SRTC
SPOKANE REGIONAL TRANSPORTATION COUNCIL

SYSTEM RESILIENCY ASSESSMENT

November 2024

Abstract

The System Resiliency Assessment establishes a baseline for SRTC and its member agencies to assess, prepare, and respond to long-term risks to transportation infrastructure from natural and human-caused stressors.

Prepared by

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SRTC Resiliency Plan

Introduction

The Spokane Regional Transportation Council (SRTC) System Resiliency Assessment (Plan) establishes a baseline for SRTC to assess, prepare, and respond to long-term risks to transportation infrastructure from natural and human-caused stressors. SRTC is the federally designated Metropolitan Planning Organization (MPO) and Transportation Management Area (TMA) for the Spokane Metropolitan Planning Area in Washington. At the state level, SRTC is the designated Regional Transportation Planning Organization (RTPO). As the MPO and RTPO, SRTC coordinates regional transportation planning within its planning area of Spokane County. SRTC's guiding principles are the foundation of the agency's plans and programs. While resiliency touches on each of the six guiding principles, it is particularly applicable to Stewardship, Safety and Security, and System Operations, Maintenance, and Preservation.

The Plan builds upon local hazard mitigation efforts to identify major hazards and their potential impacts to the functionality of transportation assets within the planning jurisdiction of SRTC. It presents a systemic approach to resilience planning and decision-making for the regional transportation system through the identified strategies, actions, and performance metrics.

The Plan serves as the foundation for SRTC and member agencies to integrate and monitor transportation resilience in their planning processes over the 25-year Metropolitan Transportation Plan (MTP) planning period. It was developed with input from a Stakeholder Advisory Group (SAG) and the SRTC Transportation Advisory Committee (TAC), Transportation Technical Committee (TTC), and Board of Directors.

The organization of the Plan is:

Appendices

Transportation Resilience

A reliable transportation system is essential for communities and economies to function. Natural or human-caused hazards threaten the reliability, safety, and efficiency of transportation systems. In recent decades, these hazards have increased in frequency and severity, a trend that is projected to continue. While it's impossible for transportation agencies to plan for or predict all potential hazard scenarios, planning for a resilient transportation system can mitigate the impacts to the safety and security of transportation users caused by uncertain or unpredictable events.

> *The Federal Highway Administration (FHWA) defines **resilience** as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.*

A resilient transportation system adapts to the changing conditions of a disruptive event and the cascading effects of those disasters, allowing the system to maintain essential services and quickly recover to normal operations after an event. Integrating resilience into long-range transportation planning allows SRTC and its member agencies to be prepared for and respond to changing conditions from ongoing threats such as climate change or a sudden, severe shock such as a sudden failure of a critical transportation asset.

Planning for a Resilient Transportation System

Recent disasters across the Pacific Northwest and broader United States highlight the need for transportation systems to be able to withstand, respond to, adapt to, and recover from disruptive events. Additionally, the costs of climate-related disasters are increasing due to a combination of increased exposure (i.e., more transportation assets at risk as urban areas grow), vulnerability of critical assets (e.g., aging infrastructure), and increased intensity of specific hazard types due to climate change.[1]

Spokane County may seem to be less vulnerable to large-scale, catastrophic events like other areas of the state or country, but several recent events have had significant consequences to transportation system operations and functionality. For example, major flooding events in 2017 and 2019 washed out or damaged numerous roadways throughout Spokane County, resulting in roadway closures and hundreds of thousands of dollars in roadway repairs. In 2020, the COVID-19 pandemic reduced ridership on Spokane Transit Authority (STA) fixed route services by nearly half, resulting in a reduction in transit service for an extended period and consequently, reducing STA revenue by over 18 percent[2,3]. In 2021,

[1] Adam B. Smith, "2023: A historic year for U.S. billion-dollar weather and climate disasters," Climate.gov, January 8, 2024, https://www.climate.gov/news-features/blogs/beyond-data/2023-historic-year-us-billion-dollar-weather-and-climate-.disasters#:~:text=Adding%20the%202023%20events%20to,376%20events%20exceeds%20%242.660%20trillion.
[2] Spokane Transit Authority (STA). *Fixed Route System Performance Report – 2022 Data*, 2023,https://www.spokanetransit.com/wp-content/uploads/2023/05/2022-Annual-Performance-Report_Final.pdf.
[3]Spokane Transit Authority (STA). *Financial Statements and Federal Single Audit Report for the period January 1, 2021 through December 31, 2021,* 2022, https://www.spokanetransit.com/wp-content/uploads/2022/07/2021-Financial-and-Single-Audit-report.pdf.

Spokane experienced a long duration heat dome where temperatures were recorded up to 109 degrees. The high temperatures damaged roads, caused power outages, and required trains to operate at reduced speeds to account for potential shifts in the tracks. In 2023, multiple wildfires burning in Spokane County, including the Gray Fire, resulted in a federal state of emergency declaration, caused millions of dollars in property damage, and prompted the closure of critical transportation routes for a short period of time, including I-90, SR 204, and SR 902.

As for future anticipated hazards, large-scale disasters such as a major subduction zone earthquake along the Cascadia fault line could require Spokane County and the surrounding region to serve as a vital hub for emergency and evacuation services, adding strain to the transportation system.

Emergency planning and response efforts are led at the state and county levels by organizations such as the Spokane County Department of Emergency Management and through the Emergency Operations Center (EOC). The role of EOC is to coordinate a multi-agency response to facilitate the flow of information, resources, and services throughout the community. SRTC also has an important role to play for regional coordination, including planning and programming projects that improve transportation system resiliency. As SRTC continues to refine and develop strategies, policies, and actions for increasing resiliency of the transportation system, lessons learned from other agencies are valuable resources. Federal agencies such as FHWA and USDOT are providing ongoing guidance on best practices for incorporating resilience into transportation planning processes. Transportation agencies including Washington State Department of Transportation (WSDOT) and comparable Metropolitan Planning Organizations (MPOs) across the Pacific Northwest have started to adopt this guidance into planning strategies, project prioritization, operations and maintenance, construction, and design/ environmental review of transportation projects. As part of the development of this Plan, a review of 17 MPOs across the United States and Canada was conducted to understand current best practices in transportation planning for resilience.

EQUITY

Climate-related hazards disproportionately affect vulnerable populations, including transportation disadvantaged populations and historically underserved communities. SRTC is committed to mitigating these disproportionate impacts to ensure vulnerable populations have equal access to safe, reliable, and sustainable transportation options. An equitable approach prioritizes resilience projects in transportation disadvantaged areas, engages key populations and interest groups throughout planning processes, and monitors the effectiveness of resilience-focused projects to ensure equity goals are met.

FEDERAL REQUIREMENTS

The SRTC Resiliency Plan aligns SRTC with federal requirements for MPOs to incorporate resilience in transportation planning. The Fixing America's Surface Transportation "FAST Act" was signed into law in December 2015 and requires metropolitan and statewide planning agencies to consider resiliency during transportation planning processes (23 CFR 450.306(b)). In November 2021, the FAST Act was replaced by the Infrastructure Investment and Jobs Act (IIJA), which carries forward many of the requirements of the FAST Act and expands the focus of federal programs to include resilience-related planning activities. The IIJA provides the first ever legislative definition of resilience, defined with respect to a project as:

> *"A project with the ability to anticipate, prepare for, or adapt to conditions or withstand, respond to, or recover rapidly from disruptions, including the ability—(A)(i) to resist hazards or withstand impacts from weather events and natural disasters; or (ii) to reduce the magnitude or duration of impacts of a disruptive weather event or natural disaster on a project; and (B) to have the absorptive capacity, adaptive capacity, and recoverability to decrease project vulnerability to weather events or other natural disasters."*

Since the FAST Act was passed in 2015, states and MPOs have started to integrate transportation resilience concepts into goals, strategies, actions, and policies to differing extents.

IIJA also established the Federal Highway Administration's (FHWA) Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program to help make surface transportation more resilient to natural hazards through support of planning activities and resilience improvements. The PROTECT discretionary program offers two types of awards: planning grants and Competitive Resilience Improvement Grants[4]. Eligible uses include highway and transit projects that include resilience planning, strengthening, and protecting evacuation routes, enabling communities to address vulnerabilities, and increasing the resilience of surface transportation infrastructure from the impacts of sea level rise, flooding, wildfires, extreme weather events, and other natural disasters. For Planning Grants, the merit criteria are:

- 1. Program Alignment
- 2. Schedule and Budget
- 3. Public Engagement, Partnerships and Collaboration.
- 4. Innovation

For Resilience Grants, the merit criteria are:

- Vulnerability and Risk
- Criticality to Community
- Design Elements
- Public Engagement, Partnerships and Collaboration
- Equity and Justice40
- Climate Change and Sustainability
- Schedule and Budget
- Innovation

This plan provides baseline information to facilitate future grant applications by SRTC and/or local agencies, positioning the Spokane region for increased federal funding for transportation projects that improve resilience.

[4] § 11405; 23 U.S.C. 176(e)(2)

STATE REQUIREMENTS

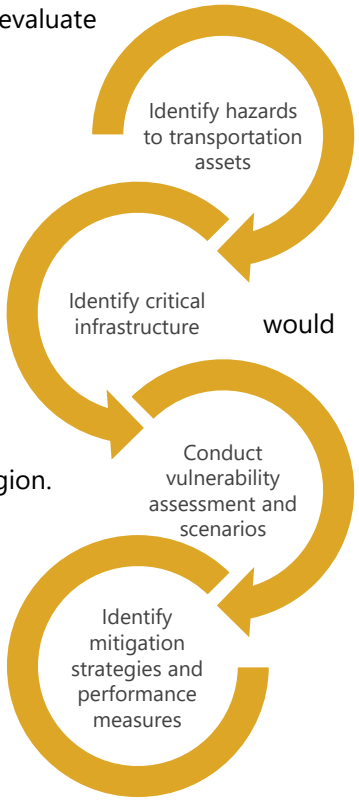
The Washington State Growth Management Act was amended in 2023 (HB 1181) requiring counties and cities (with a population greater than 6,000) to plan for climate resilience and greenhouse emission reductions as part of their comprehensive planning processes, including updates to the transportation element, land use element, and the addition of a climate element. One of the key objectives of HB 1181 is to improve the resilience of transportation infrastructure through goals, policies, and programs, with a targeted focus on equity. The SRTC Resiliency Plan will support resiliency planning efforts so that applicable jurisdictions can integrate into long-range planning efforts to meet these new requirements.

APPROACH

The general approach for this plan is described below. The approach includes four steps that establish an understanding of the current state of the system, evaluate how the system could perform under potential hazard scenarios, and identify strategies that can be implemented by SRTC and member agencies to work towards a more resilient system.

1. **Identify hazards to transportation assets**: Understand the natural and human-caused hazards in the Spokane region that could impact transportation infrastructure and operations.
2. **Identify critical infrastructure**: Identify infrastructure assets that have high impacts to functionality and connectivity in the transportation network if failure occurs.
3. **Conduct vulnerability assessment and scenarios**: Evaluate the impacts of hazards to transportation infrastructure in the Spokane region. Using the Resilience and Disaster Recovery (RDR) tool, assess vulnerability in a range of future hazard scenarios to inform criticality and prioritization of an asset.
4. **Identify mitigation and adaptation strategies and performance measures**: Understand where and what assets to prioritize first. Develop performance measures to assess progress towards a resilient transportation system.

Resiliency Plan Approach



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Hazards

The Spokane County Hazard Mitigation Plan (HMP)[5] serves as the local hazard mitigation plan for the Spokane region and identifies resources, information, and strategies for reducing risk from natural hazards. Non-natural hazards are addressed in the Spokane County threat and hazard identification and risk assessment (THIRA) but are not publicly available for security reasons. Therefore, a list of non-natural hazards is identified through other emergency management or long-range transportation plans.

It is important to note that both natural and human-made hazards can also result in cascading or compounding events such as power/ grid failures that can disrupt other transportation assets that rely on electricity to function, such as telecommunications, Intelligent Transportation Systems (ITS), electric vehicle or e-bike charging stations for personal vehicles and transit, traffic control (signals), rail operations, and airport operations.

NATURAL HAZARDS

The HMP identifies the following natural hazards as being most likely to affect the Spokane region:

- Drought
- Earthquake
- Flood and dam failure
- Landslide, rockfall, debris flow
- Severe weather (damaging winds, winter storms, dust storms, thunderstorms)
- Volcanic eruptions
- Wildfire

Natural hazards can occur as long-term stressors (e.g., climate change) or as sudden shocks to the region (e.g., volcanic eruption). The HMP uses a Calculated Priority Risk Index (CPRI) score[6] to rank each hazard based on five criteria: probability, magnitude, geographic extent and location, warning time/ speed of onset, and duration of the event. The CPRI ranges from 0 to 4, with "0" being the least hazardous and "4" being the most hazardous situation. Based on the CPRI scores, severe weather and wildfires are the highest concern for the Spokane region. According to WSDOT, flooding and wildfires have had the most immediate impact on Washington's transportation system to date.

Table 1 summarizes the CPRI and potential effects on the transportation system for each hazard. The potential effects are not exhaustive and may be cumulative if multiple hazards occur at the same time such as flooding and landslides. The impacts are also dependent on the frequency and intensity of the event, as well as the infrastructure age and condition, design standards to which the facilities were built, and redundancy in the system.

[5] Spokane County. *Spokane County Hazard Mitigation Plan: Volume 1*, (Spokane, WA: Spokane County, 2020), https://www.spokanecounty.org/DocumentCenter/View/34414/Hazard-Mitigation-Plan-Update-Volume-1.

[6] The CPRI provides a relative indicator of the region's vulnerability to a specific hazard in terms of critical facilities, structures, population, economic value, and functionality of government after an event occurs. While the CPRI is not specific to transportation assets, it provides context for what hazards are of highest concern in the Spokane region.

Table 1. Potential Effects of Natural Hazards on the Transportation System

Hazard	CPRI[1]	Asset	Effect
Drought	2.75 (Medium Concern)	Roadways	Ground shrinkage below asphalt can cause pavement cracking, buckling, and subsidence.
		Rail	Runoff, leaching, slope instability, load bearing capacity, track stability and visibility.
		Airports	Stress on water supply for cooling power sources, irrigation, pavement power washing.
Earthquake	2.85 (Medium concern)	All	Bridge failures, road cracking, rail track damage, pipeline breaks, loss of electricity to communication and fueling systems, building damage at operations and maintenance facilities, potential to trigger landslides or dam failures, potential for fires from gas leaks.
Flood (including dam failures)	3.0 (Medium concern)	Roads	Asphalt stripping, washouts, subbase erosion, route closures, delays, damage to electrical equipment.
		Rail	Substructure erosion, inundation, delays, damage to electrical equipment.
		Buses	Delays and route changes, inundation of maintenance facilities.
		Airports	Runway damage.
Landslide	3.1 (Medium concern)	All	Road and track closures, power and communication line damage, potential for flooding if a waterway is blocked, potential for lake tsunamis if the landslide enters a lake.
Severe weather	3.4 (High concern)	All	Road, bridge, rail and airport damage and closures (surface cracking, systems power loss, obstructions, collapses, rail and bridge joint expansion (heat-related), increased potential for roadway crashes, damage to utilities and transportation-related buildings, staff difficulty (e.g., maintenance workers, bus drivers) getting to work, potential for heavy rain to trigger flooding.
Volcano (ash fall)	1.75 (Low concern)	All	Ashfall causes road, track, and airport closures; sufficient ash accumulations can cause roof collapses.
Wildfire	3.30 (High concern)	Roads	Rutting, softening, closures, need for safe evacuation routes, poor visibility.
		Rail	Blocked routes, delays.
		Airports	Route closures and detours.
		Buses	Delays due to poor visibility and worker safety (smoke).
		Utilities	Damage to power and communications lines.
		Facilities	Damage to vehicles and facilities in the fire zone.
		All	Poor air quality preventing use of active transportation modes.

HUMAN-CAUSED HAZARDS

The impacts of human-caused hazards to transportation assets are more difficult to predict or plan for but generally include the same kinds of issues associated with natural hazards, such as long-term closures, the need to evacuate potentially large populations, and unprecedented changes in travel behavior. Table 2 summarizes potential human-caused hazards and possible impacts to transportation.

Table 2. Potential Effects of Human-Caused Hazards on the Transportation System

Hazard	Description
Infrastructure Failure	• Examples include lack of or deferred maintenance, aging infrastructure, dam failure, bridge collapse. Some events may result in mass evacuations. • Deteriorating infrastructure can lead to load restrictions on roads and bridges. • Long-term impacts to services, functionality, and connectivity.
Operational Incidents	• Technical or mechanical failures or human errors such as train derailment or multi-vehicle crash resulting in closures and infrastructure damage.
Hazardous Materials Release	• Release of hazardous materials could prompt a mass evacuation. • Long-term impacts to services, functionality, and connectivity due to contaminants.
Cyber Incident	• Cyber incidents could be a malicious attack or occur because of human error. Any computer-related activities are at risk. • Potentially lead to a complete operational shut-down of impacted organizations for an extended time. • Incidents could damage equipment, impact emergency or public safety systems, and be costly to impacted organizations.
Civil Disturbance and Terrorism	• Damage to critical infrastructure or utilities. • Civil disturbance or terrorist events may lead to mass evacuations.
Public Health Events (Pandemics)	• Sudden changes in travel behavior. • Long-term impacts to funding, operations, and services.
Financial Instability	• Long-term impacts to the functionality and performance of the transportation network due to limited investments in maintenance, operations, capital projects, and personnel.
Mass Migration	• A mass migration could occur if an extreme event prompts mass evacuations of nearby regions, such as a Cascadia Earthquake event impacting the Seattle metro area population. • A rapid influx of a high volume of people would severely stress the existing transportation system, which is planned to accommodate just the population of the Spokane region.
Power Outage, Geomagnetic Storm	• Impacts to communication systems, signal systems, and intelligent transportation systems software (ITS). • Disruptions to rail, transit, and air operations. • Potential long-term outages on the electrical grid and satellites, disrupting day-to-day activities and prompting a rapid change in travel patterns and behavior.

Critical Infrastructure

Critical infrastructure refers to the vital structures, systems, and services that are considered essential to the functioning and safety of area residents. Transportation infrastructure becomes especially important as it enables and facilitates emergency operations during events and connections to critical facilities such as shelters, medical facilities, Fairchild Airforce Base, Spokane International Airport, and other essential services. The transportation system in Spokane County consists of roads, bridges, airports, rail, and pedestrian/ bicycle networks, along with maintenance and operations facilities and equipment. It also includes Intelligent Transportation Systems (ITS) infrastructure, EV chargers, and other essential infrastructure like traffic signals and signage, all of which support the system's daily operations.

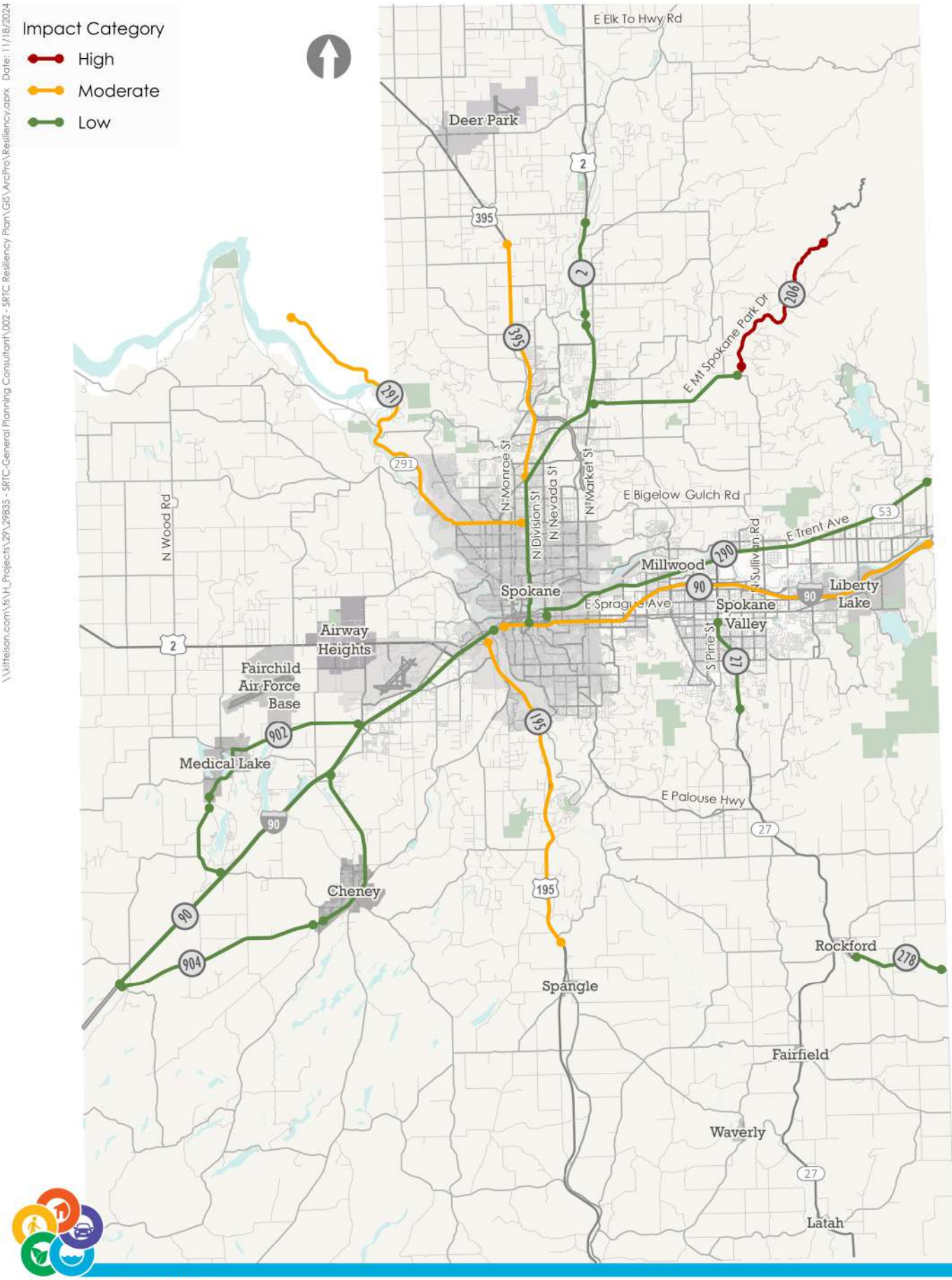
The Spokane County HMP identifies critical facilities and infrastructure. For security reasons, the specific details and locations are not published. Therefore, the critical infrastructure identified in this plan is described more generically, identified from other publicly available sources like WSDOT, or identified through the Stakeholder Advisory Group (SAG). The roadways identified by WSDOT as the most vulnerable to extreme weather events and other potential climate change from the 2011 Climate Impact Vulnerability Assessment are shown Figure 1.

Additionally, WSDOT identifies the following specific facilities as the most critical facilities[7]:

1. I-90 Latah Creek Bridge
2. Viaduct Structures Downtown (elevated I-90 through downtown. Once it is complete, the NSC bridge over the Spokane River would be #3)
3. US 2 west overcrossing at US 2 and I-90
4. US 195 overcrossing at I-90
5. Hwy 290 spur bridge

More details on critical transportation infrastructure identified by the Spokane County HMP and the WSDOT Climate Impacts Vulnerability Assessment are provided in Appendix B.

[7] These facilities were identified through conversations with Spokane County Emergency Management and WSDOT.



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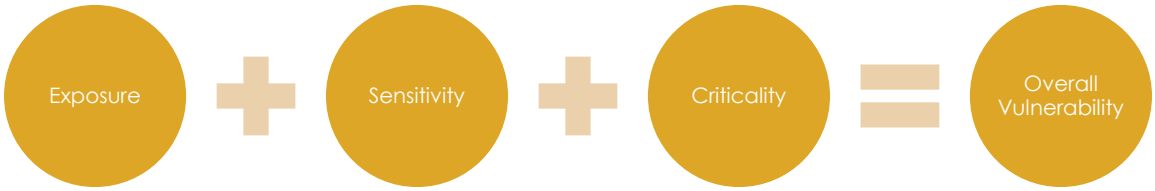
Source: WSDOT 2011 Climate Impact Vulnerability Assessment

Figure 1

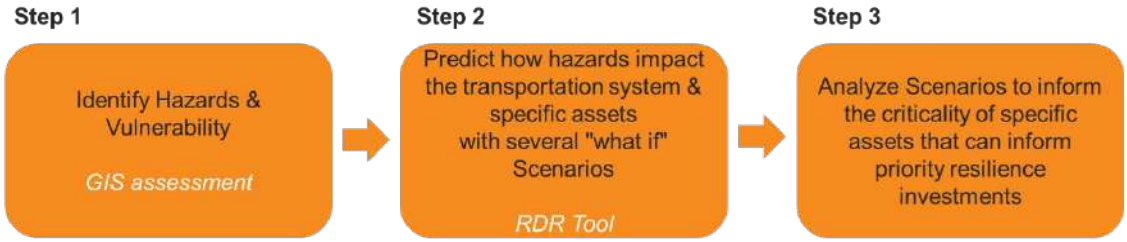
WSDOT Roadways Vulnerable to Extreme Weather Events and Other Potential Climate Change Impacts

Vulnerability Assessment & Scenarios



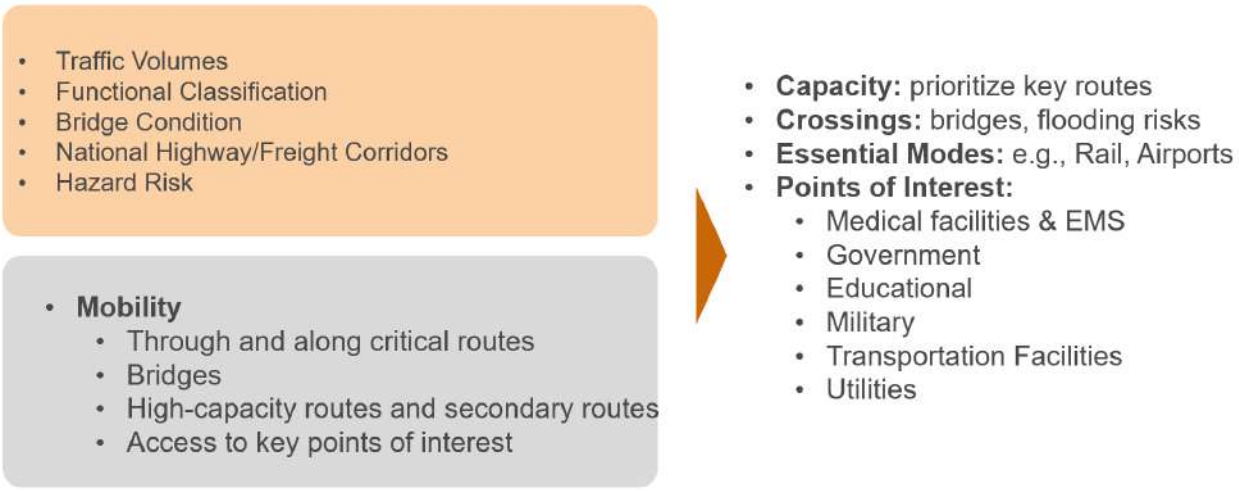
A two-phased approach was used to inform the direction and recommendations of the resiliency plan.

- **Phase 1** included a system-level sensitivity analysis to help identify which hazards paired with which transportation assets using geospatial mapping to identify critical roadway transportation assets exposure risk (vulnerability) to natural hazards based on data from the National Risk Index (NRI)[8], The National Risk Index calculates a community's risk to a hazard by developing a store based on three components: a natural hazards component (Expected Annual Loss), a consequence enhancing component (Social Vulnerability), and a consequence reduction component (Community Resilience).
- **Phase 2** used the USDOT Resilience and Disaster Recovery Tool (RDR) to assess the impact of hazards on the transportation system and travel behavior and to refine the prioritized list of critical infrastructure.



Key data inputs for both analyses are summarized below. The criticality of any facility is a cumulative assessment of the factors shown in the figure. There are physical attributes that can be assessed for each highway segment, but the second box shows that if mobility attributes are accounted for additional insights can be gleaned to understand the importance of any roadway in the region. Highway facilities serve to connect to points of interest as well as serve through traffic. Specific facilities such as bridges or high-capacity routes (e.g., I-90) have additional importance because there are fewer options if those facilities are affected by a hazard. Additional detail can be found in Appendix B and Appendix C.

[8] Federal Emergency Management Agency (FEMA), "The National Risk Index," Accessed July 8, 2024, https://hazards.fema.gov/nri/.



PHASE 1 OUTCOMES

The CPRI score (risk and exposure) and transportation facility characteristics (criticality) were combined in a composite map (heat map) to identify the critical infrastructure that is at a higher risk. Each transportation asset was scored based on specific attributes that may contribute to the overall risk score. The more feature layers that share multiple exposures and higher sensitives, the higher the risk/score. For example, a critical freight route with poor pavement is more likely to fail in a flood and will be more at risk than a roadway with good infrastructure. The scoring methodology and data sources are provided in Appendix B. Risk and exposure outcomes are illustrated by hazard in the following sections.

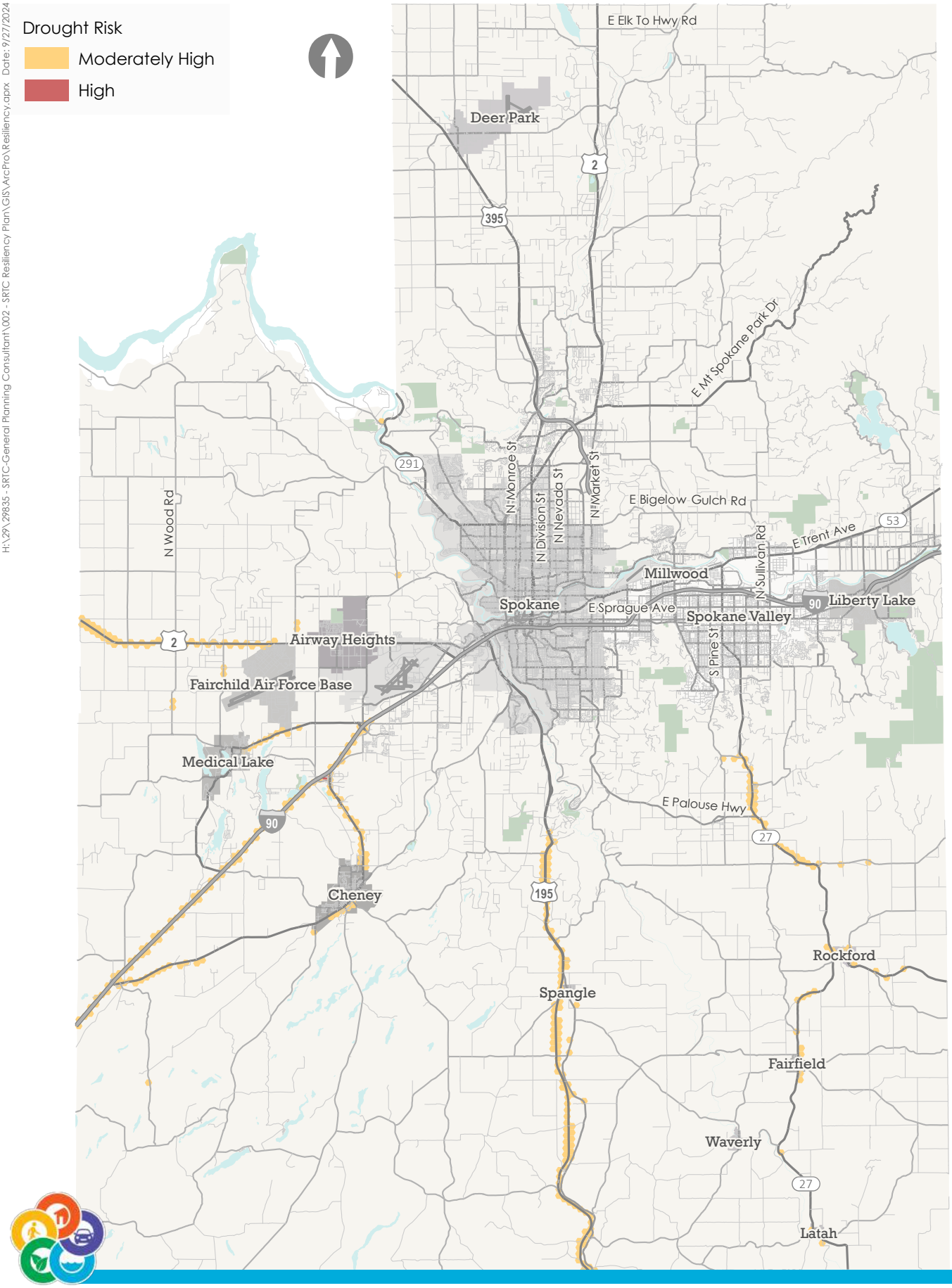
Drought Vulnerable Transportation Assets

The region has experienced several severe droughts, including in 2021, when 36% of Washington was classified as experiencing "Exceptional" drought - the highest level of drought according to the U.S. Drought Monitor (USDM). The state of Washington defines an area as being in a drought when:

- The water supply for an area is below 75 percent of normal; and
- Water uses and users in the area will likely incur undue hardship because of the water shortage.[9]

Climate change is expected to exacerbate drought conditions, increasing the extent, intensity, frequency, and duration, particularly in areas east of the Cascades.[10] Drought Vulnerable Transportation Assets (Figure 2) are classified as moderately high for segments of **US 2, I-90, SR 904, SR 902, US 195, and SR 27**. While droughts are an indirect hazard to transportation infrastructure, they can intensify other hazards, such as wildfires or landslides.

[9] Washington State Code, RCW 43.83B.400.
[10] Washington Emergency Management Division. *Washington State Enhanced Hazard Mitigation Plan*, 2023, https://mil.wa.gov/enhanced-hazard-mitigation-plan.



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Data sourced from the Federal Emergency Management Agency (FEMA) National Risk Index.

Figure 2

Drought Risk

Earthquake Vulnerable Transportation Assets

While the probability of an earthquake directly impacting the Spokane region and the greater eastern Washington region is not zero, the expected impacts of such an event is forecast to be minimal. Other regions of the state, specifically the region west of the Cascades, are highly susceptible to catastrophic events due to the Cascadia subduction zone. A catastrophic event in western Washington could have indirect impacts on the transportation system due to Spokane's ideal location for emergency operations and recovery, which would put pressure on the transportation network.

Figure 3 shows Earthquake Vulnerable Transportation Assets. **Roadway assets in Airway Heights, Cheney, and the northern and eastern areas of the City of Spokane** are most susceptible to earthquake impacts compared to other areas of the county.

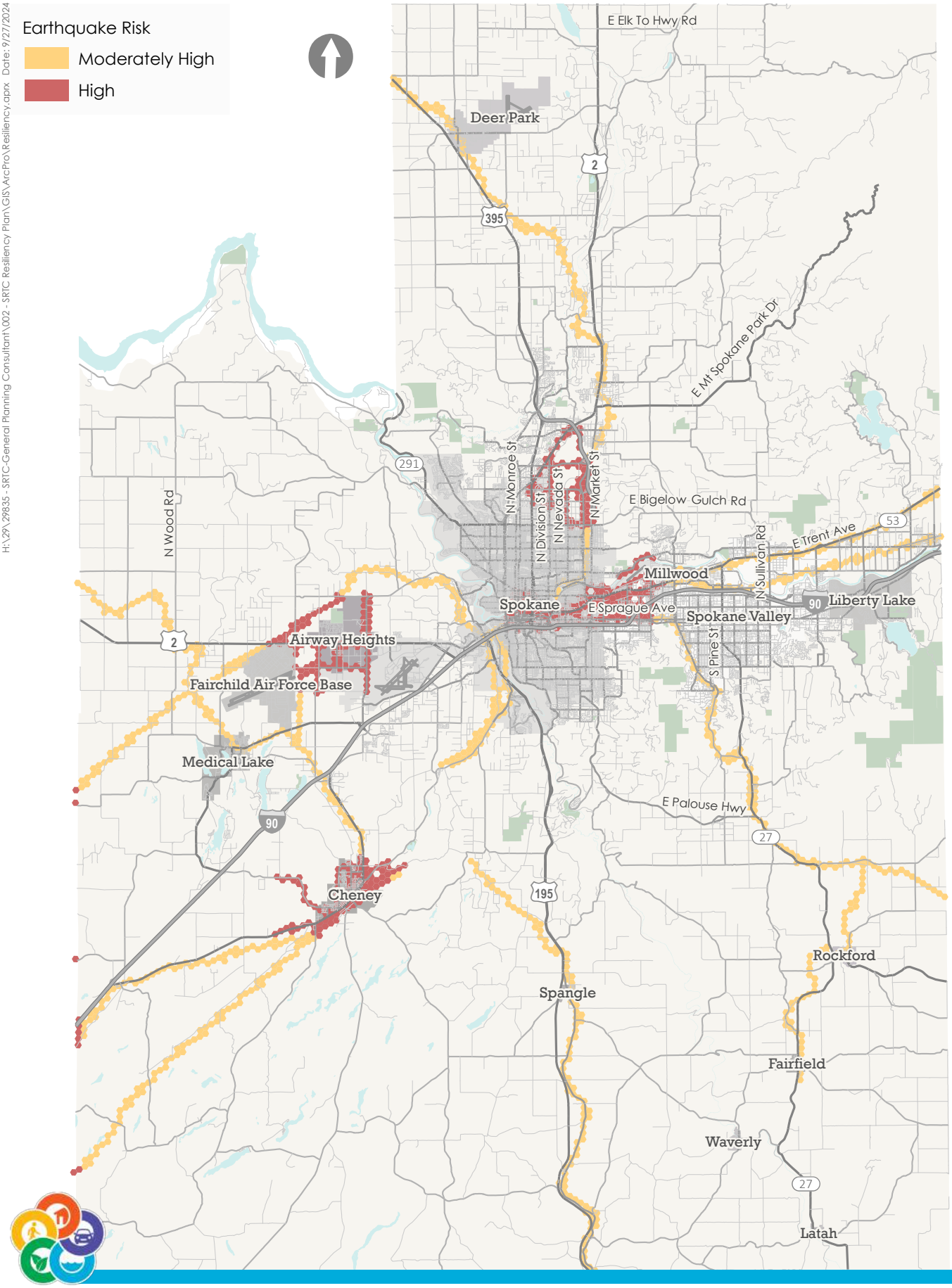

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Figure 3

Earthquake Risk

Data sourced from the Federal Emergency Management Agency (FEMA) National Risk Index.

Flood and Dam Failure

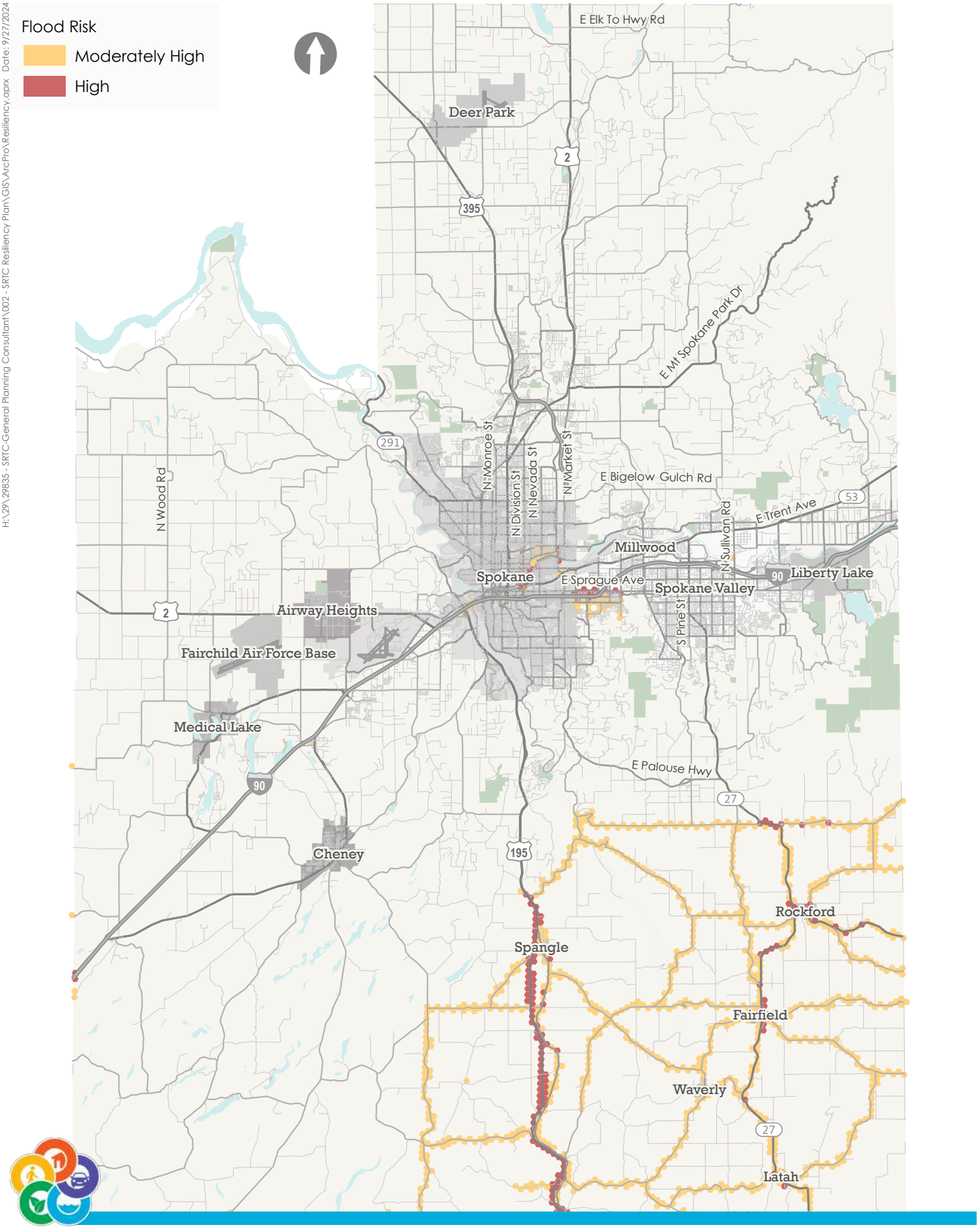
Extreme flooding can occur when there are periods of heavy rains, rapid snowmelt from increasing temperatures, or a combination of both events. Urbanization can also contribute to flooding as the surface area of impervious materials increases, increasing stress on stormwater infrastructure. Flooding can also lead to secondary disasters, such as landslides, erosion, and power outages, resulting in disruptions to essential infrastructure and services. The major floods in Spokane County have typically resulted from intense weather rainstorms or the combination of rain on snow events between November and March and are often associated with frozen ground conditions which reduces infiltration.

Although floods in the region are infrequent, their occurrence in Eastern Washington is expected to increase in frequency and severity as the effects of climate change intensify.[11] Flooding events can damage transportation infrastructure, disrupt traffic operations, and increase maintenance costs.

Of the 31 dams overseen by the Washington Dam Safety Office (DSO), 11 are listed as high or significant hazard, meaning that there are lives at risk downstream of the dam if the infrastructure were to fail.[12] Although the county has not experienced any major dam failures to date, a significant portion of critical transportation infrastructure could be at risk if such an incident were to occur, especially in communities adjacent to the Spokane River.

Figure 4 illustrates the Flood Vulnerable Transportation Assets. In general, the southeast areas of the county as well as some areas in the City of Spokane are at high or moderate risk of flooding compared to the rest of the county. The highest risk locations include segments of **I-90, US 195, SR 53, and SR 27**. For the more rural southeast areas, the number of creeks, such as Hangman, Spangle, Rock, and Saltese creeks and the Mica River, which run through or pass nearby the smaller communities combined with the lack of redundant transportation networks elevate the risk.

[11] Washington Emergency Management Division. *Washington State Enhanced Hazard Mitigation Plan*, 2023, https://mil.wa.gov/enhanced-hazard-mitigation-plan.
[12] Spokane County. *Spokane County Hazard Mitigation Plan: Volume 1*, (Spokane, WA: Spokane County, 2020), https://www.spokanecounty.org/DocumentCenter/View/34414/Hazard-Mitigation-Plan-Update-Volume-1.



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Data sourced from the Federal Emergency Management Agency (FEMA) National Risk Index.

Figure 4

Flood Risk

Landslide, Rockfall, and Debris Flow

Landslide, rockfall, and debris flow events are triggered or exacerbated by flood events, heavy precipitation, earthquakes, fires, volcanic activity, or man-made changes to the land. They typically occur in mountainous, hilly areas. Spokane County defines landslide hazard areas as "areas where the land has characteristics that contribute to the risk of downhill movement of material, such as the following:

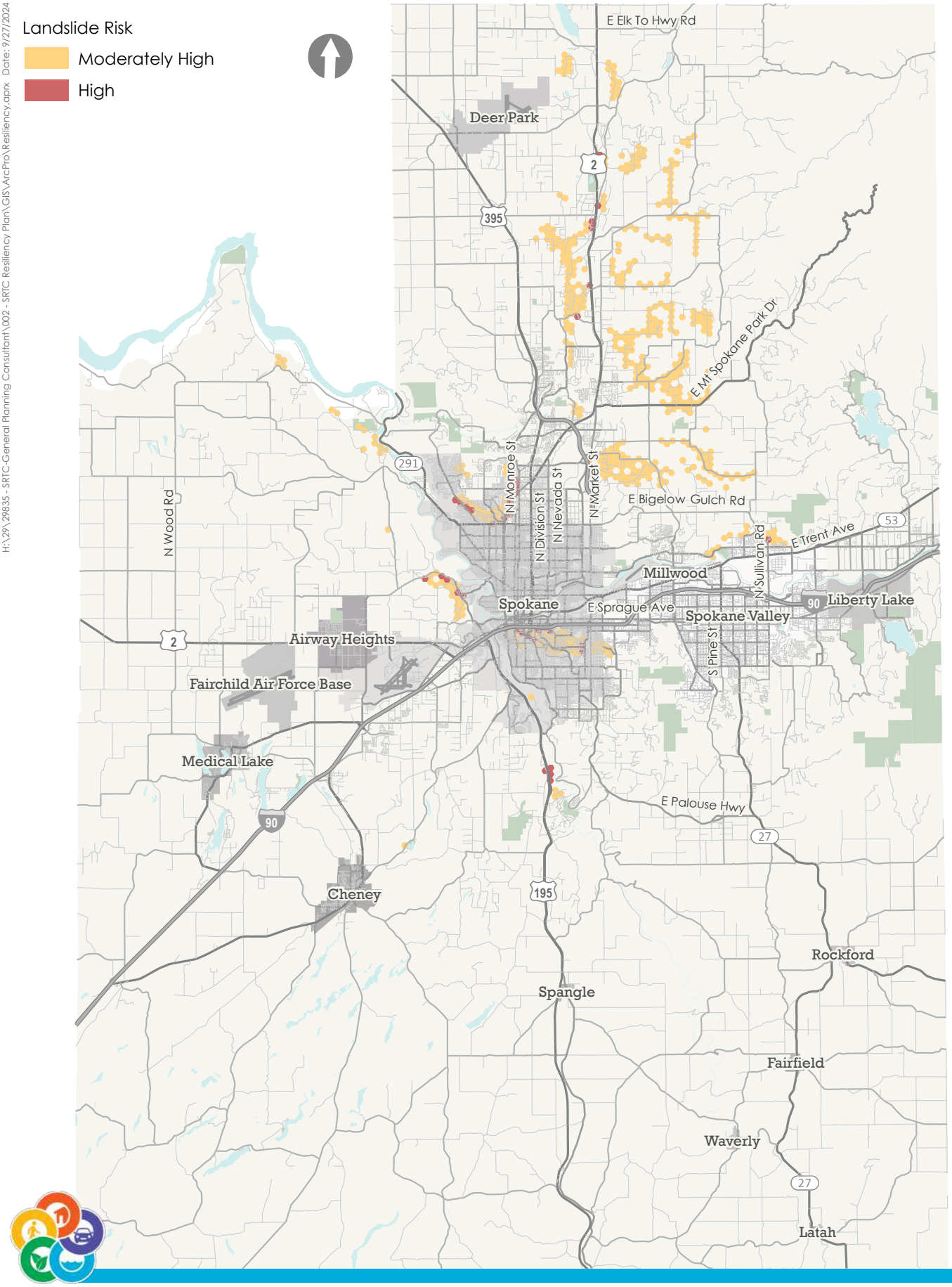
- A slope greater than 30 percent as identified in Spokane County's Critical Areas Ordinance
- A history of landslide activity or movement during the last 10,000 years
- Stream or wave activity, which has caused erosion, undercut a bank, or cut into a bank to cause the surrounding land to be unstable
- The presence or potential for snow avalanches
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel."[13]

Historic landslide data in Spokane County such as landslide events and damage reports on assets or structures is limited. In recent history, there have been a few minor landslides associated with periods of severe storms with minimal damage. There have been no documented incidents of landslides causing significant impacts to transportation infrastructure in the county.

Climate change is projected to increase the frequency and severity of storms and heavy precipitation events. Additionally, warming temperatures may contribute to prolonged droughts and heightened wildfire risk. Both wildfires and heavy precipitation can increase the severity and frequency of landslide events. Although landslide risk is generally low throughout the county, these climate-induced changes can increase the risk of landslide events in susceptible areas, potentially leading to damage to transportation infrastructure and disruptions to traffic operations.

Figure 5 displays Landslide Vulnerable Transportation Assets. Most of the transportation assets are at low to zero risk for landslides. There are some pockets of high risk on **US 195, US 2, Indian Trail Road, and North Government Way**. Moderately high landslide risk generally occurs in the northern area of the county where the terrain is hillier.

[13] Spokane County. *Spokane County Hazard Mitigation Plan: Volume 1*, (Spokane, WA: Spokane County, 2020), https://www.spokanecounty.org/DocumentCenter/View/34414/Hazard-Mitigation-Plan-Update-Volume-1.



SRTC Resiliency Plan

Data sourced from the Federal Emergency Management Agency (FEMA) National Risk Index.

Figure 5

Landslide Risk

Severe Weather

Severe weather refers to dangerous weather events that have the potential to be destructive or deadly. In the Spokane region, the most common severe weather events include thunderstorms, damaging winds, snow and ice storms, extreme heat or snowfall, and tornados. Severe weather events are projected to become more extreme with climate change, particularly more high-heat days and shorter periods of intense rainfall.[14]

The effects of severe weather on transportation infrastructure and operations vary based on the type, severity, and frequency of the event. Immediate effects may include impassable roadways due to flooding or debris, power outages disrupting transportation operations, or erosion of soil and material leading to pavement and structural damage. Severe weather can also lead to longer-term issues that increase costs of maintenance or repair over time. For example, freeze-thaw cycles can worsen the stability of pavement, and extreme heat can cause bridge expansion, potentially compromising stability and strength over time.

Severe weather events can occur on an annual basis, at any time of year. Historically, severe weather events in the region are associated with high winds from thunderstorms or snowstorms. Although tornadoes are not common in Eastern Washington, there are reports of them occurring in Spokane County as recently as 2022. The tornados caused some damage in the northeast of Airway Heights and near Dishman Hills.

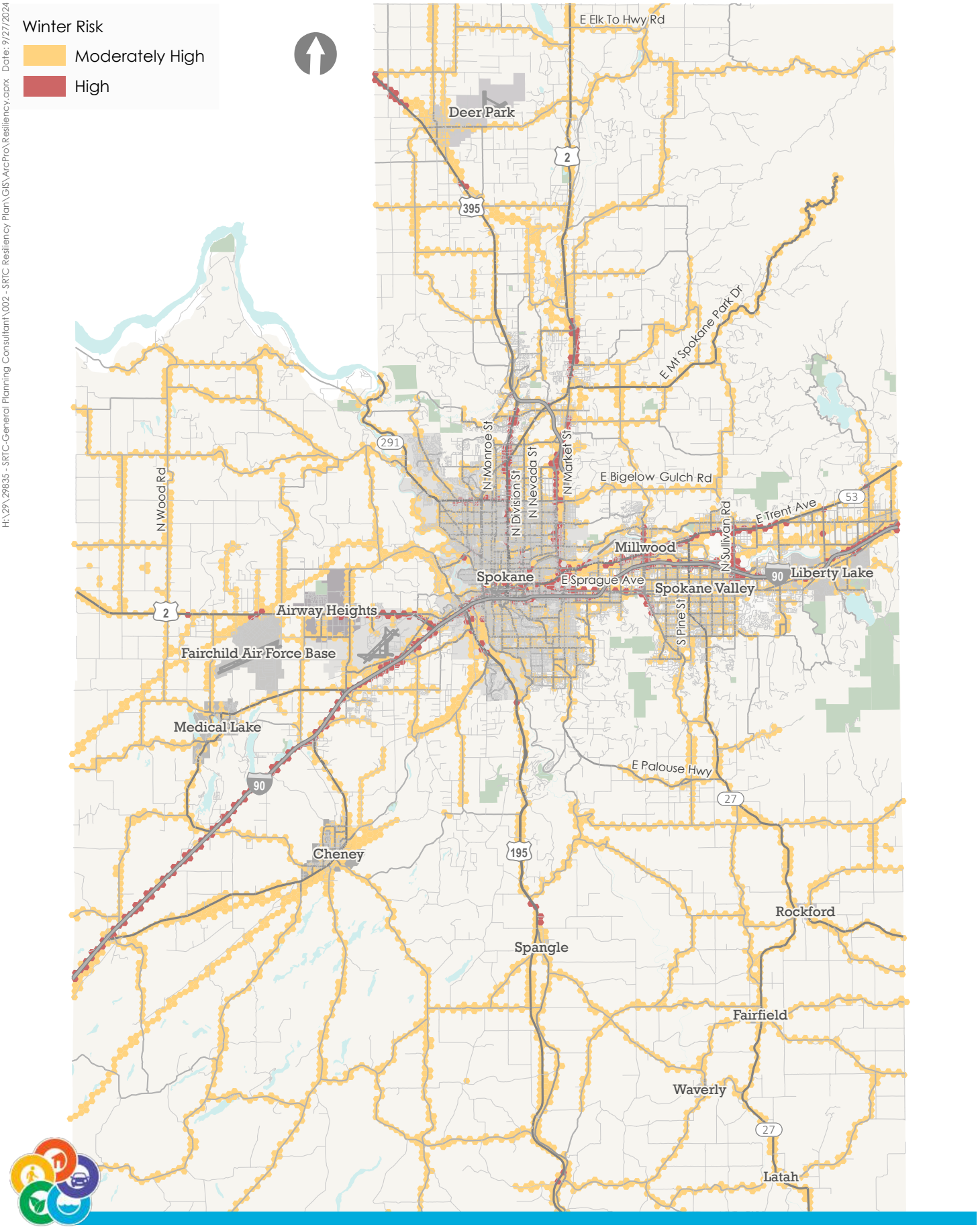
Summer 2021 was the hottest summer on record for Spokane County, with temperatures reaching up to 109 degrees Fahrenheit. The extreme temperatures were caused by a heat dome that lasted 6 days, from June 26th to July 2nd, 2021. Extreme heat can weaken roadway and bridge structures, resulting in increased maintenance and repair needs of transportation assets over time.[15] Additionally, extreme heat can cause rail tracks to shift, leading to service disruptions or even train derailment.

During winter, blizzards or ice storms can impact large geographical areas. Figure 6 displays Winter Vulnerable Transportation Assets[16] in Spokane County, showing that most of the roadway network is at moderately high or high winter risk. The highest risk areas are located along **I-90, US 2, US 395, SR 53, and Division Street.**

[14] Washington Emergency Management Division. *Washington State Enhanced Hazard Mitigation Plan*, 2023, https://mil.wa.gov/enhanced-hazard-mitigation-plan.

[15] The U.S. Senate Committee on Environment and Public Works reports that the additional road maintenance and replacement costs caused by extreme heat could reach a total cost of $26 billion by 2040. <https://www.epw.senate.gov/public/index.cfm/2023/9/chairman-carper-s-opening-statement-hearing-on-the-impacts-of-extreme-heat-on-the-transportation-sector>

[16] "Winter weather" refers to winter storm events in which the main types of precipitation are snow, sleet, or freezing rain.



SRTC Resiliency Plan

Figure 6

Winter Risk

Data sourced from the Federal Emergency Management Agency (FEMA) National Risk Index.

Volcanic Eruptions

There are five active volcanoes along the Cascade Range that are classified as high or very high threat potentials due to their ability to generate destructive lava and debris flows, lahars, and ash flow.[17] The most significant threat to transportation infrastructure is from ash accumulation which can disrupt traffic operations and service for extended periods of time. Additionally, machinery, vehicles, and other equipment can be clogged or damaged by ash particles.

Overall, the anticipated impacts of volcanic hazards are low-to-moderate, depending on the eruption's intensity and wind patterns. Spokane County is outside of the areas modeled to have the most severe destruction from an eruption within the Cascade Range; however, the May 18, 1980, Mount St. Helens eruption demonstrated that volcanoes can still significantly impact the region. An estimated inch of ash fell and disrupted daily activities for several days including a complete shutdown of vehicular travel as planes were grounded, buses were put on a limited service, and people were advised against driving until roadways were cleared.[18]

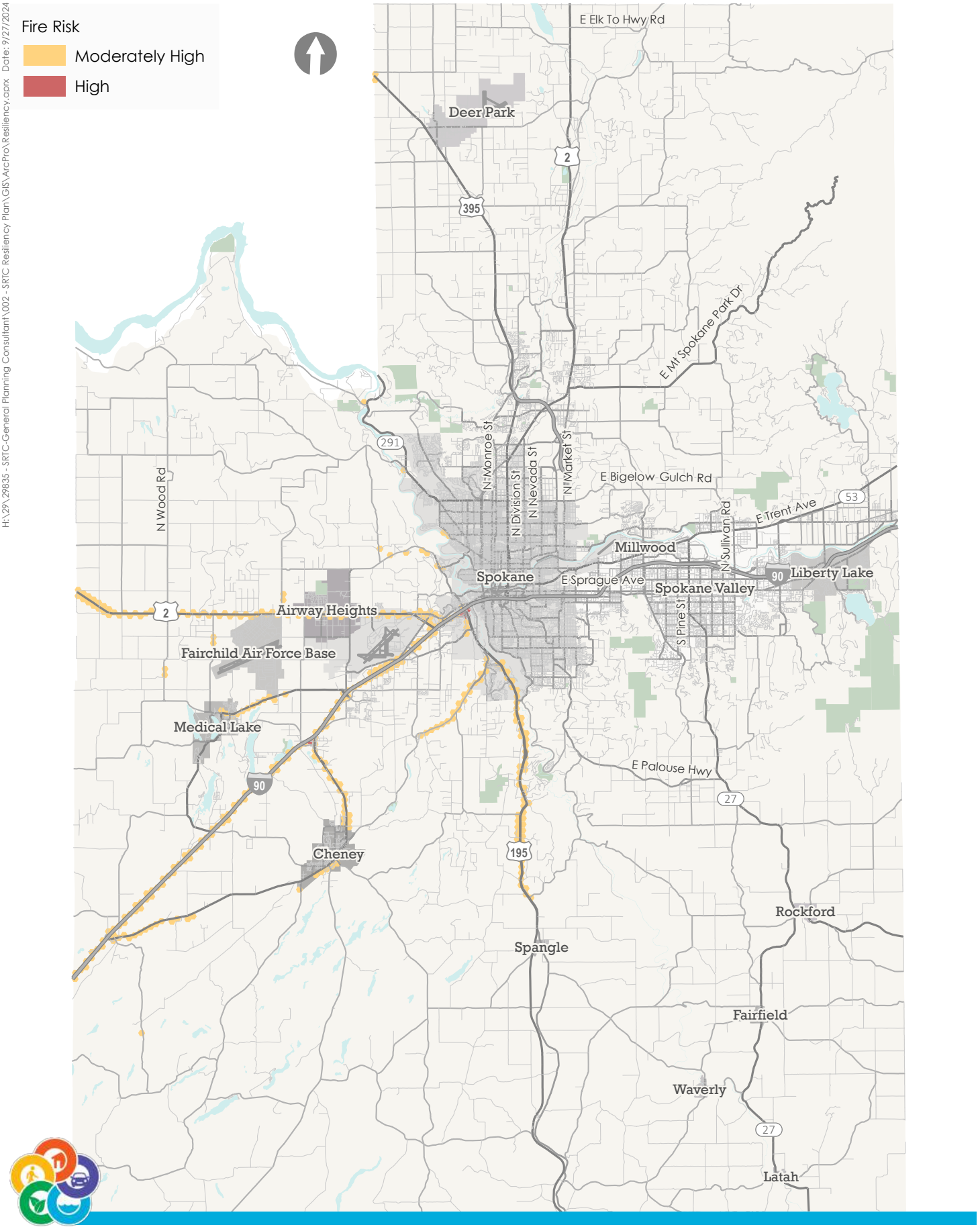
Wildfire

Wildfires are an annual threat, and the risk of wildfire events is expected to increase from climate-induced factors such as extreme heat and reduced snowpack. In August 2023, the Gray and Oregon Road wildfires destroyed an estimated $160 million in assessed property value, resulting in a federal disaster declaration.[19] The wildfires ranked among the most destructive natural disasters in Washington's history, prompting evacuations of several communities and resulting in closure of several critical transportation routes, including I-90, SR 204, and SR 902, as crews mobilized to contain the fires and conduct emergency response. Additionally, the wildland-urban-interface (WUI), which refers to the zone where human development meets undeveloped wildland or vegetative fuels, is increasing. These conditions make both the natural and built environments more susceptible to intense wildfire events.

Wildfire can cause both indirect and direct impacts to transportation infrastructure, equipment, and operations. Critical facilities may need to be closed due to limited visibility from smoke and proximity to the active burning. Additionally, they may be closed to facilitate emergency response. Extreme heat can also impact the strength and stability of pavement and steel bridge structures, reducing the life expectancy of an asset and increasing future maintenance and repair costs. Furthermore, wildfires can increase the vulnerability of impacted areas to erosion or landslides.

Figure 7 shows Wildfire Vulnerable Transportation Assets. In general, wildfire risk is moderately high in the areas west and southwest of the City of Spokane, such as **I-90, US 2, US 195, and SR 904**.

[17] Washington State Department of Natural Resources, "Volcanoes and Lahars," Accessed September 19, 2024, https://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/volcanoes-and-lahars#:~:text=Washington%20has%20five%20volcanoes%20that,British%20Columbia%20to%20northern%20California.
[18] Carolyn Lamberson. "*Following Mount St. Helens' cataclysmic blast, region struggled with an epic cleanup*," *The Spokesman-Review*, May 17, 2020, https://www.spokesman.com/stories/2020/may/17/following-mount-st-helens-cataclysmic-blast-region/%3e.
[19] Federal Emergency Management Agency (FEMA). "FEMA Grants to Spokane County Wildfire Survivors Tops $3 Million", May 22, 2024, https://www.fema.gov/press-release/20240621/fema-grants-spokane-county-wildfire-survivors-tops-3-million%3e.



SRTC Resiliency Plan

Data sourced from the Federal Emergency Management Agency (FEMA) National Risk Index.

Figure 7

Fire Risk

PHASE 2 OUTCOMES

Phase 2 uses the spatial analysis of vulnerabilities to assess various degrees of risk on the list of critical infrastructure from Phase 1 and applies the USDOT Resilience and Disaster Recovery (RDR) Tool to assess the hazard impact on the transportation system and travel behavior. The closure and reduced capacity of roadway facilities is analyzed to better understand diversion routes to meet the daily mobility needs as well as the level of stress on those facilities during an event. The scenarios also inform overall network redundancy and add information to determine the level of criticality in the network.

The first step to refining the criticality analysis incorporates information from the SRTC regional travel demand model and its traffic analysis zone (TAZ) data. The model has nearly 700 TAZs that include information on population, jobs, and the transportation network. This information informs the level of transportation demand associated with each TAZ. Joining the traffic demand from each TAZ to the potential hazards produces a visual indicator of the degree that travel and mobility would be affected by:

- Earthquake
- Landslide and Earthquake
- Flooding

This provides valuable insights as to where the greater risks may exist in the community. Some risks and risk scenarios offer less valuable insight given the widespread risk or the degree of uncertainty, such as fire, drought, and extreme heat and have not been mapped.

Earthquake Traffic Impact

The earthquake risks to traffic and vehicle mobility are most likely to occur in the downtown area along the Spokane River, the northeast corner of the city along US-395, Cheney area, and the Airway Heights area along US 2 between Fairchild AFB and Spokane International Airport (Figure 8).The areas of elevated risk include:

- US 2: Access to Fairchild AFB could be affected given limited capacity for alternative routes if US 2 is closed in the Airway Heights area.
- US 395 is a high capacity north-south arterial. The new construction of the North South Corridor is immediately along and in an area of elevated risk for earthquake and landslides. Along with mobility challenges, those hazards would have an impact on the rail line and adjacent industrial land uses.
- Downtown and I-90 Viaduct. The downtown areas both north and south of I-90 and along Hwy 290 and the rail lines all could be affected by these risks. While a dense and redundant network exists, particularly for east-west travel, there are important constraints to north-south mobility if I-90 were to have partial collapses to the viaduct or to overbridges.

The zoomed in view in Figure 9 shows transportation facilities that overlay the areas of elevated risk and the roadway capacity.

Figure 8. Earthquake Risk

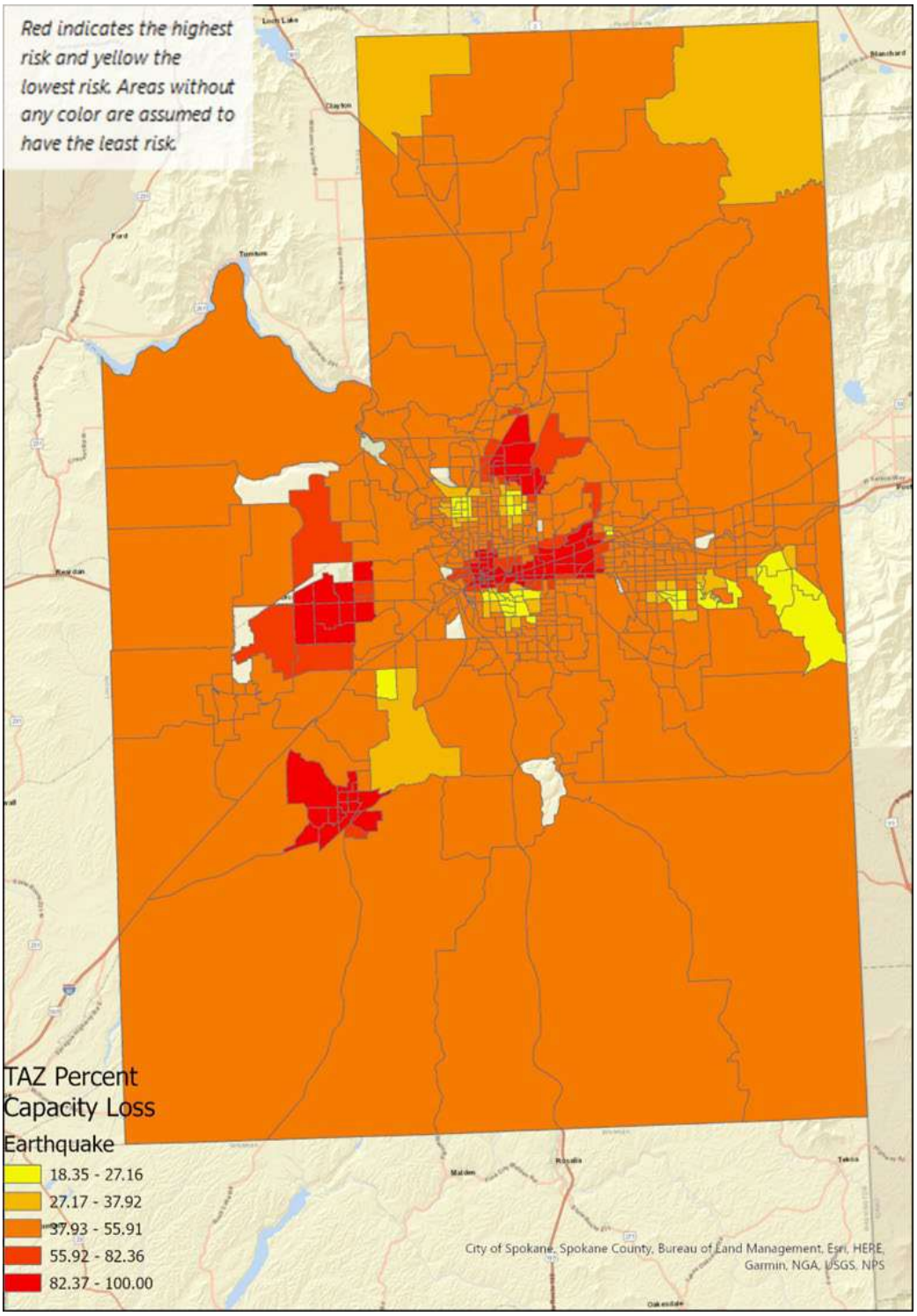
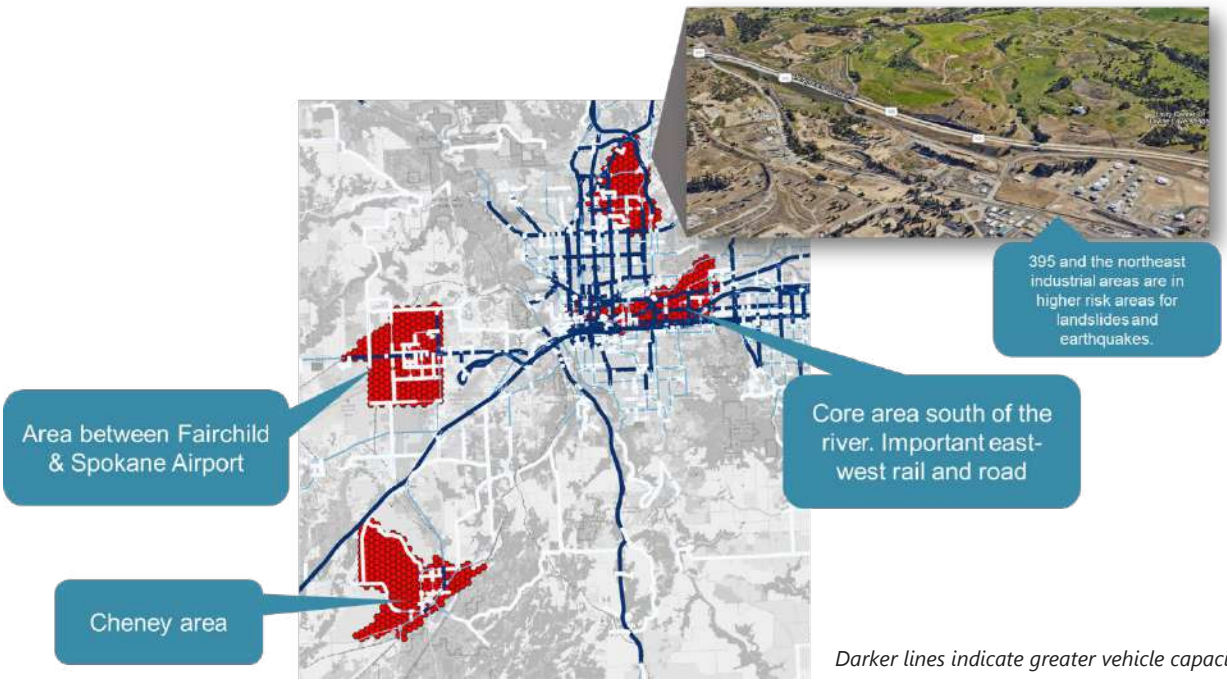


Figure 9. Earthquake Risk - Zoomed



Darker lines indicate greater vehicle capacity.

Landslide Plus Earthquake Traffic Impact

The addition of landslide risk to the earthquake risk scenario increases the geographic area impacted (Figure 10):

- **West Spokane and TJ Meenach Bridge over the Spokane River**. The area west of the river presents a risk to an important east-west alternative route over the river. North Government Way could also be affected.
- **Downtown and I-90 Viaduct**. The downtown areas both north and south of I-90 and along Hwy 290 and the rail lines all could be affected by these risks. While redundant network exists, particularly for east-west travel, there are important constraints to north-south mobility if I-90 were to have partial collapses to the viaduct or to overbridges. Important community resources and places of interest such as the many health facilities on the south side of I-90 are critical in hazard situations and could be challenged to access if the viaduct is impacted and/or landslide/earthquake affects the nearby road grid.

The zoomed in view in Figure 11 shows transportation facilities that overlay the areas of elevated risk and the roadway capacity.

Figure 10. Landslide & Earthquake Traffic Impact

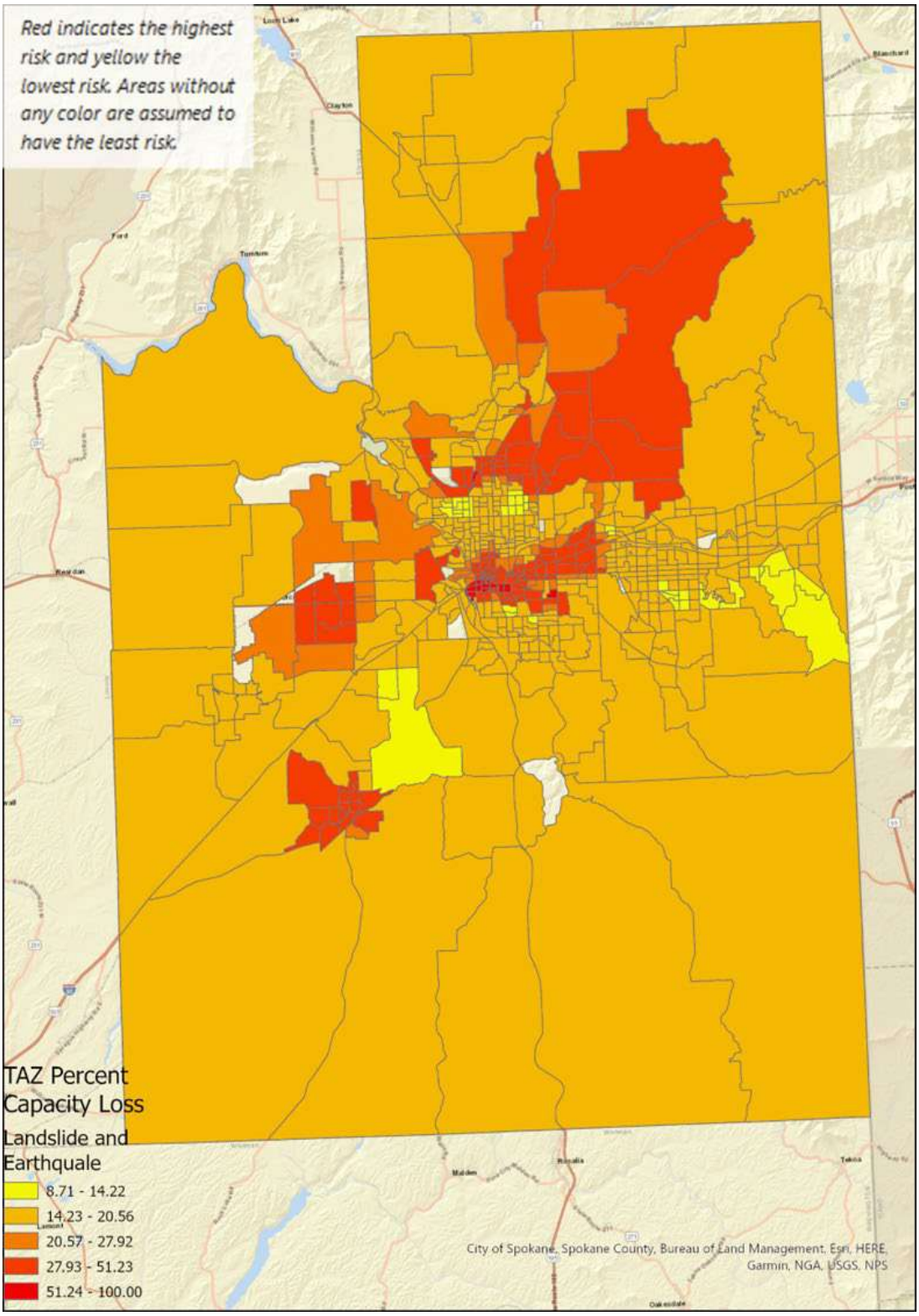
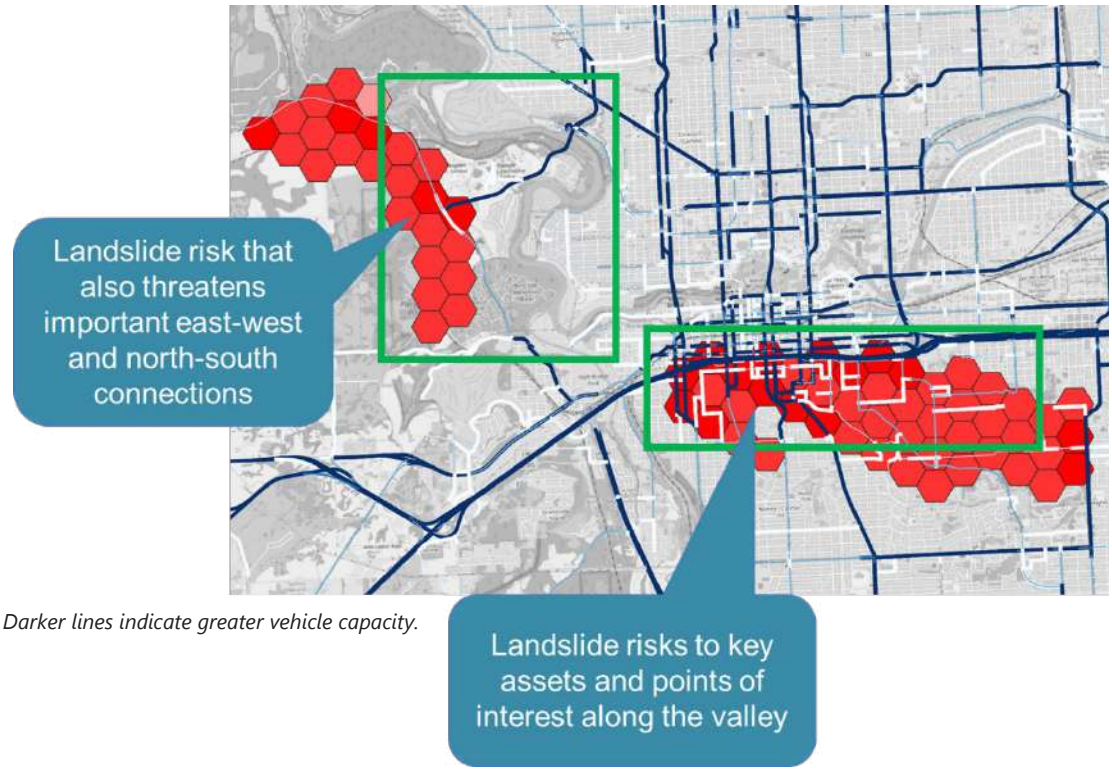


Figure 11. Landslide Risk - Zoomed and Annotated

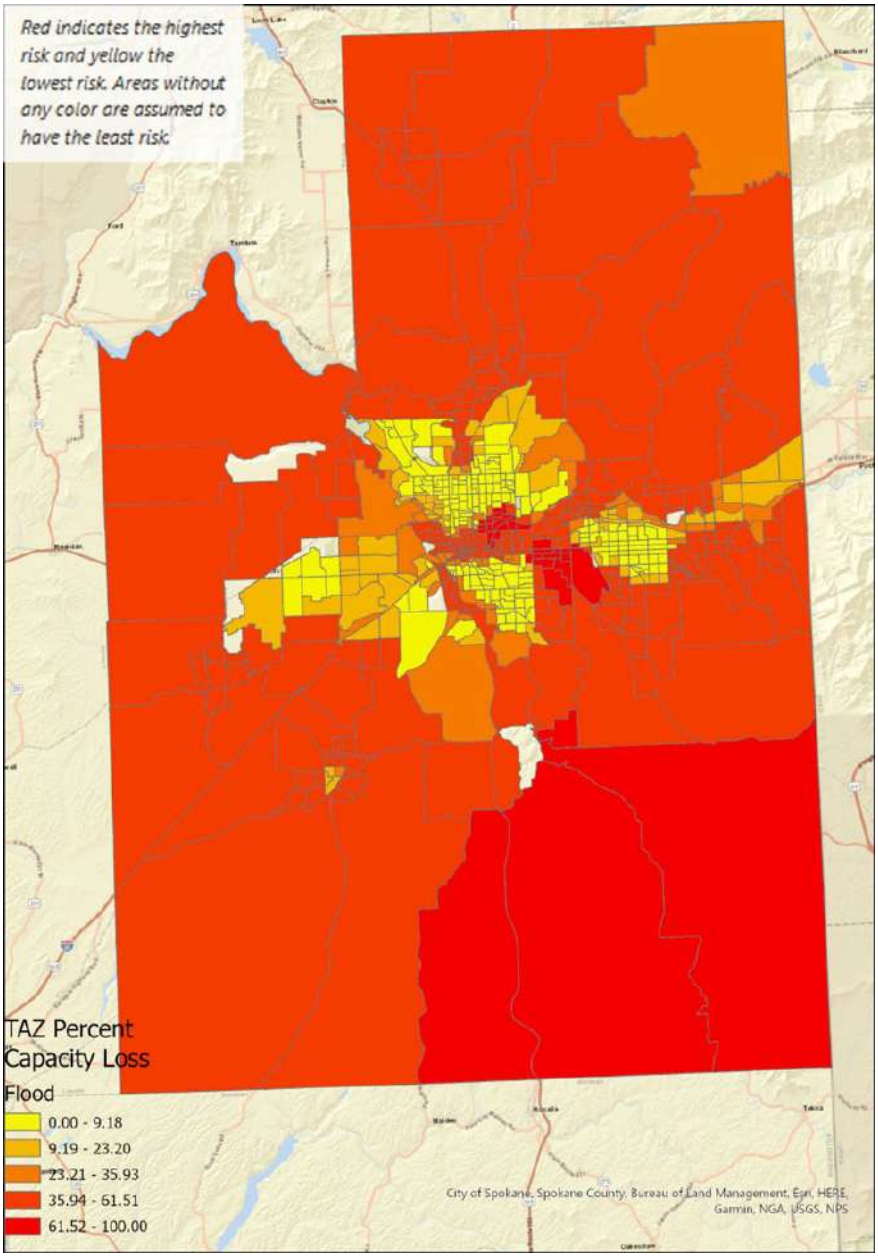


Darker lines indicate greater vehicle capacity.

Flooding Traffic Impact

The flooding risk is a challenge because of the widespread nature of the risk. As previously noted in the County HMP, flooding is primarily associated with dam failure as only a few structures lie within the 100-year flood zone. It is insightful that aside from the large southeast corner of the county, the downtown area along the Spokane River, upstream of the Upper Falls dam, has some elevated flooding risks (Figure 12).

Figure 12. Flooding Traffic Impact

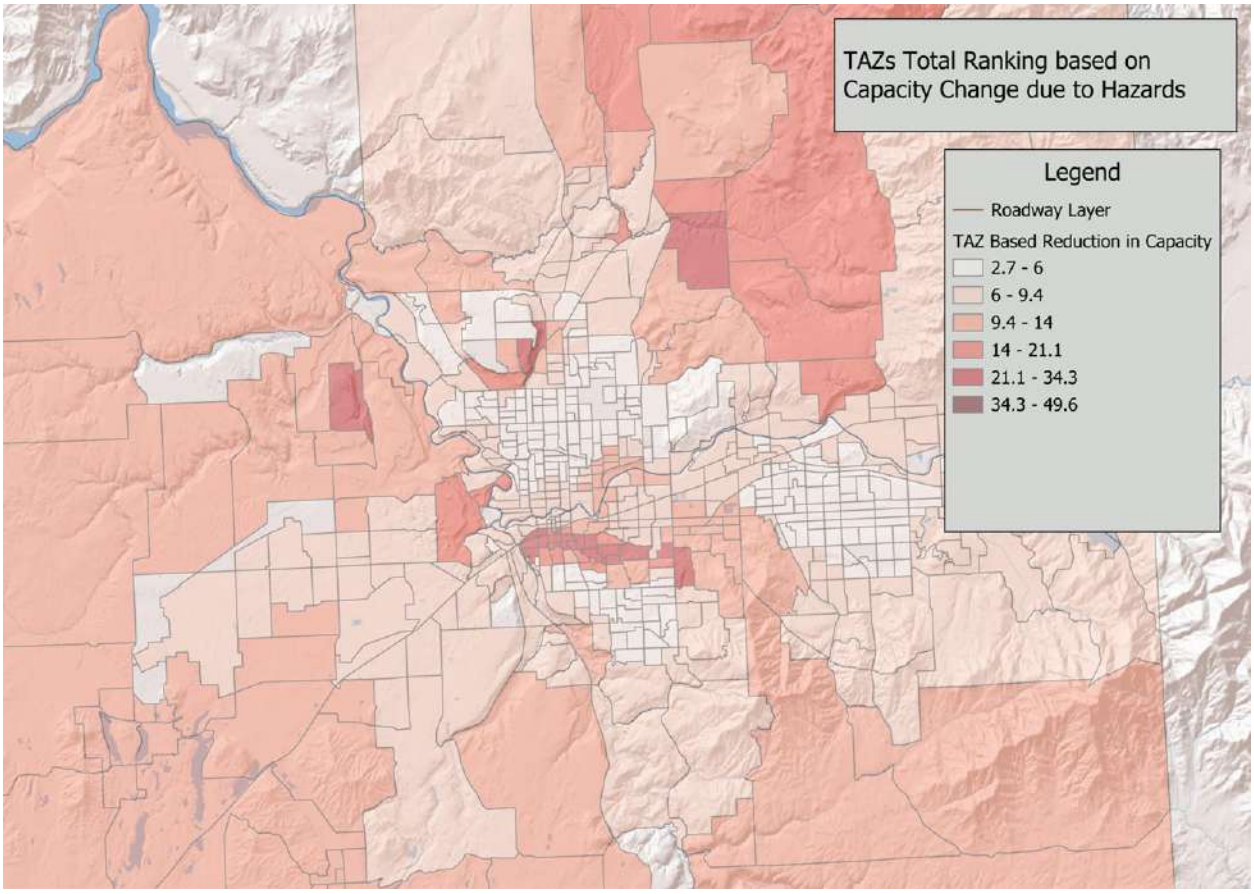


Traffic Impacts and Equity Considerations

Resiliency planning needs to account for those facing additional burdens and may disproportionately experience risks and hazard events. It may be more difficult for communities with greater social and economic burdens to return to normal, and these communities may face additional challenges during hazards. For example, evacuation may be more challenging for people with disabilities, people with limited English proficiency, and households with limited access to a private vehicle.

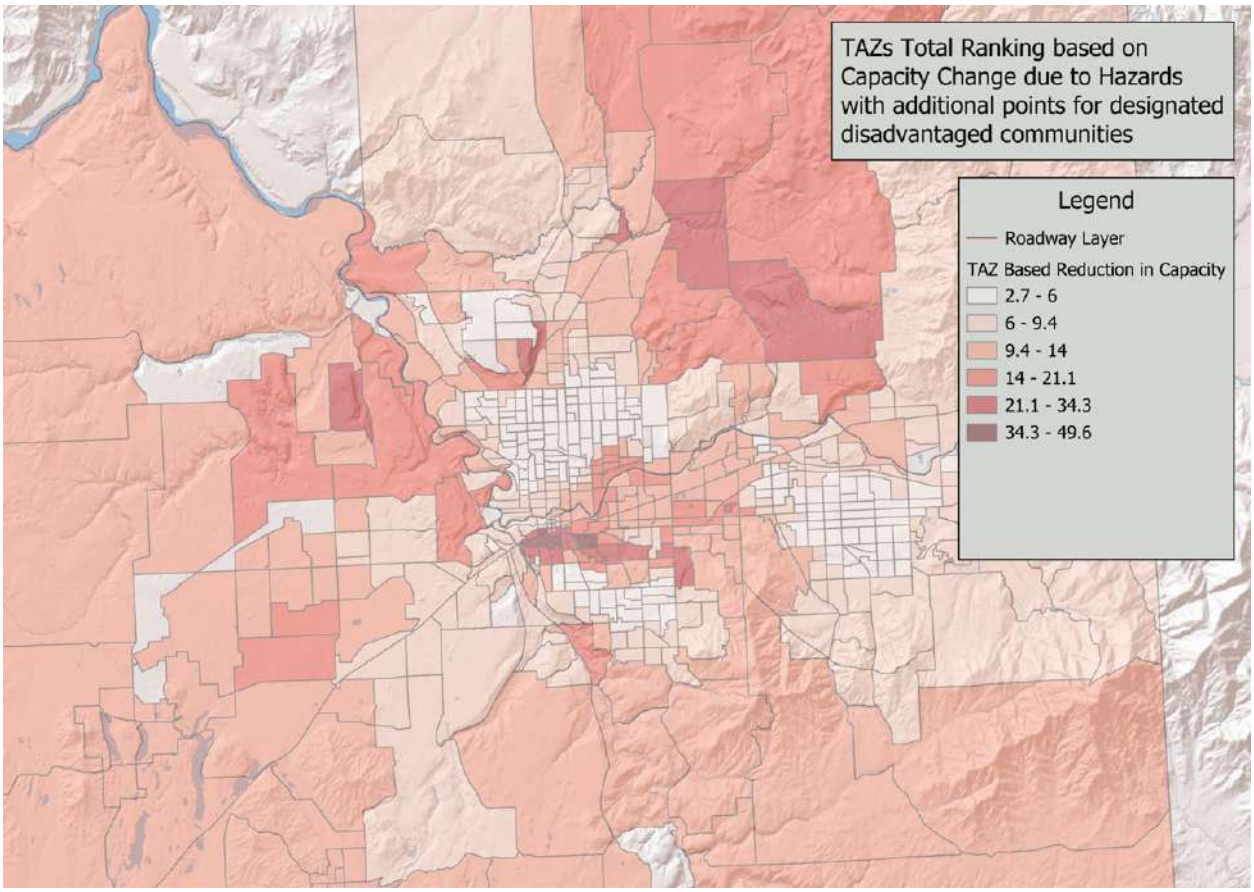
To better understand widespread community impacts, the cumulative traffic impacts from earthquakes, landslides, and flooding hazards are illustrated in Figure 13. Next, those cumulative traffic impacts were combined with areas designated as disadvantaged communities identified by the US Council on Environmental Quality's Climate and Economic Justice Screening Tool (EJST)[20]. When traffic impact is combined with equity factors, as shown in Figure 14, changes in darker red that may be disproportionately impacted by the hazardous events.

Figure 13. Traffic Reduction in Capacity from All Hazards



[20] Council on Environmental Quality, "Climate and Economic Justice Screening Tool: Explore the Map," Accessed September 10, 2024, https://screeningtool.geoplatform.gov/en/#6.28/34.972/-114.644.

Figure 14. Traffic Reduction in Capacity from All Hazards Factoring in Disadvantaged Communities



Resilience and Disaster Recovery (RDR) Tool

The RDR Tool assesses the routes and travel times for trips throughout the network between their origin and destination under normal, hazard, and partially mitigated scenarios. The traffic demand is routed along the network allowing for comparison of roadway capacities between the scenarios, which in turn affects the preferred routing path. The model works by routing trips along their fastest path given the reduced travel speeds and increased travel times associated with hazards.

The analysis from RDR Tool provides guidance for planning purposes but there are some challenges with the interpretation of the results. Key consideration include:

- The RDR Tool is less effective for widespread hazards. It is best when used to evaluate effects at specific points in the network, for example if the flood hazard disrupts one part of the county (as opposed to the entire county).
- The RDR Tool reinforced the importance of redundancy and the impact that hazards have on rural facilities versus more urban facilities. For example, in the rural parts of the county, roadways have spare capacity (they are not operating in a congested manner) and the RDR tool shows that when other busy routes are affected by a hazard, that spare capacity benefits the network.

Using the RDR Tool with flooding as the hazard, the transportation system was assessed to see how it performed with and without certain critical roadways. Figure 15 illustrates the flood hazard overlaid with the roadway network with a resulting change in daily traffic capacity. Scoring is as follows:

- Score 3 (darkest links) has 25% of the normal capacity.
- Score 2 (lighter links) has 75% of the capacity.
- Score 1 has 98% of the available capacity.
- Score 0 has 100% of the available capacity.

Figure 15. Flood Highway Capacity Reduction

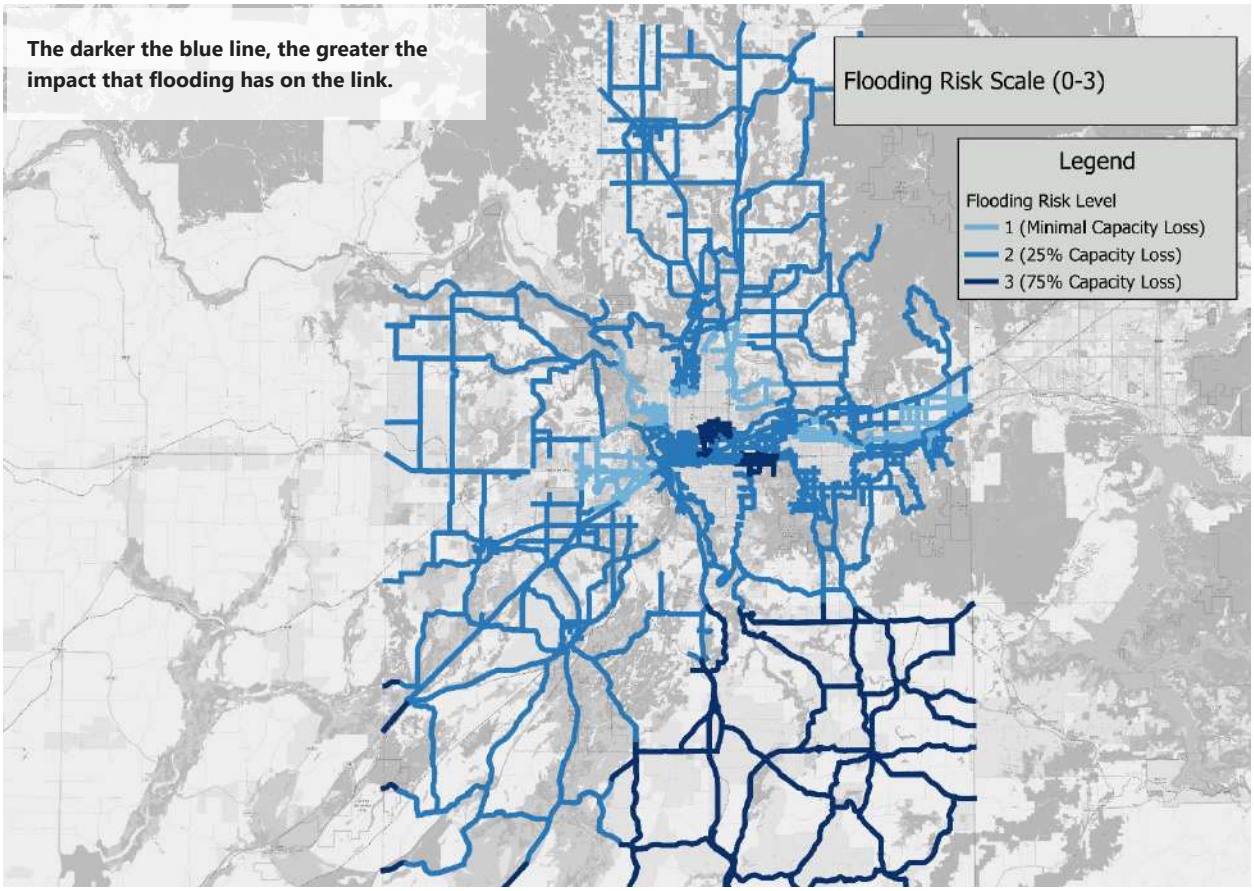
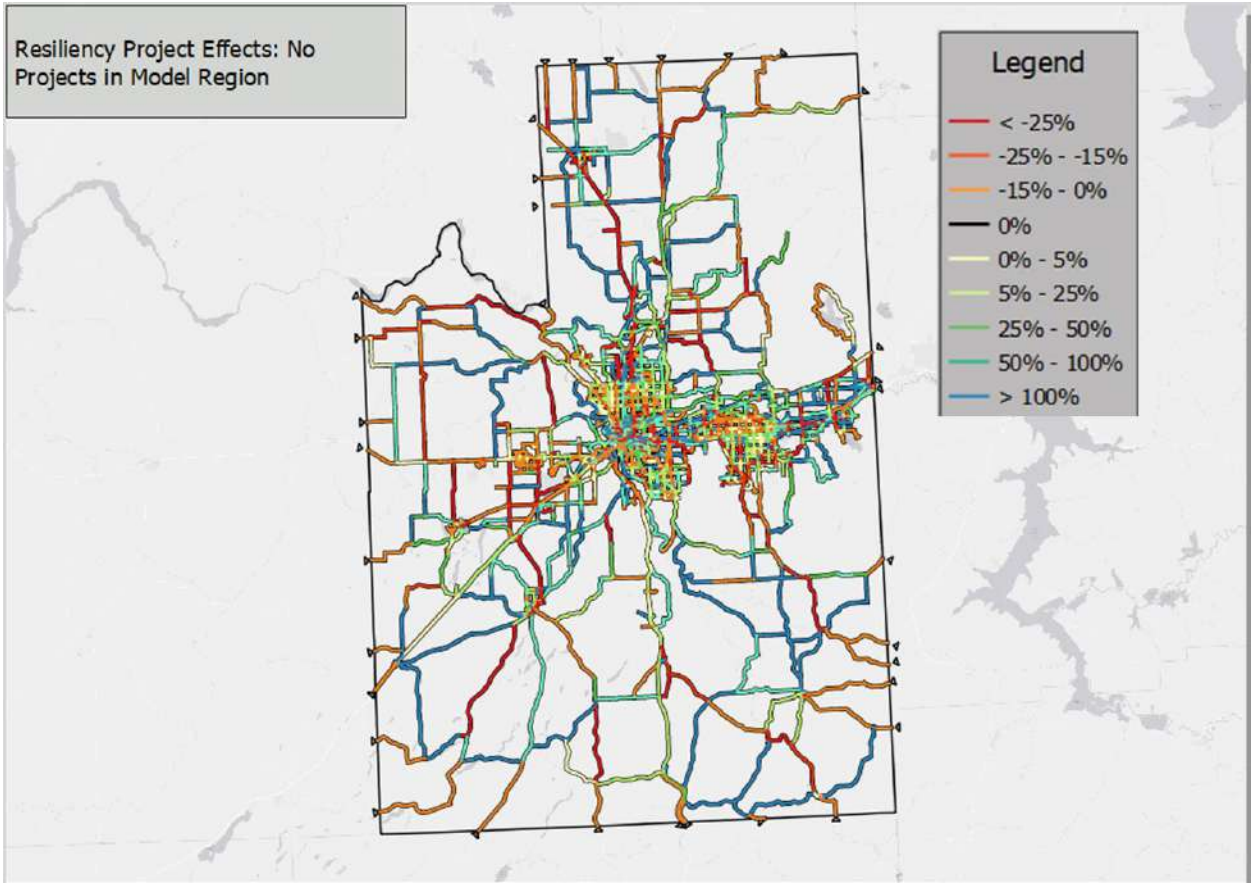


Figure 16 shows routes that are most affected by the flood hazard reductions in roadway capacity. Figure 16 and the network changes should not be used to forecast any specific scenario. It represents an abstract scenario where the flooding risk affects a wide area and reduces capacity across the network to understand potential network issues. In some areas it is possible to see the red lines show the reduction in demand due to the reduction in capacity with a blue line nearby which receives that shift in demand.

Figure 16. Change in Traffic Flow with the Flooding Hazard

Roadway segments with values greater than 0% represent an increase in traffic due to the hazard, with blue lines representing the most saturated segments.



Next, the RDR Tool was used to assess how the network operates under the flood hazard when certain assets are improved to be more resilient. The analysis provides a relative way to compare how specific parts of the network provide greater mobility than others and where there are detours that provide alternative pathways to meet daily travel needs. Assumptions used in the analysis include:

- The flooding hazard is widespread.
- Residents will want to follow their normal "day to day" routine, connecting the same origin and destinations that they did pre-hazard.
- The change in vehicle miles of travel (VMT) and vehicle hours of travel (VHT) is a result of changes in network capacity due to the flooding.
- Each scenario represents the strengthening of one critical asset.

Table 3 illustrates the results and indicates that some strengthening projects have more benefit than others. This is because either there are alternative pathways that are being used to achieve the same trips or there is spare capacity in the network. It also shows that the widespread flood hazard increases VMT by only 0.9% but total VHT by 371%. This indicates that the travel distances may not increase substantially due to the hazard being analyzed, but there would be significant changes in congestion and travel times. The two most significant strengthening projects to reduce overall network travel times include the

strengthening I-90 and US 2. These are critical facilities for carrying long-distance trips and are the two highest priority routes for adapting to flood risks. The maps of each of these project scenarios are included in Appendix C and provide insight on where and how to identify alternative routes.

Table 3. RDR Analysis Scenarios – VMT and VHT Changes

Scenario	Assets	Total Daily VMT[22]	Change in VMT from the No Hazard (1)	% Change in VMT	Change in VHT from the No Hazard (1)	% Change in VMT
1	No hazard	11,066,407	-	-	-	-
2	Flooding & No strengthening	11,168,971	102,564	0.9%	874,300	371.0%
3	Strengthened I-90 Latah Creek Bridge	11,171,371	104,964	0.9%	873,921	370.9%
4	Strengthened I-90 Viaduct Downtown	11,174,312	107,905	1.0%	873,738	370.8%
5	Strengthened US 2 west overcrossing at I-90	11,170,810	104,403	0.9%	872,532	370.3%
6	Strengthened US 195 over crossing I-90	11,172,739	106,332	1.0%	873,640	370.8%
7	Strengthened HWY 290 spur bridge	11,170,307	103,899	0.9%	873,854	370.8%
8	Strengthened all bridges (scenarios 3 -7)	11,178,166	111,759	1.0%	870,771	369.5%
9	Strengthened I-90	11,270,861	204,454	1.8%	854,193	362.5%
10	Strengthened US 2	11,194,225	127,817	1.2%	853,405	362.2%
11	Strengthened US 395	11,126,466	60,058	0.5%	858,377	364.3%
12	Strengthened US 195	11,174,245	107,838	1.0%	873,097	370.5%
13	Strengthened SR 27	11,170,572	104,165	0.9%	873,339	370.6%

Strategies and Actions

Spokane County can sustain a high degree of regional mobility during most hazards, but a hazard can still have significant consequences to transportation system operations and functionality. Focusing on preventive action is critical. Investments in resilience won't prevent losses, but they can significantly reduce their impact. The Climate Resiliency Report from the U.S. Chamber of Commerce, Allstate, and the U.S. Chamber of Commerce Foundation[21] shows that investments in resilience and preparedness can substantially reduce the economic costs associated with disasters. The study shows that for every $1 invested in resilience and preparedness (including but not limited to transportation infrastructure) saves $13 in damages, cleanup costs, and economic impact.

Asset management and resiliency upgrades of key routes and their alternative route options in the event they fail will be critical. Most of the region's roads were designed using standards that pre-date the increased number of extreme weather events from the changing climate. Transportation modernization efforts should promote infrastructure that is built or retrofitted to revised design standards that take the anticipated climate of the region into account. This includes the upgrading and expansion of intelligent transportation system devices for traffic management and communications to facilitate evacuations and emergency response times, support weather responsive traffic management strategies (such as instituting variable speed limit systems to reduce speeds during inclement weather, coordinating traffic signal timing that reflects the slower speed of travel in corridors during bad weather), employing alternative signal plans to support detours, and increasing coverage of emergency vehicle patrols to remove disabled vehicles more quickly.

- US 2 and I-90 serve important regional mobility needs. Without these two routes, travel times increase significantly. Key segments include:
  - The north/south bridges over the Spokane River and the I-90 Latah Creek Bridge.
  - The I-90 Viaduct is critical due to its east/west capacity. However, it is more critical because of the risk that it poses to north/south mobility if the Viaduct itself experiences a failure that limits the use of the street grid. Critical medical facilities on the south side of I-90 could face limited accessibility.
  - The North/South Corridor bridge over the Spokane River, once it is complete.
  - Access further east in the grid, via Hwy 290 or the Spokane Falls Boulevard/Sherman Street bridge, becomes increasingly important if the Viaduct is affected.
  - The immediately adjacent facilities of the railroad, High Bridge, and West Sunset Boulevard could also be affected by any hazard that affects I-90, creating a compounding challenge to east/west mobility.
  - US 2 west overcrossing at US 2 and I-90
- US 395 and US 195 both serve as critical north/south routes; however, if these facilities were to be compromised, there would be long and circuitous detours with limited roadway capacity as options.

[21] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.uschamber.com/assets/documents/USCC_2024_Allstate_Climate_Resiliency_Report.pdf

US 395 requires traffic to detour through busy and congested parts of the network, whereas US 195 has spare capacity and may increase miles traveled, it does not dramatically affect travel times.

- Although SR 27 is in an area with greater flooding risk, there are detour routes available and most of the roadways in the more rural parts of the county have adequate capacity for re-routed travel demand. The reductions in capacity associated with a partial closure due to a flooding event may not significantly disrupt travel.
- Rural areas have fewer travel options and are more vulnerable to isolated shocks because of fewer roads in and out of their locations. Although the analyzed flooding hazard indicated that capacity will be reduced along several roads, the rural areas are able to maintain most of their mobility. This is less applicable in the case of fire or earthquake hazards where focused intensity removes one or more roadways from the travel network.

The strategies and actions presented in Table 4 provide guidance for SRTC and its member agencies to integrate resilience into long-range transportation planning processes, starting with the most critical facilities identified above. The approach for making the Spokane region more resilient requires cooperation between multiple agencies and stakeholders to implement key strategies, programs, and infrastructure improvements. By consistently engaging with these groups, the region can strengthen its resilience efforts, ensuring that the transportation system not only supports overall resilience but also reduces disproportionate impacts of climate change on transportation disadvantaged or historically underserved communities. Strategies and actions are grouped into two sub-categories:

- **Adaptation Measures and Planning/Policy Solutions**. Adaptation measures include strategies that address modifications or updates to the transportation system to be more responsive to hazards.
- **Planning and Policy Solutions** focus on developing the regional framework for coordinating, regulating and prioritizing resiliency projects.

The natural hazards that each strategy addresses are identified in the table. Though not specifically called out, many of the strategies also apply to human-caused hazards. A lead agency has been identified to champion the implementation of each specific strategy.

Table 4. Recommended Strategies / Actions

Strategy/ Action	Hazard	Lead Agency
Adaptation Measures		
Inventory, maintain, and upgrade existing roadway infrastructure, including roadside devices. ■ Implement the use of drones and remote sensors to inspect and monitor assets proactively to help identify and mitigate potential issues early. ■ Ensure bridge crossings and structures are maintained in good condition. The Latah Creek crossings, the elevated rail and section of I-90, and bridges over the Spokane River are the highest priority assets for a rigorous maintenance program.	All	WSDOT, County, Cities
Identify options for maintaining and increasing transportation network redundancies within and across jurisdictional boundaries: ■ Improve street connectivity and walkability, including sidewalks and street crossings, to strengthen alternative evacuation routes. ■ Preserve and extend existing roadway grid networks. ■ Support transportation options for disadvantaged communities and critical facilities. ■ Complete gaps in multimodal transportation network.	All	SRTC, WSDOT, County, Cities
Design and construct climate-resilient transportation infrastructure: ■ Enhance and harden roadway subgrade to prevent damage/failure to pavement structures. ■ Use permeable pavements in low traffic areas to manage flooding. ■ Based on flood projections and flood history, elevate bridges and road profiles, and upgrade the size of culverts to prevent inundation and reduce service disruptions. ■ Incorporate hydrologic climate impacts into the design and upgrade of water-crossing structures (i.e., climate-smart culverts and bridges) for fish passage and habitat quality.	Flooding, Severe Weather	WSDOT, County, Cities
Implement slope stabilization measures along transportation networks, including: ■ Vegetation planting and management. ■ Drainage improvements. ■ Grading to lessen slopes. ■ Constructing retaining walls to fortify steep slopes.	Landslides	WSDOT, County, Cities

Strategy/ Action	Hazard	Lead Agency
Install snow fences and wind breaks along critical routes and in high hazard areas.	Severe Weather	WSDOT, County, Cities
Optimize operations practices and invest in ITS to lessen impacts and facilitate recovery: ■ Updated plans for weather emergencies. ■ Traveler info systems and early warning systems. ■ Continued monitoring of infrastructure performance during and after hazard events. ■ Reporting systems for monitoring/detecting/tracking network obstructions. ■ Maximize use of technology such as drones for traffic conditions and remote inspections of bridges and other infrastructure pre- and post-hazards. ■ Monitor and update navigation apps/maps (road closures, work zones, detours, etc.) to disseminate accurate information. ■ Equipment for post-hazard recovery.	All	SRTC, Counties, Cities, Emergency Management
Continue to integrate green infrastructure into transportation network design, including: ■ Fire-resistant vegetative buffers. ■ Shade features. ■ Stormwater management structures.	Flooding, Severe Weather, Landslides	WSDOT, County, Cities
Optimize maintenance practices to lessen hazard impacts, including: ■ More frequent storm drain and culvert cleaning. ■ More frequent damage repairs. ■ More frequent herbaceous vegetation clearing along roadways. ■ Targeted forest thinning along roadways.	Flooding, Landslides, Wildfires	WSDOT, County, Cities
Planning/Policy Solutions		
Explore federal, state, and local funding solutions for upgrading and maintaining transportation infrastructure to be more resilient.	All	WSDOT, SRTC, County, Cities
Develop regional data-gathering and sharing process for the region on climate impacts.	All	SRTC, County, Cities

Strategy/ Action	Hazard	Lead Agency
Develop criteria for measuring resiliency in project identification and prioritization, including: ■ Connectivity to critical facilities (e.g., medical centers, Fairchild AFB, SIA). ■ System redundancy along critical routes and connections. ■ Project-level benefit-cost analyses to compare capital costs to response costs.	All	SRTC, County, Cities
Consider forming an Extreme Weather Resilience Working Group to guide regional coordination on responses to severe weather events.	Severe Weather	SRTC, County, Cities
Develop climate resilient transportation design standards. For example: ■ Climate resistant pavements, such as – Greater use of concrete due to its higher temperature resistance and other advantages (longer lifespan, possibility of increased load, lower need for maintenance). – Adjustments to asphalt mixtures. – Options for permeable/reservoir pavements (water is stored in pavement structure and infiltrated into soil or discharged to drainage system. ■ Culvert designs to accommodate higher water volumes. ■ Vegetation requirements for roadways to address heat islands, wildfire hazards, and infiltration. ■ Erosion and slope stabilization measures post wildfire. ■ Roadway shoulder design for use as travel lane during events. ■ Maintenance/inspection schedules.	All	SRTC, County, Municipalities
Incorporate hazard risks into asset management frameworks.	All	SRTC, County, Cities
Regularly monitor and evaluate progress towards increasing resilience.	All	SRTC
Support legislation for investment in transportation resiliency.	All	SRTC, WSDOT
Conduct local heat awareness campaigns on the dangers of extreme heat events.	Severe Weather	SRTC, County, Cities, Emergency Management
Promote alternative fuel vehicles and infrastructure to reduce greenhouse gas emissions and diversify fuel sources.	All	SRTC, WSDOT, County, Cities

Strategy/ Action	Hazard	Lead Agency
Adopt preventative measures in local land use regulations such as: ■ Additional regulatory restrictions to reduce risks in hazard areas (e.g., wildfire or floodplain overlay district). ■ Low-Impact Development Standards to protect water quality, manage stormwater. ■ Zoning for mixed use development to reduce vehicle miles traveled (VMT).		County, Cities
Incorporate mitigative measures in local land use management and design such as: ■ Land conservation. ■ Green infrastructure to offset heat islands. Update local Comprehensive Plans to address resiliency and identify hazard mitigation measures.		County, Cities
Update hazard mapping as new data becomes available to help agencies identify the vulnerability of new and existing transportation assets.		SRTC, County, Cities

PERFORMANCE MEASURES

Ongoing evaluation and adaptation will enable the Spokane region to plan for and respond effectively to the challenges of climate change, unanticipated events, regional growth, and the evolving demands on the transportation system. Performance measures monitor and evaluate progress towards transportation resiliency goals. SRTC is already required to report on a list of performance measures focused on vehicular travel and demand.[22] These measures include:

- Condition of pavements on the Interstate and the non-Interstate National Highway System (NHS)
- Condition of bridges on the NHS
- NHS Travel Time Reliability
- Freight movement on the Interstate System
- Traffic congestion
- On-road mobile source emissions

In addition to these performance measures, SRTC may consider additional measures to work towards regional resiliency, sustainability, and smart mobility goals. Table 5 provides additional performance measures that can be used to assess and monitor progress towards resilience. These measures capture goals from SRTC's Regional Safety Action Plan and Smart Mobility Plan, as well as Emergency Management Strategies to create an integrated approach that addresses various factors influencing community resilience.

[22] 23 CFR 490.105(c)

Table 5. Recommended Resiliency Performance Measures

Category	Description	Measures	Metric
Infrastructure Resilience	Assess the ability of infrastructure to withstand and recover from extreme events.	Increase green infrastructure	Number, acres, miles, etc. constructed.
		Increase mode share for transit and active transportation	Miles of pedestrian/ bicycle infrastructure installed or enhanced and increased transit ridership
		Reduce the frequency and duration of service disruptions due to climate events	Number of significant service disruptions (e.g., road closures, transit service interruptions) within a defined time period
		Preserve transportation infrastructure	Number of bridges or culverts or miles of pavement that are in "fair" or better condition
		Reduce roadway, bridge, and culvert vulnerability to floods	Number of road drainage features installed or enhanced on critical routes in high flood risk areas
Sustainability	Track reductions in emissions from transportation sources.	Reduce VMT per capita	Regional vehicle miles traveled (VMT)
		Increase electric vehicle (EV) adoption	Number of charging stations/number of registered EVs
Risk Reduction	Implement projects designed to minimize the impact of hazards to the transportation system.	Reduce hazard risk to transportation infrastructure	Percentage of transportation assets (miles, number) within high-risk areas
		Increase the use of advance warning systems and Intelligent Transportation Systems (ITS)	Number of warning systems or sensors
		Reduce detour length for critical facilities	Length of detours (miles)
Community and Equity	Ensure that all communities have equitable access to resilient transportation options.	Disadvantaged or underserved communities affected by hazard-impacted transportation infrastructure	Number of people from transportation disadvantaged populations or underserved communities with improved access to critical services, facilities, and evacuation routes
Land Use	Implement land use strategies that promote efficient use of the transportation system and minimize impacts of hazards.	Increase density and diversity of land uses	Proportion of mixed-use developments within a given area

FUNDING

Implementing a resilience strategy requires significant investment to preserve, upgrade, and maintain existing assets. Building resilience is like an insurance policy – by identifying the risk and implementing a mitigation measure, it reduces the future risk to the system. This minimizes the resources needed to rebuild and restore service, minimizes the disruptions to people's lives and to economic activity, and lowers the cost to agencies.

Resilience projects can have a long lead time to integrate into local or statewide Transportation Improvement Programs due to existing backlogs of capital projects and increasing maintenance and operations costs. Therefore, identifying new funding sources is a critical element of transportation resilience to ensure that priority strategies, programs, and projects can be implemented. In 2021, two new programs from the Federal Highway Administration (FHWA) were established to fund projects aimed at enhancing USDOT's goals, which include improving resiliency of the surface transportation network. The two funding programs are:

- The **Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT)** program provides funding to ensure surface transportation resilience through planning activities, resilience improvements, community resilience and evacuation routes, and at-risk coastal infrastructure.
- The **Rebuilding American Infrastructure with Sustainability and Equity (RAISE)** program is aimed at investments in surface transportation that will have a significant local or regional impact and support projects that are consistent with USDOT's strategic goals: improve safety, economic strength and global competitiveness, equity, and climate and sustainability. Eligible activities include projects that strengthen infrastructure to all hazards including climate change.

Appendices

A. Critical Infrastructure
B. Vulnerability Assessment Phase 1: Scoring Methodology
C. Vulnerability Assessment Phase 2: Project Scenarios

Appendix A. Critical Infrastructure

WSDOT Climate Impacts Vulnerability Assessment

In 2011, WSDOT conducted a qualitative climate vulnerability assessment of all state highways, documented in the Climate Impacts Vulnerability Assessment (CIVA)[23]. Each state highway was assigned a score based on Criticality (*How critical is that site or corridor to overall transportation operations and public safety?*) and Impact (*How might potential climate changes impact site or corridor operations?*), where a high criticality and high impact facility is the most vulnerable to hazards. Scores for state highways in Spokane County are summarized in Table A.1. SR 206 is the most vulnerable with "High" scores for both Impact and Criticality. I-90, U.S. Route 395, and U.S. Route 195 are also vulnerable, with "High" scores for criticality and "Moderate" scores for Impact.

Table A.1. Summary of Statewide Roadway Vulnerability Ratings for WSDOT Facilities (Spokane Co.)

Roadway	Criticality	Impact
I-90	High	Low/ Moderate
U.S. 2	High	Low
SR 291	Moderate	Moderate
Hwy 290	High	Low
SR 278	Low	Low
SR 206	High	Low
U.S. 395	High	Low/ Moderate
SR 904	Low/ Moderate	Low
SR 902	Low/ Moderate	Low
SR 206	High	High
U.S. 195	High	Moderate
SR 027	High	Low

Spokane County Hazards Mitigation Plan

The Spokane County HMP[24] conducted a vulnerability analysis of critical infrastructure for the six hazards impacting the Spokane region. The critical infrastructure for transportation assets generally focuses on

[23] Washington Department of Transportation. (2011). Climate Impact Vulnerability Assessment. <https://wsdot.wa.gov/sites/default/files/2021-10/Climate-Impact-AssessmentforFHWA-12-2011.pdf>

[24] Spokane County. *Spokane County Hazard Mitigation Plan: Volume 1*, (Spokane, WA: Spokane County, 2020), https://www.spokanecounty.org/DocumentCenter/View/34414/Hazard-Mitigation-Plan-Update-Volume-1.

bridges (highway and railway). The findings from the HMP vulnerability assessment are summarized in Table A.2, including the number of critical assets that are vulnerable to each hazard. The exact locations of the critical bridges identified are not publicly available at this time.

Table A.2. Summary of HMP Vulnerability Assessment

Hazard	Vulnerability Assessment
Drought	Drought is not expected to have significant impacts on critical transportation infrastructure. However, it could exacerbate other hazards, such as wildfires or landslides.
Earthquake	The HMP assessed the vulnerability of critical transportation facilities (bridges) for a 100-year earthquake event. Of the 383 critical bridge facilities identified, most (98.78%) are expected to have No Damage and nearly 100% are expected to be fully functional after Day 1 of the event (*based on Tables 6-10 and 6-11 of the HMP*).
Floods and Dam Failure	There are 26 bridges identified as critical infrastructure within the 100-year floodplain (*Table 7-14 of the HMP*). Of those bridges, 8 are in Spokane, 3 are in Spokane Valley, and 15 are in unincorporated areas. There are 2 bridges in the 500-year floodplain, both in Spokane. Additionally, the following major roads in Spokane County pass through 100-year floodplains: ■ Interstate 90 ■ U.S. Highways 2, 195, and 395 ■ State Highways 27, 206, 290, 291, 902, and 904
Landslide	The HMP identifies 14 bridges that are exposed to landslide hazards (*Table 8-4*).
Volcanoes	All critical transportation facilities would be exposed to ash accumulation in the event of a volcanic eruption from any of the five Cascade Region volcanoes.
Wildfires	The HMP identifies 407 critical transportation facilities (including bridges) that are exposed to wildfire hazards, including: • Interstate 90 • U.S. Highways 2, 195, and 395 • State Highways 27, 278, 290, 291, 902, and 904 Most roads and railroads would be without damage except in the worst scenarios. Many bridges in areas of high to moderate fire risk are important because they provide the only ingress and egress to residential and/or large areas.

Appendix B. Vulnerability Assessment Phase 1: Scoring Methodology

Table B.1. Scoring Methodology

Hazard scores below commensurate with the expected risk with 5 being the highest risk.

Scoring System						
Infrastructure	**Data Fields**	**Description**	**Classification**	**Score**	**Layer Composite Score**	**Combined Composite Score**
HPMS 2020	ADT	Average Daily Traffic Volume	Equal Interval	1 - 5	Average Score for All Infrastructure Layers (Infra_SC)	Score Generated for each Hazard (Infra_SC + (Hazard Layer * Rank)) / 2
	NHS	National Highway System	Absolute	5		
Public_Safety_Streets	Fclass	Functional Classification	Freeway	5		
			Maj Arterial	4		
			Min Arterial	3		
			Collector	2		
			Local	1		
Bridge	Age	Year Built - 2024	Equal Interval	1 - 5		
	Cond		Good	2		
			Fair	3		
			Poor	4		
	FedHwy		US Hwy	5		
			Interstate	5		
			All Others	1		
	STRAHNET		Absolute	5		
Hazards					Average Score for Each Hazard Layer (Drght_SC, Erqk_SC, Fld_SC, Lndsld_SC, Wntr_SC, Fire_SC)	
Drought	Index Rating		No Rating	0		
			Very Low	1		
			Relatively Low	2		
			Relatively Moderate	3		
Earthquake	Index Rating		Very Low	1		
			Relatively Low	2		
			Relatively Moderate	3		
Flood	Index Rating		No Rating	0		
			Very Low	1		
			Relatively Low	2		
			Relatively Moderate	3		
			Relatively High	4		
Landslide	Index Rating		Low-Moderate	2		
			Moderate	3		
			Moderate-High	4		
Winter	Index Rating		Very Low	1		
			Relatively Low	2		
			Relatively Moderate	3		
			Relatively High	4		
Fire	Index Rating		No Rating	0		
			Very Low	1		
			Relatively Low	2		
			Relatively Moderate	3		
			Relatively High	4		

Table B.2 Data Sources

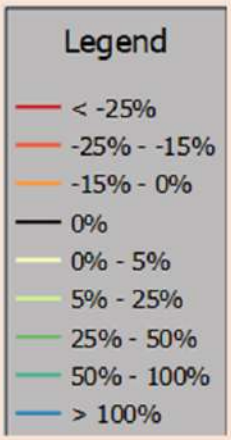
Infrastructure Layers	Source	Data Fields
Traffic Volumes/National Highway System	SRTC - HPMS 2020	ADT
		NHS
Functional Class	SRTC	Fclass
Bridges	WSDOT	Age
		Cond
		FedHwy
		STRAHNET
Truck_Freight	WSDOT	FGTSClass
Rail_Freight		FGTS
Hazard Layers	**Source**	**Data Fields**
National Risk Index	FEMA	Drought Index Rating
		Earthquake Index Rating
		Flood Index Rating
		Winter Index Rating
		Fire Index Rating
Landslide	Washington Department of Natural Resources	Data_Confidence

Appendix C. Vulnerability Assessment Phase 2: Project Scenarios

Network Changes with the Mitigation (i.e., Strengthening) Projects

The Appendix depicts how specific parts of the network may be affected by the flooding hazard and when parts of the network are made resilient to that flooding hazard. The important note to remember is the flooding hazard affects a large area with many roadways having reduced capacity, see Figure 15.

The strengthening projects analyzed here assume that the flood hazard has affected the entire region and only these specific links are improved to be made resilient to the flood hazard.



How to interpret the following maps:

Each scenario is designed to reflect network outcomes following the implementation of a specified resilience project. These scenarios are then compared to the base "No projects" scenario (Ex. Scenario #11 shows traffic flow changes when implementing the SR 27 project in comparison to no projects being implemented).

The Red scale (negative values) shows where scenario traffic volume is reduced in comparison to the "No projects" scenario.

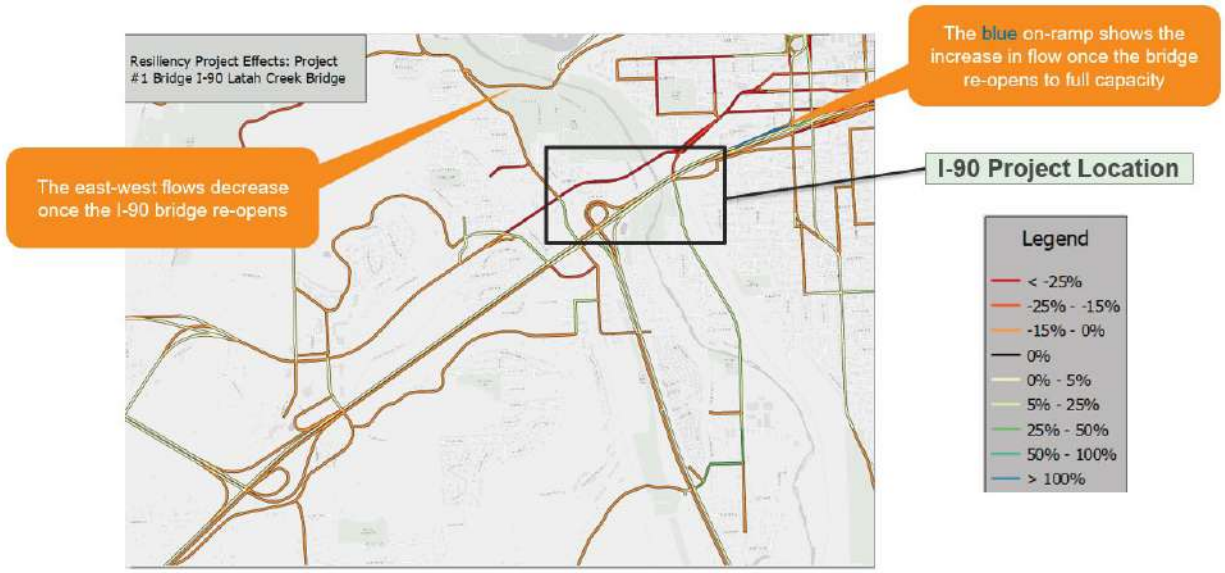
The Blue scale (positive values) shows where scenario traffic volume increases in comparison to the "No projects" scenario.

SR 27

This scenario accounts for the widespread flooding hazard. SR27, if made resilient to flooding, would attract additional demand from the roads shown in red and orange. The scenario indicates that strengthening SR 27 compared to no strengthening would reduce hours traveled by 0.11%.

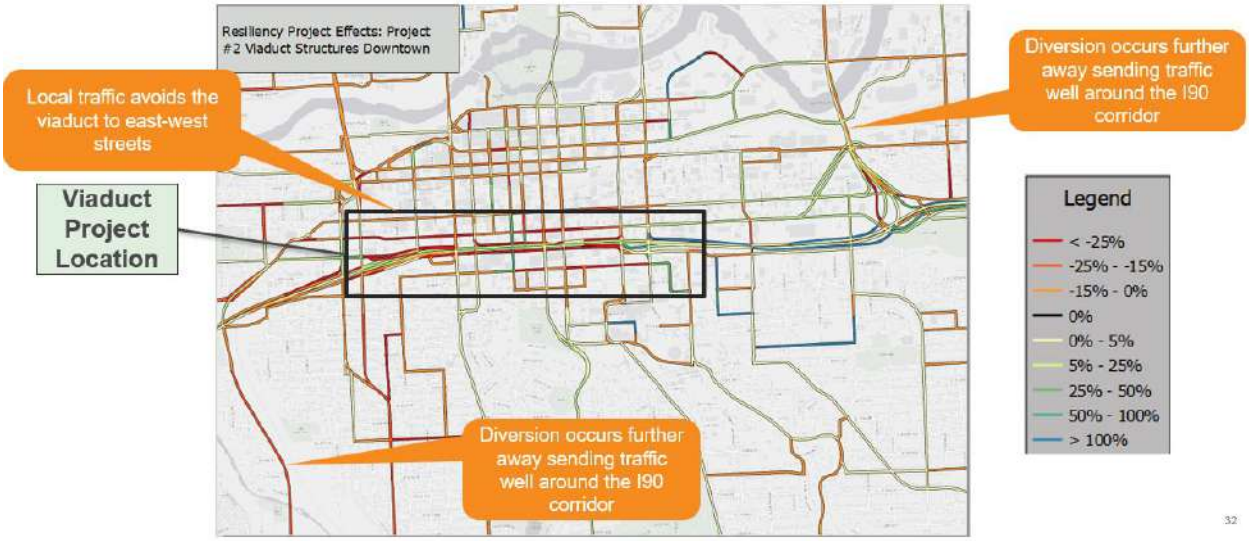
I-90 Latah Creek Bridge

Under this widespread flooding hazard scenario, the I-90 bridge over Latah Creek would have slightly reduced capacity and be made more resilient. The resilient bridge project would attract additional demand from the roads shown in red and orange (if the bridge had a capacity constraint, those roads in red and orange would increase in daily demand).



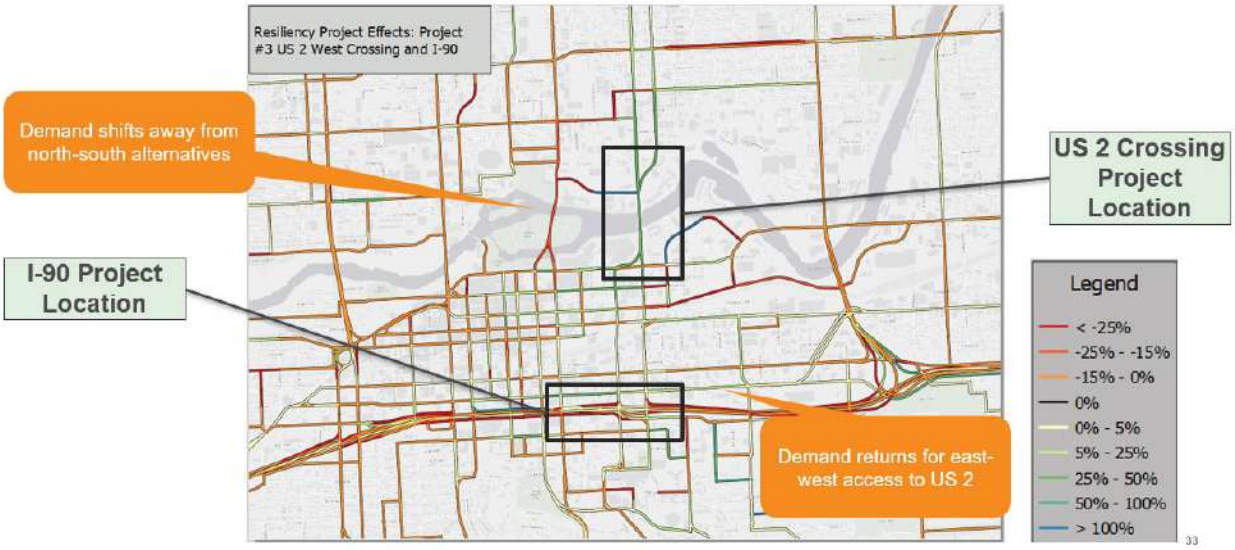
Viaduct Structures Downtown

This scenario explores how the flood hazard risk would affect flows in the downtown area if the I-90 Viaduct were resilient to those risks. If the viaduct had a reduced capacity, the dense street grid south of the Spokane River would accommodate much of the interstate traffic, albeit with much higher travel times.



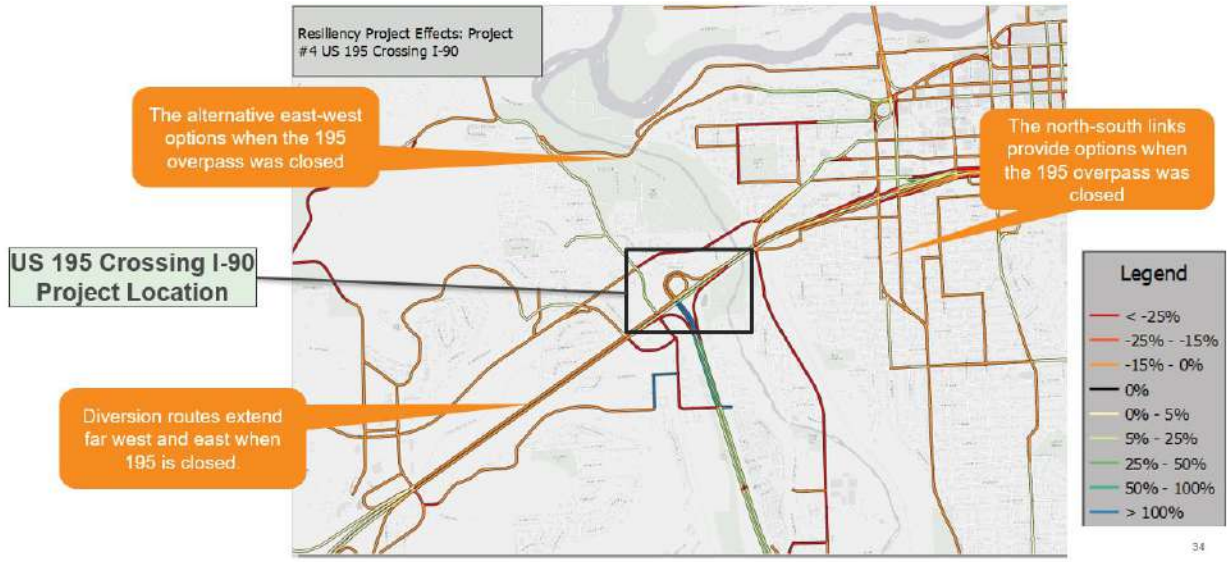
US 2 West Crossing and I-90

This scenario explores the impacts of the widespread flooding risk and making the US 2 interchange with I-90 and the US 2 bridge over the Spokane River more resilient. The red and orange highlight the routes used if US 2 was less available. The north/south bridges are in high demand as alternative routes. This scenario reduces vehicle hours of travel by 0.20% compared to the no strengthening scenario.



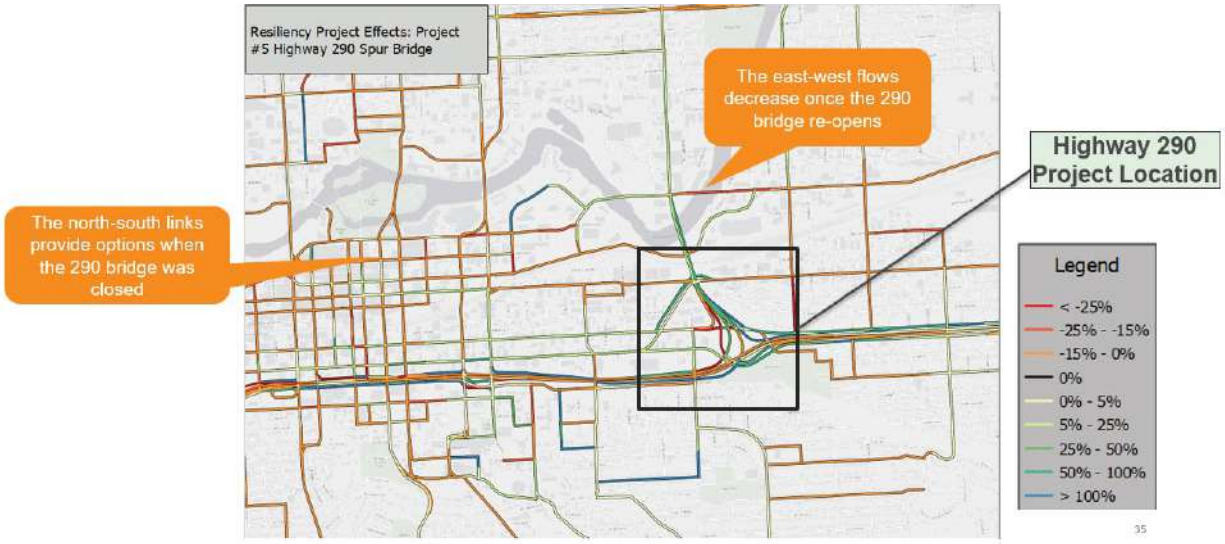
US 195 Crossing I-90

This scenario explores the impacts of the widespread flooding risk and making the I-90 / US 195 interchange more resilient. The red and orange highlight the routes used if the overpass is not available. The limited facility requires large scale detours to avoid I-90 and then to access US 195 via secondary roads.



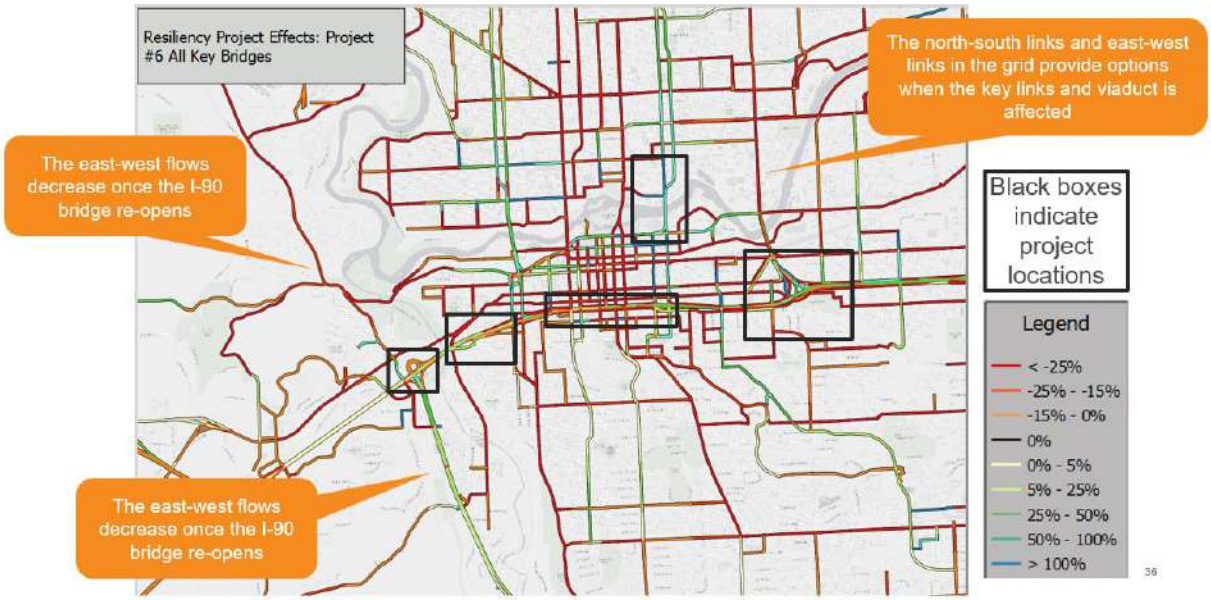
Highway 290 Spur Bridge

This scenario explores the impacts of the widespread flooding risk and making the Hwy 290 bridge over the Spokane River more resilient. Because of the elevated flooding risks in this area, the locations in red and orange are further west, and show the benefits of the street grid and the redundant north/south bridges. The blue shows the areas which would have no traffic if the bridge had a reduced daily capacity.



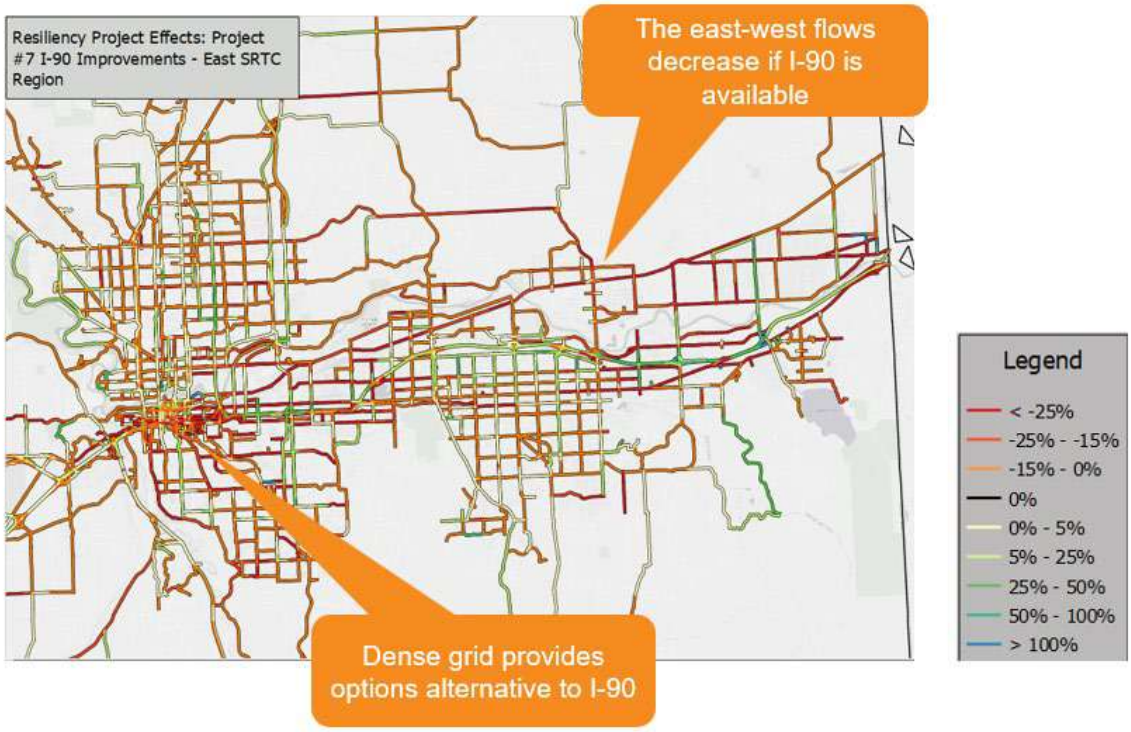
All Key Bridges: US 195, I-90, US 2, and Hwy 290 Spur

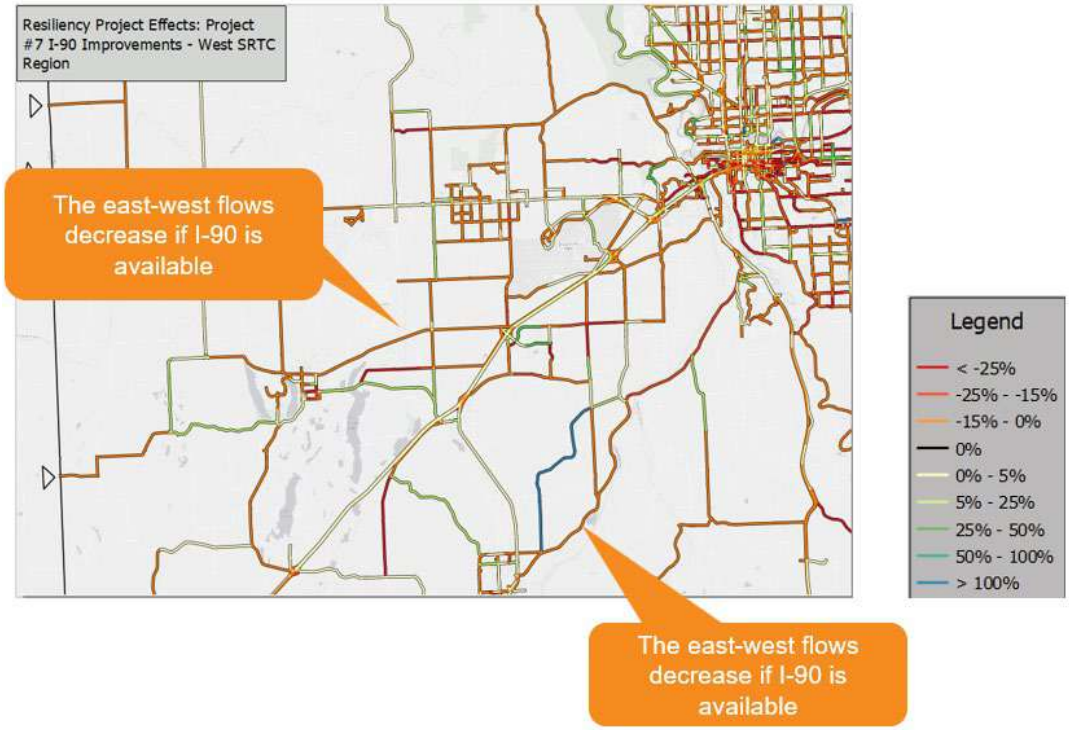
This scenario explores the impacts of the widespread flooding risk and making the Hwy 290 bridge over the Spokane River more resilient. Because of the elevated flooding risks in this area, the locations in red and orange are further west, and show the benefits of the street grid and the redundant north/south bridges. The blue shows the areas which would have no traffic if the bridge had a reduced daily capacity.



I-90

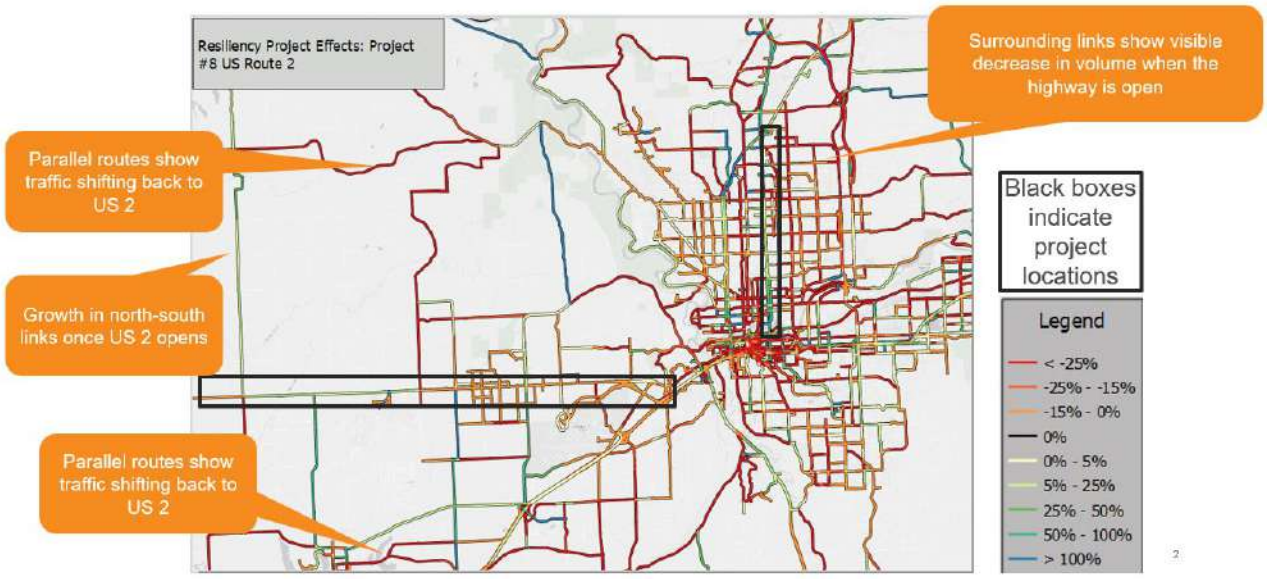
This scenario accounts for the widespread flooding hazard while strengthening all of I-90. If I-90 and other parts of the roadway have less daily capacity, regional diversions are necessary. US 2 doesn't increase in capacity because US 2 is limited by I-90 across Latah Creek. For this reason, US 2 doesn't attract a higher degree of displaced trips. This second figure shows the extent alternative routes are used when I-90 has reduced capacity. The red and orange routes provide alternative east/west options.





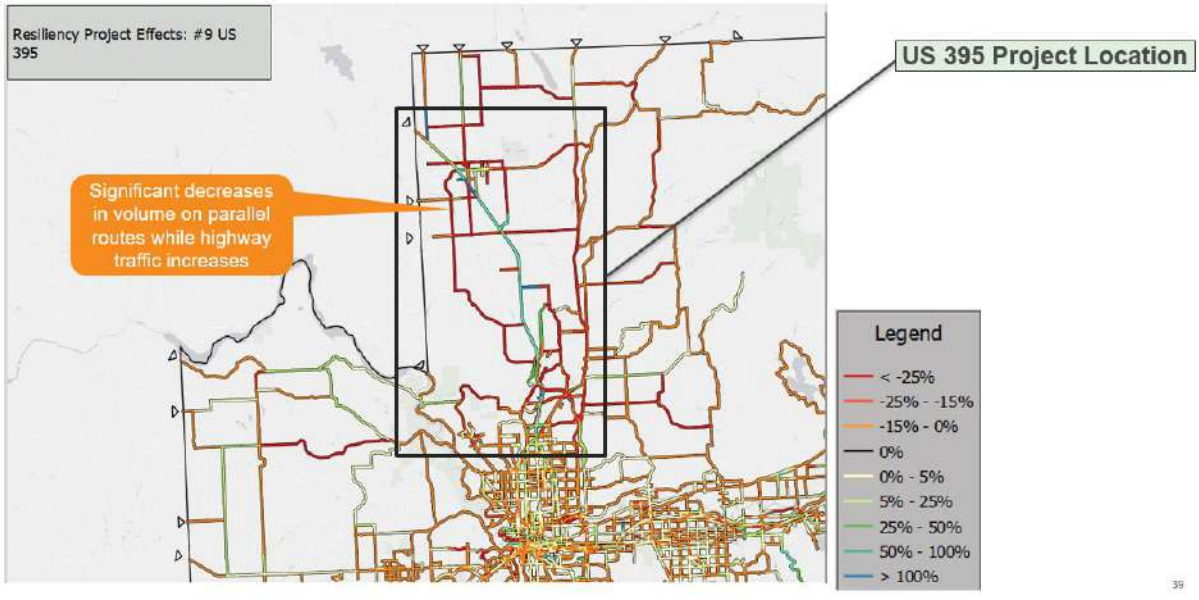
US 2

This scenario accounts for the widespread flooding hazard while strengthening all of US 2. If US 2 and other parts of the roadway have less daily capacity, large diversions are necessary. The parallel east/west links serve as alternative routes. The downtown section of US 2 requires traffic to route throughout the network. Improving the resiliency of US 2 is shown to be one of the more impactful scenarios by reducing daily vehicle hours by 2.4% as opposed to the full flood scenario because of the large diversions to more congested corridors.



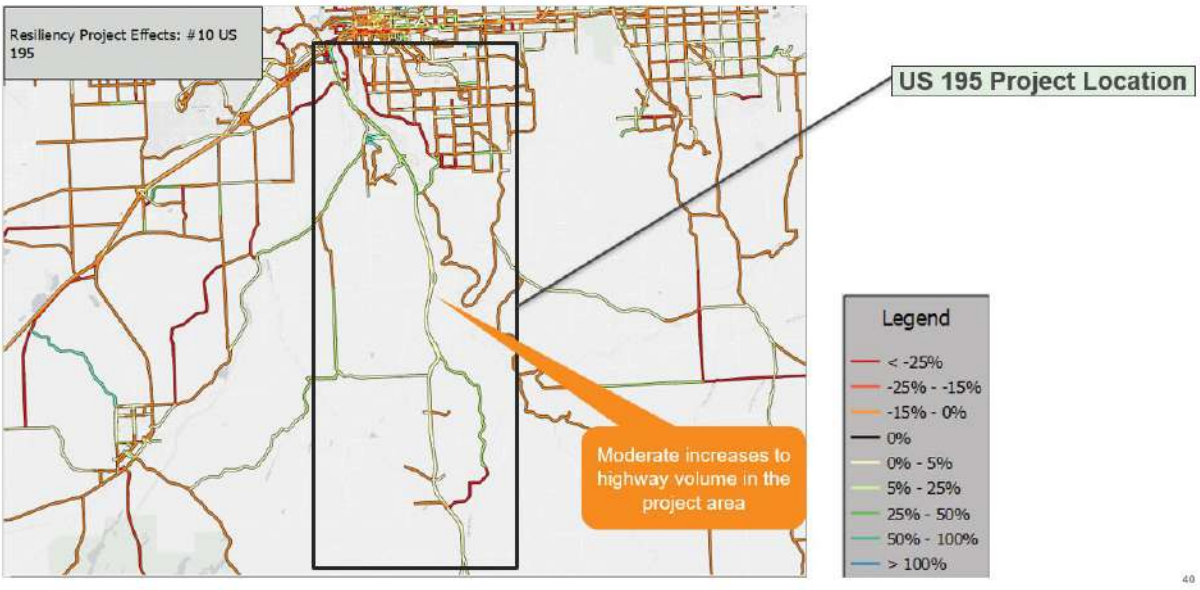
US 395

This scenario accounts for the widespread flooding hazard while strengthening all of US 395. If US 395 and other parts of the roadway have less capacity, diversions are needed downtown and parallel to US 395. The strengthening of US 395 is one of the more impactful scenarios by reducing daily vehicle hours by 1.8% because of the diversions to more congested corridors, especially downtown.



US 195

This scenario accounts for the widespread flooding hazard while strengthening all of US 195. If US 195 and other parts of the roadway have less daily capacity, then diversions are needed along routes parallel to US 195. The limited alternative routes require long detours. However, the US 195 route and the alternatives appear to have spare capacity today and under a flood scenario, the reduced capacity doesn't have a significant impact on mobility in the region (presuming it is still open for at least 25% of daily capacity).



Appendix D. Resiliency Best Practice Review

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TECHNICAL MEMORANDUM

November 18, 2024

Project #29835.002

To: Jason Lien, Principal Transportation Planner, SRTC

From:Wende Wilber, Abby Morgan, and Paul Ryus

RE:MPO System Resiliency Assessment Review

Introduction

The Fixing America's Surface Transportation (FAST) Act of 2015 introduced new requirements for metropolitan planning organizations (MPOs) to include transportation system resilience as a planning factor in their metropolitan or regional transportation plans (MTPs, RTPs). One definition of *resiliency* is the following:[1]

> "Resiliency is the ability to anticipate, prepare for, adapt to, withstand, and recover from disruptions and changing conditions. At its core, the resiliency of the transportation infrastructure system allows the region to maintain essential services in the event of a human-caused or natural disaster, such as an earthquake. But a resilient system can also withstand not only a single event, but a series of events or a permanent change in the environment, such as a major landslide."

A related concept is *adaption,* "the built environment reacting to changing conditions brought about by the effects of climate change, such as rising sea levels or temperature fluctuations…. Considerations will differ regionally and may include preparing for effects associated with flooding of airports or roadways, landslides that may interrupt traffic flow or rail lines, heat waves or subsidence causing roadway buckling, or increased maintenance attributable to fire damage or arson."[2]

[1] Wasatch Front Regional Council. 2023. *Regional Transportation Plan 2023–2050.* Salt Lake City, UT.
[2] San Joaquin Council of Governments. 2022. *Regional Transportation Plan and Sustainable Communities Strategy.* Stockton, CA.

The Infrastructure Investment and Jobs Act of 2021 defined a *resilience improvement* as follows:[3]

> "The term 'resilience improvement' means the use of materials or structural or non-structural techniques, including natural infrastructure (A) that allow a project (i) to better anticipate, prepare for, and adapt to changing conditions and to withstand and respond to disruptions; and (ii) to be better able to continue to serve the primary function of the project during and after weather events and natural disasters for the expected life of the project; or (B) that (i) reduce the magnitude and duration of impacts of current and future weather events and natural disasters to a project; or (ii) have the absorptive capacity, adaptive capacity, and recoverability to decrease project vulnerability to current and future weather events or natural disasters."

Although emergency planning and response is led at the state and county levels by organizations such as the Spokane Department of Emergency Management, MPOs such as the Spokane Regional Transportation Council (SRTC) have an important role to play in agency coordination and planning and programming projects that improve transportation system resiliency.

This memo begins by describing the types of natural and man-made hazards that may be experienced in the Spokane region and their potential effects on the transportation system. The remainder of the memo provides a high-level overview of ways that 17 peer agencies have incorporated resilience into their MTPs and related planning efforts.

Potential Hazards in the Spokane Region

Natural Hazards

The Spokane County Hazard Mitigation Plan identifies the following natural hazards as being most likely to affect the Spokane region:[4]

- Drought
- Earthquake
- Flood and dam failure
- Landslide, rockfall, debris flow
- Severe weather (damaging winds, winter storms, dust storms, thunderstorms)
- Volcanic eruptions
- Wildfire

Table 1 summarizes potential effects of these hazards on the transportation system. In addition to the hazards listed above, some MTPs and emergency management plans identify pandemics as a form of natural hazard.

[3] U.S.C. Title 23, Chapter 1, §176(a)(4).
[4] Bridgeview Consulting. 2020. *Spokane County Hazard Mitigation Plan.* Spokane Department of Emergency Management, Spokane, WA.

Table 1: Potential Effects of Hazards on the Transportation System

Hazard	Potential Transportation System Effects
Drought	Roads: Ground shrinkage below asphalt can cause pavement cracking Rail: Runoff, leaching, slope instability, load bearing capacity, track stability and visibility Airports: Stress on water supply for cooling power sources, irrigation, pavement power washing
Earthquake	Bridge failures, road cracking, rail track damage, pipeline breaks, loss of electricity to communication and fueling systems, building damage at operations and maintenance facilities, potential to trigger landslides or dam failures, potential for fires from gas leaks
Flood and dam failure	Roads: asphalt stripping, washouts, subbase erosion, route closures, delays, damage to electrical equipment Rail: substructure erosion, inundation, delays, damage to electrical equipment Buses: delays and route changes, inundation of storage and maintenance facilities Airports: Runway damage
Landslide	Road and track closures, power and communication line damage, potential for flooding if a waterway is blocked, potential for lake tsunamis if the landslide enters a lake
Severe weather	Road closures, airport closures, increased potential for roadway crashes, damage to utilities and transportation-related buildings, staff difficulty (e.g., maintenance workers, bus drivers) getting to work, potential for heavy rain to trigger flooding
Volcanic eruptions	Ashfall causes road, track, and airport closures; sufficient ash accumulations can cause roof collapses
Wildfire	Roads: Rutting, softening, closures, need for safe evacuation routes Rail: Blocked routes, delays Buses: Route closures and detours Airports: Delays due to poor visibility and worker safety (smoke) Utilities: Damage to power and communications lines Facilities: Damage to vehicles and facilities in the fire zone May increase landslide potential in following winters

Sources: Adapted from *Spokane County Hazard Mitigation Plan*[5] and *San Joaquin Climate Adaptation Report.*[6]

[5] Bridgeview Consulting. 2020. *Spokane County Hazard Mitigation Plan.* Spokane Department of Emergency Management, Spokane, WA.
[6] San Joaquin Council of Governments. 2020. *Climate Adaptation Report.* Stockton, CA.

Man-Made Hazards

Examples of man-made hazards that appear in some emergency management plans include the following:[7,8]

- Hazardous materials release (e.g., tanker truck fire, train derailment, pipeline break)
- Utility failures and cyberattacks
- Civil disturbance and terrorism
- Major aircraft crash

The potential effects of these hazards vary by the type of incident, but generally include the same kinds of issues associated with various kinds of natural hazards, such as:

- Road and other transportation facility closures, potentially for long periods of time
- Need to evacuate potentially large populations
- Inability/difficulty of transportation workers to get to work
- Communication and/or power failures
- Secondary hazards, such as fires

Two regions included in the review presented later in this memo, Salt Lake City and Vancouver, BC, included special events as a kind of man-made event that required resilience planning. Major sports events, large conferences, community festivals, etc. can bring large volumes of people unfamiliar with the area into a relatively small area.

Although not mentioned directly in the resiliency plans that were reviewed, bridge failures or closures (e.g., due to insufficient maintenance) and large-scale maintenance projects that significantly reduce capacity (e.g., freeway pavement reconstruction, airport runway paving) are other types of man-made events that affect transportation patterns over a longer period of time and can require resiliency planning.

Communicating the Need for Resiliency Planning

Most hazards fortunately are infrequent, but this characteristic can also make planning for hazards and funding hazard mitigation projects challenging, because relatively rare (albeit potentially severe) events that could occur in any number of locations are competing with known existing needs for funding. Newcomers to a region, as well as younger members of the community, may not be aware of the potential for some hazards, as they have never experienced them.

[7] TetraTech. 2023. *2022 Ada County Multi-Hazard Mitigation Plan.* Ada County Emergency Management & Community Resilience, Boise, ID.
[8] Pikes Peak Regional Office of Emergency Management. 2022. *Pikes Peak Regional Multi-Hazard Mitigation Plan 2020* (2022 Review Update). Colorado Springs, CO.

To raise public and decision-maker awareness of potential hazards, some resiliency and emergency management plans—including Spokane County's—document past instances of major emergencies and disaster declarations, including (when available) estimates of property damage, injuries and fatalities, and regional disruptions. Examples include plans for the Boise, Colorado Springs, and Sacramento regions.

Where no local example is available, well-covered examples in the news could be used to demonstrate a hazard's potential impact. For example, two bridge-related incidents in the first half of 2024 in the U.S. have led to major transportation-related problems. The collapse of the Francis Scott Key Bridge in Baltimore severed an important route for travelers and hazardous materials vehicles that bypassed the harbor tunnels in downtown Baltimore, added an hour or more of travel time each way for residents on one side of the bridge to access their jobs on the other side of the bridge, and cut off ship access to much of the Port of Baltimore. A long-term bridge closure on US 50 in central Colorado following a bridge inspection has required up to 6 to 7 hour detours due to a lack of paved, snow-free alternate routes.

A report commissioned by COMPASS, the MPO serving the Boise region, concluded that natural disasters are becoming more frequent and expensive, that resilience planning saves money (e.g., mitigating infrastructure saves $4 for every $1 spent), and that resilience planning is good asset management, considering that roads moved "an estimated $27.3 billion of cargo into, out of, and within the Treasure Valley" in 2017 and that "even minor disruptions along… critical transportation routes can disrupt economic activity."[9]

MPO Review

This section of the memorandum provides examples of how peer MPOs have addressed resiliency in their MTPs and supporting plans. Topics included in this review include:

- MPO policies, objectives, goals, and strategies related to resiliency
- Examples of resiliency plans and projects
- Performance measurement

MPOS Included in the Review

This review selected 16 MPOs and one regional agency serving regions similar in size or larger than Spokane located in the western U.S. and Canada. This geographic area was selected because regions in this area are more likely to experience natural and man-made hazards similar to those faced by the Spokane region. In addition, the North Central Texas Council of Governments (Dallas, TX) was included in the review because it was also reviewed for the smart mobility task that is

[9] Klopfenstein, Lila. 2021. *Understanding Current Resilience Practices and Their Application to the Treasure Valley.* Boise State University, Boise, ID.

happening concurrently. Table 2 lists the MPOs included in the review and the categories of hazards included in their MTPs and supporting plans. Some MTPs do not identify any hazards.

Table 2: MPOs Included in the Review

MPO Name	Region	Hazards Considered		
		Natural Hazards	Man-made Hazards	Effects on the Natural Environment
Central Lane MPO	Eugene, OR	✓	✓	
COMPASS	Boise, ID	✓	✓	
Denver Region COG (DRCOG)	Denver, CO	✓	✓	
Maricopa AG	Phoenix, AZ			
Metro	Portland, OR	✓		✓
Metropolitan Transportation Commission	San Francisco, CA	✓		
Mid-Region COG	Albuquerque, NM	✓	✓	✓
North Central Texas COG	Dallas, TX	✓		✓
Pikes Peak Area COG	Colorado Springs, CO	✓	✓	
Pima AG	Tucson, AZ			
Puget Sound Regional Council	Seattle, WA	✓		✓
RTC of Southern Nevada	Las Vegas, NV			
RTC of Washoe County	Reno, NV	✓	✓	
Sacramento Area COG	Sacramento, CA	✓		
San Joaquin COG	Stockton, CA	✓		
TransLink	Vancouver, BC	✓		
Wasatch Front Regional Council (WFRC)	Salt Lake City, UT	✓		✓

Note: AG = association of governments, COG = council of governments, RTC = regional transportation commission

Natural and man-made hazards were described earlier in this memo. Five of the reviewed MPOs included “environmental resiliency” as part of their overall treatment of resiliency. This category included transportation’s effects on the environment (e.g., wildlife habitat, water quality, climate change) and/or the potential of transportation projects to worsen existing hazards (e.g., building on steep slopes could increase rockfall or landslide hazard, new construction in flood plains could change water levels during floods).

The review included each MPO’s current MTP or regional transportation plan, along with any planning documents or program descriptions related to resiliency available on each MPO’s website or referenced in their MTP (typically, county and state hazard mitigation plans).

Resiliency Policy, Goal, Objective, and Strategy Examples

Thirteen of the 17 MPOs reviewed had policies, goals, objectives, and/or strategies specific to resiliency. The other MPOs addressed resiliency indirectly. For example, the Maricopa Association of Governments (Phoenix, AZ) identified that the federal "improve resiliency and reliability" planning factor was addressed through its MTP's mobility, responsiveness, and preservation goals. This section documents peer MPO policies, goals, objectives, and strategies related to resilience.

Central Lane MPO (Eugene, OR)

- Objectives:
  - Reduce the transportation system's vulnerability to natural disasters and climate change.
  - Reduce the transportation system's vulnerability to crime and terrorism.
  - Strive to reduce vehicle-related greenhouse gas emissions and congestion through more sustainable street, bike, pedestrian, transit, and rail network design, location, and management.
  - Reduce the impact of roadway incidents on the regional arterial roadway network and frequent transit routes.
  - Develop a transportation system that is adaptable and flexible to changing needs and conditions.
  - Build an integrated and connected system of regional arterial roadways, freight routes and intermodal facilities, transit, bicycling and walking facilities.
  - Reduce the transportation system's vulnerability to natural disasters and climate change.
  - Preserve and maintain transportation system assets to maximize their useful life and minimize project construction and maintenance costs.

COMPASS (Boise, ID)

- Goal: Support a resilient transportation system by anticipating societal, climatic, and other changes; maintaining plans for response and recovery; and adapting to changes as they arise.

DRCOG (Denver, CO)

- Outcome: The risks and effects of natural and human-created hazards are reduced.
- Actions: Transportation safety, security, and maintenance activities to mitigate the effects of hazards and improve local and regional resiliency.

Metro (Portland, OR)

- Transportation preparedness and resilience policies:
  - Designate and maintain regional emergency transportation routes that would be prioritized for rapid damage assessment and debris removal.

- Consider climate and other natural hazard–related risks during transportation planning, project development, design, and management.
- Optimize operations and maintenance practices that can help lessen impacts on transportation from extreme weather events and natural disasters (e.g., more frequent storm drain cleaning; improved plans for weather emergencies, closures and reroutings; traveler info systems; debris removal; early warning systems; damage repairs; performance monitoring).
- Integrate green infrastructure into the transportation network to avoid, minimize, and mitigate negative environmental impacts of climate change, natural disasters, and extreme weather events.
- Protect and avoid natural areas and high value natural resource sites, especially the urban tree canopy and other green infrastructure.
- Avoid transportation-related development in hazard areas such as steep slopes and floodplains.

MTC (San Francisco, CA)

- Statement: Perhaps the most serious existential consideration of all is climate change, a growing crisis that threatens to reshape the region through worsening cycles of flooding, extreme heat, drought, and wildfire. While not tied to climate change, a major earthquake is also likely to hit the Bay Area in the coming decades.

Mid-Region COG (Albuquerque, NM)

- Potential regional transportation security planning efforts:
  - Conduct vulnerability analyses on critical regional transportation facilities and services.
  - Analyze the transportation network for redundancies in moving large numbers of people and for strategies dealing with “choke” points and bottlenecks.
  - Analyze the transportation network for emergency route planning/strategic gaps in the network.
  - Provide a forum for security/safety agencies to coordinate prevention strategies.
  - Conduct transportation network analyses to determine most effective recovery investment strategies
  - Act as a forum for regional assessment of organizational and transportation systems response.
  - Conduct targeted studies on identified deficiencies and priority reconstruction needs and recommend corrective action to restore critical and strategically important transportation facilities.
- Other potential resiliency actions:
  - Increase roadway connectivity
  - Promote alternative fuels (diversify fuels)
  - Promote alternative transportation modes

- Promote a mix of land uses and complete neighborhoods
- Increase ITS and traveler information services to collect and analyze real-time roadway conditions

North Central Texas COG (Dallas, TX)

- Objective: Implement resilient roadway and transit projects that are protected from floods and minimize impact on the natural environment.

Puget Sound Regional Council (Seattle, WA)

- Regional Transportation Plan (2022)
  - Policy: Advance the resilience of the transportation system by incorporating redundancies, preparing for disasters and other impacts, and coordinated planning for system recovery.
  - Action: Cities and counties will update land use plans for climate adaptation and resilience. Critical areas will be updated based on climate impacts from sea level rise, flooding, wildfire hazards, urban heat, and other hazards. The comprehensive plans will identify mitigation measures addressing these hazards including multimodal emergency and evacuation routes and prioritizing mitigation of climate impacts on highly impacted communities.
  - Action: PSRC is working to prepare more detailed guidance on planning for resilience for the 2024 comprehensive plan update process. These efforts will be done in partnership with the Puget Sound Climate Preparedness Collaborative and will include guidance for incorporating resilience into broader transportation planning efforts.
- Vision 2050 policies:
  - Enhance urban tree canopy to support community resilience, mitigate urban heat, manage stormwater, conserve energy, improve mental and physical health, and strengthen economic prosperity.
  - Advance state, regional, and local actions that support resilience and adaptation to climate change impacts.
  - Increase resilience by identifying and addressing the impacts of climate change and natural hazards on water, land, infrastructure, health, and the economy. Prioritize actions to protect the most vulnerable populations.
  - Promote cooperation and coordination among transportation providers, local government, and developers to ensure that joint- and mixed-use developments are designed to promote and improve physical, mental, and social health and reduce the impacts of climate change on the natural and built environments.
  - Ensure that economic development sustains and respects the region's environment and encourages development of established and emerging industries, technologies, and services, that promote environmental sustainability, especially those addressing climate change and resilience.

- Advance the resilience of the transportation system by incorporating redundancies, preparing for disasters and other impacts, and coordinated planning for system recovery.
- Address impacts to vulnerable populations and areas that have been disproportionately affected by climate change.
- Address rising sea water by siting and planning for relocation of hazardous industries and essential public services away from the 500-year floodplain.
- Support efforts to increase the resilience of public services, utilities, and infrastructure by preparing for disasters and other impacts and coordinated planning for system recovery.

RTC of Southern Nevada (Las Vegas, NV)

- Shift to autonomous transit vehicles as technology permits (10+ years).
- Monitor and incorporate emerging transportation technologies and update road designs as needed.

SACOG (Sacramento, CA)

- Policies
  - Modernize the way we pay for transportation infrastructure.
  - Reduce the growing system maintenance funding gap by prioritizing spending flexible revenues on state-of-good repair improvements before investing in system expansion.
  - Transportation infrastructure investments should be planned and built in a way that makes the system more resilient to extreme weather events and natural disasters.
  - Prioritize investments in transportation improvements that reduce greenhouse gas emissions and vehicle miles traveled.
- Actions
  - Pursue new and reformed transportation funding methods and sources to implement the MTP/SCS that are stable, predictable, flexible, and adequate to operate, maintain, and expand the transportation system
- Other statements
  - Take into consideration resiliency needs.
  - SACOG serves as a forum for the study, planning, and resolution of other issues facing local governments including challenges related to flooding and wildfires.

SJCOG (Stockton, CA)

- Policies
  - Enhance the environment for existing and future generations and conserve energy.
- Supporting Actions
  - Improve air quality by reducing transportation-related emissions.
  - Enhance the connection between land use and transportation choices through projects supporting energy and water efficiency.

- Other statements
  - Prioritize transportation infrastructure durability and resilience.
  - Partner with local jurisdictions to ensure the region can withstand changes to climate conditions or other disrupting events. Local agency climate action plans are instrumental in these activities.
  - Complete a Climate Adaptation and Resiliency Planning Study as a future action.

TransLink (Vancouver, BC)

- Approaches to mitigate impacts of shocks on safety:
  - Maintaining infrastructure in a state of good repair, robust asset management, and operational practices to enable infrastructure to better withstand climate or extreme weather impacts.
  - Establishing standards for infrastructure development that prepare new projects for climate impacts such as excessive heat, floods, and temperature fluctuations.
  - Prioritizing bus-based investments over fixed rail infrastructure in areas of high risk for flooding, seismic activity, or earthquakes; buses can be more easily redeployed if local conditions change.
- Strategy: Maintain transportation infrastructure in a state of good repair.
  - Deploy routine **surveys and technologies**, such as real-time sensors and software as they become available, to monitor conditions to inform predictive maintenance priorities
  - Enable crowd-sourced reporting of maintenance issues for quick identification.
- Strategy: Safely respond to and recover from disruptions and disasters. To ensure the safety and security of the public, as well as regional prosperity, recovery, and resilience, the transportation system must be available to support communities before, during, and after emergencies and disasters. The ability to respond when time is of the essence and when lives and property are at stake urgently requires that we work together.
- Actions:
  - Create, maintain, and audit **emergency and business continuity plans** and programs based on regional assessment of existing and changing hazards, risks, and vulnerabilities.
  - Conduct period public-facing **emergency-response training** and exercises with the public, stakeholders, the media, and all levels of government.
  - Maintain an **emergency operations framework** that enables intergovernmental partners to efficiently respond and recover from emergencies and disasters, and that aligns with provincial and municipal response structures.
  - Support an integrated **community-based approach to community safety**… to build system resiliency to help (a) manage major events with large crowds and (b) respond and help manage in the immediate aftermath of disruptions and disasters.
  - Engage partners and stakeholders to identify **critical infrastructure dependencies,** align response and recovery strategies, training, and exercise plans, and establish partnership

agreements so that these plans can be put into action directly when events occur or when additional flexibility is needed.
- Develop and implement a regional transportation **resiliency strategy and action plan.**
- Prioritize investment in modes, corridors, and technologies with the **greatest capacity to adapt** to shocks, stresses, and changing conditions.
- Update **state of good repair** programs… to account for resiliency.[10]

Wasatch Front Regional Council (Salt Lake City, UT)

- Policy: Prepare for resiliency in the face of uncertainty. WFRC seeks to have a transportation plan that helps the region be resilient in the face of an uncertain future. WFRC will highlight key vulnerabilities to our member communities and region.

MTP Resilience Plan and Project Examples

Plans

Several of the peer MPOs have conducted one or more planning studies focusing on resiliency. These plans include:

- COMPASS (Boise, ID)
  - Understanding Current Resilience Practices and Their Application to the Treasure Valley (2021)—a review of then-current MPO resilience practices and how they could be applied in the Boise region's context
- Puget Sound Regional Council (Seattle, WA)
  - Climate Change and Resilience Guidance (2022)—provides guidance, best practices, and technical assistance for local governments as they update their comprehensive plans to address emission reduction and resilience activities
- SACOG (Sacramento, CA)
  - Sacramento Region Transportation Climate Adaptation Plan (2015)—examined potential climate-related hazards that could impact the region's transportation system and recommended policies and strategies addressing those impacts
  - Sacramento Regional Emergency Preparedness Strategy (2023)—identifies emergency preparedness gaps in the region's transit and transportation system, identifies interagency coordination needs, and recommends actions
- SJCOG (Stockton, CA)
  - Climate Adaptation Report (2020)—conducted a vulnerability assessment and provided recommendations for integrating resilience into the RTP

[10] The last three items in the list provided long lists of subactions describing how to implement the action; see pages 184–185 of the *Transport 2050 Regional Transportation Strategy* for details.

  - Regional Resiliency Implementation Plan and Adaptation Guidance (2022)—identifies solutions to the hazard-related transportation impacts listed in the Climate Adaptation Report and identifies a prioritized list of 20 implementation strategies

- Wasatch Front Regional Council (Salt Lake City, UT)
  - RTP Appendix M: Addressing Resiliency in Relation to Transportation Planning (2023)—reviewed transportation projects being considered for programming in the RTP with respect to potential to be impacted by various natural hazards, as well as their potential impact on various aspects of the natural environment

Although not included as part of this review, several peer MPOs have developed plans that address mitigating the impact of their regions on climate change. These plans may be indirectly relevant to their regions' resiliency planning efforts.

Projects

Few of the peer MPOs, including most of the ones that had prepared resilience plans, highlighted resilience-related projects in their MTPs. The following are examples of projects that were highlighted:

- DRCOG (Denver, CO): system preservation projects
- Metro (Portland, OR): update and prioritize Regional Emergency Transportation Routes to connect critical infrastructure and essential facilities, as well as the region's population centers and vulnerable communities; conduct a regional vulnerability assessment; seismic upgrades to roads and bridges
- SACOG (Sacramento, CA): summary of transit agency vehicle resources for emergency evacuations

DRCOG included "reduce the risks of hazards and their effects" along with "improve air quality and reduce greenhouse gas emissions" and "connect people to natural resource and recreation areas" as the factors in the "Environment" category used to score potential MTP projects. Collectively, these factors were worth up to 12 points out of a maximum of 51 points across all scoring categories.

Resilience Performance Measurement

The FHWA requires that MPOs set targets for and report the following performance measures related to pavement and bridge condition:[11,12]

- Percent of Interstate pavements in Good condition

[11] FHWA. 2017. Pavement Performance Measures (fact sheet). https://www.fhwa.dot.gov/tpm/pubs/PM2PavementFactSheet.pdf
[12] FHWA. 2017. Bridge Performance Measures (fact sheet). https://www.fhwa.dot.gov/tpm/pubs/PM2BridgeFactSheet.pdf

- Percent of Interstate pavements in Poor condition
- Percent of non-Interstate National Highway System (NHS) pavements in Good condition
- Percent of non-Interstate NHS pavements in Poor condition
- Percent of NHS bridges by deck area classified as in Good condition
- Percent of NHS bridges by deck area classified as in Poor condition

Perhaps due to the fact that federal requirements for MTPs to consider resiliency are relatively new, only two regions had established any resiliency measures beyond the federally required pavement and bridge measures. The North Central Texas COG (Dallas) included "NHS lane miles in flood zones" in its MTP. The RTC of Southern Nevada (Las Vegas) included "transit system state of good repair" as a measure supporting its "maintain current infrastructure" strategy in addition to the federally required measures. Clark County, which includes Las Vegas, developed a Resilient County Operations plan that included the following performance measures:

- Number of county assets "vulnerable" [to be defined] to climate risks
- Dollar value of resilience investments, compared to property loss risk value
- Percent of county property area shaded or vegetated
- Number of trees planted on county property
- Number of cooling stations
- Percent of capital projects meeting resilience guidelines

A 2021 review of MPO resiliency practices commissioned by COMPASS, the MPO for the Boise region, studied five other MPOs not included in this review (Bend, OR; Skagit County, WA; Cheyenne, WY; Fort Lauderdale, FL; and Kansas City, MO-KS). None of those MPOs had developed resiliency-specific performance measures at the time the study was performed.[13]

[13] Klopfenstein, Lila. 2021. *Understanding Current Resilience Practices and Their Application to the Treasure Valley.* Boise State University, Boise, ID.

Summary

Most MPOs are still working to integrate resiliency into their planning processes. Although hazard planning and response is a function of emergency management agencies, MPOs have a role in identifying potential hazard impacts to the regional transportation system and planning and programming projects to address those hazards. MPOs can also work with their member jurisdictions to provide guidance and technical assistance with integrating resiliency into their plans, design standards, and development codes.

A large majority of the peer MPOs have developed policies, goals, objectives, and/or strategies in their MTPs that are specific to resiliency. TransLink, the equivalent of an MPO for the Vancouver, BC region, is particularly notable for the amount of detail that has gone into that region's resiliency strategies and actions. Smaller MPOs, such as those serving Boise, ID and Stockton, CA, have sponsored studies on transportation resilience and participate in other regional emergency planning activities.

The review did not find many resilience-specific projects highlighted in the peer MTPs, including most of those regions that had developed resilience-related plans. It may require one more MTP update cycle before these regions take strategies from their resilience plans and turn them into funded MTP projects.

The review also found that only two of the 17 peer MPOs had developed resilience performance measures beyond the federally required pavement and bridge condition measures. However, Clark County, Nevada's Resilient County Operations plan provides some additional examples of measures that could be adapted for regional resilience performance measurement.