IOWA | DOT

RESILIENCE IMPROVEMENT PLAN

2024

CONTENTS

1. INTRODUCTION

38 74 94 100 124

These aren't lottery numbers - these are the total number of days that various highway segments were closed to traffic during 2019 due to widespread flooding that also devastated many homes and businesses and disrupted lives throughout western Iowa.

In March 2019, rapid snowmelt and heavy rain caused widespread flooding and flash flooding events in the Missouri River basin in western Iowa. This event caused parts of Interstate 680, Interstate 29, U.S. Highway 34, Iowa Highway 2, and many local roads to go out of service for weeks or months. Some routes experienced multiple closures for flooding throughout the year as Iowa's transportation system was inundated and heavily damaged in many places along the Missouri River.

March

April

June

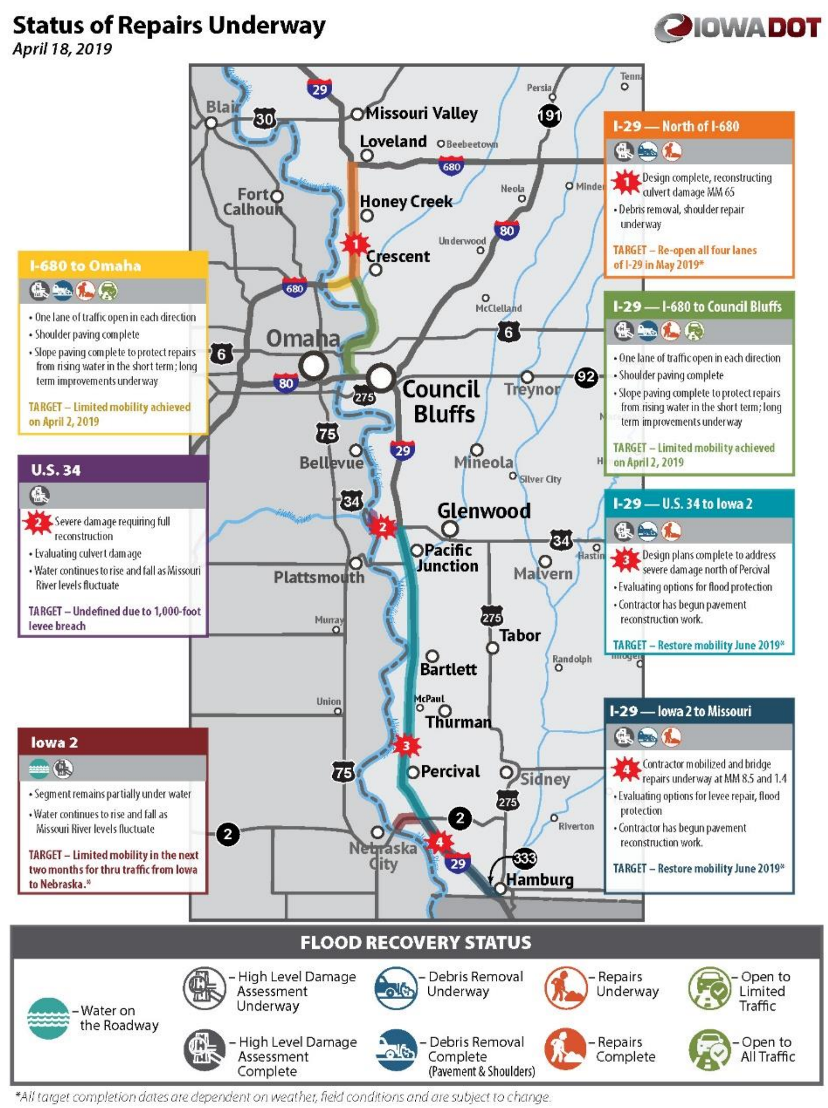
October

The Great Flood of 2019 was an extreme example of the natural hazards that Iowa's transportation system faces year in and year out. Improving system resiliency is not a new concept for the Iowa Department of Transportation (DOT) – it is a key element in its mission of stewardship for the transportation system and making lives better through transportation. As hazards threaten and countermeasures evolve, the Iowa DOT has routinely incorporated proactive and reactive resiliency measures to mitigate the impact of disasters on the transportation system.

The flooding in 2019 provides a unique case study for resiliency because it involved so many aspects of proactive and reactive mitigation strategies that are not normally applied all at the same time and place.

- **Preparedness** activities that were in place at the time of flooding included coordination agreements among agencies involved in the response to flooding and traffic incident management plans that had predetermined detour routes for specific road closures.
- **Reactive** activities that occurred throughout 2019 were numerous. Among the most critical were multiagency coordination and communication, clear communication with the public on the status of closures and repairs, and emergency work to open critical routes.
- **Mitigation** activities were undertaken during the rebuilding process, such as shoulder hardening and installation of materials to help mitigate future slope erosion due to overtopping.
- **Prevention** activities were also incorporated into major rebuilding work, such as the reconstruction of the Iowa 2 corridor in Fremont County. While temporary solutions were put into place within a few months, it was necessary 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.
    - A federal levee was relocated and two new bridges were constructed immediately adjacent to the river bridge, dubbed the “overflow bridges,” to allow floodwaters to run under Iowa 2.
    - The grade of Iowa 2 was raised four feet and four bridges were constructed to allow for water flow.
    - A protective dike was constructed around the I-29/Iowa 2 interchange to protect both the roadways and nearby businesses.

Figure 1.1: Example communication of road closures and repairs, April 2019



1.1 Why Resiliency?

The Great Flood of 2019 is just one in a long series of natural hazards that have impacted Iowa's land, people, and infrastructure. Chapter 2 details additional colloquially known disasters from Iowa's past. Lessons learned through these disasters have increased the resiliency of the transportation system and the Iowa DOT as an agency. This plan documents the integration of these resilience efforts into Iowa DOT's planning, programming, and project development process.

Iowa's extensive transportation system empowers the movement of people and goods throughout the state to reach diverse destinations. This network provides a reliable backbone for the state's economy and serves as a crossroads for economic productivity for the nation. However, this system, like all systems, is vulnerable to disruptions in the form of natural and human-induced events. When these events occur, the state's transportation system provides critical support for the initial response to the event and the phases of recovery afterwards. But what happens when a disruption impacts the transportation system? How can recovery begin when the network we rely on is taken offline? What can we do to prevent or minimize these impacts?

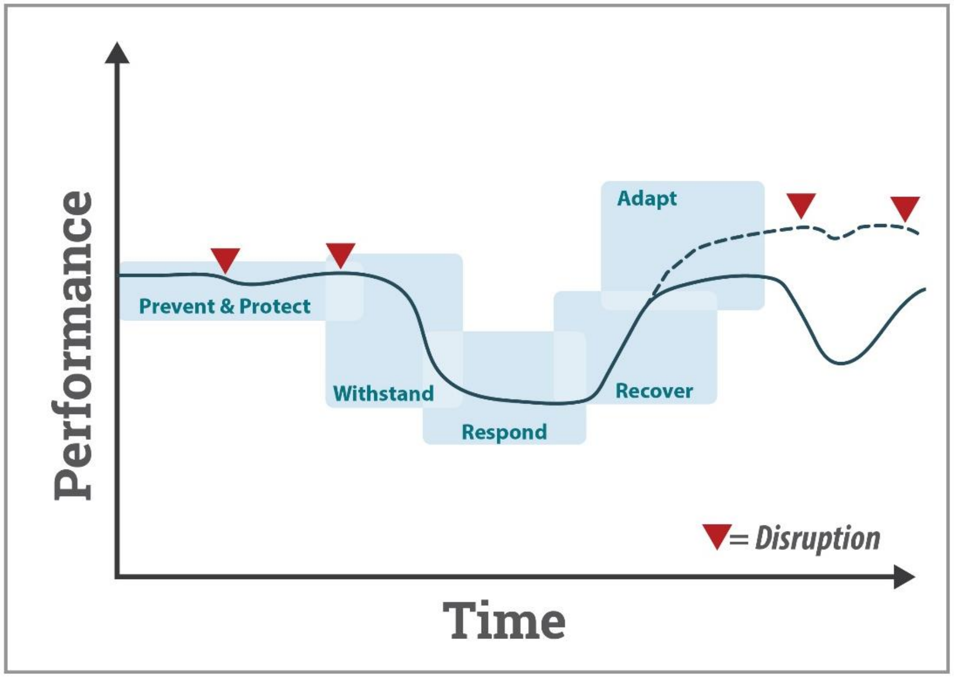
The Iowa DOT has the responsibility to not only meet the expectations of the public by ensuring the transportation system is available and in good condition, but to also ensure it will continue to be so in the future, despite pressures from aging infrastructure, fiscal constraints, and increasing natural disasters. Incorporating resiliency principles into the decision-making and project development process will further support the Iowa DOT's commitment to stewardship of the transportation system.

This chapter will introduce how the Iowa DOT defines resiliency and why it is more important than ever to consider the concept of resiliency as we plan for the future.

Defining Resiliency

The 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. Figure 1.2 provides a visual representation of the resiliency of an asset during times of disruption. Initially, an asset will withstand the impacts of a disruption until it meets a level of impact that initiates failure in performance. When failure is met, the asset's performance will degrade until proper response and recovery efforts are implemented. When recovery efforts are underway, there is typically a crucial decision point in the process – should the asset be replaced as it was, or should adaptation occur to mitigate similar disruptions in the future? In the Figure 1.2 example, adaptation of an asset occurs following disruption to the performance of the asset. This would be a reactive response to the resiliency of that asset. Ideally, improvements to increase the resiliency of an asset occur concurrently to other improvements.

Figure 1.2: Resilience of an asset over time



Although the Iowa DOT has developed a definition of resiliency, the concept of resiliency is complex. The four properties of robust, redundant, resourceful, and responsive are often used to convey the essence of what a resilient transportation system is.

Figure 1.3: The 4 Rs of resilience

Robust	The system is strong enough to withstand a given level of stress or demand without suffering degradation or loss of function.
Redundant	Elements of a system exist that are substitutable and capable of satisfying the functional requirements of the system in the case of disruption.
Resourceful	There are resources (e.g., monetary, physical, technological, and informational) available that can be leveraged in the process of recovery.
Responsive	There is capacity to meet priorities and achieve goals in a timely manner in order to minimize losses, recover functionality, and avoid future disruption.

Iowa DOT's Resiliency Efforts

Over the last few decades, Iowa has been increasingly impacted by natural disasters including historic flooding, snowstorms, tornados, and straight-line wind events. This is likely to continue as data shows trends towards increasing temperatures, precipitation, stream flows, and flooding. Additionally, awareness of human-induced disruptions has been amplified as vigilance for potential terrorism and cyberattacks has increased. These trends have prompted the Iowa DOT to bolster resiliency efforts to ensure the system is safe and reliable for users.

Resiliency Working Group (RWG)

The RWG was created in response to significant flooding in southwest Iowa in 2019 as the department coordinated and facilitated recovery efforts in response to the flooding. As flood waters receded and improvements were made, the purpose of the group transitioned from that of reactive response to proactive resiliency planning. The current mission of the RWG is to properly prepare for and reduce the impact of future disruptions to Iowa's transportation system by concentrating on how resilient improvements can be planned for, designed, and implemented to support the transportation system.

This holistic approach to resiliency at the Iowa DOT is purposeful. The RWG is intentionally a multidisciplinary group of professionals from across the department's many divisions and bureaus. Group members have diverse professional expertise including the areas of planning, engineering, operations, law enforcement, and asset management, among others. The RWG provides guidance, support, and coordination of resiliency efforts within the Iowa DOT. This includes proactive efforts to increase the system's resiliency and response efforts to get the system functioning quickly and safely after a disruption.

Sustainability Working Group (SWG)

Although the focus of this Plan is resiliency, the department's sustainability efforts work in tandem with our resiliency efforts to ensure the Iowa DOT is practicing effective stewardship with the resources of the state. The SWG was created to support and guide decision making within the department as it relates to sustainability. The concept of sustainability is multifaceted but, simply put, sustainability is the acknowledgement that resources and energy are finite. The group serves as the governance body within the department and acts as a resource for new sustainability efforts. Ongoing support from the SWG will help ensure that the Iowa DOT considers and integrates new sustainability practices as appropriate.

2021 Visioning Workshop

On November 30, 2021, the RWG and SWG participated in a Visioning Workshop. The goal of the workshop was to identify long-term and near-term goals and strategies for each group, with the outcome being several strategies for each group to focus on.

Resiliency Working Group Strategies

- Explore vulnerability assessments for various hazards for our transportation system and others.
- Employ a programmatic method for implementing vulnerability or resiliency into the Five-Year Program.
- Improve department cybersecurity.
- Determine alternative routes for emergency closures.
- Incorporate resiliency into planning and design of roadways, roadsides, and vertical infrastructure.

Sustainability Working Group Strategies

- Support workforce sustainability – attract and retain a quality workforce.
- Incorporate renewable energy and other sustainable design methods; expand alternative uses of roadsides and roadside vegetation management.
- Utilize long-life pavements and research recycled/sustainably sourced materials.
- Invest in innovation.
- Collaborate with other state agencies (within and between states).
- Promote electric and alternative-fueled vehicles.

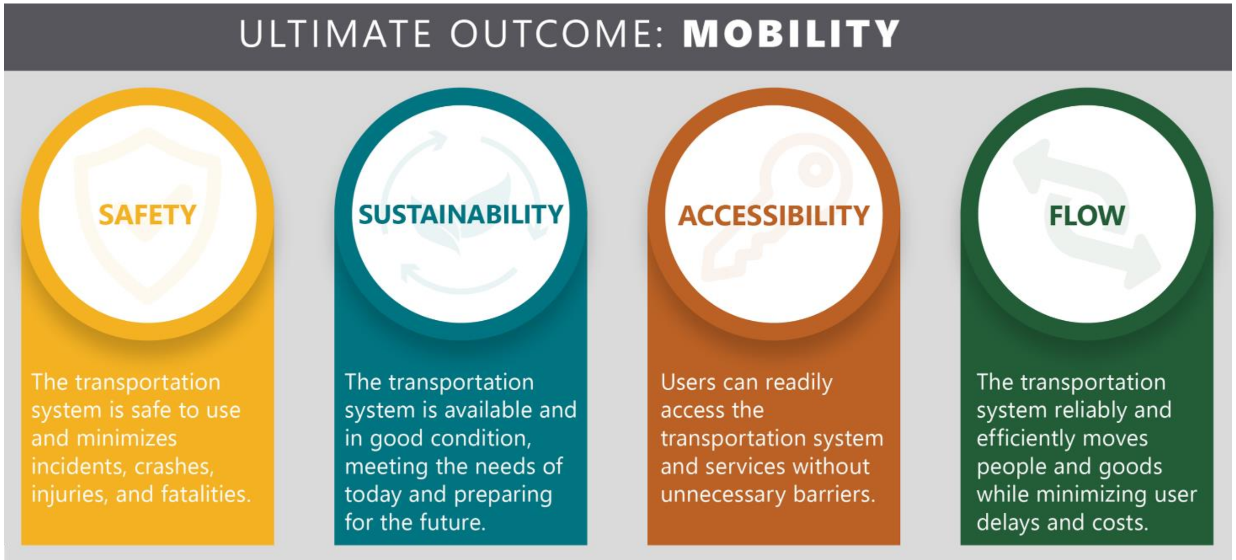
Resiliency's Role in Statewide and Long-Range Planning

While resiliency and sustainability activities have been occurring for some time, the focus has increased significantly in recent years. Safety, financial, social, and economic benefits are among the widespread and multifaceted outcomes of proactively addressing the resiliency of Iowa's transportation system. Measured and appropriate improvements can be made prior to disruptions in areas of need; these improvements to the resiliency of assets results in Iowa's roadways being safer and more reliable for the traveling public. This approach is often less costly than taking a reactive response after an event. Finally, acting before a disruption occurs means that businesses may continue to operate and have access to markets through Iowa's transportation system. Ultimately, this ensures Iowa will remain economically competitive at a regional and national level. Although near-term costs may be higher, investing in resilience can reduce long-term, life-cycle infrastructure costs by avoiding and mitigating disruptions of the future.

System Objectives

By focusing on resiliency, the Iowa DOT is supporting the ultimate purpose of the transportation system – getting people and goods where they need to go. In Iowa in Motion 2050, the State Long-Range Transportation Plan (SLRTP), this ultimate outcome of mobility is further defined through the four system objectives of safety, sustainability, accessibility, and flow. Resiliency planning aligns with and supports the system objectives identified in the SLRTP, particularly sustainability.

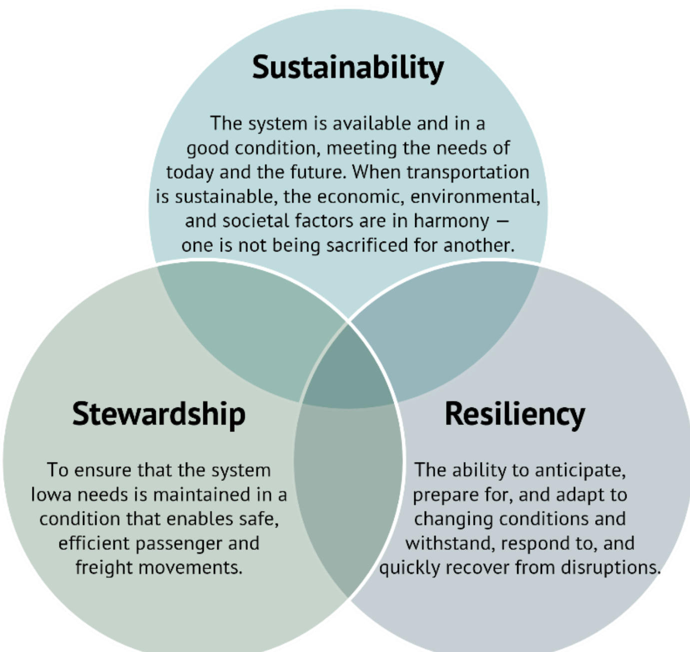
Figure 1.4: Iowa DOT System Objectives



Stewardship

The Iowa DOT views stewardship as efficient investment and prudent, responsible management of the existing transportation system. Resiliency and sustainability are building blocks of stewardship. Incorporating resiliency and sustainability principles into the decision-making and project development process will further support the Iowa DOT's commitment to stewardship of Iowa's transportation system. Being good stewards ensures that the system Iowa needs is maintained in a condition that enables safe and efficient passenger and freight movements.

Figure 1.5: Stewardship, resiliency, and sustainability definitions



Rightsizing Policy

A new Rightsizing Policy was adopted as part of the most recent update of the SLRTP to clarify Iowa DOT's definition of rightsizing and to help further formalize and institutionalize rightsizing practices. At its essence, rightsizing is about trying to make the best choices for the overall transportation system when developing individual projects. The Iowa DOT 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. To support rightsizing implementation, ten policy statements have been developed to help guide investment decisions for Iowa DOT projects, one of which focuses on resiliency.

- Project needs
- Comprehensive needs
- Stewardship priority
- Stratification of the system
- Equity
- Resiliency
- Congestion or operational issues
- Emerging technologies
- Speculative development
- New or revised interchange access

Resiliency Rightsizing Policy Statement

The department shall assess, plan for, and invest in the resiliency of the multimodal transportation system to mitigate against natural and human-made disruptions. Such activities should consider proactive and reactive measures that are proportional to existing and potential threats.

1.2 Resilience Improvement Plan (RIP) Background

On November 15th, 2021, the President signed the Infrastructure Investment and Jobs Act (IIJA) into law. The law added the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Formula Program in section 176c of Title 3, United States Code (23 U.S.C.). As part of the PROTECT program, states may develop a voluntary RIP to address transportation system resiliency. Developing a RIP can reduce a state's overall non-federal share of the cost of projects funded through the PROTECT program.

PROTECT Program

The purpose of the PROTECT program is to provide formula funding for states to address resiliency through four eligible activities.

- **Planning Activities** include developing a RIP; resilience planning, predesign, design, or the development of data tools to simulate transportation disruptions scenarios, including vulnerability assessments; technical capacity building to facilitate the ability of the state to assess the vulnerabilities of its surface transportation assets and community response strategies under current conditions and a range of potential future conditions; or evacuation planning and preparation.
- **Resilience Improvements** to improve the ability of an existing surface transportation asset to withstand one or more elements of a weather event or natural disaster, or to increase the resilience of surface transportation infrastructure from the impacts of changing conditions, such as sea level rise, flooding, wildfires, extreme weather events, and other natural disasters.
- **Community Resilience and Evacuation Route Activities** that strengthen and protect evacuation routes that are essential for providing and supporting evacuations caused by emergency events, including: resilience improvements if they will improve evacuation routes, and projects to ensure the ability of the evacuation route to provide safe passage during an evacuation and reduce the risk of damage to evacuation routes as a result of future emergency events.
- **At-Risk Coastal Infrastructure Activities** to strengthen, stabilize, harden, elevate, relocate or otherwise enhance the resilience of highway and non-rail infrastructure, including: bridges, roads, pedestrian walkways, and bicycle lanes, and associated infrastructure, such as culverts and tide gates to protect highways that are subject to, or face increased long-term future risks of, a weather event, a natural disaster, or changing conditions, including coastal flooding, coastal erosion, wave action, storm surge, or sea level rise, in order to improve transportation and public safety and to reduce costs by avoiding larger future maintenance or rebuilding costs.

RIP

A RIP is developed by a state DOT to address surface transportation system resilience to current and future weather events and natural disasters. The development of a RIP is optional, but it is encouraged as an integral part of the transportation planning process. The development of a RIP and resulting information produced to support the effort may help identify vulnerabilities, develop proposed resilience solutions, and schedule and prioritize resilience improvements to meet the needs of travelers. The RIP should be informed by asset management plans, evaluations of repeatedly damaged facilities, and state freight plans, and must be consistent with state and local hazard mitigation plans. States are also encouraged to align the development timeline with that of the SLRTP and to incorporate information from the RIP into the SLRTP.

According to (23 U.S.C. 176 (e)(2), the RIP shall:

- Be for the immediate and long-range planning activities and investments of the State with respect to resilience of the surface transportation system within the boundaries of the State, as applicable.
- Demonstrate a systemic approach to transportation system resilience and be consistent with and complementary of the State mitigation plans required under section 322 of the Stafford Act.
- Include a risk-based assessment of vulnerabilities of transportation assets and systems to current and future weather events and natural disasters, such as severe storms, flooding, drought, levee and dam failures, wildfire, rockslides, mudslides, sea level rise, extreme weather, including extreme temperatures, and earthquakes.

The development of a RIP is not required for the state to receive funding through the PROTECT Program. However, the benefit to state is an authorized reduction in the non-Federal share of the cost of a project carried out using PROTECT Formula Program funds. The non-Federal share of a project may be reduced by the following amounts, subject to the limitations and requirements detailed below. Iowa DOT has developed this RIP to meet both requirements.

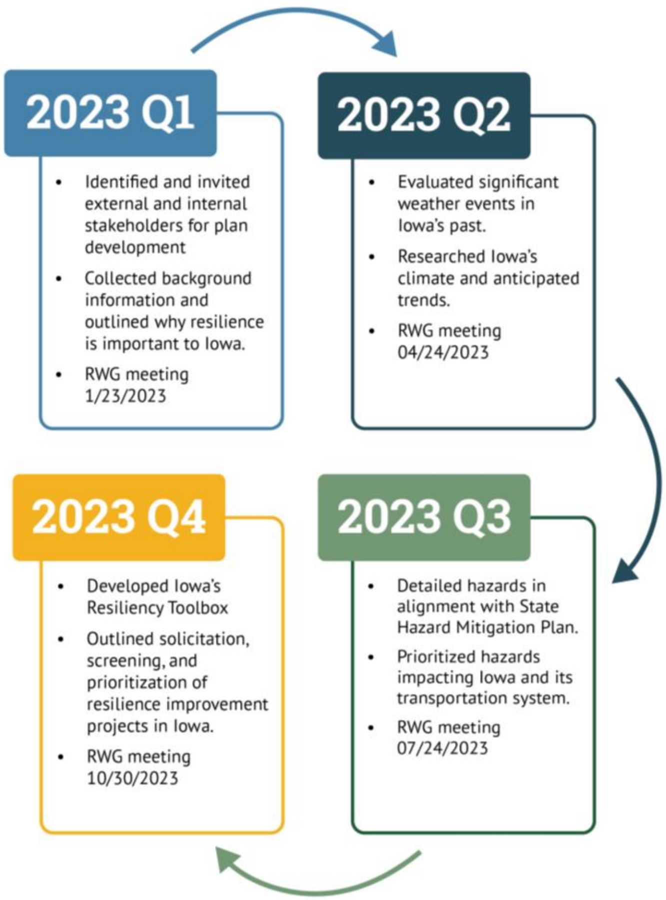
- 7 percentage points if the State has developed a RIP and prioritized the project in the RIP (23 U.S.C. 176 (e)(1)(B)(i)).
- 3 percentage points if a State RIP developed in accordance with Section 176(e) is incorporated (directly or by reference) into the metropolitan transportation plan under 23 U.S.C. 134 or the statewide long-range transportation plan under 23 U.S.C. 135, as applicable. (23 U.S.C. 176 (e)(1)(B)(ii)).

Iowa RIP Development

Timeline

Development of this plan began in January 2023 and concluded in January 2024. The plan was then approved and published in the first quarter of 2024.

Figure 1.6: RIP Development Timeline



Key Components

Key components of this plan include the following.

- **Consideration of Iowa's climate**
    - Review over time and evaluation of billon dollar natural disasters.
    - Near-term and long-term trends in Iowa's climate and weather.
- **Summary and assessment of Iowa's hazards**
    - Natural and other hazards that may impact Iowa's transportation system.
    - Risk prioritization matrix and priority hazard analysis.
- **Iowa's resiliency toolbox**
    - Identification of natural and man-made infrastructure countermeasures to mitigate hazards to Iowa's transportation system.
    - Discussion of other potential tools including policy, research, and co-beneficial improvements.
    - Identification of strategies to increase transportation resiliency in Iowa.
- **Targeted corridors and segments**
    - Listing of specific corridors and/or segments of Iowa's transportation system with a high risk for flooding or other natural disasters.

Stakeholder Input

Two groups of stakeholders were consulted during the development of this RIP. The first was the RWG, which provided input related to how the plan could best be utilized and implemented throughout the department, including the internal project development process. The second was an external group that included representatives from other state agencies and universities that provided input related to their fields of resiliency expertise. The external stakeholders included subject matter experts in climatology, hydrology, meteorology, hazard mitigation, economic development, and climate research. Specific input included hazard identification, risk prioritization, and strategy and toolbox development. Both the internal RWG and external stakeholders met on a quarterly basis during plan development.

External stakeholders that supported plan development include:

- Iowa Department of Agriculture & Land Stewardship
- Iowa Department of Homeland Security & Emergency Management
- Iowa Department of Natural Resources - GIS Analysis and Support
- Iowa Economic Development Authority - Disaster Recovery
- Iowa State University – Institute for Transportation
- Iowa State University – Department of Geological and Atmospheric Sciences
- University of Iowa – Iowa Flood Center

Coordination and Integration of Other Plans and Studies

This RIP is the Iowa DOT's primary document to support integration of resiliency into the transportation system and the planning, programming, and project development processes. In development of this Plan, a variety of other plans, reports, and studies were considered. As other plans were reviewed, consideration was given as to how the RIP could align with and be consistent with existing efforts. Many of these documents may be referenced throughout this plan; a full list and specific descriptions for many of these plans, reports, and studies is included in the Appendix.

Plans particularly critical for the RIP's development included:

- SLRTP – Iowa in Motion 2050
- Iowa Transportation Asset Management Plan
- Iowa State Freight Plan
- Iowa Drought Plan
- State Hazard Mitigation Plan

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2. UNDERSTANDING IOWA

2.1 A Blip or a New Normal?

On June 30 and July 1, 2018, a thunderstorm that was producing localized heavy rainfall stalled over parts of central Iowa. During this storm, parts of the Des Moines metropolitan area received rainfall totals of 5-10 inches. At two National Oceanic and Atmospheric Administration (NOAA) weather stations in Ankeny, weather observers recorded 24-hour precipitation totals of 7.2-8.7 inches. While that amount of rain is already extremely high for a 24-hour period, two factors combined to supercharge the impacts of this event. The first was that this event followed the 10th wettest June in Iowa, which had 50% more rain than average. The second factor was the duration and intensity of rainfall. Nearly 9 inches of rain fell in a matter of hours. In the Fourmile Creek Basin near Ankeny, over the span of 6 hours, the discharge stream flow changed from a flow of 29 cubic feet per second (ft^3/s) and a gauge height of 2.4 feet (ft) to its record peak discharge of 10,000 ft^3/s and a gauge height of 16.2 ft. This peak discharge rate lasted for nearly 2.5 hours.

Figure 2.1: Precipitation for July 1, 2018 and the discharge measured by a streamgage near Ankeny

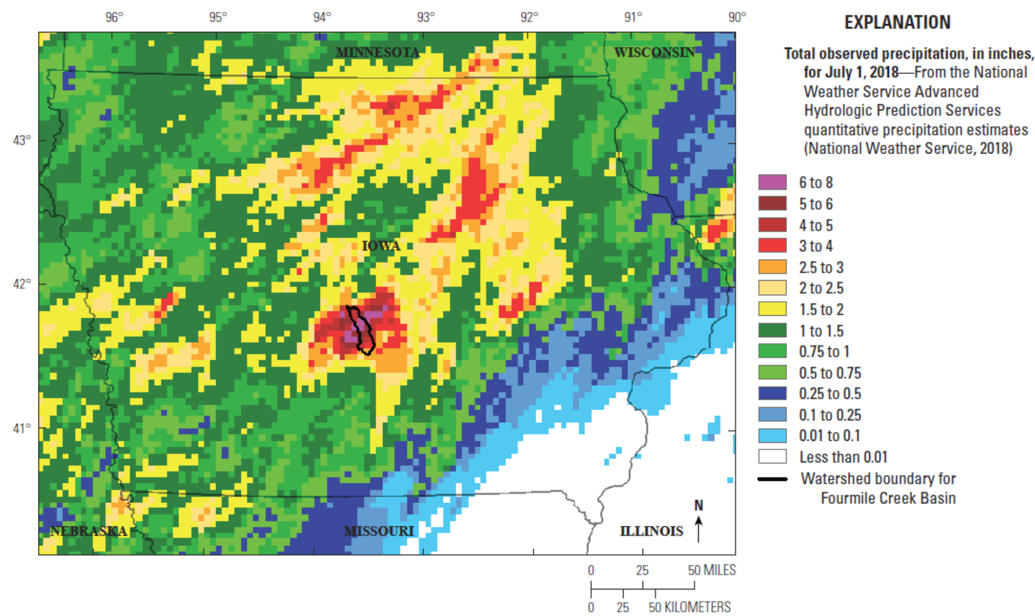
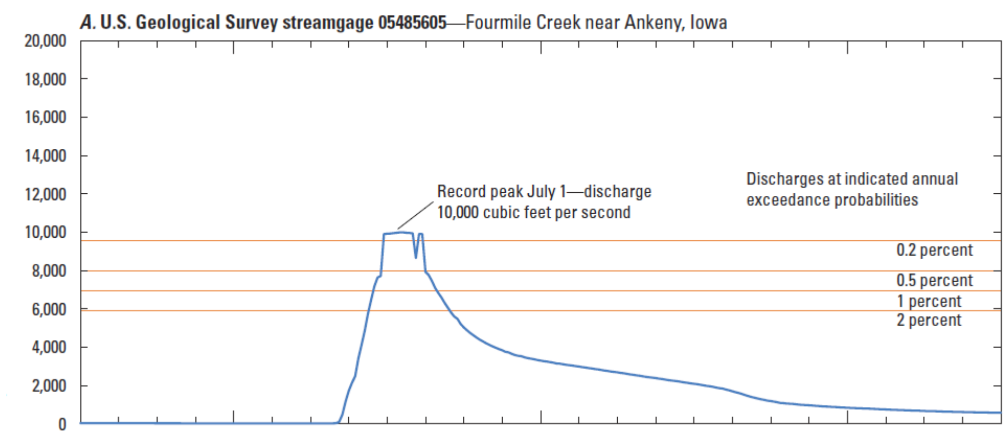


Figure 2. Advanced Hydrologic Prediction Service observed precipitation for Iowa on July 1, 2018, with an inset of the Fourmile Creek Basin watershed boundary (National Weather Service, 2018).



Source: National Weather Service

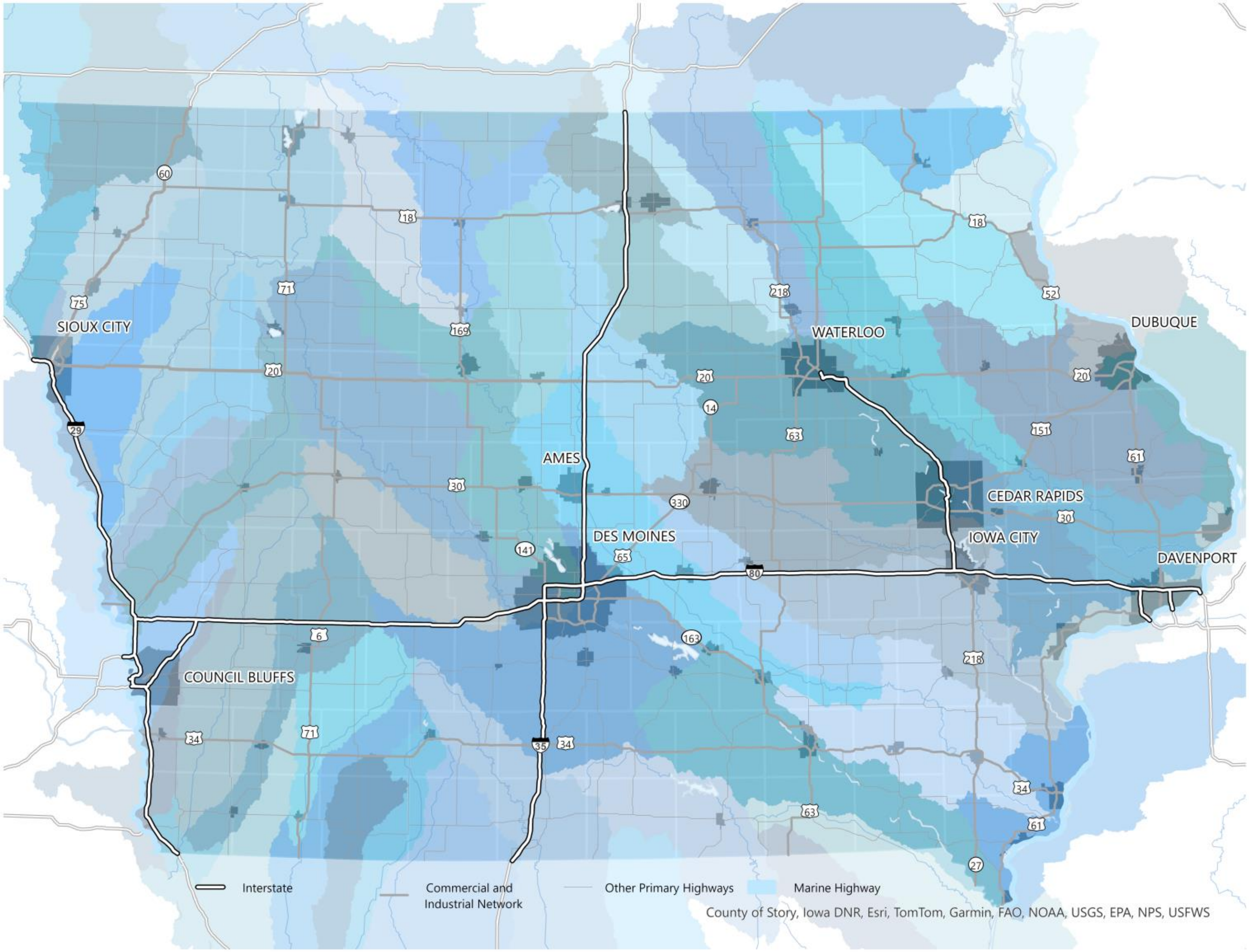
This event surpassed an annual exceedance probability (more commonly known as flood probability) of 0.2 percent, or a flood-recurrence interval of once every 500 years. Although short-lived, the event resulted in a fatality and a major disaster area being declared in Polk County and 30 other counties in Iowa. Damages in Polk County alone were estimated at over $15 million, nearly $1 million of which included damages to roadways and bridges. Extreme weather events like this have been occurring more frequently in the early 21st century. This trend in extreme weather events is not merely anecdotal or a blip, but a noticeable shift in weather, not only in Iowa, but across the globe. This chapter provides an overview of Iowa's geography and environment, the differences between weather and climate, Iowa's climate over time, and previous significant weather events that have occurred in Iowa. The chapter also provides a brief overview of Iowa's transportation system, which provides a foundation for understanding the interactions between hazards and infrastructure.

2.2 Iowa's Geography and Environment

Iowa's weather and climate is experienced through the lens of the state's topography and environment. Located in the north central portion of the country, most land within the state is rural and devoted to agricultural production. The state is bordered by the Mississippi and Missouri rivers, the nation's two longest rivers. The terrain is generally flat with rolling hills with the exception of two areas. The Driftless region in the far northeastern portion of the state is characterized by steep hills, forested ridges, deeply carved river valleys, and spring fed waterfalls and streams. In the western portion of Iowa are the Loess Hills, unique features formed from clay deposits blown eastward from the Missouri River that stretch north and south across the entire state will hilltops reaching nearly 200 feet.

Iowa has nearly 19,000 miles of interior rivers and streams, approximately 209 square miles of lakes and reservoirs, and 79 square miles of wetlands. All interior rivers in the state are part of either the Mississippi or Missouri River systems and can be subject to sudden fluctuations due to the nature of soils, intensive farming, small grain crops, and drainage. Iowa has 56 watersheds that range from 390 to 1,954 square miles in size and include 420 smaller basins. Understanding watersheds and river basins is critical for resiliency planning as infrastructure impacts from flooding are likely to be concentrated in these patterns. Woodlands can be found adjacent to the many rivers and streams and at the edge of agricultural land, as well as areas where the opportunity for agricultural production is limited by topography. There are numerous state, county, and municipal parks devoted to preserving woodland areas; the most prominent are the four major State Forests that consist of 43,917 managed acres.

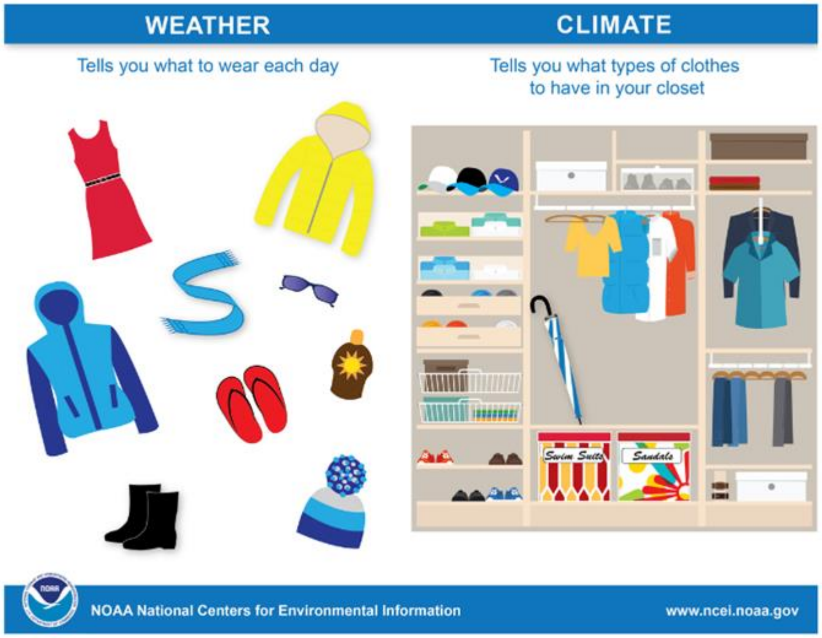
Figure 2.2: Iowa drainage basins



Weather vs. Climate

Although weather and climate are closely related, they are not the same. The U.S National Climate Assessment (NCA4) states that “weather” is a term applied to short-term, daily phenomena, while “climate” describes long-term trends related to averages and the prevalence and intensity of extremes. Weather can be described as a mix of events that happen each day in our atmosphere. These events vary in different parts of the world and can quickly change over time. Climate, on the other hand, describes what weather is like over time in a specific area or region. When describing climate for a particular location it is regularly done using long-term averages of temperature, precipitation, humidity, or wind, and often under the context of a specific season such as summer or winter. When evaluating a particular location, descriptions of an area’s climate can provide a sense of what to expect, while weather gives us the short term anticipated conditions on any given day.

Figure 2.3: Weather vs. climate



Source: NOAA National Centers for Environmental Information (NCEI)

Iowa’s Climate

All parts of the U.S. are experiencing subtle changes in in their climate, but the magnitude and impact of these changes vary from one region to the next. Iowa is located in the interior of North America and is largely exposed to incursions of bitterly cold air masses from the Arctic and warm humid air masses from the Gulf of Mexico. The state has a continental climate with hot, moist summers and cold, generally dry winters. Weather can be highly variable from season to season and year to year. With this variability comes extremes in weather events. These extreme events may become more frequent for Iowa as observational data collected over several decades show trends of increasing temperature and precipitation.

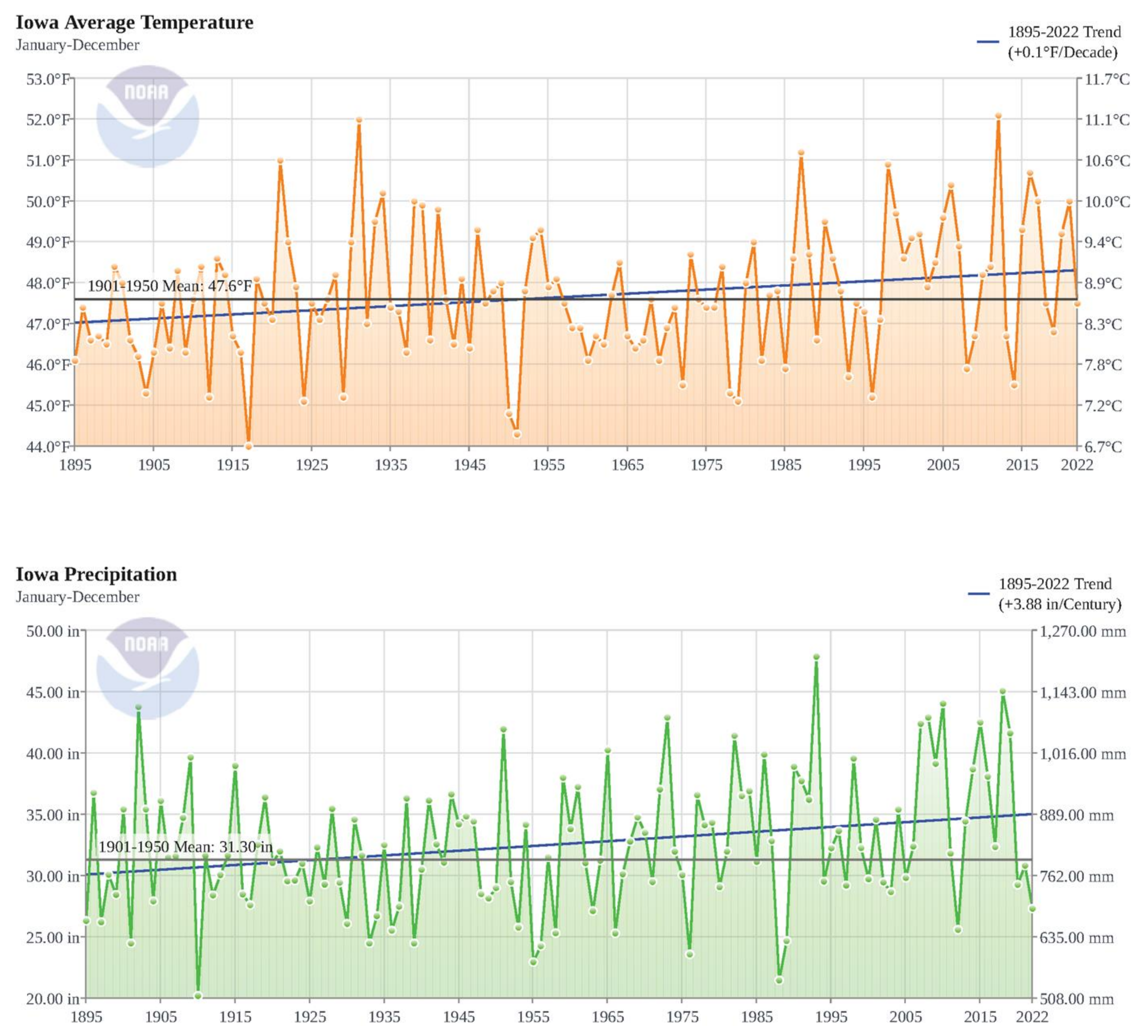
Temperature

Average temperatures in Iowa have risen more than 1 degree Fahrenheit (° F) since the beginning of the 20th century to 47.7° F. The hottest year on record was 2012, with an average of 52.1° F. Averages only portray part of the story, as the nuance to temperature trends is when specifically these increases are occurring throughout the day and year. The increasing trend is mostly attributed to increases in nighttime minimum temperatures. From a seasonal perspective, warming temperatures have been more concentrated during Iowa's fall and winter seasons.

Precipitation

Precipitation in Iowa can be highly variable, with southeastern portions of the state generally receiving more than northwestern portions. Most precipitation that falls in Iowa does so in the summer, which averages about 14 inches of rain per year for the central part of the state. In general, average precipitation has been increasing, with springtime precipitation being above average since 1990 and annual and summertime precipitation being above average since 2005. One notable trend has been the seasonality of precipitation, as much of it occurs in the first half of the year, leading to wetter springs and drier autumns. Similarly, Iowa has been experiencing more intense rainfall, with the frequency of 2-inch extreme precipitation events increasing over the last few decades.

Figure 2.4: Iowa annual average temperature and precipitation, 1895-2022



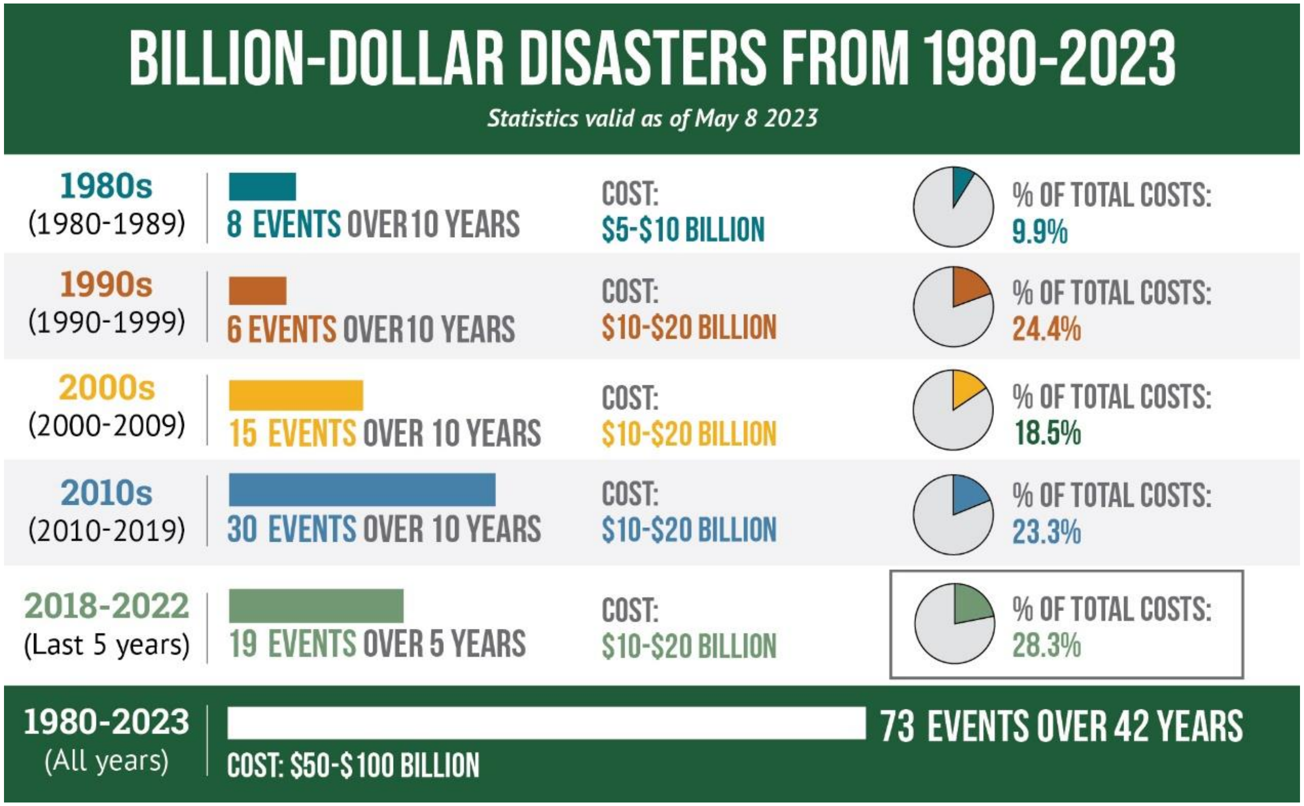
Source: National Oceanic and Atmospheric Administration (NOAA)

Significant Weather Events

With the increasing trends in warmer temperatures and precipitation in Iowa, there has also been an increase in the frequency, severity, and cost of weather events. The National Centers for Environmental Information (NCEI) tracks the nation's severe weather and climate events. As part of this responsibility, NCEI evaluates weather events that have great economic and societal impacts, including those that exceed $1 billion in cost. Figures 2.5 and 2.6 provide a comparison of the billion-dollar events that have occurred in Iowa by each decade since 1980 (the earliest year available).

Since 1980 Iowa has had 73 events with an estimated Consumer Price Index (CPI) adjusted cost exceeding $1 billion. From 1980 to 2023, Iowa has averaged just under two of these events per year. However, the frequency has increased as Iowa has averaged over three billion-dollar events per year since 2010. Over 28% of the total costs of natural disaster events since 1980 have occurred within the last 5 years.

Figure 2.5: Major disasters in Iowa since 1980 by time period



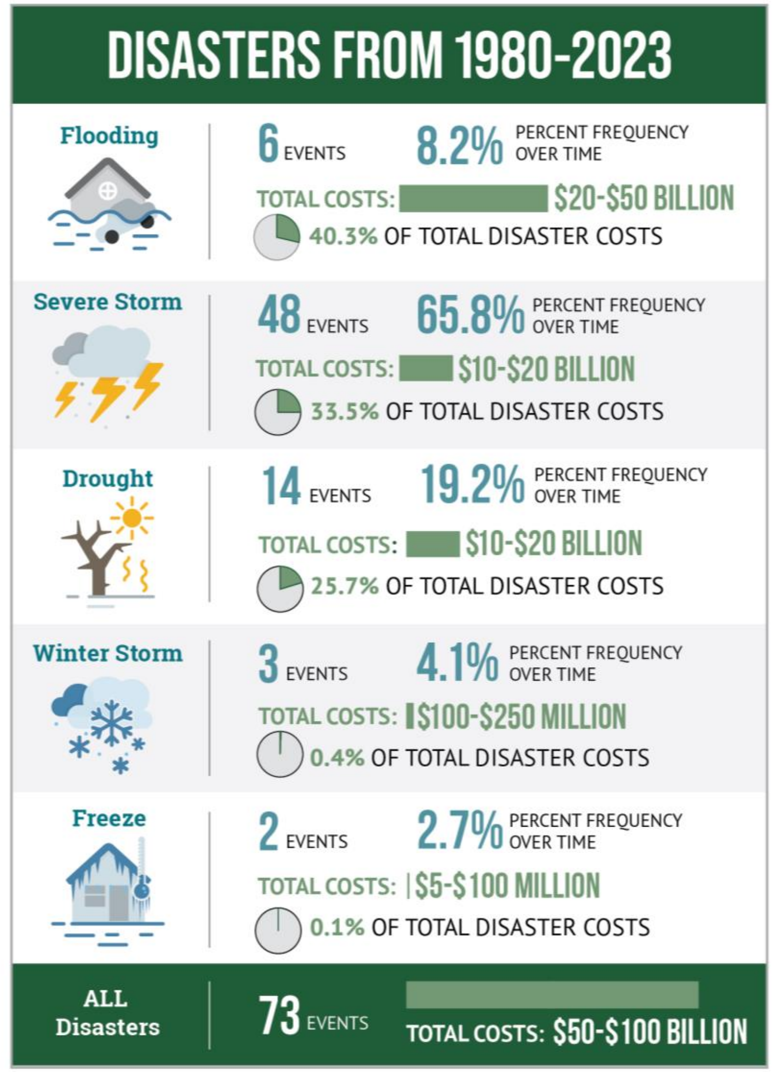
Source: NOAA NCEI

Escalating frequency and costs

The last five years have seen over 26% of the occurrences and over 28% of the costs of natural disaster events that have happened since 1980.

The most frequent types of disasters impacting Iowa since 1980 are severe storms, which occurred 48 times. Although flooding events occur quite frequently in Iowa, only six have exceeded the billion-dollar threshold. Despite the low count, flooding has still been the costliest of these disasters, representing just over 40% of the total cost of all billion-dollar events in the state during this timeframe.

Figure 2.6: Major disasters in Iowa since 1980 by type



Source: NOAA NCEI

Some recent significant weather events are all too familiar to residents in Iowa, and are often referred to in shorthand with names like “The Great Flood of 1993”. What makes a particular event memorable or significant comes from a combination of factors, including cost to the state and its residents, duration of the event, and the geographic extent. The following significant weather events are some of the more well-known and costly in Iowa’s recent history.

The Great Flood of 1993

From April through October, Iowa and much of the Midwest was devastated by flooding of both the Mississippi and Missouri rivers and their respective tributaries. There were numerous factors that contributed to the flooding, including above normal soil moisture, persistent precipitation, and snowfall. The flood resulted in over 50 deaths (in Iowa and other states) and damages approached $15 billon ($44.4B CPI adjusted). Over the course of this event, flood waters receded and returned as many as five times in some locations before the disaster was officially over.

Parkersburg Tornado, 2008

On May 25th, a strong supercell developed in northeast Iowa and resulted in one of the strongest tornados in the state’s history. After touching down just south of Aplington, the tornado eventually traveled east towards Parkersburg and became extremely violent, intensifying to EF5 strength. As the tornado continued, it leveled much of the town of Parkersburg and the neighboring town of New Hartford. Nine individuals lost their lives and over 70 were injured. The tornado resulted in an estimated $75 million in damages.

Iowa Flood of 2008

In June, a major flood event impacted most of the rivers and tributaries in eastern Iowa. The most significant flooding occurred in the Cedar Rapids and Iowa City areas. Flooding records in many locations were greatly surpassed, including in Cedar Rapids where the flood waters crested at 31.1 feet on June 13th. This flood event is one of the costliest flooding events in Iowa’s history with estimated damages of over $6 billion.

Blizzard of 2009

On December 8th and 9th, a long-lived storm system brought heavy amounts of snow and blizzard conditions to Iowa. Snow totals measured between 8-15 inches and all 99 counties were under a blizzard warning. Drifting snow caused many roadways to be impassable and residents across the state were unable to access vehicles and homes. This was the first of many storms that impacted the state during the winter of 2009-2010.

Missouri River Flood, 2011

Record snowfall in the Rocky Mountains of Montana and Wyoming and near-record spring rainfall contributed to trigger significant flooding along the Missouri River.

Drought of 2012

Much of the Great Plains, including Iowa, suffered through an intense but relatively short-lived drought characterized by both a lack of precipitation and excessive heat, particularly in the month of July. Some locations in Northwest Iowa recorded the second driest summer on record.

The Great Flood of 2019

In March, a major flood impacted the Missouri River and its tributaries in Nebraska, Missouri, South Dakota, Iowa, and Kansas. The duration lasted well into the fall as multiple rounds of flooding damaged areas repeatedly. At least one million acres of farmland in nine states were flooded. The event resulted in an estimated $1.6 billion in property damage in Iowa alone.

Midwest Derecho, 2020

On August 11th, a powerful derecho (a widespread, long-lived, straight-line windstorm) impacted large swaths of the Midwest, primarily in Nebraska, Iowa, Illinois, Wisconsin, and Indiana. The highest winds were measured in Iowa at nearly 126 mph. The derecho caused over $11 billion in damages.

Winterset Tornado, 2022

A significant early spring tornado outbreak occurred during the afternoon and evening hours of March 5th. One of the largest of these was an EF 4 tornado that caused damage near the towns of Winterset and Norwalk, resulting in six fatalities.

What Do These Trends Mean?

The observational trends of increasing temperature and precipitation along with the increasing number of costly and significant weather events establish a pattern of changes in Iowa's weather and climate. Assuming these trends continue, conditions in Iowa will gradually evolve over time to include more extreme weather events and highly variable weather patterns. In projecting these changes, scientists often refer to trajectory models of greenhouse gas (GHG) emissions called representative concentration pathways (RCP). The NCA4 analyzes the effects of two scenarios: one in which GHG concentrations continue to rise and temperatures rise by 5.8 to 9.7°F by the end of the century (known as RCP 8.5), and one in which GHG concentrations are significantly reduced by midcentury and warming is limited to 3.1 to 5.8°F at the end of the century (known as RCP4.5). NCA4 suggests that a lower GHG concentration scenario (e.g., RCP 1.9 or 2.6) would require significant and immediate reductions in carbon and methane concentrations. The lower end of this range still carries with it the effects already seen, but likely more severe. The higher end of this range could lead to a series of catastrophes. We will not likely see either extreme, but rather somewhere in the middle – an intermediate or mid-high GHG concentration scenario, such as RCP 4.5 or 6.0, respectively. Still, a mid-range temperature increase would result in a very different world than what existed in the 20th century, including more frequent and intense natural disasters and fragile, fluctuating ecosystems and agriculture.

The shifts in Iowa's climate and weather will occur gradually and compound over time. Some years may see variability and extremes in the weather, while other years may seem more average or mild. Over time, these changes will have wide-ranging impacts to the various sectors within Iowa, including transportation. The most direct impact to transportation will be in the form of hazards to the system. The trends in Iowa's weather and climate point to increased variability and more significant impacts from these hazards.

2000 vs. 2100

A mid-range temperature increase by the end of the 21st century would result in a very different world than what existed in the 20th century, including more frequent and intense natural disasters and fragile, fluctuating ecosystems and agriculture.

Table 2.2: Projected changes in Iowa's weather and climate

Near-term: Next 20-30 years	Long-term: By 2100
Annual average temperatures at least 2.4F higher compared to the first half of the 20th century, according to NOAA.	Trend continues.
Increased heat waves. • Most of Iowa is projected to see about one extra month per year of daily high temperatures above 90° F than was observed from 1961 to 1990, according to the U.S. Climate Resilience Toolkit.	More extreme heat waves. • Most of Iowa is projected to see about six weeks more per year above 90° F than was observed from 1961 to 1990, according to the U.S. Climate Resilience Toolkit. In some areas, there may be nearly four months of these hot days. • Iowa is projected to see at least a tenfold increase in days per year above 100° F than was observed from 1961 to 1990. With higher GHG concentrations, the increase in some counties may be closer to a hundredfold, with some seeing several weeks over 100° F per year. • Decreased yields due to heat stress despite higher CO_2, according to NCA4.
Increased humidity. • Leads to increased spring rainfall, soil erosion, and fewer days suitable for fieldwork during planting season.	Trend continues.
Lower air quality. • Warmer temperatures lead to higher surface-level ozone. NCA4 notes that higher ozone levels could lead to 200 to 550 more premature deaths annually across the Midwest by 2050. Livestock are also vulnerable to higher ozone levels.	Trend continues.
Frost-free seasons increasing by up to 10 days by 2045 and 20 days by 2065 compared to the period of 1976-2005, according to NCA4 (these numbers are projections under the RCP 8.5 scenario).	Frost-free seasons increasing by 30 days compared to the period of 1976-2005, according to NCA4.
Increased heavy precipitation and flooding events.	Increases in precipitation are projected for Iowa, most likely during the winter and spring.
Increased drought. • With warmer air, the atmosphere pulls more moisture from plants, leading to increased tree mortality and stressed crops. • Decreased corn yields due to heat stress, despite longer growing season and higher CO_2. • Decreased snowpack and early spring melts may lead to lower stream flows at times (combined with high heat will drive demand for water).	Trend continues.

2.3 Iowa's Transportation System, Resources, and People

To understand how the weather and climate trends are likely to impact transportation in Iowa, it is important to provide some context for the transportation system, important facilities and resources, and Iowa's population.

Transportation System

Iowa has an extensive highway system complemented by a vast secondary (county) and municipal (city) roadway network. Among the 50 states, Iowa ranks fifth in rural roadway miles. In addition to this expansive roadway system, other transportation options include the following. Full inventories of these modes are available in the SLRTP.

- A variety of **bicycle and pedestrian accommodations** such as multiuse trails, side paths, sidewalks, and on-road bicycle accommodations
- **Public transit** service availability in all 99 counties
- **Passenger transportation options** such as intercity bus service, paid rideshare, and other shared transportation options
- **Freight and passenger rail** service
- Commercial, general, and freight **aviation** service
- Mississippi and Missouri **waterway systems**

The state's roadway system is the predominant mode of transportation for both passenger and freight traffic. A little over 60% of total Vehicle Miles Traveled (VMT) and over 90% of large truck VMT occurs on the Primary Highway System, owned by the Iowa DOT. Most Primary Highway System traffic occurs on the National Highway System (NHS), which includes Interstates, Iowa's Commercial and Industrial Network, and other key highways for traveling across the state.

The state's highway system provides the backbone for the overall transportation system. It is a mature and extremely accessible network that provides a high level of mobility throughout the state. While there are locations that can experience bottlenecks or congestion, the vast majority of the highway system operates smoothly. Highways are typically the focus for resiliency planning given their critical role in facilitating most transportation throughout the state. However, the other modes of transportation are also key considerations, both in terms of their resiliency to hazards and the role they play in helping to move people and goods in times of crisis. Access to Iowa's diverse range of modal options is critical during times of disruptions.

Getting from A to B

Almost the entirety of the state's land area is **within ten miles** of an Iowa DOT highway. The system's criticality in traveling throughout the state reinforces the importance of increasing its resilience.

Figure 2.7: Iowa DOT highways

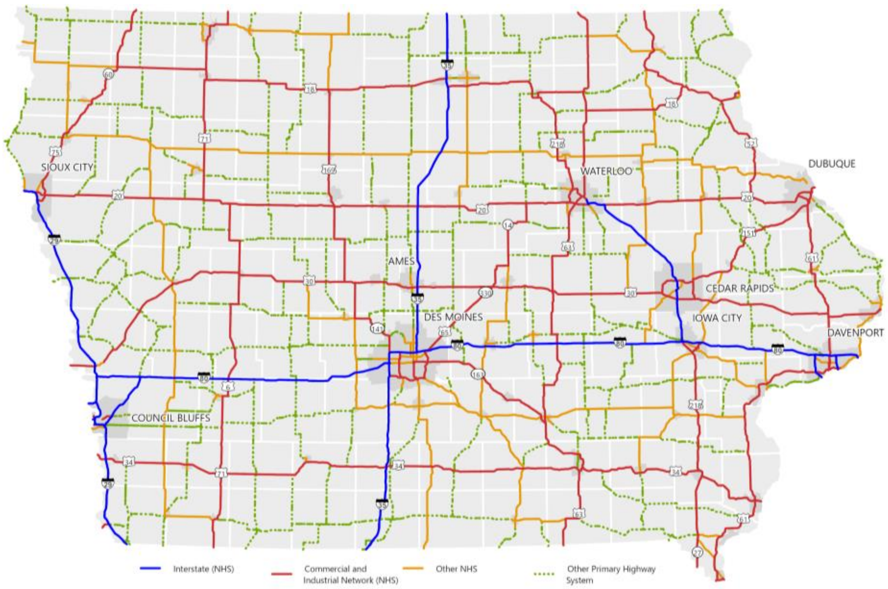
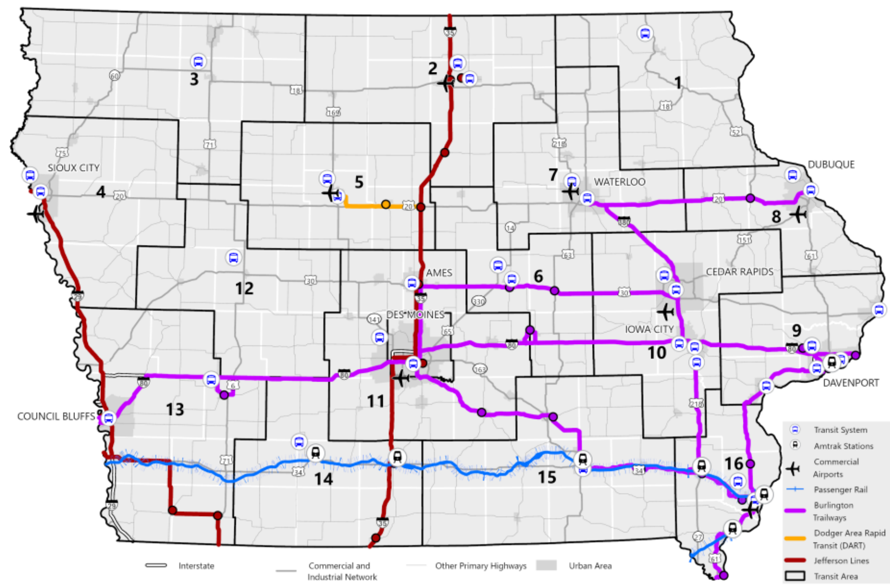


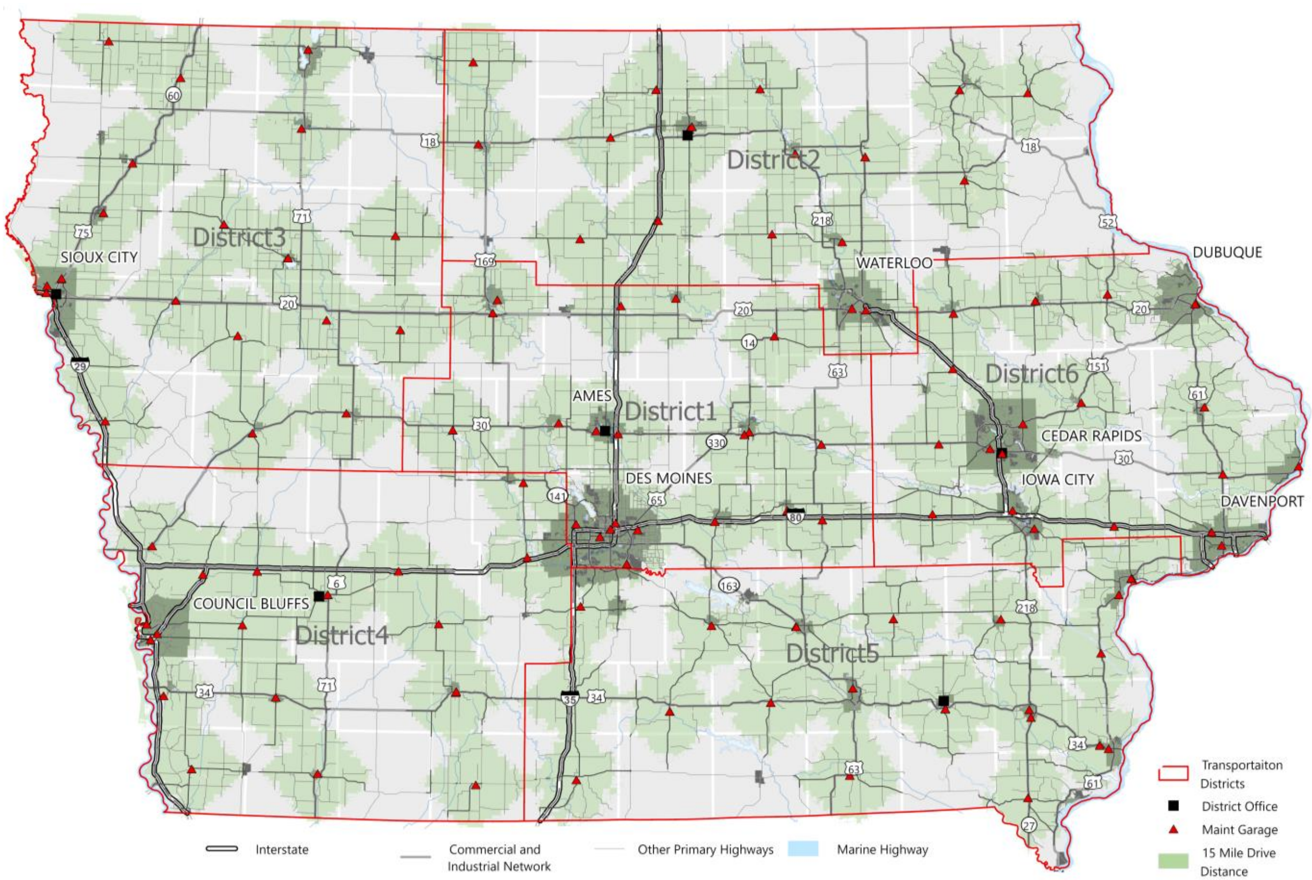
Figure 2.8: Iowa's passenger transportation connections



Iowa DOT Facilities and Resources

With such a vast transportation system, an equally vast system of facilities and resources are needed to support and maintain that system. The Iowa DOT provides statewide oversight with its central office located in Ames and six district offices throughout the state. Within each district a network of offices and garages provide stewardship of the transportation system within their region. Figure 2.9 shows how much of Iowa's primary network is within 15 miles from these facilities. When a disruption to Iowa's transportation system occurs, the Iowa DOT has significant resources that can be leveraged to address the situation. This includes physical equipment such as snow removal trucks, motor graders, endloaders, and tow plows. Or this could include materials like rock salt, liquid salt brine, or sand. The Iowa DOT also has significant staff resources with over 2,800 permanent full-time staff within the department.

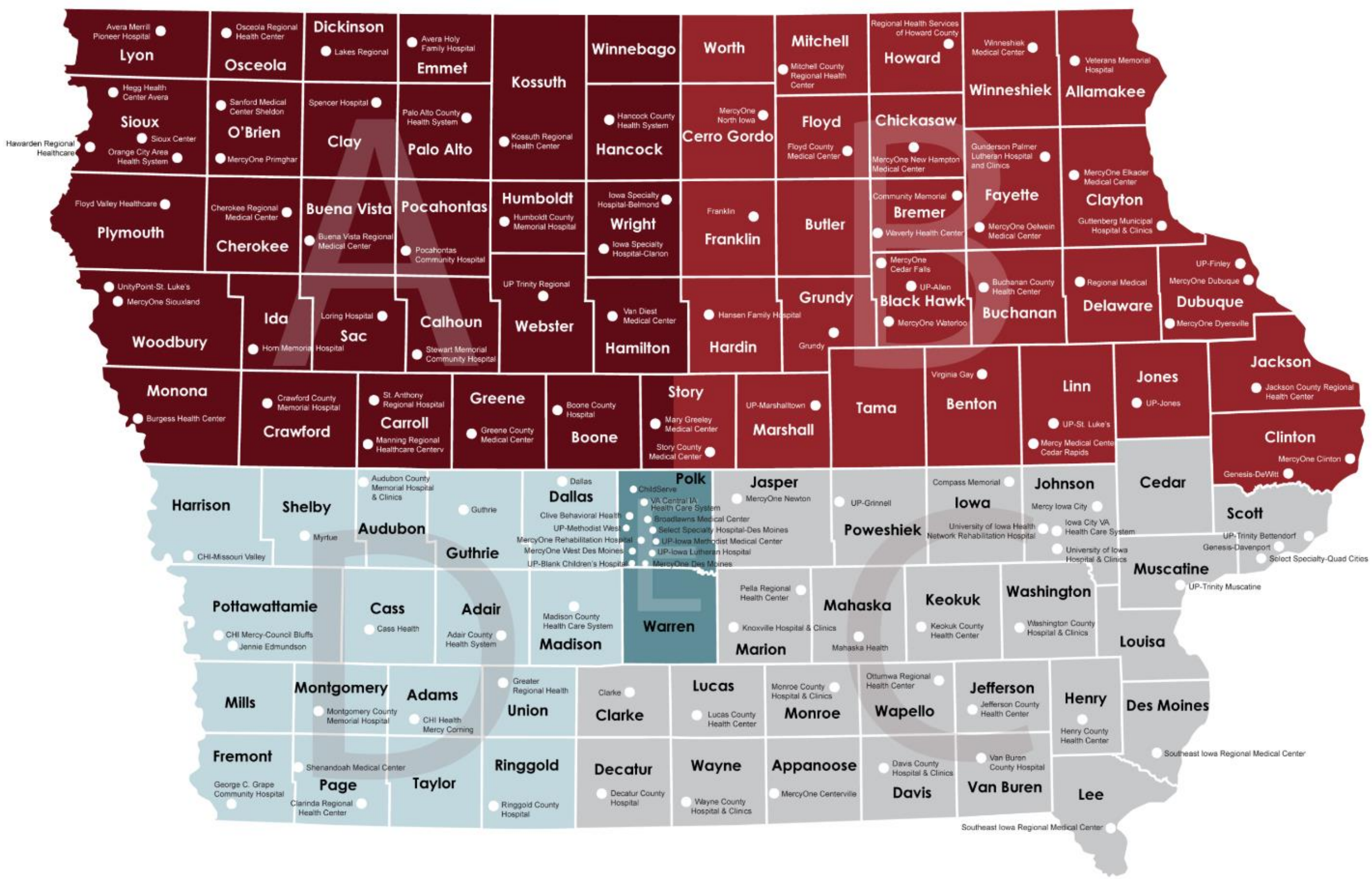
Figure 2.9: Areas within 15 miles of Iowa DOT maintenance garages



Hospitals and Emergency Medical Services (EMS)

Health care and emergency services are critical during disasters. Iowa has 117 hospitals, including two veteran hospitals and two state psychiatric facilities. There are 54 hospitals providing some level of EMS services to their community, with 75% of Iowa's EMS services being entirely volunteer based. In addition to the many hospitals, there are numerous other regulated medical and health care facilities, including long-term care facilities, hospices, end stage renal disease units, rural health clinics, and child-placing agencies.

Figure 2.10: Iowa's hospitals



Source: Iowa Hospital Association

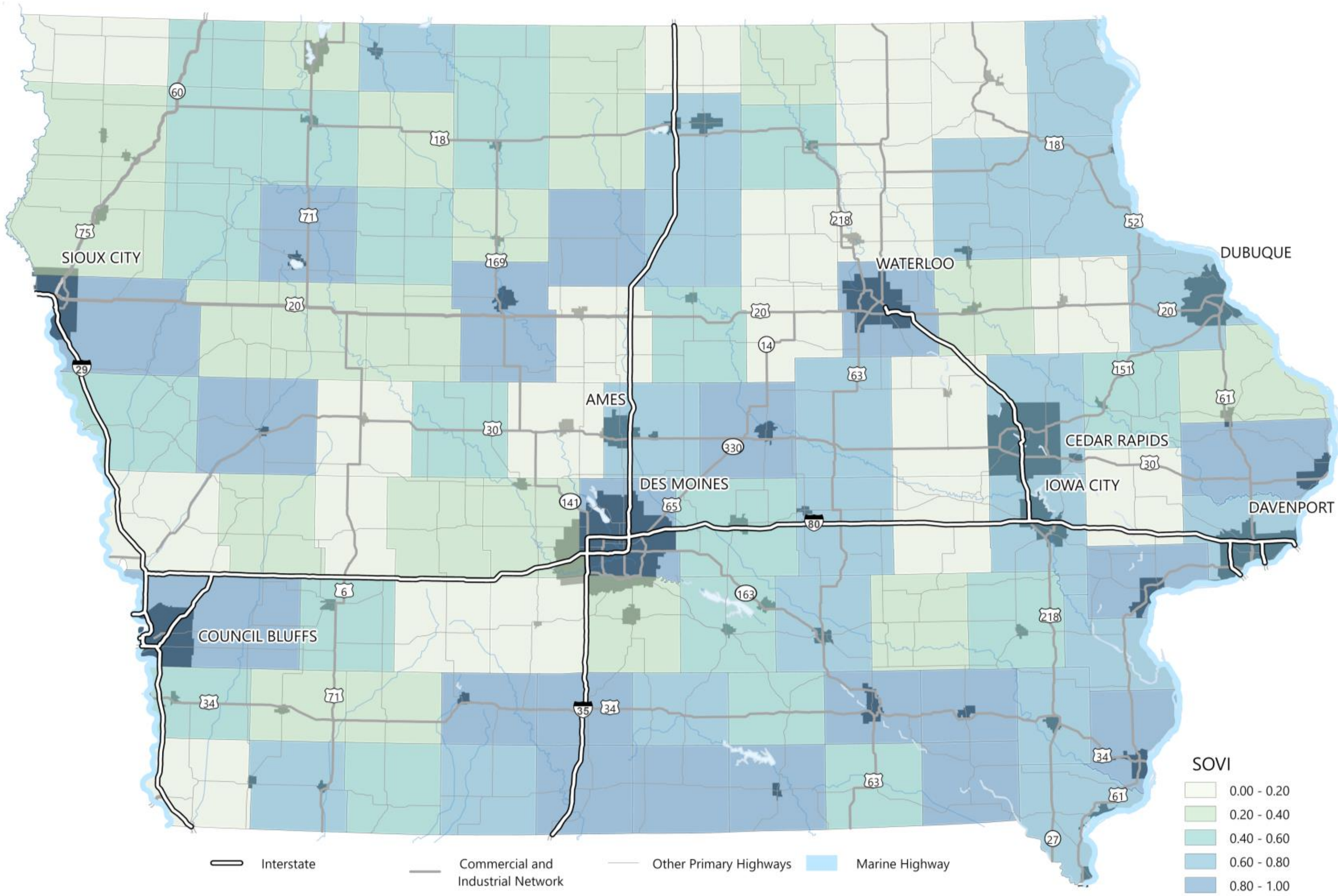
Iowa Demographics and Social Vulnerability

The criticality of the transportation systems and facilities discussed in the prior section comes into focus when considering Iowa's demographics and vulnerable populations.

- Iowa's 2020 population was 3,190,369 with much of this population concentrated in relatively few counties. Iowa's population has become increasingly urbanized and population growth has primarily been in the state's nine metropolitan areas. The percent of the population living in incorporated cities and communities that would be defined as urban or urbanized areas has increased steadily over time, from 58% in 1930 to 81% in 2020.
- The percent of Iowa's population that is 65 and older continues to increase. Iowa's median age has increased steadily over time to 38.2 in 2020. Rural areas of the state tend to be older and metropolitan areas are trending younger.
- Iowa's employment has grown steadily over time, however, most employment increases have been concentrated around the state's nine metropolitan areas.
- Among Iowa's households, the median income is currently $60,523, slightly less than the national median income of $62,843. While the statewide median household income has been increasing over time, it varies considerably for different areas of the state and for different racial and ethnic groups.

As Iowa's population continues to change over time, it is important for decision makers to routinely evaluate which communities would most likely need support before, during, and after hazardous events or natural disasters. The Centers for Disease Control and Prevention (CDC) has developed the Social Vulnerability Index (SV) to provide a high-level assessment of a community's need during a disruption. The index ranks counties based on 14 social factors including poverty, lack of vehicle access, crowded housing, and others, and groups them into four related themes.

Figure 2.11: Social Vulnerability Index for Iowa Counties



Source: Centers for Disease Control and Prevention

3. UNDERSTANDING IOWA’S HAZARDS

Iowa experiences significant variability in weather conditions due to its geographic location, even on a day-to-day basis. For example, on December 28, 2013, Sioux City experienced a 24-hour period where the temperature dropped from a high of 62 degrees to -3 degrees the next day. The regularity of these swings in the weather have prompted common phrases around the state such as "if you don't like the weather now just wait 10 minutes." Unfortunately, variability in Iowa's weather is often associated with hazardous conditions with far reaching impacts on the health, economy, and transportation within the state. In this chapter, the various hazards that impact Iowa's transportation system are profiled.

Natural Hazards Impacting Iowa's Transportation System

The guidance for the PROTECT Program published by FHWA on July 29, 2022, states, "If developed, Resilience Improvement Plans shall be consistent with State and local hazard mitigation plans, including as required by the Federal Emergency Management Agency (FEMA) (23 U.S.C 176(e)(2)B; 42 U.S.C. 5165)." Iowa's State Hazard Mitigation Plan identifies 19 natural and other hazards. Of those 19, nine were chosen to be evaluated and prioritized in this plan due to their potential impacts to mobility and transportation systems in Iowa. The nine hazards include dam/levee failure, drought, excessive heat/cold, freeze/thaw, flooding (flash and riverine), landslide, hail and thunderstorms, tornado/windstorm, and winter storms.

Other Hazards Impacting Iowa's Transportation System

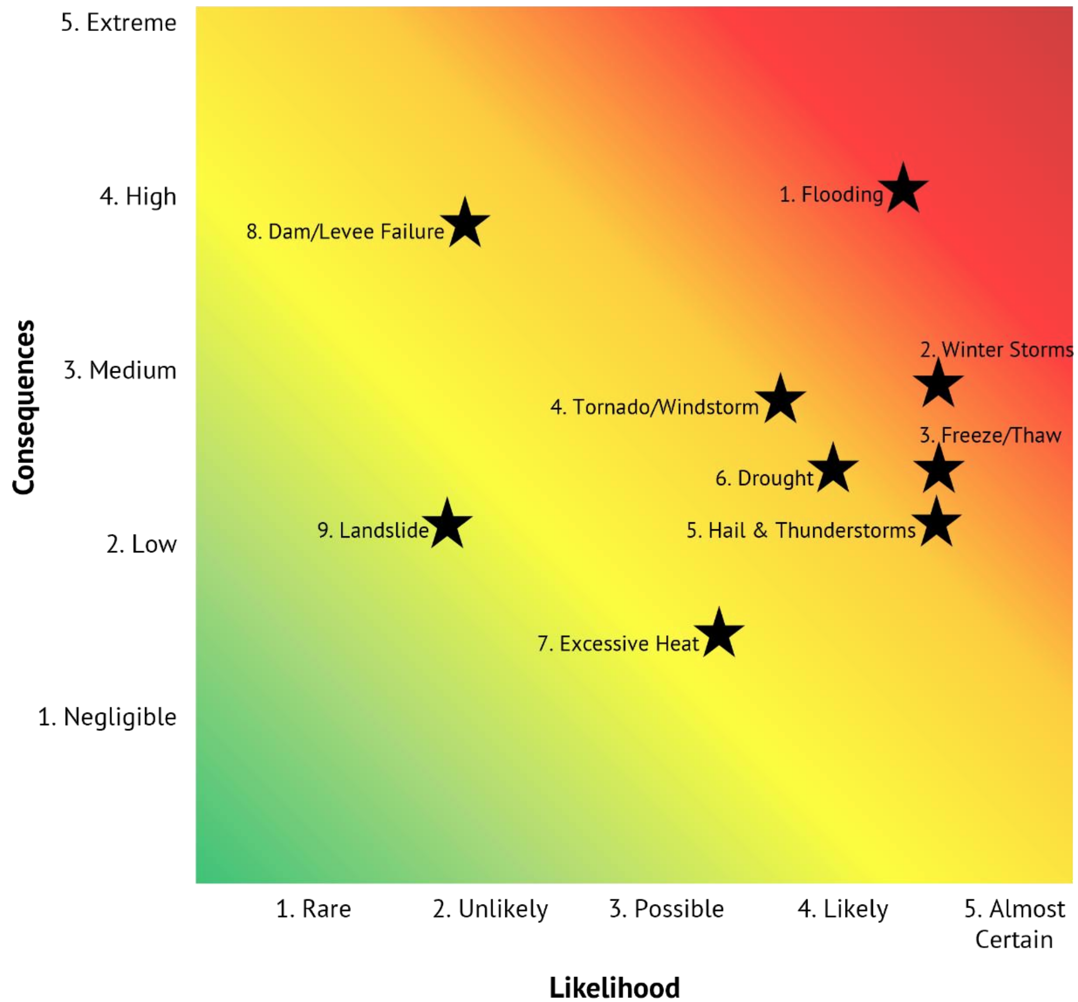
Although the primary focus of this plan is on natural hazards that impact the transportation system, it is important to recognize that departments of transportation are increasingly faced with hazards that do not originate from weather events or natural processes. These could include human induced events such as arson, cyber-attacks, and terrorism. There are also hazards related to the types of vehicles and commodities that travel on the transportation system. For example, hydrogen and electric vehicles have, on rare occasions, exploded and caught fire. Similarly, there are hazardous materials that travel on semi-trucks, trains, barges, and pipelines that could pose a significant threat to communities if an accident were to happen. In the unlikely event that one of these hazards does occur in Iowa, the impacts (e.g., loss of life, damage of infrastructure, delay in travel, etc.) could be very similar to that of a natural hazard.

3.1 Natural Hazard Assessment and Prioritization

Iowa is vulnerable to several natural hazards that can result in various impacts and consequences to the transportation system. The Iowa DOT Resiliency Working Group (RWG) was asked to evaluate and prioritize these natural hazards through a risk-based assessment considering the likelihood and consequence of each. For likelihood, lower response values indicated that the hazard rarely occurred and higher response values indicated a higher probability of occurrence. For consequence, lower values indicated a lower impact to the Iowa transportation system while higher values indicated significant damages. Risk or vulnerability is calculated by multiplying the likelihood and consequence.

Flooding was prioritized as the highest risk hazard to Iowa's transportation system while landslides were the lowest overall risk. Many of the hazards identified are likely to occur (e.g., thunderstorms, drought, and freeze/thaw) but the impact or consequences of these events do not present as significant of a threat to Iowa's transportation system. In other instances, the consequences of an event (e.g., dam/levee failure) would cause significant damage to the transportation system but the likelihood of those events are rare.

Figure 3.1: Risk prioritization matrix



For the purposes of this plan, the RWG has grouped the nine hazards into three different tiers based on risk scores and preferred mitigation methods for each. The tiers are outlined in Table 3.1. While each tier of hazards is being targeted with a particular mitigation approach, individual hazards may involve a variety of mitigation measures as appropriate.

Table 3.1: Risk prioritization scores

Tier	Hazard	Likelihood	Consequence	Risk	Preferred mitigation methods
Tier 1	Flooding	4.02	3.94	15.83	Take proactive steps to mitigate the risks of these hazards
	Winter Storms	4.27	2.88	12.28	
	Freeze/Thaw	4.23	2.38	10.04	
Tier 2	Tornado/ Windstorm	3.31	2.77	9.18	Have strategies in place to quickly react when these events occur
	Hail & Thunderstorms	4.23	2.02	8.55	
	Drought	3.6	2.33	8.41	
Tier 3	Excessive Heat	3.69	1.69	6.22	Monitor and conduct prevention activities as appropriate
	Dam/Levee Failure	1.58	3.71	5.87	
	Landslide	1.42	2.02	2.86	

3.2 Hazard Profiles

Flooding (Flash and Riverine)

Description

Flooding occurs when the flow of water is greater than the normal capacity of the stream channel. Flash and riverine flooding are two different types of events, although most people often refer to these as simply "flooding." A flash flood occurs when water levels rise quickly with little warning, often a result of intense rainfall over a brief period. These floods can be compounded by other factors such as snowmelt, ice jam release, and frozen or saturated soil. The real danger presented by flash flooding is how quickly waters reach full peak and the damage this causes over a short period of time. Riverine flooding, on the other hand, often occurs gradually over the course of days. These floods result in partial or complete inundations of normally dry lands near rivers.

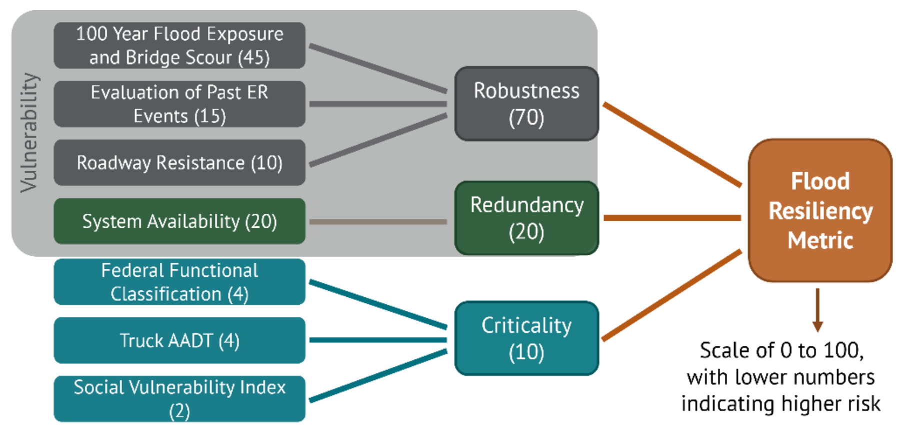
Analysis and Mapping

Floods are the most common and widespread of all natural disasters in Iowa. There is special emphasis on planning for and mitigating these events due to the frequency and associated cost. As part of the last update of the State Long Range Transportation Plan (SLRTP), a statewide flood resiliency analysis was developed to screen the Primary Highway System for locations vulnerable to 100-year flood events. The analysis was comprised of three broad components and seven individual factors that ultimately comprised a composite metric to assess Iowa's vulnerability to flooding.

Frequent flooding

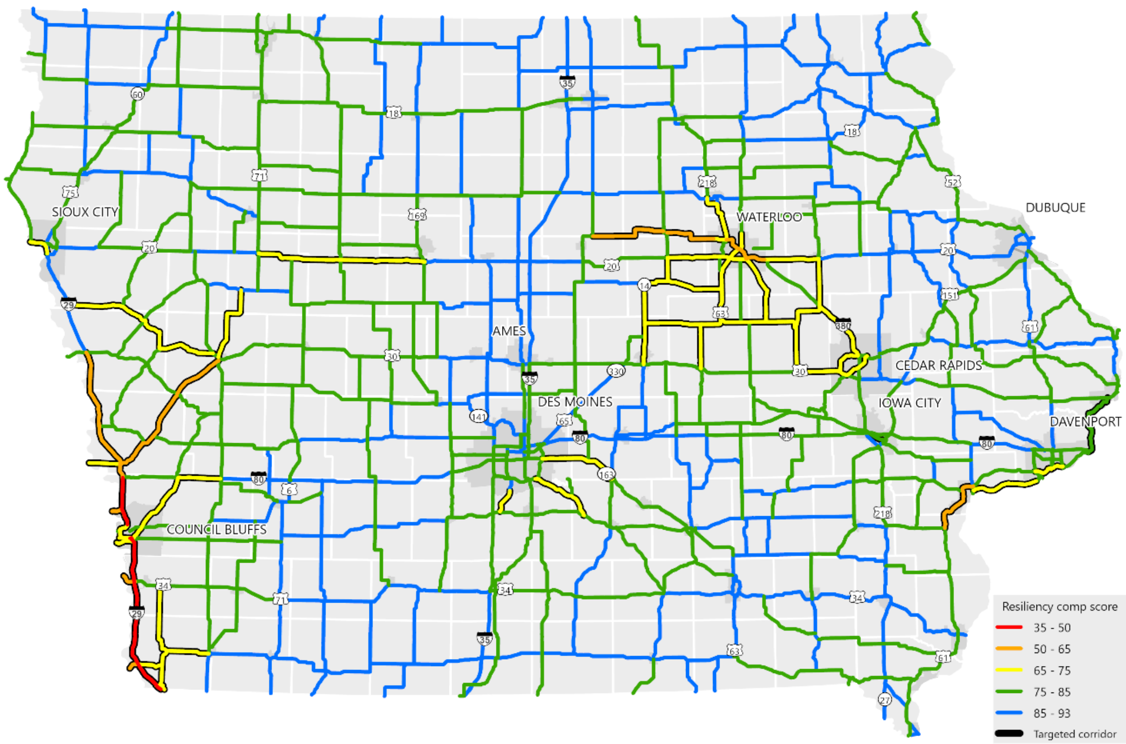
In the last 30 years, every county in the state has received at least five Presidential Disaster Declarations that included flooding.

Figure 3.2: Flood resiliency analysis factors and weighting



The data for each attribute were normalized on a 1 (worst) to 10 (best) scale, then combined based on the weighting factors which were determined by the RWG. The maximum composite score is 100; higher scores indicate greater resiliency to a 100-year flood event, whereas lower scores indicate greater vulnerability to those events. The analysis helps identify corridors where strategies related to preparedness for possible flooding events and infrastructure improvements to enhance the resiliency of the system may be most beneficial. Figure 3.3 shows the results of the flood resiliency analysis. 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 long-range planning perspective, corridors with a composite score that was one or more standard deviation below the statewide average were identified. There are 72 such corridors with an average composite score of 75.1.

Figure 3.3: Flood resiliency analysis composite scores and corridors targeted for resiliency improvements



Impacts to Transportation

Flooding has significant short- and long-term impacts. In the short term, route closures affect all highway traffic, from commuters to freight transportation to emergency services. This inconvenience can be compounded by the out-of-distance travel required to detour around closed areas. These distances can be long when there are limited routes across rivers or when there is significant flooding throughout the river basin. Flooding can have significant impacts on other modes of transportation as well. Normal operations for transit operators, railroads, barge companies, and airlines can be delayed or canceled until flood waters recede. Iowans who rely on walking or cycling can be impacted when flood waters cut off normal routes.

The most significant long-term impact flooding has on transportation is the inundation and destruction of roadways and bridge structures, both of which are susceptible to erosive forces of water during a flood event. When a roadway is overtopped, the erosive nature of the flowing water can cause the shoulder and embankment of the roadway to be compromised and eventually result in washout or breach. Similarly, bridge scour is the removal of sediment from bridge abutments/piers caused by flowing water and can result in downstream scour holes that can eventually undermine the integrity of the structure.

Winter Storms

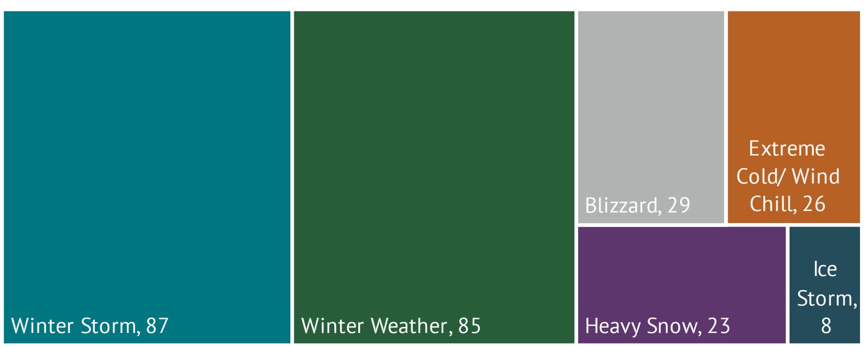
Description

"Winter storms" is a generalized term that includes blizzards, heavy and blowing snow, freezing rain, and extreme cold. Blizzards are storms that last three hours or longer with sustained winds of 35 mph or more, often resulting in reduced visibility of a quarter mile or less or whiteout conditions. Heavy snows are events of six inches of snow or more in a 12-hour period. Blowing snow events occur when loose snow begins to drift, which is more likely in rural areas where there are less objects to obstruct wind. Freezing rain can result in ice storms that cause power outages from downed trees, limbs, and utility poles. Extreme cold occurs when temperatures are near zero degrees Fahrenheit and can be magnified by wind.

Analysis and Mapping

Iowa, like many of the northern Midwest states, experiences time periods with poor weather and/or roadway conditions, especially during the winter season (October through April). These winter weather events are cataloged by the National Centers for Environmental Information (NCEI).

Figure 3.4: Winter weather events from 2018-2022

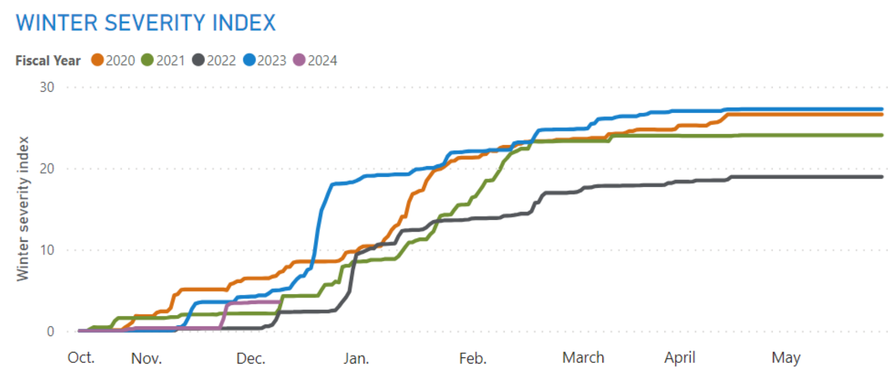


Source: NCEI

From 2018 to 2022, winter weather storms resulted in three deaths directly attributed to the event, 10 deaths and 16 injuries indirectly attributed, and $516,800 in property damage – $377,000 from ice storms alone.

The Iowa DOT has developed a winter severity index that provides a score for locations based on event duration, event frequency, snowfall amount, and temperature. The duration and frequency are normalized by the expected extreme for each event, then scaled by an "importance" factor. Generally, colder pavement temperatures during an event result in higher index scores, which correlate to more severe winters.

Figure 3.5: Iowa DOT winter severity index, 2019-2023



Impacts to Transportation

The mobility and safety of Iowa's transportation users can be compromised during winter weather events. Significant snowfall, extreme cold, high winds, and ice can all immobilize Iowa's transportation system resulting in travel delay, vehicle crashes, and the need for around-the-clock maintenance of the roadways.

Excessive Heat and Freeze/Thaw

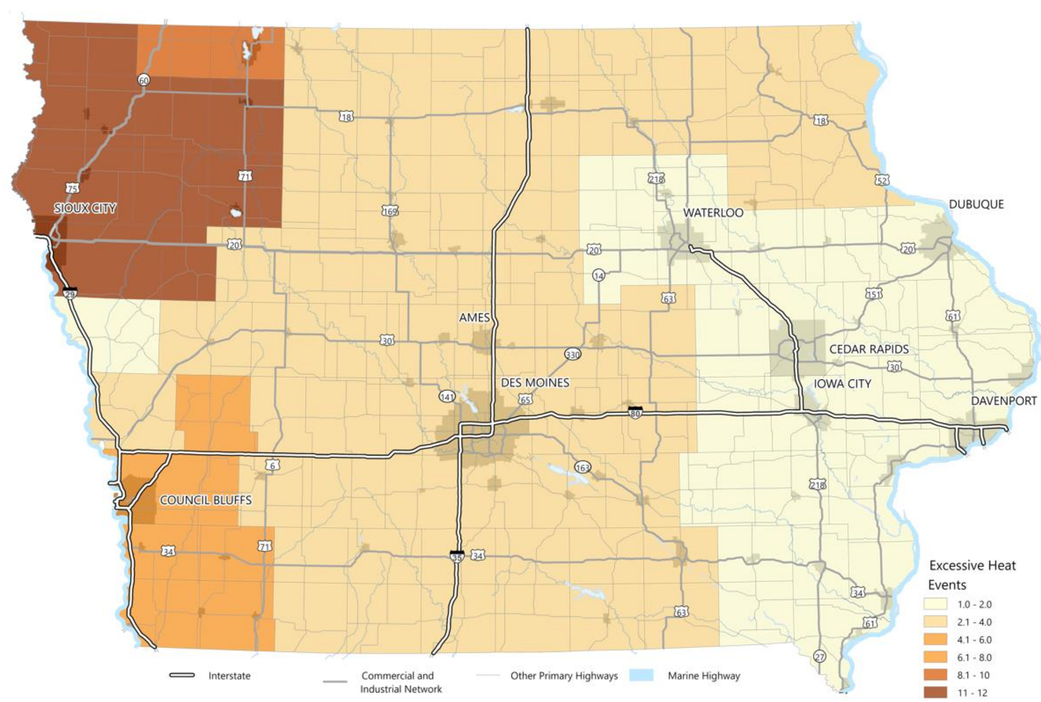
Description

Excessive heat can generally be defined as a period where the temperature is substantially hotter and/or more humid than average for a location at a given time of year. The National Weather Service in Des Moines defines excessive heat as a heat index greater than 110 degrees Fahrenheit for two or more consecutive days. This is not the only temperature related threat in Iowa as temperatures can also fluctuate rapidly. This can lead to dramatic freeze/thaw cycles that occur when air temperature drops low enough to freeze water, then increase enough for it to thaw again. These types of temperature changes occur most frequently from fall until spring in Iowa.

Analysis and Mapping

Since 2009, most Iowa counties have experienced at least one excessive heat event. The most frequent occurrence of these events has happened in northwest and southwest counties. Data collection of excessive heat events began in 2009, so while it is not appropriate to say that the western counties are more likely to see these types of events, one could surmise there may be a trend.

Figure 3.6: Excessive heat events in Iowa, 2009-2019



Source: NCEI

Impacts to Transportation

Excessive heat and drastic variability in freeze/thaw cycles can have significant impacts to transportation. Pavement buckling can occur when the air temperatures reach extreme highs. Pavement needs space to expand when temperatures rise and buckling occurs when there is not enough space available and/or expansion of the pavement happens rapidly. There are also modal considerations during excessive heat. Railroad tracks may buckle (referred to as a "sun kink") when temperatures are excessive; the bending, warping, or distortion of rail tracks can cause issues and potentially derail engines or rail cars. Excessive heat events can cause reduced transit ridership as transit users are particularly vulnerable if transit stops do not provide refuges, which can result in users experiencing heat related illnesses.

Thunderstorms & Hail and Tornado/Windstorm

Description

Thunderstorms come in different forms and produce threatening conditions such as tornados, windstorms, and hail. Although hailstorms can produce damage that impacts Iowa travel, the focus of this section will be on thunderstorms that produce tornados and windstorms. Portions of Iowa are in what has been colloquially defined as "Tornado Alley," an area of the country stretching from central Texas to northern South Dakota where tornadoes are most frequent. Tornados are violently rotating columns of air that contact the earth's surface with wind speeds ranging from 65 mph to over 300 mph and diameters up to two miles wide. The peak month for tornadoes in Iowa is June followed by May, July, and April; however, they can occur any month of the year. Like tornados, windstorms involve violent winds that can cause extreme damage. A type of windstorm known as a derecho includes high wind gusts (at least 58 mph) oriented in one direction along a wide, straight swath of land for an extended period. Most derechos will occur between May and August but can occur in the cooler months as well.

Analysis and Mapping

When and where a tornado or derecho will happen is unpredictable. When tornadoes do occur, they are rated based on estimated wind speeds and related damage under the Enhanced Fujita (EF) Scale. When tornado damage is surveyed, it is compared to a list of Damage Indicators (DIs) and Degrees of Damage (DoD), which provide better estimates of the range of wind speeds the tornado likely produced. From that, an EF rating (0-5) is assigned. From 1992-2022 there were 1,773 tornados in Iowa. Since 2007, when the Enhanced Fujita Scale was initiated, there have been five tornados with EF-4 ratings or above.

Table 3.2: Enhanced Fujita Scale

EF Rating	3 Second Gust (mph)	Description
0	65-85	Gale
1	86-110	Weak
2	111-135	Strong
3	136-165	Severe
4	166-200	Devastating
5	Over 200	Incredible

Source: NOAA NWS

Windstorms are rated on the Beaufort Wind Scale that relates windspeed and description of potential resulting damage. Windstorms have occurred in every county in Iowa. In the five-year period between December 2017 and November 2022, Iowa experienced more than 400 wind events according to the NCEI Storm Events Database. This includes thunderstorm wind, straight-line high or strong winds, and funnel clouds, which are tornado-like events that do not have contact with the ground. These events caused three fatalities (and at least one more indirectly). Property damage from those events was estimated to be $12,245,000 with crop damages over $700,000.

Table 3.3: Beaufort Wind Scale

Windspeed (mph)	Description - Visible Condition
0	Calm smoke rises vertically
1 to 4	Light air direction of wind shown by smoke but not by wind vanes
4 to 7	Light breeze wind felt on face; leaves rustle; ordinary wind vane moved by wind
8 to 12	Gentle breeze leaves and small twigs in constant motion; wind extends light flag
13 to 18	Moderate breeze raises dust and loose paper; small branches are moved
19 to 24	Fresh breeze small trees in leaf begin to sway; crested wavelets form on inland water
25 to 31	Strong breeze large branches in motion; telephone wires whistle; umbrellas used with difficulty
32 to 38	Moderate gale whole trees in motion; inconvenience in walking against wind
39 to 46	Fresh gale breaks twigs off trees; generally impedes progress
47 to 54	Strong gale slight structural damage occurs; chimney pots and slates removed
55 to 63	Whole gale trees uprooted; considerable structural damage occurs
64 to 72	Storm very rarely experienced; accompanied by widespread damage
73+	Hurricane-like devastation occurs

Source: NOAA NWS

Impacts to Transportation

Tornados and windstorms can devastate areas with strong winds that pick up debris and move it significant distances. This can include cars, trees, and even vertical structures like buildings and homes. All forms of transportation may be impacted during these events. Traditional transportation infrastructure such as roadways are typically left undamaged; however, in many cases debris removal and maintenance are required. These storms can also cause power outages and communication disruptions that can impact the ability of the Iowa DOT to coordinate response efforts across the state.

Drought

Description

A drought is defined as a period consisting of abnormally dry weather that persists long enough to impact agriculture and water supplies. During this period, the soil moisture does not meet the water needs of a particular region. In Iowa, drought can occur throughout the state and be particularly challenging as there has been a tendency to quickly transition from drought to flood and back to drought within short periods of time.

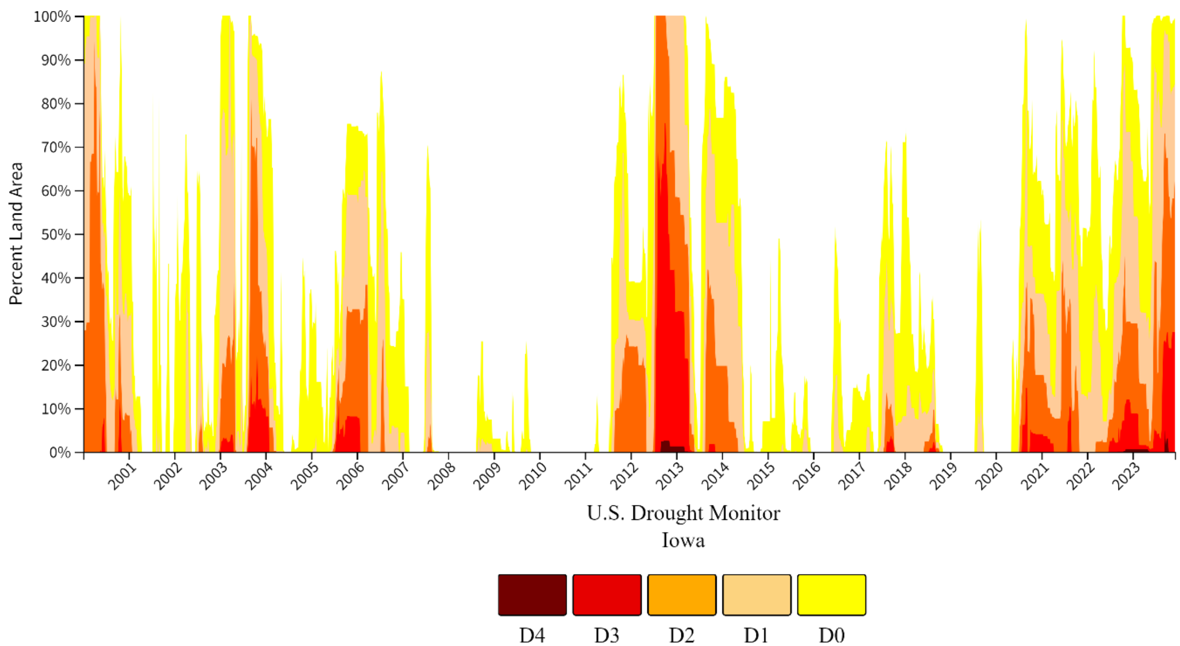
Analysis and Mapping

Drought is tracked and monitored nationally by the National Drought Mitigation Center in partnership with several federal agencies using the U.S. Drought Monitor (USDM). The USDM uses criteria that are evaluated and updated weekly to determine the severity of drought based on regional specific indicators.

The northwest and central portions of Iowa have typically experienced the most pronounced drought conditions while the northeast portion of the state has experienced the fewest non-consecutive weeks of drought.

Figure 3.7: U.S. Drought Monitor categories and Iowa drought conditions, 2000-2023

Category	Description	Example Percentile Range for Most Indicators	Values for Standard Precipitation Index and Standardized Precipitation-Evapotranspiration Index
None	Normal or wet conditions	31 or above	-0.49 or above
D0	Abnormally Dry	21 to 30	-0.5 to -0.79
D1	Moderate Drought	11 to 20.99	-0.8 to -1.29
D2	Severe Drought	6 to 10.99	-1.3 to -1.59
D3	Extreme Drought	3 to 5.99	-1.6 to -1.99
D4	Exceptional Drought	0 to 2.99	-2.0 or less

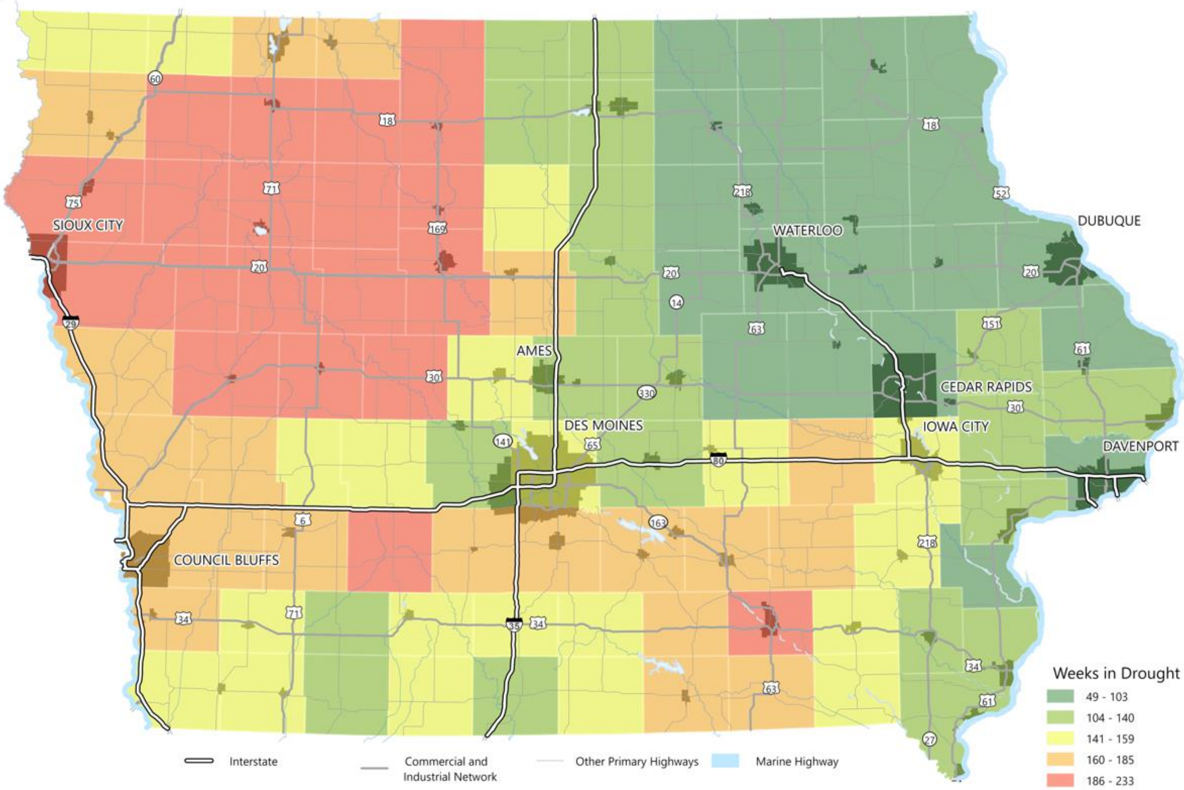


Source: National Integrated Drought Information System

Impacts to Transportation

Iowa is known for its prime topsoil, plentiful rainfall, and widespread river systems which make it one of the top agriculture production areas in the world. Farmers and ranchers who depend on rainfall to water their crops and support grazing lands can be severely impacted by even short-term droughts, especially considering supplemental irrigation is rarely practiced in the state. Iowa producers rely on a robust highway system, a dense network of rail lines, and major consolidation points like elevators and barge terminals to export agricultural products outside of the state. Drought's largest impact to this supply chain is low water levels on the Mississippi and Missouri rivers. As recently as the fall of 2022, drought impacted barge capacity on the Mississippi River. Low water levels meant that limits needed to be placed on barge capacity resulting in about a one third loss in capacity and a 41% jump in barge shipping prices year over year. Ironically, only six months later in the spring of 2023, the Mississippi River was experiencing significant flooding.

Figure 3.8: Non-consecutive weeks in Severe Drought (D2) or worse, 2000-2022



Source: U.S. Drought Monitor

Abnormally Dry

Iowa ended 2023 with over 80% of its land area in drought.

Over one third of Iowa was in extreme drought.

Dam/Levee Failure

Description

Dams and levees provide essential functions in the protection of communities and the controlled flow of water. A dam is an artificial barrier constructed to hold back water, typically used for flood control, erosion control, water supply impoundment, hydroelectric power generation, and recreation (artificial lake). Levees are man-made structures, usually made of earthen embankment, and are designed to contain, control, or divert the flow of water to provide protection during flood events. The construction of a dam or levee can create opportunities for development in what would otherwise be considered flood-prone areas. Failures of dams or levees can have catastrophic impacts to communities and transportation within a region. Dam failures can occur for many reasons, including prolonged rainfall or flooding, overtopping, internal erosion caused by embankment or foundation leakage, improper maintenance, improper design, improper operation, or failure of upstream dams. Levee failures are often caused by foundation failure, levee boils/sand boils, surface erosion, and/or overtopping.

Analysis and Mapping

In Iowa, dams are grouped into three different classifications according to the downstream damage that would result from a failure. These three classifications are:

- **High Hazard –** Failure may create a serious threat of loss of human life.
- **Moderate Hazard –** Failure may damage isolated residential structures, industrial or commercial buildings, moderately-traveled roads, or interrupt major utility services, but does not present a substantial risk of loss of human life. This also includes dams and associated impoundments that are themselves of public importance (e.g., associated with public water supply systems, industrial water supply or public recreation, or integral features of a private development complex).
- **Low Hazard –** Damage from a failure would be limited to loss of the dam, livestock, farm outbuildings, and agricultural land.

The location and condition of levees within the state are primarily inventoried in the National Levee Database (NLD), which includes the FEMA accreditation status. The three levels of accreditation are:

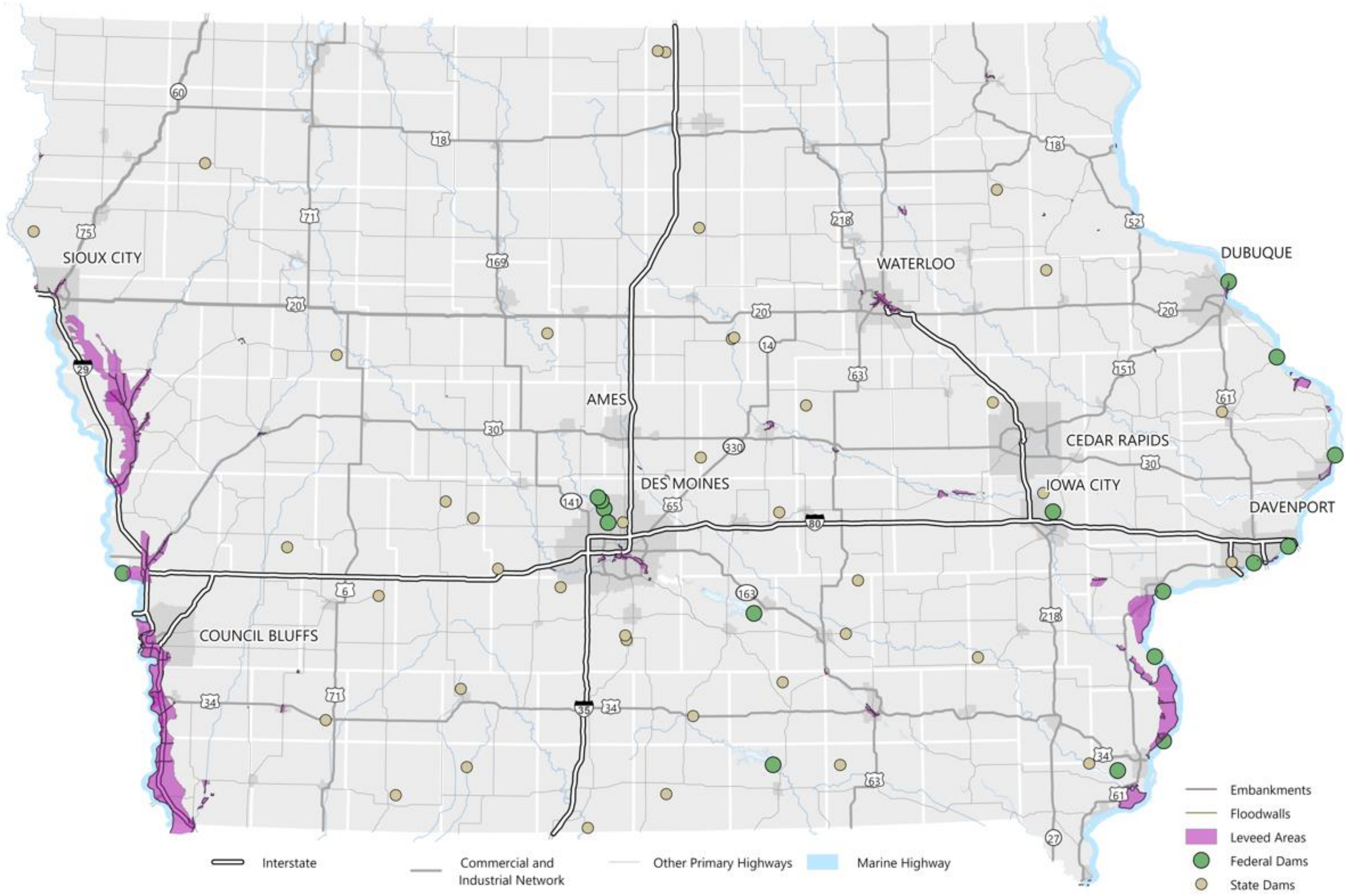
- **Accredited Levee System –** meets the design, data, and documentation requirements of 44 CFR 65.10.
- **Provisionally Credited Levee (PAL) System –** Previously accredited as providing base flood hazard reduction on an effective Flood Insurance Rate Map (FIRM), and for which FEMA is awaiting data and or documentation that will show compliance with 44 CFR 65.10.
- **Non-Accredited System or De-Accredited System –** Not providing base flood hazard reduction on an effective FIRM.

Non-levee embankments have been identified by the Iowa Department of Natural Resources (DNR) using LiDAR (light detection and radar) mapping. The non-levee embankments are not accredited in any way but may contain, control, or divert the flow of temporary flood waters in some cases.

Impacts to Transportation

Dam and levee failures are infrequent but do occur occasionally following periods of intense rainfall and/or flooding. The largest impact of failures is the quick release and flow of water in areas they were intended to protect (e.g., communities and transportation systems). This typically exacerbates tenuous natural disasters and hinders emergency and rescue operations. The most recent dam failure in Iowa occurred in July of 2010 at Lake Delhi. The most recent levee failures occurred in southwest Iowa in 2019 following significant flooding, which impacted several primary highways including I-29, I-680, and U.S. 34.

Figure 3.9: Dams, levees, and embankments in Iowa



Landslide

Description

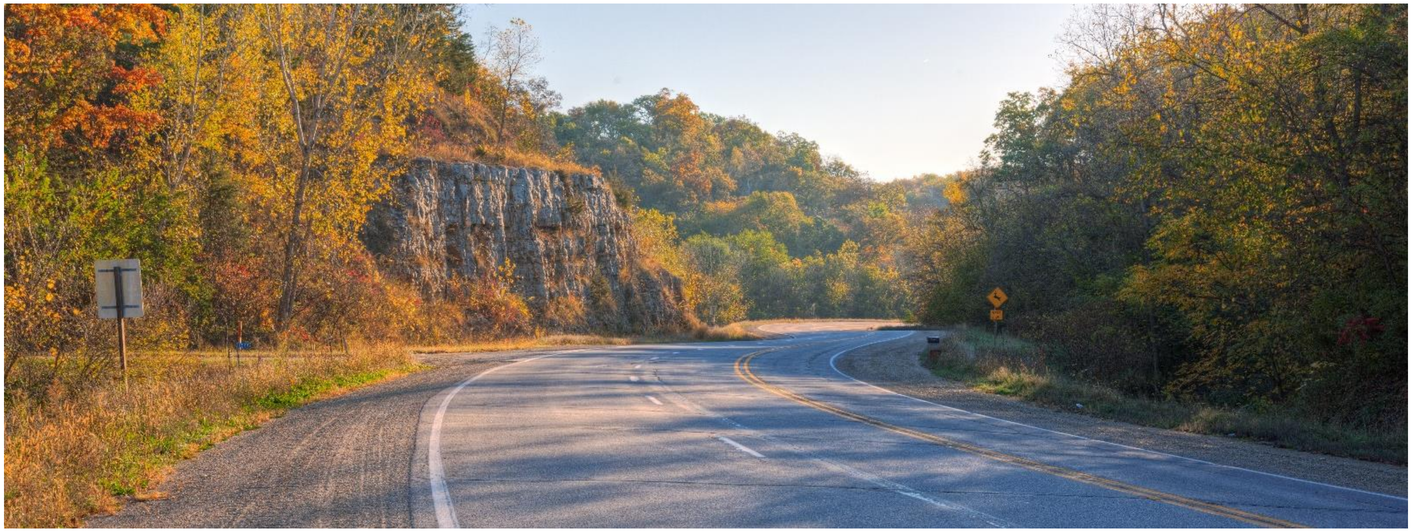
Landslides are natural phenomenon that occur when rainstorms, fires, or human activities modify the slope and drainage of the landscape in slide-prone areas. Rockfalls occur when susceptible rock, earth, and/or debris move down a slope under the force of gravity and water. These events can be small or large and move at varying speeds.

Analysis and Mapping

Although a significant landslide or rockfall has not occurred in Iowa, the risk still exists with the right combination of factors. Data collection of landslides and rockfalls in Iowa is sporadic with no state agency maintaining an inventory or database. The United States Geological Survey (USGS) does collect data at a national level as part of the Landslide Hazards Program. There were 13 events in Iowa from 2007-2019 with no fatalities or significant damage reported.

Impacts to Transportation

Landslides and rockfalls typically cause network blockages, delays, damage, and closures on the transportation system with the impact typically contained to the area the landslide/rockfall occurred. Economic and societal impacts can go beyond that area through delay costs associated with the closures and/or damage.



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4. IMPLEMENTATION

4.1 Iowa's Resiliency Toolbox

A multifaceted approach that includes strategies, countermeasures, and research will be implemented to mitigate the hazards prioritized by the Resiliency Working Group (RWG). Collectively, this combination of activities will represent Iowa's Resiliency Toolbox and will serve as a planning level resource in identifying approaches for each hazard. As discussed in Chapter 3, hazards have been prioritized into three different response categories based on their risk scores and preferred mitigation approaches. The Tier 1 hazards, which have the highest risk scores, are the primary focus of the toolbox. Iowa's Resiliency Toolbox also includes both typical roadway improvements (grey infrastructure) and natural infrastructure improvements (e.g., native plantings and bioretention).

The strategies, countermeasures, and research initiatives align to the 4 Rs first identified in Chapter 2, with each R icon used to designate which topic each tool relates to most strongly.

Figure 4.1: The four Rs of resiliency

Robust	The system is strong enough to withstand a given level of stress or demand without suffering degradation or loss of function.	**Redundant**	Elements of a system exist that are substitutable and capable of satisfying the functional requirements of the system in the case of disruption.
Resourceful	There are resources (e.g., monetary, physical, technological, and informational) available that can be leveraged in the process of recovery.	**Responsive**	There is capacity to meet priorities and achieve goals in a timely manner in order to minimize losses, recover functionality, and avoid future disruption.

Many of the ideas listed in Iowa's Resiliency Toolbox benefit the operation of the transportation system beyond mitigation of the specific hazards they are listed for. For example, shoulder improvements may mitigate the impact flowing water has on the roadway, but they also serve as a safety benefit by allowing users space to recover from departing their lane. Stewardship of the transportation system means that increased consideration should be given to the improvements that are co-beneficial to our mission of keeping users safe on the system.

Tier 1 Hazards

-Highest risk scores
-Preferred mitigation method:
Take proactive steps to address these hazards

Flooding | Winter Storms | Freeze/Thaw

Flooding Strategies

Strategies

S1. Approve resiliency policy in the Bridge Design Manual and plan for increased precipitation events, water elevations, and flow.

S2. Engage internal and external stakeholders regarding watershed management, flood preparation, and emergency protocols.

S3. Allow more ponding at certain “control” structures.

S4. Determine critical routes for emergency routing during flood events at known areas of vulnerability.

S5. Develop a Flood Operations Plan to support in the response of future flood events.

S6. Proactively stockpile flood fighting material and assets including AquaDam and wrapped revetment bags.

S7. Partner with the Iowa Department of Homeland Security and Emergency Management (HSEMD) on projects that reduce road damage from flooding and erosion through stream channel improvements.

S8. Partner with HSEMD and local jurisdictions on comprehensive flood mitigation planning that considers watershed approach or green infrastructure options, then implement planned projects to mitigate flood damage to roads by installing watershed approach practices (e.g. upstream detention), retrofitting bridges, elevating roads, or installing culverts.

S9. Develop a comprehensive statewide flood mitigation strategy that considers flood buy-outs, watershed approach flood mitigation, levees, and other solutions and outlines where, and under what, conditions these different strategies are best applied.

S10. Evaluate key locations to increase waterway capability including widening upstream bench and channelization of the waterway.

Flooding Countermeasures and Research

Countermeasures

C1. Roadside and waterway erosion protection – Use engineered (e.g., concrete blocking or Flexamat) or natural (e.g., bio-retention or native planting) materials to control or stop the movement of soil along slopes.

C2. Native plantings on roadsides – Certain native grasses and plants have deep roots that make them drought-resistant and can reduce soil erosion and flooding.

C3. Bridge pier scour protection – Bridge scour is the removal of sediment from around bridge abutments. Countermeasures can include concrete armoring, spurs, revetments, wire enclosed riprap, etc.

C4. Bridge/culvert conveyance improvements – Adequate sizing of bridges and culverts to ensure the proper conveyance of water through the channel and floodplain with the consideration of future increased precipitation.

C5. Dikes/levees – Embankments of stone, cement, or soil that protect roadways and land during significant rainfalls and flooding.

C6. Roadway/bridge grade raise – Increasing the elevation grade of a roadway or bridge to reduce overtopping due to flooding conditions.

C7. Shoulder improvements – Increasing the width or improving the type of shoulder can mitigate the impacts of flowing water across roadways in low-lying areas.

C8. Median crossover – Add median crossovers at key locations to allow for continued operations during flood events.

Research

R1. Develop and populate a Riverine Infrastructure Database that supports real time flood flow and levels across Iowa.

R2. Develop a benefit/cost analysis tool to evaluate cost effectiveness of resilience improvements.

R3. Research how native plantings can support flood mitigation for Iowa's transportation system.

Winter Storms Strategies, Countermeasures, and Research

Strategies

S11. Design roadways that are less prone to blowing/drifting snow and winter drainage issues.

S12. Plan for operational impacts of significant winter and ice events.

S13. Plan a winter operations peer exchange or summit with neighboring states to share best practices and coordinate responses.

S14. Develop internal guidance or policies for pre-staging winter operations assets in advance of storms.

S15. Proactively remove vegetation along the Primary Highway System that could break during winter or ice storms.

S16. Consider bridge design methods that mitigate the impact of ice accumulation on bridges and structures.

S17. Evaluate recruitment strategies for part-time snowplow drivers to fill critical vacancies.

Countermeasures

C9. Snow fencing – Installation of engineered or natural materials that serve as windbreaks from blowing and drifting snow.

C10. Anti-icing applications – The use of salt and water in precise concentrations known as brine to prevent ice formation on roadways.

C11. Median crossover – Adding median crossovers at key locations to allow for improved snowplow operations during winter events.

Research

R4. Research low visibility navigation technology for Iowa's snowplows.

R5. Continue to research the best material use and products for ice mitigation (melt).

Freeze / Thaw Strategies, Countermeasures, and Research

Strategies

S18. Develop methods to better maintain pavement joints during intense freeze/thaw cycles.

S19. Continue to monitor pavement condition throughout the state and implement asset management techniques to minimize the impacts of freeze and thaw cycles.

S20. Monitor subdrain performance and placement to ensure proper drainage during freeze and thaw cycles.

Countermeasures

C12. Crack and joint cleaning and sealing – Cleaning and sealing with joint sealer to ensure water does not enter and undermine the integrity of pavement or asphalt during freeze and thaw cycles.

C13. Improve subgrades and subdrains – Improving subgrades and subdrains in key locations supports the facilitation and movement of excess water away from the roadway and minimizes damage.

C14. Integral bridge abutments – Integral bridges contain no expansion joints and span monolithically from abutment to abutment. This allows thermal expansion without damage to the structure.

Research

R6. Research how freeze/thaw cycles have changed and what we can anticipate in the future.

Tier 2 Hazards

Tornado/Windstorm Hail/Thunderstorms Drought

-Medium risk scores
-Preferred mitigation method:
Have reactive strategies in place to respond when these hazards occur

Tier 2 Strategies and Countermeasures

S21. Ensure Iowa DOT owned structures and signs are designed to withstand high wind events.

S22. Develop internal guidance or policies on clearing or trimming trees that could fall on the roadway.

S23. Purchase vegetation management equipment specifically for debris removal on the Primary Highway System.

S24. Develop internal plan to pre-stage Iowa DOT assets in support of debris and vegetation removal following tornados or windstorms.

S25. Engage with local communities regarding the resources and assets the Iowa DOT possesses to support debris removal and cleanup after significant events.

C15. Underground utilities – Storage and coordination of utilities underground to ensure continued service during significant tornados and windstorms.

C16. Solar as primary or backup electrical – Installation of solar arrays for traffic controls or facilities as a primary or backup energy source.

C17. Generator backup – Purchase of backup generators to provide energy for traffic controls or facilities during major tornados or windstorms.

S26. Improve roadway design to accommodate increased precipitation events.

S27. Plan for operational impacts of severe weather and continue to enhance communication of rapid weather changes to the public.

S28. Develop regulations or waivers to ease in the transport of water, livestock feed, etc. during drought conditions.

S29. Coordinate across public and private sectors during times of low water levels to help facilitate shifts of bulk transportation from rivers to railroads or highways.

Tier 3 Hazards

-Lowest risk scores
-Preferred mitigation method: Monitor hazards and support mitigation methods where appropriate

Excessive Heat

Dam/Levee Failure

Landslide

Tier 3 Strategies

S30. Consider strategies to reduce the impacts of excessive heat on vulnerable transportation users.

S31. Consider strategies to mitigate the effects of excessive heat on construction workers.

S32. Be prepared to address issues such as pavement buckling during heatwaves throughout the state.

S33. Coordinate with the new Office of Levee Safety within HSEMD to plan for and support the levees throughout Iowa.

S34. Regularly review traffic incident management plans and detour routing plans around critical assets.

S35. Develop internal guidance for land management practices (e.g., removing bluffs, terracing, etc.) that prevent landslides.

S36. Stage equipment strategically if conditions such as an area's topography and recent weather result in an increased likelihood of rockfalls or landslides.

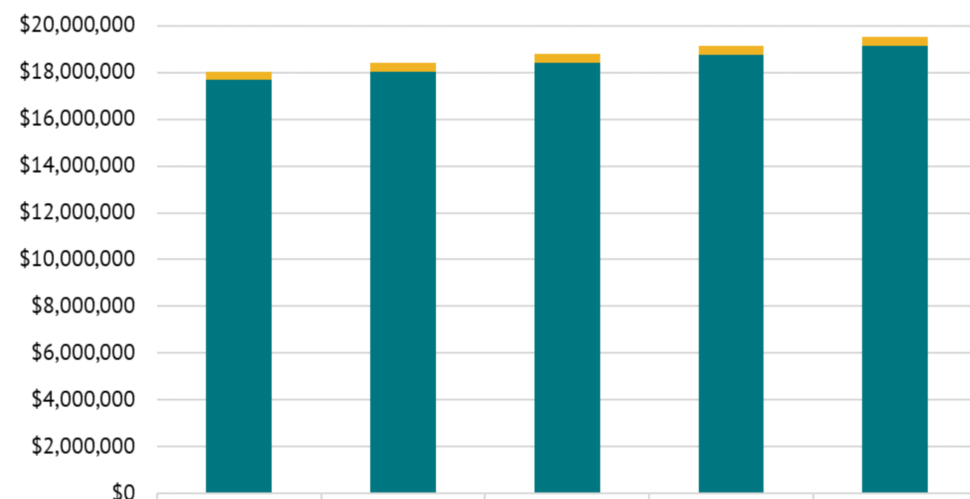
4.2 PROTECT Funding

Improvements identified in Iowa's Resiliency Toolbox will be supported through the use of multiple funding sources, including new dedicated funding. While many of these resiliency improvements have already been occurring and funded out of existing funding sources, the creation of the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) program in 2021 provides funding specifically for resiliency improvements. The program's purpose is to increase the resiliency of the nation's transportation system. PROTECT provides this support through a formula program which distributes apportioned funds to each state and a discretionary program which offers nationally competitive grants that states and other entities can apply for.

PROTECT Formula Funding

The PROTECT Formula Program will provide $7.3 billion over five years, fiscal year (FY) 2022 – FY 2026, which will be distributed to the states. States are required to use at least 2% of their Protect Formula Program funding each fiscal year for specific types of resilience-related planning activities, such as developing a resilience improvement plan; resilience planning, predesign, or design; technical capacity-building; or evacuation planning and preparation.

Figure 4.2: Iowa's PROTECT formula funding for FY 2022-2026, showing the breakout of the 2% set-aside for planning

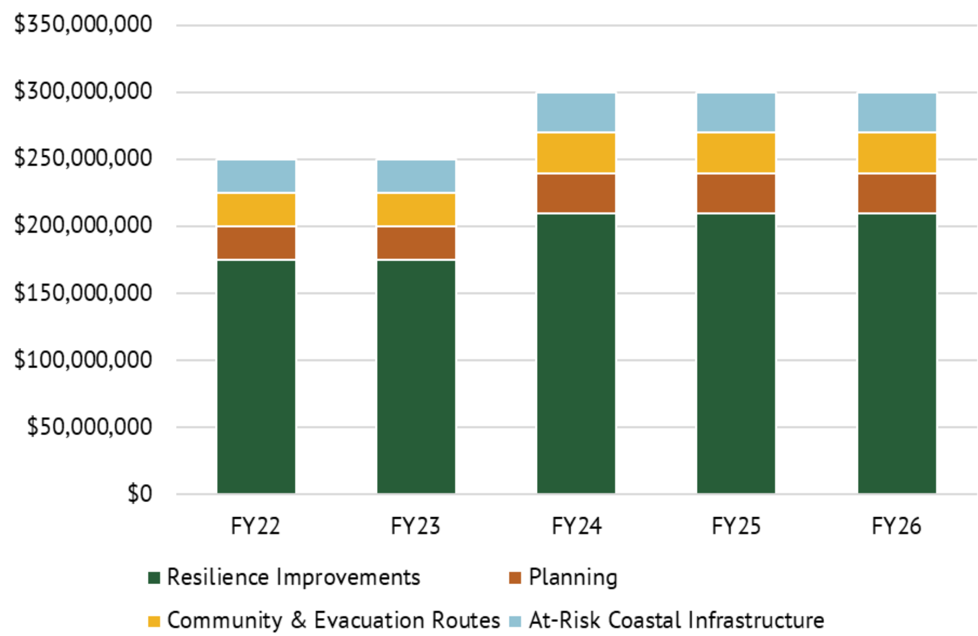


	FY22	FY23	FY24	FY25	FY26
2% Set-Aside	$360,839	$368,056	$375,417	$382,925	$390,584
Any eligibility	$17,681,109	$18,034,731	$18,395,425	$18,763,334	$19,138,600

PROTECT Discretionary Grant Program

The PROTECT Discretionary Grant Program funds projects that can include resilience improvements to highways, public transportation, ports, and intercity passenger rail. Like the formula side of the PROTECT program, there are four different project types that grants are available for including Planning Grants, Resilience Improvement Grants, Community & Evacuation Route Grants, and At-Risk Coastal Infrastructure Grants. The discretionary program retains many of the same eligible facilities, activities, eligible entities, and costs with only minor differences. The total funding authorization for the PROTECT Discretionary Grant Program is $1.5 billion dollars over five years.

Figure 4.4: PROTECT discretionary funding by project type for FY 2022-2026



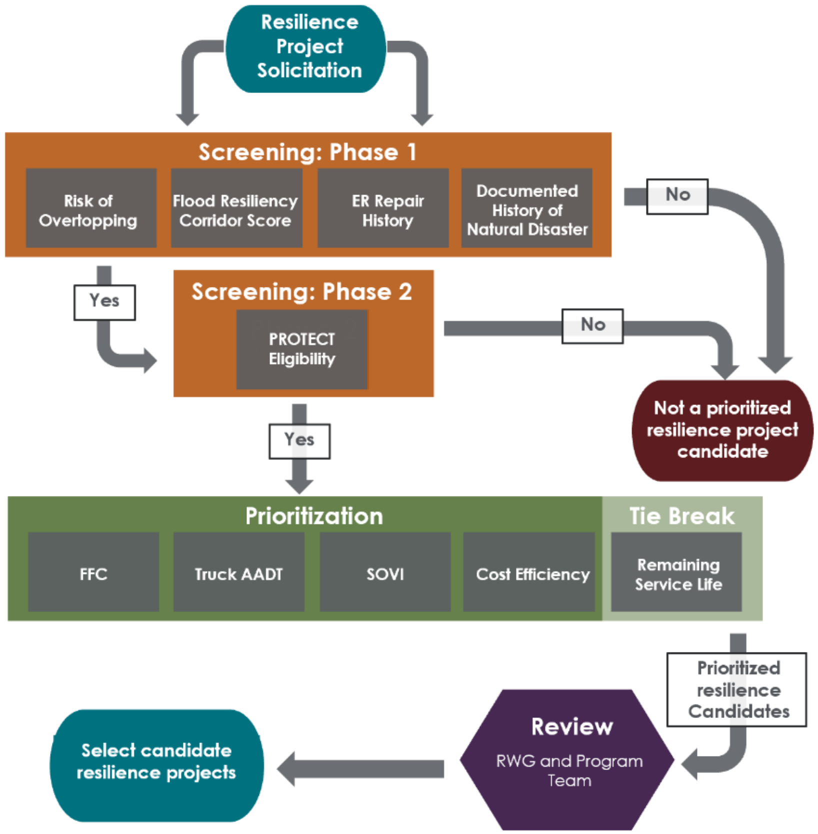
Project Selection and Programming

The Five-Year Program (5YP) lists the investments that translate planning into projects. This document is updated and approved each June by the Iowa Transportation Commission, and encompasses investments in aviation, transit, railroads, trails, and highways. The Iowa DOT has developed a solicitation and prioritization method to identify and select resilience improvement projects to be considered for inclusion in the 5YP.

- **Solicitation**: Each year the department's six Districts are invited to submit resiliency projects for consideration. This solicitation process helps create a robust list of projects of various types throughout the state and provides insight into regional and local needs that are unique to each District. Projects may be programmed or unprogrammed at the time of submittal.
- **Screening**: The first phase screens projects to identify the vulnerabilities that may exist and to which hazards. The second phase evaluates if the identified project is an eligible activity under the PROTECT program, which provides a second confirmation that the project is focused on resiliency. This does not necessarily mean that projects identified through this process will specifically be funded with PROTECT program funds.
- **Prioritization**: Projects are ranked based on how critical the project location is for the system and cost effectiveness, ensuring that the Iowa DOT is effectively using the funds available for the most appropriate improvements.
- **Output**: A composite ranking for each project is produced and used to prioritize. After projects have been scored, they are reviewed by the RWG and Program Team. Ultimately, the prioritized resiliency improvement projects are selected as candidates for programming in the 5YP. The 5YP is then incorporated into the Statewide Transportation Improvement Program (STIP).

The screening and prioritization framework provides the Iowa DOT a structure to rank projects. This will be important in the future when it is anticipated that the number of projects will exceed the availability of funding. The results of this screening and prioritization process will help inform, but not determine, specific project timing and programming. Many factors influence when a project is ready to be programmed and let.

Figure 4.3: Resilience project prioritization process



Iowa's Prioritized Resiliency Projects

The PROTECT Discretionary Grant Program provides a unique opportunity for states to fund projects that support the operation and rapid recovery of crucial local, regional, or national transportation facilities. The program supports the use of innovative and collaborative approaches to mitigating hazards and there is an emphasis on the use of natural infrastructure, also called nature-based solutions, like conservation, restoration, or construction of riparian and streambed treatments, levees, marshes, wetlands, native vegetation, stormwater bioswales, and breakwaters. The Iowa DOT has identified and prioritized several projects (below) that are in alignment with the PROTECT Discretionary Grant Program for future applications. Projects that are not successful in competing for PROTECT Discretionary Grant Program awards will be considered for programming and evaluated against other candidates for PROTECT Formula Program funding.

1. Desoto Bend Extension
Construction of Rand-Peterson Levee (flood fight levee) to protect U.S. 30.
Without this levee, U.S. 30 is impacted by 65-year flood events.

2. Repair of substandard portions of the Rand-Peterson Levee
Reconstruction and repair of portions of the Rand-Peterson Levee in areas where problematic sand boils exist and substandard materials pose risks. This work will support the continued operations of portions of I-29 and U.S. 30 during flood events.

3. Mitigation Sites 2 and 3 – Modale area
These sites maintain I-29 mobility north of the I-29/I-880 systems interchange through a 200-year event.

4. Mitigation Site 1, U.S. 30/Union Pacific Railroad (UPRR) Overflow
This site prevents 'runaway' scouring at the UPRR overflow bridge in the event of a Rand-Peterson Levee failure.
This improvement will allow for mobility to be re-established at a 20-year flowrate.

4.3 Building Resilience

Iowa's Resilience Improvement Plan provides a framework of strategies, countermeasures, and research to draw upon to increase the resiliency of Iowa's transportation system through strategic investment. This plan is being incorporated by reference into the current State Long-Range Transportation Plan (SLRTP), Iowa in Motion 2050, and will be reevaluated in conjunction with subsequent updates of the SLRTP. Future investments will support mitigation of Iowa's most threatening hazards and ensure that our department continues to make lives better through transportation.

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APPENDIX

Coordination with Other Planning Activities

This RIP is the Iowa DOT's primary document to support integration of resiliency into the transportation development process. However, it is important to recognize and point to other plans and documents that inform this plan and help guide resiliency efforts within the state. Consistency and alignment with the following plans and documents is an integral part in fully implementing the resiliency efforts identified in this Plan.

Iowa in Motion 2050

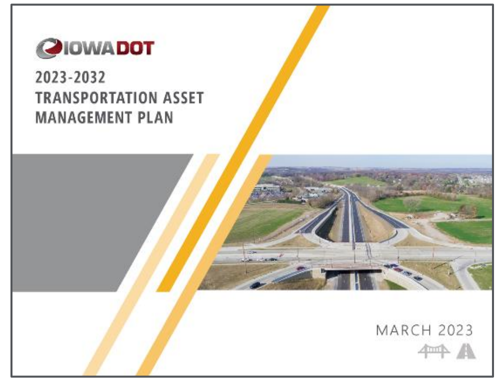
Iowa's State Long Range Transportation Plan (SLRTP) is a multimodal plan that forecasts the demand for transportation infrastructure and services to 2050 based on consideration of social, economic, travel, and technological changes likely to occur during this time. The SLRTP provides the long-range vision, policies, and decision-making framework that will guide investments in Iowa's transportation system over the coming years. The most recent update of the SLRTP included important changes related to transportation resiliency, including integration of a statewide flood resiliency analysis, resiliency rightsizing policy statement, and strategies related to resiliency. The analysis and rightsizing policy were discussed in prior chapters; the two strategy statements are referenced below. This RIP is also being incorporated by reference into the SLRTP.

Resilience Related Strategies

- **Continue advancing resiliency planning at the Iowa DOT**
    - Resiliency is an increasingly important planning area. Proactive analysis and planning efforts, including the work of the Resiliency Working Group should continue to be enhanced, as should disaster response planning. Resiliency considerations should also continue to be integrated into project scoping, prioritization, and design, as well as maintenance and operations, to make assets less susceptible to disruptions.
- **Target investment to address corridors with higher risks from a flood resiliency perspective.**
    - Locations vulnerable to a 100-year flood event were identified by using a resiliency metric that includes robustness, redundancy, and criticality components. For the purposes of the SLRTP, corridors that were one or more standard deviation below the statewide average score were identified as the highest priority corridors from a flood resiliency perspective. These locations should be used to help focus consideration of flood resiliency improvements.

2023-2032 Iowa Transportation Asset Management Plan (TAMP)

Iowa's TAMP is a strategic approach to managing infrastructure. The TAMP provides a systemic 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. The most recent update of Iowa's TAMP included enhanced consideration of extreme weather and resilience in life cycle planning and risk management analysis. A key part of Iowa's TAMP is identifying and mitigating transportation asset management risks. Below are the priority risk and mitigation actions related to resiliency identified in the most recent update.



Reslience Related Risks and Responses

Risk Statement	Response Strategies
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. *<u>Likelihood</u>: 3.9* *<u>Consequence</u>: 4.0*	**3A**. Adapt to and incorporate evolving protective measures utilizing findings of the Resiliency Working Group. **3B**. Incorporate climate change and extreme weather considerations into design manuals and processes.
4. If Iowa DOT takes advantage of increased discretionary funding programs, then additional funds could be available to implement asset management and resiliency investments. *<u>Likelihood</u>: 4.0* *<u>Consequence</u>: 3.5*	**4A**. As an agency be more strategic in pursuing discretionary grants. **4B**. Monitor local agency applications for discretionary grants. **4C**. Coordinate on what will be the priority applications in order to avoid competing internally for funds. **4D**. Undergo vetting process of options within and across the agency.
9. If flooding becomes more severe and/or frequent then additional labor, funding, and other resources will be diverted from TAM and other activities. *<u>Likelihood</u>: 3.4* *<u>Consequence</u>: 3.6*	**9A**. Improve documentation of flood incidents to maximize reimbursement opportunities for Federal ER funds. **9B**. Fund resiliency investments for critical infrastructure (e.g., U.S. 30 over the Skunk River).

Iowa State Freight Plan

The primary purpose of Iowa's State Freight Plan (SFP) is to document the immediate and long-range freight planning activities and investments in the state. The SFP provides guidance on how to address issues, adapt to emerging trends, invest strategically in the freight system to grow Iowa's economy, strengthen the nation's competitive advantage, and enhance the quality of life for Iowans. The most recent update of Iowa's SFP included an enhanced consideration of resiliency and its impact on freight within the state. As part of that consideration, multiple strategies were identified and the key resiliency strategies are listed below.

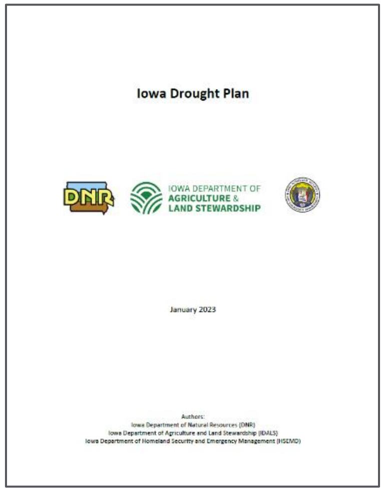
Resilience Related Strategies

- **Improve freight transportation system resiliency**
    - A resilient freight transportation system is responsive. It is able to provide reliable service when small disruptions occur and return to service quickly after large disruptions. Reducing the vulnerability of highway infrastructure by investing in improvements such as roadway grade raises and foreslope erosion countermeasures and working with partners to do the same for other modes and supply chains should be a priority. Operational improvements to address small disruptions can also be made by leveraging real-time information from users of the system to support advanced decision making, incidence avoidance, and faster response times, as well as by providing real-time information on system conditions to support the movement of freight.

- **Target investment in Iowa Multimodal Freight Network (IMFN) at a level that reflects the importance of this system for moving freight.**
    - The IMFN consists of priority airports, highways (including Interstate, U.S., and Iowa routes), railroads, and waterways representing the most critical freight corridors in the state. Operational and physical improvements that increase the safety, efficiency, reliability, and resilience of this network, as well as associated first/last mile connections, should be prioritized.

Iowa Drought Plan

The Iowa Drought Plan was published in 2023 by the Iowa Department of Natural Resources (DNR). The intended purpose of the plan is to provide the state of Iowa with a planned and collaborative approach to plan for, identify, respond to, and recover from drought. To accomplish this purpose the plan establishes drought regions, drought triggers and actions, an assessment of vulnerability and impact, mitigation and response, and implementation steps. Below is a list of the actions identified in the Iowa Drought Plan assigned to the Iowa DOT.


Iowa Drought Plan

IOWA DEPARTMENT OF AGRICULTURE & LAND STEWARDSHIP

January 2023

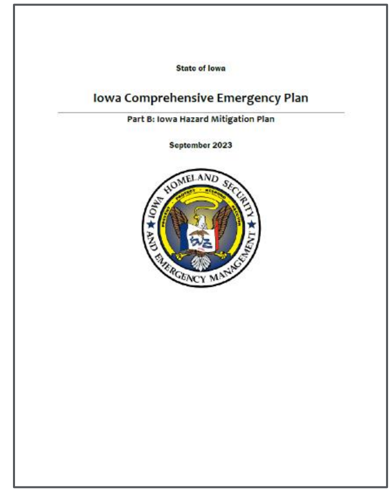
Authors:
Iowa Department of Natural Resources (DNR)
Iowa Department of Agriculture and Land Stewardship (IDALS)
Iowa Department of Homeland Security and Emergency Management (HSEMD)

Iowa DOT Actions

- Encourage and implement green infrastructure practices to create healthier urban environments and manage storm water in cities.
- Expand drought-resistant native plantings along highways and local roads.

State Hazard Mitigation Plan

The purpose of hazard mitigation planning is to identify policies and actions that can be implemented over the long term to reduce risk and future losses of life, property, and economic injury. That State of Iowa Hazard Mitigation Plan is an interagency plan that integrates local and state planning efforts through the State Hazard Mitigation Team, a group comprised of representatives of several state, federal and nonprofit agencies and associations, with the lead agency being the Iowa Department of Homeland Security and Emergency Management (HSEMD). The team performed a hazard analysis and risk assessment in which hazards that may affect the state were identified.


State of Iowa

Iowa Comprehensive Emergency Plan

Part B: Iowa Hazard Mitigation Plan

September 2023

Iowa is one of only 11 states and territories that has an Enhanced Mitigation Plan that has been approved by the Federal Emergency Management Agency. Approval of an enhanced plan qualifies state and local governments to receive additional hazard mitigation disaster funding, which is crucial to funding projects to reduce or eliminate hazards and avoid disaster-caused damage associated costs.

Included in Iowa's State Hazard Mitigation plan is a summary table of mitigation-related programs in Iowa. Below is a listing of programs for which the Iowa DOT is the sponsoring agency.

Iowa DOT Sponsored Programs

Flooding

- **Bridge Watch**
  - A web-based monitoring software solution that empowers bridge owners to predict, identify, prepare for, manage, and record potentially destructive environmental events. Proactively monitors, in real time, road overtopping and bridge infrastructure to better protect against hazardous, costly, and potentially catastrophic events. Iowa DOT personnel are now able to examine those bridges that are at risk, rather than blanketing an area of the state where flooding may be occurring.
- **Roadside vegetation grants**
  - Three percent of REAP funds are available through the Iowa DOT's Living Roadway Trust Fund (LRTF) for integrated roadside vegetation management (IRVM) activities, including the establishment of native prairie vegetation in rights-of-way. Low-maintenance prairie roadsides reduce erosion, slow runoff, trap sediment, and provide habitat.

Hazardous Materials

- **Cargo Tank Program**
  - Similar to the hazardous materials awareness for First on the Scene Program. This is both education about hazardous materials and instructions on regulations.
- **Distribution of Emergency Response Guidebook to first responders**
  - Through a joint effort of the Iowa DOT Motor Vehicle Enforcement Bureau, the DNR, and HSEMD the guidebook is distributed to fire departments, law enforcement agencies, emergency medical services, and other emergency responders. This includes all state, local, EMS responders, and DOT groups.
- **Hazardous materials awareness for First on the Scene Program**
  - The training program is to educate members of the motor carrier industry, agricultural dealers of chemicals, petroleum marketers, and propane gas associations on hazardous materials awareness and regulations.

Infrastructure Failure – Transportation Incident

- **Federal-Aid Rail/Highway Crossing Safety Program**
  - The Crossing Safety Program participates in the cost of safety improvements at rail/highway crossings. It is funded by the Federal Highway Trust Fund. These funds are used to install new crossing signal devices, to upgrade existing signals, to improve crossing surfaces, and to provide low-cost improvements, such as increased sight distance, widened crossings, increased signal lens size, or crossing closures.
- **Rail Revolving Loan and Grant (RRLG) Program**
  - The RRLG Program provides funding to improve rail facilities that will spur economic development and job growth and provide assistance to railroads for the preservation and improvement of the railroad transportation system.
- **State Grade Crossing Surface Repair Program**
  - Provides annual appropriation from the Road Use Tax Fund to assist railroad companies and highway jurisdictions repair rail/highway grade crossings. The Grade Crossing Surface Repair Fund will pay 60% of the cost of repairs, with the responsible roadway jurisdiction and the railroad company each paying 20%.
- **Traffic Safety Improvement Program**
  - Traffic safety improvements or studies on public roads under county, city, or state jurisdiction.

Radiological

- **Highway Route Controlled Quantities**
  - This is a program to train officers to inspect trucks carrying radioactive waste (spent fuels).

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