



U.S. Department of Transportation
Federal Highway Administration

ADAPTATION TO CLIMATE CHANGE IN TRANSPORTATION OPERATIONS AND MAINTENANCE

Technical Staff Briefing

CLIMATE
CHANGE





- Climate change and extreme weather events
- Impacts of climate change on transportation systems management and operations (TSMO) and maintenance
- Why address climate change?
- Getting started: an adaptation framework
- Resources

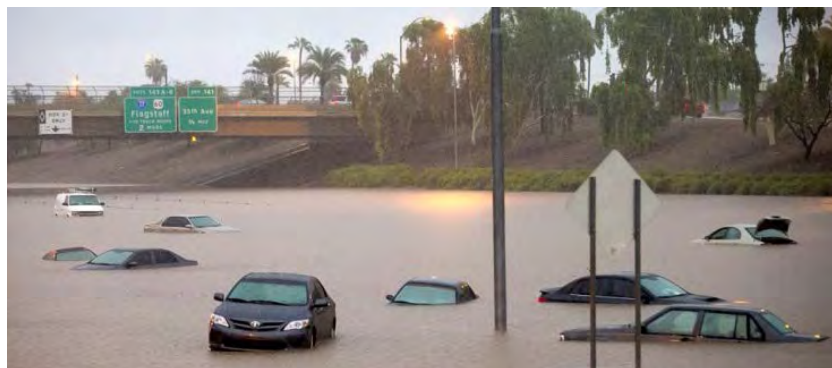


A CHANGING CLIMATE



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- DOTs are already observing and responding to the impacts of climate change
- Accelerating climate change means more frequent or more intense weather events (e.g., large storms, changes in winter precipitation, heat waves)
- These events will have critically important ramifications on the planning, design and engineering, management, operations, and maintenance of transportation facilities and services



Flooding in Phoenix in 2014.

Source:

<http://jimbakkershow.com/news/record-rainfall-causes-phoenix-flooding/>



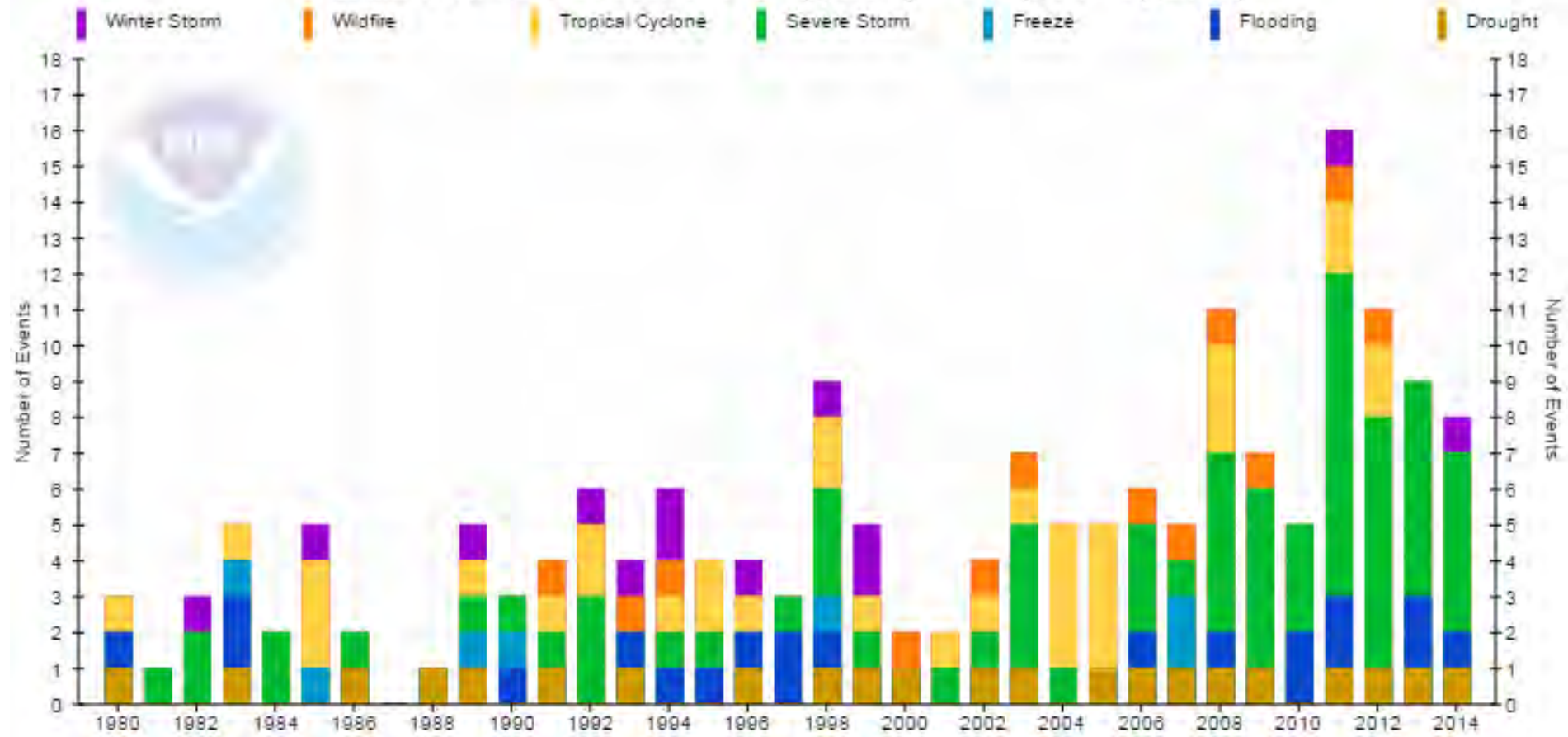
A CHANGING CLIMATE



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Extreme weather events are becoming more frequent and severe

Billion-Dollar Disaster Event Types by Year (CPI-Adjusted)



CLIMATE CHANGE



EXTREME EVENTS IN 2014



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Source: *The Daily Record*



Source: *breakingnews.com*

- Anne Arundel County in Maryland received over ten inches of rain on August 12, 2014, washing out roadways

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EXTREME EVENTS IN 2014



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Source: azcentral



Source: azcentral

- Phoenix, Arizona, broke 24-hour rainfall records with nearly three inches of rain on September 8, 2014, causing widespread flooding that closed Interstate highways

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EXTREME EVENTS IN 2014



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- Buffalo, New York, received over seven feet of snow November 17 - 21, 2014, stranding drivers in their cars



Source: *The Telegraph*



Source: *neen*

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EXTREME EVENTS IN 2014



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- California experienced a severe drought and thousands more wildfires than usual



Source: Fox News



Source: Daily News

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WEATHER, EXTREME WEATHER EVENTS, AND CLIMATE CHANGE



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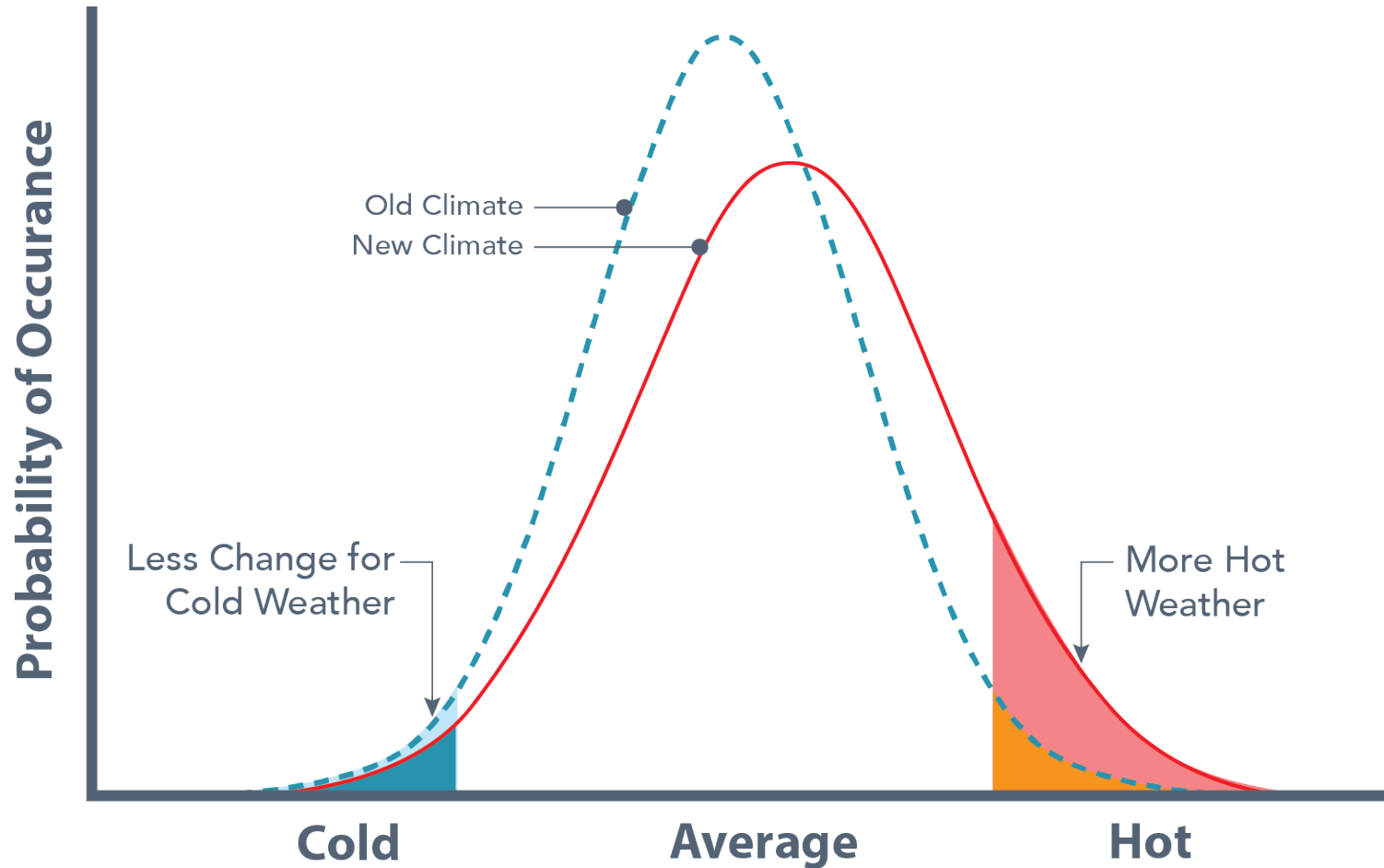
Weather refers to the atmosphere state in a particular location at a particular time

Extreme weather events refer to **significant anomalies in temperature, precipitation and winds** (e.g., heavy precipitation and flooding, heatwaves, drought, wildfires and windstorms (including tornadoes and tropical storms))

Climate change refers to any significant change in the measures of climate lasting for an extended period of time

Climate change includes major variations in temperature, precipitation, or wind patterns, among other environmental conditions, that **occur over several decades or longer** (e.g., a rise in sea level, increase in the frequency and magnitude of extreme weather events now and in the future)

CLIMATE CHANGE IS WIDENING AND SHIFTING WEATHER PROBABILITY DISTRIBUTIONS



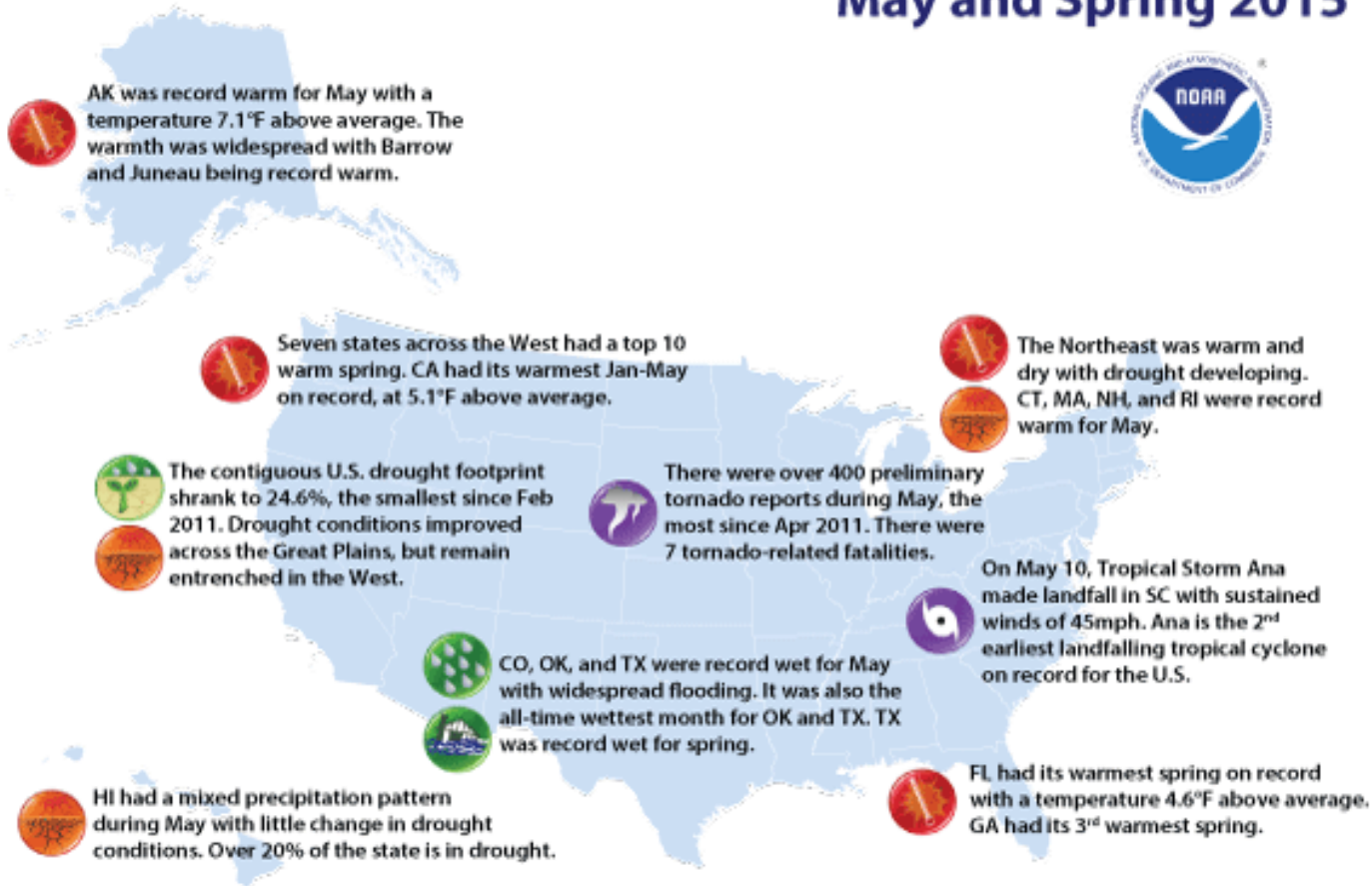
Source: Huber, Daniel G. and Gullette, Jay. 2011. "Extreme Weather and Climate Change: Understanding the Link and Managing the Risk" Science and Impacts Program. Center for Climate and Energy Solutions: Arlington, VA. Available at: <http://www.c2es.org/publications/extreme-weather-and-climate-change>

RARE WEATHER EVENTS COULD BECOME INCREASINGLY FREQUENT



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U.S. Selected Significant Climate Anomalies and Events May and Spring 2015



The average U.S. temperature during May was 60.8°F, 0.6°F above average. The spring U.S. temperature was 53.2°F, 2.2°F above average. May U.S. precipitation was 4.36 inches, 1.45 inches above average and the wettest month of any month on record. The spring precipitation total was 9.33 inches, 1.39 inches above average.

THE PAST IS NO LONGER A RELIABLE PREDICTOR OF THE FUTURE



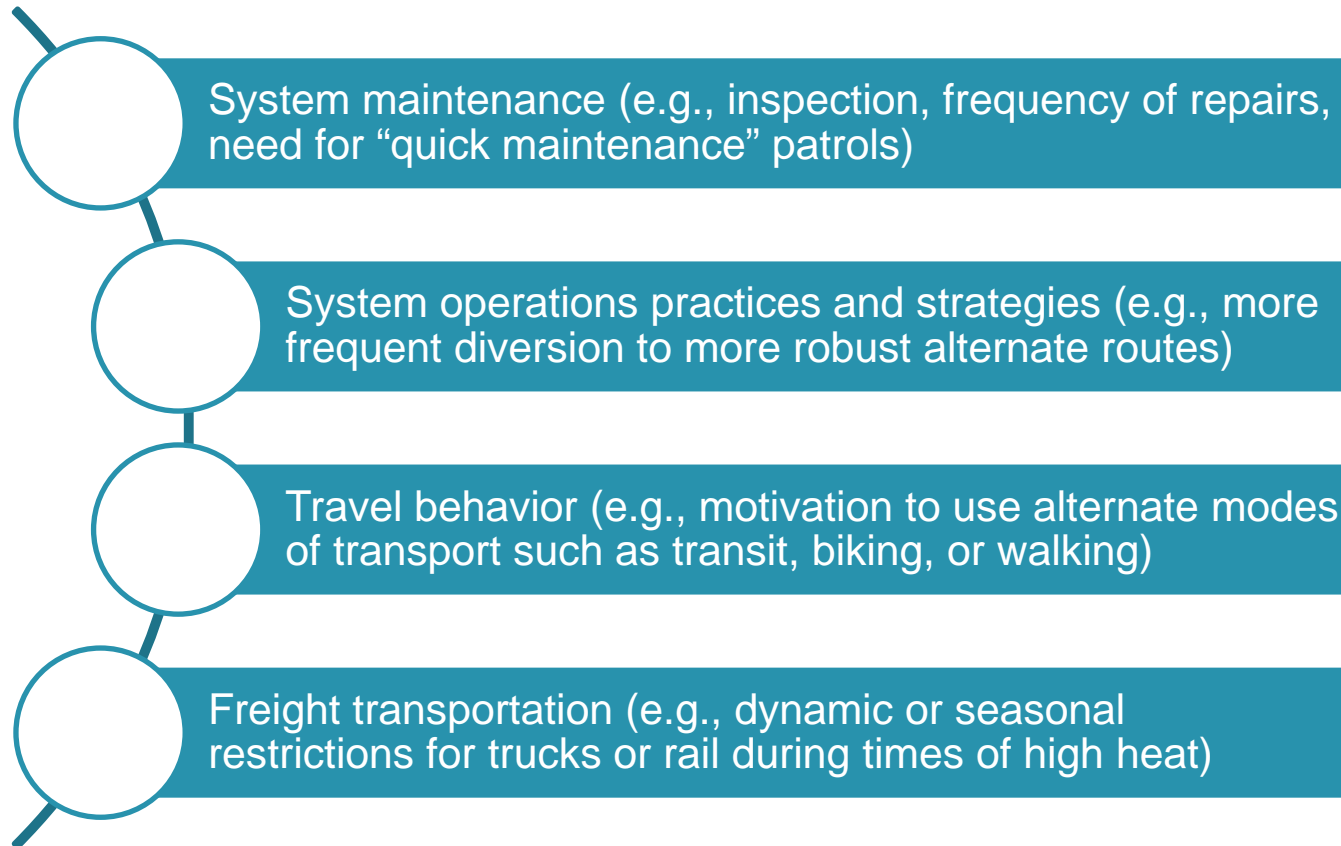
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Historical climate ≠ Future climate

- Because of climate change, historical climate is no longer a predictor of future climate
- Assumptions based on historical climate may need to be revisited
 - Expected timing of freeze/thaw, snow melt, vegetation growth
 - Rates of weather-related degradation
 - Weather conditions over asset lifetime
 - Optimal construction work times



CHANGES WILL BE NEEDED IN:



Source: FHWA, 2013, “Planning for Systems Management & Operations as part of Climate Change Adaptation,” available at: <http://ops.fhwa.dot.gov/publications/fhwahop13030/index.htm#toc>

CLIMATE CHANGE EFFECTS ON TSMO AND MAINTENANCE



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Climate changes could result in:

- Reduced roadway capacity
- Loss of alternative routes
- Decreased situational awareness (due to power/communications outages)
- Inability to evacuate
- Shortened service life (due to faster deterioration)
- Increased safety risk
- Loss of economic productivity
- Reduced mobility



Landslide from heavy rain in August 2013.
Source: TN DOT



WHY ADDRESS CLIMATE CHANGE?

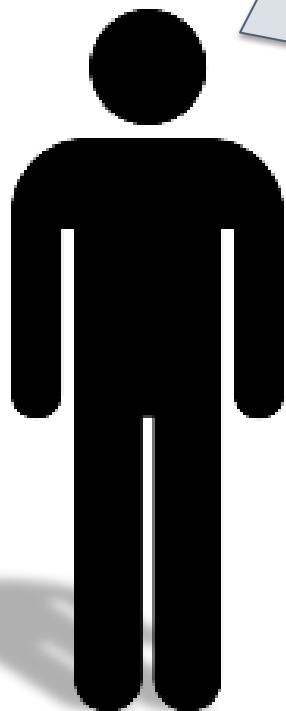


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- Climate change presents a **business risk** for transportation agencies
 - *Not addressing climate change could put transportation agencies at greater risk than changing practices now*
- TSMO is the public face of extreme weather response
- Even though many agencies are successful operators and maintainers of facilities, they still need to revisit their approach and practices given these changes

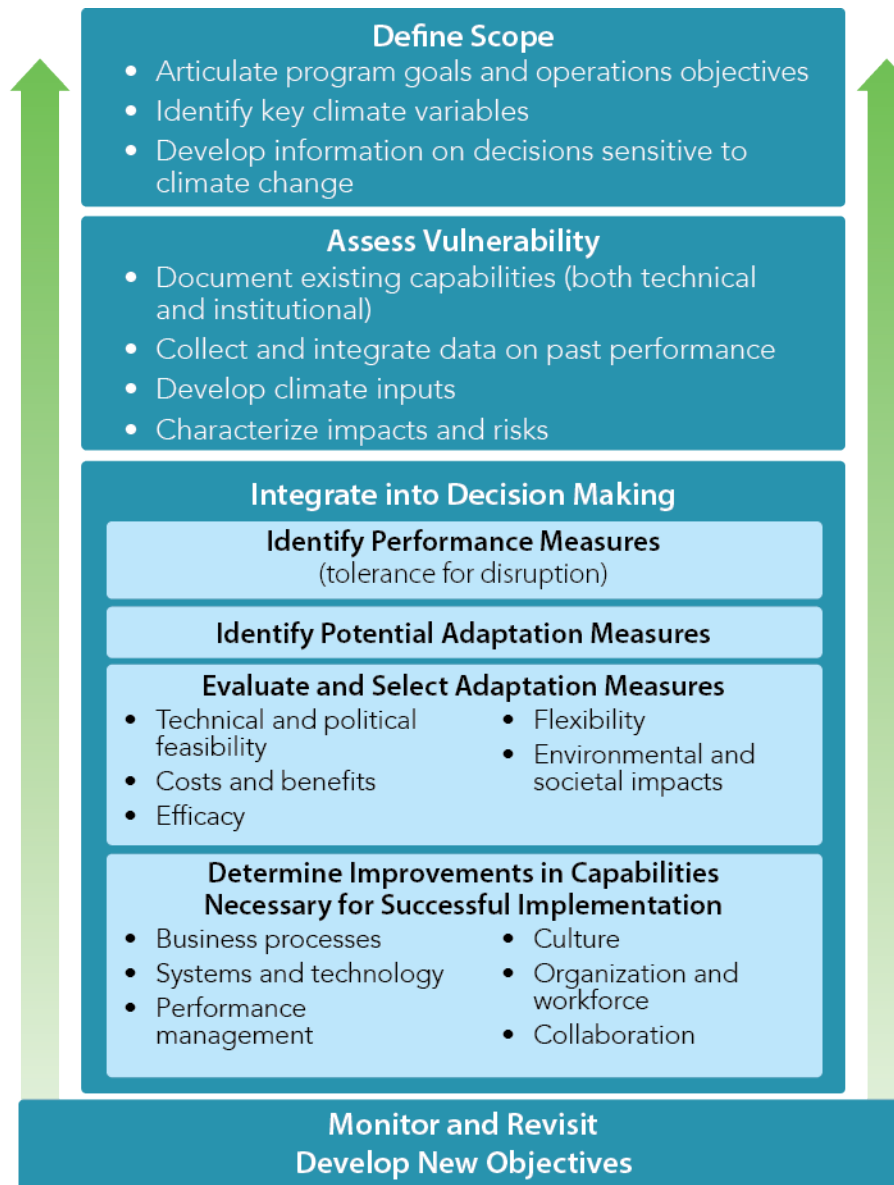


STAFF MAY BE ASKING...



- Over the last 20 years, we have gotten really good at managing winter storms. We will deal with whatever nature throws at us. **Do I need to plan for climate change?**
- My last few summers have resulted in a lot of delays in construction due to the heat. **Should I change how I bid out my projects?**
- Over the last 20 years, we've never had an ice storm, and I don't typically budget for ice removal equipment. We got one last year. **Should I invest?**
- My maintenance budgets are typically insufficient, and I end up going over each year. **How can I plan ahead and better use my limited resources?**
- We worked well together during Hurricane Sandy, but there were still a lot of challenges. **What will help us be better prepared?**

GETTING STARTED: AN ADAPTATION FRAMEWORK



Articulate Program Goals and Operations Objectives

- Define what must be achieved to ensure resilient operations
 - Include expected level of performance during adverse weather
- Determine outcome-based operations objectives

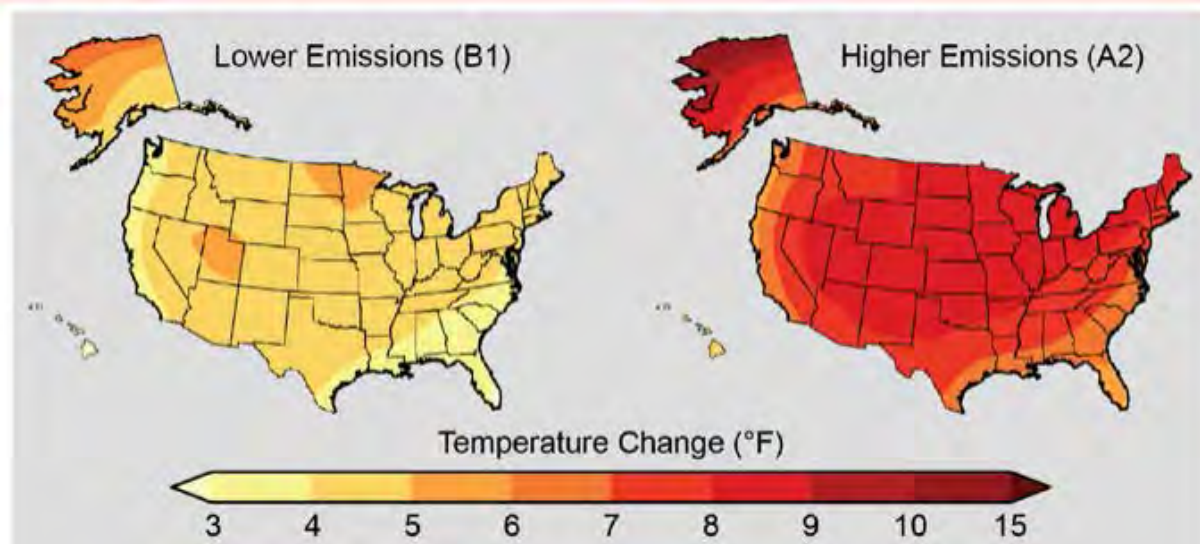
Identify Key Climate Stressors

- Which climate change stressors or extreme weather events are projected to occur locally?
- Which climate change stressors or extreme weather events could affect TSMO and maintenance programs?

DEFINE SCOPE: IDENTIFY KEY CLIMATE VARIABLES



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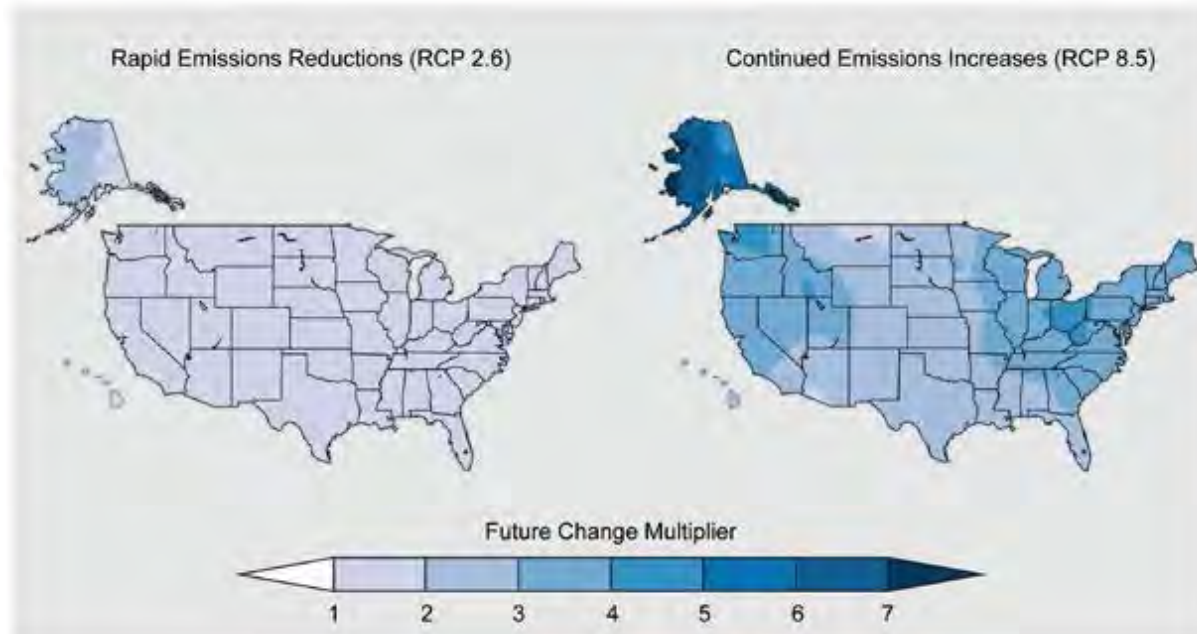


Projected Temperature Changes

Source: 3rd National Climate Assessment

Projected Change in Heavy Precipitation Events

Source: 3rd National Climate Assessment





DEFINE SCOPE

Develop Information on Decisions Sensitive to Climate Change

Decisions are climate-sensitive if their continued effectiveness could be compromised by projected changes in climatic conditions (e.g., changes in temperature, precipitation, weather patterns, and the frequency and intensity of extreme weather events)

Climate-Sensitive Decision Areas	Specific Decisions	Description
1. Plan for future workforce needs.	Determine the right level of workforce requirements and capabilities.	Operating agencies make a variety of workforce related decisions, including the number of staff required, their locations, and capabilities necessary to monitor, control, report and maintain the roadway system.
2. Plan for Operations and Maintenance investments.	Determine criteria to prioritize operational resource investments (including capital improvements).	Resource investments may include new capital improvements for operations and maintenance. They may also include investments for annual maintenance.

**CLIMATE
CHANGE**



Document Existing Capabilities (both technical and institutional)

- Document current capabilities across the six areas of the Capability Maturity Framework (CMF):

Business processes

Systems and technology

Performance management

Culture

Organization and workforce

Collaboration



Collect and Integrate Data on Past Performance

Examples of vulnerabilities:

- Loss of roadway capacity
- Loss of alternative routes
- Loss of situational awareness (due to power/communication)
- Inability to evacuate/shelter-in-place
- Loss of service life (e.g., due to faster deterioration)
- Increased safety risk
- Loss of economic productivity
- Reduced mobility



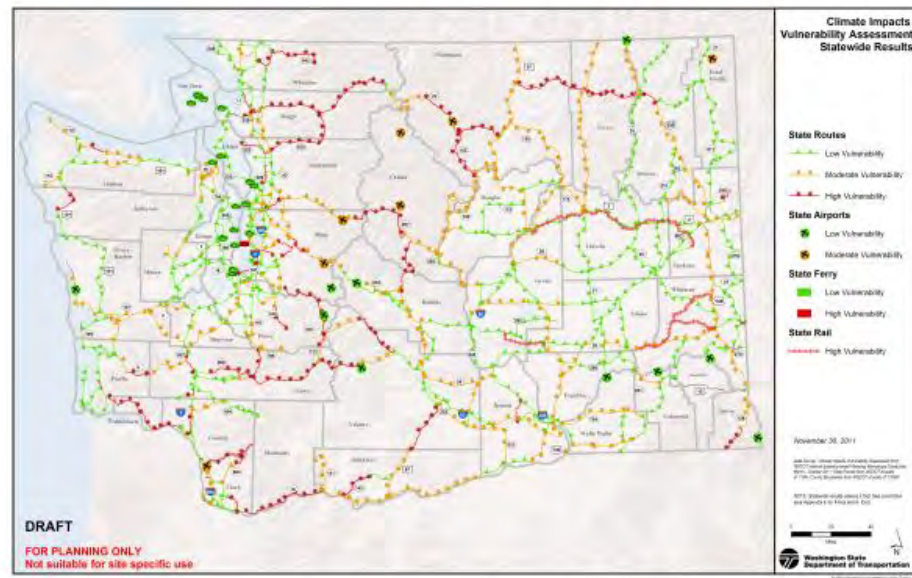
ASSESS VULNERABILITY

Develop Climate Inputs

- Determine local projected changes
- Utilize readily-available sources of information

Characterize Vulnerabilities and Risks

- Conduct a qualitative or quantitative assessment, depending on output needs



WSDOT 2010-2011 FHWA Climate Resilience Pilot Vulnerability Assessment Results.
Source: WSDOT



Identify Performance Measures

- Integrate climate change adaptation and resiliency into existing performance measures
- Adopt as stand-alone measures
- Consider whether existing measures will be achievable with a changing climate



Source: MnDOT



Identify Potential Adaptation Measures

- Consider a range of strategies
- Consider phased strategies (near-term, medium-term, long-term)
- Look for best practices in regions with experience, e.g.:
 - Southern states may look north for ice storm preparedness strategies



INTEGRATE INTO DECISION MAKING



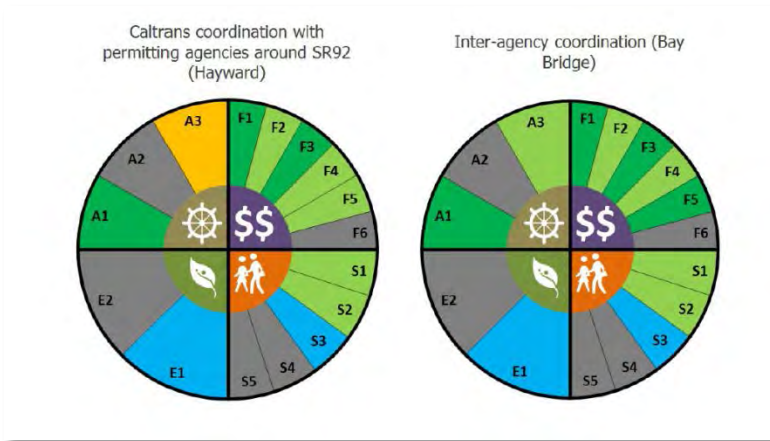
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Vulnerability	Response	Implementing Department
<p>Increased frequency of extreme events may require additional personnel to monitor, control, report, and respond to events</p> <p>Changes in long-term climate trends may also change seasonal work requirements</p>	<p>Short-term: Train staff on climate change and how this may affect their roles and responsibilities</p> <p>Medium-term: Increase availability of contract staff to assist during extreme events</p> <p>Long-term: Hire additional staff to keep pace with increasing TSMO, maintenance, and emergency management needs</p>	<p>TSMO, Maintenance, Emergency Managers</p>



Evaluate and Select Adaptation Measures

- Use relevant evaluation criteria from other agency projects and/or consider these:
 - Technical and political feasibility
 - Costs and benefits
 - Efficacy
 - Flexibility
 - Sustainability
- Circulate results and accept revisions of priorities from staff and decision makers



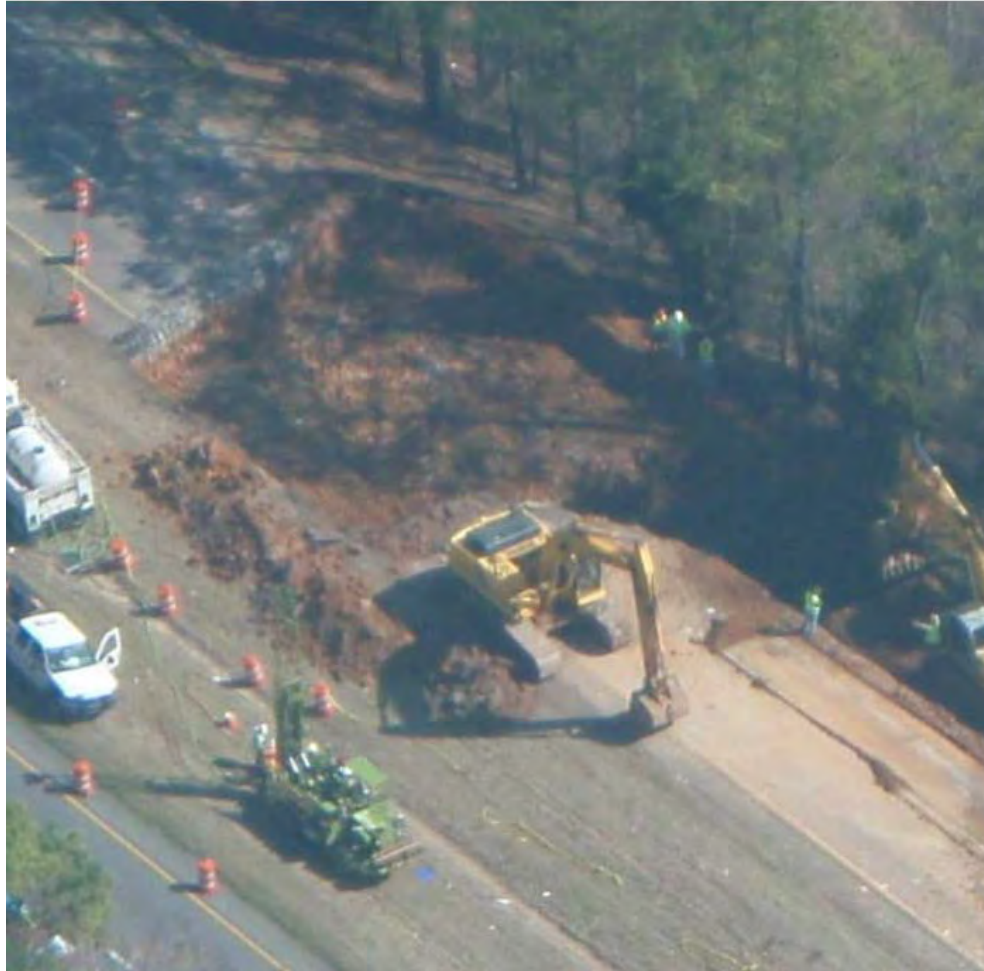
MTC 2013-2015 FHWA Climate Resilience Pilot Results of Qualitative Assessment of Adaptation Strategies. Source: MTC, *Climate Change and Extreme Weather Adaptation Options for Transportation Assets in the Bay Area Pilot Project*



CASE STUDY: ALDOT



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- Alabama experiences hurricanes, tornados, wet and dry cycles, and snow and ice events
- Pace and severity of weather events have increased in recent years, along with public expectations about levels of service
- Post-event recovery affects ability to perform regular operations
- Infrastructure damage disrupts regular operations

Source: Conner, G. 2013. ALDOT Operations and Extreme Weather Events. Presentation at AASHTO 2013 Extreme Weather Events Symposium, May 22, 2013.

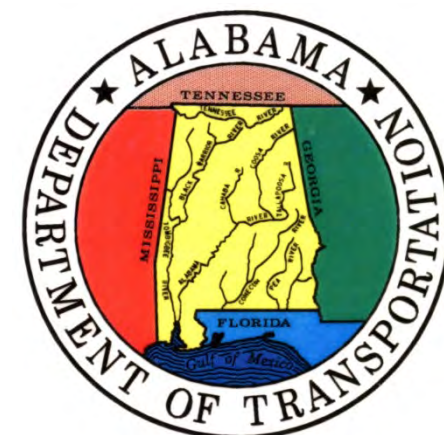


CASE STUDY: ALDOT



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- Renewed emphasis on emergency management (EM)
 - Created full-time EM position
 - Improved relationship with state EM agency
 - Increased recurring emergency training
- Focused on “smaller” solutions
 - Portable Highway Advisory Radios (HARs)
 - Coordination across and between divisions
 - Procuring less specialized equipment
- Improved dissemination of road condition information in everyday and extreme events



Source: Conner, G. 2013. ALDOT Operations and Extreme Weather Events. Presentation at AASHTO 2013 Extreme Weather Events Symposium, May 22, 2013.



Improvements in Capabilities Necessary for Implementation

- Successful implementation of adaptation measures may require more overarching enhancements to the agency’s capabilities

Adaptation Strategies	CMF Category							Maintenance
	Business processes	Systems & Technologies	Performance Management	Culture	Organization & Workforce	Collaboration		
Develop climate resilient design guidelines	X	X		X		X	X	
Track weather-related trends and costs over time	X	X	X					
Establish stand-by contracts for extreme event response	X				X			
Consider the life-cycle costs of resiliency investments and savings in budgeting and design	X							



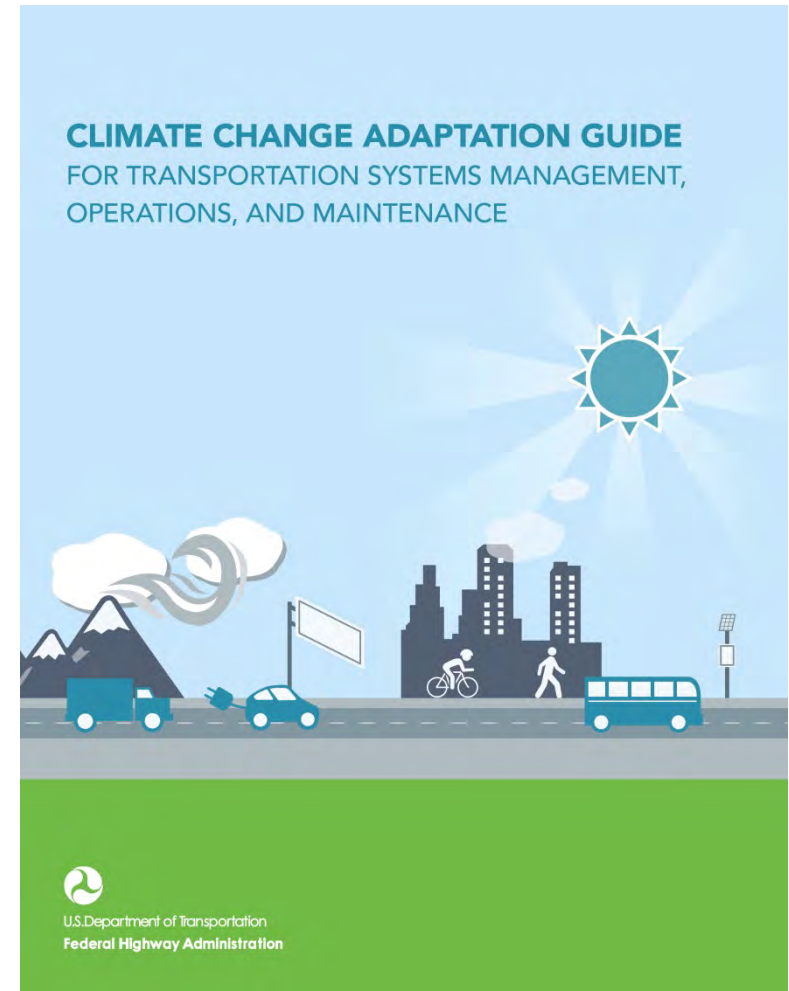
Monitoring and evaluation helps keep adaptation efforts on track as:

- New information on climate risks emerges
- Evidence of the effectiveness of adaptation strategies becomes available
- Other programmatic changes occur

Key steps include:

- Establish a monitoring and evaluation plan
- Engage stakeholders
- Monitor and collect data on relevant indicators
- Evaluate the project and its outcomes
- Revisit

- Guide developed to lead State/local DOTs and MPOs in adopting climate change adaptation strategies at the institutional, technical, and financial levels for their TSMO and maintenance programs.
- Available at:
<http://www.ops.fhwa.dot.gov/publications/fhwahop15026/index.htm>





WHAT'S IN THE GUIDE?



- How to obtain buy-in
- Risk assessment checklists and guidance
- Climate change focused performance measures
- How to track progress over time
- Existing benefit-cost assessment tools
- Matrix of climate sensitive decisions
- Sample handout for workshop on climate risk
- Gap assessment for climate ready TSMO and maintenance
- Glossary of terms

Figure 2. Diagram. Overlapping Responsibilities of Different Transportation Agency Offices.

A. Who Should Use this Guide?

This guide is meant for practitioners involved in the day to day management, operations, and maintenance of surface transportation systems at State and local agencies. Climate change will affect different offices and their varying responsibilities in different ways. As shown below in Figure 1, some responsibilities among this staff are also overlapping and will require coordination. For example, DOT emergency management staff and TSMO staff need to coordinate during an emergency to provide accurate and up-to-date traveler information. In some DOTs, staff may serve both a TSMO and maintenance function. All staff might have a role in major emergencies. In a majority of functional areas, TSMO and maintenance depend on the collaboration between multiple agencies.

Unless otherwise specified, the content in the guide is applicable to all:

- State and local DOT TSMO and maintenance managers.
- State and local DOT planning staff.
- Metropolitan planning organization (MPO) staff.
- State and local DOT emergency management staff.

B. How Will this Guide Help Agencies Adapt?

The guide provides the rationale and specific guidance for integrating the capability for climate change adaptation and extreme weather response into TSMO and maintenance programs. It also articulates why doing so will lead to greater sustainability.

OPERATIONS GUIDE BOOK | 2



OTHER RESOURCES



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FHWA VIRTUAL ADAPTATION FRAMEWORK

- Organized around FHWA Vulnerability Assessment Framework key steps
- For each key step, includes guidance, training videos, case studies, related resources, and tools
- Available at: www.fhwa.dot.gov/environment/adaptationframework/

Climate Change & Sustainability
Adaptation

Virtual Framework for Vulnerability Assessment

1. Define Scope

- Identify Key Climate Variables
 - Climate impacts of concern
 - Sensitive assets & thresholds for impacts
- Articulate Objectives
 - Actions motivated by assessment
 - Target audience
 - Products needed
 - Level of detail required
- Select & Characterize Relevant Assets
 - Asset type
 - Existing vs. planned
 - Data availability
 - Further delineate

2. Assess Vulnerability

Collect & Integrate Data on Assets

Develop Climate Inputs

Assess Asset Criticality (Optional)

Identify & Rate Vulnerabilities

Develop Information on Asset Sensitivity to Climate

Incorporate Likelihood & Risk (Optional)

Monitor and Revise!

3. Integrate into Decision Making

- Incorporate into Asset Management
- Integrate into Emergency & Risk Management
- Contribute to Long Range Transportation Plan
- Assist in Project Prioritization
- Identify Opportunities for Improving Data Collection, Operations or Design
- Build Public Support for Adaptation Investment
- Educate & Engage Staff & Decision Makers

Introductory Video

Overview of NEPA as Applied to Vulnerability Assessment

This short video provides an overview of FHWA's Climate Change and Extreme Weather Vulnerability Assessment Framework, and describes the benefits of conducting a vulnerability assessment.

Recent Case Studies

- Washington State Department of Transportation Case Study

Recent Tools and Documents

- NEV-DCP 30 Climate Data Viewer



FOR MORE INFORMATION



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For national-level questions, please contact:

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