2023-2032 TRANSPORTATION ASSET MANAGEMENT PLAN

MARCH 2023

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IA 100/Edgewood Rd. interchange
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1. INTRODUCTION

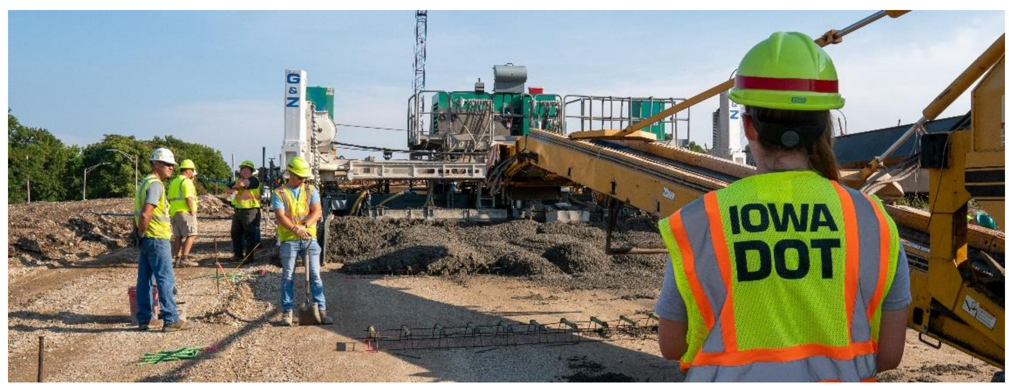
Transportation asset management is a strategic approach to managing transportation infrastructure. It embodies a philosophy that is comprehensive, proactive, and long term. The overall goals of asset management are to minimize long-term costs, extend the life of the transportation system, and improve the transportation system's performance.

Background

Iowa Department of Transportation (DOT) has worked to implement Transportation Asset Management (TAM) across its business practices and processes. In the past, Iowa DOT had used a combination of preventive maintenance and worst-first approaches to manage its bridges and pavements. In a worst-first approach, agencies rank their assets from worst to best condition and then work down the list repairing assets until they exhaust available funds. Often, the assets in the worst condition require expensive reconstruction. This approach is costly and leaves limited resources for preserving and maintaining other parts of the network.

Asset management provides an alternative approach in which agencies strike a balance between reconstructing poor assets and preserving good assets so that they do not become poor. As defined in 23 CFR 515, asset management means a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the life cycle of the assets at minimum practicable cost. Transportation agencies throughout the United States have found that this balanced approach extends the useful lives of their assets and is more cost-effective in the long run.

Faced with budgetary constraints and a substantial need for investment in infrastructure, Iowa DOT's executive leadership determined that TAM was necessary for the successful long-term operation of Iowa's transportation system.



1.1 Transportation Asset Management Plan Overview

Federal Requirements

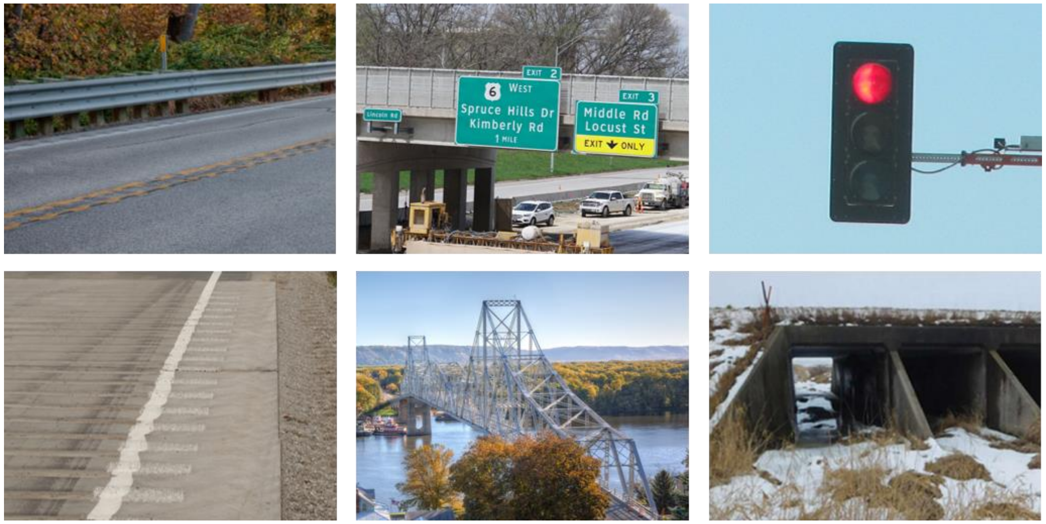
The last three federal transportation reauthorization bills, the 2012 Moving Ahead for Progress in the 21st Century (MAP-21) Act, the 2015 Fixing America's Surface Transportation (FAST) Act, and the 2021 Infrastructure Investment and Jobs Act (IIJA), have emphasized a performance-based planning and programming (PBPP) process. MAP-21 established seven national performance goals for federal highway programs, including maintaining a state of good repair for highway infrastructure. MAP-21 also initiated the requirement that every state DOT develop a risk-based transportation asset management plan (TAMP) to improve and preserve the condition of assets on the National Highway System (NHS). The NHS is a federal designation for a system of roadways which includes the Interstate Highway System and other roads important to the nation's economy, strategic defense, and overall mobility. In Iowa, the vast majority of the NHS is owned and maintained by Iowa DOT. Iowa's TAMP has been expanded to include the entire Primary Highway System, which is the complete highway network owned and maintained by Iowa DOT. The TAMP is required to include the following elements.

- Summary listing of the bridge and pavement assets on the NHS in the state, including a description of the condition of those assets
- Asset management objectives and measures
- Performance gap identification
- Life cycle cost and risk management analysis, including consideration of extreme weather and resilience
- Financial plan
- Investment strategies

Figure 1.1 shows examples of typical highway assets in Iowa. While the TAMP focuses on bridges and pavements, the transportation network includes a variety of other assets. Iowa DOT works to maintain all these assets in order to keep travelers safe, promote mobility, and make progress towards state and national transportation goals.

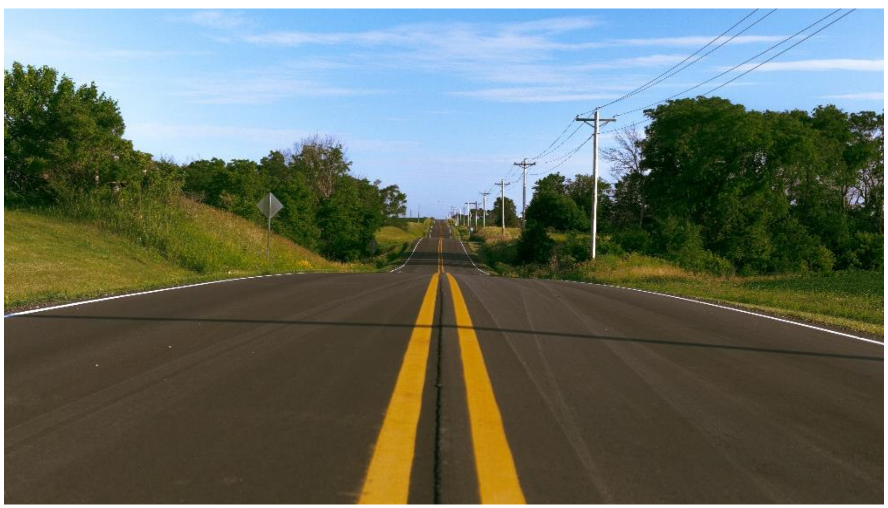
Figure 1.1: Examples of typical highway assets

Clockwise from upper left: pavement and guardrail; bridge and traffic signs; traffic signal; culvert; bridge; pavement markings and rumble strips.



This document, Iowa DOT's TAMP, meets federal requirements. It describes how Iowa DOT manages its bridges and pavements throughout their lives and provides a framework that will guide funding decisions across Iowa DOT districts, divisions, and bureaus. In addition to meeting federal requirements, Iowa DOT's TAMP meets the following objectives.

- Defines clear links among agency goals, objectives, and decisions
- Defines the relationship between proposed funding levels and expected results
- Develops a long-term outlook for asset performance
- Documents how decisions are supported by sound information
- Develops a feedback loop from observed performance to subsequent planning and programming decisions
- Improves accountability for decision making
- Unifies existing data, business practices, and divisions to achieve Iowa DOT's asset management goals



Iowa DOT Asset Management Plans

Iowa DOT's first TAMP was developed in 2016 prior to the final rulemaking for asset management plans. In 2018, an 'initial' TAMP (referred to as 2018 TAMP) was completed in compliance with 23 CFR 515. As allowed by the regulations, the 2018 TAMP did not include a full analysis for some asset management processes or targets for NHS pavement and bridge condition, which were established after the 2018 TAMP was complete.

Following completion of the 2018 TAMP, work began to address all remaining areas required to be documented in the TAMP and create a 'fully-compliant' TAMP that addressed Federal Highway Administration (FHWA) comments on the 2018 TAMP and contained all required elements and process documentation outlined in 23 CFR 515. The 2019 TAMP built off the 2018 TAMP and included improved descriptions of processes, more specific discussion of Iowa DOT's asset management practices, NHS pavement and bridge condition targets, and updated analysis of the highway system.

This document, the 2022 TAMP, builds off the prior versions and provides updated information and process descriptions for asset management activities. In addition, several components of the plan have been added or significantly enhanced from the 2019 TAMP.

- Enhanced discussion of the TAMP's role in the planning and programming process
- Incorporation of additional pavement management analysis
- Expanded gap analysis discussion
- Additional clarity for state vs. federal performance projections
- Updated risk register
- Enhanced consideration of extreme weather and resilience in life cycle planning and risk management analysis

1.2 TAM Goals and Guiding Principles

This TAMP supports Iowa DOT's goals and objectives and supports progress towards national goals established in MAP-21. Consistent with best practices nationally, Iowa DOT's asset management goals are to:

- Build, preserve, operate, maintain, upgrade, and expand the transportation system more cost-effectively throughout its whole life
- Improve performance of the transportation system
- Deliver to Iowa DOT's customers the best value for every dollar spent
- Enhance Iowa DOT's credibility and accountability in its stewardship of transportation assets

Iowa DOT is implementing and practicing TAM according to a set of guiding principles that shape the TAMP development process. Iowa DOT's guiding principles for transportation asset management are the following.

- Asset management is policy driven. Funding decisions reflect Iowa DOT's vision for how the transportation system should look in the future.
- Asset management is performance based. Iowa DOT understands the condition of its assets, defines performance targets, and makes decisions that support these targets.
- Asset management involves making trade-offs. Iowa DOT has options for how to allocate transportation funding. It evaluates these options and makes informed decisions regarding the best path forward.
- Asset management relies on quality information. Iowa DOT uses data and analytical tools to support its decisions.
- Asset management requires transparency and accountability. Iowa DOT documents how funding decisions are made. It monitors performance, tracks progress towards performance targets, and reports on results.

These guiding principles align with Iowa DOT's 2021-2025 Business Plan, which outlines Iowa DOT's core focus of making lives better through transportation. Asset management is a key component of reaching the priority goal of improving transportation system safety and performance, which includes the outcome of increased efficiency, reliability, resiliency, and condition of Iowa's transportation system. Implementing asset management in alignment with the TAM guiding principles will help Iowa DOT meet this goal.

1.3 Local Coordination

Many highways and roadways transition ownership as they cross jurisdictional boundaries, and Iowa DOT recognizes that most people using the transportation system are not concerned with who manages each road section. Iowa DOT works with local agencies in Iowa to coordinate asset management efforts to help everyone get the most value from public roads. Although the primary focus of this document relates to the management of Iowa's Primary Highway System managed by Iowa DOT, there are places where the plan also references the condition of local National Highway System (NHS) assets, and how Iowa DOT works with local governments in Iowa to coordinate management of the system. Such references are intended to be responsive to federal requirements related to the content of this plan, in particular with respect to the NHS. Iowa DOT does not direct local agency investment decisions, and the inclusion of information concerning these assets should not be considered a substitute for local agency decision-making processes.

City and county owners of NHS assets are also involved in asset management planning at a regional level through their Metropolitan Planning Organization (MPO) and/or Regional Planning Affiliation (RPA). MPOs and RPAs are required to produce Long-Range Transportation Plans (LRTPs) and Transportation Improvement Programs (TIPs). Iowa DOT passes federal funding from the Surface Transportation Block Grant Program to MPOs and RPAs for local programming; projects programmed by MPOs/RPAs in their TIPs are then incorporated into the Statewide Transportation Improvement Program (STIP). This includes projects on the NHS when applicable.

Federal regulations require the state, MPOs, and providers of public transportation to establish agreements related to performance management elements, including the target setting and reporting process and the collection of data for the state asset management plan for the NHS. Iowa DOT has established agreements between the state and MPOs in each MPO's annual Unified Planning Work Program (UPWP), and with transit providers through their annual consolidated funding applications. The agreements provide for coordination with MPOs during Iowa DOT's target setting process, and for MPOs to coordinate with Iowa DOT during their target setting processes. The agreements also provide for Iowa DOT to take the lead in providing performance-related data for the NHS, and focus on sharing existing data rather than creating new data collection responsibilities. Specific examples of coordination for data collection and sharing of pavement and bridge data are discussed in Chapter 3.

1.4 Related Planning Documents

Iowa DOT's 2022 statewide transportation plan, **Iowa in Motion 2050**, established a transportation system vision of "A safe and efficient multimodal transportation system that enables the social and economic wellbeing of all Iowans, provides enhanced access and mobility for people and freight, and accommodates the unique needs of urban and rural areas in a sustainable manner." The plan notes that the ultimate purpose of the transportation system is to get people and goods where they need to go, or more simply, mobility. The plan defines mobility through four system objectives – safety, sustainability, accessibility, and flow – and sets up a performance management framework for Iowa DOT planning and programming processes to align with in order to help ensure a unified approach to developing the transportation system. This is visualized in Figure 1.2.

Figure 1.2: Iowa DOT system objectives

This TAMP describes how Iowa DOT manages the existing highway system. Preserving and improving this system is critical for achieving the system vision. The TAMP relates most strongly to the sustainability objective, but also has important ties to safety, accessibility, and flow, as the condition of the system helps lead to successful outcomes for those objectives as well.

Iowa in Motion 2050 also established Iowa DOT's **rightsizing policy**, which has a strong tie to asset management and stewardship. The policy defines rightsizing as "seeking an appropriate level and type of investment that avoids overinvesting or underinvesting, overbuilding or underbuilding, and overserving or underserving the market based on user and system needs. The department's role in rightsizing should be viewed as leveraging existing assets and limited resources to maximize the returns for users of the multimodal transportation system, with operating, maintaining, and constructing this system as a means to this end."

The rightsizing policy includes ten policy statements for various areas, many of which relate to asset management. These include defining project needs, incorporating comprehensive needs, placing an emphasis on stewardship, and stratification of the system for purposes like setting state of good repair targets and defining asset management treatments. The topic of system stratification is discussed further in Chapter 4.

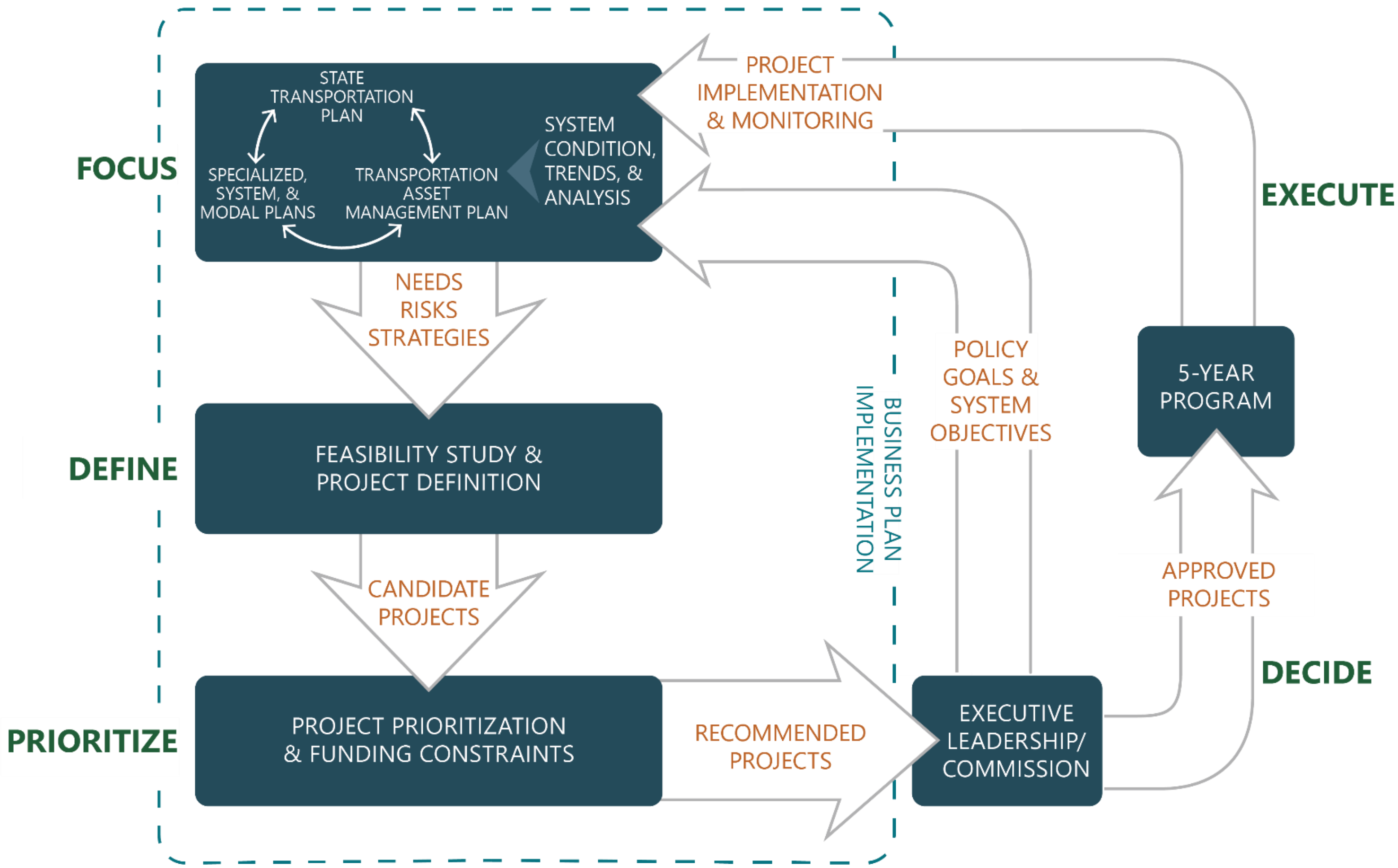
In the overall planning and programming process, the TAMP, along with Iowa in Motion and **other system and modal plans**, plays a role in helping to focus attention and priorities based on system needs, risks, and strategies. Figure 1.3 shows how these broader planning efforts help guide the planning and project development process that ultimately leads to the **Five-Year Program**, which identifies specific investments over the next five years. The TAMP describes the life cycle planning processes that are undertaken for pavements and bridges, identifies current and projected performance gaps, prioritizes risks to managing the system, identifies risk mitigation strategies, and outlines investment strategies used to determine projects. While the TAMP does not identify projects or dictate investment decisions, it helps ensure that the investments in the Five-Year Program are consistent with Iowa DOT's longer-term vision by connecting system- and network-level planning to specific project programming. While not shown on Figure 1.3, the Five-Year Program is incorporated into the **Statewide Transportation Improvement Program (STIP)**, which includes all federal funding programmed for transportation improvements in the state.

The **Iowa Transportation Commission (Commission)**, a seven-member, governor-appointed body, is responsible for ultimately approving each iteration of Iowa in Motion and the Five-Year Program. Iowa DOT must implement asset management in alignment with the guiding principles in this chapter and through a funding program developed and approved by the Commission. Each year, department staff provide a series of asset management related presentations to the Commission at their monthly workshops, which provide an asset management overview, a review of pavement and bridge needs and performance scenarios, a review of special asset management related efforts, such as the **Iowa Interstate Investment Plan** and **integrated corridor management** efforts, and a series of presentations and discussions that transition from the overview material to iterating through decision points during the development of the Five-Year Program. The recurring dialog with the Commission regarding asset management and program development provides an opportunity to converse with the Commission on the importance of asset management and the strategies staff recommend pursuing. It is also one of the most visible components of the department's asset management efforts, as these discussions occur at workshops that are open to public and streamed online.

The Commission's emphasis on asset management is documented in the 2023-2027 Five-Year Program, which notes the following.

> *The Commission's primary investment objective remains stewardship (i.e. safety, maintenance, and modernization) of Iowa's existing highway system…A critical part of the Commission's stewardship strategy includes effective use of asset management tools and techniques. These tools and techniques serve as a guide for making the right kind of investments at the right time in order to maximize the benefit to the transportation system while minimizing lifecycle costs. These tools help the Commission identify the most effective treatment strategies for pavement and bridge repair, rehabilitation, and replacement projects. These tools also guide decisions about investment levels by creating projections for future condition levels based on different funding scenarios.*

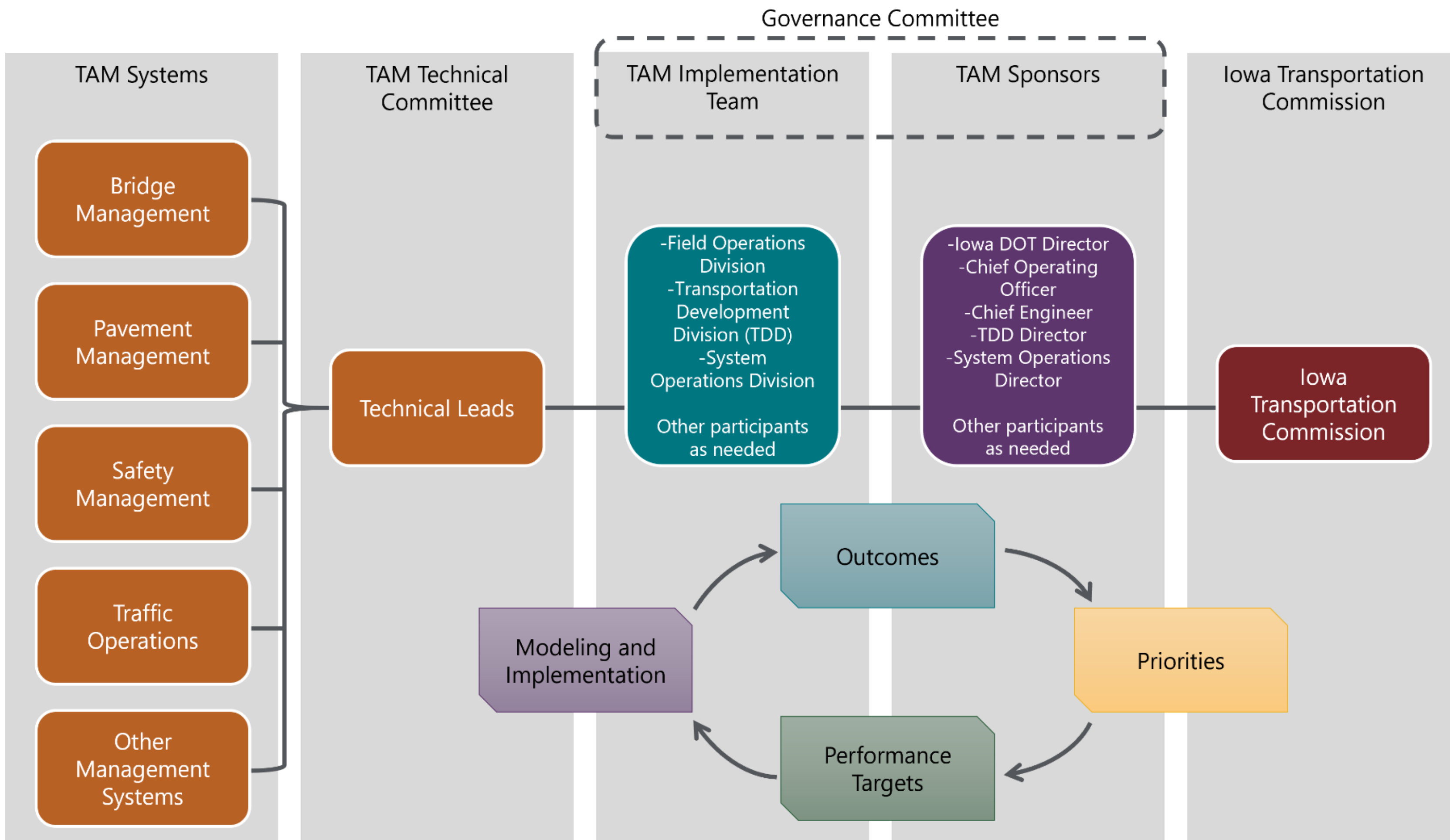
Figure 1.3: Iowa DOT planning and programming documents and processes



1.5 Agency Structure Related to TAM

The development of Iowa's first TAMP was led by a TAMP steering committee and completed in November 2016. The current TAM governance structure was developed based on the recommendation of the first TAMP and a subsequent gap analysis process. Iowa DOT's TAM governance structure is depicted in Figure 1.4.

Figure 1.4: Iowa DOT TAM governance structure



The foundation of TAM rests with the TAM Systems teams, particularly the pavement and bridge management teams, which play a key role in facilitating the processes discussed in the TAMP. The TAM Technical Committee brings team leads and others from the department together to share team-level discussions and delve into cross-cutting topics.

The Governance Committee is composed of staff involved with developing and delivering the highway program. The Governance Committee's role is to design a process and governance structure that will achieve the following.

- Add transparency to the programming process, align associated tools and plans, and incorporate appropriate stakeholders
- Define roles and responsibilities of the associated stakeholders
- Create a process that is adaptable over time as technology, initiatives, and priorities change
- Oversee the incorporation of risk management into the prioritization process
- Provide input to critical plan development efforts, including the TAMP and long-range transportation plan
- Propose performance targets, propose funding levels to achieve those performance targets, and coordinate the associated monitoring and reporting

1.6 TAMP Organization

The TAMP is organized as follows.

1. **Introduction**. This chapter provides an introduction of TAM, an overview of Iowa's asset management goals, and a description how the document is organized.
2. **Asset Inventory and Condition**. This chapter presents the inventory and current condition of both National Highway System (NHS) and state-owned pavements and bridges in Iowa, categorized by system and owner. This chapter also defines Iowa's performance measures.
3. **Life Cycle Planning**. This chapter describes Iowa DOT's strategies for managing pavements and bridges over their life cycles to minimize agency and user costs.
4. **Performance Assessment**. This chapter details a set of scenarios predicting future conditions of Iowa's pavements and bridges over a ten-year period, detailing the gaps between current and predicted conditions and Iowa DOT's desired state of good repair. This chapter also includes Iowa DOT's targets for asset condition.
5. **Risk Management**. This chapter discusses risks to Iowa's pavements and bridges that could impact the achievement of TAM goals and objectives. It presents strategies for addressing Iowa's highest priority risks.
6. **Financial Plan and Investment Strategies**. This chapter details projected future revenues and expenditures for asset management-related uses. It also describes Iowa's investment strategies for best achieving its goals and objectives given available resources.
7. **Process Improvements**. This chapter includes a set of planned future asset management-related improvements.

Iowa DOT's TAMP is not a fix for an emergency. It represents a way of doing business. When used effectively, TAM will assist Iowa DOT in more effectively managing Iowa's most critical transportation assets and in proactively planning for future needs.

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2. ASSET INVENTORY AND CONDITION

Asset inventory and condition data are the foundation for managing transportation assets. Inventory and condition data are valuable for communicating the extent of Iowa's assets and the current state of those assets. These data are also the building blocks for other asset management processes. Accurate inventory and condition data are needed for supporting asset management processes such as life cycle planning, projecting funding needs, developing projects, and monitoring asset performance.

Introduction

This chapter presents a brief overview of Iowa, provides summary information on asset inventory, outlines how Iowa Department of Transportation (DOT) assesses asset condition, and describes the current condition of Iowa's bridges and pavements. Assets in this chapter, and throughout the Transportation Asset Management Plan (TAMP), are broken out to show both the state-owned system and the National Highway System (NHS). The NHS includes both state-owned and locally owned assets.

Federal Requirements

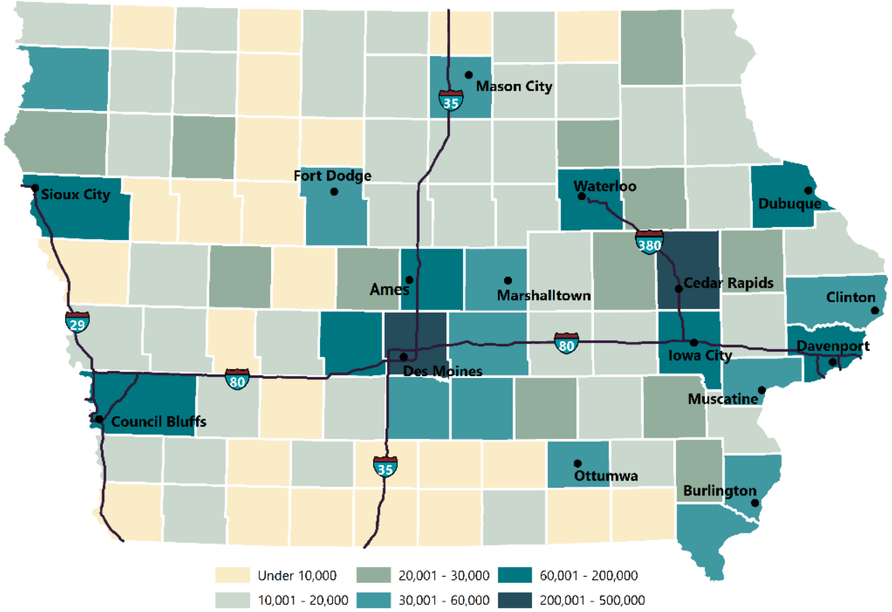
A state's TAMP must contain a description of asset inventory and condition of NHS bridges and pavements. In reporting conditions for pavements and bridges on the NHS, the TAMP must include the federally defined condition performance measures detailed in 23 CFR 490. These requirements describe measures of good, fair, and poor condition for pavements and bridges calculated using data reported to the Federal Highway Administration (FHWA). States are also required to obtain necessary data from other NHS owners in a collaborative and coordinated effort.

2.1 Iowa Overview

Iowa's demographic and economic landscape provides important context for asset management planning for the highway system. Iowa is a predominately rural state. Population by county and population change from 1990-2020 are shown on Figures 2.1 and 2.2. Over half the state's population and jobs are located in just 10 of its 99 counties. Increasing urbanization is expected to continue in the future, which puts additional pressure on maintaining urban highway systems to keep them operating smoothly for commuter and freight traffic. At the same time, maintaining the rural highway system is critical for continuing to move people and goods throughout the state.

Figure 2.1: Iowa's population by county, 2020

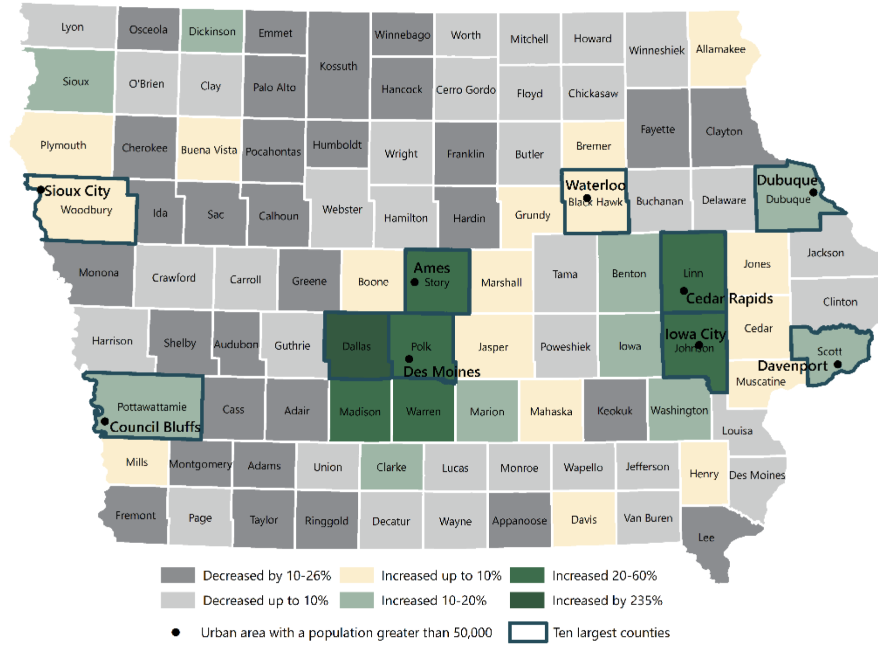
The state's population continues to concentrate in its urban areas.



Source: U.S. Census Bureau

Figure 2.2: County population change, 1990-2020

Over half the state's population and jobs are now located in just 10 counties.



Source: U.S. Census Bureau

Iowa's population and employment are expected to continue to grow, but at a slow pace. Slow growth could make it more difficult for transportation revenues to keep up with the growing maintenance and operational needs of the state's transportation system. Most travel in Iowa is by personal vehicle. According to the U.S. Census Bureau, over 81% of Iowans drive themselves to work and 8% carpool. Public transit, rideshare, walking, and bicycling are important modes, especially in urban areas and for those that may lack a vehicle, be unable to drive, or choose not to drive. However, the majority of travel is anticipated to continue to be by personal vehicle, reinforcing the need to efficiently maintain the state's highway system.

Iowa's traditional employment sectors have changed over time, with service sector growth outpacing manufacturing and farm jobs. However, the farm and manufacturing sectors still account for the largest percentage of jobs in 54 of Iowa's counties. These industries can have a major impact on the roadway system, as heavy trucks and equipment can cause operational and maintenance issues. Iowa is a producer state, meaning it exports more goods than it imports, and agricultural output continues to increase. This growth has a corresponding impact on Iowa's transportation system. While several modes are critical for freight movements, the vast majority involve a truck for at least a portion of the journey, reinforcing the importance of the highway system.

2.2 System Summary

Iowa's transportation system includes many physical assets; the most important in terms of cost and extent are bridges and pavements. Highways are the backbone of Iowa's transportation system, providing service to all areas of the state. Iowa's roadways range from eight-lane Interstates, four-lane divided facilities, and multi-lane urban streets to paved secondary roads, municipal streets, and gravel roads. Iowa's bridges provide crossings of thousands of streams, rivers, railroads, roadways, and trails. These bridges range from 20-foot structures to multi-span major river crossings. This combination of roadways and bridges has created an extremely accessible network that provides a high level of mobility throughout the state. Almost the entirety of the state's land area is within ten miles of a primary (state-owned) highway.

Bridges and pavements in this TAMP are classified by the following systems; how they overlap and the relative proportions of each are shown in Figure 2.3.

- **National Highway System (NHS)**: a system of roadways that the federal government has designated as essential for national connectivity. The NHS includes all Interstates. The NHS in Iowa is shown in Figure 2.4.
- **Iowa Primary Highway System**: the network of state highways maintained by Iowa DOT, which includes both NHS and non-NHS routes. The Primary Highway System is shown by federal functional classification (FFC) in Figure 2.5.

Iowa's pavement and bridge assets are also classified by ownership.

- Iowa DOT owns and maintains Interstate, non-Interstate NHS, and non-NHS assets. Collectively, the assets owned by Iowa DOT comprise the Primary Highway System.
- Local entities own and operate portions of the non-Interstate NHS, as well as large extents of county and local roadways.

Most vehicle-miles traveled (VMT) occur on the Interstate System and other state-owned roadways. Over the last 30 years, Interstate and other primary highways have accounted for 62% of the VMT on Iowa's roadway system, with secondary and municipal highways and roadways accounting for the remainder. Commodity movements by truck in Iowa are heavily concentrated on the Interstate System and portions of the non-Interstate NHS; overall, state-owned roadways accounted for over 91% of large truck VMT in 2019, with the Interstate System alone carrying over 53%.

Figure 2.3: Pavement and bridge assets included in the TAMP, showing relative proportions of the NHS and the Primary Highway System

Less the 3% of the NHS in Iowa is owned by local entities.

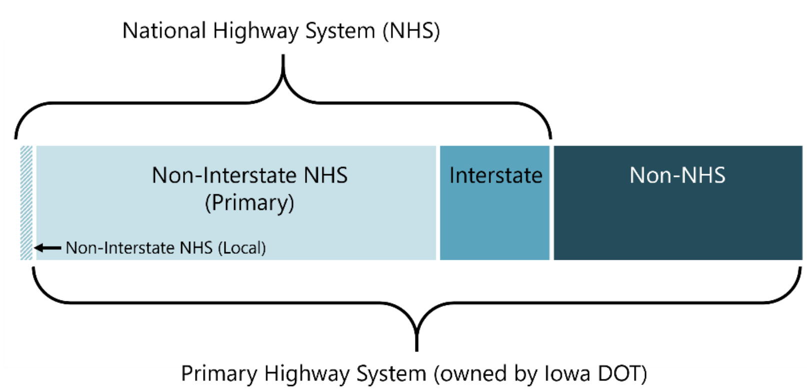


Figure 2.4: National Highway System (NHS) in Iowa

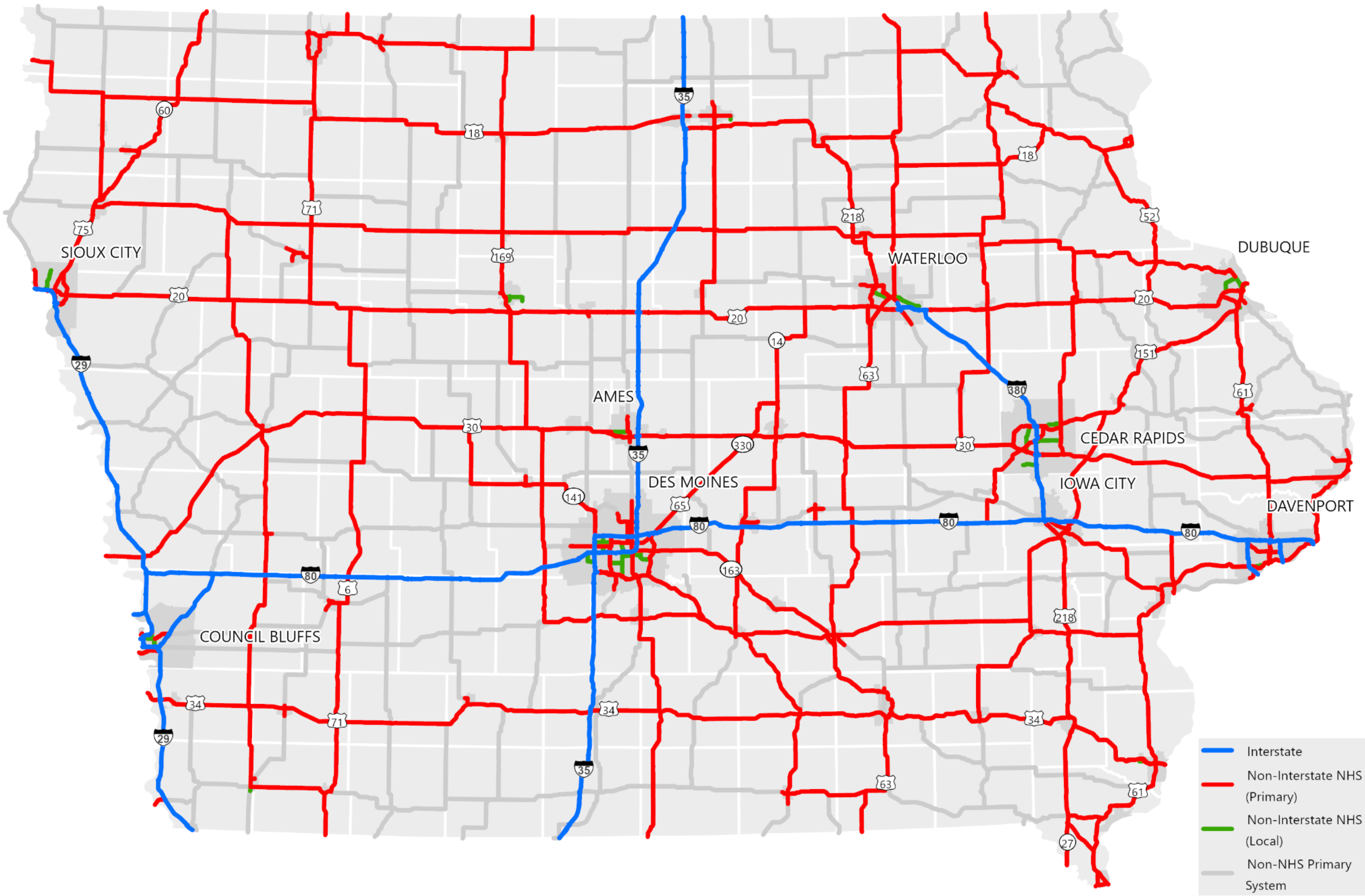
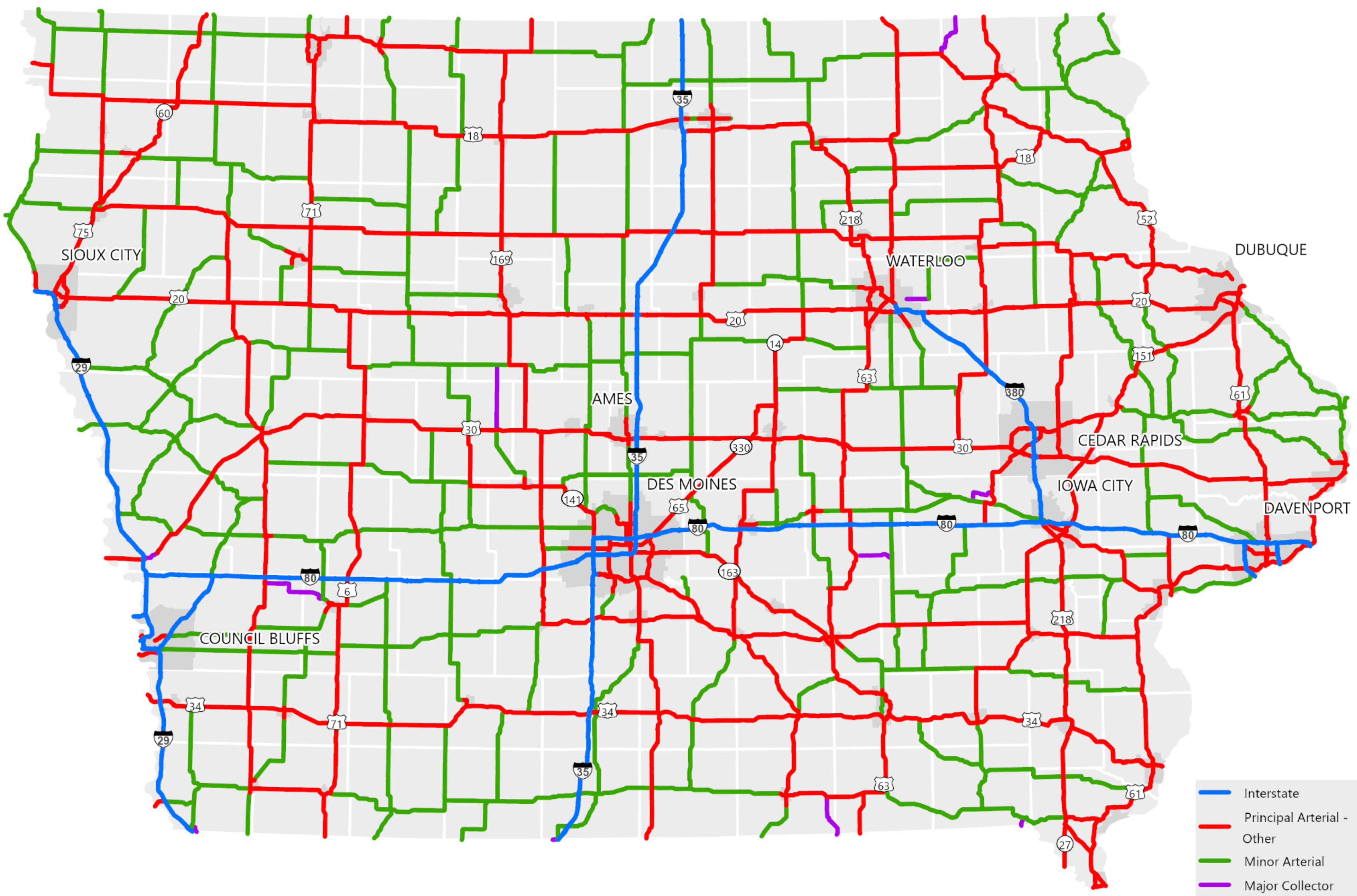


Figure 2.5: Iowa Primary Highway System by federal functional classification (FFC)



This plan presents bridges and pavements on the NHS and on the state-maintained system. For depicting NHS conditions, this TAMP uses definitions of good, fair, and poor condition developed by FHWA and required for use in the TAMP. Iowa DOT also tracks state performance measures on the Primary Highway System for bridges and pavements.

This TAMP uses bridge data reported by Iowa DOT to the National Bridge Inventory (NBI) and NHS pavement data reported by Iowa DOT to the Highway Performance Monitoring System (HPMS) for the NHS inventory and condition values.

As detailed later in the document, Iowa DOT works with other agencies in Iowa to manage the transportation network. A small portion of the NHS in Iowa is locally owned or maintained. Local owners of NHS assets in Iowa are listed in Table 2.1.

Table 2.1: Local NHS asset inventory

Planning Agency	Jurisdiction	Number of Bridges	Bridge Deck Area (ft^2)	Pavement Lane Miles
RPA 10	Benton County	-	-	0.2
INRCOG	Black Hawk County	-	-	0.5
RPA 16	Des Moines County	-	-	1.0
DMATS	Dubuque County	-	-	1.3
RPA 16	Henry County	-	-	0.6
CMPO	Linn County	2	16,099	8.1
AAMPO	Story County	-	-	0.6
RPA 5	Webster County	-	-	1.9
AAMPO	City of Ames	1	14,058	15.7
BSRC	City of Bettendorf	-	-	0.5
RPA 8	City of Camanche	-	-	0.6
INRCOG	City of Cedar Falls	-	-	10.0
CMPO	City of Cedar Rapids	2	93,505	63.0
DMAMPO	City of Clive	1	9,496	4.8
MAPA	City of Council Bluffs	6	321,493	31.7
BSRC	City of Davenport	1	2,986	3.3
DMAMPO	City of Des Moines	10	287,482	74.3
DMATS	City of Dubuque	6	60,629	34.4
INRCOG	City of Elk Run Heights	-	-	5.7
INRCOG	City of Evansdale	2	12,681	3.8
RPA 5	City of Fort Dodge	1	4,441	25.6
MPOJC	City of Iowa City	1	16,936	-
CMPO	City of Marion	1	18,724	16.6
RPA 1	City of Marquette	-	-	0.4
RPA 2	City of Mason City	-	-	2.0
RPA 1	City of McGregor	-	-	0.4
RPA 16	City of Mount Pleasant	-	-	1.4
DMAMPO	City of Pleasant Hill	2	7,329	2.3
INRCOG	City of Raymond	1	1,702	2.3
DMATS	City of Sageville	-	-	3.0
SIMPCO	City of Sioux City	3	32,948	20.9
DMAMPO	City of Urbandale	2	8,025	29.6
INRCOG	City of Waterloo	5	82,078	35.6
RPA 16	City of West Burlington	-	-	5.5
DMAMPO	City of West Des Moines	1	7,304	33.6
Total		**48**	**997,917**	**441.2**

2.3 Bridge

A bridge is a structure built to span barriers to the roadway. Bridges help transportation networks cross over waterways, terrain obstacles, and other roads or rail lines. FHWA defines a bridge as a structure having an opening measured along the center of the roadway of more than 20 feet, which includes some culverts. Bridges play a critical role in a transportation system, enabling travel where it would otherwise be unsafe or impossible. Bridges must be preserved and maintained to keep transportation user costs low and to guarantee the safe, efficient movement of people and freight.

Bridge Performance Measures

Federal

FHWA has developed condition ratings to describe the overall condition of bridges and culverts nationally. Ratings of good, fair, and poor are used as classifications for bridge condition. A bridge in good condition has no or minor isolated deficiencies and may only require preventative maintenance. A bridge with a poor condition rating is not unsafe, but should be considered for repair, replacement, restriction posting, weight limits, or monitoring on a more frequent basis.

FHWA requires that states use the following measures in their TAMPs to describe condition, set targets, and analyze performance gaps of NHS bridges.

- Percentage of NHS bridges classified in good condition (by deck area)
- Percentage of NHS bridges classified in poor condition (by deck area)

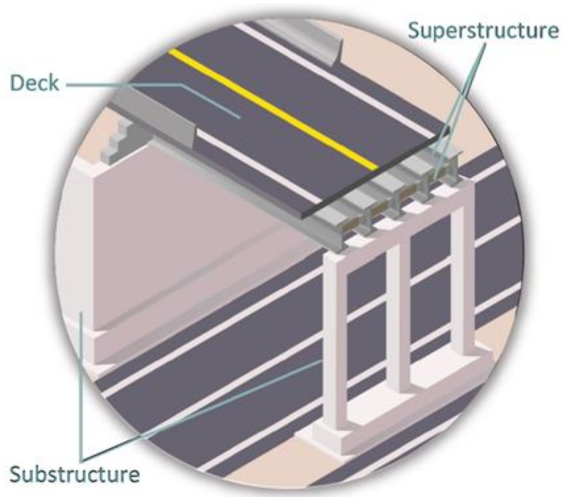
Note that if a bridge is not in good or poor condition, it is deemed to be in fair condition.

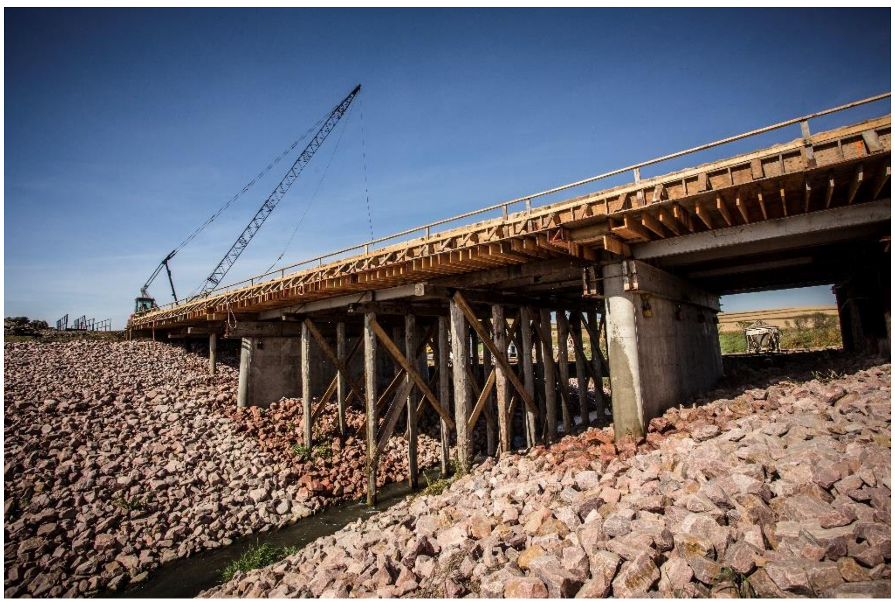
Iowa DOT inspects its bridges using practices consistent with the National Bridge Inspection Standards (NBIS) for federal bridge inspections. Most bridges must be inspected on a 24-month cycle at a minimum. More frequent inspections are required when a bridge meets specific criteria established by the state.

FHWA allows a state to establish criteria to extend the inspection frequency for a given bridge to a maximum of 48 months. Iowa has FHWA-approved criteria to extend the frequency to 48 months on some bridges. The NBIS requires each bridge owner to provide a specific set of NBI items to FHWA annually. Iowa bridge inspection data has been maintained for almost 40 years and is used to calculate federal and state performance measures.

Inspectors record overall ratings for a bridge's deck, superstructure and substructure on a scale from 0 (failed) to 9 (excellent) for each component. Bridge component condition ratings are used to classify the bridge as being in good, fair, or poor condition. A graphical depiction of the three bridge components is shown in Figure 2.6. The lowest of the three ratings for deck, superstructure, and substructure (or a culvert rating for a culvert) determines the overall rating of the bridge. If this value is 7 or greater, the bridge is classified as being in good condition. If it is 5 or 6, the bridge is classified as being in fair condition, and if it is 4 or less, the bridge is classified as being in poor condition.

Figure 2.6: Bridge components





State

In addition to the federal performance measures, Iowa DOT developed and uses a Bridge Condition Index (BCI) to aid in the prioritization of state maintained bridge projects for replacement and maintenance. The BCI is based on data collected as part of the National Bridge Inventory (NBI) inspections. The index combines a bridge's condition, its ability to provide adequate service, and how essential it is for the traveling public into a single index.

The BCI is reported on a 100-point scale, with 100 representing the best condition. A bridge rated 50 or higher is considered to be in a state of good repair.

The BCI reflects the overall condition of the bridge, considering structural condition, load carrying capacity, horizontal and vertical clearances, width, traffic levels, type of roadway it serves, and the length of out-of-distance travel if the bridge were closed.

Bridge Inventory and Condition

Iowa has 23,799 bridges and Iowa DOT is responsible for maintaining 4,195 of these bridges, including bridges on the National Highway System (NHS) and state highways. Local governments throughout the state maintain the remaining bridges. A small number of bridges owned by local governments are on the NHS and these assets are included in the TAMP. A summary of Iowa DOT and NHS bridges is presented in Table 2.2. Bridge condition is represented in terms of FHWA's performance measure. State-owned bridges are also measured using BCI.

Table 2.2: Bridge inventory and condition

Owner	System	Count	Deck Area (ft²)	Good	Fair	Poor	BCI<50
Iowa DOT	NHS	2,600	34,081,466	49.0%	48.7%	2.3%	77
	Non-NHS	1,595	12,255,071	49.8%	49.4%	0.8%	39
	Total	**4,195**	**46,336,537**	**49.2%**	**48.9%**	**1.9%**	**116**
Other	NHS	48	984,324	32.1%	60.6%	7.3%	
	Total	**48**	**984,324**	**32.1%**	**60.6%**	**7.3%**	
All	NHS	2,648	35,065,790	49.4%	48.2%	2.4%	
	Total	**4,243**	**47,320,861**	**48.9%**	**49.1%**	**2.0%**	

Note: there are more than 19,000 bridges owned by cities and counties in Iowa that are not on the NHS. Those assets are not included in the TAMP.

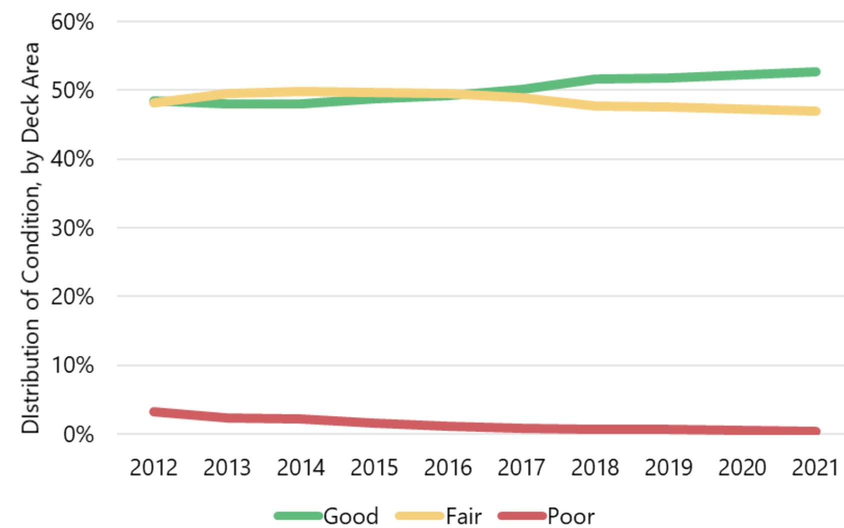
Bridge Condition History

Iowa DOT's bridges are in relatively good condition overall, and recent trends show that overall conditions are generally stable. Although the number of poor bridges has been decreasing over the past decade, it is expected to begin to grow again due to funding limitations to address bridges in fair condition. In addition, many structures are coming to the end of their designed service life. This means that they will need major rehabilitation or even replacement at some point in the near to mid-term future.

Figure 2.7 shows the historical percentage of good, fair, and poor bridges of the Primary Highway System, as defined by the FHWA bridge measure. Trends show that conditions have been fairly stable, although they do fluctuate from year to year. The percentage of deck area in poor condition has decreased and the percentage of deck area in good condition has increased.

Figure 2.7: Primary Highway System bridge condition history

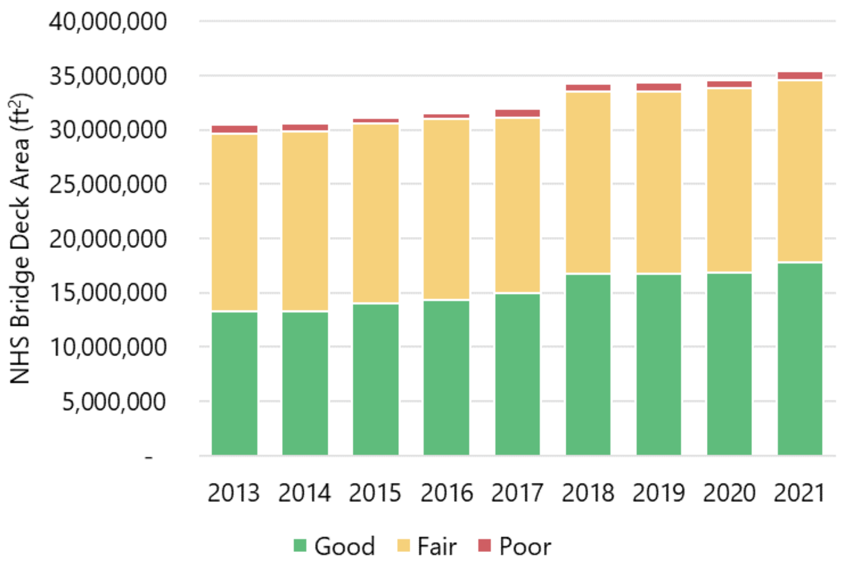
Condition has stayed relatively stable over the past decade.



The NHS has also seen a slight uptick in deck area in good condition over recent years, and its amount of deck area in poor condition has remained relatively flat. Figure 2.8 shows bridge condition on the NHS in recent years by bridge deck area. As shown, the amount of bridge deck area on the NHS has increased by 16.4% from 2013 to 2021. This is primarily due to new structures often being up to two times larger than the structures they are replacing. This impacts performance metrics as a bridge replacement will result in more square feet being added to the 'good' inventory than the amount of square feet removed from the 'fair' or 'poor' inventory.

Figure 2.8: National Highway System bridge condition history

While condition has stayed relatively stable, the amount of deck area on the system has increased over time.

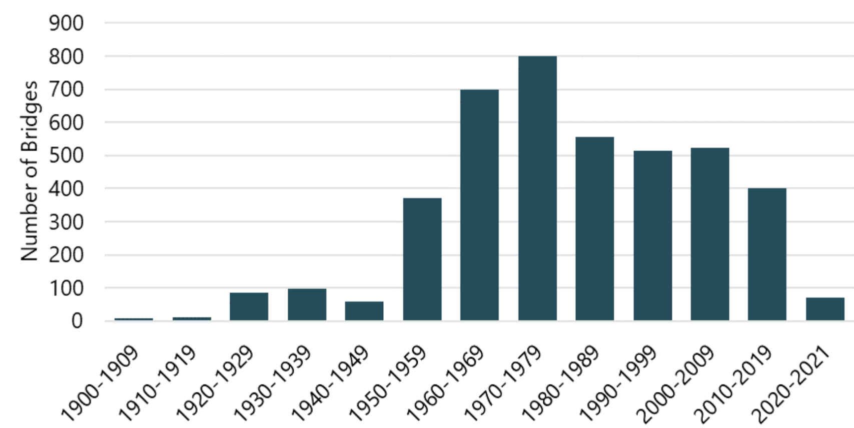


Bridge Age

The average age of Iowa DOT's bridges is 41 years. About 35% of the bridges are over 50 years old, and the average age of bridge structures is going up. In seven years, the average age of bridges on the Primary Highway System will be 50 years old. This is the common age used to describe how long a bridge should last, though the average age of bridges being replaced on Iowa DOT's system is 64 years. Figure 2.9 shows the age distribution of the bridges on the Primary Highway System by their decade of construction.

Figure 2.9: Primary Highway System bridges by decade of construction

Due to the large number of bridges built in the 1960s and 1970s, a 'wave' of bridge replacement needs is approaching.

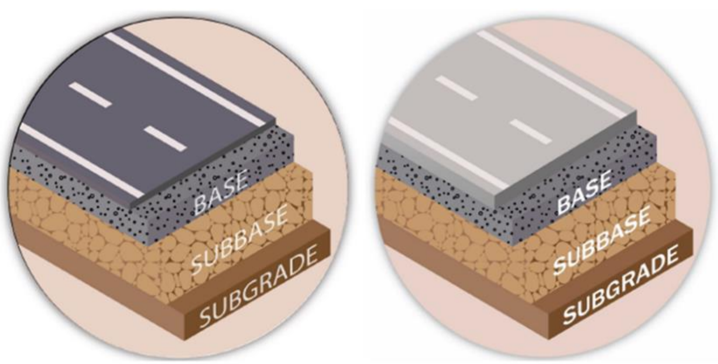


2.4 Pavement

Pavement is the layered structure that forms the road. Pavements are designed to support anticipated traffic loads and provide a safe and relatively smooth driving surface. Maintaining pavements in good condition lengthens their life, enhances safety, helps reduce road users' operating costs, and reduces vehicle emissions. On the other hand, rough roads cause more wear and tear on vehicles, which increases user costs. Iowa DOT's pavements represent a mixture of asphalt pavement, concrete pavement, and composite pavement (asphalt over concrete or concrete over asphalt). Just over half of the network is composite pavement. The vast majority of the state's composite pavement is asphalt over concrete; the small amount of composite pavement that is concrete over asphalt is currently classified as a concrete pavement for the purpose of management.

A typical asphalt pavement structure and a typical concrete pavement structure is shown in Figure 2.10.

Figure 2.10: Asphalt pavement structure (left) and concrete pavement structure (right)



Pavement Performance Measures

Federal

FHWA has established the following four performance measures for NHS pavement condition based on lane miles.

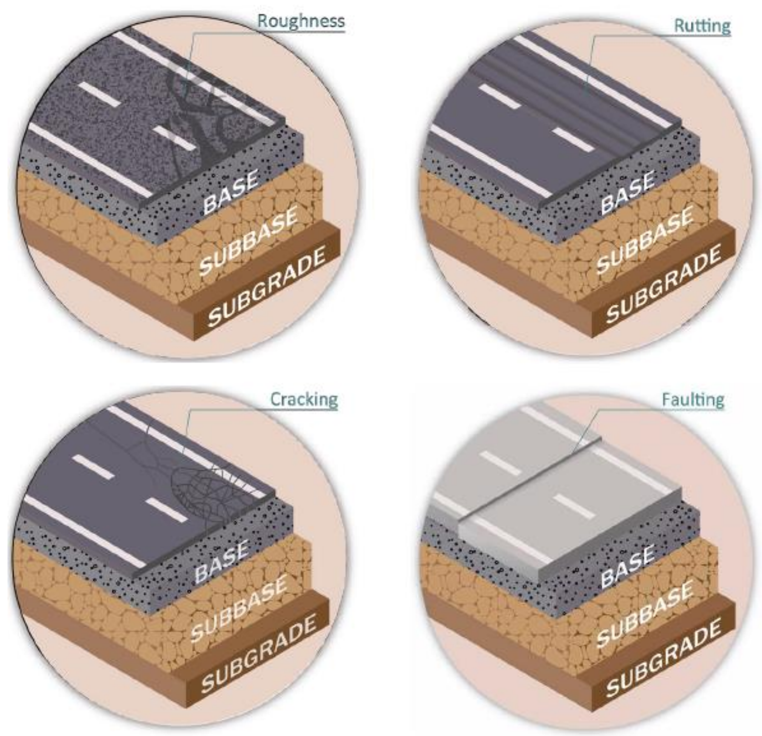
- Percentage of pavements on the Interstate System in good condition
- Percentage of pavements on the Interstate System in poor condition
- Percentage of pavements on the NHS (excluding the Interstate System) in good condition
- Percentage of pavements on the NHS (excluding the Interstate System) in poor condition

Each of the performance measures is calculated based on data reported to the HPMS. The following metrics are used to calculate the pavement condition performance measures.

- **Pavement roughness** is an indicator of discomfort experienced by road users traveling over the pavement and is measured using the International Roughness Index (IRI).
- **Rutting** is quantified for asphalt and composite pavements by measuring the depth of ruts along the wheel path. Rutting is commonly caused by a combination of high traffic volume and heavy vehicles.
- **Cracking** is measured in terms of the percentage of cracked pavement surface. Cracks can be caused or accelerated by excessive loading, poor drainage, frost heaves or temperature changes, and construction flaws.
- **Faulting** is quantified for concrete pavements. Faulting occurs when adjacent pavement slabs are misaligned. It can be caused by slab settlement, curling, and warping.

A graphical depiction of the four pavement condition metrics is shown in Figure 2.11.

Figure 2.11: Pavement condition metrics



For each of the pavement condition metrics, FHWA has established thresholds for good, fair, and poor condition. Conditions are assessed using these threshold criteria for each 1/10-mile pavement section. An individual section is rated as being in good condition if all of the metrics are rated as good, and poor when two or more are rated as poor. All other combinations are rated as fair. The lane miles in good, fair, and poor condition are tabulated for all sections to determine the overall percentage of pavements in good, fair, and poor condition. These thresholds are summarized in Table 2.3.

Table 2.3: FHWA pavement condition metric thresholds

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

State

Iowa DOT reports pavement condition using a Pavement Condition Index (PCI). The PCI is a metric developed by Iowa DOT that accounts for a pavement's ride quality and the amount of cracking, faulting, and rutting on it. Iowa DOT uses PCI thresholds for good, fair, and poor that differ by roadway type, as shown in Table 2.4.

Iowa DOT uses the good, fair, and poor categories to track and communicate the overall condition of its pavements. It uses the more detailed underlying condition data when evaluating and prioritizing specific pavement projects.

Table 2.4: PCI thresholds

System	Good	Fair	Poor
Interstate	76-100	51-75	0-50
Non-Interstate NHS	71-100	46-70	0-45
Non-NHS	71-100	41-70	0-40

Pavement Inventory and Condition

Iowa's pavements include the NHS (which is broken into Interstate and non-Interstate systems), non-NHS state highways, county roads, and city streets. Overall, Iowa's roadway system includes over 240,000 lane miles of roadway. Iowa DOT is responsible for 23,825 of these lane miles. Iowa DOT-owned highways are known as the Primary Highway System. As noted in Chapter 1, the emphasis for management of the Primary Highway System is stewardship of the existing system. In some cases, the primary highway pavement inventory is expected to grow in a limited and strategic manner over the next decade as targeted corridors may be expanded to improve mobility and address existing and projected capacity concerns.

Pavement inventory and conditions in Iowa are summarized in Table 2.5. Pavement condition is represented in terms of FHWA's performance measure. State-owned assets are also measured using PCI. Note that Iowa does not currently track conditions on non-Interstate NHS by asset owner. Total non-Interstate NHS conditions are tracked and reported on the table.

Table 2.5: Pavement inventory and condition

Owner	System	Lane Miles	Good	Fair	Poor	Average PCI
Iowa DOT	Interstate	3,479	58.8%	40.8%	0.4%	81
	Non-Interstate NHS	12,426				74
	Non-NHS	7,920	28.2%	69.2%	2.6%	71
	Total	**23,825**				**74**
Other	NHS	441				
	Total	**441**				
All	Interstate	3,479	58.8%	40.8%	0.4%	81
	Non-Interstate NHS	12,867	37.9%	58.4%	3.7%	
	Non-NHS	7,920	28.2%	69.2%	2.6%	71
	Total	**24,266**				

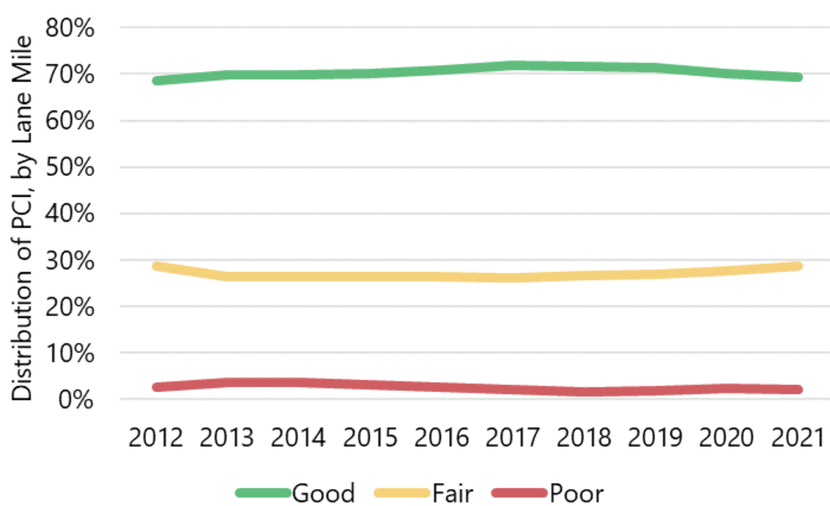
Note: there are more than 200,000 lane miles of pavement in Iowa that are not owned by Iowa DOT and are not on the NHS. Those assets are not included in the TAMP.

Pavement Condition History

Figure 2.12 shows the distribution of good, fair, and poor non-Interstate Primary Highway System pavements based on PCI over the past decade. Conditions on the network have fluctuated slightly from year to year, but have remained relatively stable overall.

Figure 2.12: Non-Interstate Primary Highway System pavement condition history

Condition has stayed relatively stable over the past decade.

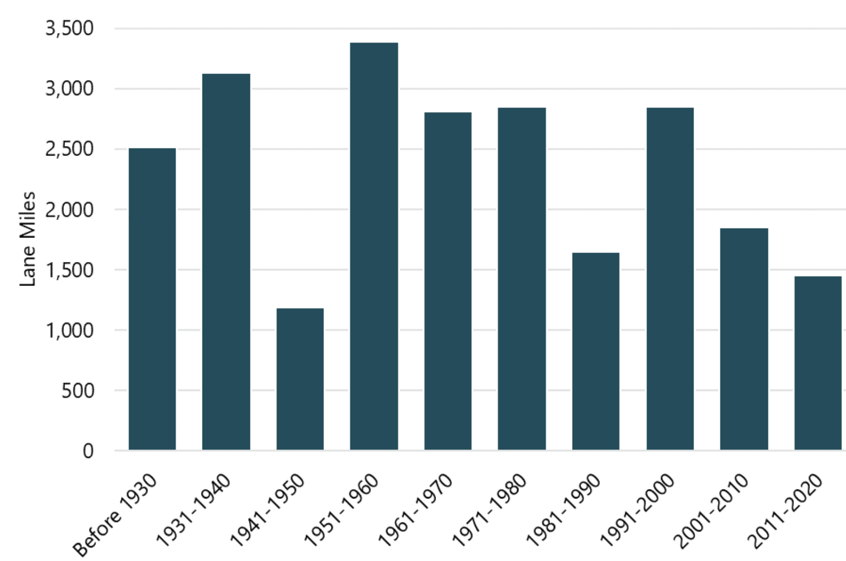


Pavement Age

The pavements of the Primary Highway System are aging. Over half are more than 55 years old, substantially exceeding their design service life. Nearly a third of the pavements are over 80 years old. In addition, thousands of miles of the primary system have had significant rehabilitation to keep them in serviceable condition, with about 20% of the system's lane miles having had three or more resurfacings. As pavements age these treatments become less effective, and eventually pavement replacement will be required. Figure 2.13 shows the age distribution of the pavements on the Primary Highway System by their decade of construction.

Figure 2.13: Primary Highway System lane miles by decade of construction

Nearly a third of the system's pavements are over 80 years old, increasingly requiring more signficant rehabilitation or reconstruction.



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3. LIFE CYCLE PLANNING

Asset management is a series of processes intended to achieve and maintain a state of good repair over the life cycle of an asset. One key process is life cycle planning (LCP), the process of developing a strategy for managing an asset class to achieve a target level of performance while minimizing life cycle costs. LCP is a network level analysis intended to help lower costs and improve condition. Using bridge and pavement management systems, Iowa DOT can estimate the cost of managing its bridges and pavements and determine the optimal mix of treatments to perform to achieve condition goals at lower life cycle costs.

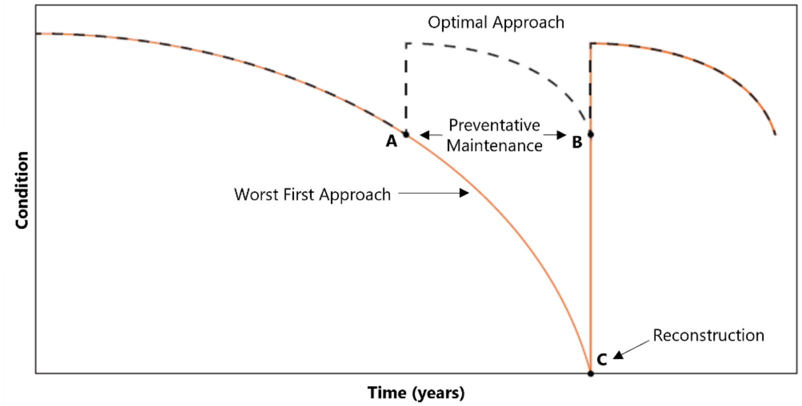
Introduction

This chapter presents Iowa DOT's LCP approach for bridges and pavements. LCP is defined in 23 CFR 515.5 as "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 condition."

Life cycle costs are the costs of managing an asset from inception through disposal. Many agencies, including Iowa DOT, historically used a "worst-first" approach to bridge and pavement management. This approach focuses on replacing the poorest bridges and pavements first. A more cost-effective approach considers treatments that slow down deterioration and prolong asset life. This strategy is typically less expensive than letting an asset deteriorate to the point of needing replacement.

Figure 3.1 illustrates the two approaches. The solid line represents an asset that is built and deteriorates to point C before any work is performed. Once work is performed, in this case reconstruction, the condition returns to its original level. The dashed line shows preventative maintenance work being done at point A. The asset's condition improves and then eventually deteriorates to point B, which occurs in the same timeframe at point C but represents much better condition. The cost of performing work at points A and B can be significantly lower than waiting until point C.

Figure 3.1: LCP approach of preventative maintenance vs. worst-first approach



Generally, an effective life cycle plan emphasizes performing timely maintenance activities to keep an asset in good condition while avoiding, where possible, assets deteriorating to poor condition. Once an asset deteriorates to poor condition, treatment options are more expensive. The benefit of an effective LCP strategy over a worst-first strategy is that it has the potential to reduce long-term costs to both the transportation agency and road users. Treating assets long before they reach a poor condition shortens the impact to the motoring public, yields a higher level of pavement or bridge condition over time, and improves the image of the state. LCP also provides the information needed to determine how best to prioritize asset investments when funding levels are insufficient to meet all the transportation system's needs. This is critical because, as discussed in Chapter 4, there are anticipated funding shortfalls over the next 10-20 years that would prevent maintaining the desired condition levels for bridges and pavements statewide.

Federal Requirements

FHWA requires that state DOTs establish a process for conducting LCP at the network level for NHS pavements and bridges. The following elements must be included in an LCP process.

- Identification of deterioration models
- Potential work types, including treatment options and unit costs
- A strategy for minimizing life cycle costs and achieving performance targets
- Asset performance targets

In addition, LCP should include future changes in traffic demand and information on current and future environmental conditions, including extreme weather events, climate change and seismic activity. In 2021, the Infrastructure Investment and Jobs Act added the specific requirement that life cycle cost analysis consider extreme weather and resilience.

3.1 Bridge

Data Collection

Bridge inventory and condition data is collected as part of a field inspection that is performed every 12, 24, or 48 months, depending on the designated inspection frequency, in accordance with FHWA's National Bridge Inspection Standards (NBIS). Each inspection is documented in the Structure Inventory and Inspection Management System (SIIMS) database. The documentation for an inspection includes photos, sketches, inspector's notes, condition ratings for specific elements, National Bridge Inventory (NBI) data, and recommendations for maintenance. The inspection documents are collected and reviewed by qualified bridge inspectors.

Along with the required NBI data, additional information is collected to enhance and support bridge management. Many individual bridge items and their corresponding conditions and configurations are documented during the biennial inspections for bridges on the NHS. These elements include the National Bridge Elements (NBE), Bridge Management Elements (BME), and Agency Developed Elements (ADE). Iowa DOT also collects additional data items during every inspection.

NHS bridges, including locally owned NHS bridges, make up the bridge asset class. For bridges, the asset sub-groups include mostly concrete bridges and steel bridges, along with other types.

A culvert is considered to be an NBI bridge if the culvert or multiple culverts is greater than 20 feet in length and the clear distance between openings for multiple culverts is less than half the width of the opening along the roadway. The bridge asset subgroup of culverts is excluded from LCP because no material adverse effect on the development of sound investment strategies will occur by eliminating these assets.

This lack of impact is due to the extremely long life along with the long-term stability of these assets. Maintenance considerations only begin to occur around 75 years of service. Additionally, there is only one condition rating for culverts, making it difficult to determine the specific factors contributing to the rating and therefore the optimal way to treat it. Of the 475 culverts on the NHS in Iowa, only one is not in good or fair condition. Relatively few culverts are worked on each year, and they do not have a significant impact on the budget.

The SIIMS database is used by all bridge owners in Iowa. The NBE and NBI data collected in this system are imported into the AASHTOWare Bridge Management System (BrM). The BrM will be used in the future to model deterioration and forecast budget needs based on NBE and NBI data collected for NHS bridges.

Treatments

Bridges are designed to last over 50 years and to withstand a variety of different distresses over their life. However, the individual components of a bridge deteriorate at different rates over time and require treatment – in some cases multiple times over the life of the bridge – to maintain a bridge in good overall condition.

An example of routine maintenance is joint replacement. If joints are allowed to fail, then water and road salts may seep into the bridge deck, superstructure, and substructure, shortening the life of these components.

A bridge deck is exposed to truck traffic, road salt, and other distresses. Bridge decks typically last 20 to 30 years before they require maintenance, and they are often patched multiple times over their life. A deck overlay is a common maintenance practice. If a deck is not rehabilitated in a timely fashion, then the only feasible treatment may be to replace the deck or the entire bridge.

Treatments performed on a bridge's superstructure and substructure vary depending on the bridge's materials. Steel bridges require periodic repainting to avoid corrosion. Weathering steel does not require paint but may need to be washed on a regular basis. Concrete girders and other structural members may require periodic patching. The beam ends near joints are the structural members most prone to deterioration, and these may require periodic repair.

Various preservation and maintenance activities are undertaken to help maintain a bridge's condition. Many decks have overlays or sealers applied, which helps keep chloride out and maintain the deck in better condition. Iowa DOT also has a robust bridge painting program. Washing and cleaning bridges can be helpful for removing contaminants and slowing deterioration, but this can be challenging to implement in a systemic fashion due to a lack of staff and the inefficiencies of hiring contractors for this type of work. Also, traffic control can become a major issue for preservation treatments, particularly in urban areas, which adds to the project's expense and decreases acceptance of the work due to potential operational issues.

As a bridge ages the maintenance and rehabilitation costs incurred in keeping the bridge in service tend to increase. At some point it becomes more cost effective to replace a bridge than to continue to rehabilitate it. Also, it is generally more cost effective to replace smaller structures such as culverts, rather than to rehabilitate them.

Where there are functional issues with a bridge, such as limitations in the bridge's clearances, load carrying capacity, or traffic capacity, replacement is often the most cost-effective alternative.

Iowa DOT's typical bridge treatments and costs are listed in Table 3.1. These treatments and costs are entered into the NBI Optimizer described in the next section, and used to generate recommendations for treatments. Treatment costs are reviewed and updated annually.

Table 3.1: Bridge treatments and unit costs

Work Type	Treatment Family	Project Treatment	Typical Unit Cost
Preservation	Paint steel	Routine painting of steel girders	$12/sq. ft.
Preservation	Wash weathering steel	Wash weathering steel girders on a regular basis	$10,000/bridge
Preservation	Epoxy injection	Inject epoxy into delaminated areas under deck overlays	$18/sq. ft.
Maintenance	Strip seal joint repair	Replace glands	$240/ft.
Maintenance	Expansion joint replacement	Install new expansion joints	$3,000/ft.
Maintenance	Deck patching	Repair delaminated and spalled areas of a deck	$110/sq. ft.
Maintenance	Prestressed girder repair	Repair girder ends under joints	$2,000/beam end
Rehabilitation	Deck overlay	Dense concrete overlay	$50/sq. ft.
Rehabilitation	Deck overlay	Epoxy polymer overlay	$33/sq. ft.
Rehabilitation	Deck replacement	Replace bridge deck	$115/sq. ft.
Reconstruction	Bridge replacement	Replace bridge	$375/sq. ft. of existing bridge deck area
Reconstruction	Culvert replacement	Replace culvert	$850/CY/ft. of culvert length*
Construction	New bridge	New bridge	$200/sq. ft.
Construction	New culvert	New culvert	$900/CY/ft. of culvert length*

**Cost depends upon culvert configuration. E.g., for a new culvert, if a single barrel culvert takes one cubic yard of concrete per foot of length, the cost is $900 per foot of culvert length; if it is a triple barrel culvert that takes three cubic yards of concrete per foot, the cost is $2,700 per foot of length.*

Modeling Approach

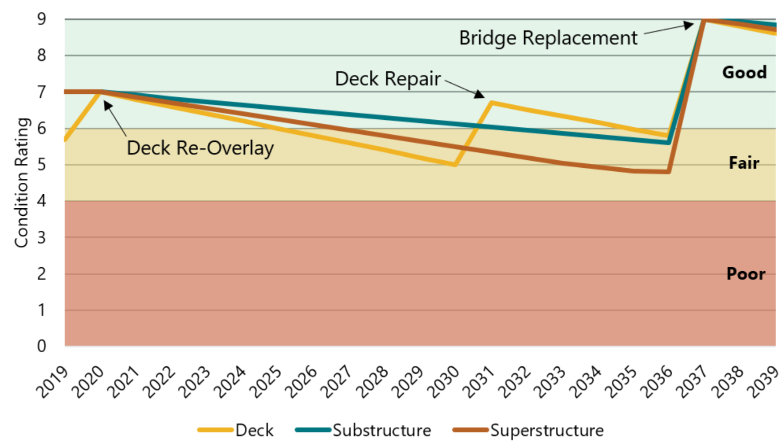
Iowa DOT models deterioration and forecasts future conditions using a tool called NBI Optimizer, developed by Infrastructure Data Solutions (IDS). The NBI Optimizer predicts future conditions of each bridge in the network, simulates the application of bridge treatments, and prioritizes treatments subject to a budget constraint or condition target.

Performing an analysis in the NBI Optimizer requires data on existing conditions, a set of feasible treatments, business rules concerning what treatments are feasible under what conditions, and models for predicting deterioration.

Most of the treatments listed in Table 3.1 are included in the system. For each of these the system further specifies for which types of bridges the treatment may be performed, under what circumstances the treatment is feasible, and the impact of the treatment. The treatment assumptions and other details of the system that are provided for in the configuration of the NBI Optimizer are detailed in the 2014 report "Risk-Based Prioritization and Multi-Objective Optimization for Long-Term Network-Level Preservation Planning of Bridges in Iowa" prepared by IDS for Iowa DOT.

The NBI Optimizer uses historic NBI data to create multivariate inductive deterioration models for approximately 3,200 bridge structures (culverts and border bridges excluded) on the state highway system. The deterioration models incorporate consideration of a range of variables, such as age, traffic volume, design load, and deck type. The deterioration models also evolve over time as additional years of NBI data are added to the system. The tool includes separate deterioration models for deck, superstructure, and substructure ratings for 13 different groups of Iowa DOT bridges. Each deterioration model predicts condition ratings as a function of age. Figure 3.2 shows an example scenario recommended by the deterioration modeling for a 50-year-old bridge that was built in 1969. As bridges age, it is difficult to repair and maintain superstructures and substructures and replacement becomes the preferred option if funding is available.

Figure 3.2: Example recommended treatments from bridge modeling system for a 50-year-old bridge



Note that certain bridges are excluded from the NBI Optimizer analysis, and their needs are handled outside the system. These include locally owned NHS bridges as well as complex structures that are not easily modeled, including selected "major bridges" with unique design characteristics. There are 34 such "major bridges," 18 of which are on the NHS. For each of these bridges, Iowa DOT establishes specific maintenance and preservation activities; these bridges are typically maintained in a higher condition due to their importance and expense. These bridges include the large Mississippi and Missouri River bridges on Iowa's eastern and western borders, which are managed through coordination with the neighboring states. Five-year project needs are evaluated annually with each border state. If one of these bridges is nearing replacement, the planning effort will begin ten years before the replacement is needed. Culverts are also handled separately outside of the NBI Optimizer, for reasons previously discussed.

Future modeling will also be accomplished using the AASHTO BrM system. Iowa DOT is in development of rules and scenarios using NBE and NBI data.

Strategy

Developing the life cycle strategy for a bridge network involves determining what work should be performed on a given bridge, and how to prioritize the work between bridges given a constrained budget. The prioritization approach must consider both life cycle cost considerations and the criticality of addressing a bridge's needs.

For instance, a deck overlay may have high priority given that an overlay, if performed in time, can reduce the life cycle cost of maintaining the bridge. However, rehabilitating or replacing a bridge in poor condition may merit high priority as well, if the bridge is at risk of closure in the event needed work is deferred.

The NBI Optimizer applies the treatments and business rules described previously to determine what work is recommended for a given bridge. To prioritize work between bridges the system calculates a measure called Risk Index (RI). This index is the product of two separate values: a condition index and a risk factor. In the system, bridges are prioritized for treatment based on the change in RI resulting from the work recommended for the bridge.

When performing an analysis in the system the user specifies an overall budget or condition target, as well as budgets by treatment type. The user also specifies whether the objective of the analysis is to minimize risk or maximize condition. The system then simulates bridge conditions and selects treatments for each bridge to maximize the objective function subject to the budget constraints.

During the configuration of the NBI Optimizer, Iowa DOT implemented a risk-based prioritization scheme based on the existing Iowa DOT Priority Ranking method, as well as a comprehensive database of preservation methods commonly used by Iowa DOT. The preservation methods database included the range of work types, formulae for calculating costs and benefits, and a set of applicable constraints for each preservation method based on policies and work practices.

During the initial configuration of the NBI Optimizer, Iowa DOT evaluated a range of different scenarios for different groups of bridges and different budgets. For each scenario Iowa DOT staff evaluated what treatments were recommended and the overall performance yielded in terms of condition and risk. Based on this initial analysis documented in the 2014 report, Iowa DOT finalized the treatments and business rules in the system, as well as the percentage of the total budget that can be used for each type of treatment. This effort yielded an initial, optimized, risk-based 20-year preservation plan for the state-owned bridge inventory. The plan reflected Iowa DOT's life cycle strategy for its bridges considering life cycle cost considerations, the agency's desired condition outcomes, and available resources.

For subsequent analyses, including those utilized to develop this TAMP, Iowa DOT has run additional scenarios in the NBI Optimizer using the life cycle strategies established through the initial configuration of the system. It is possible to define different sets of treatments and/or treatment constraints for different scenarios. Iowa DOT has tested scenarios in the past using a different mix of treatments to see what the impact on condition would be over time – for example, using more deck overlays rather than replacements. This type of scenario analysis has helped refine the parameters used for annual modeling scenarios. In practice, Iowa DOT currently uses the same basic life cycle strategy for each investment scenario tested. The scenarios thus vary based on overall budget, but not other parameters. By comparing scenario outcomes, bridge managers can evaluate the impacts of a given scenario on bridge condition and the level of risk, and use this information to help make the case for needed investments.

Output from the NBI Optimizer analysis is shared annually with the Iowa Transportation Commission to illustrate the impact of various funding levels on the system-level bridge condition. This helps inform the decision-making process for allocating funding for bridge asset management activities.

Implementing LCP Strategy

The NBI Optimizer output results in valuable modeling scenarios and helps provide confirmation regarding the overall mix of life cycle strategies being used as well as the overall budget necessary to maintain a specific condition. However, it cannot be used to directly select which bridges to program work for. There are additional considerations that must be factored into programming decisions, including traffic considerations, associated work on a corridor, and geographic distribution of resources, just to name a few.

At a high level, Iowa DOT uses a three-pronged bridge asset management strategy to maintain the system's bridges in a state of good repair. This strategy includes the following actions.

- Increasing bridge stewardship with an emphasis on more bridge replacements
- Investing in service-life design materials and details so that the bridges built today last longer than those built under earlier design standards
- Investment in bridge preservation so that bridges in the current inventory last longer

To determine how to implement the LCP strategy across the system's bridges, several steps are routinely taken. Iowa DOT's Bridge Maintenance and Inspection Unit recommends bridge maintenance activities based on the results of the bridge inspections described previously. This information is then forwarded to a bridge maintenance and inspection engineer, who is responsible for making rehabilitation and reconstruction recommendations and developing cost estimates.

The Bridges and Structures Bureau (BSB) compiles the rehabilitation and reconstruction recommendations and prioritizes them based on their urgency. Urgency is evaluated on a scale of one to four, where one means "implement a project as soon as practical," and four means "hold as a future candidate for the Five-Year Program."

Each year, BSB discusses the priorities with each District. At this annual meeting, BSB reviews all newly recommended projects from the past year to determine if they should be candidates for the Five-Year Program. If more than one work type is proposed for a given structure, each recommendation is given an importance rating of high, medium, or low.

After meetings with Districts, BSB reviews all priority one candidates to determine if the current Five-Year Program needs to be adjusted to accommodate project scheduling changes. BSB also determines which projects can be developed for construction in the final year of the upcoming Five-Year Program.

If costs of priority one candidates exceed available budgets, BSB prioritizes them using a process that considers the Bridge Condition Index (BCI), project cost, development time, and public needs. If all priority one candidates are programmed, priority two and three candidates are then considered. This process continues until funding is exhausted.

In addition to focusing on the condition of Iowa's bridges, Iowa DOT replaces a few bridges each year to accommodate capacity needs, and major urban Interstate reconstruction projects often include replacing bridges that might not have been candidates otherwise.

To help affirm optimization criteria, the output of NBI Optimizer scenarios has been compared to the bridges selected for programming. This is done by comparing the percentages of the overall budget being spent on different types of treatments, as well as by reviewing how many of the bridges selected for programming are also selected for work in by the software. There is typically strong alignment between the modeling scenarios and the bridge component of the Five-Year Program; where there is less alignment, the NBI Optimizer results are used to review projects that may not have been identified through the typical prioritization process.

Based on the results of the NBI Optimizer analysis and process outlined above, Iowa DOT typically allocates 70 to 74 percent of bridge funding for replacements, 9 to 23 percent for rehabilitation, and 7 to 17 percent for maintenance. Preservation activities are not included in these funding breakouts as they are typically funded from a bridge maintenance program.

Local Collaboration

Iowa DOT works in partnership with local agencies to promote good bridge management practices for locally owned bridges, including the locally owned bridges on the NHS. Iowa DOT provides the SIIMS software to local agencies as a tool to help manage local bridges. This software is used to capture the inspection data local agencies are required to provide as part of the annual NBI submittal to FHWA, as well as providing document storage, dashboards, and reports to help local agencies manage their bridges. Iowa DOT also provides other tools and resources to local agencies through support of the Iowa Highway Research Board and Iowa State University's Institute for Transportation Bridge Engineering Center.

Iowa DOT provides manuals and instructional memorandums to assist local agencies in bridge inspection, maintenance, and load rating. These manuals and memorandums provide the necessary information all local agencies need to manage their bridge inventories.

Another resource for local agencies is the InfoBridge website provided by FHWA. This website can be used to quickly access and filter data from the NBI, and includes options to view performance history, performance forecasts, and various analytics.

Iowa DOT coordinates with Metropolitan Planning Organizations (MPOs) in the establishment of bridge performance targets for the NHS, which includes bridges that are owned by local jurisdictions. Targets are discussed further in Chapter 4.

Consideration of Extreme Weather and Resilience

Extreme weather and resilience are important considerations for bridge life cycle planning. Extreme rain events and areal flooding are likely the greatest risks to Iowa's bridges from natural disasters. Iowa DOT has improved infrastructure resiliency by constructing scour countermeasures, paved shoulders, upstream dikes, storm sewer improvements, and the placement of protective measures to prevent road embankment and pavement damage when a roadway overtops during a flood event, which helps in reopening the roadway more quickly. Work has also been done to harden structures against corrosion, which helps extend their service life. For the past several decades, Iowa DOT has been using bridge materials that are more resistant to corrosion (e.g., epoxy polymer-coated steel and stainless steel). Managing the risk of bridge corrosion helps extend the life of the asset, saving money over time.

Iowa DOT completed a study to assess the exposure conditions of transportation infrastructure under climate change and extreme weather events as part of the FHWA Climate Change Resilience Pilot Program. The pilot focused on the Cedar River and South Skunk River Basins and developed an innovative methodology for generating stream flow scenarios. The project was the only one of the pilots to link climate projections of precipitation with future streamflow projections to enable vulnerability assessment under climate change scenarios. Multiple bridge and highway assets in the river basins have proven to be vulnerable and will only become more vulnerable in the future as the frequency of precipitation and flooding events continues to increase. To help improve long-term resilience of Iowa's bridges and associated pavements, design guidelines to incorporate future hydrological conditions into project development have been drafted and are under review. These guidelines would utilize the procedures for incorporating climate change in the design of infrastructure that are outlined in NCHRP Project 15-61, "Applying Climate Change Information to Hydrologic and Coastal Design of Transportation Infrastructure" (2019). Incorporating these considerations would help ensure that, where appropriate, new bridges are built by considering anticipated future hydrological conditions rather than just being based on historical conditions.

In addition to integrating resilience considerations into bridge design in systemic manner, individual projects have also had significant resilience components integrated into their design due to their critical location and/or vulnerability. An example of this is the recent project on the IA 2 corridor in Fremont County. The area saw significant flooding in 2019 that closed this vital route connecting Iowa and Nebraska across the Missouri River. Closures of IA 2 and other routes in southwest Iowa lasted for weeks or months, resulting in significant impacts for transportation in the region.

While temporary solutions were put into place within a few months, it was necessarily to quickly develop and design long-term, resilient solutions to help mitigate the likelihood of future flooding impacts on the corridor. The long-term solutions were three-fold; the first two components have been completed while the third is underway.

1. Relocate a federal levee and construct two new bridges immediately adjacent to the river bridge, dubbed the "overflow bridges," to allow floodwaters to run under IA 2.
2. Raise the grade of IA 2 four feet and construct four bridges to allow for water flow.
3. Collaborate in the construction of a protective dike around the I-29/IA 2 interchange to protect both the roadways and nearby businesses.

3.2 Pavement

Data Collection

Pavement condition data is collected on the Interstate System each year. The rest of the non-Interstate NHS and Primary Highway System has data collected on a biennial cycle with data on about half of the system being collected each year. Inspection vehicles equipped with sensors collect data on pavement smoothness and pavement surface defects. These defects include items like cracking, faulting, rutting, spalling, and patching.

In addition, Iowa DOT periodically conducts the following more detailed condition assessments.

- Assessment of structural capacity using a falling weight deflectometer: 5-year cycle and upon request
- Assessment of pavement subsurface using ground-penetrating radar: 5-year cycle and upon request
- Assessment of pavement friction: 5-year cycle

The collected data is reviewed according to Iowa DOT’s Pavement Condition Management Data Quality Plan to ensure both data quality and completeness. After this review, the data is included in the pavement management information system (PMIS), which is the database for pavement data. Past years of pavement data are also saved in PMIS so pavement conditions can be tracked over time. Additional data about the history of the pavement and traffic are also stored in the system. The pavement history includes the construction date, pavement thickness, pavement width, and quality of aggregate used in the pavement. The data is assigned to individual pavement management sections that are referenced by mile posts and can be located by a linear referencing system. This allows the data to be used by geographic information systems (GIS). This methodology provides for the best available data to be used in the LCP analysis.

Interstates, Non-Interstate NHS, non-NHS, and local NHS pavements compose the pavement asset classes. With respect to asset subgroups, the pavement management system (PMS) performs analyses for the pavement types of Asphalt, Composite, and Jointed Concrete; however, the federal performance reporting requirements combines the pavement subgroups of Asphalt and Composite pavements. No pavement asset subgroup is excluded from LCP.

Treatments

Pavements deteriorate under loading from traffic, especially heavy trucks, and due to exposure to routine weather such as freeze-thaw cycles or extreme weather events such as flooding, unusual heat waves, or harsh winters. Pavements are all designed to withstand their expected conditions, but the actual conditions vary by location. There can also be some variation in the materials and techniques used in construction. These variations mean not all pavements display the same types of distresses as they age.

Common distresses include rutting, raveling, joint faulting, joint deterioration, cracking, and roughness. Depending on the age of the pavement and the types of distresses that can be seen or measured, different treatments have varying effectiveness for extending the life of the pavement.

Consistent with the principles of asset management, a wide range of work types are used to maintain pavements. These work types differ based on the pavement condition. Generally, this work is divided into five categories: construction, reconstruction, rehabilitation, preservation, and maintenance.

Construction involves building a new roadway section or a significant reconfiguration of an existing roadway. Construction projects may be identified in long-range planning documents, and are ultimately programmed in the Five-Year Program and the Statewide Transportation Improvement Program (STIP). These projects typically involve issues that extend beyond the pavement condition, such as safety, capacity, freight, operations, and other considerations. Since these projects involve many different configurations and environments, there is not a standard per-mile cost for construction. Each project will undergo individual scoping and planning to determine its cost and benefits.

Treatments for the other work types are shown in Table 3.2. The table does not cover all possible treatments for each work type, but it does cover those most commonly used and their approximate cost per lane mile. The treatment family is a grouping used in the pavement management software that helps identify the work type. The project treatment(s) are the alternatives that may be selected from a treatment family. Costs are reviewed and updated regularly, and the typical costs reflect the average project costs for each lane mile of the treatment. Actual costs of an individual project will differ from those shown in the table, but these costs are considered typical and used in the benefit/cost analysis of the pavement management software.

Table 3.2: Pavement treatments and unit costs

Work Type	Treatment Family	Project Treatment	Typical Cost per Lane Mile
Construction	Construction	New Hot Mix Asphalt (HMA) or Portland Cement Concrete (PCC) pavement	Project specific
Reconstruction	Reconstruction	New HMA or PCC pavement	$875,000 Interstate $700,000 Non-Interstate
Rehabilitation	Major structural rehabilitation (more than 4.5 inches of structure needed)	Crack and seat with HMA overlay, HMA overlay, or PCC overlay	$500,000 Interstate $441,000 Non-Interstate
Rehabilitation	Minor structural rehabilitation (3.0 to 4.5 inches of structure needed)	HMA overlay or PCC overlay	$380,000 Interstate $305,000 Non-Interstate
Rehabilitation	Functional rehabilitation (less than 3.0 inches of structure needed)	HMA overlay	$350,000 Interstate $231,000 Non-Interstate
Rehabilitation	Cold-in-place recycling	Cold-in-place recycling	$260,000
Preservation	Diamond grinding I & II	Diamond grinding I & II	$77,000
Preservation	Thin surface treatments	Thin lift HMA, microsurfacing, and chip seal	$33,000
Maintenance	Maintenance	Patching, crack filling and sealing, slurry leveling, and joint replacement	Variable – based on project quantity and density

Modeling Approach

Pavement management is a process that utilizes data describing the current condition of pavements, estimated benefits from pavement treatments, computer modeling to forecast future pavement conditions, and budget constraints to assist in determining how to best manage pavement assets over time. Done well, pavement management is using data to assist in determining the right treatment at the right time on the right pavement so that the most value is received from the funds invested in the road network.

Iowa DOT uses optimization and visualization tools to help manage state-owned highways. These tools, or pavement management systems (PMS), include the Deighton Total Infrastructure Management System (dTIMS) and an Iowa DOT developed Iowa Pavement Stewardship Tool (IPST). These tools assist in developing pavement selections and treatments based on data that will allow Iowa DOT to manage pavements over their whole life. More detailed documentation of the PMS is available in the technical document "Iowa Pavement Management System."

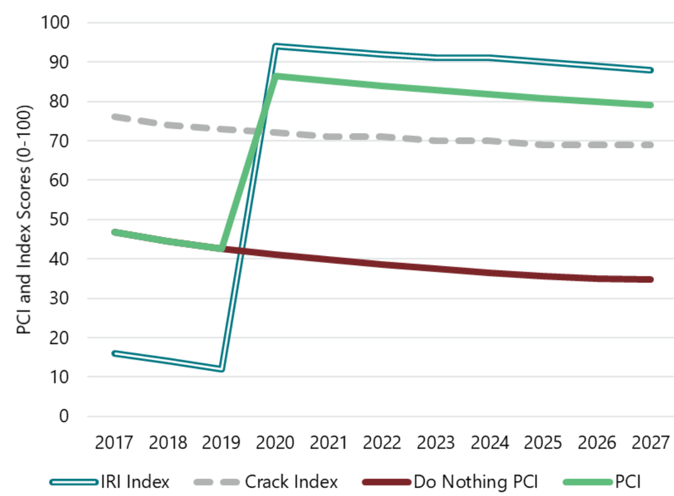
Data

To best manage the pavement network, it is divided into sections based on construction history. The limits of a pavement management section correspond with the limits of a homogenous as-built pavement cross section. As the construction year, surface type, base type, or thickness changes along a route, a new pavement management section is created. This has resulted in the number of pavement management sections growing over time while the average length of sections decreases. Iowa DOT currently maintains over 4,100 pavement management sections with an average length of 2.7 miles per section. A significant number of these segments – 40% – are less than a mile. This is much shorter than a typical project and means many projects include multiple pavement management sections, which can add complications to project development.

Deterioration Modeling

Every year, Iowa DOT pavement engineers use algorithms to develop deterioration models for each pavement section based on the condition data from that section. These performance models predict the anticipated future condition of each pavement section if no work is performed. The PMS use these deterioration models to forecast future conditions of each section and select appropriate treatments for the current and future years of an analysis scenario, which is typically 10-20 years. Figure 3.3 is an example deterioration curve from dTIMS where a diamond grind treatment is applied to an existing PCC pavement. Models are developed for each section, each distress, and each treatment. Models are updated annually, and the model error is tracked as a quality control measure.

Figure 3.3: Example PMS deterioration curve for a PCC pavement with diamond grinding applied in 2019



Decision Trees

Performing analyses in the PMS requires data on past and existing conditions, a set of feasible treatments, business rules concerning what treatments are feasible under what conditions, and models for predicting deterioration. The treatments and supporting business rules are specified through decision trees for each treatment type. Example decision trees for thin surface treatments and functional rehabilitations are shown in Figures 3.4 and 3.5.

Figure 3.4: Thin surface treatment decision tree from PMS

Cost	$30,000 / lane mile
IRI	If IRI > 80, 78% improvement, otherwise unchanged
Friction	50
Rutting	If rutting > 0.25, 50% improvement, otherwise unchanged
Fault Average	
Crack Ratio	Reset to zero
Structural Cracking	Reset to zero
Structure Need	
Joint Spalling	
Pavement Type	
Age	Reset Thin surface pavement age, Structural Cracking, Crack Ratio, and Friction to zero

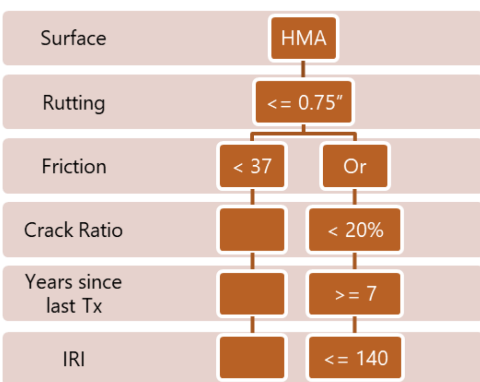
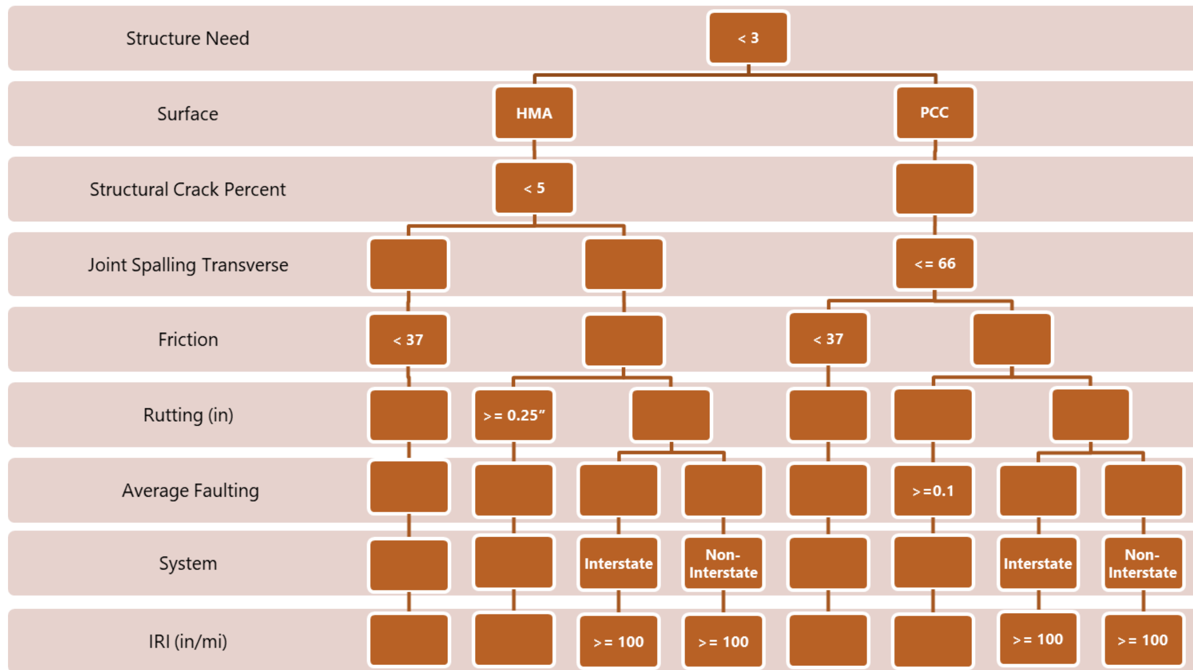


Figure 3.5: Functional rehabilitation decision tree from PMS



Optimization Tools

dTIMS

Iowa DOT utilizes a pure optimization tool, Deighton Total Infrastructure Management System (dTIMS), to establish a long-range plan of investments that yields the highest overall network Pavement Condition Index (PCI) over the analysis period. Among the advantages of dTIMS is the ability to analyze the network over long periods of more than 20 years. Each PMIS section is considered for investment if it meets the decision tree criteria. The tool outputs a recommended schedule of treatments within the budget constraints. Figure 3.6 shows the distribution of project lengths from the output, along with the output of the Grouped Benefit Cost (GBC) tool, discussed next. As shown in the figure, 41% of the recommended projects are under three lane miles. Likewise, in Figure 3.7, 67% of the projects cost less than $2 million. In practice, it is not practical to develop and administer a large number of small projects, so districts will typically combine smaller adjacent segments into a cohesive project. Typically, Iowa's six districts each develop around 4-8 projects annually, depending on the budget.

Grouped Benefit Cost (GBC)

To provide districts with project recommendations that are of a size and cost more likely to be implemented, a stand-alone engine was developed as part of the IPST. The engine uses the same decision trees, costs, and business logic as dTIMS. The primary difference between GBC and dTIMS is the project candidates are longer and coincide with the as-built limits of the last rehabilitation project constructed. In other words, the 4,100 PMIS segments used in dTIMS are grouped into roughly 1,740 longer segments. The other key difference is the GBC selects projects that yield the highest benefit/cost (B/C) instead of the highest PCI. Benefit is defined as the improvement in performance (measured by change in the area under the PCI curve multiplied by lane miles) from applying a treatment over the life of that treatment.

While these two objectives (B/C and PCI) are related, they are not the same. The GBC achieves this objective by simply ranking the B/C of each candidate and selecting the highest available B/C projects until the budget is depleted. While not a true optimization tool (i.e., more than one solution exists to achieve the objective), it results in a very similar network-level PCI as dTIMS. Figure 3.6 shows the GBC project length distributions and Figure 3.7 shows the GBC project cost distributions, with both also showing dTIMS output for comparison.

Figure 3.6: Distribution of project length in dTIMS and GBC

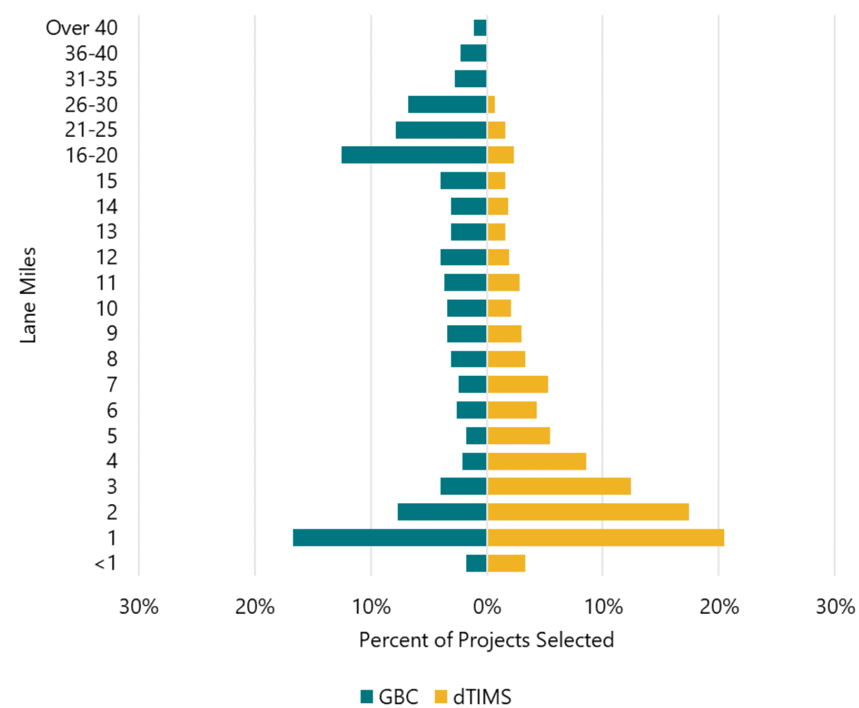
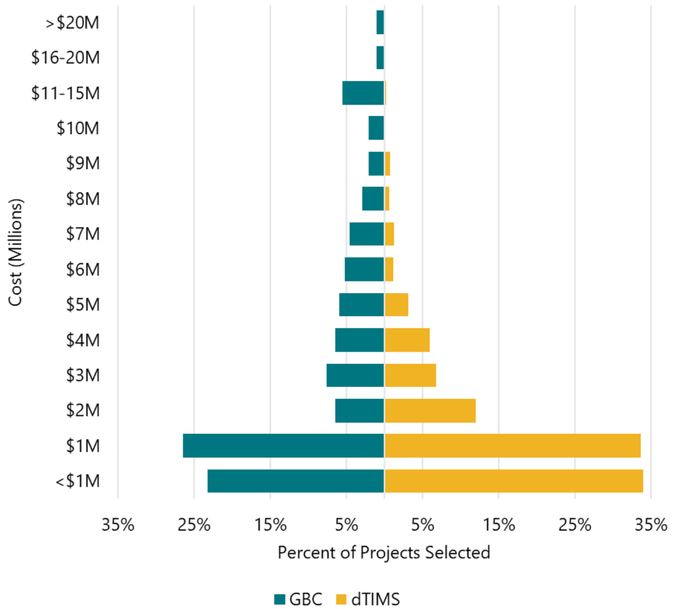


Figure 3.7: Distribution of project cost in dTIMS and GBC

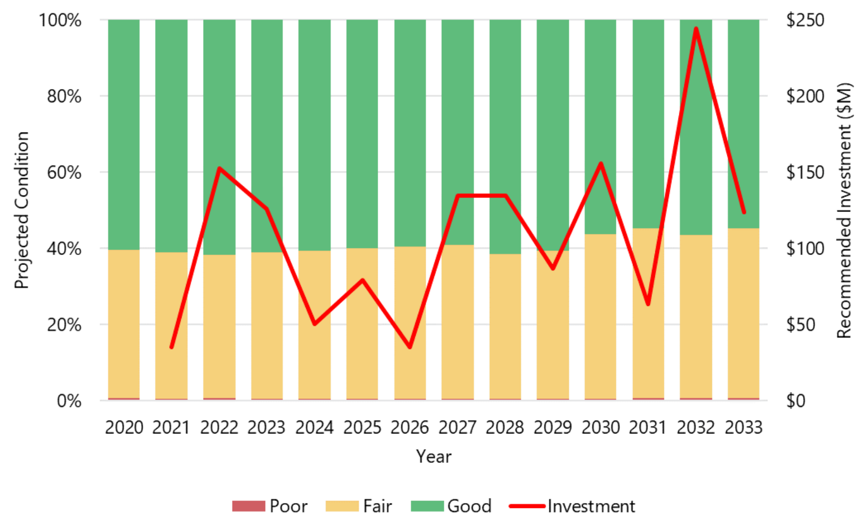


Condition Reporting

The deterioration models are developed using data that is aggregated to the limits of the pavement management sections. FHWA requires monitoring good, fair, and poor condition based on 1/10th mile aggregations, thus introducing variability that needs to be considered. To account for this variability, the models are mathematically adjusted by maintaining the same curve while shifting the intercept value to correspond to the observed values at the 1/10th mile level.

Each 1/10th mile segment on the network is forecasted over ten years using the models assigned to the section. The good, fair, and poor condition levels can then be shown for any budget scenario considered in the LCP over the 10-year run. Figure 3.8 shows the predicted condition on the Interstate System based on the status quo budget, or the amount of funding currently anticipated to be available over time. Condition projections are discussed further in Chapter 4.

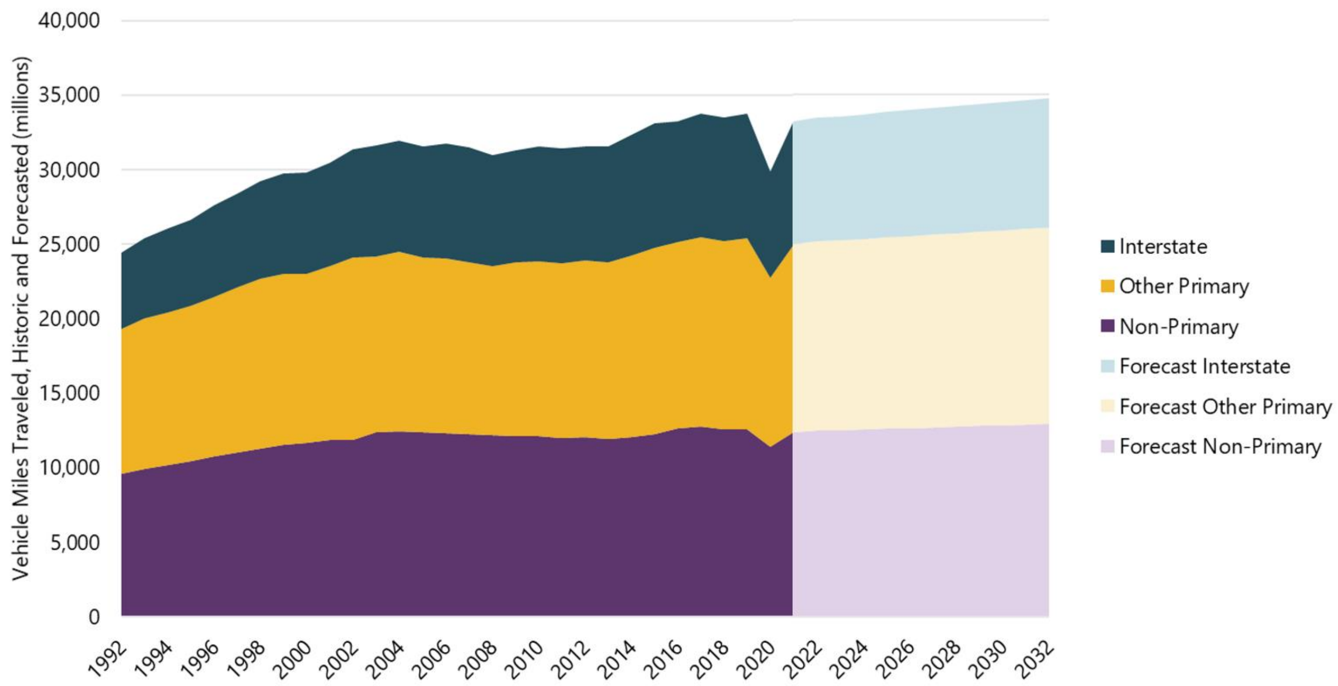
Figure 3.8: Predicted good, fair, and poor condition of the Interstate System, status quo budget



Traffic

An important consideration in the asset management planning process is the amount of traffic that Iowa's roadways serve. Figure 3.9 shows historic vehicle miles traveled (VMT) in Iowa and projected VMT through 2032. These trends further strengthen the need for Iowa DOT to implement asset management. The impact of traffic is incorporated in the deterioration models described previously. Truck traffic is particularly hard on pavements and is the primary cause of deterioration. Iowa DOT projects a 52 percent growth in truck traffic by 2050. As traffic volumes increase, the importance of maintaining existing roadways grows as wear and tear on roadways increases and requires more preservation and maintenance work. As a mitigation for the increasing truck traffic, Iowa DOT evaluates the structural capacity of all pavements at least every five years to determine the need for extra pavement thickness. This evaluation is used as a part of the PMS decision-making process.

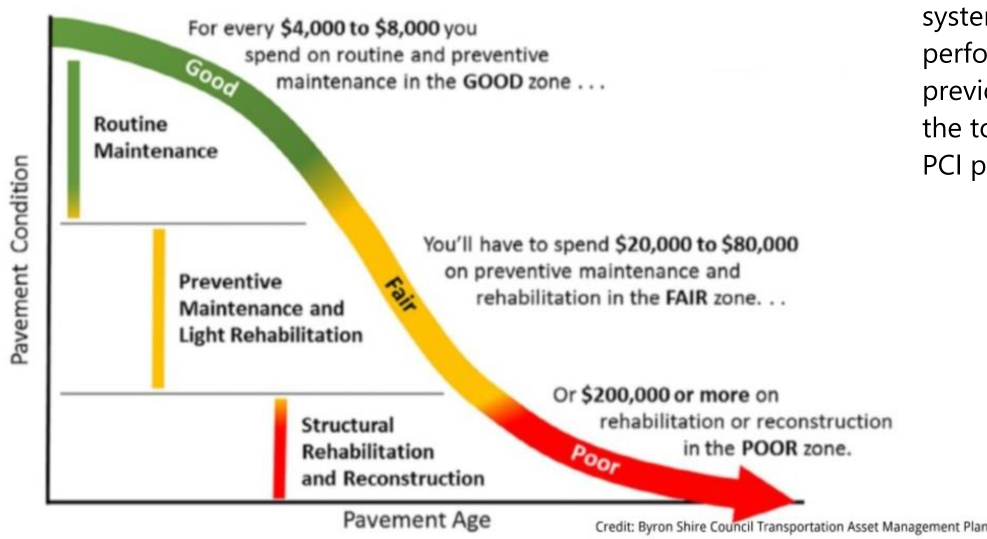
Figure 3.9: Historical and projected traffic volumes



Strategy

Good pavement management selects the right treatment at the right time on the right pavement section. The PMS allows for a systemwide identification of treatment options to help determine the right time for each treatment on each pavement section based on a given funding scenario. In most cases, a treatment is applicable to a given pavement section for multiple years. If the treatment is not applied within that time period, the pavement deteriorates to a point where a more substantial and more expensive treatment is needed. Figure 3.10 shows the value of performing timely pavement maintenance.

Figure 3.10: Pavement deterioration, treatment, and cost curve



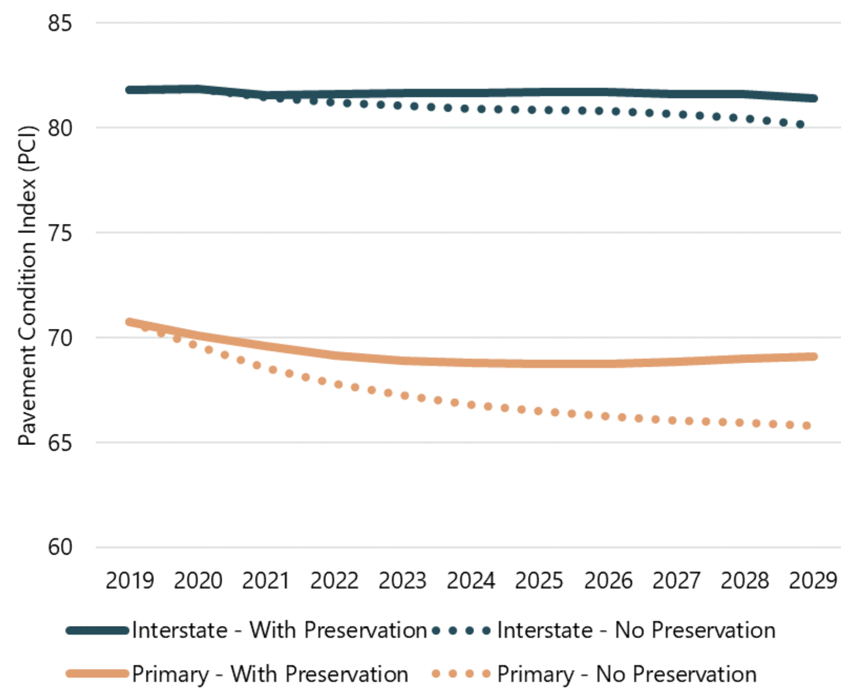
In selecting what treatments to perform, the PMS calculates the cost and benefits of applying each feasible treatment to each pavement section for each year of the analysis. As noted earlier, benefit is defined as the improvement in performance (measured by change in the area under the PCI curve multiplied by lane miles) from applying a treatment over the life of that treatment.

The PMS identifies the mix of actions that will result in the greatest benefit for the pavement network with the available budget. In the initial configuration of dTIMS, Iowa DOT configured the system such that, absent a specific funding constraint, the system tends to allocate funding to support the agency's desired life cycle strategies. That is, the system recommends treatments that yield Iowa DOT's desired level of performance for its pavements at minimal life cycle costs. As noted previously, the GBC allocates funding based on the highest B/C. Since the tools use different processes but result in very similar network-level PCI projections, they both help inform the overall LCP strategy.

When the PMS are run, scenarios are defined with a budget specified by year. Separate runs are performed for Interstates and other state-owned roads. For each system, preservation treatments are provided a spending cap to control for factors such as available contractor capacity. No additional constraints are placed on different treatments or systems. For each run, the system recommends work to perform to maximize progress towards achieving the agency's desired condition, subject to the available budget. Note that it is theoretically possible to develop and test different sets of treatments and decision trees for different scenarios. However, in practice Iowa DOT typically uses the same basic life cycle strategy for each investment scenario tested, with the scenarios varying only in available budget. Nonetheless, the specific treatments selected do vary based on the available budget, with greater emphasis on thin overlays and other lower-cost treatments when the budget is tightly constrained. By comparing scenario outcomes, pavement managers can make informed decisions about the long-term costs and benefits of their decisions.

Figure 3.11 shows the results of two analyses run in dTIMS to demonstrate the benefits of prioritizing preservation treatments. For this comparison, the PMS evaluated two scenarios at the same level of annual investment. In the "With Preservation" scenario, the PMS applied the available funding, including $10 million dedicated to preservation treatments. In the "No Preservation" scenario, the system was unable to choose any thin surface treatment or diamond grinding and allowed pavements to deteriorate to the point of needing more costly resurfacing overlays before being selected to receive work. Although neither strategy achieves the agency's pavement objective at the defined budget level, the results show consistently better network pavement conditions using the strategy that includes preservation treatments.

Figure 3.11: Effect of preservation program on pavement condition



Implementing LCP Strategy

Iowa DOT also uses the PMS to inform the process of selecting pavement projects. The PMS recommendations are used by program administrators when developing reconstruction, rehabilitation, and preservation programs. Iowa DOT has separate processes for selecting projects for the Interstate System and the remainder of the Primary Highway System.

Interstate projects are prioritized by Iowa DOT's central office. Capacity projects are guided by the Iowa Interstate Investment Plan (I3P). Interstate stewardship (preservation and maintenance) projects compete against each other for funding, regardless of location. For the Interstate System, PMIS data are part of the annual statewide review where potential pavement replacement and rehabilitation projects are evaluated. Districts also use the PMIS data as a resource in the development of the Interstate preservation and maintenance programs.

The rest of the Primary Highway System is managed collaboratively by the central office and the district offices. Generally, construction and reconstruction projects are identified by districts and prioritized by a team from the central office and districts. Rehabilitation, preservation, and maintenance projects are managed by the districts. In addition to pavement condition data, Iowa DOT also uses information on the condition of bridges and other structures, safety, traffic volume, capacity, and economic benefit when making these decisions.

For non-Interstate routes, the districts use the pavement management recommendations and data in conjunction with site visits, pavement investigations, and local knowledge about roadways to develop the district pavement rehabilitation, preservation, and maintenance programs. The pavement management recommendations do not provide specific maintenance treatments, but the PMS do provide data to the districts about the current condition and history that is used to prioritize maintenance treatments. These maintenance treatments address specific events or pavement defects in order to maintain a functional state of operation.

The rehabilitation and preservation projects developed from these procedures become part of the recommendations given to the Iowa Transportation Commission for funding consideration. If they are approved, they become part of the Five-Year Program; and if they are federally funded, the projects are placed in the Statewide Transportation Improvement Program (STIP). As part of the process, the Iowa Transportation Commission is updated on the current condition and estimated future condition of Iowa DOT's pavements based on various funding scenarios.

PMS and the modeling software are an evolving process. The modeling efforts have limitations. There are time lags between data collection, data availability, and the analysis; the models do not perfectly predict future conditions; treatment costs are estimates; treatment selection lengths may not be practical or economical; and local knowledge of pavements is not represented in the models. In addition, Iowa DOT considers other factors such as traffic, system classification, and a need for funding flexibility when making project selections. Iowa DOT tries to minimize disruption to the traveling public and promotes longer-term fixes at the end of treatment windows when they align with desired asset management and operational goals.

The factors listed above demonstrate that engineering judgement is needed when reviewing the pavement management output and developing projects. Iowa DOT strives to have a practical, low-cost approach to pavement management and continues to work to improve its pavement management systems with better models and better-aligned funding and project recommendations. As an example of this ongoing evolution, Iowa DOT has begun to program $35 million for non-Interstate pavement replacement projects, starting in FY 2027, to slow the rate of growth of the system's average age. This $35 million is just an initial step towards lowering the average age of the system; more effort will be needed to significantly slow the rate of growth. Determining which projects to prioritize for funding will involve tradeoffs, particularly between rural and urban projects. Rural projects typically take less time to be developed, involve more mileage for the cost, and make more of an impact in lowering the age of the system, while urban projects typically require more time to develop, involve less mileage for the cost, and make less of an impact in lowering the age of the system; however, they often serve more users. These and other factors will need to be considered in developing the program of pavement replacement projects.

Local Collaboration

Iowa DOT works in partnership with local agencies to promote good pavement management practices for locally owned pavements, including the locally owned pavements on the NHS. Iowa DOT participates in and is the primary funding source for the Iowa Pavement Management Program (IPMP) at Iowa State University's Center for Transportation Research and Education. IPMP has been supported by Iowa DOT since 1996; its role is to support local agencies in the collection and management of pavement data as well as with modeling and analysis tools.

IPMP focuses on local agency needs and is a technical resource for pavement management. Since 2013, Iowa DOT has expanded pavement data collection efforts to collect pavement condition data on all paved roads in Iowa. Data is currently collected annually for Interstates, every other year for the non-Interstate NHS and the remainder of the Primary Highway System, and every four years for other paved roadways. Data is shared, free of charge, with counties, cities, and planning agencies through IPMP and is available for their use. IPMP hosts a web portal that local agencies can use to view, interact with, and download their data. IPMP also facilitates a pavement management and dTIMS focus group with local agencies that meets quarterly. Additionally, work is underway to update the performance curves for local agencies so they will not depend on pavement age as that information is not always reliable.

Regarding federal performance measures, Iowa DOT coordinates with MPOs in the establishment of pavement performance targets. This includes targets for the non-Interstate NHS system, which includes segments of roadways that are owned by local jurisdictions. Targets are discussed further in Chapter 4.

Consideration of Extreme Weather and Resilience

Extreme weather and resilience are important considerations for pavement life cycle planning. Extreme rain events and areal flooding are likely the greatest risks to Iowa's roadways from natural disasters. Following the 2019 floods that had severe impacts along the Missouri River and Mississippi River, resiliency efforts have included initiation of improved design standards for vulnerable areas. The improved standards include features such as armored shoulders and embankment protections to help stabilize slopes. These types of features may not prevent the roadway from overtopping, but they increase the likelihood that the roadway will be able to be back in service more quickly with lower repair costs. Incorporating these elements and other resilience-related features into project design will help improve the resiliency of the pavement over the life cycle of the asset.

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4. PERFORMANCE ASSESSMENT

An important aspect of asset management is using data to assist in determining the right treatment at the right time on the right bridge or pavement so that the most value is received from the funds invested in the transportation network. Iowa DOT uses data about the current condition of assets, estimated benefits from asset treatments, computer modeling to forecast future asset conditions, and budget constraints to assist in determining how to best manage bridge and pavement assets over time, minimizing condition and performance gaps.

Introduction

This chapter presents the results of performance scenarios developed for the 10-year period from 2023 to 2032. These have been developed for bridges and pavements to predict future conditions for various funding scenarios for both Iowa DOT defined metrics and FHWA defined metrics. These performance scenarios build upon the asset inventory and conditions presented in Chapter 2, the life cycle planning processes described in Chapter 3, and assumptions regarding potential future funding described in Chapter 6.

This chapter shows 10-year projections for the Bridge Condition Index (BCI) and Pavement Condition Index (PCI) for various funding scenarios for the Interstate System and non-Interstate Primary Highway System. As discussed in Chapter 2, Iowa DOT uses BCI and PCI to monitor the condition of the Primary Highway System. For the federally required performance measures, this chapter also identifies the 2- and 4-year condition targets for bridge and pavement assets on the National Highway System (NHS) and the desired 10-year states of good repair (SOGR) for those assets. A gap assessment was performed to identify the difference between current and projected asset conditions in achieving the desired 10-year SOGR; other performance gaps and strategies to address them are also discussed, as well as potential future enhancements to monitoring performance.

Federal Requirements

Using the measures of condition defined by FHWA, state DOTs must specify their desired SOGR for the 10-year analysis period of the TAMP consistent with state asset management objectives. The desired SOGR must also support progress towards achieving state and national goals. National goal areas include safety, infrastructure condition, congestion reduction, system reliability, freight movement and economic vitality, environmental sustainability, and reduced project delivery delays.

As part of the FHWA rule on performance management, 23 CFR 490, states must set 2- and 4-year asset condition performance targets. These targets are included in the TAMP but are officially reported separately to FHWA. As part of this performance management rule, states are also required to maintain NHS pavements and bridges to meet the following federally established minimum condition levels.

- States must maintain bridges on the NHS (including culverts greater than 20 feet in length) so that the percentage of deck area of bridges classified as structurally deficient (equivalent to poor in FHWA's metric) does not exceed ten percent of the overall deck area in a state. If FHWA determines a state to be out of compliance for three consecutive years, the state must set aside and obligate a certain amount of National Highway Performance Program (NHPP) funding for eligible projects on bridges on the NHS.
- States must ensure that no more than five percent of pavement lane miles on the Interstate System are in poor condition. If FHWA determines a state to be out of compliance in any given year, the state must obligate a certain amount of NHPP and Surface Transportation Block Grant Program funding for eligible projects on the Interstate System.

If a state exceeds the minimum condition thresholds, funding penalty reassignments will remain in effect until the state is in compliance. Either of these funding penalty reassignments would result in a loss of some flexibility for the use of federal funds for Iowa DOT. However, the percentages of Iowa's NHS bridges and Interstate pavements in poor condition are currently below the minimum condition thresholds and are forecast to remain below those thresholds through the effective period of this TAMP.

FHWA also requires that states establish a performance gap analysis process for TAMPs that includes the following components.

- 10-year desired SOGR based on federal requirements and state goals
- 2- and 4-year state targets for asset condition
- Determine performance gaps
- Develop strategies to close or address the gaps

As part of the gap analysis, states must compare current asset performance to desired performance levels, but they may also compare desired asset performance to projected performance to calculate an expected gap.

4.1 Bridge Performance Assessment

The following sections discuss several topics related to assessing bridge condition.

- Scenarios that were developed to forecast future condition based on various funding levels.
- Projections of the BCI for the Interstate System and non-Interstate Primary Highway System, relative to Iowa DOT's desired average condition for the systems.
- Projections of the federally defined good and poor metrics for the NHS.
- 2- and 4-year targets and the 10-year desired SOGR for the federally defined good and poor metrics for the NHS.

Scenarios

Iowa DOT defined a set of three performance scenarios for its analysis of future bridge conditions. For each scenario, the same basic life cycle strategies are followed to the extent feasible considering available funding. The 100% scenario represents the expected level of funding for bridges. As discussed further in Chapter 6, a total of $2.5 billion is anticipated to be invested in bridge assets during the 2023-2032 time period.

Other scenarios were defined for budget levels at 75% and 150% of expected stewardship funding. Stewardship funding totals approximately $1.6 billion in the 100 percent scenario. The remaining funding of approximately $0.9 billion (reserved for major structures and new construction) was held constant in all of the scenarios.

Once the scenarios were defined, Iowa DOT used the NBI Optimizer to predict future bridge conditions considering existing conditions, predicted deterioration, feasible bridge treatments, and the available budget. The modeling approach, treatments, and costs are described in Chapter 3. A 20-year projection was performed for each scenario.

The following sections discuss output for the Primary Highway System in terms of BCI and the NHS in terms of federally defined good and poor condition. It should be noted that the modeling scenarios represent the most likely outcomes based on the inputs used, but their results need to be considered in the context of several factors. For example, deck area of the system is growing, because when aging structures are replaced the new structures are typically larger. This impacts the rate of change for system-level condition and is difficult to accurately model. Major bridges are typically excluded from the scenarios for reasons discussed in Chapter 3. The modeling also cannot always account for maintenance work that can help prevent a bridge from falling into poor condition. Regarding anticipated funding, the 2021 Infrastructure Investment and Jobs Act added more bridge funding for states, but much of Iowa's increase will go to local bridges. Significant inflation has also been a major concern of late; if high inflation rates continue this could significantly decrease the buying power of available funding.

Bridge Condition Index (BCI) Projections

At a system level, Iowa DOT's desired BCI is an average of 78 or greater for the Interstate System and an average of 76 or greater for the non-Interstate Primary Highway System. The desired system-level BCI was established in consultation with the Iowa Transportation Commission considering Iowa DOT's goals and the national goals articulated in MAP-21. Ideally, Iowa DOT would like to maintain current bridge conditions, but some degree of deterioration may be expected even in the most optimistic scenario. The desired system-level BCI reflects the condition Iowa DOT aims to achieve for its bridges, consistent with its goals and objectives for the transportation system, life cycle strategies, and overall level of funding.

Performance projections for Interstate bridges are shown in Figure 4.1, and projections for non-Interstate Primary Highway System bridges are shown in Figure 4.2. Each line in the figures represents average BCI for the system for one investment scenario, while the double flat lines identify the desired system-level BCI. The investment scenarios are labeled by their average level of funding, expressed as a percentage of expected funding. As indicated in the figures, the condition of Interstate and non-Interstate Primary Highway System bridges is projected to be maintained during the 10-year timeframe of the TAMP in the 75% and 100% funding scenarios, though by the end of that timeframe the condition is expected to be lower than it is currently. A longer-term projection is shown to illustrate the substantial decline anticipated across scenarios by the end of the 20-year forecast period, even in the 150% funding scenario. This indicates the importance of continuing to adequately fund bridge needs now in order to not compound the future decline.

Figure 4.1: Interstate bridge condition performance scenarios for BCI

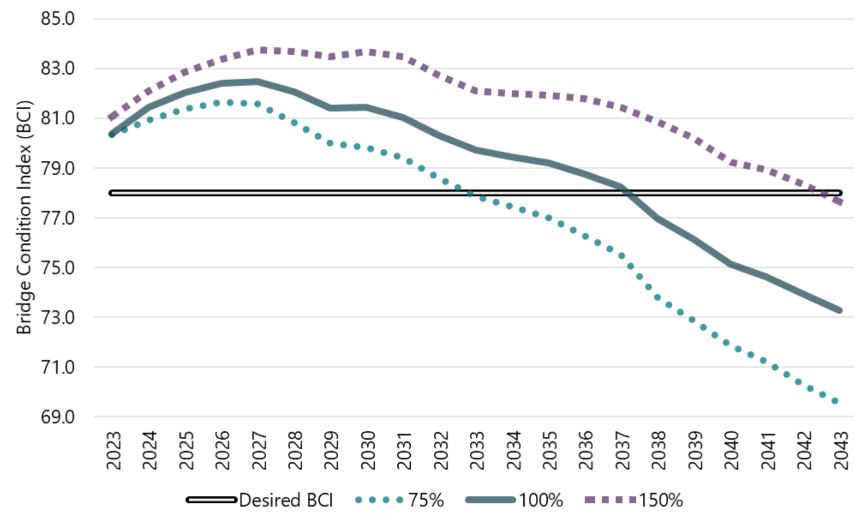
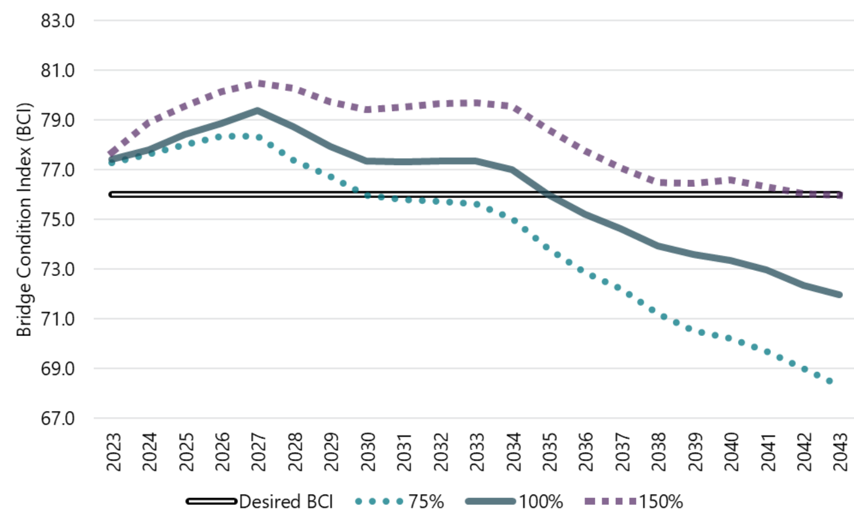


Figure 4.2: Non-Interstate Primary Highway System bridge condition performance scenarios for BCI



2- and 4-Year Targets and 10-Year State of Good Repair (SOGR)

In addition to using BCI to monitor the state-owned highway system, federally defined good, fair, and poor condition metrics are also used to monitor the NHS. These metrics are required to be used for setting 2- and 4-year targets and defining a 10-year desired SOGR for the TAMP.

2- and 4-Year Targets

Federal regulation 23 CFR 490.105 requires that 2 and 4-year targets be set for the condition of bridges on the NHS. The targets identified for bridges on the NHS document the short-term outcomes that are anticipated from project identification and programming that is based on the life cycle planning, risk management, and investment strategies described in this TAMP. The targets help document what progress is anticipated to be made and what outcomes are likely based on current and anticipated investment strategies. Performance targets create a link between projects that will occur in the next few years and the long-term goals and framework of the TAMP and other performance-based plans, providing a way to gauge whether the investments being made in the system are having the desired or anticipated effect on system condition and performance. Two iterations of targets have been established for FHWA's performance measures for NHS bridge condition.

The first performance period for which these regulations were effective was from 2018-2021. Table 4.1 shows the baselines, 2-year targets, 4-year targets, and actual performance for the period for NHS bridges. Iowa DOT achieved its 2- and 4-year targets for this time period.

Iowa DOT established 2 and 4-year targets for the 2022-2025 performance period on October 3, 2022. Targets were established in coordination with Metropolitan Planning Organizations (MPOs) and were reported to FHWA in November 2022. Baselines and targets for this performance period are shown in Table 4.2. Additional detail on the target setting methodology is available at https://iowadot.gov/systems_planning/fpmam/2022-2025-Pavement-Bridge-Targets.pdf.

Table 4.1: NHS bridge performance targets for the 2018-2021 performance period

	Baseline (CY 2017 data)	2-Year Target	2-Year Actual (CY 2019 data)	4-Year Target	4-Year Actual (CY 2021 data)
Percent of NHS bridges in good condition	48.9%	45.7%	48.7%	44.6%	49.4%
Percent of NHS bridges in poor condition	2.3%	3.7%	2.2%	3.2%	2.4%

Note: the year is the data year; e.g., 2019 means 2019 data that was submitted to NBI in calendar year 2020. The percent of bridges is measured in terms of deck area.

Table 4.2: NHS bridge performance targets for the 2022-2025 performance period

	Baseline (CY 2021 data)	2-Year Target (CY 2023 data)	4-Year Target (CY 2025 data)
Percent of NHS bridges in good condition	49.4%	52.5%	56.0%
Percent of NHS bridges in poor condition	2.4%	5.0%	6.6%

Note: the year is the data year; e.g., 2021 means 2021 data that was submitted to NBI in calendar year 2022. The percent of bridges is measured in terms of deck area.

10-Year SOGR

For NHS bridges, the desired 10-year SOGR is at least 46.8% of bridges (measured in terms of deck area) in good condition and no more than 6.5% in poor condition. The SOGRs were established by considering Iowa DOT's goals and the national goals articulated in MAP-21. As with BCI, Iowa DOT would like to maintain current bridge conditions, but some degree of deterioration may be expected even in the most optimistic scenario. The desired SOGR reflects the condition Iowa DOT aims to achieve for NHS bridges, consistent with its goals and objectives for the transportation system, life cycle strategies, and overall level of funding. The bridge management team reviewed and affirmed the desired SOGR from the 2019 TAMP for this iteration of the TAMP.

The same modeling scenarios used for projecting future BCI were used to project the percentage of NHS bridge deck area in good and poor condition. Figures 4.3 and 4.4 show the output of this analysis. Each line in the figures represents the percentage of deck area in good or poor condition for one investment scenario, while the double flat lines identify the 10-year desired SOGR. The investment scenarios are labeled by their average level of funding, expressed as a percentage of expected funding.

While Iowa DOT's desired system-level BCI was reached with a lower funding scenario, reaching the 10-year desired SOGR for the percentage of NHS deck area in good condition required slightly more than the 100% funding scenario. Also, the extended forecast shows the dramatic increase in percent poor and decrease in percent good that is projected to occur in the second decade of the projections across funding scenarios. Similar to the BCI projections, this indicates the importance of continuing to adequately fund bridge needs now in order to not compound the future decline.

The gap between projected funding and the desired 10-year SOGR is discussed further in Section 4.3, along with other performance gap considerations and strategies to address the gaps.

Figure 4.3: NHS bridge condition performance scenarios for federally defined good condition

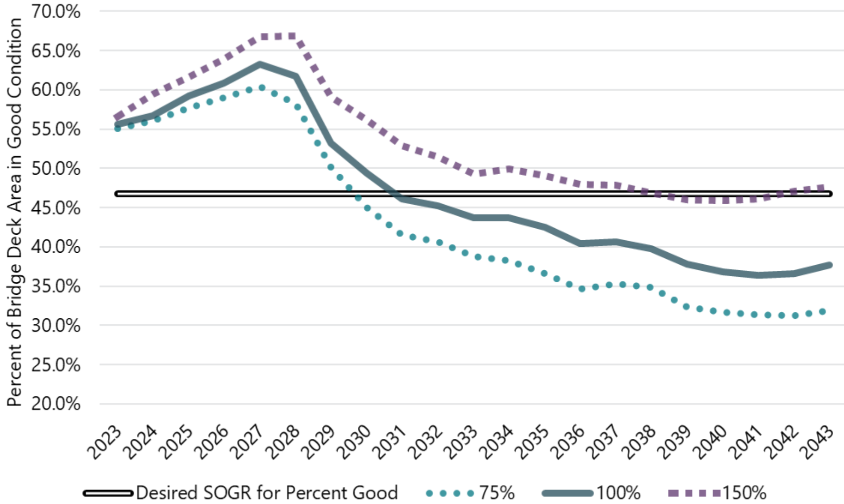
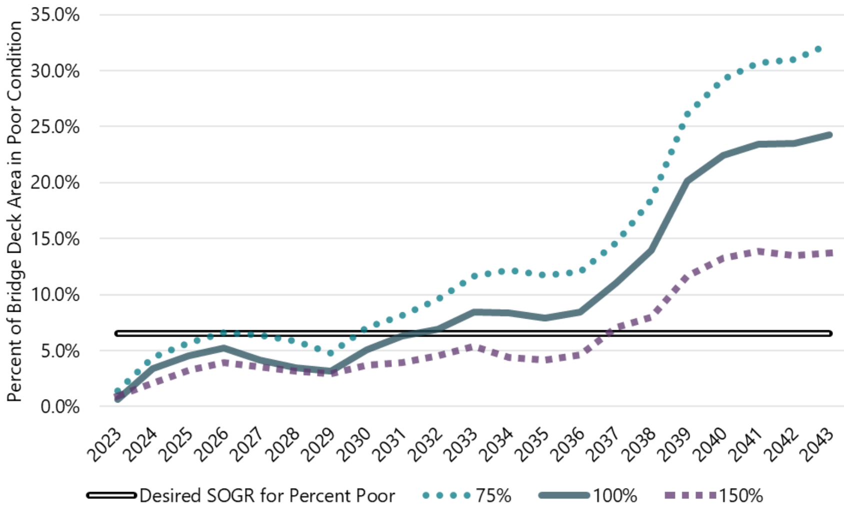


Figure 4.4: NHS bridge condition performance scenarios for federally defined poor condition



4.2 Pavement Performance Assessment

The following sections discuss several topics related to assessing pavement condition.

- Scenarios that were developed to forecast future condition based on various funding levels or treatment selection strategies.
- Projections of the PCI for the Interstate System and non-Interstate Primary Highway System, relative to Iowa DOT's desired average condition for the systems.
- Projections of the federally defined good and poor metrics for the Interstate System and non-Interstate NHS.
- 2- and 4-year targets and the 10-year desired SOGR for the federally defined good and poor metrics for the Interstate System and non-Interstate NHS.

Scenarios

The pavement performance assessment was performed in a similar manner to the bridge performance assessment. In this case, Iowa DOT defined a set of eight performance scenarios for the analysis. For each scenario, the same basic life cycle strategies are followed to the extent feasible considering available funding. The 100 percent scenario represents the expected level of funding for pavements. As discussed further in Chapter 6, a total of $5.6 billion is anticipated to be invested in pavements during the 2023-2032 time period. Other scenarios were defined at lower and higher investment levels as well as using less optimized project selection methods, where the Iowa Pavement Stewardship Tool (IPST; discussed in Chapter 3) was used to either selected projects randomly or selected the lowest benefit/cost (B/C) projects first. To streamline content for this section, only a subset representing the most realistic of the eight scenarios is shown. While the random and lowest B/C scenarios are not shown, in all cases they resulted in substantially worse performance than the status quo scenarios.

Once the scenarios were defined, Iowa DOT used the IPST to predict future pavement conditions considering existing conditions, predicted deterioration, feasible pavement treatments, and the available budget. The modeling approach, treatments, and costs are described in Chapter 3. A 10-year performance projection was performed for each scenario. The following sections discuss output for the Primary Highway System in terms of PCI and for the Interstate System and non-Interstate NHS in terms of federally defined good and poor condition.

It should be noted that the modeling scenarios represent the most likely outcomes based on the inputs used, but their results need to be considered in the context of several factors. For example, lane miles of the system are growing, because while stewardship is the main focus for most of the system, there are locations where capacity is being added to address mobility and operational issues, particularly on key Interstate corridors. This impacts the rate of change for system-level condition and is difficult to accurately model. Significant inflation has also been a major concern of late; if high inflation rates continue this could significantly decrease the buying power of available funding.

Pavement Condition Index (PCI) Projections

At a system level, Iowa DOT's desired PCI is an average 80 or greater for the Interstate System and an average of 75 or greater the non-Interstate Primary Highway System. The desired system-level PCI was established in consultation with the Iowa Transportation Commission considering Iowa DOT's goals and the national goals articulated in MAP-21. Ideally, Iowa DOT would like to maintain current pavement conditions, but some degree of deterioration may be expected even in the most optimistic scenario. The desired system-level PCI reflects the condition Iowa DOT aims to achieve for its pavements, consistent with its goals and objectives for the transportation system, life cycle strategies, and overall level of funding.

Performance projections for Interstate pavements are shown in Figure 4.5 and projections for non-Interstate Primary Highway System pavements are shown in Figure 4.6. Each line in the figures represents average PCI on the system for one investment scenario, while the double flat lines identify the desired system-level PCI. The investment scenarios are labeled by their average level of funding, expressed as a percentage of expected funding. As indicated in the figures, the condition of Interstate System is projected to be maintained in the 100% funding scenario, but the non-Interstate Primary Highway System would require more than 150% of current projected funding to achieve the desired PCI.

Figure 4.5 Interstate pavement condition performance scenarios for PCI

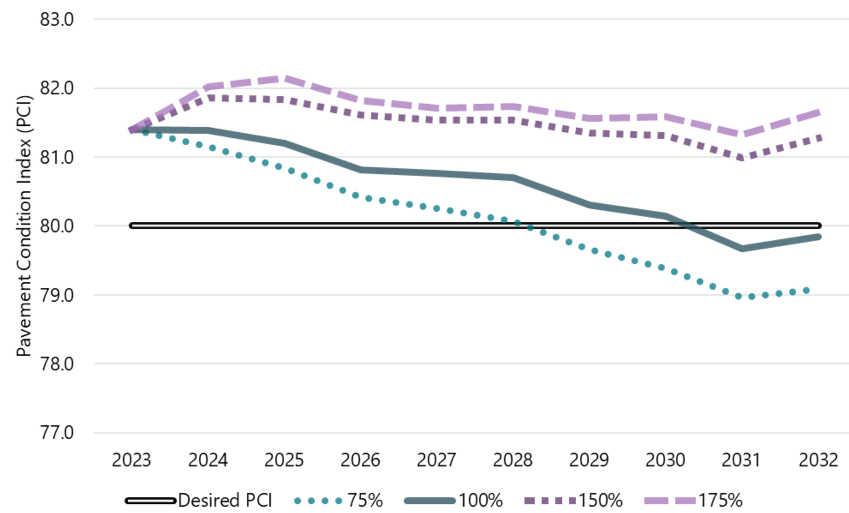
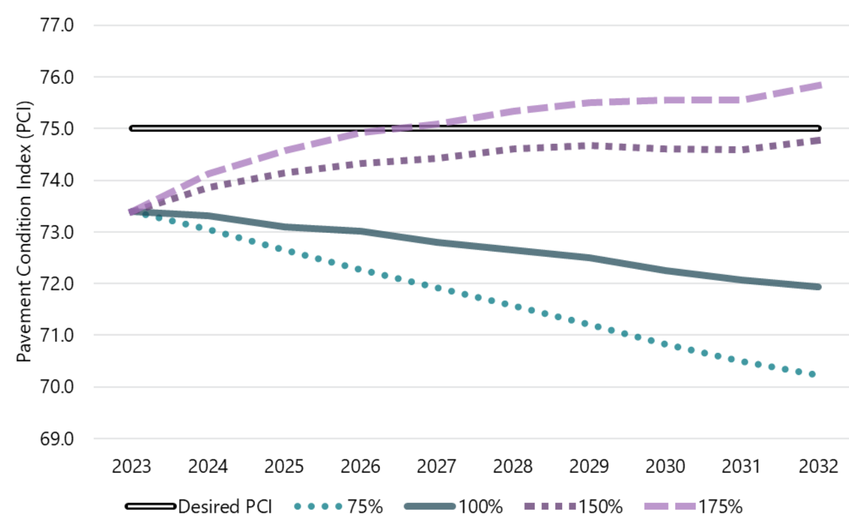


Figure 4.6 Non-Interstate Primary Highway System pavement condition performance scenarios for PCI



2- and 4-Year Targets and 10-Year State of Good Repair (SOGR)

In addition to using PCI to monitor the state-owned highway system, federally defined good, fair, and poor condition metrics are also used to monitor the NHS. These metrics are required to be used for setting 2- and 4-year targets and defining a 10-year desired SOGR for the TAMP.

2- and 4-Year Targets

Federal regulation 23 CFR 490.105 requires that 2 and 4-year targets be set for the condition of pavements on the Interstate System and the non-Interstate NHS. The targets identified for pavements on the Interstate System and non-Interstate NHS document the short-term outcomes that are anticipated from project identification and programming that is based on the life cycle planning, risk management, and investment strategies described in this TAMP. The targets help document what progress is anticipated to be made and what outcomes are likely based on current and anticipated investment strategies. Performance targets create a link between projects that will occur in the next few years and the long-term goals and framework of the TAMP and other performance-based plans, providing a way to gauge whether the investments being made in the system are having the desired or anticipated effect on system condition and performance. Two iterations of targets have been established for FHWA's performance measures for Interstate and non-Interstate NHS pavement condition.

The first performance period for which these regulations were effective was from 2018-2021. Table 4.3 shows the baselines, 2-year targets, 4-year targets, and actual performance for the period. Iowa DOT achieved its 2- and 4-year targets for this time period. It should be noted that baseline performance and 2-year targets were not required for Interstate pavements in the first reporting period. Also, the calculation methodology for non-Interstate NHS pavement condition targets in the first reporting period was based solely on the International Roughness Index (IRI) and did not include other distress metrics.

Iowa DOT established 2- and 4-year targets for the 2022-2025 performance period on October 3, 2022. Targets were established in coordination with MPOs and were reported to FHWA in November 2022. Baselines and targets for this performance period are shown in Table 4.4. Non-Interstate NHS pavement metrics for this performance period are using full distress data and are not comparable to the first performance period. Additional detail on the target setting methodology is available at https://iowadot.gov/systems_planning/fpmam/2022-2025-Pavement-Bridge-Targets.pdf.

Table 4.3: Interstate and non-Interstate NHS pavement performance targets for 2018-2021 performance period

	Baseline (CY 2017 data)	2-Year Target	2-Year Actual (CY 2019 data)	4-Year Target	4-Year Actual (CY 2021 data)
Percent of Interstate pavement in good condition	N/A	N/A	66.1%	49.4%	58.8%
Percent of Interstate pavement in poor condition	N/A	N/A	0.4%	2.7%	0.7%
Percent of Non-Interstate NHS pavement in good condition	50.9%	48.8%	55.4%	46.9%	37.9%
Percent of Non-Interstate NHS pavement in poor condition	10.6%	13.2%	9.3%	14.5%	3.7%

Note: the year is the data year; e.g., 2019 means 2019 data that was submitted to HPMS in calendar year 2020.
The percent of pavements is measured in terms of lane miles.

Table 4.4: Interstate and non-Interstate NHS pavement performance targets for 2022-2025 performance period

	Baseline (CY 2021 data)	2-Year Target (CY 2023 data)	4-Year Target (CY 2025 data)
Percent of Interstate pavement in good condition	58.8%	55.0%	55.0%
Percent of Interstate pavement in poor condition	0.4%	3.0%	3.0%
Percent of Non-Interstate NHS pavement in good condition	37.9%	35.0%	35.0%
Percent of Non-Interstate NHS pavement in poor condition	3.7%	6.0%	6.0%

Note: the year is the data year; e.g., 2021 means 2021 data that was submitted to HPMS in calendar year 2022.
The percent of pavements is measured in terms of lane miles.

10-Year SOGR

For Interstate pavements, the desired 10-year SOGR is at least 58.8% of lane miles in good condition and no more than 0.7% in poor condition. For non-Interstate NHS pavements, the desired SOGR is at least 39.4% of lane miles in good condition and no more than 5.0% in poor condition. The SOGRs were established by considering Iowa DOT's goals and the national goals articulated in MAP-21. As with PCI, Iowa DOT would like to maintain current pavement conditions, but some degree of deterioration may be expected even in the most optimistic scenario. The desired SOGR reflects the condition Iowa DOT aims to achieve for Interstate and non-Interstate NHS pavements, consistent with its goals and objectives for the transportation system, life cycle strategies, and overall level of funding. The pavement management team reviewed and reaffirmed three of the four SOGRs to be the same as those established for the 2019 TAMP; the non-Interstate NHS poor desired SOGR was lowered as it was determined that the prior SOGR was set at a level that would be higher than acceptable.

The same modeling scenarios used for projecting future PCI were used to project the percentage of Interstate and non-Interstate NHS lane miles in good and poor condition. Figures 4.7-4.10 show the output of this analysis. Each line in the figures represents the percentage of lane miles in good or poor condition for one investment scenario, while the double flat lines identify the desired 10-year SOGR. The investment scenarios are labeled by their average level of funding, expressed as a percentage of expected funding.

For both the Interstate System and the non-Interstate NHS, reaching the 10-year desired SOGR would require additional funding; in both cases, the 125% scenario achieved these condition levels. The gap between projected funding and the desired 10-year SOGR is discussed further in Section 4.3, along with other performance gap considerations and strategies to address the gaps.

Figure 4.7: Interstate pavement condition performance scenarios for federally defined good condition

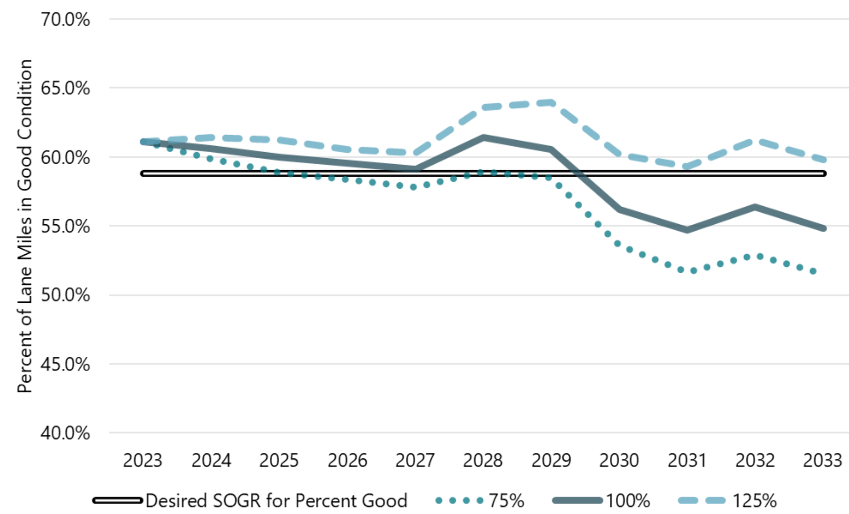


Figure 4.8: Interstate pavement condition performance scenarios for federally defined poor condition

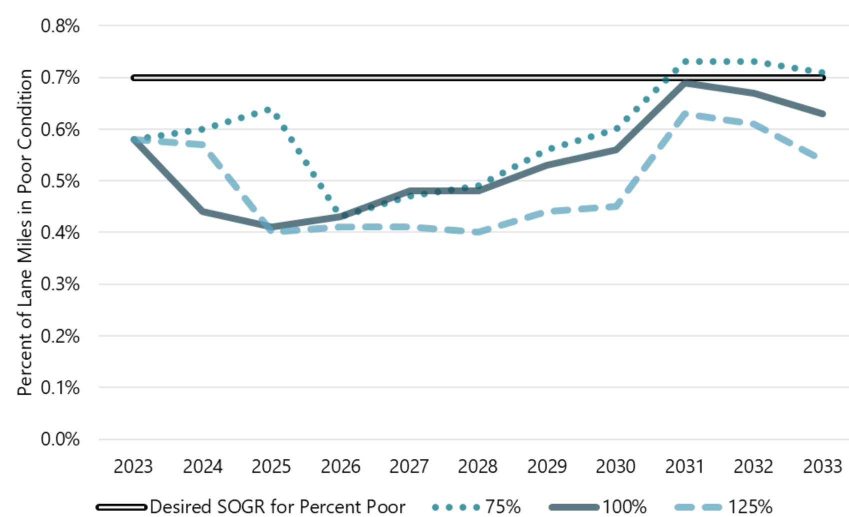


Figure 4.9: Non-Interstate NHS pavement condition performance scenarios for federally defined good condition

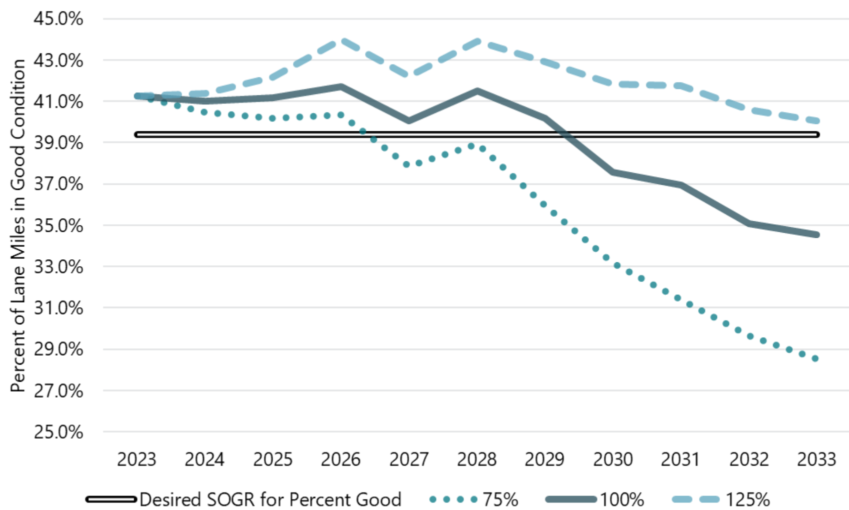
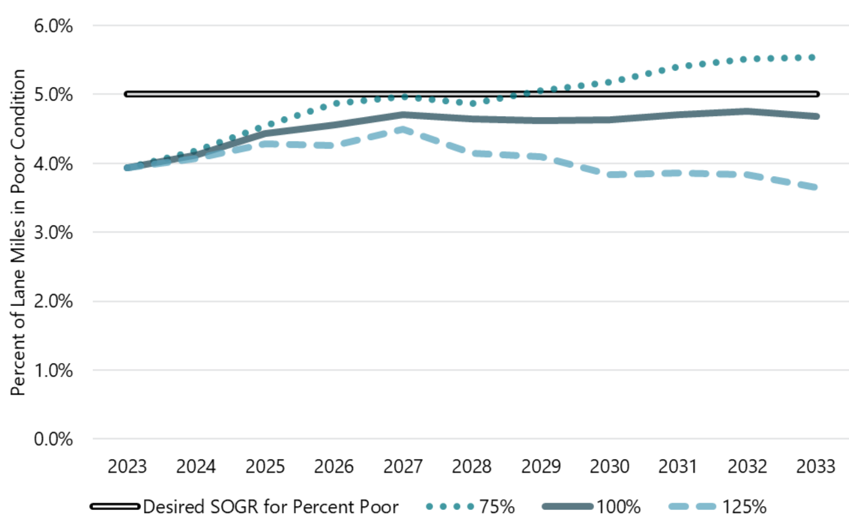


Figure 4.10: Non-Interstate NHS pavement condition performance scenarios for federally defined poor condition



4.3 Gap Assessment

Condition Gaps

FHWA defines a performance gap as "the gaps between the current asset condition and State DOT targets for asset condition, and the gaps in system performance effectiveness that are best addressed by improving the physical assets." Iowa DOT tracks the gap between current performance and desired SOGR, as well as the gap between 10-year projected performance and desired SOGR. 10-year projected performance is the predicted asset condition assuming current funding levels are continued.

As discussed earlier in this chapter, scenarios with lower funding levels or less optimized project selection were considered in addition to scenarios with additional funding. The less optimal scenarios help Iowa DOT consider the impact of risk on achieving its 10-year SOGR, as the scenarios can used as sensitivity analyses. They serve as proxies to represent scenarios such as budgets decreasing due to less funding or increased inflation, having less funding for asset management projects due to a need to divert funding for other needs (such as emergency repairs due to natural disasters), or less effectiveness of asset management strategies leading to shorter life cycles for treatments and the need for additional work sooner than anticipated.

Note that current performance uses 2022 data and is consistent with the values presented in Chapter 2 Inventory and Condition. The condition gap assessment is expressed using FHWA's performance measures for asset condition.

The gap analysis for NHS bridges is shown in Table 4.5. There is no current condition gap for NHS bridges, but there are projected gaps. At the end of the 10-year period of the TAMP, the percent of NHS bridges in poor condition will exceed the desired SOGR by 1.9% and the percent of NHS bridges in good condition will be 3.1% less than the desired SOGR. These projected condition gaps could be addressed with an additional $784 million in stewardship funding for bridges over the 10-year period of the TAMP.

Table 4.5: NHS bridges performance targets and gap assessment

	Good	Poor
Desired state of good repair	46.8%	6.5%
Current performance	48.6%	2.0%
10-year projected performance	43.7%	8.4%
Current gap	No gap	No gap
Projected gap	3.1%	1.9%

The gap analysis for Interstate pavements is shown in Table 4.6. There are no current gaps for Interstate pavements but there is a projected performance gap for Interstate pavements in good condition. At the end of the 10-year period of the TAMP, the percent of Interstate pavements in poor condition is projected to meet the desired SOGR, but the percent of Interstate pavements in good condition is projected to be 2.4% less than the desired SOGR. The projected condition gap could be addressed with an additional $77 million in stewardship funding for Interstate pavements over the 10-year period of the TAMP.

Table 4.6: Interstate pavements performance targets and gap assessment

	Good	Poor
Desired state of good repair	58.8%	0.7%
Current performance	58.8%	0.4%
10-year projected performance	56.4%	0.7%
Current gap	No gap	No gap
Projected gap	2.4%	No gap

The gap analysis for non-Interstate NHS pavements is shown in Table 4.7. There are current and projected condition gaps for non-Interstate NHS pavements in good condition. At the end of the 10-year period of the TAMP, the percent of non-Interstate NHS pavements in poor condition will be slightly under the desired SOGR, but the percent of non-Interstate NHS pavements in good condition will be 4.4% less than the desired SOGR. The projected condition gap could be addressed with an additional $254 million in stewardship funding for non-Interstate NHS pavements over the 10-year period of the TAMP.

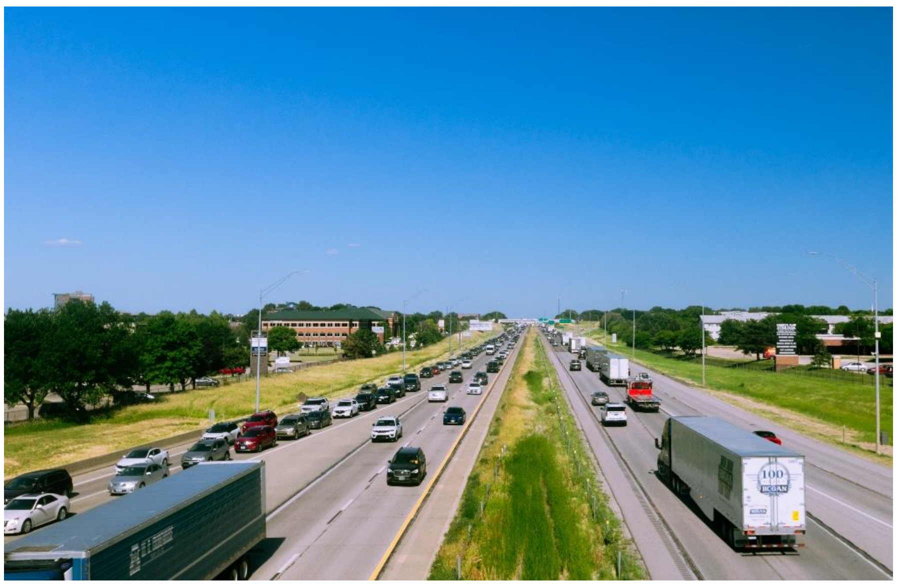
Table 4.7: Non-Interstate NHS pavements performance targets and gap assessment

	Good	Poor
Desired state of good repair	39.4%	5.0%
Current performance	37.9%	3.7%
10-year projected performance	35.0%	4.8%
Current gap	1.5%	No gap
Projected gap	4.4%	No gap

For both Interstate and non-Interstate NHS pavements, gaps are expected for good condition but not poor. This suggests Iowa DOT is doing a good job of preventing pavements from slipping into or staying in poor condition, but, overall, more pavements are expected to transition from good to fair over the next decade. This is likely partially due to the way that the federal measures are calculated, where all distress metrics must be in the good category for a segment to be rated as good; even one distress metric in the fair category results in the pavement being considered to be in fair condition.

Other Gaps

The targets documented in the prior sections help support the implementation of the goals and strategies not just of the TAMP, but also of several other Iowa DOT plans, including Iowa in Motion 2050, which is the State Long-Range Transportation Plan (SLRTP), the State Freight Plan (SFP), the Iowa Interstate Investment Plan (I3P), and the Strategic Highway Safety Plan (SHSP). As discussed in Chapter 1, in Iowa DOT's overall planning and programming process, the SLRTP, TAMP, SFP, I3P, SHSP, and other system and modal plans help to focus attention and priorities based on system needs, risks, and strategies. These broader planning efforts help guide the planning and project development process that ultimately leads to the specific investments identified in the Five-Year Program for Iowa DOT projects and the four-year Statewide Transportation Improvement Program (STIP) that includes all projects utilizing federal aid.



The TAMP focuses specifically on bridge and pavement condition. The SLRTP, SFP, I3P, SHSP, and other system and modal plans discuss other potential performance gaps through analysis of transportation system needs and risks, with the aim to improve its performance in areas aligned with national goals, including safety, infrastructure condition, system reliability, freight movement, and reduced congestion. Some of the strategies and projects identified in these plans will likely result in modifications to NHS pavements and bridges, though not necessarily within the 10-year timeframe of the TAMP. If all the strategies from the various plans were implemented, they would likely impact the gap between existing and desired pavement and bridge condition on the NHS by improving or expanding NHS pavement and bridge assets, or by diverting funding that may have otherwise been used to improve NHS pavement or bridge condition. The intent, however, is that these strategies will be implemented over a longer period, and that tactics to minimize any negative impacts on the performance gaps for pavement and bridge condition will be utilized. This would include actions such as performing work to address other issues in an opportunistic fashion when pavement and bridge condition issues are being addressed, and funding non-condition needs from sources other than funds targeted towards pavement or bridge condition improvements.

The remainder of this section highlights analysis and strategies from these other planning efforts and how they may help in closing various performance gaps.

State Long-Range Transportation Plan (SLRTP)

The SLRTP was adopted in 2022 and includes analysis and strategies for the various modes of transportation in the state. For highways, this includes the ten different analysis layers noted below. Pavement and bridge needs on the NHS are anticipated to be addressed primarily through the asset management processes described in this TAMP; for the other analysis layers, the SLRTP helps focus attention on priority locations where there are performance gaps. Implementing projects to address the pavement and bridge needs as well as the other identified needs and risks could result in changes to the bridge and pavement assets on the NHS.

- The **pavement condition** analysis identified candidate condition improvement locations by using the Infrastructure Condition Evaluation (ICE) tool, which provides a composite rating based on the most recent infrastructure condition and performance data.
- The **bridge condition** analysis identified candidate condition improvement locations by using the Bridge Condition Index (BCI), which is calculated based on structural adequacy and safety; serviceability and functional obsolescence; essentiality for public use; and special vulnerabilities.
- The **bottleneck** analysis identified candidate bottleneck improvement locations through a system screening that used traffic speed data to identify segments categorized as bottlenecks due to recurring traffic slowdowns.
- The **Super-2** analysis identified candidate statewide corridors where Super-2 improvements such as passing lanes and turn lanes would enhance operations and complement the state's multilane highway network.
- The **capacity** analysis identified candidate capacity improvement locations through analysis of volume-to-capacity (V/C) conditions based on the statewide travel demand model, MPO travel demand models, and traffic forecasts completed for studies and projects.
- The **operations** analysis identified corridors considered to be higher risk from an operations perspective by using the Infrastructure Condition Evaluation for Operations (ICE-OPS) tool, which is a system screening tool that quantifies the relative risk to the safe and reliable operation of the system.
- The **flood resiliency** analysis (discussed further in Chapter 5) identified corridors vulnerable to a 100-year flood event by using a resiliency metric that includes robustness, redundancy, and criticality components.
- The **safety** analysis identified locations with the greatest potential for crash reduction (PCR) through a statewide analysis that calculated the PCR by examining the predicted numbers of crashes based on the roadway and traffic environment.
- The **bicyclist** analysis identified locations considered to be higher risk for bicyclists based on a statewide analysis that developed composite scores for locations by considering several roadway factors related to the likelihood for risks to bicyclists.
- The **pedestrian** analysis identified locations considered to be higher risk for pedestrians based on a statewide analysis that developed composite scores for locations by considering several roadway factors related to the likelihood for risks to pedestrians.

Iowa Interstate Investment Plan (I3P)

The I3P established a long-term statewide vision for Iowa's Interstate System that can be achieved with available resources. The plan initially detailed the intended purpose and type of work to be performed on every segment of Iowa's Intestate System through the year 2040, and has since been expanded to 2050. The investments described in the I3P were identified to maintain the high level of service in terms of safety and overall pavement and bridge conditions while addressing identified capacity issues. By looking forward 30 years, the I3P ensures projects will address both current and future needs. This supports prioritization of projects by recognizing trends in travel and highway usage to ensure funding is spent where it will provide the most benefit for the longest period of time.

Most of the system will be subject to stewardship treatments aimed at managing the condition and performance of existing pavements and bridges for the lowest achievable life cycle cost. During development of the I3P, Iowa DOT identified segments of the Interstate System expected to require capacity improvements based on projections of future traffic levels. The plan addresses these capacity needs on a prioritized basis. As these projects are developed, they may improve performance in terms of congestion reduction or increased travel time reliability, but if lanes are added rather than utilizing operational solutions the result will be additional inventory of NHS lane miles and bridge deck area that will need to be accounted for in planning future maintenance needs.

State Freight Plan (SFP)

The SFP, updated in 2022, identifies important considerations that may lead to changes to some NHS routes to enhance mobility and/or reduce delay. One such consideration is the identification of the Iowa Multimodal Freight Network (IMFN), which includes several NHS routes. This network is meant to recognize corridors that are critical to truck freight in order to protect and enhance their ability to facilitate freight movement. The IMFN may also lead to department policies regarding the design and use of these corridors, and help assist in programming decisions. The SFP identifies several strategies that may result in investments on NHS routes. These include the following.

- Target investment to address mobility issues that impact freight movements.
- Target investment in the IMFN at a level that reflects the importance of this system for moving freight.
- Rightsize the highway system and apply cost-effective solutions to locations with existing and anticipated issues.
- Enhance planning and asset management practices for the IMFN by utilizing designs and treatments that are compatible with significant freight movements.

Specific investments identified in the SFP include projects on I-80 in Johnson and Cedar counties that will improve the condition and performance of the NHS; however, these projects involve lane expansions that will also increase future maintenance needs.

Strategic Highway Safety Plan (SHSP)

The 2019-2023 SHSP includes engineering strategies to help address issues with lane departure crashes and to improve intersections. These improvements are being implemented as appropriate throughout the state's highway system and may include enhancements to NHS routes. Many of these strategies would not necessarily impact the condition of pavements or bridges or the timeframe in which assets are rehabilitated or replaced. Strategies to help prevent lane departures include the installation of countermeasures such as centerline rumble strips, shoulder/edge line rumble strips, curve delineation, shoulder treatments, and median cable barriers. Strategies to help improve intersections include implementing innovative improvements such as roundabouts, reduced conflict intersections, diverging diamond interchanges, and offset turn lanes; traffic signal modifications; intersection lighting; and bicycle/pedestrian intersection improvements.

Transportation Systems Management and Operations (TSMO) Planning

Several TSMO planning efforts have been underway in recent years, aiming to improve the system's reliability. The goal of TSMO is to proactively manage the performance of the state's transportation system, particularly by managing or mitigating congestion and incidents. Iowa DOT's TSMO Plan, individual Service Layer Plans, and regional studies for integrated corridor management have included projects and activities that will continue to advance the use of TSMO strategies in the state and improve operations of the highway system. TSMO solutions can be beneficial to the NHS as they can help improve its performance without necessarily adding pavement to the system.

Closing the Gaps

Iowa DOT continually reevaluates and works to address the gaps, needs, and risks of the transportation system. This includes refining life cycle planning by integrating new or improved treatments for bridges and pavements and improving modeling systems to help determine what are the right treatments at the right times. Addressing gaps also involves considering the risks documented in Chapter 5 and implementing the response strategies that have been developed to mitigate, or, in the case of positive risks, enhance them. Investment strategies are evaluated annually as part of the development of the Five-Year Program, and funding levels for asset management have increased over time due to growing needs. Investment strategies are also evolving to address critical needs, such as programming funds towards non-Interstate pavement replacement projects.

As noted previously, if all the strategies identified in the various plans were implemented, they would likely impact the gap between existing and desired pavement and bridge condition on the NHS. The gaps, needs, and risks identified through these planning efforts need to be balanced with those discussed in the TAMP as well as the achievement of state and national goals in various areas, including safety, infrastructure condition, system reliability, freight movement, and reduced congestion. Since budgets are limited, implementing the optimal mix of strategies involves tradeoffs. While many projects have benefits for multiple goal areas, some types of projects may improve performance in one area while widening the gap in another. For example, additional lanes may decrease congestion, but those decreases may be temporary, and the long-term outcome includes additional maintenance burdens and potentially increased traffic and emissions. These tradeoffs reinforce the importance of continuing to analyze the system; monitor condition and performance gaps, needs, and risks; develop rightsized solutions that address current needs without increasing future burdens; and refine and implement effective asset management strategies.

Future Gap Assessments

Throughout this chapter, both the Primary Highway System and NHS have typically been discussed in terms of Interstate and non-Interstate portions of each system. The NHS is addressed in this manner due to the federal requirements for the TAMP to address the NHS and for pavement targets to be set separately for the Interstate System and non-Interstate NHS. Iowa DOT has also historically divided the Primary Highway System into Interstate and non-Interstate portions for the purposes of defining preferred system-level BCI or PCI and forecasting various investment scenarios.

As noted in Chapter 1, as part of the 2022 SLRTP update, a rightsizing policy was adopted. The rightsizing policy includes ten policy statements for various areas, many of which relate to asset management. These include defining project needs, incorporating comprehensive needs, placing an emphasis on stewardship, and stratification of the system for purposes like setting state of good repair targets and defining asset management treatments. A work plan is currently being developed to identify ways to implement these policies throughout the project development process, and several activities are already underway.

The rightsizing statement for stratification of the system is: "*The department shall evaluate and consider implementing an approach to stratify the Primary Highway System for the purpose of defining corresponding state of good repair targets and informing investment decisions. Such stratification should consider existing designations, including the National Highway System and Commercial and Industrial Network, functional classification, current and forecasted use, and network redundancy.*"

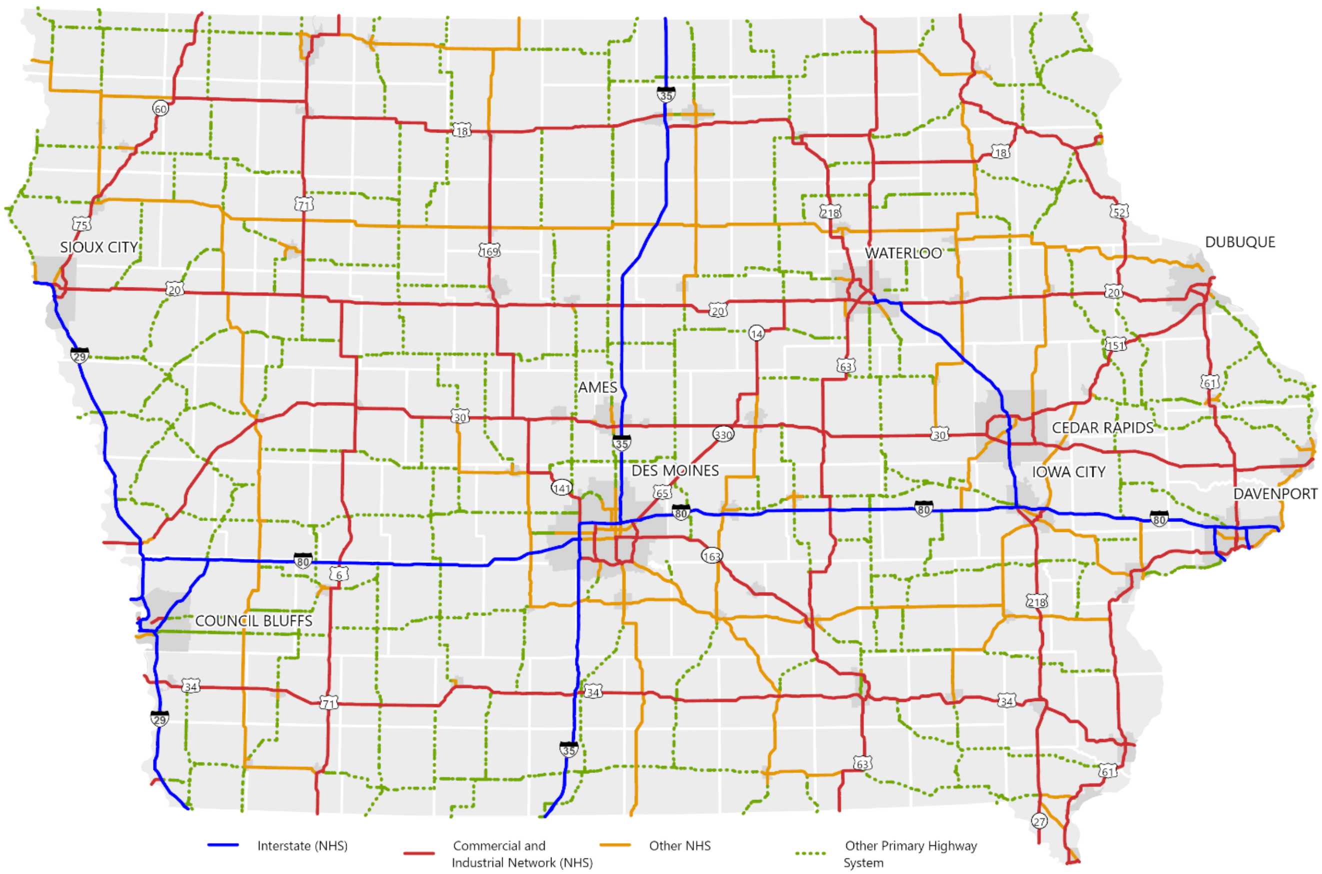
The reason this policy statement was developed is that the Primary Highway System is diverse and complex. It ranges from urban multilane Interstates with over 130,000 vehicles per day to rural two-lane roads with less than 1,000 vehicles per day. Different roadways have different contexts, users, and needs, such as freight routes, commuter corridors, community access, and so on. These purposes may need to be managed differently and to a different level. For example, it may be appropriate to target a higher level of service or condition level on a busy freight route than on a less utilized highway that primarily provides access for local traffic. Stratification beyond Interstate and non-Interstate could inform condition targets as well as the types of treatments that would be considered for particular roadways. Only defining desired PCI and BCI at the Interstate and non-Interstate Primary Highway System levels for pavements and bridges does not provide adequate delineation given the wide range of characteristics seen on non-Interstate highways. Additional stratification would provide important context to asset management planning and investment decisions.

The discussion of how to stratify the system began with a working group formed under the TAM Technical Committee. The group reviewed formal and informal ways that the highway system is classified for various purposes. Ultimately, a recommendation was made to move forward with a system stratified into the following four classifications by priority, which are shown in Figure 4.11.

- **Interstate System**
- **Commercial and Industrial Network (CIN)**, which is an Iowa DOT designation for a specific network of highways which are critical for linking regional centers, providing continuity with major highways in adjacent states, and carrying a large portion of non-Interstate traffic; the CIN is entirely on the NHS
- **Other NHS**
- **Other Primary Highway System (non-NHS)**

While not yet incorporated into the processes discussed in this TAMP, an evaluation of PCI and BCI metrics for the new stratification is currently underway. The pavement and bridge management teams will review this information and consider future steps, which may include developing distinct state-level PCI and BCI targets for the classifications, incorporating the stratification into pavement and bridge modeling scenarios, and considering policies or investment strategies related to the range of treatment types that will be considered based on stratification. Since the stratification is still separating the NHS and non-NHS portions of the Primary Highway System, it has the benefit of being able to be integrated with the TAMP and the requirements that are specific to the NHS. This could ultimately lead to a more advanced gap discussion for pavement and bridge condition in the next iteration of the TAMP by introducing additional nuances related to the more detailed stratification.

Figure 4.11: Recommended Primary Highway System stratification



5. RISK MANAGEMENT

Managing risk is an integral part of asset management. Transportation agencies manage physical assets which are subject to a range of risks, from daily operational concerns to potentially catastrophic asset failures. By anticipating, identifying, and planning for potential scenarios, Iowa DOT can reduce uncertainty and mitigate the effects of risks.

Introduction

This chapter describes the federal requirements pertaining to risk management in transportation asset management (TAM), Iowa DOT's existing risk management activities, and Iowa DOT's TAM risk management processes and risk mitigation plan. Additionally, this chapter summarizes an assessment of NHS pavements and bridges repeatedly damaged by emergency events, consistent with federal requirements, and discusses considerations of extreme weather and resilience in the context of risk management.

Iowa DOT practices formal and informal risk management and considers risks at multiple levels. This can be as granular as managing risk associated with a particular activity or phase of a project, or as wide-ranging as risks to a group of assets, a funding program, or enterprise level risks for the department. At the broader level, a recent example of risk management is the 2021 update to the department's organizational structure, which included the consolidation of planning, programming, modal, asset management, and project delivery functions within a single division, the Transportation Development Division. This change was to support continued integration of multimodal efforts, allow for more focused and integrated asset management efforts, and enhance the connection between research, data collection, analysis, planning, programming, and development activities. At the planning level, resiliency has been incorporated into the department in a more visible manner through the creation of a Resiliency Working Group. Its efforts, particularly related to extreme weather and resiliency, are discussed at the end of this chapter. At the project level, risk management efforts related to bridge and pavement life cycle planning are discussed in Chapter 3.

Federal Requirements

Requirements for consideration of risk in a TAMP are detailed in 23 CFR 515. Risk is defined as "the positive or negative effects of uncertainty or variability upon agency objectives" and risk management is defined as "the processes and framework for managing potential risks."

23 CFR 515.7(c) mandates that, "A State DOT shall establish a process for developing a risk management plan." Specific requirements for the process are listed below.

- Identification of risks that can impact the condition and performance of NHS pavements and bridges.
- Assessment of the identified risks in terms of the likelihood of their occurrence and their impact and consequence if they do occur.
- Evaluation and prioritization of the identified risks.
- Mitigation plan for addressing the top priority risks.
- Approach for monitoring the top priority risks.
- Summary of the evaluation of NHS pavements and bridges repeatedly damaged by emergency events.

In 2021, the Infrastructure Investment and Jobs Act also added the specific requirement that risk management analysis include consideration of extreme weather and resilience.

5.1 Asset Management Risks

A key part of the asset management planning process is identifying and mitigating TAM risks. The iterative process that Iowa DOT uses to manage its asset management risks is consistent with federal requirements and involves the following elements, depicted in Figure 5.1.

- **Event Identification**: Identify events that could impact Iowa DOT's ability to effectively manage its bridges and pavements.
- **Risk Assessment**: Assess the likelihood of an event happening and the consequences if it were to happen.
- **Risk Response**: Identify an approach for responding to each of the priority risks.
- **Control Activities**: Implement the risk response approaches.
- **Risk Monitoring**: Monitor and respond to possible events, and evaluate the response approaches.

Figure 5.1: TAM risk management process

Risk Identification and Assessment Methodology

Identifying risks is the first step in risk management. To begin the risk identification process, Iowa DOT distributed an online survey to key agency staff, including members of the TAM Implementation Team and technical working group leads. The survey included risks identified in the 2019 TAMP along with additional risk statements for consideration. Respondents were asked to rank the risks based on their likelihood of occurring and consequence if they occurred, and to provide any additional feedback on the risk statements. Participants were also asked to identify any additional significant risks that could enhance or constrain Iowa DOT's ability to manage its bridges and pavements.

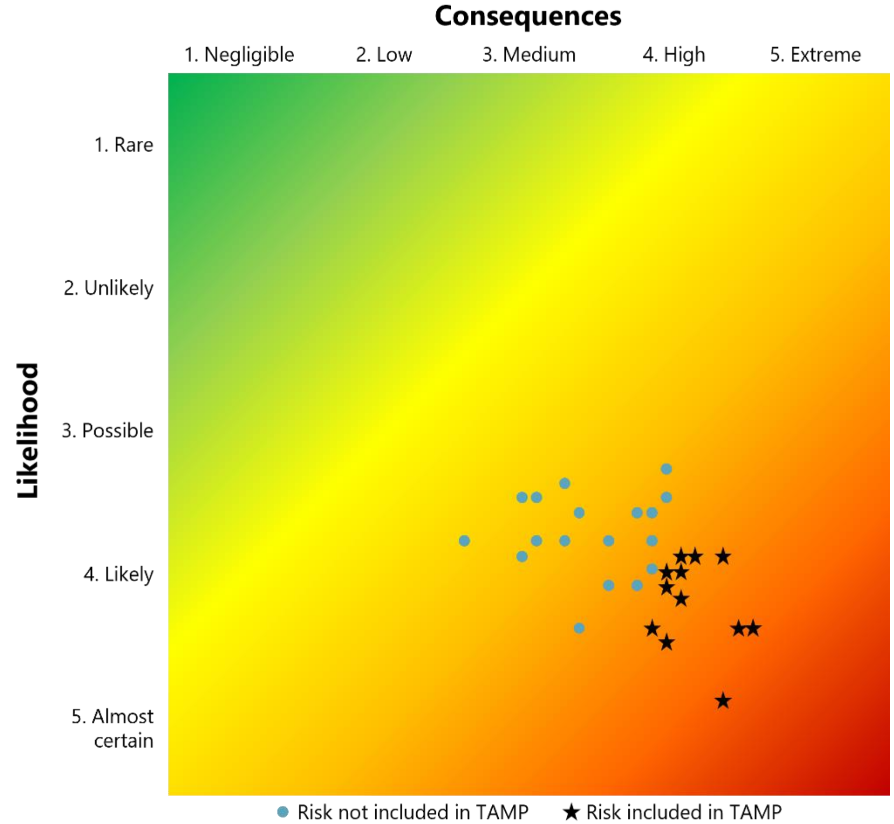
To rank the risks, respondents assessed risk likelihood on a scale of one (rare) to five (almost certain); votes were then averaged to determine the overall likelihood score. Similarly, respondents assessed risk consequence on a scale of one (negligible) to five (extreme); votes were then averaged to determine the overall consequence score. The two scores were multiplied to determine an overall score for each risk.

Risk Prioritization

The results of the online survey were compiled in ranked order for a workshop where participants discussed which risks were most critical to focus on for the TAMP. Once this was determined, participants worked to build out the TAMP's risk register by discussing response strategies, owners, and the status or actions to take regarding the response strategies.

Out of 30 strategies included in the survey, 13 strategies with a combined likelihood and consequence score of 12 or higher were carried forward into the workshop. During the workshop, these strategies were refined into nine high and medium priority risks to focus on; no very high priority risks have been identified. Figure 5.2 shows the distribution of the initial 30 risks and notes which ones were incorporated into the TAMP. These risks are identified on Table 5.1. The likely reason that no risks resulted in scores in the lowest risk quadrant is that these risks are already being handled as part of routine business practices and were not included in the survey.

Figure 5.2: Risk priority matrix, showing the survey results for 30 identified risks



Note: some of the starred risks were combined for the TAMP risk register.

After assessing and prioritizing the risks at the risk workshop, participants defined a response approach for each risk. Response approaches for risks with negative impacts included avoid, transfer, mitigate, or accept the risk. Response approaches for risks with positive impacts included exploit, share, enhance, or accept. Two of the nine risks included in the TAMP are positive risks.

Risks are also labeled according to eight risk areas defined by Iowa DOT. These areas help categorize the risks and mitigation strategies.

- **Business Processes** include operations, management, and support processes. Examples include financial forecasting and risk identification and management. Note that certain business processes (e.g., capital planning and programming; data collection) are categorized as separate areas for the purposes of this TAM risk register.
- **Capital Planning and Programming** includes long-term planning activities such as analysis of relevant trends, evaluation of potential investments, review of other factors, and stakeholder engagement; and short-term programming activities such as selecting projects, identifying funding, and finalizing investments.
- **Communication** involves communicating the asset management progress made by Iowa DOT and educating stakeholders, including state and local lawmakers, users, and institutions. This includes messages about shortcomings and needs at Iowa DOT and also messages of success.
- **Data Collection** is a key part of Iowa DOT's asset management approach. Gathering accurate, complete, and current data helps inform and drive the decision-making process.
- **Management Systems** include bridge and pavement systems. These systems can collect and store asset inventory and condition data, analyze that data to project future conditions, and recommend asset treatments.
- **Organizational Structure** refers to the interrelatedness and function of work units within Iowa DOT and how they relate to asset management. Organizational structure issues include staffing levels, roles and responsibilities, and governance.
- **Research** helps support and improve asset management practices and processes at Iowa DOT.
- **Training** is necessary to educate new staff and keep current staff up to date on asset management at Iowa DOT.

Risk Mitigation

After identifying risks and response approaches, Iowa DOT also developed response strategies for each priority risk included in the TAMP. Together, the set of risks and response strategies are the foundation of a risk mitigation plan, which is a series of strategies for addressing the priority risks identified in the risk register. Groups or individuals have been identified to take ownership of each strategy and be responsible for its implementation. Iowa DOT's risk mitigation plan for the priority risks is also presented in Table 5.1.

Risk Monitoring

Iowa DOT's risk management process does not stop with the development of the risk register. The next steps in the process are to implement the risk response strategies, monitor the risks over time, and periodically update the risk register. Iowa DOT identified an owner for each risk response strategy. Progress will be reviewed quarterly through Iowa DOT's TAM Implementation Team, and the risk responses will be reviewed annually and updated as appropriate. This group meets regularly and serves as the proper forum to monitor these risks and implement any necessary response adjustments. Over time, as Iowa DOT implements the risk response strategies, it is anticipated that some risks will fall off the priority list. These risks will be replaced with new priorities, as appropriate.

Table 5.1 (Part 1 of 4): Priority risks and mitigation actions

Risk Statement	Response Strategies	Owner(s)	Status/Actions
1. If costs continue to increase in an unpredictable manner (due to factors such as inflation, fuel, supply chain disruptions, and limited contracting workforce), the resulting increased project costs could impact the delivery of the program. *Likelihood: 4.4* *Consequence: 3.9* *Response Approach: Mitigate* *Categories: Business Processes; Capital Planning and Programming*	**1A**. Readjust the program as necessary and ensure asset management projects take priority.	Transportation Development Division (TDD) Director	Continue to discuss the outstanding issues impacting the program with the Commission. A 2022 Business Plan objective is to improve the project delivery cycle to improve agility and reduce waste.
	1B. Coordinate with the Association of General Contractors (AGC) and industry partners to discuss and address impacts of these issues.	TDD Director	Meet to coordinate as needed.
	1C. Continue research on alternative materials and construction strategies to construct and maintain assets more cost effectively over their life cycles.	Pavement and Bridge Management Teams (PBMT)	Continuous; examples include improved pavement treatments and use of accelerated bridge construction. *(Same as 5C.)*
2. If the Iowa Transportation Commission approves future increases to planned stewardship expenditures, then Iowa DOT may be able to maintain existing bridge and pavement conditions. *Likelihood: 3.9* *Consequence: 4.1* *Response Approach: Enhance* *Category: Capital Planning and Programming*	**2A**. Identify asset management projects that could be developed quickly, where feasible, and prioritize unmet needs to help guide project development activities.	Districts, Design Bureau (DB), Bridges and Structures Bureau (BSB), TAM Implemen-tation Team (TAM-IT)	Projects are being identified and prioritized for pavement replacement funding that has been budgeted in the 5-Year Program.
	2B. Identify opportunities for increasing asset life on a project if funds are available to utilize a more substantial treatment that would be more cost-effective over the life cycle of the asset (e.g., deck replacement rather than overlay).	Districts, DB, BSB, TAM-IT	
	2C. Continue annual activities to communicate stewardship needs and predicted conditions.	Districts, DB, BSB, TAM-IT	Commission discussions regarding pavement and bridge condition are scheduled for early CY 2023 as part of the annual program development cycle of presentations. *(Same as 5A.)*

Table 5.1 (Part 2 of 4): Priority risks and mitigation actions

Risk Statement	Response Strategies	Owner(s)	Status/Actions
3. If appropriate protective features are not integrated into projects in locations vulnerable to extreme weather impacts, then assets may be less resilient and response and recovery efforts may be prolonged. *Likelihood: 3.9*  *Consequence: 4.0* *Response Approach: Mitigate* *Categories: Data Collection; Management Systems; Research*	**3A**. Adapt to and incorporate evolving protective measures utilizing findings of the Resiliency Working Group.	Chief Operating Officer (COO), TDD	The Resiliency Working Group meets regularly and coordinates with the COO as their Executive Leadership Team (ELT) Champion.
	3B. Incorporate climate change and extreme weather considerations into design manuals and processes.	DB, BSB	Guidelines for considering future hydrological conditions have been drafted for consideration for the bridge design manual. The Design Bureau has been defining betterment design standards and guidance for embankment protections, which can help stabilize slopes.
4. If Iowa DOT takes advantage of increased discretionary funding programs, then additional funds could be available to implement asset management and resiliency investments. *Likelihood: 4.0*  *Consequence: 3.5* *Response Approach: Enhance* *Category: Capital Planning and Programming*	**4A**. As an agency be more strategic in pursuing discretionary grants.	TDD Deputy Director	ELT has been discussing how to be strategic with discretionary grant opportunities, including developing an improved process for identifying, screening, and prioritizing candidate projects.
	4B. Monitor local agency applications for discretionary grants.	TDD Deputy Director	
	4C. Coordinate on identifying priority applications in order to avoid competing internally for funds.	TDD Deputy Director	
	4D. Undergo vetting process of options within and across the agency.	TDD Deputy Director	

Table 5.1 (Part 3 of 4): Priority risks and mitigation actions

Risk Statement	Response Strategies	Owner(s)	Status/Actions
5. If Iowa DOT is unable to select bridge and pavement treatments consistent with its life cycle strategies, then asset management costs may increase and conditions may decrease. *<u>Likelihood</u>: 3.4* *<u>Consequence</u>: 3.9* *<u>Response Approach</u>: Mitigate* *<u>Categories</u>: Capital Planning and Programming; Management Systems*	**5A**. Communicate effectively to ELT and the Commission regarding stewardship needs.	BSB, Districts, PBMT	Commission discussions regarding pavement and bridge condition are scheduled for early CY 2023 as part of the annual program development cycle of presentations. *(Same as 2C.)*
	5B. Improve bridge and pavement asset models.	BSB, Districts, PBMT	BSB is working to utilize the AASHTO BrM system to model future conditions. Pavement management has transitioned to a new version of dTIMS and an in-house pavement stewardship tool is also being utilized. *(Same as 7A.)*
	5C. Continue to seek innovative treatments and low-cost options.	BSB, Districts, PBMT	Continuous; examples include improved pavement treatments and use of accelerated bridge construction. *(Same as 1C.)*
	5D. Continue to develop system stratification efforts, including consideration of unique state of good repair targets and policies or strategies related to the range of treatments that will be considered based on stratification.	BSB, Districts, PBMT	A preferred stratification has been developed and implementation plans are underway.
6. If transportation systems management and operations (TSMO) and travel demand strategies are not used instead of capacity expansion where feasible, then new capacity projects and long-term maintenance commitments could be required, impacting the ability to deliver the asset management program. *<u>Likelihood</u>: 3.7* *<u>Consequence</u>: 3.6* *<u>Response Approach</u>: Avoid* *<u>Categories</u>: Business Processes; Capital Planning and Programming*	**6A**. Develop a tool kit of projects/strategies that could improve operational capacity without adding lane miles.	Traffic Operations Bureau (TOB), TSMO Engineers	TOB will finish the Active Traffic Demand Management service layer plan.
	6B. Develop and implement a process for planning studies that will increase the consideration of alternatives that help address highway capacity needs without adding lanes.	Location & Environment Bureau	This initiative and several others for incorporating TSMO into project delivery are currently underway.
	6C. Continue integrating TSMO into project delivery.	TDD Deputy Director	Several objectives for integrating TSMO into project delivery have been prioritized and are underway.

Table 5.1 (Part 4 of 4): Priority risks and mitigation actions

Risk Statement	Response Strategies	Owner(s)	Status/Actions
7. If Iowa DOT is unable to adequately communicate the how and why of asset management, then the program may not be adequately funded or properly implemented. *Likelihood: 3.6* *Consequence: 3.5* *Response Approach: Mitigate* *Categories: Communication; Organizational Structure; Training*	**7A**. Improve modeling systems to enable better communication and better demonstration of funding impacts.	PBMT	BSB is working to utilize the AASHTO BrM system to model future conditions. Pavement management has transitioned to a new version of dTIMS and an in-house pavement stewardship tool is also being utilized. *(Same as 5B.)*
	7B. Prepare examples illustrating impacts of funding (e.g., before and after bridge project).	TAM-IT	Work with Asset Managers and Strategic Communications to develop this type of material.
	7C. Add more documentation to the consistency review to show what TAM investments are achieving.	TAM-IT	
	7D. Celebrate TAM successes through photos and communication materials to help institutionalize an emphasis on TAM.	TAM-IT	
8. If the State Legislature raises permit weight limits for bridges, then funding may need to be reallocated to address impacts on assets. *Likelihood: 3.5* *Consequence: 3.5* *Response Approach: Avoid* *Categories: Capital Planning and Programming; Communication*	**8A**. Perform research to quantify the loss of asset value and the impact from heavier loads on bridges.	BSB, Research & Analytics Bureau	Scope research project.
	8B. Develop a "one pager" to educate legislature on this issue and/or provide a briefing to legislature.	Strategic Comm. Bureau, BSB	Would follow research project.
9. If flooding becomes more severe and/or frequent then additional labor, funding, and other resources will be diverted from TAM and other activities. *Likelihood: 3.4* *Consequence: 3.6* *Response Approach: Mitigate* *Categories: Capital Planning and Programming; Data Collection; Management Systems; Research*	**9A**. Improve documentation of flood incidents to maximize reimbursement opportunities for Federal ER funds.	Resiliency Working Group (RWG); TOB	An RWG objective includes establishing an internal workflow for applying to FHWA's ER Program and for implementing betterments.
	9B. Fund resiliency investments for critical infrastructure (e.g., U.S. 30 over the Skunk River).	RWG, DB, BSB	A framework for identifying and prioritizing resiliency project candidates has been developed by the RWG.

5.2 Summary of Transportation Assets Repeatedly Damaged by Emergency Events

Legislative Context

As part of a separate regulation promulgated by FHWA, state DOTs must perform periodic evaluation of facilities repeatedly requiring repair and reconstruction due to emergency events. According to FHWA, state DOTs "shall conduct statewide evaluations to determine if there are reasonable alternatives to roads, highways, and bridges that have required repair and reconstruction activities on two or more occasions due to emergency events." Evaluation is defined as "an analysis that includes identification and consideration of any alternative that will mitigate, or partially or fully resolve, the root cause of the recurring damage, the costs of achieving the solution, and the likely duration of the solution." Reasonable alternatives are defined as "options that could partially or fully achieve the following:

1. Reduce the need for Federal funds to be expended on emergency repair and reconstruction activities;
2. Better protect public safety and health and the human and natural environment; and
3. Meet transportation needs as described in the relevant and applicable Federal, State, local, and tribal plans and programs."

While the requirement for evaluations is its own rule (23 CFR 667), the FHWA requires that the TAM risk management process include a summary of the evaluations for NHS pavements and bridges.

Methodology and Results

To prepare this evaluation, Iowa DOT researched records from the Emergency Relief (ER) program, including all available Detailed Damage Inspection Report (DDIR) forms since 2004. Financial records from 1997 to 2004 were also investigated. Additionally, a database of geolocated DDIRs was created. After reviewing the records, eight candidate locations were identified that appear to meet the requirements. Two of the locations are on the NHS, including U.S. 20 in Buchanan County and I-35 in Decatur County. Four other locations were on the Primary Highway System in Story, Decatur, and Appanoose counties and two were on county routes in Des Moines and Winneshiek counties.

Data gathered for this evaluation will be incorporated into Iowa DOT's Project Prioritization and Scoping (PP/S) Tool, which is used at the initial stages of the project development cycle. Any locations meeting the criteria set forth in the regulation will be noted in the case that a project encompassing that location is scoped. Including the evaluation data as a layer in the scoping tool will prompt the project development team to evaluate locations that have been identified in this analysis, including any future locations as they are added to the dataset. Furthermore, on an annual basis, local agencies will be notified of any sites that are identified by the process, and Program Management staff will compare local agency projects in the STIP against locations identified by this process to ensure compliance with the regulations. Iowa DOT will continue to monitor all identified damage locations for future ER events and communicate within the department and with other system owners whenever new locations are found to meet the requirements.

5.3 Incorporating Extreme Weather and Resilience

Iowa's extensive transportation system empowers the movement of people and goods throughout the state to reach diverse destinations. The NHS and Primary Highway System provide a reliable backbone to the state's economy and serve as a crossroads for economic productivity for the nation. However, the state's highways, like all systems, are vulnerable to disruptions in the form of natural and human-induced events. Resiliency is key to being able to maintain and operate the highway system during and after these types of events. Iowa DOT defines resiliency as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and quickly recover from disruptions. Resiliency can be enhanced through improvements in rapidity, resourcefulness, robustness, and redundancy.

Resiliency and sustainability are building blocks of stewardship and asset management. Iowa DOT has the responsibility not only to meet the expectations of the public to ensure that the system is available and in good condition, but that it will continue to be so in the future, despite pressures from fiscal constraints and the risks posed by increasing extreme weather and natural disasters. Incorporating resiliency and sustainability principles into the decision-making process and project development will further support Iowa DOT's commitment to stewardship of Iowa's transportation system.

Over the past couple decades, Iowa has been increasingly impacted by natural disasters, including historic flooding, snowstorms, tornados, and derechos. This is likely to increase in the future as climate data shows strong trends towards increasing temperatures, precipitation, stream flows, and flooding. Additionally, awareness of human-induced disruptions has amplified as vigilance for potential terrorism and cyberattacks has increased. Examples of potential disruptions to Iowa's transportation system include the following.

- Natural, environmental, and extreme weather events
    - Flooding
    - Erosion
    - High wind
    - Increased precipitation (e.g., rain, snow, ice)
    - Landslide/rockfalls
    - Tornados and derechos
    - Snow/blizzard
- Human-induced hazards
    - Adverse actor physical threat
    - Congestion
    - Crashes
    - Cyberattack
    - Asset failure

Resiliency Working Group

Iowa DOT has established a Resiliency Working Group (RWG). The group meets quarterly, has an established charter, and is working to integrate resiliency more fully into Iowa DOT's business processes. The RWG provides guidance, support, and coordination of resiliency efforts within Iowa DOT. The mission of the RWG is to properly prepare for and reduce the impact of future disruptions to Iowa's transportation system. This includes proactive efforts to increase the system resiliency as well as enhancing response efforts to restore the operation of the system after a disruption. The group plans to accomplish this through synthesizing existing efforts, developing standard operating procedures, and strategically planning for future events.

The RWG prioritized the following five strategies at a 2021 visioning workshop. These strategies are essentially risk management efforts to enhance the system's resiliency and mitigate potential impacts on the system itself and the ability of Iowa DOT to manage it in times of emergencies.

- **Explore vulnerability assessments for various hazards for the state transportation system and others.** A flood resiliency analysis has been completed and is discussed in the next section. Analyses of additional hazards will be considered as appropriate.
- **Employ a programmatic method for implementing vulnerability or resiliency into the Five-Year Program.** In 2021, the Infrastructure Investment and Jobs Act created a formula program and discretionary grant program for Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) funds. PROTECT will help fund planning, resilience improvements, and community resilience and evacuation routes. Iowa DOT plans to develop a Resilience Improvement Plan that will identify strategies and types of projects to increase the resiliency of the state highway system. Additionally, a framework has been developed for identifying and prioritizing candidate projects eligible for the PROTECT program.
- **Improve department cybersecurity.** This includes continuous evaluation of IT systems and assets for vulnerabilities, prioritizing risk mitigation, investing in automated systems to improve cybersecurity incident response, developing redundant infrastructure and system restoration processes, and upgrading legacy systems that were not engineered to meet the current cyber threat environment. Iowa DOT also partners with the State of Iowa Office of the Chief Information Officer (OCIO) and the Federal Cybersecurity and Infrastructure Security Agency (CISA) to protect critical infrastructure. Additionally, emergency network communication kits are being developed that would include multiple methods for communication in case of issues such as the commercial cellular network being down. These kits would be available throughout DOT districts and would enhance the ability of the department to maintain communication during disaster events, which will help keep the transportation system operational.
- **Determine alternative routes for emergency closures.** This is particularly important for critical routes, such as Interstates and heavy freight corridors. Efforts such as the flood resiliency analysis may help in prioritizing emergency routing locations.
- **Incorporate resiliency and climate change into the planning and design of roadways, roadsides, and vertical infrastructure.** This is a particularly important strategy for improving resiliency in the context of asset management. Efforts to incorporate resiliency and extreme weather considerations into pavement and bridge life cycle planning are discussed in Chapter 3.

Flood Resiliency Analysis

A recent example of incorporating resilience and extreme weather considerations into the highway planning process is the flood resiliency analysis, which assessed the Primary Highway System in terms of its robustness and redundancy against flooding. The analysis focused on screening the system to identify locations vulnerable to a 100-year flood event. The analysis was comprised of three broad components under which seven individual factors were considered, with the outcome of a composite metric to assess highways' vulnerability to flooding.

- **Robustness component**: analyzes the vulnerability of the highway network to a 100-year flood event based on the 100-year floodplain boundary, whether past flooding events have occurred, and roadway shoulder data to estimate how sensitive a specific location may be to flooding.
    - 100-year flood exposure and bridge scour (45 percent)
    - Evaluation of past flood events (15 percent)
    - Roadway resistance (10 percent)
- **Redundancy component**: reviews the extent of alternative routes that can be employed in the event that elements of the system lose function.
    - System availability (20 percent)
- **Criticality component**: identifies the most operationally important assets within the system.
    - Federal functional classification (4 percent)
    - Annual average daily truck traffic (4 percent)
    - Social vulnerability index (2 percent)

The data for each attribute were normalized on a one (worst) to ten (best) scale, then combined based on the weight factor for each attribute. This weighting was determined by the RWG. The maximum composite score is 100; higher scores indicate greater resiliency towards a 100-year flood event, whereas lower scores indicate greater vulnerability to those events.

Figures 5.3 and 5.4 show the results of the flood resiliency analysis. For analysis purposes, the Primary Highway System was divided into 464 planning corridors. The overall distribution of corridor-level composite ratings ranged from 36.6 to 93.4, with a corridor-level average of 82.4. To identify corridors of most concern from a planning standpoint, corridors that had a composite score that was one or more standard deviation below the statewide average were identified. There are 72 such corridors which have a composite score of 75.1 or less and are highlighted on Figures 5.3 and 5.4. The majority of these corridors are on the NHS.

The analysis helps identify corridors where there is a greater risk of flood events and where strategies related to preparedness for possible flooding events and infrastructure improvements to enhance the resiliency of the system may be most beneficial. This helps Iowa DOT manage its assets more effectively by potentially mitigating impacts before they occur through enhanced design and construction activities, and through being prepared to respond by having emergency communication protocols and proactive traffic detour planning in place for vulnerable locations.

Figure 5.3: Flood resiliency analysis composite scores and corridors targeted for resiliency improvements – statewide view

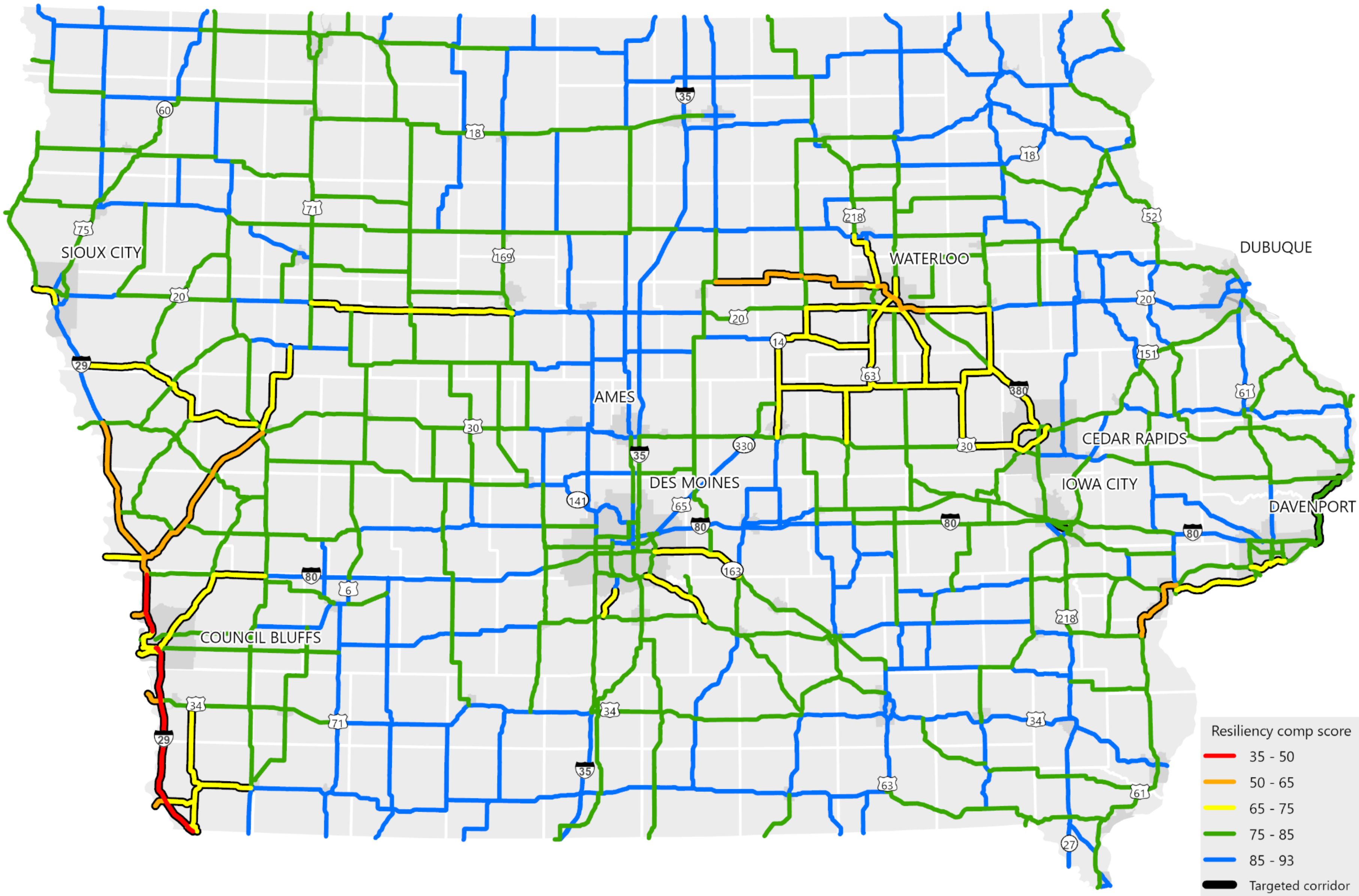
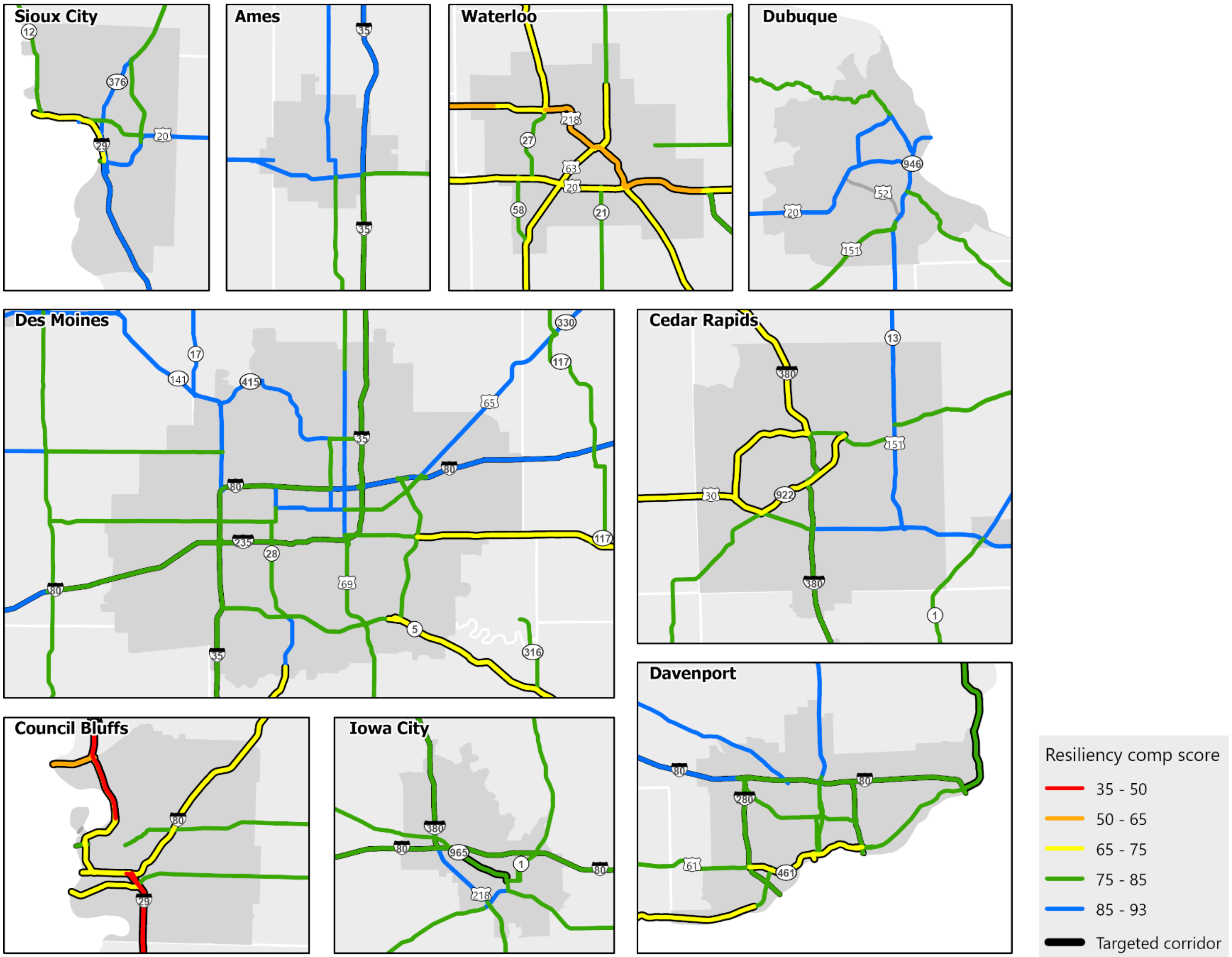


Figure 5.4: Flood resiliency analysis composite scores and corridors targeted for resiliency improvements – urban insets



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6. FINANCIAL PLAN AND INVESTMENT STRATEGIES

The financial plan presents the funding picture at Iowa DOT, identifies revenues needed to maintain asset conditions today and into the future, and identifies any gaps between funding needed to meet condition targets and funding available. Investment strategies for pavements and bridges are informed by the life cycle planning, performance gap analysis, and risk considerations discussed in prior chapters, with the goal of maximizing return on investment and making progress towards state and national goals and targets.

Introduction

This chapter details Iowa DOT's TAM investment strategy development process and presents the financial plan resulting from this process. The process utilizes the pavement and bridge life cycle plans developed as described in Chapter 3, as well as the predicted pavement and bridge conditions for the investment scenarios detailed in Chapter 4. The process also incorporates considerations of risk, including resilience and extreme weather, as discussed in Chapter 5. The financial plan shows Iowa DOT's planned and estimated available funds for TAM and anticipated expenditures by asset class over the 10-year period of the TAMP resulting from the selected investment strategies. This chapter also provides a summary of asset valuation for Iowa's Primary Highway System and National Highway System (NHS) pavements and bridges.

Federal Requirements

FHWA requires that states include investment strategies as part of their TAMP. FHWA defines investment strategies as "a set of strategies that results from evaluating various levels of funding to achieve State DOT targets for asset condition and system performance effectiveness at a minimum practicable cost while managing risks." The TAMP must discuss how the investment strategies make progress towards achieving a desired SOGR over the life cycle of the assets in the plan, improving or preserving asset condition, achieving 2-and 4-year state DOT targets for NHS asset condition and performance, and achieving national performance goals. "Desired SOGR" means the desired asset condition over the 10-year period of the TAMP.

FHWA also requires that states establish a process for developing investment strategies as part of the TAMP. The process must describe how investment strategies are influenced, at a minimum, by the following.

- Life cycle planning
- Performance gap analysis
- Risk management analysis
- Anticipated available funding and estimated cost of future work

In addition to requiring details on investment strategies, FHWA requires each state to include a financial plan that spans at least ten years and identifies funding and costs over that time in the TAMP. FHWA defines financial plan as "a long-term plan spanning 10 years or longer, presenting a State DOT's estimates of projected available financial resources and predicted expenditures in major asset categories that can be used to achieve State DOT targets for asset condition during the plan period, and highlighting how resources are expected to be allocated based on asset strategies, needs, shortfalls, and agency policies."

The plan should provide a summary of financial resources and needs for pursuing asset management objectives and achieving performance targets. FHWA also requires that states establish a process for developing a financial plan as part of the TAMP. The process must produce the items listed below.

- Estimated cost of expected future work to implement the investment strategies of the TAMP, by fiscal year and work type
- Estimated funding levels to address the costs of future work types, by fiscal year
- Identification of anticipated funding sources
- Asset valuation estimates for NHS bridge and pavement assets and the needed annual investment to maintain asset value

6.1 Investment Strategies

Investment Strategy Development Process

Iowa DOT's approach to developing its investment strategies is patterned on the guidance provided in NCHRP Report 898, A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management (2019). This guide details a 10-step process for investment strategy development. The output of the process is a high-level financial plan, supplemented with additional details on the investments in the plan and expected outcomes of implementing the plan. The following paragraphs describe the investment strategy steps, reproduced from NCHRP Report 898, and the specific activities performed by Iowa DOT at each step. This process is performed for all state-owned roads, but this document focuses on results for NHS pavement and bridges. Note that steps 4 to 7 of the process are iterative. These steps are performed at least once when evaluating alternative investment strategies, and an additional time when finalizing funding levels.

Step 1: Define Investment Scenarios

The first step of the strategy development process is to define alternative investment scenarios. NCHRP Report 898 recommends considering at least three alternative scenarios: funding estimated to be reasonably available; funding required to achieve targets; and funding required to maintain asset value. As described in Chapter 4, for its TAMP development, Iowa DOT considered numerous funding scenarios for pavements and bridges. This included a scenario reflecting expected funding and scenarios at higher and lower funding levels. As Chapter 4 highlighted, more funding is necessary than the amount currently projected to be available during the 10-year period to achieve the SOGR targets. Also discussed in Chapter 4, scenarios with lower funding levels or less optimized project selection were considered in addition to scenarios with additional funding. The less optimal scenarios help Iowa DOT consider the impact of risk on achieving its 10-year SOGR targets, as the scenarios can be used as sensitivity analyses. They serve as proxies to represent scenarios such as budgets decreasing due to less funding or increased inflation, having less funding for asset management projects due to a need to divert funding for other needs (such as emergency repairs due to natural disasters), or less effectiveness of asset management strategies leading to shorter life cycles for treatments and the need for additional work sooner than anticipated.

Step 2: Identify Current and Planned Projects

The next step in the process is to identify projects that are currently underway or that the agency has committed to perform in the near term. Ideally, the different investment scenarios should account for these ongoing and committed projects. Iowa DOT's Five-Year Program identifies committed projects. The expected funding scenario (as well as scenarios with increased funding) has been defined consistently with the program budgets levels such that the predicted budget is sufficient to fund these projects.

Step 3: Use Management Systems to Predict Future Conditions

The agency next uses its pavement and bridge management systems to predict future conditions for the different investment scenarios. As described in Chapter 3, Iowa DOT uses dTIMS and IPST to predict future conditions for pavement and the NBI Optimizer to predict future conditions for bridges. These systems are designed to follow Iowa DOT's life cycle strategies, subject to budget constraints. Chapter 3 further details the modeling assumptions in each system and how Iowa DOT uses each system to determine the conditions that will result from a specified level of funding.

Step 4: Perform Initial Budget Allocation

In this step, the overall budget level identified for the investment scenario is allocated between assets and specific uses. In Iowa DOT's case, this initial allocation is performed within the management systems following the life cycle strategies described in Chapter 3.

Step 5: Identify Candidate Projects

Next, it is necessary to determine what work may potentially be performed, given current and predicted future asset conditions. As in the case of Step 4, this step is initially performed within Iowa DOT's management systems using the life cycle strategies described in Chapter 3. Once funding levels are finalized in Step 8, Iowa DOT revisits this step to determine potential projects to add to the next year of its Five-Year Program.

Step 6: Select Projects

NCHRP Report 898 describes that different approaches may be used in this step to determine what projects to perform for each investment scenario. The selection of projects incorporates consideration of risk, performance gaps, and the agency's life cycle strategies. These strategies help achieve and maintain assets in a SOGR at minimum life cycle costs. In Iowa DOT's case, the management systems initially simulate the selection of projects for each scenario as part of the simulation process as described in Chapter 3. Once funding levels are finalized in Step 8 through review of the management system results, Iowa DOT revisits this step to select potential projects to add to the next year of its Five-Year Program.

Step 7: Revise Prediction of Future Conditions

At this step, the agency may need to revise its predictions of future conditions if Steps 4 to 7 result in a different allocation from that assumed in developing investment scenarios. In this instance, the investments scenarios that were considered remained consistent through the process and no revisions were required.

Step 8: Finalize Funding Levels by Use

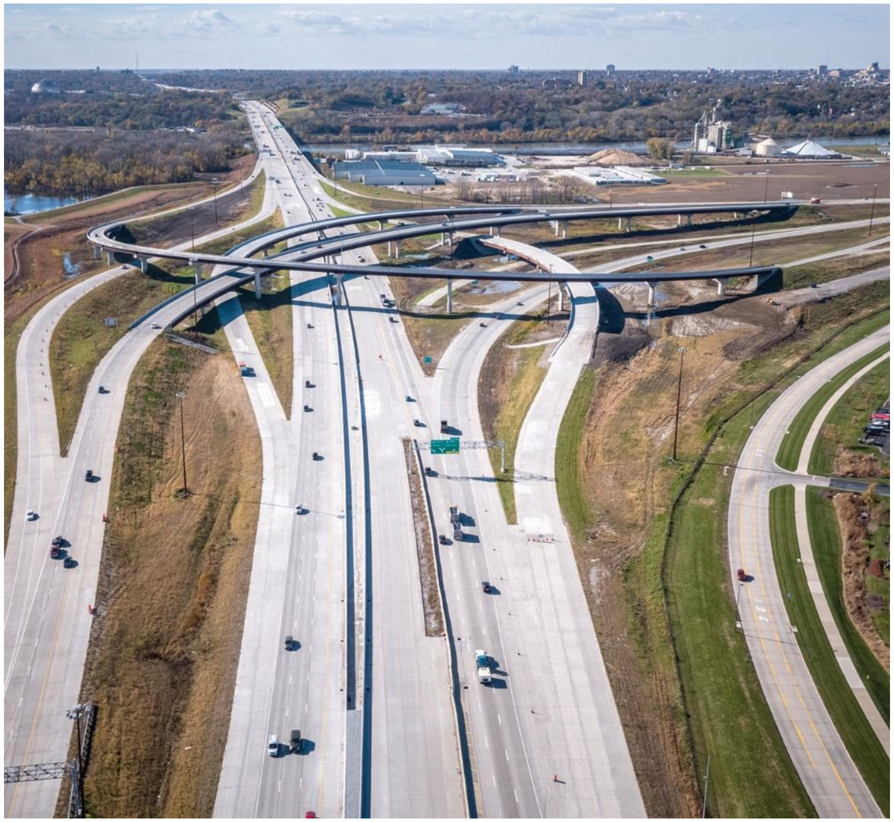
At this point, it is necessary to review the investment scenario results to determine how funds will be allocated in the TAM financial plan. For Iowa this determination is made by the Iowa Transportation Commission, as described further in the next section. Once funding levels are finalized, Iowa DOT repeats steps 4 to 7 to revise the predictions of future condition (if necessary) and determine what specific projects to add to the Five-Year Program.

Step 9: Perform Gap Assessment

Once funding levels have been finalized, it is necessary to determine the gaps between existing conditions, targeted conditions, expected future conditions, and the desired SOGR. Chapter 4 summarizes the results of the gap assessment.

Step 10: Document Assumptions and Investment Strategies

Finally, NCHRP Report 898 recommends documenting the assumptions followed as part of the investment strategy development process, and the strategies resulting from the process. This documentation has been prepared through the presentations to the Commission and this TAMP.



Finalizing the Investment Strategy

Regarding the approach to finalizing funding levels (Step 8 above), the Iowa Transportation Commission (Commission) determines how to allocate the funding available through Iowa DOT's Highway Program. The Commission establishes funding levels for the following six major investment categories.

- Stewardship categories
  - Interstate pavement and bridge
  - Non-Interstate pavement
  - Non-Interstate bridge
  - Safety-specific
- Capacity categories
  - Major Interstate
  - Non-Interstate

In recent years, the Commission has incorporated recommendations from Iowa DOT staff for the funding levels for the four stewardship categories, and then allocated the remaining funds to the two capacity categories. Iowa DOT recommendations for stewardship funding levels are based on historical funding trends, consideration of the national goals described in MAP-21, and asset management needs identified through analysis of the system. Over the past several years, program development has included a series of asset management presentations to the Commission, including one dedicated to pavements and one dedicated to bridges. During the presentations, the Commission is presented with information on the status of the system, treatment strategies, and output of the modeling systems for various funding scenarios. This cycle of asset management discussions has helped bolster the case for increasing stewardship funding for pavements and bridges.

The Commission approves the Five-Year Program in June of each year. The transportation programming process is a continuous, year-round effort. Once the Commission approves the funding for these categories, the funds are allocated to specific projects.

Investing Towards National Goals

The investment strategy development process results in a set of asset investments that supports state goals as well as the national goals defined in 23 USC 150(b). The selected strategies also help maximize progress towards achieving Iowa's SOGR, and in so doing, help minimize asset life cycle costs to the extent possible given available funding. Table 6.1 summarizes how the selected investment strategies help support the national goals.

Table 6.1: National goals and related investment strategies

National Goal	Related Investment Strategies
Safety To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.	The TAMP investment strategies support the goals and objectives of the Iowa Highway Safety Improvement Program and the Iowa Strategic Highway Safety Plan. Implementing these plans will help reduce traffic fatalities and serious injuries.
Infrastructure Condition To maintain the highway infrastructure asset system in a state of good repair.	Iowa's TAMP investment strategies are aligned with the STIP and constrained by available funding to maintain highway assets as funding permits. Implementing the TAMP investment strategies through the STIP will help maintain highway assets in a SOGR. By following the life cycle strategies described in Chapter 3, the selected strategies will help Iowa DOT minimize asset life cycle costs to the extent feasible given available funding.
Congestion Reduction To achieve a significant reduction in congestion on the NHS.	Implementing Iowa's TAMP investment strategies will enable more efficient use of available TAM resources, freeing additional resources to dedicate to making progress towards national goals related to congestion reduction.
System Reliability To improve the efficiency of the surface transportation system.	Any improvement in infrastructure condition will have secondary benefits related to system reliability. Implementing Iowa's TAMP investment strategies will also enable more efficient use of available TAM resources, freeing additional resources to dedicate to making progress towards national goals related to system reliability.
Freight Movement and Economic Vitality To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development.	Any improvement in infrastructure condition will have secondary benefits related to freight movement and economic vitality. Implementing Iowa's TAMP investment strategies will also enable more efficient use of available TAM resources, freeing additional resources to dedicate to making progress towards national goals related to freight movement and economic vitality.
Environmental Sustainability To enhance the performance of the transportation system while protecting and enhancing the natural environment.	Implementing Iowa's TAMP investment strategies will also enable more efficient use of available TAM resources, freeing additional resources to dedicate to making progress towards national goals related to environmental sustainability
Reduced Project Delivery Delays To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices.	The selected investment strategies do not specifically support this goal. However, in implementing the TAMP Iowa DOT will monitor actual expenditures and compare these with those projected in the TAMP. Supporting the investment strategies in the TAMP will require timely project delivery. Thus, actively monitoring TAMP implementation will help support minimizing delivery delays.

6.2 Funding Sources

Iowa DOT's Program Management Bureau forecasts state and federal revenue annually in preparation for the development of the Highway Program. State revenue sources have proven to be stable over time, and actual receipts typically track very closely to forecasted amounts. Iowa DOT estimates future federal funds based on existing funding identified in federal authorization bills. The current bill, the Infrastructure Investment and Jobs Act (IIJA), has provided federal funding authorization through September 30, 2026. The forecasts include the formula funding increases from the IIJA. The IIJA also includes many discretionary programs that could benefit Iowa DOT projects, but given the uncertain nature of obtaining funding through those programs, they are not added to the revenue forecasts. Longer term forecasting beyond this timeframe remains uncertain. Therefore, Iowa DOT uses a more conservative approach for forecasting funds for the outer years of the financial plan by holding them constant.

Iowa DOT's budget comes from three primary sources of funding: the Road Use Tax Fund (RUTF), the Transportation Investment Moves the Economy in the Twenty-First Century (TIME-21) fund, and federal funding.

A significant portion of Iowa DOT's funding is provided through the RUTF. The RUTF consists of revenue from annual vehicle registration fees, fees for new registration, state fuel taxes and other miscellaneous fees. These funds are allocated by law to Iowa DOT and Iowa's cities and counties according to a formula. After off-the-top allocations, 47.5% of the RUTF is distributed to the Primary Road Fund (PRF), which is dedicated to the construction and maintenance of the Primary Highway System. In 2023, Iowa DOT anticipates $747 million in funding from the RUTF will be allocated to the Primary Road Fund (PRF).

In 2008, the Iowa Legislature increased transportation funding and created a separate funding stream, titled TIME-21, by increasing registration fees for motor vehicles and trailers. This revenue is dedicated primarily to maintenance and construction of certain primary highways in the state (60 percent), but also of secondary roads (20 percent) and municipal streets (20 percent). In 2023, Iowa DOT anticipates receiving $135 million in TIME-21 funding.

Other state revenue sources include items such as reimbursements from other states for border bridge maintenance and improvements, revenue from the sale of excess right-of-way, PRF investment income, reimbursements from cities and counties, liquidated damages from contractors, reimbursements from insurance claims (e.g., bridge hits), and various other fees and income to the PRF. In 2023, Iowa DOT anticipates receiving $25 million in funding from other sources.

The Federal Government collects transportation funding and disperses it to the states through its Highway Trust Fund. The Highway Trust Fund is funded primarily by a motor fuel tax and fees charged to heavy vehicles. In 2023, Iowa DOT anticipates receiving $488 million in federal highway funding.

These funding sources are not all available for TAM. Iowa DOT has non-discretionary funding that cannot be used TAM purposes. This value is subtracted from the total available funding to calculate available TAM funding. Based on funding requirements and historical averages, Iowa DOT anticipates about 62% of this funding to be available for asset management uses. Over the 10-year period of the TAMP, funding sources are expected to total approximately $8.9B, as shown in Table 6.2. (Note that Iowa's state fiscal year runs from July 1 to the following June 30 and is numbered for the calendar year in which it ends. All years in this chapter are represented as fiscal years; for example, 2023 represents July 1, 2022 – June 30, 2023.)

Table 6.2: Summary of funding sources for TAM ($M)

Source	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Federal funds	**488**	**496**	**505**	**513**	**513**	**513**	**513**	**513**	**513**	**513**
State funds	**907**	**913**	**918**	**925**	**931**	**931**	**931**	**931**	**931**	**931**
PRF	747	753	758	765	771	771	771	771	771	771
TIME-21	135	135	135	135	135	135	135	135	135	135
Miscellaneous	25	25	25	25	25	25	25	25	25	25
Non-discretionary & line items (excluding TAM Contract Maintenance)	**-504**	**-517**	**-530**	**-543**	**-555**	**-555**	**-555**	**-555**	**-555**	**-555**
Total	**891**	**892**	**893**	**895**	**889**	**889**	**889**	**889**	**889**	**889**

6.3 Funding Uses

This section shows Iowa DOT's projected asset management expenditures over the 10-year period of the TAMP, organized by asset and work type. These expenditures draw on the funding sources described previously. These estimates were developed based on current funding, historical work type distribution, projected available funding, anticipated projects, and professional judgement. Note that in some years the projected funding uses slightly exceed funding sources; this is because Iowa DOT over-programs to account for any potential delay or suspension of projects. This helps mitigate project development risks. Table 6.3 shows a summary of funding uses for TAM.

Spending on NHS assets in Iowa is not currently tracked as a separate item. Funding estimates for NHS bridges and pavements were developed using assumptions based on work type history and the current Five-Year Program. Table 6.4 presents projected NHS TAM expenditures over the 10-year period of the TAMP. A discussion of projected performance and the funding gap to achieving a desired SOGR is included in Chapter 4.

Table 6.3: Summary of funding uses for TAM ($M)

Use	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Bridge	**199**	**252**	**221**	**243**	**339**	**252**	**252**	**252**	**252**	**252**
Maintenance	4	6	3	13	7	7	7	7	7	7
Preservation	10	3	6	3	5	5	5	5	5	5
Rehabilitation	35	53	56	43	35	45	45	45	45	45
Replacement	88	119	150	183	292	167	167	167	167	167
Construction	62	72	7	1	0	28	28	28	28	28
Pavement	**514**	**582**	**594**	**621**	**487**	**562**	**562**	**562**	**562**	**562**
Maintenance	22	17	17	17	18	18	18	18	18	18
Preservation	12	7	7	3	6	7	7	7	7	7
Rehabilitation	182	202	243	231	218	216	216	216	216	216
Replacement	169	182	148	158	183	169	169	169	169	169
Construction	130	174	178	210	63	152	152	152	152	152
Other*	**144**	**71**	**58**	**48**	**51**	**75**	**75**	**75**	**75**	**75**
Total	**857**	**905**	**873**	**912**	**877**	**889**	**889**	**889**	**889**	**889**

Other TAM spending on assets including but not limited to signs, lighting, and culverts.

Table 6.4: Summary of NHS funding uses for TAM ($M)

Use	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Bridge	**180**	**139**	**198**	**194**	**269**	**197**	**197**	**197**	**197**	**197**
Maintenance	4	6	3	12	7	6	6	6	6	6
Preservation	10	3	6	3	5	5	5	5	5	5
Rehabilitation	23	45	47	35	27	36	36	36	36	36
Replacement	81	78	137	142	231	134	134	134	134	134
Construction	62	8	7	1	0	16	16	16	16	16
Pavement	**434**	**491**	**468**	**497**	**367**	**454**	**454**	**454**	**454**	**454**
Maintenance	20	17	17	17	18	18	18	18	18	18
Preservation	8	7	7	3	6	6	6	6	6	6
Rehabilitation	114	112	151	136	117	127	127	127	127	127
Replacement	163	182	115	130	164	152	152	152	152	152
Construction	130	173	178	210	63	151	151	151	151	151
Total	**614**	**631**	**666**	**691**	**636**	**651**	**651**	**651**	**651**	**651**

6.4 Asset Valuation

FHWA requires state DOTs to include an estimate of asset value for NHS pavements and bridges in the TAMP. The financial plan process must also calculate the investment needed to maintain asset value. Iowa DOT uses a replacement value methodology to estimate asset value. The asset values are calculated by multiplying the inventory unit by the unit replacement cost. Given how Iowa DOT estimates asset value, asset values do not change as a function of asset condition. Thus, no investment is required to maintain asset value per this methodology. Asset values for Iowa DOT's bridges and pavements are included in Tables 6.5 and 6.6.

Iowa DOT estimates that it would cost more than $49 billion in current dollars to replace bridges and pavements on the Primary Highway System and more than $35.5 billion in current dollars to replace NHS bridges and pavements. Costs are routinely monitored and updated as part of the annual program development process. Cost increases have resulted in these system-level replacement costs being substantially higher than those documented in the 2019 TAMP; this cost is significant and reinforces the need for Iowa DOT to maintain its existing assets effectively in order to minimize expensive reconstruction activities.

Table 6.5: Bridge asset valuation

System	Deck Area (sq. ft.)	Unit Replacement Cost	Value
All State-owned	46,336,537	$394	$18,256,595,578
State-owned NHS	34,081,466	$362	$12,337,490,692
Other NHS	984,324	$292	$287,422,608

Table 6.6: Pavement asset valuation

System	Lane Miles	Unit Replacement Cost	Value
All State-owned	23,825	$1,300,000	$30,972,500,000
State-owned NHS	15,905	$1,400,000	$22,267,000,000
Other NHS	441	$1,400,000	$617,400,000

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7. PROCESS IMPROVEMENTS

Asset management is a process of continuous improvement. Each process used to develop the TAMP, whether it be life cycle planning or risk management, needs to be reevaluated on an ongoing basis to keep practices current. Process improvements are the stepping stones to the next iteration of the TAMP. By identifying, maintaining, and updating a list of process improvements, Iowa DOT will have a roadmap for future advances in TAM practice.

Introduction

This chapter supplements the discussion of current asset management practices in Iowa with key process improvements that will serve as a guide to enable Iowa DOT to continue maturing TAM practices. Not only must Iowa DOT update the TAMP every four years, but it is also good practice to maintain a list of process improvements. The TAMP is a living document that will evolve to reflect changing TAM practices and processes.

Federal Requirements

FHWA requires that a state DOT update its TAMP and development processes every four years. FHWA recommends that state DOTs conduct periodic self-assessments of TAM capabilities in 23 CFR 515.19(d). Based on the results of the self-assessment, the state DOT should conduct a gap analysis to determine which areas of its asset management process require improvement. In conducting a gap analysis, the state DOT should complete the following.

- Determine the level of organizational performance effort needed to achieve the objectives of asset management.
- Determine the performance gaps between the existing levels of performance effort and the needed levels of performance effort.
- Develop strategies to close the identified organizational performance gaps and define the period of time over which the gaps are to be closed.

7.1 TAM Process Improvements

Development of Initiatives

This TAMP describes Iowa DOT's existing asset management practices. With an eye toward the future, Iowa DOT conducted an asset management self-assessment and identified a series of initiatives for enhancing asset management. The self-assessment effort consisted of the following activities.

- **Step 1: Gap analysis survey.** Over 30 Iowa DOT staff members completed an online gap analysis survey based on one provided in the American Association of State Highway and Transportation Officials' (AASHTO's) Transportation Asset Management Guide, Volume I. Participants were asked to rate the degree to which Iowa DOT practices align with the state-of-the-art in asset management.
- **Step 2: In-depth interviews.** Several staff members participated in a series of face-to-face interviews. The objective of these interviews was to discuss existing practices in more detail.
- **Step 3: Self-assessment workshop.** The objective of this workshop was to discuss and prioritize the gaps and to discuss options for addressing them. The workshop was an all-day event in which senior staff discussed Iowa DOT's asset management vision and goals and identified initiatives for asset management improvement.
- **Step 4: Development of an implementation plan.** The results of the assessment are documented in an Asset Management Implementation Plan.

List of Initiatives

The following process improvement initiatives were developed as part of the TAM self-assessment effort; as noted, many have seen significant progress over the past several years.

- Implement an **asset management governance structure**. Iowa DOT has established this structure as discussed in Chapter 1; the structure will continue to be reevaluated to ensure it is effective in advancing asset management across the department.
- Develop an **asset management communications plan** that describes how Iowa DOT will communicate with key stakeholders regarding asset management. The plan, parts of which are already being implemented, will address the strengths, weaknesses, opportunities, and threats to implementing TAM. A key component of this plan has been the annual cycle of presentations to the Iowa Transportation Commission to discuss asset management, bridge and pavement needs, and planning efforts related to the Iowa Interstate Investment Plan, integrated corridor management efforts, and resiliency.
- Develop an **asset management training plan** that identifies who would benefit from asset management training and defines a training strategy for each group. The training could also include helping staff across Iowa DOT understand asset management roles and responsibilities.

- Develop **asset management procedures** for each asset class. The goal of this initiative is to advance each asset class into a mature state so that Iowa DOT can eventually incorporate all assets into its performance-based planning framework. Iowa DOT has reviewed examples from other states and initiated discussions with the TAM Technical Committee on this topic.
- Develop a **maintenance quality assurance program** to apply to the assets managed by Iowa DOT's Districts. This effort focuses on assets beyond bridges and pavements. The goal of the effort is to understand the performance of Iowa DOT's maintenance operations and relate outcomes to expenditures.
- Develop an **asset management data governance strategy** to identify the data and analytical capabilities required to support asset management practices and define an approach to meet these needs in the most efficient and effective manner. Iowa DOT has developed a Strategic Data Business Plan to lay the groundwork for how data is managed and governed across the department.
- Develop a **formal risk management process** to enable Iowa DOT to formally consider risks in investment decisions. Risk continues to be integrated into the pavement and bridge management systems; also, a workshop was held with members of the TAM governance structure to update the risk register for this TAMP.
- Develop procedures for incorporating **whole-life considerations**, including managing bridges and pavements throughout their whole life and incorporating whole-life costs into Iowa DOT's decision-making process.
- Develop a method for performing **risk-based tradeoffs** between investments in bridges and pavements in order to optimize budget allocations.

Additional Initiatives

The following process improvement initiatives were developed independent of the TAM self-assessment effort.

Project Prioritization and Scoping

An ongoing process improvement effort has included refinement of the Project Prioritization and Scoping Tool. This application includes pavement management software recommendations as well as bridge data and a host of other roadway and reference data. The current prioritization schema includes scores for safety, pavements, bridges, roadway class, traffic, and mobility that can be used to prioritize projects. The application allows users to access asset management data to assist in project decision-making. The application also includes information on other system needs and risks, such as the State Long-Range Transportation Plan (SLRTP) analysis layers discussed in Chapter 4. The tool helps make this data more readily available for project designers and decision makers.

Building from Iowa DOT's robust linear referencing system (LRS) and many Iowa DOT data sources, a new project concepting tool is also being explored. A current prototype tool helps bring together sources of data to streamline the development of certain types of project concepts, leading to more consistent and data-driven project concept statements that align with the SLRTP and TAMP.

Pavement

Iowa DOT is continuing work to configure its pavement management software program so it can better understand the relationship between funding and future conditions. As discussed in Chapter 3, Iowa DOT is also using an in-house pavement stewardship tool for planning purposes and evaluating the performance of pavement management software against this tool. As Iowa DOT continues to enhance its pavement management system, it will be able to estimate the remaining service life of its pavements and incrementally improve pavement strategies to maximize pavement investment.

Additional improvements to pavement management processes could include performing life cycle planning with longer analysis periods to provide decision-makers and the public with better information, further inclusion of traffic and/or truck volume in pavement recommendation analysis, decentralized access to pavement management data and analysis tools, and additional training for Iowa DOT staff.

Iowa DOT also continues to institutionalize its TAM governance structure relative to pavement management. While a pavement management team has been meeting regularly for the past few years to work on improvements to pavement management systems and practices, a recently completed pavement management strategic planning effort will help guide the future of pavement management at Iowa DOT. The following plan components were developed.

- **Pavement Management Strategic Plan (PMSP)**: Discusses Iowa DOT pavements, the business case for pavement management, and an overview of efforts to-date.
- **Pavement Management Programmatic Plan**: Discusses proposed organizational structure, needs and gaps, recommended actions, and an implementation schedule.
- **Pavement Management Tactical Plan**: Discusses detailed actions, tasks, responsibilities, investments, and deadlines.

Recommendations of the PMSP include the following.

- **Organization and staffing**: No Iowa DOT staff are dedicated to pavement management full time. There is an immediate need to establish a dedicated team led by a champion with the vision and authority to fully implement pavement management at Iowa DOT.
    - Work has begun on this recommendation; as this TAMP is being finalized, Iowa DOT is in the process of hiring a new supervisor who will oversee and champion the implementation of the PSMP by building a team to lead pavement management efforts into the future.
- **Policy**: The establishment of policies and procedures related to pavement management will help unify pavement management efforts across Iowa DOT and provide continuity amid staffing changes and turnover.
- **Communication/Coordination**: Improvements will provide data to decision makers and feedback to owners of the pavement management system. This coordination will enable a continual-improvement feedback loop.
- **Life Cycle Planning**: More effective life cycle planning will help Iowa DOT put its substantial data collection to work in selecting projects and developing the resurfacing, restoration, and rehabilitation (3R) program, Interstate renewal (4R), and maintenance programs (MP/MPIN).
- **Technology**: Without dedicated staff to ensure pavement management models are up to date, decisions will be suboptimal, and staff will lose confidence in pavement management recommendations. Additional staff are needed for keeping pavement management models up to date, reviewing and realigning decision trees used for treatment selection with field practice across the state, and running needed analysis scenarios to support planning and project selection.

Implementing the PMSP will support developing the organization, policies, procedures, and technology that will result in more effective pavement management at Iowa DOT, helping to fully implement a philosophy of stewardship that supports delivering the right treatment to the right pavement at the right time.

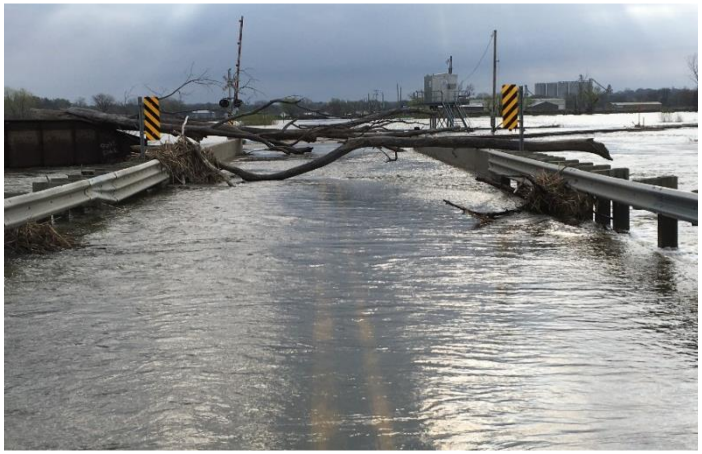
Bridge

As noted in Chapter 3, Iowa DOT currently uses an optimization and prioritization system called NBI Optimizer, developed by Infrastructure Data Solutions, but is working to develop its use of the AASHTOWare Bridge Management System (BrM) program. Once the BrM program is fully functional, deterioration modeling and project planning will be done with BrM. The BrM program incorporates element-level data and will be able to provide more detailed project types than the current NBI Optimizer software. The Bridges and Structures Bureau is partnering with the Bridge Engineering Center at InTrans to develop BrM.

The Bridges and Structures Bureau has also been part of the national pooled fund study led by Michigan DOT on major bridges. This project has developed new elements for the BrM to use with major bridges. These new elements may be incorporated into major bridge inspections if they are approved by AASHTO.

Resiliency

As discussed in Chapters 3 and 5, significant efforts are underway related to resiliency planning. This includes the creation of a Resiliency Working Group (RWG) to help lead the department's resiliency efforts; a flood resiliency analysis of the Primary Highway System that assessed the system in terms of its robustness and redundancy against flooding; work to incorporate future hydrological conditions into bridge design for critical structures, with draft design guidelines currently under review; and continued efforts to improve pavement standards with features like armored shoulders and embankment protections. Future RWG efforts include additional vulnerability assessments; implementing vulnerability or resiliency into the Five-Year Program, particularly in the context of the Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) program; improving department cybersecurity; determining alternative routes for emergency closures; and continuing to incorporate resiliency and climate change into planning and design. The RWG will continue to be a critical sounding board for the topic of resiliency and asset management.



Financial Sustainability

As bridges and pavements deteriorate, work is required to fix them. As the backlog of required work increases, the value of the assets decreases. This decrease is further impacted by inflation, which increases the cost of the required work. This loss of value can be offset by investing in the assets. Over the long term, if the investment levels keep up with the loss of value due to deterioration, then a transportation system is considered financially sustainable. If, however, the system loses value over time, it is unsustainable. Because bridge and pavement conditions are expected to deteriorate over the next ten years, Iowa DOT considers its highway system to be financially unsustainable.

Iowa DOT is working to develop a more detailed approach for assessing financial sustainability. Part of this effort is to develop an improved asset valuation approach. The goal of this effort is to better understand and communicate the long-term financial implications of the expected budget levels. One outcome of this effort would be the ability to present condition gaps in terms of dollar funding.

Iowa DOT is looking for opportunities to implement recently completed research, such as NCHRP Web-Only Document 335: A Guide to Computation and Use of System-Level Valuation of Transportation Assets (NCHRP 23-06). Iowa DOT staff participated in the development of this report, and there may be an opportunity to pilot the resulting framework. Iowa DOT has a long and rich tradition of supporting research, including research on topics related to asset management.

Cross Asset Resource Allocation

In the future, Iowa DOT plans to use bridge and pavement management systems and other resources to better link asset performance with funding levels, as well as to evaluate risk and whole-life cost. As these tools improve, Iowa DOT will be better able to inform the Iowa Transportation Commission and other stakeholders of the relationship between funding and future performance levels. In the past, Iowa DOT has used similar tools for specific asset classes but rarely in a general fashion to describe investment tradeoffs across assets and programs.

Other Improvements

Other future initiatives include the following.

- Determining the optimal steady state asset conditions
- Tracking maintenance costs
- Life cycle cost analysis for bridges
- Further exploration of the topic of TAM and equity
- Enhancements to the annual consistency report submitted to FHWA that outlines TAMP implementation and asset management investments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