Quad Cities

Iowa/Illinois MPO

Extreme Weather and Transportation Resilience Report

September 2020

Bi-State Regional Commission

U.S. Department of Transportation
Federal Highway Administration

Quad Cities Iowa/Illinois MPO

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NOTICE:

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[3] Vice-Chair, Transportation Technical Committee.

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NOTE: Additional membership may include advisory representatives from the Illinois and Iowa Departments of Transportation, planning and research engineers from the Illinois and Iowa Federal Highway Administration, and a community planning representative from the Federal Transit Administration Region VII.

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Chapter 1 Introduction

A safe and reliable transportation network is critical to the functioning of a community. This is never more obvious than during a sudden and extreme weather event. In worst case scenarios, the transportation network is a means of providing emergency supplies to residents, conveying the injured to hospitals and trauma centers, and then bringing resources into the community to aid in the recovery. Even in events that cause less extensive damage, disruptions to the transportation network can impair the ability of residents to travel efficiently to their homes, businesses, schools, and institutions, affecting the day-to-day functioning of workplaces and households.

Study purpose

The purpose of this study is to assess the vulnerability of the transportation network in the Quad Cities, Iowa/Illinois Metropolitan Planning Area to extreme weather disruptions and identify adaptation strategies to mitigate their effects. With a 2018 grant from the Federal Highway Administration for a Resilience and Durability to Extreme Weather Pilot Program, Bi-State Regional Commission was able to conduct this vulnerability assessment study for the Quad Cities metropolitan area, document a model process for other peer metropolitan areas, and incorporate findings in the *2050 Quad Cities Long Range Transportation Plan*.

Extreme weather events

In recent decades, many types of extreme weather events have increased in strength and frequency. Within the 28-month grant period for this project, several record-breaking weather events occurred in the Quad Cities Area. Among other events, these new records included:

- Records for daily maximum rainfall occurring on August 28, 2018 (3.31 inches), Nov. 4, 2018 (1.17 inches), and Feb. 23, 2019 (1.48 inches)
- Record for daily high temperature of 94 degrees for September 2019
- Record for monthly snowfall (30.2 inches) in January 2019
- All-time record low temperature of -33 degrees, recorded January 31, 2019

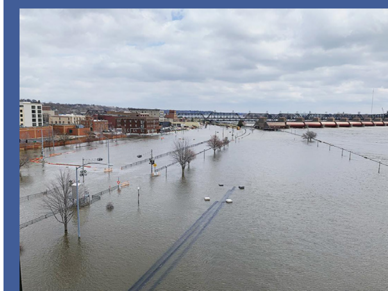
Record of 51 days for the length of time the Mississippi River has been at or above major flood stage (18 feet), set March 24-May 12, 2019

- Highest flood crest recorded on the Mississippi River in the Quad Cities Area, 22.7 feet, recorded May 2, 2019

The record-breaking winter events resulted in regional disruptions that included cancelled flights and Amtrak service regionally, stranded semi-trucks along the Interstate highways, suspended mail delivery, broken water mains, and an inability for Quad Cities residents to travel to school and work.

Likewise, the record flooding that followed disrupted traffic patterns through downtown Davenport and across the Centennial and Government bridges, displaced residents, caused business closures, and resulted in lost economic activity estimated by the Downtown Davenport Partnership to total $2.5 million per month. It also created construction delays for the I-74 Mississippi River Corridor reconstruction project and added greater traffic congestion within the work zone resulting from these other bridge crossing limitations in the core metropolitan area, and elsewhere on the road network.

MISSISSIPPI RIVER FLOODING



RIVER ICE AND SNOW

MISSISSIPPI RIVER FLOODING

Notable among the infrastructure impacts was the April 29, 2019 breach in a temporary HESCO flood barrier that resulted in inundation of additional areas of Davenport. The structural failure was initially attributed to the erosion of the road surface beneath the barrier. Although the cause was later determined by the U.S. Army Corps of Engineers to be a lack of friction between the barrier and the pavement surface[1], both possibilities underscore the integral connection between permanent infrastructure and any additional, emergency structures put in place. Unless existing facilities are able to maintain some level of function in the face of extreme weather events, they may not be able to adequately sustain the structural integrity of emergency measures.

While such events do not indicate that every winter going forward will have the same amounts of snow, every summer the same high temperatures, or every rain event the same volume of precipitation, they do point to a trend of increasing variability in area weather events. Although we do not know exactly what that variability will entail from one year to another, data collected by the National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA) does point to a clear pattern of extreme weather events becoming more common now as compared to the past.

Pilot study

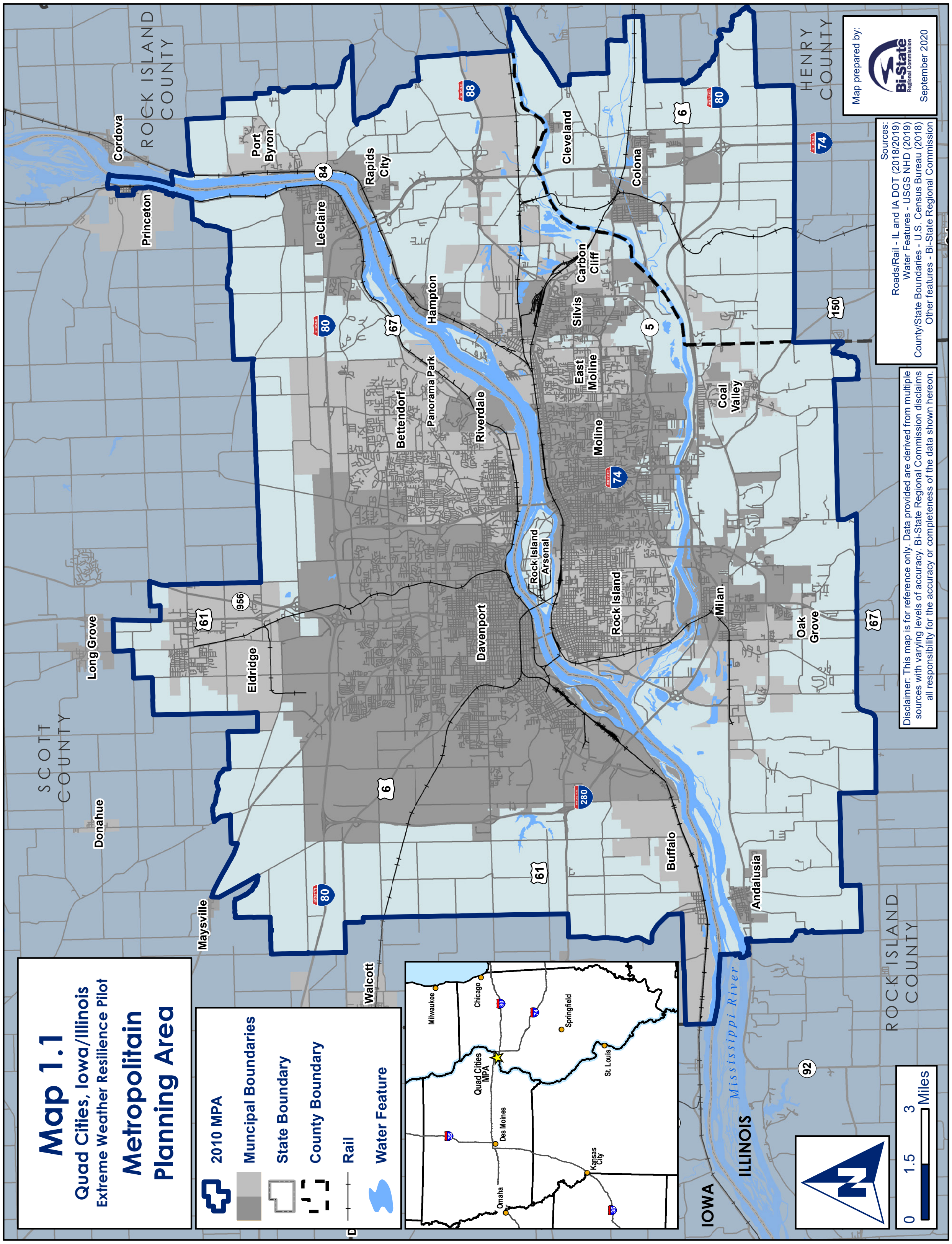
This study differs from a disaster preparedness plan or an emergency evacuation plan in that it is less focused on formulating a response to sudden, infrequent events and directed instead at identifying vulnerabilities in the transportation network that might result from more persistent and pervasive weather stresses occurring with increased frequency. Extreme weather, in this case, is best understood as those events that fall on the outer limits of observed phenomena whether or not their impact is immediate. This can include some catastrophic events such as tornadoes or flash flooding, but also includes extreme high and low temperatures, recurring freeze-thaw cycles, precipitation events of extreme volume and duration, and flooding that lasts for months rather than days. This study asks what the impacts of repeated exposure to such extremes might be on the transportation network and seeks to identify adaptation strategies that might enable the network to better withstand them.

1 https://www.wvik.org/post/report-reveals-why-davenports-temporary-levee-failed#stream/0

Study area

The Quad Cities is a metropolitan area located in western Illinois and eastern Iowa divided by the Mississippi River. Refer to Map 1.1. for the geographic boundary of the Quad Cities metropolitan planning area. Combined, the communities that make up the metropolitan area are home to about 300,000 people and are served by a true diversity of transportation facilities. This includes Interstate Highways 74, 80, 88 and 280, as well as various state and local roads; freight rail lines maintained by Canadian Pacific, Burlington Northern Santa Fe, and Iowa Interstate railroads; the Quad City International Airport in Moline and the Davenport Municipal Airport; passenger rail service that is under development and will terminate in a newly constructed station in Moline; multiple river terminals and two Mississippi River lock and dam pools (14 and 15); and more than 100 miles of trails, including two national trails, the Mississippi River Trail (MRT) and the American Discovery Trail (ADT), on either side of the Mississippi. There are also several bridge crossings over the Mississippi and Rock Rivers, the oldest of which is the Government Bridge, a 360-swing span structure built in 1896 and still in active use today accommodating vehicular, rail, pedestrian, bicycle, and river barge traffic. The newest bridge, a twin-span 6-lane bridge for I-74, is currently under construction and scheduled to be completed in 2021.

Despite the geographic boundaries, the residents of the Quad Cities are accustomed to moving freely between the different communities that make up the metropolitan area. Maintaining the smooth operation of so many transportation facilities requires coordinated efforts among the many Quad Cities communities, particularly given the famously changeable Midwestern climate. Past resilience efforts have included the development of two county FEMA predisaster hazard mitigation plans for Rock Island County, Illinois, and Scott County, Iowa, in which the Quad Cities are located, that identified river flooding, flash flooding, combined storms (hail, lighting, thunder, wind, and tornado), severe winter storms, heat, and levee failure events all as potential hazards. The area also experiences some limited extreme cold as well as extreme heat events. Each of these has varying degrees of impact on the transportation system related to surface travel, river navigation, and facility or asset conditions.


Map 1.1
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Metropolitan Planning Area
2010 MPA
Muncipal Boundaries
State Boundary
County Boundary
Rail
Water Feature
SCOTT COUNTY
ROCK ISLAND COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
Cordova
Port Byron
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Quad Cities MPA
Des Moines
St. Louis
Omaha
Kansas City
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Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
Map prepared by:
Bi-State Regional Commission
September 2020

Metropolitan planning organization

The Bi-State Regional Commission serves as a forum for intergovernmental cooperation and provides assistance to local governments, including those in the Quad Cities, in planning and project development. As the designated Metropolitan Planning Organization (MPO) for the Quad Cities Area, Bi-State is responsible for the Quad Cities Long Range Transportation Plan, and Bi-State Staff helped prepare both the Scott County and Rock Island County hazard mitigation plans. [Bi-State likewise prepared two evacuation plans for the area and worked with local and state partners to prepare an incident management plan for the metropolitan area.] This study builds on the work done for those plans by undertaking a more in-depth examination of the vulnerabilities related to extreme weather events. It also evaluates adaptation strategies that could be adopted to increase the resilience of the multi-modal transportation system.

**FLOOD FIGHTING
MAY 2019**

Key findings

Climate

Chapter 4 identifies those elements of climate change and extreme weather that will impact the Quad Cities in the short-term and long-term future. The Midwest will see an increase in annual precipitation, extreme precipitation events, and changes in seasonal precipitation patterns for spring and summer. Local area annual precipitation trends follow these upward regional trends. The extremes are becoming more extreme. Annual average maximum temperatures are rising. Wet springs are followed quickly by hot dry summers and fall leading to drought conditions. Temperature differentials will play a role in freeze-thaw cycles and the creation of fog.

**WINTER FLOODING
FEBRUARY 2019**

Impacts to critical and vulnerable facilities

The climate and extreme weather changes will result in disruptions of the metropolitan area transportation system based on climate trends if mitigation measures or adaptation strategies are not employed for critical and vulnerable facilities. The resultant increased precipitation events lead to flooding. This was the more prevalent stakeholder discussion as part of this pilot study as outlined in Chapters 3 and 5, and as a direct result of extreme weather events in 2019. Freeze-thaw events and fog were also interesting extreme weather contributors to the disruption in travel for a variety of modes, including air and water navigation based on stakeholder input.

ICE STORM
FEBRUARY 2019

FREEZE THAW
PAVEMENT EFFECTS

A criticality and vulnerability analysis was conducted during the pilot study, and indicates that the Mississippi River and Duck Creek flooding will require attention in mitigating extreme weather hot spots in the metropolitan area. Temperature extremes will require application of adaptation strategies from a more widespread approach, such as more durable materials or those than can withstand wide variations in temperature. For ice and winter snow storms, looking at higher speed and traffic corridors, the interstates and U.S. highway routes were assessed as facilities requiring adaptation strategies to move people and goods safely. Since 1995, there have been 157 to 377 extreme wind events by county respectively, recorded by the National Weather Service. The August 10, 2020 derecho with maximum wind speeds through the Quad Cities of 80 mph or higher highlighted area susceptibility to disruptions of roadways by downed power lines and trees, and facilities dependent on single power sources.

Mitigation and adaptation strategies

Adaptation strategies to mitigate extreme weather events are as varied as the events and assets that are impacted. From a practical perspective, these strategies mirror some of the same elements that traffic safety programs promote: engineering solutions, education and outreach, emergency response with the added emphasis on transformational policies that will address climate change and reverse the predicted extreme weather episodes.

While climate change is global, weather is local. They each affect our metropolitan area in a variety of disruptive ways, through road closures, air travel delays, temporary and permanent transportation infrastructure damage, and a number of other impacts. Adaptation strategies are also local to the type of extreme weather events predicted to recur and a strategy's capacity to mitigate or eliminate disruptions of the transportation system or asset. More universally to these local solutions are those that can be applied consistently through standards in project or facility design for durability and resistance to the weather elements.

Applicability to other metropolitan area planning organizations

The pilot served two purposes. One, to develop a path forward to discuss climate change and resilience in the MPO Long Range Transportation Plan update, and bring it forward into the transportation planning process. Two, to model the use of the FHWA Vulnerability Assessment and Adaptation Framework with in-house staff resources to build capacity in climate change knowledge and analysis of critical and vulnerable facilities as a roadmap for other peer organizations. Lessons learned include: using regional documents to frame the climate change impacts and limiting the deep-dive into local weather data for later research and analysis; understanding limitations of local stakeholder knowledge, data and feedback as part of the first iteration of the planning process; and providing more time to review the vulnerability assessment data to frame overarching themes for adaptation strategies. As with any pilot, lessons learned help frame future efforts and conversations on resilience.

Chapter 2 Project Scope

RESILIENCE

The ability to prepare and plan for, absorb, recover from, or more successfully adapt to adverse events

— AASHTO

Resilience and the planning process

In recent years, increased emphasis on mitigation and adaptation activities aimed at addressing a range of vulnerabilities has resulted in a many definitions of "resilience." Although they can differ in details, each is based on the ability of a system or community to continue functioning under challenging conditions. For the purposes of this study, the definition established by the American Association of State Highway and Transportation Officials (AASHTO) has been employed as the working definition of resilience and applied to all transportation modes.

Resilience, as defined by AASHTO, is "the ability to prepare and plan for, absorb, recover from, or more successfully adapt to adverse events." Like mitigation, it includes efforts undertaken in advance to protect assets from damage or disruption ("prepare and plan for… adverse events"). It moves beyond mitigation, though, to also include activities during an event to maintain some level of operations ("absorb… adverse events"). Likewise, it further includes efforts following an event to return a system to a previous or improved level of functioning ("recover" and "more successfully adapt to adverse events").

This understanding of resilience touches on a range of activities, from design and construction to maintenance and repair, and necessitates cooperation and coordination between the many agencies and functional units responsible for these activities. Within the Quad Cities metropolitan area, an added layer of collaboration across municipal and state boundaries is also required. Extreme weather events, after all, do not stop at jurisdictional boundaries or change how they manifest to match different resilience strategies adopted in different locations.

A shared emphasis on resilience throughout the transportation network can result in a number of collective benefits for the Quad Cities, including:

- Safeguards to protect the investments made within each community to ensure transportation access to and from their jurisdictions

- Assurances for residents, businesses, and other transportation users of reliable and efficient transportation facilities
- Established lines of communication that can be activated to speed recovery during an adverse event
- Recognition of the connection between the transportation system and other policy areas such as economic activity or health and safety, and vice versa, for other resilience planning efforts
- Consideration of cascading effects of system failure and the ability to collaborate on precautions
- Evidence for local government bonding requirements that "due process" of infrastructure risk has been duly considered
- Compliance with risk-based asset management requirements for federal funding of projects

By undertaking a study of extreme weather and transportation system resilience now, this project aims to identify the most critical and vulnerable assets, assess vulnerabilities, and identify adaptation strategies and best practices that can be incorporated into future planning documents. This includes the Long Range Transportation Plan, *2050 Quad Cities Long Range Transportation Plan,* forthcoming in 2021, as well as future land use plans, transit development plans, and transportation improvement plans. It also aims to determine priorities among transportation stakeholders and instigate ongoing discussions of resilience for planning purposes.

Extreme weather

The connection between climate change and extreme weather events has resulted in the terms sometimes being used interchangeably. However, they are most easily distinguished by understanding extreme weather events as individual (though often repeated) occurrences and climate change as pertaining to aggregated long term trends. The connection between the two is explored in more detail in Chapter 4.

Generally speaking, an extreme weather event is one that falls outside the normal patterns recorded by meteorologists. Although similar events may have occurred in the past, they have not done so with the same frequency as other events considered normal. The definition of "extreme weather" can therefore vary by season and geography. For the purposes of this study, definitions established by the National Weather Service for extreme weather events for this region were used. This includes:

- **Extreme precipitation** – Effective rainfall in excess of infiltration capacity – more than 2 inches of rain within a 24-hour period in the Midwest
- **Excessive heat** – A heat index of 105 degrees F or greater that will last for 2 hours or more
- **Excessive cold** – Wind chill warnings and advisories are set locally at a threshold when the wind chill falls below an expected level, and are based on the rate of heat loss from exposed skin caused by wind and cold
- **Extreme wind** – Sustained, non-convective winds of 35 knots (40 mph) or greater lasting 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration of time
- **Severe storms** – Thunderstorms that produce a tornado, winds of at least 50 knots (58 mph), and/or hail at least 1 inch in diameter
- **Severe winter weather** – A combination of heavy snow, blowing snow and/or dangerous wind chills, including blizzards, ice storms that result in an accumulation of at least 0.25 inches of ice on exposed surfaces, and snow squalls
- **Flash flooding** – A flood that is caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours
- **River flooding** – The rise of a river to an elevation such that the river overflows its natural banks – defined locally as a crest of 15 feet or more on the Mississippi River at Davenport and a crest of 12 feet or more on the Rock River at Moline. Major flooding is defined as a crest of 18 feet on the Mississippi River at Davenport or more and 14 feet or more on the Rock River at Moline.[1]

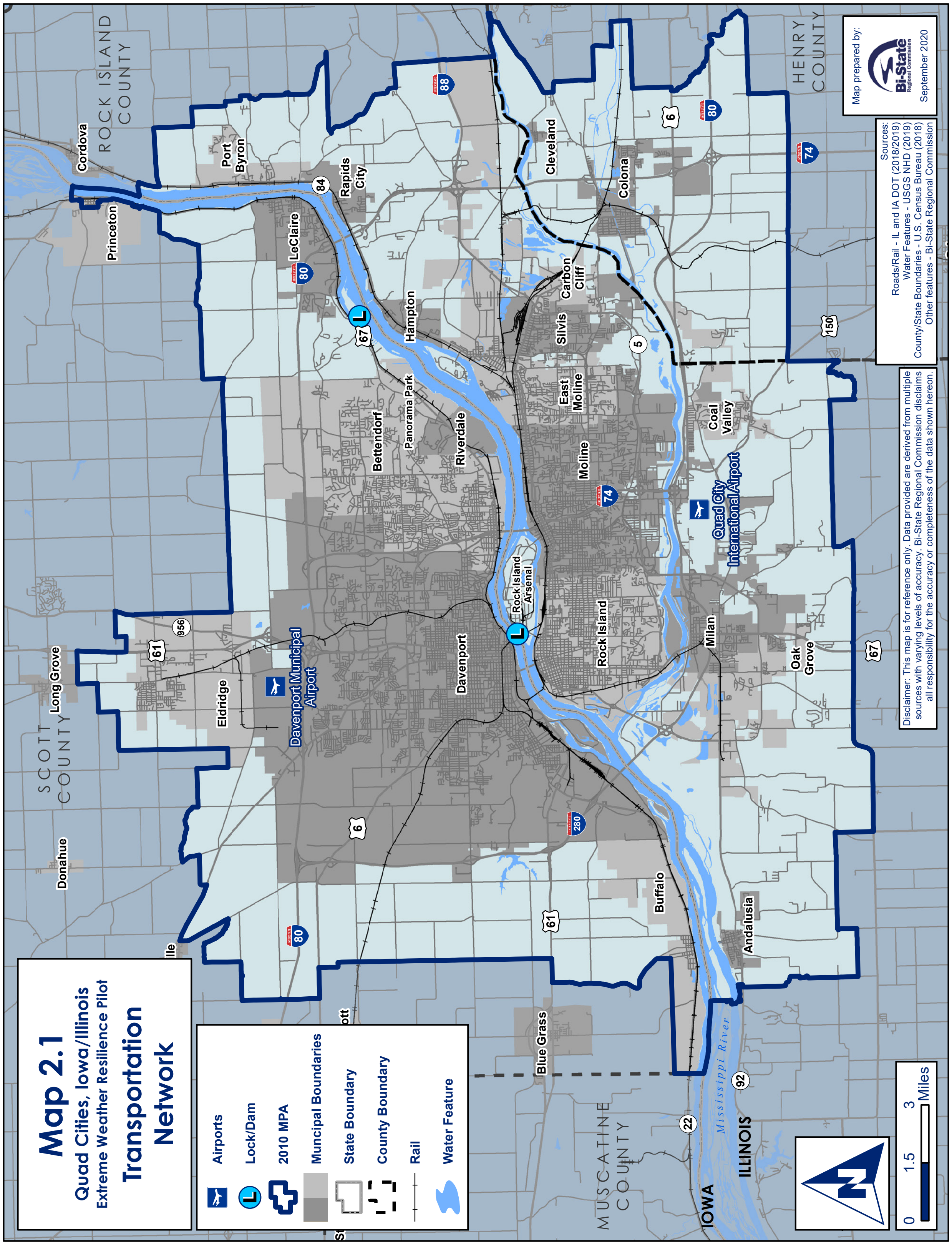
Geographic focus

To reiterate, the Quad Cities is a metropolitan area located in western Illinois and eastern Iowa. Geographically, the area is defined by the Mississippi River, which runs along the border between the two states and through the heart of the Quad Cities, and the Rock River, which flows through Illinois and bounds the Quad Cit-

1 National Weather Service, https://w1.weather.gov/glossary/ and https://www.weather.gov/bgm/severedefinitions

ies to the south. Both rivers flow in an east-to-west direction in this area, with the communities of Davenport, Bettendorf, Riverdale, and LeClaire located along the northern banks of the Mississippi River, and the communities of Rock Island, Moline, East Moline, and Hampton situated on the southern banks. In addition, portions of Rock Island and Moline are located along the Rock River to the south, as are northern portions of the communities of Milan and Coal Valley. The communities of Silvis, Carbon Cliff, and Colona are also affected by the Rock River to varying degrees. Map 1.1 outlines the geographic boundary of the Quad Cities Metropolitan Planning Area (MPA) and the major communities contained within that boundary in Chapter 1.

The area is served by a number of transportation facilities, each with their own vulnerabilities. Map 2.1 represents the transportation system within the Quad Cities MPA. A portion of the metropolitan area is unprotected by the upper Mississippi River levee system, including the largest community, Davenport, Iowa where flooding impacts to the state highway, railroad tracks, and pedestrian and bike trails are growing in frequency and duration. Two Mississippi River lock and dam pools (14 and 15) within the metropolitan area have aging infrastructure maintained by the U.S. Army Corps of Engineers and are on a fix-as-fails maintenance regime.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Quad Cities, Iowa/Illinois
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Lock/Dam
2010 MPA
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SCOTT COUNTY
ROCK ISLAND COUNTY
HENRY COUNTY
MUSCATINE COUNTY
IOWA
ILLINOIS
Mississippi River
Davenport Municipal Airport
Quad City International Airport
Davenport
Bettendorf
Rock Island
Rock Island Arsenal
Moline
East Moline
Silvis
Carbon Cliff
Colona
Cleveland
Hampton
Rapids City
Port Byron
Cordova
Princeton
LeClaire
Panorama Park
Riverdale
Eldridge
Long Grove
Donahue
Blue Grass
Buffalo
Andalusia
Milan
Oak Grove
Coal Valley

The oldest river crossing in the metro area is the 1896 Government Bridge at the Rock Island Arsenal (RIA), a 360-swing span vehicular and rail bridge at Lock and Dam 15. Still a viable crossing, this bridge is just past 10 percent of its design life. The newest river crossing is a replacement of the existing I-74 river crossing. It will be a twin-span 6-lane interstate Mississippi River bridge and is currently under construction. It will provide a reliable and redundant crossing of the upper Mississippi River in the greater region. The new bridge is designed to withstand a full barge impact at flood stage and to mitigate potential impacts of an earthquake from the New Madrid Fault in southern Illinois and Missouri. Other major river crossings include the U.S. 67/Centennial, I-80, and I-280 bridges which, though at various points in their respective design lives, provide additional redundancy for travelling between the two states.

The metropolitan area also is served by freight rail, Canadian Pacific, Burlington Northern Santa Fe, and Iowa Interstate railroads, with several lines that run parallel to the Mississippi River. Passenger rail service is under development from Chicago to Quad Cities, and a new station in Moline nearing completion. Like the rail lines, two key national bike and pedestrian trails, the Mississippi River Trail (MRT) and American Discovery Trail (ADT), are positioned alongside the Mississippi River. While some portions of the ADT are located atop the levy on the Illinois side of the river, other portions of that trail and nearly all of the MRT are located in the floodplain and therefore subject to flooding. While the freight rail companies have equipment that enables them to raise their rail lines out of the floodwaters in order to continue operations, the trail systems must be closed during flooding.

The passenger rail station under development ties into a three-system transit network serving the metropolitan area as well as two regional transit systems serving urban-rural connections. Of these systems, the Citibus transit station in downtown Davenport is located in an area most susceptible to flooding impacts from the nearby Mississippi River. However, a combination of station design and temporary flood measures put in place as needed by Davenport has allowed that station to continue functioning during periods of flooding. The MetroLINK transit station in Moline (which is connected to the future passenger rail station) is sufficiently removed from the Mississippi River to not be regularly impacted by flooding. The MetroLINK transit station in Rock Island, though close to the river, is currently protected by the levee along the stretch of the Mississippi River on Rock Island's northern border. A levee breach, however, would result in impacts to that station.

GOVERNMENT BRIDGE

I-74 BRIDGE

I-80 BRIDGE

METROLINK STATION

Both the Quad City International Airport in Moline and the Davenport Municipal Airport are located sufficiently far from the rivers so as to not be subject to flooding concerns. Like all airports, the large open areas in which they function make them more vulnerable to impacts from high winds. They are also periodically subject to delays as the result of heavy precipitation in the form of severe storms, snow, and ice. However, most weather events fall within the parameters either airport is able to address through normal operational procedures.

Limitations of project scope

A more thorough discussion of the geographic vulnerabilities and extreme weather impacts are explored in subsequent sections of this report. It is worth noting, though, that however detailed the project findings may be, certain limits exist simply as a result of the project scope itself. No city exists in a bubble. While that is often taken as a matter of course within the Quad Cities metropolitan area, where the necessary collaboration across municipal and state boundaries underscores the interdependence of the constituent jurisdictions, it is equally true of the connections between the Quad Cities and the surrounding states and metropolitan areas.

For example, there is appreciable redundancy in the number of bridge crossings over the Mississippi River within the Quad Cities Area, allowing for continued egress even when one of the crossings is impaired or otherwise restricted. The flow of traffic may become slower on the other crossings as a result of vehicles diverted from the other bridge, but on the whole, the system continues to function. However, a bridge failure or disruption in access to that structure further upstream or downstream has the potential to add stress to the traffic system as more regional traffic gets diverted to the Quad Cities crossings – even more so if bridges within the metropolitan area are impacted by the same event.

The regional connections are even more pronounced in the case of the lock and dam system along the Mississippi River. The two locks and dams within the Quad Cities metropolitan area are not the only such infrastructure functioning past the end of its intended design life. If any one of the downstream locks or dams were to fail, barge traffic passing through the Quad Cities to the Gulf of Mexico would effectively cease, with profound economic impacts, particularly to the agricultural sector for which the river functions as a major way of shipping commodity grains to international markets. Recovery from such a catastrophic lock and dam failure would take years, during which time extra stress would be placed on truck and rail systems with detrimental effects to that infrastructure.[2]

Just as the transportation network within the Quad Cities is connected by degrees to outlying regional, national, and international networks, weather events experienced within the Quad Cities are likewise part of weather systems that extend well beyond the boundaries of the metropolitan areas. Chapter 4 discusses the connection between extreme weather events and climate change, which is subject to impacts from many different human activities; and the Chapter 5 outlines types of measures that can be taken to mitigate these effects on the transportation network. It is important to note, however, that climate change is a global challenge requiring multi-layered and coordinated efforts from many stakeholders in order to safeguard the healthy functioning of weather systems.

This project is necessarily limited to examining impacts to the Quad Cities metropolitan area and adaptation strategies that can be used to address transportation vulnerabilities within those boundaries. Some policy recommendations, such as support for the reduction of fossil fuel use and decreasing the use of volatile chemicals for agricultural applications, can be initiated on the local level. However, they will be most effective when adopted as part of larger regional, national, and even international efforts to address climate change. By pursuing these strategies locally, the Quad Cities can serve as an important partner in these efforts while also meeting its own needs to protect local investments made in transportation infrastructure and operations.

2 Center for Ports and Waterways, Texas Transportation Institute, "America's Locks & Dams: A Ticking Time Bomb for Agriculture?", December 2011. https://static.tti.tamu.edu/tti.tamu.edu/documents/TTI-2011-9.pdf

Chapter 3 Planning Process

FHWA framework

In January 2018, a solicitation was sent out by the Iowa Division of the Federal Highway Administration (FHWA) for letters of interest in a Resilience and Durability Pilot Project. The program purpose was for FHWA to seek State Department of Transportation, Metropolitan Planning Organizations (MPO), Federal Land Management Agencies to address one of three resilience solutions:

1) Integrating resilience and durability into agency practices
2) Using available tools and resources to assess the vulnerability and risk of transportation projects or systems
3) Deploying a resilience solution and monitoring performance

The pilot program sponsor, FHWA Office of Planning Environment and Realty, facilitates the Resilience and Durability to Extreme Weather Program to address transportation network interruption, repair, and maintenance under natural disaster events and increasing effects of climate change, particularly the variability and effects of extreme weather events. The program was established in 2010 with five pilots, and in 2018, eleven pilots were awarded funds to examine extreme weather resilience and transportation. Refer to www.fhwa.dot.gov/environment/sustainability/resilience/pilots for more details on the Resilience Pilots.

In February 2018, Bi-State Regional Commission submitted a letter of interest to assess the vulnerability and risk to the transportation system in the Quad Cities, Iowa-Illinois and enable the MPO to incorporate findings into the *2050 Quad Cities Long Range Transportation Plan* update. A federal requirement for the metropolitan plan is to include resilience as an issue to examine. In late February 2018, Bi-State Regional Commission was allocated $37,500 in Surface Transportation Research, Development, and Deployment funds. In addition, Illinois State Comprehensive Planning Funds in the amount of $37,500 and local member funds of $1,500 were used to match the federal dollars, for a total project cost of $75,000. Bi-State Regional Commission became one of the eleven pilots awarded funds in the 2018-2020 period.

Project process

Extreme weather events can have a significant impact on the transportation system either as short-term disruptions to mobility and connectivity within a metropolitan area or longer-term effects on the infrastructure related to maintenance, facility condition or facility failure. The intent of this pilot project was to apply the FHWA *Vulnerability Assessment and Adaptation Framework*, Third Edition (December 2017) to assess and understand extreme weather threats on transportation infrastructure in the Quad Cities Metropolitan Area, and utilize the information to frame future projects and decisions related to the *2050 Quad Cities Long Range Transportation Plan*. The project was conducted in-house without consultant services. Data was used from available federal, state, and local sources that was readily available and/or could be used to develop specific analysis for the metropolitan area. It was important that the project be replicable by other peer MPOs in Iowa and Illinois.

The project scope of work followed the elements of the *Vulnerability Assessment and Adaptation Framework*. The following items were proposed and will be discussed further in this chapter as they unfolded in the pilot process description. The Bi-State Regional Commission proposal indicated:

1) Develop Extreme Weather Transportation Planning Advisory Committee and solidify the extreme weather planning effort, including objectives, assets, and hazards.

   a) Establish Planning Advisory Committee based on multidisciplinary partners (Examples include transportation planners, city/county planners, asset managers, transportation maintenance personnel, emergency responders, engineers, climate research centers/climatologists, and environmental resource agency staff.)

   b) Review Pilot Program objectives and the Vulnerability Assessment Adaptation Framework.

   c) Summarize hazard mitigation planning within the Quad Cities and discuss the explicable weather related hazards that would apply to the transportation system.

   d) Define resiliency and vulnerability in local terms, whether related to facility stage of life, vital or critical facilities, recurring effects, or geography.

2) **Secure data on transportation assets and on climate, and assess potential effects**.
   a) Review best practices in vulnerability assessments.
   b) Work with emergency management, natural resource, and environmental partners to secure applicable climate variables, such as temperature, precipitation, freeze-thaw cycles, drought trends, and streamflow data.
   c) Work with state and local transportation officials to determine the transportation asset types to assess and determine the level of detailed data available for smaller assets, such as culverts.
   d) Analyze where extreme weather events intersect with the transportation system geographically, by recurrence, or by facility condition or failure.

3) **Access vulnerability and analyze adaptation options**.
   a) Review data and analysis with the Planning Advisory Committee and other appropriate stakeholders in workshop format to facilitate discussion on ways to mitigate effects.
   b) Identify most critical and vulnerable facilities or assets (current and future) for long-range planning purposes, that may involve some scenario analyses and/or indicator-based desk review based on determined criteria and risk.
   c) Cross-reference with long-range planning goals and objectives, including connectivity, accessibility, multimodal nature, safety and security, environmental justice, and resource effects.
   d) Identify types of adaptation options available and best practices for potential application, based on vulnerability assessment, including relative costs, as appropriate.

4) **Determine priorities and opportunities to incorporate adaptation into the transportation planning process**.
   a) Use a workshop with stakeholders to recommend priorities, including "no action" and "action" items, relative cost, and other criteria for determining priorities.
   b) Finalize prioritization with the Planning Advisory Committee which adaptation options would best address the critical facilities and assets within the metropolitan area.

5) **Determine and work to integrate assessment results into existing transportation programs and put into practice**.
   a) Integrate resiliency and sustainability into the *2050 Quad Cities Long Range Transportation Plan* (March 2021) based on the priorities identified in the Extreme Weather Adaptation Vulnerability Assessment.
   b) Integrate Extreme Weather Adaptation language into the Transportation Improvement Program and consider ways to incorporate the weather and climate results and criteria into other planning and programming opportunities for the MPO.
   c) Consider a design-oriented policy framework to include extreme weather adaptation as part of transportation system design, based on the vulnerable facilities and assets identified as part of the Pilot Program process.
   d) Catalog or direct local and regional stakeholders to extreme weather adaptation resources and toolkits to further education and local knowledge and capacity on this subject.

In addition to the local pilot effort, a component of the Resilience and Durability to Extreme Weather Program included two peer exchanges where those awarded pilot funds shared project status, learned of other prior pilot programs, and advanced the discussion of creating a more resilient transportation system through planning for extreme weather and climate change. Sessions were held in December 2018 and December 2019 at U.S. Department of Transportation headquarters in Washington, D.C.

Lessons learned

As a pilot project, lessons learned will add to the depth of knowledge as part of the transportation planning process. An underlying premise for the Quad Cities MPO project was that it be replicable by Iowa and Illinois MPO and Regional Planning Agency (RPA) peers under typical time and annual budgetary constraints. The intent was to use tools that were readily available and the MPO could deploy under the lens of extreme weather resilience and transportation systems.

Advisory committee and pilot objectives

Review program objectives and assessment framework

The project was initiated in July 2018. A critical component of the project was increasing staff background and capacity in the area of climate change, extreme weather, and understanding the key components of the Vulnerability Assessment and Adaptation Framework. Four planning staff composed the team to complete the project including the Planning Director and three senior planners. GIS and desktop publishing staff supplemented the project intermittently. To simulate conditions of other MPOs, the project represented a portion of the assigned staff duties.

Prior to initiating a kick-off meeting with an advisory group, staff collected research on the subject matter and studied topical information and began to apply the framework to the MPO's situation. One planner researched weather and extreme weather data. Another examined impacts of climate change specific to the Midwest, and a third looked at state and peer reports and pilots. The later was helpful in framing the document and direction for the effort. Chapter 5 outlines the results of this resources review in the section "Examination of Best Practices and Peer Experiences."

Establish advisory group

A kick-off meeting was held in November 2018 with an advisory group. The Advisory Committee was formed based on partners at various levels of government, resource agencies, and transportation interests. The goal based on the original scope of work was to include transportation planners, city/county planners, asset managers, transportation maintenance personnel, emergency responders, engineers, climate research centers/climatologists, and environmental resource agency staff. Table 3.1 outlines the organizations invited to participate.

Table 3.1 – List of Planning Advisory Committee by Organization

Bettendorf Public Works	Midwestern Regional Climate Center
Burlington Northern Santa Fe Railroad	Moline Engineering Department and/or Public Works
Canadian Pacific Railroad	Moline Planning Department
Citizen and former Alderman City of Davenport	National Weather Service
Davenport Planning Department	NRCS Rock Island County District Conservationist
Davenport Public Works	NRCS Scott County District Conservationist
East Moline Engineering Department	Quad City International Airport
Federal Highway Administration – Illinois Division	Red Cross
Federal Highway Administration – Iowa Division	River Bend Transit
Federal Highway Administration, Office of Natural Environment	Rock Island Arsenal Public Works
Illinois Department of Transportation, Springfield	Rock Island County Emergency Management Agency
Illinois Department of Transportation, District 2	Rock Island County Engineering Department
Illinois State Water Survey State Climatologist	Rock Island County Sherriff's Department
Iowa Department of Agriculture State Climatologist	Rock Island Engineering Department and/or Public Works Director
Iowa Department of Transportation, District 6	Scott County Emergency Management Agency
Iowa Flood Center, University of Iowa	Scott County Health Department
Iowa Interstate Railroad	Scott County Secondary Roads
Iowa State University Climate Science Program, Assistant Director	Silvis City Administration
Iowa State University Director, Climate Science Program	US Army Corps of Engineers Hydrologic and Hydraulic Branch
MetroLINK –Illinois Quad Cities public transit	

The initial meeting was held on November 13, 2018 with a dozen people in attendance, in person or via conference call, in addition to Bi-State Regional Commission staff. Representatives from the following organizations participated:

- Scott County Health Department
- National Weather Service
- City of Moline – Planning
- Illinois Department of Transportation
- Illinois Department of Natural Resources
- Federal Highway Administration – Headquarters and Iowa Division
- Rock Island Arsenal – Public Works

Summarize kick-off meeting discussion

The November 2018 Advisory Committee meeting included an outline of the project purpose, objectives, and a description of the Vulnerability Assessment Adaptation Framework. (Slides from the presentation are included in the Appendix.) Information was shared on types of natural hazards identified in the Scott and Rock Island County Hazard mitigation plans. Common events for the Quad Cities include river and flash flooding, combined storms, severe winter storms, extreme heat, and tornados.

Discussion included data sources that would be best targeted for the pilot and what other extreme weather events affect the metropolitan area with impacts to the transportation system. Staff shared a synopsis of data trends from key sources: FEMA Flood Risk Report, CMIP Climate Data Processing Tool, National Climate Data Center, Extreme Weather Resilience Pilots of Iowa and Illinois Departments of Transportation, Midwest Climate Data Center, U.S. Geological Survey, and National Weather Service. Additional sources were noted by participants including the American Meteorological Society on climate change. Representatives at the meeting noted specific extreme weather events to consider in addition to the hazards noted. They included road impacts from freeze-thaw cycles, fog impeding road and river navigation, secondary traffic congestion related to emergency or temporary road closures, and visibility impaired by fires under drought conditions. It was also noted that system redundancy is important. As an example, the Quad Cities has five key Mississippi River crossings within the metro area, three being interstate bridges.

Further discussion included known hot spots where natural events intersected with the transportation system. Flooding on the Mississippi and Rock Rivers, and Duck, Coal, and Mill Creeks were noted. Thoughts were discussed about future land use changes and best practices for storm water management. Extreme cold was noted for its reduction in travel as part of the *2014 MPO Household Travel Survey*. Very cold weather also creates ice dams on the rivers and can affect roads and bridges. The Upper Mississippi River Lock and Dam system are susceptible to low and high flow episodes, either affect river navigation and result in river closures affecting freight transport. Extreme heat has impacted rail and roads with buckling. Attention to standards for engineering was noted, and that criteria for average events requires examination as event frequencies and intensity change. Criticality was discussed related to land use, critical facilities access and system redundancy, and the need for economic vitality. Final comments included verbalizing and illustrating the concept of risk and the challenge of looking at unrealistic benchmarks when examining extreme weather.

A pilot project implementation hurdle with a broad-based representative Advisory Committee was how to interact with the group during the process. The initial Kick-Off meeting had modest participation. However, it did have valuable input. As it turns out, subgroups or individual resource agencies were consulted as the project progressed. The MPO Transportation Technical Committee was utilized for consultation discussions of criticality and vulnerability during the assessment process to bring the project from larger concepts of climate change and extreme weather down to the transportation system level. The MPO Transportation Policy Committee was provided updates on the project status. The final report was shared with the original Advisory Committee at the end of the project, and stakeholders that participated in the process.

Review hazard mitigation planning

Hazard mitigation plans for the two counties containing the MPO were used as a springboard for data and natural hazards analysis. These plans look at types of hazards, magnitude and frequency, risk, and prioritization of those that a county is most vulnerable to their effects. The *2016 Rock Island County Hazard Mitigation Plan* looked at 16 natural and human-caused hazards and identified mitigation activities for the following priority natural hazards:

- Severe Storms Combined (Hail, Lightning, Thunderstorms, Tornados, and Wind)

KEY EXTREME WEATHER PILOT TERMS

Adaptation: Adjustment in natural or human systems in anticipation of or response to a changing environment in a way that effectively uses beneficial opportunities to reduce negative effects.

Asset: Both physical transportation infrastructure, such as roads, vehicles, intelligent transportation systems, and ecosystem-related projects.

Climate Change: Any significant change in measures of climate lasting for an extended period of time.

Extreme Weather Events: Weather events that display significant anomalies in temperature, precipitation, and winds, and their consequences result in safety concerns, damage, destruction, and/or human and economic loss. Climate change can cause or influence extreme weather.

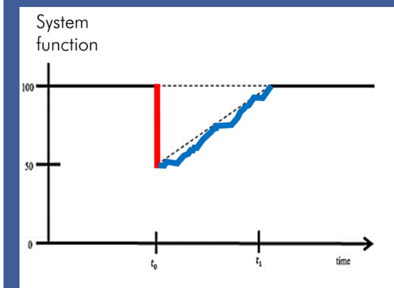
Resilience: The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.

Sensitivity: Refer to how an asset or system responds to, or is affected by exposure to a climate stressor.

Vulnerability: The degree to which a system is susceptible to, or unable to cope with adverse effects of climate change or extreme weather events.

Source: Vulnerability Assessment and Adaptation Framework, Third Edition, December 2017, Glossary. Page 81-82.

FIGURE 3.1 – RESILIENCE TRIANGLE



Source: sciencedirect.com (adapted from M. Bruneau, S.E. Chang, R.T. Eguchi, G.C. Lee, T.D. O'Rourke, A.M. Reinhorn, M. Shinouzuka, K. Tierney, W.A. Wallace, A framework to quantitatively assess and enhance the seismic resilience of communities, Earthquake Spectra, 19 (4) (2003), pp. 733-752)

- Severe Winter Storms
- Extreme Heat
- River Flooding
- Flash Flooding

The *2018 Scott County Hazard Mitigation Plan* looked at 16 natural hazards. A planning committee as part of the plan update process determined the following hazards as a priority:

- Thunderstorms and Lightning
- Severe Winter Storm
- Flash Flood
- Tornado
- Windstorm
- Hail Storm
- River Flood

These plans provide insight into hazards that could intersect the transportation system in some way as part of extreme weather. They offer important historical information and outline priorities for hazards mitigation actions. Information was shared at the kick-off meeting with the Advisory Committee. The mitigation activities also were reviewed as part of the adaptation strategies development near the end of the project.

Define terminology

As part of the capacity building within the MPO, clear definitions of terminology were important to understanding extreme weather, climate change, and the implementation of the vulnerability assessment framework. Terminology used in the pilot framework mirrored those used by FHWA in the *Vulnerability Assessment and Adaptation Framework*, *Third Edition*.

Terminology that was specific to the Quad Cities pilot process included the following definitions. These definitions were shared in presentations to provide common vocabulary on which decision-making would be based.

- **Criticality assessment** involves identifying the most critical elements of the transportation system for analysis using quantitative and qualitative data.

- Vulnerability assessment is what critical facilities/infrastructure are more vulnerable to disruptions or likely to be impacted by extreme weather, now and in the future.
- Adaptation options are strategies that can increase resilience of the regional transportation system.

Resilience was defined in the project using the "Resilience Triangle" for illustration. Figure 3.1 suggests that with a disruption in the system shown by the red line, system function becomes less than 100%. The time it takes to resume 100% function is the level of resilience of that system. The shorter the time to reestablish service or function, the more resilient that service or system is to impacts. This can be applied to extreme weather and the ability of the transportation system to be resilient and return to service.

Secure data and literature review

A premise for the project was to use readily available data for analysis. The following sources were examined for climate and extreme weather data:

- NOAA-National Weather Service
- U.S. Army Corps of Engineers Mississippi River Gauge Data
- National Center for Environmental Information – State Climate Summaries
- Midwestern Regional Climate Center
- Illinois Water Survey
- Iowa State University – Iowa Environmental Mesonet (IEM)
- Iowa Department of Natural Resources

The following sources were examined for transportation data:

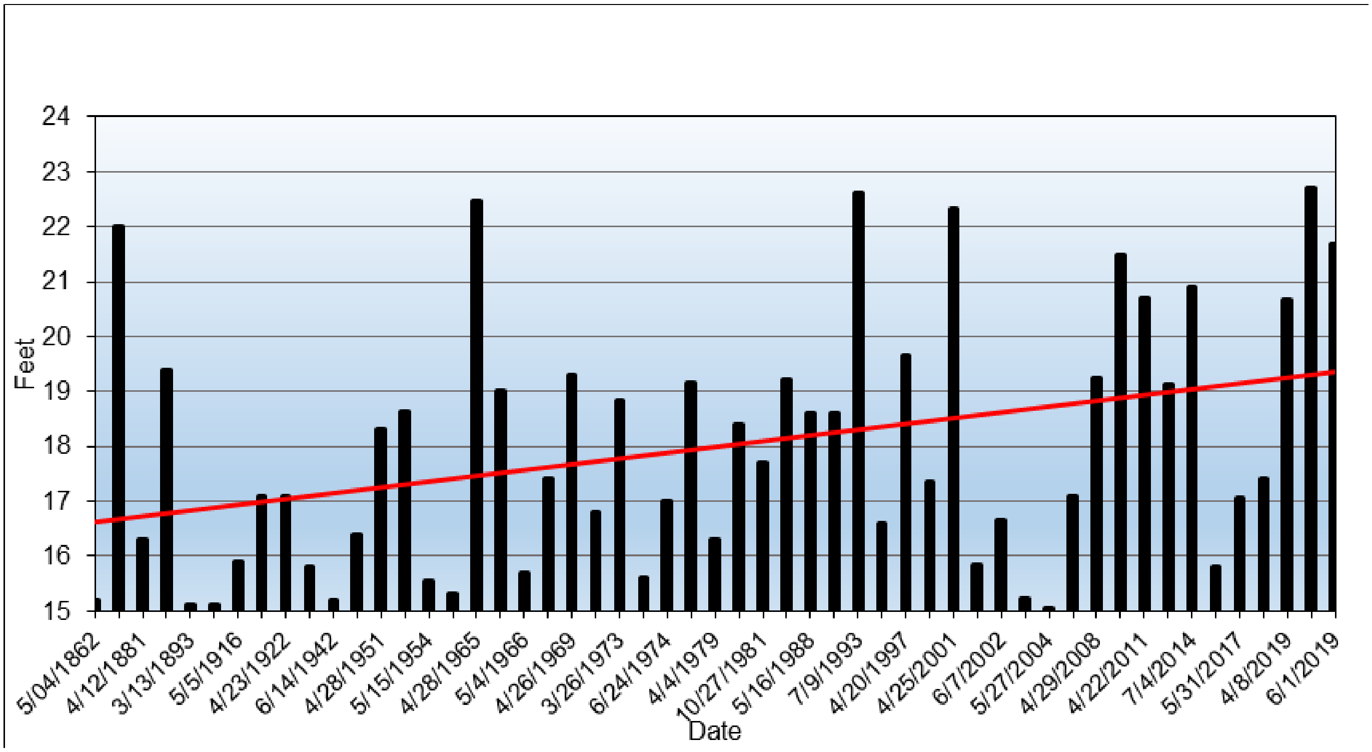
- Federal Highway Administration
- State Departments of Transportation
- Local transit systems
- Local public works departments

Examine data for the Midwest and MPO area

A document that proved very helpful in boiling down the climate discussion for the Midwest was the *Fourth National Climate Assessment (NCA4)* of 2018. The report is mandated under the Global Change Research Act of 1990 with a report to Congress no less than every four years. The assessment is written by a team of private-public cross-sector experts. Chapters on climate change, the urban built environment, transportation impacts, Midwest impacts, and adaptation strategies were helpful in framing key issues for our MPO in the larger context of the Midwest. Another report, *Intergovernmental Panel on Climate Change – Climate Change 2014 Impacts, Adaptation, and Vulnerability Part B: Regional Aspects*, was another report that was helpful for similar reasons as *the Fourth National Climate Assessment*. For regional climate projections, the *Journal of Great Lakes Research 26 (2010) 7-21 Regional climate change projections for Chicago and the US Great Lakes* was consulted for development of the climate chapter of this report.

As part of the review of local weather related data, staff checked with the standard data sources (National Weather Service, and U.S. Army Corps of Engineers) and other local data sources such as emergency management, natural resource, and environmental partners to determine applicable climate variables. Chapter 4 notes data collection for precipitation, temperature, river flooding, tornados and freeze-thaw cycles. Mississippi and Rock River information was collected on extreme flood events based on river gauge data, and discussed in Chapter 4. Figure 3.2 illustrates the Mississippi River crests over flood stage for a 157-year timeframe. The overall trend is rising as shown by the graph and points to the need to examine impacts to bridge access points and corridors adjacent to these major rivers.

Figure 3.2 – Mississippi River Crests Over 15 Foot Flood Stage at Lock and Dam 15 Rock Island 1862-2019



Source: NOAA *National* Weather Service Advanced Hydrologic Prediction Service *https://water.weather.gov/ahps2/hydrograph.php?gage=rcki2&wfo=dvn*

One of the challenges in the pilot project was determining which data supported the discussion and its respective relevance to the transportation network. Without having the vulnerability assessment completed to inform and target weather and climate data sets most relevant to the pilot, time was spent collecting more than was necessary for discussion purposes. Using regional data for initial discussions to solicit hot spots would be recommended for future projects, and more detail on specific local data can further inform these identified problem areas. In one case, the weather and climate data informs the type, magnitude, and frequents of extreme weather events, and in another case, determining what weather events occur in the geographic area that impact the transportation network can lead to the weather and climate data sets that require attention.

Review best practices in vulnerability assessments and related reports

Reviewing peer reports from the prior pilot programs and related reports was seen as critical to understanding both climate effects and potential adaptation strategies for the Quad Cities MPO. Bi-

State staff examined other prior pilots and related reports from the Iowa and Illinois Departments of Transportation, as well as pilots from Atlanta, Kansas City, Missouri, Hillsborough, Florida and a climate resilience strategy from Kansas City. Chapter 5 summarizes the key items relevant for the Quad Cities MPO. State transportation asset management plans for Iowa and Illinois were reviewed for their assessment of transportation assets within the Quad Cities MPO.

Staff used a method called "Study Circles" to assign reading materials, summarize, and report back to the group for discussion. Staff summarized reading material in a slide presentation format. This worked well for subsequent presentations and identification of key items from the source materials, but it was not as helpful for writing the report because the slides did not have enough detail. The method was useful to educate staff quickly on the material without each one reading all the resources. However, this process only occurred once during the project and couldn't be sustained due to workload and scheduling conflicts of multiple staff.

Canvass stakeholders

To assess vulnerability, Bi-State staff use the "Stakeholder Input Approach" outlined in the *FHWA Vulnerability Assessment and Adaptation Framework (Third Edition)*. Bi-State staff created a stakeholder survey (Appendix) as detailed in Chapter 5.

A challenge during this time was the Quad Cities experienced record flooding, and a number of the targeted stakeholders shifted their work focus to emergency response and flood fighting, so subsequent follow-ups on the survey participation were required continuing through August 2019. Approximately half of the contacts provided information for the assessment.

As part of the general public education on the project, presentations were made to other groups for information sharing and to receive general feedback on the topic of extreme weather resilience, including Quad Cities Flood Resiliency Alliance (November 2018), Iowa Freight Advisory Committee (September 2019) and Iowa Council of Governments Staff Retreat (February 2020). Information was also shared at the Quad Cities Riverfront Council and Bi-State Regional Trails Committee meetings. As an introduction to the climate change discussion, the National Weather Service provided a presentation to the Bi-State Regional Commission board (June 2019). There are a number of members of the Quad Cities MPO Transportation Policy Committee that sit on the Commission board, and the presentation allowed for a wider reach to the region's membership to provide an introduction at a local level the topic of climate change and extreme weather.

The Quad Cities MPO Transportation Technical Committee was used as technical reference during the project, and received project progress reports in December 2018, September 2019 and 2020, April 2020, and May 2020. Reports were also given to the Quad Cities MPO Transportation Policy Committee in September 2019 and 2020.

Intersection of events and the transportation system

To further the vulnerability assessment, Bi-State staff held a stakeholder workshop to share the survey data, affirm hot spots, and determine if there were any other transportation assets that would be vulnerable to extreme weather events not already identified in the surveying effort. The August 2019 half-day workshop was structured with presentations to overview regional climate change and other vulnerability assessment work at the state level. The other half of the workshop was structured to conduct two exercises. One exercise was to review the vulnerable facilities identified prior to the workshop then add any others at the workshop. The second exercise was a facilitated adaptation prioritization exercise with two weather scenarios. Chapter 5 outlines the results of the workshop, and workshop materials are provided in the Appendix. Overall, there was good discussion at the workshop between stakeholders. More time to discuss the adaptation priorities was a lesson learned, and the group ran out of time to report out by table, which would have added to suggestions on adaptation strategies. The Transportation Technical Committee was later consulted on adaptation strategies from a broad perspective

Assess vulnerability and adaptation options and priorities

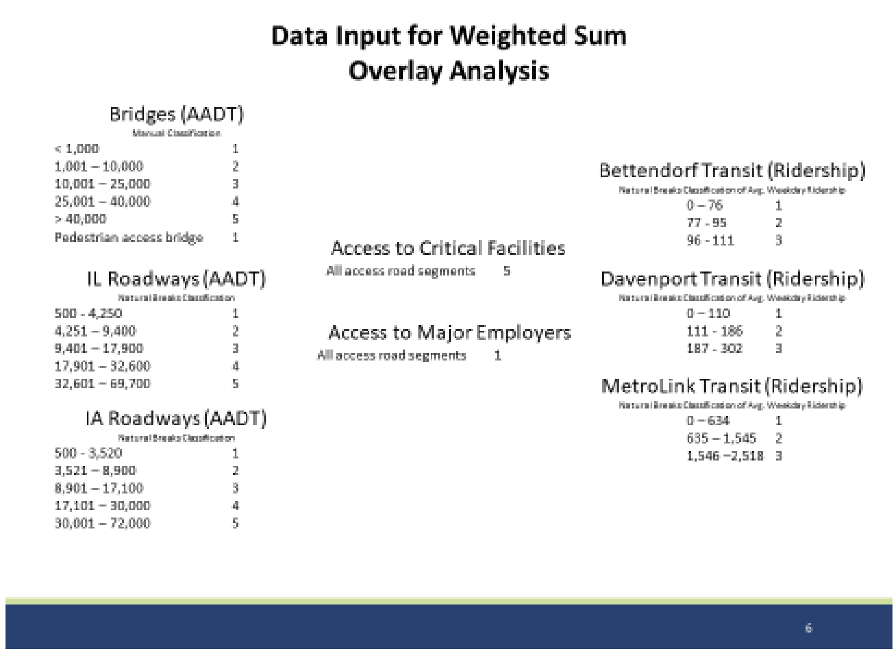
It is at this point in the pilot scope of work that project tasks #3 and #4 began to merge together and overlap from the original scope of work. The stakeholder input through the survey and workshop captured the input on vulnerable facilities, while the criticality assessment utilized the MPO Transportation Technical Committee for feedback and guidance. In lieu of the Advisory Committee coming together, individual resource agencies, such as the National Weather Service and Corps of Engineers, were consulted on weather data, and the Departments of Transportation data was utilized for the analysis of criticality through sources already familiar as an MPO.

Identifying critical and vulnerable facilities

The final process before determining adaptation strategies involved a GIS analysis by layering weighted criticality data with vulnerability data to establish locations and apply adaptation strategies. The following criteria was used to assess critical facilities:

- High Use Routes by Average Daily Traffic
- River Crossings
- Transit Routes by Average Weekday Ridership by Route
- Access to Critical Facilities
- Access to Major Employers with Greater than 100 Employees
- Population by Census Block Group

Figure 3.3 – Criticality Assessment Weighted Sum Overlay Analysis



Source: Bi-State Regional Commission, 2020

Chapter 5 provides the results of the criticality assessment. This was followed by layering the extreme weather related "hot spots" identified in the stakeholder survey and workshop by type of event. The last component of the analysis was to focus on each event, and identify priority areas to recommend adaptation strategies by location or corridor. The primary issues at the Mississippi and Rock Rivers were the bridges with ice/snow, and some related to flooding.

Adaptation strategies and the long range transportation plan

The final scope of work item #5 is underway at the writing of this report. General suggestions have been outlined on how resilience can be integrated into the Long Range Transportation Plan (LRTP) and other planning documents of the Quad Cities MPO. The 2050 Quad Cities Long Range Transportation Plan is anticipated to be adopted in March 2021. The vulnerable and critical facilities will be a component of the discussion with the Technical and Policy Committees during the fiscal constraint analysis as part of projects contained in the plan. A new objective and strategies has been developed for consideration in the LRTP, and noted in Chapter 5.

Chapter 5 identified priority segments most at risk for extreme weather based on the type of event. The Long Range Transportation Plan process will assess these locations in relation to other factors, such as safety and pavement condition.

BUILDING DURABILITY

Integrating resilience into the transportation planning process

One of the goals of this project was to conduct a vulnerability assessment to bring the discussion forward into the Long Range Transportation Plan (LRTP) as part of resilience planning. The mission is to reduce recovery time and disruptions to the Quad Cities transportation system due to extreme weather. Beyond the LRTP, MPO staff will be examining how to bring the findings of this report into the transportation programming process, either as a cross-reference during the project selection process or to become part of the selection criteria.

In addition, the MPO staff will provide technical assistance related to working with local jurisdictions to write grants for priority projects and assist within the project development process with data to support resilience priorities.

To summarize lessons learned for MPOs looking to incorporate a resilience discussion in their LRTPs, and other transportation planning processes:

- Develop resource contacts and staff capacity in the general, overall climate and extreme weather discussion, information and resources available – start at the national level, shift to regional summaries, and target local recurring incidents
- Focus on the regional climate data for an overview and its impact on the MPO's specific geography

- Solicit local input for hot spots and vulnerable facilities
- Select criteria for a criticality GIS analysis based on available data and keep it simple
- Use the analysis to determine priority corridors or "hot spots"
- Determine short or long-term advisory, control, treatment, or policy adaptation strategies to make improvements and reduce disruptions due to extreme weather

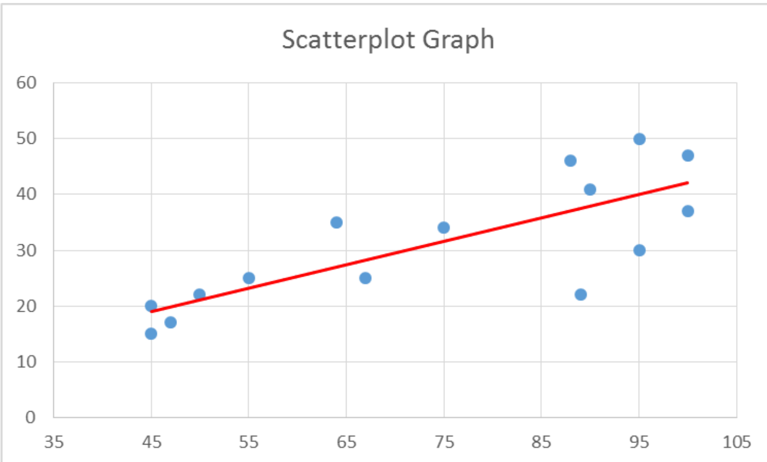
Chapter 4 Changing Regional Weather Patterns and Ramifications for the Quad Cities Metropolitan Area

The first part of the 21st century has been a period of notable extremes in terms of weather. Heavy rainstorms, flooding, hurricanes, record high temperatures, and drought-fueled wildfires have all captured national headlines. The weather extremes are not merely anecdotal, however. Meteorological data collected on variables including storm activity, surface and atmospheric temperature, precipitation frequency and volume, droughts, and floods over the last century have documented clear shifts in weather patterns. In the Midwest, as in other parts of the country, extreme weather events are happening more frequently, and in some cases, with record-setting effects.

As described in the Fourth U.S. National Climate Assessment (NCA4), "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. Although the focus of this study is on the potential effects of extreme weather events to the transportation network, an understanding of the relationship between weather and climate can provide context for the changing patterns being observed.

Put simply, a weather event is like a single point on a scatterplot graph, while climate corresponds with the trend line. Looking at a single isolated point cannot tell you whether the trend line on the graph will be going up, down, or staying flat. Likewise, the trend line cannot tell you exactly where a future point will appear on the graph, though it can suggest certain probabilities.

Figure 4.1



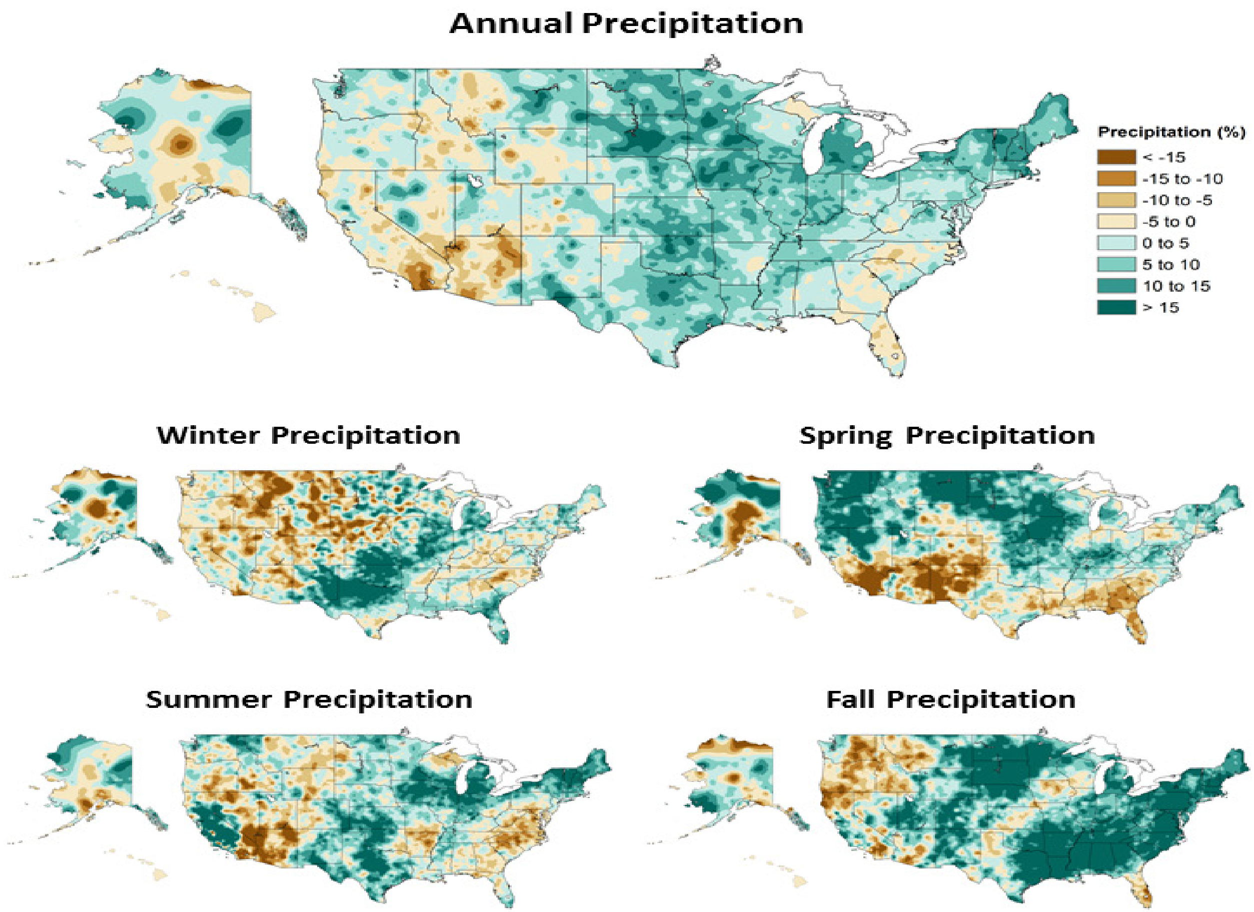
Each weather event is equivalent to a point on a scatterplot graph, while climate is represented by the trend line.

In this same way, a snow storm in late May is a singular event that on its own cannot prove or disprove climate trends, though it adds to the pool of data. Changes in climate, meanwhile, are aggregated data that can point to long-term trends.

All parts of the U.S. are experiencing changes, though the nature and impact of those changes varies from one geographic region to another. Whereas coastal areas are more likely to contend with storm surges and sea level rise, and mountainous regions are grappling with increased drought, projected changes in the Midwest are chiefly related to precipitation and temperature. Observed changes noted in the Fourth National Climate Assessment, Volumes I and II (NCA4) report between the present day (1986-2016) and the first half of the last century (1901-1950) include:

- An overall increase in annual precipitation by 5% to 15% throughout the Midwest.
- Changes in seasonal precipitation patterns are shown in Figure 4.2. The largest precipitation increases have been recorded in the spring and summer, while in the fall and winter, some areas of the Midwest have experienced a more modest increase of precipitation, and others have experienced a decrease in precipitation.

Figure 4.2



Source Fourth National Climate Assessment, Volume II: Our Changing Climate, U.S. Global Research Program, 2017.

Changing precipitation patterns show wetter springs and drier falls in the Quad Cities region.

- Increases in extreme precipitation events in the Midwest, with the maximum 1-day precipitation totals increasing by 0.13 inches in winter, 0.15 inches in spring, 0.10 inches in summer, and 0.27 inches in fall.
- An increase in annual average temperature by 1.26°F in the Midwest.
- An increase in the annual average maximum temperature by 0.77°F, and an even larger increase of 1.75°F for the annual average minimum temperature.
- A change of 2.93°F in the coldest day of the year in the Midwest, and a change of -2.22°F in the warmest day of the year.
- The most severe summer meteorological drought on record for the region (the Great Plains/Midwest drought of 2012), described as a "heat wave flash drought," a type of rapidly evolving drought that has decreased in frequency over the last century.
- Increases in flood risk and severity in the upper Mississippi River valley as well as throughout the Midwest, attributed mostly to observed increases in precipitation.

Although it is possible to imagine an increase in frequency of weather events might result in a decrease in severity by spreading the rainfall or spikes/dips in temperature out over more events, in fact the data suggests many weather events are increasing in both frequency and severity. The following chart broadly summarizes observed weather events in the Midwest as categorized on these two axes:

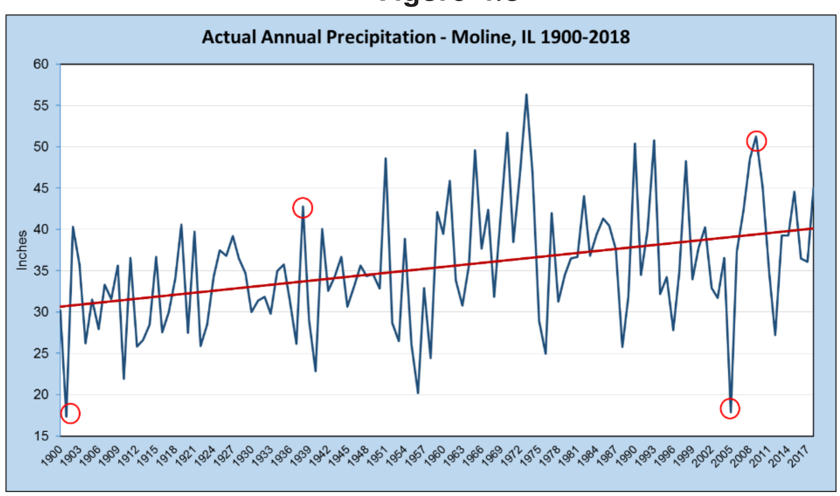
	Decreased frequency	Increased frequency
Decreased severity	Cold waves	
Increased severity	Droughts	Precipitation events Heat waves Floods

Local weather data

The NCA4 designates the present day as a 30-year period of data recorded from 1986-2016 and uses a 50-year period at the beginning of the 20th century (1901-1950) as the basis of comparison. This is the international standard of practice. In analyzing local data, this document has used the same approach where possible, both for ease of comparison between local and regional data and because these time periods have particular implications for the transportation network. Many of the structures in the Quad Cities were designed and/or constructed in the first half of the 20th century and built to withstand weather patterns as understood at that time. In determining what adaptation strategies are appropriate, it makes sense to understand those same structures in the context of the weather patterns of the present day, particularly where they differ from the earlier period, and what changes may be necessary as a result.

Local data show that in most cases the trends recorded regionally for the Midwest parallel those observed in the Quad Cities metropolitan area over the same time period. For example, data maintained by the National Weather Service (NWS) for Moline from 1900-2018 shows an increase in the average number of days of annual precipitation by almost five full days, as shown in Figure 4.3.

Figure 4.3



Source: National Weather Service

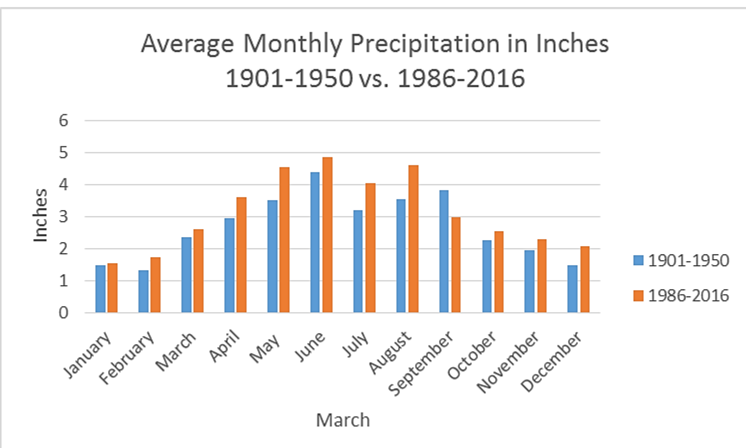
Annual precipitation recorded in Moline has been trending upward, while the differences in extremes (red circles) has also become greater.

Although the amount of precipitation recorded from year to year is highly variable, with the highest annual precipitation recorded in 1973 at 56.36 inches and the lowest annual precipitation recorded in 1901 at 17.33 inches, the average amount of rainfall overall has been on the rise. The trend line in Figure 4.3, shown in red, corresponds with a nearly 10-inch increase in current average annual precipitation as compared to the beginning of the 20th century.

Overall variability has also increased. In the first half of the 20th century, the highest total annual precipitation for the Quad Cities was 42.8 inches recorded in 1938, and the lowest total annual precipitation was 17.33 inches recorded in 1902. That is a difference of 25.47 inches. In comparison, during the first part of the 21st century, the data for Moline records show the highest total annual precipitation of 51.3 inches occurred in 2009, while the lowest recorded total annual precipitation of 17.89 inches occurred in 2005, a difference of 33.41 inches. The average is rising, but in other words, the extremes are also becoming more extreme.

Average precipitation per month also has changed over the last century. Figure 4.4 shows NWS data on the average monthly precipitation from 1901-1950 as compared to 1986-2016. Only the month of September shows a substantial decrease in the average amount of rainfall. All other months show an increase, with the exception of January, which is relatively unchanged. The most significant increases occurring in April, May, June, and July. The trend toward wetter springs and somewhat drier falls has particular implications for the transportation network.

Figure 4.4

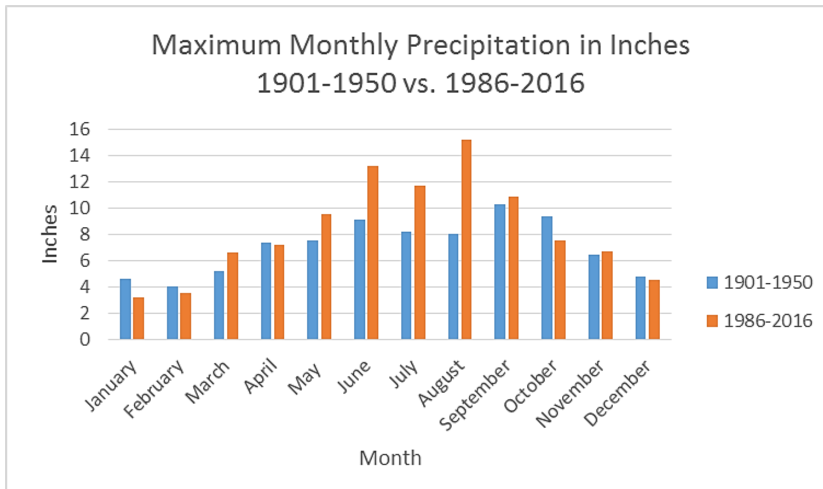


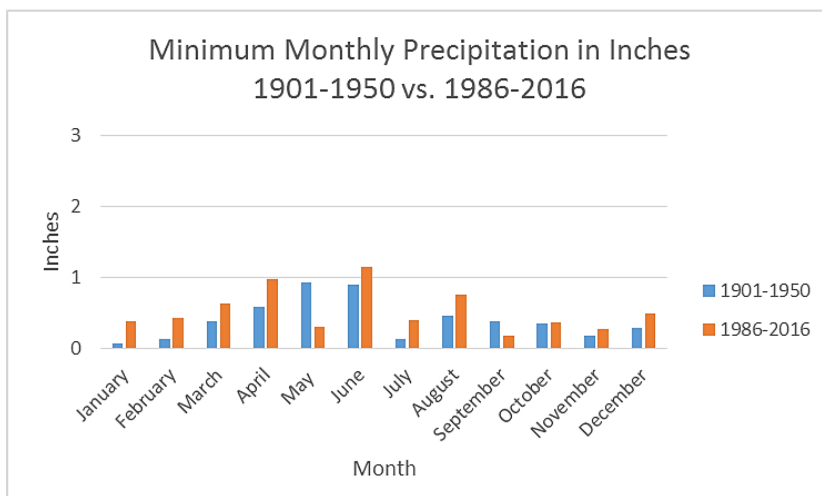
Source: National Weather Service

Average monthly precipitation recorded for the Quad Cities show a trend toward wetter spring, summer, and winter months.

This pattern of increased precipitation is even more pronounced when comparing the extremes of maximum and minimum monthly precipitation for the same periods of time. As Figures 4.5 and 4.6 show, the maximum rainfall amounts recorded in the Quad Cities in May, June, July, and August in the present day exceed those recorded for the early 20th century by more than an inch, and in the case of August, by a full seven inches. The minimum precipitation data, meanwhile, shows that while the present day rainfall amounts differ in tenths of an inch rather than full inches, the minimum amounts still exceed those recorded previously for most months other than May and September. Together, this suggests a shift toward wetter weather on the whole.

Figures 4.5 and 4.6



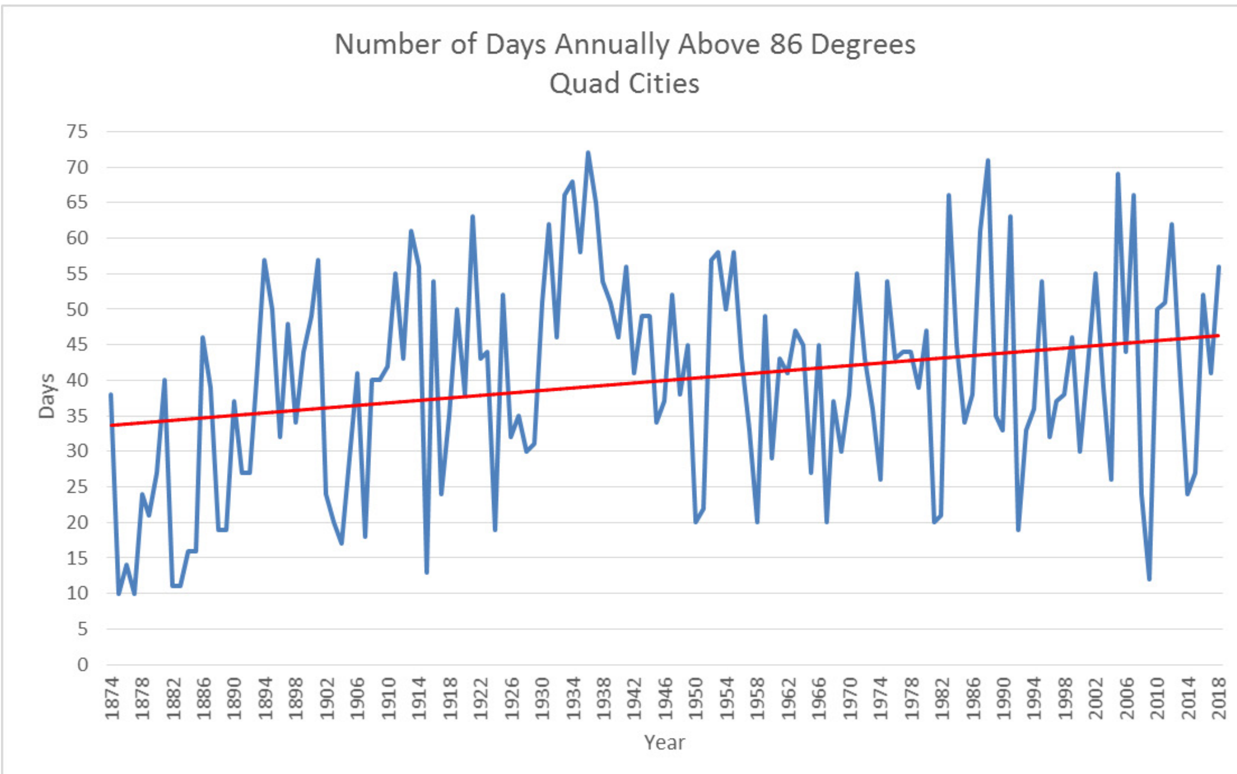


Source: National Weather Service

Maximum and minimum rainfall amounts recorded in the Quad Cities both show an upward trend

A similar upward trend has been observed in temperature data for the Quad Cities metropolitan area. Between 1874 and 2018, the average number of days annually with temperatures greater than 86 degrees has been trending upward, as shown in Figure 4.7. In terms of extreme weather temperatures, however, it is important to note that the number of very hot days has not increased as markedly as the decrease in the number of cold days. As shown in Figure 4.8, temperature data for the Quad Cities in recent decades shows a decline in the total number of days below freezing, while the number of days above 93 degrees has not increased as significantly. In other words, winters are becoming warmer more so then summers are becoming hotter, which tracks with weather trends recorded throughout the Midwest.

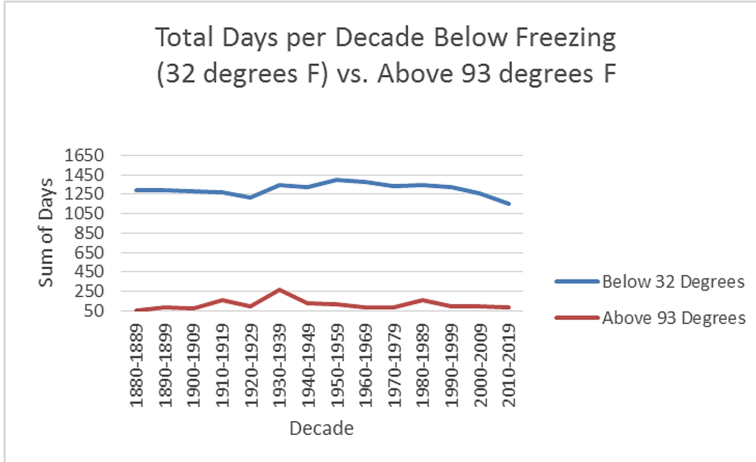
Figure 4.7



Source: Iowa State University – Iowa Environmental Mesonet, Moline, Illinois 1874-2018

The average number of days annually recorded in the Quad Cities with temperatures greater than 86 degrees has been trending upward

Figure 4.8



Source: National Weather Service

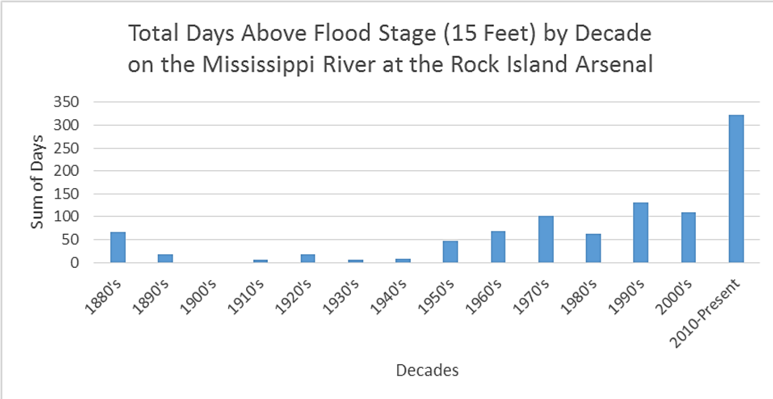
Temperature data recorded in the Quad Cities also shows a more pronounced trend toward warmer winters than hotter summers.

Crucially, the observed changes in temperature and precipitation are related. As noted in NCA4, "Extreme precipitation events occur when the air is nearly complete saturated. Hence, extreme precipitation events are generally observed to increase in intensity by about 6% to 7% for each degree Celsius of temperature increase." Simply put, as annual average temperatures rise, storms increase in intensity proportionally.

Flooding impacts

Increased precipitation, especially heavy precipitation, is a contributing factor to both river flooding and flash flooding. Here, too, local data suggest a marked upward trend. Along the length of the Mississippi River that runs through the Quad Cities, flood stage is defined as a crest of 15 feet or more. River gauge data maintained by the U.S. Army Corps of Engineers at the Rock Island Arsenal indicate an increase in the number of days above flood stage in recent decades, as shown in Figure 4.9. Between 2010 and the present, the Mississippi River has been above flood stage for a total 323 days, giving the current decade the highest number of flood days on record. In effect, an equivalent of almost one full year out of the last ten has been spent in flood stage.

Figure 4.9



Source: U.S. Army Corps of Engineers Mississippi River Gauge Data at Rock Island Illinois (2019)

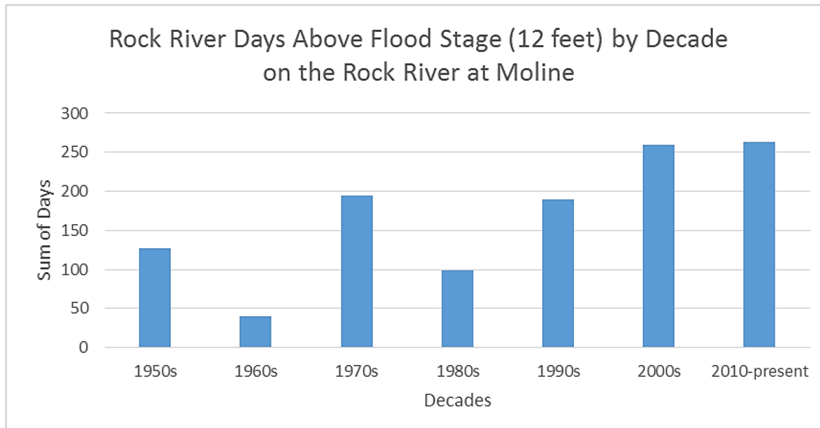
River gauge data maintained by the U.S. Army Corps of Engineers on the Mississippi River at the Rock Island Arsenal indicate a substantial increase in recent decades in the total number of days above flood stage.

Notably, this is also nearly three times as much flooding as the previous record-holding decade, 1990-1999, when a total of 131 days were observed above flood stage. Furthermore, it is a significant increase over flooding as compared to the decades of the 20th century. Between 1900 and 1949, for example, there were a combined total of 37 days recorded above flood stage – making the flooding experienced on the Mississippi River in the last decade nearly a hundredfold increase over the flooding experienced during the first half of the previous century.

The volume of precipitation is not the only factor that affects flooding patterns in the Quad Cities. The seasonality of the rainfall also has implications for changing flood patterns. Although snowmelt is widely understood to be a main cause of spring flooding, heavy rains can lead to saturated soils and late season flooding. This, in turn, is a contributing factor in rivers freezing at high levels leading to widespread ice jams that affect bridges, dams, and locks. At the same time, if the soil freezes in a saturated state, snowmelt in the spring will flow over the ground rather than trickling down through it, worsening spring flooding.

The Rock River, which flows along the southern edge of the Quad Cities metropolitan area, is prone to this type of ice-jam related flooding. Although the river gauge data maintained by the U.S. Corps of Engineers for the Rock River at Moline does not reach as far back into the 20th century as the data for the Mississippi River, the data collected since 1951 reveals a similar pattern to flooding from the mid-century onward as for the Mississippi. As shown in Figure 4.10, the total days above flood stage for the Rock River show an upward trend, with the current and previous decade each having more than 250 days above flood stage as compared to fewer than 150 days at mid-century. When these days above flood stage are analyzed by month, as shown in Figure 4.11, a clear pattern of flooding in the early half of the year emerges. Notably, two of the highest monthly totals for flooding occur in the winter months of January and February, when ice jams are a key factor.

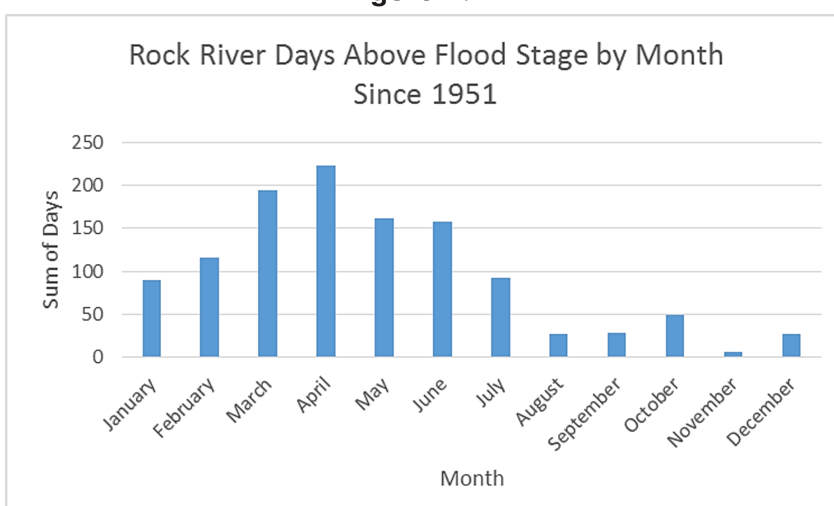
Figure 4.10



Source: U.S. Army Corps of Engineers Rock River Gauge Data Moline Illinois (2019)

River gauge data maintained by the U.S. Army Corps of Engineers on the Rock River at Moline indicate an increase in recent decades in the total number of days above flood stage.

Figure 4.11



Source: U.S. Army Corps of Engineers Rock River Gauge Data Moline Illinois (2019)

River gauge data maintained by the U.S. Army Corps of Engineers on the Rock River at Moline indicate a pattern of flooding in the early half of the year, including in January and February, when ice jams are likely to be a factor.

Other local weather events

Although the overall trend for the Quad Cities and the Midwest more broadly has been toward more frequent and heavier precipitation events, it is important to note this does not eliminate the possibility of droughts also occurring. Droughts can take several forms, including meteorological droughts determined by lack of precipitation and hydrological droughts characterized by rain and snow shortfalls resulting in reduced streamflow. In 1988, 2005, and 2012, meteorological and hydrological droughts were recorded with consequences for the transportation network, including limiting barge traffic on the Mississippi River.

In fact, recent weather trends have suggested heavy precipitation can be followed by prolonged dry periods, sometimes even within the same year, as was observed in 2011 and 2013. In both years, wet springs were followed by dry summers, and a drought year occurred in between. A similar wet spring/dry summer pattern emerged in 2019, in which the total rainfall for April, May, and June was 2.92, 5.44, and 0.05 inches above average respectively, followed by rainfall in July that was 3.13 inches below average. By September, unusually high rainfall events were once again recorded, with a total precipitation 4.72 inches above normal. Similar to the fluctuations observed in the temperature data, the pendulum between maximum and minimum rainfall amounts seems to be swinging wider.

Local data have also been collected for weather events not explored as explicitly in the NCA4 report for the Midwest but that likewise can impact the transportation network. These include several types of damaging winds associated with extreme storms, such as rotating winds/tornadoes and straight-line winds like downbursts (severe downdraft winds) or gust fronts (the leading edge of outflow winds caused by thunderstorms).

Since 1997, the National Weather Service Office at the Quad City International Airport has recorded 26 incidents of surface winds exceeding 57 mph during thunderstorms. Thirty-five recorded tornados have touched down in Rock Island County, Illinois, since 1959. Of them, five were rated EF3, five were rated EF2, 13 were rated EF1, and 12 had a rating of EF0. The average tornado path was 6.8 miles. In Scott County, Iowa, 64 recorded tornados have touched down since 1954. Eight were rated EF3, eight were rated EF2, 25 were rated EF1, and 22 had a rating of EF0. The average tornado path length was 7.3 miles. A fraction of these tornados have occurred within the metropolitan area on both the Iowa and Illinois side, as can be seen in Figure 4.12.

DAMAGING WINDS/ TORNADOS

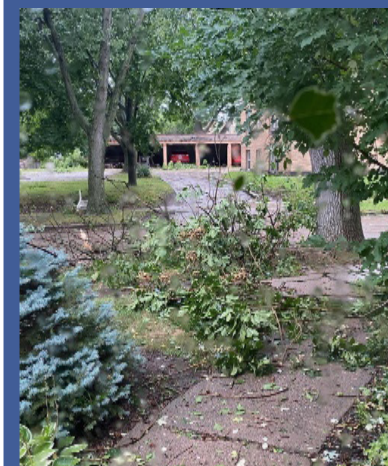
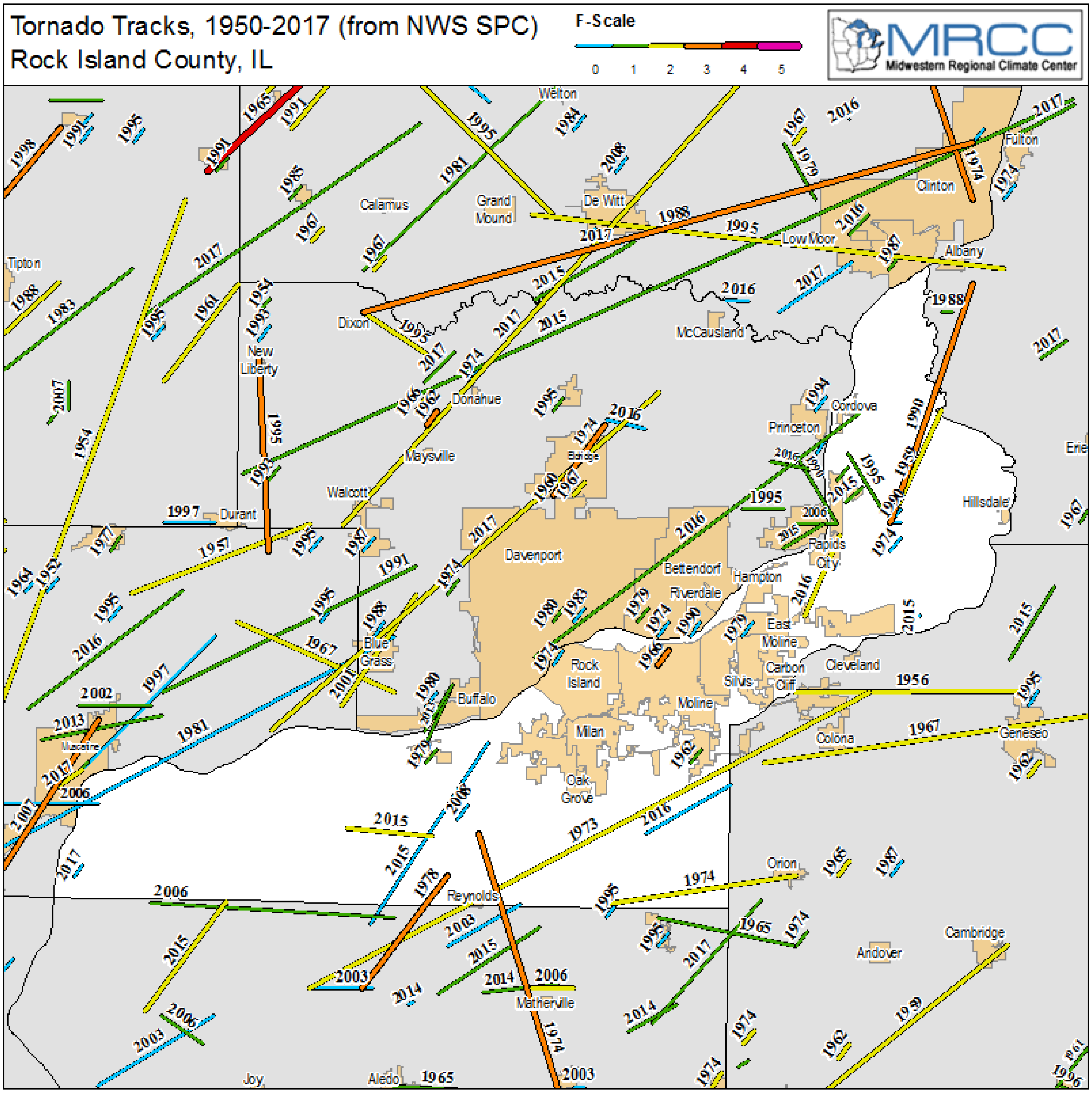


Figure 4.12

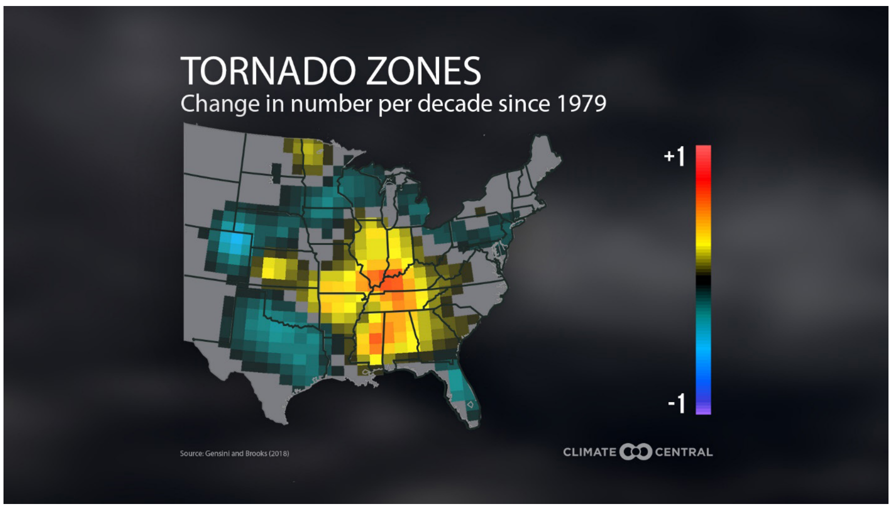


Source: Midwestern Regional Climate Center, Rock Island County Illinois

Recorded paths of tornados for the region show a number tornados have occurred within the Quad Cities on both the Iowa and Illinois side of the Mississippi River.

Tornadoes are notoriously difficult to predict in terms of when and where they will occur. In part because there is less complete historical data for tornados and other wind events, it is also difficult to determine what long-term trends may be changing. Recent data collected over the last 40 years does suggest increased tornadic activity in some parts of the Midwest, as shown in Figure 4.13, though in the Quad Cities this increase can best be described as slight to negligible. Nonetheless, tornados remain a feature of local weather patterns with the potential to disrupt the transportation network and, as such, are important to consider in infrastructure design.

Figure 4.13



Source: Nature Research Journals Climate and Atmospheric Science (October 2018)

Changes in the number of tornados per decade have been more pronounced in other parts of the Midwest as compared to the Quad Cities.

Other extreme weather events of note are winter weather events such as snow, sleet, and ice storms that can disrupt transportation systems. Snowfall can be difficult to measure and compare given the variable densities of different kinds of snow. Generally, snow that falls in the autumn and early winter tends to be lighter as compared to the snow that falls in late winter and spring, though on average 13 inches of snow is regarded as being equivalent to one inch of rain. As noted previously in Figure 4.2, annual precipitation recorded for the region has increased in the spring and decreased in the fall. From this we can extrapolate that the transportation system in the Quad Cities has had to contend more with the heavier spring snowfalls in recent years thanks with the lighter snowfalls that occur in autumn.

PAVEMENT DEGRADATION

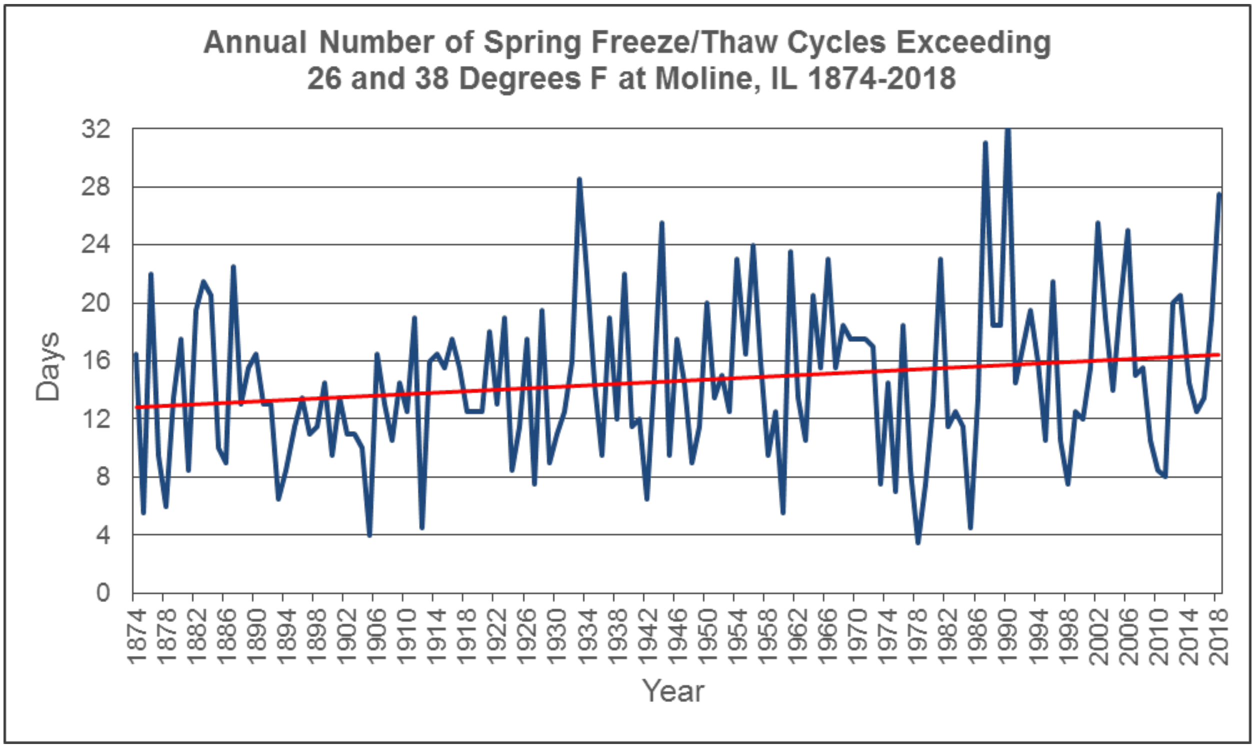
Of particular relevance to the transportation network are freeze/thaw cycles in which temperatures fluctuate between low and high thresholds. Such rapid shifts between temperatures above and below freezing can cause pavement and subsurfaces to expand and contract, leading to pavement degradation, upheaval, pothole formation, and other structural concerns. A number of freeze/thaw parameters exist, each with different low- and high-temperature thresholds, and these cycles can occur in a spring period (during the months of March, April, and May) or in a fall period (during the months of September, October, and November).

Table 4.2 – Trends in Freeze/Thaw Cycles as Recorded for the Quad Cities from 1874-2018

National Weather Service Office Moline, IL		
Freeze/Thaw Temperature Parameters	Spring Trend	Fall Trend
Below 26 and above 38 Degrees F	Increasing	Increasing
Below 24 and above 40 Degrees F	Decreasing	Increasing
Below 20 and above 44 Degrees F	Decreasing	Increasing
Below 14 and above 50 Degrees F	Decreasing	Neutral

As Table 4.2 shows, the total number of days in which temperatures have cycled below 26 degrees F and above 38 degrees have shown an upward trend in the Quad Cities between 1874 and the present in both the spring and fall periods. This can also be seen in Figure 4.14, which show the total number of such days increasing over this period of time.

Figure 4.14



Source: National Weather Service

The annual number of spring/thaw cycles with temperatures below 26 degrees F and above 38 degrees F recorded for the Quad Cities indicate an upward trend in such occurrences. Similarly, the number of fall freeze/thaw cycles with the same temperature thresholds recorded for the Quad Cities show an upward trend.

Other, larger fluctuations between increasingly lower and higher temperatures, meanwhile, have trended downward in the spring and upward in the fall, with the exception of the largest swing between 14 and 50 degrees F, which has shown no real trend difference in the fall. Practically speaking, this means the stresses on the transportation system resulting from freeze/thaw cycles are more pronounced in the fall as compared to the spring.

Temperature differentials play a role in another weather phenomenon, fog, which has particularly notable effects on river navigation in the Quad Cities. Fog is formed when air temperatures cool to the point at which the water vapor contained by the air condenses. This can happen at any time of year when the air temperature reaches the dewpoint, but when warm, humid air passes over cold ground, as often happens in freeze/thaw cycles, the chilling effect on the air can result in fog that in turn accelerates snowmelt. It thus becomes a weather event with compound effects: in the short-term, the fog reduces visibility, and the snow melt can create slick road conditions, while in the long-term, repeat freeze/thaw cycles contribute to pavement degradation.

Preparing for the future

As the climate changes, so do our vulnerabilities to weather events. As previously discussed, climate is a term applied to long-term trends related to averages – and since each weather event adds to the climate record, the averages are always shifting. Likewise, the factors impacting the climate are subject to change. Greenhouse gases in the future will continue to increase, although the degree of increase will be driven by societal choices and technological changes. The degree of increase will result in different outcomes.

To address this variability, scientists use different scenarios to suggest a range of possibilities when using climate data to predict future trends. In the NCA4 report as with other climate reports, a number of future scenarios referred to as Representative Concentration Pathway (RCP) trajectories are presented. On the high end is RCP 8.5, which represents a "business as usual" scenario in which greenhouse gas emissions continue to rise. On the lower end is RCP 4.5, which calculates projections based on a scenario in which emissions peak around 2040 and then decline.

Because of this, projections for future patterns include continuing trends for both increased temperature and precipitation in the Midwest region.

- Increase in annual average temperature:

Table 4.3 – Projected Changes in Annual Average Temperature

RCP 4.5 Mid-Century (2036-2065)	RCP 8.5 Mid-Century (2036-2065)	RCP 4.5 Late-Century (2071-2100)	RCP 8.5 Late Century (2071-2100)
4.21°F	5.29°F	5.57°F	9.49°F

- Increase in temperature extremes:

Table 4.4 – Projected Changes in Temperature Extremes

Change in Coldest Day of the Year (RCP 8.5)	Change in Warmest Day of the Year (RCP 8.5)
9.44°F	6.71°F

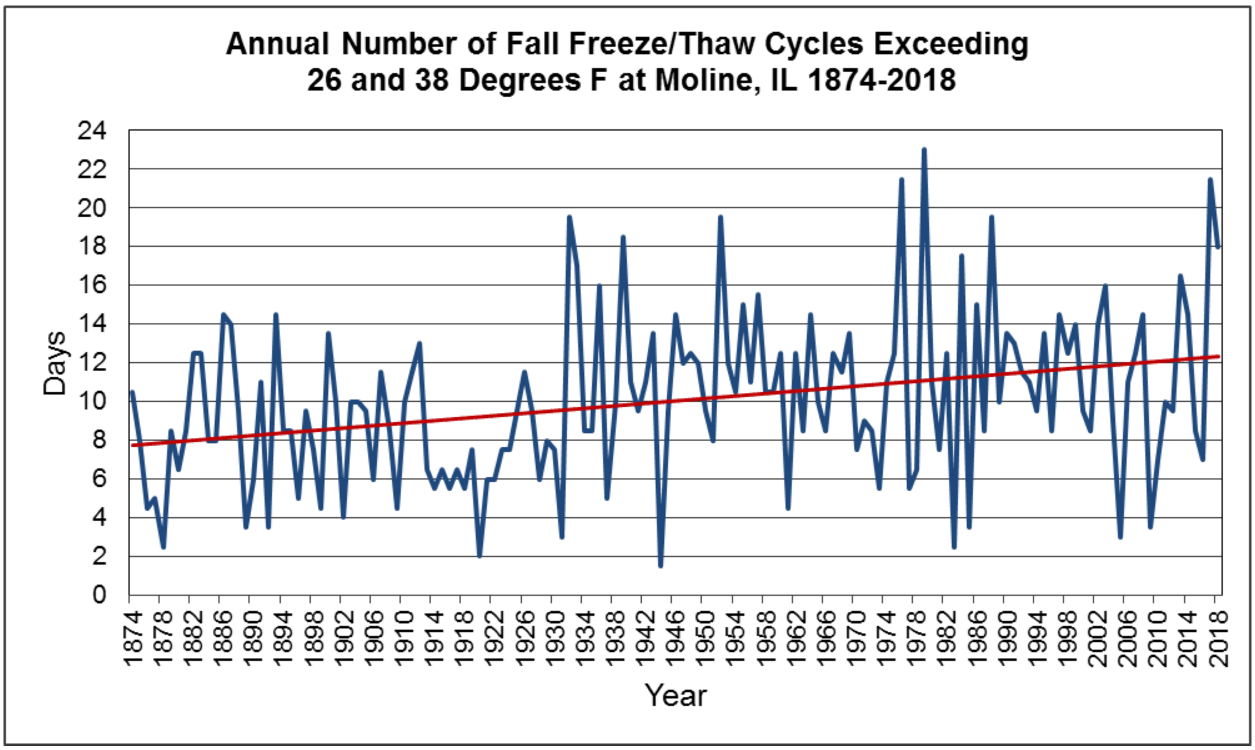
- Increase in extreme precipitation event frequency:

Table 4.5 – Projected Percent Change in the 20-Year Return Period (Recurrence Interval) for Daily Precipitation

RCP 4.5 Mid-Century (2036-2065)	RCP 8.5 Mid-Century (2036-2065)	RCP 4.5 Late-Century (2071-2100)	RCP 8.5 Late-Century (2071-2100)
+10%	+13%	+11%	+20%

In a study published in 2010 titled "Regional Climate Change Projections for Chicago and the US Great Lakes," researchers summarized the cumulative effects of these different climate projections for various scenarios by identifying analogous regions of the country experiencing similar weather patterns in the present day. As shown in the graphic created for that report, Figure 4.15, in a lower emissions scenario like RCP 4.5, the Quad Cities could expect to have conditions similar to those in present-day Arkansas in the mid- and late 21st century. Under a higher emissions scenario like RCP 8.5, conditions would be similar to those in present-day Oklahoma by mid-century and akin to those in present-day central Texas by the century's end.

Figure 4.15



Source: National Weather Service

Current understanding of climate trends suggest in a lower emissions scenario, weather patterns in the Quad Cities will be similar to those in present day Arkansas by mid- to late century, while in a higher emissions scenario, weather patterns will be similar to those in Oklahoma by mid-century and similar to those in Texas by late century.

Implications for the transportation network

Extreme weather can have both short- and long-term effects on the functioning of all parts of the transportation network. The immediate effects tend to be the most obvious: reduced visibility during a heavy downpour, increased crash risk on icy surfaces, and impaired traffic flow as a result of storm debris. By nature, these impacts are also more likely to be able to be resolved during and after an event through relatively simple measures such as reduced speeds, the application of road salt, and the clearing of debris.

Long-term effects may be more subtle but have the added risk of cumulative damage. This can include impacts such as degraded pavement, pothole formation, and reduced capacity in culverts resulting from silt and debris. More serious effects can include mechanical/electrical failures in signaling devices along roads, runways, and rail lines and structural weaknesses resulting from scouring beneath bridges and rail beds.

Three broad categories of practices are available to transportation managers to mitigate these impacts: advisory, control, and treatment strategies. Efforts to inform and, when necessary, warn the public are considered advisory strategies. These include measures such as storm warnings, travel advisories, and campaigns to raise awareness of the dangers of driving in floodwaters. Control strategies are efforts to regulate transportation flow in response to hazards, such as closing roads or on-ramps or posting reduced speed limits in affected areas. The third set of practices, treatment strategies, augment or change structural elements of transportation infrastructure to better withstand environmental stressors. This can include raising roads above projected flood levels, installing larger culverts, redesigning bridges, and other structural changes.

Of these categories of mitigation strategies, the first two tend to be deployed within the time period immediately before, during, and after an extreme weather event and are best suited to mitigating short-term impacts. Often, advisory and control practices are undertaken in coordination with emergency management agencies. The third strategy, treatment effects, represents a more sustained effort to mitigate long-term impacts. For this reason, this study largely focuses on treatment effects. Chapter 5 discusses potential effects to the Quad Cities transportation network as well as potential types of mitigation strategies in more detail.

Chapter 5 Vulnerability Assessment

With an understanding of the climate and extreme weather events that could continue or increasingly impact the Quad Cities, the pilot project shifted to an assessment of vulnerable facilities. A review of literature relevant to the Midwest, and other metropolitan areas was completed. Having reviewed other best practices, Bi-State staff worked with the Transportation Technical Committee and other stakeholders to refine information on what facilities might be deemed critical, what facilities could be identified as vulnerable to determine priorities for adaptation strategies, and future mitigation.

Examination of best practices and peer experiences

The FHWA *Vulnerability Assessment and Adaptation Framework, Third Edition*, was the blueprint for the Quad Cities MPO pilot project. The document outlines the steps to conduct a vulnerability assessment and provide examples in a clear and straightforward manner. Other pilot projects were reviewed for their relevance to the Quad Cities situation.

Illinois Department of Transportation (ILDOT). The *Illinois All-Hazards Transportation System Vulnerability Assessment*, October 2017 used FHWA's Vulnerability Assessment Framework to better prepare for extreme weather events and its effect on the state's transportation system. It categorized assets by corridors, bridge infrastructure, transportation hubs, and operations. For natural hazards, the report focused on precipitation, temperature, wind, and geology. Peak vulnerability was identified as the "convergence of exposure, sensitivity and criticality." The study resulted in the ILDOT developing a methodology to review hydraulic information to estimate changes to flooding potential. The report provided a summary of climate and weather relevant to the Quad Cities MPO to inform potential future seasonal effects of climate change, such as increasing freeze-thaw cycles, less snow, and increasing days over 95 degrees Fahrenheit.

Other Illinois-related references examined as part of the literature review:

- *Institute of Government & Public Affairs – Climate Change Policy Initiative*, May 2015

- *Illinois Natural Hazard Mitigation Plan 2018*
- *Illinois State Water Survey Contract Report 2019-05 Frequency Distributions of Heavy Precipitation in Illinois:* Updated Bulletin 70
- *NOAA National Climatic Data Center Climate of Illinois summary*

Iowa Department of Transportation. The pilot report examined precipitation in two river basins and determined streamflow discharge forecasts to identify impacts on bridges. The *Iowa's Bridge and Highway Climate Change and Extreme Weather Vulnerability Assessment Pilot*, March 2015 was used for its references to inland flooding and precipitation data relevant to the Cedar River Basin near the Quad Cities MPO and predicted future stream flow modeled through 2059. It showed that for the Cedar River, the 2008 flood of record would be exceeded based on projected climate conditions at various locations to substantially affect bridges under review in the study. The conclusion was to develop approaches to design review using confidence intervals and historical records to allow for future changes in precipitation to be addressed in the design process.

Interstate 80 Planning Study (PEL) – Evaluation of I-80 Resiliency and Vulnerability, June 2017 identified eastern Iowa along I-80 for risk of high-temperature average change and particular risk for snow, blizzard and/or icing. Recommendations in the report included developing road closure monitoring and documentation, monitoring of maintenance performance and practices, reviewing stormwater design standards, and conducting risk analysis at vulnerable locations. The appendix summarized existing data relevant to I-80, which is within the Quad Cities metropolitan planning area.

Other Iowa-related references examined as part of the literature review:

- *Climate Change Impacts on Iowa 2010, Iowa Climate Change Impacts Committee*
- *Iowa Climate Change and Adaptation & Resilience Report 2011, U.S. Environmental Protection Agency*
- *What Climate Change Means for Iowa, U.S. Environmental Protection Agency, August 2016*
- *NOAA National Climatic Data Center Climate of Iowa summary*

Atlanta Regional Commission. The Vulnerability and Resiliency Framework for The Atlanta Region, January 2018 was identified as a peer report similar in nature to the proposal by Bi-State Regional Commission. It was reviewed for its discussion on climate, reference to the vulnerability framework, and discussion of linkage to the transportation planning process.

Hillsborough County MPO. *The Hillsborough County MPO Vulnerability Assessment and Adaptation Pilot Project* was another peer report similar in nature to the proposal by Bi-State Regional Commission. It was reviewed for its vulnerability assessment process and screening, as well as the analysis of adaptation strategies relevant for sea level rise, storm surge, and special flood hazard areas.

Mid-America Regional Council. A review of the Kansas City region Climate Resilience Strategy, June 2017 was examined for its assessment of Midwestern climate trends, and framework for resilience. The goals and strategies were reviewed for potential relevance to the Quad Cities MPO for broader policy issues.

Other related references examined as part of the literature review included:

- *Climate Look – Understanding Long-Term Climate Changes for Kansas City, Missouri report prepared with Kansa City Water Services*
- *Transportation Section Midwest Technical Input Report National Climate Assessment – Climate Change Impacts on Transportation in the Midwest, March 2012*

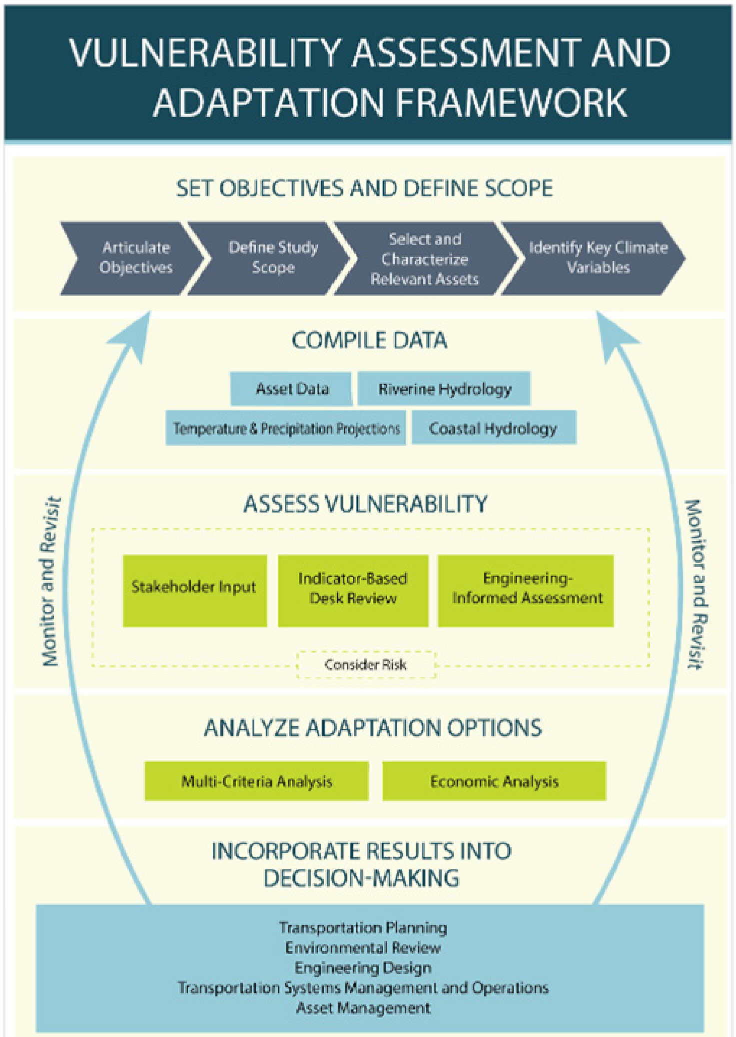
Peer Exchanges. The two peer exchange workshops in December of 2018 and 2019 also provided valuable information on formulating the Quad Cities MPO pilot.

Conducting a vulnerability assessment

Figure 5.1 outlines the vulnerability assessment process that follows the familiar 3-C Transportation Planning Process (comprehensive, coordinated, and continuing) to set a vision and goals, compile and evaluate the data to address a problem, develop options to mitigate the problem, and incorporate the findings into the system as a whole to allow for ongoing review and evaluation of its effectiveness. In this Pilot Project, an advisory group and other targeted stakeholders were solicited for background and information as a desk-top review of vulnerable facilities. The project objectives were two-fold: to address resilience in the Quad Cities Long

Range Transportation update using information compiled in the pilot study; and to provide model for small and mid-sized MPOs to replicate and use in their long range planning processes.

Figure 5.1 – Vulnerability Assessment and Adaptation Framework Flow Diagram



Source: Vulnerability Assessment and Adaptation Framework, Third Edition (2017)

Compile data

Chapter 4 outlined the wide range of extreme weather stressors that are predicted to effect the Midwest in the future. Preparing for these short-term immediate events, and planning for the longer term changes in climate will lay the groundwork for a more resilient metropolitan area. It is on the short-term, extreme weather events that the Quad Cities vulnerability assessment focused its work.

For a vulnerability assessment, an understanding of what types of extreme weather disruptions are likely, and then what transportation facilities would most likely be impacted by these disruptions due to extreme weather. *The IPCC Working Group II Fifth Assessment Report – Climate Change 2014 Impacts, Adaptation and Vulnerability Part B: Regional Aspects* outlines climate stressors of changing precipitation, rising temperatures and other stressors. Changing precipitation is expected to lead to severe storms and require more effective stormwater management practices. Road surfaces may need to be elevated from flooding where there are no redundant facilities, or designed to mitigate high-intensity rainfalls. Counter to more precipitation is drought conditions leading to reduced streamflow and impacts to river navigation. Rising temperatures are expected to increase risk for heat waves, rapid snow melt, greater frequency of freeze/thaw cycles, and wildfires. Transportation impacts from rising temperatures are expected to require more surface maintenance, disruptions from ice and snow storms, and closures due to fire. Other stressors include higher energy demand, impacts on air quality, and increasing incidents of invasive species.

Weather data. Weather data specific to the Quad Cities area was reviewed and compiled. Chapter 4outlines the weather data reviewed for the pilot, including precipitation, temperature, river flooding, tornados and freeze-thaw cycles. The Scott and Rock Island County Hazard mitigation plans were found to be sources of compiled hazards data, and had already evaluated weather related hazards to these counties. Combined priorities of the two counties included severe storms, winter storms, and river flooding.

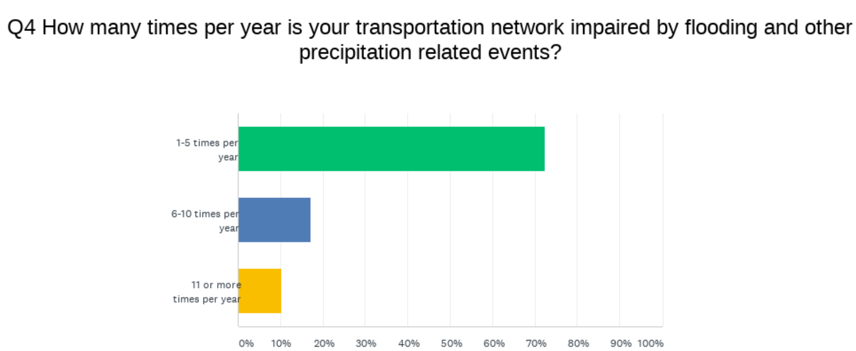
Transportation data. As the Quad Cities MPO, there was a solid base of transportation assets information. The current long range transportation plan and other data readily available through the departments of transportation was utilized. Available data included federal functional classification of roads, annual average daily traffic (AADT), inventories of transportation facilities and locations, bridge and pavement condition data, transit ridership and routes, and crash history data. Discussions with the Technical Committee narrowed the use of data in the criticality analysis.

Stakeholder input approach. A desktop survey was used to collect data on the alignment of weather and extreme weather events as it related to impacts on the transportation system. The survey was prepared online, and a link was sent to sixty-three contacts representing the transit systems, parks and public works staff, and Departments of Transportation staff within the metropolitan planning area. Surveys were also sent to the U.S. Army Corps of Engineers, Rock Island District, railroads, airports, and local emergency management agencies.

The survey was the first assessment of vulnerable transportation infrastructure as part of the Quad Cities pilot project. The intent was to determine extreme weather events that were assessed as affecting the Quad Cities transportation network, and locate "hot spots," defined as areas of ongoing concern where extreme weather played a role in disruption of the transportation system. Within the survey, another link was provided to an online geographic information mapping tool (ArcGIS online) to pinpoint specific locations of hot spots or vulnerable facilities. The survey was launched in March 2019 and completed by April 2019. Results are summarized in the Appendix. There were 34 participants responding to the survey.

As an example, Figure 5.2 shows responses to a question related to flooding and precipitation's impact on the transportation system by number of events. A follow-up question to this asked what was the known or assumed cause of the disruption. Responses indicated either heavy rain/flash flooding or prolonged rain/river flooding. As part of this questioning, it was suggested, as an example of the feedback, that consideration be given to raising portions of River Drive, Moline, Illinois to lessen impacts of flooding, and to look at durable construction materials to prevent washouts of aggregate materials into the stormwater system. Similar questions related to other types of events such as extreme heat or cold, severe winter weather, high winds, or other events.

Figure 5.2 – Survey Results for Number of Flood and Preciptation Related Events Impacting the Transportation Network



Source: Bi-State Regional Commission using Survey Monkey. Community based stakeholder input collected from 34 participants from March – April 2019.

When asked to rank listed extreme weather events common to our metropolitan area, the top three ranked events included heavy rain/flash flooding, prolonged rain/river flooding, and severe winter storms. This input aligned with prior hazard mitigation work and affirmed these as higher priorities in the metropolitan area when addressing transportation impacts.

Assessing asset criticality

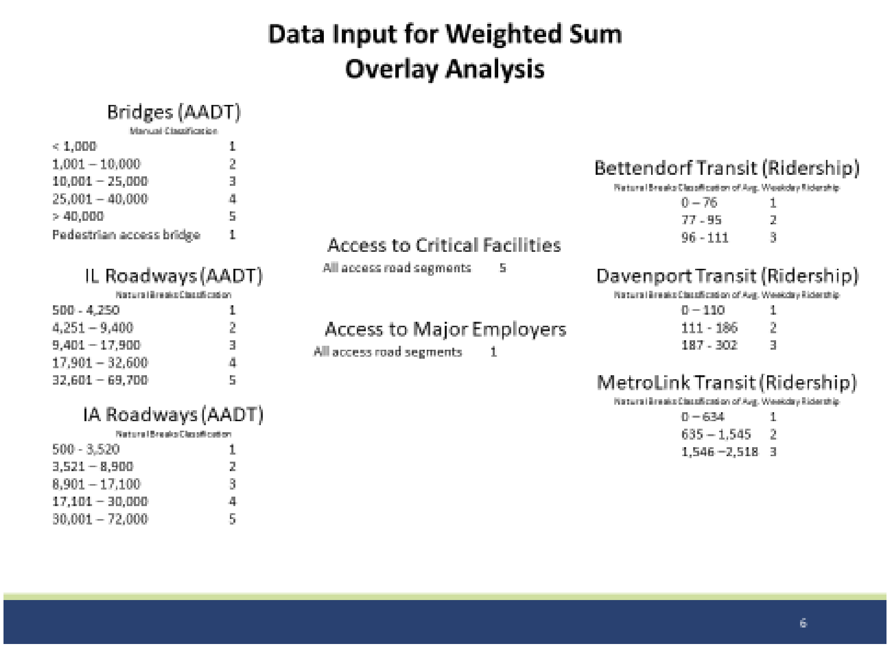
The second step in understanding the vulnerability of the Quad Cities MPO transportation network was identifying critical transportation assets and prioritizing them using a number of criterion. Criticality, for the purpose of the project, was defined as the extent to which an asset is critical to continued regional network functionality and movement of people and goods. A number of criteria, to prioritize assets as more critical or less critical, were developed by the Quad Cities MPO Technical Committee. According to the Technical Committee, the following criteria determined the criticality of a transportation asset:

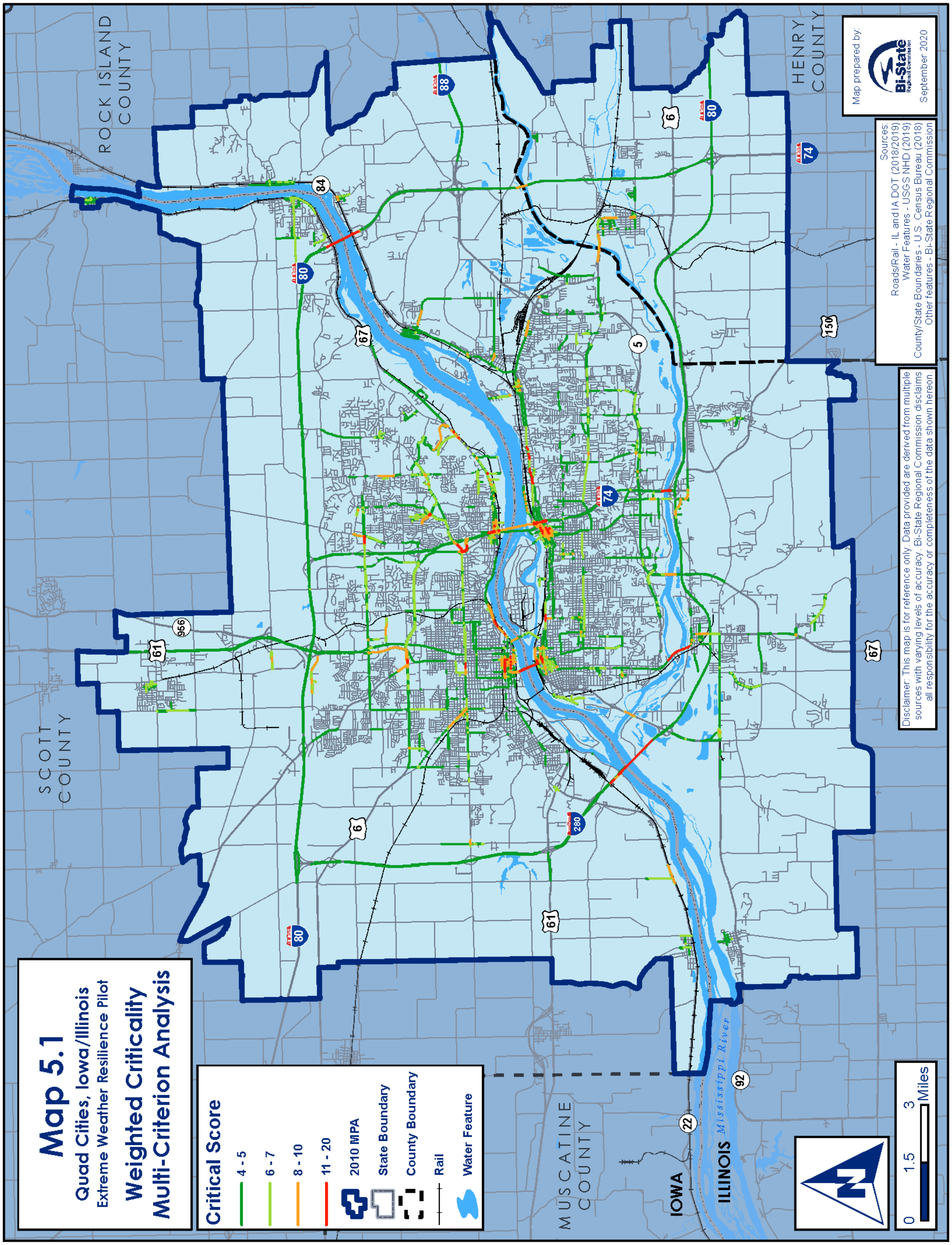
- High traffic routes
- River crossings
- Redundancy in network
- Transit routes
- Access to large employers
- Access to critical facilities
  - Hospitals
  - Public works and other municipal facilities
  - Transit facilities
  - Airports

These criteria were then quantified and given a weight to score each road segment in the Quad Cities MPO transportation network. The weight represents the level of criticality said criteria has on the continued function of the transportation network. For example, transit routes were deemed critical to the continued movement of persons without a personal vehicle or means to get around. The transit routes were weighted based on average weekday ridership per each provider. Higher use routes therefore score higher because they are moving more people than other routes. This is not to say that other routes are less important. It simply as-signs a lesser weight to routes with lower ridership. See Figure 5.3 for the data input for weighted sum overlay analysis.

Weights were transposed to the road network using raster analysis in GIS, each cell representing a weight given to it by the criterion it serves. These cells were summed to account for road segments serving more than one criteria. The resulting dataset represents road segments that are deemed most critical to the Quad Cities MPO transportation network.

Figure 5.3




Map 5.1
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Weighted Criticality
Multi-Criterion Analysis
Critical Score
4 - 5
6 - 7
8 - 10
11 - 20
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
ROCK ISLAND COUNTY
SCOTT COUNTY
MUSCATINE COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
0 1.5 3 Miles
Map prepared by:
Bi-State Regional Commission
September 2020
Sources:
Roads/Rail - IL and IA DOT (2018/2019)
Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
Disclaimer: This map is for reference only. Data provided are derived from multiple sources with varying levels of accuracy. Bi-State Regional Commission disclaims all responsibility for the accuracy or completeness of the data shown hereon.

Vulnerability assessment and prioritization

Vulnerability was assessed using a combination of weather data, transportation criticality, and stakeholder input as outlined above. Identifying vulnerable assets in the network to consider adaptation or mitigation being the end goal, vulnerability was considered for each individual extreme weather type.

Assessment

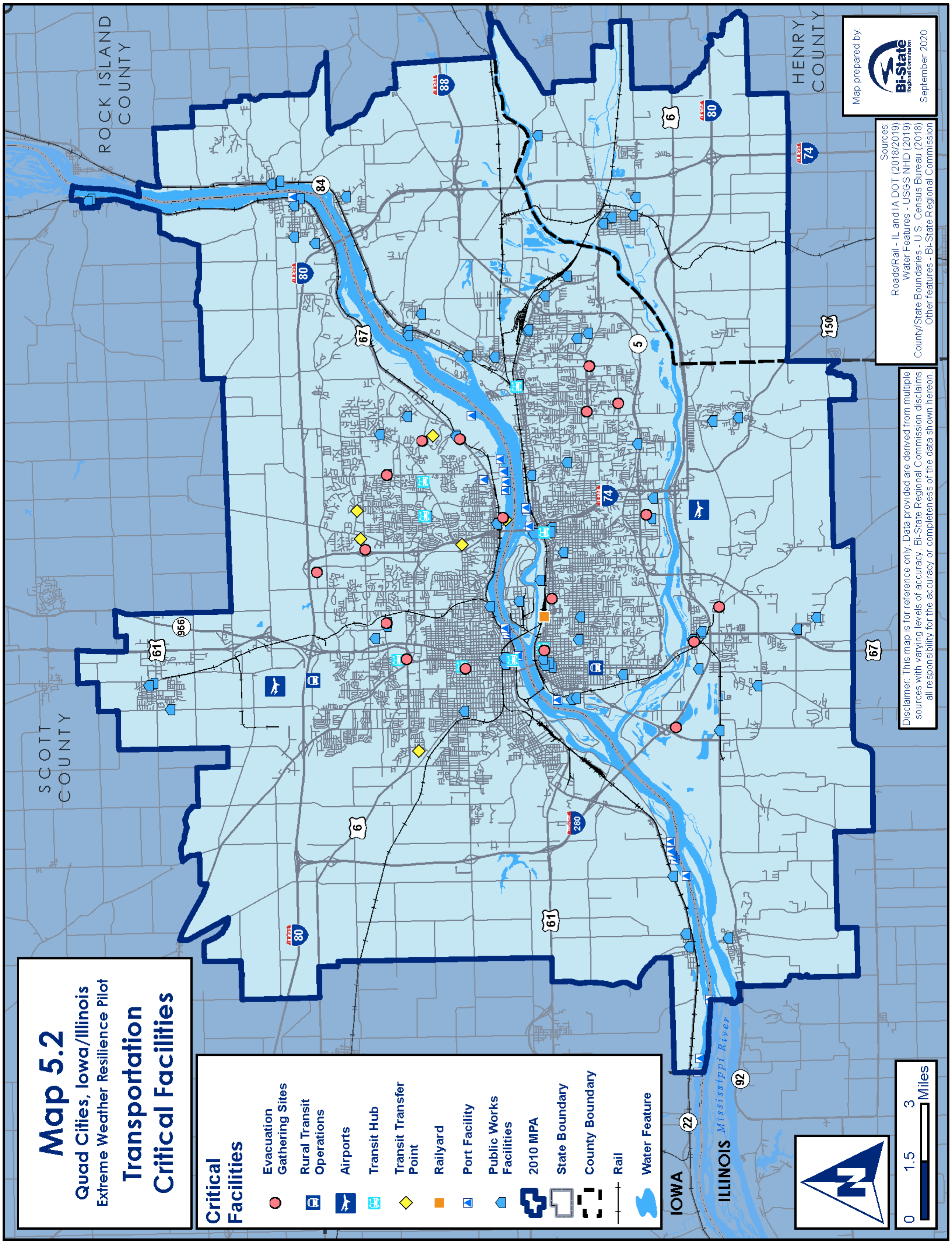
To collect this information, a stakeholder workshop was held in August 2019. After sharing the background on the project and providing other examples of extreme weather studies and work, two exercises were conducted. The first exercise was used to review the results of the desktop survey and add additional vulnerable assets not already collected. The second exercise was used to discuss adaptation strategies for selected weather scenarios.

Inventory review exercise. Results from the stakeholder survey asked about organizations' goals and strategies to address resilience. This helped shape the discussion of the workshop. The top three activities noted from the stakeholder survey on how participants' organizations address resilience were:

- Include resilience goals and strategies in comprehensive plans, hazards plans, or other guidance documents
- Update construction and building specifications to include resilience measures
- Incorporate more intensive maintenance for vulnerable assets

As part of the workshop, transportation assets were provided for the discussion including the transportation system with the area transportation critical facilities, pavement conditions, sidewalk network, bike and shared use trails, and transit routes. These maps were displayed at the workshop for reference to help support the inventory review exercise and adaptation strategies multi-criteria analysis exercise.

Floodplain delineation maps (Map 5.7) were provided to each table at the workshop; in addition to a larger plotted map of the metropolitan planning area, locating the "hot spots" identified during the stakeholder survey by extreme weather type with federal functional classification and entitled weather-related vulnerabilities (Map 5.8).


Map 5.2
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Transportation
Critical Facilities
Critical Facilities
Evacuation Gathering Sites
Rural Transit Operations
Airports
Transit Hub
Transit Transfer Point
Railyard
Port Facility
Public Works Facilities
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
SCOTT COUNTY
ROCK ISLAND COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
0 1.5 3 Miles
Map prepared by:
Bi-State Regional Commission
September 2020
Sources
Roads/Rail - IL and IA DOT (2018/2019)
Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
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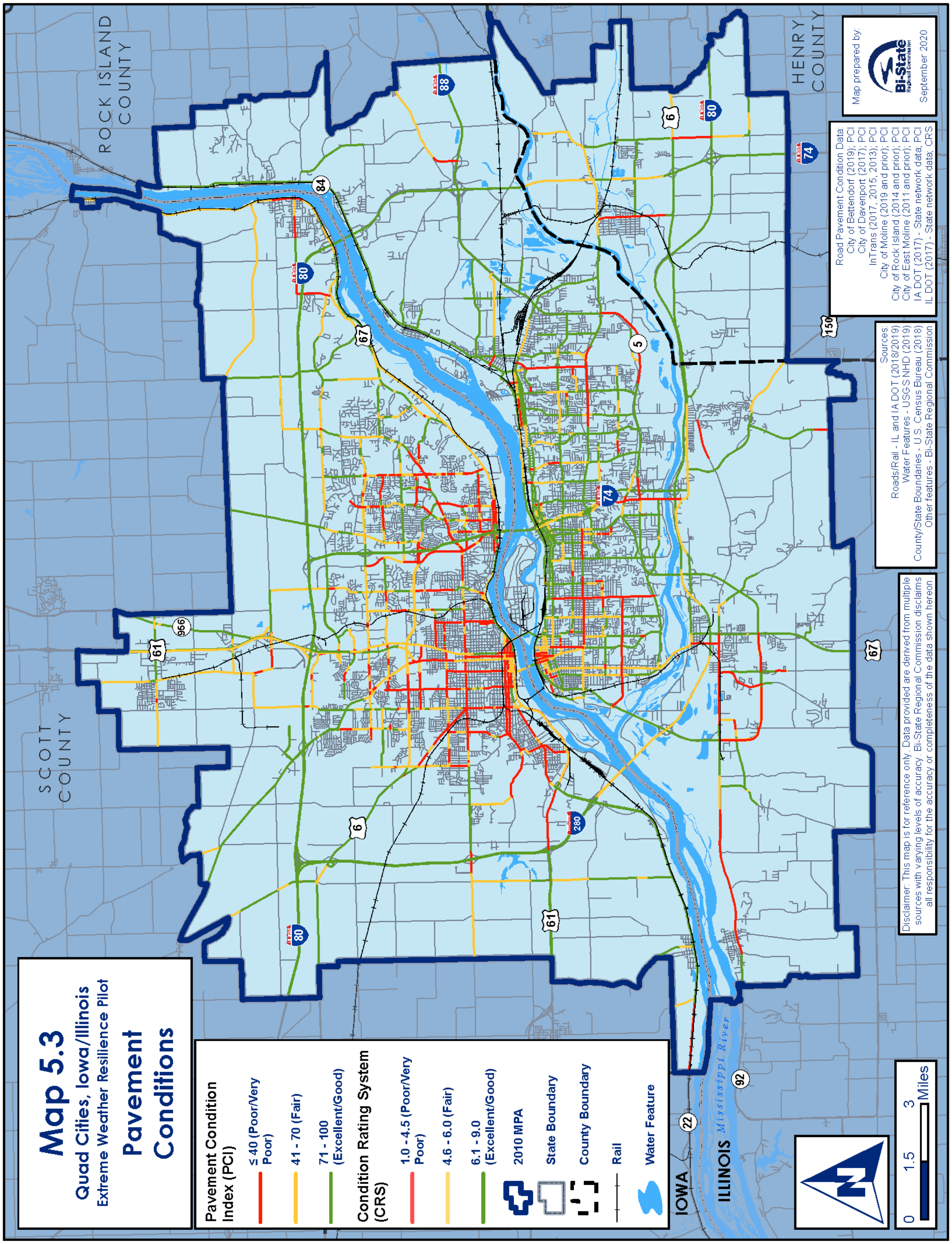

Map 5.3
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Pavement Conditions
Pavement Condition Index (PCI)
≤ 40 (Poor/Very Poor)
41 - 70 (Fair)
71 - 100 (Excellent/Good)
Condition Rating System (CRS)
1.0 - 4.5 (Poor/Very Poor)
4.6 - 6.0 (Fair)
6.1 - 9.0 (Excellent/Good)
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
0 1.5 3 Miles
ROCK ISLAND COUNTY
SCOTT COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
Road Pavement Condition Data:
City of Bettendorf (2019); PCI
City of Davenport (2017); PCI
InTrans (2017, 2015, 2013); PCI
City of Moline (2019 and prior); PCI
City of Rock Island (2014 and prior); PCI
City of East Moline (2011 and prior); PCI
IA DOT (2017) - State network data; PCI
IL DOT (2017) - State network data; CRS
Sources:
Roads/Rail - IL and IA DOT (2018/2019)
Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
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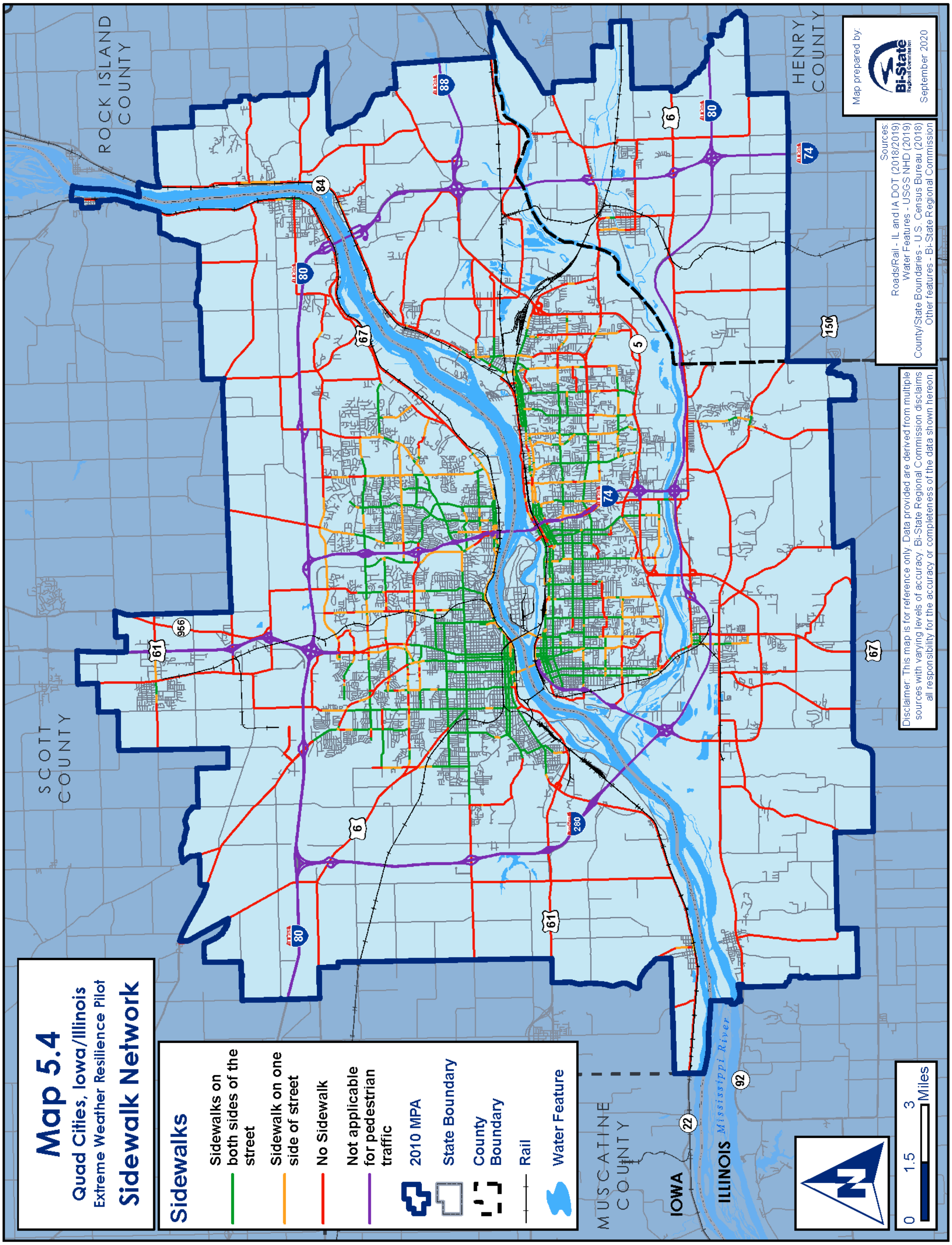
Map prepared by:
Bi-State Regional Commission
September 2020


Map 5.4
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Sidewalk Network
Sidewalks
Sidewalks on both sides of the street
Sidewalk on one side of street
No Sidewalk
Not applicable for pedestrian traffic
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
0 1.5 3 Miles
ROCK ISLAND COUNTY
SCOTT COUNTY
HENRY COUNTY
MUSCATINE COUNTY
IOWA
ILLINOIS
Mississippi River
Map prepared by:
Bi-State Regional Commission
September 2020
Sources:
Roads/Rail - IL and IA DOT (2018/2019)
Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
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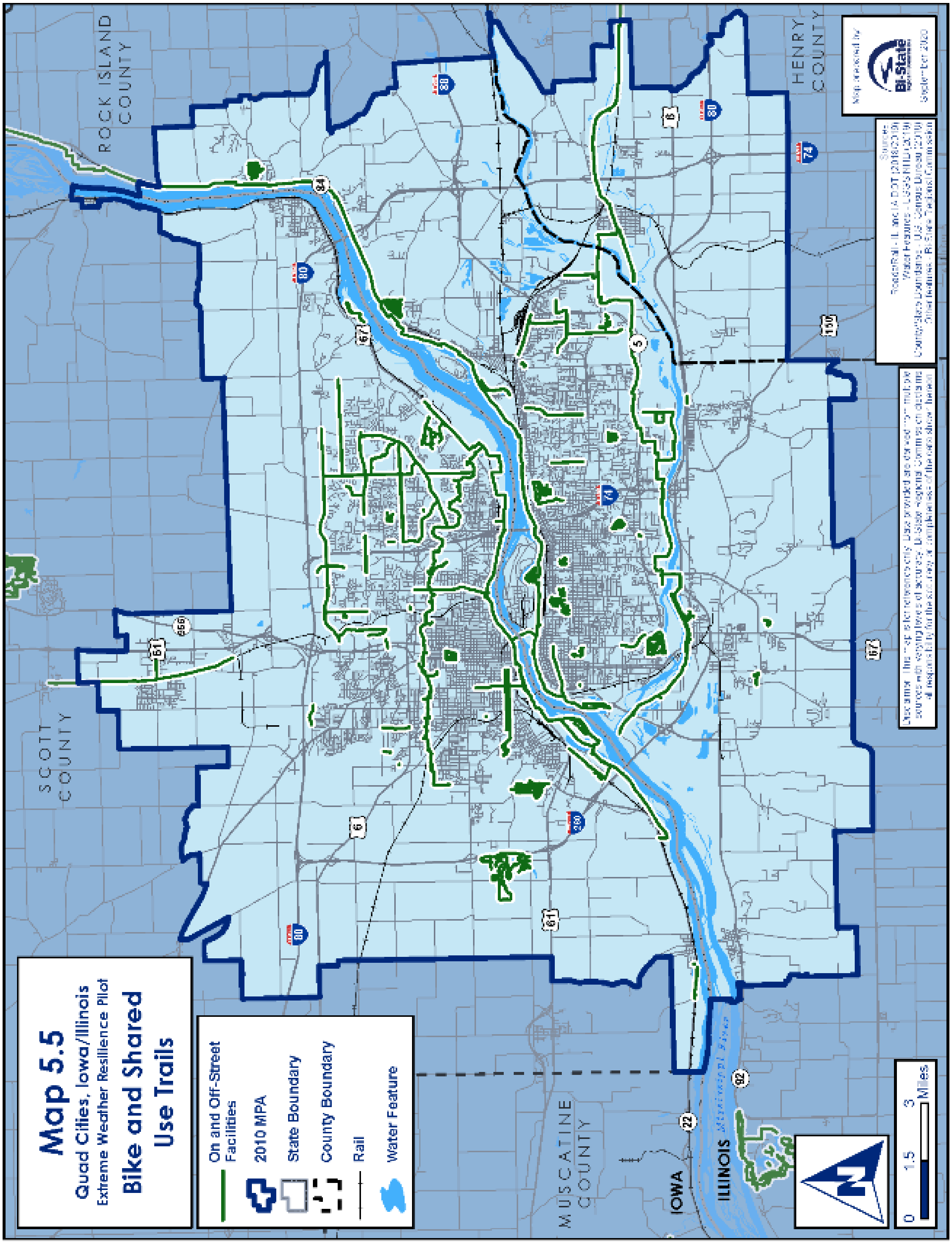
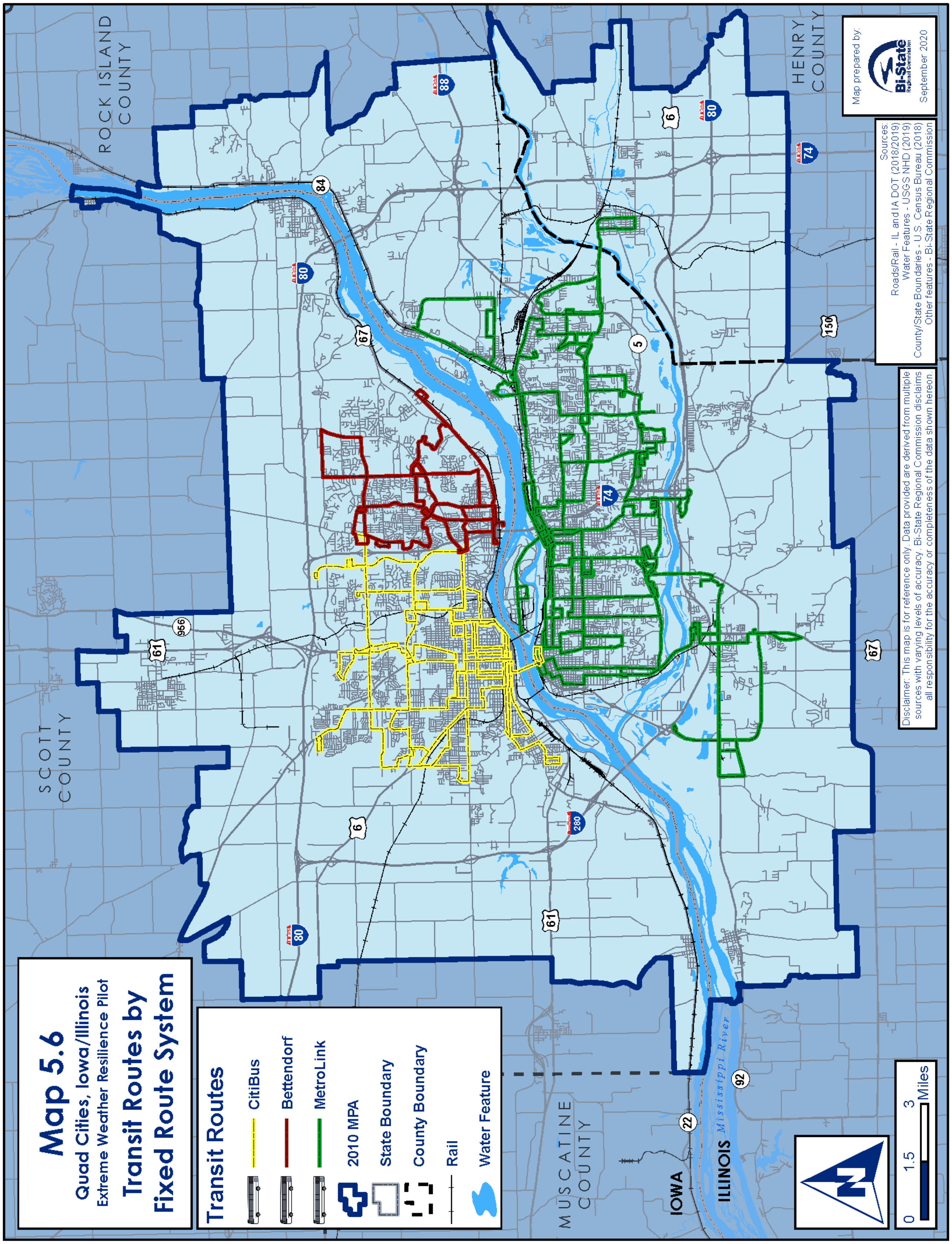
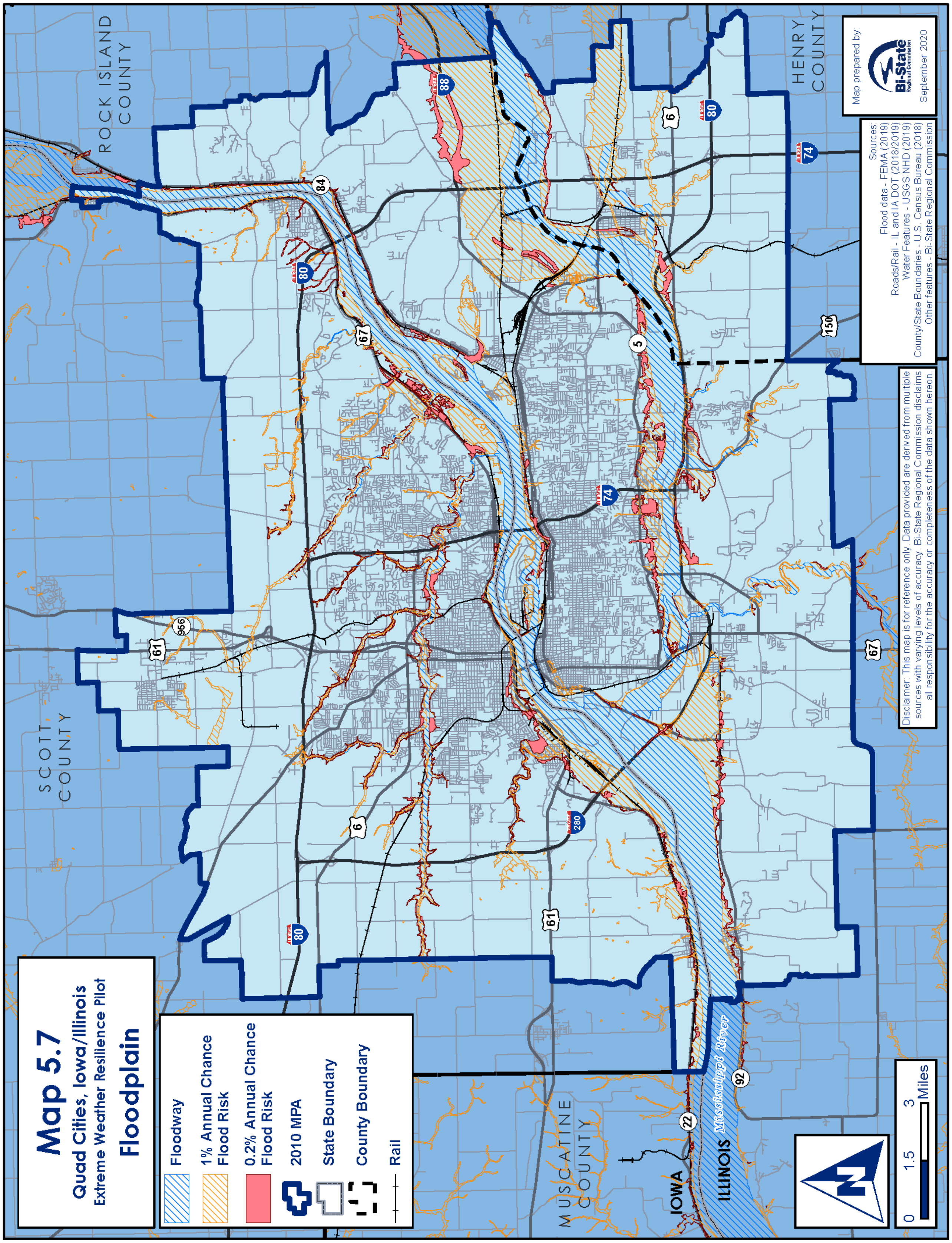

Map 5.5
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Bike and Shared Use Trails
On and Off-Street Facilities
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
ROCK ISLAND COUNTY
SCOTT COUNTY
MUSCATINE COUNTY
HENRY COUNTY
IOWA
ILLINOIS
0 1.5 3 Miles


Map 5.6
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Transit Routes by Fixed Route System
Transit Routes
CitiBus
Bettendorf
MetroLink
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
ROCK ISLAND COUNTY
SCOTT COUNTY
MUSCATINE COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
0 1.5 3 Miles
Disclaimer: This map is for reference only. Data provided are derived from multiple sources with varying levels of accuracy. Bi-State Regional Commission disclaims all responsibility for the accuracy or completeness of the data shown hereon.
Sources:
Roads/Rail - IL and IA DOT (2018/2019)
Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
Map prepared by:
Bi-State Regional Commission
September 2020


Map 5.7
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Floodplain
Floodway
1% Annual Chance Flood Risk
0.2% Annual Chance Flood Risk
2010 MPA
State Boundary
County Boundary
Rail
ROCK ISLAND COUNTY
SCOTT COUNTY
MUSCATINE COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
0 1.5 3 Miles
Sources:
Flood data - FEMA (2019)
Roads/Rail - IL and IA DOT (2018/2019)
Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
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September 2020
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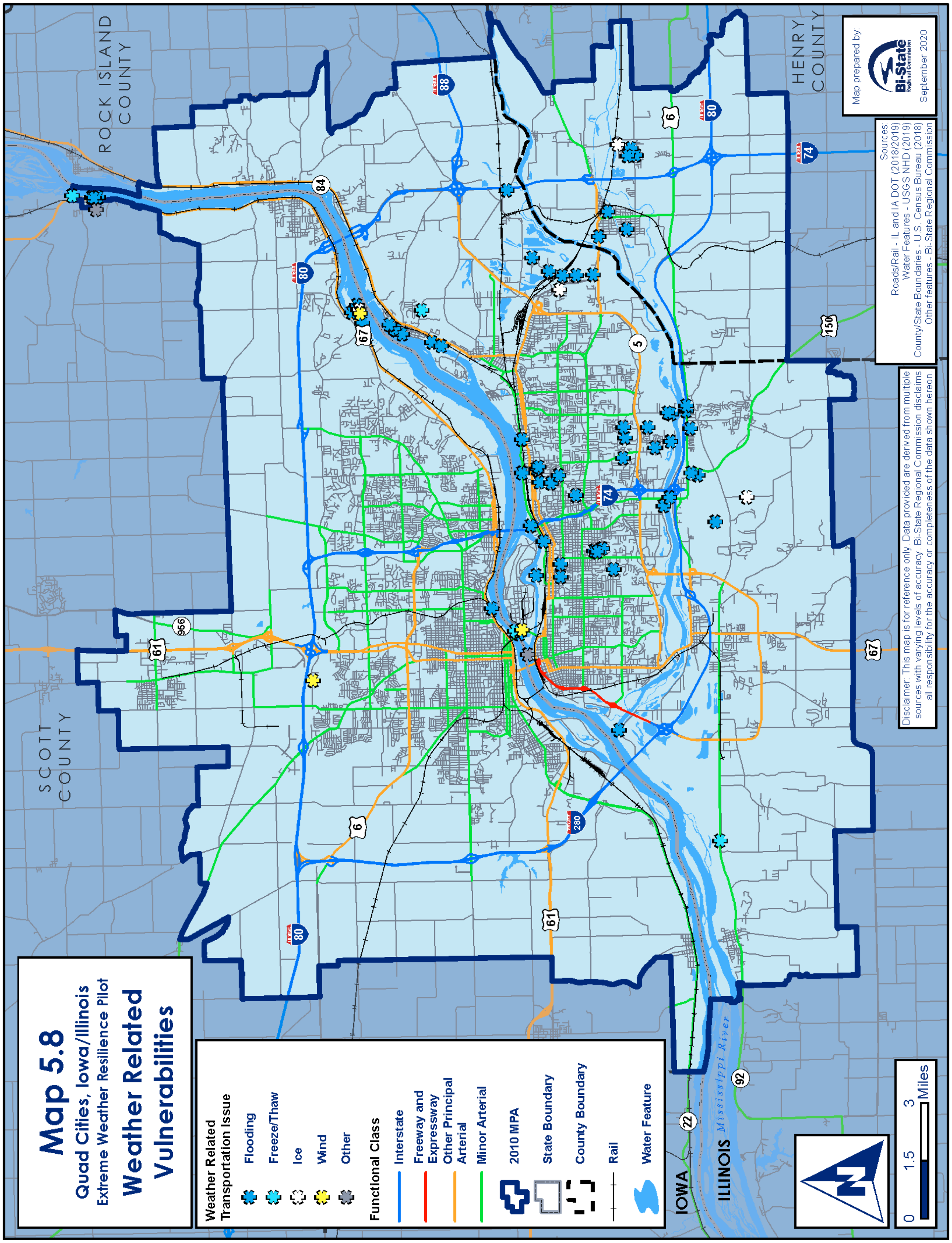
Map 5.8
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Weather Related Vulnerabilities
Weather Related Transportation Issue
Flooding
Freeze/Thaw
Ice
Wind
Other
Functional Class
Interstate
Freeway and Expressway
Other Principal Arterial
Minor Arterial
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
ROCK ISLAND COUNTY
SCOTT COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
0 1.5 3 Miles
Map prepared by:
Bi-State Regional Commission
September 2020
Sources:
Roads/Rail - IL and IA DOT (2018/2019)
Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
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Adaptation strategies multi-criteria analysis exercise. The workshop concluded with an exercise to draw out potential adaptation strategies for the identified extreme weather events affecting the MPA. The exercise worksheet was developed using the multi-criteria analysis approach to evaluate adaptation options from the *FHWA Vulnerability Assessment and Adaptation Framework*, Third Edition (December 2017). The approach uses different quantitative and qualitative criteria to evaluate adaptation options as they apply to specific scenarios. It also allows for considerations that may be difficult to quantify, such as potential negative externalities, public acceptance, or residual risk.

In the workshop, the exercise was applied to specific locations or situations, such as an ice/sleet event with icing on Interstate 80 at the Mississippi River. Participants then discussed potential adaptation strategies under the categories of advisory, control, or treatment measures. Based on the adaptation strategies, workshop participants then provided feedback on whether these strategies would be effective, costly, or impact the environment or vulnerable asset, among other criteria. The Appendix contains the workshop summary as a service report and details the results of the discussion. Time constraints limited the discussion on some of the criteria. Flooding, which was top-of-mind following record flooding on the Mississippi River, captured most of the participants' discussion time.

As a post-workshop conclusion, this exercise was determined to be more useful during MPO project selection process as another evaluative component of project prioritization. The worksheet was determined to be a helpful tool to bring resilience planning into the project programming and development process.

Prioritization

The following summarizes the criticality and vulnerability multi-criteria analysis as a follow-up to the workshop. Summaries are described by extreme weather type and indicate areas of the transportation network that are priorities for mitigation and adaptation strategies as a result of prior and anticipated disruptions due to extreme weather.

Flooding

The Quad Cities Area is no stranger to flooding. Two large rivers traverse the MPA in addition to multiple stream tributaries. The Mississippi River, the largest of the two rivers, was made navigable by the construction of the lock and dam system. The Quad Cities MPA sits along Pools 14 (1938) and 15 (1934), which maintain

MAJOR RIVER FLOODING 2011

MAJOR RIVER FLOODING 2018

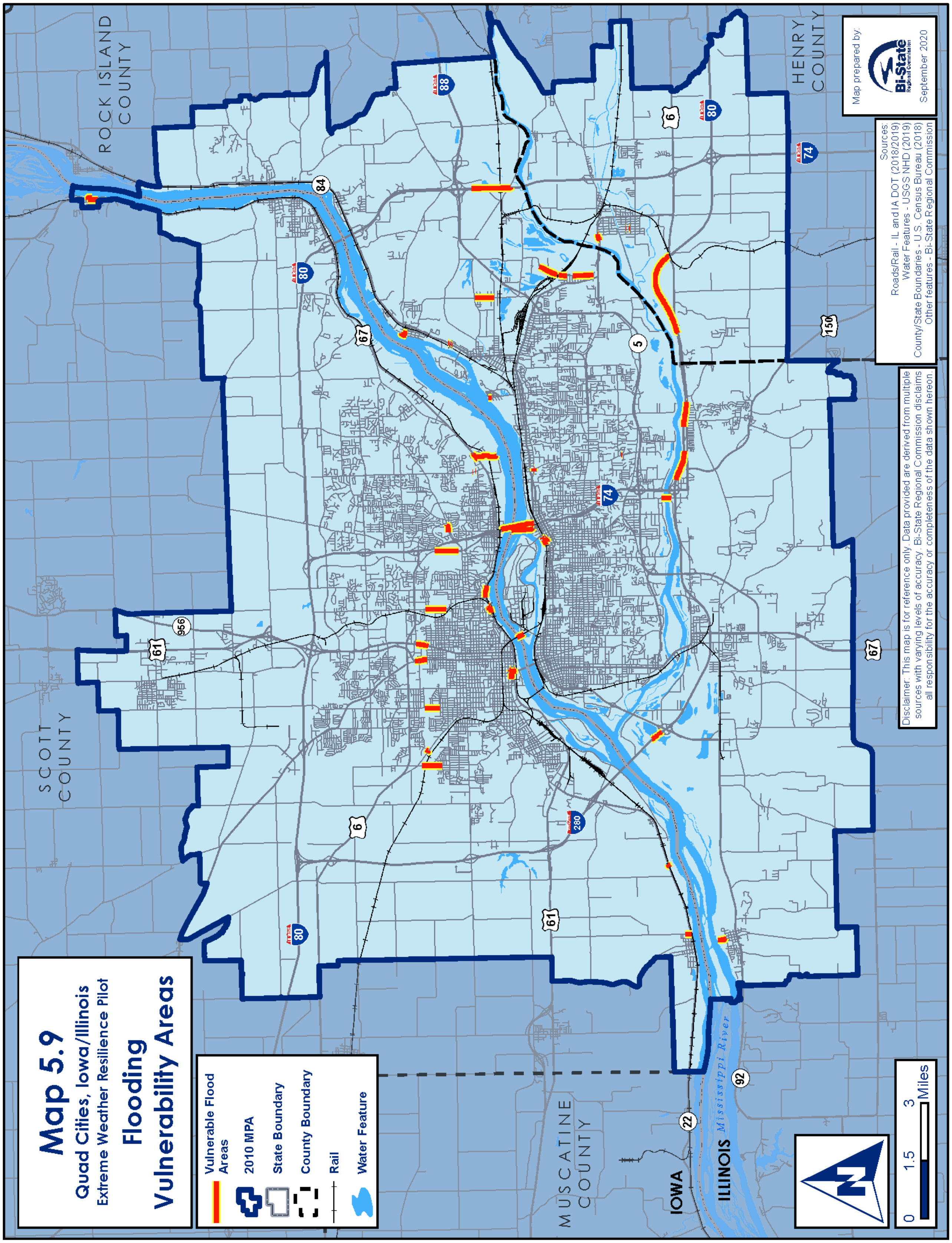
a 9-foot navigation channel for barge traffic. While the dams serve as a level of flood control, the majority of the Quad Cities transportation assets are protected by levees and flood walls. The exception is along the Davenport, Iowa riverfront, as one of the largest communities on the
Mississippi River without flood protection. Similarly, levees are the primary flood control method mitigating flood waters from the Rock River, though this waterway is much smaller in water volume and not "navigable," per the U.S. Army Corps of Engineer's definition.

In addition to riverine flooding, increased precipitation in both quantity and event frequency cause flash flooding or stormwater flooding. This situation is found to be a common issue in under-engineered or lower lying areas. During extreme rain events, roadways and other transportation assets can quickly become impassable or inoperable. In the last 25 years, there have been 110 flash flood or flood events recorded in the National Weather Service's (NWS) Storm Data database for Rock Island County, IL. Similarly, there have been 128 events in Scott County, Iowa. Record riverine flooding occurred in the Quad Cities during spring 2019, resulting in the highest river crest and most consecutive days above flood stage on record. The Quad Cities, especially the Davenport, Iowa riverfront areas, were underwater for 96 consecutive days.

To prioritize transportation assets at risk, road segments with a criticality score above four were considered for flood vulnerabilities. These segments were compared spatially to FEMA identified Special Flood Hazard Zones and stakeholder "hot spots" where flooding has been known to cause disruptions. The overlay analysis results show transportation network areas and specific road segments/corridors that are deemed both critical to the network and vulnerable to flooding (Map 5.9). Specific areas highlighted by this analysis are:

- Road segments and bridges crossing Duck Creek:
  - North Fairmount Street (Davenport)
  - Hickory Grove Road (Davenport)
  - North Division Street (Davenport)
  - North Harrison Street (Davenport)
  - North Brady Street (Davenport)
  - Eastern Avenue (Davenport)

  - Kimberly Road (Davenport)
  - Middle Road (Bettendorf)
  - Devil's Glen Road (Bettendorf)
  - 42nd Street near Duck Creek confluence (Bettendorf)
- Northern access to Centennial Bridge in Davenport
- East River Drive near the Village of East of Davenport and Iowa American Water
- Interstate 74 Bridge
- Arsenal Bridge
- Downtown Moline near the Tax Slayer Event Center
- 5th Avenue and 49th Street area in Moline
- 7th Street area near the Mississippi Mobile Home Park in East Moline
- Illinois State Route 84 northeast of Campbell's Island and southwest of Empire Park in Hampton
- 1st Avenue area in Hampton
- 40th Street in East Moline in the Babcock Neighborhood
- North 1st Avenue in Carbon Cliff
- Illinois State Route 84 east of the Rock River in Colona
- Great River Road and River Drive in Princeton
- Interstate 280
- 27th Street bridge in Moline
- Interstate 280 and Centennial Expressway interchange
- East Front Street/Highway 22 bridge over Donaldson Creek
- Highway 22 and Dodge Street in Buffalo
- 1st Street in Andalusia

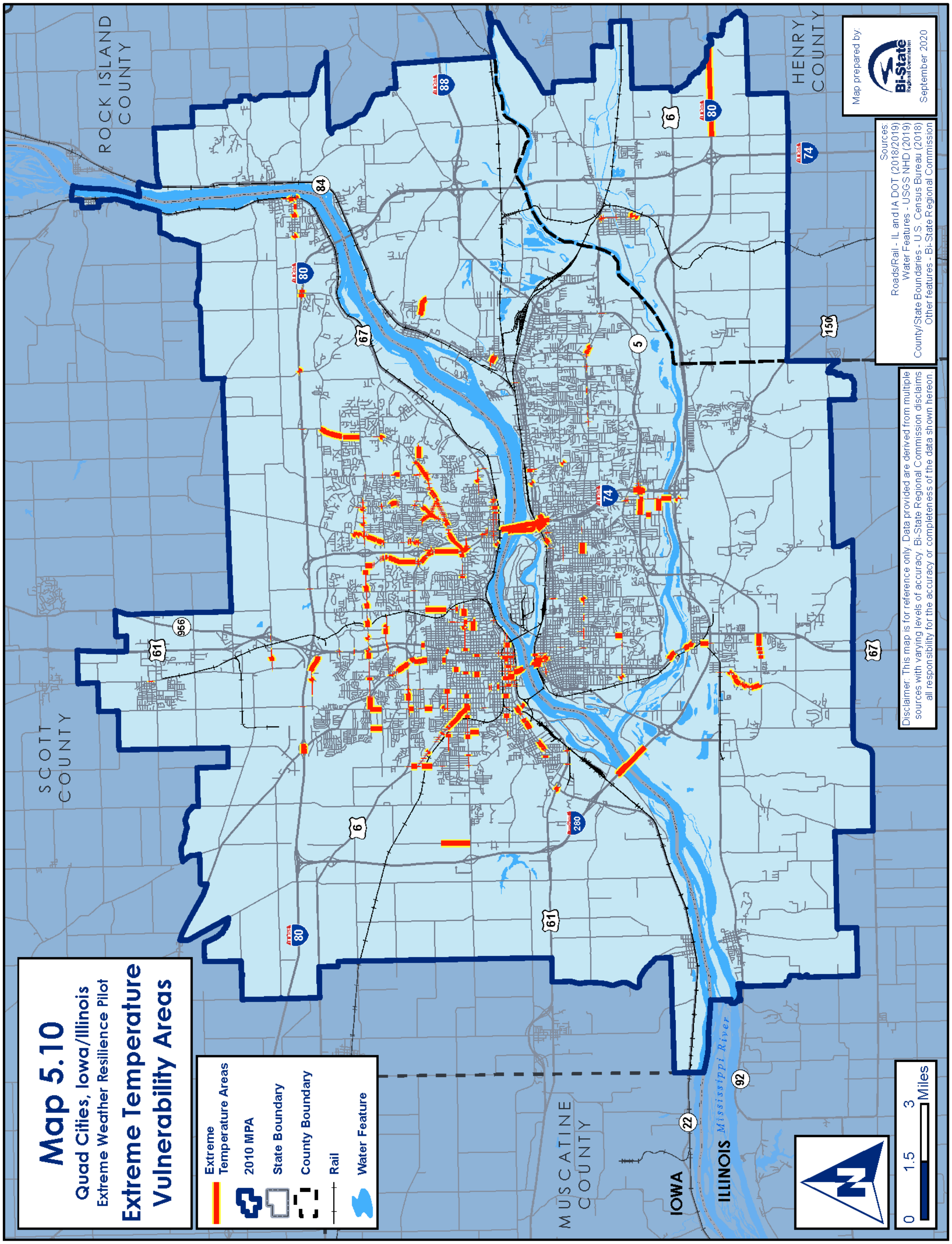

Map 5.9
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Flooding
Vulnerability Areas
Vulnerable Flood Areas
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
ROCK ISLAND COUNTY
SCOTT COUNTY
MUSCATINE COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
0 1.5 3 Miles
Map prepared by:
Bi-State Regional Commission
September 2020
Sources:
Roads/Rail - IL and IA DOT (2018/2019)
Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
Disclaimer: This map is for reference only. Data provided are derived from multiple sources with varying levels of accuracy. Bi-State Regional Commission disclaims all responsibility for the accuracy or completeness of the data shown hereon.

Future analysis should look at locally available inundation mapping completed by the U.S. Army Corps of Engineers, and areas that were not flooded but very close to flooding had additional rain occurred during the record flooding period in 2019. Such areas included, I-280 westbound near the weigh stations, Illinois 92 from the Rock River to I-280, including ramps, and Airport Road near the Quad City International Airport. These are examples and there could be more based on local knowledge of the March-June 2019 flooding event.

Extreme temperatures & freeze/thaw

Temperature changes were identified as a vulnerability to the network by stakeholders, citing specific areas that seem to struggle with extreme temperatures or freeze/thaw cycles. As discussed in Chapter 2, there's an upward trend line of annual number of spring freeze/thaw cycles exceeding 26 and 38 degrees Fahrenheit. Extreme heat can cause pavement rutting, buckling and concrete joint heaving (FHWA Climate Change Adaptation Guide for Transportation System Management, Operations and Maintenance, 2015). Freeze/thaw cycles can cause potholes and dangerous, unexpected surface hazards for motorists. To prioritize transportation assets most at risk from temperature related events, stakeholder identified locations were combined with pavement and bridge condition to assess vulnerability, and then overlaid with road segments deemed critical (Map 5.10). Many areas were identified by this analysis. The following are considered high traffic corridors:

- Segments along Interstate 80
- Hickory Grove Road in Davenport
- West 53rd Street and North Division Street in Davenport
- 53rd Street corridor
- Northwest Boulevard near Northpark Mall in Davenport
- Welcome Way/North Harrison Street near Duck Creek
- Locust Street/Middle Road Corridor
- Interstate 74 Bridge
- Centennial Bridge
- Interstate 280 Bridge
- John Deere Road near Interstate 74 interchange in Moline
- Avenue of the Cities in Silvis
- 4th & 5th Avenue corridor in Moline


Map 5.10
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Extreme Temperature Vulnerability Areas
Extreme Temperature Areas
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
ROCK ISLAND COUNTY
SCOTT COUNTY
HENRY COUNTY
MUSCATINE COUNTY
IOWA
ILLINOIS
Mississippi River
Map prepared by:
Bi-State Regional Commission
September 2020
Sources:
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Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
Disclaimer: This map is for reference only. Data provided are derived from multiple sources with varying levels of accuracy. Bi-State Regional Commission disclaims all responsibility for the accuracy or completeness of the data shown hereon.
0 1.5 3 Miles

Ice and Snow

Winter storms in the Midwest can severely impact the functionality of transportation networks, especially automobile traffic. The various types of extreme winter weather cause considerable damage. Heavy snows cause immobilized transportation systems, downed trees and power lines, and collapse of buildings. Blizzard conditions are winter storms that last at least three hours with sustained wind speeds of 35 mph or more, reduced visibility of ¼ mile or less, and white out conditions. Heavy snows of more than 6 inches in a 12-hour period or freezing rain greater than ¼-inch accumulation may cause hazardous conditions in the community and slow or stop the flow of vital supplies, as well as disrupting emergency and medical services. Loose snow begins to drift when the wind speed reaches a critical speed of 9 to 10 mph under freezing conditions.

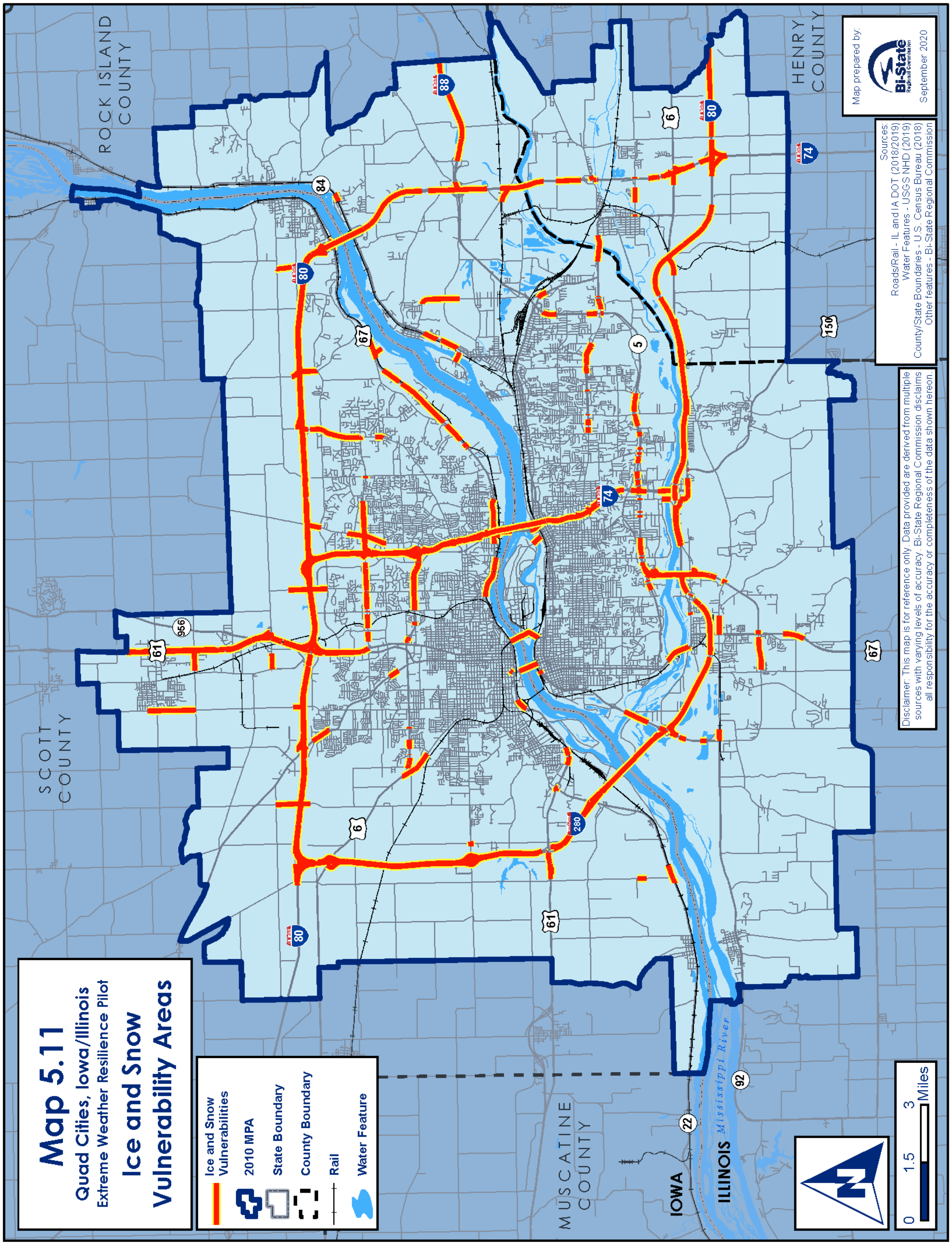
The potential for some drifting is substantially higher in open country than in urban areas where buildings, trees, and other features obstruct the wind. Ice storms result in fallen trees, broken tree limbs, downed power lines and utility poles, fallen communications towers, and impassable transportation routes. Severe ice storms have caused total electric power losses over large areas of Illinois and Iowa and rendered assistance unavailable to those in need due to impassable roads.

In the last 25 years, there have been 65 winter storm events recorded in the National Weather Service's (NWS) Storm Data database for Rock Island County, IL. Similarly, there have been 70 events in Scott County, Iowa. To prioritize transportation assets most at risk from extreme winter storm related events, stakeholder identified locations were combined with road segments with a 45 mph speed limit or above and river crossings to assess vulnerability, then overlaid with road segments deemed critical (Map 5.11).

Driving too fast for conditions is one of the major causes of roadway disruptions during winter storm events. Whether it be ice, snow, or slush on a roadway and varying degrees of surface treatment (e.g. salt, plowing, sand, etc.), roads with higher speed limits are at more risk of experiencing disruptions. These corridors are also often higher trafficked areas. As such, road segments with a 45 mph speed limit or above where used consider vulnerability during extreme winter storm conditions. In addition to all Mississippi River and Rock River bridges, specific corridors highlighted by this analysis are:

- Interstate 80

- Interstate 280
- Interstate 74
- Interstate 88
- U.S. 61
- John Deere Road/Illinois Route 5
- U.S. 6
- Rock Island-Milan Parkway
- U.S. 67
- Illinois State Route 84
- Highway 22
- West Kimberly Road/Hickory Grove Road
- 53rd Street
- East Kimberly Road
- River Drive
- Utica Ridge Road
- Middle Road
- Northwest Boulevard


Map 5.11
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Ice and Snow
Vulnerability Areas
Ice and Snow Vulnerabilities
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
ROCK ISLAND COUNTY
SCOTT COUNTY
MUSCATINE COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
0 1.5 3 Miles
Disclaimer: This map is for reference only. Data provided are derived from multiple sources with varying levels of accuracy. Bi-State Regional Commission disclaims all responsibility for the accuracy or completeness of the data shown hereon.
Sources:
Roads/Rail - IL and IA DOT (2018/2019)
Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
Map prepared by:
Bi-State Regional Commission
September 2020

WIND DAMAGE

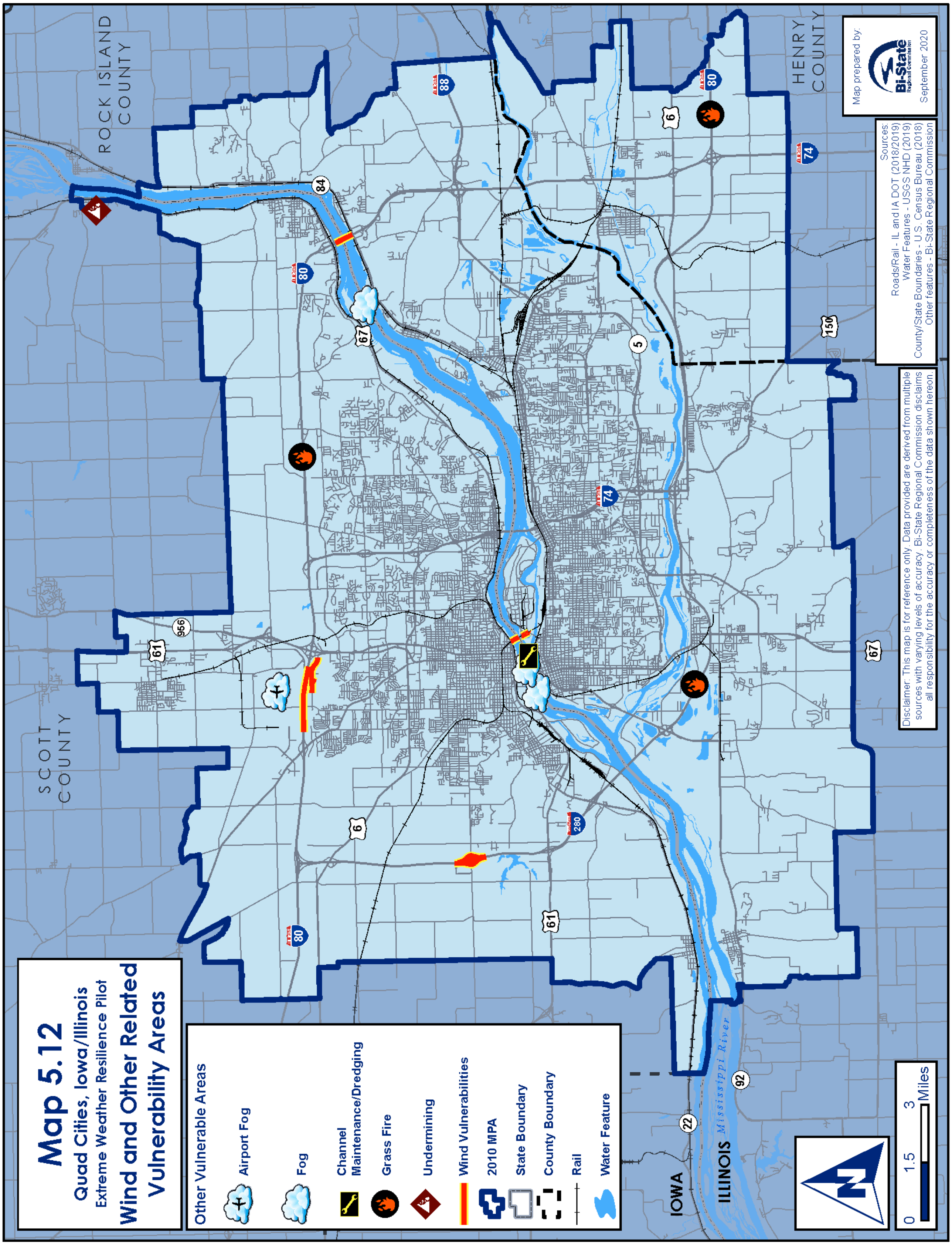
Wind and Other

Tornadoes and strong winds can impact the transportation network in many ways. More often than not, disruptions occur when strong winds cause blocked roadways from downed trees, powerlines, and other storm debris. Tornadoes consist of violent whirling wind characteristically accompanied by funnel-shaped clouds extending down from a cumulonimbus cloud. Rotating wind speeds can exceed 300 mph and travel across the ground at average speeds of 25 to 30 mph. Windstorms can be described as extreme winds associated with severe winter storms, severe thunderstorms, downbursts, and very strong pressure gradients. It is difficult to separate the various wind components that cause damage from other wind-related natural events that often occur with or generate windstorms. Historically, windstorms are associated with severe thunderstorms and blizzards. High impact derechos are associated with bands of rapidly moving thunderstorms known as bow echoes, squall lines, or quasi-linear thunderstorm systems. They are widespread, long-lived storms that race across a large area such as a state or region. Between 1995-2020, 157 extreme wind related events were recorded in the National Weather Service's (NWS) Storm Data database for Rock Island County, IL and 337 for Scott County, IA. These recorded events include tornadoes, strong winds, and strong winds associated with a thunderstorm.

Extreme wind can potentially canvas the entire MPA, and adaptation should be considered for all critical roadways and transportation assets. Specific areas highlighted by stakeholders deemed vulnerable to extreme wind events are:

- Interstate 80 Bridge
- Centennial Bridge
- Interstate 80 west of the U.S. 61 interchange
- Interstate 280 and Locust Street area

Other extreme events were considered throughout the project that are considered more unique or situational and conducive to the blanket analysis approach. These specific events and vulnerabilities were identified by stakeholders either through surveying or workshop results. The vulnerabilities are labeled as "Other" on Map 5.12. These events include river navigation disruptions caused by fog, airport disruptions from fog, grass fires along rural roadways, and land subsidence or undermining.


Map 5.12
Quad Cities, Iowa/Illinois
Extreme Weather Resilience Pilot
Wind and Other Related Vulnerability Areas
Other Vulnerable Areas
Airport Fog
Fog
Channel Maintenance/Dredging
Grass Fire
Undermining
Wind Vulnerabilities
2010 MPA
State Boundary
County Boundary
Rail
Water Feature
ROCK ISLAND COUNTY
SCOTT COUNTY
HENRY COUNTY
IOWA
ILLINOIS
Mississippi River
0 1.5 3 Miles
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Water Features - USGS NHD (2019)
County/State Boundaries - U.S. Census Bureau (2018)
Other features - Bi-State Regional Commission
Map prepared by:
Bi-State Regional Commission
September 2020

Reports used to glean information on adaptation strategies included the Adaptation Framework itself with peer examples from other pilots, and the following:

- *Climate Change Adaptation Guide for Transportation Systems Management, Operations and Maintenance* (2015), FHWA-HOP-15-026
- *Planning for Infrastructure Resilience (2019) Planning Assistance Service Report 596*, American Planning Association

Analyze adaptation options

Adaption strategies to mitigate extreme weather come in many shapes and forms, more typically, permanent construction or complex engineering types of strategies to provide the ultimate solutions. These can be highly effective but can be costly. From a practical perspective, it is also important to consider the less obvious strategies such as education, communication, and more temporary structures as solutions.

Combining a number of different adaption options may be the perfect adaption strategy for a specific vulnerability in a specific location. The point is that the adaptation option will depend greatly on the specifics of the existing vulnerability and future risk. Adaption options can be categorized into three main categories: Control, Advisory, and Treatment. Control includes more temporary adaptation strategies like variable speed limits, vehicle restrictions, and road surface treatments (e.g. salt, sand, etc.). Advisory options include adaption communications like road side warning systems, motorist alerts, Intelligent Transportation System (ITS), and a number of other interactive and automated systems. Lastly, treatment refers to the more commonly known adaption strategies like green infrastructure, levee construction, culvert sizing, and road/bridge elevation to name a few.

The strategies are also coupled with policies that provide for overarching considerations to address the root cause of the extreme weather event, or climate change. Policies may address reductions in greenhouse gases, evaluation and changes to engineering design and specifications, or deployment of resources to address maintenance and operations before, during, or after events.

Throughout this pilot project, not one single adaptation option can be used uniformly across the MPA to address any one specific vulnerability or even one type of transportation asset. Rather, a more useful strategy to build resilience in the transportation network is to incorporate adaptation options into the project development phase using the resources and data identified by the Prioritization Analysis (Critical + Vulnerable hot spots).

We've also learned that it is important to consider a jurisdiction's resiliency efforts when developing recommendations for specific transportation assets. Adaptation strategies should be developed using a combination of Control, Advisory, and Treatment options; should consider existing resiliency efforts of the specific jurisdiction/municipality; should be tailored to meet the mitigation goals of the specific extreme weather vulnerability; and should consider feasibility and effectiveness in different climate scenarios or other types of extreme weather. Developing an adaptation strategy should also be a creative process involving many different stakeholders. This project has helped in realizing specific areas or corridors where this process should be triggered and provides a pool of adaptation options to serve as a springboard for adaptation strategy development.

Lesson learned: Examples of vetted adaptation strategies could have been considered if more time were given to the latter end of the project. Once specific transportation assets were identified as key places for adaptation, stakeholder input could have been revisited to develop an adaptation strategy development process. This was touched on during the Stakeholder Workshop, but could have been further developed to build a stronger resiliency foundation in future transportation project development.

Integrating resiliency and sustainability in the transportation planning process

Long Range Transportation Plan

It is recommended that another performance objective be added to the Quad Cities Long Range Transportation Plan update. The following objective and strategies will be forwarded for consideration in the LRTP:

Address System Resilience from Extreme Weather and Climate Change Impacts

- Protect and enhance vulnerable transportation facilities subject to recurring extreme weather events that serve critical and/or vulnerable facilities to eliminate or reduce disruptions in the system as a whole.

Connect QC 2050
Progress, Innovation, and Connectivity

- Assess planned and new projects for extreme weather vulnerability and evaluate mitigation strategies or actions to reduce impacts.
- Consider building more durable and resilient transportation facilities if damaged and rebuilt.
- Support air emission reductions to lesson impacts for climate resilience.

The criticality and vulnerability analysis described in this chapter identified priority segments most at risk for extreme weather based on the type of event. As part of the Long Range Transportation Plan process, these assets will be assessed in relation to other factors, such as safety and pavement condition to help focus metropolitan transportation priorities.

Transportation improvement program and project selection process

As part of the pilot process, the creation of the adaptation strategy multi-criteria analysis exercise worksheet was found to be better suited to project specific applications. This tool is anticipated to be carried forward to be utilized with the Surface Transportation Block Grant (STBG) Evaluation Manual, and either used as a complimentary tool or to integrate it fully into the scoring criteria.

Technical assistance and outreach

The MPO provides transportation technical assistance to governments within the MPA. As projects with resilience components are moved from planning to programming, staff can aid in seeking grant funds, and facilitating cooperative discussions between jurisdictions on priority corridors, similar to Complete Streets priority corridors.

Appendix

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National Weather Service https://www.weather.gov/dvn/

U.S. Army Corps of Engineers River Gauges https://rivergages.mvr.usace.army.mil/WaterControl/new/layout.cfm

Glossary

Adaptation: Adjustment in natural or *human* systems in anticipation of or response to a changing environment in a way that effectively uses beneficial opportunities to reduce negative effects.

Asset: Both physical transportation infrastructure, such as roads, vehicles, intelligent transportation systems, and ecosystem-related projects.

Climate: The composite or generally prevailing weather conditions of a region, throughout the year, averaged over a series of years.

Climate Change: Any significant change in measures of climate lasting for an extended period of time.

Drought: A deficiency of moisture that results in adverse impacts on people, animals, or vegetation over a sizeable area. NOAA together with its partners provides short- and long-term Drought Assessments.

****Extreme Cold:** What constitutes extreme cold and its effects can vary across different areas of the country. Generally, temperatures are considered extreme cold when they drop distinctly below normal.

****Extreme Heat:** Extreme heat is defined as summertime temperatures that are much hotter and/or humid than average. Because some places are hotter than others, this depends on what's considered average for a particular location at that time of year.

***Extreme Wind:** Sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration (or otherwise locally/regionally defined). In some mountainous areas, the above numerical values are 43 knots (50 mph) and 65 knots (75 mph), respectively.

Extreme Weather Events: Weather events that display significant anomalies in temperature, precipitation, and winds, and their consequences result in safety concerns, damage, destruction, and/or human and economic loss. Climate change can cause or influence extreme weather.

Flash Flooding: A rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g., intense rainfall, dam failure, ice jam).

Heat Wave: A period of abnormally and uncomfortably hot and unusually humid weather. Typically a heat wave lasts two or more days.

NCA4: The fourth national climate assessment, published by the U.S. Global Change Research Program (USGCRP). *****Representative Concentration Pathways (RCPs):** RCPs usually refer to the portion of the concentration pathway extending up to 2100, for which Integrated Assessment Models produced corresponding emission scenarios.

RCP4.5 and RCP6.0: Two intermediate stabilisation pathways in which radiative forcing is stabilized at approximately 4.5 W m-2 and 6.0 W m-2 after 2100 (the corresponding ECPs assuming constant concentrations after 2150)

RCP8.5: One high pathway for which radiative forcing reaches greater than 8.5 W m-2 by 2100 and continues to rise for some amount of time (the corresponding ECP assuming constant emissions after 2100 and constant concentrations after 2250).

Resilience: The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.

River Flooding: The rise of a river to an elevation such that the river overflows its natural banks causing or threatening damage.

Sensitivity: Refer to how an asset or system responds to, or is affected by exposure to a climate stressor.

Vulnerability: The degree to which a system is susceptible to, or unable to cope with adverse effects of climate change or extreme weather events.

Sources:

National Oceanic and Atmospheric Administration's National Weather Service

*NATIONAL WEATHER SERVICE INSTRUCTION 10-1605

**The Center of Disease Control and Prevention

*** Intergovernmental Panel on Climate Change

Bi-State Regional Commission

Serving local governments in Muscatine and Scott Counties, Iowa; Henry, Mercer, and Rock Island Counties, Illinois

MEMORANDUM

TO: Local Transportation and Planning Officials, State Departments of National Resources, Climate, Water Resources and Transportation

FROM: Gena McCullough, AICP, Assistant Executive Director/Planning Director

DATE: November 5, 2018

RE: Kick-Off Meeting for Federal Highway Administration Vulnerability Framework Assessment Pilot for the Quad Cities, Iowa/Illinois

You are invited to attend the kick-off meeting for an Extreme Weather Resiliency and Durability Pilot project for the Quad Cities metropolitan area. The purpose of the project is to examine the types of extreme weather seen or expected to occur in the area, determine what transportation facilities are vulnerable to the effects of extreme weather, and develop policies and strategies to mitigate impacts when possible. These concepts would then fold into the 2050 Quad Cities Long Range Transportation Plan update to be considered for adoption in March 2021.

The meeting is scheduled for Tuesday, November 13, 2018 11:30 a.m. – 1:00 p.m. at Bi-State Regional Commission, Room 320, 1504 Third Avenue, Rock Island, Illinois. For those not located in the Quad Cities who are not be able to travel for the meeting, we are providing a teleconference option. The teleconference number is 1-701-801-1211 using the following meeting ID: 185378269. Please provide an e-mail to me at gmccullough@bistateonline.org, and we will provide you with a copy of the slide presentation. I invite local partners to attend the meeting in person. We will have light refreshments at the meeting.

Attached you will find some background information on the project. The effort is funded through a grant from the Federal Highway Administration, and Bi-State Regional Commission, as the Metropolitan Planning Organization (MPO), is the recipient tasked with developing a vulnerability assessment and adaptation framework for the Quad Cities. At the meeting, an overview of the project will occur and a discussion of resource information and next steps will be shared.

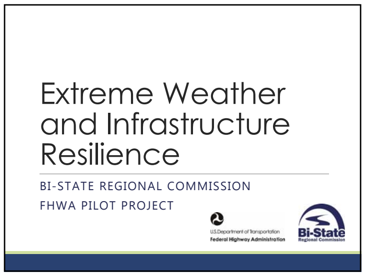
I would appreciate if you are able to attend to, let me know via my e-mail and or you can contact our office at (309)793-6300. If there is someone from your organization that would be more appropriate to attend or would attend in your place, we would welcome their participation. I look forward to starting this interesting and important project and to your participation to develop strategies to make our transportation system more resilient to nature.

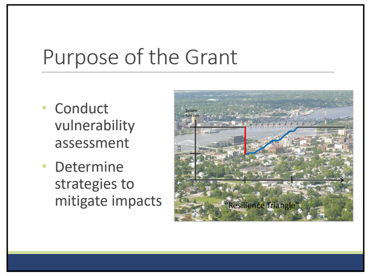
Enclosure: Planning for Extreme Weather Resiliency and Durability of the Quad Cities, Iowa/Illinois Transportation System – Meeting Background

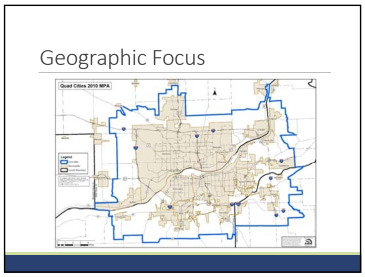
1504 Third Avenue, Third Floor, Rock Island, Illinois 61201
Phone (309) 793-6300 • Fax (309) 793-6305
E-mail: info@bistateonline.org • Website: www.bistateonline.org

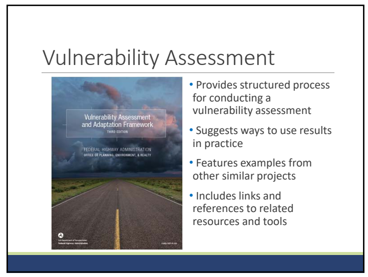
Kick-Off Meeting

9/30/2020









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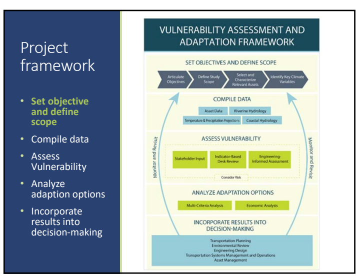

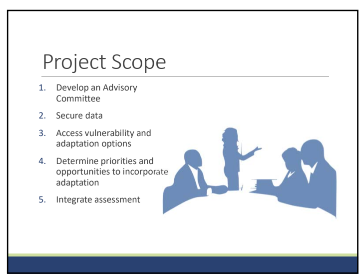

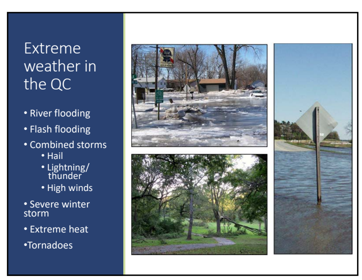

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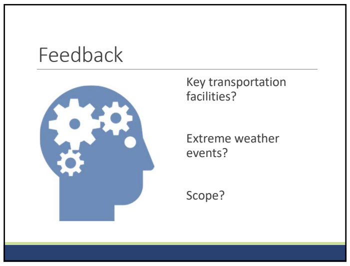

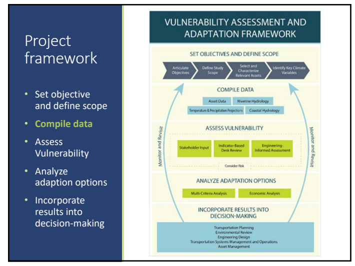

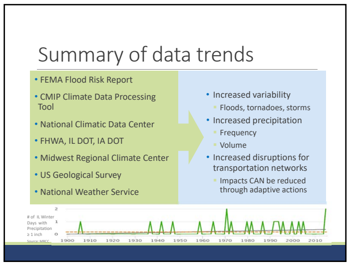

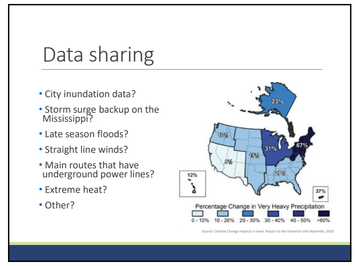

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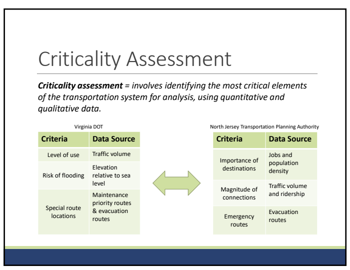


4

Stakeholder Survey EMAIL #1:

Greetings,

The Bi-State Regional Commission is participating in a Federal Highway Administration (FHWA) pilot study of the transportation network within the Quad Cities metropolitan area and extreme weather resilience.

We our reaching out to you as someone with a direct connection to the functioning of our [tailor to transportation network asset(s)]. To help collect information for the study, we are hoping to gather information about weather impacts you have observed on transportation infrastructure in your jurisdiction.

To aid in this process, we have prepared a survey available at this link, as well as an interactive map available at this link. Both should take between 30-40 minutes to complete, as the information we need to be effective in planning is somewhat detailed.

We would like to ask for your assistance in filling in information for the transportation facilities in your network at both links. If there is another or more appropriate colleague to complete this assessment, we would appreciate it if you could forward this message to him or her.

We are hoping to have all the survey and map data gathered by April 1. Information gathered through this process will be used in a workshop later this year to help identify priorities and opportunities for resilience planning. At the conclusion of the study, the findings will be incorporated into our long range transportation plan.

The information and insights you can provide are invaluable to this process. If you have any questions about the process, please feel free to reach out to me directly. Thank you for contributing to the study.

Best regards,

--

Send to:

Iowa and Illinois Transportation Technical Committee + Other City Interests, Departments of Transportation Contacts, and public and regional transit, Quad City International Airport, Davenport Municipal Airport, U.S. Army Corps of Engineers, city/county trails managers, and local railroad representatives.

Stakeholder Survey Follow-Up EMAIL #2

Hello, [Name].

Back in March, you may recall receiving a survey available at this link, as well as an interactive map available at this link, from Bi-State. Both aimed to gather information on vulnerabilities in our transportation network from extreme weather. [Thanks for taking the time to fill out the survey/map.]

Of course, ironically, the flooding we've been experiencing in the Quad Cities has been a bit of a real time demonstration of some vulnerabilities – and that has understandably slowed down our information gathering process a bit.

I wanted to touch in with you to see if you believe you might have the capacity to fill in the survey and map by the end of April? We're hoping to get the information gathered so we can move on to the next step of compiling it for a stakeholder meeting/discussion.

Alternately, would it be helpful for me to pay a visit to your office to give you a sense of what we're looking for and go through the map/survey together? That might enable you to fill it in more efficiently. I'm happy to do so if you think it would be useful.

Thanks for your help with this project. Just let me know what your preference would be.

Best,

Extreme Weather Transportation Resilience Stakeholder Questionnaire*

The Bi-State Regional Commission is participating in a Federal Highway Administration pilot study of the transportation network within the Quad Cities metropolitan area as it relates to extreme weather events. Information gathered as part of this study will be used as part of the next long range transportation plan to help identify priorities and opportunities to make our network better able to maintain function in the face of extreme weather events. The information and insights you provide are invaluable to this process. Thank you for contributing to the study.

Name:____

Position: ____

Community: ____

For this project, we would like your help identifying "hot spots" in your transportation infrastructure.

"Hot spots" are defined as areas of ongoing concern (i.e. potholes that develop in the same spot year after year, streets that reliably flood during rain events, etc.). They can be minor or major concerns, but are characterized by persistence. An ArcGIS map for the Quad Cities metropolitan area is provided at this link. (*formerly linked to module on homepage of Bi-State website*). For each of the following sections, please consider where the related hotspots are in your network. Once you have completed the questionnaire, please visit the map and place pins on the hot spots within your jurisdiction *(formerly linked to module on homepage of Bi-State website)*.

Section One – Heavy rain and flooding related impacts

1. How many times per year is your transportation network impaired by flooding and other precipitation related events?

    1-5 times per year

    6-10 times per year

    11 or more times per year

2. What caused the negative impacts? (check all that apply)

    Heavy rain/flash flooding

    Prolonged rain/river overflow

    Other: ______________________________

3. For the worst event in terms of damage in the last 5 years (2013-2018), what parts of your transportation network were interrupted/degraded? (see table on next page)

Facility	Interrupted (how long)	Repairs needed (such as resurfacing, replacing buckled ties, etc.) where degraded	N/A
Interstate highways			
State highways			
Municipal roads/ streets			
Airport			
Railroad lines			
Lock/dam			
Transit facility			
Trails			

4. How did you respond to the degradation in the short-term? Were any long-term changes made to prevent/reduce future impacts?

Section Two –Winter storm impacts

5. How many times per year is your transportation network impaired by severe winter storm events?

   1-5 times per year

   6-10 times per year

   11 or more times per year

6. What caused the negative impacts? (check all that apply)

   Ice/Sleet

   Snow

   Other: ______________________________

7. For the worst event in terms of damage in the last 5 years (2013-2018), what parts of your transportation network were interrupted/degraded?

Facility	Interrupted (how long)	Repairs needed (such as resurfacing, replacing buckled ties, etc.) where degraded	N/A
Interstate highways			
State highways			
Municipal roads/ streets			
Airport			
Railroad lines			
Lock/dam			
Transit facility			
Trails			

8. How did you respond to the degradation in the short-term? Were any long-term changes made to prevent/reduce future impacts?

Section Three – Extreme heat and cold impacts

9. How many times per year is your transportation network impaired by extreme heat (temperatures above 100 degrees) or extreme cold (temperatures in the negative degrees)?

   1-5 times per year

   6-10 times per year

   11 or more times per year

10. What caused the negative impacts? (check all that apply)

    Extreme heat

    Extreme cold

    Freeze/thaw cycle

    Other: ________________________________

11. For the worst event in terms of damage in the last 5 years (2013-2018), what parts of your transportation network were interrupted/degraded?

Facility	Interrupted (how long)	Repairs needed (such as re-surfacing, replacing buckled ties, etc.) where degraded	N/A
Interstate highways			
State highways			
Municipal roads/ streets			
Airport			
Railroad lines			
Lock/dam			
Transit facility			
Trails			

12. How did you respond to the degradation in the short-term? Were any long-term changes made to prevent/reduce future impacts?

Section Four – High wind impacts

13. How many times per year is your transportation network impaired by wind related events?

    1-5 times per year

    6-10 times per year

    11 or more times per year

14. What caused the negative impacts? (check all that apply)

    High winds (sustained winds in excess of 40 mph or gusts above 58 mpg)

    Straight-line winds

    Tornado

    Other: ______________________________

15. For the worst event in terms of damage in the last 5 years (2013-2018), what parts of your transportation network were interrupted/degraded?

Facility	Interrupted (how long)	Repairs needed (such as re-surfacing, replacing buckled ties, etc.) where degraded	N/A
Interstate highways			
State highways			
Municipal roads/ streets			
Airport			
Railroad lines			
Lock/dam			
Transit facility			
Trails			

16. How did you respond to the degradation in the short-term? Were any long-term changes made to prevent/reduce future impacts?

Section Five – Other extreme weather impacts

17. How many times per year is your transportation network impaired by other extreme weather events (i.e. fog, drought, etc.)?

    1-5 times per year

    6-10 times per year

    11 or more times per year

18. What caused the negative impacts? Please describe: ____________________________________
    ____
    ____
    ____

____

19. For the worst event in terms of damage in the last 5 years (2013-2018), what parts of your transportation network were interrupted/degraded?

Facility	Interrupted (how long)	Repairs needed (such as resurfacing, replacing buckled ties, etc.) where degraded	N/A
Interstate highways			
State highways			
Municipal roads/ streets			
Airport			
Railroad lines			
Lock/dam			
Transit facility			
Trails			

20. How did you respond to the degradation in the short-term? Were any long-term changes made to prevent/reduce future impacts?

Section Six – Criticality and resilience

21. Within your transportation network vulnerable to extreme weather, what would you deem to be the critical areas and why?

22. How does your organization address resilience?

Include resilience goals and strategies in comprehensive plan

Update construction and building specifications to include resilience measures

Retrofit existing assets to withstand impacts

Define adaptation strategies in organizational policies

Conduct lifecycle cost analysis to reduce asset vulnerability

Increase redundancy in transportation network to lessen interruptions

Incorporate more intensive maintenance for vulnerable assets

Other: ____

23. Do you have goals or strategies in place to adapt infrastructure for (check all that apply):

Heavy rain/flash flooding events

Prolonged rain/river flooding concerns

Extreme heat

Extreme cold

Severe winter storms

High winds

Other: ____

24. Based on your experience, please rank these extreme weather events in terms of your highest priority (#1) to lowest priority (#7) to address in your community in order to be more resilient.

— Heavy rain/flash flooding events

— Prolonged rain/river flooding concerns

— Extreme heat

— Extreme cold

— Severe winter storms

— High winds

— Other: ____

25. Please rate the transportation infrastructure in your community in terms of most vulnerable, moderately vulnerable, and least vulnerable to extreme weather events. (Mark those that do not apply a N/A)

Facility	Most vulnerable	Moderately vulnerable	Least vulnerable	N/A
Interstate highways				
State highways				
Municipal roads/ streets				
Airport				
Railroad lines				
Lock/dam				
Transit facility				
Trails				

26. Is there anything else relevant to extreme weather and transportation resilience in your jurisdiction you would like to share?

*Survey transferred to Survey Monkey platform to collect stakeholder input.

Appendix

Stakeholder Survey Results

Q1 What is your name?

Answered: 34 Skipped: 0

Q2 What community/entity do you represent?

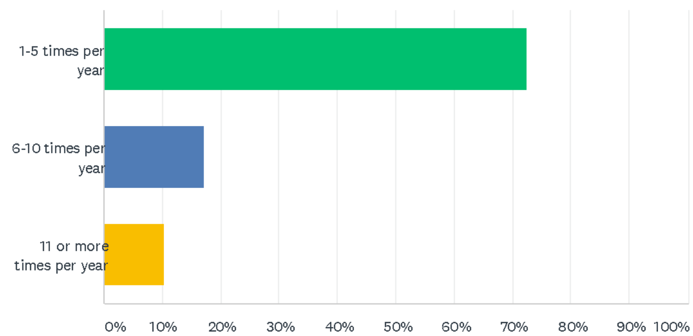
Answered: 34 Skipped: 0

Q3 What is your job title?

Answered: 34 Skipped: 0

Q4 How many times per year is your transportation network impaired by flooding and other precipitation related events?

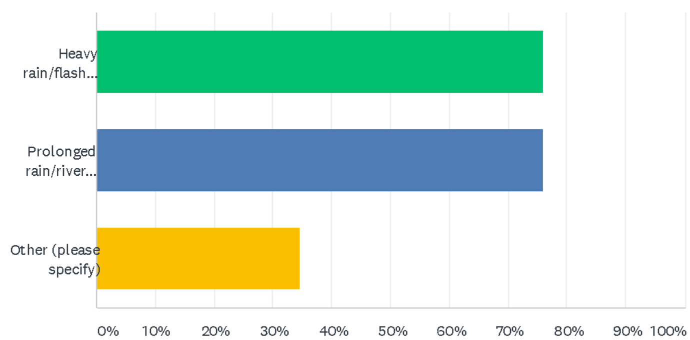
Answered: 29 Skipped: 5



ANSWER CHOICES	RESPONSES	
1-5 times per year	72.41%	21
6-10 times per year	17.24%	5
11 or more times per year	10.34%	3
TOTAL		29

Q5 What caused the negative impacts? (check all that apply)

Answered: 29 Skipped: 5



ANSWER CHOICES	RESPONSES	
Heavy rain/flash flooding	75.86%	22
Prolonged rain/river overflow	75.86%	22
Other (please specify)	34.48%	10
Total Respondents: 29		

Extreme Weather and Transportation Resilience SurveyMonkey

Q6 For the worst event in terms of damage in the last 5 years (2013-2018), how long were parts of your transportation network interrupted/degraded? (Mark any parts of your network that weren't affected "N/A")

Answered: 28 Skipped: 6

ANSWER CHOICES	RESPONSES	
Interstate highways	82.14%	23
State highways	82.14%	23
Municipal roads/streets	82.14%	23
Airport	82.14%	23
Railroad lines	85.71%	24
Lock/dam	82.14%	23
Transit facility	85.71%	24
Trails	85.71%	24

Extreme Weather and Transportation Resilience SurveyMonkey

Q7 For the worst event in terms of damage in the last 5 years (2013-2018), what repairs were needed throughout your transportation network? (Mark any parts of your network that weren't affected "N/A")

Answered: 28 Skipped: 6

ANSWER CHOICES	RESPONSES	
Interstate highways	75.00%	21
State highways	75.00%	21
Municipal roads/streets	78.57%	22
Airport	71.43%	20
Railroad lines	75.00%	21
Lock/dam	71.43%	20
Transit facility	75.00%	21
Trails	75.00%	21

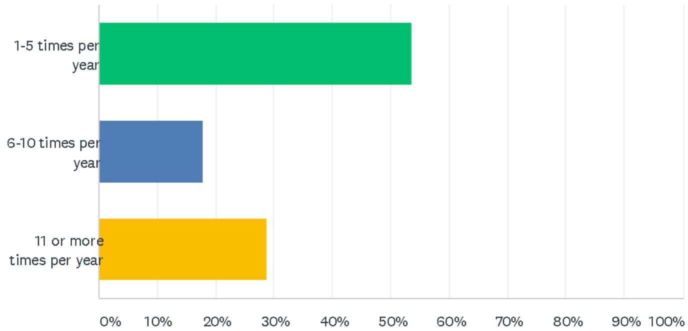
Extreme Weather and Transportation Resilience SurveyMonkey

Q8 Please describe any long-term changes made to prevent/reduce future impacts.

Answered: 22 Skipped: 12

Q9 How many times per year is your transportation network impaired by severe winter storm events?

Answered: 28 Skipped: 6

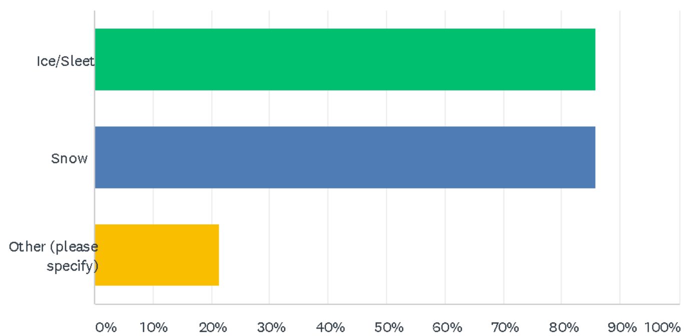


ANSWER CHOICES	RESPONSES	
1-5 times per year	53.57%	15
6-10 times per year	17.86%	5
11 or more times per year	28.57%	8
TOTAL		28

Extreme Weather and Transportation Resilience SurveyMonkey

Q10 What caused the negative impacts? (check all that apply)

Answered: 28 Skipped: 6



ANSWER CHOICES	RESPONSES	
Ice/Sleet	85.71%	24
Snow	85.71%	24
Other (please specify)	21.43%	6
Total Respondents: 28		

Extreme Weather and Transportation Resilience SurveyMonkey

Q11 For the worst event in terms of damage in the last 5 years (2013-2018), how long were parts of your transportation network interrupted/degraded? (Mark any parts of your network that weren't affected "N/A")

Answered: 27 Skipped: 7

ANSWER CHOICES	RESPONSES	
Interstate highways	74.07%	20
State highways	74.07%	20
Municipal roads/streets	77.78%	21
Airport	74.07%	20
Railroad lines	77.78%	21
Lock/dam	74.07%	20
Transit facility	77.78%	21
Trails	81.48%	22

Extreme Weather and Transportation Resilience SurveyMonkey

Q12 For the worst event in terms of damage in the last 5 years (2013-2018), what repairs were needed throughout your transportation network? (Mark any parts of your network that weren't affected "N/A")

Answered: 26 Skipped: 8

ANSWER CHOICES	RESPONSES	
Interstate highways	76.92%	20
State highways	76.92%	20
Municipal roads/streets	84.62%	22
Airport	76.92%	20
Railroad lines	76.92%	20
Lock/dam	76.92%	20
Transit facility	80.77%	21
Trails	80.77%	21

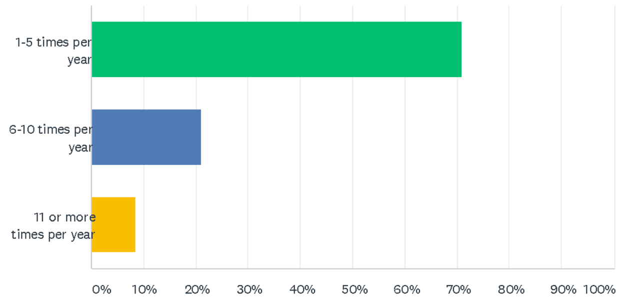
Extreme Weather and Transportation Resilience SurveyMonkey

Q13 Please describe any long-term changes made to prevent/reduce future impacts

Answered: 15 Skipped: 19

Q14 How many times per year is your transportation network impaired by extreme heat (temperatures above 100 degrees) or extreme cold (temperatures in the negative degrees)?

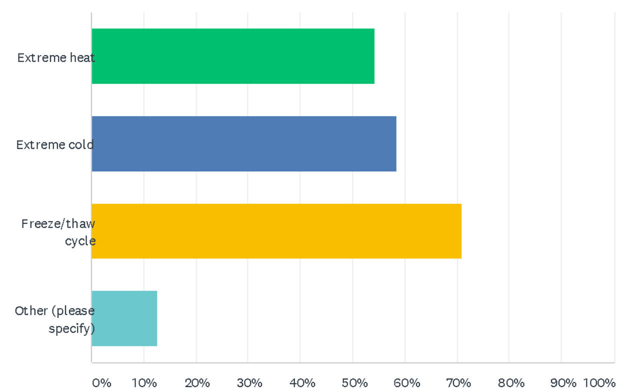
Answered: 24 Skipped: 10



ANSWER CHOICES	RESPONSES	
1-5 times per year	70.83%	17
6-10 times per year	20.83%	5
11 or more times per year	8.33%	2
TOTAL		24

Q15 What caused the negative impacts? (check all that apply)

Answered: 24 Skipped: 10



ANSWER CHOICES	RESPONSES	
Extreme heat	54.17%	13
Extreme cold	58.33%	14
Freeze/thaw cycle	70.83%	17
Other (please specify)	12.50%	3
Total Respondents: 24		

Q16 For the worst event in terms of damage in the last 5 years (2013-2018), how long were parts of your transportation network interrupted/degraded? (Mark any parts of your network that weren't affected "N/A")

Answered: 24 Skipped: 10

ANSWER CHOICES	RESPONSES	
Interstate highways	79.17%	19
State highways	79.17%	19
Municipal roads/streets	83.33%	20
Airport	79.17%	19
Railroad lines	79.17%	19
Lock/dam	79.17%	19
Transit facility	83.33%	20
Trails	87.50%	21

Extreme Weather and Transportation Resilience SurveyMonkey

Q17 For the worst event in terms of damage in the last 5 years (2013-2018), what repairs were needed throughout your transportation network? (Mark any parts of your network that weren't affected "N/A")

Answered: 24 Skipped: 10

ANSWER CHOICES	RESPONSES	
Interstate highways	83.33%	20
State highways	83.33%	20
Municipal roads/streets	79.17%	19
Airport	70.83%	17
Railroad lines	70.83%	17
Lock/dam	70.83%	17
Transit facility	75.00%	18
Trails	83.33%	20

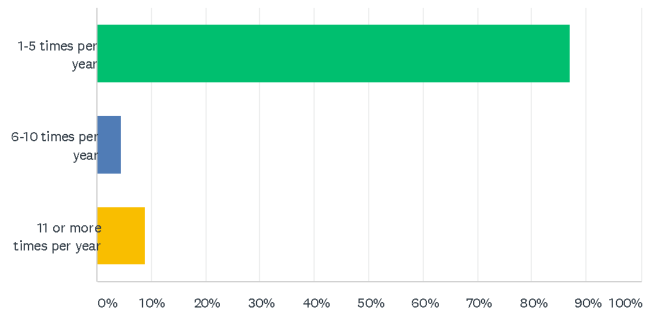
Extreme Weather and Transportation Resilience SurveyMonkey

Q18 Please describe any long-term changes made to prevent/reduce future impacts.

Answered: 14 Skipped: 20

Q19 How many times per year is your transportation network impaired by wind related events?

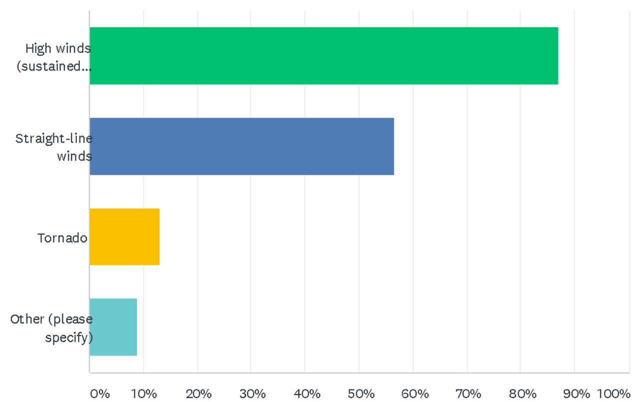
Answered: 23 Skipped: 11



ANSWER CHOICES	RESPONSES	
1-5 times per year	86.96%	20
6-10 times per year	4.35%	1
11 or more times per year	8.70%	2
TOTAL		23

Q20 What caused the negative impacts? (check all that apply)

Answered: 23 Skipped: 11



ANSWER CHOICES	RESPONSES	
High winds (sustained winds in excess of 40 mph or gusts in excess of 58 mph)	86.96%	20
Straight-line winds	56.52%	13
Tornado	13.04%	3
Other (please specify)	8.70%	2
Total Respondents: 23		

Extreme Weather and Transportation Resilience SurveyMonkey

Q21 For the worst event in terms of damage in the last 5 years (2013-2018), how long were parts of your transportation network interrupted/degraded? (Mark any parts of your network that weren't affected "N/A")

Answered: 25 Skipped: 9

ANSWER CHOICES	RESPONSES	
Interstate highways	80.00%	20
State highways	80.00%	20
Municipal roads/streets	84.00%	21
Airport	76.00%	19
Railroad lines	76.00%	19
Lock/dam	76.00%	19
Transit facility	80.00%	20
Trails	84.00%	21

Extreme Weather and Transportation Resilience SurveyMonkey

Q22 For the worst event in terms of damage in the last 5 years (2013-2018), what repairs were needed throughout your transportation network? (Mark any parts of your network that weren't affected "N/A")

Answered: 25 Skipped: 9

ANSWER CHOICES	RESPONSES	
Interstate highways	80.00%	20
State highways	80.00%	20
Municipal roads/streets	84.00%	21
Airport	72.00%	18
Railroad lines	72.00%	18
Lock/dam	72.00%	18
Transit facility	76.00%	19
Trails	84.00%	21

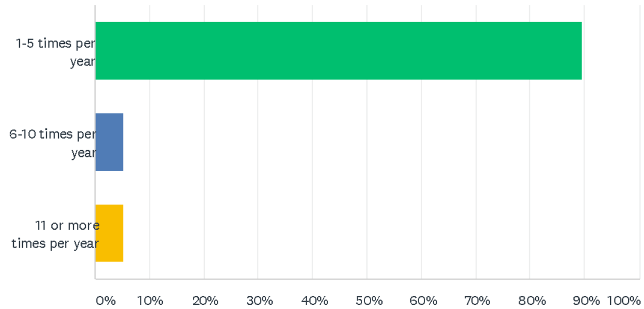
Extreme Weather and Transportation Resilience SurveyMonkey

Q23 Please describe any long-term changes made to prevent/reduce future impacts.

Answered: 14 Skipped: 20

Q24 How many times per year is your transportation network impaired by other extreme weather events (i.e. fog, drought, etc.)?

Answered: 19 Skipped: 15



ANSWER CHOICES	RESPONSES	
1-5 times per year	89.47%	17
6-10 times per year	5.26%	1
11 or more times per year	5.26%	1
TOTAL		19

Q25 What caused the negative impacts? Please describe.

Answered: 19 Skipped: 15

Q26 For the worst event in terms of damage in the last 5 years (2013-2018), how long were parts of your transportation network interrupted/degraded? (Mark any parts of your network that weren't affected "N/A")

Answered: 21 Skipped: 13

ANSWER CHOICES	RESPONSES	
Interstate highways	85.71%	18
State highways	85.71%	18
Municipal roads/streets	85.71%	18
Airport	80.95%	17
Railroad lines	80.95%	17
Lock/dam	80.95%	17
Transit facility	85.71%	18
Trails	85.71%	18

Extreme Weather and Transportation Resilience SurveyMonkey

Q27 For the worst event in terms of damage in the last 5 years (2013-2018), what repairs were needed throughout your transportation network? (Mark any parts of your network that weren't affected "N/A")

Answered: 21 Skipped: 13

ANSWER CHOICES	RESPONSES	
Interstate highways	85.71%	18
State highways	85.71%	18
Municipal roads/streets	85.71%	18
Airport	80.95%	17
Railroad lines	80.95%	17
Lock/dam	85.71%	18
Transit facility	85.71%	18
Trails	85.71%	18

Extreme Weather and Transportation Resilience SurveyMonkey

Q28 Please describe any long-term changes made to prevent/reduce future impacts.

Answered: 15 Skipped: 19

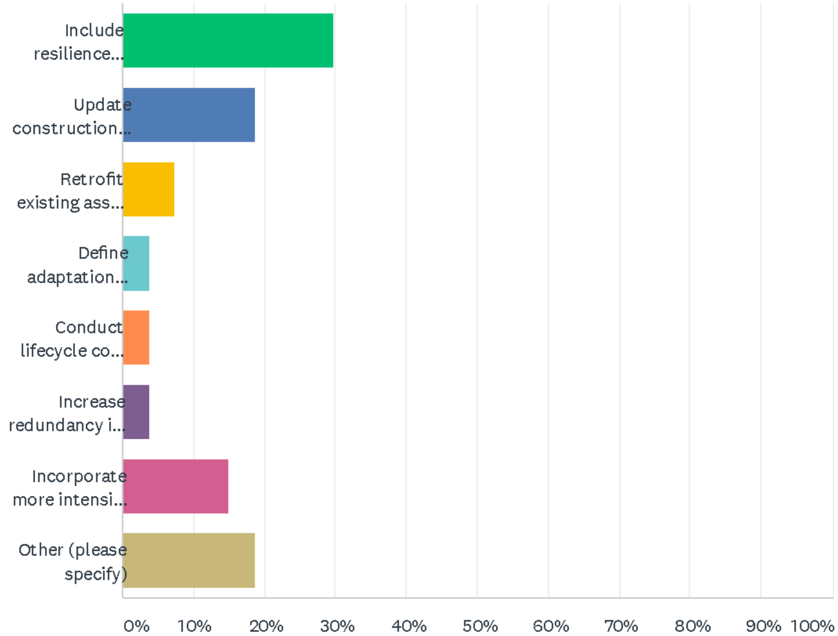
Extreme Weather and Transportation Resilience SurveyMonkey

Q29 Within your transportation network vulnerable to extreme weather, what would you deem to be the critical areas and why?

Answered: 25 Skipped: 9

Q30 How does your organization address resilience?

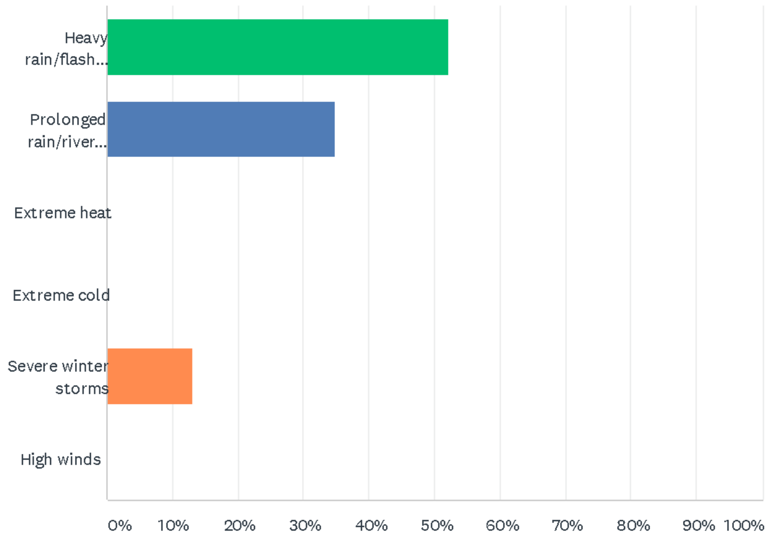
Answered: 27 Skipped: 7



ANSWER CHOICES	RESPONSES	
Include resilience goals and strategies in comprehensive plan, hazards plan, or other guidance document	29.63%	8
Update construction and building specifications to include resilience measures	18.52%	5
Retrofit existing assets to withstand impacts	7.41%	2
Define adaptation strategies in organizational policies	3.70%	1
Conduct lifecycle cost analysis to reduce asset vulnerability	3.70%	1
Increase redundancy in transportation network to lessen interruptions	3.70%	1
Incorporate more intensive maintenance for vulnerable assets	14.81%	4
Other (please specify)	18.52%	5
TOTAL		27

Q31 Do you have goals or strategies in place to adapt infrastructure for (check all that apply):

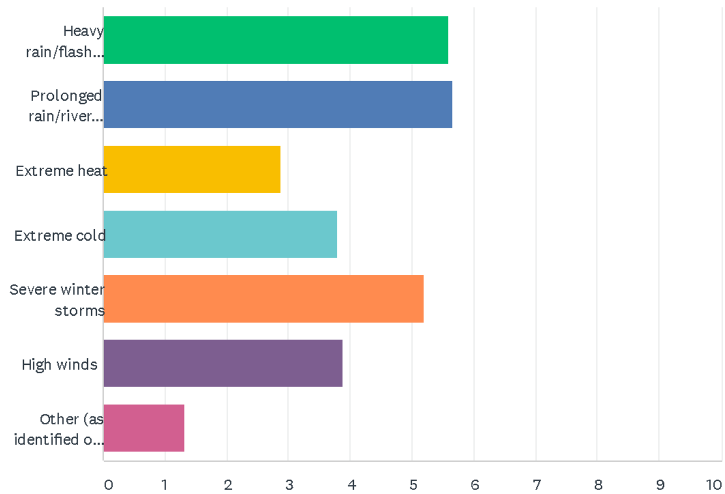
Answered: 23 Skipped: 11



ANSWER CHOICES	RESPONSES	
Heavy rain/flash flooding events	52.17%	12
Prolonged rain/river flooding concerns	34.78%	8
Extreme heat	0.00%	0
Extreme cold	0.00%	0
Severe winter storms	13.04%	3
High winds	0.00%	0
TOTAL		23

Q32 Based on your experience, please rank these extreme weather events in terms of your highest priority (#1) to lowest priority (#7) to address in your jurisdiction in order to be more resilient.

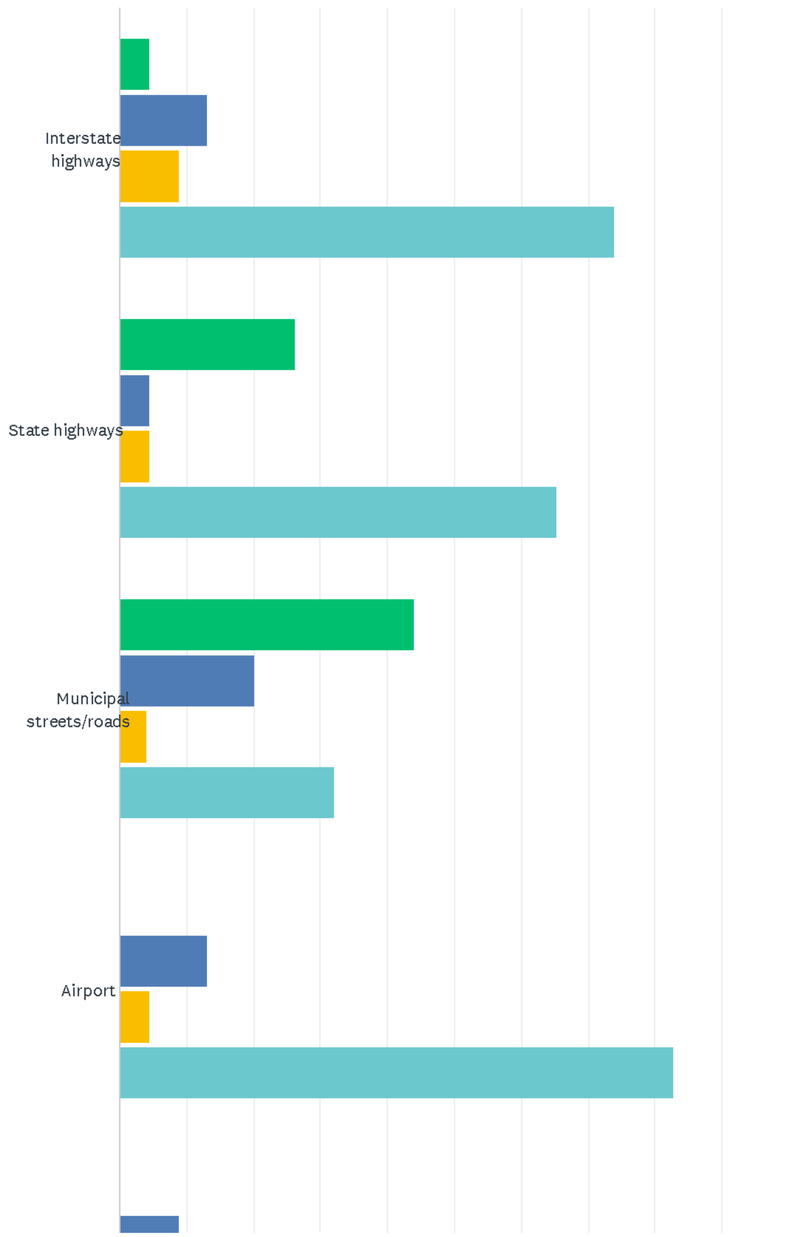
Answered: 27 Skipped: 7



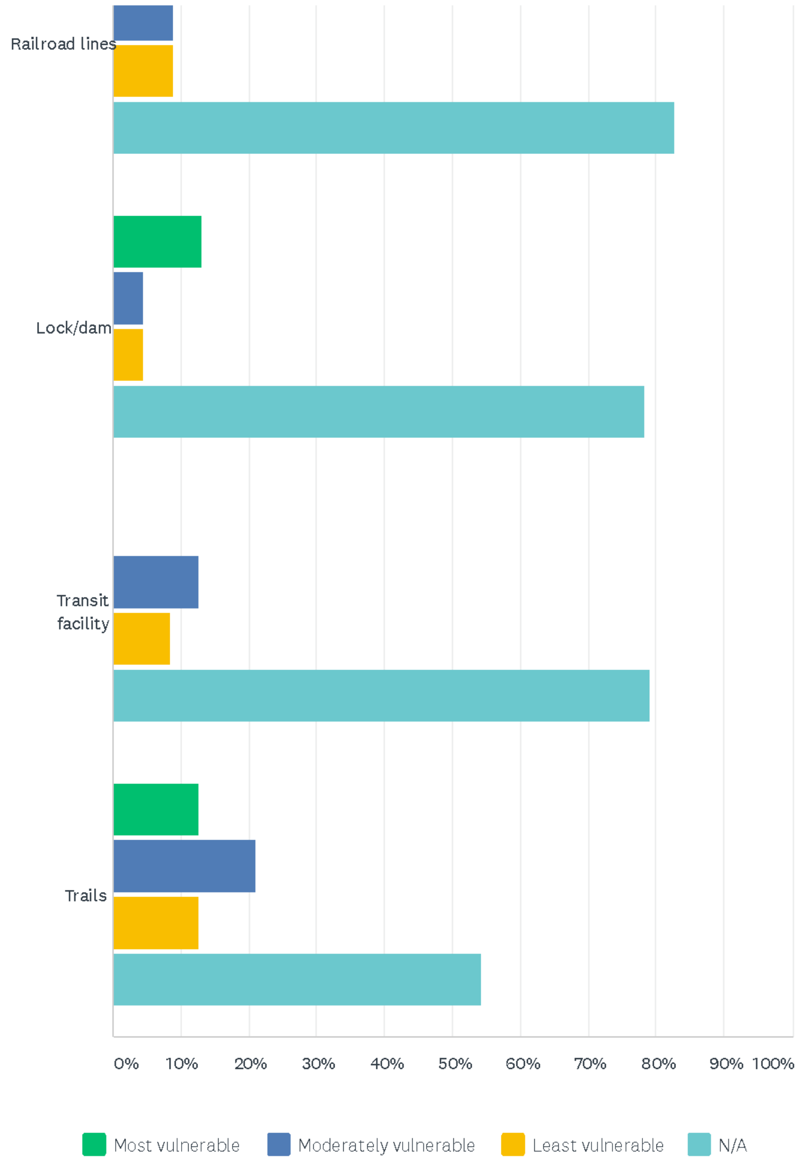
	1	2	3	4	5	6	7	TOTAL	SCORE
Heavy rain/flash flooding events	34.62% 9	30.77% 8	15.38% 4	3.85% 1	7.69% 2	7.69% 2	0.00% 0	26	5.58
Prolonged rain/river flooding concerns	32.00% 8	32.00% 8	20.00% 5	8.00% 2	4.00% 1	0.00% 0	4.00% 1	25	5.64
Extreme heat	4.55% 1	0.00% 0	0.00% 0	18.18% 4	27.27% 6	50.00% 11	0.00% 0	22	2.86
Extreme cold	4.17% 1	4.17% 1	16.67% 4	25.00% 6	41.67% 10	8.33% 2	0.00% 0	24	3.79
Severe winter storms	22.22% 6	14.81% 4	33.33% 9	22.22% 6	3.70% 1	3.70% 1	0.00% 0	27	5.19
High winds	4.17% 1	16.67% 4	12.50% 3	25.00% 6	12.50% 3	29.17% 7	0.00% 0	24	3.88
Other (as identified on previous page (6) on this survey)	0.00% 0	6.25% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	93.75% 15	16	1.31

Q33 Please rate the transportation infrastructure in your jurisdiction in terms of most vulnerable, moderately vulnerable, and least vulnerable to extreme weather events. (Mark those that do not apply a N/A)

Answered: 26 Skipped: 8



Extreme Weather and Transportation Resilience SurveyMonkey



	MOST VULNERABLE	MODERATELY VULNERABLE	LEAST VULNERABLE	N/A	TOTAL
Interstate highways	4.35% 1	13.04% 3	8.70% 2	73.91% 17	23
State highways	26.09% 6	4.35% 1	4.35% 1	65.22% 15	23
Municipal streets/roads	44.00% 11	20.00% 5	4.00% 1	32.00% 8	25
Airport	0.00% 0	13.04% 3	4.35% 1	82.61% 19	23
Railroad lines	0.00% 0	8.70% 2	8.70% 2	82.61% 19	23
Lock/dam	13.04% 3	4.35% 1	4.35% 1	78.26% 18	23
Transit facility	0.00% 0	12.50% 3	8.33% 2	79.17% 19	24
Trails	12.50% 3	20.83% 5	12.50% 3	54.17% 13	24

Q34 Is there anything else relevant to extreme weather and transportation resilience in your jurisdiction you would like to share?

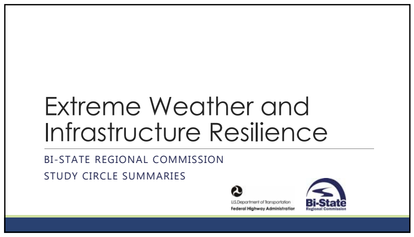
Answered: 7 Skipped: 27

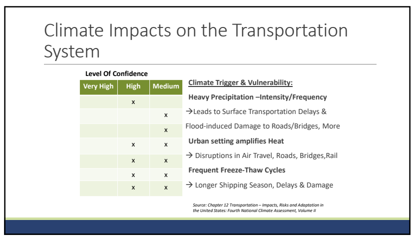
Q35 Do you have any additional information or comments to share about how extreme weather impacts your transportation network within your jurisdiction or within the Quad Cities metropolitan area?

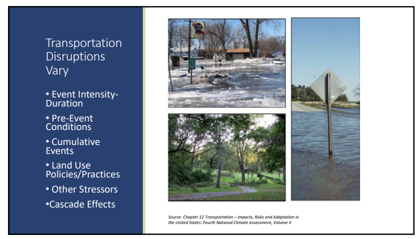
Answered: 9 Skipped: 25

Study Circle Summary

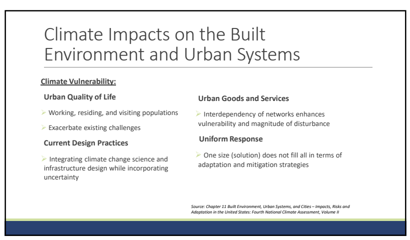
9/30/2020

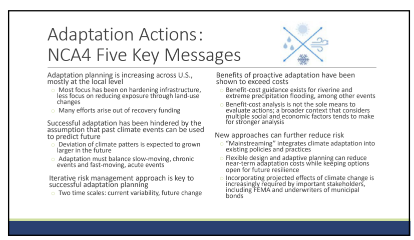






9/30/2020





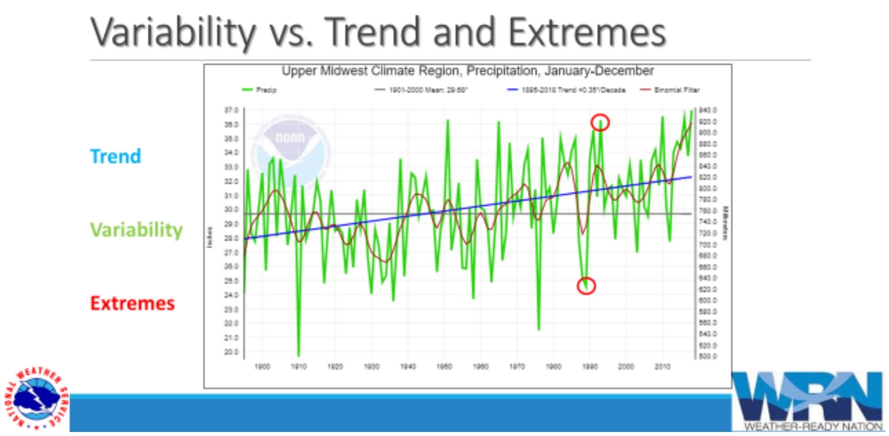
Bi-State Regional Commission - Commission in Review Article (June 2019)

[*Presentation to agency board on weather and climate by National Weather Service*]

Weather and Climate Resilience – Are We Ready?

Ray Wolf, Science and Operations Officer with the National Weather Service (NWS) under the parent agency-National Oceanic and Atmospheric Administration (NOAA) provided an overview on weather and climate resilience. With a mission of a "Weather-Ready Nation", the NWS provides weather, water and climate forecasts and warnings for the protection of life and property, and for the enhancement of the national economy. Hazards planning and preparedness is core to this mission.

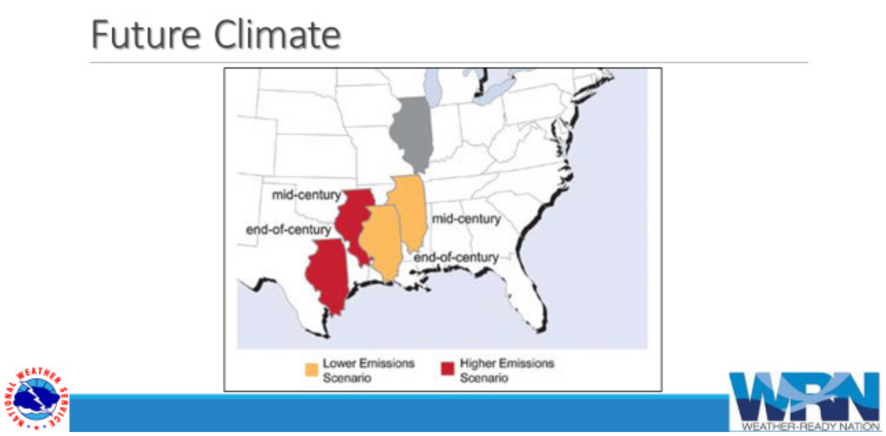
Climate vs. Weather. Climate is what you expect while weather is what you get. Weather records demonstrate variability and extremes while climate is a trend over time. He illustrated this with a graph on annual precipitation for the upper Midwest with the precipitation trend increasing between 1900 and 2010 from 28 inches to 32 inches annually. This change represents an increase of 1/3 per inch over a decade, and has contributed to a 28% increase in flow of the Mississippi River. Understanding that climate change is occurring and the science behind these trends, will be critical for planning and preparedness as part of community resilience strategies.



Source: National Weather Service 2019

Disasters' Impacts. In 2018 alone, there were 14 separate billion-dollar weather and climate disasters impacting the United States. Between 1980 and 2019 year to date, the average trend has escalated from less than one to more than six per year on average. In 2011, there were 16 disasters. Resilience has significant economic importance as well as social component of affected citizens. Urban areas with their redundant facilities tend to be more resilient than rural areas where there are fewer roads and resources. As well-demonstrated this past winter and spring, winter storms interrupted travel, and resulted in higher costs for snow removal. Increased frequency of free-thaw cycles effecting road surfaces are evidenced by potholes and poor pavement conditions. Record flooding impacted bridges and culverts and closed roads. He noted that Bi-State staff are working on a metropolitan extreme weather transportation resilience pilot that will help bring attention to these issues.

Future Climate and Strategies. Our future climate is predicted to be similar to the climate of our most southern states using lower emission and higher emission scenarios. The illustration below highlights this probability for mid-century to end-of-century forecasts for the State of Illinois. As an example of best practices, the NWS office in Davenport is powered by 40% renewable energy. Other national and local air emission reduction efforts will help to contribute to the slowing of climate trends. For more information on climate, refer to U.S. Global Change Research Program – National Climate Assessment at www.climate.gov.



Source: NOAA-National Weather Service

Stakeholder Workshop

Bi-State Regional Commission

Serving local governments in Muscatine and Scott Counties, Iowa;
Henry, Mercer, and Rock Island Counties, Illinois

MEMORANDUM

TO: Local Transportation and Planning Officials, State Departments of National Resources, Climate, Water Resources, and Transportation

FROM: Gena McCullough, AICP, Assistant Executive Director/Planning Director

RE: Stakeholder Indicator-Based Desktop Review Workshop for the Bi-State Regional Commission Extreme Weather Resiliency and Durability Pilot

Please join us for the next phase of the Extreme Weather Resiliency and Durability of the Quad Cities, Iowa/Illinois Transportation System Pilot, the Metropolitan Area Stakeholder Indicator-Based Desktop Review Workshop. This stakeholder workshop will involve informative presentations from the National Weather Service and Bi-State Regional Commission, small group discussion for mapping assets and critical infrastructure, and large group discussion on adaptation strategies for addressing resilience and durability in the Quad Cities.

The workshop is scheduled for **Thursday, August 29, 2019 from 10:00 a.m. – 2:00 p.m. at the Bettendorf Public Library, 2950 Learning Campus Drive, Bettendorf, Iowa 52722.** A light lunch will be provided to attendees at no cost. An RSVP is required.

Through the Federal Highway Administration (FHWA), Bi-State Regional Commission received grant funds to conduct a vulnerability assessment and determine strategies to mitigate weather related impacts in the Quad Cities metropolitan planning area's (MPA) multi-modal transportation system. Bi-State is using FHWA's Vulnerability Assessment Framework to identify key weather variables and vulnerable assets specific to the greater Quad Cities region, to focus strategic, extreme weather hazards planning efforts for future transportation planning. The goal of the project is help shape a more resilient and durable Quad Cities transportation system by incorporating specific mitigation and adaptation strategies in the 2050 Long Range Transportation Plan and future short- and long-range transportation and hazard mitigation planning efforts.

Hosting the Kick-off meeting last fall, collecting local data from city and county staff, and collecting available transportation and weather related data puts our efforts at the middle point of the project timeline:

- ☑ Develop Planning Advisory Committee & host Kick-off meeting
- ☑ Secure data on transportation assets and weather impacts
- ➢ **Access vulnerability and analyze adaptation options**
- ☐ Determine priorities and opportunities to incorporate into planning processes
- ☐ Incorporate results and integrate customized adaptation strategies into regional transportation planning practice

I would invite you to attend as a key stakeholder in our Quad Cities Metropolitan Area. **Please RSVP via e-mail at tcullison@bistateonline.org or by contacting our office at (309)793-6300.** If there is someone from your organization that would be more appropriate to attend or is able to attend on your behalf, we would welcome their participation and confirmation.

I look forward to continuing our steady progress on this project. I am excited to share our findings to date and to hear what your insights will bring to the discussion on how our transportation system can be more resilient in the face of extreme weather and future climate trends.

1504 Third Avenue, Third Floor, Rock Island, Illinois 61201
Phone (309) 793-6300 • Fax (309) 793-6305
E-mail: info@bistateonline.org • Website: www.bistateonline.org

AGENDA

QUAD CITIES, IOWA-ILLINOIS
METROPOLITAN PLANNING AREA
EXTREME WEATHER RESILIENCE PILOT PROJECT
STAKEHOLDER WORKSHOP

Thursday, August 29, 2019 – 10:00 a.m. - 2:30 p.m.
Bettendorf Public Library, 2nd Floor Bettendorf Room
2950 Learning Campus Drive
Bettendorf, Iowa 52722

1. Check-In/Registration [9:30 a.m.]
2. Welcome and Overview [10:00 a.m.] – Gena McCullough, Bi-State Regional Commission
3. Extreme Weather Resilience Pilot Project Overview on Regional Climate, Department of Transportation Assessments and Local Vulnerability Assessment [10:05 a.m.]
   - Ray Wolf, NOAA-National Weather Service
   - Chris Schmidt, Illinois Department of Transportation
   - David Claman, Iowa Department of Transportation
   - Sarah Gardner, Bi-State Regional Commission
4. Break & Lunch Set-Up [11:30 a.m.] (Organize at tables to include at least one local city/county official, state or federal transportation official, state or federal resource agency, and other interested parties.)
5. Stakeholder Vulnerable Facilities Mapping Exercise and Discussion [11:45 a.m.] (Exercise to review hot spots and vulnerable transportation facilities and other important critical facilities. Working lunch.) – Sarah Gardner/Brad Lathrop, Bi-State Regional Commission
6. Adaptation Prioritization Exercise [1:00 p.m.] – Tara Cullison, Bi-State Regional Commission
7. Workshop Summary and Next Steps [2:00 p.m.] – Sarah Gardner and Tara Cullison
8. Adjournment

Bi-State Regional Commission

Contacts:
Gena McCullough, (309) 793-6300 Ext. 1146, gmccullough@bistateonline.org
Sarah Gardner, (309) 793-6300 Ext. 1148, sgardner@bistateonline.org
Tara Cullison, (309) 793-6300 Ext. 1145, tcullison@bistateonline.org
Patty Pearson, (309) 793-6300 Ext. 1138, ppearson@bistateonline.org

TC\sdg
P:\USERS\WORD\Agendas - 30\Extreme Weather Resilience Stakeholder Workshop Agenda.docx

Adaptation Options: A Multi-Criteria Analysis Exercise

Scenario 1— River flooding

Scoring Impact of Criteria
H = High
M = Moderate
L = Low

Instructions: When river levels rise, many of the MPA's transportation assets become either inundated or vulnerable to inundation. Choose either **one location** or **general corridor** that is disrupted by river flooding and develop an Advisory, Control, and Treatment adaptation option that would increase its resiliency.

Criteria

Adaptation Options

	Effective in other extreme weather?	Capital/life-cycle costs?	Environmental impacts?	Impact to the vulnerability?	Permitting constraints?	Public acceptance?	Environmental justice impacts?	Feasibility?
Advisory								
Control								
Treatment								
No Action								

Extreme Weather and Infrastructure Resilience

BI-STATE REGIONAL COMMISSION

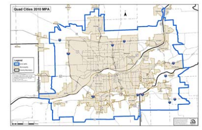
FHWA PILOT PROJECT

U.S. Department of Transportation Federal Highway Administration

Bi-State Regional Commission

Pilot Project Goals

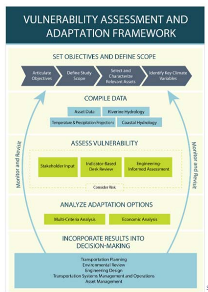
- Assess vulnerability within MPA
- Determine strategies to mitigate impacts
- Incorporate into Long Range Transportation Plan



2

Project framework

- **Set objective and define scope**
- Compile data
- Assess Vulnerability
- Analyze adaptation options
- Incorporate results into decision-making



3

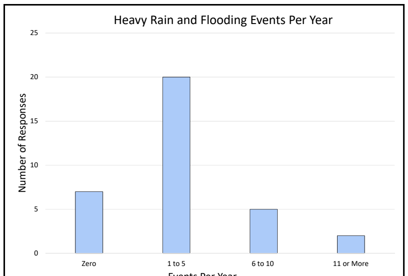
Survey results

4

Impacts related to five groupings of extreme weather events

- Precipitation
  - Heavy rain/flash flooding
  - Prolonged rain/river flooding
  - Other
- Winter Storms
  - Ice/sleet
  - Snow
  - Other
- Extreme Temperatures
  - Extreme heat
  - Extreme cold
  - Freeze/thaw cycle
  - Other
- Wind
  - High winds
  - Straight-line winds
  - Tornado
  - Other
- Other
  - Fog?
  - Drought?
  - Other?

5



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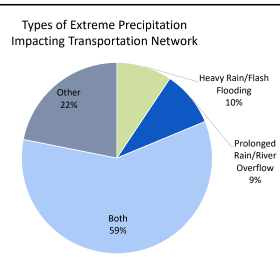

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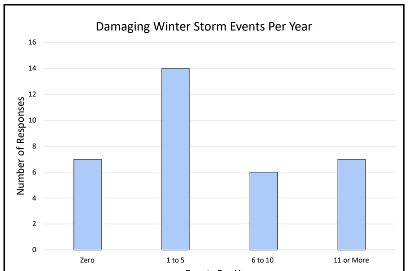

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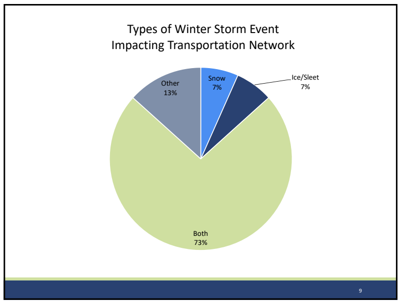
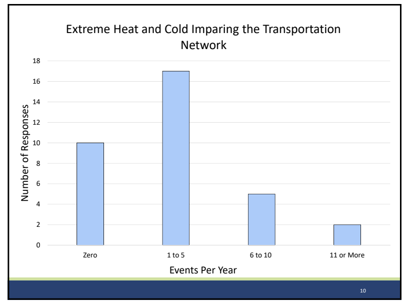
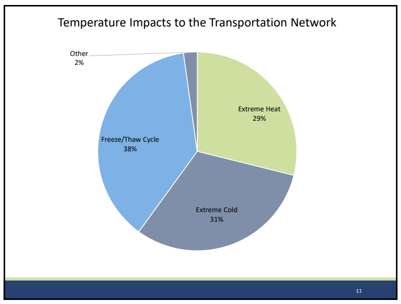
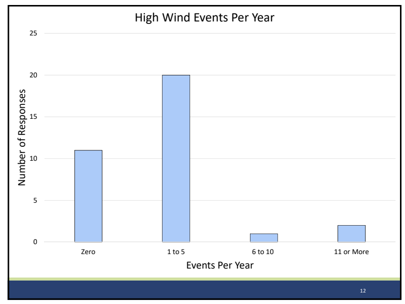
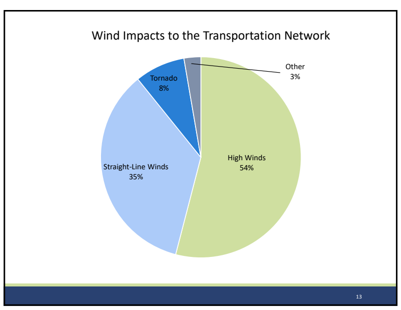

Types of Winter Storm Event
Impacting Transportation Network
Snow 7%
Ice/Sleet 7%
Other 13%
Both 73%
9

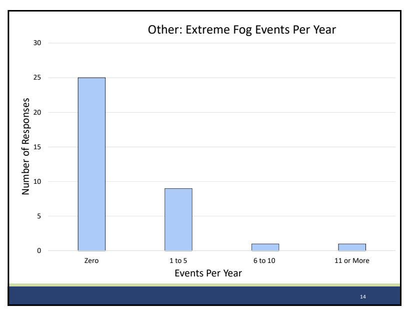

Extreme Heat and Cold Imparing the Transportation Network
Number of Responses
Zero
1 to 5
6 to 10
11 or More
Events Per Year
10

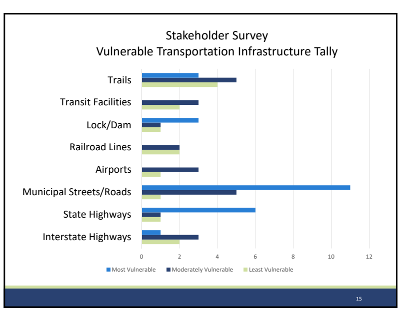

Temperature Impacts to the Transportation Network
Other 2%
Extreme Heat 29%
Freeze/Thaw Cycle 38%
Extreme Cold 31%
11

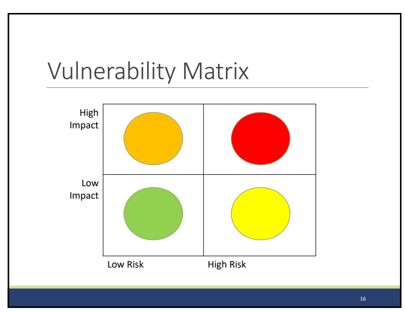

High Wind Events Per Year
Number of Responses
Zero
1 to 5
6 to 10
11 or More
Events Per Year
12

3


Wind Impacts to the Transportation Network
Other 3%
Tornado 8%
Straight-Line Winds 35%
High Winds 54%
13


Other: Extreme Fog Events Per Year
Number of Responses
Zero
1 to 5
6 to 10
11 or More
Events Per Year
14

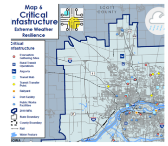

Stakeholder Survey
Vulnerable Transportation Infrastructure Tally
Trails
Transit Facilities
Lock/Dam
Railroad Lines
Airports
Municipal Streets/Roads
State Highways
Interstate Highways
Most Vulnerable
Moderately Vulnerable
Least Vulnerable
15


Vulnerability Matrix
High Impact
Low Impact
Low Risk
High Risk
16

4

Critical Infrastructure & Facilities

- Evacuation gathering sites
- Public works facilities
- Transit hubs
- Transit transfer points
- Rural transit operations
- Airports
- Port facilities
- Railyard



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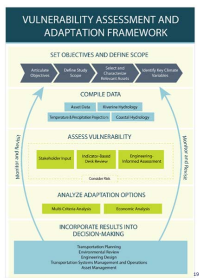
Adaptation Prioritization

18

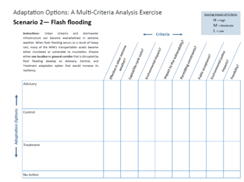
Project framework

- Set objective and define scope
- Compile data
- Assess Vulnerability
- **Analyze adaptation options**
- Incorporate results into decision-making



19

Analyzing Adaptation Options



20

Advisory *Informing the public*

Adaptation Options:

- Intelligent Transportation System (ITS)
- Motorist alerts
- Communication & Outreach Plan
- Road side active warning systems
- Pre-trip traveler information systems
- Social media

(Asam et. al., FHWA, 2015)

Photo sources: IL DOT gettingaroundillinois.com; Bi-State; IA DOT 511ia.org

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Control *Operational controls and maintenance*

Adaptation Options:

- Variable speed limits
- Vehicle restrictions
- Route restrictions
- Road-surface treatments
- Weather responsive traffic signal management

(Asam et. al., FHWA, 2015)

Photo sources: City of Davenport; Iowa State Patrol; Iowa 511 Traveler Information – Northeast Region Facebook

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Treatment *Infrastructure construction & design*

Adaptation Options:

- Green infrastructure
- Levee construction (traditional and living)
- Culvert sizing
- Road/bridge elevation
- Temporary measures (flood wall, pumping)
- Floodproofing

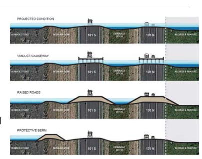

Photo source: Crow et. al., 2014 – FHWA Climate Resilience Pilot Final Report

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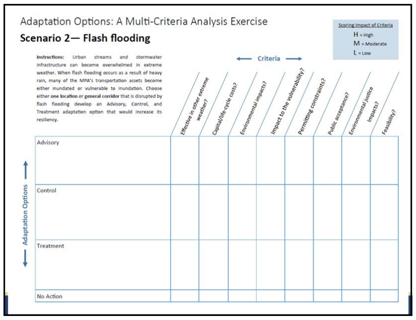
Adaption Prompt Questions

1. If money were no object, what would you do?
2. Is there a partial solution that you could implement now, and complement it with further action at a later time?
3. What steps could improve resilience without spending any money?
4. Could a public education campaign reduce risk by raising awareness of an issue?

24


Adaptation Options: A Multi-Criteria Analysis Exercise
Scenario 2— Flash flooding
Scoring Impact of Criteria
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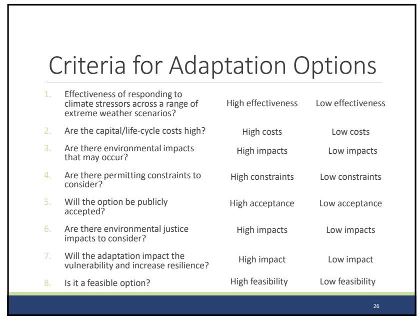
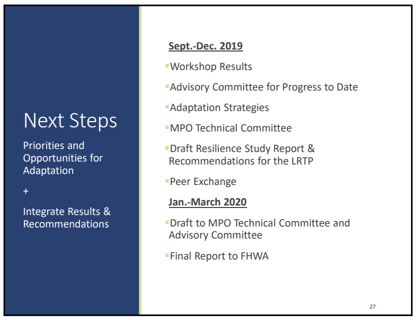
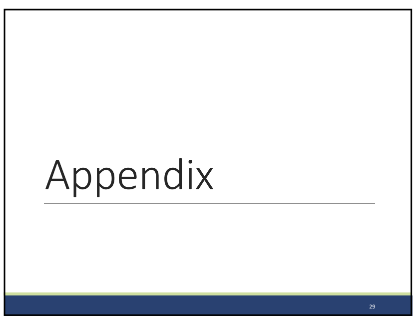
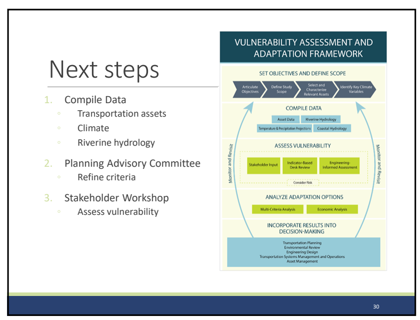
L = Low
Instructions: Urban streams and stormwater infrastructure can become overwhelmed in extreme weather. When flash flooding occurs as a result of heavy rain, many of the MPA's transportation assets become either inundated or vulnerable to inundation. Choose either one location or general corridor that is disrupted by flash flooding develop an Advisory, Control, and Treatment adaptation option that would increase its resiliency.
Criteria
Effective in other extreme weather?
Capital/life-cycle costs?
Environmental impacts?
Impact to the vulnerability?
Permitting constraints?
Public acceptance?
Environmental justice impacts?
Feasibility?
Adaptation Options
Advisory
Control
Treatment
No Action

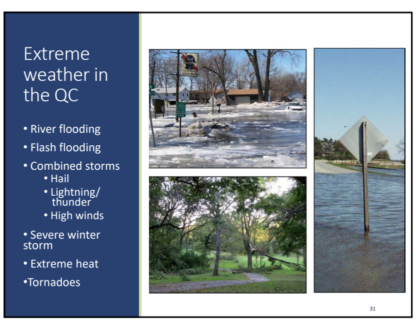

Criteria for Adaptation Options
1. Effectiveness of responding to climate stressors across a range of extreme weather scenarios? High effectiveness Low effectiveness
2. Are the capital/life-cycle costs high? High costs Low costs
3. Are there environmental impacts that may occur? High impacts Low impacts
4. Are there permitting constraints to consider? High constraints Low constraints
5. Will the option be publicly accepted? High acceptance Low acceptance
6. Are there environmental justice impacts to consider? High impacts Low impacts
7. Will the adaptation impact the vulnerability and increase resilience? High impact Low impact
8. Is it a feasible option? High feasibility Low feasibility
26

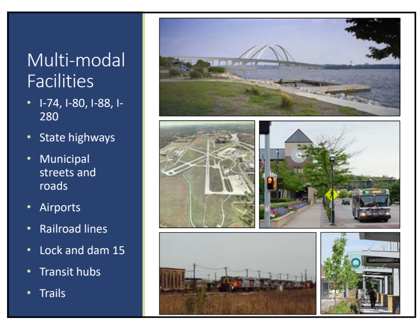

Next Steps
Priorities and Opportunities for Adaptation
+
Integrate Results & Recommendations
Sept.-Dec. 2019
Workshop Results
Advisory Committee for Progress to Date
Adaptation Strategies
MPO Technical Committee
Draft Resilience Study Report & Recommendations for the LRTP
Peer Exchange
Jan.-March 2020
Draft to MPO Technical Committee and Advisory Committee
Final Report to FHWA
27


Questions? Suggestions?
GENA MCCULLOUGH, GMCCULLOUGH@BISTATEONLINE.ORG
TARA CULLISON, TCULLISON@BISTATEONLINE.ORG
SARAH GARDNER, SGARDNER@BISTATEONLINE.ORG
PATTY PEARSON, PPEARSON@BISTATEONLINE.ORG


Appendix
29


Next steps
1. Compile Data
Transportation assets
Climate
Riverine hydrology
2. Planning Advisory Committee
Refine criteria
3. Stakeholder Workshop
Assess vulnerability
VULNERABILITY ASSESSMENT AND ADAPTATION FRAMEWORK
SET OBJECTIVES AND DEFINE SCOPE
Articulate Objectives
Define Study Scope
Select and Characterize Relevant Assets
Identify Key Climate Variables
COMPILE DATA
Asset Data
Riverine Hydrology
Temperature & Precipitation Projections
Coastal Hydrology
ASSESS VULNERABILITY
Stakeholder Input
Indicator-Based Desk Review
Engineering-Informed Assessment
Consider Risk
ANALYZE ADAPTATION OPTIONS
Multi-Criteria Analysis
Economic Analysis
INCORPORATE RESULTS INTO DECISION-MAKING
Transportation Planning
Environmental Review
Engineering Design
Transportation Systems Management and Operations
Asset Management
Monitor and Revisit
Monitor and Revisit
30


Extreme weather in the QC
River flooding
Flash flooding
Combined storms
Hail
Lightning/ thunder
High winds
Severe winter storm
Extreme heat
Tornadoes
31


Multi-modal Facilities
I-74, I-80, I-88, I-280
State highways
Municipal streets and roads
Airports
Railroad lines
Lock and dam 15
Transit hubs
Trails

Interactive map

https://bsrc.maps.arcgis.com/apps/CrowdsourceReporter/index.html?appid=9a94d1115813424c9e6fc6c95307a165

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Bi-State Regional Commission
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Phone: (309) 793-6300 • Fax: (309) 793-6305
Website: http://www.bistateonline.org

SERVICE REPORT

COUNTY/COMMUNITY: Quad Cities Metropolitan Planning Area

DATE: August 29, 2019

FILED BY: Gena McCullough

MEETING: Quad Cities, Iowa-Illinois Metropolitan Planning Area Extreme Weather Resilience Pilot Project Stakeholder Workshop

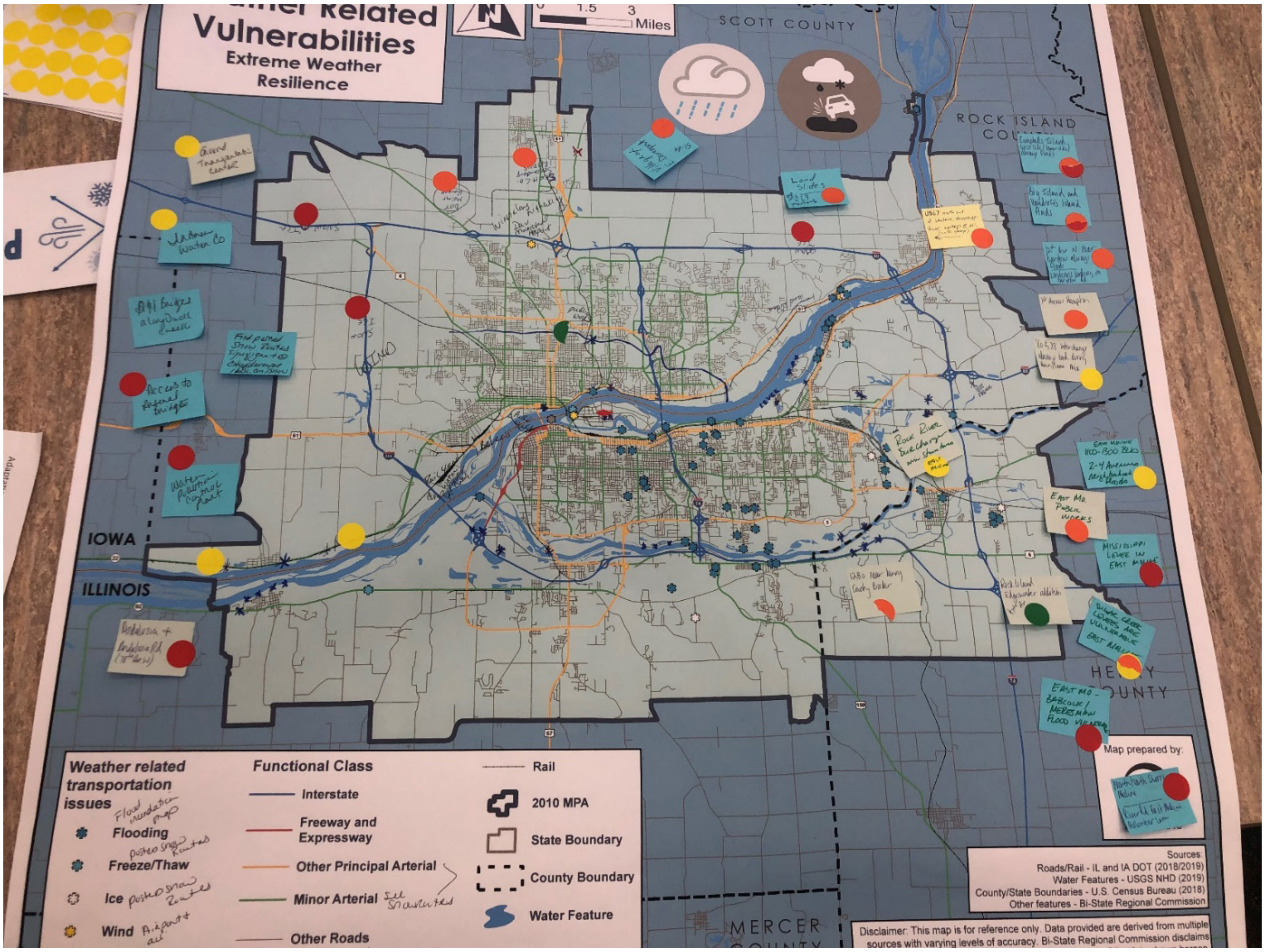
PRESENT:

COUNTY/COMMUNITY	BI-STATE	OTHERS	COPIES TO:
City of Davenport	Tara Cullison		File
City of East Moline	Sarah Gardner		
City of Moline	Brad Lathrop		
City of Rock Island	Gena McCullough		
Davenport Municipal Airport			
Federal Highway Administration			
Illinois Department of Transportation			
Iowa Department of Transportation			
MetroLINK			
National Weather Service			
Scott County Emergency Management Agency			
US Army Corps of Engineers			

Workshop Background Presentations. In addition to Bi-State staff, twenty three people were present for the workshop, held at the Bettendorf Public Library. Presentations to overview extreme weather and climate, state vulnerability assessments, and the pilot project were the first part of the four and a half hour workshop. Mr. Ray Wolf, National Weather Service, outlined his agency's role in being a weather ready nation, the difference between weather and climate, impact of billon dollar disasters, and the impacts on transportation and energy production. He overviewed future climate models and why there is a need to look at long term resilience. Mr. Chris Schmidt, Illinois Department of Transportation, reviewed the State of Illinois' 2017 All Hazards Vulnerability Assessment. The plan outlined a variety of partners who play a role in transportation resilience in the state, and how the plan looked at hubs where vulnerable facilities were located. The analysis focused on critical facilities, risk and sensitivity in defining its priorities. Mr. David Claman, Iowa Department of Transportation, shared information on the recovery aspect of resilience. The Iowa DOT has been doing 2D modeling of streamflow and its intersection with bridges within the state. In 2010, I-35 was overtopped by a flood that exceeded its highest peak by 38%. In Spring 2019, western Iowa experienced significant flooding on the Missouri River with 13 major levee breaches, south of Council Bluffs. He noted pending projects to raise road grades and add more water flow conveyance to reduce washouts. He noted an NCHRP 1561 Report coming out that related to the workshop topic. There is a likelihood that the next reauthorization of the Federal transportation act will include more on resilience.

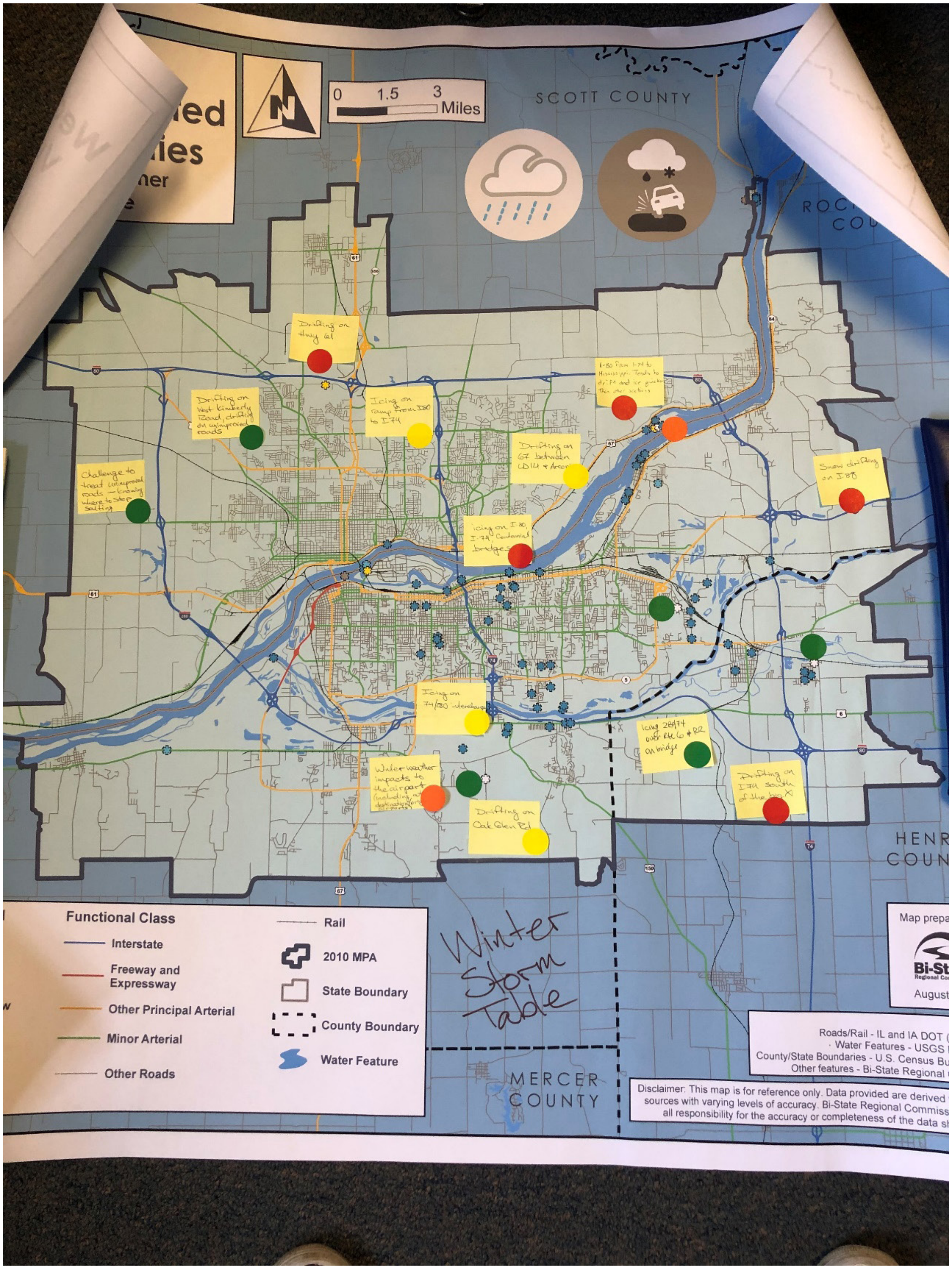
Table Top Vulnerable Facilities Review. Following presentations, participants were asked to sit at tables that would include at least one city/county representative, state or federal official, state or federal resource agency and other interested parties. Maps with results from the stakeholder survey were placed at each table with a specific weather topic – flash flooding, precipitation, wind-other, and wind storm. The first exercise was to review these maps and use markers and post-it notes to determine if there were any additions needed to identify hot spots and vulnerable transportation facilities, or other important critical facilities that had not already been noted on the respective map. The information was captured in the following photos and transferred to our GIS system to locate vulnerable areas within the MPO.

Precipitation Table



Wind – Other Table

Winter Storm Table



Multi-Criteria Adaptation Exercise. The final exercise included looking at a multi-criteria adaptation options. Workshop participants were provided worksheets with two scenarios. For example, at the Precipitation Map table these included Scenario 1: River Flooding and Scenario 2: Flash Flooding. The other tables examined: fog and drought; heavy snow and ice/sleet; and freeze/thaw and extreme heat. Questions were posed along the x-axis of the chart and ques for adaptation options were noted on the y-axis with headings of Advisory, Control, Treatment or No Action. Participants were asked to score impact by high, moderate or low. A sample of the exercise chart is noted below:

Adaptation Options: A Multi-Criteria Analysis Exercise

Scenario 2— Flash flooding

Scoring Impact of Criteria
H = High
M = Moderate
L = Low

Instructions: Urban streams and stormwater infrastructure can become overwhelmed in extreme weather. When flash flooding occurs as a result of heavy rain, many of the MPA's transportation assets become either inundated or vulnerable to inundation. Choose either **one location** or **general corridor** that is disrupted by flash flooding develop an Advisory, Control, and Treatment adaptation option that would increase its resiliency.

← Criteria →

↑ Adaptation Options ↓

	Effective in other extreme weather?	Capital/life-cycle costs?	Environmental impacts?	Impact to the vulnerability?	Permitting constraints?	Public acceptance?	Environmental justice impacts?	Feasibility?
Advisory								
Control								
Treatment								
No Action								

Due to time constraints, the adaptation options exercise did not generate as much input as had been expected. The results are summarized as follows:

Scenario 1: River Flooding – Andalusia Road, southwest portion of the MPO

1. Advisory: I-PAWS (Integrated Public Alert and Warning System) usage and public outreach; existing strategy = signage; expand commitment to outreach and planning
2. Control: Barricades
3. Treatment: Divert water to retain on agricultural land; possible box culvert or diversion of water

Scenario 2: Flash Flooding – thinking in terms of 29th Street at Duck Creek

1. Advisory: Level notifications, permanent high water sign
2. Control: Automated control arm when water reaches a certain level; barricades
3. Treatment: Install temporary overflow, and detention at Garfield Park

These items were noted as lower cost, medium impact, low environmental justice impacts, and higher feasibility. The treatment using stormwater detention was seen as medium cost, higher permitting constraints, low environmental justice impacts and higher feasibility.

Scenario 1: Fog – focus on river navigation

1. Advisory: Broadcast marine notices (BNM-broadcast notice to mariners) are put out by the Coast Guard when fog events occur currently. The National Weather Service puts out advisories for the airport as well as general notice for highways. Use advisory radio or highway signs (dynamic messaging or if recurring fog area, permanent sign in that area.
2. Control: Emission reduction measures would help reduce the formation of fog. Use of barges that carry bulk commodities by shifting transportation from highways/trucks to river would reduce emissions.
3. Treatment: Burn it off or blow it away (fans).

Existing advisories were considered high in effectiveness to communicate extreme weather events related to fog. Shifting modes of transportation was thought to be high in effectiveness, low environmental impacts and high in public acceptance. Manually moving air as a treatments or dissipating it would likely have low effectiveness and feasibility, medium environmental impacts and medium to high permitting constraints.

Scenario 2: Drought – focus on river navigation

1. Advisory: Broadcast no burn advisories, and use BNMs for river navigation. Use fire danger signing to warn of risk.
2. Control: Use the lock and dam system on the Mississippi River to control water flow, already existing for low flow events. Use training structures. Store water in reservoirs for water shortage and flood control. Conduct highway roadside maintenance to mitigate grass fires adjacent to roadways.
3. Treatment: Use of dredging to maintain navigable channel in rivers. Use firebreaks and streambank maintenance along rivers/streams, and roadside maintenance along highways.

Advisories were considered high in effectiveness to communicate extreme weather events related to drought for non-river impacts but lower for river navigation. Using existing broadcast media and signing were seen as low cost and high public acceptance. Physical controls on the Mississippi River or for other streams was seen as medium to high cost, low effectiveness, high public acceptance and high feasibility. Roadside maintenance was discussed as medium effectiveness, medium to high impact on vulnerability and high feasibility.

Scenario 1: Ice and Sleet – icing on the Interstate 80 Bridge

1. Advisory: Use intelligent transportation systems, such as dynamic message signs, to provide motor vehicle alerts. Utilize broadcast media to provide alerts when extremes are present but not routine winter situations. Use of automated vehicle/GPS dynamic signaling.
2. Control: Pretreat pavement. Reduce speeds. Restrict lane usage. Divert to other bridges if needed. Implement higher level of service with snow plowing and deicing measures during events, and at entry points.
3. Treatment: Consider automated brining systems or covered bridges.

Advisories were considered high in effectiveness to communicate extreme weather events related to ice and sleet. All the advisory measures were seen as low-medium cost, low environmental impact, low vulnerability impact, permitting, public acceptance, effects on environmental justice and feasibility. Control measures were thought to be highly effective, variable in cost, and variable in feasibility. Treatments suggested were mixed in the effectiveness and public acceptance, and lower in feasibility.

Scenario 2: Heavy Snow – drifting on Interstate 80 between the Mississippi River and Middle Road, Bettendorf

1. Advisory: Use similar advisories as noted for ice and sleet.
2. Control: Do not pre-treat. Reduce speeds, and use other controls noted for ice and sleet.
3. Treatment: Utilize green/natural snow-fences that are larger than the right-of-way. Adjust elevation with grade of the right-of-way.

See ice and sleet Scenario 1 related to advisories adaptation strategies. Under heavy snow, some control measures were noted as different when treating roadway surfaces but the other controls were similar. Natural landscaping as snow-fences was seen as highly effective and feasible, as well as benefitting the environment and vulnerable facility. This treatment was also rated as high acceptance by the public. Adjusting roadway elevations would also be highly effective but lower in feasibility according to the participants.

Scenario 1: Freeze/thaw cycle - roadways

1. Advisory: No input.
2. Control: General cleaning and maintenance of the stormwater intake system, and road maintenance -
3. Treatment: Replace sub-based and enlarge storm sewers

For treatment, the noted engineering adaptation strategies were discussed as highly effective but also costly. These strategies were rated as medium positive environmental impact and vulnerability impact, and likely highly acceptable to the public but low feasibility due to funding constraints (scope dependent).

Scenario 2: Extreme Heat

1. Advisory: No input.
2. Control: Ensure proper mix for the area.
3. Treatment: No input.

The group ran out of time to deliberate on this scenario.

Multi-Criteria Analysis Exercise Conclusion Post-Workshop. While not as robust as anticipated, the discussion did generate ideas and pointed to a number of existing advisory options already being implemented to address extreme weather events to support MPO resilience. The adaptation exercise may be better suited for a project selection process to better inform project selection by introducing a deliberative discussion for projects being considered. Those that rate higher in effectiveness, life-cycle costs, reduction of impacts, public acceptance and feasibility would then be projects supported as priorities for funding.

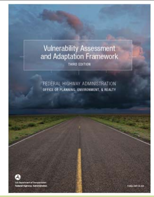
Status Presentations

Extreme Weather and Infrastructure Resilience

BI-STATE REGIONAL COMMISSION
FHWA PILOT PROJECT
GENA MCCULLOUGH, ASST. EXECUTIVE/PLANNING DIRECTOR

U.S. Department of Transportation Federal Highway Administration
Bi-State Regional Commission

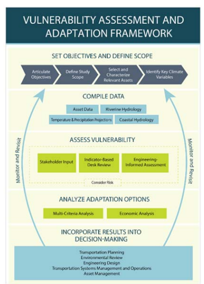
Vulnerability Assessment



- Provides structured process for conducting a vulnerability assessment
- Suggests ways to use results in practice
- Features examples from other similar projects
- Includes links and references to related resources and tools

Project framework

- Set objective and define scope
- Compile data
- Assess Vulnerability
- Analyze adaption options
- Incorporate results into decision-making



Prioritizing Assets

Criticality assessment *= involves identifying the most critical elements of the transportation system for analysis, using quantitative and qualitative data.*

Vulnerability assessment *= what critical facilities/infrastructure are more vulnerable to disruptions or likely to be impacted by extreme weather, now and in the future.*

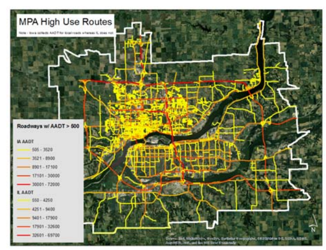
Adaptation options *= strategies that can increase resilience of the regional transportation system.*

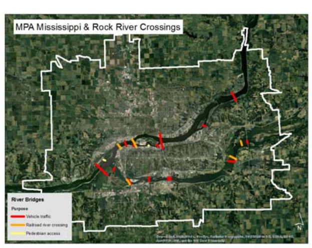
Refining Criticality Criteria

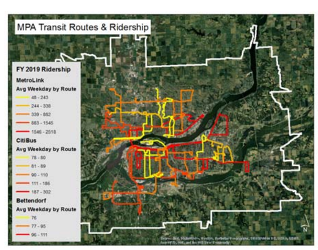
Stakeholder & Transportation Technical Committee Input

What is critical to our region's transportation system?

- High use areas/routes
- Land use/destinations of importance
  - i.e. RI Arsenal, densely populated areas
- Mississippi River crossings
- Medical/emergency routes
  - i.e. hospital access
- Redundancy throughout network
- Economic vitality
  - i.e. access to large employers



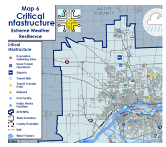


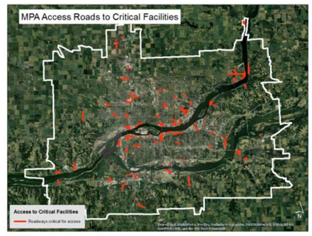


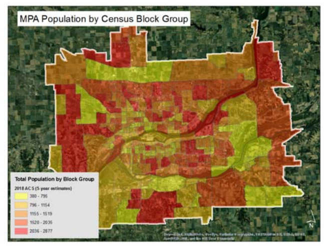
Critical Infrastructure & Facilities

- Evacuation gathering sites
- Public works facilities
- Transit hubs
- Transit transfer points
- Rural transit operations
- Airports
- Port facilities
- Railyard

+ Emergency Management & Medical Facilities







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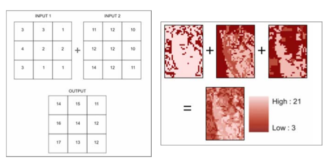
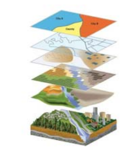
Next Step → Weighted Overlay

Examples



Using Spatial Analysis for Adaptation Options



Weighted Criticality Data

Vulnerability Data

Locations for Adaptation

Photo source: ESRI.com

Questions?

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Extreme Weather and Infrastructure Resilience

BI-STATE REGIONAL COMMISSION

FHWA PILOT PROJECT

GENA MCCULLOUGH & TARA CULLISON

TPC- MAY 26, 2020

U.S. Department of Transportation Federal Highway Administration

Bi-State Regional Commission

Project Status

- Analyze/Apply adaption options
- Incorporate results into decision-making

Assess Vulnerability: Prioritizing Assets

Criticality assessment = *involves identifying the most critical elements of the transportation system for analysis, using quantitative and qualitative data.*

Vulnerability assessment = *what critical facilities/infrastructure are more vulnerable to disruptions or likely to be impacted by extreme weather, now and in the future.*

Adaptation options = *strategies that can increase resilience of the regional transportation system.*

Criticality Criteria Weighting

Stakeholder & Transportation Technical Committee Input

Measures used for our region's transportation system

- High use areas/routes
- Land use/destinations of importance
  - i.e. RI Arsenal, densely populated areas
- Mississippi River crossings
- Medical/emergency routes
  - i.e. hospital access
- Redundancy throughout network
- Economic vitality
  - i.e. access to large employers

Data Input for Weighted Sum Overlay Analysis

Bridges (AADT)
Manual Classification

< 1,000	1
1,001 – 10,000	2
10,001 – 25,000	3
25,001 – 40,000	4
> 40,000	5
Pedestrian access bridge	1

IL Roadways (AADT)
Natural Breaks Classification

500 - 4,250	1
4,251 – 9,400	2
9,401 – 17,900	3
17,901 – 32,600	4
32,601 – 69,700	5

IA Roadways (AADT)
Natural Breaks Classification

500 - 3,520	1
3,521 – 8,900	2
8,901 – 17,100	3
17,101 – 30,000	4
30,001 – 72,000	5

Access to Critical Facilities
All access road segments 5

Access to Major Employers
All access road segments 1

Bettendorf Transit (Ridership)
Natural Breaks Classification of Avg. Weekday Ridership

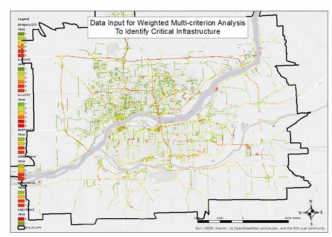
0 – 76	1
77 - 95	2
96 - 111	3

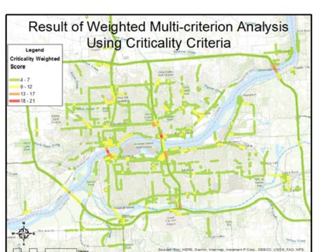
Davenport Transit (Ridership)
Natural Breaks Classification of Avg. Weekday Ridership

0 – 110	1
111 - 186	2
187 - 302	3

MetroLink Transit (Ridership)
Natural Breaks Classification of Avg. Weekday Ridership

0 – 634	1
635 – 1,545	2
1,546 –2,518	3





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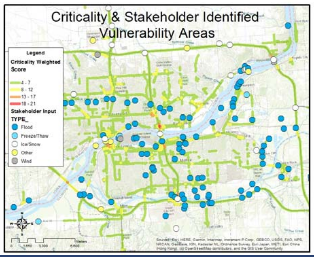

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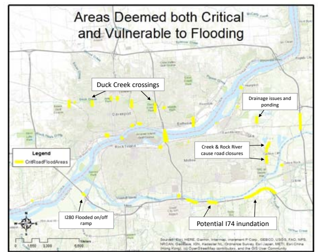

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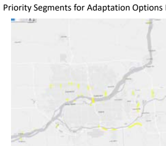
Focus for Adaptation Options Prioritization

- Most at-risk
  - Corridors
  - Hot spots
- Already Planned Projects
- Asset by State or Jurisdiction
- Combination

Priority Segments for Adaptation Options Review



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Review Priorities by Potential Solutions

Advisory	Control	Treatment
Intelligent Transportation System (ITS)	Variable speed limits	Green infrastructure
Motorist alerts	Vehicle restrictions	Levee construction (traditional and living)
Communication & Outreach Plan	Route restrictions	Culvert sizing
Road side active warning systems	Road-surface treatments	Road/bridge elevation

(Asam et. al., FHWA, 2015)

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Criteria for Adaptation Options Review

1.	Effectiveness of responding to climate stressors across a range of extreme weather scenarios?	High effectiveness	Low effectiveness
2.	Are the capital/life-cycle costs high?	High costs	Low costs
3.	Are there environmental impacts that may occur?	High impacts	Low impacts
4.	Are there permitting constraints to consider?	High constraints	Low constraints
5.	Will the option be publicly accepted?	High acceptance	Low acceptance
6.	Are there environmental justice impacts to consider?	High impacts	Low impacts
7.	Will the adaptation impact the vulnerability and increase resilience?	High impact	Low impact
8.	Is it a feasible option?	High feasibility	Low feasibility

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Incorporating into Transportation Planning Process

LRTP — Extreme Weather Resilience Objective
- Develop objective for LRTP – policy statement
- Incorporate Adaptation Priorities in chapters
- Consider resilience review for planned projects

TIP — Resilience Discussion & Project Selection
- Recognize resilience in TIP – use environmental maps to highlight vulnerabilities
- Review selection criteria to incorporate resilience

Technical Asst. — Resilience in Project Development Process
- Write grants for priority resilience projects
- Work with local jurisdictions during project development process to incorporate adaptation options into project development

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Questions?

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