 12,872,596	\$ 13,194,411	\$ 13,524,272	\$ 13,862,378	\$ 14,208,938	\$ 14,564,161	\$ 14,928,265	\$ 15,301,472
Trans Alt.	\$ 3,268,617	\$ 3,520,615	\$ 3,608,630	\$ 3,698,846	\$ 3,791,317	\$ 3,886,100	\$ 3,983,252	\$ 4,082,834	\$ 4,184,904	\$ 4,289,527	\$ 4,396,765
PDD Admin	\$ 23,817,481	\$ 24,412,918	\$ 25,023,241	\$ 25,648,822	\$ 26,290,043	\$ 26,947,294	\$ 27,620,976	\$ 28,311,500	\$ 29,019,288	\$ 29,744,770	\$ 30,488,389
Rest Areas	\$ 679,706	\$ 730,060	\$ 748,312	\$ 767,020	\$ 786,195	\$ 805,850	\$ 825,996	\$ 846,646	\$ 867,812	\$ 889,508	\$ 911,745
P&P	\$ 11,192,221	\$ 11,472,027	\$ 11,758,827	\$ 12,052,798	\$ 12,354,118	\$ 12,662,971	\$ 12,979,545	\$ 13,304,034	\$ 13,636,634	\$ 13,977,550	\$ 14,326,989
Maint	\$ 93,913,939	\$ 108,261,787	\$ 110,968,332	\$ 113,742,540	\$ 116,586,104	\$ 119,500,757	\$ 122,488,275	\$ 125,550,482	\$ 128,689,244	\$ 131,906,476	\$ 135,204,137
Transit	\$ 34,024,399	\$ 34,875,009	\$ 35,746,884	\$ 36,640,556	\$ 37,556,570	\$ 38,495,484	\$ 39,457,872	\$ 40,444,318	\$ 41,455,426	\$ 42,491,812	\$ 43,554,107
Aviation	\$ 9,344,636	\$ 7,600,620	\$ 7,790,636	\$ 7,985,401	\$ 8,185,036	\$ 8,389,662	\$ 8,599,404	\$ 8,814,389	\$ 9,034,749	\$ 9,260,617	\$ 9,492,133
Rail	\$ 32,852,832	\$ 38,784,674	\$ 39,754,291	\$ 40,748,148	\$ 41,766,852	\$ 42,811,023	\$ 43,881,299	\$ 44,978,331	\$ 46,102,789	\$ 47,255,359	\$ 48,436,743
CG	\$ 20,151,942	\$ 20,655,741	\$ 21,172,134	\$ 21,701,437	\$ 22,243,973	\$ 22,800,073	\$ 23,370,075	\$ 23,954,326	\$ 24,553,185	\$ 25,167,014	\$ 25,796,189
Bldgs	\$ 907,746	\$ 3,000,000	\$ 3,075,000	\$ 3,151,875	\$ 3,230,672	\$ 3,311,439	\$ 1,697,112	\$ 1,739,540	\$ 1,783,029	\$ 1,827,604	\$ 1,873,294
T-Board	\$ 282,191	\$ 289,246	\$ 296,477	\$ 303,889	\$ 311,486	\$ 319,273	\$ 327,255	\$ 335,436	\$ 343,822	\$ 352,418	\$ 361,228
Town Prog	\$ 62,731,902	\$ 101,208,604	\$ 103,738,819	\$ 106,332,290	\$ 108,990,597	\$ 111,715,362	\$ 114,508,246	\$ 117,370,952	\$ 120,305,226	\$ 123,312,857	\$ 126,395,678
Total Needs	\$ 617,546,634	\$ 875,792,983	\$ 895,553,158	\$ 925,787,044	\$ 948,931,720	\$ 972,655,013	\$ 995,274,276	\$ 1,020,156,133	\$ 1,045,660,037	\$ 1,071,801,538	\$ 1,098,596,576

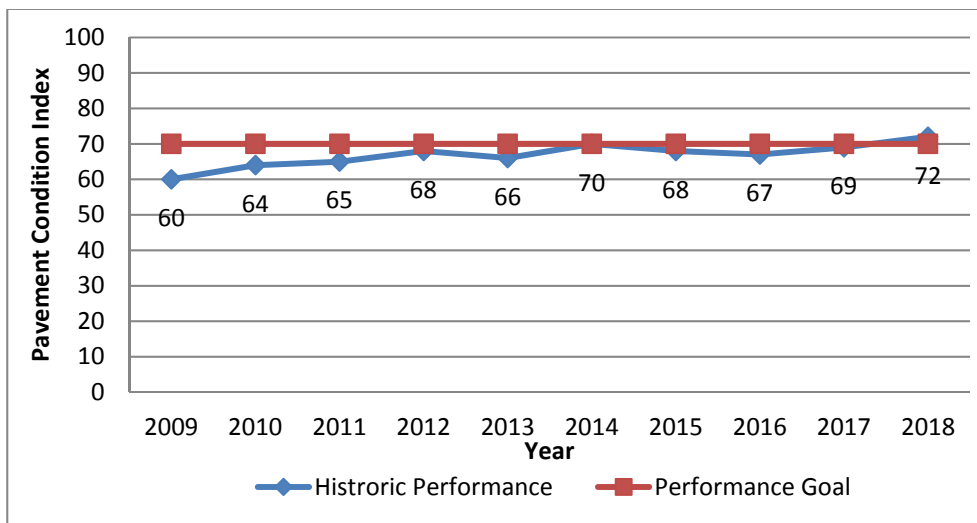
Source: VTrans Highway Division

Paving Needs

VTrans' Paving Program needs are determined from Pavement Management System analyses which model network deterioration and optimize a strategy of treatments over time to maximize asset conditions for given budget scenarios.

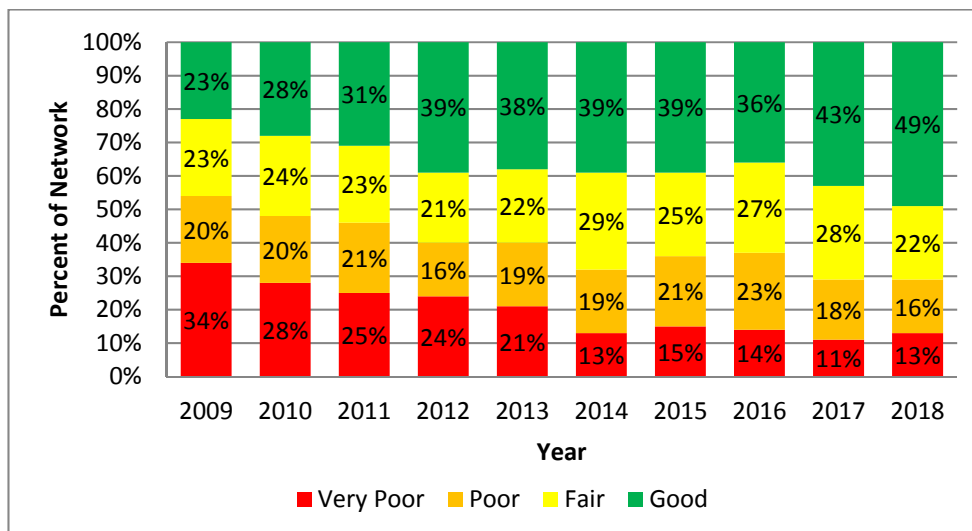
Current program goals are to maintain the "Travel Weighted Average Network Condition" at a level of 70 out of 100, and to keep the proportion of roads in very poor condition at no more than 25%. Figures 16 and 17 represent our progress towards these goals.

Figure 14: Travel Weighted Average Network Pavement Condition



Source: VTrans Highway Division

Figure 15: Pavement Condition by Category (%)

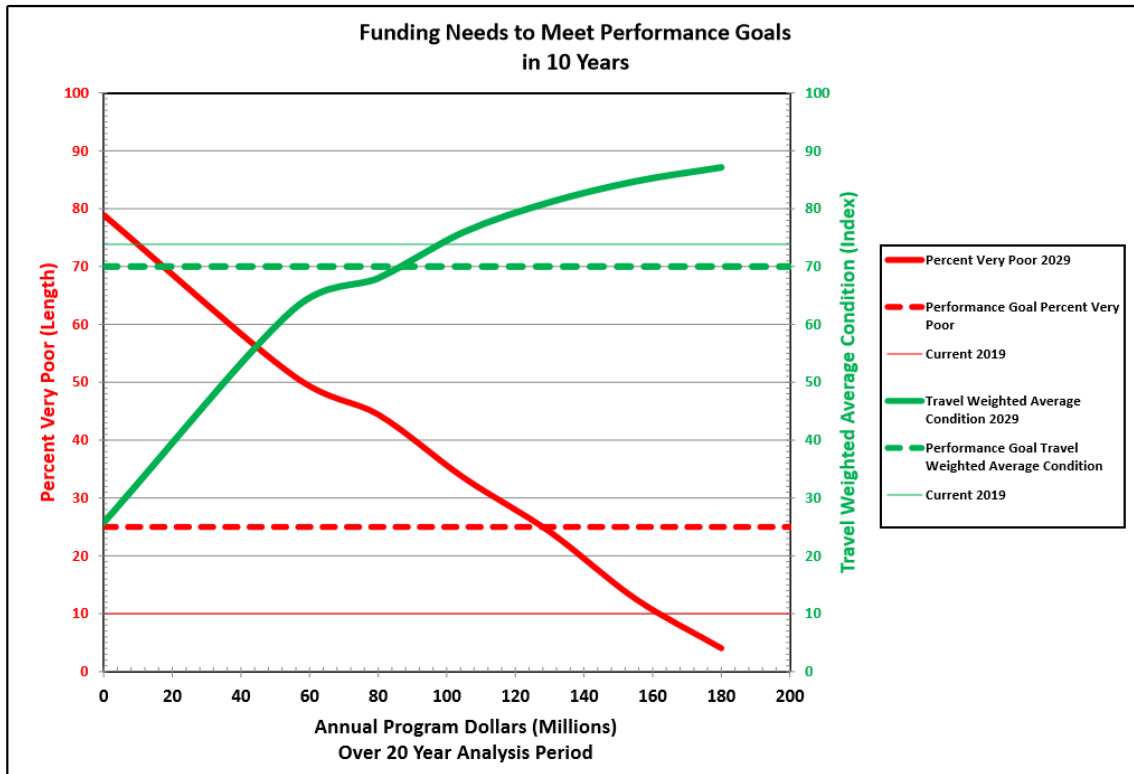


Source: VTrans Highway Division

VTrans uses its pavement management system to identify an optimal program of investment strategies on its entire network of pavements to deliver the best conditions in return for the investment made. This approach places an emphasis on lower-cost preservation treatments to maximize network-wide conditions and to defer costly replacements.

Long-range pavement analyses indicate that an investment of approximately \$130 million per year in current dollars is necessary to meet these targets over the next ten-years.

Figure 16: Pavement Conditions vs. Paving Program Investments over 10-yr Time Period



Bridge Needs

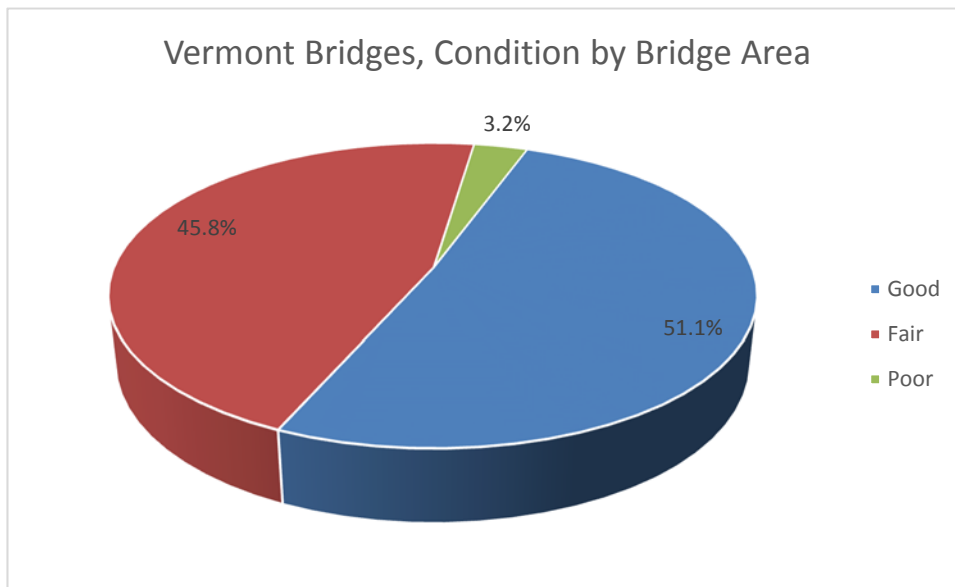
Bridge program needs are determined from a combination of subject matter expert input and VTrans’ rapidly maturing Bridge Management System (BMS) analyses. The latest bridge network analyses are run in the same software as the well-established Pavement Management System, modeling network deterioration and optimize a strategy of treatments over time to maximize asset conditions for given budget scenarios.

VTrans uses National Bridge Inspection Standards (NBI) to inspect and assess the condition of its bridges. Using this approach, VTrans has traditionally categorized the performance of its bridge

network based on the proportion classified as “Structurally Deficient”. Moving forward, VTrans is describing the proportion of its bridges in “Poor” condition. Those performance targets are:

- No more than 6% of Interstate bridges be in Poor condition
- No more than 10% of State Highway bridges be in Poor condition
- No more than 12% of Town Highway bridges be in Poor condition

Figure 17: Condition of Vermont Bridges by Bridge Deck Area



In advance of the results of the latest dTIMS analyses, a 2012 analysis indicates that annual investments of approximately \$153M (in today’s dollars) are appropriate to preserve, rehabilitate, and replace Vermont’s network of Interstate, State Highway, and Town Highway bridges from 2021 to 2033.

Roadway Needs

The Roadway Program contains many elements. Many (but not all) elements constitute the “basic needs” preservation of the state’s existing transportation. By far the biggest contributor to these needs are infrequently necessary but expensive rehabilitations and reconstructions of highway roadbeds. Those needs include the following:

- Asphalt on Concrete Highway Segments: Asphalt on concrete comprises 9% of the overall network miles. These segments are a challenge to manage effectively. Often, they are discernible to the untrained eye by cracks that reflect through the asphalt and reveal the concrete slabs beneath. While concrete slabs are strong, problems exist where a lane has been widened beyond the slab’s edge as the additional pavement distresses or settles

differently, creating a poor ride. These road structures are typically maintenance intensive and do not respond well to conventional resurfacing treatments. Adding to the challenge and cost, many of these segments are in our cities, town centers, and villages where reconstructions can be complex and involve other utilities and amenities. For the purposes of this analysis, the goal is to reconstruct these sections over a 20-year period. The estimated annual need for this work is \$85 million.

- Reconstruction – State Highways: Over 50% of Vermont’s highway network was never properly engineered, with many segments being former farm to market roads built for horse and wagon rather than today’s large vehicles. While some of these highway segments have strong foundations of quality, native subbase material, many run through mountain passes or in valleys where the underlying material is silt or clay. In addition, increases in traffic volumes and loadings in some areas of the state are accelerating the deterioration of the pavement structure. For this analysis, it is assumed that 5% of the state highway system will need to be reconstructed, and 20% rehabilitated, over a 20-year period to address the greatest needs on the network that cannot be addressed through basic pavement surfacing. The estimated annual need for these projects is \$52 million.
- Reconstruction – Interstates: Vermont’s Interstate system was designed for an estimated 20-year pavement life and a 40-year subbase life. Given that most of Vermont’s Interstate system began construction in the 1960’s and was completed in the 1970’s, this vital infrastructure has already exceeded its initial service life. With increasing traffic volumes and weights, it is time to begin the process of major rehabilitation and or reconstruction of Vermont’s Interstate pavement structures. In addition, VTrans is increasingly faced with maintenance challenges of slopes, sinkholes, and aging assets on this system. For the purposes of this analysis, it is assumed that 50% of Vermont’s Interstate system will require rehabilitation or reconstruction over the next 40-years. The estimated annual need for this work is \$22.5 million.
- Culverts: Culverts are a critical part of the highway network, providing passage for water and wildlife, and contributing to the effective drainage of roadbed material which significantly effects its performance and lifespan. Many of Vermont’s culverts are at or beyond their service lives. Analyses indicate that the rehabilitation and replacement of failed and poor condition culverts will require an annual investment of approximately \$30 million.
- Other Roadway Needs: Safety projects, capacity expansions, stormwater control, and roadside slope projects are all funded out of the Roadway Program. While not typically associated with the preservation of existing assets, these projects have required annual expenditures of approximately \$36 million in recent years.

Maintenance Needs

The VTrans Maintenance Division developed an estimate of its needs based on historical expenditures and the following known pressures:

- The Maintenance Division budget includes personal services and operating money. Historically, personal services were approximately one-third of total expenditures. Over the past few years, a challenging trend has emerged, with personal services expenditures now accounting for almost 50% of the total. This trend is expected to continue reducing the relative portion of the budget available for materials and operating costs.
- Changing environmental regulations continue to require more and different activities. There is a definite cost associated with compliance, but it is difficult to quantify with certainty.
- Increases in training costs are anticipated over the next few years to comply with the large number of required safety trainings. Training is also needed to improve supervisor and management skills for engineers, technicians, and maintenance staff.
- Implementation of the Vermont Asset Management Information System (VAMIS), purchased in 2019 and to be implemented in 2019 and 2020, will help to optimize maintenance resources and activities. There will be costs associated with the implementation of this new software, as well as labor costs associated with maintaining asset inventories, monitoring and analyzing data, and training.
- Materials and fuel prices typically increase over time. Sometimes unit prices can change suddenly and significantly, particularly diesel and road salt, which represent a significant proportion of VTrans' expenditures.
- The Maintenance Division recognizes that there has been a growing backlog of routine highway system maintenance over the past several years. Tree and brush cutting, ditch and drainage system cleaning and repairs, and minor repairs of assets are getting a renewed emphasis, internally championed as "back-to-basics". It is difficult to quantify this need, as there is always more that could be done, but it is estimated that an additional \$12 million annually would close this gap.

The Maintenance Division estimates a basic need of \$108 million and a 2.5% annual increase thereafter to maintain the status quo based on all the factors listed above, and to help with its back-to-basics efforts.

Transportation Needs Funding Gap

Vermont’s transportation funding needs exceed its anticipated revenues. The needs illustrated in Table 4, and the two funding scenarios illustrated in Tables 2 and 3, reveal an annual funding gap of between \$244M and \$418M over the next 10-years (Table 5).

Table 5: VTrans’ Anticipated Funding Gap

SFY	Anticipated Revenue (0% growth scenario)	Anticipated Revenue (2% growth scenario)	Anticipated Needs	Anticipated Funding Gap
2021	\$ 613,497,324	\$ 632,242,140	\$ 875,792,983	\$244M - \$262M
2022	\$ 618,215,789	\$ 643,620,261	\$ 895,553,158	\$252M - \$277M
2023	\$ 630,031,205	\$ 662,228,527	\$ 925,787,044	\$264M - \$296M
2024	\$ 634,945,576	\$ 674,211,605	\$ 948,931,720	\$275M - \$314M
2025	\$ 639,960,948	\$ 686,437,057	\$ 972,655,013	\$286M - \$333M
2026	\$ 652,079,407	\$ 705,909,798	\$ 995,274,276	\$289M - \$343M
2027	\$ 657,303,086	\$ 718,774,845	\$1,020,156,133	\$301M - \$363M
2028	\$ 662,634,159	\$ 731,900,113	\$1,045,660,037	\$314M - \$383M
2029	\$ 675,074,848	\$ 752,290,881	\$1,071,801,538	\$320M - \$397M
2030	\$ 680,627,420	\$ 766,092,534	\$1,098,596,576	\$333M - \$418M

Source: VTrans Highway Division

Asset Sustainability Index

The ratio of anticipated needs to anticipated revenues yields an Asset Sustainability Index (ASI). VTrans’ current ASI is approximately 0.7, meaning that we currently have about 70% of what is necessary to maintain our transportation assets in a state of good repair. With anticipated needs growing faster than anticipated resources, VTrans’ ASI is anticipated to decline further in the future (Figure 18). Annual revenue growth of approximately 4.5% would be necessary to achieve an ASI of 1.0 in 20-years (Figure 19).

Figure 18: VTrans' Projected Asset Sustainability Index (ASI)

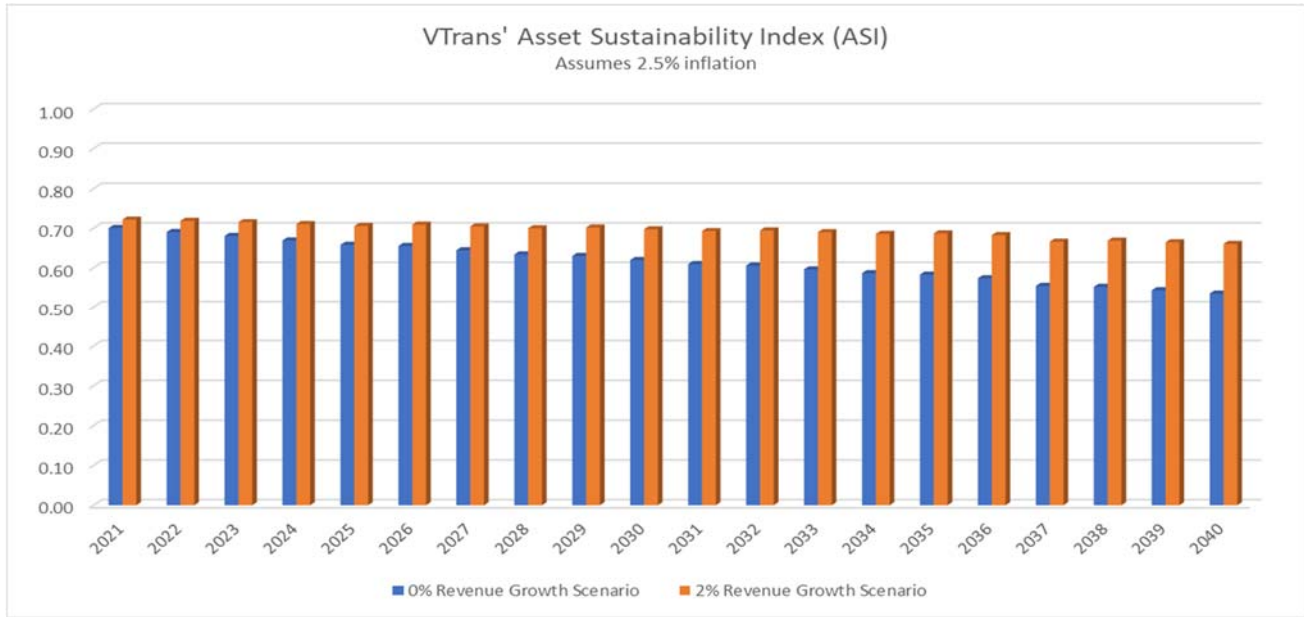
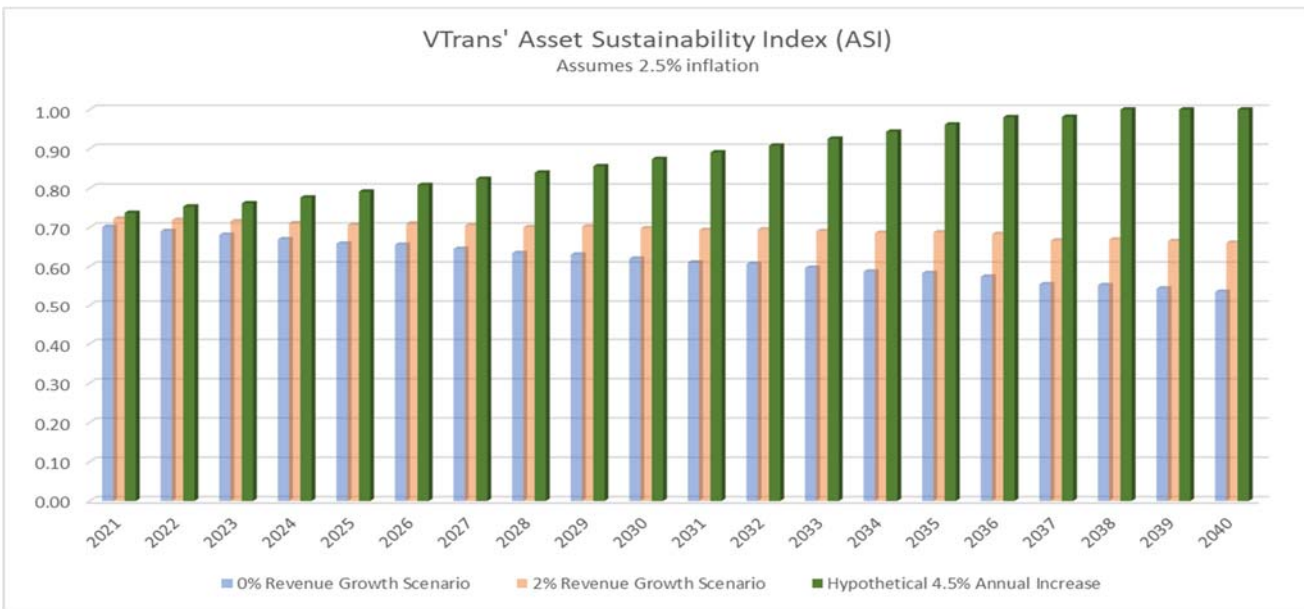


Figure 19: VTrans' Projected Asset Sustainability Index (ASI)



Existing and Projected NHS Pavement Conditions

While VTrans does not typically manage its NHS pavements separately from the rest of its pavement network, we can separately report on the existing and projected conditions of this subset and the resources allocated towards its preservation, see Figure 21.

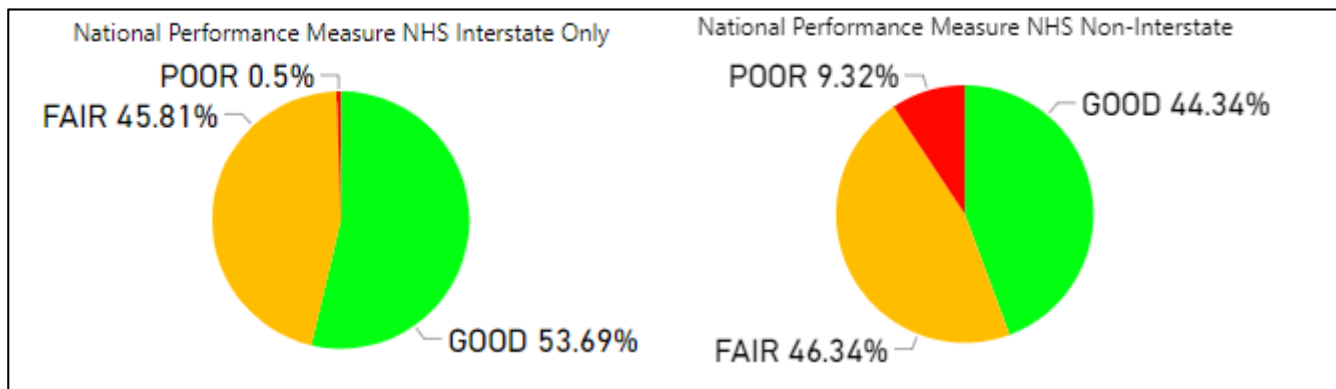
FHWA has provided the following targets for NHS pavements, using MAP-21 National Performance Measures¹:

- Interstate pavement: ≤5% in poor condition
- Non-Interstate NHS pavements: ≤10% in poor condition

The most recent analyses of 2018 inventory data indicates that VTrans currently has:

- 0.5% of its Interstates NHS pavement in poor condition, and
- 9.3% of its Non-Interstate NHS pavements in poor condition

Figure 20: MAP-21 National Pavement Performance Measures



As such, VTrans is currently meeting MAP-21 targets for its NHS pavements.

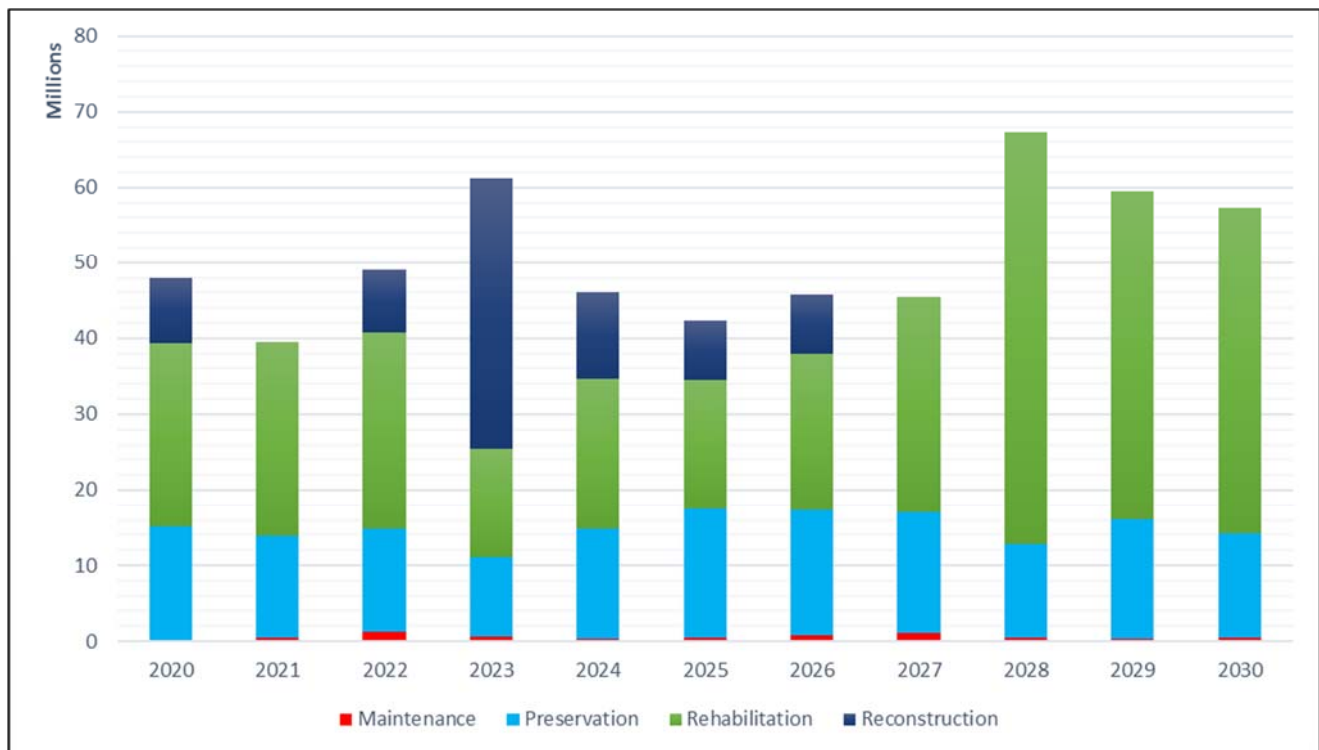
Analyses indicate the NHS MAP-21 National Performance Measure targets will be maintained at the network-wide (NHS and Non-NHS) annual investment levels presented in Table 4. Regardless of total program funding, VTrans is committed to funding NHS pavements at a level that will ensure we are meeting the minimum national performance targets.

¹ Note that MAP-21 National Performance Measures have different methodologies and definitions from Vermont specific measures.

Projected 10-yr Investment Plan for NHS Pavements by Work Type

VTrans anticipates investing an average of approximately \$50 million dollars over the next 10 years in its pavements on the NHS. A breakdown of those investments by work type is shown below in Figure 21. We are not reporting any new construction, only replacement or reconstruction, because most of Vermont’s highway network is already constructed and our current focus is on “taking care of what we have”. These projected investment levels will allow VTrans to achieve its federal performance targets for NHS pavements.

Figure 21: 10-year Spending Projection for NHS Pavements

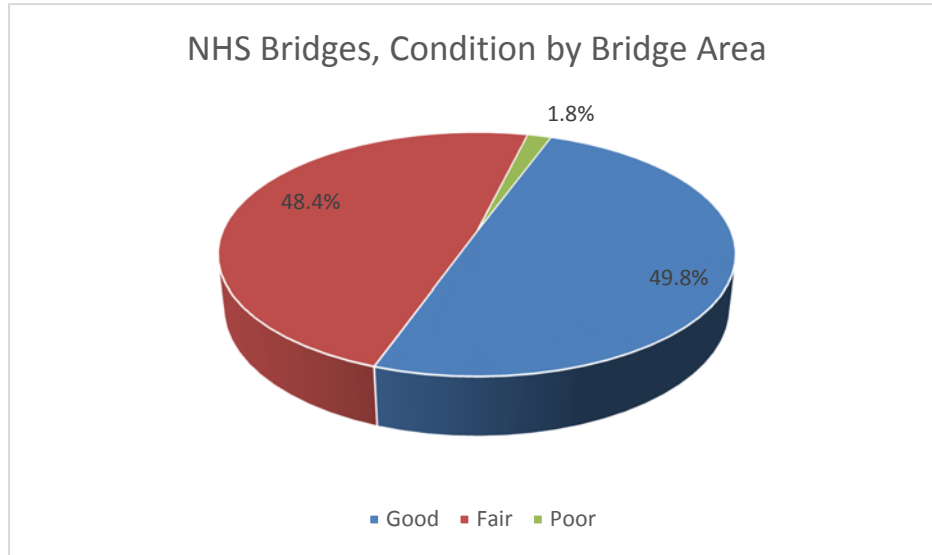


Existing and Projected NHS Bridge Conditions

The MAP-21 National Performance Measure target is that no more than 10% of the bridge deck area on the NHS will be in poor condition. The most recent (2018) inventory information indicates that that only 1.8% of VTrans’ bridge deck area on the NHS is in poor condition. As such, VTrans is currently meeting the MAP-21 target for bridge conditions.

As with NHS pavements, VTrans does not typically manage its NHS bridges separately from its statewide network of bridge assets. However, we can separately analyze bridges on the NHS to report their existing and projected conditions, and quantify the resources allocated to this subset of the overall bridge network.

Figure 22: MAP-21 National Bridge Performance Measures



Source: VTrans Highway Division

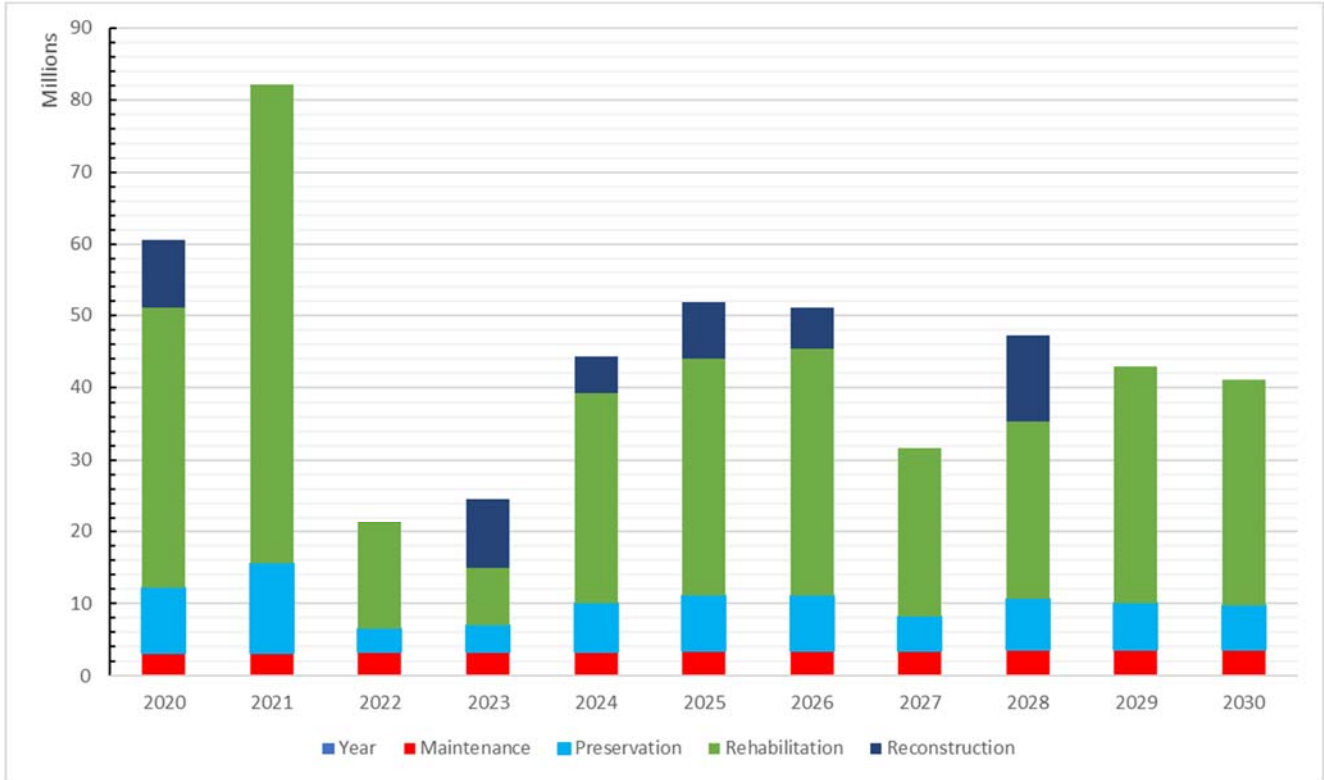
Analyses indicate the MAP-21 National Performance Measure targets for NHS bridges will be maintained at the network-wide (NHS and Non-NHS) annual investment levels presented in Table 4. Regardless of total program funding, VTrans is committed to funding NHS bridges at a level that will ensure we are meeting the minimum national performance targets.

Projected 10-yr Investment Plan for NHS Bridges by Work Type

Over the last five years VTrans has invested an average of \$49 million its bridges on the NHS. VTrans most recent analysis looked at spending across four work types; maintenance, preservation, rehabilitation, and reconstruction. Similar to NHS pavements, VTrans is not constructing any new highways on the NHS thus the new construction work type was not included in the 10-year analysis.

VTrans' bridge management system (BMS) is currently being used but much refinement and validation is necessary to ensure accurate projections. Thus, financial projections were made with significant input from various subject matter experts coupled with output from the BMS. The estimated investment in NHS bridges was developed over the next 10 years and the results are depicted in Figure 23. The results indicated an average annual investment of nearly \$45 million dollars over the next 10 years; including a \$3 million minimum annual investment in NHS bridge maintenance and a 15% average investment in preservation strategies. These projected investment levels will allow VTrans to achieve its federal performance targets for NHS bridges.

Figure 23: 10-year Spending Projection for NHS Bridges



APPENDIX C: TAMP-WG PARTICIPANTS

VTrans' TAMP submittal represents a large organizational commitment that began in December 2013. The TAMP-WG has varied in number of participants over the years but has represented nearly 27 assets or focus areas. It has weathered organizational changes with members coming and going but still managed to meet mostly every two weeks during this span.

VTrans would like to recognize people who helped initiate the process, who have kept it going, and who are currently serving on the TAMP-WG. VTrans will continue to improve the TAMP and the associated asset management processes. Future enhancements will be shaped by experiences implementing asset management in Vermont for not only pavements and bridges but other assets as well. VTrans will incorporate change management principles take advantage of the best practices that emerge as states across the nation implement their first formal asset management plans.

VTrans intends to continue to foster the gathering of asset management professionals within VTrans for the foreseeable future. Initial plans may reduce the meeting frequency down to monthly or quarterly depending upon the needs of the TAMP-WG.

Early VTrans Leaders Who Served on the TAMP-WG

Diane Bigglestone; Finance & Administration; fixed asset accounting
Jesse Blondin; Finance & Administration; fixed asset accounting
June Burr; Finance & Administration; business process management
Martin Churchill; Finance & Administration; fixed asset accounting
Erik Filkhorn; Finance & Administration; communications and outreach
Mladen Gagulic; Planning & Intermodal Development; rail assets
Mike Hedges; Highways – AMP Budget & Programming; budget and programming
Nelson Hoffman, FHWA
Lenny LeBlanc; Finance & Administration; CFO - TAMP Financial Plan
Marcy Meyers - Montague; Highways –Materials; geotechnical assets, rock slopes, retaining walls
Shawn Nailor; Finance & Administration; IT, systems development
Guy Rouelle; Planning & Intermodal Development; aviation assets
Costa Pappis; Planning & Intermodal Development; TAMP Financial Plan
Betsy Ross-Mobbs; Finance & Administration; IT, systems - MATS
Trevor Starr; Highways – Maintenance & Operations; maintenance equipment / stockpiles
Rob White; Highways – ROW; right-of-way, parcel management

Current Asset Management Professionals Serving on the TAMP-WG

*denotes those who have served from the beginning or nearly the beginning

*Jennifer Royer; Highways - AMP Programming; small culverts & ancillary assets
Larkin Wellborn; FHWA

*Pam Thurber; AMP Budget & Programming; bridge and large culverts, budget & programming

Michael K. Johnson; Highways - Maintenance & Operations; stormwater

*Jennifer Callahan; Highways - Maintenance & Operations; stormwater

*Barbara Donovan; Policy, Planning & Intermodal Development; Transit

- *Reid Kiniry; Highways - AMP Data Management; pavement management system, pavements
- Jacqueline LeBlanc; Finance & Administration; communications and outreach
- Derek Lyman; Highways – Maintenance & Operations; traffic signals
- *Roger Lyon-Surrey; Highways - AMP Data Management; bridge management system, bridges
- Kevin Marshia; Highways - AMP Budget & Programming; budget and programming manager
- *JB McCarthy; Highways - Structures; bridge management, bridge maintenance & design
- Zoe Neaderland; Policy, Planning & Intermodal Development; Lead TAMP writer, planning
- *Jason Owen; Policy, Planning & Intermodal Development; aviation assets
- Dave Pelletier; Planning & Intermodal Development; Long Range Trans. Plan coordinator, planner
- *Michael Pologruto; Finance & Administration; performance, pavements
- *Joe Segale; Planning & Intermodal Development; Strategic Plan Coordinator, planner
- Stephen Smith; Highways - AMP Data Management; rail assets, data management
- *Jason Tremblay; Finance & Administration; risk management
- *Ken Valentine; Highways - Maintenance & Operations; maintenance equipment & processes
- *Chad Allen; Highways – AMP; asset management
- *Kevin Viani; Finance & Administration; data, risk and performance management

Special Thanks and Recognition

These staff members graciously served in leading roles or as a leader on one of the many TAMP-WG taskforces

Life-Cycle Planning: *JB McCarthy*

TAMP Financial Plan: *Costa Pappis*

Data Management: *Kevin Viani*

AM Processes and Customer Service: *Chad Allen*

Meeting Agendas & Minutes: *Marcy Meyers-Montague*

Strategic Plan Alignment: *Joe Segale*

Long Range Plan Alignment: *David Pelletier*

APPENDIX D: CORRESPONDENCE TABLE TO FHWA REQUIREMENTS

This table is based on “Transportation Asset Management Plan Development Processes Certification and Recertification Guidance” published in the Federal Register on 2/22/2018. The TAMP is designed to engage and inform while also fully meeting federal regulations. This reader-focus results in contents on requirements in various parts of the report. Main locations to look for contents is listed below but reading the whole report will provide a more complete answer.

Process	Summary of Required Elements	Main Location in VTrans TAMP
Performance Gap Analysis (23 CFR 515.7(a))	<p>Identify gaps affecting targets or state of good repair and develop strategies to close them.</p> <p>Analyze gaps in performance of the NHS to move people and goods efficiently and identify strategies to close them.</p>	<p>VTrans Vision, Measures, and Targets</p> <ul style="list-style-type: none"> • Integration of Asset Management in the Current Decade • Bridge Condition Measures and Targets • Pavement Condition Measures and Targets <p>Comparison of existing condition to targets and state of good repair: Note that the TAMP uses “issue” unless “gap” is the precise word.</p> <ul style="list-style-type: none"> • Bridge Conditions • Pavement Conditions <p>VTrans identifies strategies to close gaps Each section in chapters 3 (short-term), 4 (long-term), and 5 (risk management) ends with strategies. Families of strategies are discussed in Chapter 6. The Action Plan is the summary.</p> <ul style="list-style-type: none"> • Action Plan <p>Additional considerations</p> <ul style="list-style-type: none"> • Transportation Trends • Risk Management
Life-cycle planning Analysis (23 CFR 515.7(b))	<p>Incorporate targets</p> <p>Model deterioration by asset class</p> <p>Analyze potential work types across the life of each asset class with the general unit costs identified</p> <p>Identify life cycle management strategies by asset class</p>	<p>Incorporating Targets</p> <ul style="list-style-type: none"> • Bridge Condition Measures and Targets • Pavement Condition Measures and Targets <p>Asset classes Bridge asset classes are NHS-Interstate, NHS non-interstate, non-NHS (state and town); Pavement is divided by CSL.</p> <ul style="list-style-type: none"> • Pavement Inventory <p>Deterioration modeling</p> <ul style="list-style-type: none"> • Bridge Data and Tools • Pavement Data and Tools <p>Categories of work types</p> <ul style="list-style-type: none"> • Main approaches are on the first page of Chapter 6. • General unit costs: Bridges (Table 5: Bridge Project Costs Based on Work Type) and Pavement (Table 9: Cost by

Process	Summary of Required Elements	Main Location in VTrans TAMP
		<p>Pavement Investment Strategy and Figure 11: Typical Vermont Pavement Deterioration Curve)</p> <p>Life cycle strategies</p> <ul style="list-style-type: none"> • Bridge Life-Cycle Planning at VTrans • Pavement Life-Cycle Planning at VTrans
<p>Risk Management Analysis (23 CFR 515.7(c))</p>	<p>Identify and prioritize risks that can affect the condition of NHS</p> <p>Assess likelihood and impacts</p> <p>Develop mitigation plan and monitor changes</p> <p>Process to identify and reduce facilities repeatedly damaged by emergency events</p>	<p>Prioritized enterprise and asset-level risks</p> <ul style="list-style-type: none"> • Enterprise-Level Bridge and Pavement Risk Focus Areas – Built on likelihood and impact analysis for assets, include strategies • Bridges and Pavement Program Risks from Registers – for strategies, see risk registers in Practitioners’ Guide. Maintaining the registers includes monitoring change in risk and effectiveness of strategies <p>VTrans coordinated internally to identify repeatedly damaged facilities and is following through with next steps.</p> <ul style="list-style-type: none"> • Resilience and Repeatedly Damaged Facilities <p>The action plan is categorized by risk management strategy addressed. It includes implementing resilience analysis statewide and incorporating results of a Vermont seismic activity readiness study.</p> <ul style="list-style-type: none"> • Action Plan
<p>Financial Plan Development (23 CFR 515.7(d))</p>	<p>Prepare financial plan that covers at least 10-year period and includes</p> <ul style="list-style-type: none"> • Estimated cost to implement strategies • Estimated funding levels • Anticipated funding sources • Investment needed to maintain asset valuation 	<p>These items are in the 2019 Vermont TAMP Financial Plan. Also see</p> <ul style="list-style-type: none"> • Anticipated cost to implement: Bridges (Table 5: Bridge Project Costs Based on Work Type) and Pavement (Table 9: Cost by Pavement Investment Strategy and Figure 11: Typical Vermont Pavement Deterioration Curve) • Funding levels: Table 10: VTrans Funding Availability and Needs Analysis (2019) • Funding sources: Vermont Transportation Revenue Sources • Asset valuation: Use a Systematic Approach to Increase the Value of Vermont’s Assets • Overall: Maintain TAMP Financial Plan and Enhance Financial Planning
<p>Investment Strategies (23 CFR 515.7(e) and 515.9(f))</p>	<p>Produce strategies that support progress toward</p> <ul style="list-style-type: none"> • State of good repair • Achieving targets • Achieving national goals 	<p>The TAMP is helping VTrans define and advance strategies that help achieve the state of good repair defined by targets and goals for Vermont and the Nation.</p> <ul style="list-style-type: none"> • Bending Trends Toward Policy Goals (scroll down from Trends) <p>Selection of strategies and short-term actions</p> <ul style="list-style-type: none"> • Chapter 6: How VTrans Improves Assets • Project Selection and Prioritization

Process	Summary of Required Elements	Main Location in VTrans TAMP
		<ul style="list-style-type: none"> • Action Plan
Obtaining Data from Other NHS Owners (23 CFR 515.7(f))	Methodology for obtaining necessary data from other NHS owners	<p>VTrans gathers data for all NHS pavements. It coordinates with the other NHS asset owners, primarily the MPO as the main other owner of NHS inventory. An example is coordinated updating of NHS designation.</p> <ul style="list-style-type: none"> • Pavement Inventory <p>VTrans works closely with its partners in a range of ways.</p> <ul style="list-style-type: none"> • Communication Plan
Use of best available data and bridge and pavement management systems to develop TAMP (23 CFR 515.7(g))	<ul style="list-style-type: none"> • Ensure use of best available data for development of the TAMP • Identify sources of information and management system needs • Coordination and use of information from STIP 	<p>Best Available Data</p> <ul style="list-style-type: none"> • Bridge Data and Tools • Pavement Data and Tools <p>Data Needs</p> <ul style="list-style-type: none"> • Short-Term Bridge Issue 2: Bridge Data is a Bottleneck for Cross-Asset Optimization Processes • Short-Term Pavement Issue 1: Pavement Deterioration Curves Require Updating and Validation Review <p>STIP</p> <ul style="list-style-type: none"> • Project Selection and Prioritization