TRANSPORTATION ASSET MANAGEMENT PLAN

New Hampshire DOT
Department of Transportation

JUNE 2022

Transportation Asset Management Plan

New Hampshire Department of Transportation

7 Hazen Drive
Concord, NH 03301

This Transportation Asset Management Plan for pavements and bridges on the National Highway System has been developed in accordance with 23 U.S.C. Parts 110 and 150 as well as 23 C.F.R. Parts 515 and 667. The Plan will continue to be reviewed on a biennial basis to ensure consistency with the planning process and will be updated at least every 4 years.

Victoria Sheehan, Commissioner

July 1, 2022

Date

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EXHIBITS

1. PURPOSE OF THE TAMP

Objective of the TAMP

Per the Federal Highway Administration (FHWA),[1] Transportation Asset Management Plans (TAMPs) act as a focal point for information about assets and for the management strategies, long-term expenditure forecasts, and business management practices of State Departments of Transportation (DOTs). Each State is required to develop a risk-based TAMP for assets on the National Highway System (NHS) in order to improve and preserve the condition of assets and the performance of the system. A TAMP should bring together all relevant business process and stakeholders, internal and external, to achieve a common understanding and commitment to improve performance.

Updated over time, the TAMP is a tactical-level document which documents how data, analysis, programs, and delivery and reporting mechanisms are brought to bear on achieving performance goals, sustainable asset stewardship, effective use of resources, and robust justifications for funding.

Federal Rules Governing the TAMP

The requirement for each DOT to develop a TAMP was established in the Moving Ahead for Progress in the 21st Century (MAP-21) Act of 2012 (23 U.S.C. 119(e)(1), MAP-21 § 1106) and confirmed in the Fixing America's Surface Transportation (FAST) Act of 2015. Pursuant to 23 U.S.C. 119(e)(4)(A), the DOT is required to include NHS pavement and bridges regardless of the ownership of the facility. FHWA must certify every four years that the DOT's processes for developing the TAMP meet the applicable requirements. New Hampshire DOT (NHDOT) formally last met this requirement in June, 2018 (modifications to the document were made in 2019), establishing the need for an update to be certified in June, 2022.

Per FHWA Consistency Determination Final Guidance dated February, 2019,[2] the TAMP must include:

- A summary listing of the pavement and bridge assets on the NHS in the State, including a description of the condition of those assets.
- Asset management objectives and measures.
- Performance gap identification.
- Lifecycle cost and risk management analysis.
- A financial plan.
- Investment strategies.

[1] https://www.fhwa.dot.gov/asset/plans.cfm.

[2] https://www.fhwa.dot.gov/asset/guidance/consistency.pdf.

After all DOTs had certified TAMPs in 2019, FHWA sponsored a review of the documents to grade their maturity and identify areas of strength and improvement. NHDOT scored a 3.5 out of 5 on overall maturity against a national average of 3.6. This TAMP resolves the identified areas needing improvement while maintaining the identified strengths of the 2019 document.

The TAMP is a component of the Department's management of the Federal-aid highway program in support of the National Goals (23 U.S.C §150(b)). The Department's lifecycle approach, incorporating risk and resiliency, helps ensure that asset conditions are efficiently managed to provide a safe NHS for travelers and freight, that is reliable with minimal disruptions. In addition, the integration between the TAMP and the continuous planning process, including the TYP and the STIP, ensures both consistency and that projects are appropriately planned and budgeted for to minimize project delivery delays.

NHDOT's Approach to Asset Management

NHDOT's is guided by its mission, vision, and strategic goals and objectives in making business decisions. By integrating asset management into strategic goals, NHDOT improves decision-making around allocating limited resources in order to achieve performance targets.

NHDOT's Mission

Transportation excellence enhancing the quality-of-life in New Hampshire.

NHDOT's Vision

Transportation in New Hampshire is provided by an accessible, multimodal system connecting rural and urban communities. Expanded transit and rail services, a well-maintained highway network, and an airport system provide mobility that promotes smart growth and sustainable economic development, while reducing adverse transportation impacts on New Hampshire's environmental, cultural, and social resources. Safe bikeways, sidewalks, and trails link neighborhoods, parks, schools, and downtowns. Creative and stable revenue streams fund an organization that uses its diverse human and financial resources efficiently and effectively.

NHDOT's Strategic Goals

NHDOT has four strategic goals to help accomplish the Department's mission:

1. Increase Customer Satisfaction providing transparent communication and being responsive to the residents of New Hampshire and users of the systems.
2. Improve Performance in all business operations including asset conditions, mobility, system safety and security, department efficiency, and stakeholder engagement.
3. Improve Resource Management by effectively managing financial resources, protecting and enhancing the environment, and implementing strategic workforce planning.

4. Implement Employee Development strategies that increase bench strength, optimize employee health and safety, and align employees around the Department's mission.

NHDOT has developed 12 strategic objectives to monitor performance toward the achievement of these goals. Many of these form the foundation of asset management practice and frame the implementation of the TAMP. The logical flow from mission, goals, and objectives is illustrated in Exhibit 1.1.[3]

Exhibit 1.1 NHDOT's Mission, Goals, and Objectives

GOALS	OBJECTIVES
Customer Satisfaction	Improve customer satisfaction
Performance	Improve asset conditions
	Increase mobility
	Improve system safety and security
	Improve Department efficiency
	Identify, communicate, and collaborate with customers
Effective Resource Management	Effectively manage financial resources
	Implement strategic workforce planning
	Protect and enhance the environment
Employee Development	Increase bench strength
	Optimize employee health and safety
	Align employees around the Department's mission

Asset Management Governance at NHDOT

NHDOT created the Office of Asset Management, Performance, and Strategy (AMPS) in 2014. Staffed by eight full-time positions, it is housed within the NHDOT Commissioner's Office and has responsibility to:

- Facilitate and coordinate asset management and transportation performance management activities across the Department.
- Develop and implement the TAMP.
- Develop FHWA Consistency Reports and report performance measures and targets to FHWA.
- Coordinate five management-level workgroups and participate in committees that manage pavement and bridges.

NHDOT manages pavement and bridges through five multidisciplinary workgroups, established in 2016 and chaired at the executive level by commissioners or directors. The workgroup chairs meet monthly to coordinate asset management and performance management activities. The workgroups oversee performance reporting, work order management, performance and asset management records and data, inventory, and technical systems/tools; and performance and asset management policy. In addition, two committees, the Bridge Management Committee and the Pavement Management Committee, focus on program development.

[3] https://www.nh.gov/dot/org/commissioner/balanced-scorecard/goals.htm#ed.

More detail on governance for NHS pavement and bridge assets is provided in Chapters 2 and 3, respectively.

Benefits of Transportation Asset Management

Ensuring that the Department's business processes embrace an asset management philosophy will produce many benefits for the Department; partnering stakeholders; and the residents, businesses, and visitors of New Hampshire; including:

- **Transparency and repeatability |** The decision-making processes will be clear and well-documented, enabling consistent and straightforward communication about how an investment decision was made.
- **Long-term thinking |** An asset management-based approach will ensue that the Department is always considering the entire life cycle of assets – including long-term needs, costs, and implications of investment decisions – helping to ensure that the State makes the best investment possible.
- **Minimal practicable cost |** Through consideration of the entire life cycle, use of quality data, and a thorough systematic approach, the Department will identify the most cost-effective approach that provides the greatest benefits for the available budget.
- **Integration with performance and risk management |** The asset management approach at NHDOT integrates performance and risk management within business and planning processes to ensure that the Department always moves in the right direction while considering uncertainty.

FHWA has established National Goals to be supported by universal implementation of asset management in DOTs. FHWA seeks...

- **Safety |** To achieve a significant reduction in traffic fatalities and serious injuries on public roads.
- **Infrastructure Condition |** To maintain the highway infrastructure asset system in a state-of-good-repair.
- **Congestion Reduction |** To achieve a significant reduction in congestion on the NHS.
- **System Reliability |** To improve the efficiency of the surface transportation system.
- **Freight Movement and Economic Vitality |** To improve the National Highway Freight Network (NHFN); strengthen the ability of rural communities to access national and international trade markets; and support regional economic development.
- **Environmental Sustainability |** To enhance the performance of the transportation system while protecting and enhancing the natural environment.
- **Reduced Project Delivery Delays |** To reduce project cots, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including by reducing regulatory burdens and by improving agencies' work practices.

New Hampshire's Transportation Assets

This document addresses the NHS in New Hampshire: 3,180 lane-miles of road and 726 bridges, of which 2,600 lane-miles of road and 696 bridges are managed by NHDOT (including the Bureau of Turnpikes). The remaining lane-miles and bridges are owned and managed by municipalities. This section will discuss how NHDOT generally categorizes its highway assets and how those assets are divided among owners.

Structure of the Highway System

NHDOT prioritizes its roadways through a system of Tiers 1-6. Tiers 1 and 2 include most of the NHS and virtually all of the State-owned NHS. Tiers that include any percentage of NHS roadways are:

- **Tier 1: Interstates, Turnpikes, and Divided Highways (55% of NHS lane-miles) |** These multi-lane, divided highways convey the majority of commuter, tourist, and freight traffic throughout the State.
- **Tier 2: Statewide Corridors (39% of NHS lane-miles) |** These roads carry passengers and freight between regions of the State and to/from neighboring states. They can have moderate and high traffic volumes, particularly during morning and afternoon peak hours.
- **Tier 3: Regional Transportation (less than 1% of NHS lane-miles) |** These corridors provide travel within regions and access to Tier 1 and Tier 2 highways. They support moderate traffic volumes at moderate speeds.
- **Tier 5: Local Roads (5% of NHS lane-miles) |** These may be owned locally or by the State but are maintained by local governments. They provide local travel within communities.

Maps of the New Hampshire highway system are shown on the following pages. Exhibit 1.2 differentiates the roads by tier, while Exhibit 1.3 shows on the NHS differentiated by jurisdiction. Exhibit 1.4 differentiates Interstates from non-Interstates within the NHS, as these categories are subject to different performance targets.

Exhibit 1.2 New Hampshire's Highway System by Tier

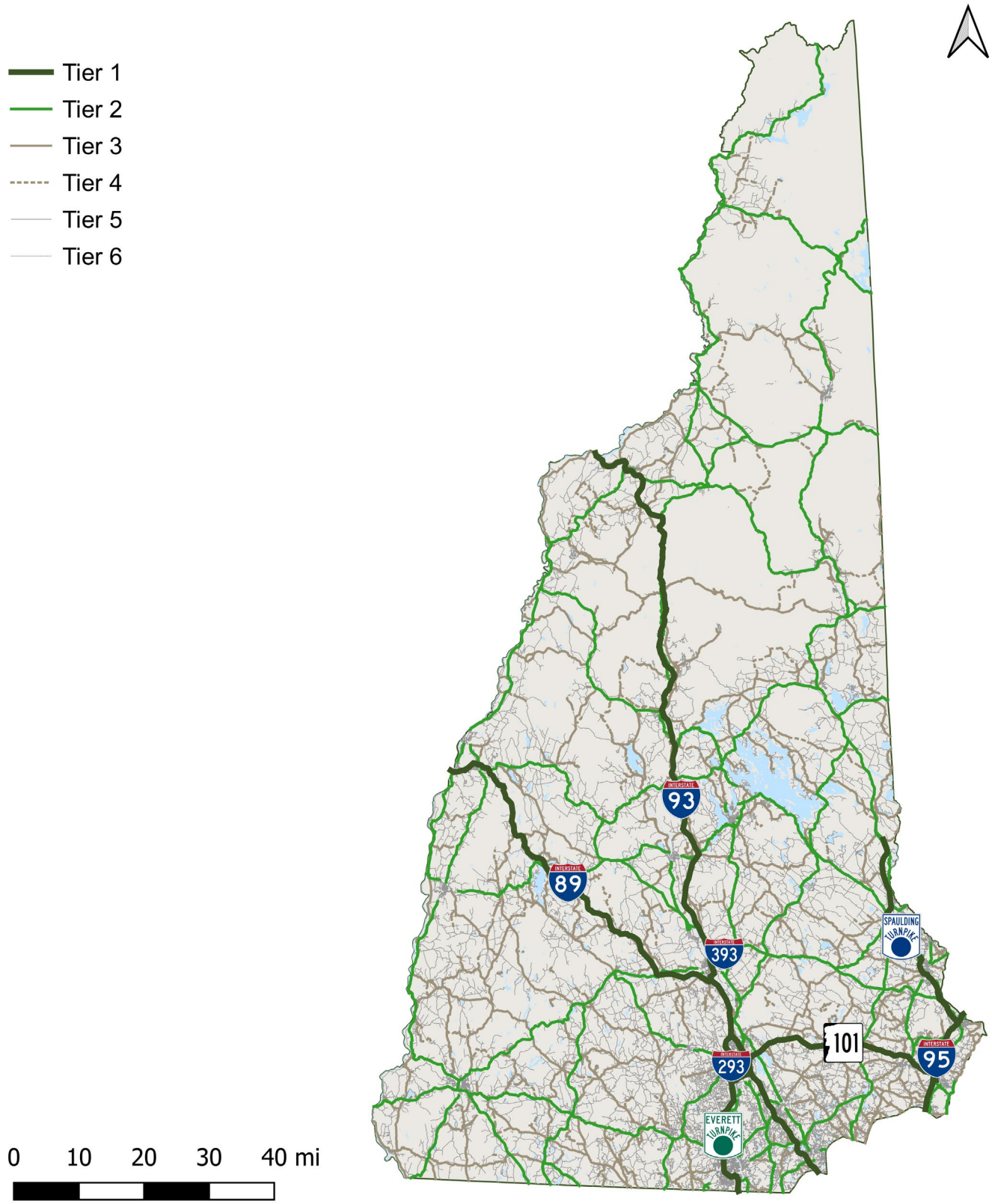


Exhibit 1.3 New Hampshire's NHS Highways by Jurisdiction

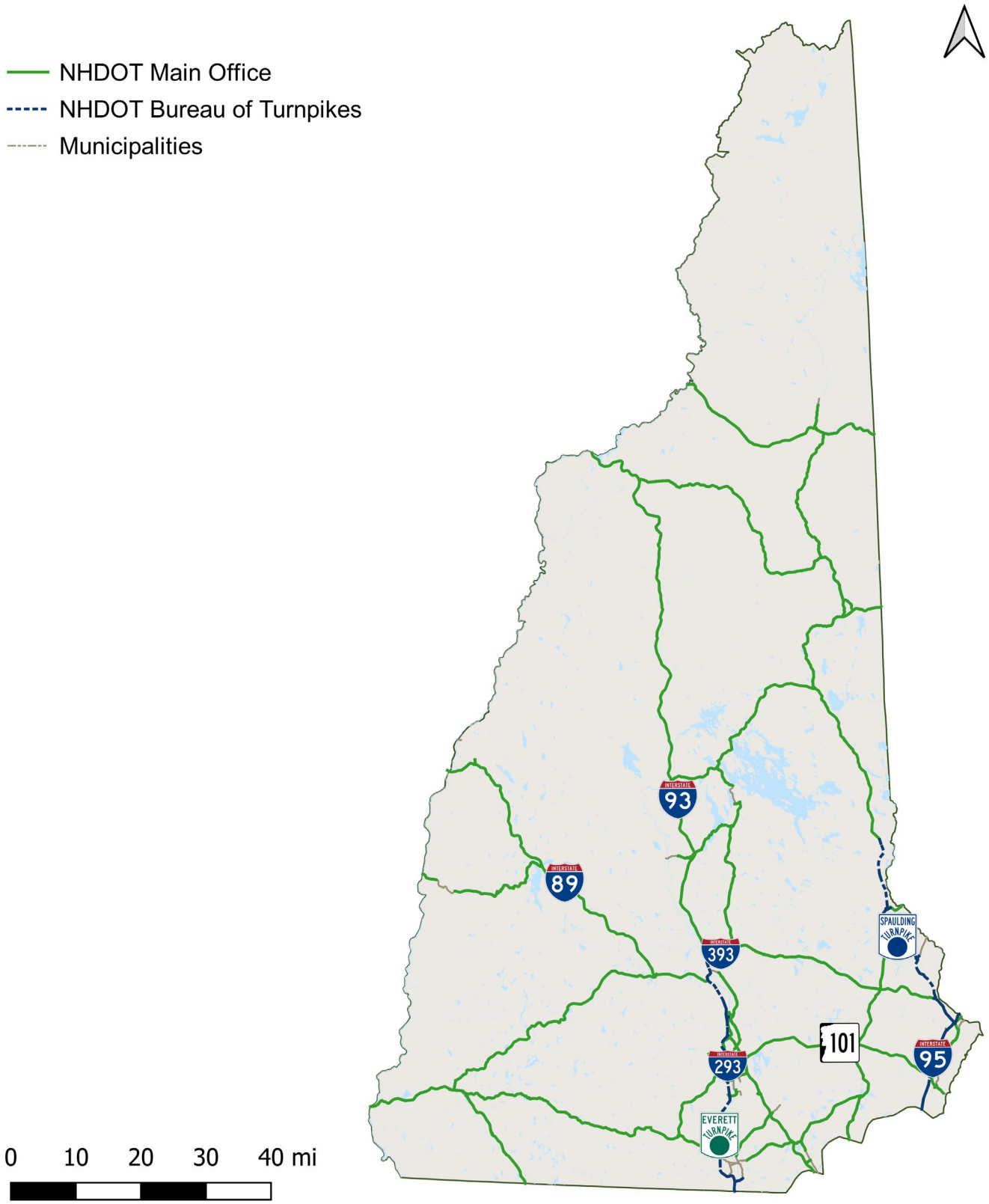
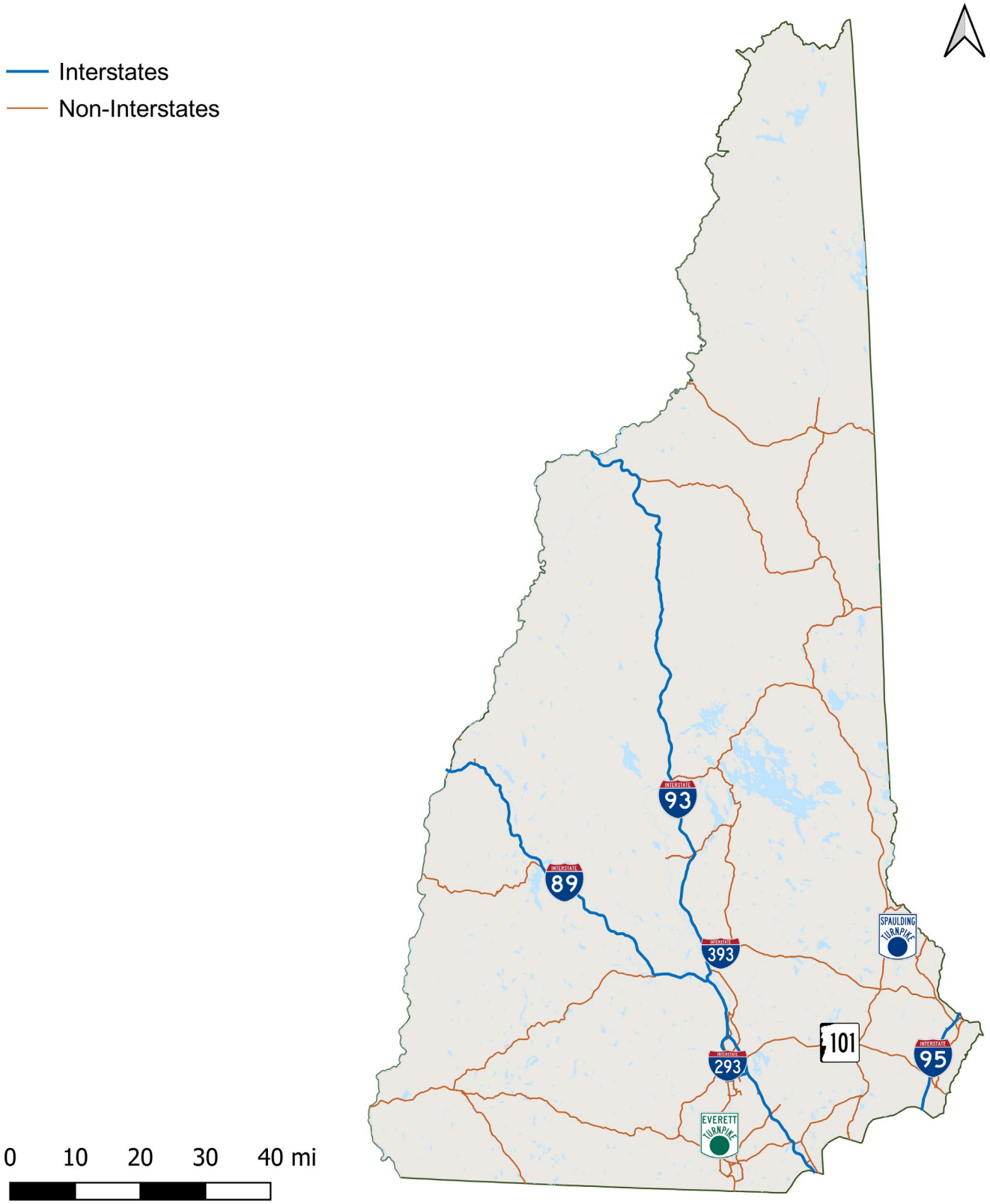


Exhibit 1.4 New Hampshire's NHS Highways by Interstate Status

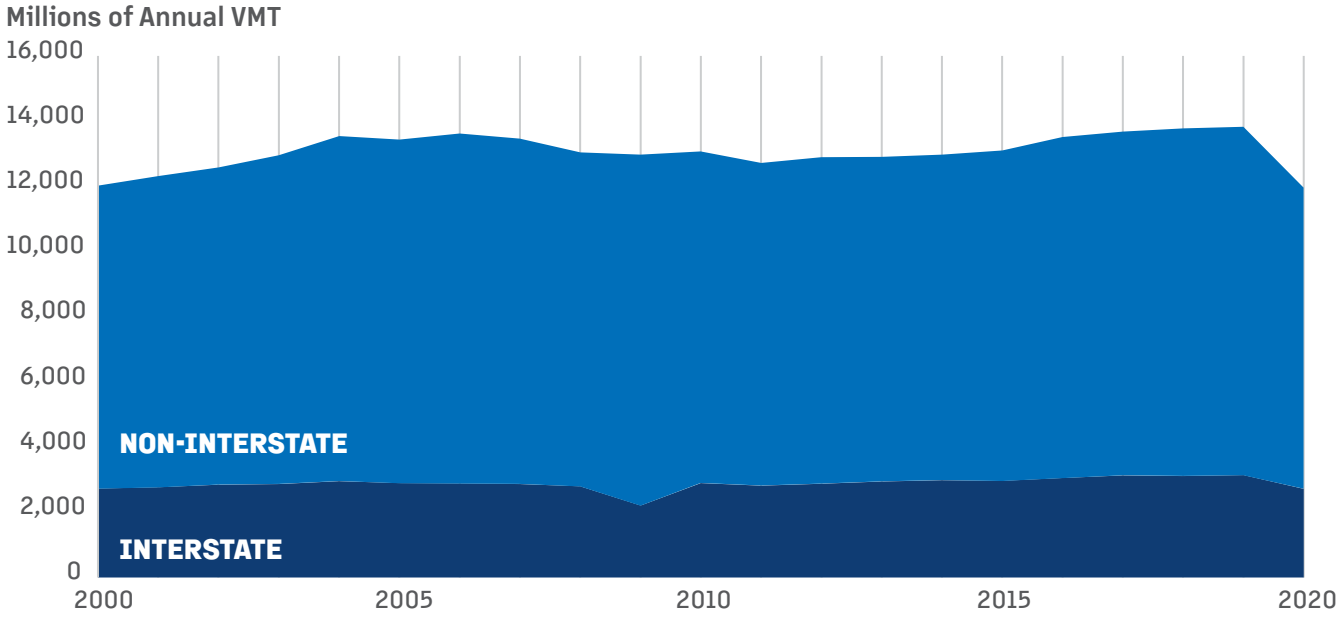


Demand on New Hampshire's Highways

Demand can be measured in several ways, the most commonly tracked being vehicle-miles traveled (which is typically divisible among different classes of vehicle by weight or number of axles) and person-miles traveled (which accounts for the varying capacity or occupancy of private vehicles, carpools, buses, etc.). Understanding how system demand changes over time enables NHDOT to model performance of the system (i.e., delay, travel time reliability, and deterioration of assets) and to anticipate future funding needs.

Exhibit 1.5 illustrates the trend in VMT on all of New Hampshire's roads since 2000. While VMT in New Hampshire fell in 2020 during COVID-19, it had been growing slowly since 2011 and set new records in 2018 and 2019. VMT growth slightly increases deterioration of pavement and bridge assets, but not by enough to warrant changes in asset management strategies.

Exhibit 1.5 VMT on New Hampshire Roadways, 2000-2020



Source FHWA Office of Highway Policy Information, Table VM-2.

Organization of the TAMP

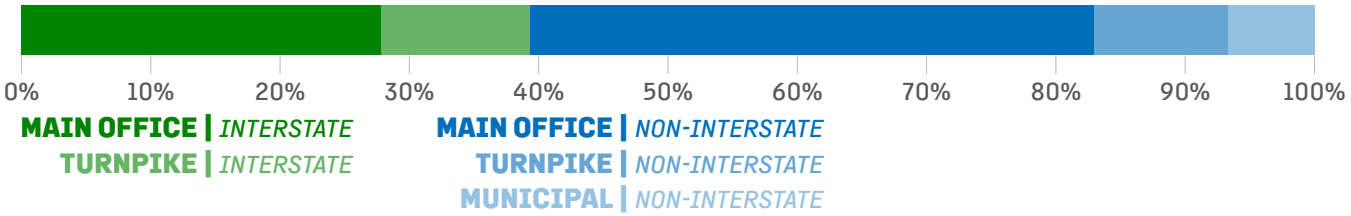
This TAMP meets all FHWA reporting requirements. Chapters 2 and 3 review the inventory and condition; performance management and modeling; gap analysis; life cycle planning; investment strategies; and TAMP implementation for NHS pavement and NHS bridges, respectively. Chapter 4 describes NHDOT's risk assessment and Chapter 5 the Department's financial plan for its NHS assets.

2. NHS PAVEMENT

Inventory/Condition for NHS Pavement

NHS pavement is overwhelmingly managed by NHDOT – approximately 76% by the Pavement Management Section, Materials and Research Bureau and 17% by the Bureau of Turnpikes (by lane-mileage). The remaining 7% is maintained by municipalities, as New Hampshire's county governments do not own highway infrastructure. Exhibit 2.1 breaks down NHS lane-mileage in New Hampshire by jurisdiction and Interstate status.

Exhibit 2.1 New Hampshire's NHS Lane Mileage by Interstate Status and Jurisdiction



	TOTAL	NHDOT HIGHWAYS		NHDOT TURNPIKES		MUNICIPALITIES	
	LANE-MILES	LANE-MILES	%	LANE-MILES	%	LANE-MILES	%
Total NHS	**2,839**	**2,144**	**76%**	**486**	**17%**	**208**	**7%**
Interstate	**1,060**	833	79%	228	21%	0	0%
Non-Interstate NHS	**1,779**	1,312	74%	259	15%	208	12%

Source: NHDOT Annual Road Inventory, January 2022.

The whole of the NHS in New Hampshire is surfaced with asphalt. Per FHWA's 2016 Final Rule following the FAST Act, NHDOT expresses the condition of its asphalt pavements using an index of three distresses: international roughness index (IRI); rutting; and cracking. Exhibit 2.2 illustrates how the condition index is computed from the distress measurements.

NHDOT contracts for pavement data collection vehicles that sense the condition of all Interstates and non-Interstate NHS pavements annually. All three component distresses have been collected beginning 2015. Data on roughness and rutting has been collected since 2009. NHDOT's practice meets all applicable requirements and are documented in an approved data quality management program (NHDOT Data Quality Management Plan (DQMP), 2020). The DQMP details the Department's approach for: 1) managing equipment, 2) certifying personnel, 3) process control, 4) reviewing the data, 5) resolving errors, and 6) accepting the data.

Exhibit 2.2 Calculation of the FHWA Pavement Condition Measure

Roughness | *Measures by the "International Roughness Index" or IRI.*

0 **Good** *95* **Fair** *170* **Poor**

Cracking | *Measures by percent of wheelpath area with fatigue cracks.*

0 **Good** *5%* **Fair** *20%* **Poor**

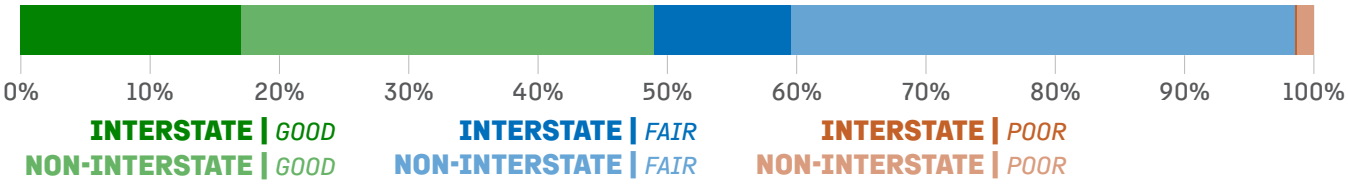
Rutting | *Measures by average depth to the nearest 0.1 inch.*

0 **Good** *0.2"* **Fair** *0.4"* **Poor**

If **all three distresses are good,** *the segment overall is* **good.** *If* **two or three distresses are poor,** *the segment overall is* **poor.** *All other segments are* **fair.**

Exhibit 2.3 summarizes the lane-mileage of Interstate and Non-Interstate NHS pavement in New Hampshire that is good, fair, and poor as of June, 2021 (measured in 2020). There are small difference in the lane-miles reported between Exhibit 2.1 and Exhibit 2.3 due to condition computations and roadway segmentations.

Exhibit 2.3 NHS Pavement by System and Condition, 2020



	TOTAL	GOOD		FAIR		POOR	
	LANE-MILES	LANE-MILES	%	LANE-MILES	%	LANE-MILES	%
Total NHS	**2,813**	**1,378**	**49%**	**1,395**	**50%**	**41**	**1%**
Interstate	**779**	479	62%	296	38%	3	0%
Non-Interstate NHS	**2,034**	898	44%	1,098	54%	38	2%

Note: Total Lane-Miles may differ from Exhibit 2.1 due to condition collection segmentation.

Source: NHDOT Annual Road Inventory, June 2021.

Performance Management/Modeling for NHS Pavement

The Final Rule requires NHDOT to set two-year, four-year, and state-of-good-repair (SOGR) goals for Interstate and Non-Interstate NHS pavement in good and poor condition. The Department set those goals for the first time in 2018 through extensive collaborative outreach to Metropolitan Planning Organizations (MPOs). The goals have been updated for the new performance period, 2022-2026.

To set two and four-year and SOGR targets for the 2022-2026 period of performance, NHDOT used the following process:

- Pavement conditions were forecasted for 20 years utilizing the Department's Asset Analytics and Forecasting System (AAFS) with budgets based on the proposed 2023-2032 Ten Year Plan[4] as the constrained scenario.
- The outputs from this scenario were reviewed with the Pavement Management Committee where subject matter experts considered the forecasted conditions and historical information to establish the targets.
- To inform the SOGR target setting process an unlimited budget scenario was run in AAFS, allowing the application to select a solution optimized for cost/benefit without financial constraint while maintaining the Department's lifecycle approach.
- The Performance Workgroup reviewed the results of the constrained and unconstrained scenario runs, also taking into account historical information, current conditions, forecasted information, and knowledge of the cracking data.
  - Considering the information and with a recognition that conditions appeared to meet user expectations, the SOGR Interstate targets were set near 2020 actual conditions.
  - SOGR targets for the non-Interstate NHS were established in recognition of the forecasted decline in condition balanced with the goal of minimizing poor condition within reasonable 10-year budgets.
- The methodology and targets were reviewed with all 4 MPOs and FHWA on February 2, 2022 and throughout the spring.

Exhibit 2.5 provides the anticipated two-year, four-year, and SOGR targets for the 2022-2026 period of performance. All three component distresses are used to set all of the anticipated targets. As such, it is important to note that Non-Interstate targets cannot be compared across the periods of performance. The targets represent the best information available in NH based on modeling, subject matter expertise, and engineering judgment, combined with MPO feedback.

Exhibit 2.5 Anticipated NHDOT Pavement Condition Targets for 2022-2026

% OF LANE-MILES	GOOD				POOR			
	BASE	2YR	4YR	SOGR	BASE	2YR	4YR	SOGR
Interstate	63.8	57.0	57.0	57.0	0.0	0.5	0.5	0.5
Non-Interstate NHS	39.4	35.0	35.0	35.0	3.6	7.0	7.0	5.0

Note: Targets are anticipated. Final targets will be confirmed and submitted to FHWA in September 2022.

In general, the Department focuses more on Good/Fair as a single metric compared with Good. This reflects both the stringent standards for Good and the efficiency of managing and preserving assets in Fair condition.

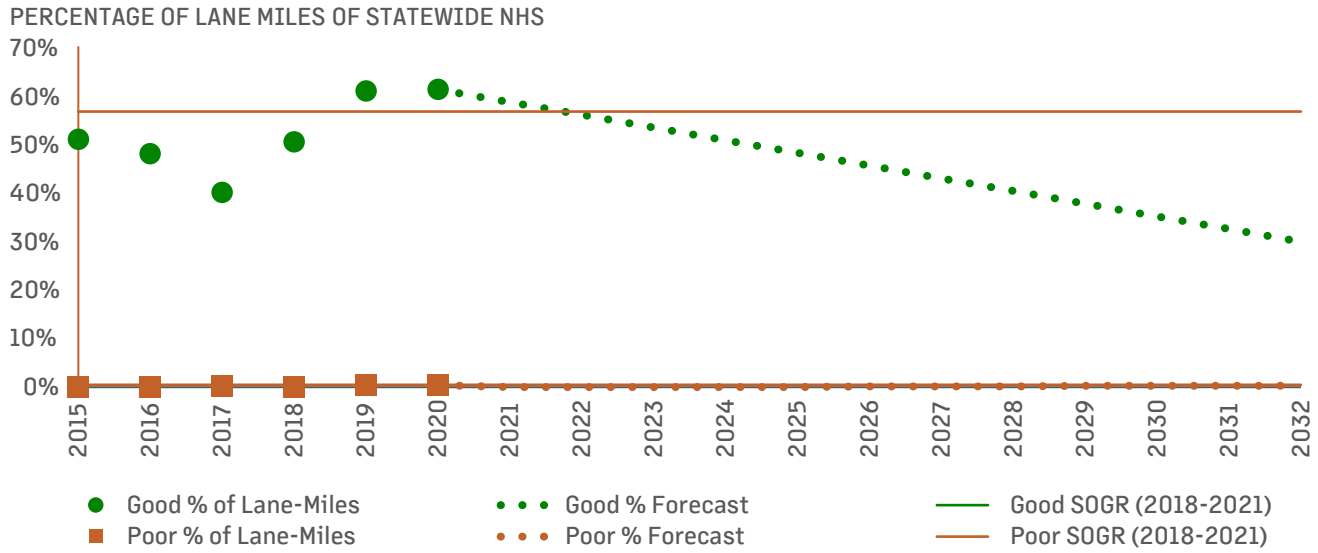
NHDOT uses deterioration models for pavement to analyze the natural deterioration in the condition of pavement and the consequence of the four FHWA work types: preservation, maintenance, rehabilitation, and reconstruction. The 2019 TAMP did not report model results for pavement condition. Between 2019 and 2022, the Department

[4] https://www.nh.gov/dot/org/projectdevelopment/planning/typ/index.htm.

developed a state-of-the-art modeling methodology based on multivariate regression at the distress-level – the model assesses the consequence of each work type on IRI, cracking, and rutting individually and rolls these up to an overall good, fair, or poor for each roadway segment. Technical details of this model are provided in **Appendix B**.

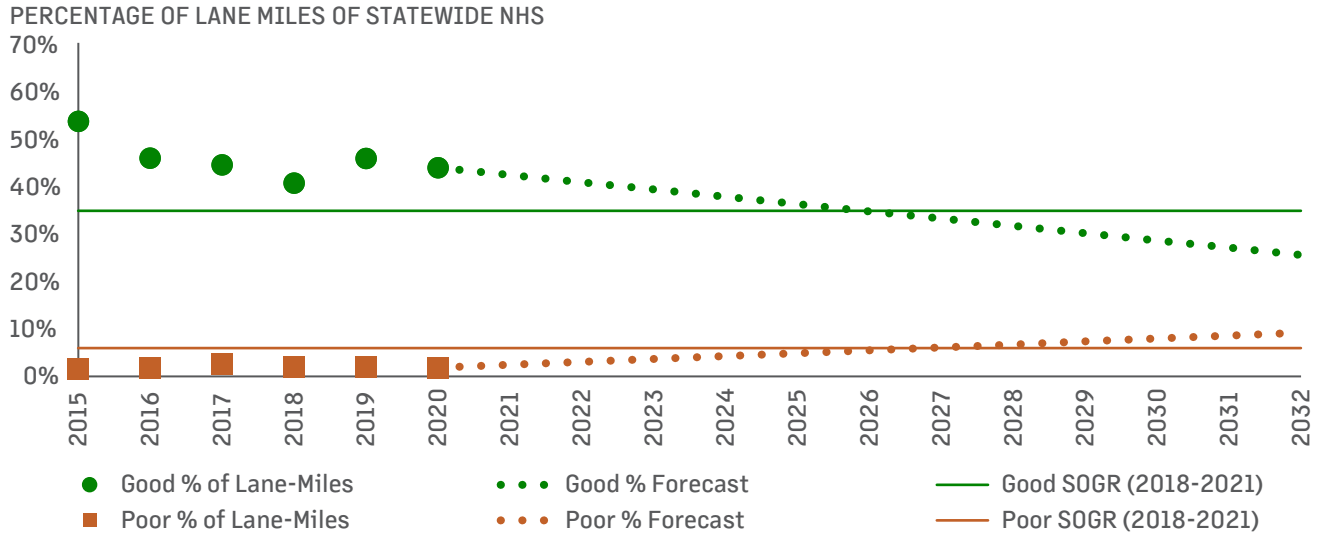
Exhibits 2.6 and 2.7 illustrate 17 years of pavement condition – six measured years from 2015 (when NHDOT began collecting cracking percent) to 2020 and 10 modeled years from 2021 to 2030. The SOGR targets from the 2018-2021 period of performance are also shown.

Exhibit 2.6 Good and Poor Pavement Condition on Interstates, 2015-2032



Source: NHDOT Annual Road Inventory, Asset Analytics and Forecasting System.

Exhibit 2.7 Good and Poor Pavement Condition on Non-Interstate NHS, 2015-2032



Source: NHDOT Annual Road Inventory, Asset Analytics and Forecasting System.

Gap Analysis for NHS Pavement

Under all scenarios the quantity of good miles is expected to decline, primarily due to cracking. NHDOT expects severe freeze-thaw cycles and has mitigated these with a crack-sealing program. Cracking data is also the least mature nationwide and at NHDOT. Protocols and guidance were updated within the past five years and the Department recently switched to an automated rating process from a semi-automated one.

For both the Interstate and non-Interstate NHS current conditions are better than the two-year, four-year, and SOGR targets. The model forecasted conditions (Exhibit 2.6, Exhibit 2.7) show declines in good condition for both systems below the targets and an increase in poor condition on the non-Interstate NHS above the SOGR target. The results of those models were reviewed with subject matter experts and in the context of past practices and conditions. Based on discussions and analysis, the Department is not confident that the forecasted good conditions, particularly in the short-term, will become reality. Our intent is to continue to monitor actual conditions and investments while refining the models.

There is more confidence that the forecasted increase in poor condition on the non-Interstate NHS is a potential reality. To analyze the gap, the Department ran unconstrained and budget-work type iterative models. The results of those models showed that an average additional investment of $5.0 Million per year beginning in 2033 in the Maintenance work-type and an average additional investment of $10.0 Million in 2035, 2038, and 2041 in the Rehabilitation work-type would most efficiently reduce the gap. While decision-makers are aware of the gap and analysis there is not currently any intent to change the investment approach and the budget is constrained.

The Final Rule also sets a threshold that a maximum 5% of Interstate NHS pavement can be in poor condition – New Hampshire has met this threshold in each of the past ten years and is projected to meet it in the next ten.

Life Cycle Planning for NHS Pavement

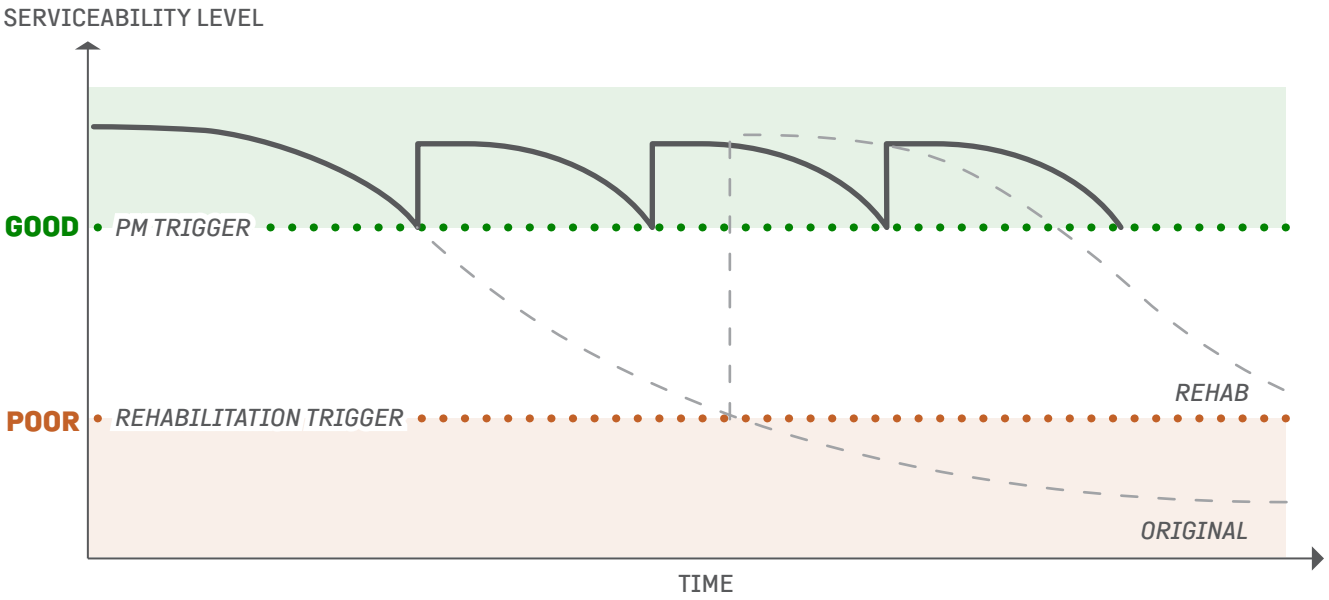
Life cycle planning for pavement assets keeps roadway surfaces serviceable and protects investments. As noted above, NHDOT performs four types of work on pavement assets:

- **Preservation |** Work to deter or correct deterioration of a transportation asset, intended to extend its useful life. Preservation work is conducted on roads that are generally in Good condition and structurally sound. This work does not entail any structural or operational improvements of an existing transportation asset beyond its originally designed strength or capacity.
- **Maintenance |** Treatments applied to a transportation asset that is in reasonable condition, but is not suitable for Preservation. Maintenance work extends the transportation asset's life by preventing the propagation of distresses. Periodic maintenance work will occur over the long-term to keep the asset in reasonable condition. Maintenance work does not completely fix the underlying defect (i.e. structure, drainage, etc.).
- **Rehabilitation |** The result of rehabilitation is a "like new" pavement that is suitable for Preservation moving forward. Work often consists of multiple phases intended to correct structural deficiencies impairing the asset. Rehabilitation may include replacing parts of the transportation asset but not the entire asset, and is generally understood to be more significant in scale than Maintenance.

» **Reconstruction |** Work consisting of disposal of an existing transportation asset and substitution of a new asset serving in the same functional requirements and possibly additional requirements in the same approximate location. The distinction between Rehabilitation and Reconstruction is that Reconstruction removes and replaces the base gravels beneath the existing pavement. Rehabilitation may remove and replace some or all of the existing pavement, but does not replace the base gravels.

Department policy favors preserving and maintaining pavements. Rehabilitation and reconstruction are expensive endeavors, and the need for them can be postponed through preservation and maintenance. Exhibit 2.8 illustrates the difference between a treatment plan that allows deterioration to failure before periodic reconstruction and a life cycle planning approach that centers on preservation and maintenance. Note that NHDOT's approach ideally keeps pavement consistently out of poor condition.

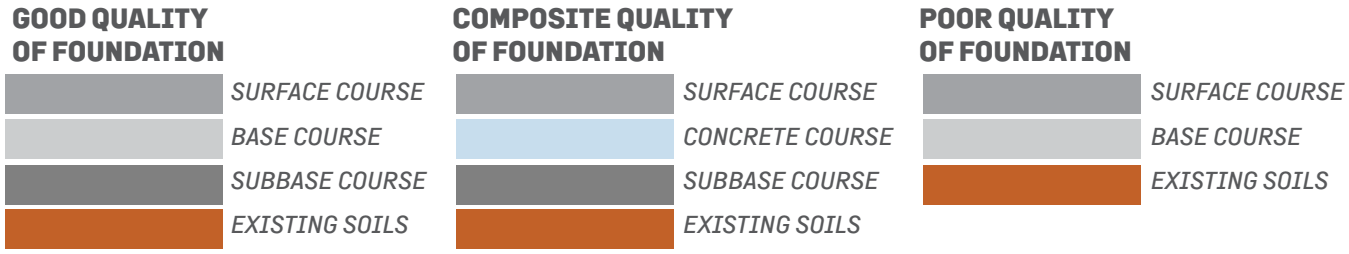
Exhibit 2.8 Visualization of Deterioration/Construction vs. Life Cycle Planning



Quality of Foundation

NHDOT's life cycle planning approach recognizes that treatment selection must vary with the Quality of Foundation under roads. A Good Quality of Foundation road is well engineered while a Poor Quality of Foundation road may not have necessarily been engineered prior to construction and may not contain sufficient base or subbase courses. A Composite Quality of Foundation roadway is a road segment that contains concrete under the surface layer and may perform between Good and Poor foundations in performance. Exhibit 2.9 illustrates the difference.

Exhibit 2.9 Structure of Built and Unbuilt Asphalt Pavement



Poor Quality of Foundation, Composite Quality of Foundation and poor performing Good Quality of Foundation roads are inappropriate targets for preservation treatments, as those treatments will not function as designed or must be applied at a cost-prohibitive frequency. NHDOT applies maintenance treatments to these roads instead – the treatments raise the condition of the pavement to good but subsequent performance will vary.

Decision-Making for Pavement Treatments

Pavement management decision-making at NHDOT begins at the Pavement Management Committee, which is led by the Chief of Pavement Management with participation from the Bureau of Highway Design; the Bureau of Turnpikes; AMPS; the Bureau of Highway Maintenance, including Maintenance Districts; and the Bureau of Construction. The Pavement Management Committee is responsible for overall pavement program management and coordination. Exhibit 2.10 summarizes more roles and responsibilities for NHS pavement management.

Exhibit 2.10 Roles and Responsibilities for NHS Pavement Management

FUNCTION	AMPS FUNCTION	PAVEMENT MANAGEMENT SECTION	BUREAU OF HIGHWAY DESIGN FUNCTION	BUREAU OF HIGHWAY MAINTENANCE FUNCTION*	BUREAU OF CONSTRUCTION
Inspect pavement	N/A	Full	N/A	N/A	N/A
Manage pavement data	Partial	Full	N/A	N/A	N/A
Pavement Data Analytics	Full	Partial	N/A	N/A	N/A
Select, plan, and schedule pavement treatments	Partial	Full	Partial	Partial	N/A
Pavement project design and advertising	N/A	Partial	Full	Partial	N/A
Field work and construction oversight	N/A	N/A	N/A	Full	Full
Initial emergency response	N/A	N/A	Partial	Full	Partial

* The Bureau of Turnpikes serves these functions on the Turnpike System.

NHDOT developed new decision trees for pavement in 2019. The decision trees were developed using a combination of data driven analysis using condition and historical data in conjunction with interviews with subject matter experts. The Department developed several candidate trees using a recursive partitioning algorithm (i.e., a machine learning approach) from historical construction records, highway attributes, and condition measurements between 2013 and 2018, then asked the engineers to review the alternatives for accuracy and identify the best fit option.

Once a work type is recommended, the pavement management engineer selects and develops an appropriate treatment project. Some examples of treatments are provided in Exhibit 2.11.

Exhibit 2.11 Example Pavement Treatments for FHWA Work Types

PRESERVATION TREATMENTS	MAINTENANCE TREATMENTS
» Full width hot mix overlays (depth varies between 3/8" – 2") – Tier 1 – All spot inlays under 50% of section length acceptable – Tier 2 – Good Condition and Good/Composite Foundation spot inlays acceptable » Chip Seal » Bonded Wearing Course, any depth – Tier 1 – All spot inlays under 50% of section length acceptable – Tier 2 – Good Condition and Good/Composite Foundation spot inlays acceptable » Crack Seal » Paver shim » Spot inlays (less than 50% of section length) » Tier 2 – Fair/Poor Condition and/or Composite/Poor Foundation	» Full width hot mix overlays (depth varies, but most often ¾")
REHABILITATION TREATMENTS	**RECONSTRUCTION TREATMENTS**
» Any contiguous inlay treatment (mill and fill) » Any contiguous inlay/overlay treatment » Reclamation » Cold-in-place recycling » Hot-in-place recycling » Remove and replace	» Full box reconstruction

Resiliency

NHDOT incorporates resiliency to extreme weather events and sea-level rise into the pavement lifecycle in various ways. Resiliency, as part of lifecycle planning for pavements, is primarily considered as part of rehabilitation and reconstruction. In addition to the current practices outlined below, the Department has undertaken an effort to develop a coastal risk framework that will provide more information about risks to pavements due to sea-level rise to help inform lifecycle decisions.

1. **Sea-Level Rise –** As projects are considered for the TYP, the Projects Review Committee reviews them for scope, cost, and sea-level rise implications using forecasts recommended in the NH Coastal Flood Risk Summary, Part II: Guidance for Using Scientific Projects (2020). The results of that review will inform lifecycle investment decisions.
2. **Part 667 Analysis –** The Project Managers of any highway projects that are in proximity to a transportation asset that was damaged during a declared natural disaster is notified.
3. **Design Information –** As projects advance from planning into design, experts in various subject areas will include feedback about any operational issues during past storms, such as inundation or erosion, as well as concerns about elevations in relation to sea-level rise forecasts. The information will be considered as part of lifecycle investment decisions.
4. **Culverts –** Culverts are inspected, maintained, and cleaned by Department personnel. Culvert condition and capacity are reviewed as part of rehabilitation and reconstruction projects. In addition, a separate program is part of the TYP to replace and upgrade poor condition and undersized culverts. Culverts are prioritized based on condition, size, material, facility carried, traffic and other factors. Culvert lifecycles are often connected to pavements as the Department seeks to coordinate rehabilitation and replacement activities.

Coordination with Municipalities on NHS Pavement

NHDOT coordinates with municipal pavement owners in a couple important ways. First, results of pavement inspections (conducted by NHDOT for all NHS pavement regardless of owner) are shared annually with the public. Second, personnel at the Department review capital improvement plans from the largest municipalities to identify planned work on NHS pavements. Any identified projects are included in the pavement information as committed work.

Investment Strategies for NHS Pavement

NHDOT's investment strategies for NHS pavement are expressed in its Transportation Improvement Plan (TYP), updated every two years; and its State Transportation Improvement Program (STIP), updated every two years. They are built around two core principles:

» **Highway Priorities (Tiers) |** NHDOT prioritizes and treats pavements based on tier. Tier 1 and Tier 2 (Interstates, Turnpikes, divided highways, and Statewide Corridors as discussed in Section 1.2.1) together include most of the NHS. By prioritizing these highways, the Department alleviates operational and reputational risks. As the tier system is informed by quantitative indicators: traffic volume, level of roadway connec-

tivity, economic importance, etc., NHS pavements are on a data-driven foundation prioritized above other roads for resource allocation.

» **Making Sustainable Investment |** This principle guides the Department to meet current pavement needs while provisioning for future demand. As discussed in Section 2.4, NHDOT recommends treatments that will keep pavement in good condition for as much of its life span as possible and that will minimize the need to reconstruct roads.

Specifically, the 2023-2032 TYP lays out the following strategies with relevance to NHS pavement:

» Focus on maintenance & preservation of existing pavements.

– Maintain and extend all programs by two years.

» Continue to focus on road conditions statewide.

– Increase program budgets for annual inflation.

– Continued and enhanced investment in roadside (culverts, guardrail, etc.) assets.

» Fund regional priority projects.

» Incorporate changes associated with the IIJA.

Exhibit 2.12 crosswalks these principles by (a) prioritizing preservation for all roads; (b) eliminating unacceptable roads through maintenance paving; (c) maintaining a reasonable condition through maintenance; and (d) rehabilitating high-volume corridors with the remaining funds.

Exhibit 2.12 Pavement Strategy Decision Matrix

WORK TYPES	TIER 1	TIER 2	TIER 3	TIER 4
Reconstruction	-	-	-	-
Preservation	High	High	High	High
Maintenance	-	High	Moderate	Moderate
Rehabilitation	High	Moderate	Low	Low

Source: NHDOT Pavement Strategy Summary (2017).

Within the work types, NHDOT engineers use subject matter expertise to consider combinations of treatments – "mixes of fixes" – to each tier of pavements. The Department minimizes life cycle cost for the tiers by excluding costly alternatives not justified through expected extension of useful life.

In order to allocate funds to maintain SOGR for NHS pavement assets, the Department computes the funding need by tier for maintenance/preservation and rehabilitation and reconstruction, using the following steps:

» Using weighted averages of historical construction records, NHDOT produces a per-lane mile unit cost for maintenance, preservation, rehabilitation, and reconstruction.

For example, the preservation cost per lane mile for Tier 1 could be $77,500 per lane mile.

» Using the decision matrix in Exhibit 2.12, the pavement engineers identify a work type need for each segment of road. The total mileage by work type and by tier is multiplied by the per-mile cost to generate a total need.

For example, if 516 lane miles of Tier 1 road were identified for preservation, the overall cost to preserve the tier would be approximately $40.0 million.

» Maintenance and preservation needs are summed by tier. Rehabilitation and reconstruction needs are summed by tier.

» During the TYP development process, NHDOT allocates available funds taking into account the forecasted needs by year by asset and by tier, consistent with its two guiding principles.

NHS pavement is subject to systemwide investment strategies in the TYP process. These strategies, along with the resulting funding levels for 2020-2029 for NHS pavement, are presented in Chapter 5.

TAMP Implementation for NHS Pavement

The Department believes in a continuous improvement approach regarding asset management and the TAMP. The following actions will be pursued to enhance the Department's understanding and approach toward managing NHS pavements.

» Pavement Modeling & Forecasting:

2022 | Refine and incorporate treatment-level deterioration and decision making.

2023 | Enhance the inclusion of paving history.

2023 | Continuously monitor unit costs and update biennially in conjunction with the TYP.

2023 | Incorporate feedback from the Pavement Management Committee as they review treatment candidates.

» Lifecycle Planning:

2022 | Incorporate candidate treatments from the model into pavement program development.

2023 | Utilize model information, unit costs, and treatment scenarios to test for the best returns on investment.

» Risk:

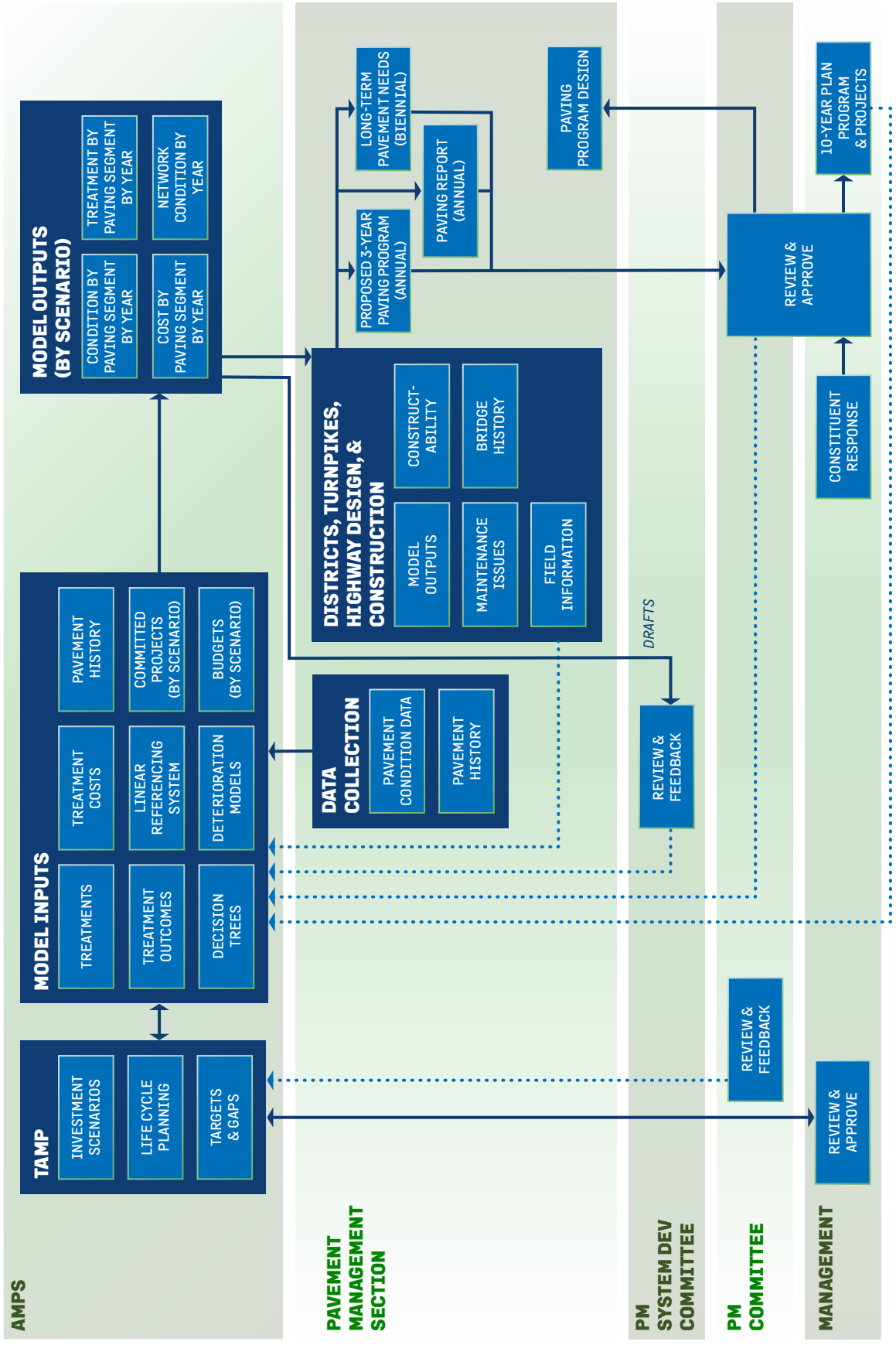
2023 | Utilize a coastal risk framework to proactively identify NHS roads that are at risk.

2023 | Enhance the connection between single occurrence events identified in the Part 667 analysis with the program of projects.

2024 | Expand the risk framework to include culverts & extreme precipitation statewide.

Exhibit 2.13 illustrates the parties, roles, and processes involved in the management of New Hampshire's NHS Pavement.

Exhibit 2.13 Pavement Management Process



3. NHS BRIDGES

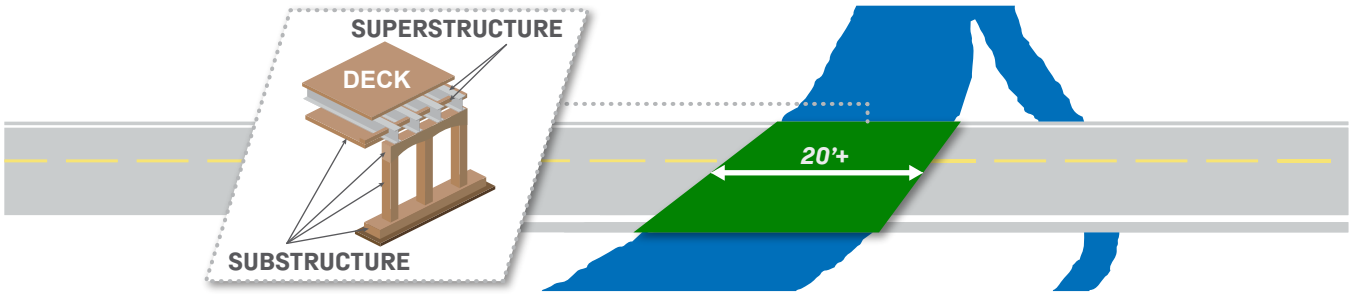
Inventory/Condition for NHS Bridges

FHWA definition of a bridge:[5]

- *A structure including supports and a track or passageway for carrying loads.*
- *An opening (or set of multiple openings) measuring 20 feet or longer on the centerline of the roadway.*

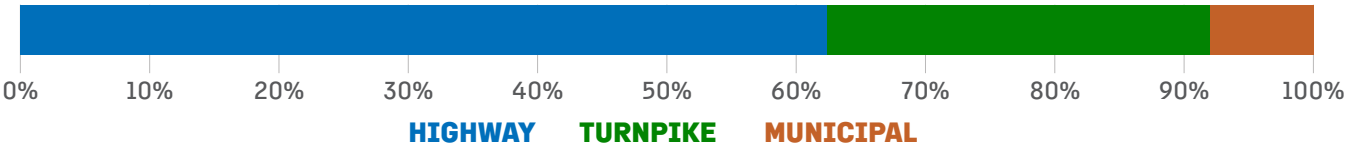
This definition is illustrated in Exhibit 3.1, which also includes a diagram of the three components that the National Bridge Inventory (NBI) records for a bridge: deck, superstructure, and substructure.

Exhibit 3.1 Diagram of a "Bridge" Under the Federal Definition



There were 726 bridges on the New Hampshire NHS in 2021. These bridges represent 18.8% of the bridges in NHDOT's total inventory and comprise 55.9% deck area measured in square feet. NHDOT's inventory includes bridges owned and maintained by multiple jurisdictions. Exhibit 3.2 illustrates the distribution of area of NHS bridges in New Hampshire by owner. The entire Interstate and most of the Non-Interstate NHS is managed by NHDOT. A small portion of the non-interstate NHS is managed by municipalities.

Exhibit 3.2 New Hampshire's Bridge Deck Area by Owner



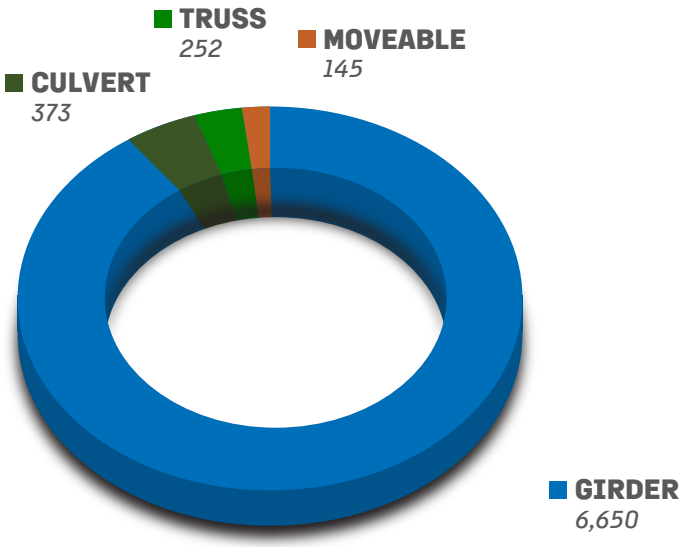
	TOTAL	NHDOT HIGHWAYS		NHDOT TURNPIKES		MUNICIPALITIES	
	DECK AREA (FT^2)	DECK AREA (FT^2)	%	DECK AREA (FT^2)	%	DECK AREA (FT^2)	%
NHS	7,433,194	4,753,125	63.9%	2,111,412	28.4%	568,657	7.7%

Source: NHDOT 2021 Annual Bridge Condition Snapshot, March 2022.

[5] 23 CFR 650.315.

NHDOT classifies bridges into five structural types: girder, truss, moveable, culvert, and timber. Exhibit 3.3 illustrates the distribution of NHS deck area among these structural types – no timber bridges are on the NHS.

Exhibit 3.3 NHS Bridge Deck Area by Structural Type (Thousands of Square Feet)



Source: NHDOT 2021 Annual Bridge Condition Snapshot, June 2021.

NHDOT defines bridge condition using a nine-point National Bridge Inspection Standards (NBIS). Components (i.e., deck, superstructure, and substructure) receive ratings on the scale shown in Exhibit 3.4. The bridge overall receives the lowest of the three component ratings.

Exhibit 3.4 NBIS Condition Rating Scale for Bridge Elements

SCORE	NAME	DESCRIPTION
9	Good	Pristine condition.
8		No problems noted.
7		Insubstantial flaws.
6	Fair	Minor deterioration.
5		Elements sound, some defects.
4	Poor	Advanced defects.
3		Local failures, cracking begins.
2		Support failure, closure possible.
1		Elements moving, bridge closed.
0		Out of service, beyond repair.

Source: Adapted/shortened from Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, FHWA PD 96-001, 1995.

Exhibit 3.5 summarizes the deck area of Interstate and Non-Interstate NHS bridges in New Hampshire that is good, fair, and poor based on inspections through December 31, 2021.

Exhibit 3.5 NHS Bridges by Condition, 2021

	TOTAL	GOOD		FAIR		POOR	
	DECK AREA (FT²)	DECK AREA (FT²)	%	DECK AREA (FT²)	%	DECK AREA (FT²)	%
NHS	7,433,194	4,341,869	58.4%	2,771,647	37.3%	319,678	4.3%

Source: NHDOT 2021 Annual Bridge Condition Snapshot, March 2022.

Performance Management/Modeling for NHS Bridges

The Final Rule requires NHDOT to set two-year, four-year, and state-of-good-repair (SOGR) goals for NHS bridge deck area in good and poor condition. The Department set those goals for the first time in 2018 through extensive internal coordination and collaborative outreach to Metropolitan Planning Organizations (MPOs). The proposed targets (Exhibit 3.7) were similarly developed by NHDOT and reviewed with the MPOs.

Exhibit 3.7 provides the anticipated two-year, four-year, and SOGR targets for NHS bridge condition for the 2022-2026 period of performance. To set these targets, NHDOT:

- Modeled bridge condition and forecasted it under expecting funding levels.
- Reviewed results with internal stakeholders and calibrated them to budgets, life cycle planning, and desired conditions.
- Reviewed results with MPOs and calibrated as above.
- Reviewed results with DOT leadership to formally establish the targets.

Exhibit 3.7 NHDOT Bridge Condition Targets for 2022-2026

% OF DECK AREA	GOOD				POOR			
	BASE	2YR	4YR	SOGR	BASE	2YR	4YR	SOGR
NHS	58.4%	57.0%	57.0%	39.4%	4.3%	5.0%	5.0%	5.0%

Source: 2021 Annual Bridge Condition Snapshot, Asset Analytics and Forecasting System.

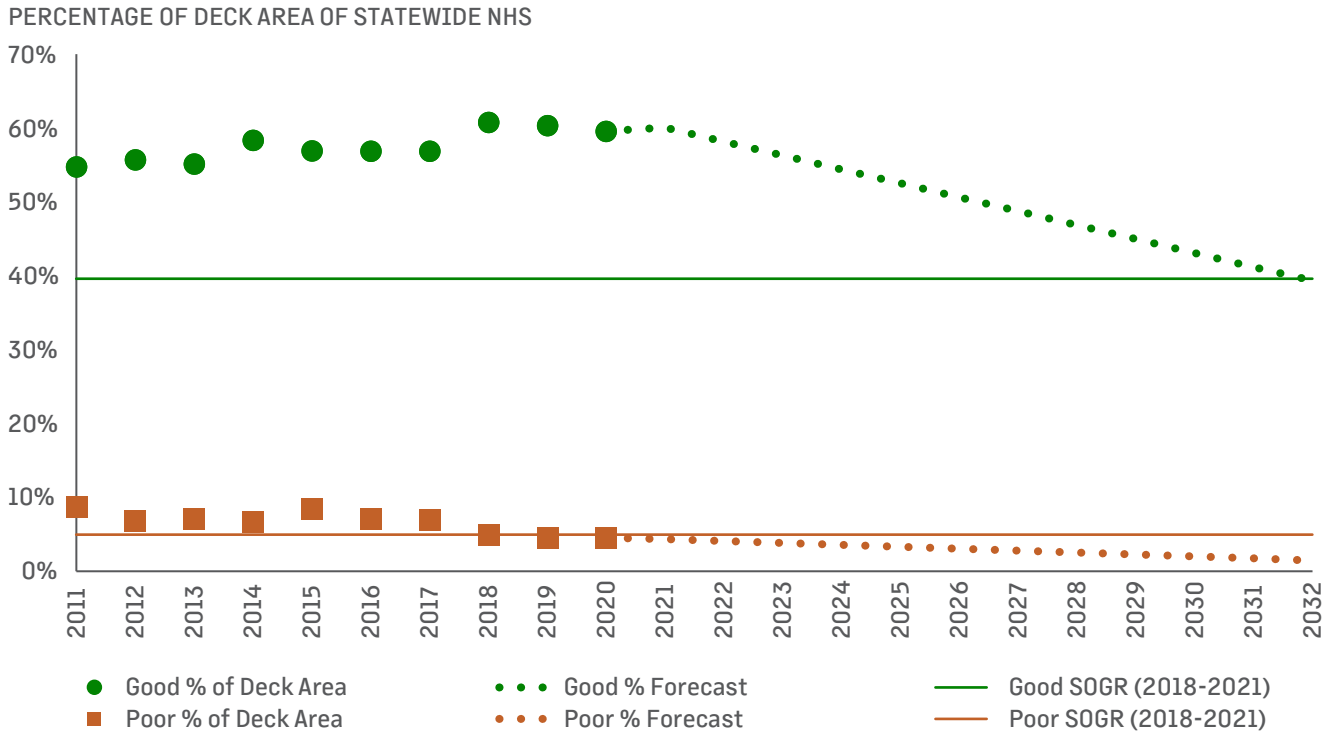
NHDOT uses deterioration models to analyze the natural deterioration in condition of the four major bridge components: Decks, Superstructures, Substructures, and Culverts. In conjunction with deterioration models, NHDOT uses the following bridge information to construct long term condition forecasting:

- **TYP |** Project information from the TYP is utilized for incorporating committed work and for producing estimated long-term budgets.
- **Unit Costs |** A cost per square feet of bridge was estimated based on historical bridge projects for each structure class (Girder, Timber, Truss, etc.) and for each treatment type (Preservation, Rehab, and Replacement).
- **Decision Trees |** These are used to determine when a bridge is eligible for a particular treatment type.

- **Treatment Resets |** Each treatment (Preservation, Rehabilitation, etc.) affects bridge condition differently.
- **Bridge Importance |** Apart from bridge condition, several aspects of a bridge are incorporated in the model to reflect potential risk and consequence of failure. These include: tier, deck area, scour critical, traffic, structure class, and detour length.
- **Cost/Benefit |** The model calculates the best possible investment toward a budget based on treatment resets, cost per treatment, and risk/importance.

Exhibit 3.8 illustrates 20 years of bridge condition – ten measured years from 2011 to 2020 and 10 modeled years from 2022 to 2031. The targets are also shown.

Exhibit 3.8 Good and Poor Bridge Condition on the NHS, 2011-2032



Source: NHDOT Annual Bridge Inventory 2011-2021, Asset Analytics and Forecasting System.

Gap Analysis for NHS Bridges

The lifecycle approach that NHDOT has implemented for bridges has resulted in improved conditions over the past 10 years with the percentage of good deck area increasing. In the long term, as the overall inventory of bridges in NH continues to age, the number of good condition bridges is expected to decline below current conditions (Exhibit 3.8). Based on information from the condition forecasts (Exhibit 3.8), the lifecycle analysis (Exhibit 3.9), and subject matter experts the SOGR for good condition was established consistent with anticipated conditions in the future. The Department will continue to monitor bridge inspection results for consistency with the expected trends and SOGR.

The two-year, four-year, and SOGR target for poor condition bridges were established similarly utilizing the lifecycle analysis, forecasts, and information from subject matter experts. While the lifecycle analysis shows a higher percentage of bridges may be expected to become poor over the long term (Exhibit 3.9), the forecast for the next 20 years supports a lower SOGR target. In addition, the Department emphasizes the significance of addressing poor condition bridges and will continue to focus on meeting the 5% target.

Life Cycle Planning for NHS Bridges

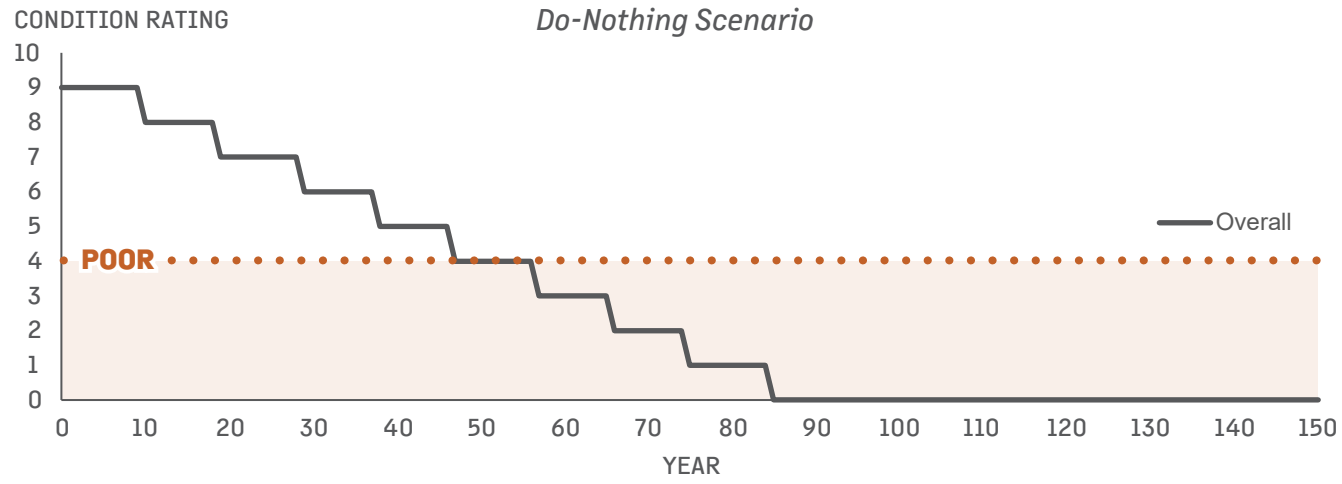
Life cycle planning for bridges keeps them serviceable and protects investments. As noted above, NHDOT performs four types of work on bridges:

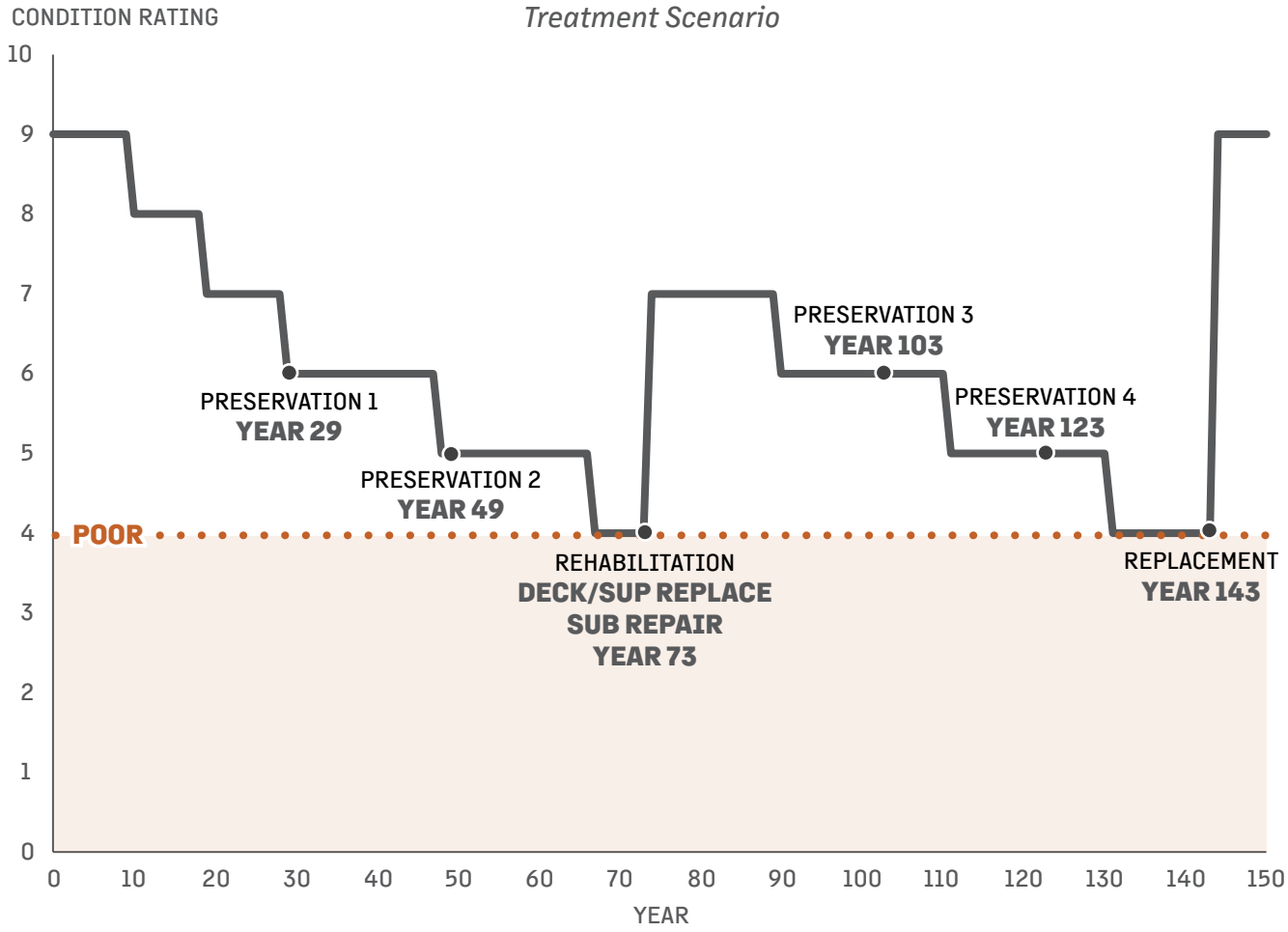
- **(Re)construction |** Work consisting of disposal of an existing transportation asset and substitution of a new asset serving in the same functional requirements and possibly additional requirements in the same approximate location. Also includes the initial development of an asset to serve functional requirements.
- **Preservation |** Work to deter or correct deterioration of a transportation asset to extend its useful life. This work does not entail any structural or operational improvement of an existing transportation asset beyond its originally designed strength or capacity. This work usually consists of one level or treatment and not in combination with any other treatment(s).
- **Maintenance |** Work applied to a transportation asset while the asset is still in good or fair condition; extends the transportation asset life by preventing the onset or propagation of distress. Every bridge, regardless of where within life cycle, requires routine maintenance to extend life.
- **Rehabilitation |** Work consisting of multiple treatments intended to correct physical or functional defects that impair on the satisfaction of a level of service standard of the transportation asset. May include replacement of parts of the transportation asset but not the entire asset, and generally understood to be more significant in scale than maintenance. Intended to restore pavements in poor condition to good or fair condition.

NHDOT's life cycle planning approach addresses bridge needs holistically and minimizes overall long-term cost. The Department's highest priorities involve applying low-cost preservation treatments at the right time to keep assets in good and fair condition.

Exhibit 3.9 shows the expected condition of a bridge in NH over the course of a typical lifecycle. This analysis was conducted for the life of the bridge using information from the Department's deterioration models and decision trees. Based on this information, a bridge in NH with 3 components (deck, superstructure, substructure) will spend approximately 31% of the time in an overall good condition, 55% in fair condition, and 14% in poor condition. Note that NHDOT's approach ideally keeps bridges consistently out of poor condition.

Exhibit 3.9 Example Bridge Deterioration in Do Nothing and Treatment Scenarios





Decision-Making for Bridge Treatments

Bridge management decision-making at NHDOT begins at the Bridge Management Committee, which is led by the Administrator of the Bureau of Bridge Design with participation from the Bureau of Bridge Maintenance; AMPS; and the Bureau of Planning and Community Assistance. The Bridge Management Committee is responsible for overall bridge program management and coordination. Exhibit 3.10 summarizes more roles and responsibilities for NHS bridge management.

Exhibit 3.10 Roles and Responsibilities for NHS Bridge Management

FUNCTION	AMPS FUNCTION	BUREAU OF BRIDGE DESIGN FUNCTION	BUREAU OF BRIDGE MAINTENANCE FUNCTION	BUREAU OF CONSTRUCTION
Inspect bridges	-	Full	-	-
Manage bridge data	Partial	Full	Partial	-
Bridge Data Analytics	Full	Partial	Partial	-
Select, plan, and schedule bridge treatments	Partial	Full	Partial	-
Preserve and maintain bridges	-	-	Full	Full
Rehabilitate and reconstruct bridges	-	-	Full	Full
Initial emergency response	-	Partial	Full	-

NHDOT prioritizes bridges for investment based on importance (e.g., facility type, traffic volume), risk (e.g., scour criticality), bridge type/size, and condition. Most data elements used in the process come from NBI with weighting that was developed by engineers at NHDOT. This process is also incorporated into a cost benefit calculation that suggests the best possible investment strategy for a given budget. Recent and planned work is then used to adjust the proposed strategy to create a final prioritization.

Each treatment applied to a bridge represents investments in extending the bridges service life. Unlike some assets that are continuously maintained above a minimum service life, all bridges will age and deteriorate to a point where replacement is the most efficient action. Maintenance work will occur regularly throughout the life of a bridge regardless of condition or recent work.

Many treatments are unique to the bridge types, for example repairs of electrical components are isolated to moveable bridges and invert repairs are unique to culverts. As noted, bridge data is coarse and complicated creating a stronger reliance on field observations to plan bridge work. Often, deficiencies not explicit in the data are identified through field observations that trigger specific treatments.

NHDOT developed decisions trees for bridges in 2020. These trees were developed using a combination of the NHDOT Recommended Investment Schedule (described in Section 3.5) and practical engineering knowledge from subject matter experts. Exhibit 3.11 presents the current bridge decision tree.

Resiliency

NHDOT incorporates resiliency to extreme weather events and sea-level rise into the bridge lifecycle in various ways. Resiliency, as part of lifecycle planning for bridges, is primarily considered as part of preservation, rehabilitation, and reconstruction. In addition to the current practices outlined below, the Department has undertaken an effort to develop a coastal risk framework that will provide more information about risks to bridges due to sea-level rise to help inform lifecycle decisions.

1. **Scour Criticality –** is a component of performance modeling and the selection of bridge projects for the TYP. In both cases, scour critical bridges, one aspect of bridge resiliency, receive additional points during prioritization for lifecycle treatments.

2. **Sea-Level Rise –** As projects are considered for the TYP, the Projects Review Committee reviews them for scope, cost, and sea-level rise implications using forecasts recommended in the NH Coastal Flood Risk Summary, Part II: Guidance for Using Scientific Projects (2020). The results of that review will inform lifecycle investment decisions.

3. **Part 667 Analysis –** The Project Managers of any bridge projects that are in proximity to a transportation asset that was damaged during a declared natural disaster are notified. The information will be considered as part of lifecycle investment decisions.

4. **Design Information –** As projects advance from planning into design, experts in various subject areas will include feedback about any operational issues during past storms, such as inundation or over-topping, concerns about bridge heights in relation to sea-level rise forecasts, and standard design information like bank-full width measurements, elevations, and hydraulic analysis.

Coordination with Municipalities on NHS Bridges

NHDOT coordinates with municipal bridge owners in several important ways. First, results of routine bridge inspections (conducted by NHDOT for all NBI structures regardless of owner) are shared annually with municipalities. If those inspections identify items of concern leading to a posting or closure recommendation, then the inspections and additional information are shared immediately. Second, NHDOT administers the Bridge Aid Program, an application-based, State-funded program that reimburses up to 80% of eligible bridge project costs. Third, the Bureau of Planning and Community Assistance works directly with municipalities to provide guidance on municipal bridge management. Fourth, personnel at the Department review capital improvement plans from the largest municipalities to identify planned work on NHS bridges.

The Department is developing a program to further enhance cooperation and to expand access to funding opportunities for municipally managed bridges of the NHS. Fundamentals of the program will include:

1. Proactive communication with municipalities and MPOs/RPCs;
2. A focus on condition and efficient lifecycle approaches for managing bridges;
3. Broader access to funding programs through the established continuous planning process (TYP, STIP, TIP);
4. Leveraging federal and state funds with a local match;
5. Agreements to maintain a reasonable duty of care following an investment.

Investment Strategies for NHS Bridges

NHDOT's investment strategies for NHS bridges are expressed in its Ten Year Plan (TYP), updated every two years; and its State Transportation Improvement Plan (STIP), amended regularly. They are built around two core principles:

» **Bridge Priorities (Ranking Process) |** This Ranking Process will initially separate bridges into two categories: NH R&R (bridges eligible for Reconstruction or Rehabilitation – including Redlist bridges) and NH M&P (bridges eligible for Preservation). NHDOT staff then prioritizes and treats bridges based on importance, risk, condition, and other factors described in Section 3.4.1 within each of these categories.

» **Making Sustainable Investment |** This principle guides the Department to meet current bridge needs while provisioning for future demand. As discussed in Section 3.4, bridges by their very nature deteriorate constantly. NHDOT recommends treatments that will keep bridges in safe operating condition for as long as possible. The goal is to delay the need to reconstruct until the bridge requires a functional update, often in response to increased traffic needs or modern design techniques.

Specifically, the 2023-2032 TYP lays out the following strategies with relevance to NHS bridges:

» **Focus on maintenance & preservation of existing bridges**

– Maintain and extend all programs by two years

» **Continue to focus on bridge conditions statewide**

– Increase program budgets for annual inflation

– Rehabilitation & reconstruction of poor condition bridges

– Allocate additional funds to the municipal bridge programs

» **Fund regional priority projects**

» **Incorporate changes associated with the IIJA**

The Department has developed Recommended Investment Schedules (RIS) for each of the major bridge types. The general schedule is presented in Exhibit 3.11.

Exhibit 3.11 General Recommended Investment Schedule for NHDOT Bridges

PRESERVATION AND MAINTENANCE TREATMENTS	REHABILITATION TREATMENTS	RECONSTRUCTION TREATMENTS
» Wash and Oil Every Year » Crack Seal the Pavement (every 10 years starting in year 5) » Inlay the Bridge Pavement (every 10 years starting in year 10) » Replace Membrane and Expansion Joints (every 20 years) » Repair Electrical and Mechanical Parts, if any (every 25 years) » Patch Concrete or Repair Inverts on Culverts (every 10 years) » Paint exposed steel, if any (every 20 years)	» Replace Worn Out Components (every 25 years) » Replace concrete decks (year 60) » Completely Replace Culvert Type Bridges (year 60) » Completely Replace Moveable & Truss Type Bridges (year 100) » Completely Replace Timber Type Brides (year 80)	» Completely Replace Girder Type Bridges (year 120)

New Hampshire's NHS includes various bridge types that are built with many types of materials. They were built over a long period and many components that are decades old are still functioning in the field today. In some cases, work is deferred in anticipation of larger projects that will replace assets through reconstruction. Data is collected to evaluate these alternatives, assess network needs, and to develop deterioration rates. While service life is generally predictable for NHS bridges, specific site conditions, such as environment and level of usage, introduce variability.

Given the age distribution of the bridge population, many bridges were designed for smaller and lighter loads and constricted waterways. Reconstructing or replacing these bridges generally involve building larger structures to handle today's traffic and to allow for the safer flow of water during extreme precipitation events. Bridge replacements and reconstructions are complicated processes. Temporary bridges and additional land acquisition are often needed to maintain traffic during the construction period. In some situations, the transportation network surrounding the bridge has developed to a point where it is not essential from a traffic perspective.

Costs and outcomes for the different work types vary with maintenance generally being lowest cost, preservation generally providing the highest level of service, and reconstruction generally being very expensive. Site specific conditions such as traffic management, initial construction methods, and right of way purchasing produce variability in costs, which can affect how reasonable potential work is. For example, when temporary bridges or night construction are required total project costs may outweigh anticipated benefits.

NHS bridges are subject to systemwide investment strategies in the TYP process. These strategies, along with the resulting funding levels for 2023-2032 for NHS bridges, are presented in Chapter 5.

TAMP Implementation for NHS Bridges

The Department believes in a continuous improvement approach regarding asset management and the TAMP. The following actions will be pursued to enhance the Department's understanding and approach toward managing NHS bridges.

» Bridge Modeling & Forecasting:

2023 | Develop and incorporate element-level deterioration and decision making.

2023 | Enhance the inclusion of bridge history.

2023 | Continuously monitor unit costs and update biennially in conjunction with the TYP.

2023 | Incorporate feedback from the Bridge Management Committee as they review treatment candidates.

» Lifecycle Planning:

2022 | Development of an enhanced program for municipally managed NHS bridges.

2023 | Incorporate candidate treatments from the model into bridge program development.

2023 | Utilize model information, unit costs, and treatment scenarios to test for the best returns on investment.

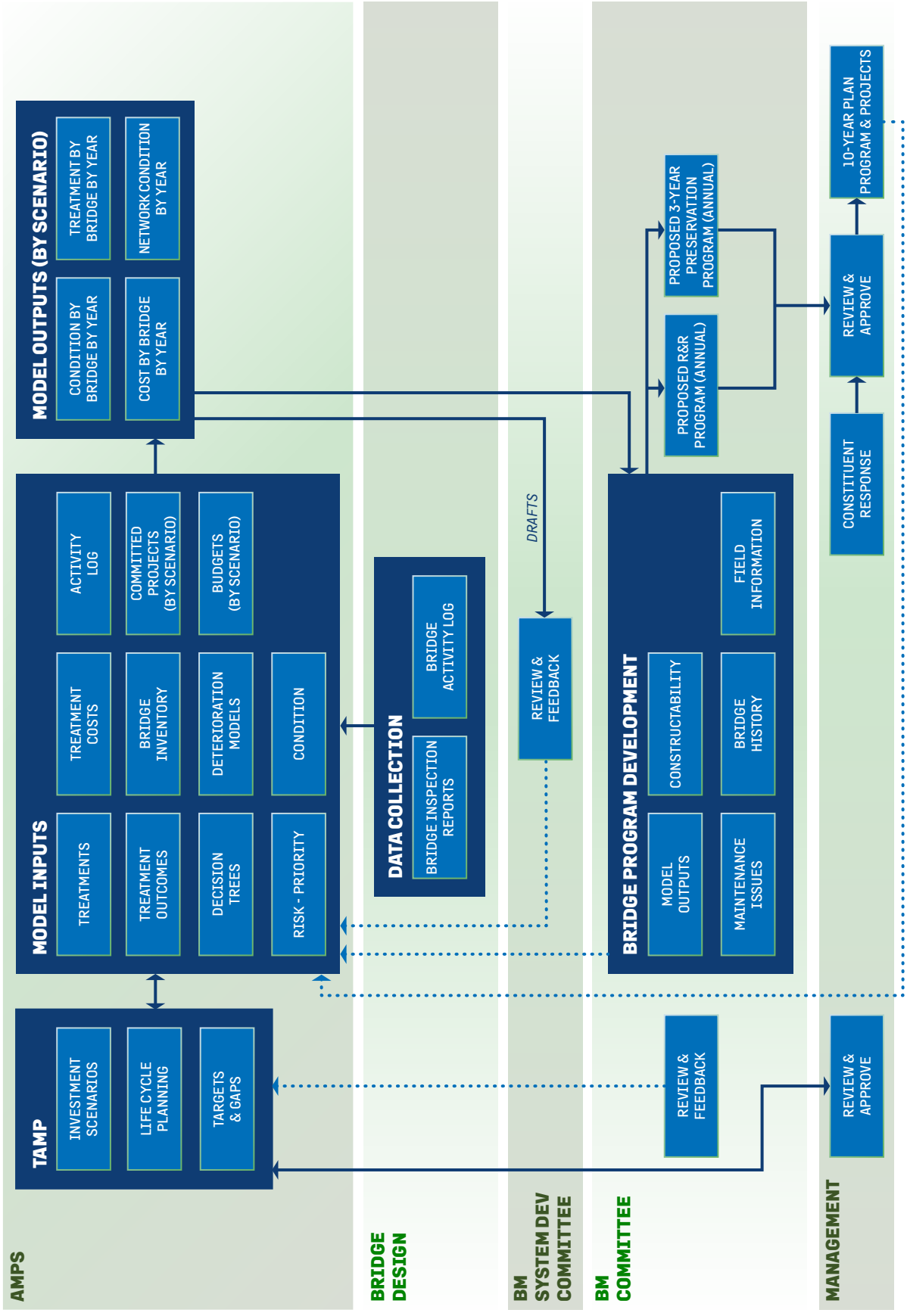
» Risk:

2023 | Utilize a coastal risk framework to proactively identify NHS bridges that are at risk.

2023 | Enhance the connection between single occurrence events identified in the Part 667 analysis with the program of projects.

Exhibit 3.12 illustrates the parties, roles, and processes involved in the management of New Hampshire's NHS Bridges.

Exhibit 3.12 Bridge Management Process



4. RISK ASSESSMENT

FHWA defines risk as "the positive or negative effects of uncertainty or variability upon agency objectives."[6] Accounting for this uncertainty is essential to objective asset management. Building an enterprise risk management approach and risk tolerance for NHDOT will allow the department to foster responsible and informed risk-taking and communicate the benefits of doing so to stakeholders and the public.

This chapter establishes NHDOT's enterprise risk posture, discusses risks that directly cause asset damage, interrupt service, or hold the Department back from accomplishing its NHS pavement and bridge programs and meeting its performance objectives and targets. It also presents the Department's ongoing efforts to measure, monitor, manage, and mitigate these risks while implementing and solidifying a shared risk management culture throughout the organization.

The chapter closes with a discussion of vulnerable assets that satisfies 23 CFR Part 667: *"Periodic Evaluation of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events."*

NHDOT's Enterprise Risk Management Approach

NHDOT's approach to enterprise risk management distinguishes between engineering risk and strategic risk:

- Engineering risks are managed by developing flexible and effective designs for projects to minimize risk of asset failure and service disruption while also minimizing cost. These risks are owned by the Department's engineering managers, who have the expertise to weigh design choices when developing project scope and documents.
- Strategic risks are managed by ensuring (a) that NHDOT is prioritizing investments in the areas that reflect the Department's tolerance for risk in different parts of the network (e.g., bridges vs. approaches); (b) that resources such as money, schedule, and internal and consultant workforce are available to address the Department's upcoming work program, given uncertainty around project demands in each of those areas; (c) that NHDOT minimizes the uncertainty around budget, schedule, and scope through strong coordination and communication, and (d) that a backlog of projects is maintained at-the-ready if a surplus of any of these resources exists. These risks are owned at the executive level, enabling communication and coordination of strategies across the Department. NHDOT manages strategic risk through several ongoing efforts, including mobility projects review meetings and the "on-shelf list" of projects.

In general, the NHDOT enterprise risk management approach is top-down, because the top levels of the Department have more tools to manage risk and a wider view.

[6] https://www.fhwa.dot.gov/asset/guidance/faqs.cfm.

Risk Register

NHDOT has developed a Risk Register that includes three types of risk:

- **Asset risks** involve damage to NHS pavement and bridges and can pose a direct danger to travelers. Examples include weather (extreme and routine), natural disasters, vehicle impacts, and damage from failure of co-located assets, such as drainage and utilities.
- **Program risks** impact NHDOT's ability to deliver projects and meet program performance objectives for NHS pavement and bridges. These include organizational and systemic inefficiencies, data and technical limitations, and cost variability of labor and materials.
- **Department risks** affect NHDOT's ability to perform its basic functions and serve its customers. These may include revenue and staffing/skills uncertainty.

The Department identified risks for inclusion in the TAMP through a collaborative workshop that included executive-level participants from across the Department. Following national best practice for risk registers, NHDOT has assigned each risk a risk score comprised of a likelihood score and five component consequence scores, all evaluated on a five-point scale by a panel of engineers and planners who work with NHS pavement and bridges daily (the scores were refined by AMPS in discussion with NHDOT executives).

The scoring rubric is provided in Exhibit 4.1. The overall risk score on a 0-100 scale was computed as:

$$Risk\ Score = 4 \times P \times [(S + C + G + M + F) / 5]$$

The higher the risk score, the more important NHDOT believes it is to mitigate the risk with a new or existing strategy. A risk register is provided in Exhibit 4.2, identifying NHDOT's strategies for mitigating the highest scoring risks, the team responsible for doing so, and NHDOT's monitoring approach and potential milestones.

Exhibit 4.1 Key for Likelihood and Consequence Components of Risk Score

SCORE	GUIDELINE
0.	In all categories: no impact or no likelihood
Likelihood (P)	
1.	Fewer than 1 instance over 10 years
2.	Approximately 1 instance over 10 years
3.	Approximately 2 instances over 10 years
4.	Approximately 5 instances over 10 years
5.	One or more instances per year
Public Safety (S)	
1.	Property damage only, no injuries possible
2.	Minor injuries possible
3.	Non-incapacitating injuries possible
4.	Incapacitating injuries possible
5.	Fatalities possible
Asset Condition (C)	
1.	No direct asset damage OR deferred maintenance accumulates over 1 year
2.	Minor repair OR deferred maintenance accumulates over 2 years
3.	Routine repair OR deferred maintenance accumulates over 5 years
4.	Major repair or closure OR deferred maintenance accumulates over 10 years
5.	Asset is unfit for service or destroyed OR deferred maintenance accumulates over >10 years
Geographic Scope (G)	
1.	Damage or reduction of funding affects a single asset
2.	Damage or reduction of funding affects several co-located assets
3.	Damage or reduction of funding affects several assets in a small area
4.	Damage or reduction of funding affects many assets on a corridor or in a large area
5.	Damage or reduction of funding affects many asset across a region
Mobility (M)	
1.	Situation affects a small number of travelers (neighborhood or town) for a short time (hours)
2.	Situation affects a small number of travelers for a moderate time (days-to-months)
3.	Situation affects a small number of travelers for a long time
4.	Situation affects a large number of travelers (multiple towns or a region) for a short time
5.	Situation affects a large number of travelers for a long time
Finance (F)	
1.	Lowers transportation network value by <1% OR costs <$1M per year
2.	Lowers transportation network value by 1-2% OR costs $1-10M per year
3.	Lowers transportation network value by 2-3% OR costs $10-25M per year
4.	Lowers transportation network value by 3-4% OR costs $25-50M per year
5.	Lowers transportation network value by >4% OR costs >$50M per year

Exhibit 4.2 NHDOT Risk Register for NHS Bridges and Pavement

LEVEL	RISK STATEMENT	ASSETS IMPACTED	SCORE (/100)
Asset	**Sea level rise contributes to more significant coastal flooding.**	NHS Bridges NHS Pavement	47.6
» Mitigation Actions: 1) Address site specific issues associated with projects, 2) Develop and apply the risk tolerance framework for coast flooding, 3) Proactively review infrastructure along the coast that is increasingly at-risk during different future timeframes and sea-level rise estimates.			
» Team Responsible: Project Managers, Project Review Committee, Climate Change Committee			
» Milestones/Monitoring Plan: 1) Coastal Risk Tolerance Framework completed, 2) Application of the framework for projects			
Asset	**Severe storm events damage assets on rivers and creeks.**	NHS Bridges NHS Pavement	45.4
» Mitigation Actions:1) Continue to assess and manage culverts, 2) Continue to monitor the impacts of storms via assessments and Part 667 evaluations.			
» Team Responsible: Culvert Management Committee			
» Milestones/Monitoring Plan: 1) Quarterly Part 667 reporting, 2) Culvert condition monitoring			
Asset	**Strikes by vehicles damage assets.**	NHS Bridges	36.3
» Mitigation Actions: 1) Continued over-sized / overweight application process, 2) Maintenance of clearance signs			
» Team Responsible: Highway Maintenance, Bridge Design, Bridge Maintenance			
» Milestones/Monitoring Plan: Performance monitoring of number of strikes			
Asset	**A large-scale traffic incident significantly disrupts travel.**	NHS Bridges NHS Pavement	35.7
» Mitigation Actions: 1) Management and coordination of response via Traffic Management Center			
» Team Responsible: Transportation Systems Management and Operations Bureau (TSMO)			
» Milestones/Monitoring Plan: Quarterly reporting by TSMO			
Program	**Shortfalls in funding for specific programs prevent full implementation.**	NHS Bridges NHS Pavement	41.5
» Mitigation Actions: 1) Communication about gaps in funding and effects of those gaps, 2) Be aware of flexibility across programs where applicable			
» Team Responsible: Commissioner's Office, AMPS Office, Program areas			
» Milestones/Monitoring Plan: Monitor program needs versus funding availability, most often communicated during TYP process.			
Program	**Staff departures result in loss of knowledge and skills.**	NHS Bridges NHS Pavement	39.2
» Mitigation Actions: 1) Program documentation, procedures, and policies within the Standard Operating System, 2) Retention and cross training.			
» Team Responsible: Program areas, Commissioner's Office			
» Milestones/Monitoring Plan: Workforce reporting, SOS reporting			
Program	**Instability in the price of labor impacts project costs.**	NHS Bridges NHS Pavement	38.3
» Mitigation Actions: 1) Monitor item prices (which include labor) and adjust estimates accordingly			
» Team Responsible: Project managers, AMPS			
» Milestones/Monitoring Plan: Construction cost index reporting, Estimate performance reporting			
Program	**An unexpected availability of resources is not met by on-shelf projects.**	NHS Bridges NHS Pavement	36.0

LEVEL	RISK STATEMENT	ASSETS IMPACTED	SCORE (/100)
» Mitigation Actions: 1) Ensure a robust list of on-shelf projects is maintained » Team Responsible: Commissioner's Office, Program areas » Milestones/Monitoring Plan: Quantity ($) of on-shelf project reporting			
Program	**Instability in the price of materials impacts project costs.**	NHS Bridges NHS Pavement	31.0
» Mitigation Actions: Monitor item prices (which include labor) and adjust estimates accordingly » Team Responsible: Project managers, AMPS » Milestones/Monitoring Plan: Construction cost index reporting, Estimate performance reporting			
Department	**NHDOT cannot hire necessary staff and skills.**	NHS Bridges NHS Pavement	39.2
» Mitigation Actions: 1) Develop and manage hiring channels, 2) Support programs at schools and colleges that educate and excite our future workforce, 3) Manage the portfolio of consulting contracts to meet Department needs. » Team Responsible: Human Resources, All managers » Milestones/Monitoring Plan: Outreach efforts			
Department	**NHDOT cannot provide competitive compensation to retain staff and skills.**	NHS Bridges NHS Pavement	38.4
» Mitigation Actions: 1) Leverage flexibility provided within contracts and advertise the benefits afforded to personnel, 2) Participate in wage studies and the contract negotiation process. » Team Responsible: Commissioners Office, Human Resources » Milestones/Monitoring Plan: Outreach efforts			
Department	**Expected Federal funding does not arrive to sustain NHDOT investment.**	NHS Bridges NHS Pavement	33.0
» Mitigation Actions: 1) Utilize flexibility of contracting authority and advance construction to address short-term delays, 2) Pursue other innovative financing options, e.g., TIFIA, GARVEE, to bridge gaps, 3) Manage the program to available funding and advocate for system needs. » Team Responsible: Bureau of Finance, Commissioner's Office » Milestones/Monitoring Plan: STIP, TYP			
Department	**Expected State funding does not arrive to sustain NHDOT investment.**	NHS Bridges NHS Pavement	32.2
» Mitigation Actions: 1) Manage the program to available funding and advocate for system needs, 2) manage innovative funding options such as bonds. » Team Responsible: Bureau of Finance, Commissioner's Office » Milestones/Monitoring Plan: STIP, TYP, Turnpike program			

Additional Efforts Supporting Risk Management

The Department has numerous established practices to manage risks at the asset, program, and department levels. Some key examples include:

1. **Bridge Inspection Program –** all bridges owned by the state and municipalities in NH are inspected every two years and those in poor condition are inspected more frequently. The inspection program is reviewed and certified regularly. Processes are in place to notify NHDOT personnel and municipalities quickly is any items of concern are identified. Inspection results are reviewed regularly and shared with municipalities annually. In addition to the routine inspection programs, bridges that are identified as being susceptible to scour have additional plans in place for monitoring and mitigation.

2. **Transportation Management Center –** as a focal point for communication, the TMC helps gather information from numerous devices, the public, department personnel, and state police related to crashes involving assets (bridges, guardrail, etc.), other emergency events, natural disasters, and general concerns. Practices are in place to ensure that pertinent information is quickly conveyed to appropriate personnel for review and action.

3. **On-Shelf Program –** a long standing practice at NHDOT is the identification of projects that could be advertised earlier than anticipated should additional funding become available or if other projects encounter delays. This approach helps to mitigate both a positive funding risk (additional funds) and filling any gaps in a program due to other project delays.

Resiliency

Included as part of the Department's approach to enterprise risk management are strategies and practices to help plan for and mitigate future impacts of extreme precipitation and sea level rise associated with climate change.

Coastal Flood Risks

For several years, NHDOT has coordinated with other state agencies on the development of projections relating to sea-level rise, precipitation, and storm surge in the coastal region. The most recent publication of those projections along with additional information are contained in the NH Coastal Flood Risk Summary (2020). The report recommends the consideration of greenhouse gas scenario representative concentration pathway 4.5 (RCP 4.5). Additional information in the report relates probabilities of differing amounts of sea level rise with risk tolerances over the years from 2030 to 2150.

The Department is in the process of developing a flood risk tolerance framework for coastal assets utilizing the information and guidance from the Coastal Flood Risk Summary. Steps in this process include: 1) reviewing the climate data and asset data, 2) determining the criticality of the transportation assets, and 3) assessing the vulnerability of and risk to those assets. The final critical aspect will be developing a guide for NHDOT engineers to consistently utilize the framework for future projects. This effort is expected to be completed in 2022 and involves NHDOT, other state agencies, and 2 coastal MPOs.

Current practices for considering flood risk to NHS assets in the coastal region is predominantly handled on a project-by-project basis. Throughout the project development process, engineers at NHDOT review data as well as input from planners, municipal staff, and the public. That information, including any pertaining to sea level rise, is incorporated into the project design. The most common approaches for enhancing resiliency in the coastal region has been raising elevations and reducing obstructions at bridges and culverts as part of rehabilitation and replacement projects.

Inland Flood Risks

Per the risk register (Exhibit 4.2), flooding due to severe storms is the second highest risk to assets. The Department has recently completed an inventory and inspection of all culverts along the NHS, identifying those that are

in poor condition. Partners at other agencies have worked to identify culverts in particular watersheds with various risk factors, including some that contribute to flooding vulnerability. The Culvert Management Committee at NHDOT reviews this information to create a risk-based priority list. In the most recent TYP, funding for programs that address culverts was increased. In addition to culverts, various bridge programs help ensure that the NHS is resilient to flooding, including the bridge inspection program and the bridge scour program.

Vulnerable Assets (Part 667)

NHDOT has conducted a study of assets damaged in declared emergencies between January 1, 1997 and December 31, 2021, pursuant to 23 CFR Part 667. Specifically, the Department has:

- Identified the location of infrastructure repairs associated with emergency events declared by the Governor or President since January 1, 1997.
- Maintained the inventory of locations with every new declared event.
- For any locations damaged more than once, identified the root cause of the vulnerability and developed a mitigation strategy. NHDOT must complete this step before developing any new projects in these locations.
- Incorporated the results of the evaluation into the project development process and the TAMP.

NHDOT maintains a GIS layer of transportation infrastructure damaged by emergency events that includes the date and description of the event; the type, location, description, and extent of infrastructure damage; NHS status of the infrastructure; and details on projects to repair the damage. NHDOT checks monthly to ensure that any new damage from emergency events did not occur at locations damaged by previous emergencies.

NH-9 in Roxbury is the only location to have been damaged in multiple emergencies since 1997. Approximately 1,200 feet north of Houghton Ledge Road, the location was damaged in both 2005 (DR-1610) and 2007 (DR-1695) when high flows in Otter Brook damaged the embankment and roadway. To resolve the recurring damage and in conjunction with other functional improvements at the site, NHDOT replaced the bridge, installed a riprap embankment, and significantly upgraded drainage in 2020.

5. FINANCIAL PLAN

Cost of Future Work

This section summarizes planned spending between 2022 and 2032 for NHS bridges and pavement in FHWA's four categories of work. The information is drawn from the TYP, which establishes NHDOT's asset investment strategy and is informed by the life cycle management systems and processes outlined in the prior chapters.

Exhibit 5.1 shows the 10-year trend in spending on NHS pavement.

Exhibit 5.1 NHS Pavement Spending by FHWA Work Type, 2022-2032 (millions)

WORK TYPE	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	AVG
Preservation	$21	$17	$19	$20	$19	$21	$21	$22	$20	$28	$28	**$22**
Maintenance	$5	$10	$13	$9	$14	$13	$18	$16	$17	$18	$14	**$13**
Rehabilitation	$10	$41	$12	$12	$11	$30	$7	$27	$27	$14	$6	**$18**
Reconstruction	$17	$42	$121	$22	$11	$59	$8	$3	$106	$0	$0	**$35**

Exhibit 5.2 shows the 10-year trend in spending on NHS bridges.

Exhibit 5.2 NHS Bridge Spending by FHWA Work Type, 2022-2032 (millions)

WORK TYPE	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	AVG
Preservation	$2	$11	$5	$4	$6	$6	$7	$8	$13	$10	$18	**$8**
Rehabilitation	$11	$10	$8	$17	$15	$38	$8	$22	$38	$32	$8	**$19**
Replacement	$0	$5	$0	$0	$0	$29	$21	$0	$10	$0	$0	**$6**

Future Funding Levels

Each TYP and STIP update requires NHDOT to consider forecasted funding scenarios for Federal Aid and State matching funds. NHDOT assigns revenues to two principal funds, the Highway Fund and the Turnpike Fund. Both funds accumulate three general types of revenue:

- **Unrestricted revenue** can be apportioned at the discretion of NHDOT with the approval of the New Hampshire Legislature to any operations or construction use at any location. In practice, it is used almost exclusively for operating costs. Unrestricted revenue is generated from the Road Toll, Fees and Sales, tolls, motor vehicle fines, and proceeds from the sale of property. The amount available to NHDOT is calculated by subtracting the following from the total revenue from these sources:
  - Revenue that is apportioned or transferred is either designated for a non-NHDOT use by statute or is used to pay the operating budget of a sister agency (i.e., the Department of Safety – DOS). A portion of the DOS operating budget is paid for through the Highway Fund.

  - Debt service from each fund is designated by the terms of the bond or loan.

Additional earmarks apply to some unrestricted funds. Of Road Toll and Fees and Sales, 12% is allocated to Municipal Aid and $0.026 is dedicated to the State Highway and Bridge Betterment Account. SB 367 required funds be allocated to State Aid Bridge and I-93 debt service.

- **Restricted revenue** that covers most construction and maintenance activities on NHDOT's highways and turnpikes. Federal Aid is the largest category of restricted revenue. Other restricted sources include revolving funds (i.e., those that take in funds from a program to fund that same program), private and local funds, interagency transfers, and agency income (e.g., from right-of-way property sales).
- **Bonds** are issued with the authority of the State Legislature. They are restricted but accounted for separately.

Once apportionments, transfers, and debt service are subtracted, the majority of the Highway Fund that is available to NHDOT is from restricted sources. As toll revenue is unrestricted, a much larger share of revenue in the Turnpike Fund is unrestricted as compared to the Highway Fund.

Funding Levels for Federal Aid

The 10-year trend in Federal Aid is estimated based on assessment of the 2021 Bipartisan Infrastructure Law (BIL). As matching funds for projects are not projected to be available throughout the TYP, NHDOT will continue to use toll credits. This method applies tolling revenue from turnpikes in place of State matching funds for Federal projects and effectively reduces the number of projects that can be funded with Federal Aid. A portion of indirect costs for Administration are reimbursed from Federal Aid.

Funding Levels for State Funds

State funds include several revenue sources collected by the New Hampshire Department of Safety (DOS), which forecasts them as described below:

- **State Road Toll (gas tax) |** New Hampshire collects $0.222 per gallon of fuel, which can only be modified by an act of the State Legislature. DOS projects traffic volume and the price of gasoline over 10 and 20-year study periods to estimate future Road Toll proceeds.
- **Fees and Sales |** This category includes motor vehicle registration fees and proceeds from the sale of NHDOT and DOS equipment and vehicles. As with the Road Toll, the size of each fee is determined through legislative action. DOS estimates this revenue to be relatively stable over time.

The NHDOT Bureau of Turnpikes collects tolls on New Hampshire's three turnpikes and uses this revenue to construct, operate, maintain, and administrate the turnpike system. Changes to toll rates are subject to approval by the Governor and Executive Council. The Department conducted a comprehensive 10-year forecast for toll revenue in 2021 covering fiscal years through 2030. The toll revenue forecast was developed by analyzing historical traffic and revenue data to determine historical trends; by correlating traffic with key economic indicators; and by researching demographic data and other factors that affect traffic volumes. The study also included the use of

a financial model to estimate net revenues, operating costs, debt service requirements, and bond coverage ratios and cash reserves for the Turnpike System, concluding that sufficient revenues will be generated to fund the proposed capital plan, meet the State's bond resolution minimum debt service coverage, and meet the Turnpike's internal minimum requirements through 2030.

Development of the TYP

The TYP is updated every two years, serves as the basis for the vast majority of the capital investments in New Hampshire, and is required by State law.

The TYP is developed through a continuous, coordinated planning process that is grounded in input from regional planning councils (RPCs) and MPOs. MPOs identify projects for TYP consideration in their long-range plans (LRPs) through a process that includes public outreach. NHDOT considers the RPC and MPO project lists with statewide system needs including preservation, congestion, and safety to develop a draft TYP. The draft is reviewed at public hearings around the state and by the Governor's Advisory Commission on Intermodal Transportation (GACIT). After the GACIT review, the TYP is considered by the Governor and the Legislature before being proposed as a State law and signed by the Governor.

NHDOT's top-line takeaways from the 2023-2032 TYP were that:

- The plan is similar to previous plans.
  - It is fiscally-constrained.
  - It includes increases in the federal program associated with the IIJA and continuous level funding thereafter.
  - It continues to prioritize investing in preservation of the existing road and bridge network.
  - It continues to address bridges in poor condition.
- The condition of roads in New Hampshire that would improve remain consistent in the short term and then gradually decline.
- The number of bridges in poor condition would continue to decrease.
- The plan presents some risks/challenges:
  - Condition of assets may begin to degrade in the last years of the plan due to SB367 road and bridge funding ending in 2025 and because of inflation.
  - Limited funding is available for non-highway modes.

Development of the STIP

The STIP is required by Federal law for most projects receiving Federal Aid from both FHWA and the Federal Transit Administration (FTA) as well as for any projects considered regionally significant. The STIP is updated every two years following the TYP update through a collaborative process between NHDOT and MPOs.

Programs and projects identified in the STIP are selected to meet performance targets. Programs for the preservation and maintenance of NHS pavements and bridges are detailed in the STIP alongside the Highway Safety Improvement Program (HSIP), the Congestion Management and Air Quality Program (CMAQ), the National Highway Performance Program (NHPP) and other that support NHDOT's attainment of its performance targets and align with FHWA national goals.

Projects and programs for the locally-managed portions of the NHS include:

- **Bridge Aid Program |** Application-based program to provide up to 80% of funding for projects on locally-managed bridges.
- **Local Public Agency (LPA) programs |** Portions of several funding sources from FHWA, such as the Transportation Alternatives Program (TAP), are made available to municipalities for transportation investments.
- **Highway Block Grant Aid |** Distributed by the State to every municipality, based predominantly on mileage of locally-managed public roads.
- Municipalities may adopt an **additional vehicle registration fee** (up to $5) and this may only be used for transportation improvements.

2021-2030 TYP Balance Sheet for Highway

Exhibit 5.3 shows the balance sheet in the 2023-2032 TYP by fiscal year and funding category for categories associated with highway and bridge.

Exhibit 5.3 TYP Budget (millions) for Highway and Bridge Categories, 2023-2032

FISCAL YEAR	HIGHWAY FUND							TURNPIKE FUND			
			SB367								
	FHWA	BETTERMENT	SAB	I-93 DEBT SERVICE	TIFIA PLEDGED PAVING AND BRIDGE	OTHER MATCHING FUNDS	**HIGHWAY SUBTOTAL**	TURNPIKE IMPROVEMENT	TURNPIKE REHAB AND REPLACEMENT	TURNPIKE SUBTOTAL	**TOTAL**
2023	$299	$21	$18	$2	$25	$24	**$388**	$43	$19	$62	**$450**
2024	$298	$21	$9	$2	$21	$2	**$353**	$48	$14	$62	**$415**
2025	$291	$20	$9	$2	$14	$6	**$342**	$54	$15	$69	**$411**
2026	$286	$20	$6	$23	$0	$3	**$338**	$34	$16	$50	**$388**
2027	$292	$20	$6	$23	$0	<$1	**$341**	$39	$16	$55	**$396**
2028	$245	$20	$5	$23	$0	$2	**$295**	$52	$15	$67	**$362**
2029	$246	$20	$5	$23	$0	$5	**$299**	$44	$15	$59	**$358**
2030	$247	$19	$5	$23	$0	<$1	**$294**	$58	$15	$73	**$367**
2031	$244	$19	$4	$23	$0	<$1	**$291**	$71	$15	$86	**$377**
2032	$244	$19	$4	$23	$0	<$1	**$291**	$55	$16	$71	**$362**
Total	$2,690	$199	$71	$170	$60	$42	**$3,233**	$489	$154	$643	**$3,876**
Revenue	$2,711	$199	$301	$42	$3,354	$489	**$154**	$643	$3,997		
Surplus/ (Deficit)	$21	$0	$0	$0	$21	$0	**$0**	$0	$21		

Source: NHDOT 2023-2032 Ten Year Plan.

Asset Valuation

NHDOT values its NHS pavement and bridge assets using a method that incorporates asset condition. By doing so, NHDOT can use asset value as a driving performance measure for investment decisions. These valuations can also be a tool to evaluate the effectiveness of future investment scenarios and condition forecasts. Further, valuation conveys the significance of the transportation system to the public and decision-makers in easy-to-understand dollar terms.

Valuation of NHS Pavement

NHDOT values its pavements in three component layers: Surface, Structure, and Base. Not every road segment is comprised of all three layers – roads that have a Poor Quality of Foundation have no structure. Valuation of each layer is handled as follows (all values vary by highway tier):

1. **Surface |** The as-new value of the surface layer was determined using the FHWA Pavement Condition Measure Calculation (Exhibit 2.2) as collected in 2020. The cost per square yard of preservation treatment, the area of the segment of pavement, and the functional system types were also used in the surface valuation calculation with the formulas as seen below:

   a. Interstate

      I. Segment Condition = Good – (Area of Segment (sq yd)) x $11

      II. Segment Condition = Fair – (Area of Segment (sq yd)) x $11 x Condition Factor of 0.75

      III. Segment Condition = Poor – (Area of Segment (sq yd)) x $11 x Condition Factor of 0.25

   b. Non-Interstate

      I. Segment Condition = Good – (Area of Segment (sq yd)) x $10

      II. Segment Condition = Fair – (Area of Segment (sq yd)) x $10 x Condition Factor of 0.75

      III. Segment Condition = Poor – (Area of Segment (sq yd)) x $10 x Condition Factor of 0.25

2. **Structure |** The value of the structure layer is calculated similarly to the surface calculation but consists of utilizing different condition factors and the difference in cost between a rehabilitation and preservation treatment for the pavement segment. Also, the Quality of Foundation for the segment was used to determine the formulas used rather than the collected condition. The formulas used are as follows:

   a. Interstate

      I. Segment Condition = Good – (Area of Segment (sq yd)) x ($48 - $11)

   b. Non-Interstate

      I. Segment Condition = Good – (Area of Segment (sq yd)) x ($30 - $10)

      II. Segment Condition = Composite – (Area of Seg (sq yd)) x ($30 - $10) x Condition Factor of 0.50

      III. Segment Condition = Poor – no value

3. **Base |** The value of the base layer is calculated in the same methodology as the structure layer, relying on the Quality of Foundation to determine which formulas used in the calculations of segment and utilize different condition factors and the difference between reconstruction and rehabilitation for the pavement segment. The formulas used are as follows:

   a. Interstate

      I. Segment Condition = Good – (Area of Segment (sq yd)) x ($280 - $48)

   b. Non-Interstate

      I. Segment Condition = Good – (Area of Segment (sq yd)) x ($206 - $30)

      II. Segment Condition = Composite – (Area of Seg (sq yd)) x ($206 - $30) x Condition Factor of 0.85

      III. Segment Condition = Poor – (Area of Segment (sq yd)) x ($206 - $30) x Condition Factor of 0.75

The total value of NHS roads in New Hampshire is $8.1 billion dollars by this method.

Valuation of NHS Bridges

Every bridge on the New Hampshire highway network has value to users measured in time, money, and convenience. This methodology is used to summarize the value of the bridge network to the State of New Hampshire. It uses the following data:

» Expected costs for projects advertised by NHDOT in recent years2022.

» NBI bridge ratings by component derived from NHDOT bridge inspections.

A bridge's current value (CV) reflects its replacement value, its sufficiency rating, and its age relative to service life, computed as:

$$CV = RV \times (Sufficiency\ Rating) / 100 \times [1\text{-}0.25\ ((Year\ Today\text{-}Year\ Built) / 120)]$$

These terms are defined in the sections below.

Replacement Value

Replacement value is defined as the cost to fully replace the bridge or superstructure and is computed as:

$$RV = Deck\ Area \times Unit\ Cost$$

Unit cost was derived from a review of project estimates for 30 structures of different types. The estimates included all costs associated with the structures. Exhibit 5.4 shows the unit replacement costs.

Exhibit 5.4 Unit Replacement Costs for Bridges by Material

MATERIAL	REPLACEMENT COST ($/FT^2)
Culvert	$3,100
Girder	$1,000
Moveable	$1,400
Timber	$500
Truss	$725

Sufficiency Rating

Sufficiency Rating is the sum of the following values. It ranges from zero to 100.

S1 – Structural Condition | Value from 0-55 that represents the condition of the superstructure, substructure, or culvert as applicable as recorded in NBI Items 59, 60, and 62, as well as the load rating of the bridge as recorded in NBI Item 66.

S2 – Quality of Service | Value from 0-30 that represents the condition of the deck as recorded in NBI Item 58; the structural evaluation (relating bridge condition to traffic served) as recorded in NBI Item 67; the deck geometry, vertical clearances, load posting, waterway adequacy, and approach alignment as recorded in NBI Items 53 and 68-72; relationship between bridge width and approach width using NBI Items 32 and 51; and lane width using NBI Items 28 and 51.

S3 – Detour Length | Value from 0-15 that reflects the detour length as recorded in NBI Item 19.

S4 – Negative Modifiers | A negative value from 0-13 that modifies the total of the other components in response to detour length as recorded in NBI Item 19; the structure type as recorded in NBI Item 43B; and the absence of safety devices as recorded in NBI Item 36.

Age of Structure

NHDOT assumes that a brand new bridge has complete functionality and that a 120-year-old bridge has 75% of its original functionality, regardless of the bridge's observed condition. This assumption reflects obsolescence – advances in bridge technology over such a period render it inherently less functional. NHDOT further assumes that this degradation due to obsolescence occurs linearly – at a steady rate – over the 120-year period.

Results

By this methodology, New Hampshire's bridges have a current value of $5.9 billion and a replacement value of $7.4 billion. This valuation includes 726 bridges that carry an NHS roadway. The results of the analysis are summarized in Exhibit 5.5.

Exhibit 5.5 Valuation for NHS Bridges by Structural Type

	COUNT	DECK AREA	% DECK AREA	REPLACEMENT VALUE	AVERAGE AGE (YEARS)	CURRENT VALUE
Total	726	7,362,350	100%	$7,439,197,044	49.1	$5,871,968,592
Culvert	67	46,717	1%	$144,821,522	57.0	$109,033,993
Girder	647	6,882,499	93%	$6,882,498,740	47.9	$5,471,523,945
Moveable	2	144,969	2%	$202,956,838	53.0	$167,630,366
Timber	0	0	0%	$0	0.0	$0
Truss	10	288,165	4%	$208,919,944	74.2	$123,780,288

APPENDIX A: GLOSSARY OF TERMS

Exhibit A.1 Definitions of Common Terminology

AAFS	Asset Analytics and Forecasting System | NHDOT's name for dTIMS and other related systems, visualizations, and analytics.
BIL	Bipartisan Infrastructure Law (also the IIJA)
CFR	Code of Federal Regulations | A codification of the general and permanent rules published in the Federal Register by the Executive departments and agencies of the Federal Government, based on an interpretation of the U.S. Code.
dTIMS	Deighton Total Infrastructure Management System
FHWA	Federal Highway Administration
GACIT	Governor's Advisory Commission on Intermodal Transportation | Consisting of the five Executive Councilors in NH and the Commissioner of NHDOT, the Commission advises the Governor on transportation topics.
GARVEE	Grant Anticipation Revenue Vehicle | Bonds or other financing that will be repaid using expected future federal funding
IIJA	Infrastructure Investment and Jobs Act (also the BIL)
MPO	Metropolitan Planning Organization | There are 4 MPOs in NH: Nashua Regional Planning Commission, Rockingham Planning Commission, Southern NH Planning Commission, and Strafford Regional Planning Commission.
SB 367	Senate Bill 367 | Legislation in NH that primarily increased the road toll (gas tax) by 4.2 cents per gallon to support bond payments for the I-93 Improvement project.
STIP	State Transportation Improvement Program | A 4-year document that is updated biennially and combines the products of 4 TIPs and the TYP into a statewide fiscally constrained list of Federally aided or regionally significant projects.
TIFIA	Transportation Infrastructure Finance and Innovation Act | Credit assistance for qualifying projects from the US Department of Transportation.
TIP	(Regional) Transportation Improvement Program | A program of projects that is financially constrained and managed by an MPO. The 4 MPOs in NH produce TIPs that are integrated into the STIP.
TYP	Ten Year Transportation Improvement Plan | A 10-year program of all transportation projects, updated biennially, approved by GACIT, the Legislature, and signed into law by the Governor, most recently for 2023-2032.

APPENDIX B: PAVEMENT CONDITION FORECAST MODEL METHODOLOGY

B.1 Background

NHDOT has divided its implementation of a new Pavement Management System (PMS) into two phases – Phase 1 is for NHS roadways and is relevant to the TAMP while Phase 2 extends to all NHDOT-owned roadways. Phase 1 is intended to satisfy FHWA rules, while Phase 2 is for the general benefit of the traveling public in New Hampshire. NHDOT uses two types of pavement models:

- Performance models that predict pavement surface condition over time (also referred to in general parlance as deterioration models).
- Treatment consequence models that predict the immediate change in pavement surface condition as a consequence of applying a specific treatment.

Relating these models to each other are decision trees that predict when and what type of treatment to apply to each pavement section at a given point in time based on surface condition and pavement attributes. The entire NHS in New Hampshire is surfaced with asphalt pavement, the performance of which is measured using three distresses. Roughness, expressed using International Roughness Index (IRI), cracking, and rutting are all measured using fully-automated sensors.

This appendix focuses on NHDOT's current modeling infrastructure as applied for the TAMP. The Department is in the process of implementing improved models, discussed in Chapter 2.

B.2 Pavement Model Inputs

B.2.1 Pavement 2021 Snapshot

The first and foundational input to NHDOT's pavement models is the "Pavement Snapshot": the condition data collected on pavement in the prior year. For the TAMP, the models used the 2021 Pavement Snapshot, consisting of data collected in Calendar Year 2020.

B.2.2 Roads Inventory Snapshot

NHDOT's road inventory is based on a linear referencing system (LRS) defined at the beginning of Calendar Year 2021. An LRS is the mileposts on the roadway network and can be used to crosswalk and geolocate assets across NHDOT's systems – in essence it serves as geographic coordinates relative to highways.

B.2.3 Pavement Analysis Sections and Families

While pavement condition data is collected in short segments, the network was simplified for modeling. Longer sections were created by combining strings of adjacent segments. Component distresses (IRI, rutting, and cracking percentage) were averaged, weighted by length. Generally speaking, the analysis sections were defined between pavement joints on a historic roadway project.

The sections were further sorted into families for deterioration modeling based on three criteria:

- **Quality-of-foundation |** Sections whose foundation is in good or poor condition or has composite base materials (i.e., concrete under asphalt).
- **Tier |** Sections on a particular tier of highway as defined by NHDOT.
- **NHS |** Sections on or off of the NHS.

The deterioration model used five families, as illustrated in Exhibit B.1.

Exhibit B.1 Pavement Modeling Families

FAMILY	DESCRIPTION	SECTIONS	CENTERLINE-MILES
Totals	Totals	468	1,246.4
A_1_NHS	Good foundation; Tier 1; NHS	176	617.7
A_2_NHS	Good foundation; Tier 2; NHS	199	464.9
A_0_NHS	Good foundation; Tier 3-5; NHS	60	81.9
C_NHS	Composite foundation; any tier; NHS	11	30.0
P_NHS	Poor foundation; any tier; NHS	22	51.9

B.2.4 Pavement Unit Costs

Pavement unit costs were calculated per square yard using proposed contract item costs for 2016-2020. These were increased by 20% to simulate Construction Engineering (CE) and indirect costs. The items included: resurfacing; restoration and rehabilitation; reconstruction added capacity; reconstruction no added capacity; new construction; and relocation. The unit costs are provided in Exhibit B.2.

Exhibit B.2 Pavement Modeling Families

WORK TYPE	TIER 1	ALL OTHER TIERS
Preservation	$11 per square yard	$14 per square yard
Maintenance		$10 per square yard
Rehabilitation	$48 per square yard	$30 per square yard
Reconstruction		$206 per square yard

B.3 Pavement Models

B.3.1 Pavement Deterioration Curves

The model used deterioration curves to predict both component distresses and indexed performance measures of analysis sections. Each combination of family and distress was represented by a curve, the equation for which is presented in Exhibit B.3.

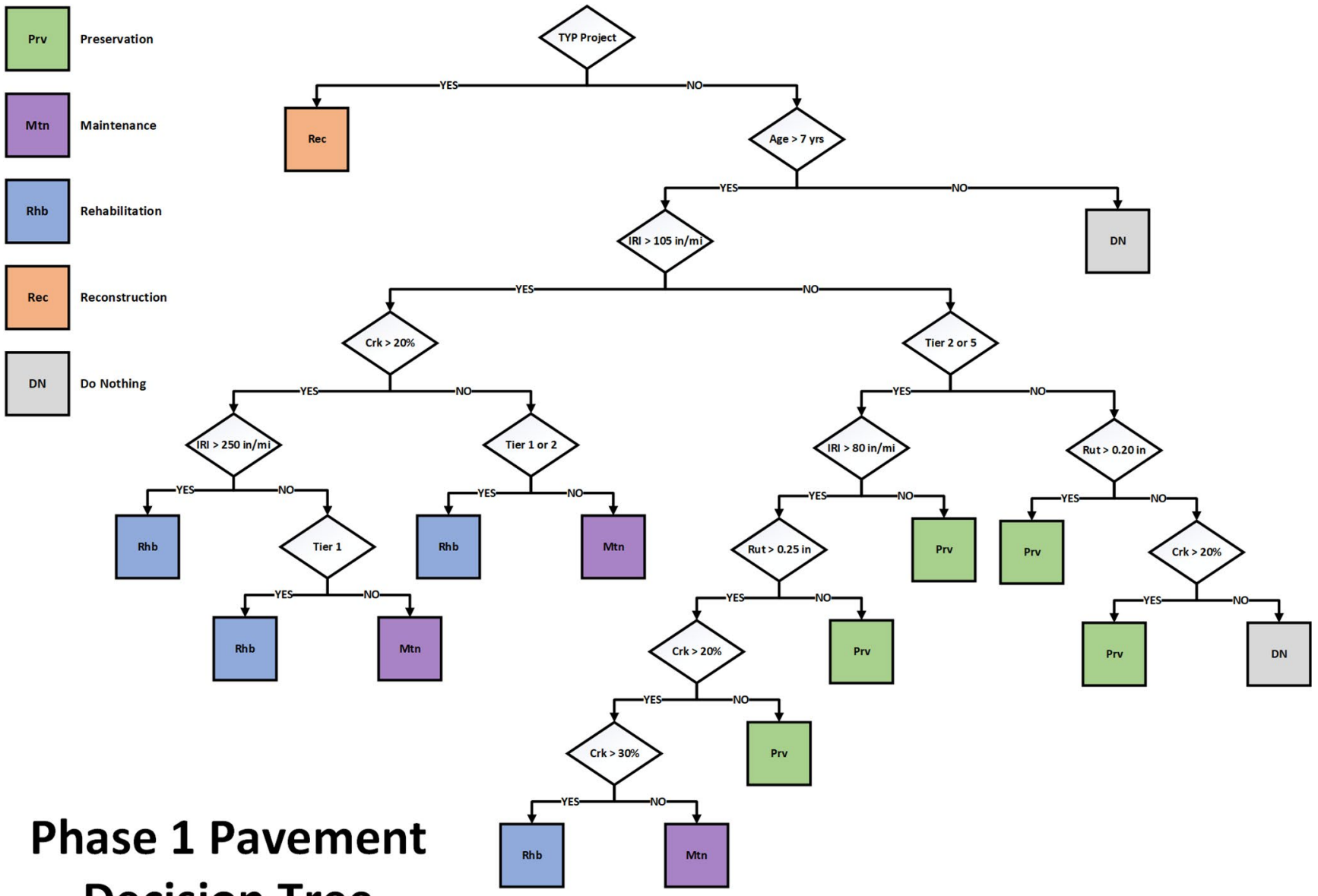
Exhibit B.3 Pavement Modeling Families

FAMILY	DESCRIPTION	EQUATION
A_1_NHS_CRK	Good foundation; Tier 1; NHS, cracking %	0.2578x^2 + 0.2348x + 0.0451
A_1_NHS_IRI	Good foundation; Tier 1; NHS, IRI	0.133x^2 + 0.7567x + 30.38
A_1_NHS_RUT	Good foundation; Tier 1; NHS, rutting	-0.0004x^2 + 0.0182x + 0.0972
A-2_NHS_CRK	Good foundation; Tier 2; NHS, cracking %	0.2876x^2 + -0.014x + -0.1995
A_2_NHS_IRI	Good foundation; Tier 2; NHS, IRI	0.5273x^2 + 1.2559x + 56.074
A_2_NHS_RUT	Good foundation; Tier 2; NHS, rutting	0.00099x^2 + 0.00883x + 0.03224
A-O_NHS_CRK	Good foundation; Tier 3-5; NHS, cracking %	0.2876x^2 + -0.014x + -0.1995
A_O_NHS_IRI	Good foundation; Tier 3-5; NHS, IRI	0.5273x^2 + 1.2559x + 56.074
A_O_NHS_RUT	Good foundation; Tier 3-5; NHS, rutting	0.00099x^2 + 0.00883x + 0.03224
C_NHS_CRK	Composite foundation; any tier; NHS, cracking %	-0.016x^2 + 3.8403x + 0
C_NHS_IRI	Composite foundation; any tier; NHS, IRI	0.2712x^2 + 9.6943x + 44.601
C_NHS_RUT	Composite foundation; any tier; NHS, rutting	0.00084x^2 + 0.01013x + 0.00438
P_NHS_CRK	Poor foundation; any tier; NHS, cracking %	0.0114x^2 + 3.5051x + 0
P_NHS_IRI	Poor foundation; any tier; NHS, IRI	0.3445x^2 + 8.86x + 54.246
P_NHS_RUT	Poor foundation; any tier; NHS, rutting	0.00005x^2 + 0.02821x + 0.01043

B.3.2 Pavement Decision Tree

Decision trees crosswalk deterioration and treatments. For this model, NHDOT created a decision tree that reflected the expertise and professional experience of the Department's subject matter experts (SMEs). NHDOT's decision tree for pavement is provided on the next page as Exhibit B.4. As discussed above, "Phase 1" indicates that this decision tree is for NHS pavements.

Exhibit B.4 Pavement Decision Tree for NHS Pavement

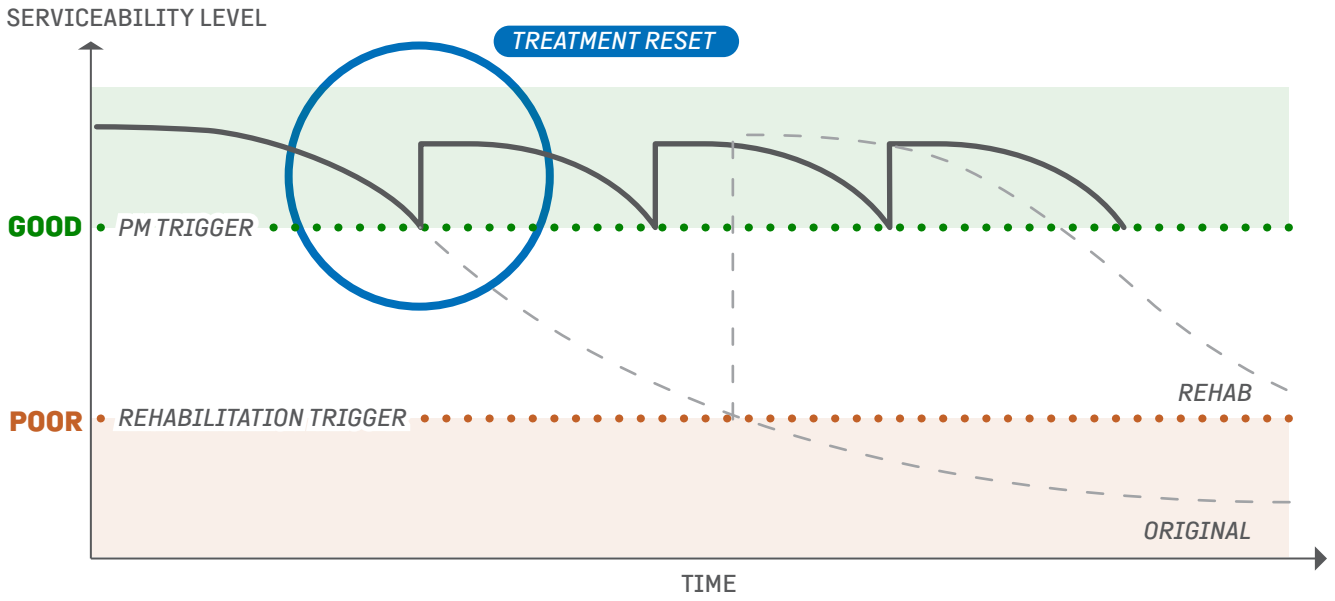


Phase 1 Pavement Decision Tree

B.3.3 Pavement Treatment Resets

When a treatment was applied to an analysis section within the model, a treatment reset was applied to IRI, rutting, and cracking percentage before deterioration continued, as illustrated in Exhibit B.5.

Exhibit B.5 Visualization of Deterioration/Construction vs. Life Cycle Planning



Treatment resets were specific to work type and component distress and are provided in Exhibit B.6.

Exhibit B.6 Pavement Modeling Families

WORK TYPE	ROUGHNESS	RUTTING	CRACKING
Preservation	Roughness improves approximately 25% and then deteriorates normally	Rutting improves approximately 40% and then deteriorates normally	Cracking reset to 0 and then deteriorates normally
Maintenance	Roughness improves approximately 50% and then deteriorates normally	Rutting improves approximately 65% and then deteriorates normally	Cracking improves 75% and then deteriorates normally
Rehabilitation	Reset to 50 and then deteriorates normally	Rutting resets to 0 and then deteriorates normally	Cracking reset to 0 and then deteriorates normally
Reconstruction	Reset to 50 and then deteriorates normally	Rutting resets to 0 and then deteriorates normally	Cracking reset to 0 and then deteriorates normally

B.3.4 Pavement Budgets

Pavement budgets were generated for the model using the 2023-2032 Ten Year Plan (TYP). Committed projects located along the NHS were identified and placed within the model at the year and cost listed in the TYP. Paving program amounts were the average of the TYP period.

APPENDIX C: BRIDGE CONDITION FORECAST MODEL METHODOLOGY

C.1 Background

NHDOT uses the AASHTOWare Bridge Management software (BrM) to store and manage bridge management data, and the Deighton Total Infrastructure Management System software (dTIMS) to conduct bridge investment analysis. The investment analysis run by dTIMS applies deterioration models using the data stored in BrM.

The deterioration models developed by NHDOT and currently applied in dTIMS predict the condition of bridge components (i.e., deck, superstructure, substructure, and culvert) as a function of the component age. These models were developed based on linear regression analysis of component condition data. Bridges are classified, for modelling purposes, by structural type and traffic volume. The deterioration rates of each of the bridge families were grouped into fast, medium, and slow deterioration bridges. Currently, only the models for slow-deteriorating components are implemented.

Although using deterministic models in the prediction of bridge performance has the advantage of simplicity and practicality at the network level, these models are not capable of considering uncertainty due to the inherently probabilistic nature of infrastructure. Bridge component ratings do not provide enough information to enable the selection of appropriate maintenance and preservation actions, nor do they provide enough information on the extent of deterioration for cost estimation. NHDOT is currently in the process of developing stochastic element-level deterioration models. This appendix, however, describes the deterministic, component-level models used in 2022.

C.2 Bridge Model Inputs

C.2.1 Bridge Inventory

NHDOT only modeled the condition of bridges that meet the Federal definition of 20 feet or greater span. In the Annual Bridge Condition Snapshot, this is represented by the field “FED_DEF” being “Y”. The NHS status of bridges in the Snapshot is represented by the field “NHS_IND” being equal to 1. For budgetary purposes, bridges were sorted by owner – the “Owner_” and “Owner_Detail” fields in the Snapshot corresponding to:

- NHDOT ownership when “Owner_” is “State” and “Owner_Detail” <> 31.
- Bureau of Turnpikes ownership when “Owner_Detail” = 31.
- Municipal ownership when “Owner_” has any value other than “State”.

For modelling, bridges were further sorted into families based on:

- **Structure class |** Bridges were generalized into girder, truss, timber, moveable, and culvert.
- **AADT |** Annual Average Daily Traffic, the total volume over a year divided by 365 days.

A summary of bridge families is provided in Exhibit C.1.

Exhibit C.1 Bridge Modeling Families by Number of Bridges

STRUCTURE CLASS	TOTAL	AADT < 20,000	AADT > 20,000
TOTAL	**726**	**500**	**226**
Culvert	**136**	105	31
Girder	**584**	391	193
Moveable	**2**	2	0
Truss	**4**	2	2

C.2.2 Bridge Unit Costs

Bridge unit costs were calculated based on five years of bid item data in the NHDOT "IPD" database. These were increased by 20% to simulate Construction Engineering (CE) and indirect costs. Projects identify unit costs from the field "ASSET_TYPE", which can be filtered on the additional field "BRIDGE_ASSET_TYPE". The unit costs listed included pavement and drainage costs directly related to a bridge, but excluded larger drainage networks and pavement projects. In general, the analysis excluded painting, scour, and pavement projects.

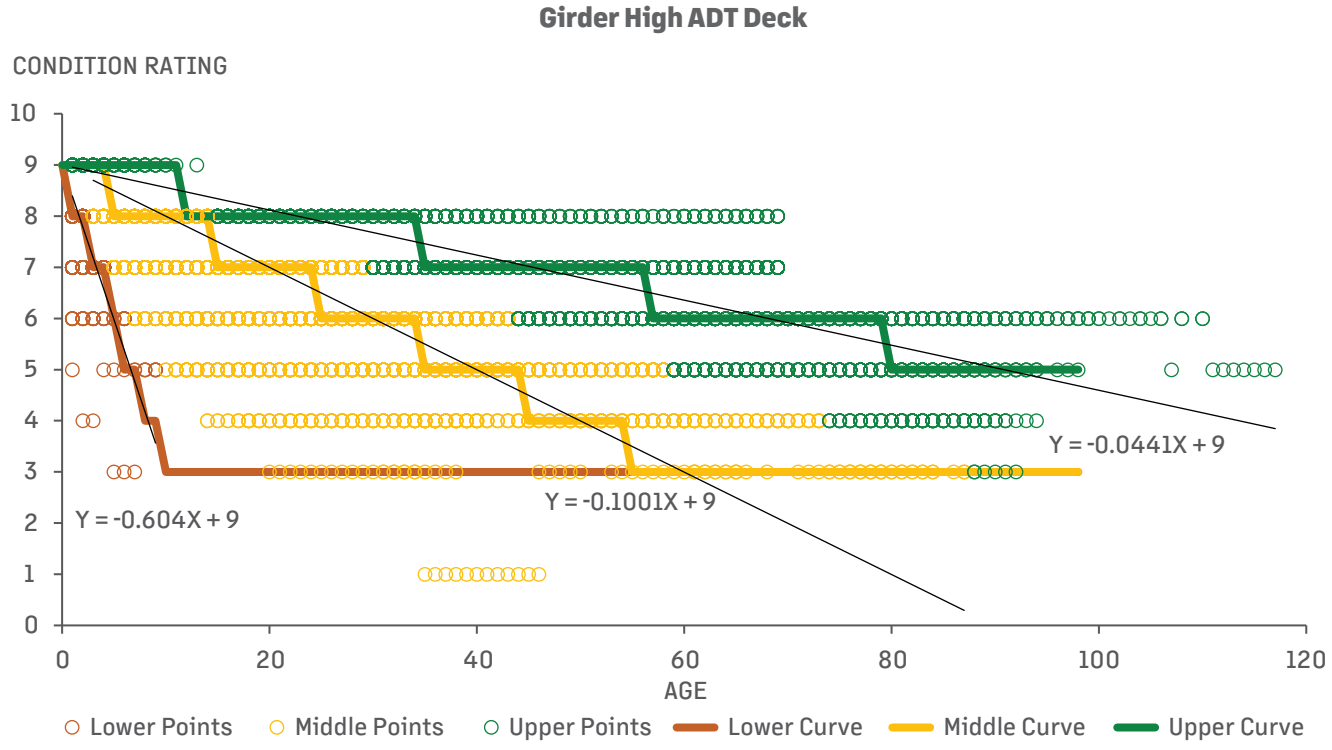
Truss bridges did not have enough historic data to adequately generate unit costs. As such, additional projects were added to the analysis from the NHDOT ProMIS Database (which contains all of NHDOT's project details and estimates). ProMIS includes CE, so only a 10% increase was applied for indirect costs.

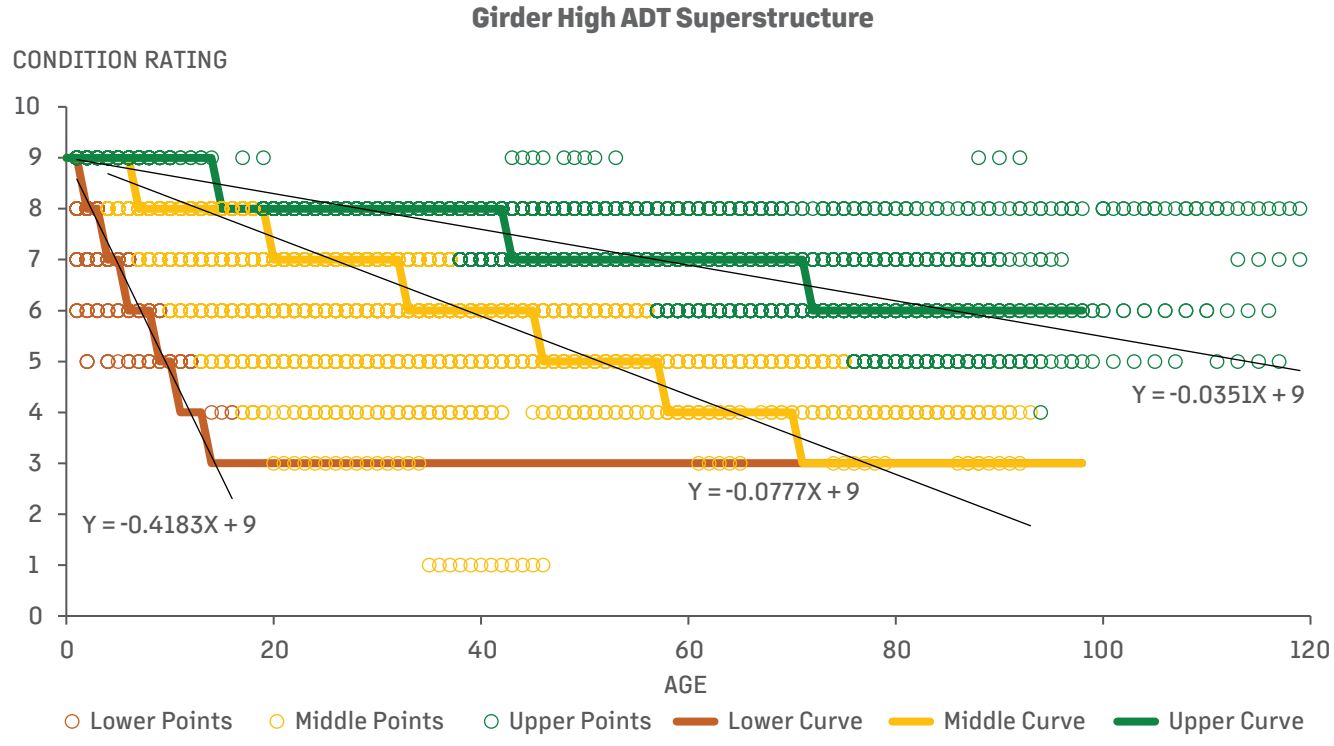
C.3 Bridge Models

C.3.1 Bridge Deterioration Curves

Deterioration curves were developed using linear regression of component condition against component age (based on the time constructed or last reconstructed) on the other. These dates were derived from inspection data (i.e., replacement at a sudden jump in observed condition); activity logs; or (as a last resort) the "YEAR-BUILT" and "YEARRECON" fields from the bridge inventory table. NHDOT split the model into three groups based on percentile deterioration rate: the fastest 5% were classed as "Fast", the next 45% were classed as "Middle"; and the remaining 50% were classed as "Slow". The "Slow" deterioration model, representing the plurality of the data, was the only one used in the actual forecast. The models are illustrated by component family in Exhibit C.2 on the following pages.

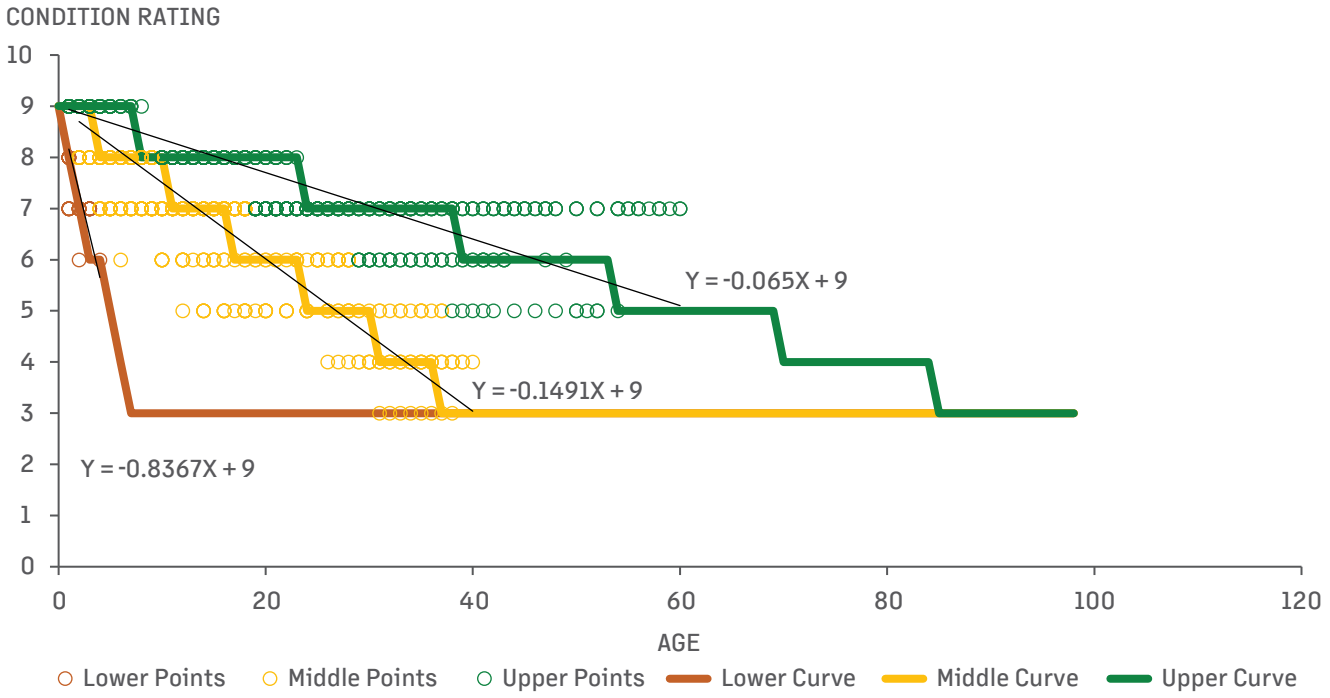
Exhibit C.2 Bridge Deterioration Models by Component Family



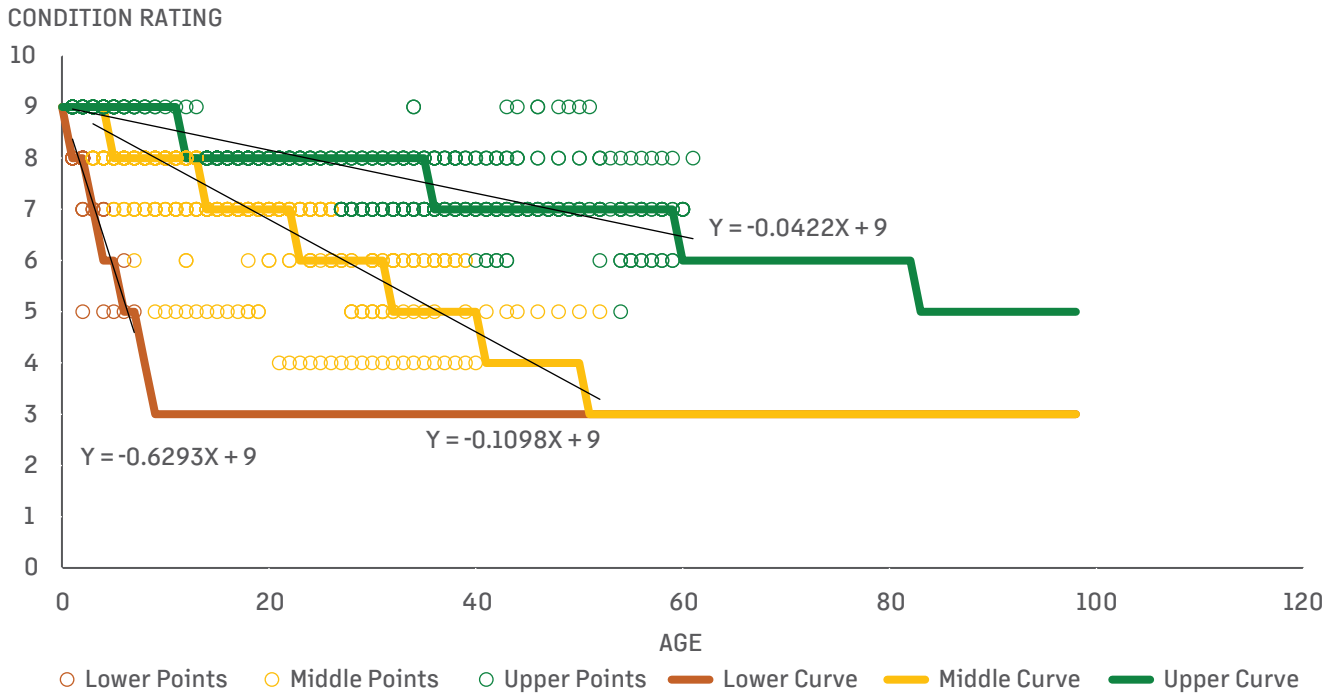


Girder High ADT Substructure

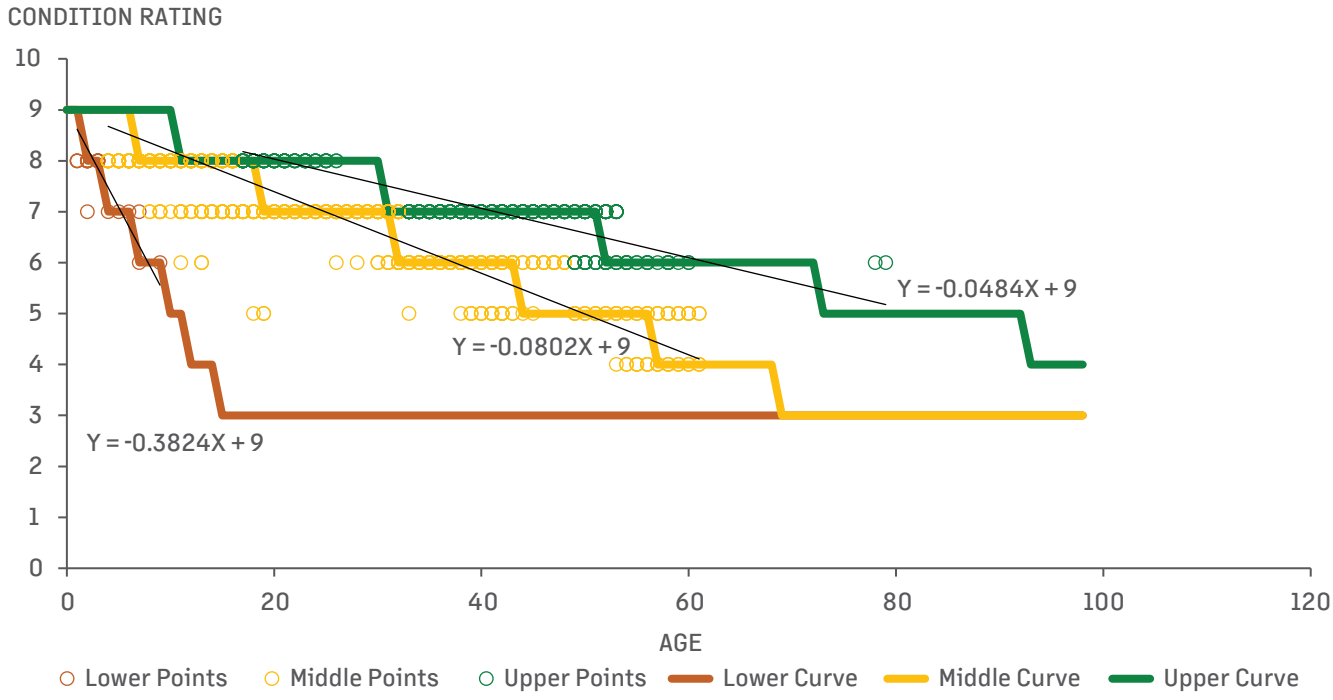
Girder Very High ADT Deck



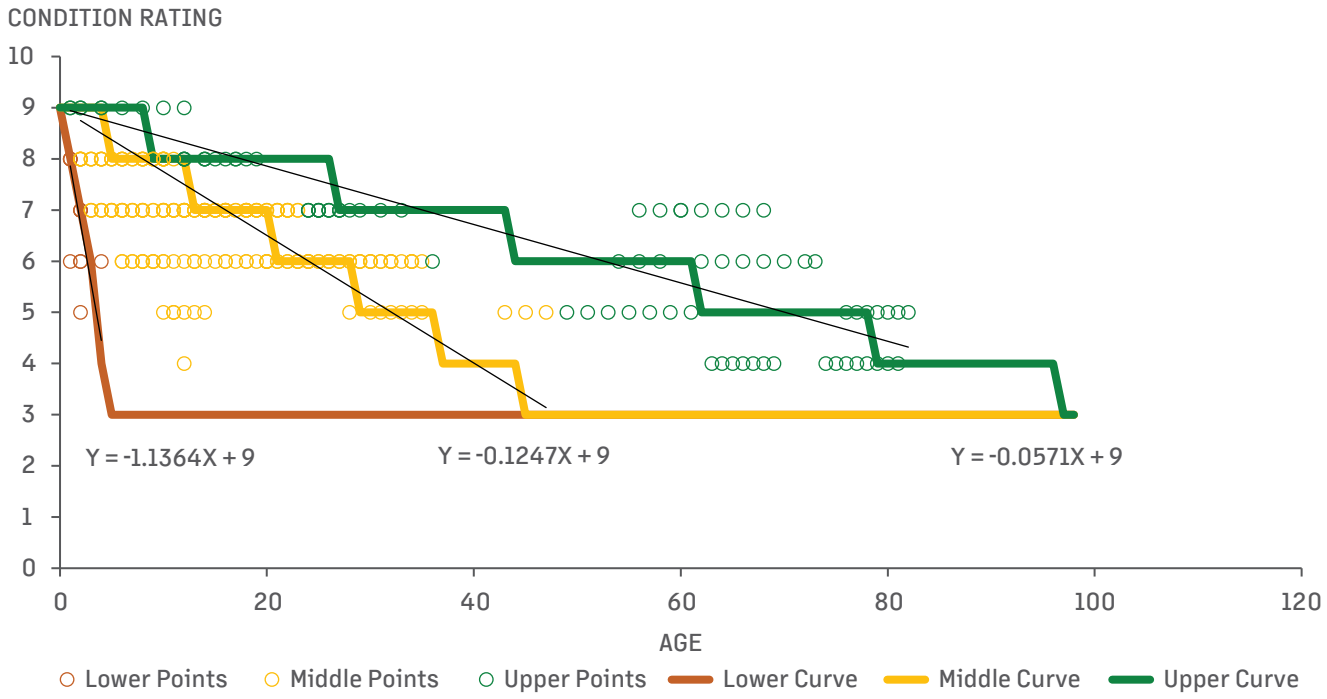
Girder Very High ADT Superstructure



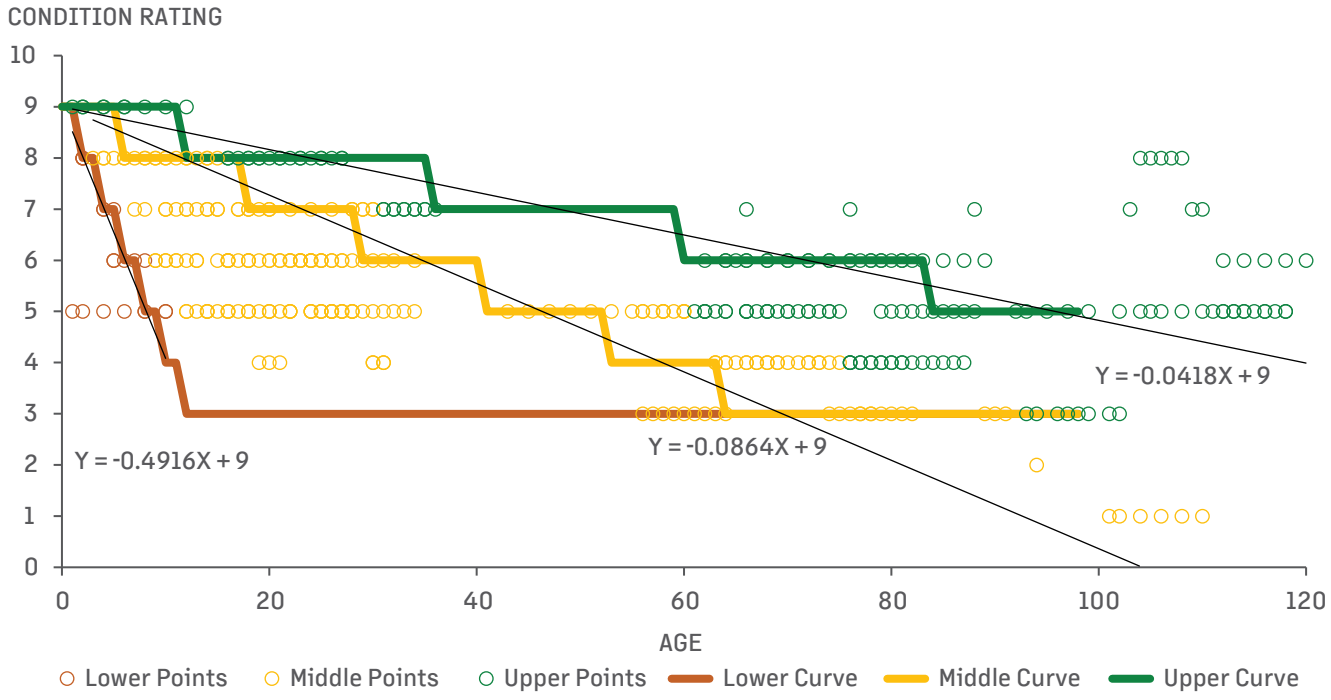
Girder Very High ADT Substructure



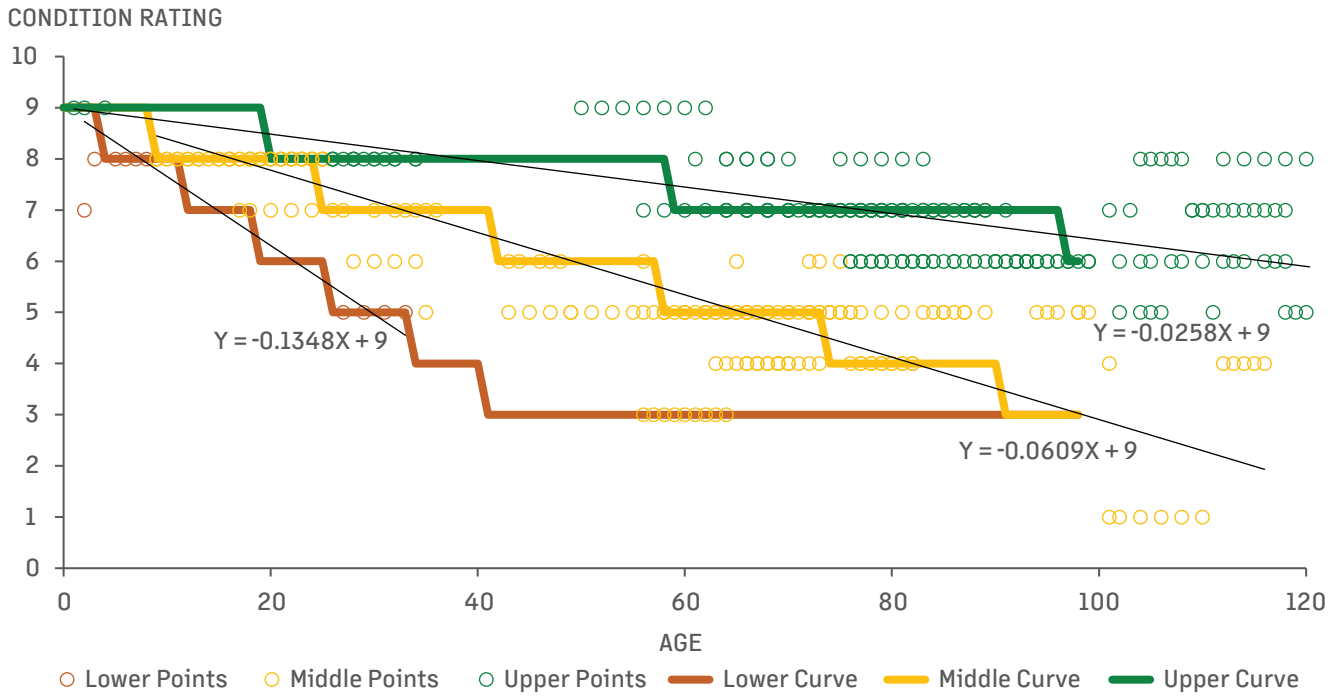
Truss Deck



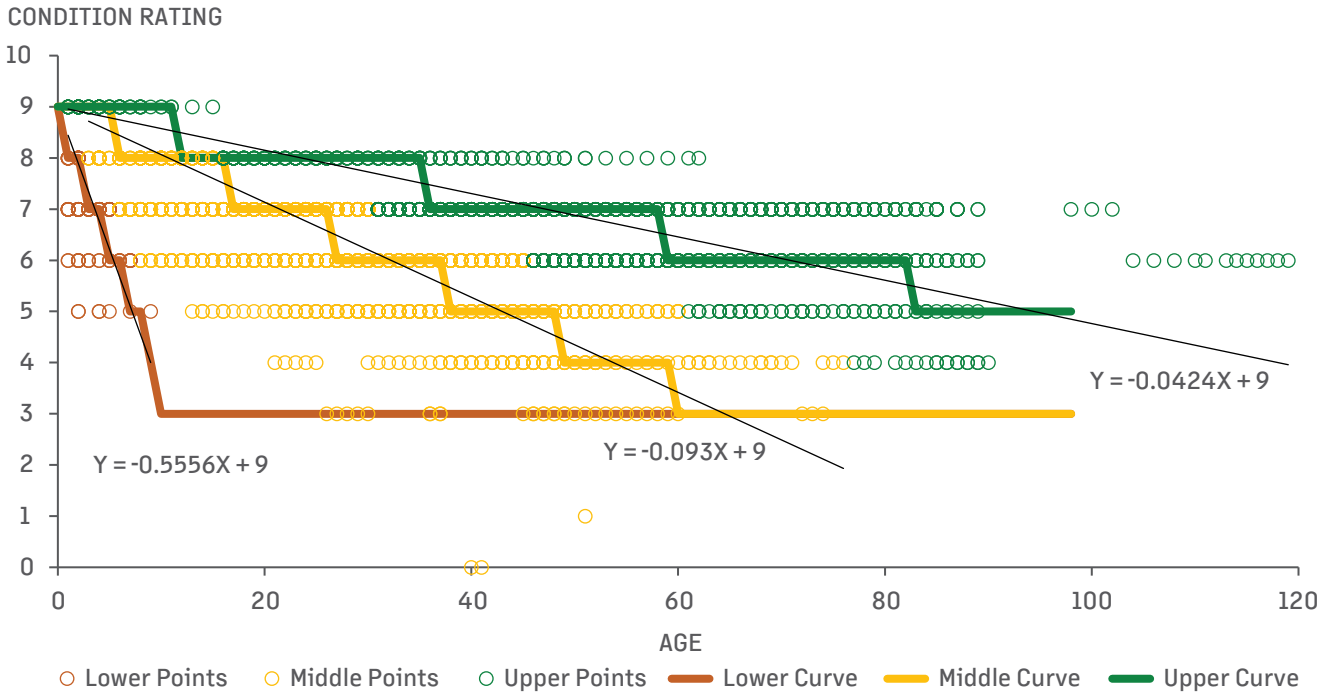
Truss Superstructure



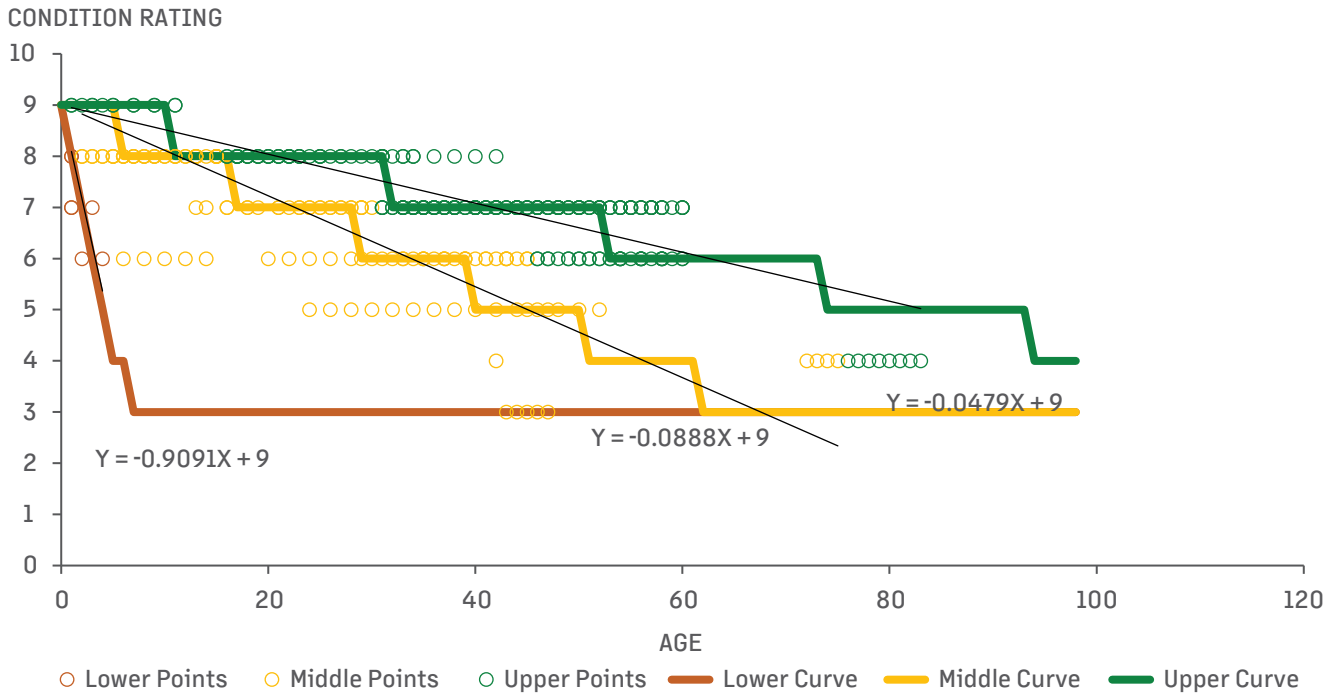
Truss Substructure



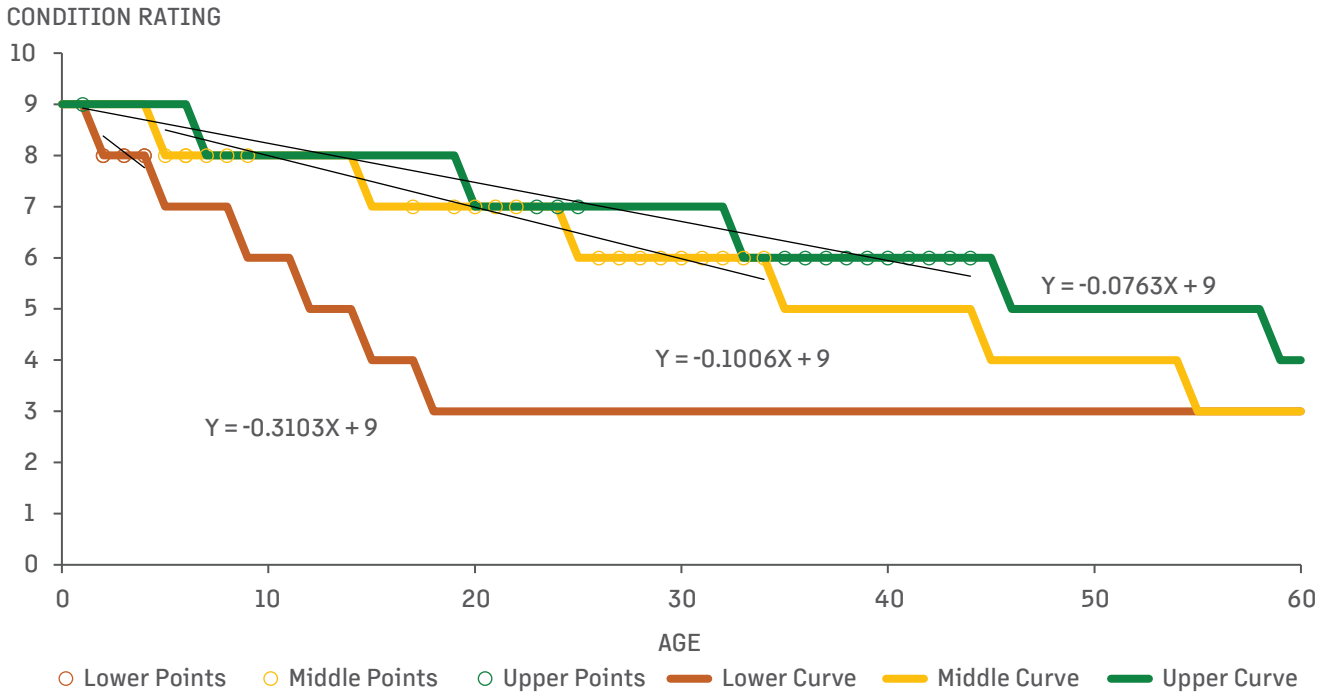
Culvert High ADT



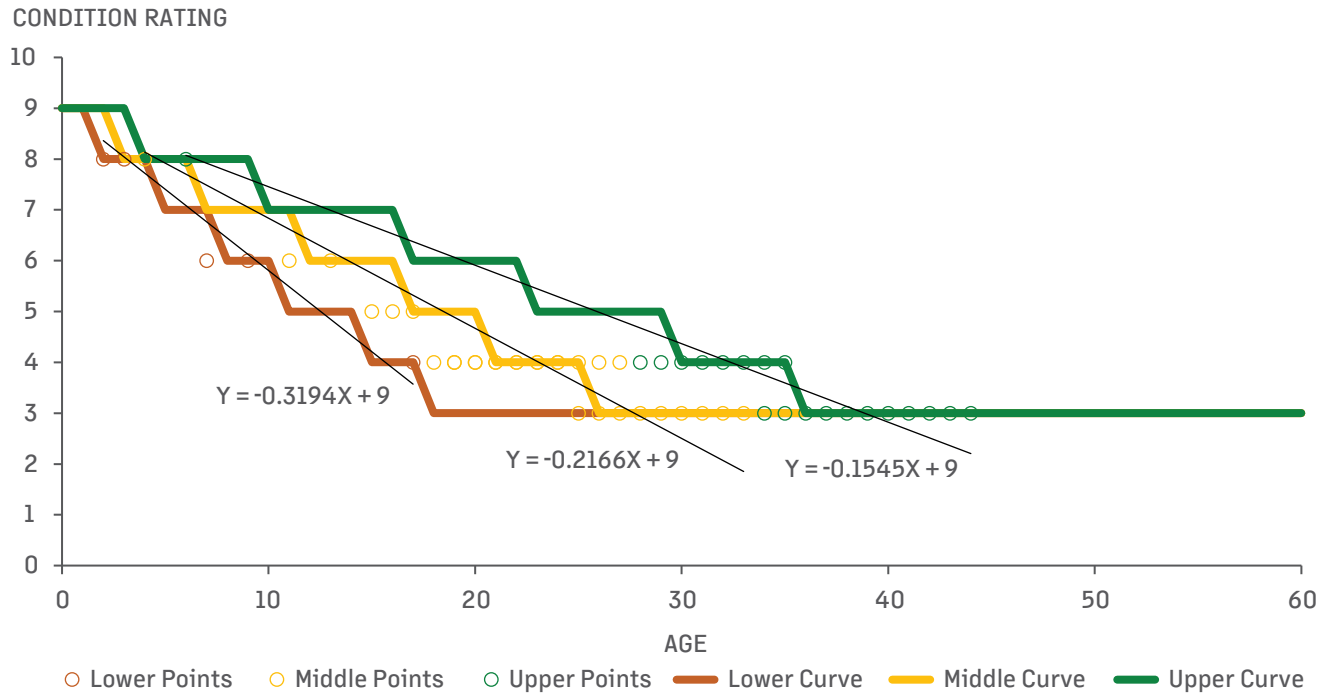
Culvert Very High ADT



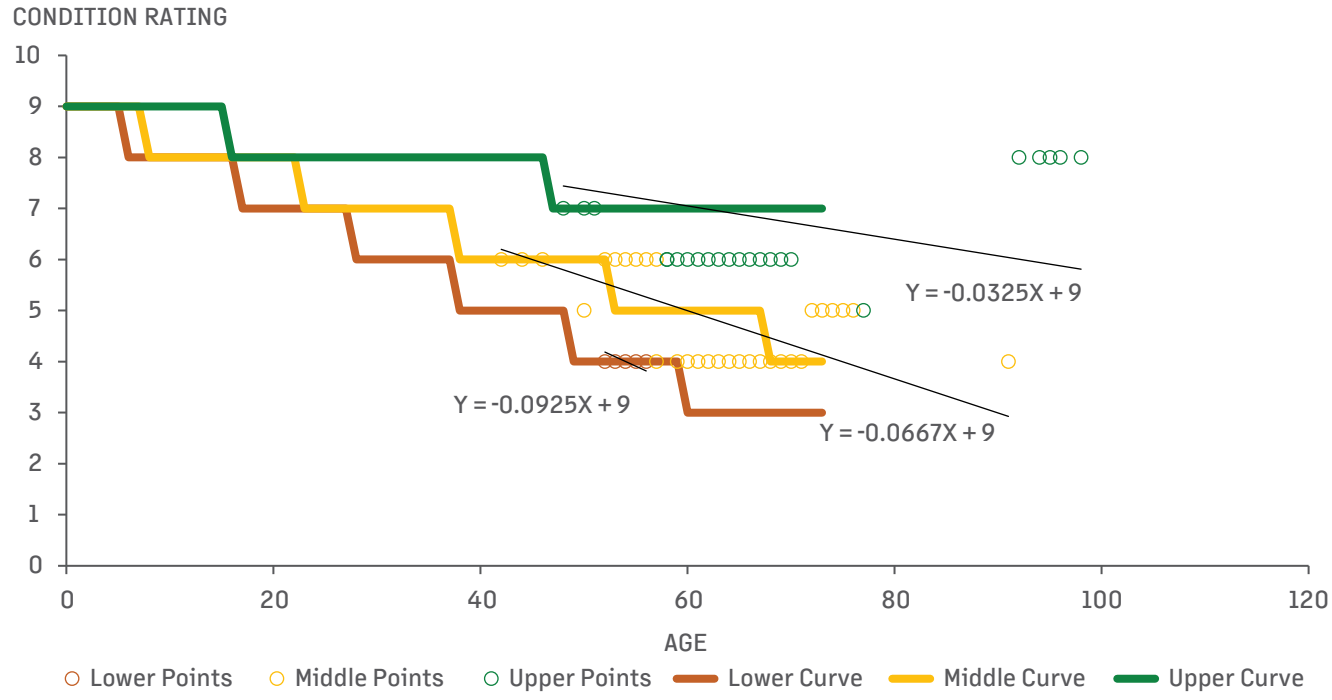
Moveable Deck



Moveable Superstructure



Moveable Substructure



C.3.2 Initial Bridge Condition

The deterioration models were based on age relative to a baseline initial component condition. They used "time in condition state" (TICS) for each component family relative to that initial condition. For example: two bridges ("A" and "B") both have a deck rating of 7. Bridge A has a TICS of 1 while Bridge B has a TICS of 18. Using the deterioration curve, a bridge will drop to a rating of 6 after 20 years at a rating of 7. Thus, we calculate that Bridge A is 5% (1/20) of the way to a rating of 6, while Bridge B is 90% (18/20) of the way to that rating. This translates to an initial deck condition of 6.95 for Bridge A and 6.10 for Bridge B. While both bridges will appear to be at a deck rating of 7, Bridge A will deteriorate in 19 years and Bridge B in 2 years.

C.3.3 Bridge Decision Tree

Decision trees crosswalk deterioration and treatments. For this model, NHDOT created a decision tree based on trigger criteria that reflected the expertise and professional experience of the Department's subject matter experts (SMEs) and generally-accepted investment schedules. NHDOT's decision tree for bridges is provided below as Exhibit C.3. Exhibit C.4 (next page) is a table of the trigger criteria.

Exhibit C.3 NHDOT Bridge Decision Tree

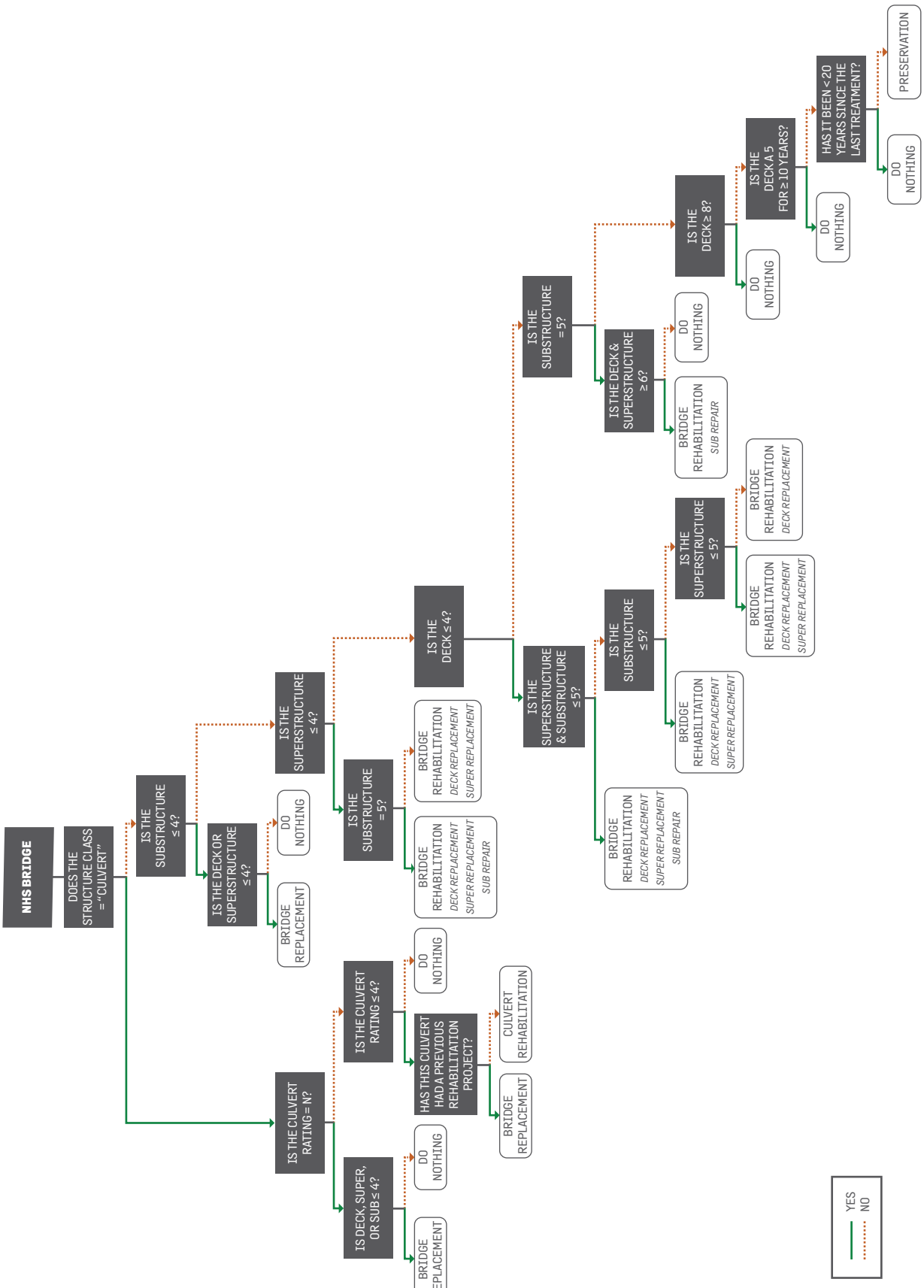


Exhibit C.4 Treatment Trigger Criteria for Bridges

WORK TYPE	TRIGGERS - COMPONENTS	TRIGGERS - OTHER
Bridge Rehabilitation: » Deck Replacement » Super Replacement » Sub Repair	Deck and Super ≤ 4 Sub = 5	Culvert Rating = 'N'
Bridge Rehabilitation: » Deck Replacement » Super Replacement	Super ≤ 4 Sub ≥ 6	Culvert Rating = 'N'
Bridge Rehabilitation: » Deck Replacement » Sub Repair	Deck ≤ 4 Super ≥ 6 Sub = 5	Culvert Rating = 'N'
Bridge Rehabilitation: » Deck Replacement	Deck ≤ 4 Super and Sub ≥ 6	Culvert Rating = 'N'
Bridge Rehabilitation: » Sub Repair	Deck and Super ≥ 6 Super = 5	Culvert Rating = 'N'
Bridge Replacement	Sub ≤ 4 and (Deck or Super ≤ 4)	Culvert Rating = 'N'
Culvert Rehabilitation	Culvert Rating ≤ 4 or Deck, Super, or Sub ≤ 4	Structure Class = 'Culvert' Last Treatment was not a Rehab
Culvert Replacement	Culvert Rating ≤ 4 or Deck, Super, or Sub ≤ 4	Structure Class = 'Culvert' or Structure Class <> 'Culvert' and Culvert Rating <> 'N'

C.3.4 Bridge Treatment Resets

The model assumed that the resets in Exhibit C.5 will occur following treatments of different work types.

Exhibit C.5 Treatment Trigger Criteria for Bridges

TREATMENT	DECK	SUPERSTRUCTURE	SUBSTRUCTURE	CULVERT
Bridge Preservation	Hold Condition for 10-Years	Hold Condition for 5-Years	Hold Condition for 5-Years	N/A
Deck Replacement	Reset to 9	No Change	No Change	N/A
Superstructure Replacement	Reset to 9	Reset to 9	No Change	N/A
Substructure Repair	No Change	No Change	Reset to 7	N/A
Bridge Replacement	Reset to 9	Reset to 9	Reset to 9	N/A
Culvert Rehabilitation	N/A	N/A	N/A	Reset to 7
Culvert Replacement	N/A	N/A	N/A	Reset to 9

C.3.5 Bridge Budgets

NHS bridge budgets were generated for the model using the 2023-2032 Ten Year Plan (TYP) by calculating the current investment value applied specifically to NHS bridges.

The model accounted for committed projects in the TYP and modifications and funding adjustments in a letter from the Governor's Advisory Committee on Intermodal Transportation (GACIT) to the Governor, dated December 22, 2021. In cases where a bridge in Poor condition did not have a defined project, the most likely treatment option was identified based on current conditions and schedule. Because the model does not currently track painting and scour projects, these were excluded.

C.4 Bridge Priority

The model incorporated a scoring procedure to simulate a Priority Index for each bridge, derived from the following characteristics:

- Importance:
  - Bridge tier.
  - AADT.
  - Bypass (detour) length.
- Risk:
  - Scour criticality.
  - Fracture criticality.
- Structure type and size:
  - Structure class.
  - Deck area (bridge length vs. bridge width).
- Condition (i.e., the area under the condition curve for the bridge).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