Climate Resilient and Sustainable Transportation: Strategic Economic and Financial Management challenges and opportunities with FAST Act

Webinar Moderator:
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Delaware Department of Transportation
2016

Summary

- Disasters tolls on investment and development on DOT’s planned construction and maintenance projects, amid aging assets and constrained budgets
- FAST Act sets a program for 5 years and emphasizes resilience to sea-level-rise and extreme events
- DOTs must consider complete cycles of management for both economic and financial areas of State and federally sponsorship
- Need for Enterprise Resilience Management

Speakers

- **Christine Baglin** – Principal at PPC, a DC-based management and IT consulting firm with a decision support and data analytics practice supporting resiliency and information security;. For TRB, she has served as an expert panel member and Principal Investigator of studies on topics relating to extreme weather and climate change response. Past Director of the Office of Policy Analysis at the Department of the Interior. She also served as Counsel to the U.S. Senate's Government Affairs Committee
- **Rajib Mallick** - Ralph White Family Distinguished Professor Associate Head and Graduate Program Coordinator Civil and Environmental Engineering Department - Worcester Polytechnic Institute (WPI). conducted numerous research projects for the Federal Highway Administration (FHWA), state departments of transportation (DOT) and Federal Aviation Administration (FAA) and consulting work in the area of both highway and airport pavements. Rajib has close to 150 publications, including a textbook, and a US patent.
- **Emmanuel Liban** - Executive Officer, Environmental Compliance and Sustainability Program Management – LA Metro; Council Member of the US Environmental Protection Agency's National Advisory Council on Environmental Policy and Technology, Los Angeles County Beach Commissioner and Commissioner in the City of Los Angeles Board of Transportation Commissioners
- **Robert Paddon** - Executive Vice President, Strategic Planning and Public Affairs ; Past Chair of Board of Directors of the Canadian Urban Transit Association; Chair of the Strategic Management Committee of the Transportation Research Board, National Academy of Sciences (Washington, D.C.)

Building the Evidence Base for Climate Resiliency

Presented as part of the TRB Webinar, "Climate Resilient and Sustainable Transportation: Strategic Economic and Financial Management"

Chris Baglin, PPC

September 2016

The economic importance of a climate-resiliency

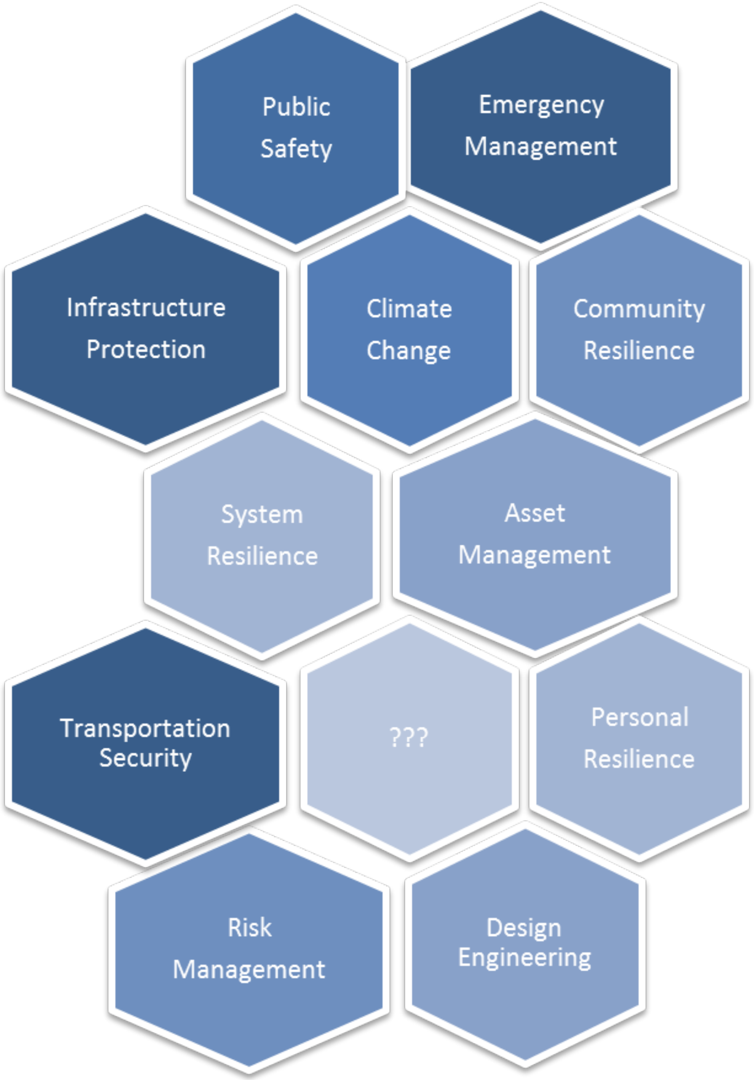
- **Transportation's relationship to the economy**
  - Promotes growth
  - Is a cost of growth (e.g. environmental impacts)

- **Transportation's relationship to adverse events**
  - Mode damage can slow economic recovery from the event, affecting communities (e.g. reduced independence/self-help, reduced revenue base)
  - Supports recovery through state DoT purchasing power

- **Transportation's relationship to Resiliency**
  - One of the interdependencies frequently cited as most critical
  - A sector where government has a direct and significant role, e.g. governance, funding

- **Transportation's relationship to Climate Change**
  - A contributor to the problem
  - Major thought leader and investor in adaptation and other responses

The Transportation Resilience Honeycomb



Mapping the organizational mission and appreciating transportation's broader role: Transportation resilience can effectively support community resilience when transportation organizations plan for and accommodate unforeseen financial and economic conditions affecting system sustainability and regional economic conditions.

In other words,
We want to "prevent a hazard from becoming a disaster"

The aim of a resiliency approach

- **A quicker, safer return to organizational functionality.**

- **Characteristics of resiliency:**

  – Spare capacity – which ensure “back-up” or alternatives when system components fail

  – “Safe” failure – which prevents failures from cascading across a system

  – Rapid rebound – which is the capacity to re-establish function and avoid long term disruption

  – Flexibility – which is the ability to change, evolve and adapt

  – Constant learning – which includes robust feedback loops and allows new solutions as conditions change

  – Feasibility – which includes optimal engineering approaches and alternatives by weighing costs and benefits

A good starting point

National Infrastructure Protection Plan (NIPP) Risk Management Framework

- Calls on each sector to identify those **functions, assets, networks, systems, and people** (FANSP) that make up the nation's critical infrastructure and key resources.

TRB encourages use of these NIPP categories

- **"Functions"** refers to the assignments, tasks, and positions in a state DOT that are critical to the performance of continued transportation service through any hazard or disruption
- **"Assets"** refers to the infrastructure, equipment, resources, tools, vehicles, hardware, roadways, tunnels, and facilities owned and operated by a state DOT to ensure the continued safe transport of goods and people through any hazard or disruption
- **"Networks"** refers to the relationships maintained by a state DOT with local municipalities, contractors, the private sector, and other branches of local, state and federal government to ensure continuity of transportation operations through any hazard or disruption
- **"Systems"** refers to the variety of critical technology platforms and applications, including all software utilities and electronic forms of data, utilized by state DOT personnel to operate assets and infrastructure, support functional continuity, and enable network communication and reliability through any hazard or disruption
- **"People"** refers to the inherently necessary human resources and personnel needed by a state DOT to ensure transportation service is provided through any hazard or disruption.

Considerations

•**Interdependencies.** Each category has interdependencies to recognize and understand to in order to build resiliency

•**Complexities** Adverse events can produce different levels of disruption - damage, destruction or failure – while affecting in different ways interdependent systems managed by personnel trained in different disciplines.

•**Priorities.** What functions, assets, networks, and systems will be enhanced through an action taken in the name of resiliency? What hazard has been the primary focus up until now? What are emerging threats?

And..

•**The Knowledge Base.** How to align data, information, and knowledge management to needs?

Common barriers to aligning information and data management to needs:

- Difficulty compiling the data needed for a major planning effort
- Difficulty gathering and integrating data needed to produce agency performance reports
- Inability to comply with current or emerging external reporting requirements
- Emerging agency policy initiative or priorities that require new or different information
- Data quality problems, including accuracy, currency, completeness, and reliability
- Perception that the agency is behind its peers with respect to data management practices or data availability
- Recognized data problems expressed by users; people aren't getting what they need when they need it, or it is taking too much work to get the data into a useful form
- Risk of data loss associated with informally or unmanaged databases
- Lack of documentation leading to potential misuse of data
- Loss of key staff with specialized knowledge of key data sets
- Perceived mismatch between money spent on data collection and the value realized
- High-value databases are owned and operated by individual business areas (silos) and are not easily integrated, shared, or accessed

From: NCHRP Report 814, Data to Support Transportation Agency Business Needs: A Self-Assessment Guide

Added considerations relating to Climate Resiliency

The knowledge, information, and data needed to make decisions about the adverse events and conditions stemming from projected climate changes

- May differ in type and scale
- May differ across short, medium, and long term timeframes.

Transportation managers can focus now on what's needed for decisions in the future

- Identify the types of site-specific knowledge, information and data needed for
  - a quantitative risk analysis
  - analyzing the cost and benefits of current, emerging, and alternative capabilities, practices, and structural solutions.
- Develop methods for its normalization, stewardship, and facilitated sharing
- Build long term strategies
  - Given the characteristics of climate change (e.g. non-stationarity, uncertainties, and variances in the confidence in projections)
    - Continue to build the datasets, information feedback loops, and continual knowledge transfer that can inform decisions.

U.S. Climate Resilience Toolkit

http://toolkit.climate.gov/

https://www.nist.gov/el/resilience

Community Resilience

Other sources - Learning from organizational experience

Timing in Relation to Extreme Weather Event	Activity
Before	Develop a way to locate and contact agency experts easily.
Before	Develop succession planning to maintain continuity and a knowledge base.
Before	Collect and report on emerging maintenance practices related to more severe and unpredictable weather.
During	In the absence of preassigned staff, leverage the knowledge base of personnel with experience from a previous disaster.
Before, during, and after	Ensure information sharing through SharePoint or other collaboration software and conference calls.
Before, during, and after	Identify the data sets (e.g., bridge information or plan drawings) that benefit decision making; identify ways to improve data collection and access to the data.
Before, during, and after	Capture images of locations or of the critical infrastructure likely to be affected.
After	Develop an After Action Report that records effective practices, lessons learned, and new approaches.
After	Include in any After Action Report contributions from all regions, not only from those affected.
After	Conduct postevent workshops and other activities to share and record knowledge and lessons learned.
After	Provide a forum for the public to tell stories about transportation issues from the event—for example, through a web-based personal account project.
After	Store applications for financial assistance in paper or scanned form, with a defined retention schedule; make projects searchable by event code.
After	Use in-house staff resources to collect and analyze data on extreme weather event impacts to support decision making.
After	Use in-house and academic resources to research information on key issues relating to impacts from extreme weather events of concern—such as flooding—and develop a synthesis of the body of knowledge.
After	Distinguish emergency management processes from day-to-day processes in postevent assessments of the state DOT response to the event.
After	Provide a structured forum and process for developing lessons learned from extreme weather events to capture practices and ideas for improvement; if necessary, hire an external facilitator.

Source: Baglin, C, "Responses to Extreme Weather Impacts - Practices in the U.S. Transportation Sector" TRNews Volume 301 (2015)

Applying these considerations to climate risks

- **Determine relevant hazards.**
  - Understand current, emerging, and future hazards to see where to position and leverage limited human, time, and monetary resources.
  - With respect to future hazards, expert knowledge, information from models, and observational data can support understanding of threats, but some these sources may not be accessible or created yet.
    - Focus on likely indicators of change: An indicator of a climate change-induced hazard may be findable in publicly available remote sensing/earth observation data and products. Utilizing such information could support the identification, analysis, and management of climate change risk through tracking of indicators over time.
- **Assess vulnerabilities:**
  - Transportation system vulnerabilities are inventoried and assessed to help identify where to focus resources, i.e. where they are most needed.
  - Critical inputs include the past performance of a system, such as a key asset or operational functions.
    - Information may not be aggregated for the hazard in question, resulting in ad hoc, disruptive data calls
  - Several TRB tools provide lists of potentially vulnerable areas for multiple modes to assist such assessments, and as such can supply the start of a framework for a data, information and knowledge strategy

Applying these considerations to climate risks

- **Analyze risks:**
  - Decision makers require a common way to look at the variety of risks that may arise from identified hazards and vulnerabilities.
  - Traditionally, risk is equal to the magnitude of the harm multiplied by the frequency of its occurrence. Two points illustrate the role of a data strategy in progressing risk analysis to a more sophisticated state:
    - An indicator of potential harm may be exceedance of a threshold, such as the amount of rain within a certain timeframe . Where measurements (quantitative data) are not available, organizations may have to rely on the professional judgment of maintenance staff, e.g. their conclusory opinions, which constitute qualitative data which has not been normalized or validated outside the organization
    - More fundamentally, the named threshold may or may not be suitable to the local conditions (e.g. additional margins of safety were built into an asset when the threshold assumes a lower margin of safety).

Applying these considerations to climate risks

Developing a response to enhance climate change resiliency and reduce vulnerability:

- Small, strategic investments
  - Monitoring
  - Acquisition of data sets
  - Operational changes
- Targeted project to address severe risks
- Mainstreaming into broader strategies
  - Organizational planning
  - Geospatial planning
  - Corridor planning
  - Disinvestment
- Robust, routine, and timely updates to
  - Needed data streams
  - Information feedback loops, and
  - The knowledge base

TRB & Resiliency

- **National Cooperative Highway Research Program**
- NCHRP Report 750: Strategic Issues Facing Transportation, Volume 2: Climate Change, Extreme Weather Events, and the Highway System: Practitioner's Guide and Research Report
- NCHRP Synthesis Report 454: Response to Extreme Weather Impacts on the Transportation System
- NCHRP 20-59(53): FloodCast: A Framework for Enhanced Flood Event Decision Making for Transportation Resilience
- NCHRP 20-59(55): Transportation System Resilience: CEO Primer & Engagement
- NCHRP 20-101: Guidelines to Incorporate the Costs and Benefits of Adaptation Measures in Preparation for Extreme Weather Events and Climate Change
- NCHRP 15-61: Applying and Adapting Climate Models to Hydraulic Design Procedures

- **Transit Cooperative Research Program**
- TCRP A-41: Improving the Resiliency of Transit Systems Threatened by Natural Disasters

- **National Cooperative Freight Research Program**
- NCFRP Report 30: Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains
- NCFRP-50: Freight Resiliency: Dealing with Major Cargo Traffic Diversions in National Emergencies

- **Airport Cooperative Research Program**
- ACRP Synthesis Report 33: Airport Climate Adaptation and Resilience
- ACRP Report 147: Climate Change Adaptation Planning: Risk Assessment for Airports
- ACRP Report 160: Addressing Significant Weather Airports on Airports
- ACRP 2-74: Integrating Climate Resiliency into Airport Management Systems
- ACRP 02-78 Handbook for Airports Evaluating Climate Resilience through Benefit Cost Analysis

Thank you!

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Understanding the Impact of Flooding on Roadways - A Simulation Based Approach

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Acknowledgements

- Silvana Croope (Delaware DOT)
- Federal Highway Administration (FHWA)
- Jo S. Daniel, University of New Hampshire
- Jennifer M. Jacobs, University of New Hampshire
- Michael J. Radzicki, Worcester Polytechnic Institute (WPI)
- Karim Chichakly (ISEE Systems)
- Transportation Research Board (TRB)

Content

- Background – problem, needs
- Formulation of the problem
- Modeling
- Results of simulation
- Conclusions
- Recommendations

Background

- Flooding can weaken roadways
  - Weakened roadways
    - Can deteriorate faster and develop premature problems under traffic
    - Need a significant amount of resources and time for repair or rehabilitation
    - Can be a hazard that can lead to death, or damage of vehicles
    - Can prevent timely evacuation of citizens if needed during an extreme weather event
    - Signs of weakness may not be visible on the surface

Background

- Needs
  - A knowledge of the damage potential of the pavement
    - Can help identify vulnerable sections
    - Allow precautions/corrective actions to prevent/minimize damage
    - Can help in making decisions to utilize specific sections for flood related emergency/evacuation traffic
  - A knowledge of the condition of the pavement after flooding
    - Can help in making decisions regarding opening or closing of roads to traffic after flooding
    - Can help in planning for allocating resources for post-flooding investigative actions
    - Can help agencies develop methods for building more resilient roads in the future

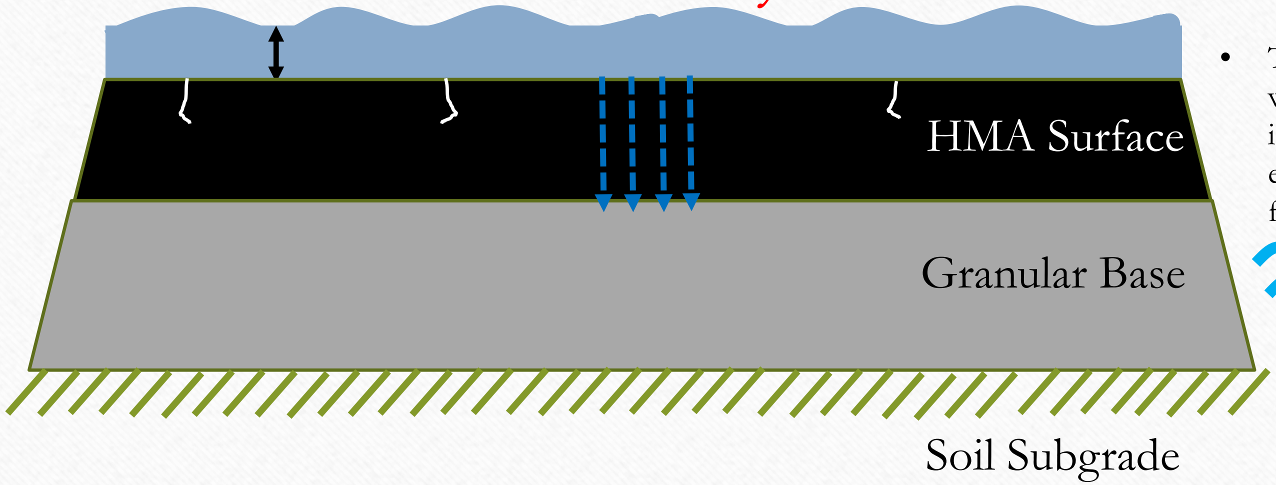
Formulation of the problem

- The pavement is weakened significantly when the granular base layer is fully saturated

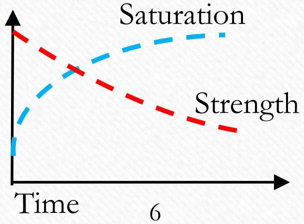
- Time to saturate the base depends on:
  a. Permeability
  b. Matric suction
  c. Fillable pore space
  d. Depth of ponded water
  e. Thickness of surface and base layers
  f. Condition of surface layer

- The pavement is weakened significantly if HMA tensile strength < critical strength

Why simulation?
Coupled problem – hydrologic, hydraulic and structural analysis



- The pavement is also weakened significantly if it is subjected to the eroding action of flowing water



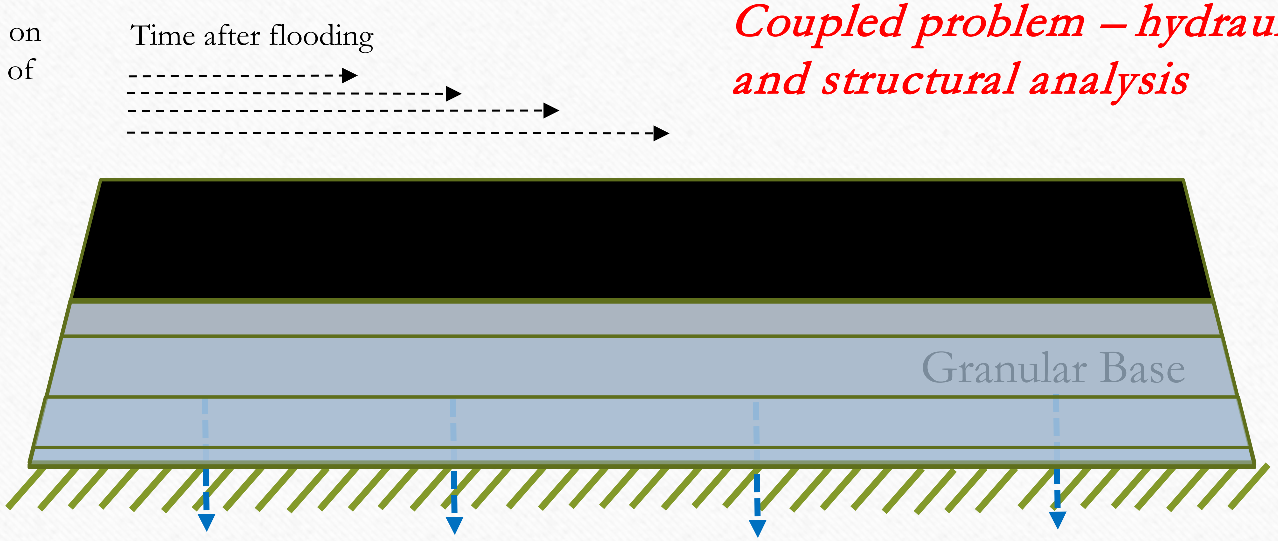
Mallick et al, Development of a methodology and a tool for the assessment of vulnerability of roadways to flood-induced damage. Journal of Flood Risk Management. doi: 10.1111/jfr3.12135, 2015.

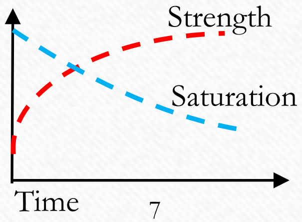
Pre-Flooding:
Will the flood weaken the pavement?

Formulation of the problem

- The structural strength of the pavement depends on the saturation level of the base and the condition of the surface layer
- Saturation level of the base layer depends on:
  a. Suction, volumetric water content, hydraulic conductivity of the base layer
  b. Suction, volumetric water content, hydraulic conductivity of the subgrade
- Condition of the surface layer depends on:
  - Moisture susceptibility of the HMA
  - Presence/absence of anstripping agents

Why simulation?
Coupled problem – hydraulic and structural analysis



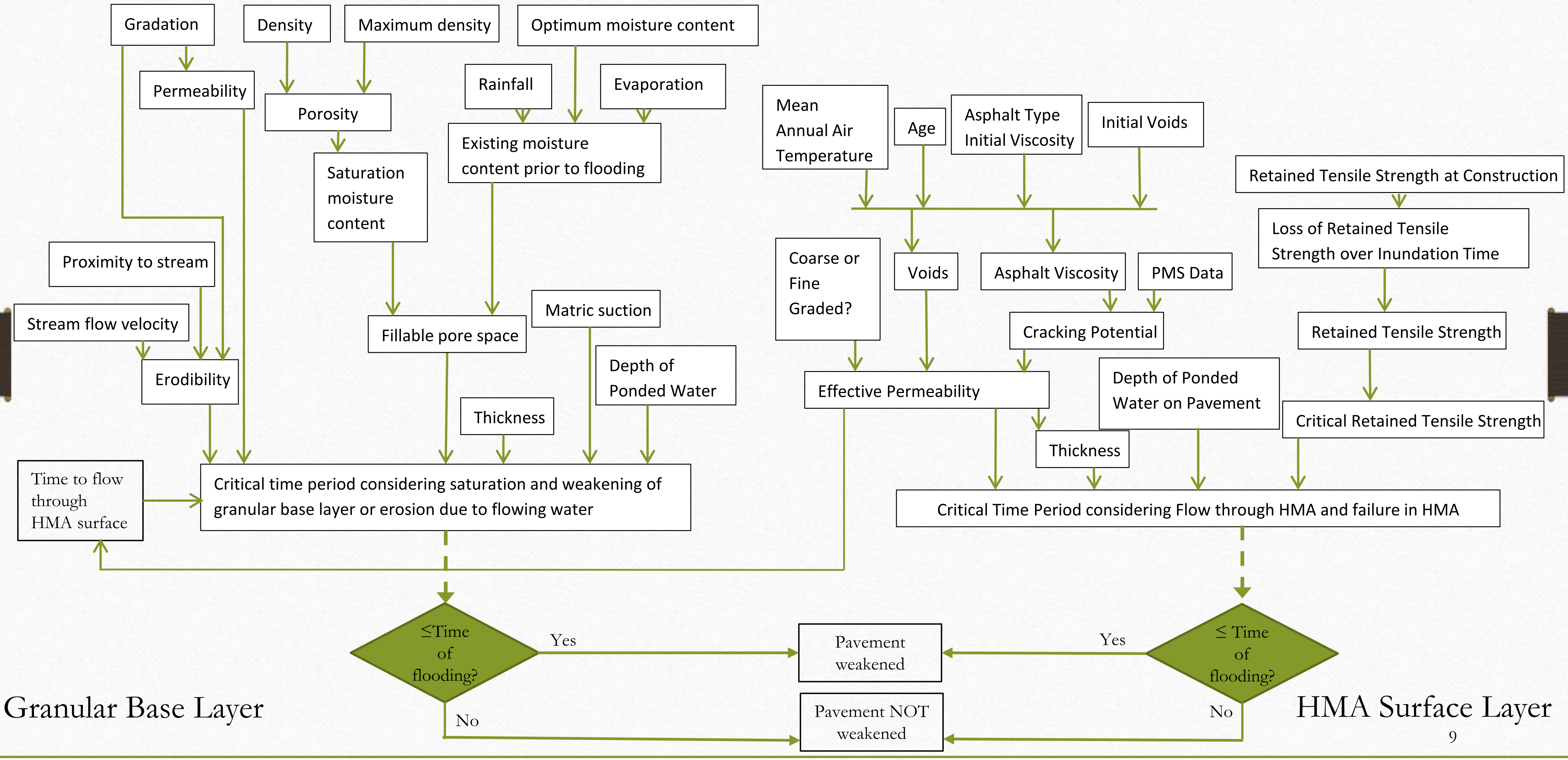


Post-Flooding:
Is the pavement in an unsafe/weakened state?

Mallick et al, A Coupled Model Framework for Asphalt Pavement Condition Determination after Flooding. Interim Report, FHWA, 2016.

Pre-Flooding

Will the flood weaken the pavement?


Gradation
Density
Maximum density
Optimum moisture content
Permeability
Porosity
Rainfall
Evaporation
Existing moisture content prior to flooding
Saturation moisture content
Mean Annual Air Temperature
Age
Asphalt Type Initial Viscosity
Initial Voids
Retained Tensile Strength at Construction
Loss of Retained Tensile Strength over Inundation Time
Proximity to stream
Stream flow velocity
Erodibility
Fillable pore space
Matric suction
Depth of Ponded Water
Thickness
Coarse or Fine Graded?
Voids
Asphalt Viscosity
PMS Data
Cracking Potential
Retained Tensile Strength
Effective Permeability
Depth of Ponded Water on Pavement
Critical Retained Tensile Strength
Thickness
Time to flow through HMA surface
Critical time period considering saturation and weakening of granular base layer or erosion due to flowing water
Critical Time Period considering Flow through HMA and failure in HMA
≤Time of flooding?
Yes
No
Pavement weakened
Pavement NOT weakened
Yes
No
≤ Time of flooding?
Granular Base Layer
HMA Surface Layer

Determination of Critical Time of Flooding for Damage of Hot Mix Asphalt Pavements with Granular Base Course Layers

Courtesy: US Army Corps of Engineers

Overview

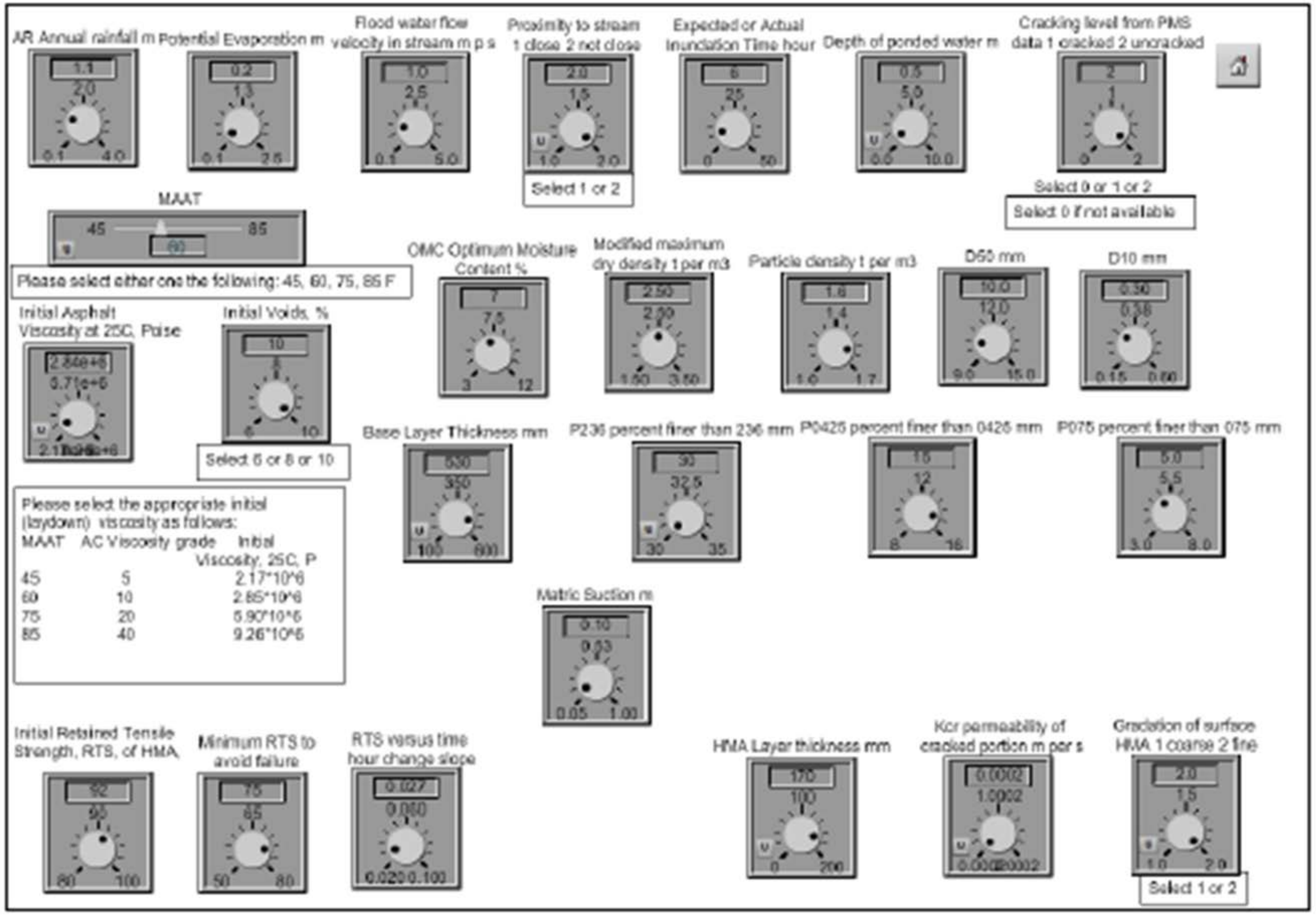
View and Change Parameters

Simulate

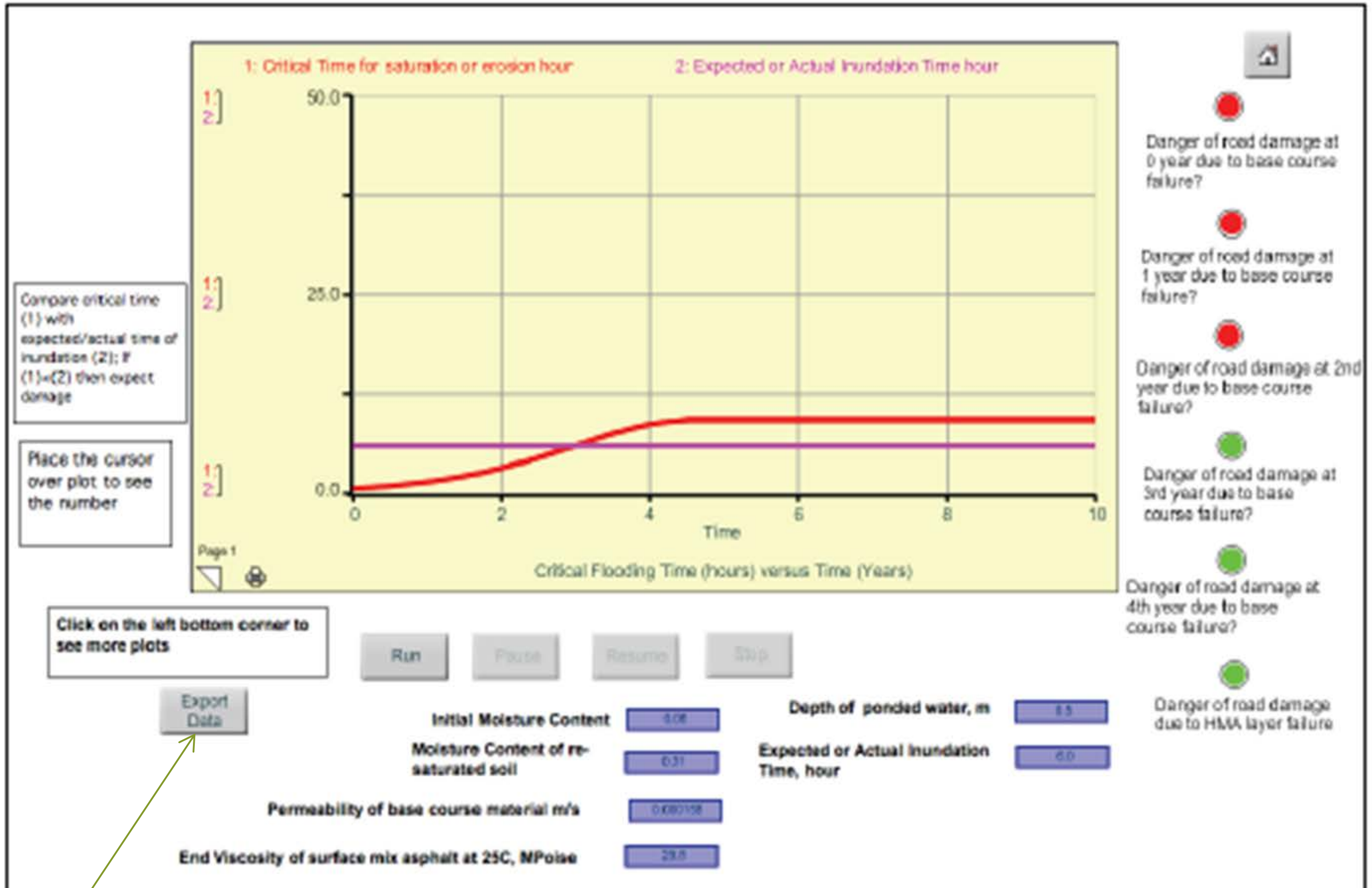
Unfurl Model

Visual programming language: STELLA (isee systems)

Simulation tool at: http://goo.gl/1esRKC



Change Parameter page

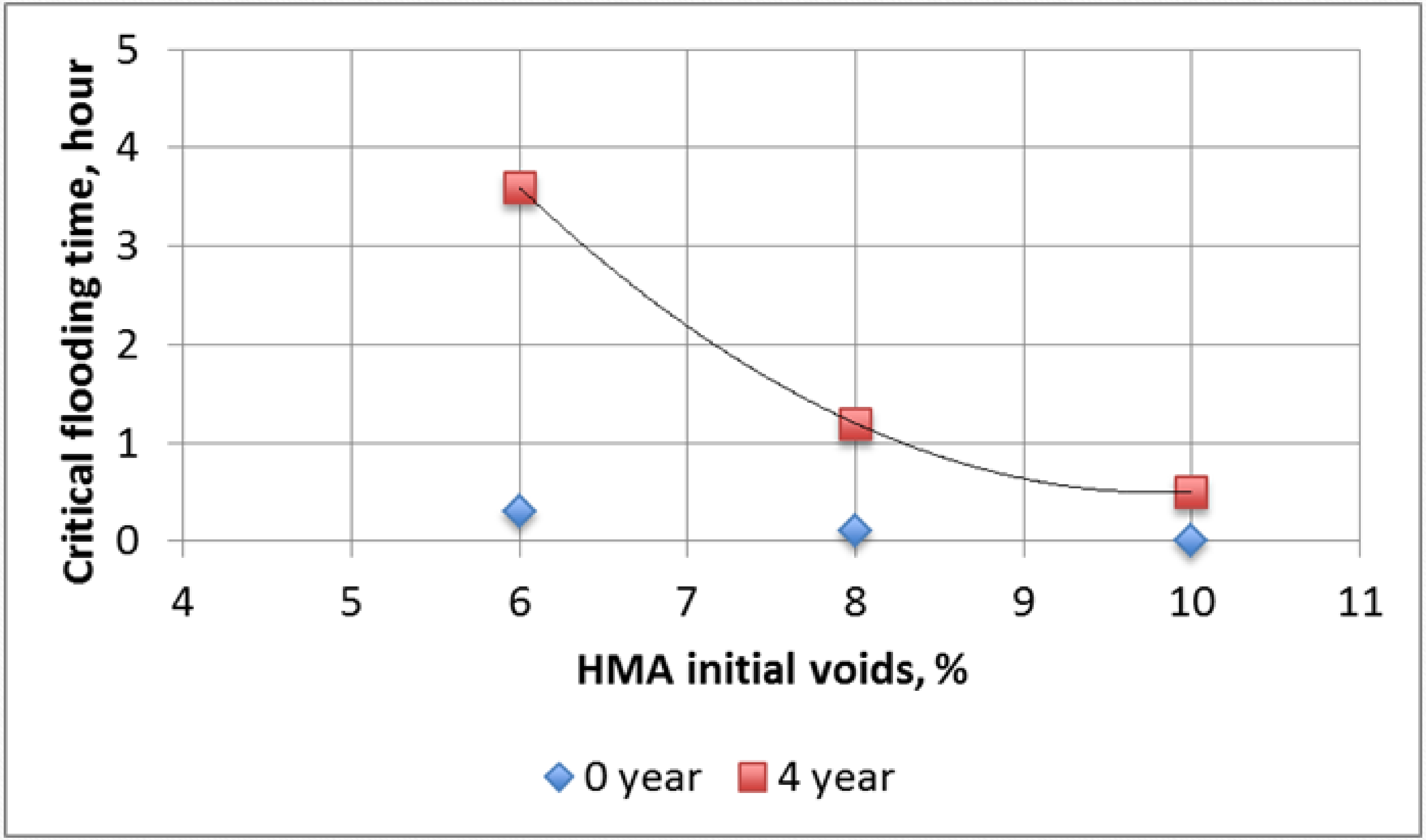


Allows the user to export data to a spreadsheet for further analysis

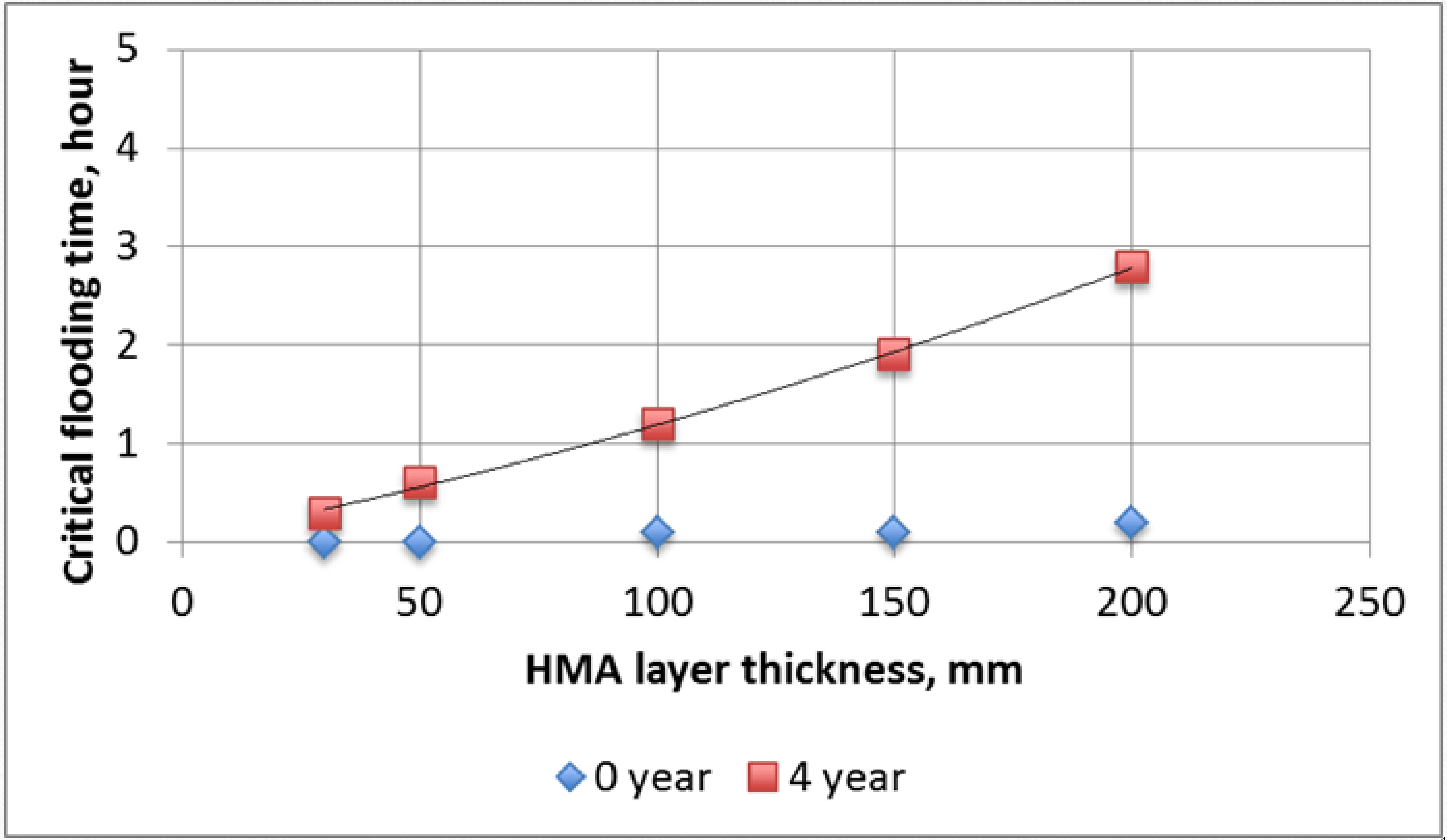
Simulation Results page

Results of Simulation

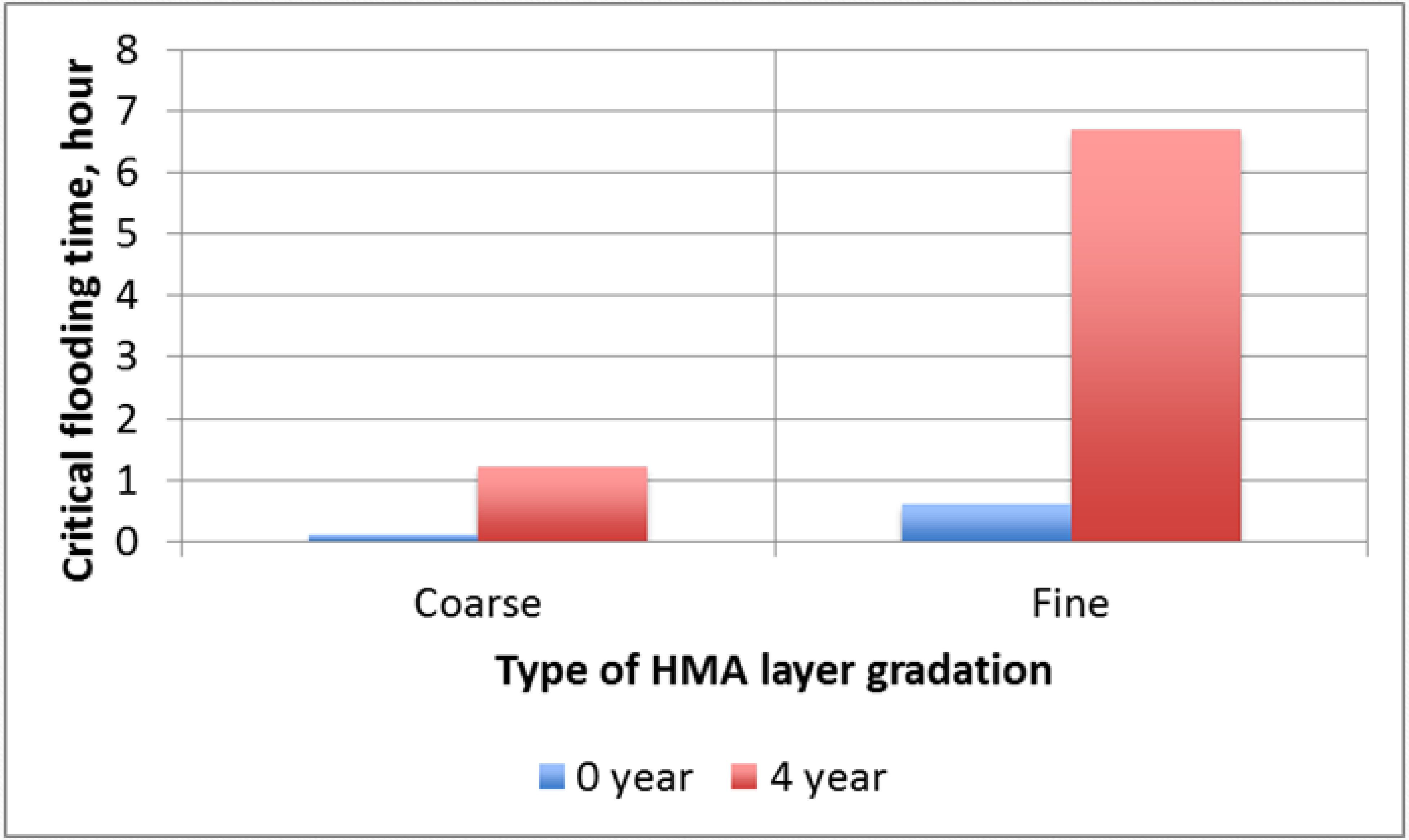
Effect of Controllable Parameters

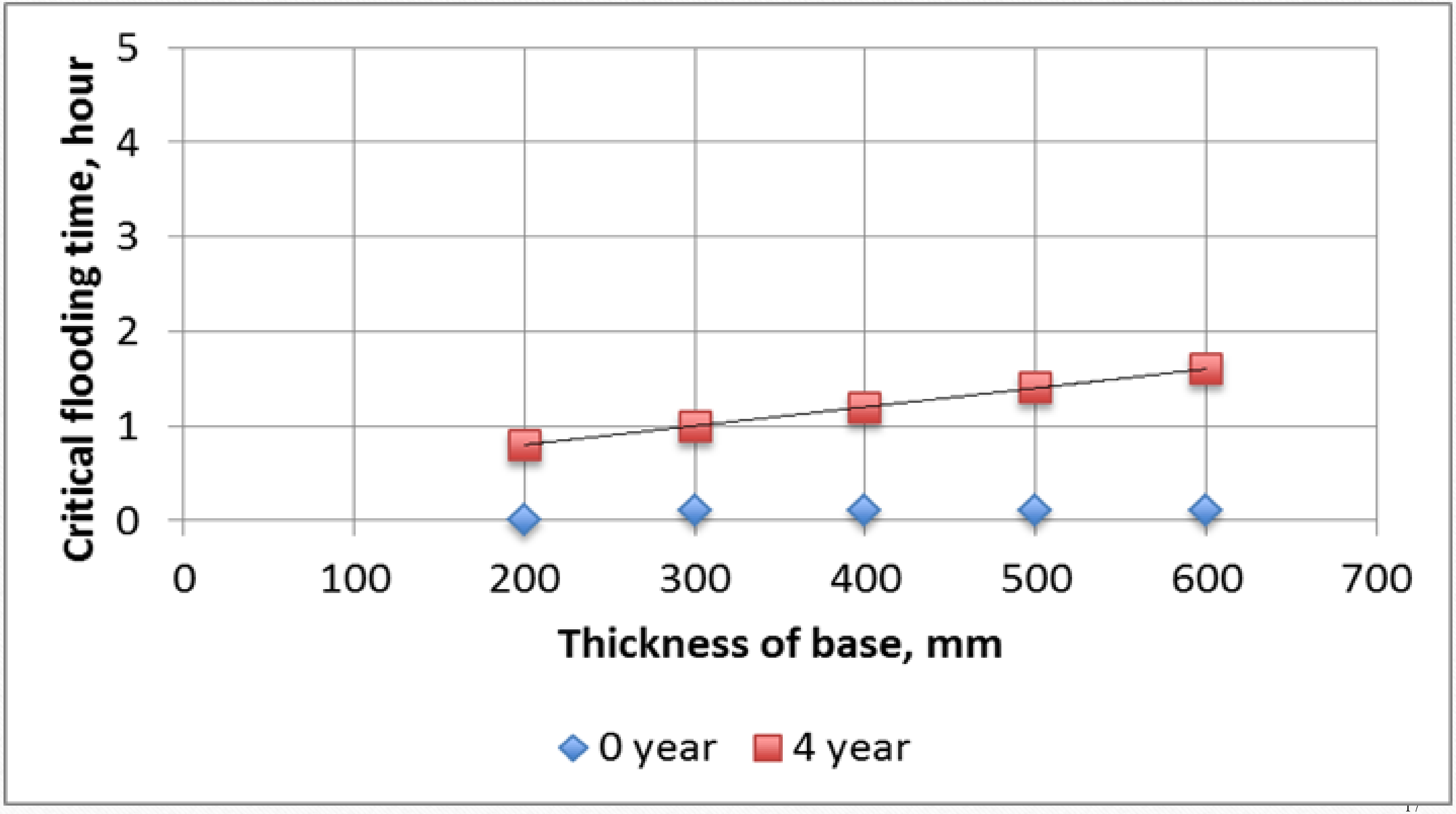


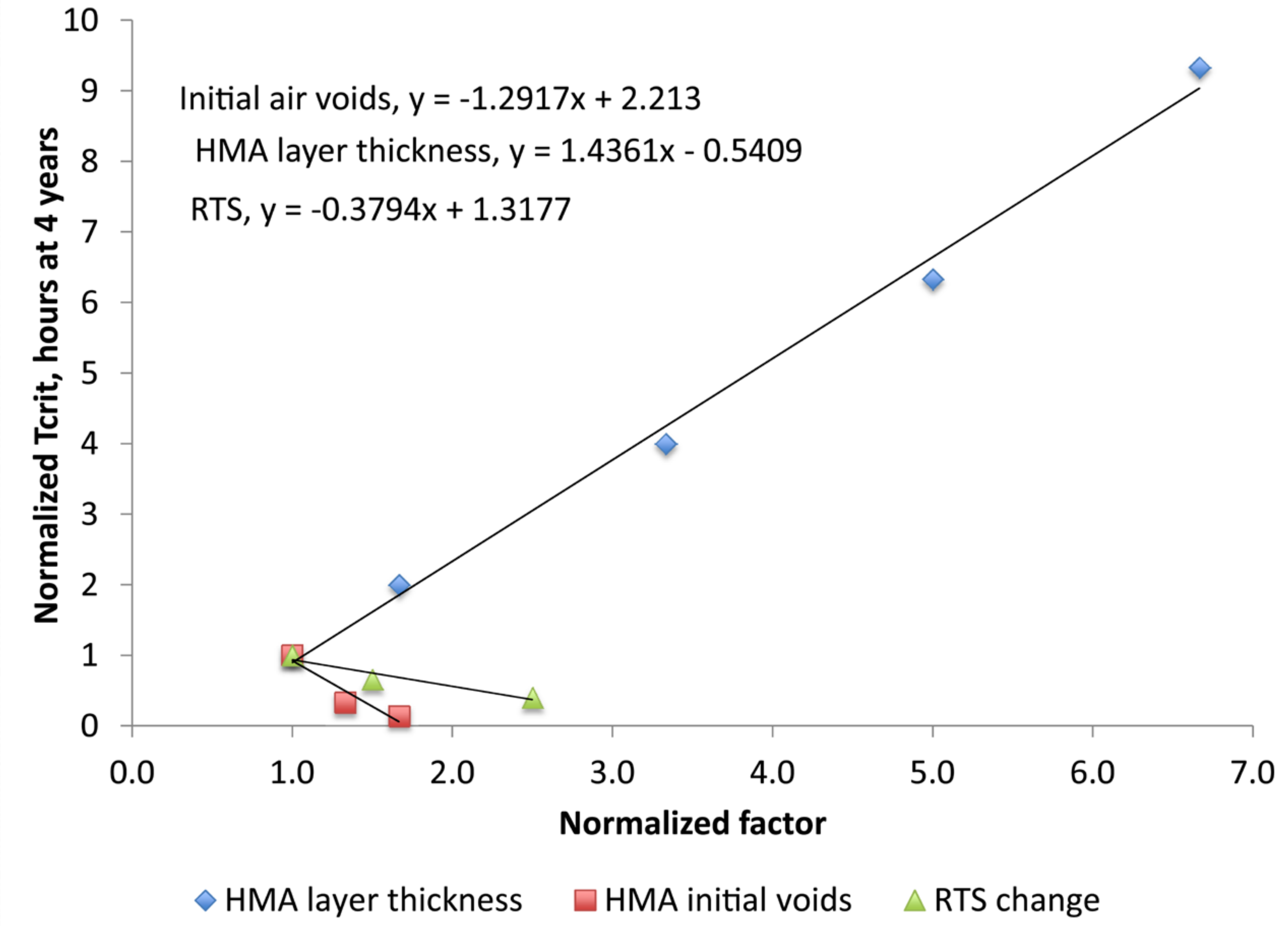
Critical flooding time, hour
0
1
2
3
4
5
4
5
6
7
8
9
10
11
HMA initial voids, %
0 year
4 year



Critical flooding time, hour
5
4
3
2
1
0
0
50
100
150
200
250
HMA layer thickness, mm
0 year
4 year


Critical flooding time, hour
8
7
6
5
4
3
2
1
0
Coarse
Fine
Type of HMA layer gradation
0 year
4 year

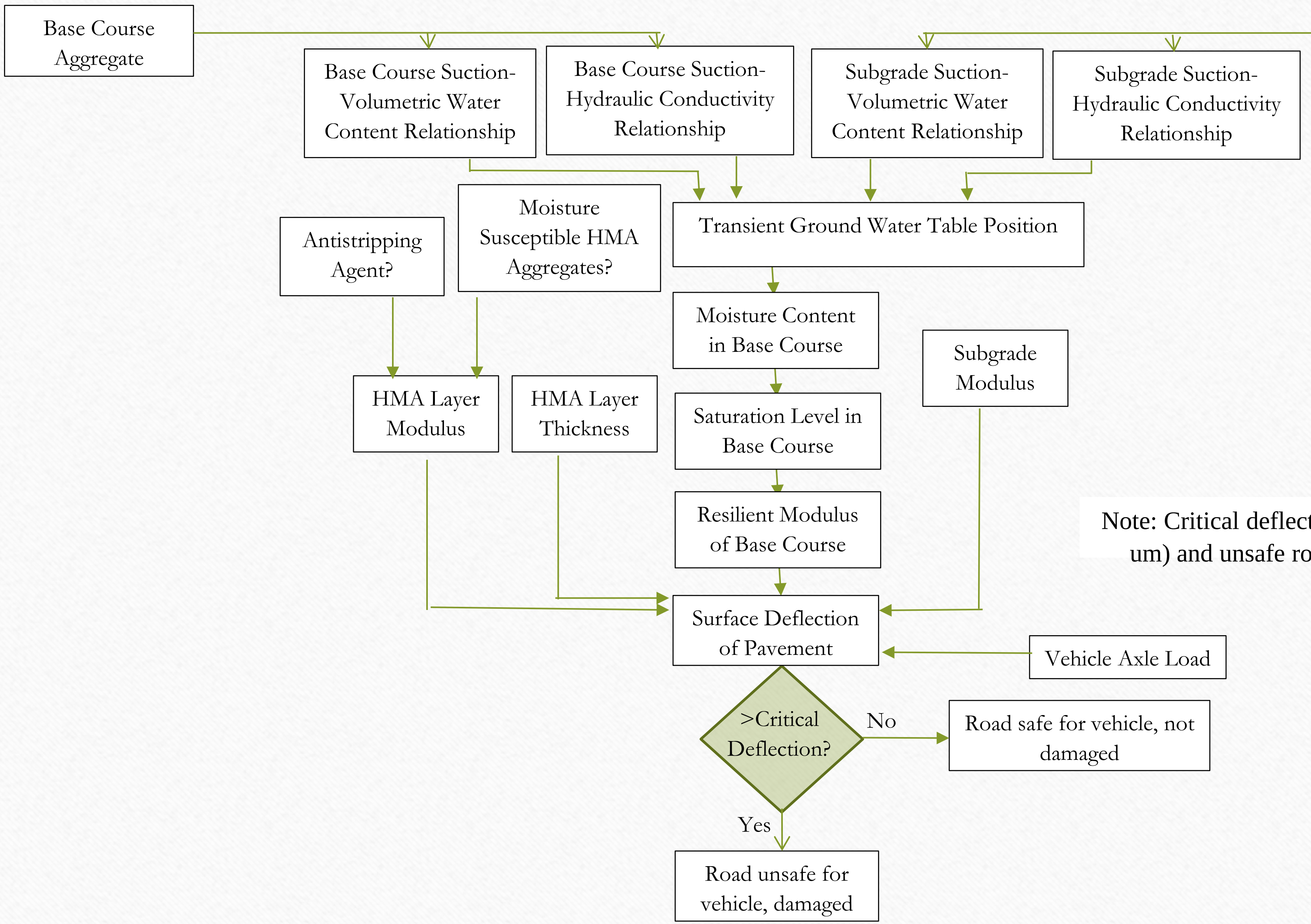

Critical flooding time, hour
5
4
3
2
1
0
0
100
200
300
400
500
600
700
Thickness of base, mm
0 year
4 year



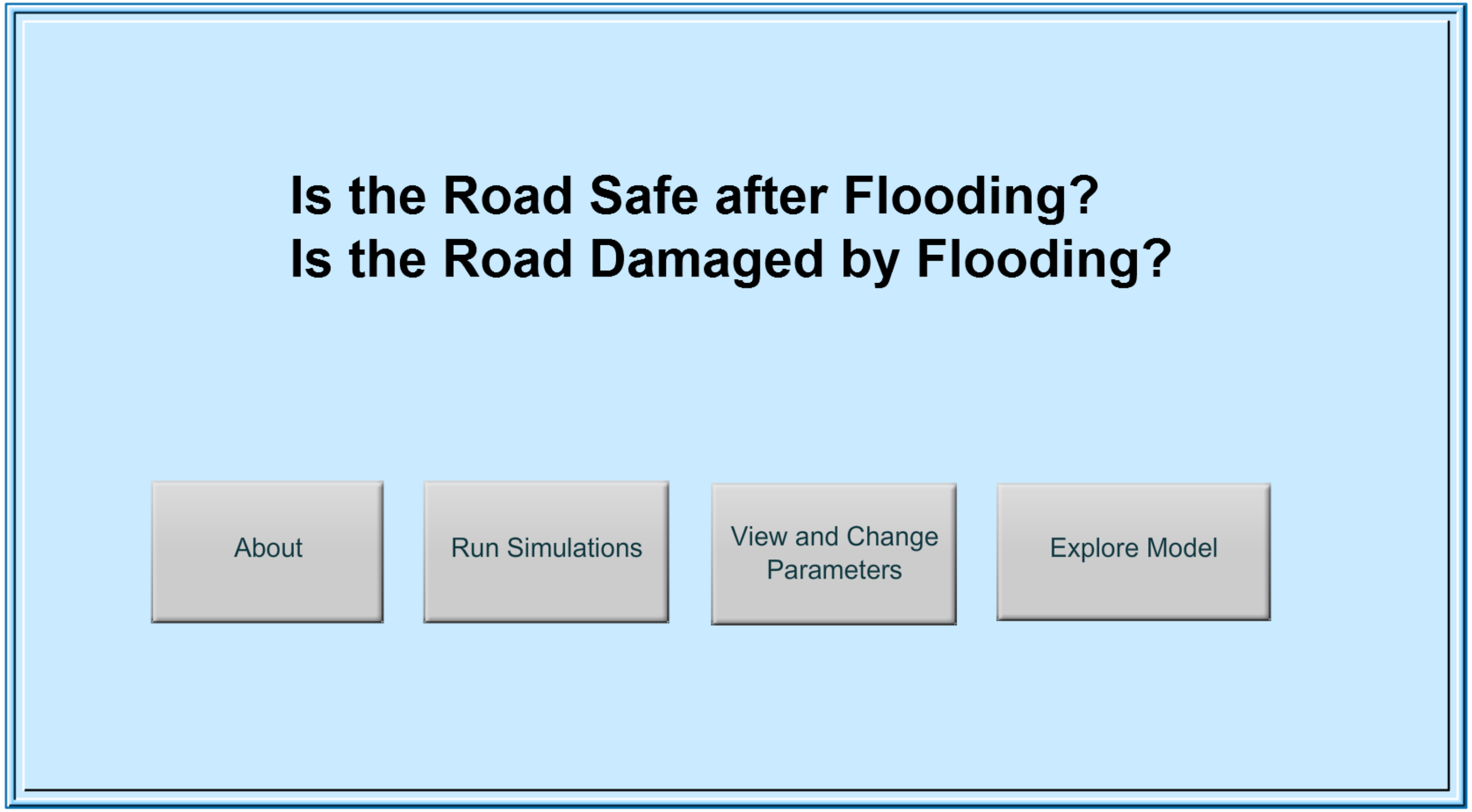
RTS – Retained Tensile Strength

Post-Flooding

Is the pavement in an unsafe/weakened state?

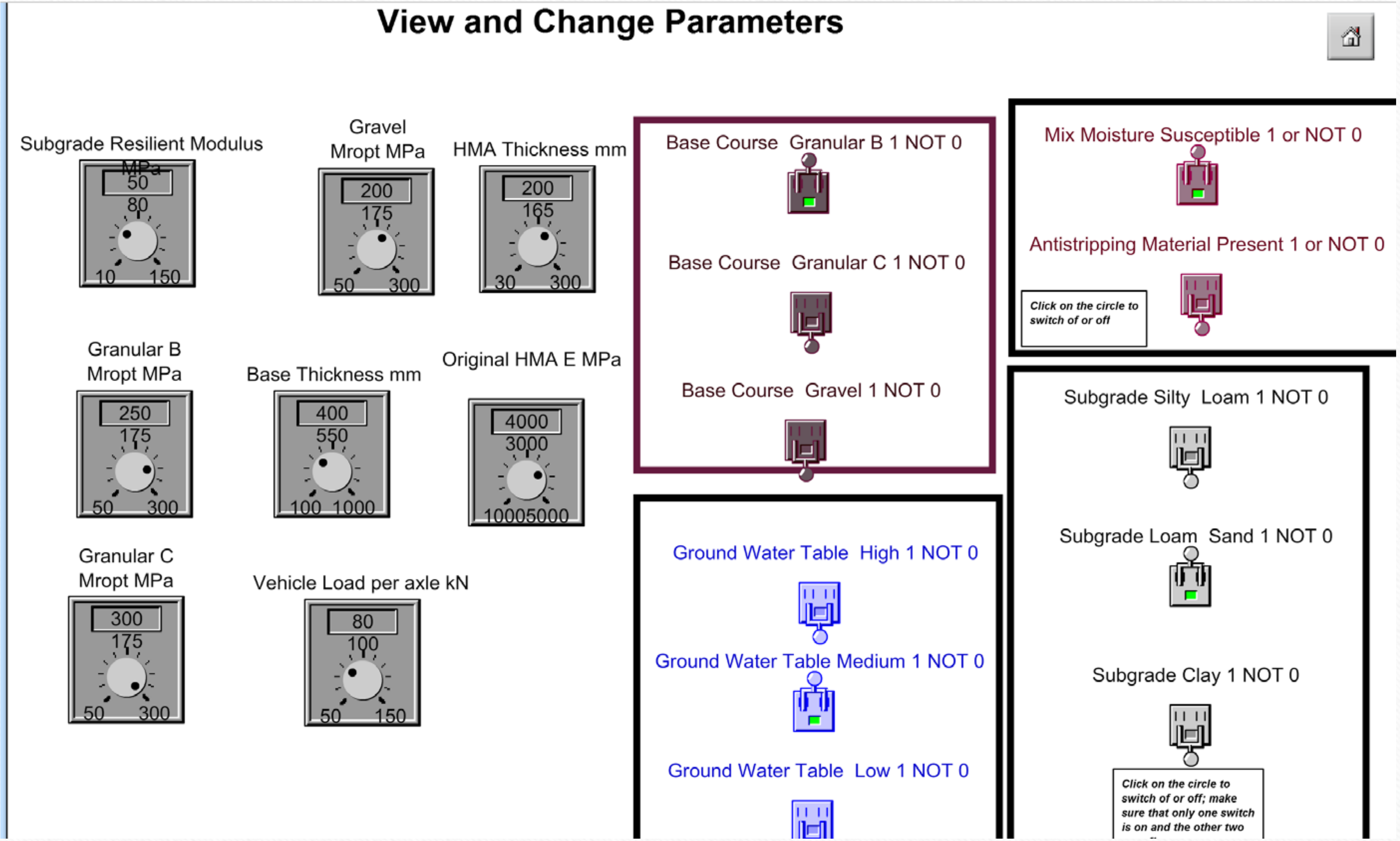


Note: Critical deflections for damaged road (500 um) and unsafe road (750 um) are different

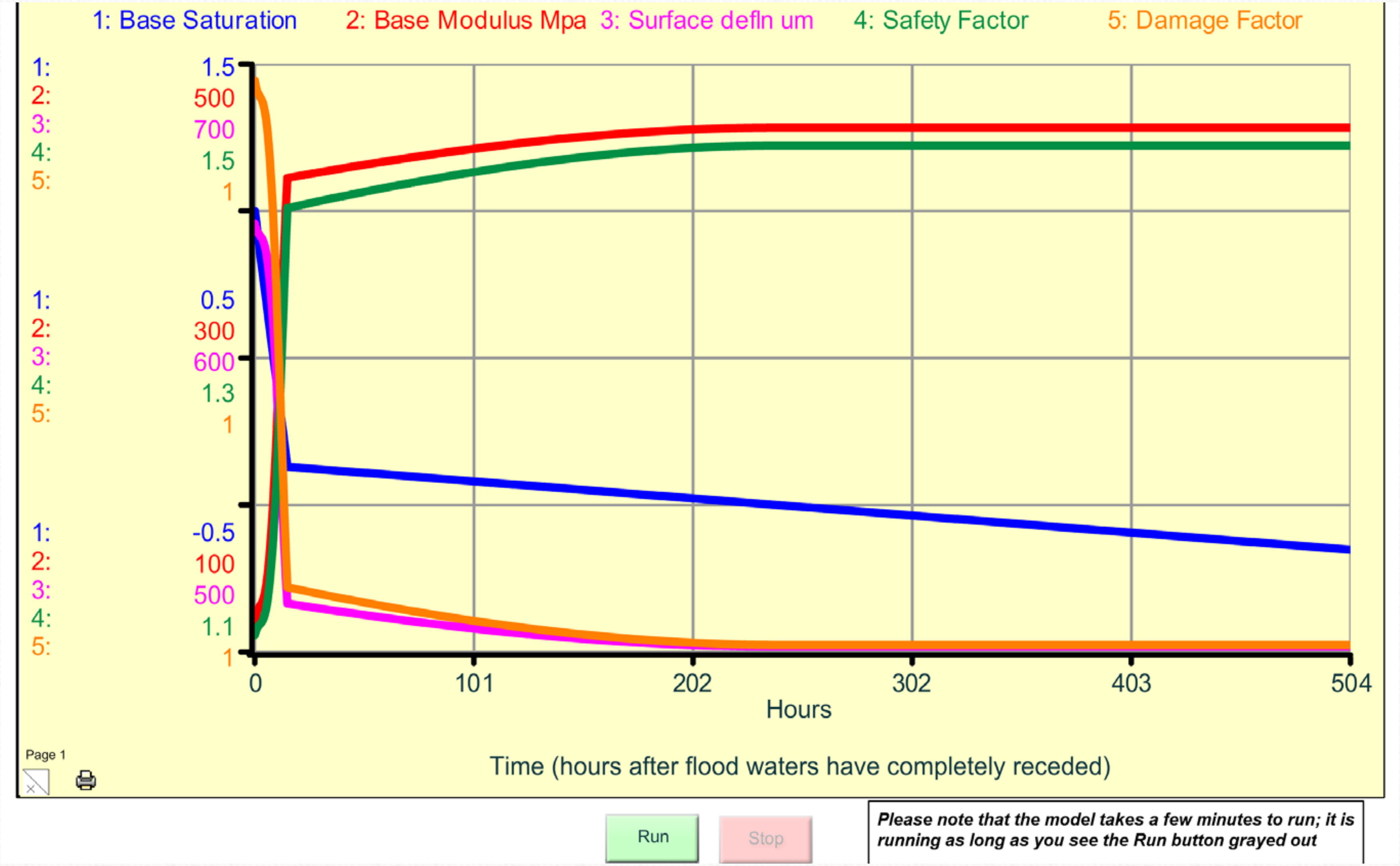


Simulation tool at:

http://goo.gl/jsPrKi



Change Parameter page



Simulation Results page

Results of Simulation

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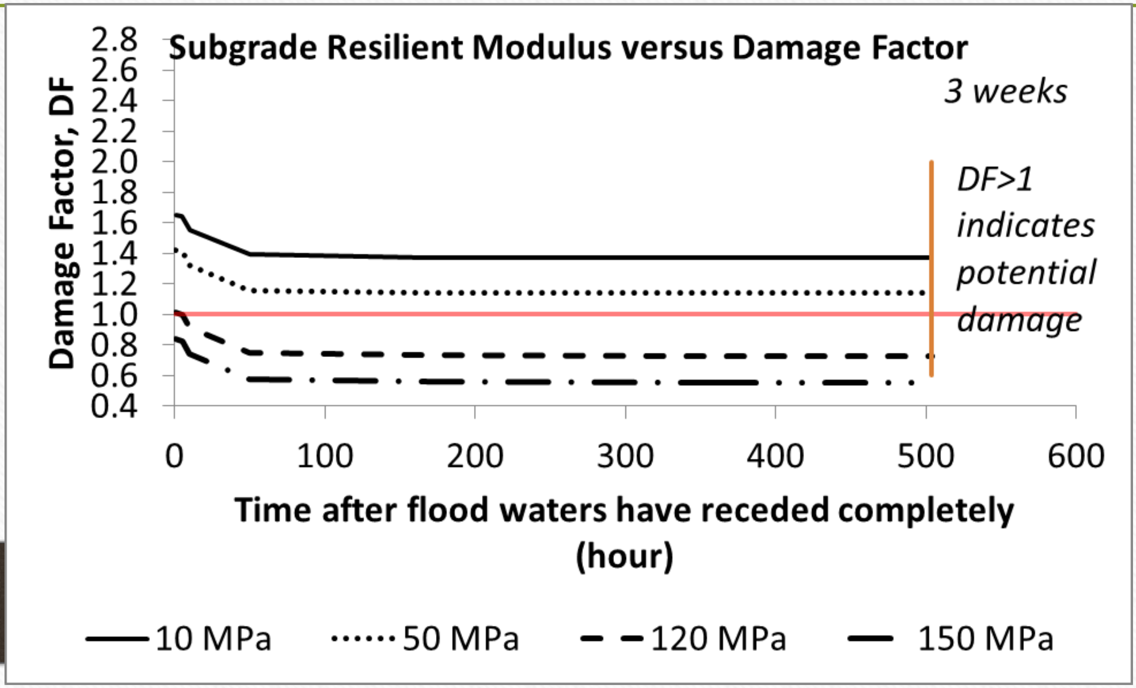
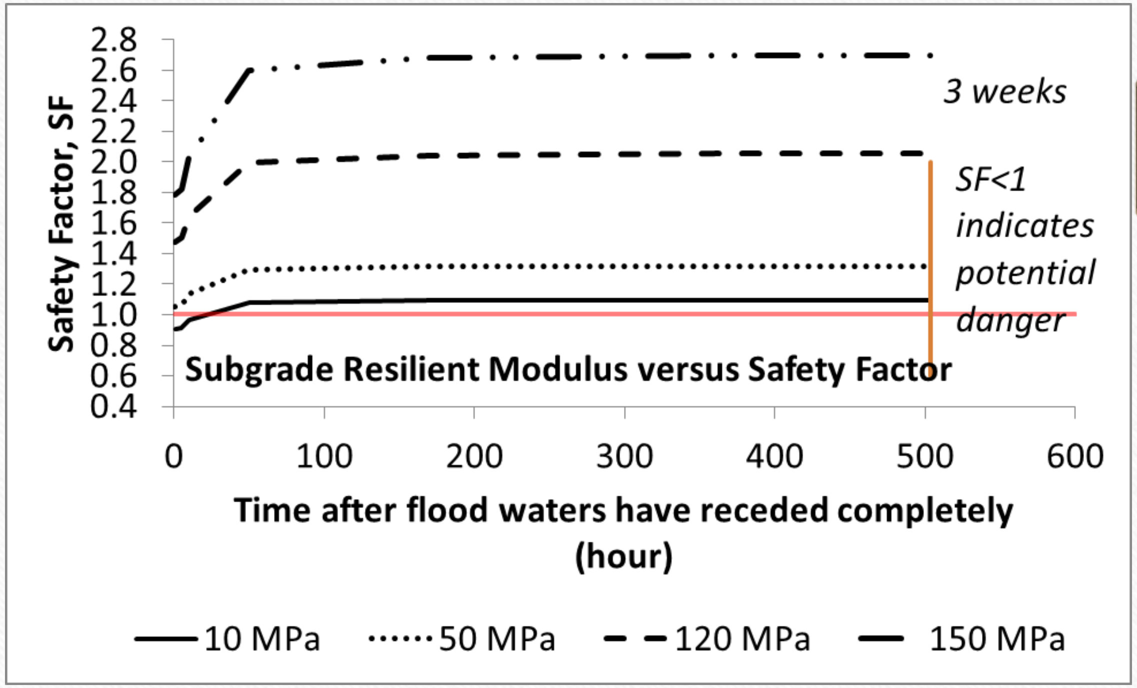

Subgrade Resilient Modulus versus Damage Factor
3 weeks
DF>1 indicates potential damage
Damage Factor, DF
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
100
200
300
400
500
600
Time after flood waters have receded completely (hour)
10 MPa
50 MPa
120 MPa
150 MPa


Subgrade Resilient Modulus versus Safety Factor
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Safety Factor, SF
2.8
2.6
2.4
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1.8
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1.0
0.8
0.6
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Time after flood waters have receded completely (hour)
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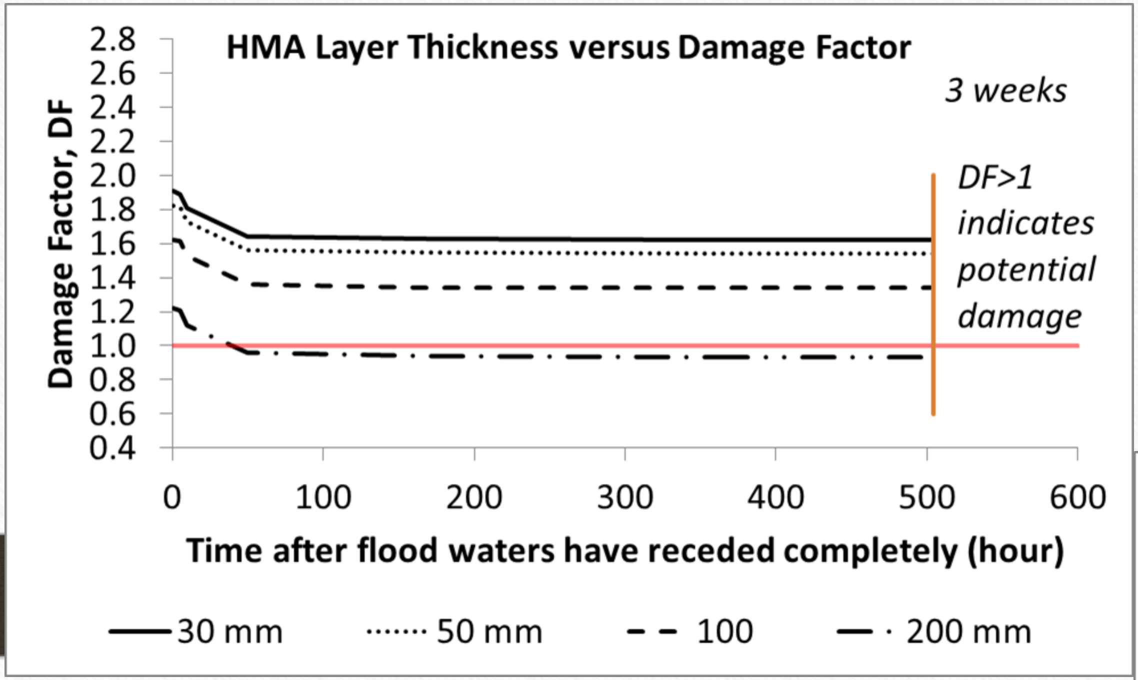
HMA Layer Thickness versus Damage Factor
3 weeks
DF>1
indicates
potential
damage
Damage Factor, DF
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
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100
200
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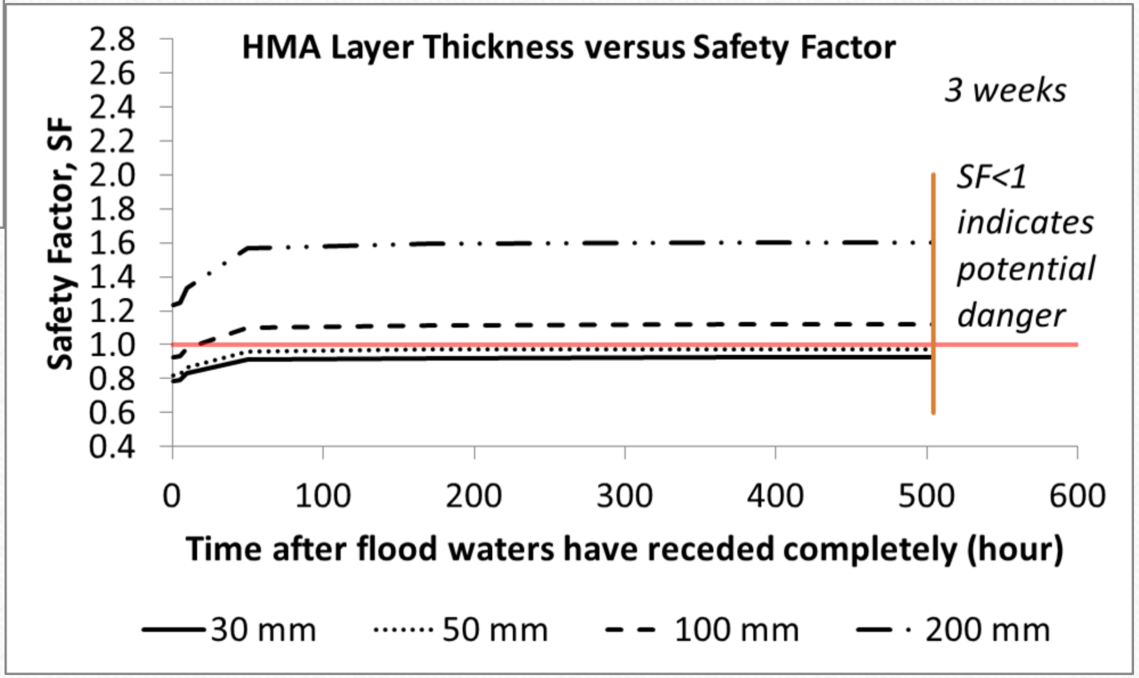
400
500
600
Time after flood waters have receded completely (hour)
30 mm
50 mm
100
200 mm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3 weeks
SF<1
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Time after flood waters have receded completely (hour)
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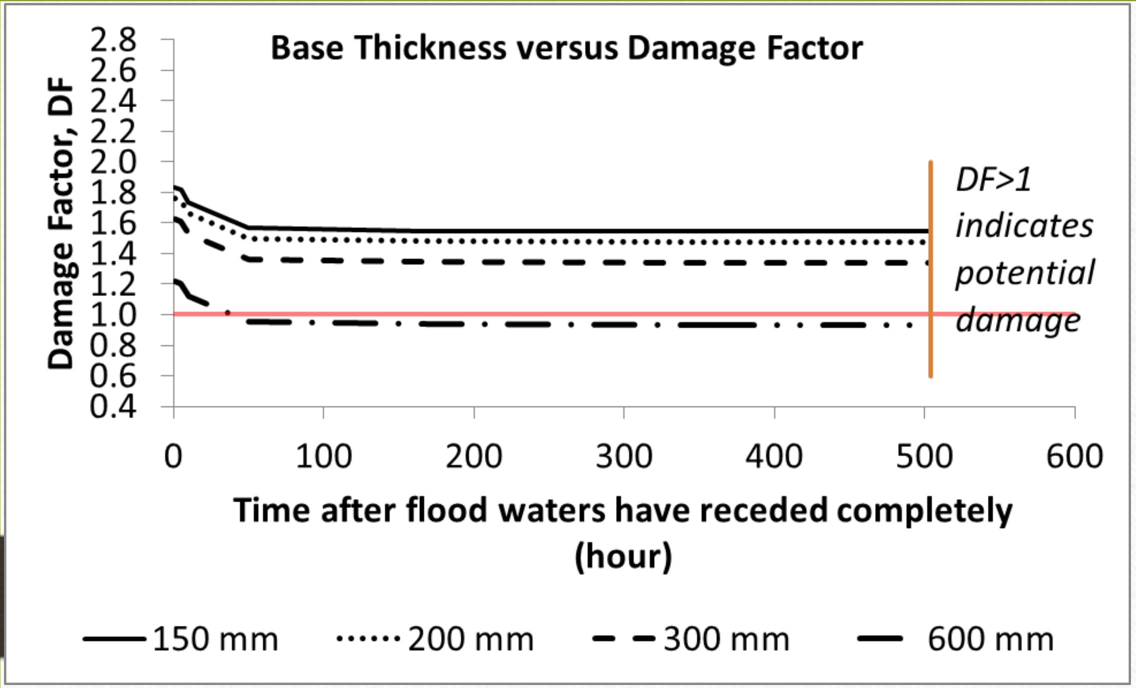
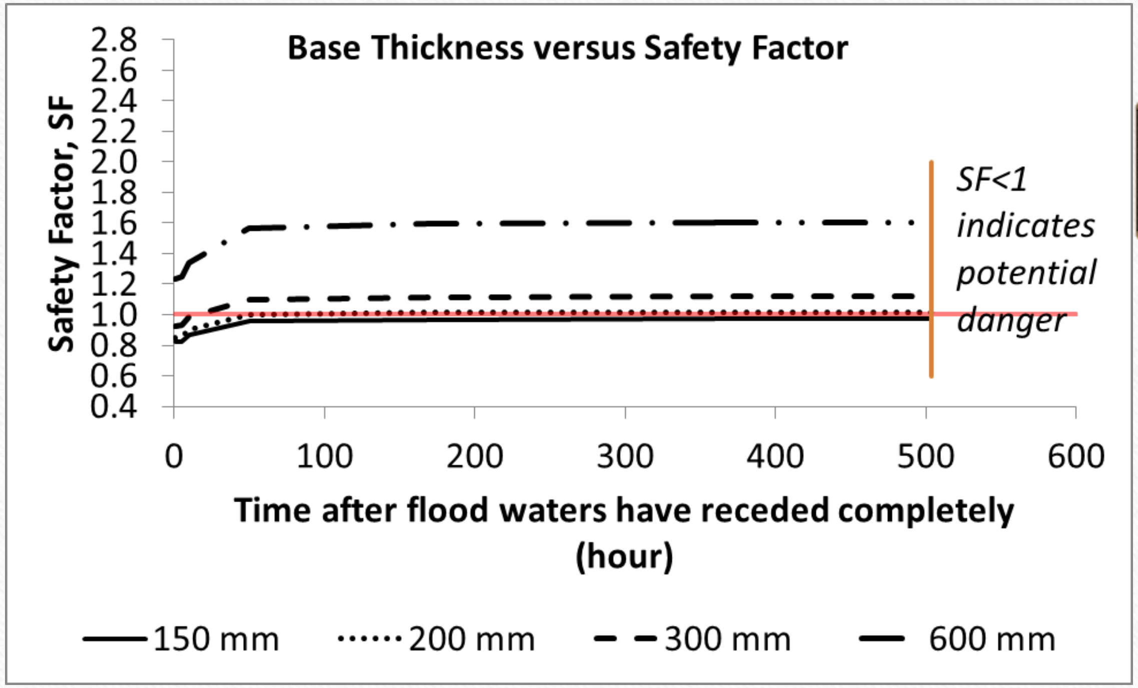
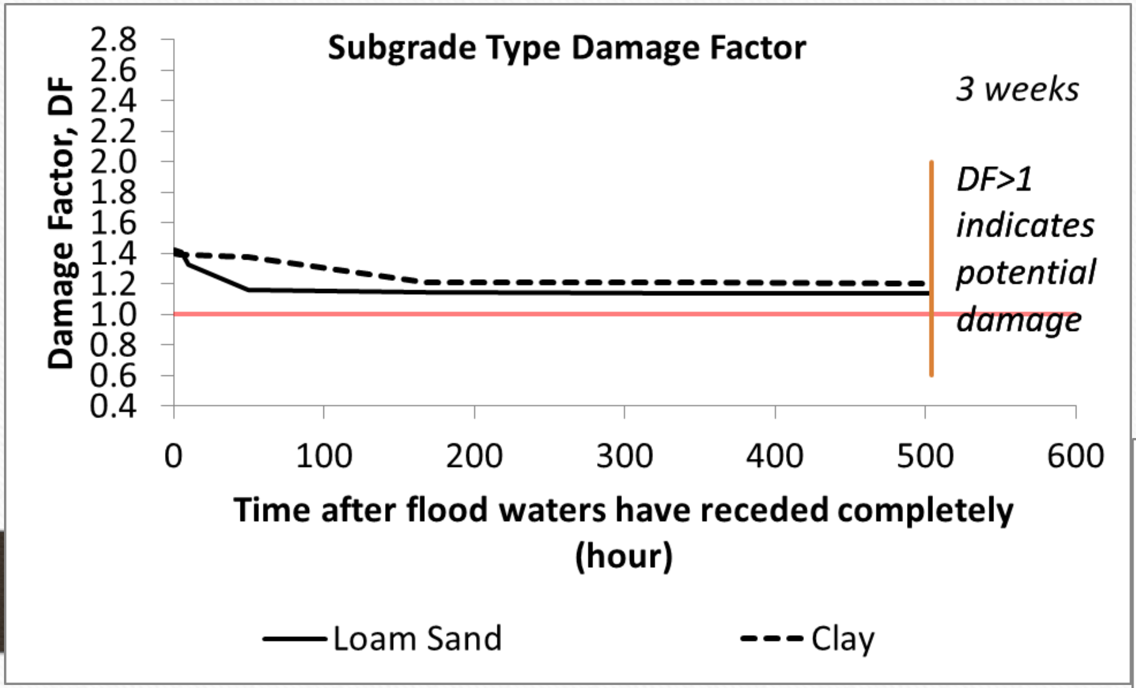
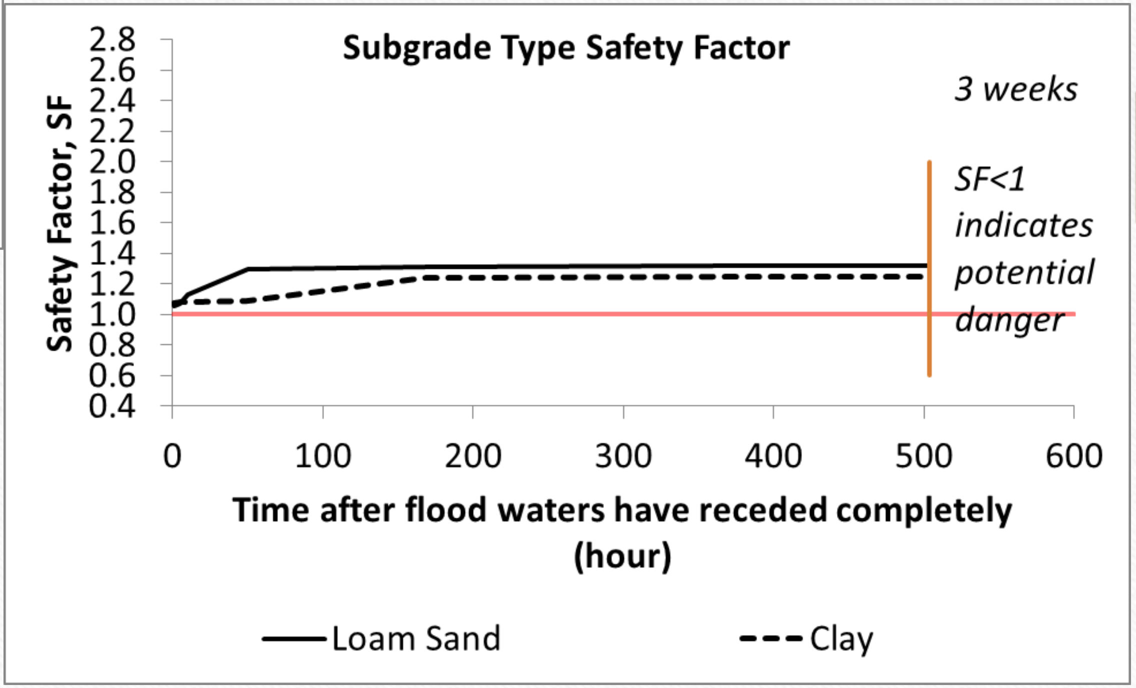

Base Thickness versus Damage Factor
Damage Factor, DF
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
100
200
300
400
500
600
Time after flood waters have receded completely (hour)
DF>1 indicates potential damage
150 mm
200 mm
300 mm
600 mm


Base Thickness versus Safety Factor
Safety Factor, SF
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
100
200
300
400
500
600
Time after flood waters have receded completely (hour)
SF<1 indicates potential danger
150 mm
200 mm
300 mm
600 mm


Subgrade Type Damage Factor
Damage Factor, DF
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
100
200
300
400
500
600
Time after flood waters have receded completely (hour)
3 weeks
DF>1 indicates potential damage
Loam Sand
Clay


Subgrade Type Safety Factor
Safety Factor, SF
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
100
200
300
400
500
600
Time after flood waters have receded completely (hour)
3 weeks
SF<1 indicates potential danger
Loam Sand
Clay

Pavement Type	Critical Time for SF (SF<1), hours
Low subgrade resilient modulus (10 MPa)	20
Low HMA layer thickness (30 mm)	>3 weeks
Low Base layer thickness (200 mm)	50
Low HMA layer modulus (1,000 MPa)	30
High vehicle load (100 kN per axle)	20

Conclusions

- Simulation based approach can help us
  - Understand the effect of multiple factors and their interactions
  - Evaluate the time-dependent effect of factors
  - Understand the implications of using alternative materials, methods or systems
  - Promote strategic thinking by allowing scenario and "what-if" analysis
  - To reach informed consensus among different stakeholders

Recommendations

- Reduce the permeability of the surface layer
- Provide a thicker surface layer to protect the underlying granular base course
- Use appropriate materials to prevent cracking of the surface layer
- Seal cracks on a regular basis, especially prior to flooding seasons
- Protect embankments from erosion near flowing streams

Recommendations

- Use and continuously improve the simulation tool
  - Incorporate other realistic conditions such as edge drains
  - Use state/location specific soils and pavement conditions to update the model
  - Conduct pre- and post-flooding tests on pavements
  - Utilize in-place data to improve the model

For the model and details, please contact rajib@wpi.edu

Thank you!

Los Angeles County
Metropolitan Transportation Authority

Rethinking Adaptation and Resiliency
(In A Rapidly Expanding System)

Dr. Cris B. Liban, P.E.
Los Angeles County Metropolitan Transportation Authority
September 8, 2016

Metro

Our Challenges

- Can we capitalize on the things we already do
- How will vulnerable populations affect our decisions
- Is there room for data-driven decision making
- Who are our partners
- We need to be fiscally responsible
- How do we achieve continual improvement

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LA Metro is Los Angeles County's…

Regional Transit Planner/Funder

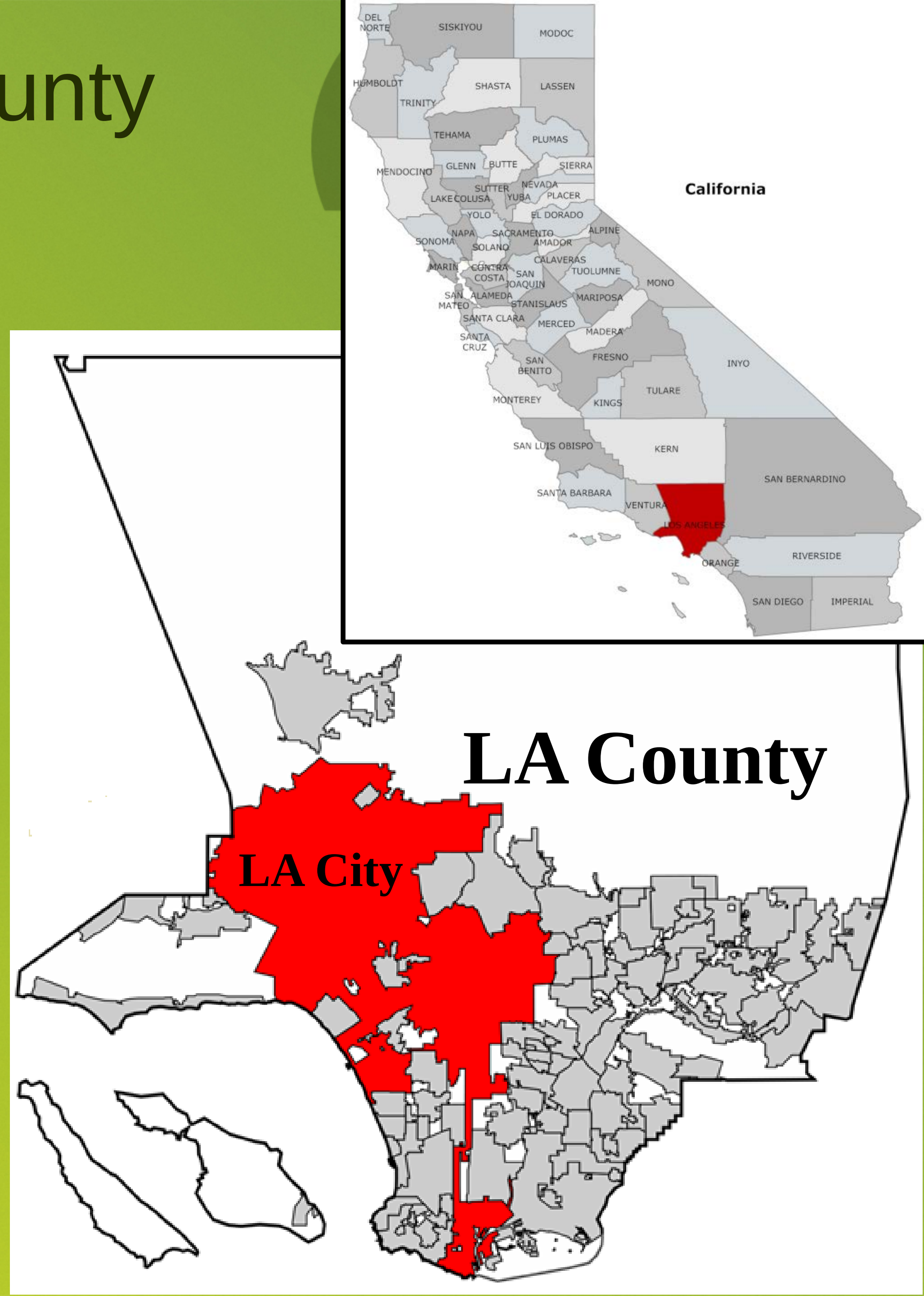
Regional Transit System Builder

Regional Transit Operator

Metro

Los Angeles County

- Includes Los Angeles City and 88 other cities
- Large area– 12,308 km^2
- Large Population
  - Over 10 million people in LA County; 17.6 million in surrounding counties
  - More than 42 states
- Diverse – More than 40% foreign-born, over 220 languages spoken
- County with largest economy in the U.S.; 19^{th} largest economy in the world
- Projected to grow by 1.5 million by 2050



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Measure R Transit Program (Existing and Future)

$120B Measure M :
November 2016 Ballot Initiative

Getting Ready for the 2024 Olympics

Existing Lines:

96 stations

105 miles

370,000 Daily Boardings

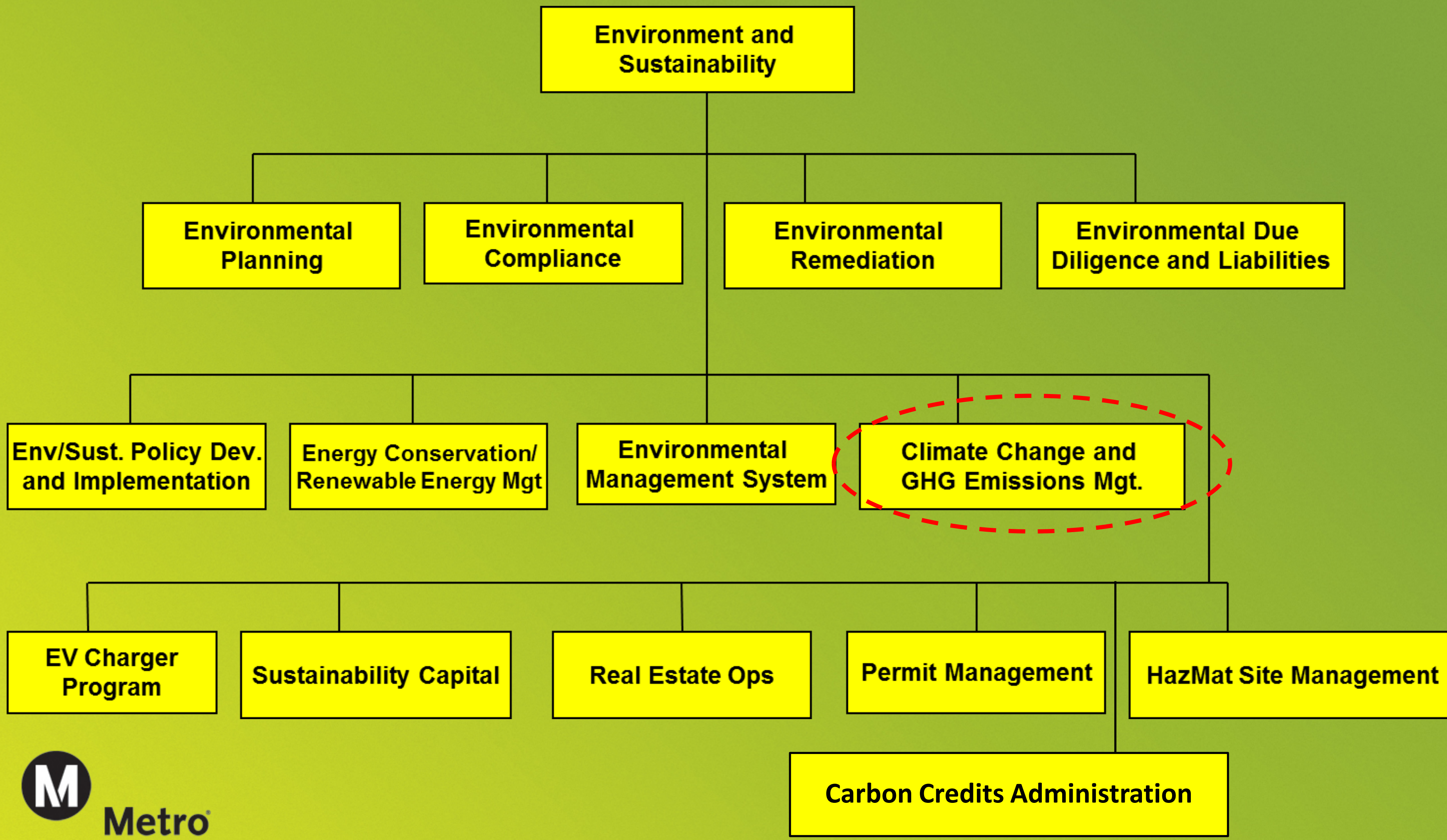
Existing + Measure R:

Total: 197-205 stations,
236+ miles

390,000+ New Boardings

Major Capital Projects

An Integrated Approach



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Adaptation Metrics

1. Has a vulnerability assessment been conducted?
2. Have adaptation actions been prioritized?
3. Have vulnerable assets been mapped with transit dependent and low-income populations?
4. Number of injuries/medical emergencies to workers and riders by temperature and rainfall.
5. Does the agency have overheating standards for public transport facilities and rolling stock?
6. Capacity to monitor weather and temperature conditions in real time at key locations in the service area.
7. Extreme weather impacts on service delays and cancellations.

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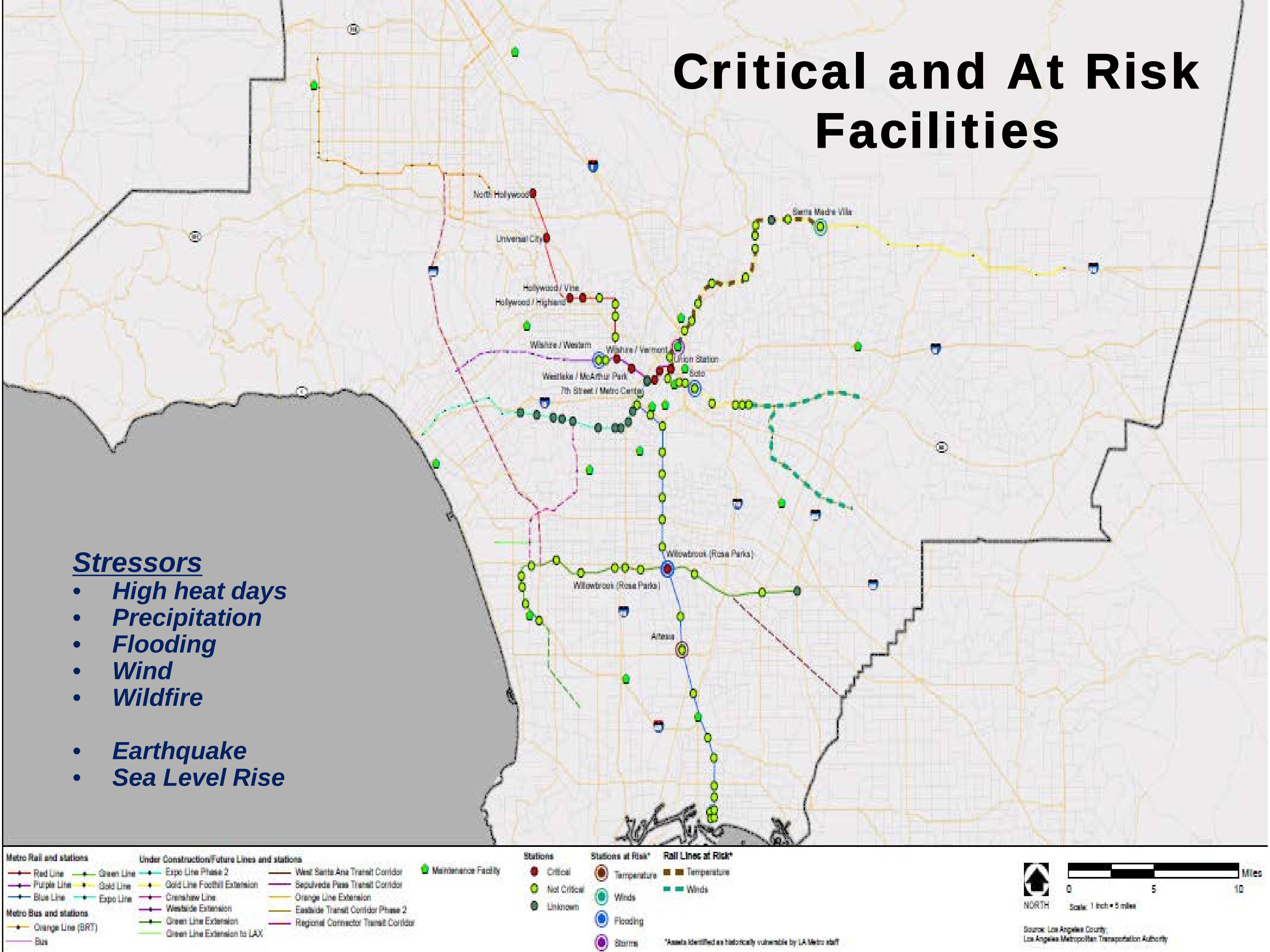
Urban & Environmental Policy Institute
OCCIDENTAL COLLEGE
...for a more just, livable and democratic region.
UEPI

Critical and At Risk Facilities

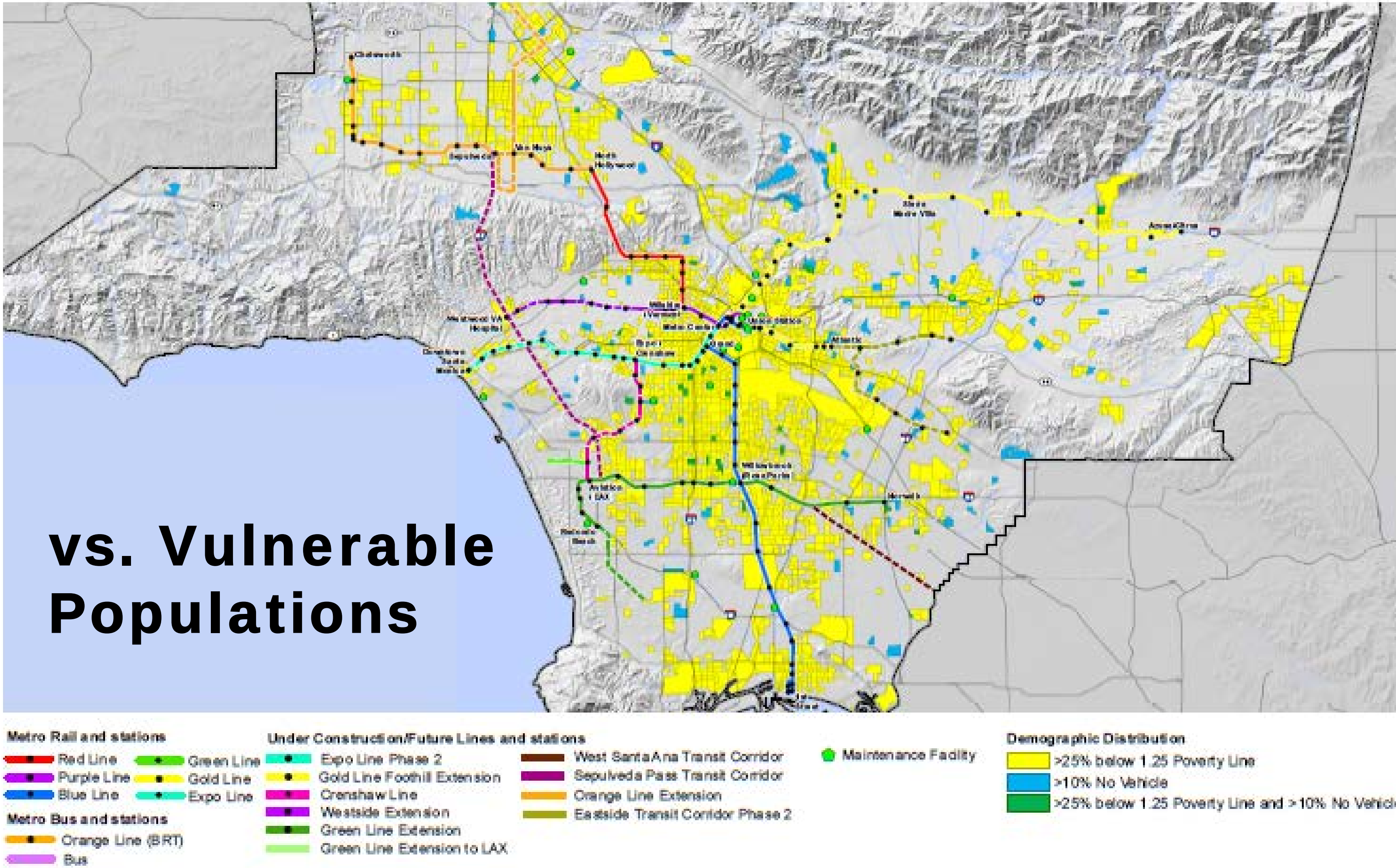


Stressors

- *High heat days*
- *Precipitation*
- *Flooding*
- *Wind*
- *Wildfire*

- *Earthquake*
- *Sea Level Rise*

vs. Vulnerable Populations



Source: Los Angeles County; Los Angeles Metropolitan Transportation Authority 2013, AECOM 2013.

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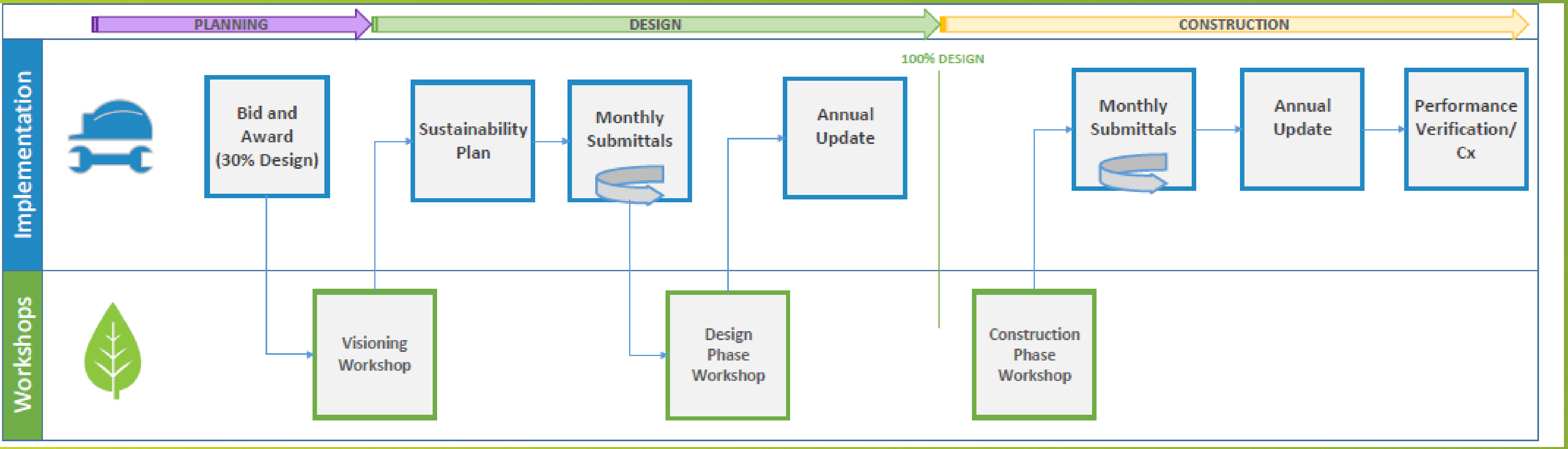
What Have We Done Since Then?

- Update Design Criteria
- Enhanced Project Specifications
- Require Project Sustainability Plan
- Develop Agency-wide Environmental Management System
- International Engagement
  - Federal/State: FTA/FHWA and Caltrans
  - City and County of Los Angeles
  - USGBC/TRB/APTA/ASCE

Metro

Sustainability Plan Process Map
(Existing Framework for Design/Build Project Delivery)



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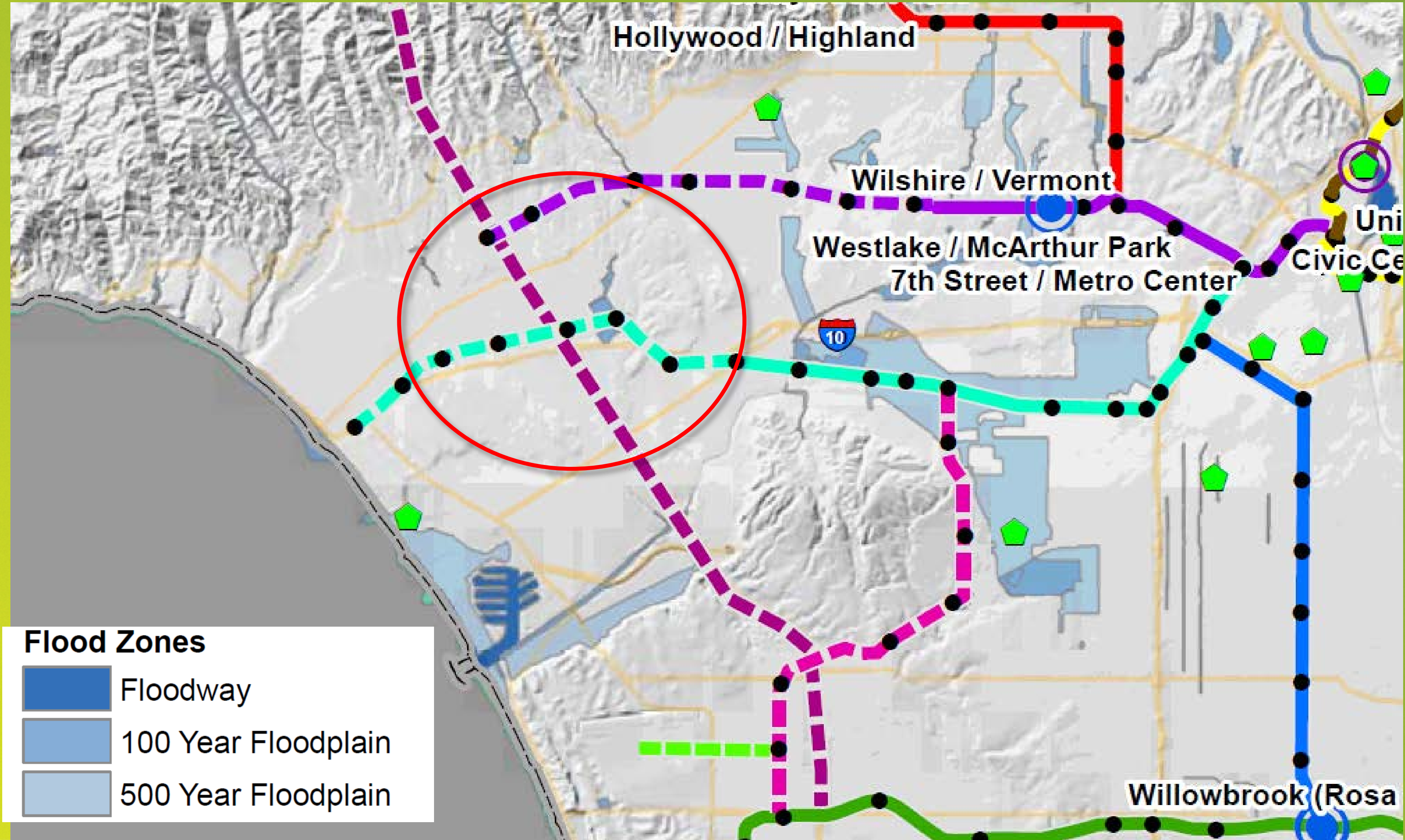
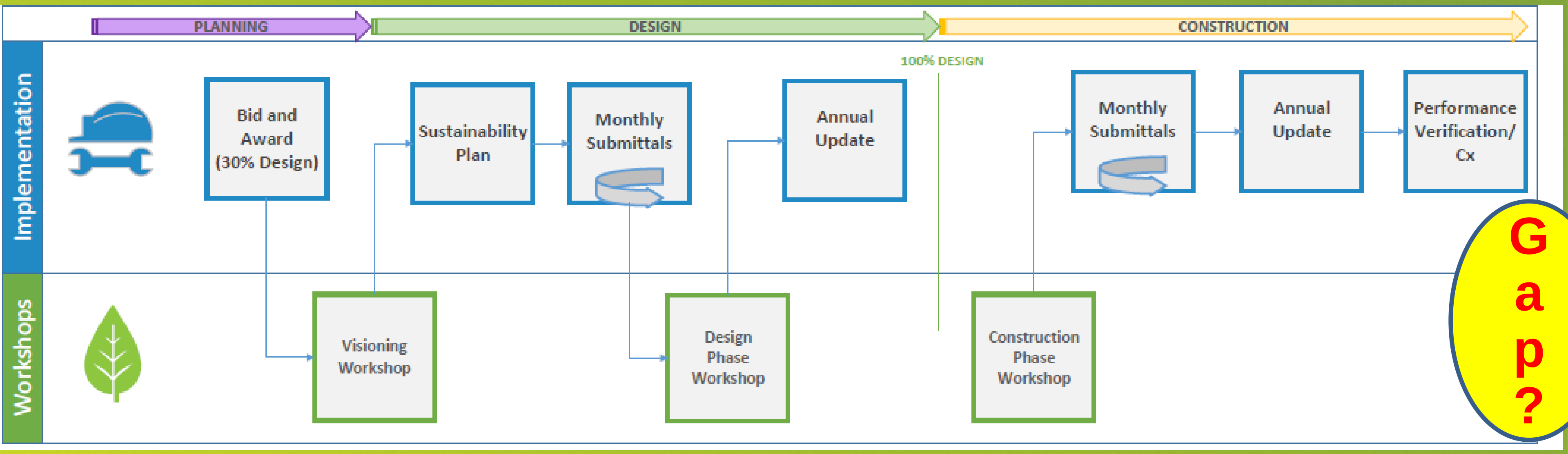
Siting Integration/Floodplain Analysis



Sustainability Plan Process Map
(Existing Framework for Design/Build Project Delivery)



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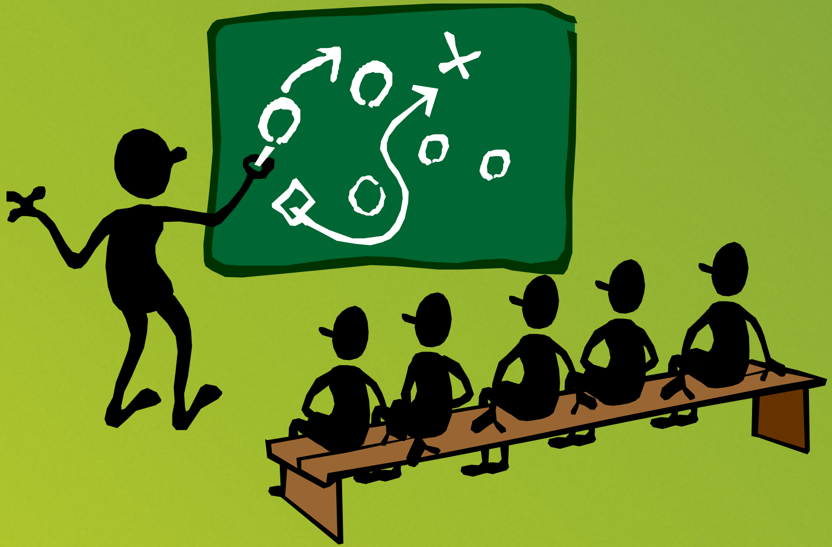
Operational Strategies

- Pre-emptive maintenance or inspection
  - Bus and Rail Assets and Facilities
- Weather/climate-related monitoring and alerts
- Operational design criteria, e.g., materials up to 120° F
- Energy efficiency and off-peak activities planning
- Upgrade and update of OCS



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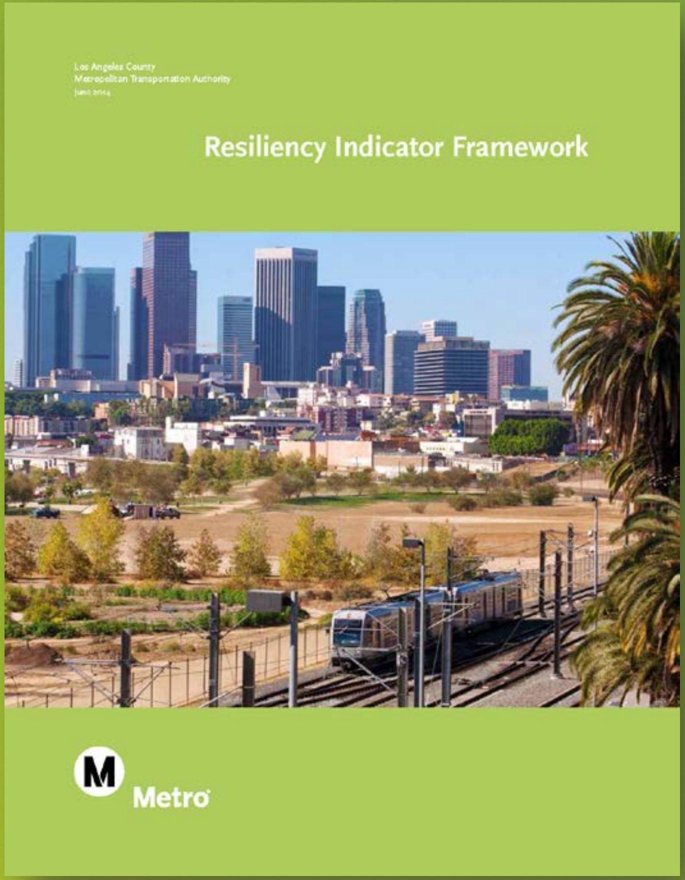
LA Metro Resiliency Indicator Framework Project

Scope

- Develop a framework to evaluate technical and organizational resilience to climate change
- Key climate stressors considered: extreme heat and precipitation

LACMTA definition of resiliency

- Ability to provide core functions in the face of threats and recover quickly from major shocks or changing conditions



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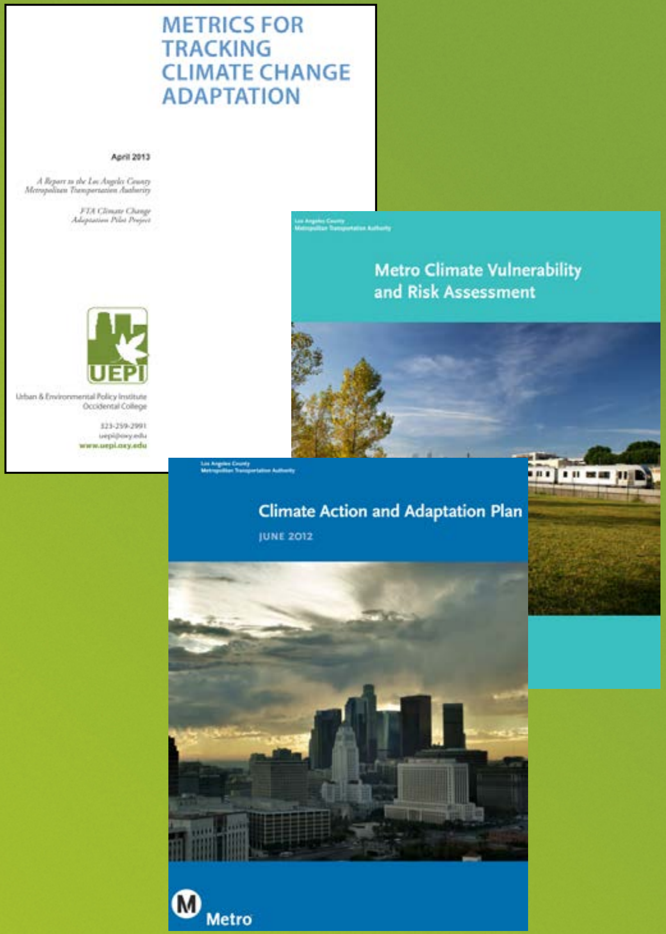
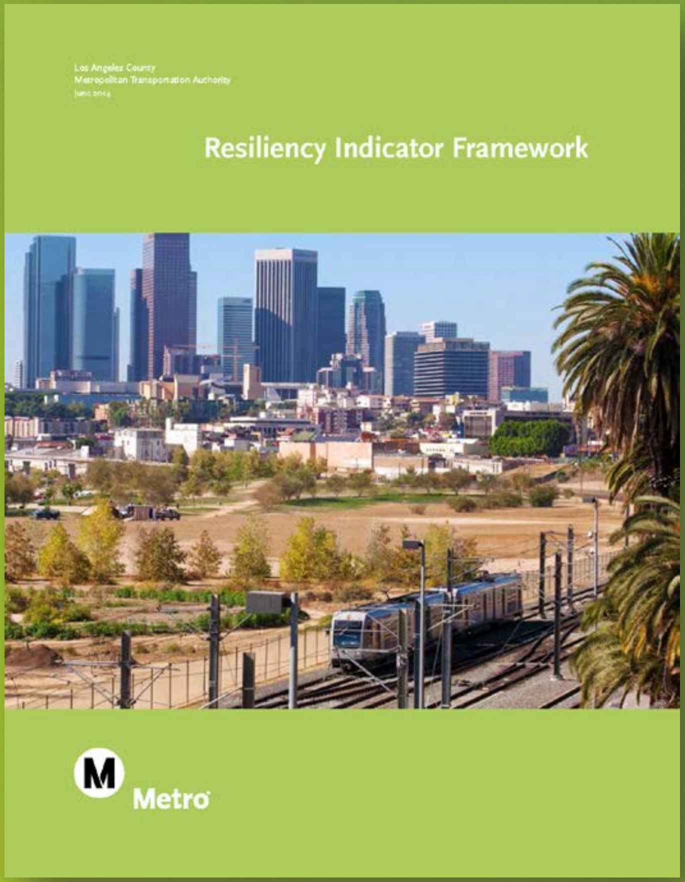
Technical Basis

- Builds on existing Metro climate work
- Indicators help prioritize and evaluate adaptation implementation priorities
- Criteria for future funding streams
- Mapping of assets vs. vulnerable populations
- Incorporating resiliency into Metro processes (e.g., in State of Good Repair Asset Management Database)
- Familiarizing Metro team with concept of Resiliency and Team
  - Internal and External



Implementation

- Continuity of business assessments and coordination
- Design Criteria strategies
- Strengthen implementation strategies
  - o Asset Management Integration
  - o Connections with other Metro efforts
  - o Evaluate Metro’s Technical resiliency
- Identify potential cost impacts
- Energy and Water Resiliency
- City-wide resiliency efforts to disasters and climate change
- Resiliency Policy



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Unified Cost Management Process and Policy

- Design Criteria
- Specifications
- Sustainability Plan
  - Metro Policies and Requirements
  - CA Green Building Code
  - Statutes and Regulations
  - Ordinances
  - Best Management Practices from Certification Systems (as applicable)

- Operations and Maintenance
  - Costs
  - Technology Advancement
  - Workforce Development

Metro

Our Reality

- Unified Cost Management Process and Policy

(Additional Mandates [with Life Cycle])

- Design Criteria
- Specifications
- Sustainability Plan
  - Metro Policies and Requirements
  - CA Green Building Code
  - Statutes and Regulations
  - Ordinances
  - Best Management Practices from Certification Systems (as applicable)

- Operations and Maintenance
  - Costs
  - Technology Advancement
  - Workforce Development

- Sustainability Implementation Plan
  - Internal facing
  - External Input
  - Sustainability Council

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<u>Proposed Strategy</u>

Underlying Financial Questions/Themes

- Blended Return on Investment for all of the sustainability investments already made

- Life cycle costing and/or total cost of ownership method to determine the benefits of implementing new projects

- Winter 2017

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Underlying Financial Questions/Themes

- Cost impacts associated with new regulatory requirements and additional mandates as dictated by the 2016 California Green Building Code. Consider above and beyond requirements anticipated to be mandatory in a 5, 10, 20 year horizon

- Cost impacts for any new updated or mandated inter-jurisdictional ordinances

- Cost impacts on the associated operations and maintenance costs and requirements to operate existing systems as well as the additional resources (e..g., manpower) needed

- Spring 2017

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Underlying Financial Questions/Themes

- Determination of feasible numerical sustainability goals that Metro can adhere to and the ongoing operations and maintenance associated with maintaining that goal through a full life-cycle analysis
- Provide a standardized process into where such goals will be commenced (i.e., either in the planning process, design, construction, or maintenance)
- Fall 2017

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Participation in Research Projects

- TCRP A-41
  - Improving the Resiliency of Transit Systems Threatened by Natural Disasters
- NCHRP SP20-101
  - Framework for Analyzing the Costs and Benefits of Adaptation Measures in Preparation for Extreme Weather Events and Climate Change

TRB
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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Key Take-Aways

- Capitalized on the things we already do
- Vulnerable Populations are Important
- Data-driven decision making/not paralysis
- We cannot do this alone
- Fiscal Responsibility is Key
- M/V for continual improvement

Metro

Questions/Discussion

Cris B. Liban, D.Env., P.E.

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TRB
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Strategic Management Challenges for Climate Resilient and Sustainable Transportation

Robert Paddon

“Rare Harmony as China and U.S. Commit to Climate Deal”

September 3, 2016

The New York Times

The Paris Agreement is a bridge between today's policies and climate-neutrality before the end of the century

Picture sourced from www.anthropocene.info

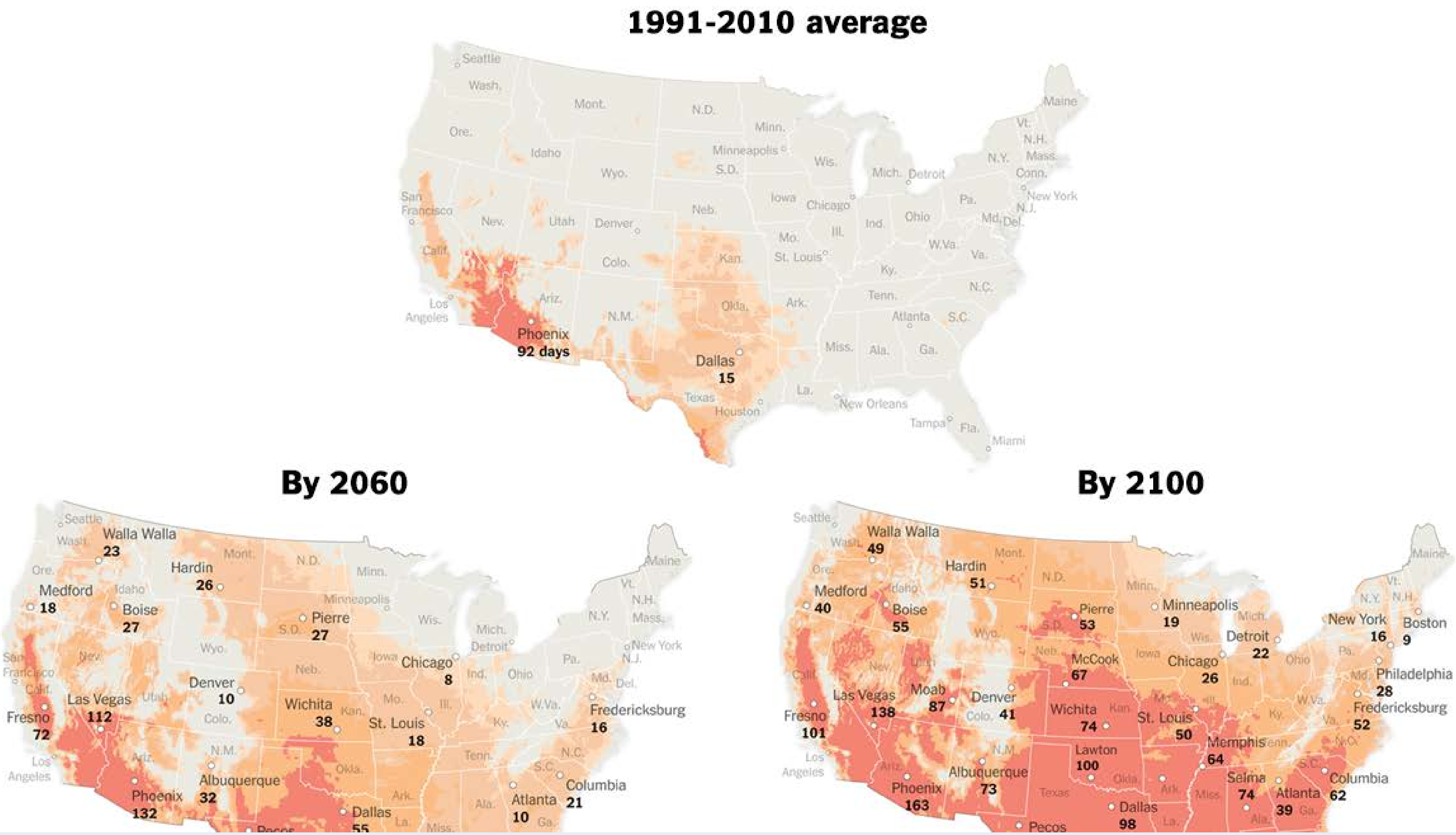
The Anthropocene defines earth's most recent geologic time period as being human-influenced, or anthropogenic

The National Climate Assessment summarizes the impacts of climate change on the United States, now and in the future

Picture sourced from www.orchard.co.uk

Some of the reasons for inaction include limited funding, policy and legal impediments and difficulty in anticipating climate-related changes

The heat affects our health, air quality, food, water supplies
and our transportation networks



Think it's Hot Now? Just Wait

New York Times, August 20, 2016 - Days above 100 degrees Fahrenheit


HOW DID THIS HAPPEN?

The stranded: Thousands of students stuck at school and weary travelers finally make it home.

The firestorm: Public safety officials and government leaders respond to criticism over the chaos.

SIX PAGES OF COVERAGE INSIDE

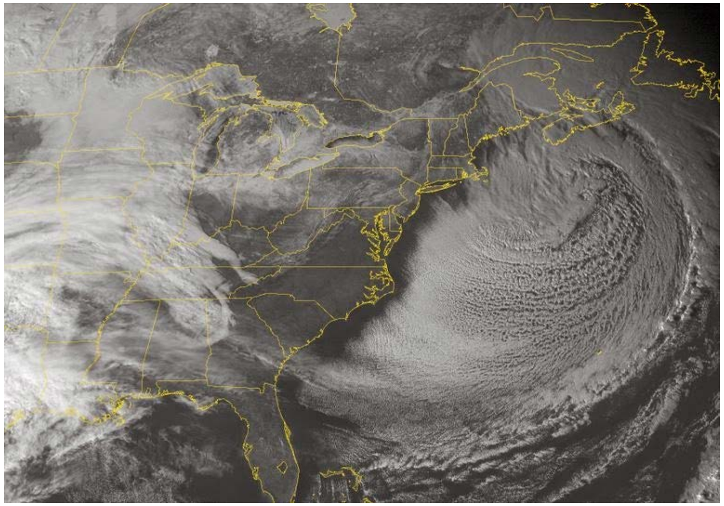
In the U.S., heavy rain has increased 71 percent in the northeast, 37 percent in the Midwest and 27 percent in the southeast

Picture sourced from www.theadvocate.com

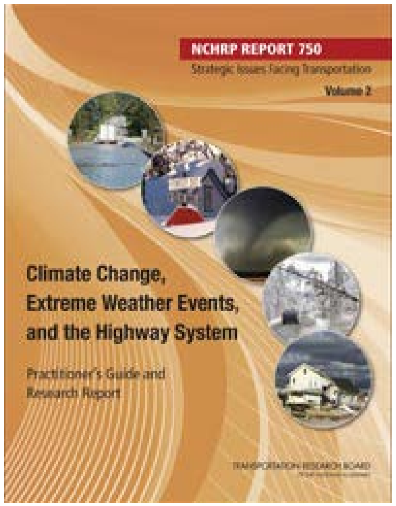
A state official in Louisiana attributed the recent catastrophic flood to climate change

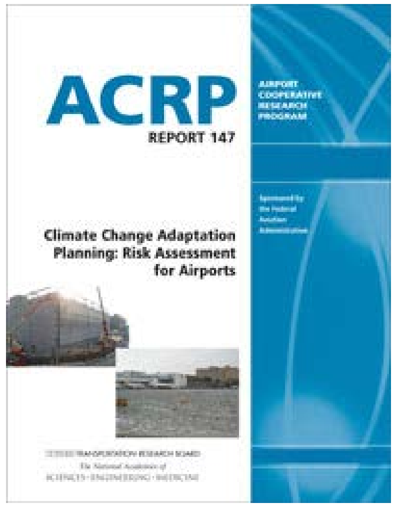
Picture sourced from www.dailymail.co.uk

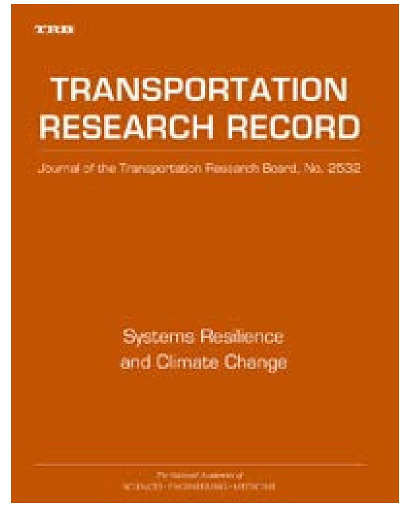
The inundation of the coast has begun and costal communities are feeling the impact

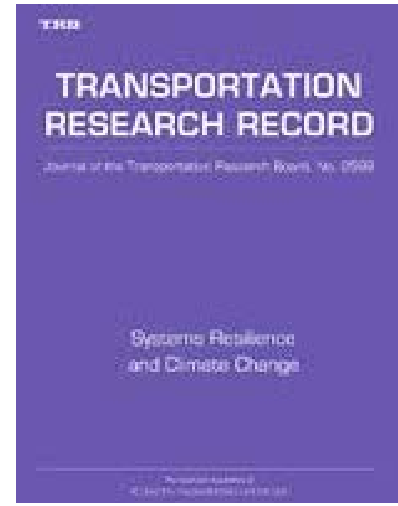


The impacts of climate change are being observed across Canada's diverse geographic regions

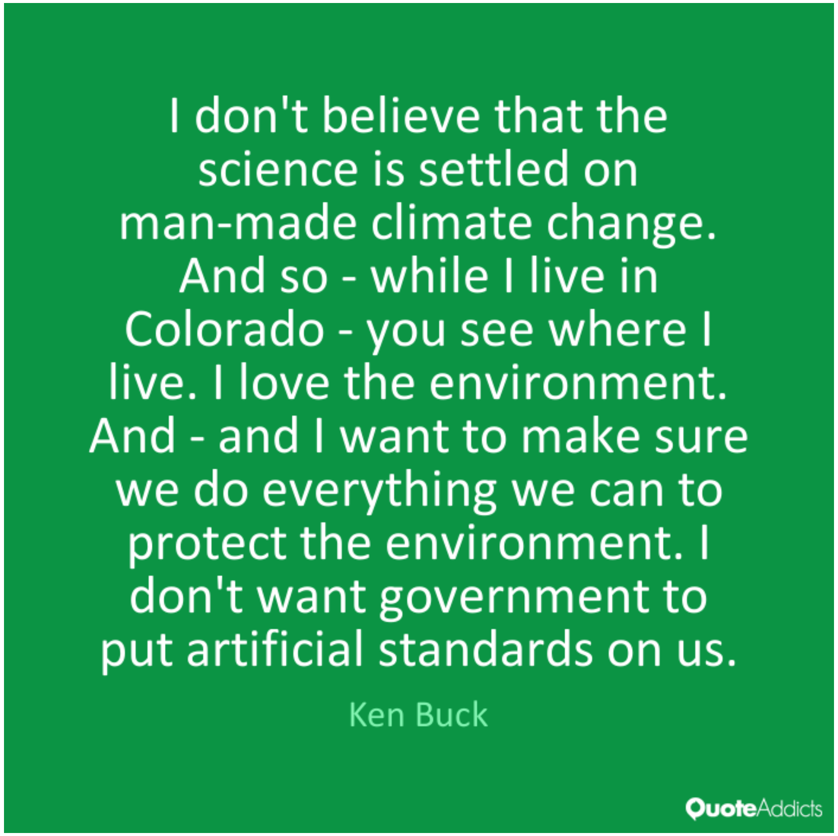


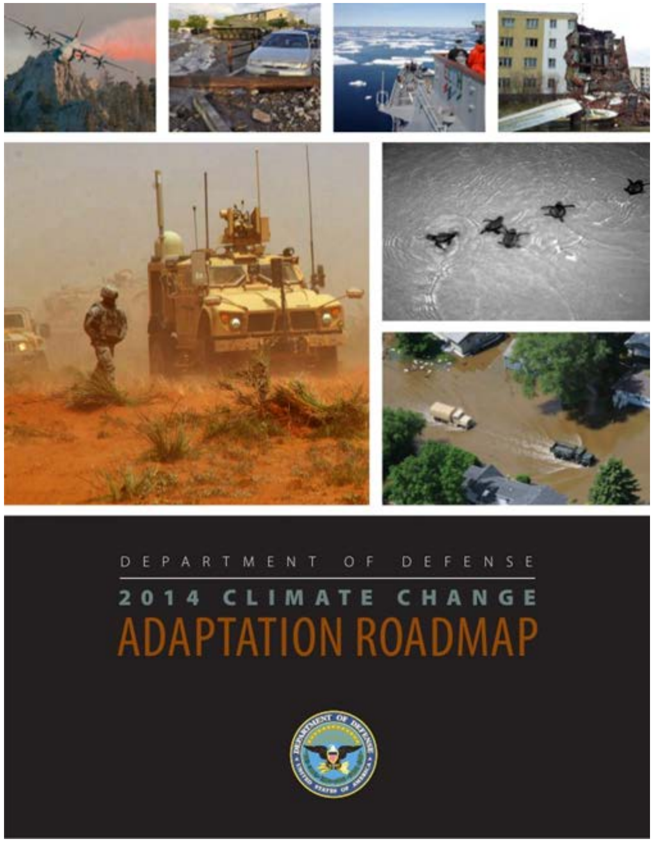






The Transportation Research Board has undertaken significant work on climate change adaptation





Federal agencies are required to plan for adaptation; however, there are many challenges when trying to move from plan to action

Barriers to Adaptation

- Climate change information and decision-making
- Lack of resources to begin and sustain adaptation efforts
- Fragmentation of decision-making
- Institutional constraints
- Lack of leadership
- Divergent risk perceptions, cultures and values

Picture sourced from www.cea-ace.ca

The National Climate Assessment has identified several barriers to adaptation including political leadership

Picture sourced from http://pixabay.com

Adaptation + Mitigation = Synergy