

Developing a Resilient Texas Transportation System

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Transportation Resiliency Forum

- Forum Objectives:
 - Review state-of-the-practice in resiliency research in Texas
 - Discussed Texas Transportation Resiliency Framework
 - Identify steps and research needed/ gaps in developing Texas Transportation Resiliency Framework

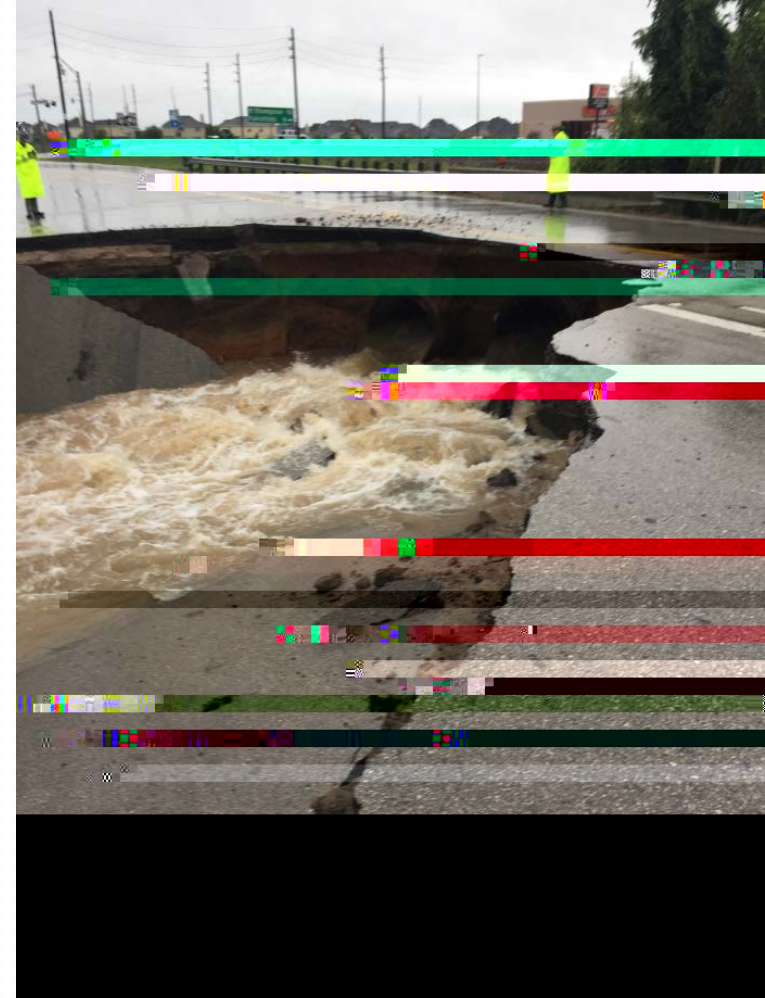


Transportation Resiliency Forum

- Morning Session
 - “FHWA Resiliency Framework for Extreme Weather Events” (FHWA)
 - “Ecological Resiliency: Lessons for Transportation” (TTI)
 - “Emerging Issues in Resiliency to Weather and Climate” (Texas A&M University)
 - “Network-Level Analysis of Transportation Resilience” (Texas A&M University)
 - “Transit-Oriented, High-Interaction Neighborhoods Key to a Resilient Transportation System” (Texas A&M University)
 - “Coastal Shipping Resiliency Following Major Hurricanes and Trains in Coastal Crosswinds” (Texas A&M University)
 - “Understanding the Influence of Climate Change on Texas Pavements” (University of Texas at El Paso)
 - “Combined Sustainability — Resiliency (S-R) Framework for Assessing Three Transportation Infrastructure Case Studies” (University of Texas at Arlington)

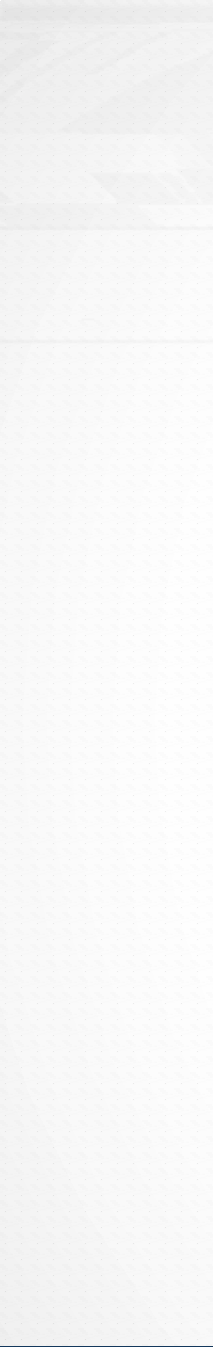
Transportation Resiliency Forum

- Afternoon Session
 - Characteristics of desired resilient transportation system
 - Vulnerable transportation system components
 - Data/tools
 - To understand, assess and predict impacts of long-term trends on resiliency
 - To quantify impacts of extreme events and options for mitigation, recovery, and adaption



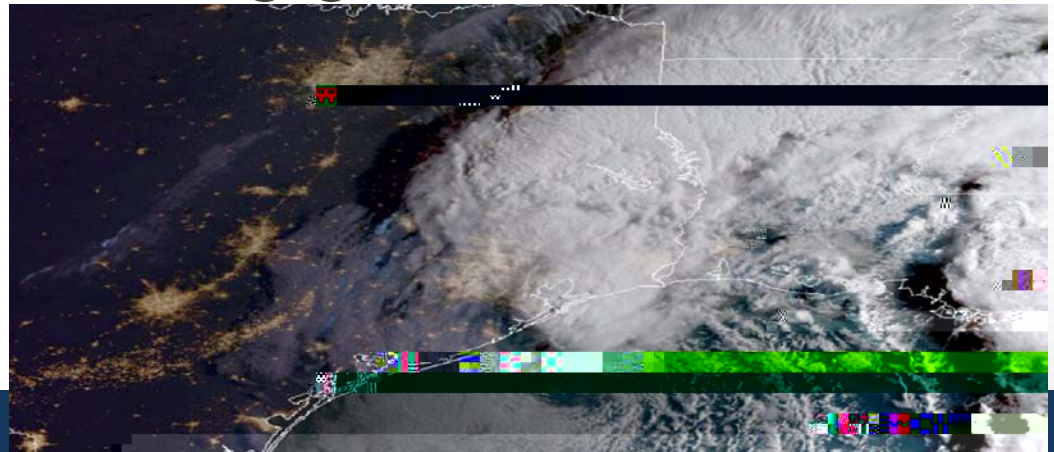
Resilient Texas Transportation Planning Framework

1. Define resiliency for Texas' transportation system
2. Identify resiliency goals and objectives
3. Identify resiliency performance measures
4. Assess vulnerability of Texas' transportation system
5. Assess/quantify adaption, mitigation and recovery options



2. Identify Resiliency Goals/Objectives

- Develop standalone resiliency goal
 - Maintain critical function after extreme weather event
 - Minimize recovery time
 - Minimize infrastructure damage/operational impacts
- Adapt existing planning goal to include resiliency objectives





4. Assess Vulnerability

- a. Identify and characterize extreme weather events of concern
- b. Determine risk/likelihood of extreme weather events occurring
- c. Identify vulnerable transportation system elements
- d. Determine potential impact of extreme weather event if occurring
- e. Identify the critical transportation assets

4a. Identify and characterize extreme weather events of concern

Projected Climate Impacts (All Texas Counties)

Climate Factor	Projected Impact
Precipitation	<ul style="list-style-type: none"> x > 1- to 3-day increase in number of wettest days (low emissions assumptions) x > 1- to 3-day increase in number of wettest days (high emissions assumptions) x > 1- to 3-day increase in monthly runoff
Extreme heat/higher temperature	<ul style="list-style-type: none"> x < 1- to 34-day increase in the number of hottest days x 1- to 3-day increase in annual mean maximum temperature
Drought	<ul style="list-style-type: none"> x < 1- to 3-day increase in the number of consecutive dry days at a time x 1- to 3-day reduction in mean annual soil storage x Potential increase in drought conditions
Extreme weather events	<ul style="list-style-type: none"> x Potential for more severe storms
Sea-level rise (Gulf of Mexico)	<ul style="list-style-type: none"> x 1- to 3-foot increase in sea level rise (low emissions assumptions)

4d. Determine potential impact of extreme weather event if occurring

Climate Stressors	Examples of Impacts on Transportation Infrastructure and Operations
Increases in very hot days and heat waves	<ul style="list-style-type: none"> x d Z Œ u o Æ % v •] } v } v Œ] P Æ % v •] } v i }] v š • v % À • μ C x Concerns about pavement degradation rates, traffic-related rutting, and migration of liquid asphalt x Railtrack deformities x Limits on periods of construction activity due to health and safety concerns
Sea level rise combined with storm surges	<ul style="list-style-type: none"> x Inundation of roads, rail lines and airport runways in coastal areas x Erosion of road base and bridge supports x Reduced clearance under bridges, and changes in harbor and port facilities to accommodate high tides and storm surges x More frequent interruptions to coastal and low-lying roadway travel and rail service due to storm surges x More severe storm surges and wave heights, requiring evacuation
Increases in intense precipitation events	<ul style="list-style-type: none"> x Increases in weather-related delays and traffic disruptions x Increased flooding of evacuation routes x Increases in road washout, damages to road support structures, and landslides and mudslides that damage roadways and tracks x Increases in scouring of pipeline roadbeds and damage to pipelines
Increase in frequency of intense hurricanes	<ul style="list-style-type: none"> x Greater probability of infrastructure failures x Increased threat to stability of bridge decks x Impacts on harbor infrastructure from wave damage and storm surges

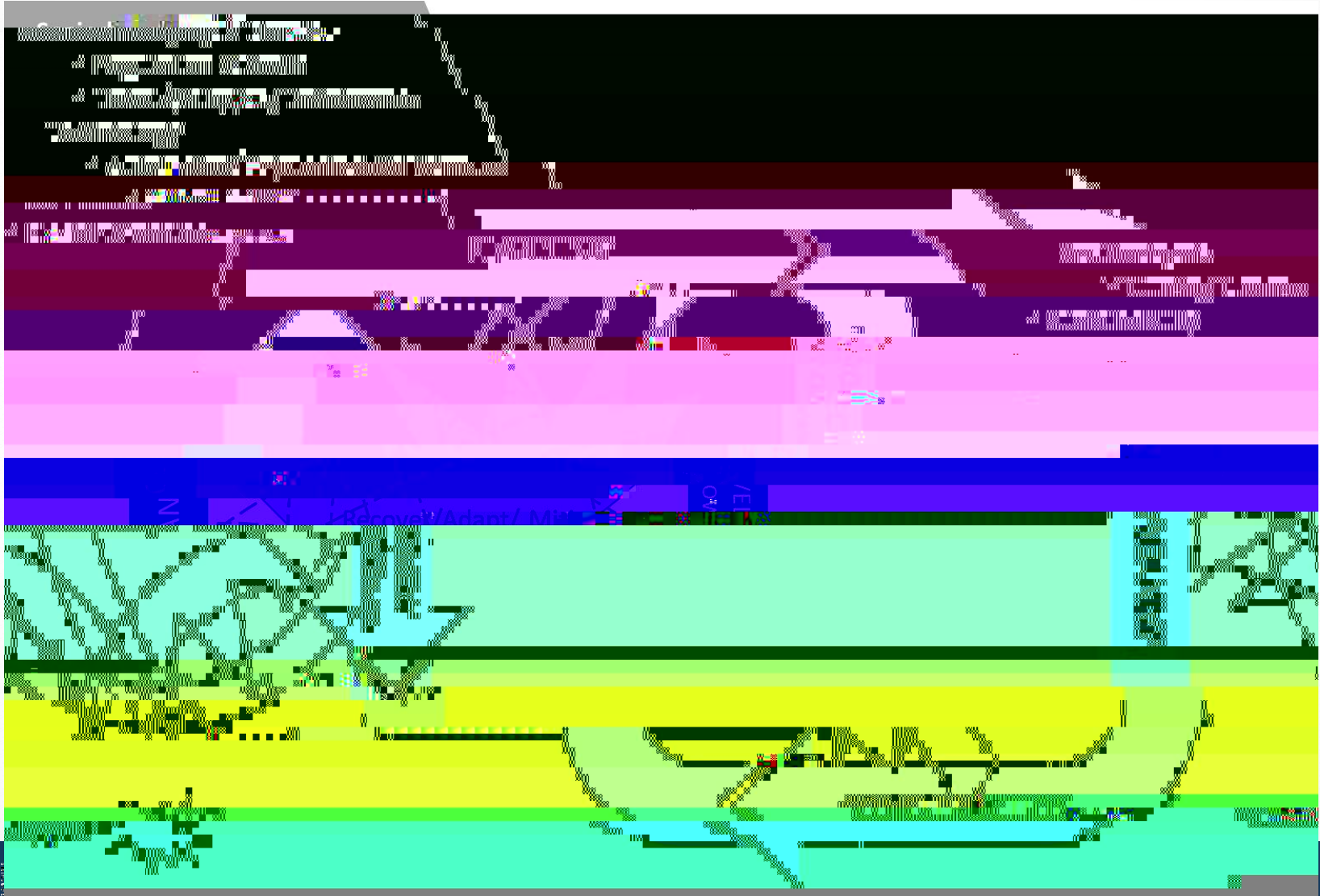


5. Identify Adaption, Mitigation, Recovery Options

- Build/rebuild assets to withstand anticipated environmental conditions
- Site new facilities outside floodplains or reconstruct at-risk highways considering more conservative flood frequency event assumptions
- Increase system redundancy
- More frequent maintenance schedules

5. Identify Adaption, Mitigation,

Inform Project Development and Management



Past and Ongoing Research

- Vulnerable Freight Infrastructure in Texas
- Applying Resilience Theory to Transportation Problems
- Update Rainfall Coefficients with 2018 NOAA Atlas 14 Rainfall Data (Ongoing)
- Developing a Resilient Texas Transportation System
- Asset Management, Extreme Weather, and Proxy Indicators (FHWA Pilot Project)
- Addressing Resiliency in Regional Transportation Plans (Ongoing)

Lessons Learned

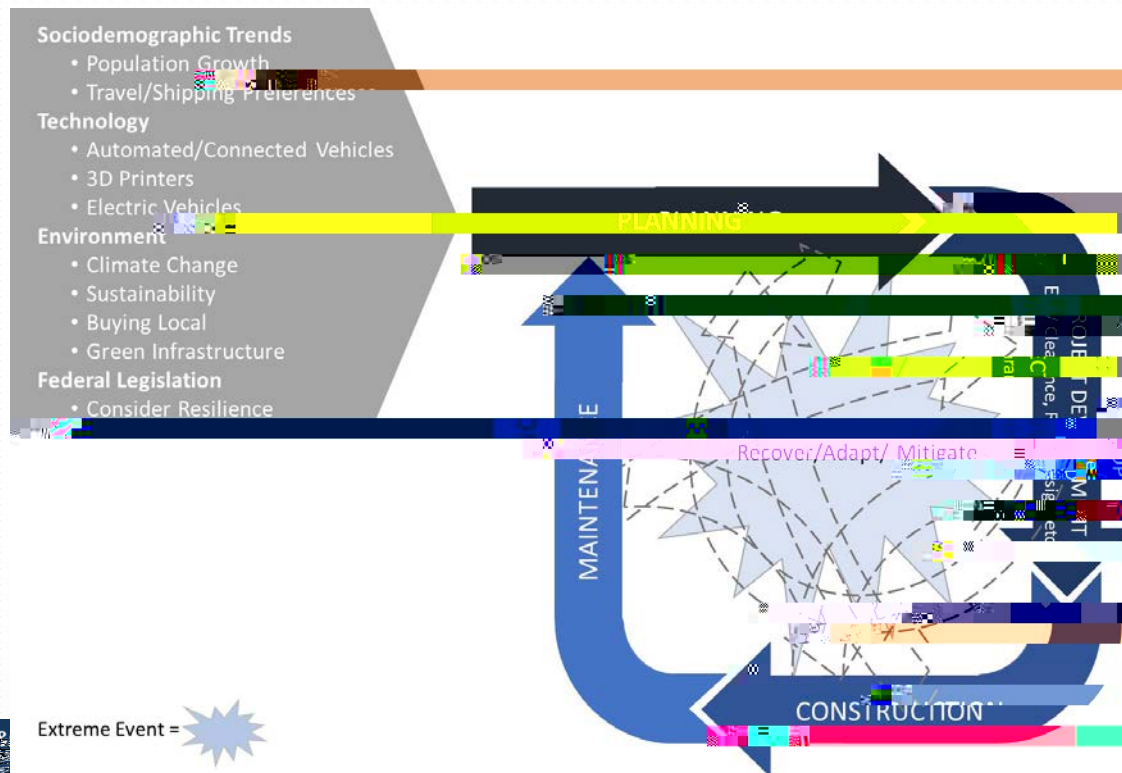
1. Frameworks are important

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Lessons Learned

1. Frameworks are important

$\frac{3}{4}$ Guide planning, programming, design, construction, and maintenance of transportation system



Lessons Learned

1. Frameworks
are important
 - $\frac{3}{4}$ Assess risk to
specific asset



Lessons Learned

3. Data and models/tools are important

$\frac{3}{4}$ Data (too much, not enough, not quite right)

$\frac{3}{4}$ Tools/models

- í Understanding pavement impacts - more frequent maintenance of culverts, improved drainage, adding shoulders to mitigate flooding on pavement service life (heat?)

- í Lifecycle planning analysis does not consider the cost and disruption of road closures

- í

Lessons Learned

3. How to plan?

$\frac{3}{4}$ Feedback into planning process

Questions?

