Reducing the Impact of Climate Change Through Improved Pavement Resiliency

John Harvey
City and County Pavement Improvement Center, UC Davis
Public Works Officers Insitute, Monterey, CA, March 18, 2020

Goal of this presentation

- The goal of this presentation is to discuss a few concepts for the why, what, where, when, how of thinking about pavements and climate change, based on current knowledge of the presenter
- Focus on California
- Stimulate thinking, discussion and collaboration

Climate Resiliency and Pavement
What are the issues?

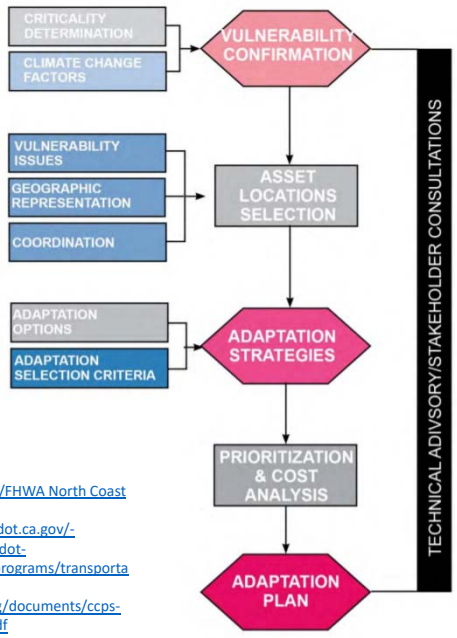
- How does climate change directly affect pavement?
  - Temperatures
  - Rainfall
  - Groundwater
  - Sea level rise
  - Responding to extreme events: rainfall events, fires
- How do measures to reduce climate change affect pavement?
  - Changes in vehicles
  - Changes in materials
  - Changes in design decision-making criteria
- Stationarity
  - Assumption in design that distributions of past conditions will continue
  - Climate change takes away the assumption of stationarity

Goals of Climate Resilience

- Balance risk of not functioning, investment, and cost to customers
- Long-term: maintain functionality over entire design life
  - What is the life of roads? Seldom abandoned or torn out
  - What is the life of reconstruction and rehabilitation treatments?'
  - Designing in flexibility and adaptability
- Short-term crises: remain functional in extreme climate events
  - During the event
  - As the event subsides
- How well can we predict either of these?

Climate change is about risks: Basic steps in risk management

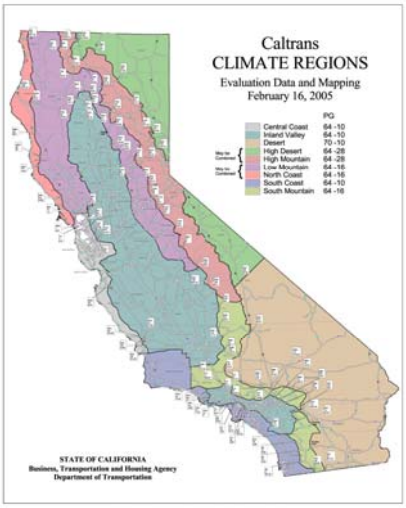
- Identification
- Quantification
  - Outcome
  - Probability of outcome
- Response development
  - What is the plan
  - Performance measures
- Response control
  - Are we doing what we said we were going to do?
  - Should the plan change?
- Stakeholder engagement throughout
- Is this process underway for California local government pavement?



Caltrans/FHWA North Coast Pilot https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/ccps-a11y-.pdf

Risks for pavement: functionality over the long-term with climate change

- Temperatures
  - Asphalt high temperatures (PG maps)
  - Concrete temperature gradients
  - Concrete drying shrinkage gradients
- Rainfall
  - Culvert designs
  - Embankment heights
  - Pavement heights and drainage
- Groundwater
  - Generally falling in California, except where sea level rise
- Repeated flooding from sea level rise
  - Hardening approaches?
  - Plans for abandonment?

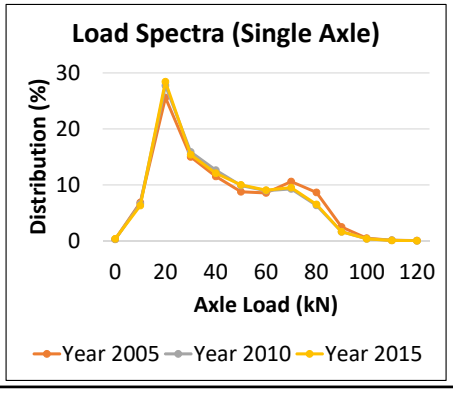


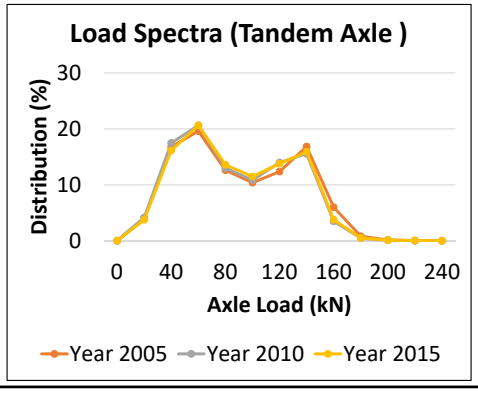
Risks for pavement: functionality over the long-term responding to climate change reduction measures

- Changes in vehicles
  - Heavier axles for electric vehicles
  - Increasing tire pressures
  - Not related to climate change: increasing numbers of heavier vehicles on city streets
- Changes in materials
  - Changes in oil refining industry
  - Changes in cement
  - Other materials?
- Changes in design decision-making criteria
  - Consideration of environmental impact + cost

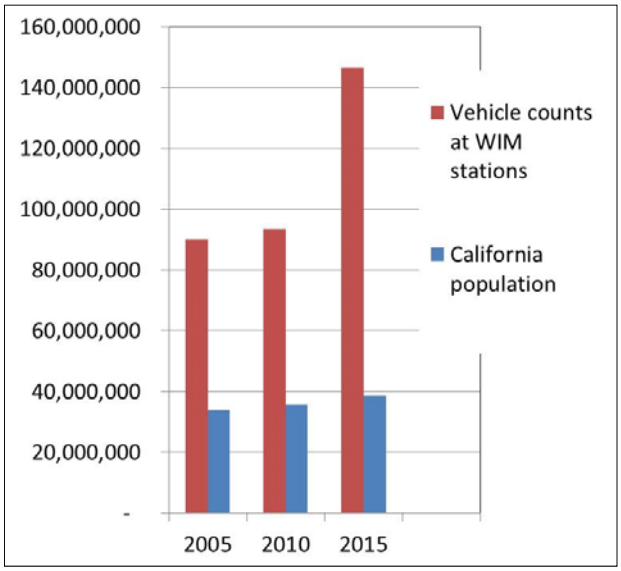
Truck traffic axle weights increasing?

- State-wide average axle loads (115 WIM stations) virtually unchanged in 10 years
- Gross vehicle weights slightly reduced
- Battery electric trucks will increase some axle loads over next decades





Freight growth: more trucks



- 62% increase in truck counts vs 14% growth in population
- Short-haul: 69% increase
- Long-haul: 59% increase

UCPRC/Caltrans WIM data

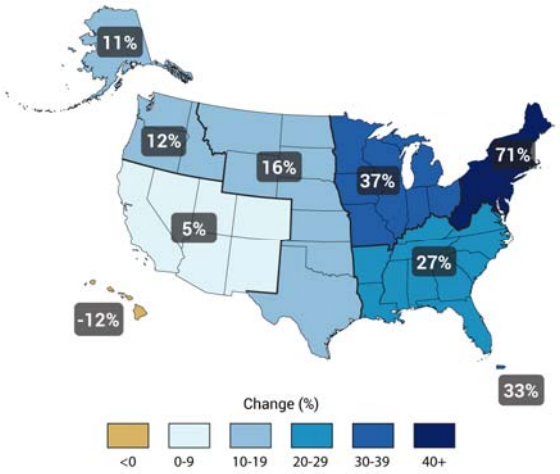
Risks for pavement: functionality during and after extreme events

- Functionality during extreme events:
  - Mostly light vehicles going out of affected areas
- Most damage occurs during the recovery:
  - Heavy vehicles hauling out debris, demolition
  - Heavy vehicles hauling in relief materials
  - Pavements in vulnerable condition:
    - High water contents in pavement materials
    - Eroded support
    - Fire damaged materials

Risk quantification

- Climate change information
  - Do pavement and roadway designers have access to updated climate projections
  - Climate projections are at the regional level, major disconnect to local design inputs:
    - Design storm rainfall probabilities
    - Local temperature distribution changes
    - Humidity changes?
  - Sea level and groundwater changes
- Vulnerability for extreme events
  - Identification of probabilities for different locations
  - Planning for access after events

Observed Change in Intensity of Very Heavy Precipitation Events in US 1958 to 2012
National Climate Assessment 2014



Response development

- There is often a mixing of messages about reducing climate change and responding to climate change
- Designers need specific information for the design context and location, and recommended alternatives for different risks
- Maintenance forces need specific response plans for a given location
- Planners and policy-makers need to be assessing potential for major changes
- Researchers need to be working in a cross-disciplinary manner to develop design information, new approaches, and realistic assessment of risks
- Climate change response has not occurred until new information and processes are a part of the standard way of doing business

Adaptation options

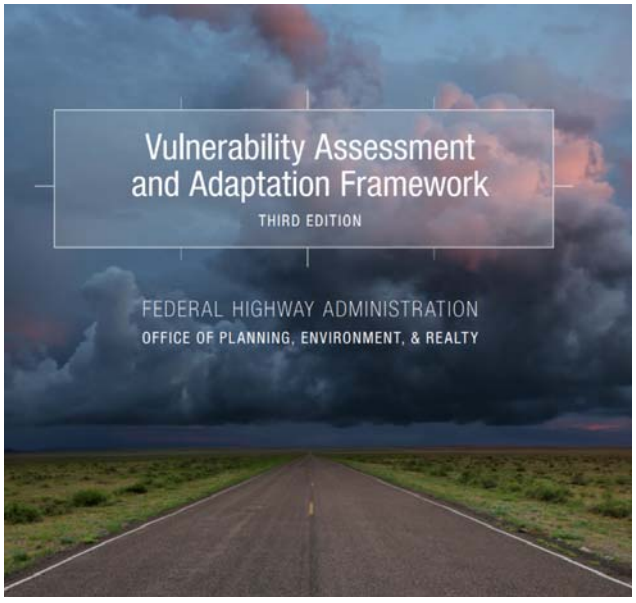
- Examples from Caltrans District 1 and local communities
- Based on criticality and cost

Table 1: Adaptation Option Categories Developed from Adaptation Tool

Approach	Adaptation Option
Defend	Provide major structural protection
	Provide protection at existing elevations/locations
Accommodate	Elevate the infrastructure above the impact zone
	Enhance drainage to minimize closure time and/or deterioration levels
Retreat	Abandon infrastructure
	Relocate infrastructure (horizontally)
	Temporarily restrict use of infrastructure
Changes in policies or practices	Increase the infrastructure's maintenance and inspection interval and continue to monitor/evaluate
	Modify land use and development policies to account for future impacts

Where are we at?

- FHWA
  - Guidance
  - Framework and pilots
  - Research projects
  - Resilience Guidebook being put together
  - https://www.fhwa.dot.gov/environment/sustainability/resilience/
  - Rob Kafalenos
- Caltrans
  - Developing guidance
  - Pilot project in District 1 with FHWA



Resources Agency: Transportation Sector Plan

- Lays out framework for identification, quantification, response development and response control
- https://resources.ca.gov/CNRALegacyFiles/docs/climate/safeguarding/Transportation%20Sector%20Plan.pdf

Institute for Local Government

- Regional collaborations
- https://www.ca-ilg.org/post/regional-collaborations-adaptation

Specifics for pavements

- Few well reviewed specifics exist for pavement and there is no research program focused on pavement climate resilience
- An example road map exists for permeable pavements
  - Similar issues with cross-silo responsibilities
  - Transportation, flood management, stormwater
- Includes road map for developing:
  - Management structures
  - Planning guidance
  - Cost and environmental impact information
  - Asset management guidance
  - Structural design guidance
  - Construction guidance
  - Maintenance guidance
  - Training and communication guidance

https://ncst.ucdavis.edu/research-product/2018-authors-harvey-john-tsmith-david-r-early-2017-university-california-pavement

Conclusions and a Question

- Climate resilience for transportation infrastructure will likely grow in importance
- Efforts to date for pavement and transportation are primarily high level
- Initial specific guidance is becoming available, primarily through FHWA piloting with Caltrans
- Question:
  - Is it worthwhile to explore a state-wide local government collaboration?