Session 1: Determining Assets to Study and Using Climate Information

May 16, 2013

Missouri River flooding, Jefferson City, Missouri
Photo: Missouri DOT
Agenda

Intro to Vulnerability Assessment Framework  Becky Lopes  
FHWA Office of Natural Environment

Assessing Criticality of Transportation Assets  Mike Flood  
Parsons Brinckerhoff

Developing Projected Climate Information for Transportation Asset Analysis  Joel Smith  
Stratus Consulting

Case study: Gulf Coast II SLR and Storm Surge Projections  Rob Kafalenos  
FHWA Office of Natural Environment

Q & A Session
Introduction to Vulnerability Assessment Framework

Becky Lupes
Federal Highway Administration
Sustainable Transport & Climate Change Team
Vulnerability Assessments

- Understanding how climate change effects and extreme weather will affect your transportation network is key first step for climate change planning
FHWA’s Climate Change and Extreme Weather Vulnerability Assessment Framework (December 2012)
Climate Change & Extreme Weather Vulnerability Assessment Framework

1. Define Project Scope
   • Objectives
   • Relevant Assets
   • Climate Variables

2. Assess Vulnerability
   • Climate Inputs
   • Asset data, criticality, sensitivity
   • Vulnerabilities, risk

3. Integrate Vulnerability Into Decision Making
Defining Project Scope

ARTICULATE OBJECTIVES
• What actions are motivated by the assessment?
• Who is the target audience?
• What products are needed?
• What level of detail required?

MTC Pilot Study Area
Defining Project Scope

**Select & Characterize Relevant Assets**

- Asset type
- Existing vs. planned
- Data availability
- Further delineate
  - Critical assets?
  - Owned or managed assets?
Defining Project Scope

**IDENTIFY KEY CLIMATE VARIABLES**

- Climate impacts of concern
- Sensitive assets & thresholds for impacts
Assessing Vulnerability

- Develop Climate Inputs
- Collect and Integrate Data on Assets
- Assess Asset Criticality
- Develop Information on Asset Sensitivity to Climate
- Identify and Rate Vulnerabilities
- Incorporate Likelihood and Risk
Integrate Results into Decision Making

- Identify, analyze, and prioritize adaptation options;
- Incorporate assessment results into programs and processes

• **INTEGRATE 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 DESIGNS**
• **BUILD PUBLIC SUPPORT FOR ADAPTATION INVESTMENT**
• **EDUCATE & ENGAGE STAFF & DECISION MAKERS**
2013-2014 Pilot Locations
Assessing Criticality of the Transportation System

Michael Flood
Parsons Brinckerhoff
Presentation Outline

- Define Usage of Criticality
- Why Determine Critical Systems?
- Discuss Various Methodologies for Determining Critical Facilities
What is Critical?

- Parsing the definition– not those at high risk (critical)
- Instead the focus is - those components of the transportation network that serve functions important (critical) to the viability of the local/regional/state system
Why Ask the Question?

- To Determine Where to Focus Limited Resources on Studies or Projects
- Could Also Be Used To Help Set Agency Policies on Risk Tolerance
Methods to Approach

- **Desktop Method**
  - Determine factors that define network criticality and measure across the system

- **Stakeholder Method**
  - Work with local stakeholder groups to identify critical transportation systems

- **Hybrid Approach**
  - Apply assessment methodology and involve stakeholders to resolve final determinations
Some Drawbacks of Each Method

- **Desktop Method**
  - Can fail to reflect local input
  - Lack of data for private entities for multimodal assessments

- **Stakeholder Method**
  - No assessment basis, can be affected by personal preference
  - Facilitation methods can impact results
“Collected assets were organized into tiers of criticality, from “Low” to “Extreme” based on their respective roles in connecting critical destinations—in this case approximated by a combination of population and job density.”

*Climate Change Vulnerability and Risk Assessment of New Jersey’s Transportation Infrastructure*

http://www.njtpa.org/plan/Element/Climate/documents/CCVR_REPORT_FINAL_4_2_12_ENTIRE.pdf
Four screening criteria were used .... (1) assets on hurricane evacuation routes; (2) assets that carry high traffic volume (AADT > 10,000 vehicles/day); (3) assets that represent a maintenance priority route (e.g. snow removal priority route); and (4) those that are at low-lying elevations.”

**Desktop Example: Washington DOT**

### Criticality of asset

Notice that along with the qualitative terms there is an associated scale of 1 to 10, this is to serve as a facilitation tool for some people who may find it useful to think in terms of a numerical scale – although the scoring by each individual is of course subjective. The scale is a generic scale of criticality where “1” is very low (least critical) and “10” is very critical.

<table>
<thead>
<tr>
<th>Very low to low</th>
<th>Moderate</th>
<th>Critical to Very Critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
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<td>6</td>
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<td>8</td>
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<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

**Typically involves:**

- Non-NHS
- Low-AADT
- Alternate routes available

**Typically involves:**

- Some-NHS
- Non-NHS
- Low-to-medium AADT
- Serves as an Alternate for other State routes

**Typically involves:**

- Interstate
- Lifeline
- Some-NHS
- Sole Access
- No Alternate routes

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*Climate Impacts Vulnerability Report – WSDOT*

Available at: [http://www.wsdot.wa.gov/SustainableTransportation/adapting.htm](http://www.wsdot.wa.gov/SustainableTransportation/adapting.htm)
Example Hybrid Approach:

Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study

Gulf Coast II
What was the Purpose of This Effort?

Determine Subset of Entire Transportation Network on Which to Perform Vulnerability Assessment and Identify Adaptive Measures
Establishing a Consistent Methodology Across Modes

What is “critical” infrastructure in the Mobile region?

Effort to define a process applicable to Highways, Rail, Airports, Ports, Pipelines, and Transit
Assessment of Transportation Systems

Key Aspects of Critical Infrastructure (Theory)

- **Socio-Economic**
- **Operational**
- **Health and Safety**

Assessment Developed Looked at Three Categories

- Access to Employment Centers, Hospitals, etc.
- Distribution Centers
- Multimodal Centers
- Access to Employment Centers, Hospitals, etc.

FUNCTION

CONNECTION
Connecting Mobile to the Region & Nation
Methodology To Define Critical Infrastructure

Socio-Economic Assessment

- Serves Regional Economic Centers
- Availability of Redundant System
- Provides Community Connection

Infrastructure Important to the Functioning of the Region
Methodology To Define Critical Infrastructure

Operational Considerations
- Identify the components of critical infrastructure from a modal perspective
  - Functional Classification
  - Usage
  - Operations and Maintenance
  - Freight Route
  - Control and Enforcement Centers
Methodology To Define Critical Infrastructure

Health and Safety
- Emergency evacuation
- Disaster relief
- Disaster recovery
- Access to Hospital Facilities

Both severe events and longer-term environmental changes are considered
Methodology To Define Critical Infrastructure

Bringing it All Together

- Applying critical infrastructure tools:
  1. Delineate important assets
  2. Develop scoring summary based on available data
  3. Apply engineering judgment to fill data gaps

<table>
<thead>
<tr>
<th>Facility</th>
<th>Socioeconomic - Locally Identified Priority Corridors</th>
<th>Socioeconomic - Functions as Community Connector</th>
<th>Socioeconomic - System Redundancy</th>
<th>Socioeconomic - Services Regional Economic Centers</th>
<th>Operational - Functional Classification (Interstate, etc.)</th>
<th>Operational - Intermodal Connectivity</th>
<th>Health &amp; Safety - Identified Evacuation Route</th>
<th>Health &amp; Safety - Component of Disaster Relief and Recovery Plan</th>
<th>Health &amp; Safety - Component of National Defense System</th>
<th>Health &amp; Safety - Provides Access to Health Facilities</th>
<th>Criticality Score: (L - Low, M - Medium, H - High)</th>
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</thead>
<tbody>
<tr>
<td>Airport Blvd (West of Snow Rd)</td>
<td>1</td>
<td>1</td>
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<td>2</td>
<td>2</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>L</td>
</tr>
<tr>
<td>Airport Blvd (East of Snow Rd)</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>H</td>
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</table>
### Methodology To Define Critical Infrastructure

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>H</td>
<td>Criticality Score: H - High</td>
</tr>
<tr>
<td>M</td>
<td>Health &amp; Safety - Component of National Defense System</td>
</tr>
<tr>
<td>L</td>
<td>Health &amp; Safety - Provides Access to Health Facilities</td>
</tr>
<tr>
<td>1</td>
<td>Health &amp; Safety - Component of Disaster Relief and Recovery Plan</td>
</tr>
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</tr>
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<tr>
<td>3</td>
<td>Operational - Intermodal Connectivity</td>
</tr>
<tr>
<td>3</td>
<td>Operational - Functional Classification [Interstate, etc.]</td>
</tr>
<tr>
<td>3</td>
<td>Socioeconomic - Serves Regional Economic Centers</td>
</tr>
<tr>
<td>1</td>
<td>Socioeconomic - System Redundancy</td>
</tr>
<tr>
<td>1</td>
<td>Socioeconomic - Functions as Community Connection</td>
</tr>
<tr>
<td>1</td>
<td>Socioeconomic - Locally Identified Priority Corridors</td>
</tr>
<tr>
<td></td>
<td>Score</td>
</tr>
</tbody>
</table>

- **Socioeconomic - Locally Identified Priority Corridors**
- **Socioeconomic - Functions as Community Connection**
- **Socioeconomic - System Redundancy**
- **Socioeconomic - Serves Regional Economic Centers**
- **Operational - Functional Classification [Interstate, etc.]**
- **Operational - Usage**
- **Operational - Intermodal Connectivity**
- **Health & Safety - Identified Evacuation Route**
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- **Health & Safety - Component of National Defense System**
- **Health & Safety - Provides Access to Health Facilities**
- **Criticality Score: [L - Low, M - Medium, H - High]**
Methodology To Define Critical Infrastructure

Highway Assessment Included “Redundancy” Test

- Applied SARPC Forecasting Model
  1. Test loss of selected links in highway network
  2. Based on V/C ratios for Peak Hour
  3. Determine whether remainder of system can accommodate travel effectively
Methodology - Critical Infrastructure - Rail

Assessment by All Operators

- CSX Transportation
- Norfolk Southern
- Canadian National
- Alabama and Gulf Coast Rail
- Terminal Alabama Railroad State Docks (TASD)

Yards and Shops Included
Field Review Conducted to Fill Data Gaps
Findings - Critical Infrastructure - Rail

Criticality Results

- CSX Transportation
  - M&M and NO&M subdivisions
  - Sibert Yard
- Norfolk Southern
- Terminal Alabama Railroad
  State Docks (TASD)
  - Main Docks Complex
  - TASD Interchange Yard
  - McDuffie Terminal
FHWA Climate Change and Extreme Weather Vulnerability Assessment Framework

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
   - Develop Information on Asset Sensitivity to Climate
   - Identify & Rate Vulnerabilities
   - Incorporate Likelihood & Risk (Optional)

3. INTEGRATE INTO DECISION MAKING
   - INTEGRATE INTO ASSET MANAGEMENT
   - INTEGRATE INTO EMERGENCY & RISK MANAGEMENT
   - CONTRIBUTE TO LONG RANGE TRANSPORTATION PLAN
   - ASSIST IN PROJECT PRIORITIZATION
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   - EDUCATE & ENGAGE STAFF & DECISION MAKERS

Assess Asset Criticality (Optional)
Why Optional?

- May Want to Focus on ALL Assets
  - MTC (San Francisco)
- Can Be a Politically Unpalatable Process
- Might Apply During Regular Processes
  - Long Range Plan Development
Where to Find More Information

FHWA Vulnerability Assessment Framework
http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/vulnerability_assessment_framework/

Assessing Criticality in Transportation Adaptation Planning - FHWA
Use of Climate Change Information in Assessing Vulnerability of Your Transportation System

Joel B. Smith
Stratus Consulting Inc.

Transportation, Climate Change, and Extreme Weather Vulnerability Assessment:
Getting Started – Determining Assets to Study and Use Climate Information
May 16, 2013
The Challenge of Using Information on Climate Change

• … is we cannot forecast the exact changes
• We know the climate is changing
• We vaguely know how it will change
  – E.g., higher temperatures, sea levels, intense precipitation
• But we cannot make an accurate forecast of precisely how it will change
• So, how do we assess vulnerability?
Two Approaches for Assessing Vulnerability

- The scenario approach
  - Applies a “top-down” perspective

- The threshold approach
  - Based primarily on a “bottom-up” perspective
  - But also draws on top-down scenarios
The Scenario Approach

• We use scenarios of climate change to put an envelope around the uncertainty
• The scenarios should reflect ranges of:
  – Different GHG emissions
  – Different changes in the Earth’s climate
  – Different changes in regional climate
Stressor Scenarios: NJ TPA

- To address uncertainty, used a bracketed range of projections
- Based on a combination of climate models (GCMs) and emissions scenarios, yielded three scenarios:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Emission scenario</th>
<th>Sensitivity $(2 \times \text{CO}_2)$</th>
<th>GCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>B1</td>
<td>1.5°C</td>
<td>MIROC-MED</td>
</tr>
<tr>
<td>Mid</td>
<td>A1B</td>
<td>3.0°C</td>
<td>Ensemble</td>
</tr>
<tr>
<td>High</td>
<td>A2</td>
<td>4.5°C</td>
<td>GISS-ER</td>
</tr>
</tbody>
</table>
Days Above 95°F (ca 1990)
Days Above 95°F (A2 Scenario, 2100)

Average Annual Number of Days Exceeding 95°F

- Climate station
- A2 Scenario, 2100
- High: 60
- Low: 49
Change in 100-yr Precipitation Events (A2 Scenario, 2100)
GCM vs. RCMs

Temperature

Precipitation

GCM

RCM

STRATUS CONSULTING
Insights Into Downscaling

- Downscaling will not reduce uncertainties across GCMs
- May not correct GCM errors
- Do give more insight into regional and local factors
- Is most promising for long run
Storm Surge Scenarios

- Start with global average projections of sea level rise
  - 50 cm by 2100 (Low)
  - 100 cm by 2100 (Central)
  - 150 cm by 2100 (High)
- Add in regional variation from climate models
- HOWL elevations derived from tide gauges and interpolated to study area (NOAA, 2011)

<table>
<thead>
<tr>
<th>Station name</th>
<th>Station ID</th>
<th>Highest observed water level (station datum)</th>
<th>Mean higher high water (station datum)</th>
<th>HOWL above MHHW (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Battery</td>
<td>8518750</td>
<td>13.3</td>
<td>8.34</td>
<td>4.96</td>
</tr>
<tr>
<td>Atlantic City</td>
<td>8534720</td>
<td>13.94</td>
<td>9.56</td>
<td>4.38</td>
</tr>
<tr>
<td>Cape May</td>
<td>8536110</td>
<td>11.23</td>
<td>7.87</td>
<td>3.36</td>
</tr>
<tr>
<td>Sandy Hook</td>
<td>8531680</td>
<td>12.6</td>
<td>7.74</td>
<td>4.86</td>
</tr>
</tbody>
</table>
Sea Level Rise + Storm Surge
Bottom-up Methods

• Understand your transportation system
  – What aspects of climate currently affect it?
    • Extreme heat
    • Flooding
  – What are the critical thresholds?
    • High temperatures and duration
    • Rainfall, river flow, storm surge, and duration
  – What is the current frequency (likelihood) of exceeding these thresholds?
See How Conditions Can Change in the Future

• Examine climate model projections to see
  – Under how many scenarios (models + other assumptions) are thresholds or tolerances exceeded?
  – When is this projected to happen?

• # of models is not a probability but gives an indication of risks based on the models
Advantages of Bottom-up

• Focus on your system rather than model output
• Understand sensitivities to climate
• Get an indication of how soon and with what (imprecise) likelihood thresholds could be exceeded
Advantages of Scenario (Top-down) Approach

- Decision-makers like to see what we expect to happen under climate change
- Approach can identify surprises
Whatever Approach is Taken

• The critical thing is to understand how your transportation system could be vulnerable to:
  – Changes in climate variability
  – Long-term changes in climate

• Begin working on contingency planning and adaptation measures to reduce risks
Thank you!

jsmith@stratusconsulting.com
Gulf Coast 2 Sea Level Rise and Storm Surge Projections

Rob Kafalenos
Sustainable Transport and Climate Change Team
FHWA

May 16, 2013
Gulf Coast 2 Project: Vulnerability Assessment at Metropolitan Scale

Primary Phase 2 Tasks

- Task 1: Identify critical transportation assets in Mobile (complete)
- Task 2: Identify climate effects, assess infrastructure sensitivity (complete)
- Task 3: Assess vulnerability of critical assets (2013)
- Task 4: Develop transferable risk management tools (2014)

Completed tasks available from the FHWA website

Phase 2 performed by ICF International (prime), Parsons Brinckerhoff, South Coast Engineers, and Texas A&M, with support from USGS and Katharine Hayhoe (Texas Tech)
Climate changes examined:

- **Local sea level rise** scenarios based on range of recent global SLR scenarios plus local subsidence
- **Storm surge** modeling looked at range of storm intensities and included wave modeling
- (Temperature and precipitation statistically downscaled from GCMs)
• **Sea level rise**
  - Range of projected global SLR scenarios
  - Accounts for local land subsidence

• **Storm Surge Modeling (ADCIRC)**
  - Range of storm scenarios
  - Combined with range of SLR scenarios
  - Output includes surge distribution and depth

• **Wave Modeling (STWAVE)**
  - Inputs from ADCIRC output and boundary conditions
  - Outputs include key aspects of wave energy

• **GIS analysis – Potential inundation**
  - Exposure of transportation systems to SLR, Storm surge
Local Sea Level Rise Scenarios

- Selected scenarios based on recent understanding of Global SLR
  - 30 cm by 2050
  - 75 cm by 2100
  - 200 cm by 2100

- Included Land Subsidence/Uplift
  - Accounts for land subsidence using survey data and satellite measurements. (Data provided by USGS.)
Land Subsidence

Vertical change rate (mm/yr)
- Tide Gage
- CORS MOBI

BM surveys of 1969-2009 or 1984-2010
- -1.9 to -1.0
- -1.0 to 0.0
- 0.0 to 0.5

Estimated grid of ERS-1/2
- High: 3.6
- Low: -4.9
SLR -- 30 cm
Potential Inundation
SLR -- 75 cm
Potential
Inundation
SLR -- 200 cm
Potential
Inundation
### Critical Assets Inundated Under Each SLR Scenario

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Roads (miles)</th>
<th>Rail (miles)</th>
<th>Ports (#)</th>
<th>Transit Facilities (#)</th>
<th>Mobile Downtown Airport (mi²)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2050 0.3m</td>
<td>2 of 203 (1%)</td>
<td>0 of 194 (0%)</td>
<td>0 of 27 (0%)</td>
<td>0 of 2 (0%)</td>
<td>0 of 3 (1%)</td>
</tr>
<tr>
<td>2100 0.75m</td>
<td>5 of 203 (2%)</td>
<td>2 of 194 (1%)</td>
<td>0 of 27 (0%)</td>
<td>0 of 2 (0%)</td>
<td>0 of 3 (2%)</td>
</tr>
<tr>
<td>2100 2.0m</td>
<td>50 of 203 (24%)</td>
<td>40 of 194 (21%)</td>
<td>5 of 27 (19%)</td>
<td>1 of 2 (50%)</td>
<td>0 of 3 (3%)</td>
</tr>
</tbody>
</table>
Storm Surge Scenarios

• Scenarios based on historic hurricanes, with varying
  ▪ Track
  ▪ Sea level rise (30 cm, 75 cm, 2.0 m)
  ▪ Intensity

• Does not examine loss of barrier islands

• Why the ADCIRC model?
<table>
<thead>
<tr>
<th>Hurricane Georges</th>
<th>Hurricane Katrina</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Path, No SLR</td>
<td>Natural Path, No SLR</td>
</tr>
<tr>
<td>Natural Path, 30 cm SLR</td>
<td>Natural Path, 75 cm SLR</td>
</tr>
<tr>
<td>Natural Path, 75 cm SLR</td>
<td>Shifted, No SLR</td>
</tr>
<tr>
<td>Natural Path, 200 cm SLR</td>
<td>Shifted, 75 cm SLR</td>
</tr>
<tr>
<td></td>
<td>Shifted, Reduce Pressure, 75 cm SLR</td>
</tr>
<tr>
<td></td>
<td>Shifted, Intensified, No SLR</td>
</tr>
<tr>
<td></td>
<td>Shifted, Intensified, 75 cm SLR</td>
</tr>
</tbody>
</table>
Georges
No SLR
Georges
200 cm SLR
Katrina
Natural Path
No SLR
Shifting Hurricane Katrina’s Path

[Map showing the shifted path of Hurricane Katrina with key markers for warning dates, maximum sustained wind speed, and study area in Mobile County, AL.]

Hurricane Katrina Altered Path
With Maximum Sustained Wind Speed

- Hurricane Warning Date
- Cities
- Hurricane Path
- Study Area (Mobile County, AL)
Katrina
Shifted Path
No SLR
Wave height example
Katrina
Shifted Path
75 cm SLR
Katrina
Shifted Path
Reduced central pressure
75 cm SLR
Katrina
Shifted Path
Intensified
No SLR
## Critical Assets Inundated–Storm Surge

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Roads (mi)</th>
<th>Rail (mi)</th>
<th>Ports (#)</th>
<th>Transit Facilities (#)</th>
<th>Mobile Downtown Airport (mi²)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Georges-Natural</td>
<td>33 of 203 (16%)</td>
<td>111 of 194 (57%)</td>
<td>20 of 27 (74%)</td>
<td>1 of 2 (50%)</td>
<td>0 of 3 (4%)</td>
</tr>
<tr>
<td>Katrina-Natural</td>
<td>36 of 203 (18%)</td>
<td>116 of 194 (60%)</td>
<td>20 of 27 (74%)</td>
<td>1 of 2 (50%)</td>
<td>0 of 3 (5%)</td>
</tr>
<tr>
<td>Georges-Natural-200cm</td>
<td>78 of 203 (38%)</td>
<td>132 of 194 (68%)</td>
<td>24 of 27 (89%)</td>
<td>1 of 2 (50%)</td>
<td>0 of 3 (15%)</td>
</tr>
<tr>
<td>Katrina-Natural-75cm</td>
<td>36 of 203 (18%)</td>
<td>127 of 194 (66%)</td>
<td>22 of 27 (81%)</td>
<td>1 of 2 (50%)</td>
<td>0 of 3 (9%)</td>
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<tr>
<td>Katrina-Shift</td>
<td>73 of 203 (36%)</td>
<td>140 of 194 (72%)</td>
<td>24 of 27 (89%)</td>
<td>1 of 2 (50%)</td>
<td>2 of 3 (65%)</td>
</tr>
<tr>
<td>Katrina-Shift-75cm</td>
<td>92 of 203 (45%)</td>
<td>144 of 194 (74%)</td>
<td>24 of 27 (89%)</td>
<td>1 of 2 (50%)</td>
<td>2 of 3 (90%)</td>
</tr>
<tr>
<td>Katrina-Shift-ReducedPress-75cm</td>
<td>102 of 203 (50%)</td>
<td>146 of 194 (76%)</td>
<td>24 of 27 (89%)</td>
<td>1 of 2 (50%)</td>
<td>3 of 3 (98%)</td>
</tr>
<tr>
<td>Katrina-Shift-MaxWind</td>
<td>119 of 203 (58%)</td>
<td>150 of 194 (78%)</td>
<td>26 of 27 (96%)</td>
<td>1 of 2 (50%)</td>
<td>3 of 3 (100%)</td>
</tr>
</tbody>
</table>
Thank you

www.fhwa.dot.gov/environment/climate_change/adaptation/
QUESTIONS?
Upcoming Webinars

Session 2: System-Level Vulnerability Assessments  
*Date: Thursday, May 30, 3:00 – 4:30 pm EDT*  
This session will focus on use of information on transportation assets and climate projections to identify vulnerabilities. Representatives from the San Francisco Bay Area Metropolitan Transportation Commission, Washington DOT, and the New Jersey Transportation Planning Authority will provide example applications of system-level vulnerability and risk assessments.

Session 3: Applying the Results  
*Date: Wednesday, June 12, 2:00 – 3:30 pm EDT*  
Representatives from the Boston Region MPO and Los Angeles Metropolitan Transportation Authority will discuss incorporating vulnerability assessment results into agency decision making processes and developing adaptation options.

Session 4: Hurricane Sandy - Lessons Learned  
*Date: Thursday, June 20, 2:00 – 3:30 pm EDT*  
The impacts of Hurricane Sandy underscore the need for proactive planning for extreme weather events. This session will focus on extreme weather preparations, emergency response, recovery, and planning for long term resilience.