Transportation Asset Management Plan

July 2022

MDOT
Michigan Department of Transportation

Dear Reader:

It is my pleasure to present the Michigan Department of Transportation's (MDOT) 2022 Transportation Asset Management Plan (TAMP).

Every four years, state departments of transportation are federally required to develop a risk-based asset management plan for their National Highway System pavement and bridge assets, with the overarching goal of charting a path toward improving or preserving the condition of these assets, as well as the performance of the system. As a long-standing supporter of the need for performance management in transportation systems, MDOT greatly appreciates and commends its federal partners for their leadership in implementing performance measures in pursuit of improved asset management.

MDOT's 2022 TAMP builds off decades of transportation asset management efforts in Michigan, including the department's 2019 TAMP. Within, you will find considerations of alignment with other departmental planning processes, how the lenses of equity and environmental justice impact asset management, and how transportation resiliency efforts influence investment strategies. These considerations, as well as other financial and network condition constraints, ultimately drive MDOT's asset management processes and investment strategies.

If you have any questions, please contact either me or Todd White, director of the Bureau of Transportation Planning, at 517-335-2600 or WhiteT5@Michigan.gov.

Sincerely,

Paul C. Ajegba, P.E.

Director


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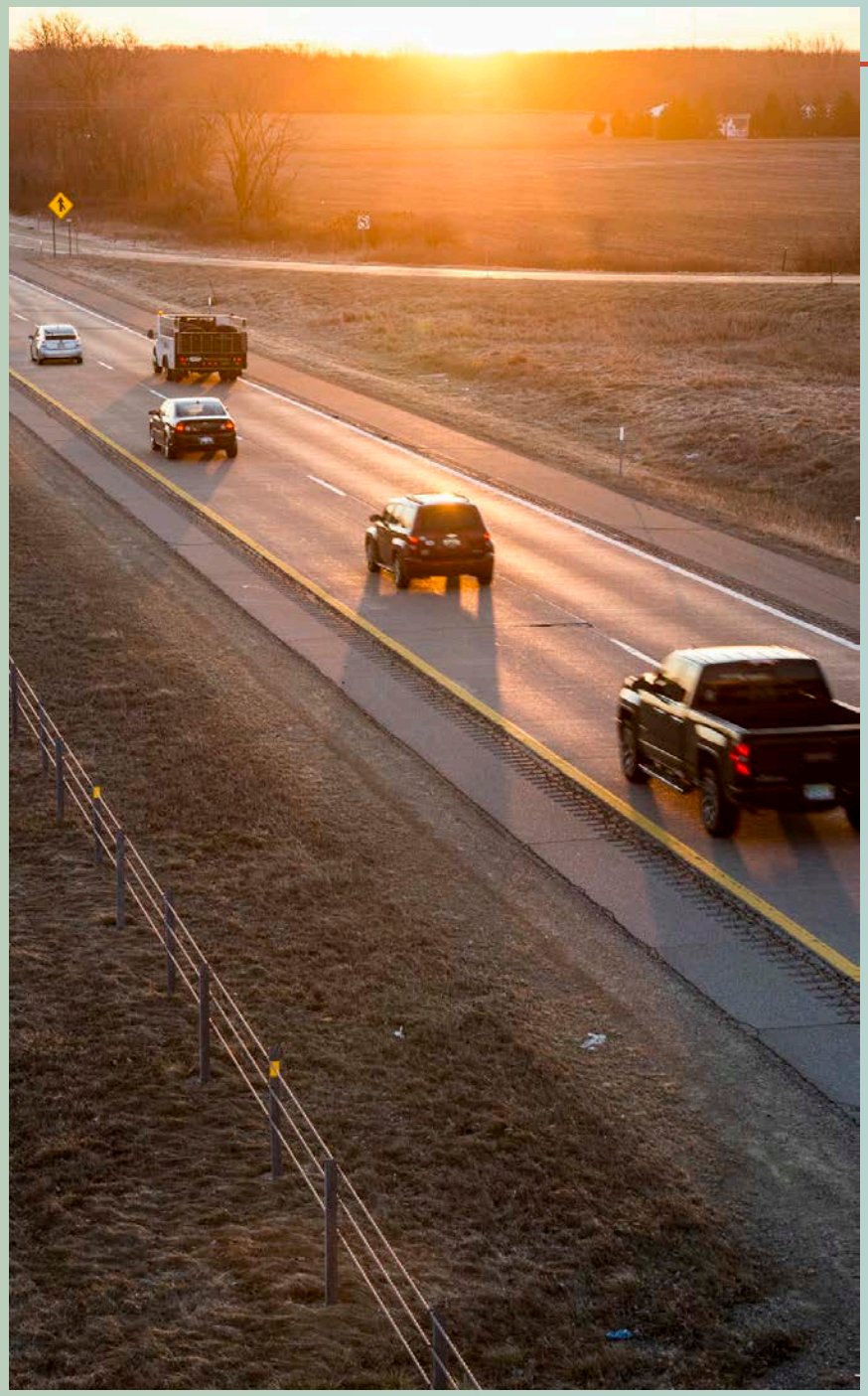
TAMP Acronyms

5YTP	Five-Year Transportation Program
AASHTO	American Association of State Highway and Transportation Officials
Act 51	Michigan Public Act 51 of 1951
AMPD	Asset Management and Policy Division
BCFS	Bridge Condition Forecasting System
BOBS	Bureau of Bridges and Structures
BrM	Bridge Management
BTP	Bureau of Transportation Planning
CFP	Highway Call for Projects
CFR	Code of Federal Regulations
CPM	Capital Preventive Maintenance
CTF	Comprehensive Transportation Fund
DEI	Diversity, Equity, and Inclusion
DI	Distress Index
DIID	Data Inventory and Integration Division
DOTs	Departments of Transportation
DTMB	Department of Technology, Management, and Budget
EJ	Environmental Justice
FAE	Federal-Aid-Eligible
FAST Act	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FRP	Fiber Reinforced Polymer
FY	Fiscal Year
HPMS	Highway Performance Monitoring System
IIJA	Infrastructure Investment and Jobs Act
IRI	International Roughness Index
IT	Information Technology
ITS	Intelligent Transportation System
LCCA	Life Cycle Cost Analysis
MAP-21	Moving Ahead for Progress in the 21st Century Act
MDOT	Michigan Department of Transportation
MIC	Michigan Infrastructure Council
MM2045	Michigan Mobility 2045
MPO	Metropolitan Planning Organization
MTF	Michigan Transportation Fund
MTPA	Michigan Transportation Planning Association
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NHS	National Highway System
P3	Public-Private Partnership
PA	Public Act
PA 325	Michigan Public Act 325 of 2018
PASER	Pavement Surface Evaluation and Rating
PCF	Pavement Condition File
PCFS	Pavement Condition Forecasting System
PCM	Pavement Condition Measure
POA	Plan of Action
R&R	Reconstruction and Rehabilitation
RBMP	Rebuilding Michigan Program
RQFS	Road Quality Forecasting System
RSL	Remaining Service Life
SEMCOG	Southeast Michigan Council of Governments
SLRTP	State Long-Range Transportation Plan
STC	State Transportation Commission
STF	State Trunkline Fund
STIP	State Transportation Improvement Program
STPD	Statewide Transportation Planning Division
TAMC	Transportation Asset Management Council
TAMP	Transportation Asset Management Plan
TAMS	Transportation Asset Management System
TASC	Transportation Asset Steering Committee
TIP	Transportation Improvement Program
TPM	Transportation Performance Management
U.S.C.	United States Code
WAMC	Water Asset Management Council



Introduction

Objective of the TAMP

The objective of the Michigan Transportation Asset Management Plan (TAMP) is to describe the asset management process by which the Michigan Department of Transportation (MDOT) makes its program and project decisions, and to report out on progress made toward achieving its pavement and bridge condition goals.

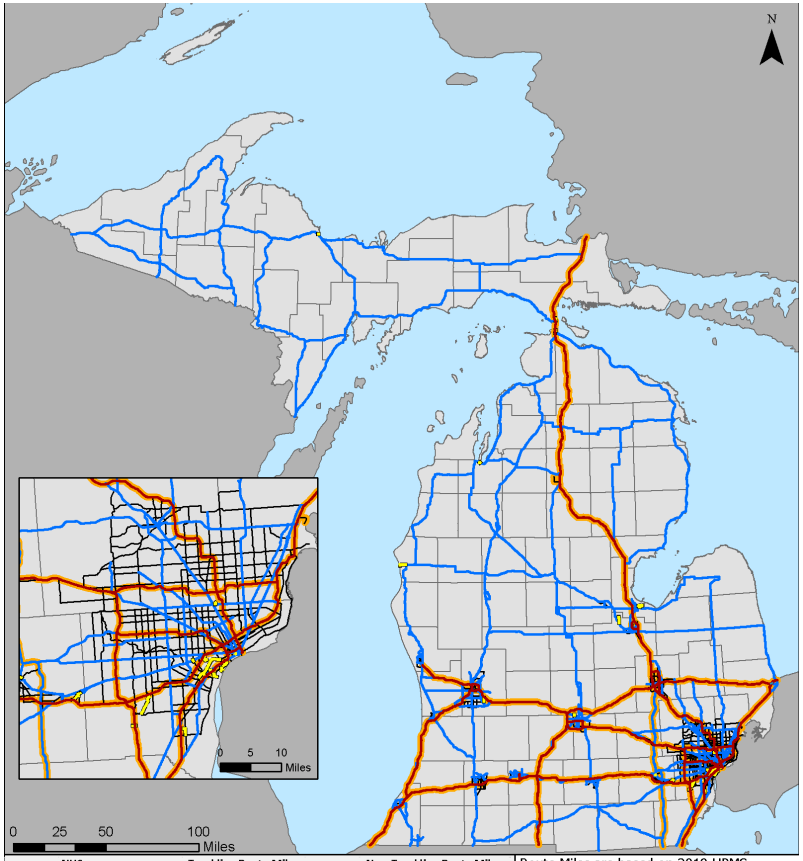
The transportation network provides mobility, access, and intermodal connectivity in support of economic activity and quality of life for Michigan citizens. To ensure its safe and effective use as an essential public resource for many years to come, the care and maintenance of this network must continue in the most cost-effective way possible, with careful consideration for constraining financial resources available to the State of Michigan and other responsible local agencies. MDOT has used asset management tools to evaluate its network condition since 1997 to guide investment and programming decisions to ensure this good stewardship.

Scope of the TAMP

Consistent with federal guidance, the focus of the Michigan TAMP is on the Interstate Highway System and National Highway System (NHS). Interstate and NHS assets, while important from a national perspective, are a subset of the total transportation infrastructure in Michigan. The entire road network in Michigan is comprised of 121,857 paved route miles[1] and 11,158 bridges. The NHS subset, shown in Figure 1-1, includes 6,456 route miles and 2,964 bridges, of which MDOT manages 81 percent. The remaining 19 percent is operated, preserved, and maintained by 84 local road agencies, including 66 cities and 19 counties or county road commissions.

[1] *For clarity, route miles are not the same as lane miles. Route miles are defined as the sum of the lengths of all routes on the network. Lane miles can be defined as roughly the total route miles multiplied by the total number of highway lanes for each portion of the network.*

Figure 1-1: Michigan's NHS Network



NHS	Trunkline Route Miles	Non-Trunkline Route Miles
Interstate	1238.4*	NA
Trunkline	5219.3	NA
Non-Trunkline	NA	1203.1
STRAHNET	1328.3**	8.1**
Intermodal Connector	7.3	27.1
Total	5226.6	1230.2
Total NHS Route Miles	6456.8	

Route Miles are based on 2019 HPMS V20 data submitted in June 2020.
* Interstate route miles are included in the Trunkline calculation.
** STRAHNET route miles are included in Trunkline and Non-Trunkline calculation. All Interstate route miles are part of STRAHNET.

The Michigan TAMP includes inventory and condition information, documentation of performance measures and targets, a description of the investment strategy and the asset management processes MDOT uses to guide program and project decisions, and financial and performance gap analyses based on four investment strategies as outlined in federal guidance and shown in Figure 1-2.

Figure 1-2: MDOT TAMP Investment Strategies

Achieve National Minimum Condition Levels	No more than 5 percent of Interstate pavements are in poor condition, and No more than 10 percent of NHS bridges are in poor condition.
Preserve Condition of Pavement and Bridge Assets	Current conditions are maintained on Interstate and NHS pavements and bridges.
Achieve and Sustain State of Good Repair	Aspirational goals for Interstate and NHS pavements and bridges based on MDOT's desired state of good repair for the freeway/non-freeway network at 95/85 percent good/fair.
Achieve Constrained Targets for Asset Conditions	Where investment of the funds reasonably expected to be available for Interstate and non-Interstate NHS pavement and bridges demonstrates a gap in revenue available to meet established condition and performance goals.

State Transportation Commission Asset Management Goals

In 1997, Michigan's State Transportation Commission (STC) approved 10-year aspirational condition goals for the state's trunkline systems based on pavement health, where 95 percent of the freeway system would be maintained in good or fair condition and 85 percent of the non-freeway system in good or fair condition. A year later, the STC approved similar goals for Michigan freeway and non-freeway bridges. These STC goals created the asset management objectives by which the department manages its pavements and bridges. In the decade that followed, MDOT worked to achieve these goals using an asset management process supported by measures and forecasting tools developed for pavement remaining service life, with 10-year condition goals for pavements met in 2007 and 10-year condition goals for freeway and non-freeway bridges in 2008.

In 2012, the Moving Ahead for Progress in the 21st Century (MAP-21) Act began a national effort to implement a performance-based approach to transportation investment decision-making. That effort was strengthened in 2015 by the Fixing America's Surface Transportation (FAST) Act. Under the asset management provisions enacted in MAP-21, codified at 23 United States Code (U.S.C.) 119, state departments of transportation (DOTs) are required to develop and implement a risk-based TAMP that includes all NHS pavements and bridges at both the state and local levels.

State Long-Range Transportation Plan (SLRTP) Vision

More recently, through the work of updating the state's long-range transportation plan, Michigan Mobility 2045 (MM2045), MDOT developed an integrated, performance-based 25-year plan for transforming Michigan's transportation system. It includes not only an overall system-wide vision, but also incorporates two federally required documents: the State Rail Plan and the State Freight Plan. To meet the challenge of providing a multimodal transportation system that can support Michigan's future economic viability and competitiveness, MM2045 established a vision, objectives, goals, and strategies for supporting improved safety, infrastructure conditions, and system reliability to drive statewide economic investments.

The MM2045 vision, with which this TAMP is in alignment, is as follows: "In 2045, Michigan's mobility network is safe, efficient, future-driven, and adaptable. This interconnected multimodal system is people-focused, equitable, reliable, convenient for all users, and enriches Michigan's economic and societal vitality. Through collaboration and innovation, Michigan will deliver a well-maintained and sustainably funded network where strategic investments are made in mobility options that improve quality of life, support public health, and promote resiliency."

Preservation is a key guiding principle for Michigan's future transportation investments, where Michigan strives to preserve, operate, enhance, and right-size the existing transportation network as efficiently and effectively as possible, build and manage it to withstand and recover rapidly from disruptions, and maintain a network that provides for predictable access, movement, and interconnectivity. The MM2045 considered and integrated national transportation goals and performance measures in developing Michigan's goals, objectives, strategies, and performance measures. Each of the policies and investments included contribute to Michigan's ability to meet the national transportation performance management (TPM) goals and are in alignment with STC-established goals and this TAMP.

MDOT's Asset Management Approach

Asset management is defined by the Federal Highway Administration (FHWA) as a "systematic process of maintaining, upgrading, and operating physical assets, such as roadways and bridges, in a cost-effective way." For Michigan, this process includes monitoring results and adjusting as needed, with the overall goal of ensuring that the state's transportation system is managed as efficiently as possible.

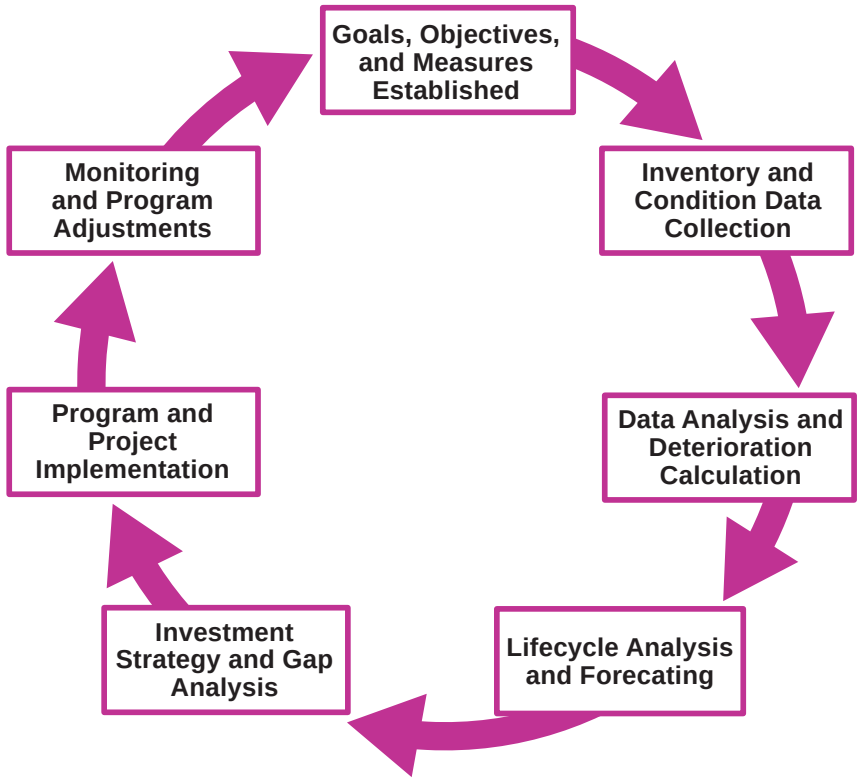
The Michigan TAMP describes the asset management process that MDOT follows (see Figure 1-3), where:

1. Goals and long-term objectives are established by the STC and the SLRTP where performance measures are set or reaffirmed;
2. System inventory and condition data are collected;
3. Condition data are analyzed and rates of deterioration are calculated;
4. Network life cycle analysis is performed using forecasting tools;
5. Investment strategies are analyzed and selected based not only on goals and financial constraints, but also risk management and life cycle analyses, which are developed with resilience considerations to - among other things - extreme weather events, and gaps in funding and performance are identified;
6. The selected investment strategy is implemented through the development of programs, the selection of projects, and the communication of the planned investments through the State Transportation Improvement Program (STIP) and the Five-Year Transportation Program (5YTP); and
7. Established processes are monitored and adjusted based on the outcome of projects and programs that are implemented.

Local Asset Management

In 2002, the Michigan Legislature created the Transportation Asset Management Council (TAMC), whose charge was to develop a statewide asset management strategy and the processes and tools needed to implement asset management practices for federal-aid-eligible (FAE) highways across the state and local jurisdictions. In July 2018, Michigan Public Acts (PA) 323, 324, and 325 established two new councils: the Michigan Infrastructure Council (MIC) and the Water Asset Management Council (WAMC), which is intended to mirror for water and sewer infrastructure the efforts

Figure 1-3: MDOT's Asset Management Process



accomplished over the past 15 years by the TAMC. Both the TAMC and the WAMC report to the MIC. The TAMC scope was modified to include requirements to address asset management plans for local road agencies.

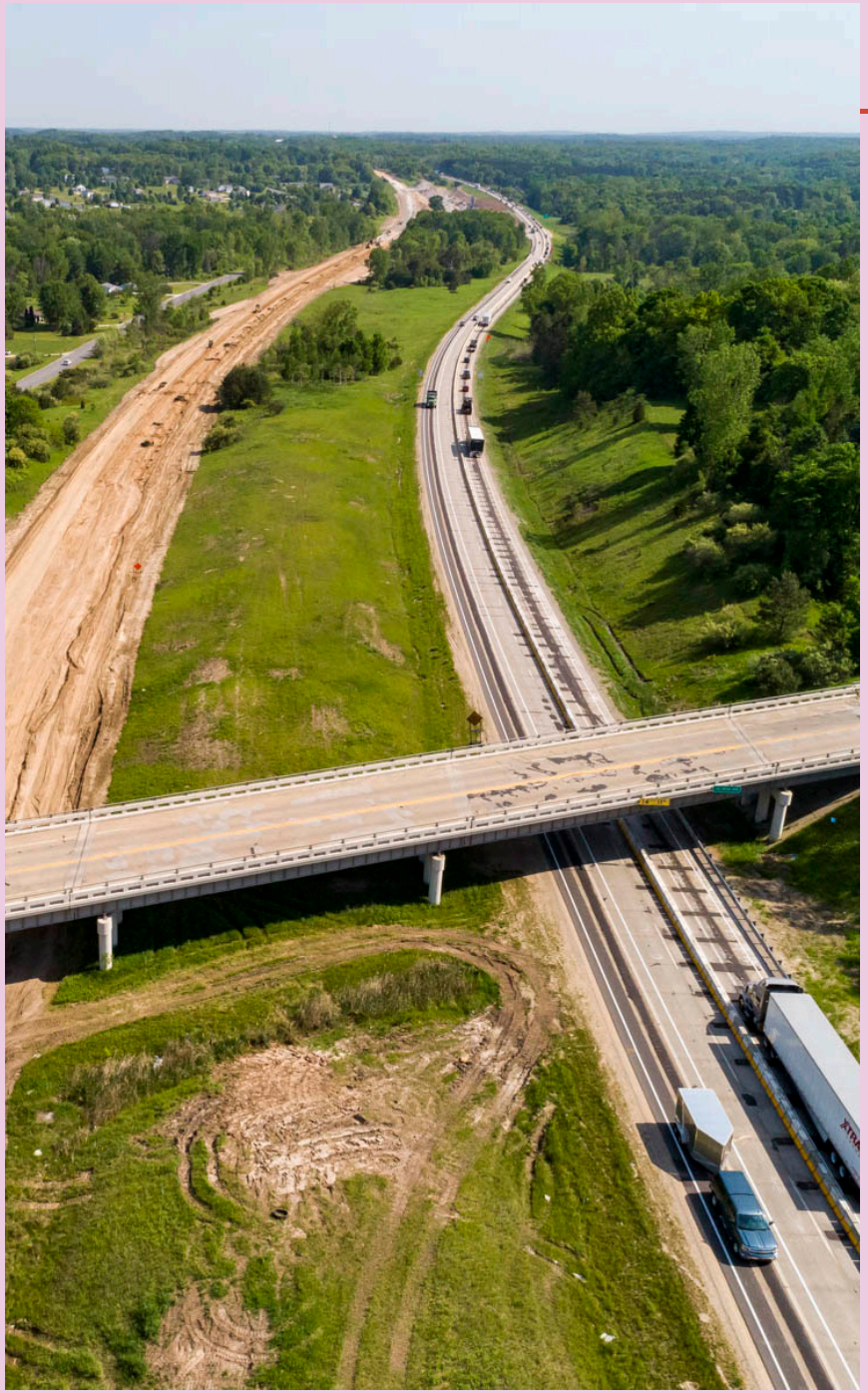
After PA 499 of 2002 was signed into law, the TAMC developed tools and a methodology for data collection and analysis that local agencies could use. As a result, several hundred road agencies work together each year through their regional planning agencies and metropolitan planning organizations (MPOs) to gather performance data on nearly 37,000 centerline miles of FAE highway pavements and more than 11,000 highway bridges across the state.

In addition, the TAMC later developed a template for asset management plans for use by local road agencies responsible for 100 or more certified centerline miles of road and established a schedule for the submission of asset management plans by local road agencies. Using the template developed by the TAMC, local asset management plans include an asset inventory, performance goals, risk of failure analysis, anticipated revenues and expenses, performance outcomes, a description of any plans to coordinate with other entities, and proof of acceptance by the local road agency's governing body.

Resilience and Extreme Weather Events

As required by Title 23, United States Code (U.S.C.), Section 119(e)(4), this TAMP fully considers extreme weather in support of MDOT's pursuit to develop and maintain a resilient transportation network. These considerations are made explicit in the Risk Assessment and Management and Life Cycle Analysis chapters. The investment strategies discussed within are influenced by the results of the department's risk management and life-cycle planning efforts, just as they are influenced by other important factors such as long-term transportation network goals and financial constraints.

MDOT aspires to more thoroughly integrate resiliency into its planning procedures and processes (of which asset management plays a critical role). As such, the department eagerly awaits additional FHWA guidance on how it might bolster its ongoing resiliency efforts in alignment with changing federal requirements.



Planning and Program Development Process

This chapter describes the MDOT program development and planning process for roads and bridges, as managed through the annual Highway Call for Projects (CFP) in alignment with the SLRTP vision, goals, and objectives and the STC-approved aspirational road and bridge condition goals.

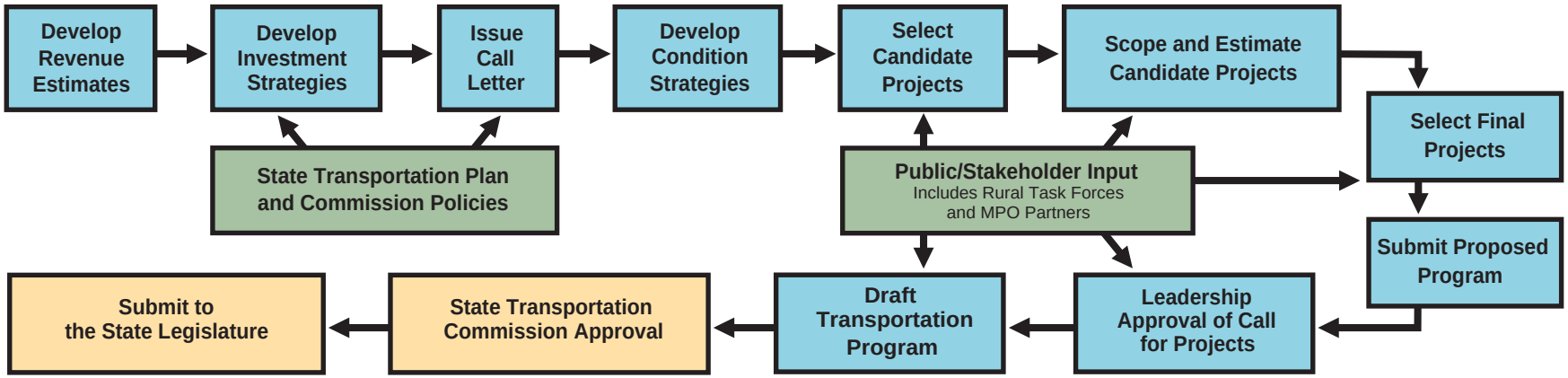
Highway Call for Projects (CFP)

The CFP defines the strategic direction and funding targets used to develop the department's highway capital program, which consists of road, bridge, safety, carpool parking lot, operations, intelligent transportation systems (ITS), and traffic signal modernization projects. The road and bridge portions of the highway capital program are the focus of the Michigan TAMP as required and defined in MAP-21, codified in 23 U.S.C. 119.

The CFP is designed to identify and select projects that ensure progress is made toward performance goals as established by the STC, as well as national requirements for pavement and bridge condition targets, both of which are reaffirmed by and communicated within the federally required SLRTP. The projects selected and the investment strategies that support them are communicated to the public and stakeholders through the state-required 5YTP and the federally required STIP.

While the CFP is the internal planning and programming process followed by the department to guide project selection decisions and reach established goals, the 5YTP is the vehicle by which the projects selected in the CFP are communicated to the STC, the public, and the state Legislature. The steps in the program development process are shown in Figure 2-1 and described in further detail in the following pages.

Figure 2-1:
Planning and Program Development Process



Develop Revenue Estimates

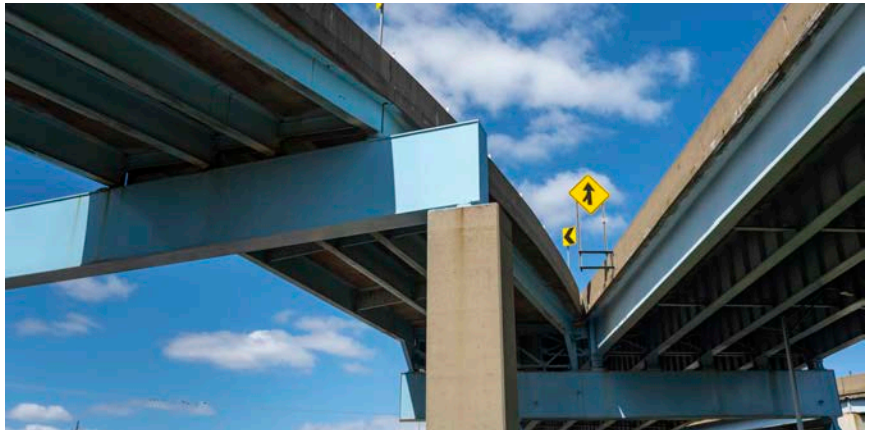
MDOT's highway capital program development process is a rolling, multi-stage effort that begins with the development of revenue estimates upon which investment strategies are based. State and federal revenue available for the capital program is forecasted based on historical trends, federal funding availability, and any changes in state legislation. From there, anticipated funding available and the cost of future work constrain program development and the project selection process.

Develop Investment Strategies

Investment targets are based on an analysis of levels of funding needed to reach the established goals for system condition. Any changes in the investment strategy are based on changes in future needs as identified by region and program managers, which are considered alongside available revenue and the department's ability to fund additional work.

Issue Call for Projects Letter

MDOT issues the CFP annually. Each year, members of the CFP team re-evaluate the department's strategic direction, and a manual and instructions are updated and issued to the seven MDOT region offices that are responsible for proposing projects. In the manual, key emphasis areas and strategic objectives are outlined, and detailed technical instructions are included. Target funding levels for each region are provided, which are calculated from a formula based on weightings related to variables such as condition, usage, costs, and eligible assets.



Develop Condition Strategies

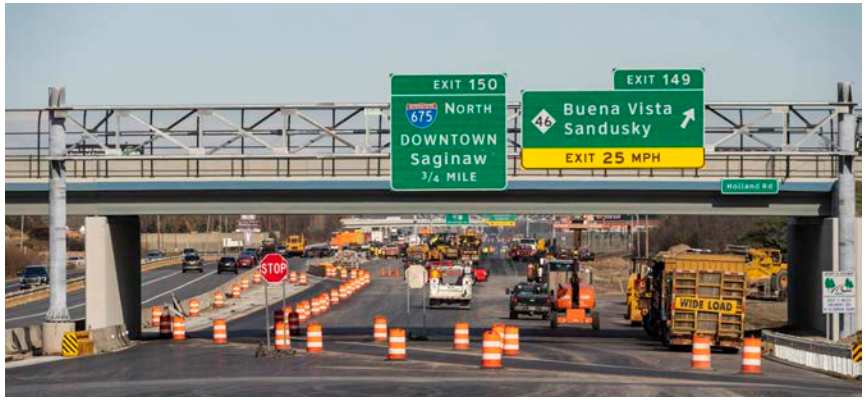
Based on the target funding levels established for each region, improvement strategies for the road and bridge networks are developed by MDOT region staff using the Road Quality Forecasting System (RQFS), the Pavement Condition Forecasting System (PCFS), and the Bridge Condition Forecasting System (BCFS) tools, as well as input from partners and stakeholders. These strategies guide project selection and ensure that a mix-of-fixes is incorporated into program development. As part of the region-level analysis of project selection, gap analysis is considered when various investment strategies are compared to determine the best strategy to meet the overall goals and objectives set by the STC.

Various fixes can be applied to existing transportation assets, each having different impacts on the trunkline network. Fixes are categorized into short-, medium-, and long-term groups. By applying this approach that includes a combination of fixes, MDOT can address system needs in the most cost-effective way possible.

Candidate Project Selection and Submittal

Once a recommended strategy is approved, candidate projects are identified by region and program managers that are consistent with the strategy and funds available.

Candidate projects are then prioritized by analyzing risks, life cycle costs, the severity of the distress, the amount of traffic on the roadway, public input, maintenance costs, and the context of the roadway. From the candidate list of projects, submittals are presented to the CFP subcommittees for approval to allow the regions to proceed with more detailed scoping and estimating.



Scope and Estimate Candidate Projects

One of the first steps in preparing a project's scope is to review and verify the proposed fix in the field to get high-level project scope and cost estimates. A group of technical staff drives (or "tours") the proposed project from end to end, either in person or virtually. This tour identifies work in addition to the pavement needs identified, including drainage work, sidewalk needs, safety work, or access issues. In addition, areas of concern, such as environmental considerations, utility conflicts, and crash history, are considered. Other items of work may be added at this point in the process, such as bridge work that could be completed with an identified road project.

During this time, public input is solicited by discussing projects with local road and governmental agencies, MPOs, and the public through these local agencies.

Once the van tour is complete, a scoping document is prepared that provides a thorough analysis of all the aspects of the project and covers several types of fixes that are possible. It analyzes available means of maintaining traffic during construction and considers the feasibility of upgrades to the operations of the roadway, complete streets and context-sensitive solutions, innovative construction methods, and addressing environmental impacts. Rough preliminary plans are drafted, which are used as the starting point for the future design phase of the project. A detailed cost estimate is performed based on estimated contract pay items and the expected unit prices for each pay item. An inflation rate is then applied to the estimate so that a more accurate cost for the year of construction can be determined.

Bridges included within the limits of a road project or selected as a standalone project will be scoped separately from the van tour. These scopes generally consist of a detailed hands-on inspection that is more thorough than a routine inspection. Detailed inspections usually include sounding concrete and other non-destructive testing to develop repair quantities. Once the detailed inspection is complete, options for repairs are proposed, detailed estimates are created, and life cycle costs for the project are considered as part of the scoping report. Prior detailed inspections and routine inspections are consulted throughout the process to ensure that all problems are identified, and a cost-effective solution is proposed.

Final Project Selection

When the scoping documents are completed, project selection can begin. Projects are selected to meet the approved strategies as closely as possible. During final project selection, consideration is given to providing a balance of work across the regions so that mobility for users can be maintained region-wide. The CFP process is integrated across programs, meaning that road and bridge project selections are chosen not only for the benefit of the individual assets but also using a corridor approach to address all assets, as allowed within constrained funding within a corridor to minimize impacts to mobility.

Proposed Program Submittal

The reviewed and scoped candidate projects are submitted to the CFP subcommittees for review and further discussion. Real-time feedback is provided to the regions based on analysis of consistency with approved strategies and submittal criteria, condition data, appropriate fix life project estimates, and if a proposed project budget is within established thresholds.

Approval Committee Review

The subcommittees are responsible for the initial approval of the submitted projects and for recommending that any unapproved projects be further reviewed by the CFP Approval Committee. The CFP Approval Committee is responsible for the following actions throughout the CFP process:

1. Approve region and statewide condition strategies;
2. Recommend CFP Program for final executive approval;
3. Provide strategic direction for pavement and bridge assets;
4. Approve funding for region allocations;
5. Resolve any projects or conflicts in the CFP submittals that do not comply with the guidelines in the CFP manual;
6. Approve changes and improvements to the CFP process, including adjustments in tools used and data analyzed; and
7. Approve adding/deleting programs to the CFP.

Draft Five-Year Transportation Program (5YTP), Approval by State Transportation Commission (STC), and Submittal to State Legislature

Once the CFP projects are approved, the regions work to program their selected jobs into JobNet, MDOT's web-based system used to manage the scope, schedule, and budget for road, bridge, and other transportation-related projects. A database pull of projects is conducted to capture the approved projects for inclusion in the 5YTP. The 5YTP packages the list of projects and the investment strategy that supports it into a public-friendly document. The 5YTP provides a broad look at MDOT's capital program over the next five years and makes progress toward attaining the department's long-term goals and objectives. Upon approval by the STC, it is submitted to the Michigan Legislature prior to March 1 each year.

In addition to public involvement at the project-level during scoping, public outreach and engagement occurs within the 5YTP process during a dedicated 30-day public comment period. Stakeholders include the public, rural task forces, MPO partners, and local units of government. MDOT is committed to improving its public involvement process and has developed the Michigan Transportation Program Portal, which serves as an online, Geographic Information Systems map-based platform for public engagement for the STIP, the 5YTP, and the Rebuilding Michigan Program (RBMP).

The 5YTP also plays a large role in maintaining uniformity throughout MDOT's planning and program development processes and provides a foundation for the development of the STIP. The 5YTP schedule is synchronized with the STIP schedule to allow for seamless STIP updates by assuring that projects appear in both documents. Throughout the year, changes to project scopes, schedules, and budgets are submitted to the STIP for inclusion in the bi-monthly Transportation Improvement Program (TIP) amendments.

The list of projects anticipated to be built within the next five years is pulled into the 5YTP and is in alignment with the constrained investment strategy in the TAMP. In addition, the 5YTP builds on the direction from the TAMP, connecting the areas of finance, long-range planning, policy, and asset management by reporting information on anticipated federal and state revenues for highway and public transportation and progress toward meeting performance measures.

As an additional step in the planning process centered on equity, the Statewide Transportation Planning Division (STPD) creates a report that provides a high-level analysis of projects in the 5YTP that are located within environmental justice (EJ) zones in the state of Michigan. To improve public outreach efforts, the report contains a listing and map of projects that may be of greater impact or concern, and also identifies which EJ groups are present within a given project area. These tools allow MDOT regional planners and engineers an early opportunity to ensure that these population groups are given fair opportunity to provide comment and input during the public involvement process for each project.

Program Delivery and Adjustments Throughout the Process

Within a strategic, proactive asset management approach to system preservation, it is essential to monitor progress, obtain feedback, and, when necessary, adjust or refine to improve the project selection process for future years. Once project selection decisions are made and communicated to the public via the 5YTP, the work of program delivery through to construction begins. Each year, through the CFP, a new list of projects is developed that incorporates any changes, including schedule delays, customer feedback, or projects added or removed due to changes in revenue.

Within each annual cycle of the CFP process, MDOT makes observations about the data, analytical tools, assumptions made in the analysis, forecasted condition, and the overall program development process, and makes the necessary modifications. STPD provides bi-weekly and quarterly monitoring reports designed to ensure projects are aligned to investment targets.

Transportation Performance Measures and Targets

This chapter introduces the Michigan asset management performance measures at a high level.

Performance Measures in Michigan

MDOT has been using asset management and performance measures to manage pavement and bridge assets for more than 25 years, starting with the STC-established goals for freeway and non-freeway networks of 95 percent and 85 percent in good/fair condition, respectively.

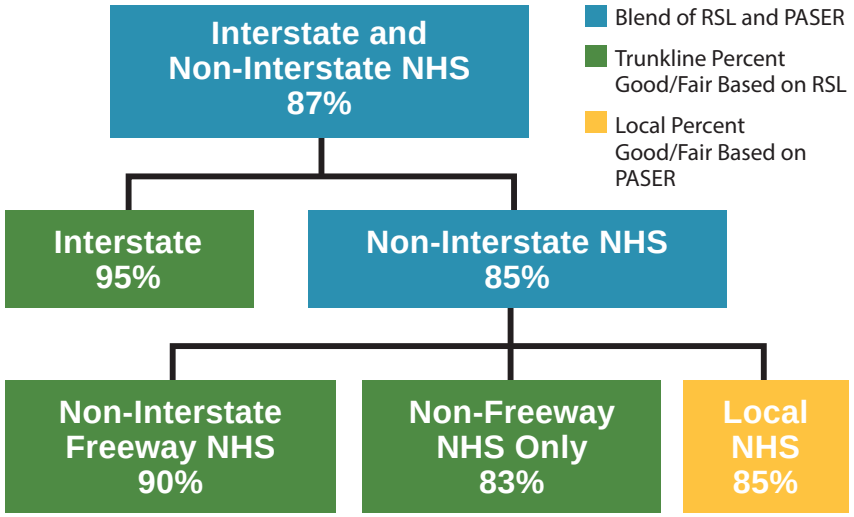
The following three performance measures are used for the monitoring of pavement:

1. Remaining Service Life (RSL),
2. Pavement Surface Evaluation and Rating (PASER), and
3. The federal Pavement Condition Measure (PCM).

MDOT and other bridge owners primarily use the National Bridge Inventory (NBI) condition ratings to measure bridge performance.

Michigan's Interstate and non-Interstate NHS State of Good Repair goal for the TAMP is a blend of RSL and PASER, as shown in Figure 3-1, with the Interstate good/fair goal of 95 percent shown in the leftmost box, and the non-Interstate NHS being a combination of trunkline and local pavements with different performance measures used depending on asset ownership. The Interstate goal is consistent with the national minimum condition level of no more than 5 percent in poor condition.

Figure 3-1: Interstate and Non-Interstate NHS Performance Measures by Trunkline (Green) and Local (Yellow)



Remaining Service Life (RSL)

RSL is an estimate of current pavement structural condition and refers to an estimated number of years a pavement has remaining before major repairs or reconstruction is more cost effective than preventive maintenance and represents what can be expected for the pavement's future.

An RSL estimate considers the structural integrity of the pavement, along with contextual data regarding the pavement's history. Because of this contextual data, RSL is a dynamic, detailed, and tactical measure that evaluates the long-term health of pavement. Having a clear understanding of the pavement's health allows MDOT to make informed investment decisions that are targeted at extending the useful life of the asset.

The condition states of the RSL estimate allow MDOT to identify pavement health in categories that represent the pavement's location in its life cycle. When generalized to the network level, RSL's condition states provide a snapshot of statewide pavement network health (Figure 3-2).

Figure 3-2: Michigan RSL Condition State Ranges

Condition State	RSL Range
Good	8+ Years
Fair	3-7 Years
Poor	0-2 Years

Because it indicates overall pavement health, the STC chose RSL to be the basis for the aspirational condition goals for the freeway and non-freeway portions of the network. This goal represents a statewide focus not just on surface condition, but also on long-term cost-effective maintenance of transportation assets through the prioritization of pavement structural health.

Road Quality Forecasting System (RQFS)

To determine the agency's progress toward the STC goal, MDOT developed RQFS, an application capable of predicting changes to pavement RSL and thereby estimating anticipated levels of system health. As a network-level model that uses the RSL performance measure, RQFS allows MDOT to make strategic investment decisions with these informed pavement impact statistics on state-owned and maintained roadways. More details about the inputs required to run RQFS are described in the Life Cycle Planning chapter.

Pavement Surface Evaluation and Rating (PASER)

To complete the evaluation of network pavement conditions, MDOT supports the use of the PASER rating system for locally owned NHS roads. PASER is a visual survey method for evaluating and rating the surface condition of roads on a scale of performance quality from 1 to 10. The method was developed by the University of Wisconsin Transportation Information Center to provide a simple, efficient, and consistent method for evaluating road surface condition.

Michigan's TAMC adopted PASER as the standard rating system for gathering pavement condition on all FAE roads in Michigan. The PASER metrics are reported on the TAMC interactive map and dashboards using the following TAMC definition of what constitutes a good, fair, or poor pavement in relation to the PASER surface rating (Figure 3-3 and corresponding pictures). For more information on PASER, please see the PASER Asphalt and PASER Concrete manuals.

Figure 3-3: PASER Rating Scale and TAMC Definitions

PASER Rating Scale	PASER Surface Rating	TAMC Definition
10 & 9	Excellent	Good
8	Very Good	
7 & 6	Good	Fair
5	Fair	
4	Fair	Poor
3	Poor	
2	Very Poor	
1	Failed	

PASER Good

PASER Fair

PASER Poor

Pavement Condition Forecasting System (PCFS)

Using the data collected according to the PASER rating system, MDOT enters the information into the PCFS, which is a spreadsheet-based Markovian model designed to predict the surface condition of Michigan's paved roads. The PCFS model uses the latest four years of pavement condition ratings to calculate the probability that a segment of road will deteriorate over the course of the forecast period. In addition to pavement condition, inputs for the model include variables such as pavement management strategies, anticipated revenues available for road construction and maintenance, and the cost of road repairs.

Through this tool, MDOT forecasts anticipated conditions on local NHS roads and integrates them into the trunkline NHS conditions forecasted by RQFS to form the Michigan Pavement Health Index, which is described in the Asset Inventory and Condition Analysis chapter in more detail.

Federal Pavement Condition Measure (PCM)

In support of the national goal to maintain the highway infrastructure asset system in a state of good repair, FHWA developed Interstate and non-Interstate NHS condition measures to assess the performance of the NHS. MDOT refers to this measure as the federal PCM, which is a composite rating of three metrics as illustrated in Figure 3-4, including International Roughness Index (IRI), Cracking Percent, and either Rutting or Faulting, depending on pavement type:

- IRI – A reference statistic of pavement surface roughness that simulates a typical vehicle body's vertical response to moving over the road at 50 mph.
- Cracking Percent – A measurement of the extent of surface cracks in the wheel paths of asphalt pavements or of transversely cracked slabs in concrete pavements.
- Rutting – A measurement of the average deformation depth of both wheel paths of asphalt pavements.
- Faulting – A measurement of the vertical separation between adjacent slabs of concrete pavements.

Figure 3-4: Illustration of Federal Pavement Condition Metrics

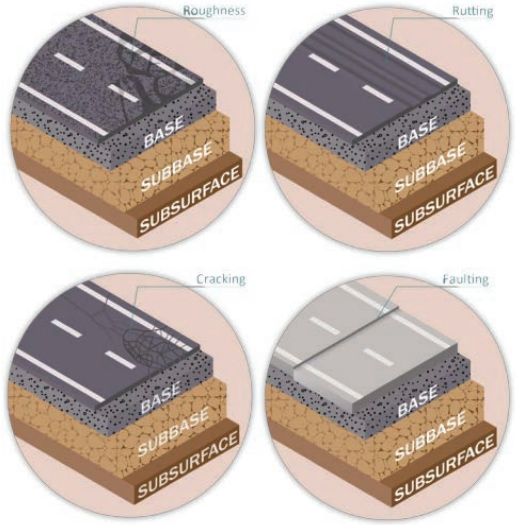


Figure 3-5: Pavement Condition Thresholds and Condition States for Federal Pavement Condition Metrics

Metric	Good	Fair	Poor
IRI (inches/mile)	<95	95-170	>170
Rutting (inches)	<0.20	0.20-0.40	>0.40
Faulting (inches)	<0.10	0.10-0.15	>0.15
Cracking (%)	<5	5-20 (Asphalt) 5-15 (Joint Concrete Pavement (JCP)) 5-10 (Continuously Reinforced Concrete Pavement (CRCP))	>20 (Asphalt) >15 (JCP) >10 (CRCP)

Figure 3-5 shows the pavement condition thresholds and condition states for the individual federal pavement condition metrics, where each metric has a condition state category of either good, fair, or poor. When combined, the individual metrics determine the overall condition in terms of the federal PCM, as depicted in Figure 3-6, where if all three applicable metrics are in good condition, the pavement is categorized as PCM good. If at least two of the metrics are in poor condition, the pavement is categorized as PCM poor. All other combinations are determined to be PCM fair. The Performance Gap Analysis chapter goes into more detail on the target-setting process for PCM. Review the Pavement Performance Management Report for more information on PCM targets and reporting.

Figure 3-6: PCM/IRI Pavement Condition Ratings

Condition	PCM	IRI
Good	Three Metrics Rated "Good"	<95
Fair	All Other Combinations	95-170
Poor	Two or More Metrics Rated "Poor"	>170

Source: MDOT Bureau of Transportation Planning

Ongoing Research to Replace Distress Index (DI)

On a two-year frequency since 1992, MDOT performed detailed surface distress (crack) type/severity surveys across the trunkline network to generate a DI that transforms the detailed data collected into a quantified index representing relative surface conditions. MDOT used DI in several interrelated ways: to assess and monitor surface condition for prospective project selection and as part of the CFP's screening procedures to verify appropriateness of proposed projects. In addition, DI time series change analysis was performed per construction fix type to develop fix-life estimates that are utilized as guidelines for project programming within the CFP process, and to support the Life Cycle Cost Analysis (LCCA) process for pavement-type selection on pending projects with large preliminary pavement cost estimates. The fix-life estimates were utilized by the RSL estimation process, which is the foundational "pavement health" input to the RQFS application used for network monitoring and planning efforts.

Changes in data collection requirements and challenges in the vendor collection industry have limited MDOT's ability to obtain reliable base data to support DI. As a result, MDOT did not collect any pavement distress data in 2020 and has indefinitely suspended the collection of highly detailed cracking data needed to compute DI. To regain consistency with the national data reporting requirements of the FHWA, in 2021 MDOT successfully returned to acquiring data on IRI, percent cracking, rutting, and faulting.

Because of these factors, MDOT has an urgent need for a new pavement cracking condition parameter that can be more readily obtained from the collection vendor's automated crack-detection technology while meeting pavement decision support needs. MDOT is working with Michigan State University and Marshall University to produce a new cracking condition parameter that can be efficiently and effectively collected and implemented, and that will be backward compatible with historical pavement data. Until this new parameter has been integrated into the RSL estimation logic, MDOT will rely on its previously collected data and calculated RSL estimates deteriorated naturally one year at a time, with engineering reviews adjusting as needed, to forecast network-level conditions until the new parameter is in place.

National Bridge Inventory (NBI) Condition Rating

The National Bridge Inspection Standards (NBIS) defines a bridge as a structure carrying traffic with a span greater than 20 feet and requires that all bridges are inspected to monitor and report condition ratings. Jurisdiction of bridges is split between MDOT, bridge authorities, and local agencies. Unlike pavements, this split has no impact on reporting methods for condition as all NHS bridges are evaluated following the NBIS.

Condition ratings are based on a 0-9 scale and are assigned for the deck, superstructure, and substructure of each bridge or as an overall rating for bridge-length culverts. Figure 3-7 identifies these components of the structure. These ratings are recorded in the NBI database. Condition ratings are an important tool for transportation asset management as they are used to maintain safety, identify preventive maintenance needs, and to determine rehabilitation and replacement projects that require funding, as shown in Figure 3-8. For more information on NBI targets and reporting, please see the latest Bridge Mid-Performance Period Report.

Figure 3-7: Anatomy of Bridge or Culvert

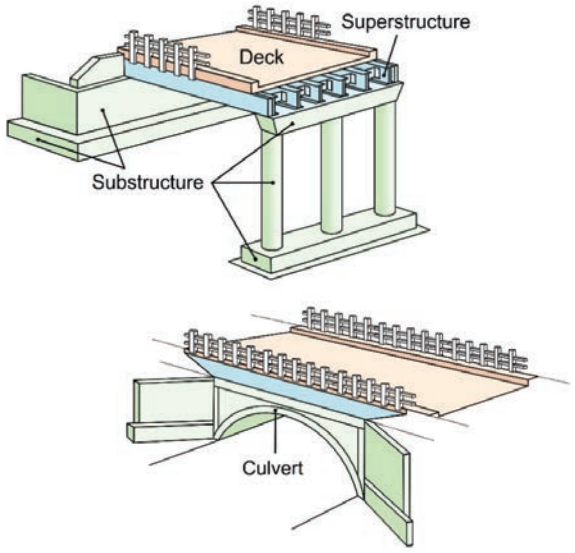


Figure 3-8: NBI Bridge Condition Ratings

7-9	Good Condition		Routine maintenance candidate.
5-6	Fair Condition		Preventive maintenance or minor rehabilitation candidate.
4	Poor Condition		Major rehabilitation or replacement candidate.
2-3	Severe Condition	Serious or Critical Condition	Emergency repair, high-priority major rehabilitation or replacement candidate. Unless closely monitored, it may be necessary to close until corrective action can be taken.
0-1	Severe Condition	Imminent Failure or Failed	Major rehabilitation or replacement candidate. Bridge is closed to traffic.

Source: MDOT Bureau of Bridges and Structures

Bridge Condition Forecasting System (BCFS)

Using the data collected according to the NBIS, MDOT enters the information into the BCFS, which is a spreadsheet-based Markovian model designed to predict the condition of Michigan's bridges. The BCFS model uses the latest four years of bridge inspection data to calculate the probability that a bridge will deteriorate over the course of the forecast period. In addition to bridge condition, inputs for the model include variables such as programmed projects, bridge management strategies, anticipated revenues, effectiveness of work types, inflation, and the cost of bridge work types.

Through this tool, MDOT forecasts anticipated conditions on local bridges and integrates them into the trunkline conditions forecasted by BCFS to predict statewide bridge conditions and identify statewide bridge needs. BCFS is described in more detail in the Life Cycle Analysis chapter.

Overview of Michigan's RSL

The federal PCM applies to all states, regardless of previous asset management efforts, and provides a standardized national snapshot of pavement surface condition – valuable at the federal level for strategic planning. While the federal PCM provides a starting place to measure the surface condition of the federal highway system, Michigan's RSL provides an assessment of the long-term health of the pavement network.

On an annual basis, the RSL estimation process begins with automation that uses inputs of project history (i.e., work type, location, and timing) and best-fit models of historically collected survey data. The outputted "Proposed RSL" values are then provided to MDOT region staff for review and adjustment as needed. Region reviews are guided by a broad range of factors including:

- Current structural health in terms of whether continued preventive maintenance treatment would be more cost-effective than major restoration, rehabilitation, or even reconstruction,
- Pavement structure (including base, subbase, and subgrade) material and dimensional quality,
- Drainage system performance,
- Construction and maintenance history,
- Traffic loading trend and quantity, and
- Surface condition in terms of cracking pattern/severity, ride quality, and rutting or faulting.

Once the region review is complete, the confirmed or adjusted values are made available to the RQFS application as an updated base-year dataset.

MDOT does not have sufficient historical data nor the forecast modeling capability to use the federal PCM to reliably predict the impact of future investments. For this reason, the agency is not yet able to base its financial strategies on the federal PCM. This issue was explored in depth with the FHWA Michigan Division during the 2019 TAMP development and this TAMP update as well. While MDOT supports the federal effort to gain a better understanding of pavement condition nationwide, for this TAMP, projections of future pavement condition will continue to rely on MDOT's RSL performance measure. MDOT continues to gather data using the federal PCM metrics, is working to obtain PCM forecast-modeling ability, and reports progress toward the PCM targets as detailed in the Performance Gap Analysis chapter.

Asset Inventory and Condition Analysis

This chapter provides a summary of the inventory and condition of lane and route miles of pavement, as well as the deck area and number of bridges on the NHS.

Pavement and Bridge Inventory

Michigan's NHS is a vital network of roads and bridges that supports the mobility of Michigan's citizens and the state's economy.

Figure 4-1 shows the NHS pavement infrastructure maintained in the state of Michigan and indicates the number of lane miles of Interstate and non-Interstate NHS pavement in the state by ownership. While MDOT manages most of the state's NHS, approximately one-fifth of the network is maintained by local transportation agencies at the county or municipal levels.

In 2016, MDOT stratified its pavement network from two tiers (freeway and non-freeway) to the following four network tiers to provide a mechanism for focusing investment on the high-volume, most economically significant roads. This stratification is show in Figure 4-3 on page 22.

1. Interstate
2. Non-Interstate Freeway
3. Non-Freeway NHS
4. Non-NHS

Analyses throughout the Michigan TAMP is done on a tiered basis, with individual analysis for Interstate and non-Interstate pavements. All tiers are covered by the department's asset management process. However, the TAMP simplifies the tiers into the pavement subnetworks noted specifically in the federal regulation and reporting requirements for the TAMP: the Intestate and non-Interstate NHS.

Figure 4-1: State of Michigan 2020 NHS Pavement Inventory

Route Type and Ownership	Lane Miles (% of total NHS)	Route Miles (% of total NHS)
Interstate (State-Owned)	6,028 (26.9%)	1238 (19.2%)
Non-Interstate NHS	16,406 (73.1%)	5,218 (80.8%)
State-Owned	12,030 (53.6%)	3,988 (61.8%)
Locally Owned	4,376 (19.5%)	1,230 (19.1%)

Source: MDOT Bureau of Transportation Planning

For bridges, Figure 4-2 summarizes the deck area of NBI structures carrying the NHS and shows the breakdown between the Interstate and non-Interstate NHS networks. Deck area numbers are based on English unit data from the March 15, 2021, NBI.

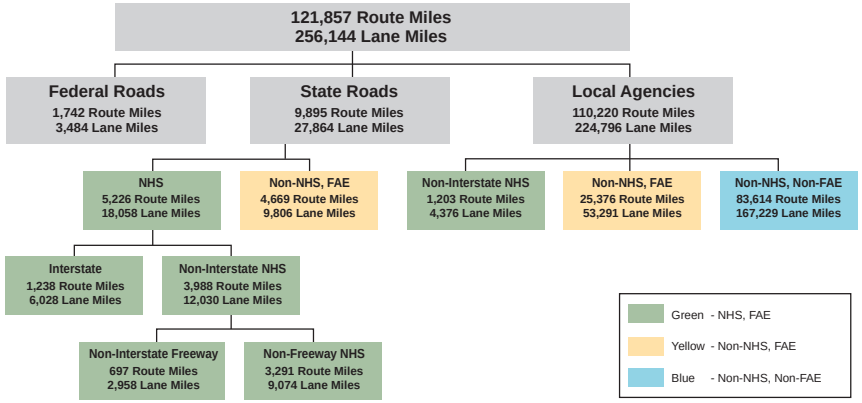
Figure 4-2: State of Michigan 2020 NHS Bridge Inventory

Route Type and Ownership	Deck Area sq. ft. (% of Total NHS Deck Area)	Number of Bridges (% of Total NHS Bridges)
Interstate	19,109,367 (51.3%)	1,247 (42.0%)
State-Owned	17,106,769 (45.9%)	1,239 (41.7%)
Bridge Authorities	2,002,598 (5.4%)	8 (0.3%)
Non-Interstate NHS	18,137,587 (48.7%)	1,725 (58.0%)
State-Owned	15,763,411 (42.3%)	1,500 (50.5%)
Locally Owned	2,332,127 (6.3%)	217 (7.3%)

Source: MDOT Bureau of Bridges and Structures

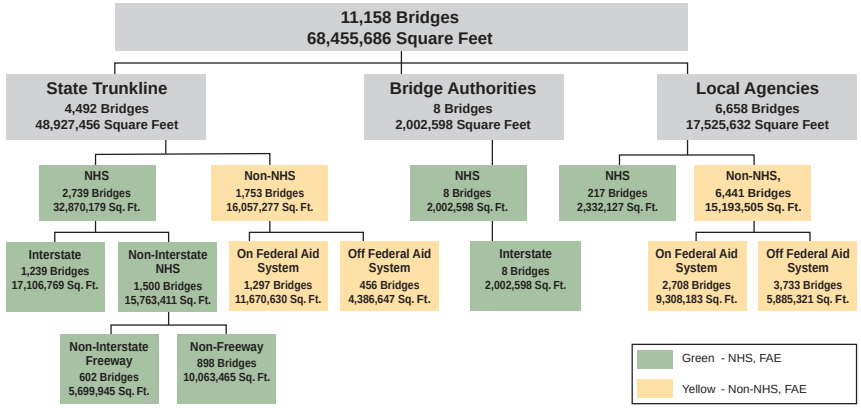
The NHS roadway and bridge system components in Michigan are indicated in green in Figures 4-3 and 4-4. To see more NHS inventory information by jurisdiction for both pavement and bridge online, visit the MDOT NHS Inventory and Condition Analysis Viewer.

Figure 4-3: Michigan's Road Network[2]



Source: MDOT Bureau of Transportation Planning

Figure 4-4: Michigan's Bridge Network



Source: Michigan Bridge Inventory

[2] *Total includes roads not under MDOT or local jurisdiction, such as state parks, federal, or roads owned by Native American tribes.*

Pavement and Bridge Condition Analysis

Pavement Condition Analysis

As previously described, MDOT's asset management process uses RSL as the primary performance measure for evaluating and forecasting pavement condition. For NHS roads that are locally owned, pavement condition is evaluated using the PASER performance measure, consistent with the data collection practices of the TAMC. While PASER data collection efforts began in 2004, the data is reported beginning in 2008 to display blended condition information on the non-Interstate NHS. Michigan continues to use these measures to track pavement health alongside the federal PCM. The different ratings for good, fair, and poor condition pavements for both RSL and PASER are shown in Figure 4-5. Together, they make up the Michigan Pavement Health Index.

Figure 4-5: Michigan Pavement Health Index

RSL and PASER Pavement Health Ratings		
Condition	RSL	PASER
Good	8+ Years	8-10
Fair	3-7 Years	5-7
Poor	0-2 Years	1-4

Source: MDOT Bureau of Transportation Planning

MDOT manages the entire Interstate system, with pavement health data exclusively using RSL data for a portion of the network, as shown in Figure 4-6. Since the non-Interstate NHS is either state-owned or locally owned, RSL and PASER data are displayed separately by pavement ownership. In addition, a combined non-Interstate NHS pavement health rating is shown using a blend of the RSL and PASER data.

Figure 4-6: Michigan NHS 2020 Pavement Health Rating

Route Type	Good		Fair		Poor	
	Percent of Network	Lane Miles	Percent of Network	Lane Miles	Percent of Network	Lane Miles
All NHS (RSL/PASER)	33%	7,505	39%	8,731	28%	6,199
Interstate (RSL)	42%	2,552	36%	2,144	22%	1,333
Non-Interstate NHS (RSL/PASER)	30%	4,953	40%	6,587	30%	4,866
State-Owned (RSL)	35%	4,183	41%	4,929	24%	2,918
Locally Owned (PASER)	18%	770	38%	1,659	45%	1,947

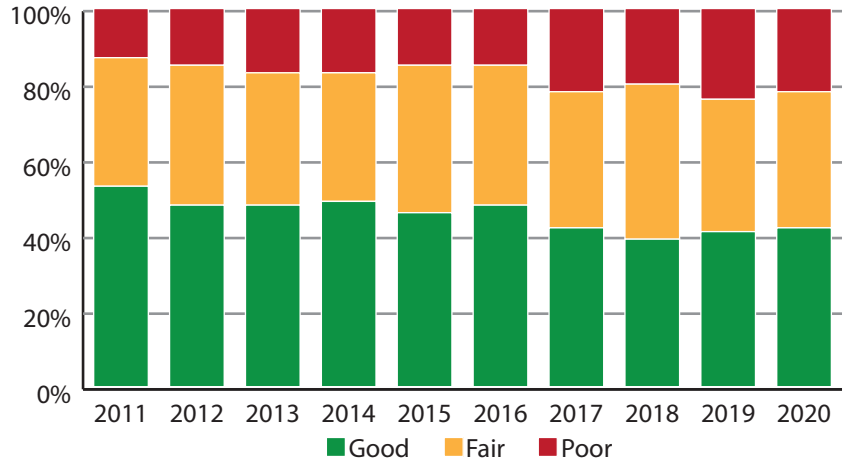
Source: MDOT Bureau of Transportation Planning

The pavement health of Michigan's Interstate system, based on the RSL performance measure, has continued to trend downward with the total percent of good health pavements decreasing. In addition, many currently fair pavements have the potential to fall into poor health in future years.

The non-Interstate NHS network's overall pavement health remained relatively stable from 2008 through 2010 based on RSL and PASER performance measures. However, due to lack of sufficient financial resources, since 2011 there has been a steady decline in good health pavements that have transitioned to fair and then into poor health. The high percentage of pavement in fair health creates a future risk that non-Interstate segments will fall into poor health.

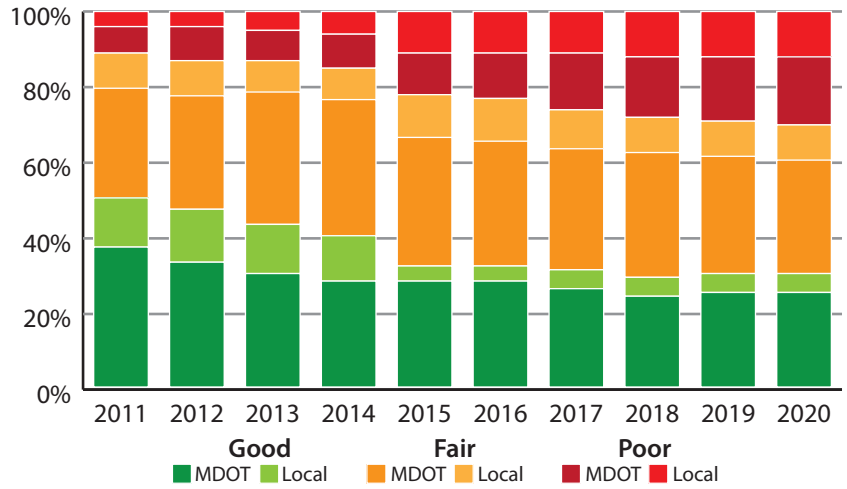
Figures 4-7 and 4-8 show the historic pavement health for both the Interstate and non-Interstate NHS networks by percent of the system in good, fair, or poor health. For each network, pavement health has declined in the past decade.

Figure 4-7: Historic Interstate RSL/PASER Pavement Health 2011-2020



Source: MDOT Bureau of Transportation Planning

Figure 4-8: Historic Non-Interstate NHS RSL/PASER Pavement Health 2011-2020

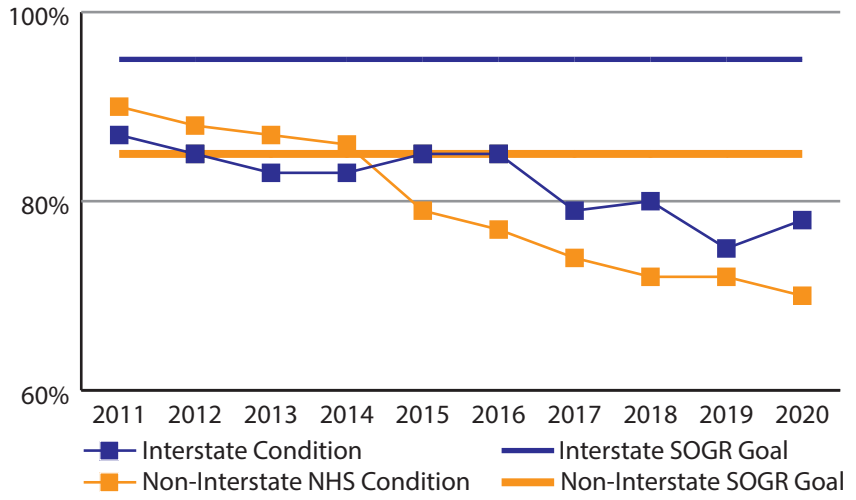


Source: MDOT Bureau of Transportation Planning

Pavement State of Good Repair

Figure 4-9 displays historic system condition based on the department's long standing RSL measure combined with PASER for the local portion of the non-Interstate NHS alongside the aspirational state of good repair goals, in alignment with the 1997 STC-established state of good repair goals for freeway/non-freeway assets.

Figure 4-9: Michigan Historic RSL/PASER Pavement Health 2011-2020



Source: MDOT Bureau of Transportation Planning

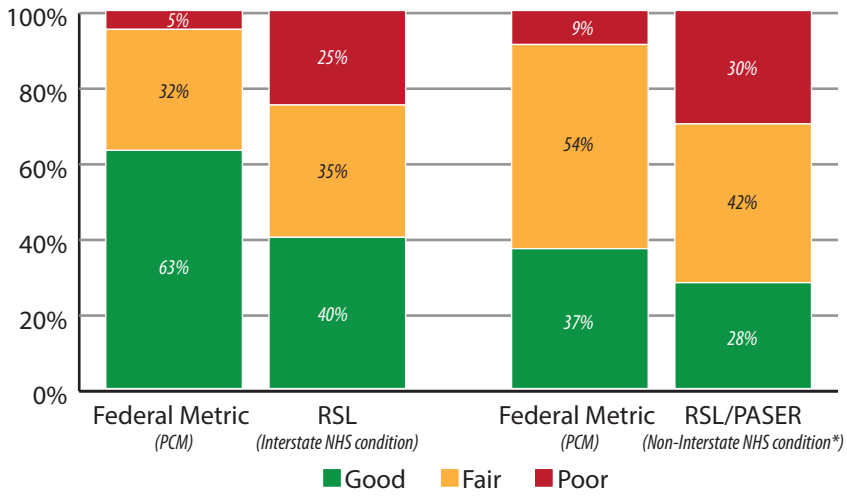
Figure 4-10 shows the current pavement condition of the NHS by PCM and IRI. It should be noted that there is a significant difference in the percentage of good, fair, and poor using these measures as compared to MDOT's RSL measure in Figure 4-11. The reason for this is that PCM and IRI evaluate surface condition, while RSL evaluates pavement health and estimates how long the pavement may remain in a condition state. The data shows the latest available data year (2019) at the time of the drafting of this document, as technical issues on the pavement side with the 2020 data collection effort significantly impacted the department's ability to report this information.

Figure 4-10: Michigan NHS 2019 Pavement Conditions - PCM and IRI

Route Type	Good		Fair		Poor	
	Percent of Network	Lane Miles	Percent of Network	Lane Miles	Percent of Network	Lane Miles
Interstate[1] (PCM)	63.6%	3,834	31.8%	1,917	4.6%	277
Non-Interstate NHS[2] (IRI)	49.5%	8,121	31.4%	5,151	19.1%	3,134

Source: 2019 HPMS submittal data, Bureau of Transportation Planning

Figure 4-11: Performance Measure Comparison 2019 Data



Note: 2019 RSL condition utilized for comparison purposes

**Includes Local NHS*

[1] *Extent excludes 122 lane miles of bridges and 180 lane miles of missing PCM condition data.*

[2] *Extent excludes 155 lane miles of bridges and 272 lane miles of missing IRI condition data.*

Bridge Condition Analysis

As discussed in the Performance Measures chapter, bridge condition is collected following the requirements of the NBIS and is recorded in the NBI for all bridges that meet the federal definition, regardless of ownership. Interstate bridge owners include MDOT and bridge authorities, and non-Interstate NHS bridge owners include MDOT and local agencies. Michigan bridge owners use a web-based inspection and reporting system called MiBridge that allows inspectors to enter both NBI component- and element-level data and provides inspection data that is accessible by the individuals managing the bridges. MiBridge provides for remote entry of data with handheld smart devices in the field for real-time bridge condition data collection. MiBridge allows the inventory to be viewed quickly on a dashboard, providing condition information and sorting functions that directly connect to the condition-based goals, ensuring that the person performing the analysis can evaluate bridge performance at the network level while drilling down to the individual structure level.

In the past two decades, investments in Interstate bridges have reduced the amount of poor deck area. MDOT used a mix of fixes to address the poor bridges, including deep and shallow deck overlays. This mix of fixes was a cost-effective way to address the large number of poor bridges. However, the service lives of those fixes are expiring and the bridges are returning to poor condition. Combining the end of fix-life for these investments with an aging infrastructure and a gap in required funding has led to some of the progress from the last decade to be lost. While poor deck areas have only started to increase in the last year, the amount of good condition deck area plateaued and then dropped significantly in the last three years, dropping almost 10 percent since the peak of condition in 2013. This increase in fair condition deck area will require an increased investment in preservation activities to slow or defer their transition to poor condition.

Non-Interstate NHS bridge poor deck area has seen all progress since 2010 lost as 2020 poor deck area exceeds that amount. Additionally, more than 10 percent of good deck area has been lost over the last 10 years. Similar to the Interstate bridges, the increase in fair condition deck area will require an increased investment in preservation activities to slow or defer their transition to poor condition. See Figure 4-12 for the full breakdown of bridge ownership and condition status, including percent of deck area in good, fair, or poor condition.

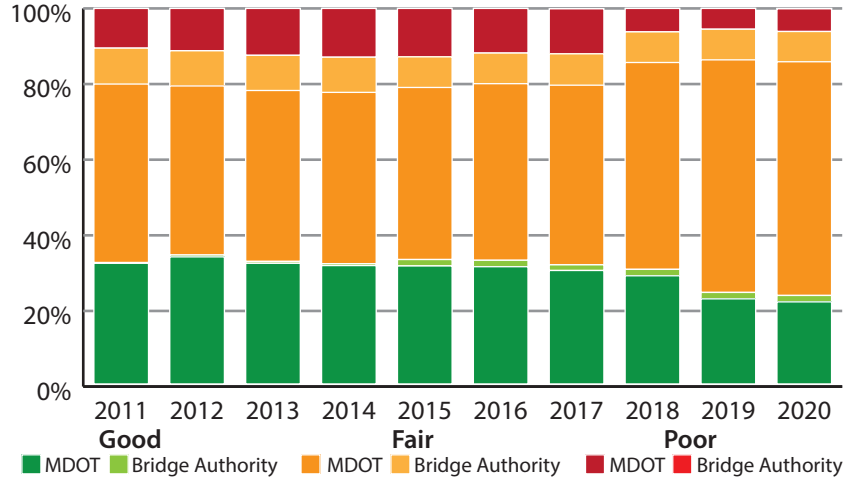
Figure 4-12: Michigan 2020 NHS Bridge Condition by Deck Area

Owner	Good		Fair		Poor	
	Deck Area	Percent	Deck Area	Percent	Deck Area	Percent
Interstate	4,470,030	23%	13,484,581	71%	1,154,756	6%
Trunkline	4,149,455	24%	11,814,502	69%	1,142,812	6.7%
Bridge Authorities	320,575	16%	1,670,079	83%	11,944	1%
Non-Interstate	4,772,714	26%	12,004,823	66%	1,360,049	7%
Trunkline	3,976,507	25%	10,747,452	68%	1,039,452	7%
Local Agencies	776,947	33%	1,234,583	53%	320,597	14%
Total NHS	9,242,744	25%	25,489,404	68%	2,514,805	7%

Source: Michigan Bridge Inventory, Bureau of Bridges and Structures

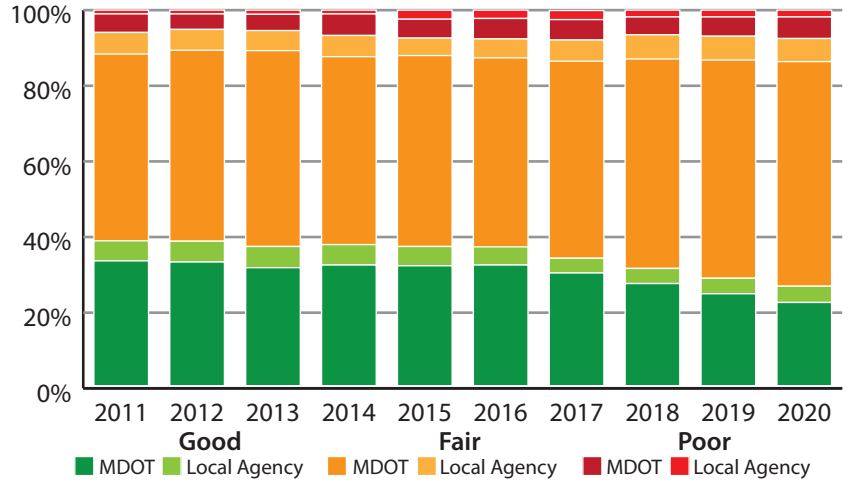
Figures 4-13 through 4-15 show the percent of Interstate and non-Interstate NHS deck area in good or fair condition based on historic NBI data. Both Interstate and non-Interstate NHS bridge conditions have improved over the past two decades; however, in recent years they have leveled out.

Figure 4-13: Historic Interstate NBI Bridge Condition by Deck Area 2011-2020



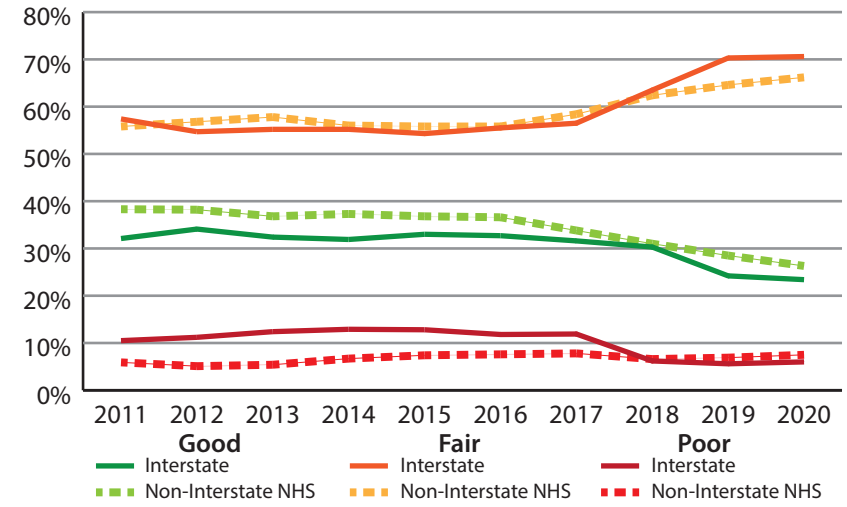
Source: Michigan Bridge Inventory, Bureau of Bridges and Structures

Figure 4-14: Historic Non-Interstate NBI Bridge Condition by Deck Area 2011-2020

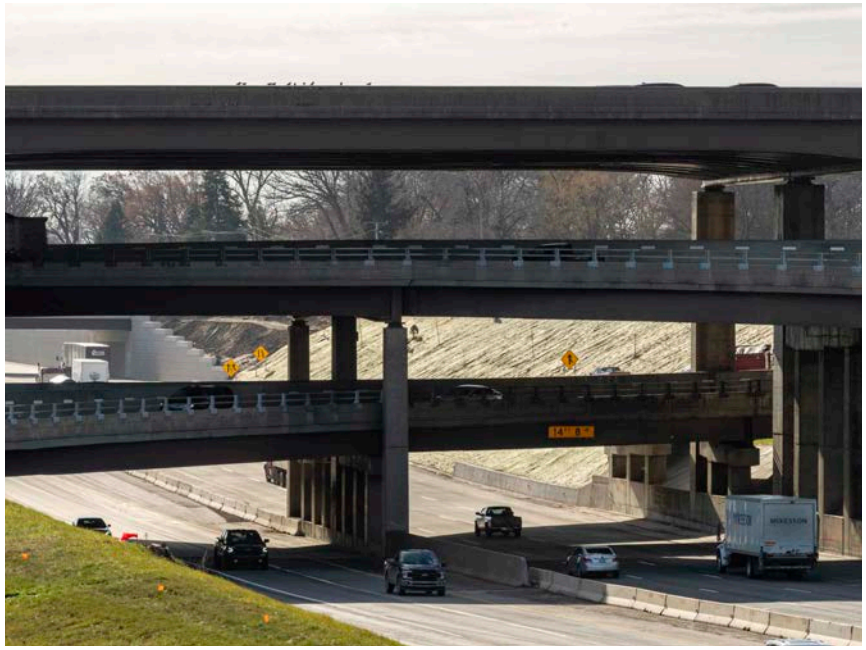


Source: National Bridge Inventory, Bureau of Bridges and Structures

Figure 4-15: Michigan Historic NBI Bridge Condition by Deck Area



Source: Michigan Bridge Inventory, Bureau of Bridges and Structures

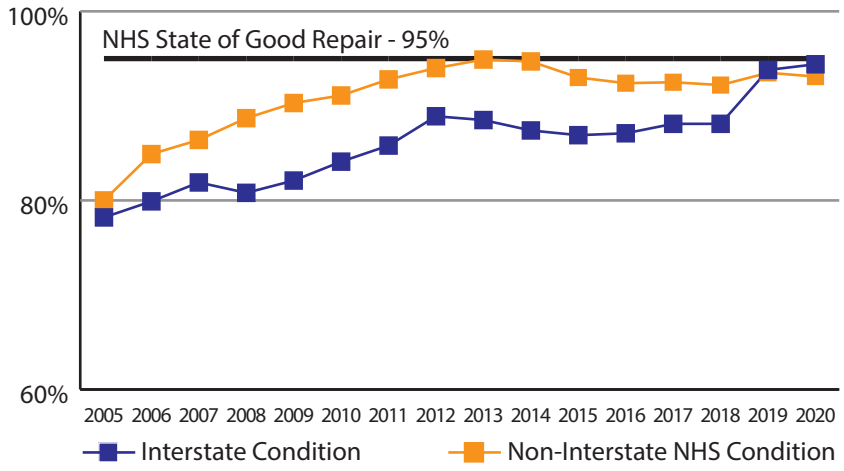


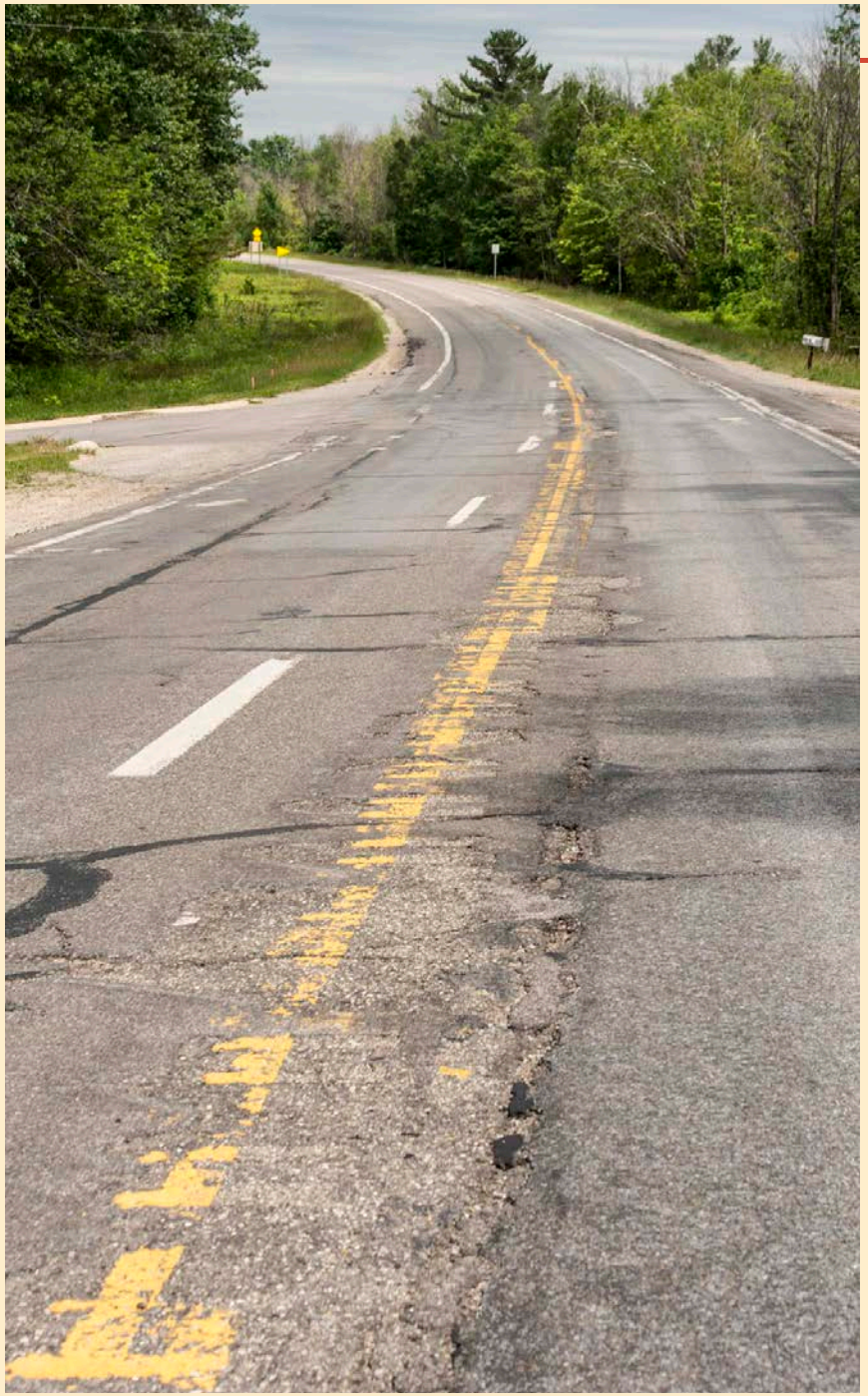
Bridge State of Good Repair

While the national bridge goals focus on NHS condition by deck area, the STC set goals based on freeway and non-freeway bridge condition by count. Measuring by deck area provides value as it can better estimate the total need, since larger bridges require a larger investment. However, each bridge is a specific link in the transportation network, and so measuring by count provides information on the number of locations in need of investment as just one link in the chain could cause disruption of the entire system. By looking at both by deck area and by count performance measures, MDOT can see a more complete picture of bridge condition.

The STC goals for bridge condition are 95 percent good or fair freeway bridges by count and 85 percent good or fair non-freeway bridges by count. MDOT freeway bridge conditions by count were maintained close to the goal through 2018. However, as projections indicated, the freeway bridge condition declined and bridge conditions are now below the freeway bridge goal and continue to drop. MDOT has met and sustained the non-freeway bridge goal of 85 percent good or fair condition since 2006.

Figure 4-16: Number of Freeway/Non-Freeway Bridges in Good or Fair Condition





Risk Assessment and Management

This chapter examines how MDOT evaluates and applies risk management as a part of the department's asset management approach and describes the processes used to identify risks to NHS pavements and bridges, NHS performance, risks related to financial planning and investment strategy development, and the steps MDOT is taking to manage these risks.

Risk Assessment and Management Process

MDOT strives to institutionalize risk mitigation as part of its ongoing investment and operations decision-making processes. This TAMP builds off the work developed for the department's 2019 TAMP, and future TAMPs will continue to augment risk management processes and associated mitigation strategies incorporated into MDOT's decision-making processes.

MDOT's risk assessment and management process follows the four analysis steps listed below:

Step 1: Define risk, risk management, and resilience;

Step 2: Identify hazards, threats, and mitigation strategies;

Step 3: Use a risk matrix to evaluate overall risk to MDOT's mission; and

Step 4: Evaluate NHS assets repeatedly damaged by emergency events.

Step 1: Define Risk, Risk Management, And Resilience

MDOT uses the FHWA definition for risk, which is "the positive or negative effects of uncertainty or variability upon agency objectives," as well as the FHWA definition for risk management, which is "the process and framework for managing potential risks, including identifying, analyzing, evaluating, and addressing the risks to assets and system performance." In addition, MDOT's recently adopted long-range transportation plan includes the following definition of transportation resilience:

"Transportation Resilience is the ability to adapt to, respond to, and recover quickly from (1) threats to physical infrastructure and routine operations of all modes and (2) threats of cybersecurity, terrorism, and all hazards. It includes reducing vulnerability and ensuring redundancy and reliability to meet essential mobility needs. Furthermore, it is the ability to minimize the impact of events across communities and ensure that the transportation system is as usable as reasonably possible following a shock or stressor."

Step 2: Identify Hazards, Threats, And Mitigation Strategies

Given the wide spectrum of hazards that can occur, MDOT decided to narrow its risk management focus for the TAMP to agency and program threats most hazardous to the transportation system. These threats are displayed in Figures 5-3 (Agency Threats) and 5-4 (Program Threats). Agency threats include changing financial, labor, and technology trends that can affect the way MDOT does business, and/or impact MDOT's ability to achieve its goals and objectives. These threats, their likelihood and impact ratings (which are defined below), and mitigation strategies are displayed in the tables to provide this information as concisely as possible.

Likelihood Definition

MDOT defines both qualitatively and quantitatively the likelihood that a threat or hazard will occur. The agency qualitatively ranks likelihood from an "almost never" chance of occurring to an "almost certain" chance of occurring, and quantitatively ranks likelihood from 1 (almost never) to 5 (almost certain) as shown in Figure 5-1.

Figure 5-1: Likelihood Rating Descriptions

5	Almost Certain:	Hazard or threat occurs frequently, often more than once annually.
4	Likely:	Hazard or threat is likely to occur at least once annually.
3	Possible:	Hazard or threat could occur at least once annually.
2	Unlikely:	Hazard or threat is unlikely to occur annually.
1	Almost Never:	Hazard or threat rarely, if ever, occurs.

Impact Definition

MDOT defines impact as the degree of transportation system disruption if a hazard occurs. MDOT's numerical consequence rating system ranges from 1 through 5 and represents the impact of risks from "minimal" to "severe," respectively. The following list provides a more detailed description of MDOT's numerical impact rating system as shown in Figure 5-2.

Figure 5-2: Impact Rating Descriptions

5	Severe:	Loss of life; Severe compromise of the strategic objectives and goals of MDOT; and Impact cannot be managed without additional funding from government.
4	Major:	Significant health and safety incident involving multiple members of the public; Significant compromise of the strategic objectives and goals of MDOT; and Impact cannot be managed without reprioritization of MDOT programs.
3	Moderate:	Health and safety incident involving multiple members of the public; Compromise of the strategic objectives and goals of MDOT; and Impact can be managed with some re-planning and modest extra financial or human resources.
2	Minor:	Minor health and safety incident involving a member of the public; Minor impact on service delivery; and Impact can be managed with current resources with some re-planning.
1	Minimal:	No loss or significant threat to health or life; Limited effect on the outcomes and/or objectives of MDOT; and Impact can be managed within current resources.

Agency Threats

MDOT identifies several agency threats in three major categories – Financial, Labor, and Technology – that, if not properly mitigated, present a risk to the department's ability to develop its highway capital program. These threats are shown in Figure 5-3 and include an associated likelihood and impact rating.

Financial

Chronic underfunding poses a significant risk to MDOT's ability to develop its highway capital program. To mitigate this risk, MDOT closely monitors expected incoming financial resources and, if needed, may employ financing mechanisms to mitigate financial gaps. Anticipated uncertainty in state and federal appropriations poses a risk as well, and MDOT continues its long-standing practice of using data to clearly describe the transportation needs both now and in the future to support timely political deliberations and appropriations.

While most transportation funding decisions are ultimately out of the department's control, MDOT partners with the American Association of State Highway and Transportation Officials (AASHTO) and other state DOTs to educate federal lawmakers about transportation funding needs. MDOT also partners with Michigan's Governor's Office, TAMC, and local road agencies to educate state lawmakers about state transportation funding needs and the importance of following an asset management approach for the most cost-effective preservation of road and bridge assets. Changes in federal regulations may also pose a risk, as the department must be able to respond to these changes that might require internal changes to staffing and other resource impacts.

Labor

Labor threats, such as staffing shortages, the ability to attract and retain talent, and staff turnover resulting in a loss of institutional knowledge, all pose a risk to MDOT's ability to develop its highway capital program. Without sufficient staff, key components of the development and implementation of the program may be delayed, and without knowledge of the intricacies of routine activities, quality assurance may be negatively impacted. To mitigate these likely scenarios, MDOT rolled out a comprehensive workforce and succession planning system known as "The House," designed to develop future leaders, assess and adjust roles and staffing, capture wisdom and information, and recruit and maintain top talent.

Technology

MDOT employs several tactics to advance its technology goals and reduce risks related to the ever-changing world of information technology (IT). The department recently hired an enterprise information management officer who provides direction and strategies to enable the department to fully utilize "big data" from ITS and connected and automated vehicles. MDOT has a Data Governance Council focused on the maintenance of data integrity. The threat of debilitating cyberattacks is a reality for many agencies around the world, so MDOT, in partnership with the Department of Technology, Management, and Budget (DTMB), has a team of resources dedicated to enhancing the security of its IT assets and works diligently to ensure its data are safe and secure.

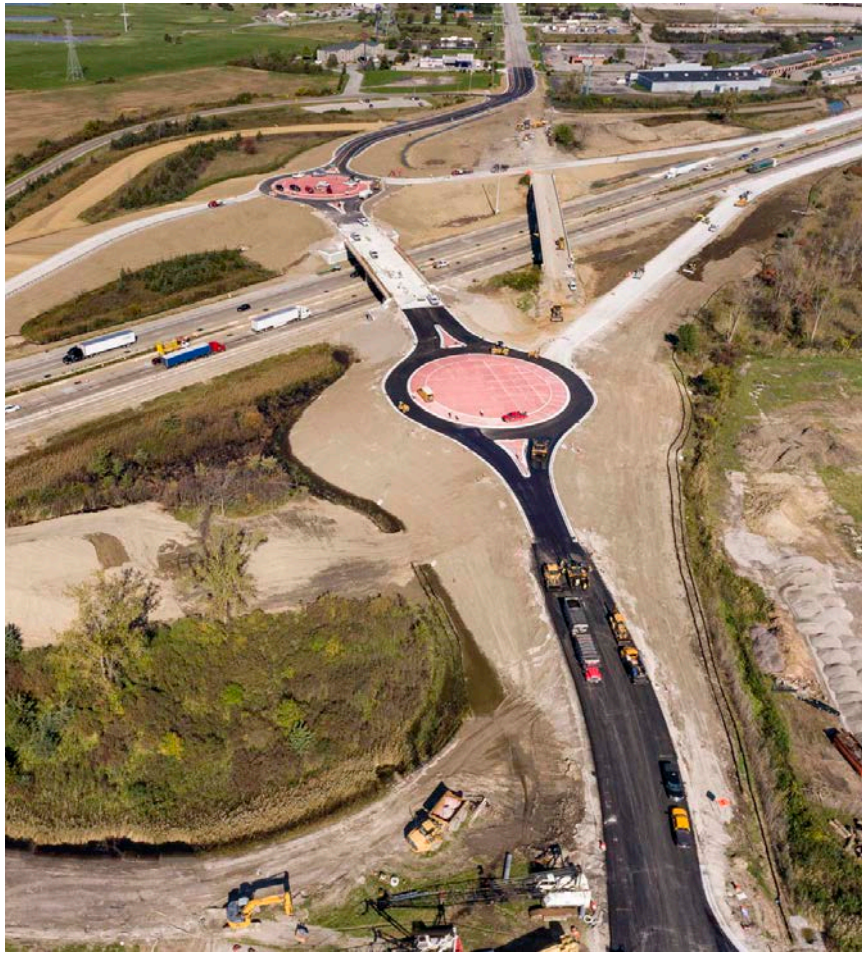


Figure 5-3:
Agency Threats Most Hazardous to MDOT

Agency Threat: Impacts what MDOT needs to develop and implement its capital program				
Category	**Threat**	**Likelihood Rating**	**Impact Rating**	**Mitigation Strategy**
Financial	Insufficient funding levels to reach agency state of good repair goals	5	4	Monitor incoming financial resources; employ financing mechanisms, such as bonding or advance construct, to shore up gaps.
	Funding appropriation uncertainty; risk of program cuts	3	4	Provide data and analysis using strategies defined herein to clearly describe the need for stable and sufficient funding that keeps pace with market changes to support timely appropriations.
	Changes in federal regulations	2	4	Monitor potential changes, brief department leadership, and advocate for MDOT's position.
	Political influences that deviate resources from the asset management approach	2	4	Provide data to support the selection of projects that aligns with asset management plans.
Labor	Staffing shortages	4	3	Targeted recruitment and retention activities in alignment with "The House."
	Ability to attract and retain talent	4	3	Implementation of a workforce development and succession planning system, a program referred to as "The House."
	Staff turnover and loss of institutional knowledge	4	3	Process documentation in alignment with "The House" objectives.
Technology	Ability to procure and implement new technology and use "big data"	3	2	Review and adjust IT structure to ensure MDOT is positioned to manage changing technology and procure new transportation system technologies.
	Cyber security	3	2	In partnership with DTMB, MDOT has a team of resources dedicated to enhancing the security of its IT assets.

Program Threats

Program risks may affect a group of MDOT projects, an MDOT program, or the ability to meet performance targets, and can include market fluctuations, climate impacts, and the age of structures and assets. Program threats are shown in Figure 5-4 and include an associated likelihood and impact rating.

Aging Infrastructure

MDOT continues to grapple with the ongoing challenge of aging infrastructure; perhaps none more challenging than MDOT's bridge network. MDOT's focus on preservation has extended the life of the average structure in the inventory and slowed the rate of structures falling into poor condition. However, the effectiveness of multiple preservation or rehabilitation projects on the same structure can diminish over time and could result in faster than expected deterioration rates or reducing the available repair options, which often leads to replacements. Any shift toward replacements, given constant fiscal constraints, would reduce the number of structures preserved each year and lead toward lower network conditions. This risk is minimal for the two-year target due to the slow deterioration of bridges; however, it is more of a concern for the four-year target and for long-term analysis and strategy setting. MDOT does not have the funding required to completely mitigate this risk, as evidenced by the projected reduced condition and performance. MDOT is working on improved deterioration models to incorporate this information to better model this risk.

Project Costs

Material and labor cost increases can lead to unexpected high bids for construction projects as well as maintenance activities. To mitigate these risks, MDOT monitors costs monthly and uses this data as part of the average prices that are used for engineering estimates, and maintenance activities are managed by MDOT's Statewide Maintenance Alignment Team, who review costs and critical maintenance needs, sometimes due to severe weather events. The team determines how best to distribute limited resources depending on need and safety considerations for the entire network. While the department cannot control material, labor, and maintenance cost increases, MDOT prepares for these events by using historical information to project future budget needs.

Climate Impacts

MDOT conducted a high-level vulnerability assessment in 2013 and plans to conduct a new assessment in accordance with new regulations and guidance from the Infrastructure Investment and Jobs Act (IIJA). The 2013 assessment identified mitigation strategies that MDOT can use to decrease the impacts of climate change-related risks. One such strategy was the collection of culvert data, an asset that, when not appropriately designed or maintained, often leads to roadway damage or closures during extreme precipitation events. This data was used to gain a better understanding of these assets and has been used to inform project scoping. To mitigate the risks associated with future climate impacts, MDOT continues to work toward the implementation of the 2013 vulnerability assessment to detail mitigation strategies needed for each asset type. The continued use of federal emergency relief funds will also play a role in the future adaptation and mitigation of this known risk.

Figure 5-4:
Program Threats Most Hazardous to MDOT

Program Threat: Impacts what MDOT needs to deliver its capital program				
Category	**Threat**	**Likelihood Rating**	**Impact Rating**	**Mitigation Strategy**
Aging Infrastructure	Preservation fixes become less effective with time	5	3	Anticipate the total future reconstruction costs needed as early as possible in the planning process.
	Emergency replacements reduce preservation resources and lead to lower network conditions, lessens ability to hit performance targets	5	3	Select conservative targets based on trend forecasting; consult with MPOs to define "reasonably conservative" and adjust targets accordingly.
Project Costs	Material, labor, and maintenance cost spikes	5	3	Monitor prices to identify ideal let timing and produce accurate engineering estimates; evaluate historical data to forecast future needs.
Climate Impacts	Threats to system operations and infrastructure from increased flooding or severe weather events	4	4	Implement the vulnerability assessment of assets and facilities to further identify the mitigation strategy needed for each asset type; Statewide Maintenance Alignment Team reviews; request emergency relief funds.

Step 3: Using a Risk Matrix to Evaluate Overall Risk

After the initial assessment, MDOT used a risk matrix approach to identify which program and agency threats posed the greatest overall risk to MDOT's ability to reach its stated goals.

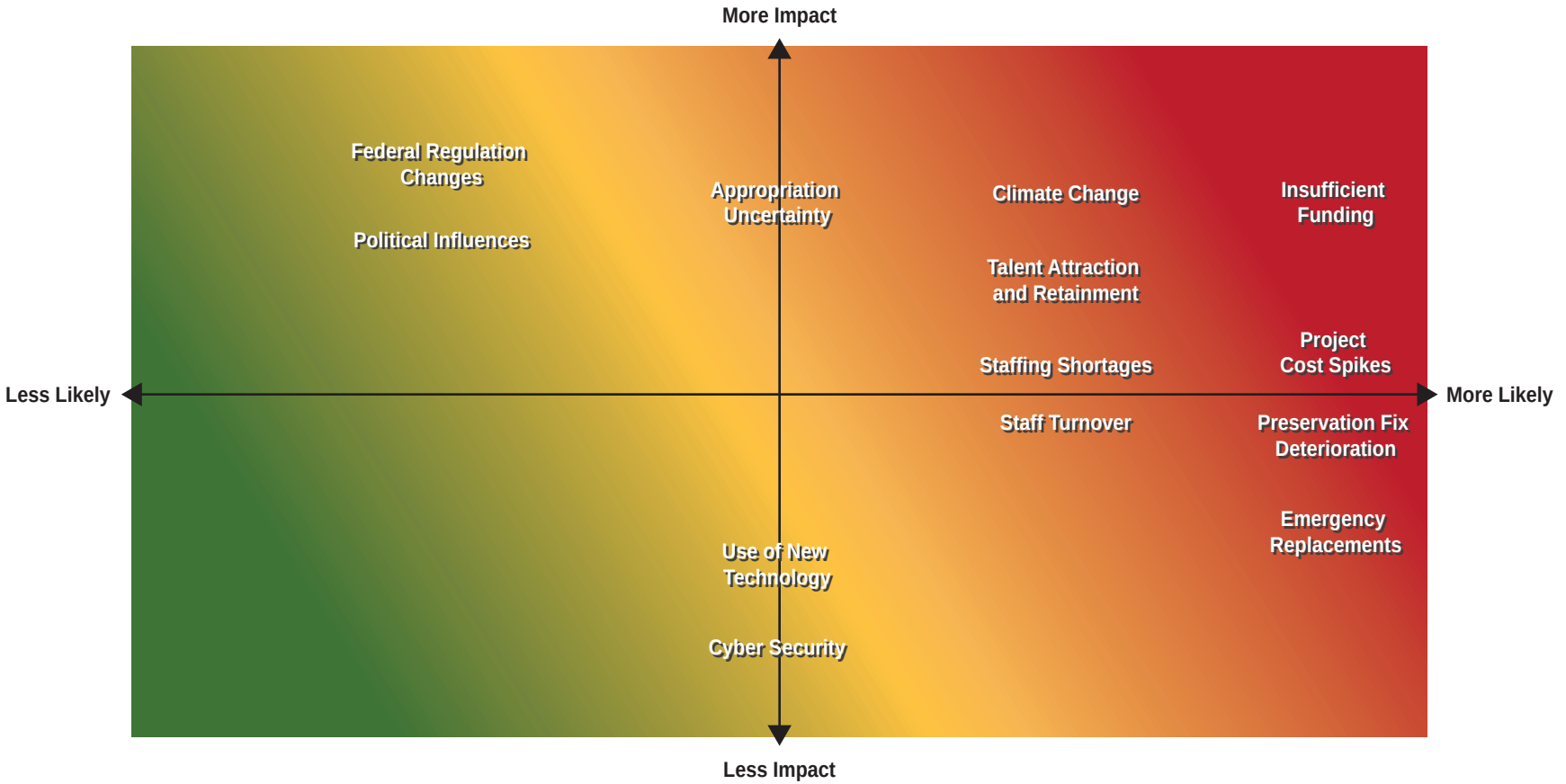
The risk matrix sets the likelihood of a threat or hazard occurring against the impact (or consequence) if the threat or hazard does occur. The combination of likelihood and impact yields the overall risk to MDOT's mission. Overall risk includes the potential for failure, including not only catastrophic failure of a transportation asset, such as a bridge, but also failure to achieve desired condition levels, preserve asset value, or ensure desired levels of service.

Overall Risk

Overall risk is defined as the combination of the likelihood of occurrence and the magnitude of consequence. Overall risk is displayed as a matrix in Figure 5-5, where the likelihood and impact of both agency and program risks are combined and overlaid on top of a color scheme that visually conveys overall risk from green (low overall risk) to red (very high overall risk).

As indicated by this color scheme in Figure 5-5, the risks that MDOT is the most concerned about are those that are both likely to occur and likely to have severe consequences when occurring. This does not mean, however, that those risks found in the green or yellow areas will be or should be ignored. There are some risks that occur regularly and require MDOT's routine attention that the agency is prepared to accommodate. The fact that these risks occur regularly, and that MDOT needs to respond each time, also suggests that varying levels of mitigation might be required to reduce the frequency and impacts of these risks. This is something MDOT endeavors to accomplish with the mitigation strategies detailed in the agency and program threat charts shown on the previous pages.

Figure 5-5:
Overall Risk – The Likelihood and Impact of Potential Agency and Program Risks



Step 4: Evaluating NHS Assets Repeatedly Damaged by Emergency Events

The review of the past 25 years, as required by 23 Code of Federal Regulations (CFR) Part 667.5, has found no instance of the same NHS roadway section or bridge having been repaired more than once using FHWA Emergency Relief Program funding. MDOT has reviewed its records and will continue to monitor, record, and issue reports regarding the use of FHWA Emergency Relief Program funding, as required by the TAMP regulations.

MDOT also reviewed the financial database for local road agencies' use of all federal emergency funds and determined there were no instances of repeated failures or damage on non-NHS routes. This database has records going back to 2000 and includes funding sources such as Emergency Relief, Emergency Relief for Rural Areas, and Emergency Relief for Urbanized Areas. MDOT will continue to monitor this data as needed to ensure compliance, as required.

Risk Management in Action: Scour Critical Bridges

As an example of risk management in action at MDOT, the following describes MDOT's approach to the risk of an increasing number of scour critical bridges. A scour critical bridge is one with abutment or pier foundations rated as unstable due to observed scour at the bridge site or a scour potential as determined by analysis. MDOT seeks to enhance bridge safety and make effective use of resources in managing bridges on a network level while ensuring safety at a bridge level. In order to accomplish these goals, MDOT uses a risk and data-driven procedure to classify and manage bridges:

Step 1: Define risk, risk management, and resilience

In 1988, FHWA initiated the National Scour Evaluation Program. The NBIS specifies that all bridges over waterways must be evaluated to assess susceptibility to scour and to determine if protection in the form of countermeasures is required to ensure the stability of the structure. MDOT uses these national standards to define the risk and to set the measures for resiliency.

Step 2: Identify hazards, threats, and mitigation strategies

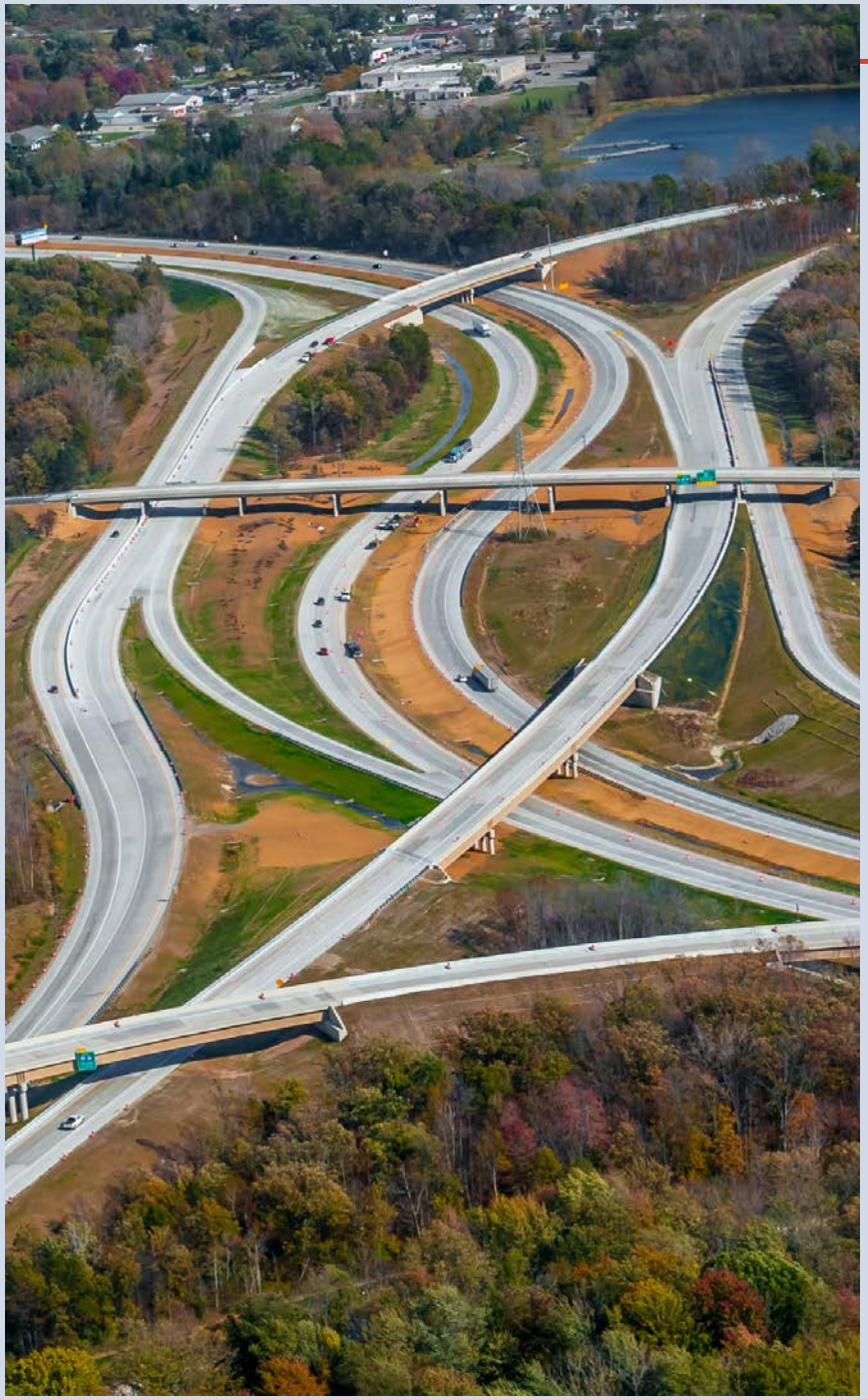
MDOT uses hydraulic analysis of scour depths combined with geotechnical and structural analysis of structures to classify all bridges according to the NBIS Scour Evaluation Rating. For Scour Critical and Scour Susceptible structures, MDOT also develops a Scour Plan of Action (POA). The POA provides requirements to monitor known and potential deficiencies and identifies mitigation strategies.

Step 3: Use a risk matrix to evaluate overall risk to MDOT's mission

Using the information contained in the Michigan Bridge Inventory and the Scour POAs, MDOT identifies factors for each bridge that contribute to the vulnerability and criticality of each structure. Each factor is weighted according to expert elicitation, and the weighted scores are plotted in a network wide matrix. This matrix is used to identify High Priority Scour Critical Structures. The MDOT CFP contains a goal to replace or mitigate 20 percent of the remaining High Priority Scour Critical Bridges during each call cycle.

Step 4: Evaluate NHS assets repeatedly damaged by emergency events

MDOT bridges impacted by emergency event-level floods have been rebuilt to meet current hydraulic standards. MDOT has found no instance of the same NHS bridge having been repaired more than once using FHWA Emergency Relief Program funding.



Life Cycle Analysis

Life Cycle Planning, as defined by FHWA, is "a process to estimate the cost of managing an asset class, or asset sub-group, over its whole life with consideration for minimizing cost while preserving or improving the condition."

This chapter provides a description of the tools used to perform life cycle analyses for proposed investment strategies on pavements and bridges.

Network-Level Deterioration Models

MDOT uses two pavement condition analysis tools mentioned in the Performance Measures chapter - RQFS and PCFS - to evaluate pavement condition, deterioration, and to perform forecasting for state and locally owned roads, respectively, and one model for bridge assets: BCFS. While these life cycle tools do not include the federal performance measures, they are used to develop and implement strategies to achieve and monitor progress toward state condition targets as established by the STC.

Trunkline Condition Forecasting: RQFS

A combination of staffing expertise and data inputs allow RQFS to produce network-level strategies and conclusions for the life cycle analysis needed for program development decision-making. Reports can be produced using RQFS on pavement condition forecasts, RSL category information, percent of the network rehabilitated, program cost, and detailed investment strategies showing category-to-category shifts for reconstruction, rehabilitation, and capital preventive maintenance (CPM).

There are four inputs to RQFS:

1. Pavement Condition File (PCF),
2. Investment strategies,
3. Treatments costs, and
4. Inflation rates.

The PCF stores RSL information and is updated annually by MDOT staff in the Data Inventory and Integration Division (DIID). Investment strategies, based on existing funding and "what if" scenarios, identify specific percentages or lane miles of the pavement network that are selected for condition improvement, therefore moving these pavement selections from a lower RSL category to a higher RSL category. These investment strategies are finalized by MDOT experts familiar with pavement deterioration and knowledge of what is best for the system. Average treatment costs are calculated using eight years of cost per lane mile data gathered from past and planned projects (see Figure 6-1). These costs are filtered, reviewed, and averaged based on work type, region, and pavement network. A standard inflation rate is built into RQFS for more accurate forecasting. MDOT uses this tool in all phases of asset management from initial investment strategy development to project selection, and for program monitoring and reporting.

Pavement Fix Types and Treatment Costs

MDOT uses a variety of work types to implement an asset management-based mix of fixes approach on pavements, which are applied throughout the life cycle of the asset. Pavement investments are distributed primarily between two main funding templates: Reconstruction and Rehabilitation (R&R) and CPM, which is preservation. Within these two templates there are several work types that are used to develop a mix of fixes. The goal is to implement the right fix at the right time in the life cycle to maximize the life of the asset and minimize the cost to maintain it. The R&R and CPM funding templates include three main categories of eligible work:

1. **Reconstruction** – Work that completely reconstructs the roadway from the base up.
2. **Rehabilitation** – Work that mostly reconstructs the roadway, such as crush and shapes, inlays, or two-course overlays. This work does not go down to the base material.
3. **Preservation (CPM)** – Work that improves or seals the roadway surface, such as milling and single-course overlays, joint and surface spall repair, chip seal, and micro-surface. This work does not include deeper repairs dealing with the base and sub-base.

Figure 6-1: Pavement Work Types and Average Costs

Fix Type	RSL Replacement (in Years)	Statewide Average Cost per Lane Mile
Reconstruction	18-26	$1,800,000 - $3,000,000
Rehabilitation	6-26	$250,000 - $1,900,000
Fix Type	**RSL Extension (in Years)**	**Statewide Average Cost per Lane Mile**
Preservation	1-10	$17,000 - $195,000

Investment Strategy Development

Investment strategies developed for the CFP consist of the expected investment distribution of available revenue amongst the available templates for road, bridge, safety, and other state and federally funded program categories. Each template has guidelines as part of the process as defined in the CFP manual. As jobs are programmed and completed, MDOT tracks and evaluates pavement condition on a project-by-project basis and uses that project-level data to develop network-level assumptions of what sort of life-adding benefits individual fix types can provide. These network-level assumptions are updated as needed.

The Pavement Operations Group tracks the performance of each work type, evaluates the potential life extension and cost of the fix, and determines the need for new work types. New fixes can be implemented using Emerging Technology funds for CPM fixes and through demonstration projects for rehabilitation and reconstruction fixes.

R&R Template

The R&R template has the most complex allocation formula of the pavement templates. It assesses 15 different data items and identifies their distribution regionally. Regions receive a portion of R&R funding in proportion to the established data item weight multiplied by their share of that item. Figure 6-2 indicates the weight of each data item.

Cost

Construction costs make up 25 percent of the target allocation formula, taking into consideration average regional costs per mile as well as urban populations that can increase the cost of traffic maintenance during construction.

Condition

Condition represents 50 percent of the allocation formula for good reason. Addressing pavement structural and surface needs is the goal of the R&R program. This formula allocates funding where the federal PCM and Michigan's RSL are rated either fair or poor.

Figure 6-2: R&R Resource Allocation Formula

	Weight		Bay	Grand	Metro	North	Southwest	Superior	University	Statewide
Cost										
25%	10.0%	% Lane miles - Urban over 50k Population	6.7%	7.2%	71.3%	0.0%	6.6%	0.0%	8.1%	100.0%
	10.0%	TAMP (I&II) Cost	14.4%	11.4%	17.8%	11.7%	14.5%	12.0%	18.2%	100.0%
	5.0%	TAMP (III & IV) Cost	16.6%	14.1%	18.4%	10.0%	14.7%	10.1%	16.1%	100.0%
Condition										
50%	6.0%	% PCM= Fair or Poor TAMP I	17.3%	11.2%	29.1%	4.6%	11.2%	1.0%	25.6%	100.0%
	3.5%	% PCM= Fair or Poor TAMP II	21.0%	21.9%	19.6%	7.4%	8.1%	0.0%	21.9%	100.0%
	3.5%	% PCM= Fair or Poor TAMP III	16.4%	10.0%	25.9%	12.8%	7.5%	14.4%	13.0%	100.0%
	2.0%	% PCM= Fair or Poor TAMP IV	19.0%	17.5%	2.5%	18.0%	14.0%	14.5%	14.5%	100.0%
	14.0%	%RSL <=7 - TAMP I	15.5%	7.6%	34.6%	5.2%	11.5%	3.4%	22.2%	100.0%
	8.0%	%RSL <=7 - TAMP II	20.8%	18.4%	19.6%	6.4%	6.1%	0.0%	28.6%	100.0%
	8.0%	%RSL <=7 - TAMP III	16.6%	10.0%	26.9%	9.3%	7.2%	17.6%	12.4%	100.0%
	5.0%	%RSL <=7 - TAMP IV	23.5%	15.5%	2.2%	15.4%	15.2%	12.1%	16.2%	100.0%
Usage										
25%	5%	% VMT RSL <=7	13.7%	11.4%	38.2%	4.4%	8.6%	2.9%	20.8%	100.0%
	7%	% Commercial VMT RSL <=7	11.6%	10.5%	27.1%	3.7%	15.3%	3.0%	28.9%	100.0%
	7%	% Lane miles RSL <=7 Comm AADT 5,000+	2.1%	7.2%	42.0%	0.0%	15.1%	0.0%	33.6%	100.0%
	6%	% Lane miles RSL <=7 AADT 50,000+	9.4%	4.8%	61.0%	0.0%	5.4%	0.0%	19.5%	100.0%
Resulting 2027 New Target With Updated Data			**$91.86**	**$70.57**	**$208.78**	**$40.42**	**$66.93**	**$34.85**	**$131.10**	**$646.50**

Usage

Usage makes up 25 percent of the allocation formula and helps the department direct funding where Michigan's motorists are driving most frequently, maximizing investment for public benefit. This formula considers both passenger and commercial traffic volumes and adds extra weight for high-traffic locations in poor condition.

Capital Preventive Maintenance (CPM) Allocation

Similar to the R&R allocation formula, the CPM allocation formula in Figure 6-3 measures regional share of data items to distribute funding. However, the CPM formula has a reduced number of data items with a greater focus on regional share of lane miles eligible for preservation work types.

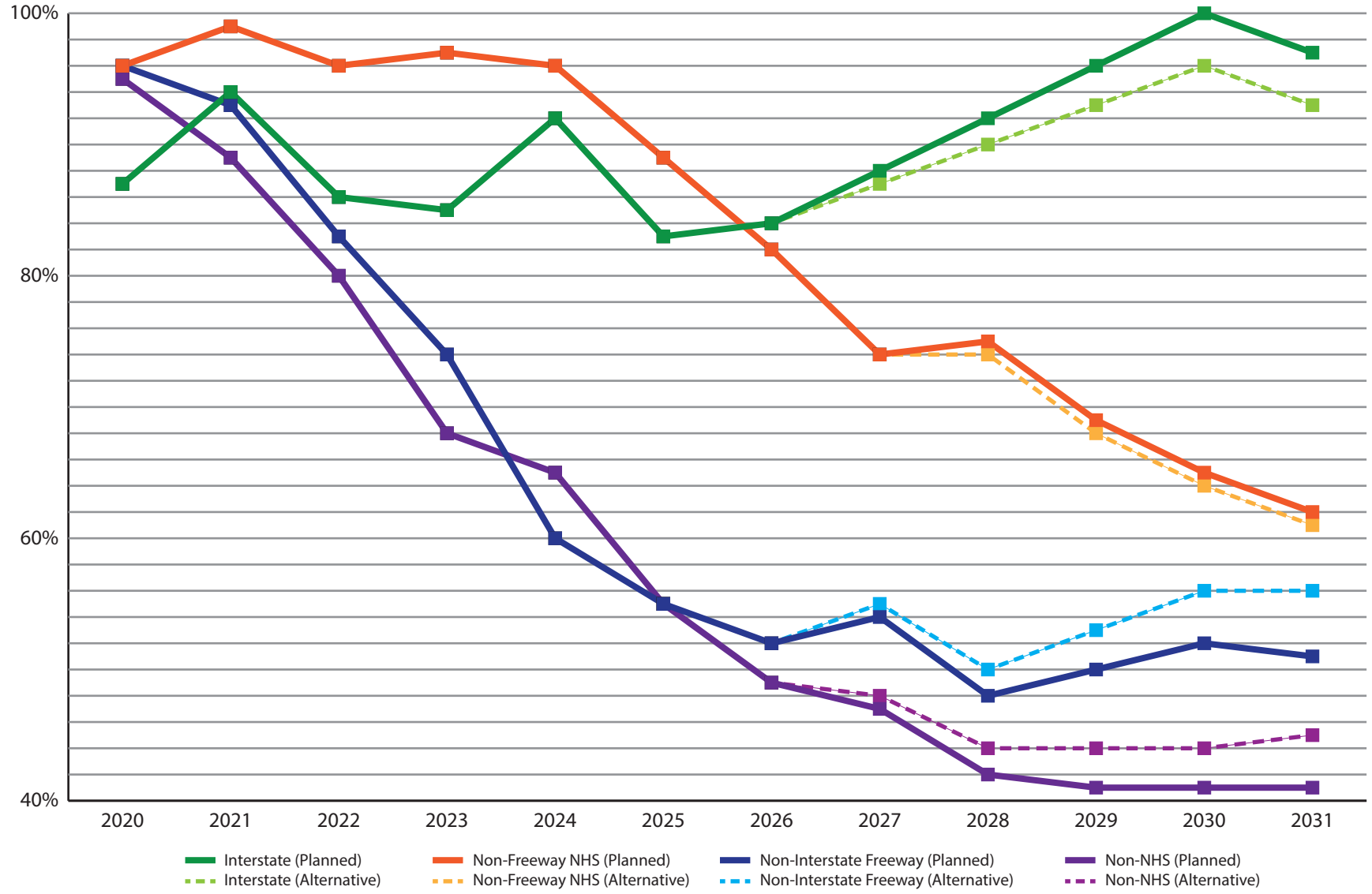
Strategic Direction

As mentioned, MDOT stratifies the trunkline system into four tiers. Internally, strategic direction is used to prioritize investment in the freeway network, requiring a minimum level of investment in those tiers. Recently, MDOT has investigated these required investments to reconsider the balance of freeway and non-freeway conditions. Utilizing RQFS, alternatives were considered, comparing the invested amounts to long-term impacts to network condition. Figure 6-4 demonstrates how these analyses were explored regionally, with the Grand Region impacts shown as an example.

Figure 6-3: CPM Resource Allocation Formula

	Weight		Bay	Grand	Metro	North	Southwest	Superior	University	Statewide
Cost										
20%	20.0%	CPM Cost Factor All Tiers (60% functional enhancement and 40% surface seals)	14.0%	13.0%	15.0%	15.0%	15.0%	10.0%	17.0%	100.0%
Condition										
65%	65.0%	% RSL >=7 - CPM Eligible Lane Miles	16.0%	19.0%	8.0%	19.0%	10.0%	20.0%	8.0%	100.0%
Usage										
15%	7.5%	% VMT RSL >=7	15.0%	23.0%	21.0%	10.0%	12.0%	6.0%	13.0%	100.0%
	7.5%	% Commercial VMT RSL >=7	15.0%	23.0%	12.0%	7.0%	22.0%	6.0%	16.0%	100.0%
Resulting 2023 New Target With Updated Data			**$13.12**	**$15.89**	**$9.18**	**$13.85**	**$10.13**	**$13.39**	**$9.43**	**$85.00**

Figure 6-4:
Grand Region RSL Pavement Condition Forecast



Local Condition Forecasting: PCFS

PCFS is the forecasting tool used to model network-level deterioration and forecast future condition for NHS pavements that are owned by county and/or local agencies in Michigan. The PCFS uses the latest four years of pavement condition PASER ratings to calculate the probability that a segment of road will deteriorate over the course of the forecast period. In addition to pavement condition, inputs for the model include such variables as pavement mix of fixes strategies, anticipated revenues for road construction and maintenance, and the cost of road repairs.

In PCFS, work type categories are assigned a cost per lane mile based on underlying project costs and lane miles treated. Investment strategies are an expression of the amount of work that can be done within a work type category (e.g., road reconstruction, rehabilitation, or preventive maintenance) within a specified amount of time. For the local NHS system, this is measured by examining the types of local projects and where and when they occur. This information comes from project reporting and tracking software, JobNet, and the Investment Reporting Tool accessed through the TAMC website.

The input investment strategy determines how much work will be performed by work category by accounting for the percent budget allocated for the work and the cost per lane mile for the treatment category. In PCFS, the work type categories are applied to the following PASER ratings with the new PASER rating shown in Figure 6-5.

Figure 6-5: Impact of Work on PASER Rating

Original PASER Rating	Work Category Applied	New PASER Rating
Ratings 1-2	Reconstruct Candidate	10
Ratings 3-4	Rehabilitation Candidate	9
Ratings 5-7	CPM - Heavy	7 or 8
Ratings 5-8	CPM - Light	Maintains current rating 5-8

The high-level calculation for PCFS factors in the current condition of the local NHS network against the lane miles treated in the various categories against the deterioration rates applied in the model. These calculations are repeated for every increment of time developed in the model (PCFS – every two years) and as far out as necessary (typically, 10-year forecasts).

Because there are multiple local jurisdictions involved in managing the local NHS system, an adjoined asset management plan or investment strategy is not available. The local investment strategy is developed from many local project lists and not based on one plan or locality. By examining historic, present, and future local project lists, assumptions can be made on how local agencies will continue to invest in the future.

PCFS can be used to forecast and analyze outcomes of proposed or hypothetical investment strategies, which allows the TAMC to analyze potential "what if" scenarios, such as "what would our network condition be if we moved 10 percent of our reconstruction budget and invested that amount in CPM projects?" This type of analysis is helpful in the decision-making process.

Figure 6-6: Alternative Investment Strategy Example for Local Pavements

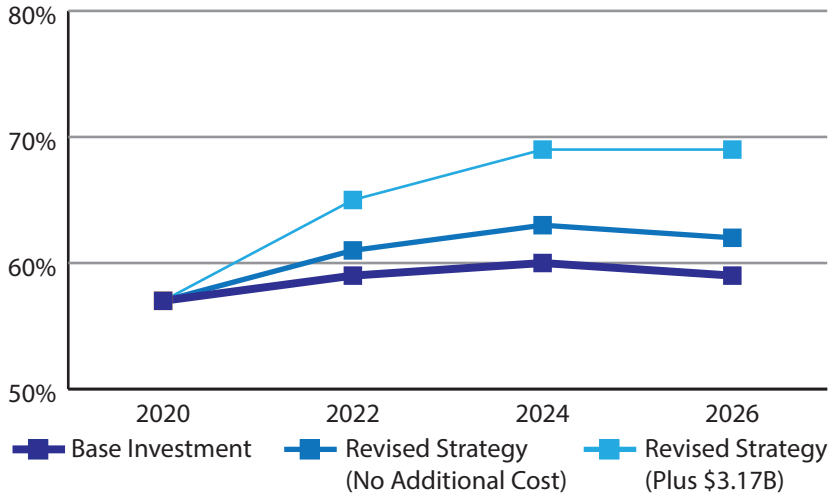


Figure 6-6 provides an example of how the pavement condition would change given modifications in funding and/or how those dollars are allocated to certain work type categories as identified in the selected investment strategy.

The PCFS model allows for analysis across the entire NHS system and can show the impacts on the overall condition based on funding or the mix of fixes that are utilized. When reviewing alternative strategies, the model showed more improved system performance when optimizing the mix of fixes when compared to only increasing the funding. A stronger focus needs to be placed on a better mix of fixes and pavement preservation to continue to improve the overall condition of the network.

Bridge Condition Forecasting

Bridge Work Types

MDOT uses a variety of work types to implement an asset management-based mix of fixes for bridges that are applied throughout the life cycle of each bridge. The primary goal is to maintain safety of the public as they cross over or under the structure, and the secondary goals are to implement the correct fix at the correct time on the correct structure to maximize the life of the individual assets as well as the overall bridge network. This must happen while also considering the work activities of other programs, such as pavement, and minimizing impacts to mobility through coordination of construction activities.

Bridge work types include Replacement (i.e., bridge or culvert replacement, superstructure replacement, substructure replacement, and deck replacement), Rehabilitation (i.e., deck overlays, barrier replacements, strengthening, etc.), and Preservation (i.e., deck sealing, patching, minor repairs, etc.). Replacement is generally performed on bridges in poor condition and will put the component in good condition. Rehabilitation is generally performed on bridges with ratings of 4-5. Rehabilitation can return the component to good or fair condition. Preservation is usually performed at an NBI rating of 6-7. It may slow deterioration, leaving the component in its current condition, or it may improve the condition slightly. When evaluating the impact on the overall bridge rating, the individual component ratings are considered. For example, a bridge with a fair superstructure that undergoes a deck replacement would have a good deck, but the fair superstructure controls the overall bridge rating, which would remain in fair condition for the purpose of the performance measures.

MDOT uses these work types to predict future network conditions based on project selections, strategies, and funding levels. To achieve the most accurate predictions possible, MDOT routinely reviews work types for average costs as well as estimating the resultant component rating. For example, a recent analysis shows that over the last three years of projects, a Rehabilitation project typically cost $1,220,000 (see Figure 6-7). From a starting population of bridges with a component rating of 4, 5 and 6, the replacement projects improved the structures where 30 percent were rated 5, 44 percent were rated 6, and 26 percent were rated 7. These results will be used in the network analysis to predict future conditions of potential projects.

Figure 6-7: Bridge Work Types and Network Analysis Values

Work Type	Average Cost	NBI Rating	0-4	5	6	7	8-9
Replacement	$6,900,000	Start Condition	85%	15%			
		End Condition			9%	26%	65%
Rehabilitation	$1,220,000	Start Condition	43%	42%	15%		
		End Condition		30%	44%	26%	
Perservation	$550,000	Start Condition		50%	50%		
		End Condition		25%	50%	25%	

Source: Bureau of Bridges and Structures

Bridge Life Cycle Costs

MDOT evaluates life cycle costs at both the network and bridge levels using different methods. At the bridge level, life cycle costs are evaluated during project scoping. For unique structures or projects, MDOT uses a LCCA spreadsheet to compare project costs and residual value of multiple work activities for a specific structure. MDOT has also performed studies to develop guidelines to predict least life cycle costs for typical structures for use in project selection. Since deck condition tends to drive most project selections, MDOT developed a preservation matrix for decks. Using the transition rate calculations within the BCFS, MDOT very recently evaluated the time to poor for decks with black bars, epoxy coated reinforcement, stainless steel, and fiber reinforced polymer (FRP). The black bar results are used to provide guidance on the timing of preservation actions of our existing bridges. The epoxy coated, stainless, and FRP results will be used both to provide guidance on preservation timing as well as to develop use cases for when it is cost effective to use stainless steel reinforcement rather than epoxy coated reinforcement. This document allows all bridge decision-makers in Michigan to benefit from the LCCA without having to run the analysis themselves. To use the chart, the decision-maker would look at the condition of the deck top and bottom surface and then select the appropriate repair option, potential result of the repair, and the anticipated fix life.

Bridge Network Life Cycle

MDOT uses BCFS to perform network-level analysis. By tracking the rate at which bridges have declined in the past, MDOT is able to predict the rate at which bridges will decline in the future. MDOT has an established process through which trends in bridge deterioration rates can be evaluated at regular intervals. These periodic reviews show whether preventive maintenance and other small actions taken on bridges are effective over time. BCFS uses the current minimum NBI conditions of the inventory as the starting point of the analysis. Anticipated budgets are entered to predict future work that will be performed on the network. BCFS also requires a preservation strategy to be entered that is used to dedicate a percentage of the budget to each primary work category. Project costs are entered for each category so that BCFS can calculate how many projects in each category can be performed. The anticipated benefits of each main work category are entered as an input and are used to determine the impacts of the proposed budgets. BCFS can also account for programmed projects.

The cornerstone of BCFS is calculating and applying transition probabilities. Using the changing minimum NBI condition rating over time, BCFS calculates the likelihood that a structure will change from one minimum condition rating to another. A matrix is developed from the historic data and is applied to the entire network of bridges to project condition out each successive year included within the analysis. This projected network condition is a combination of deteriorating the calculated percentage of bridges in each condition rating and improving bridges based on future projects, budgets, preservation strategies, and the preservation path increasing or maintaining conditions.

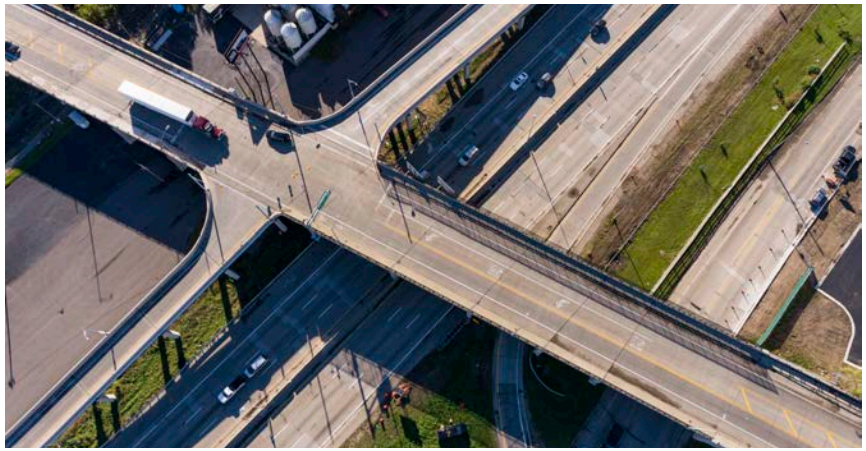
For bridges, the minimum component condition rating is forecasted using BCFS at the network level. Deterioration is performed at the bridge level, or in units of "each." Average deck areas are then applied to the assumed number of bridges expected to deteriorate. As the required measure is in square feet of deck area, there will be an increased level of uncertainty as compared to reporting in units of each. In alignment with the goals set by the STC, MDOT evaluates bridge condition by bridge in addition to the national performance measures by deck area. While monitoring by deck area reflects the impact in terms of cost of exceptionally large bridges, monitoring conditions by each reflects that each bridge is a discrete link in the transportation network. Through evaluating the projected condition of the network by bridge count and by deck area under different strategies, MDOT can identify the ideal mix of fixes as well as measure the gap in resources required to achieve various goals.

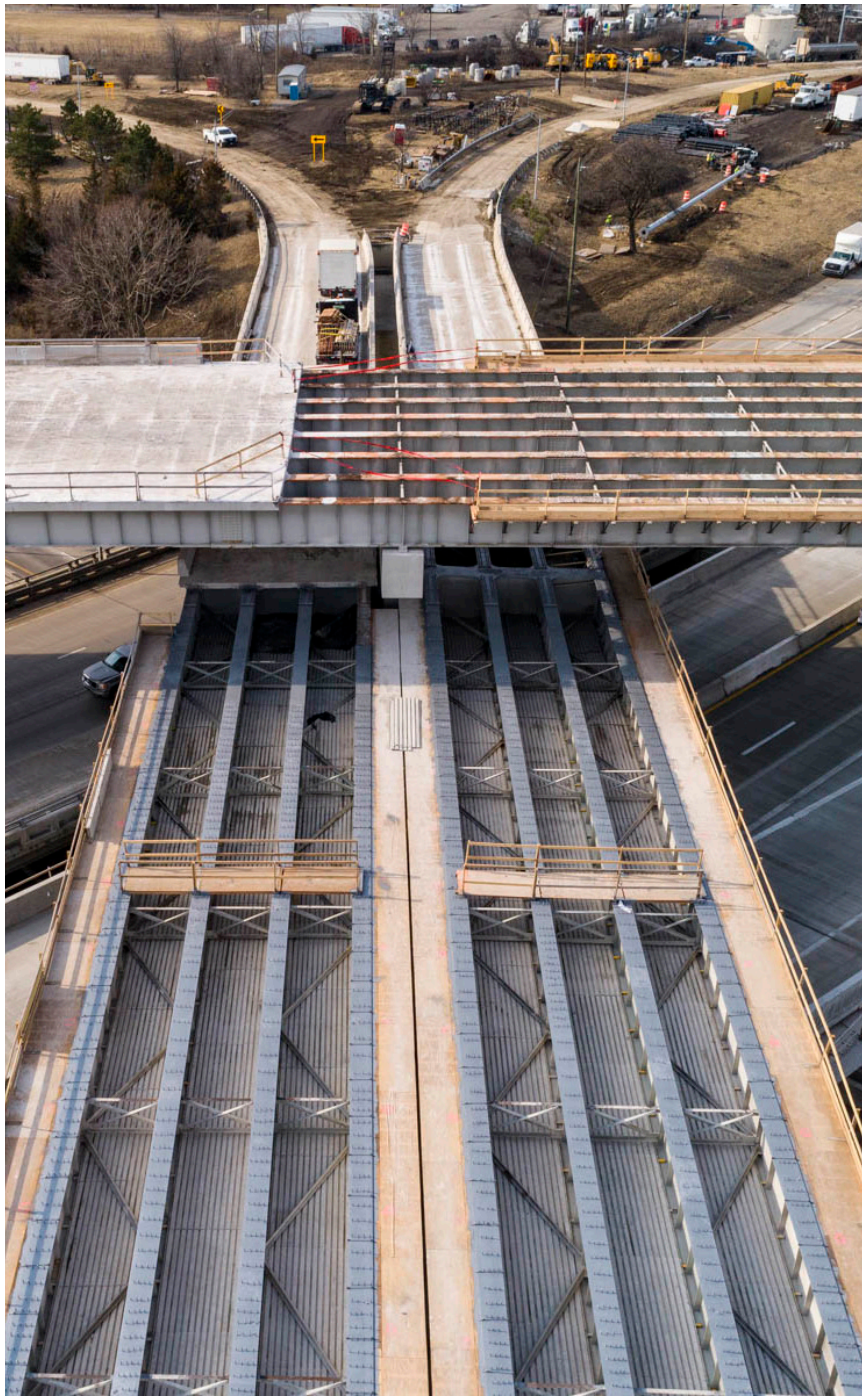
MDOT is in the process of incorporating AASHTOWare Bridge Management (BrM) software as an additional tool to improve deterioration models at the bridge level using a combination of component and element-level condition ratings. MDOT is also participating in a Midwest pooled fund to aid in calibrating this advanced method. MDOT will implement this process, when the calibration is complete, to help inform the projections.

Integrating Resiliency and Life Cycle Management

Resilience considerations are an important part of managing an asset's life cycle, especially under the specter of climate change. One of Michigan's biggest climate change-related concerns is increased flooding that can damage transportation assets severely, impact underserved communities disproportionately, and sever critical access to goods and services. MDOT is particularly concerned about its highway assets along the shores of the Great Lakes and its depressed freeway sections in heavily traveled urban areas, which are most susceptible to flooding shocks.

In the Risk Assessment and Management chapter, the process MDOT uses to address resiliency for scour critical bridges is described in detail. For the resiliency of pavements, MDOT continues to explore the use of different techniques. As an example, the MDOT Metro Region worked with the Southeast Michigan Council of Governments (SEMCOG) to build a tool to assess and identify high flood risk highway sections in the SEMCOG region. These flood risk evaluation tools are first being used in MDOT's Metro Region as a proof of concept with hopes of eventually rolling out the tool across the state. In addition, to help address flooding in depressed freeway sections, MDOT is investigating ways to use its asset management software system for more effective pump station life cycle management. Using existing software in this way will allow condition data to inform investment decisions in pump station infrastructure. As an example, MDOT is exploring how to use daily pump station data to aid in the deterioration calculation of existing pump station infrastructure. The department hopes that such data will help ensure this infrastructure is functioning appropriately during extreme precipitation events.





Financial Plan

This chapter describes the sources of funding available for Interstate and non-Interstate NHS pavement and bridge investments, how future revenues available for capital improvements are estimated as part of the financial plan development process, how the value of capital assets is determined, and how the cost of work to sustain those assets is calculated. It also provides 10-year projections of revenue available for capital investments based on the best available data.

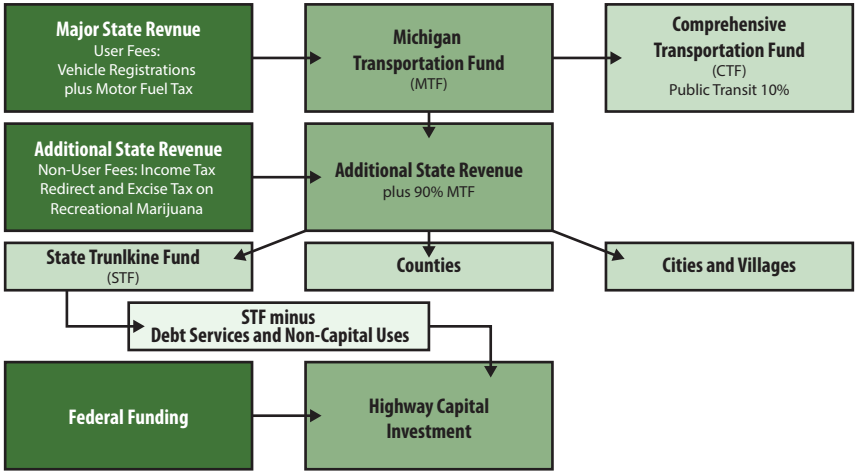
Identifying Funding Sources and Estimating Funding

Funding for the NHS system is comprised of federal aid, state revenue, and local revenue. NHS pavements and bridges are federally supported assets and therefore eligible for federal funds. The STPD develops funding estimates based on the MDOT Bureau of Finance and Administration's 5YTP forecasts, and near-term Michigan Transportation Fund (MTF) revenue estimates from the Michigan Department of Treasury.

Funding Sources

Funding sources that support investments in Michigan's transportation network are identified in Figure 7-1, which shows the influx of state funding through user fees and other sources into the MTF and distributed to county roads, municipal streets, the Comprehensive Transportation Fund (CTF) for public transit, and, finally, to the State Trunkline Fund (STF) for use on roads, bridges, and other assets under MDOT's jurisdiction. After non-capital uses and routine maintenance are accounted for, the remainder of the STF is invested in the highway capital program.

Figure 7-1: State and Federal Funding Distribution Into the MTF, CTF, and STF



Federal Transportation Funding

On Nov. 15, 2021, President Biden signed the IIJA into law. IIJA is the largest long-term investment in the country's infrastructure in nearly a century and includes a five-year surface transportation reauthorization from Fiscal Years (FY) 2022 to 2026. The legislation makes historic investments in transportation infrastructure, with particular focus areas of climate change mitigation, resilience, safety, and equity, which are emphasized in new formula programs and discretionary grant programs. Over the course of the bill, Michigan is expected to receive about $2.3 billion in new highway funding, which is an average annual increase of $468 million.

Federal aid is estimated to account for about 64 percent of MDOT's FY 2022-2031 Highway Capital Program, excluding routine maintenance. Michigan law (i.e., Michigan PA 51 of 1951 (Act 51)) dictates the share of federal aid required to be split between MDOT and local systems. Act 51 sets MDOT's share of federal aid at 75 percent of the federal apportionment and the local share at 25 percent, for use on FAE roads.

State Transportation Funding and Financing

The state has experienced challenges in providing adequate transportation funding. For many years, Michigan had difficulty finding state and local funds to match federal aid. As an example, state General Fund dollars were used from FY 2014 to 2016 to assure that MDOT did not lose available federal aid.

The 2015 state transportation revenue package generated about $1.2 billion for transportation when it took full effect in FY 2021: $600 million from user fees (i.e., gas taxes and registration fees) and $600 million from income tax revenues. Almost 94 percent of the new revenue is distributed through the Act 51 formula for road agencies: 39.1 percent for state highways, 39.1 percent for Michigan's 83 county road agencies, and 21.8 percent for 533 villages and cities.

The gasoline tax increased from 19 to 26.3 cents per gallon on Jan. 1, 2017, and the diesel fuel tax increased from 15 to 26.3 cents per gallon. The motor fuel tax was also applied to compressed natural gas. Beginning Jan. 1, 2022, per Michigan's 2015 Road Funding Package, fuel tax rates are annually adjusted for inflation to help remedy their decline in purchasing power. Registration fees for most cars and trucks also increased 20 percent at this same time. New electric car fees of $100 per year and $30 per year for plug-in hybrid cars equalize road-user fees for vehicles that use little or no taxed fuel.

In FY 2019, $150 million in income tax revenues was appropriated for roads. This increased to $325 million in FY 2020 and $600 million in FY 2021. The forecasted revenue from FY 2022 to 2031 assumes that $600 million will be transferred from income tax revenues every year to the MTF. These revenues will be distributed to road agencies only, under the current Act 51 formula.

Near-term state revenues are estimated by the MDOT Bureau of Finance and Administration based on MDOT's share of the MTF, as estimated by consensus with the Michigan Department of Treasury, Economic and Revenue Forecasting Division. Other future state revenues are forecasted using a long-range forecasting model managed by MDOT's STPD.

Before transportation revenue is available for trunkline road and bridge projects, non-capital uses must be deducted from the fund. These include funds for the RBMP and prior bond debt service, administration, grants to other departments, routine maintenance, buildings and facilities, I-75 Milestone and Availability Payments, and public-private

partnership (P3) Freeway Lighting Project payments. The estimated revenue available for the NHS portion of the trunkline Capital Program is based on MDOT's planned capital investment on the NHS. STPD and the Bureau of Bridges and Structures (BOBS) generate the costs to implement the required investment strategies for pavements and bridges, respectively. Department leadership approves investment levels, which can be annually adjusted to maintain asset values.

Rebuilding Michigan Program (RBMP) Financing

Under direction from Gov. Whitmer, MDOT developed the RBMP to generate $3.5 billion in additional financing from the sale of bonds by utilizing the bonding capacity of the STF. The RBMP will fund the rehabilitation of Michigan state roadways (the state trunkline) from FY 2020 through 2025. Bond financing is not a long-term funding solution, but a financial mechanism being used to advance projects while a long-term solution is being developed. RBMP funds are included in the forecasted revenues for FY 2022-2025.

Local Transportation Revenue Sources

Funding for roads at the local level is generally a mix of federal, state, and local general funds and/or local property taxes. Most of the funding for local roads and bridges, under the jurisdiction of a county road commission or the jurisdiction of a city or village, comes from state revenue, which is determined by the Act 51 formula distribution. Federal funding is passed through from the state level for roads that are eligible for funding. The estimates provided here for state and federal funding are for non-trunkline road and bridges on the NHS. No local general funds or local property taxes are included. These revenue estimates are based on FAST Act estimates of federal funding to local jurisdictions for use on FAE local roads, as well as additional IIJA funding allocated to local FAE jurisdictions in FY 2022-2026. The state revenue estimate is based on the share of the MTF for counties, cities, and villages, including the state transportation revenue package that was enacted in November 2015. Revenue for non-trunkline roads and bridges on the NHS are estimated based on the NHS road lane miles and number of bridges as a proportion of the total FAE road lane miles and number of bridges on the local system.

Funding Trends

Federal Transportation Revenues

In the 10 years before passage of the FAST Act, federal funding for Michigan's highways fluctuated. Apportioned program funding to Michigan first exceeded $1 billion in 2004. In 2016, apportioned program funding to Michigan still barely exceeded $1 billion. The FAST Act and its one-year extension broke this trend of level funding by providing a modest increase of about 1.9 percent per fiscal year through FY 2021.

In FY 2022, the first year of IIJA, federal revenues are estimated to increase almost 22 percent over the FY 2021 level. Then, federal revenues are estimated to grow about 2 percent per fiscal year for FY 2023-2026, the remainder of IIJA.

State Transportation Revenues

Act 51 established the MTF as the means of collecting and distributing state transportation revenues. For many years, the main sources of MTF funding were motor fuel taxes and vehicle registration fees. As previously discussed, state transportation funding shifted from two sources to three. Since FY 2019, every Oct. 1, Michigan income tax revenues are transferred into the MTF to augment the funding available for transportation within the state.

State Fuel Tax Trends

Between 2005 and 2014, Michigan's fuel tax revenues were flat or declining. In 2012, collected gasoline revenues declined to their lowest point since 1997. Between 2013 and 2016, gas revenues were flat or showed slight increases. In 2017, gas revenues rose because of the new state transportation revenue package. These revenues slightly increased in 2018, decreased in 2019 and 2020, and slightly increased in 2021. Beginning Jan. 1, 2022, the fuel tax will be annually indexed to the rate of inflation to help compensate for declines in fuel tax revenues.

State Vehicle Registration Tax Trends

Most of the vehicle registration tax in the state is based on "ad valorum" vehicles. These vehicles include the model year 1983 and newer. Their tax is calculated on the base price of the vehicle; therefore, as long as the price of vehicles are increasing steadily, and Michigan drivers are purchasing new cars, the registration taxes will reflect growth. Vehicle registration revenues have generally been increasing in Michigan annually. However, they reflected declines in 2008-2009 and 2020 due to economic downturn and the Coronavirus Disease 2019 or COVID-19 pandemic, respectively. In 2021, these revenues slightly increased.

Income Tax Revenues Transferred into the MTF

Michigan income tax revenue transfers into the MTF began in 2019. They increased the following two fiscal years, as specified by the 2015 state transportation revenue package. Income tax revenues are assumed throughout the TAMP at $600 million per fiscal year, consistent with the 2015 state transportation revenue package's language.

Estimating Funding Levels and Assumptions

State and Federal Funding Assumptions

Financial Plan assumptions that follow are based on existing legislation, historic growth rates, and estimates and guidance from federal and state agencies. Short-term federal and state revenues are developed using estimates prepared by FHWA, the Michigan Department of Treasury, and the MDOT Bureau of Finance and Bureau of Transportation Planning (BTP).

Post-IIJA federal revenues are based on estimated FY 2026 federal-aid revenue excluding General Funding, grown at 1.9 percent per fiscal year. Future income tax revenue transfers to state revenue are assumed based on existing legislation. The forecasted revenue from FY 2022 to 2031 assumes that $600 million will be transferred from the income tax revenues every year to the MTF, with these revenues distributed to road agencies under the current state Act 51 formula. Finally, base-year construction costs are developed from road construction information accumulated in RQFS and PCFS, while future construction costs are inflated based on FHWA guidance.

Trunkline Capital Program

MDOT's TAMP revenues and uses are based on historic growth, legislation, or payment schedules. Analysis is based on MDOT's Bureau of Finance 5YTP forecasts, and near-term MTF revenue estimates from the Michigan Department of Treasury, Economic and Revenue Forecasting Division. Outer year state revenues are forecasted using a long-range forecasting model managed by MDOT's STPD. The forecasting model is a multi-factor-driven process that includes vehicle miles of travel, historical revenue trends, fuel prices, number of passenger and commercial vehicles, registration fees, fleet miles per gallon (MPG), etc. The plan assumes a 1.7 percent average annual growth rate for the largest source of state revenue, the STF share of the MTF.

FY 2022-2026 federal-aid revenues are based on the IIJA available for Michigan. After IIJA, FY 2027-2031 federal-aid revenue is estimated based on annual growth of about 1.9 percent applied to FY 2026 estimated federal-aid revenue, excluding General Funding. Both IIJA funding and RBMP financing are unique. After these sources end, revenues fall and are generally flat. Figure 7-2 shows the total state and federal forecasted revenues for the trunkline before any uses are subtracted.

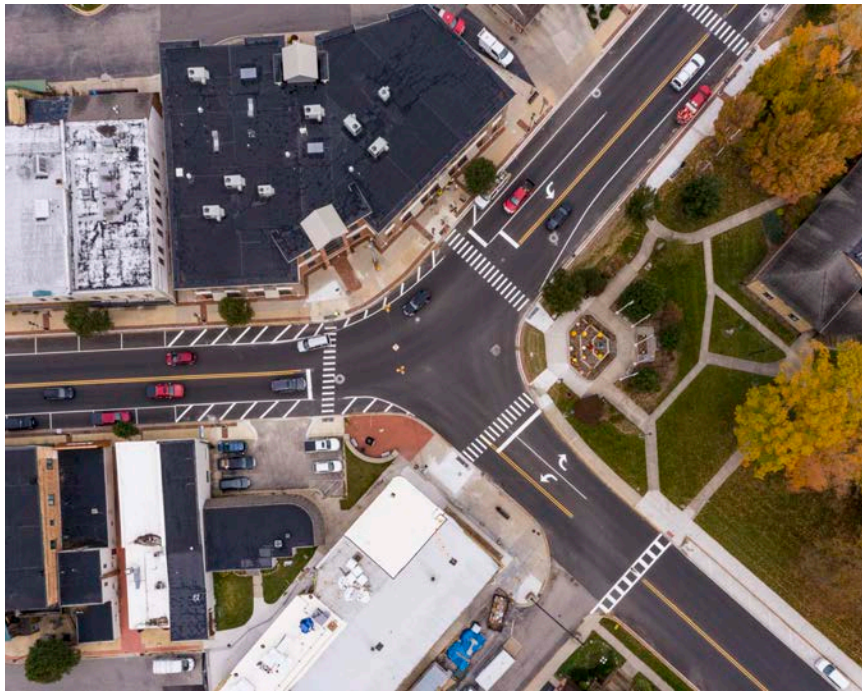
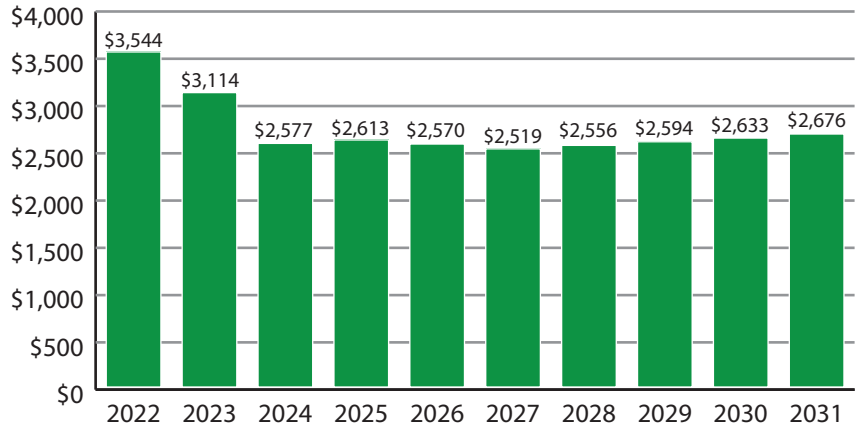


Figure 7-2: Forecasted Total Revenues for the Trunkline Before Subtracting Uses (in millions)



Source: MDOT Bureau of Transportation Planning

Includes State and Federal Revenues, FY 2022-2026 IIJA Estimated Revenues and FY 2022-2025 Rebuilding Michigan Bond Program Financing

Before transportation revenue is available for trunkline road and bridge projects, non-capital uses must be deducted. These include routine maintenance, RBMP and prior bond debt service, administration, and other uses, such as building and facilities, P3 Lighting and I-75 payments, and grants to other departments. Figure 7-3 shows the average historic trunkline uses from FY 2016 to 2020.

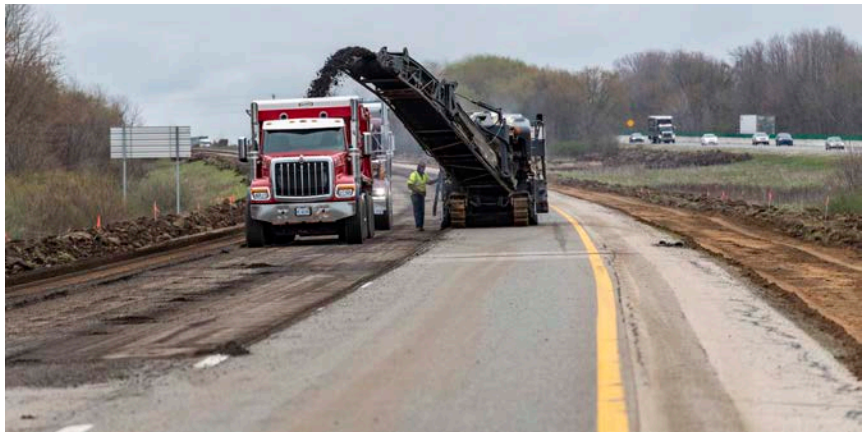
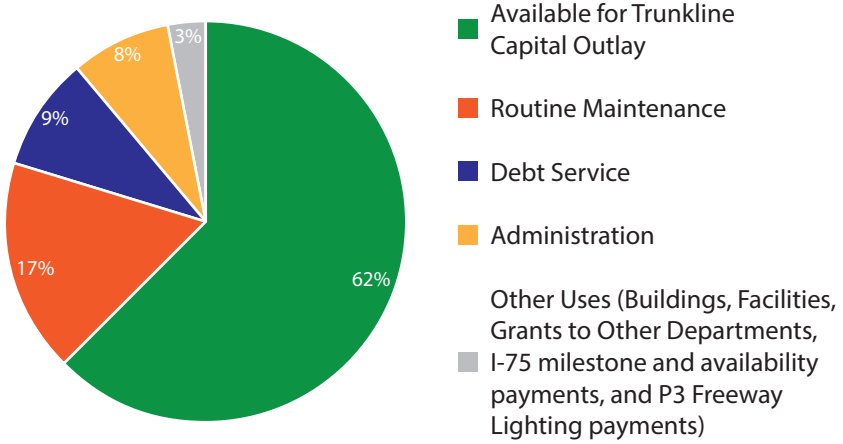


Figure 7-3: Average Historic Trunkline Uses, FY 2016-2020



Source: MDOT Bureau of Transportation Planning

Figure 7-4 summarizes state and federal revenue forecasted to be available for the highway capital program through FY 2031, after deducting dedicated revenues for non-capital uses. However, not all these funds will be available for asset management of pavements and bridges. MDOT has several other responsibilities, such as safety initiatives, system modernization, and climate change resiliency needs when rebuilding and rehabilitating certain assets. These items can add significant cost yet are necessary when addressing the physical condition of the assets through standard programs. The revenue available for the NHS portion of the trunkline capital program is estimated at about 84 percent, which is the percent of currently planned highway capital road and bridge program investments that are on the NHS. The Investment Strategies chapter includes a discussion of the estimated revenue for asset management of trunkline pavements and bridges on the NHS.

Figure 7-4:
MDOT Highway Revenue Forecast
(in millions)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Federal Highway Revenue including FY 2022-2026 IIJA	$1,073	$1,107	$1,112	$1,132	$1,153	$1,084	$1,103	$1,123	$1,143	$1,163
State Highway Revenue including FY 2022-2025 Rebuilding MI Bond Financing	$2,471	$2,007	$1,465	$1,481	$1,417	$1,435	$1,453	$1,471	$1,490	$1,513
Total Revenues for Trunkline Before Uses	$3,544	$3,114	$2,577	$2,613	$2,570	$2,519	$2,556	$2,594	$2,633	$2,676
(Less) Non-Capital Uses*	$494	$597	$618	$624	$633	$640	$567	$567	$562	$564
(Less) Routine Maintenance	$426	$444	$455	$466	$478	$490	$498	$507	$517	$526
Revenue Available for Highway Capital Program	$2,625	$2,074	$1,504	$1,523	$1,459	$1,389	$1,491	$1,520	$1,555	$1,586
Revenue Available for NHS portion of Highway Capital Program**	**$2,205**	**$1,742**	**$1,264**	**$1,279**	**$1,226**	**$1,167**	**$1,252**	**$1,277**	**$1,306**	**$1,332**

Source: MDOT Bureau of Transportation Planning

Includes FY 2022-2025 Rebuilding Michigan Bond Program Financing and FY 2022-2026 IIJA Estimated Revenues

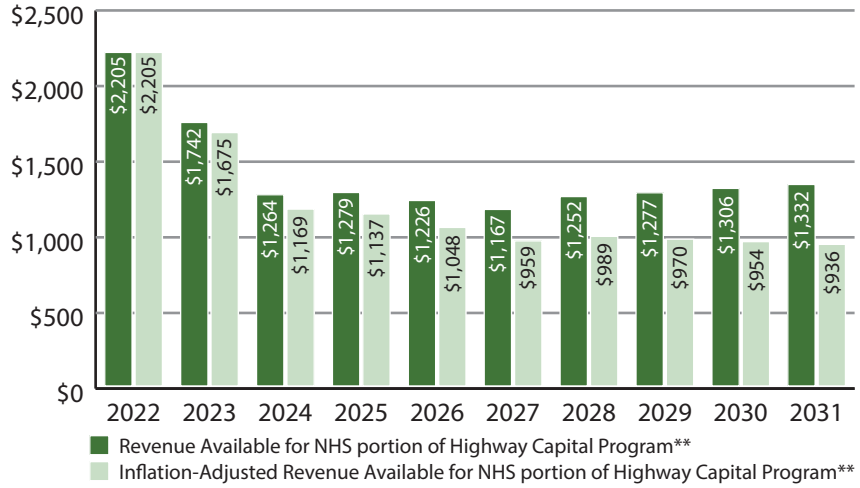
**Administration, Debt Service, Buildings and Facilities, Grants to other departments, I-75 P3 payments, and P3 Freeway Lighting Project payments*

***Includes other programs besides the road and bridge programs*

Numbers may not calculate exactly due to rounding

Figure 7-5 shows the forecasted funding for the NHS portion of the highway capital program, as well as the forecasted funding after adjusting for construction cost inflation. FY 2022-2031 state revenues excluding RBMP are estimated to grow 1.7 percent per fiscal year. FY 2022 IIJA federal revenues grow 22 percent from actual FY 2021 FAST Act revenues, while FY 2023-2026 estimated federal revenues grow 2 percent per fiscal year, and after IIJA, the FY 2027-2031 federal revenues are estimated to grow 1.9 percent per fiscal year from the FY 2026 federal revenue excluding general funds. In comparison, FY 2022-2031 construction costs are expected to increase 4 percent per fiscal year. Over time, estimated revenues lose buying power, as construction costs grow more quickly than revenues as shown by the progressively widening gap between each FY's blue and orange bars. Inflation-adjusted revenues are generally flat for FY 2027-2031.

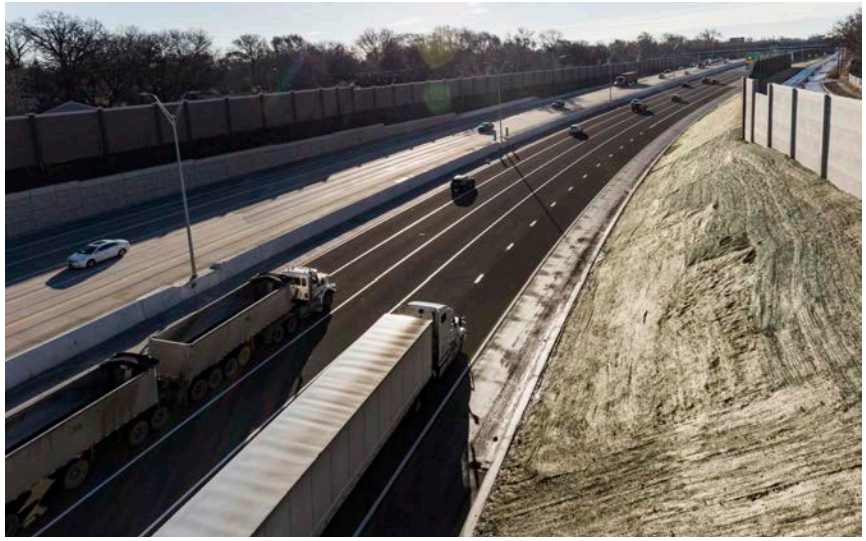
Figure 7-5: Estimated Revenue Available for NHS Portion of Highway Capital Program, Including Adjustments for Inflation



Source: MDOT Bureau of Transportation Planning

***Includes other programs beside the road and bridge programs*

Includes Federal and state estimated revenues



Revenue for Local Roads and Bridges on the NHS

FY 2021-2031 federal revenue estimates are based on FAST Act dollars allocated to local FAE jurisdictions, as well as additional IIJA funding allocated to local FAE jurisdictions in FY 2022-2026. The state revenue estimate is based on the share of the MTF for counties, cities, and villages, including the state transportation revenue package that was enacted in November 2015. Revenues for non-trunkline roads and bridges on the NHS after deducting estimated revenues for non-capital uses are shown in the following table. Estimates are based on road lane miles and number of bridges and are shown in Figure 7-6. Local NHS revenues do not have RBMP financing, and federal revenue makes up a smaller amount of local funding, compared with trunkline revenues.

Figure 7-6:
FY 2022-2031 Forecasted Transportation Revenue (after Non-Capital Uses) Available for Local Roads and Bridges on the NHS (in millions)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Federal Revenue including IIJA estimated revenue	$17	$18	$18	$18	$19	$19	$19	$20	$20	$20
State Revenue	$40	$40	$41	$41	$42	$42	$43	$44	$44	$45
Total Revenue	**$57**	**$58**	**$59**	**$60**	**$60**	**$61**	**$62**	**$63**	**$64**	**$65**

Source: MDOT Bureau of Transportation Planning

This revenue does not include previous year Highway Infrastructure Program (HIP) funding. Revenues are accounted for in the year they are received.

Numbers may not calculate exactly due to rounding.

Asset Valuation

Estimating Costs of Expected Future Work

MDOT conducts investment planning, which guides capital resource allocation to achieve established goals. Program categories, or "templates," are developed to allocate revenues according to the department's investment strategy. These program categories are defined by fiscal year, work type to be performed, or deficiency to be addressed. Asset management work types include new construction, routine maintenance, preservation (capital scheduled maintenance of bridges, capital preventive maintenance of roads), rehabilitation, and reconstruction.

Program emphasis areas are determined by MDOT leadership and help guide the allocation of funding amongst the templates. Goals and performance standards are established for many of the program categories, with funding allocated in a manner to achieve them. A strategic direction goal might be increased investment in higher level system tiers (i.e., Interstate and non-Interstate NHS) to maximize investment impacts through a balanced mix of fixes to achieve pavement and bridge condition goals. The templates provide both a tool to constrain the overall statewide program to available revenues, and a mechanism to monitor the use of funds, and are guided by the STC's policies, legislative mandates, statewide needs, geographic equity, and economic considerations. Investment strategies are summed by work type and fiscal year and are shown in the Investment Strategies chapter.

Estimating the Value of NHS Pavement and Bridge Assets

Michigan's transportation network represents significant value for the state by providing economic benefit and improved quality of life. By regularly investing in certain lower-cost preservation treatments, asset values are preserved, and more costly replacements and repairs are needed less often. Preserving the condition of pavements and bridges so that fewer assets must be replaced is an objective for the investments presented in this TAMP.

Infrastructure assets are long-lived capital assets that are typically stationary and able to be preserved for many years. Asset values are estimated for the current time; they are not the historic (original construction) costs. Asset values can be updated annually.

NHS Pavement Valuation

Two valuations of the NHS pavement system were calculated: a reconstruction cost and a condition-based valuation.

To estimate the value of NHS pavements, an average cost per lane mile for reconstruction was developed based on actual road construction costs from the MDOT Bureau of Development. The average cost per lane mile was then multiplied by the number of NHS lane miles. This estimates the amount it would cost today to reconstruct Michigan's NHS roads. NHS lane miles over bridges are excluded from the road valuation calculation. In 2021 dollars, the cost to reconstruct all of Michigan's NHS pavements was estimated at $59.2 billion based on 17,803 trunkline NHS road lane miles at $3.1 million per trunkline lane mile and 4,844 federal-aid paved non-trunkline NHS road lane miles at $0.9 million per non-trunkline lane mile. From there, a valuation based on condition was calculated. The network reconstruction cost was prorated based on the average condition rating of the NHS network compared to the maximum rating a pavement can be rated. The result represents the valuation of the NHS system weighted for condition. In 2021, the value of Michigan's NHS roads based on condition was estimated at $18.2 billion. The reconstruction cost represents the pavement value at maximum condition. The current condition-based value is less than a third of the reconstruction cost and represents the effect of a lack of sustained sufficient funding.

NHS Bridge Valuation

Like pavements, two valuations of the NHS bridge system were calculated: a reconstruction cost and a condition-based valuation.

To estimate the value of NHS bridges, a formula to calculate a replacement cost based on the current scoping costs was developed based on actual bridge construction cost information. The estimated replacement cost was calculated for each NHS bridge. This estimates the amount it would cost today to reconstruct Michigan's NHS bridges. In 2022, the cost to reconstruct all of Michigan's NHS bridges was estimated at $26.6 billion. This value represents the bridge value at maximum condition. Then, a valuation based on condition was also calculated. The network reconstruction cost was prorated based on the component condition ratings of the NHS network compared to the maximum rating of 9. This result represents the valuation of the NHS system weighted for condition. In 2022, the value of Michigan's NHS bridges based on condition was estimated at $21.9 billion.

Investment Needed to Maintain the Asset Value of NHS Pavements and Bridges

The annual investment needed to maintain Michigan's NHS pavement condition are estimated using RQFS and PCFS. Annual investments needed to maintain MDOT's NHS bridge condition are estimated using the BCFS. These software programs use current pavement condition, projected deterioration, estimated project fix life, and a mix of fixes strategy to estimate the funding that would be needed to maintain the NHS pavement and bridge conditions. The annual investments needed to maintain NHS roads and bridges are shown in the Investment Strategies chapter.

Investment Strategies

Strategies documented in the Michigan TAMP represent an investment approach that prioritizes preservation activities, seeks progress toward broad goal areas, focuses on select assets, implements sustainable practices, and supports the continued development of a multimodal transportation system.

When developing investment strategies, MDOT accounts for factors that include condition goals, revenue trends, federal and state law, level of service provided by the system, key risks to the highway system, and public input. The details of MDOT's 10-year TAMP investment strategy as well as the process for its development are included in the following pages.

Investment Strategy Process

Investment strategies are developed using anticipated available funding, asset management and life cycle planning, financial and performance gap analysis, and the results of risk analysis. Annually, MDOT uses updated information on available funding and the estimated costs of future work by work type to perform life cycle analysis for pavement and bridge assets. This analysis is produced for four strategies as defined in the Introduction.

For each strategy, gaps in funding are identified, associated risks are evaluated, and are then analyzed and compared to determine how they would impact the overall goals and objectives set by the STC. For the selected investment strategy, the desired mix of fixes, investment levels, and funding targets are developed and communicated to MDOT regions through the highway CFP manual. After the CFP process has been completed, the selected investment strategy and projects selected are exported from JobNet and prepared for public input through the 5YTP.

Figure 8-1: Influences on Investment Strategies

Financial Plan	Performance Gap Analysis	Life Cycle Analysis	Risk Management and Resiliency
Identify sources of funding, and estimate future funding and asset values for roads and bridges over the next 10 years.	Demonstrate whether levels of service provided through investment strategies meet national and state goals for asset conditions.	Evaluate and forecast the network-level impacts of varying investment strategies and estimate the cost managing whole life costs for roads and bridges.	Identify risks to NHS pavements and bridges, performance, financial planning and investment strategies, and steps to manage these risks in the pursuit of improved network resiliency.
Federal and State Revenue	National Assets Goals	Trunkline Condition Forecasting (RQFS)	Identify Agency and Program Threats
Non-capital Uses	State Asset Goals	Local Condition Forecasting (PCFS)	Risks to Mission and NHS Assets
Value of Assets	Level of Service	Bridge Condition Forecasting (BCFS)	Develop Mitigation Strategies

Local Road Agencies Investment Strategies

The state of Michigan has a substantial number of local governments, including 83 counties, townships, 275 cities, and 258 villages. Of these, 84 jurisdictions directly manage some NHS segments, which comprise 19 percent of the NHS.

The TAMC was formed to promote the use of asset management practices among Michigan's road and bridge-owning agencies, to develop a coordinated, unified effort by the various units of government within the state, and to advise the STC on a statewide asset management strategy. The TAMC's primary responsibility is to oversee the biennial collection of physical inventory and condition data on all FAE roads and bridges in Michigan, including NHS routes. The TAMC also provides training and other events to help local agencies understand the importance of asset management as they plan their capital programs.

Per Michigan PA 325 of 2018 (PA 325), local agencies with 100 or more certified route miles are required to prepare and manage their respective transportation systems through an approved asset management plan. Asset management plans submitted to the TAMC are reviewed against the required elements as outlined in PA 325. To comply, each local agency develops its own transportation investment strategy and budgets accordingly. MDOT incorporates local revenue available from state and federal sources only (excluding other local funds), along with work expected to be performed on the locally owned NHS pavement and bridges, into the Financial Plan. MDOT's STPD coordinates with local agencies and MPOs on STIP and TIP amendments and performance target-setting and monitors the local investment on non-state-owned NHS pavements and bridges.

Investment Strategy Analysis

The financial plan, life cycle planning, gap analysis, and risk mitigation strategies were considered when each investment strategy was reviewed. Anticipated funding available from the financial plan, including the local share of federal funding where appropriate, was used to determine the most realistic strategy to meet the overall goals and objectives set by the STC. For local NHS agencies, more than 50 percent prioritize projects and have a separate investment plan for their higher-level system, which includes the NHS.

To develop an investment strategy to reach each goal, MDOT used life cycle analysis that represented the most efficient and effective approach to achieving the asset management objective. MDOT currently uses two network-level pavement models and one model for bridges, which are detailed in the Life Cycle Planning chapter. The life cycle analysis constrained the amount of preservation work by year to balance mobility impacts. The desired level of work was then compared to the available funding as identified in the 10-year financial plan forecast.

Agency-level and program-level risks that could impact implementation of the analysis were also considered. Obtaining the anticipated state income tax revenue is a major risk to all the pavement and bridge preservation investment strategies as the gap between available revenue and investment needed would be greater without it.

Road Investment Strategies

Achieve the National Minimum Condition Level for Pavement

The national minimum condition level for Interstate pavement requires that no more than 5 percent of the Interstate system be in poor condition based on the federal PCM. At this time, MDOT has achieved the national minimum condition level based on the federal PCM. Michigan's 2020 Highway Performance Monitoring System (HPMS) reports 4.6 percent poor pavement on the Interstate system based on the PCM. In addition to reporting system condition based on the federal PCM, MDOT uses its own pavement performance measure, RSL, for evaluating the national minimum condition level, as it better reflects the pavement's overall health.

The investment needed to achieve no more than 5 percent poor based on RSL (rather than PCM) for the Interstate in Michigan exceeds the pavement funding available. Using the RSL performance measure, the total estimated shortfall in investment over the 10-year period is nearly $3 billion, as shown in Figure 8-2.

Figure 8-2: National Minimum Condition Level Pavement Investment Strategy Based on RSL (in millions)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	10-Year Total
Revenue for NHS											
NHS Trunkline Maintenance (Pavement and Bridge)	$358	$373	$382	$392	$401	$411	$419	$426	$434	$442	$4,037
Expected Cost of Future Work - Constrained Target											
Trunkline Pavement (Interstate Only)	$1,099	$631	$442	$78	$120	$457	$473	$473	$473	$466	$ 4,712
Pavement - National Goal -Expected work Needed											
Reconstruction	$550	$550	$443	$443	$460	$479	$498	$518	$538	$560	$5,037
Rehabilitation	$331	$331	$335	$322	$363	$327	$89	$93	$97	$101	$2,387
Preservation	$20	$20	$26	$26	$27	$28	$29	$31	$32	$33	$273
Initial Construction*	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pavement Total	**$901**	**$901**	**$803**	**$791**	**$850**	**$834**	**$617**	**$641**	**$667**	**$694**	**$7,698**
National Goal Pavement Revenue Gap	**$199**	**($269)**	**($361)**	**($713)**	**($730)**	**($377)**	**($144)**	**($168)**	**($194)**	**($228)**	**($2,985)**

**MDOT does not plan to construct additional routes within the time frame of the TAMP under any investment strategy.*

Pavement State of Good Repair

Michigan's goal for pavement state of good repair is 95 percent good/fair on the Interstate and 85 percent good/fair on non-Interstate NHS pavement using the RSL performance measure (rather than the federal PCM) and STC goals for the freeway/nonfreeway network. The investment needed to meet the state of good repair exceeds the available pavement funding. The total estimated shortfall in investment over the 10-year period is nearly **$14.8 billion**, as shown in Figure 8-3. Redirecting funding from the bridge preservation and other programs would result in an intolerable decline in the condition of those assets and would not be enough to bring the pavement condition up to a state of good repair.

Figure 8-3: State of Good Repair NHS Pavement Investment Strategy Based on RSL and PASER (in millions)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	10 Year Total
Expected Cost of Future Work - Constrained Target											
NHS pavement (Trunkline and Local)	$1,771	$1,193	$861	$611	$592	$819	$836	$832	$833	$826	$9,177
Pavement State of Good Repair - Expected Work Needed											
Reconstruction	$1,512	$1,512	$1,411	$1,411	$1,469	$1,527	$1,590	$1,653	$1,721	$1,788	$15,596
Rehabilitation	$887	$887	$929	$947	$986	$930	$618	$386	$260	$268	$7,101
Preservation	$109	$109	$120	$118	$124	$128	$135	$139	$147	$152	$1,286
Initial construction*	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pavement Total	**$2,508**	**$2,508**	**$2,461**	**$2,477**	**$2,581**	**$2,586**	**$2,344**	**$2,179**	**$2,129**	**$2,208**	**$23,984**
State of Good Repair - NHS Pavement Revenue Gap	**($737)**	**($1,314)**	**($1,600)**	**($1,866)**	**($1,988)**	**($1,767)**	**($1,508)**	**($1,347)**	**($1,295)**	**($1,382)**	**($14,807)**

**MDOT does not plan to construct additional routes within the time frame of the TAMP under any investment strategy.*

Preserve Current Condition

Michigan's current condition on Interstate routes is 78 percent good/fair and on the non-Interstate NHS pavement it is 70 percent good/fair based on Michigan's long-term health performance measure, RSL (rather than the federal PCM). The investment needed to preserve current pavement conditions exceeds the available pavement funding. The total estimated shortfall in investment over the 10-year period is more than $12.3 billion, as shown in Figure 8-4. Redirecting funding from the bridge preservation and other programs would result in an unacceptable decline in the condition of those assets and MDOT would not be able to maintain the current pavement condition.

Figure 8-4: Preserve Current Condition NHS Pavement Investment Strategy Based on RSL and PASER (in millions)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	10 Year Total
Expected Cost of Future Work - Constrained Target											
NHS pavement (Trunkline and Local)	$1,771	$1,193	$861	$611	$592	$819	$836	$832	$833	$826	$9,177
Pavement State of Good Repair - Expected Work Needed											
Reconstruction	$1,669	$1,504	$1,399	$1,399	$1,455	$1,512	$1,572	$1,633	$1,698	$1,765	$15,765
Rehabilitation	$373	$662	$759	$770	$803	$496	$207	$224	$232	$240	$4,768
Preservation	$76	$104	$112	$110	$114	$118	$122	$126	$131	$136	$1,148
Initial construction*	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pavement Total	**$2,119**	**$2,271**	**$2,271**	**$2,279**	**$2,372**	**$2,125**	**$1901**	**$1,984**	**$2,062**	**$2,141**	**$21,525**
Preserve Condition - NHS Pavement Revenue Gap	**($347)**	**($1,076)**	**($1,410)**	**($1,669)**	**($1,780)**	**($1,306)**	**($1,064)**	**($1,151)**	**($1,228)**	**($1,315)**	**($12,348)**

**MDOT does not plan to construct additional routes within the time frame of the TAMP under any investment strategy.*

Constrained Investment for Pavement

Michigan's constrained investment strategy for pavement is based on available funding. Michigan's highway capital program places significant emphasis on the preservation of pavement. MDOT's CFP process includes strategic direction that emphasizes the Interstate and NHS networks over non-NHS routes. To develop an investment strategy for available funding, MDOT used a life cycle analysis that represented the most efficient and effective approach. A mix of fixes was developed that would produce the best possible outcome with the funding available. This investment strategy represents the funding available for pavement preservation on the NHS. There is no financial gap with this investment strategy. The constrained investment strategy described in the Performance Gap Analysis chapter allows Michigan to achieve the two-year (midpoint) and four-year (full performance) targets for the TPM pavement condition.

Figure 8-5: Constrained NHS Pavement Investment Strategy Based on RSL and PASER (in millions)

Fiscal Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Expected Cost of Future Work - Constrained Target											
NHS Pavement (Trunkline and Local)	$1,771	$1,194	$861	$611	$592	$818	$836	$832	$834	$827	$9,176
Pavement - Constrained Investment - Expected Work Needed											
Reconstruction	$1,067	$785	$571	$268	$219	$366	$389	$377	$378	$371	$4,791
Rehabilitation	$644	$331	$201	$256	$286	$365	$359	$367	$368	$368	$3,545
Preservation	$60	$78	$89	$87	$87	$87	$88	$88	$88	$88	$840
Initial Construction*	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pavement Total	**$1,771**	**$1,194**	**$861**	**$611**	**$592**	**$818**	**$836**	**$832**	**$834**	**$827**	**$9,176**
Constrained Investment - NHS Pavement Revenue Gap	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

**MDOT does not plan to construct additional routes within the time frame of the TAMP under any investment strategy.*

Bridge Investment Strategies

The national minimum condition level for NHS bridges is expected to be achieved and maintained throughout the 10-year forecast period, therefore achieving the national minimum conditional level for bridges and a constrained investment of the bridge assets by deck area is achieved under the same investment strategy.

Figure 8-6: National Minimum Condition/Constrained Target Investment Strategy for NHS Bridges (in millions)

Fiscal Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Expected Cost of Future Work - Constrained Target											
Trunkline Bridge	$357	$511	$158	$201	$146	$100	$159	$104	$100	$114	$1,950
Bridge Authorities and Local Agencies	$16	$48	$39	$74	$61	$16	$12	$14	$24	$45	$349
Bridge Total	**$373**	**$559**	**$198**	**$275**	**$206**	**$117**	**$171**	**$118**	**$124**	**$158**	**$2,299**
Constrained Investment - Expected Work Needed											
Reconstruction	$264	$426	$55	$130	$78	$44	$103	$35	$38	$40	$1,212
Rehabilitation	$45	$46	$40	$25	$25	$34	$27	$37	$35	$38	$355
Preservation	$48	$39	$63	$45	$42	$22	$29	$32	$27	$35	$383
Bridge Authorities and Local Agencies	$16	$48	$39	$74	$61	$16	$12	$14	$24	$45	$349
Bridge Total	**$373**	**$559**	**$198**	**$275**	**$206**	**$117**	**$171**	**$118**	**$124**	**$158**	**$2,299**

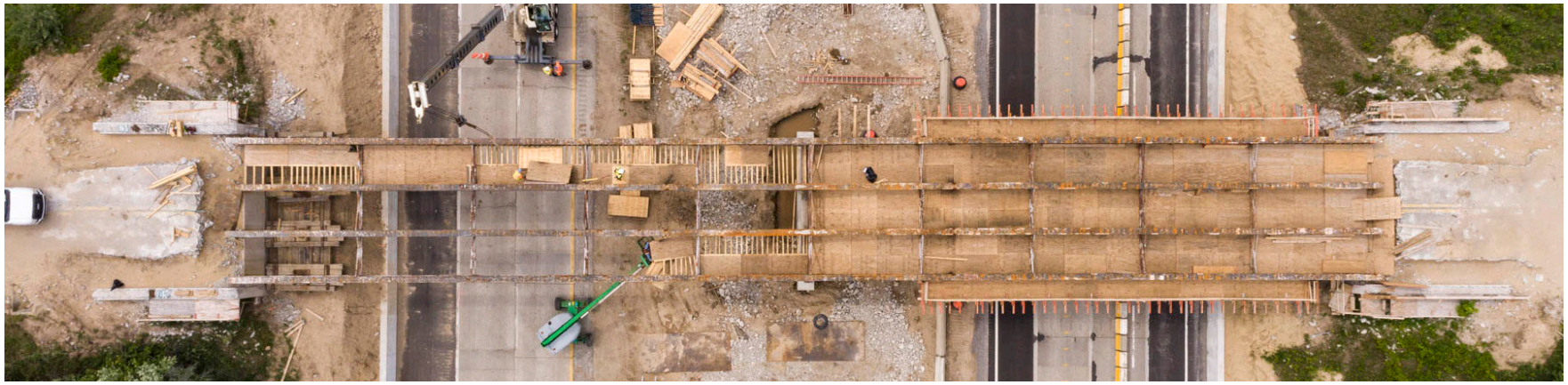
Constrained/Min Condition NHS Bridge Revenue Gap	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

Bridge Preserve Current Conditions

Michigan's 2020 NHS bridge deck area is 33 percent in good condition, 57 percent in fair condition, and 7 percent in poor condition. The large amount of deck area in fair condition requires a significant investment to prevent or reduce the bridges that fall into poor condition over time. An additional $539 million is required to preserve current conditions over the 10-year period.

Figure 8-7: Preserve Condition Investment Strategy for NHS Bridges (in millions)

Fiscal Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Expected Cost of Future Work - Constrained Target											
Trunkline Bridge	$357	$511	$158	$201	$146	$100	$159	$104	$100	$114	$1,950
Bridge Authorities and Local Agencies	$16	$48	$39	$74	$61	$16	$12	$14	$24	$45	$349
Constrained Investment - Expected Work Needed											
Reconstruction	$264	$457	$89	$157	$107	$85	$136	$82	$75	$81	$1,533
Rehabilitation	$45	$70	$61	$54	$54	$51	$56	$54	$60	$62	$567
Preservation	$48	$43	$68	$49	$45	$24	$28	$28	$25	$31	$390
Bridge Authorities and Local Agencies	$16	$48	$39	$74	$61	$16	$12	$14	$24	$45	$349
Bridge Total	**$373**	**$619**	**$258**	**$334**	**$266**	**$177**	**$232**	**$178**	**$184**	**$218**	**$2,838**
Preserve Condition - NHS Bridge Revenue Gap	**$0**	**($60)**	**($60)**	**($59)**	**($60)**	**($60)**	**($61)**	**($60)**	**($60)**	**($60)**	**($539)**



Bridge State of Good Repair

Michigan's goal for bridge state of good repair is 95 percent good/fair by deck area on the NHS. The total estimated shortfall in investment over the 10-year period is $1,008 million. Redirecting funding from the bridges not on the NHS would result in an unacceptable decline in the condition of those assets. This strategy was used to identify the revenue gap between current conditions and the state of good repair.

Figure 8-8: State of Good Repair Investment Strategy for NHS Bridges (in millions)

Fiscal Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Expected Cost of Future Work - Constrained Target											
Trunkline Bridge	$357	$511	$158	$201	$146	$100	$159	$104	$100	$114	$1,950
Bridge Authorities and Local Agencies	$16	$48	$39	$74	$61	$16	$12	$14	$24	$45	$349
Constrained Investment - Expected Work Needed											
Reconstruction	$264	$489	$114	$193	$136	$116	$169	$106	$101	$108	$1,794
Rehabilitation	$45	$85	$83	$63	$71	$65	$70	$77	$82	$81	$723
Preservation	$48	$49	$73	$56	$51	$31	$33	$33	$29	$38	$441
Bridge Authorities and Local Agencies	$16	$48	$39	$74	$61	$16	$12	$14	$24	$45	$349
Bridge Total	**$373**	**$671**	**$310**	**$387**	**$318**	**$228**	**$283**	**$230**	**$236**	**$270**	**$3,307**
State of Good Repair - NHS Bridge Revenue Gap	**$0**	**($112)**	**($112)**	**($112)**	**($112)**	**($112)**	**($112)**	**($112)**	**($112)**	**($112)**	**($1,008)**

Selected Investment Strategy - Constrained

After analyses on the preceding scenarios, MDOT's selected pavement and bridge investment strategy continues to be constrained investment, meaning it is constrained to available funding, minimizes risk, has no financial gap, and manages assets for their whole life.

This investment strategy drives project selection for both the 5YTP and the STIP. This investment strategy is implemented through the annual Highway CFP process, which provides the mechanism for project selection for both the 5YTP and the STIP. The desired mix of fixes, investment levels, and funding targets are developed for the selected investment strategy and provided in the CFP program instructions and then communicated to the public by way of the annual 5YTP.

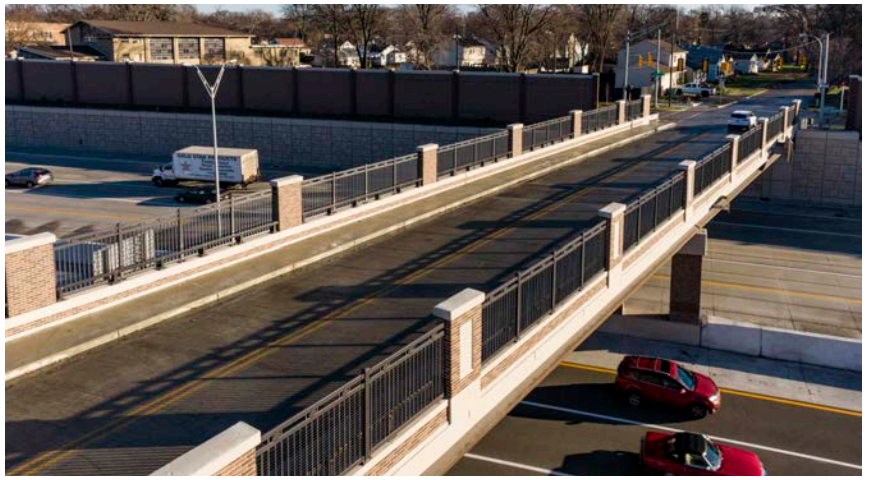


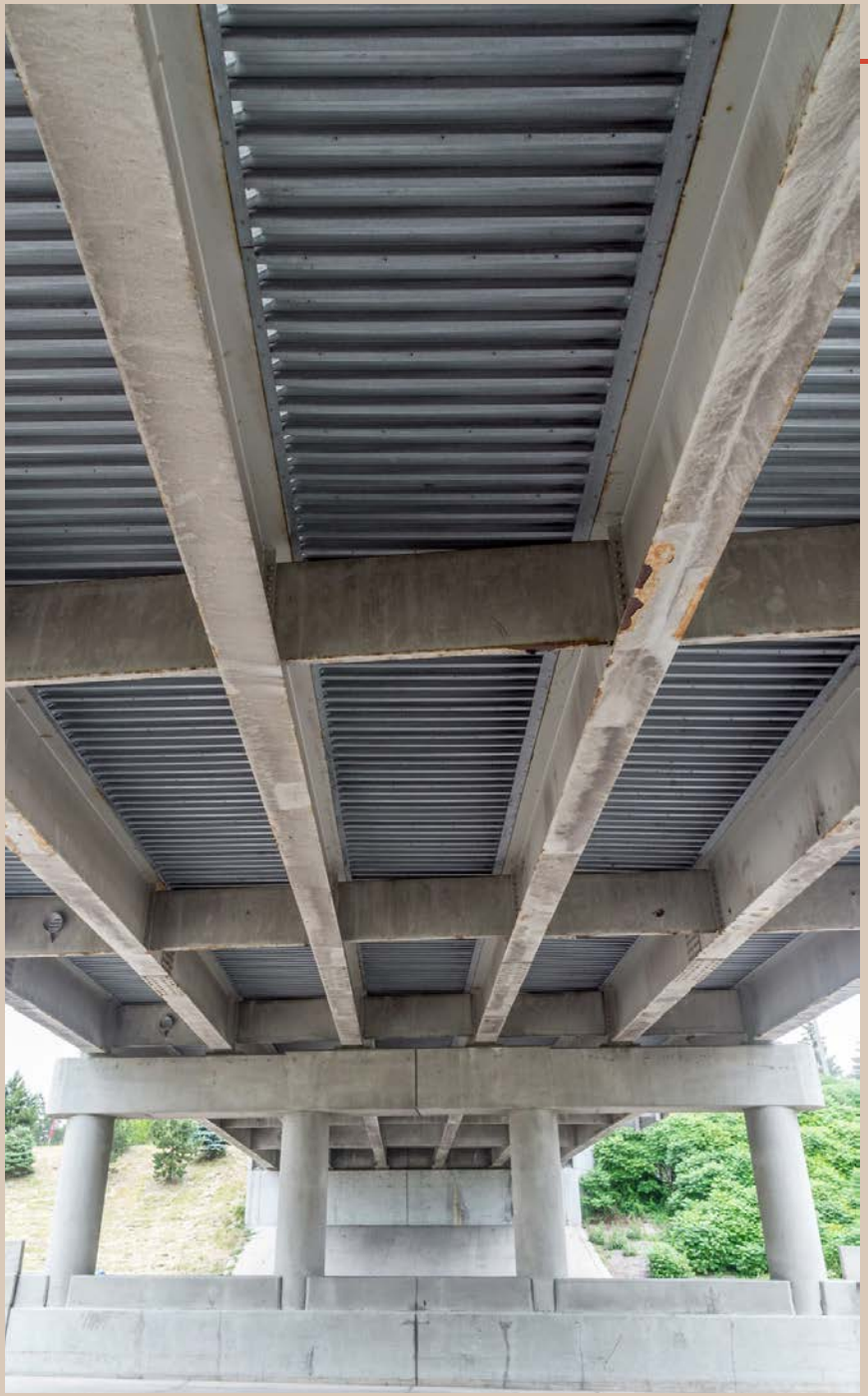
Figure 8-9: Selected Investment Strategy - Constrained NHS Pavement Investment Strategy Based on RSL and PASER (in millions)

Fiscal Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Expected Cost of Future Work - Constrained Target											
NHS Pavement (Trunkline and Local)	$1,771	$1,194	$861	$611	$592	$818	$836	$832	$834	$827	$9,176
Pavement - Constrained Investment - Expected Work Needed											
Reconstruction	$1,067	$785	$571	$268	$219	$366	$389	$377	$378	$371	$4,791
Rehabilitation	$644	$331	$201	$256	$286	$365	$359	$367	$368	$368	$3,545
CPM	$60	$78	$89	$87	$87	$87	$88	$88	$88	$88	$840
Initial Construction	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pavement Total	**$1,771**	**$1,194**	**$861**	**$611**	**$592**	**$818**	**$836**	**$832**	**$834**	**$827**	**$9,176**
Constrained Investment - NHS Pavement Revenue Gap	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

Figure 8-10:
Selected Investment Strategy - National Minimum Condition/Constrained Target Investment Strategy for NHS Bridges (in millions)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Total
Expected Cost of Future Work - Constrained Target											
Trunkline Bridge	$357	$511	$158	$201	$146	$100	$159	$104	$100	$114	$1,950
Bridge Authorities and Local Agencies	$16	$48	$39	$74	$61	$16	$12	$14	$24	$45	$349
Bridge Total	**$373**	**$559**	**$197**	**$275**	**$207**	**$116**	**$171**	**$118**	**$124**	**$159**	**$2,299**
Constrained Investment - Expected Work Needed											
Reconstruction	$264	$426	$55	$130	$78	$44	$103	$35	$38	$40	$1,212
Rehabilitation	$45	$46	$40	$25	$25	$34	$27	$37	$35	$38	$355
Preservation	$48	$39	$63	$45	$42	$22	$29	$32	$27	$35	$383
Bridge Authorities and Local Agencies	$16	$48	$39	$74	$61	$16	$12	$14	$24	$45	$349
Bridge Total	**$373**	**$559**	**$198**	**$275**	**$206**	**$117**	**$171**	**$118**	**$124**	**$158**	**$2,299**

Constrained/Min Condition - NHS Bridge Revenue Gap	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**



Performance Gap Analysis

This chapter provides background on the process utilized by MDOT to identify gaps between the current condition of NHS pavements and bridges with MDOT's TAMP targets, the department's long-term performance goals for a state of good repair, and the difference between the constrained investment strategy condition and the state-identified TAMP target for each federal condition measure. The pages that follow detail the methods and results of MDOT's performance gap analysis for the 2022 TAMP.

Establishment of Targets for Asset Condition of NHS Pavements and Bridges

MDOT has adopted a process for vetting and approving pavement and bridge targets. In addition, pavement and bridge TPM teams have been created that include multi-disciplinary representation throughout the department as well as from the Michigan Transportation Planning Association (MTPA). These teams are tasked with developing target recommendations, which are presented to the full MTPA and MDOT leadership for approval.

Pavement Target Setting Process

As required by law, MDOT has established targets for the federal PCM, identified as percent good and percent poor, on the Interstate and non-Interstate NHS. Targets are required for two- and four-year intervals for each measure, with eight targets in total. The rule establishes four metrics to be used to determine condition, depending on the surface type of the pavement: IRI, Cracking Percent, Rutting, and Faulting.

Data used to determine pavement condition are collected by a private contractor who supplies MDOT with data on an annual basis. These data are submitted to MDOT's DIID, where it is segmented into tenth-of-a-mile units. These data are used to determine overall pavement condition for each year and establish the baseline condition on which targets will be established.

Using the condition data from prior years, MDOT conducted historical trend analyses to forecast future condition, which were used to establish targets. The analysis included data on available metrics from the last decade, which was used to develop trend lines to help project future condition. Other factors considered included the largest percent changes in condition from year to year to assess variability. Reasons for year-to-year changes were determined to the best extent possible. The department subcategorized the good, fair, and poor metric ranges to consider trends within those categories and determined the likelihood of further category shifts within the two- and four-year periods.

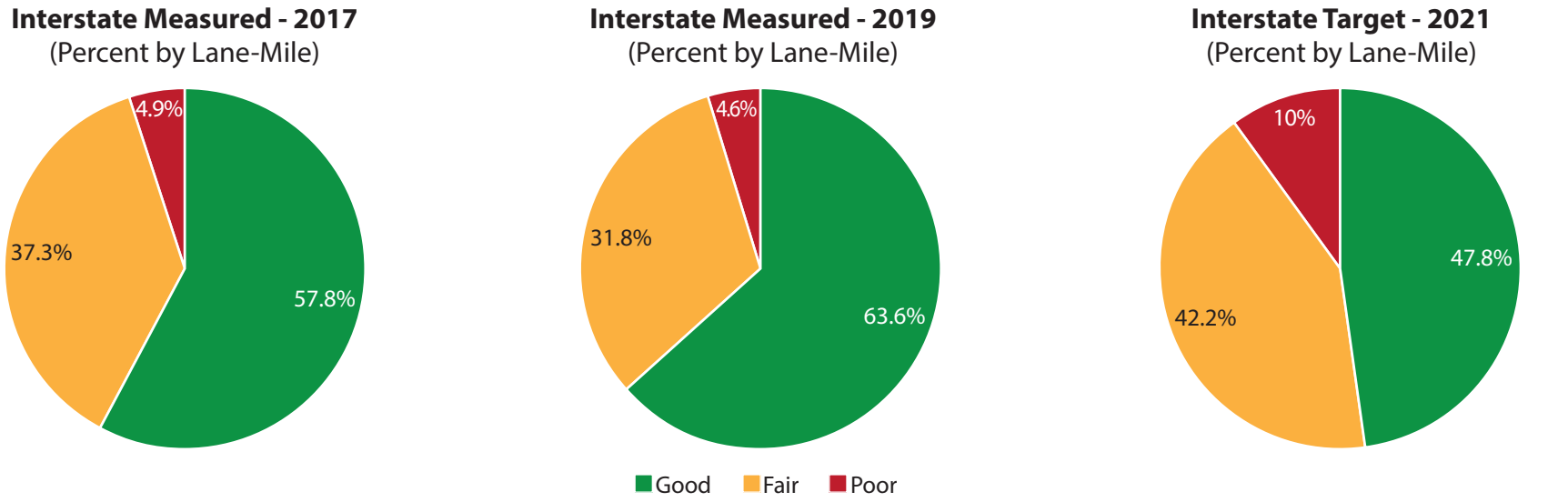
Pavement Condition Targets

The MDOT TPM pavement team developed the federally required targets for Interstate PCM and non-Interstate NHS IRI, which were submitted to FHWA on Oct. 1, 2018.

Figure 9-1 illustrates the targets MDOT set for the federal performance measure on the Interstate for 2021 and their value relative to MDOT's actual 2017 and 2019 PCM condition.

Figure 9-2 illustrates the targets MDOT set for the IRI measure on the non-Interstate NHS for 2022, and their value relative to MDOT's actual 2017 and 2019 IRI condition.

Figure 9-1: Interstate Condition Comparison 2017 to 2021 (by PCM)



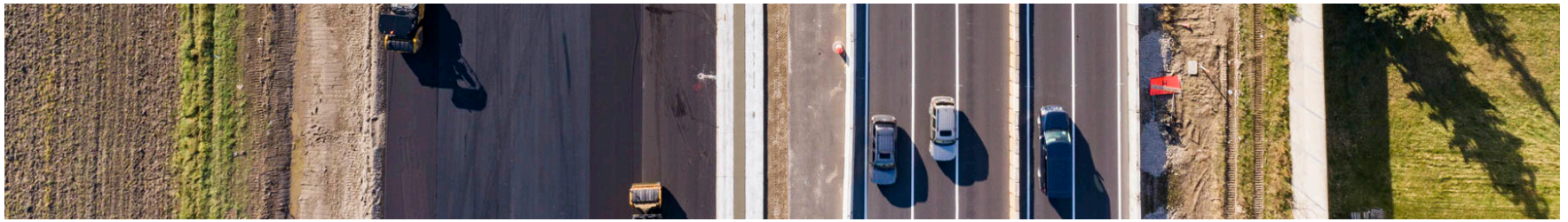
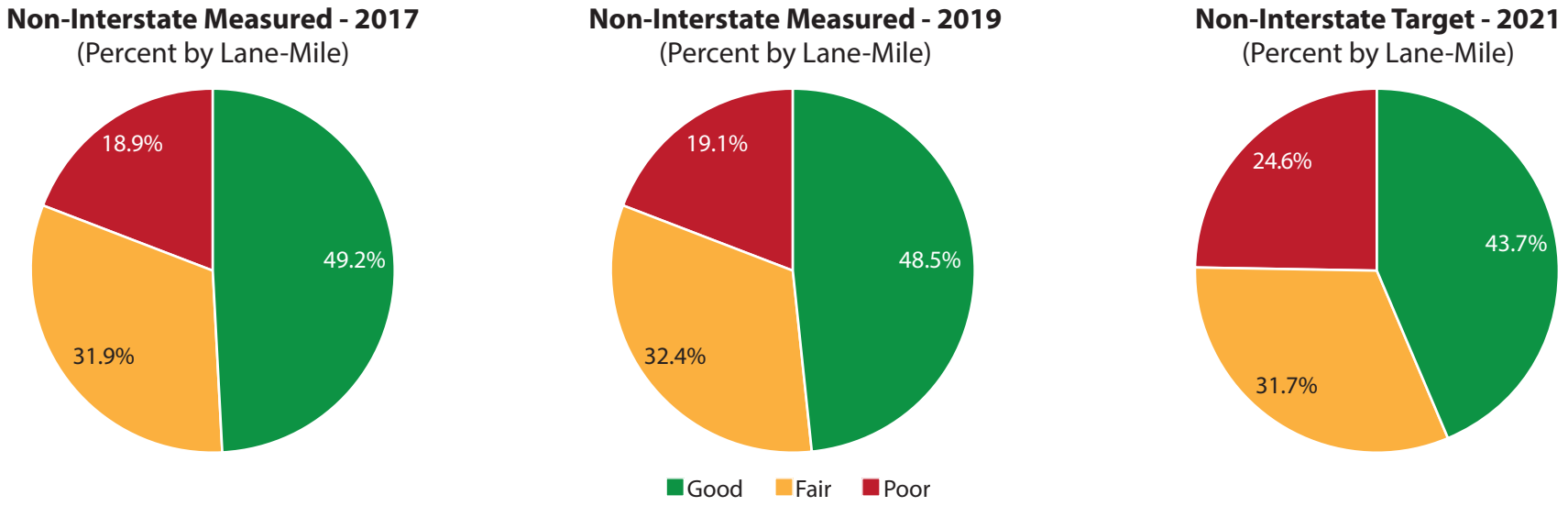


Figure 9-2:
Non-Interstate Condition Comparison 2017 to 2021 (by IRI)



Bridge Target-Setting Process

In addition to pavement targets, MDOT established targets for bridge condition measures, identified as percent good and percent poor by deck area on the NHS. Targets are required for two- and four-year intervals for each measure, with four targets in total. The minimum general condition rating from the NBI is used to determine good, fair, and poor categories.

Bridge condition data are collected throughout the year by inspectors as delegated by the bridge owner. Data collection and quality control follows the requirements of the NBIS. The national bridge condition performance measures only apply to bridges carrying routes on the NHS, including bridge on and off ramps connected to the NHS. Inspection data are submitted through MDOT's MiBridge inspection and reporting system. By March 15 of each year, the data is submitted to FHWA as required by the NBIS.

The MDOT bridge performance team, in coordination with Michigan's MPOs, evaluate current conditions, perform analysis, and consider internal and external factors of potential influence to establish the bridge performance baseline and two- and four-year Interstate and non-Interstate NHS bridge targets. The federal regulations establish minimum condition thresholds for substructure, superstructure, and deck or culvert, and require calculating the condition by the respective deck area of each bridge and expressing condition totals as a percentage of the total deck area of bridges in a state. The area is calculated using the NBI structure length and deck width or approach roadway width (for some culverts).

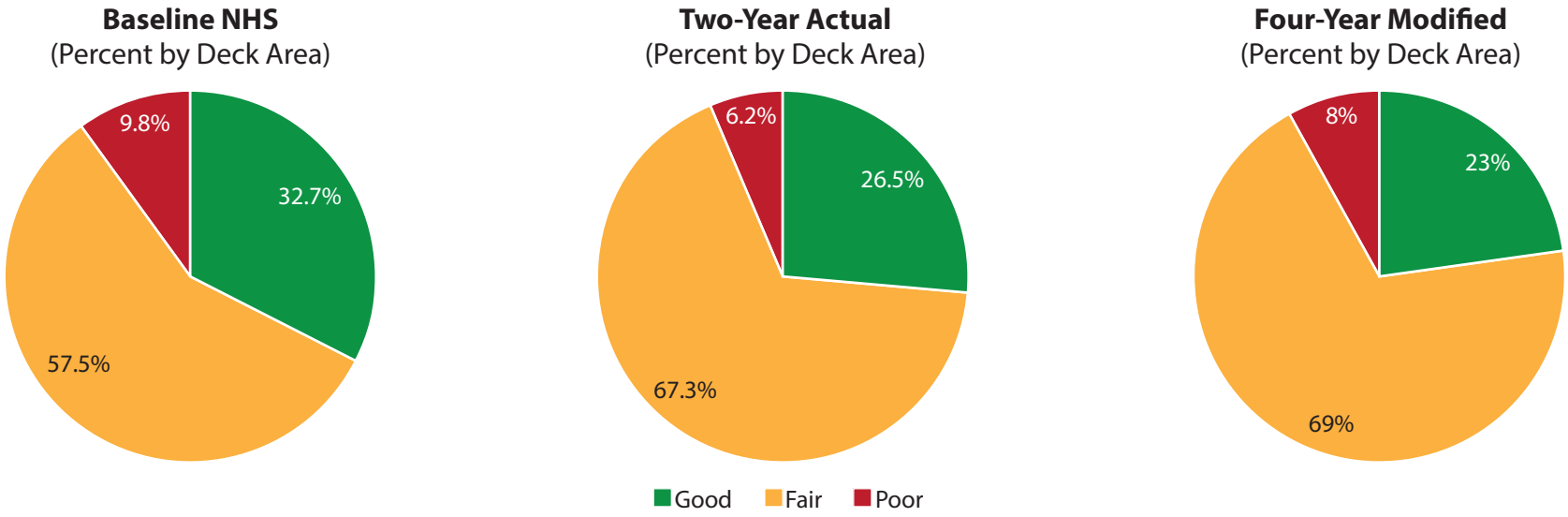
The bridge performance team started the target-setting process by identifying the baseline for good and poor condition using NBI data submitted in 2018. The next step was to evaluate potential influences, not limited to deterioration rates and planned investments. As a bridge ages, its condition declines and an increasing amount of work is required to restore condition or extend the usable life of the bridge. By tracking the rate at which bridges have declined in the past, MDOT is able to predict the rate at which a bridge will decline in the future. MDOT has an established process through which trends in bridge deterioration rates can be evaluated at regular intervals.

Bridge Condition Targets

The MDOT TPM bridge team developed the federally required targets for all NHS bridges by NBI condition rating, which were submitted to FHWA on Oct. 1, 2018.

Figure 9-3 illustrates the targets MDOT set for the NBI condition measure on the NHS by deck area, compared to actual bridge condition data collected in 2017 and 2019. Good bridge deck area deteriorated faster than predicted and consequently MDOT reduced the four-year targets.

Figure 9-3: Bridge Condition Comparison 2017-2021



Target-Setting Coordination with MPOs

The TPM rule requires MDOT to coordinate target establishment with MPOs for both pavements and bridges. The TPM pavement team has been coordinating with the MTPA since April 2017 and has included members from three different MPOs as official team members.

MDOT's coordination strategy included adding MPO representatives to its TPM pavement team and meeting with MPOs to review the rule, discuss new data requirements, and to share data and methods. To prepare for the new rule, MDOT began collecting data for all the new pavement metrics on the entire NHS in 2016. This included data collection on the non-trunkline non-Interstate NHS routes, which are under local government jurisdiction. Using these data, MDOT provided each MPO with a "report card" for pavement condition on the Interstate and non-Interstate NHS in their metropolitan planning areas and how this condition compares to the statewide condition. A similar parallel effort occurred using the bridge target-setting data.

This effort reduced the burden of data collection and analysis on MPOs and ensured that they all have consistently measured and analyzed data. MDOT and MPOs used these historical data to establish statewide targets and to understand which target option was appropriate for each MPO, whether it is to support the statewide targets or to establish their own. All of Michigan's 14 MPOs elected to adopt the statewide pavement and bridge targets.

Identifying Gaps in the Performance of the NHS That Affect Pavements and Bridges

The objective of performance gap analysis is to track performance compared to short-term targets and long-term performance goals for a state of good repair. Information from the gap analysis will be used with life cycle and financial planning to develop alternative strategies that close or address the identified gaps to operate, improve or preserve existing assets.

The gap analysis requires, at a minimum, a comparison of the current condition of NHS pavements and bridges with MDOT's TAMP targets. The gap analysis should also explain how the current conditions compare to the state DOT's long-term performance goals for the state of good repair.

MDOT identified the performance gap (percentage point difference) between the constrained investment strategy condition and the TAMP target for each federal condition measure and the MDOT long-term performance goals for the state of good repair.

Pavement Gap Analysis Process

For both the Interstate and non-Interstate NHS, MDOT determined the current pavement condition (calculated as described in 23 CFR 490.313) for each condition measure (i.e., percent good and percent poor). MDOT's current long-term pavement condition goals are based on RSL and are 95 percent good/fair on the freeway and 85 percent good/fair on the non-freeway system. As the state and federal performance measures vary on measurement units, for gap analysis comparison purposes in the TAMP, it will be assumed that the percent state of good repair good/fair goal on the Interstate is 95 percent and the percent good/fair goal on the non-Interstate NHS is 85.

Bridge Gap Analysis Process

MDOT determined the current bridge condition by deck area carrying the NHS for each condition measure (percent good and percent poor). MDOT's current long-term bridge condition goals are based on count of bridges rather than deck area and are 95 percent good or fair on the freeway and 85 percent good or fair on the non-freeway system. The non-freeway goal has been exceeded since 2007 and the freeway goal was met for a period in 2016 and 2017.

As the Michigan inventory contains a few structures with exceedingly large deck areas that can cause a noticeable swing in condition, the projections and measurements will be more sensitive to the condition of these large structures. Michigan's TAMP-reported targets to FHWA are a combination of trunkline, bridge authority, and local agency NHS bridge condition. Bridge authority bridges comprise 5 percent of the statewide NHS deck area and were all in good or fair condition in 2017. Local agency bridges comprise 6 percent of the statewide NHS deck area, with 16 percent of bridges in poor condition by deck area.

Since the state and federal performance measures vary both on measurement units, as well as inventories, the assumption is made that maintaining current condition (which exceeds the state goal) is a reasonable conversion of aspirational goals. For gap analysis comparison purposes in the TAMP, it will be assumed that the combined statewide NHS percent good aspirational goal by bridge deck area on the NHS is 95 percent good or fair.

Process for Analyzing Gaps Regardless of Physical Condition

State DOTs are required to have a process for analyzing gaps in the performance of the NHS that affect NHS pavements and bridges regardless of their physical condition. MDOT continues to analyze and address instances where the results or recommendations from other plans (e.g., Highway Safety Improvement Program, State Freight Plan, etc.) may affect NHS pavement and bridge assets. MDOT reviews these plans if there is a call for additions or changes to existing pavements or bridges in a manner beyond the current investment strategy. If significant, MDOT will identify the change in condition gap because of these strategies. Annual investment strategies are developed in cooperation with all transportation program managers during the annual CFP process. This assures that all resources invested in the NHS system have the maximum positive impact in improving physical condition along with addressing safety, congestion reduction, mobility, reliability, and environmental sustainability.

Developing Alternative Strategies to Close or Address the Identified Gaps

MDOT continues to develop and analyze alternative life cycle strategies and/or financial scenarios for closing or addressing gaps relating to the state of good repair and any other identified gaps for pavements and bridges.

Performance Gaps

National Minimum Condition Level for Interstate Pavement Condition Gap

The measure for percent poor on Interstates fell below 5 percent in 2017, attaining the threshold established by FHWA and meeting the national minimum condition level for the Interstate; therefore, there is no gap.

Short-Term Pavement and Bridge Condition Gap

MDOT established short-term targets for federal PCM on the Interstate and non-Interstate NHS and the four-condition metrics outlined in federal regulations, along with short-term targets for bridge condition measures on the NHS based on the NBI minimum condition ratings. Since both the short-term pavement and bridge targets were developed based upon the constrained investment strategy included in this TAMP, they do not represent any gap in performance at this time.

State of Good Repair Versus Constrained Performance Gap

Pavement Condition Gap

Figures 9-4 and 9-5 depict the gap in condition between the state of good repair pavement strategy and the constrained investment strategy discussed in the Investment Strategies chapter of this document.

The constrained investment strategy indicates the agency's prediction of future NHS pavement condition under existing construction funding conditions, while the state of state of good repair strategy represents the funding required to achieve the agency's NHS pavement condition goals. The NHS only makes up roughly 25 percent of Michigan's FAE pavement network, so these forecasts are not comprehensively representative of Michigan's pavement condition forecast under either scenario.

Figure 9-4: Interstate Pavement Condition Gap (RSL): Constrained Versus State of Good Repair Strategy

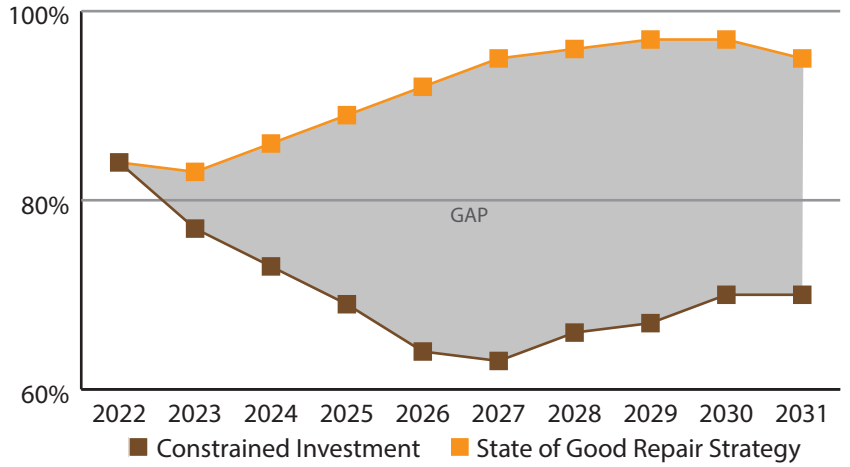
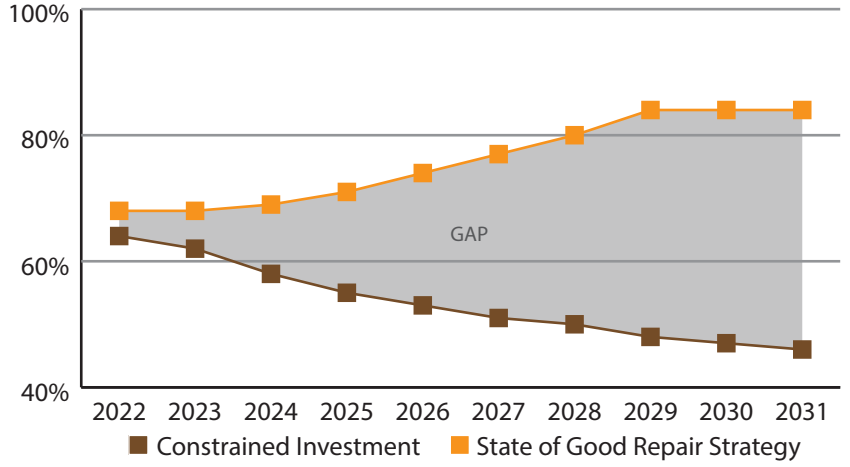


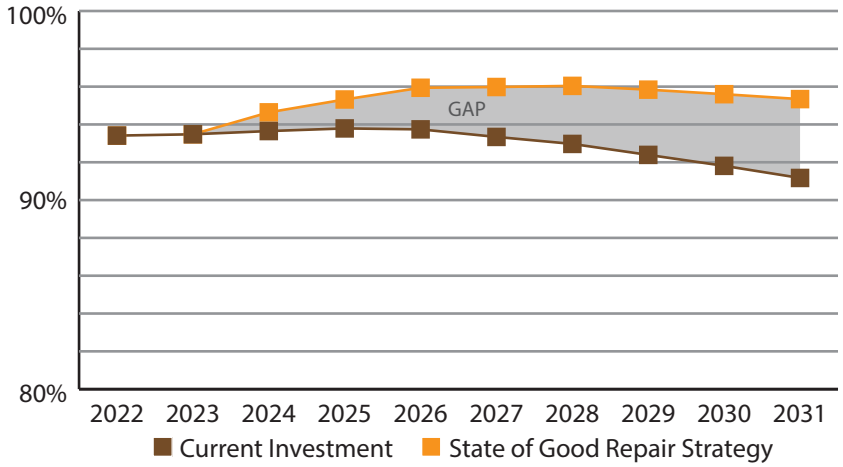
Figure 9-5: Non-Interstate NHS Pavement Condition Gap (RSL and PASER): Constrained Versus State of Good Repair Strategy



Bridge Condition Gap

Figure 9-6 depicts the gap in condition between state of good repair bridge goals and the current and/or projected future bridge condition for the NHS network. This condition is statewide NHS and includes local agency and bridge authority bridges. Future condition is forecasted based on the constrained investment strategy discussed in the Investment Strategies chapter of this plan. It is important to remember that NHS bridges represent just more than half of the total bridge deck area statewide and a little more than a quarter of the number of bridges statewide. The gap identified in this plan focuses on the condition of the bridges carrying the NHS and does not address the non-NHS assets.

Figure 9-6: NHS Bridge Condition Forecast Comparison: Current and State of Good Repair Strategy



Summary

To meet the state of good repair for NHS pavements and bridges, an average additional investment of $15.8 billion would be needed through 2031. This is comprised of an additional $3 billion over the 10-year timeframe for the Interstate system and an additional $11.8 billion for the non-Interstate NHS, and an additional $1 billion for NHS bridges. This investment improves the condition of the Interstate routes to 95 percent good or fair based on RSL and improves the non-Interstate NHS pavement conditions to 85 percent good or fair based on RSL and PASER.

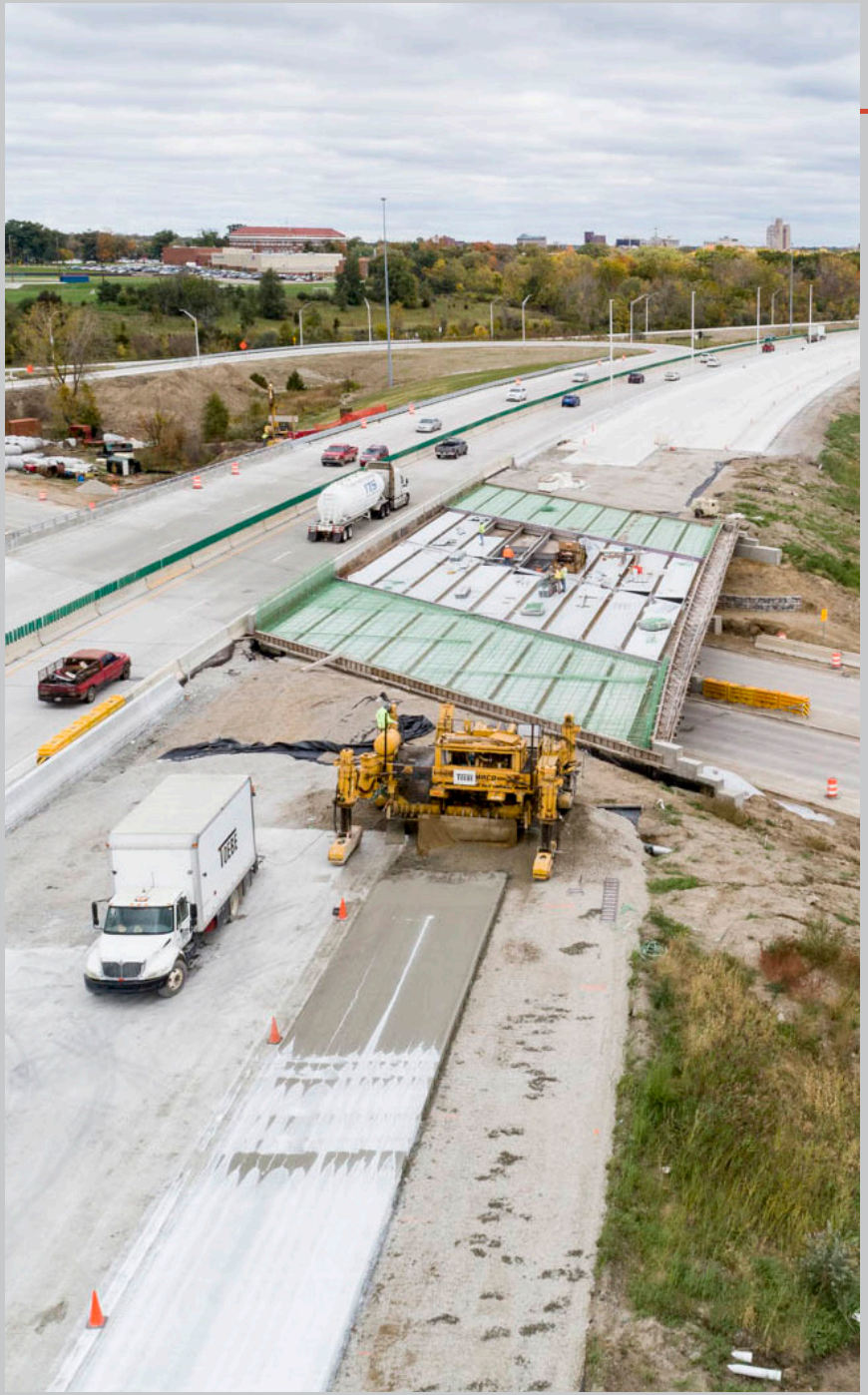
Even with the additional funding expected at the national level through IIJA, MDOT's funding levels are not enough to maintain or improve current pavement conditions. MDOT's trunkline system is projected to decline rapidly over the next decade. Without adequate funding, pavements and bridges cannot be maintained as regularly and will progress into conditions that require significantly more costly rehabilitation, leading to poor statewide road and bridge conditions. If funding for trunkline pavements is not secured today, the cost to repair these assets will continue to rise as pavement and bridge conditions continue to drop. Under the constrained investment strategy, the condition of Interstate pavement would fall to just 60 percent good or fair and non-Interstate condition would fall below 50 percent good or fair, based on their respective condition measures.

Roads and bridges are among many assets that are considered when managing funding for a transportation agency. Should other areas subject to performance measures encounter significant obstacles in meeting their minimum condition goals or performance targets, the agency will need to determine if funding should be shifted, further redirecting resources from asset management of pavement and bridge assets.

To meet the state of good repair for NHS bridges, an average additional investment of $112 million per year would be needed through 2032. This investment improves the condition of NHS bridges to 95 percent good or fair based on deck area.

Figure 9-7: Pavement and Bridge Planned and Needed Investment to Achieve Targets by 2031

Asset	Current Condition (% Good/Fair)	State of Good Repair (% Good/Fair)	Constrained/ Planned Investment (Total for 10 Years)	Investment Gap (Total for 10 Years)
Pavement: Interstate	78	95	$4.7 billion	$3 billion
Pavement: Non-Interstate NHS	70	85	$4.5 billion	$11.8 billion
Pavement: Total			**$9.2 billion**	**$14.8 billion**
Bridge NHS	93	95 (deck area)	$2.3 billion	$1.0 billion



Asset Management Plan Implementation and Integration

Asset management is most effective when integrated into existing policy, program investment, and operations plans. This final chapter summarizes the ongoing asset management implementation and integration efforts at MDOT.

TAMP Guidance

Under the asset management provisions enacted in MAP-21, codified at 23 U.S.C. 119, state DOTs must develop and implement a risk-based TAMP. This TAMP must include all NHS pavements and bridges, regardless of ownership. In addition to the basic requirements set forth in code, MDOT reviewed and incorporated suggested changes identified in the Baseline Assessment of TAMP Enhancement Opportunities for Michigan provided by the FHWA. MDOT has also participated in webinars and peer-exchanges hosted by FHWA regarding TAMP development.

This document was created in alignment with federal guidance, which states that a state must:

- Ensure its TAMP is reviewed and certified by FHWA,
- Perform an annual consistency determination to evaluate implementation of the TAMP, and
- Make significant progress toward achieving NHS performance targets.

While the focus of this document includes compliance with federal regulations, MDOT's primary focus is to improve the ongoing management of all assets under its jurisdiction. The Transportation Asset Steering Committee (TASC) is responsible for ongoing asset management leadership and stewardship for the department. The TASC is coordinated through the Asset Management and Policy Division (AMPD).

Steering and Document Development

Since asset management is a core function of MDOT, implementation occurs throughout the department, and a core group of individuals from several areas are tasked with documenting the asset management

process and progress toward performance measures and goals. For the 2022 Michigan TAMP, a Steering Committee was established, led by the BTP director, and included representatives from each division that supports asset management implementation, including the STPD and the AMPD.

In addition, a Development Team consisting of staff from BTP (STPD, AMPD, DIID), BOBS, and the Bureau of Development worked on updates to the data and performed the associated analyses. This team will be responsible for future updates with direction provided by the Steering Committee. While the Michigan TAMP covers a 10-year timeframe, it is updated every four years with new revenue projections, investment strategies, and a report out on progress made toward established goals. In addition, annual consistency determinations are performed to compare the anticipated strategies with the strategy that is delivered.

Moving Forward

Pavement Working Group

To advance communication and collaboration throughout the department, MDOT's BTP formed a cross-divisional team to provide an opportunity for pavement management professionals to suggest changes and improvements to the pavement management process. Utilizing the latest network data available, proposals are discussed and agreed upon as a team and implemented. To date, the team has made advancements in the following MDOT practices: pavement condition forecasting, the CFP process, and project estimation and programming.

Additional Assets

As MDOT's implementation of asset management continues to mature, the need to incorporate additional assets into the process and the way to do so becomes clearer. MDOT recognizes the risk associated with poor condition performance for several assets that are considered ancillary structures including (but not limited to) culverts that are not included in the traditional structure inventory, retaining walls, sign trusses, and cantilevers. Currently, an effort is underway to establish a complete inventory and associated condition data to perform asset management analysis.

In addition, MDOT is planning to incorporate pump stations into its asset management planning process. Michigan has many depressed freeway sections that require pump stations to be properly maintained to ensure the corridors are navigable during heavy rain events. MDOT currently maintains the pump station inventory within its enterprise Transportation Asset Management System and has plans to develop performance curves needed to forecast future conditions to identify future funding needs.

Risk Assessment and Resilience Efforts

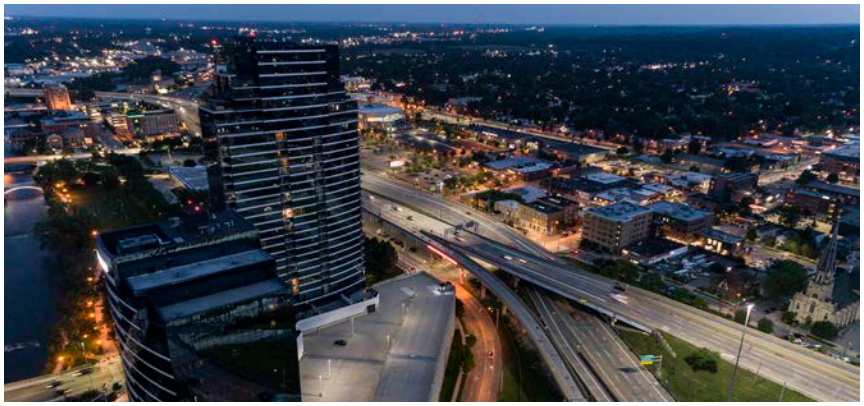
Through the adoption of the MM2045 SLRTP, the department committed to performing a transportation asset vulnerability assessment, which will be used to support TAMP development in future years. MDOT plans to accomplish this in alignment with new federal guidance that flows from the enactment of the IIJA. It is through these efforts that the department plans to bolster its ongoing resilience efforts and develop a strategy to more fully integrate considerations of resilience (particularly as it relates to extreme weather events) into its planning procedures and processes.

IT Projects

MDOT is currently working on a project to build a pavement version of the AASHTOWare BrM software to enhance project identification and forecasting capabilities, including the forecast of the federal PCM of IRI, cracking percent, rutting, and faulting. Once the project is complete, MDOT will integrate this new pavement tool into the asset management process, with future flexibility to merge with bridge and ancillary asset data.

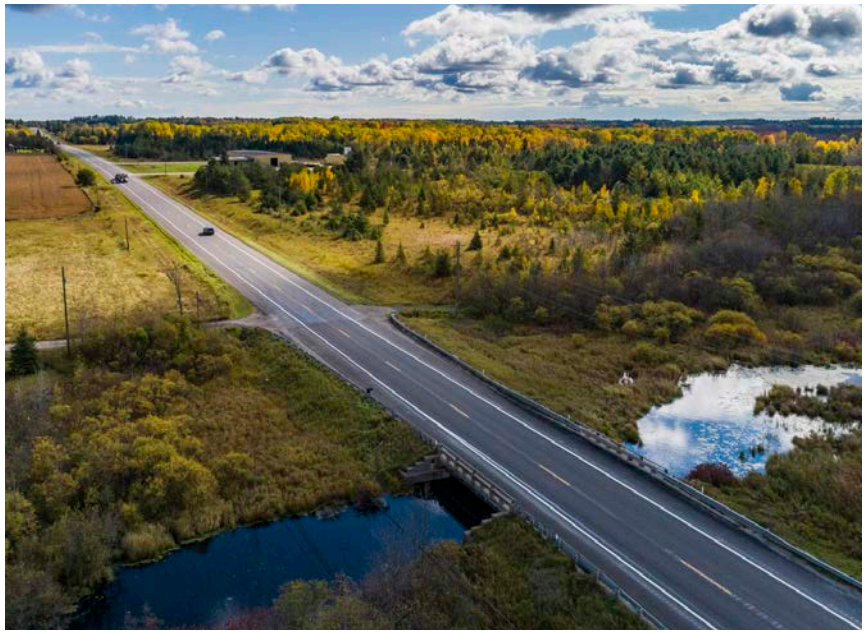
Diversity, Equity, and Inclusion (DEI)

MDOT is more thoughtfully considering the impacts of its historic and future transportation investments through the lenses of equity and environmental justice. These efforts include prioritizing how the state's transportation infrastructure can be improved to be more people-focused, equitable, reliable, convenient, and inclusive for all users. In addition, the department recognizes its responsibility to ensure DEI in all its various transportation and investment decision-making processes. MDOT is committed to continuous improvement of its DEI efforts and adoption of best practices when equity considerations inform needed change.



In Summary

To fully implement the asset management strategy that will allow the department to reach a state of good repair on Interstate and non-Interstate assets alone, MDOT needs an additional $1.6 billion annually, along with the implementation of a risk management process that is embedded in its planning and program development process. While MDOT continues to work toward the goal of a fully matured transportation asset management process, additional work is necessary to fully incorporate additional transportation assets.



TAMP Webpages

Initial TAMP –
https://www.Michigan.gov/MDOT/-/media/Project/Websites/MDOT/Programs/Planning/Asset-Management/Initial-Transportation-Asset-Management-Plan.pdf

2019 TAMP -
https://www.Michigan.gov/MDOT/-/media/Project/Websites/MDOT/Programs/Planning/Asset-Management/Transportation-Asset-Management-Plan-August-2019.pdf

Final TAMP –
https://www.Michigan.gov/MDOT/0,4616,7-151-9621_15757---,00.html

MDOT NHS Inventory and Condition Homepage –
https://mdot.maps.arcgis.com/apps/MapSeries/index.html?appid=be36cb6ba7884298b4341aa93d6e6096

Michigan Bridge Conditions –
https://mdot.maps.arcgis.com/apps/MapSeries/index.html?appid=fb70725b2be04dc7b01703d0b6c91bb6

MDOT Featured Maps –
http://featuredmaps-mdot.opendata.arcgis.com

2022-2026 Five-Year Transportation Program –
https://www.Michigan.gov/MDOT/-/Media/Project/Websites/MDOT/Programs/Planning/Five-Year-Transportation-Program/2022-2026-Five-Year-Transportation-Program.pdf

Michigan Hazard Analysis –
https://www.Michigan.gov/-/media/Project/Websites/msp/EMHSD/pdfs/pub_103_mha_2020_supplemental.pdf?rev=97ea849a8c7d4bcd88e408e-18a034379#:~:text=The%20Michigan%20Hazard%20Analysis%20(MHA,hazards%20and%20human%2Drelated%20hazards

State Transportation Commission –
https://www.Michigan.gov/MDOT/about/commissions-councils-committees/transportation-commission

Transportation Asset Management Council –
https://www.Michigan.gov/MIC/TAMC

Bridge Mid-Performance Period Report –
https://www.Michigan.gov/documents/mdot/BRIDGE_MPP-Newsletter_2020_714918_7.pdf

PASER Asphalt Roads Manual –
http://www.apa-mi.org/docs/Asphalt-PASERManual.pdf

2021 TAMC Data Collection Training Manual –
https://www.Michigan.gov/-/media/Project/Websites/tamc/Folder2/tamc-data-collection-manual-2021.pdf

Michigan Transportation Program Portal –
https://experience.arcgis.com/experience/f3a4872ac4444f5eac3adf4c656d0a53/page/page_0/?views=view_3

Pavement Performance Management Report –
https://www.Michigan.gov/-/media/Project/Websites/MDOT/Programs/Planning/STIP/TPM-Pavement-Newsletter-June-2020.pdf

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Michigan Department of Transportation

Providing the highest quality integrated transportation
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