Effective Practices for Disaster and Climate Readiness
针对预防灾害的有效实践

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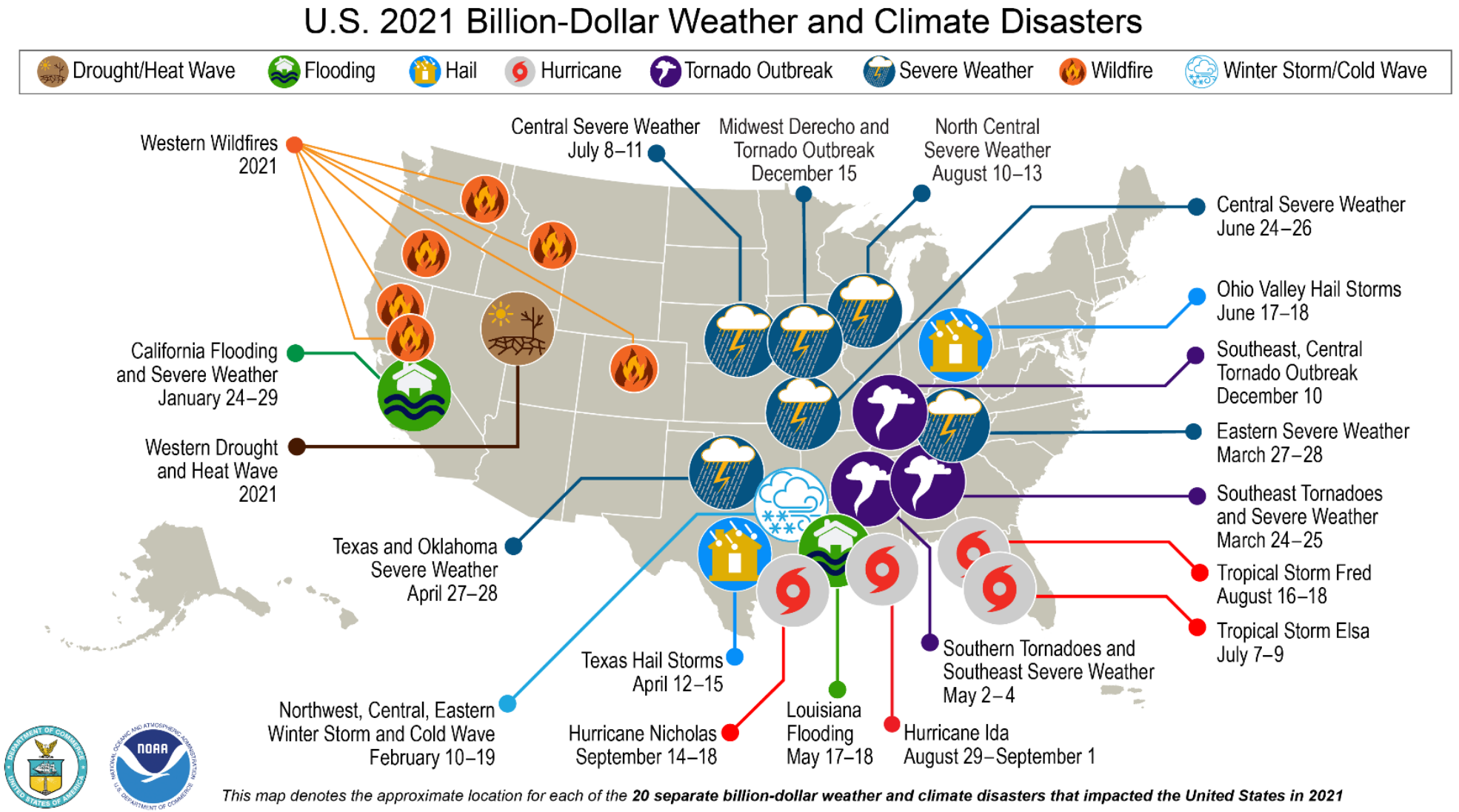
Today's Discussion: Disaster and Climate Readiness

Effective Practices in Disaster and Climate Readiness

Acknowledgements and Background

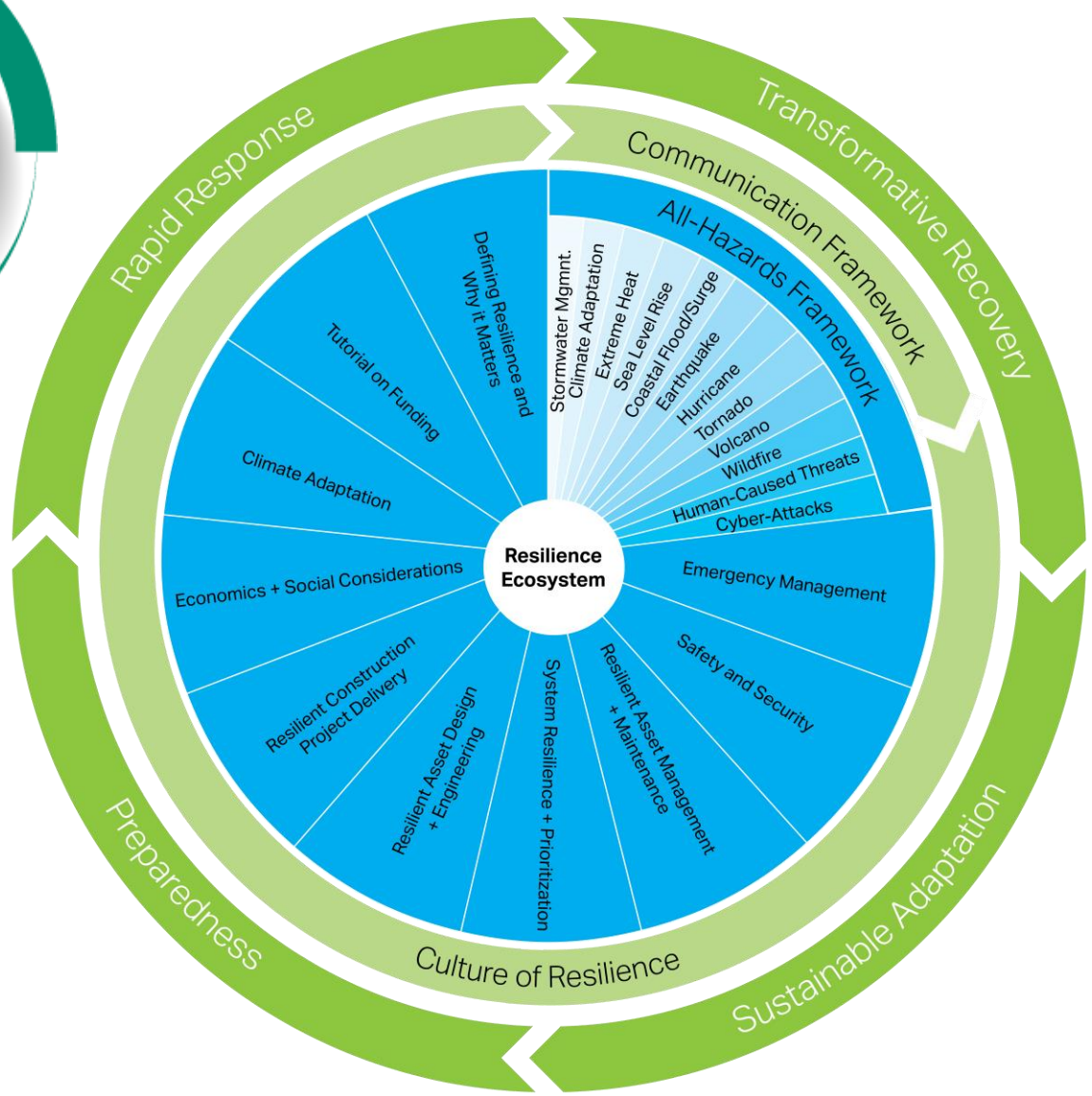
1. Build a culture of resilience
2. Anticipate Failures: Model Hazards and Conduct Vulnerability Assessments
3. Assess Risks and Conduct Benefit-Cost Analysis
4. Prioritize Investments
5. Implement Asset Performance Standards and Specifications, including Technologies
6. Conduct Disaster Response and Recovery Functional Exercises
7. Complete Environmental Planning
8. Conduct Administrative Readiness
9. Lines of Defense Adjustments in Areas or Repetitive Risk
10. Build Relationships Today

U.S. National Context



NOAA: US Billion-dollar weather and climate disasters 2021

Build a Culture of Resilience

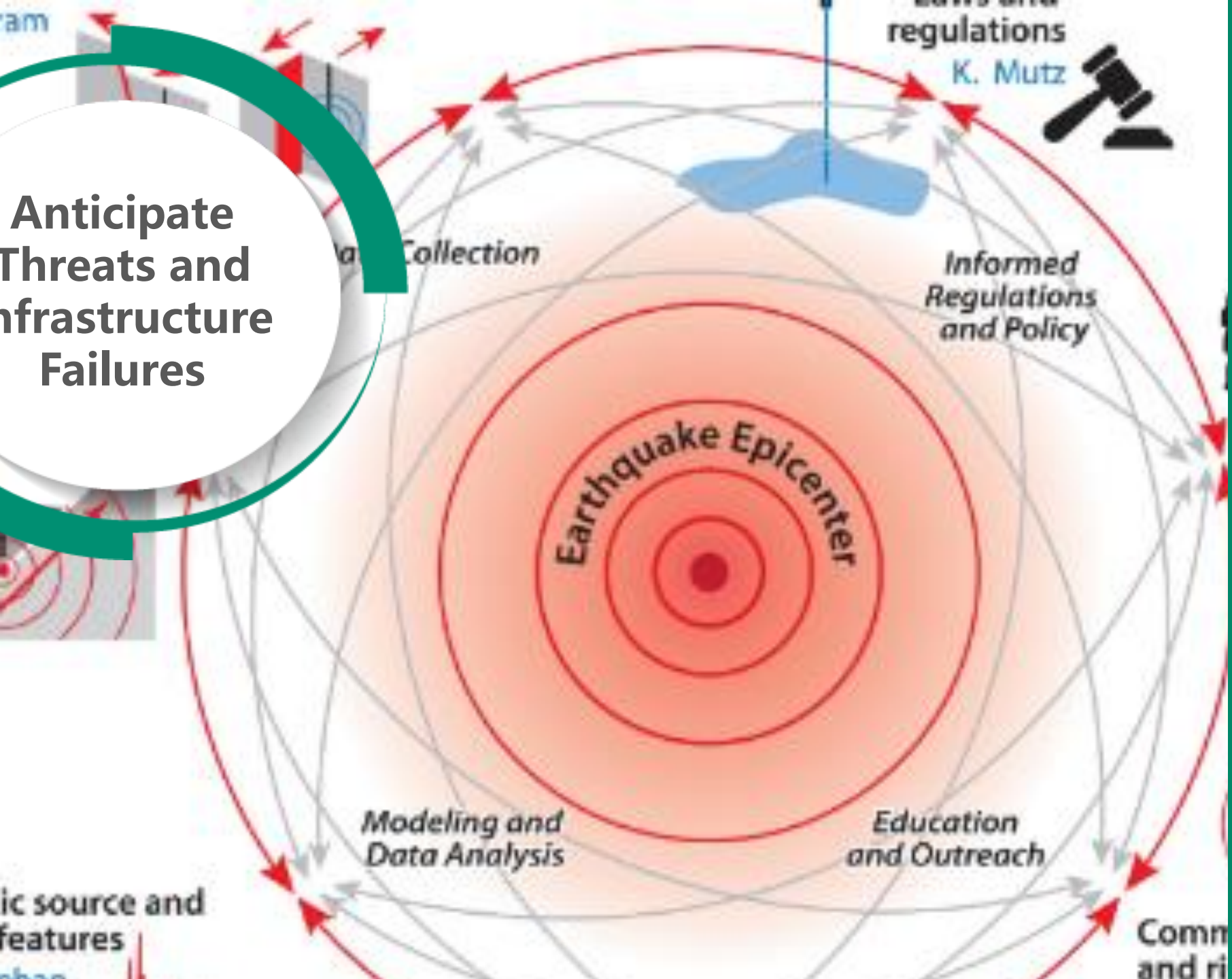


1. Build a Culture of Resilience

- AECOM Resilience Ecosystem
- Case Example: Colorado Department of Transportation after 2013 flood with over $800 million USD in direct disaster damages.

COLORADO
Department of Transportation

Resiliency Roadmap



Anticipate Threats and Infrastructure Failures

2. **Anticipate Failures: Model Hazards and Conduct Vulnerability Assessments**

- Model natural and human-caused threats.
- Complete climate change projections.
- Identify near and long-term cascading impacts on how and where we live and work
- Evaluate embedded risks in infrastructure based on remaining useful life and anticipated asset. performance in extreme weather events and climate stressors.
- Rate vulnerability of asset by segment and function.
- Consider changing use/impacts of technology.

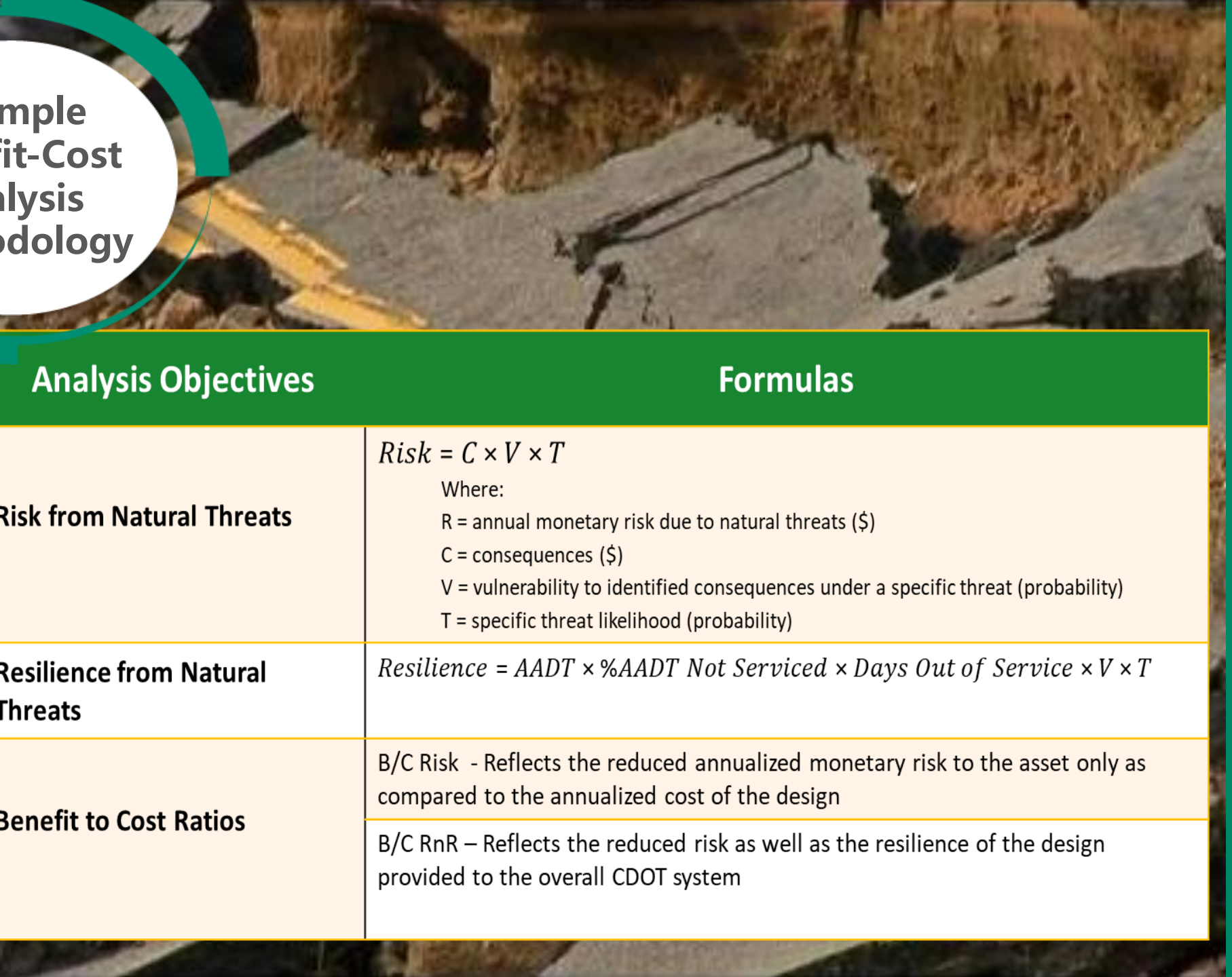
sess Risks

3. **Assess Risks**

Colorado DOT Risk and Resiliency (RnR) characteristics:

- Assess likelihood of future events.
- Assess vulnerability of infrastructure assets.
- Anticipate consequences.
- Analyze improvements to determine reduction in future risk as compared to cost of replacing infrastructure to pre-disaster conditions and engineering design standards.
- Demonstrate that building resilient infrastructure yields a strong return on investment (ROI) or Benefit-Cost-Ratio.

+ Consider emerging and future technologies.



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Analysis Objectives	Formulas
Risk from Natural Threats	$Risk = C \times V \times T$ Where: R = annual monetary risk due to natural threats ($) C = consequences ($) V = vulnerability to identified consequences under a specific threat (probability) T = specific threat likelihood (probability)
Resilience from Natural Threats	$Resilience = AADT \times \%AADT\ Not\ Serviced \times Days\ Out\ of\ Service \times V \times T$
Benefit to Cost Ratios	B/C Risk - Reflects the reduced annualized monetary risk to the asset only as compared to the annualized cost of the design
	B/C RnR – Reflects the reduced risk as well as the resilience of the design provided to the overall CDOT system

Conduct Benefit-Cost Analyses

Colorado DOT Risk and Resiliency (RnR)

- Methodology

Criticality Score

	Score				
	1 Very Low Impact	**2 Low Impact**	**3 Moderate Impact**	**4 High Impact**	**5 Very High Impact**
Road Classification	Rural Major Collector	Urban Collector (Major or Minor)	Minor Arterial	Primary Arterial	Interstate Freeway Expressway
Need for Access by Essential Traffic	Facility Open to Essential Traffic More Than 48 Hours After Event; Multiple-Redundant Routes Available with No/Minimal Loss of Capacity	Facility Open to Essential Traffic Within 48 Hours of Event; Single Redundant Route Available with No/Minimal Loss of Capacity	Facility Open to Essential Traffic Within 12 Hours of Event; Multiple Redundant Routes Available with Some Loss of Capacity	Facility Open to Essential Traffic Within 2 Hours of Event; Single Redundant Route Available with Significant Loss of Capacity	Facility Open to Essential Traffic Immediately Following Event; Single Point of Failure
Route Designation	Truck % under 10%	HAZMAT Route	Truck % over 10%	Defense Route	Evacuation Route
Capital Cost of Damaged Site (per Lane Mile)	< $5 million/lane mile	$5 – $10 million/lane mile	$10 – $20 million/lane mile	$20 – $30 million/lane mile	> $30 million/lane mile

Criticality Score

Criticality Score

- Assets are scored on 5-point scale:
  - 1=Very Low Impact
  - 5=Very High Impact
- Maximum Score: 20 with up to 5 points for each of the following ratings:
  - Roadway Classification
  - Need for Access by Essential Traffic
  - Route Designation, and
  - Capital Cost of Damaged Site (per lane mile)

Prioritize Investments

4. Prioritize Investments

- Colorado DOT Resiliency Index for prioritization of investments

Prioritization based on Resiliency Index

Area Number	Work	Lo	/2013 dway	November 2016 "Vision" Program (CP-2 Focus)	January 2017 Single Lane 3-Year Period (Optimized Resiliency)	January 2017 Permitted Closure Oct 2017 - May 2018 (Optimized Resiliency)	March 2017 Permitted Closure Oct 2017 - May 2018 (Emergency Access)	August 2017 Permitted Closure Oct 2017 - May 2018 (Project Complete Dec 2018)	March 2018 Permitted Closure Oct 2017 - May 2018 (Project Complete Dec 2018)	
				Resiliency Level	Resiliency Level	Resiliency Level	Resiliency Level	Resiliency Level	Resiliency Level	Cost
1			rtial	100-Year	Emergency Access	Emergency Access	Emergency Access	Emergency Access	Emergency Access	$ 418,266
2			ll	100-Year	Increased Risk	Increased Risk	100-Year	Emergency Access	Emergency Access	
3			ll	100-Year	100-Year	100-Year	Emergency Access	Emergency Access	Emergency Access	$ 1,933,487
4			ll	100-Year	100-Year	100-Year	Emergency Access	Emergency Access	Emergency Access	$ 928,617
5			ull	100-Year	100-Year	100-Year	100-Year	Emergency Access	Emergency Access	$ 884,401
6			artial	100-Year	100-Year	100-Year	100-Year	100-Year	100-Year	$ 2,953,047
7			Full	Emergency Access	Emergency Access	Emergency Access	Emergency Access	Emergency Access	Emergency Access	$ 6,243,805
			Full	100-Year	100-Year	100-Year	100-Year	100-Year	100-Year	$ 15,824,143
			Full	100-Year	100-Year	100-Year	Emergency Access	Emergency Access	Emergency Access	$ 5,091,470
			Full	100-Year	100-Year	100-Year	100-Year	100-Year	100-Year	$ 14,826,845
11	Riverbend		Full	100-Year	100-Year	100-Year	Emergency Access	Emergency Access	Emergency Access	$ 4,064,553
12		76.1	Full	100-Year	100-Year	100-Year	100-Year	Future Loss	Emergency Access	$ 4,418,511
13			Full	100-Year	25-Year	25-Year	100-Year	Future Loss	100-Year	$ 3,186,036
	bunty Road 43									
14	Drake West	75.1	75.65	Full	100-Year	Future Loss	Future Loss	Emergency Access	Future Loss	Future Loss	$ 2,487,558
15	Mountain Shadows	74.90	75.1	Full	100-Year	Future Loss	Future Loss	Emergency Access	Future Loss	Future Loss	
16	Pool Cabin	74.68	74.90	Full	100-Year	Future Loss	Future Loss	Emergency Access	Future Loss	Future Loss	
17	Segment 5e	74.52	74.68	Partial	100-Year	Increased Risk	Increased Risk	Emergency Access	Increased Risk	Increased Risk	$ 527,705
18	Pedestrian Bridge	74.40	74.52	Full	100-Year	Future Loss	Future Loss	Emergency Access	Future Loss	Future Loss	
19	Segments 5a - 5c	73.92	74.40	Partial	100-Year	Increased Risk	Increased Risk	100-Year	Increased Risk	Increased Risk	
20	Waltonia	73.45	73.92	Full	100-Year	Future Loss	Future Loss	Emergency Access	Emergency Access	Emergency Access	$ 3,928,613
21	Passing Lane	73.0	73.45	Full	100-Year	Future Loss	Future Loss	100-Year	Emergency Access	Emergency Access	$ 4,507,074
22	Slide Area	72.0	73.0	Partial	100-Year	Increased Risk	Increased Risk	Emergency Access	Emergency Access	Emergency Access	$ 2,067,310
23	Segment 3	70.2	72.0	Partial	100-Year	Increased Risk	Increased Risk	Emergency Access	Emergency Access	Emergency Access	$ 1,682,875
24	Segment 2	66.7	70.2	Partial	100-Year	Increased Risk	Increased Risk	Emergency Access	Emergency Access	Emergency Access	$ 2,411,432
25	Segment 1	65.0	66.7	Partial	100-Year	Increased Risk	Increased Risk	Emergency Access	Emergency Access	Emergency Access	$ 193,118

Direct/Duration Based Costs							$ 27,771,042
Mill & Overlay							$ 8,940,047
General Conditions							$ 54,078,322
Fee							$ 8,468,414
Construction Subtotal							**$ 177,836,690**
F/A, Minor Contract Revisions							$ 14,559,826
Risk							$ 12,175,234
Contruction Total							**$ 204,571,750**
CE						(10%)	$ 20,457,175
Indirects						(7%)	$ 15,752,025
Precon/Design/ROW/Utilities							$ 41,560,750
Program Total	$ 486,916,376	$333,451,519	$ 280,000,000	$ 355,563,022	$ 281,620,365		**$ 282,341,700**

Criticality Score	Criticality Level	RI
4 to 10	Low	1.0
11 to 15	Moderate	2.0
16 to 20	High	3.0

Resiliency Index

Resiliency Index (RI)

- The RI assesses criticality, which is scored on 3-point scale:
  - 1=Low Criticality
  - 2=Moderate Criticality
  - 3=High Criticality

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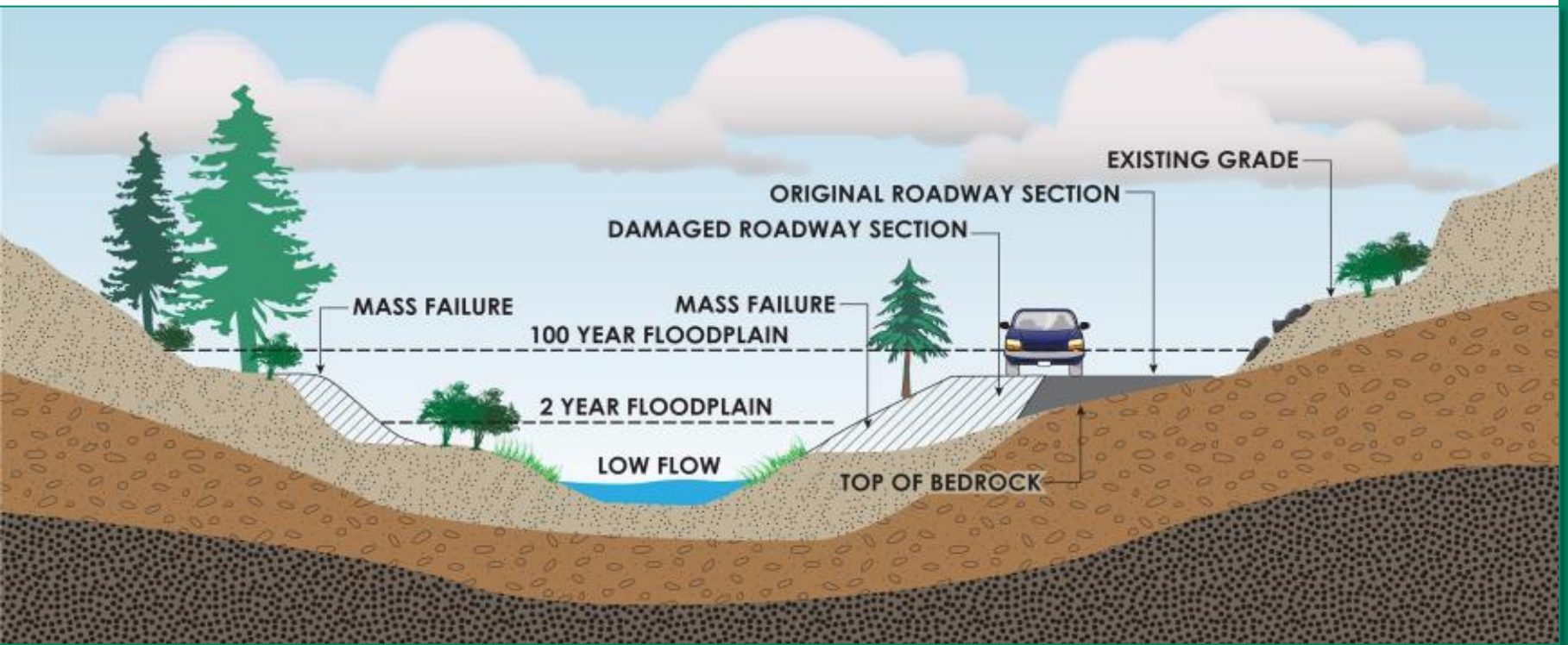
5. **Define and Implement Resilient Asset Performance Standards and Specifications**

Colorado DOT resilient and climate adaptive design example

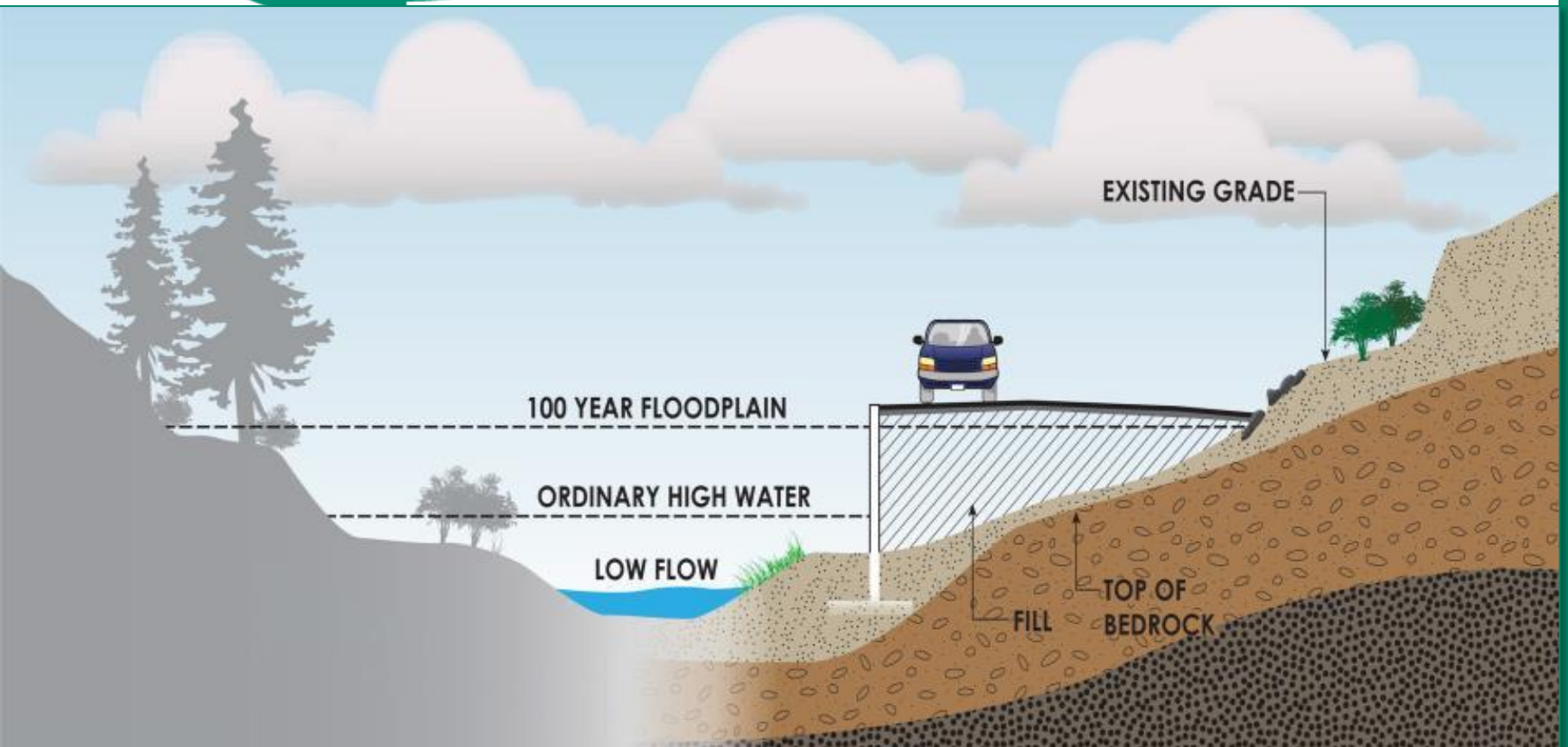
Section of Flood Event Impacts on U.S. 34



Example of applied resilience and climate adaptive asset performance standards

- 2013 Colorado Flood impacts

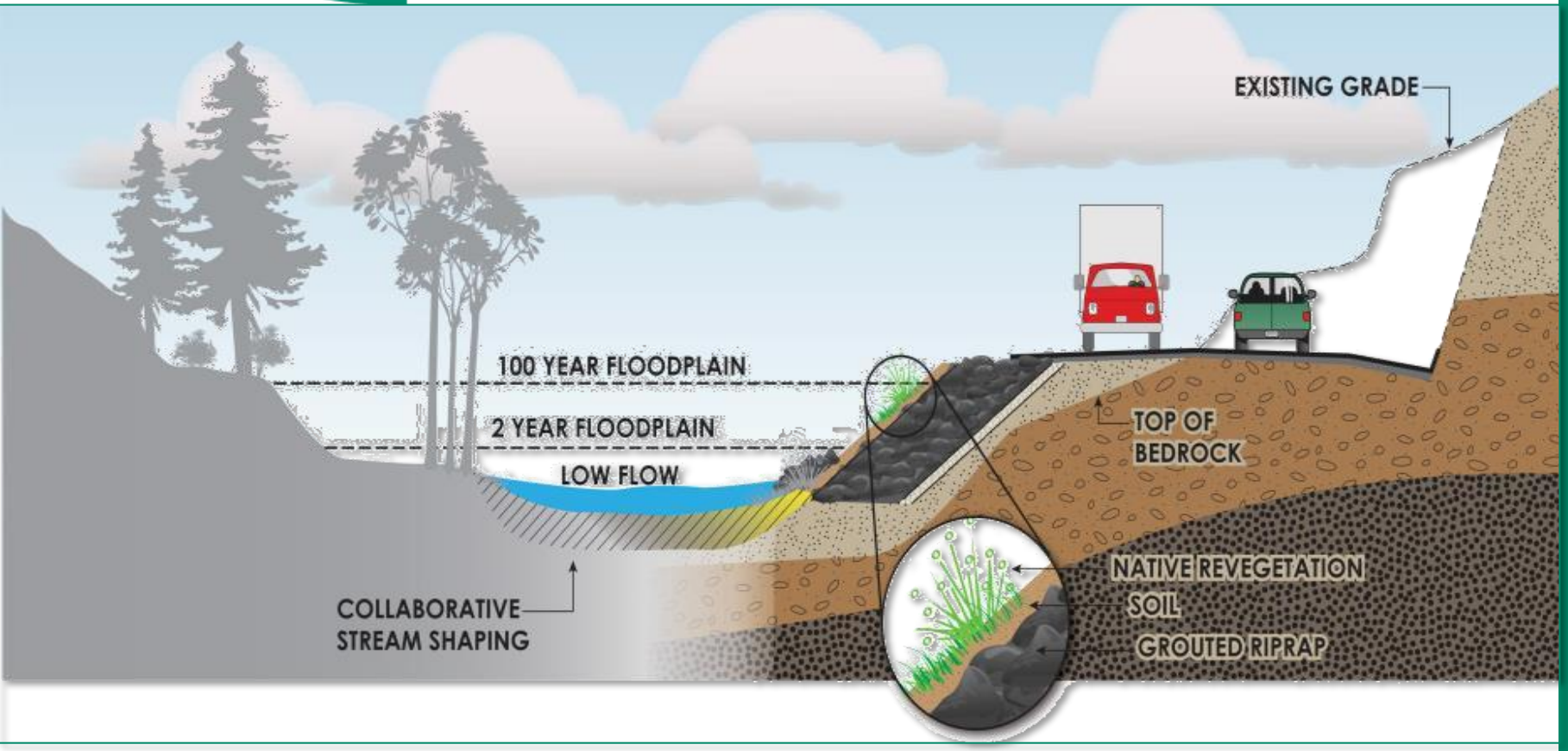
Typical Repair to Pre-Disaster Condition or Minimum Codes



Example of applied resilience and climate adaptive asset performance standards

- Typical repair to pre-disaster condition

Resilient and Climate Adaptive Reconstruction



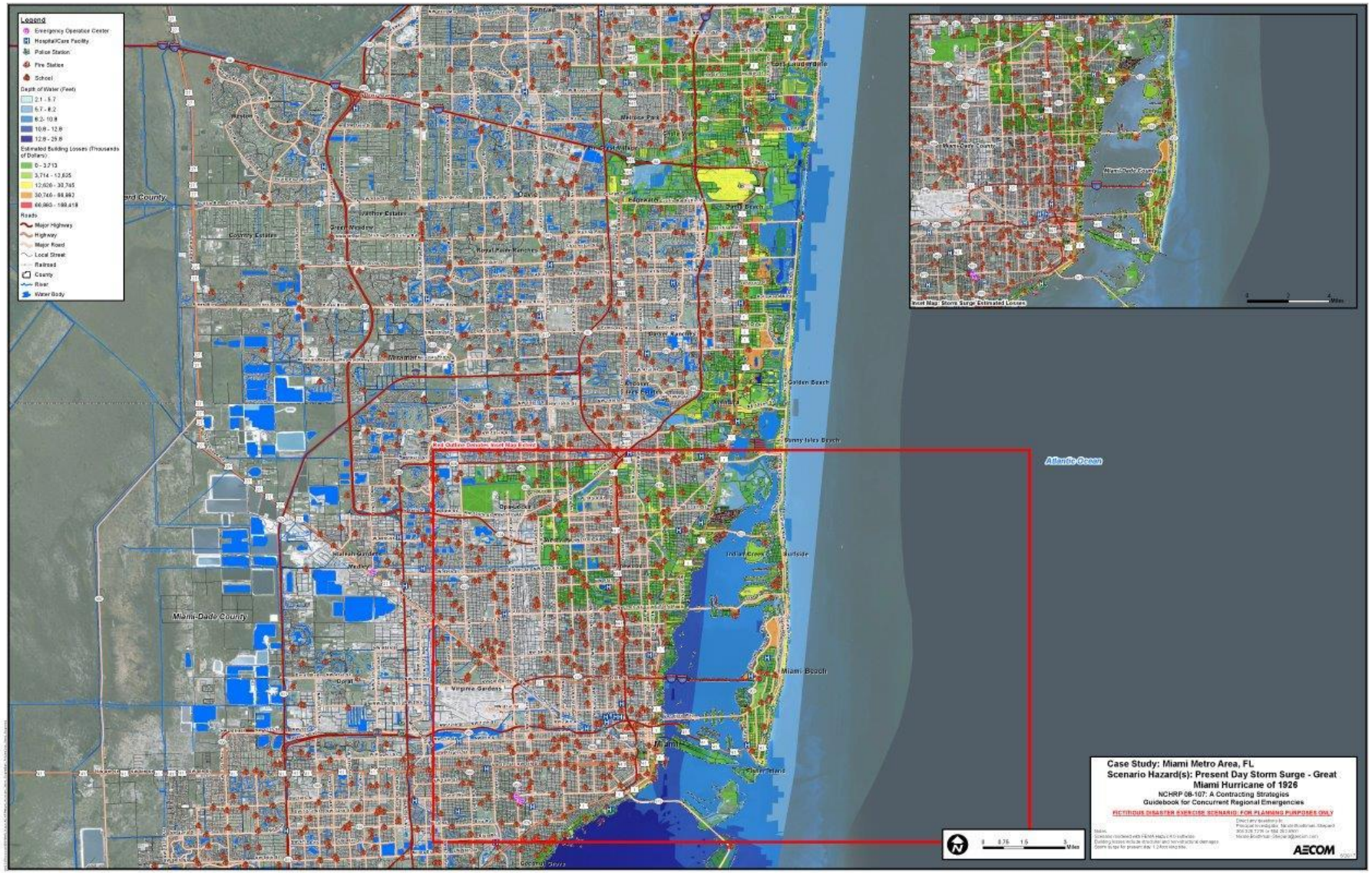
Example of applied resilience and climate adaptive asset performance standards

- Resilient and climate-adaptive solutions for reconstruction

Conduct rcises and anning for st-Disaster

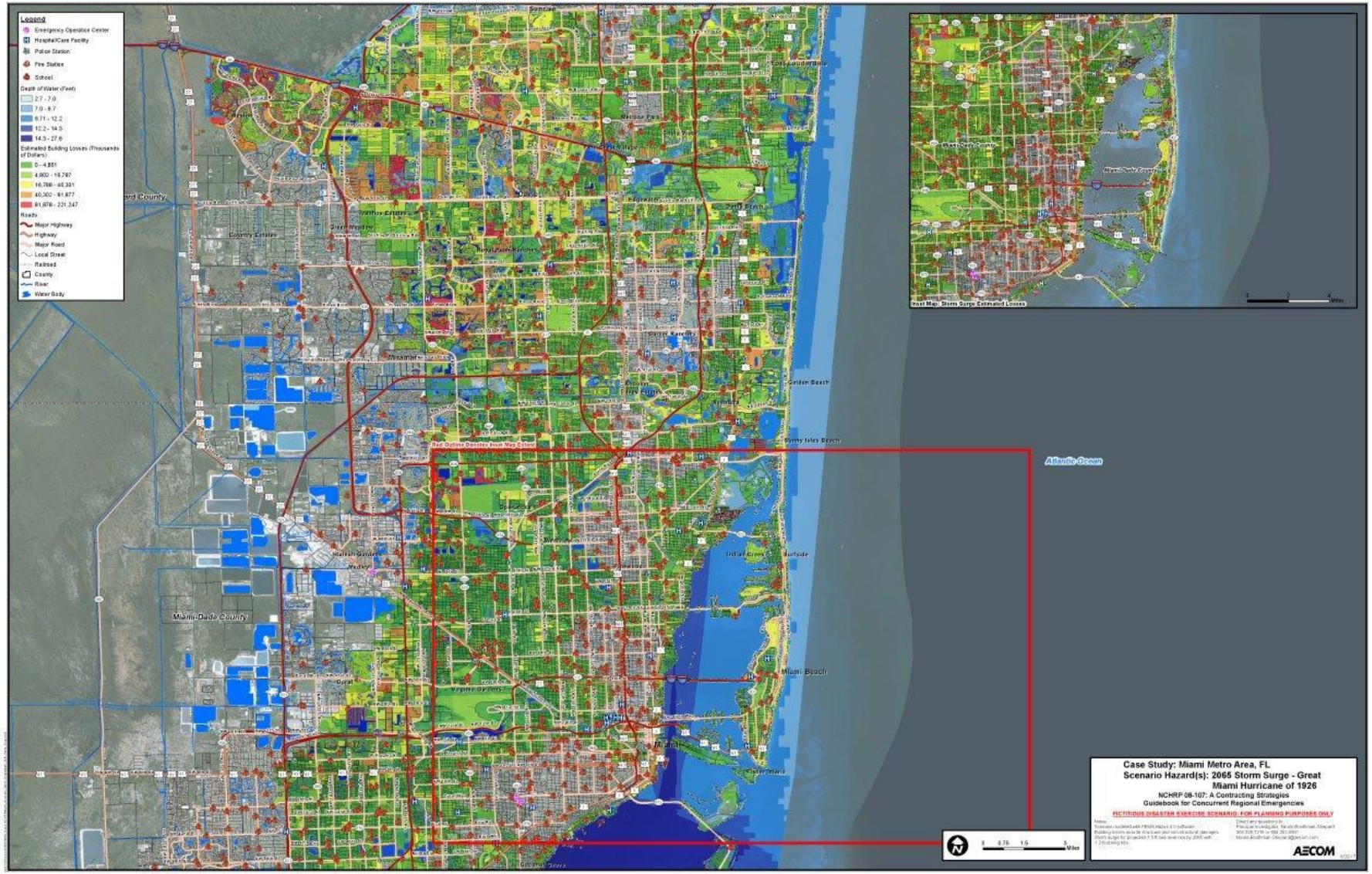
6. **Conduct Disaster Response and Recovery Functional Exercises**

- Develop Scenarios for Rapid Response
- Develop Scenarios for Resilient and Climate Adaptive Recovery
- Plan Recovery Incident Command Organization
- Plan Work Consistent with Any Capital Program



Miami and the Beaches Present Day Hurricane Storm Surge Projection

- Functional Resilience Exercises for Lifeline Infrastructure and Community Habitability
- Map shows present day development modeling the 2016 Great Miami Hurricane model at astronomical (lunar) high tide.



Miami and the Beaches 2065 Hurricane Storm Surge Projection with Sea-Level Rise

- Functional Resilience Exercises for Lifeline Infrastructure and Community Habitability
- Map shows 2065 anticipated sea-level rise and modeling the 2016 Great Miami Hurricane model at astronomical (lunar) high tide.

+ Consider technology impacts and other risks such as post-tsunami galvanic corrosion of electrical systems

7. **Complete Long-Term Environmental Planning**

- Colorado Department of Transportation's US 34 PEL Case Study

Holistic Resilience and Climate Adaptation

Resilience to Natural Hazards and Human-Caused Events

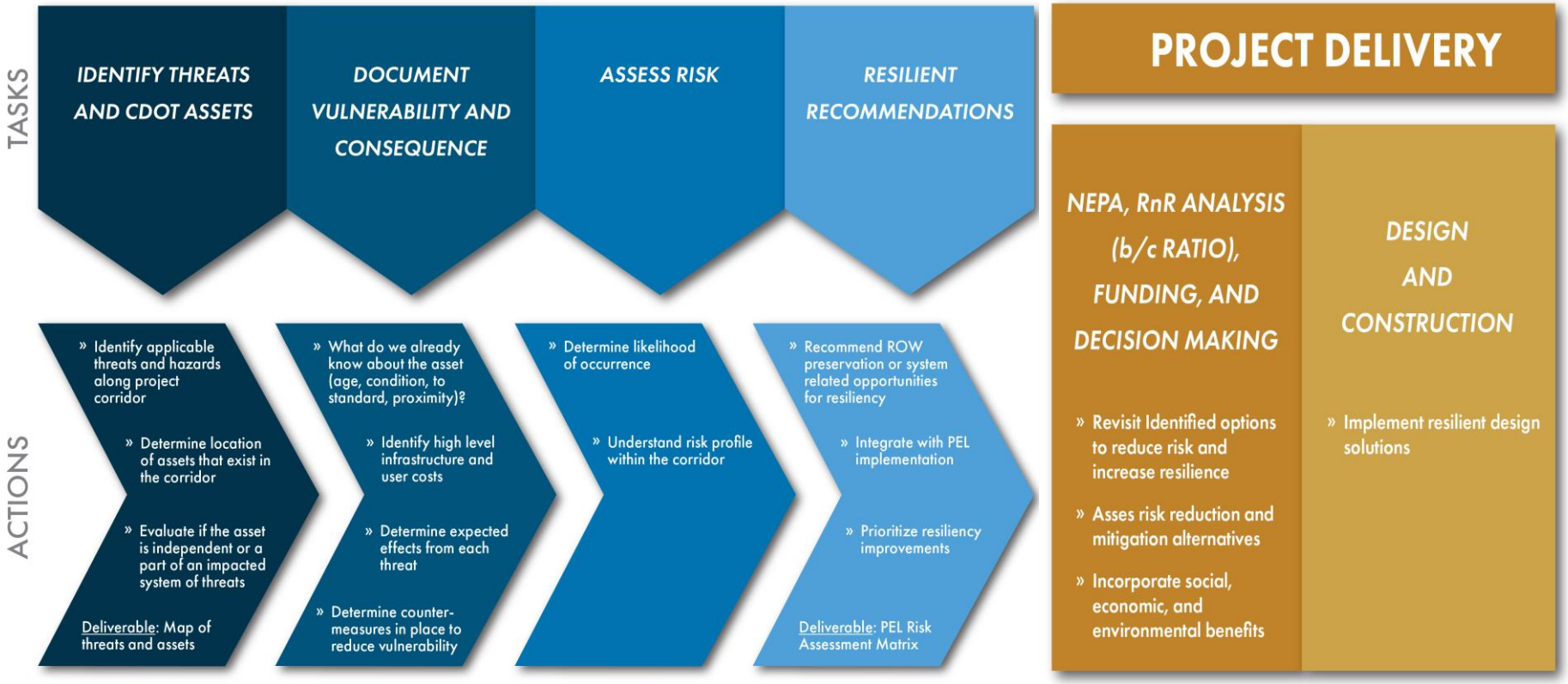
Operational Resiliency

Colorado Department of Transportation's US 34 PEL Case Study

- Considers resilience to natural hazards and human-caused events
- Considers "operational" resiliency – the changes to the built and natural environments and how they impact planning

+ Consider changing technologies and interoperable systems along with future planning

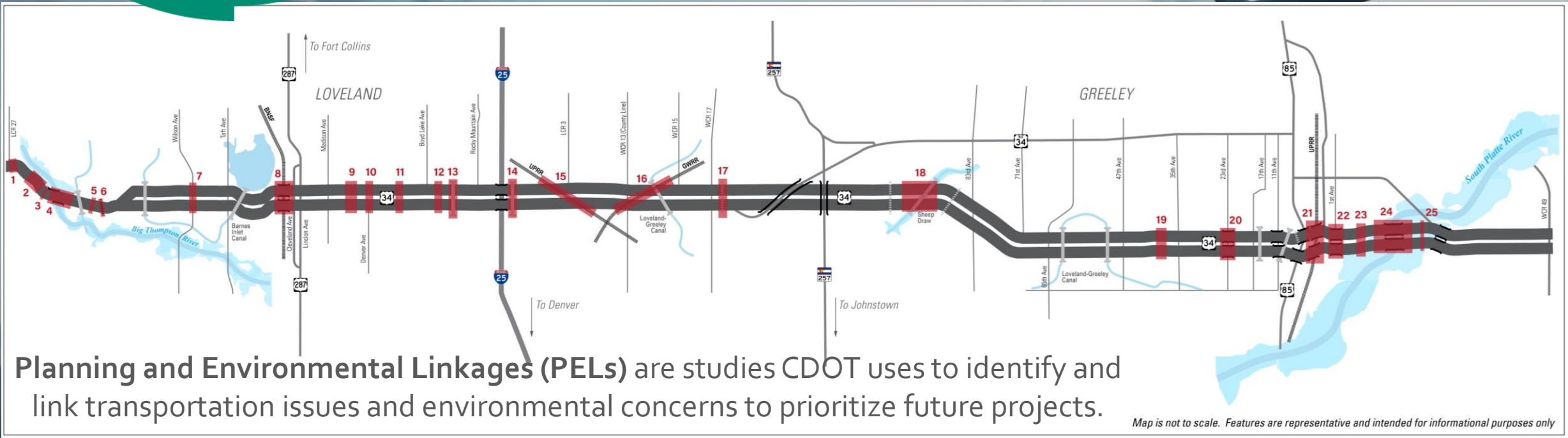
Holistic Resilience and Climate Adaptation



Colorado Department of Transportation's US 34 PEL Case Study

- Colorado Department of Transportation's US 34 PEL Case Study
  - Builds on data from proactive threat identification and mitigation
  - Focuses on resiliency and climate adaptation throughout entire Project Life Cycle

Resiliency to Threats and Hazards

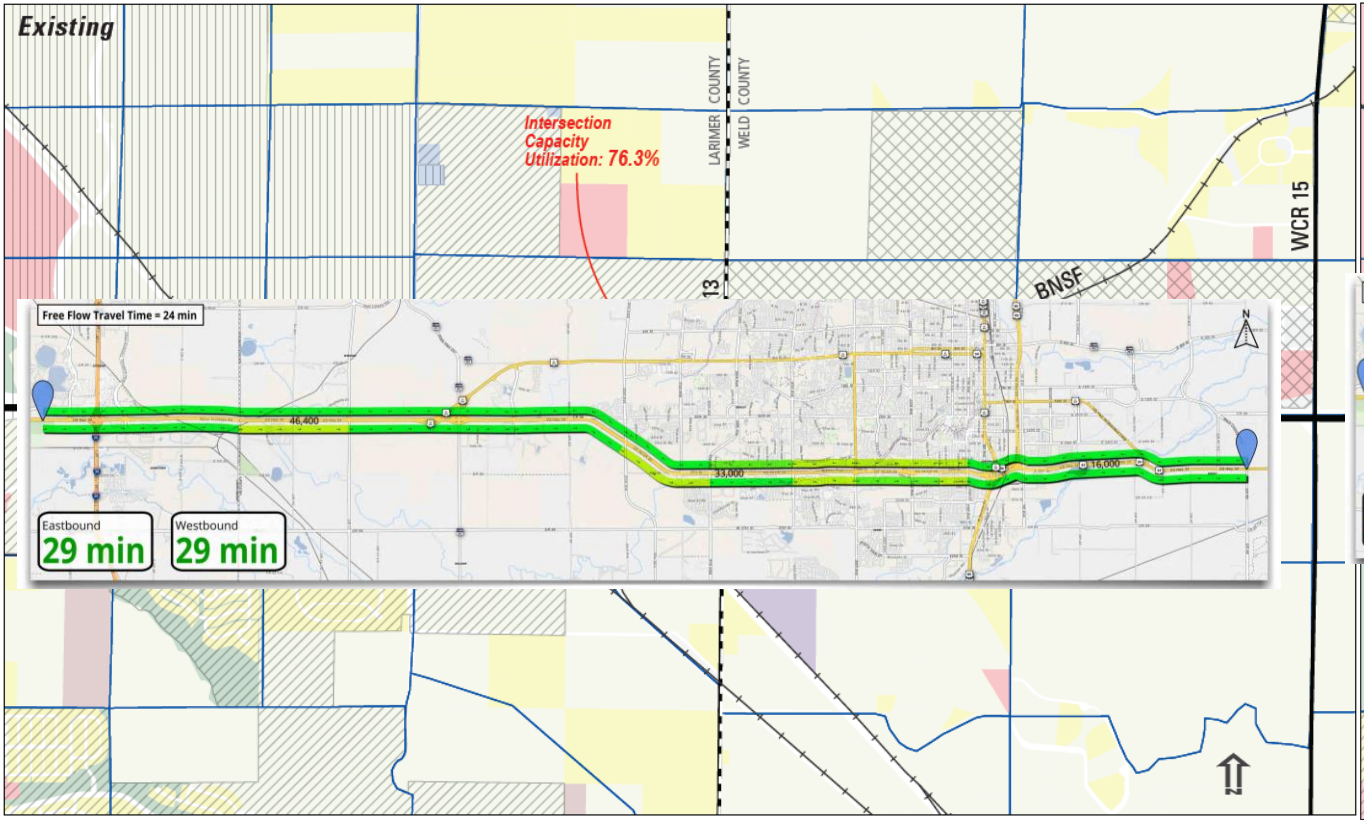


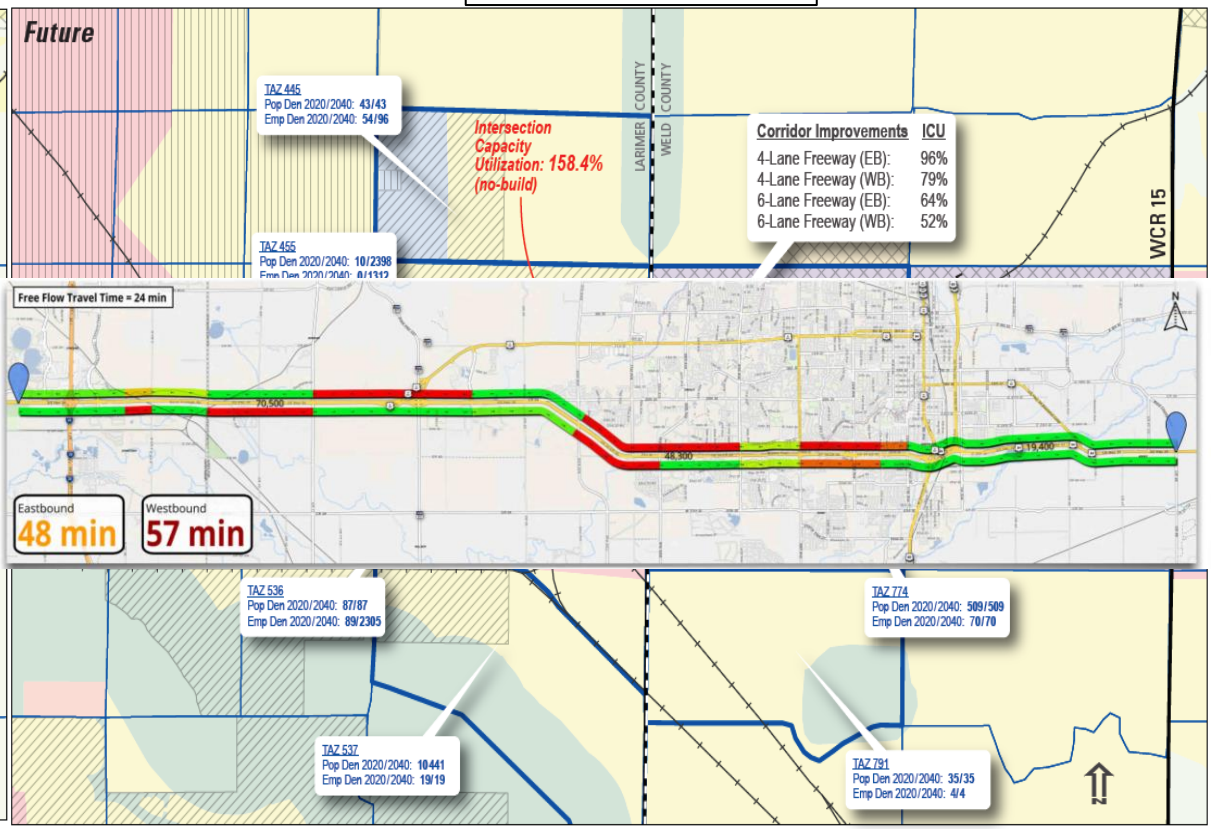
Planning and Environmental Linkages (PELs) are studies CDOT uses to identify and link transportation issues and environmental concerns to prioritize future projects.

“Operational” Resiliency

TAZ 774 - Today
50% Agricultural
50% Residential

TAZ 774 – **2040**
50% Commercial
50% Residential





PEL Risk Assessment Matrix

PEL Risk Assessment Matrix - US 34

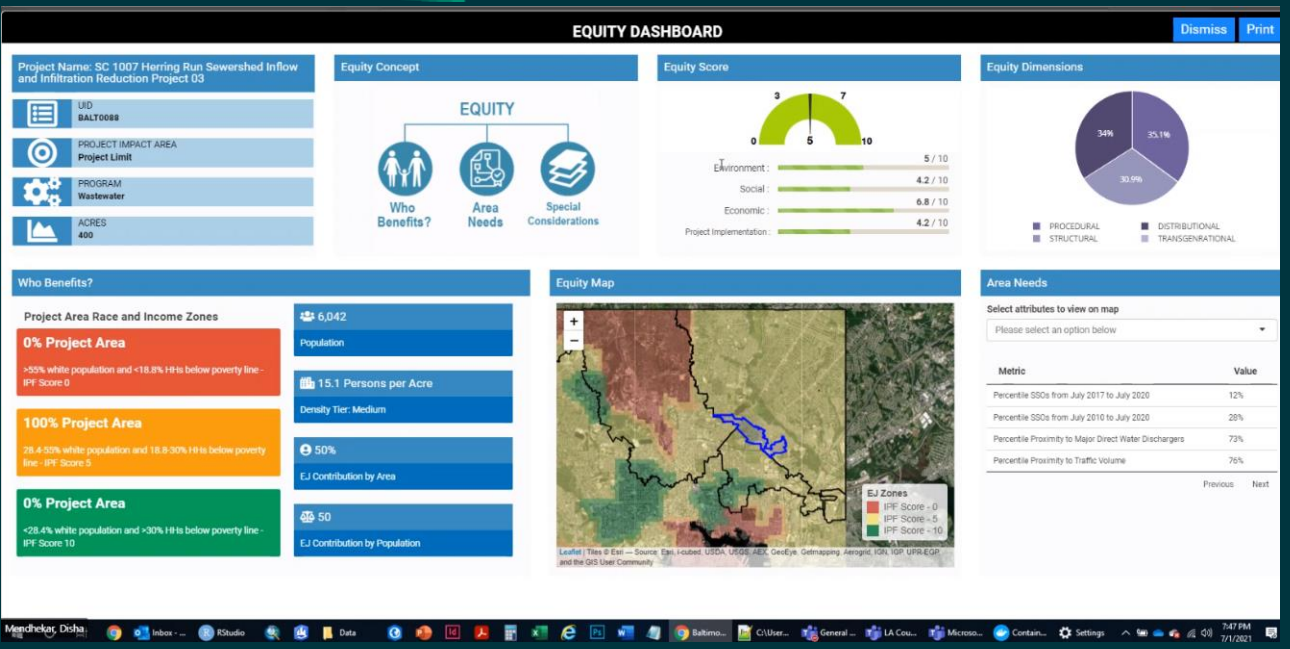
Risk Area	Threat	Assets in Threat Area	Location of Asset	Prioritization	Resilient Recommendations (includes social, economic, and environmental benefits)
1	Flood	Structures C-16-DD and C-16-AF, pavement, guardrail	Big Thompson River, MP 86.044, structures of the Big Thompson River and Buckingham Ditch	high	Ensure structure C-16-DD is built to withstand a 100-year flood event
3	Flood	Structure C-16-AE, pavement, guardrail	MP 86.931, structure over the Big Thompson River	high	Ensure structure is built to withstand a 100-year flood event, mitigate floodplain to channelize flow and prevent flooding on the north side of the highway
4	Flood	Structure C-16-AR, pavement	MP 87.651, structure over draw	moderate	Ensure structure is built to withstand a 100-year flood event
5	Utility Failure	Pavement	36" transmission water main just west of Langston Ln.	moderate	Work with utility company to replace existing waterline
15	Railroad Proximity	Guardrail, pavement	Railroad crossing just east of Lake Loveland	moderate	Elevate roadway
16	Railroad Proximity	C-17-D, pavement, guardrail, ITS device (ATR)	Structure over the Loveland-Greeley Canal, MP 99.21	moderate	Elevate roadway
17	Utility Failure	Pavement	Parallel water mains along 131st Ave.	moderate	Work with utility company to replace existing waterlines

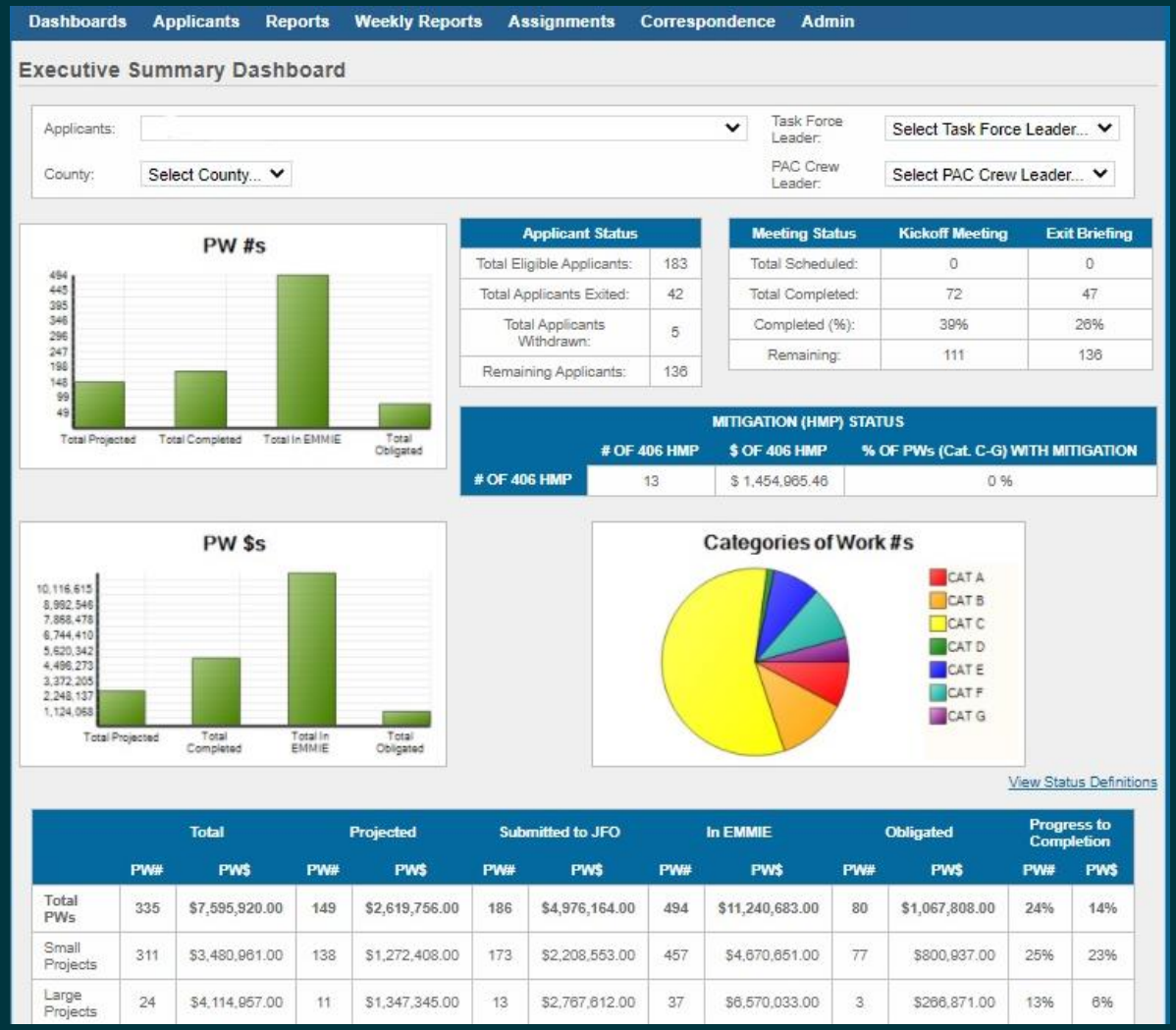
Conduct Administrative Readiness

8. **Prepare for Administrative Responsibilities**

- Set Clear Targets for Resiliency and Climate Adaptation and Monitor Progress
- Evaluate and optimize administrative systems

Set Clear Targets for Resiliency and Climate Adaptation and Monitor Progress





	Total		Projected		Submitted to JFO		In EMMIE		Obligated		Progress to Completion	
	PW#	PW$	PW#	PW$	PW#	PW$	PW#	PW$	PW#	PW$	PW#	PW$
Total PWs	335	$7,595,920.00	149	$2,619,756.00	186	$4,976,164.00	494	$11,240,683.00	80	$1,067,808.00	24%	14%
Small Projects	311	$3,480,961.00	138	$1,272,408.00	173	$2,208,553.00	457	$4,670,651.00	77	$800,937.00	25%	23%
Large Projects	24	$4,114,957.00	11	$1,347,345.00	13	$2,767,612.00	37	$6,570,033.00	3	$266,871.00	13%	6%

Begin Administrative Actions Now

- Secure funding for resilience and response.
- Identify and train the team for post-disaster responsibilities.
- Conduct exercises on restoring all connected modes of transportation infrastructure/technology.
- Simplify post-disaster administrative processes.
- Plan for urgent procurement and contract actions.
- Anticipate supply chain challenges; seek additional and redundant sources for materials and equipment.
- Identify additional sources of skilled construction labor now.
- Plan for significant staff needs in engineering, project management, finance, and technology.
- Identity vulnerable populations, and coordinate plans across modes and sectors to restore quality of life, the economy, and environmental sustainability.
- Integrate transportation technology into the future now.

Consider the Lines of Defense

9. Consider Lines of Defense Adjustments in Areas or Repetitive Risk

2013 Calgary Flood Line of Defense

2013 Calgary, CA Flood Provincial Line of Defense

- Case Example: Alberta Province *considered* progressively changing the “line of defense,” offering significantly flood-impacted homeowners to choose a one-time only flood repair or be relocated out of a high-hazard area for riverine risks. Flood insurance in Canada was provided by the government rather than the private insurance market. Public data is not available on the outcome.

Build Relationships Prior to Disaster

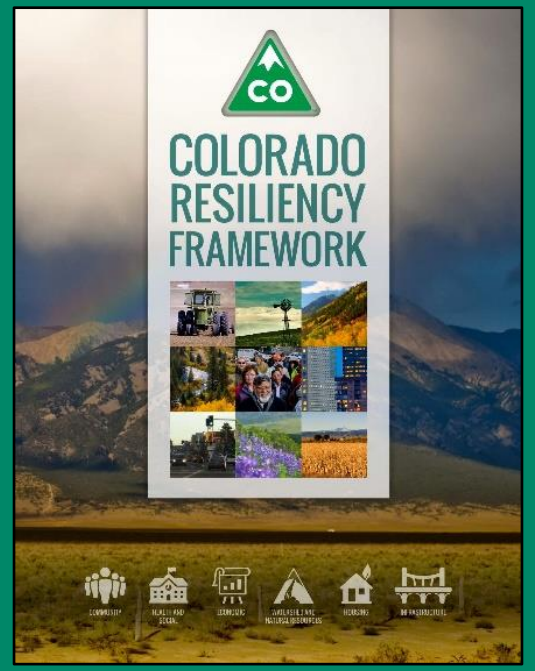
10. _____

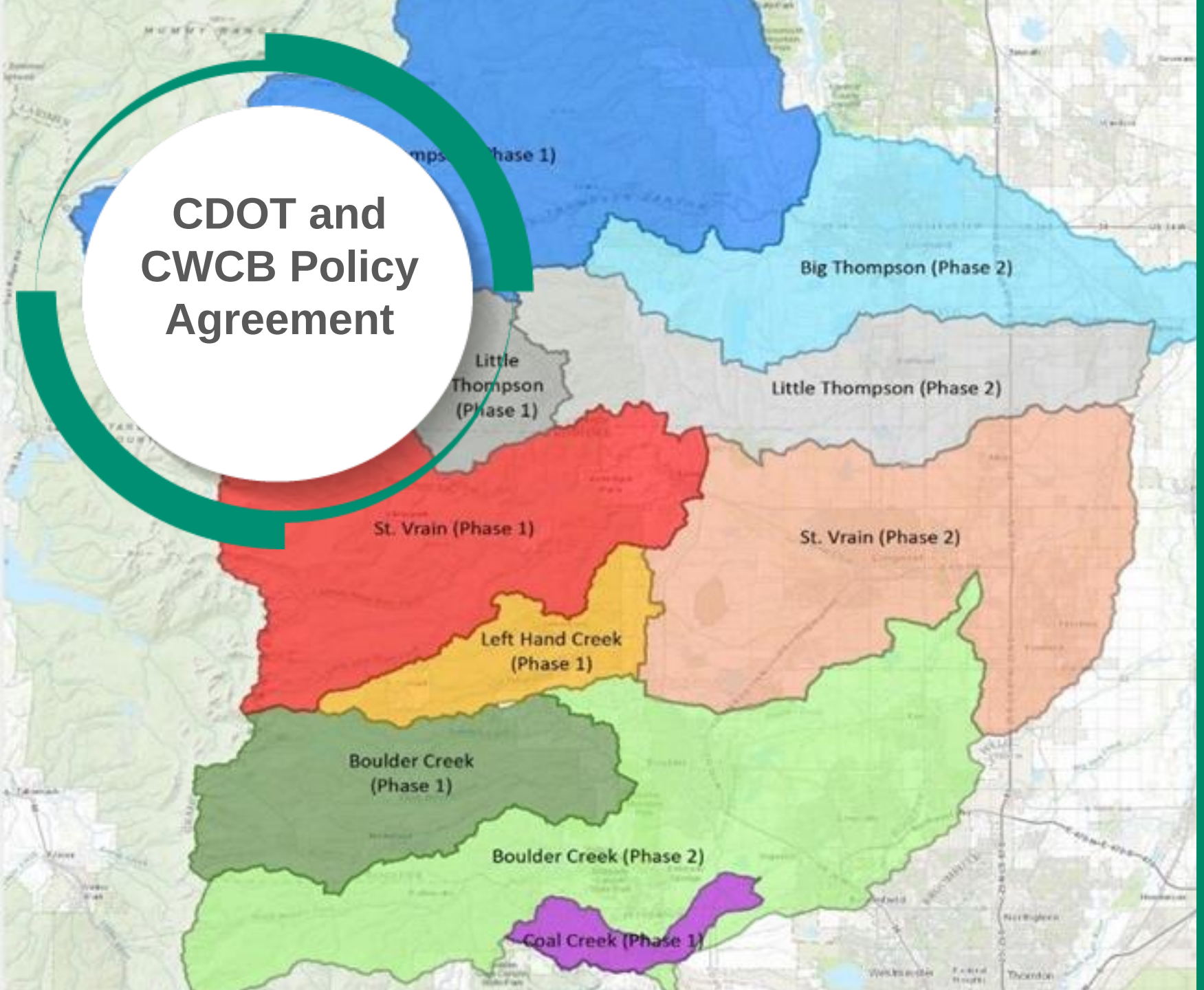
- Example: Colorado Resilience Framework
- Colorado Department of Transportation Policy Agreement with Colorado Water Conservation Board

Colorado Resiliency Framework
Uses a Transdisciplinary Approach

10. _____

- Example: Colorado Resilience Framework
- Colorado Department of Transportation Policy Agreement with Colorado Water Conservation Board



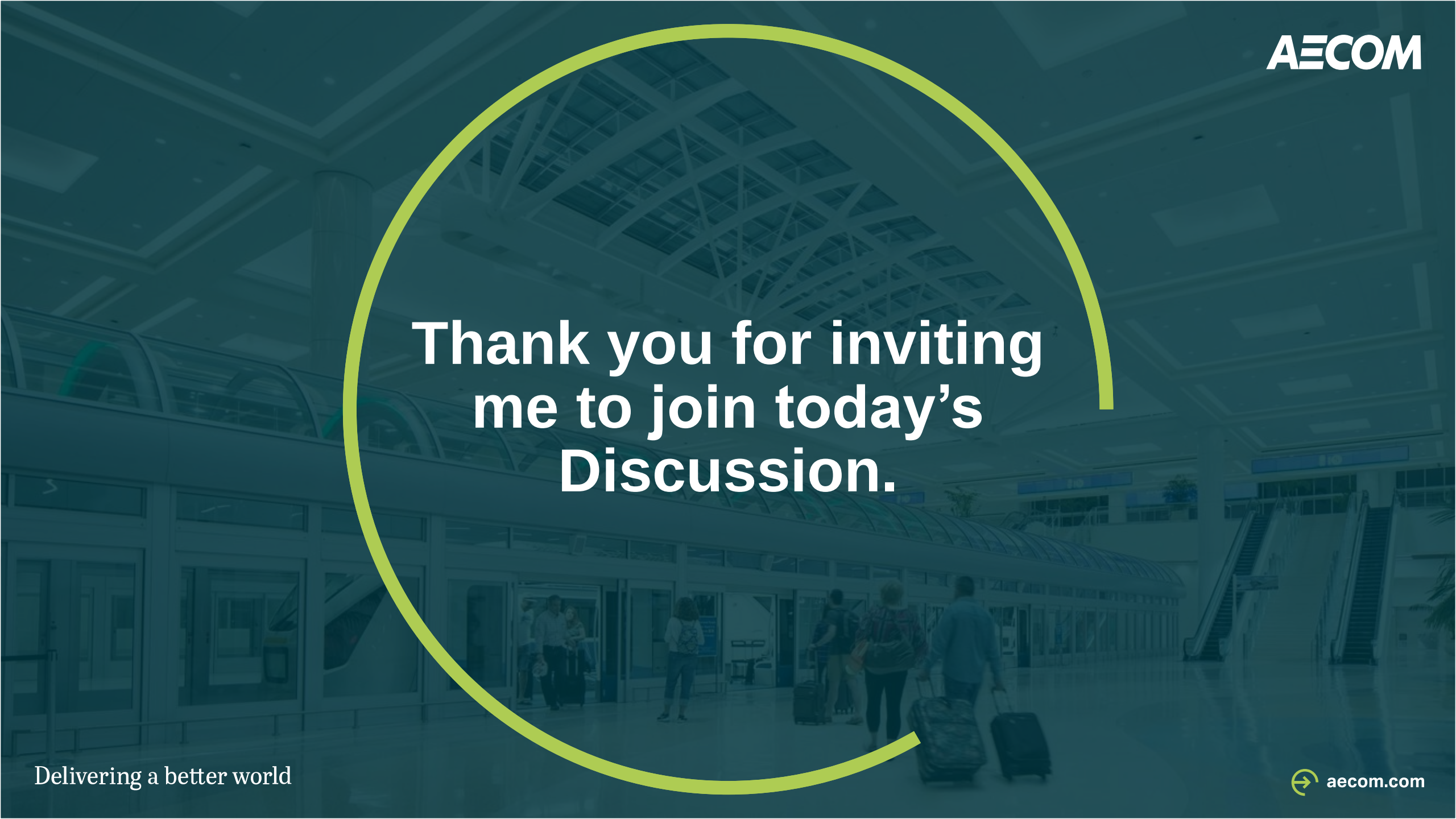


CDOT and CWCB Policy Agreement

10. Build Relationships

- Example: Colorado Resilience Framework
- Colorado Department of Transportation Policy Agreement with Colorado Water Conservation Board Policy Agreement
  - Remove or reduce roadways, bridges, and structures in the floodplain where feasible
  - Where infeasible, CWCB consults on CDOT design solutions to “make room” for rivers and other waterways and promote riparian habitat restoration

Discussion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Presenter:

Nicole Boothman-Shepard, (AECOM)

and Vice-Chair of TRB's Resilience Section (AMR00)

副总裁、美国交通运输研究会交通系统韧性委员会(AMR00)副主席

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