Colorado Infrastructure Vulnerability to Climate Change

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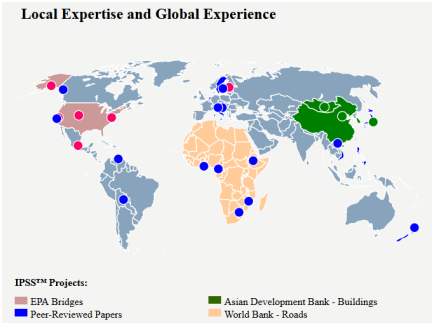
- Climate Impact Research for 10 years
- Co-Founder of Climate and Civil Systems Research Group (Resilient Analytics)
- World Bank, EPA, United Nations

RESILIENT ANALYTICS

Engineering and Applied Science
UNIVERSITY OF COLORADO BOULDER

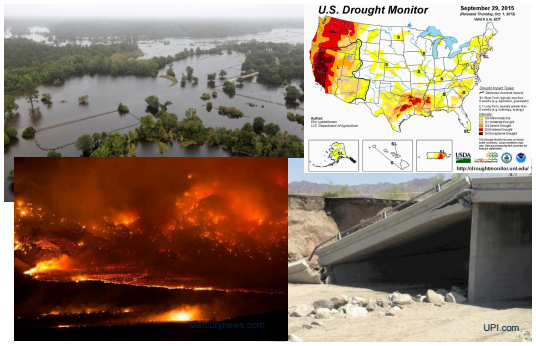
Local Expertise and Global Experience

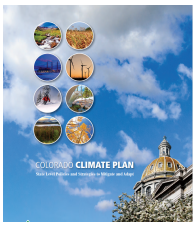


Agenda

Major Themes

1. Vulnerability – How much of an impact exists?
2. Adaptation – What options exist and what will it cost?
3. Risk – What happens if the wrong decision is made?
4. Action – What is possible?

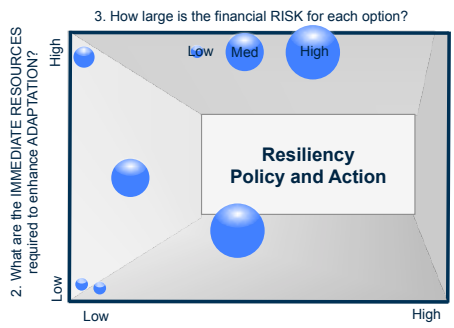




- **Executive Order – Preparing the United States for the Impacts of Climate Change**
  - **Preparedness, Awareness, Support**
- **FHWA Order 5520**
  - **Consider climate change**
- **Executive Order 11988: Floodplain Management**
  - **Reexamine flood risks**

What is the VULNERABILITY of local infrastructure assets to climate change / weather events?

- Climate resiliency is NOT emergency management
- Climate change encompasses broad issues
- Climate change encompasses uncertainty
- Climate impacts occur on multiple timelines



IPCC = Intergovernmental Panel on Climate Change

- **"Vulnerability" –** Predisposition to being adversely affected. (Sensitivity to harm/ability to cope and adapt)
- **"Adaptation" –** Process of adjustment to actual or expected climate and its effects
- **"Risk" –** potential for consequences where something is at stake and outcome is uncertain

Climate Modelling

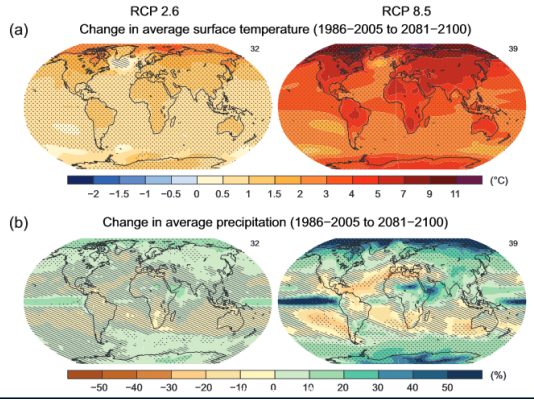
CMIP5 RCP Models

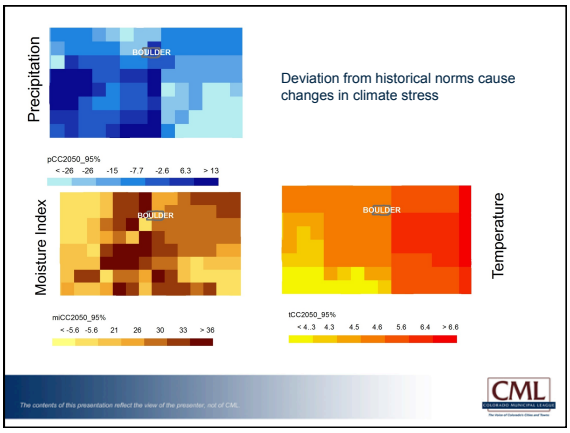
CMIP5: "Coupled Model Intercomparison Project Phase 5"

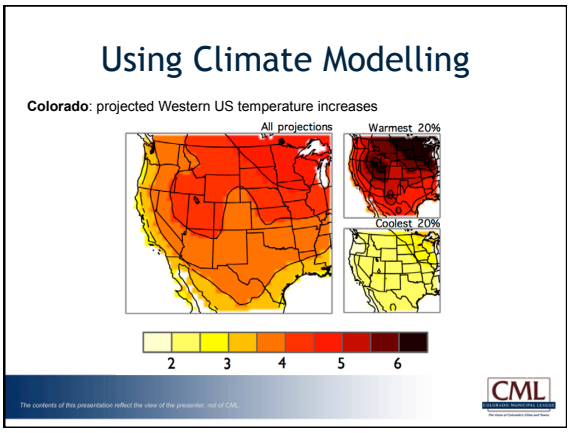
RCP: "Representative Concentration Pathways"
- Identified by total radiative forcing in year 2100 relative to 1750
  - **RCP 2.6** → New baseline - Very high mitigation measures
  - **RCP 4.5 & RCP 6.0** → Stabilization scenarios
  - **RCP 8.5** → High GHG emissions

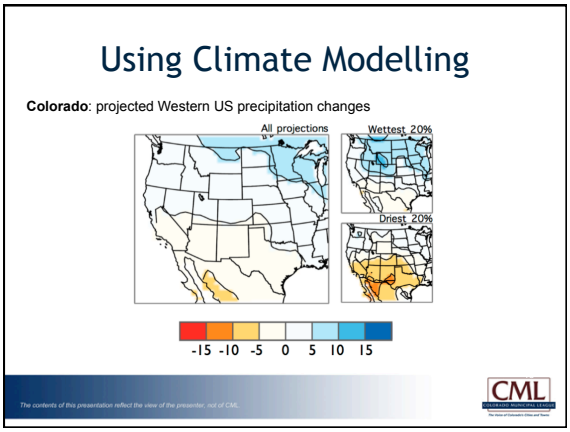
RCP scenarios produce a number of variables projected all over the world – these variables include precipitation, temperature, and more

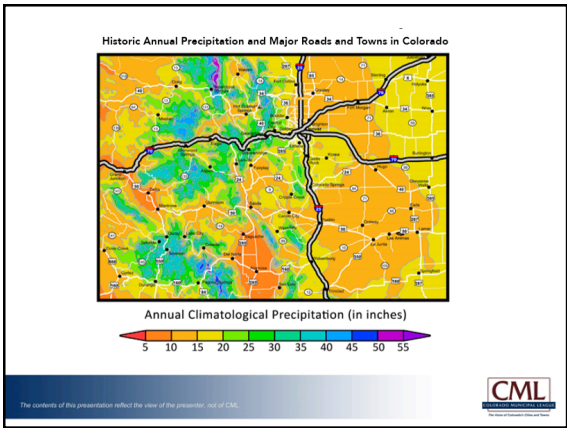
CMIP5 RCP Models

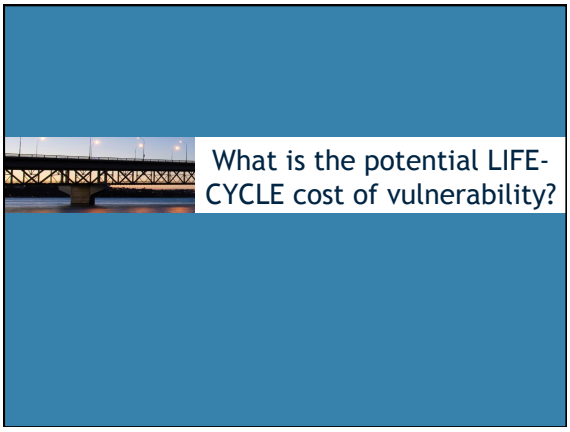


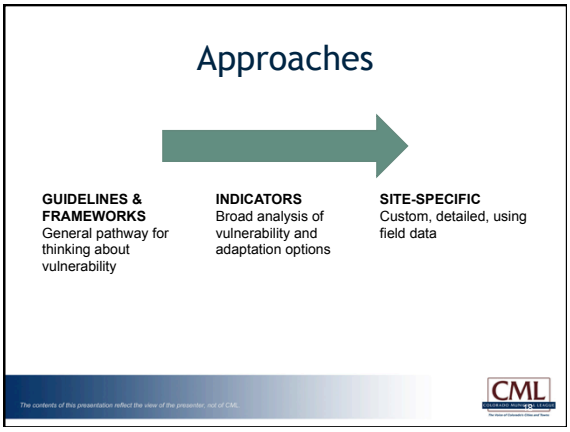

Precipitation
BOULDER
Deviation from historical norms cause changes in climate stress
pCC2050_95%
< -26 -26 -15 -7.7 -2.6 6.3 > 13
Moisture Index
BOULDER
mICC2050_95%
< -5.6 -5.6 21 28 30 33 > 36
BOULDER
tCC2050_95%
< 4.3 4.3 4.5 4.6 5.8 6.4 > 6.6
Temperature


Using Climate Modelling
Colorado: projected Western US temperature increases
All projections
Warmest 20%
Coolest 20%
2 3 4 5 6

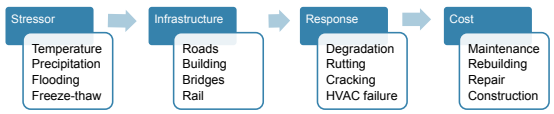

Using Climate Modelling
Colorado: projected Western US precipitation changes
All projections
Wettest 20%
Driest 20%
-15 -10 -5 0 5 10 15


Historic Annual Precipitation and Major Roads and Towns in Colorado
Annual Climatological Precipitation (in inches)
5 10 15 20 25 30 35 40 45 50 55

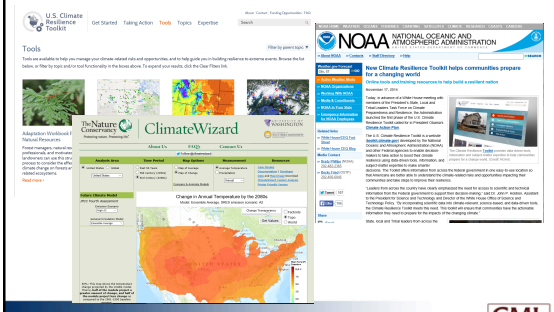

What is the potential LIFE-CYCLE cost of vulnerability?

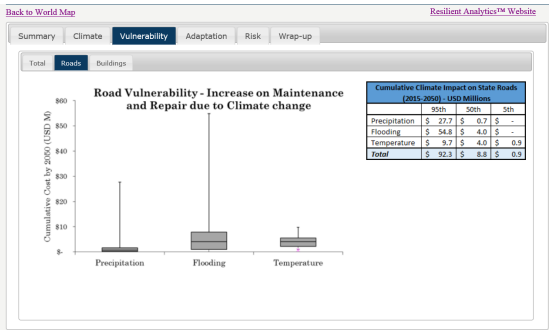

Approaches
GUIDELINES & FRAMEWORKS
General pathway for thinking about vulnerability
INDICATORS
Broad analysis of vulnerability and adaptation options
SITE-SPECIFIC
Custom, detailed, using field data

Climate Change Impacts on Infrastructure

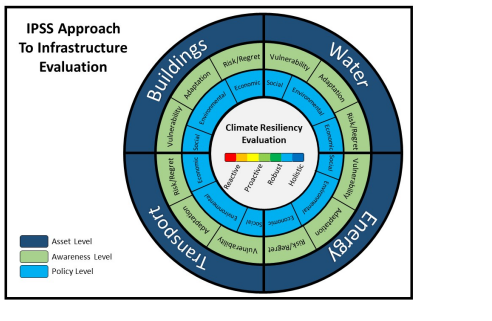


Potential LIFE-CYCLE Cost

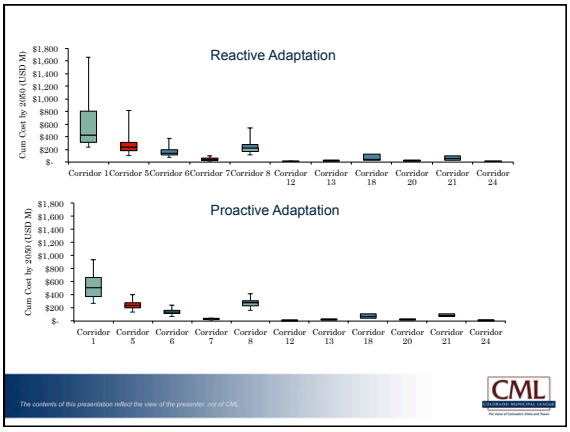




Adaptation Options and Resources

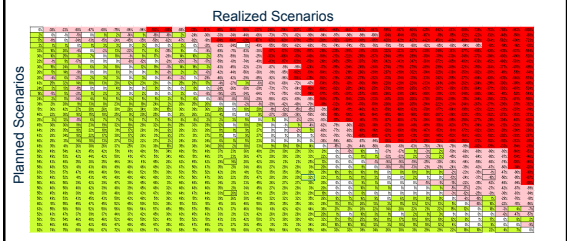


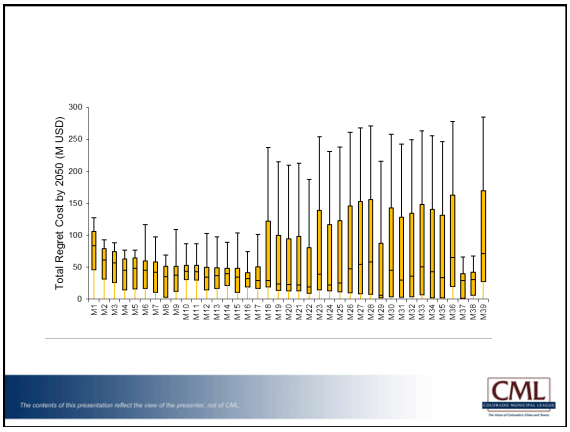
Stressor	Adaptation	adaptation factor	
		Primary	Secondary
Temperature	Construct Dense Seals	1.02	1.02
Temperature	Adjust Base Binders	1.02	1.02
Precipitation	Increase Base Strength	1.23	1.11
Precipitation	Add Wider Paved Shoulders	1.16	1.34
Flooding	Enhance Culverts and Drainage	1.17	1.08

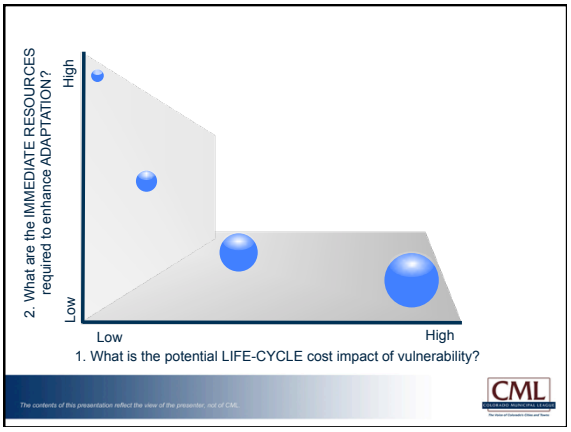


Risk and Uncertainty

- Risk emanates from difference between planned and realized scenarios
- What if climate change does not occur?
- What scenario should be the planning scenario?
- What is the variance that exists?
- What are the constraints?







Apply the Knowledge

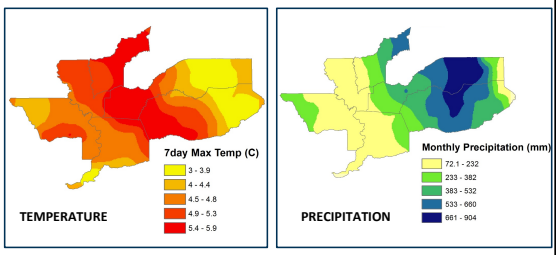
Taking Action

- Be Informed
- Determine Vulnerabilities
- Determine Adaptation Options
- Implement Plan

CML

Impact on Long-Term Planning

Climate Changes @ 2050



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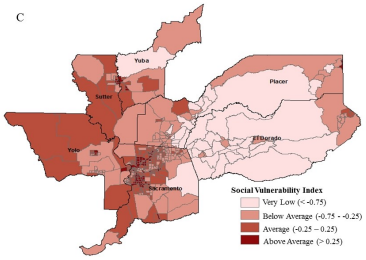
Social & Sustainability

C



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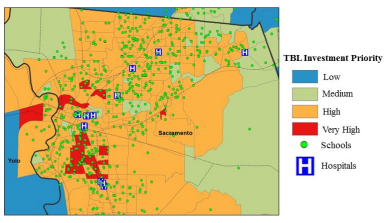
Social & Sustainability

B



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Thank You!

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