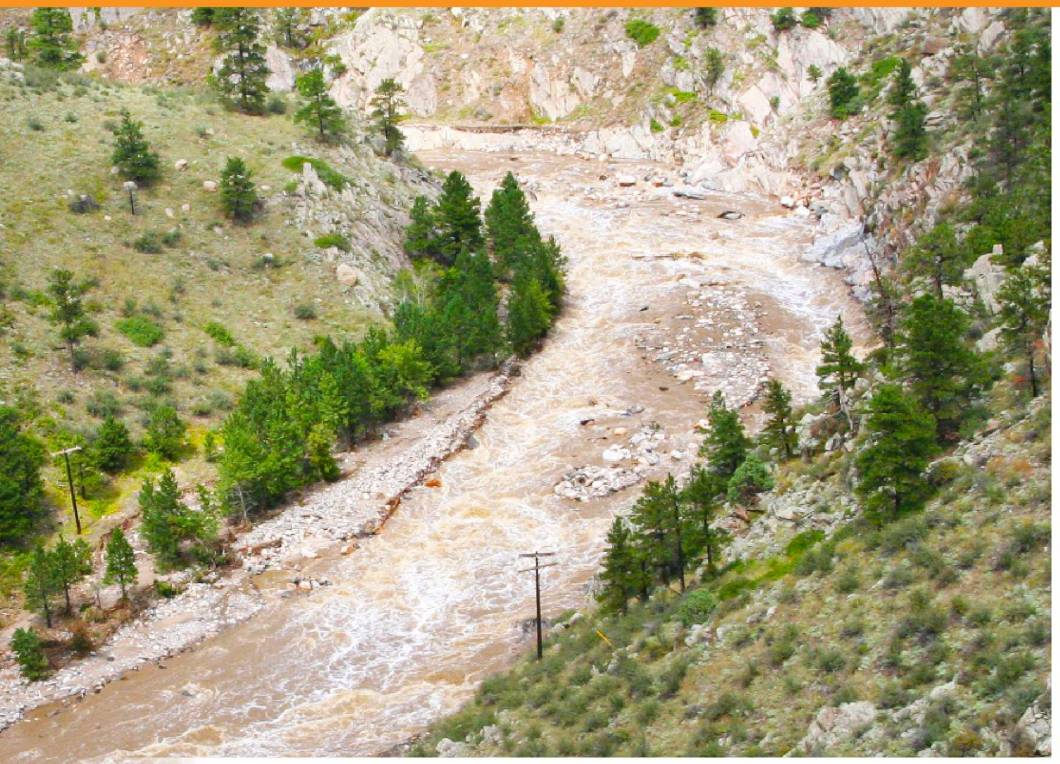
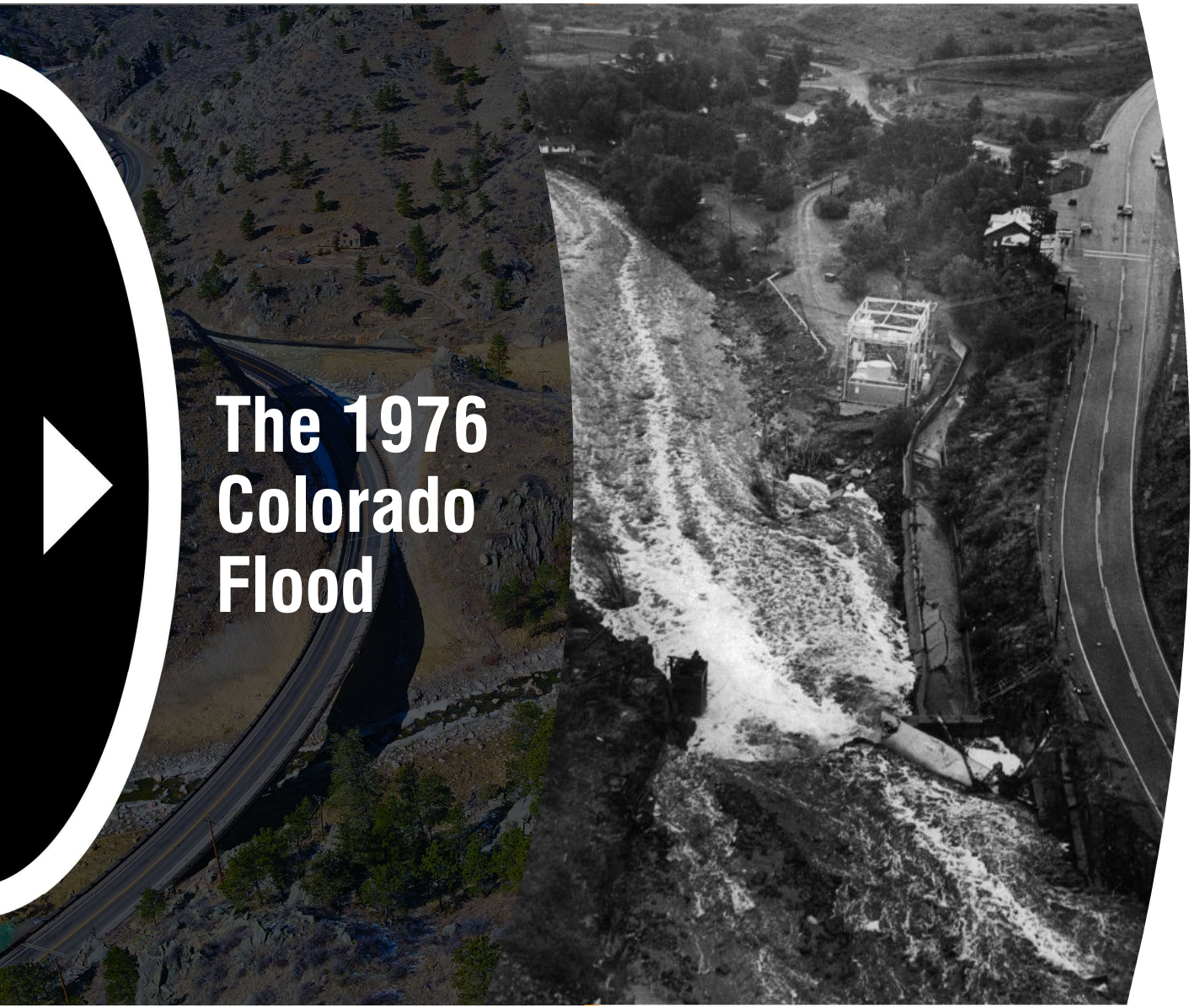
US 34 BIG THOMPSON CANYON
Flood Recovery Project

ACCOMPLISHING RESILIENCY
After the 2013 Flood



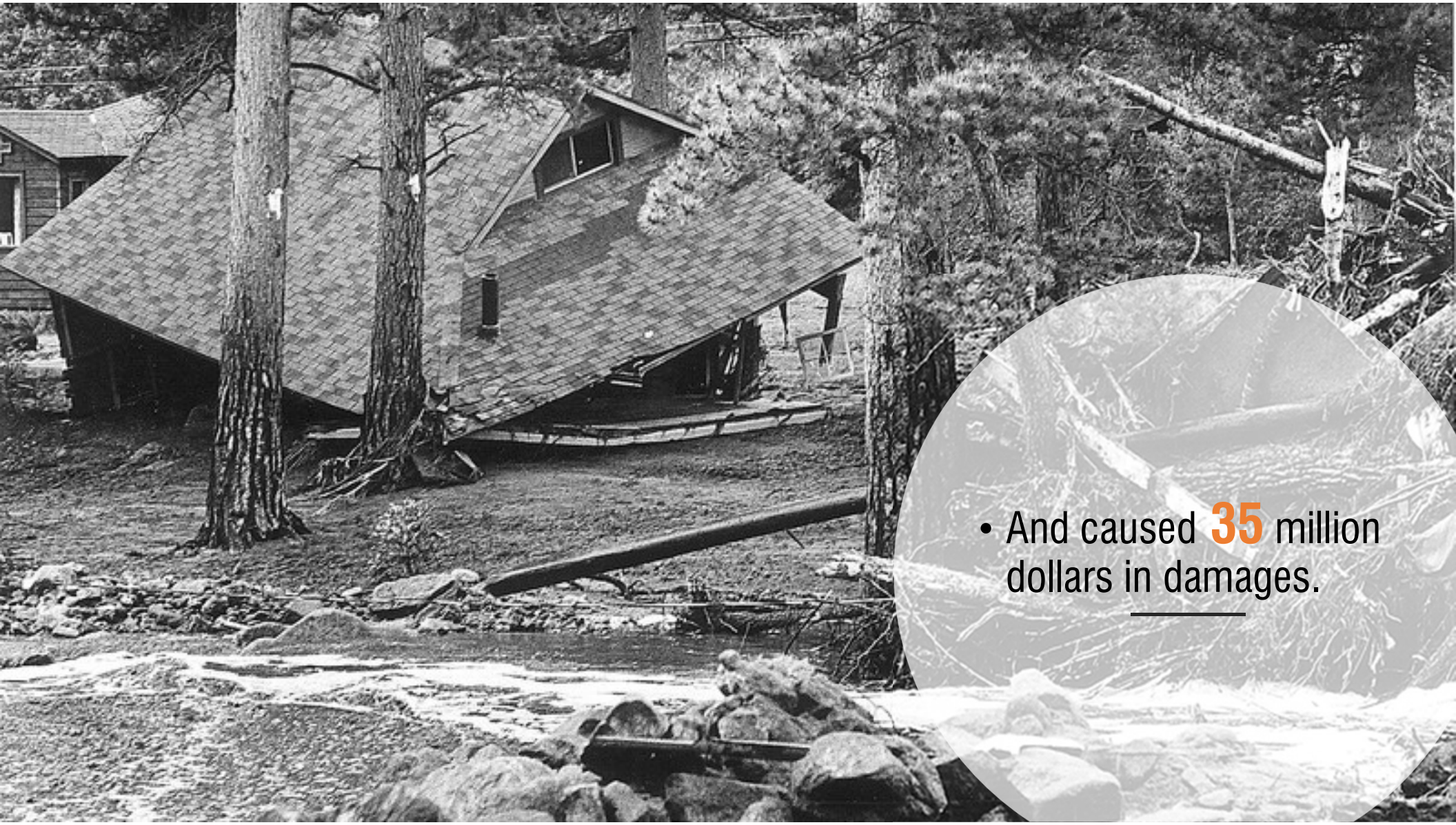
COLORADO
Department of Transportation

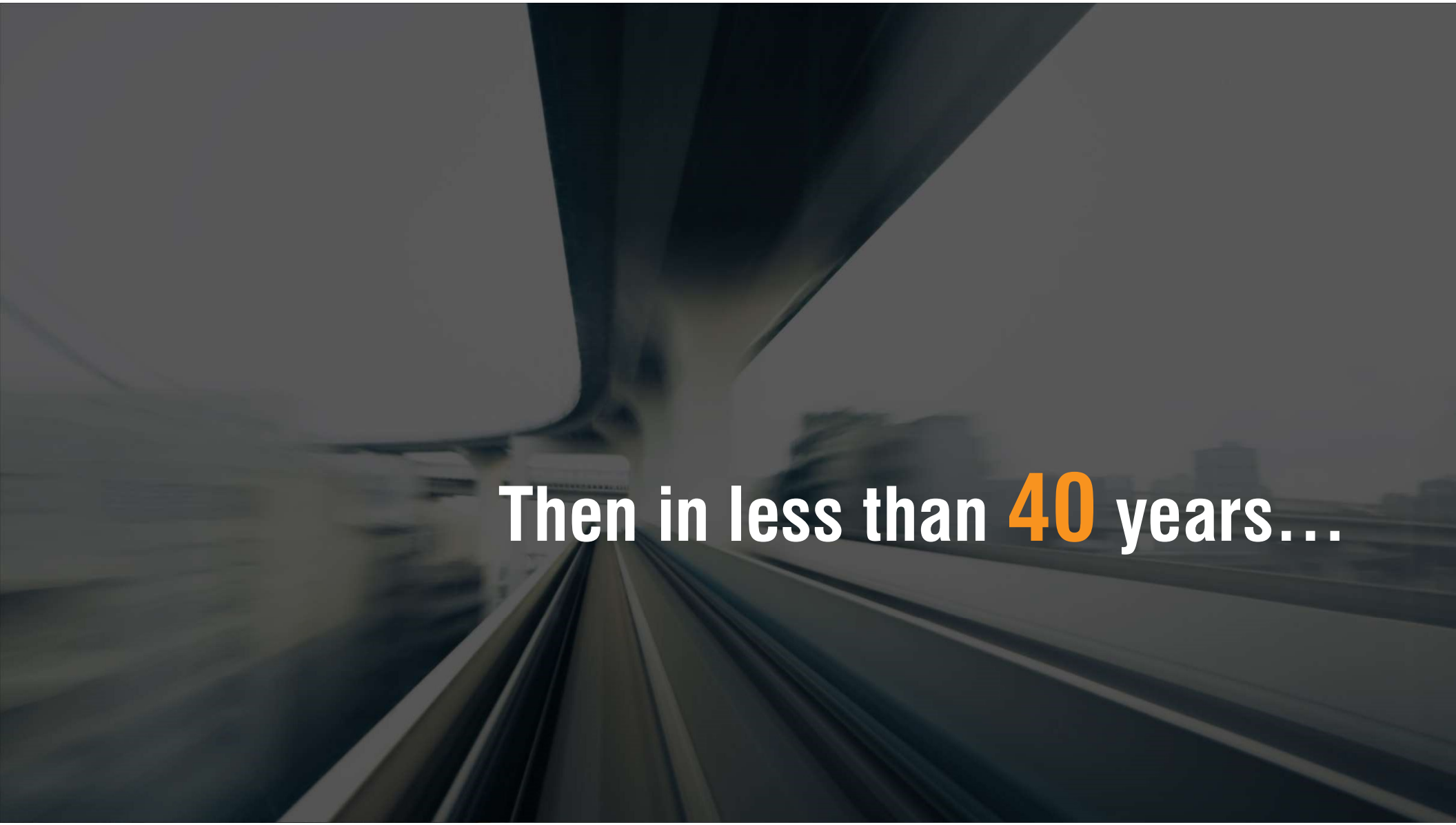


The 1976 Colorado Flood

- On July 31, a year's worth of rain fell in **70** minutes in the mountains around the resort town of Estes Park.

- This deadly natural disaster claimed a total of **144** lives.


• And caused 35 million
dollars in damages.


Then in less than 40 years…

- During the week of September 9th, 2013, a stalled cold front over Colorado collided with warm, monsoonal air from the south, causing persistent, heavy rains.

$746 Million…

- in estimated damage to facilities

486 Miles…

- of state highways closed

Over 200…

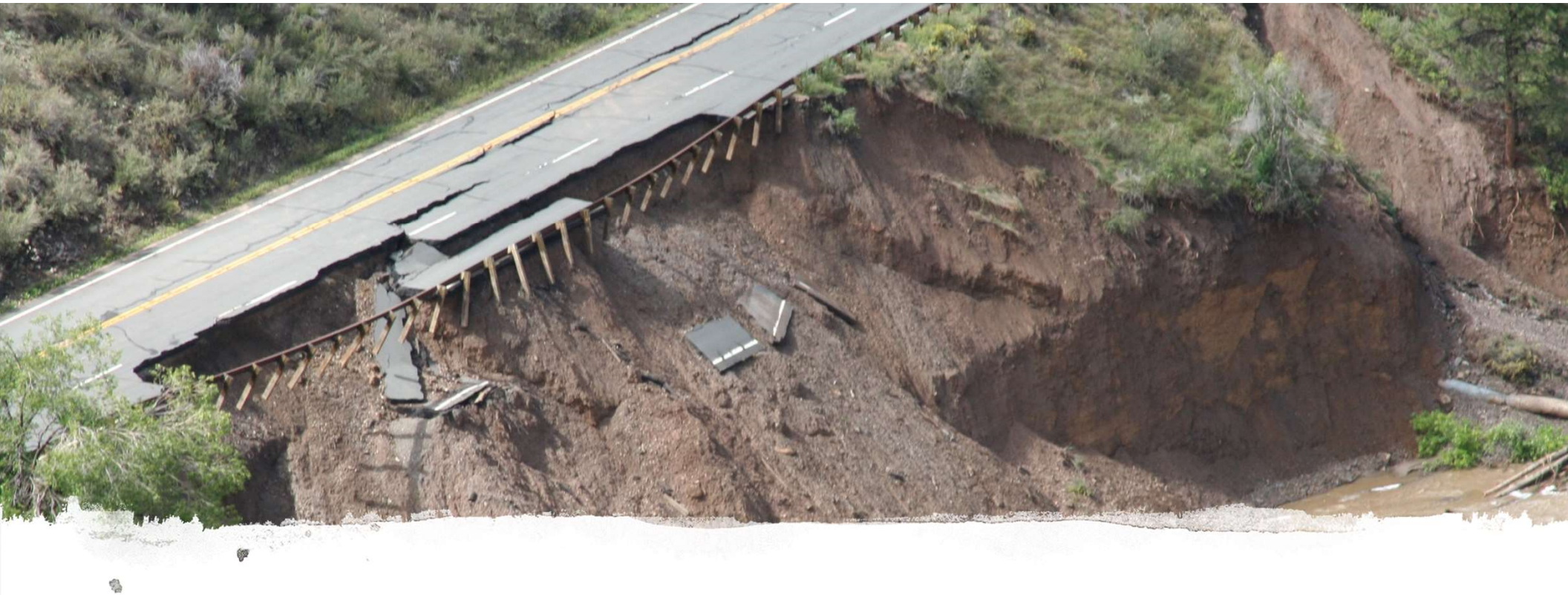
- bridges and culverts damaged

120,000 yd^3…

- of debris removed

Storm flows in excess of a 100-year event over a 10 day timeframe

707 ground evacuations, **2,256** aerial evacuations (2nd largest)



Approximately 2.5 months with no or limited access

- **23** miles of roadway damage
- **8.5** miles of full roadway loss
- **$38,728,001** in ER repair work

US 34 Path to Resiliency After ER

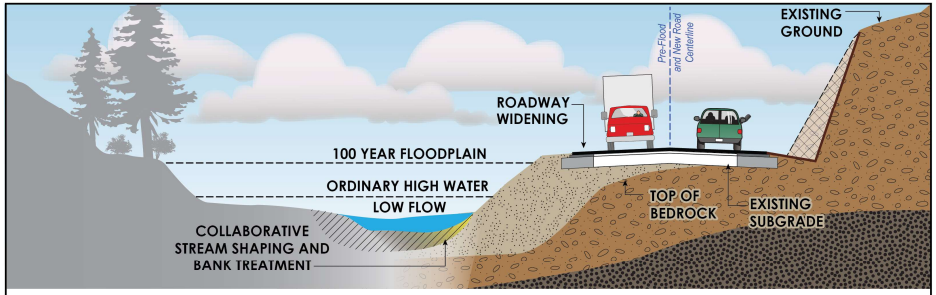
- “Build back better than before” mandate
- Innovative CMGC contracting mechanism
- Identify Risks and Resiliencies
- Prioritize improvements and develop site-specific resilient solutions
- Involve and listen to the stakeholders/partners and citizens

Accomplishing Resiliency on US 34

- Build a more resilient roadway in harmony with the river and ecological systems

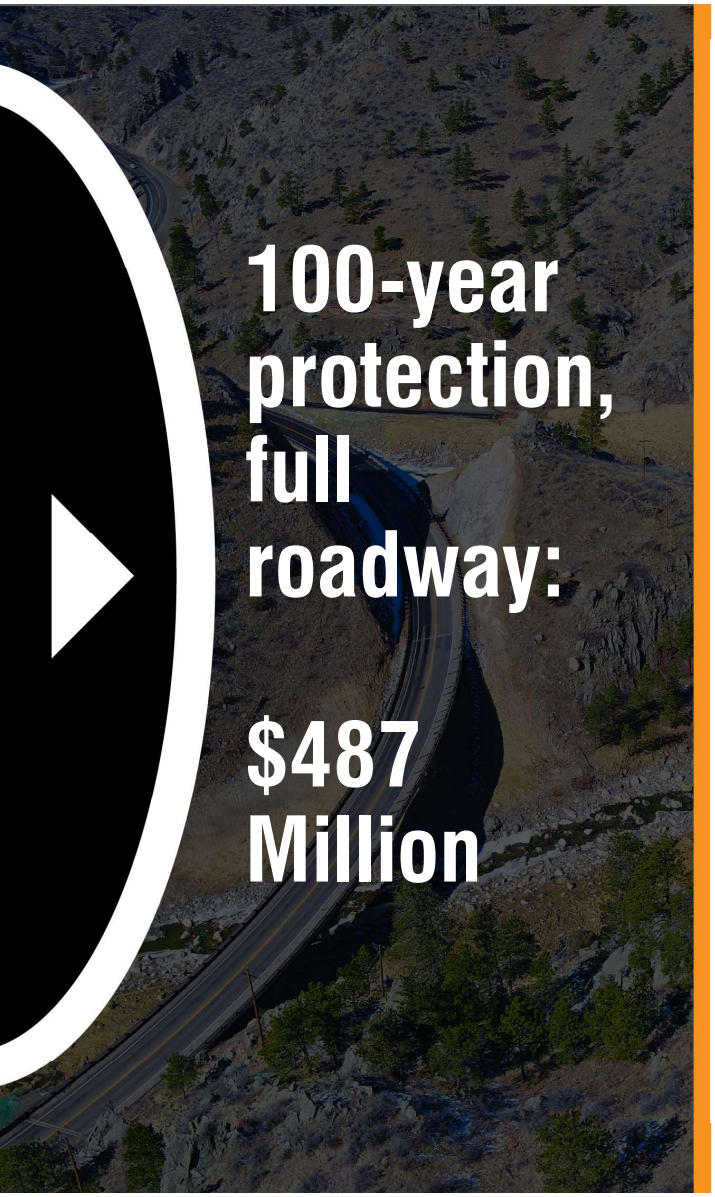
- Prioritize Emergency Access

PERMANENT ROADWAY DESIGN CONCEPT #1



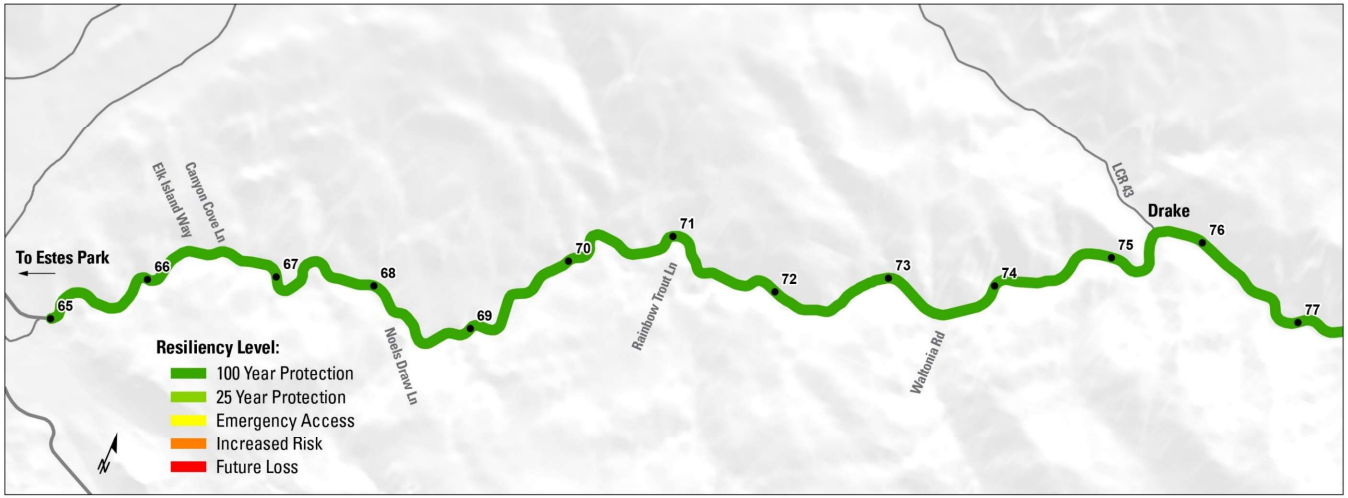
Key Features
- Widen existing road in order to establish wider shoulder up to 6 ft on either side of road and establish up to 10 ft rockfall/safety area
- Utilize as much of existing road subgrade as possible

Legend
Remove Existing Ground



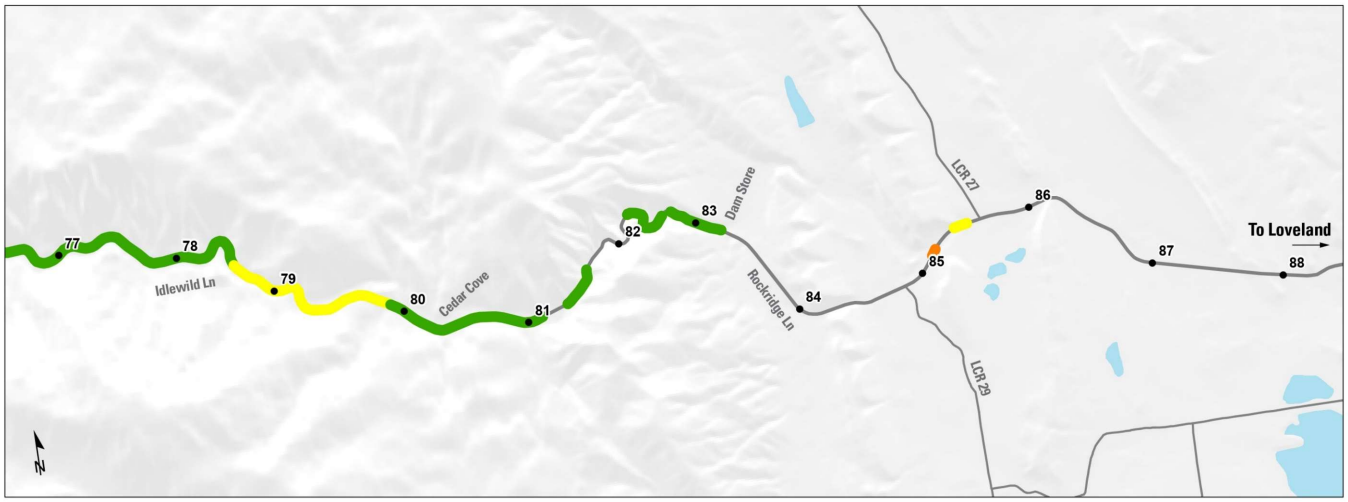
100-year protection, full roadway:

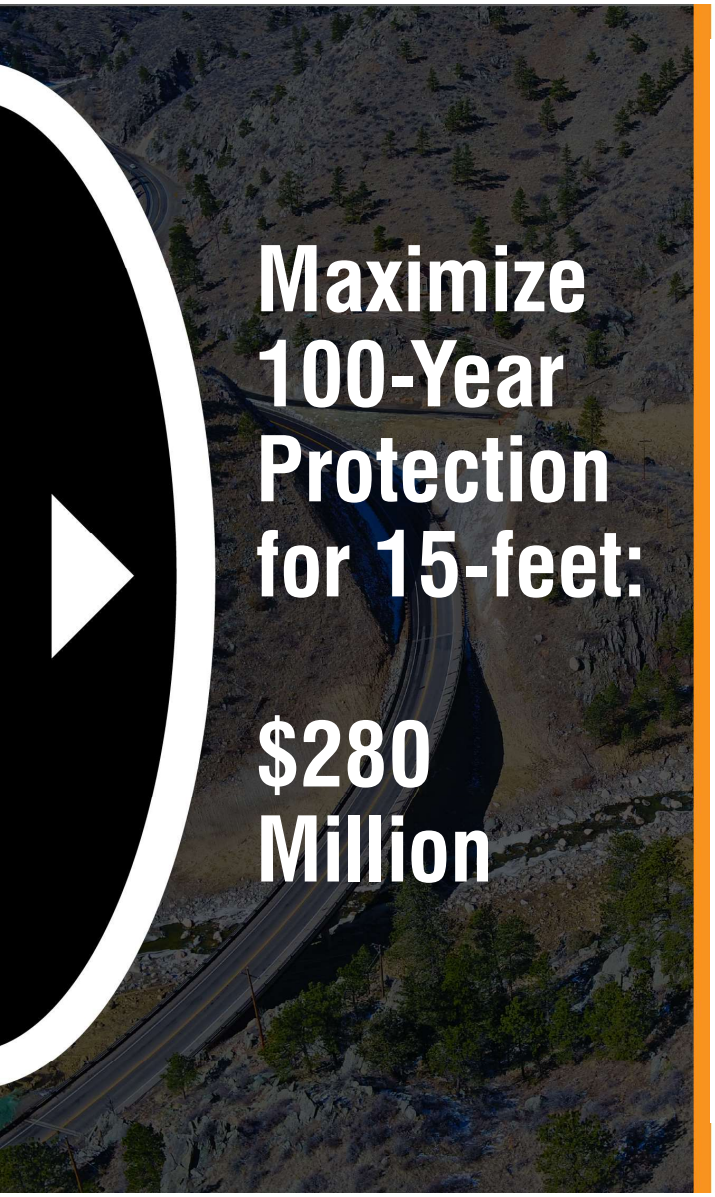
$487 Million

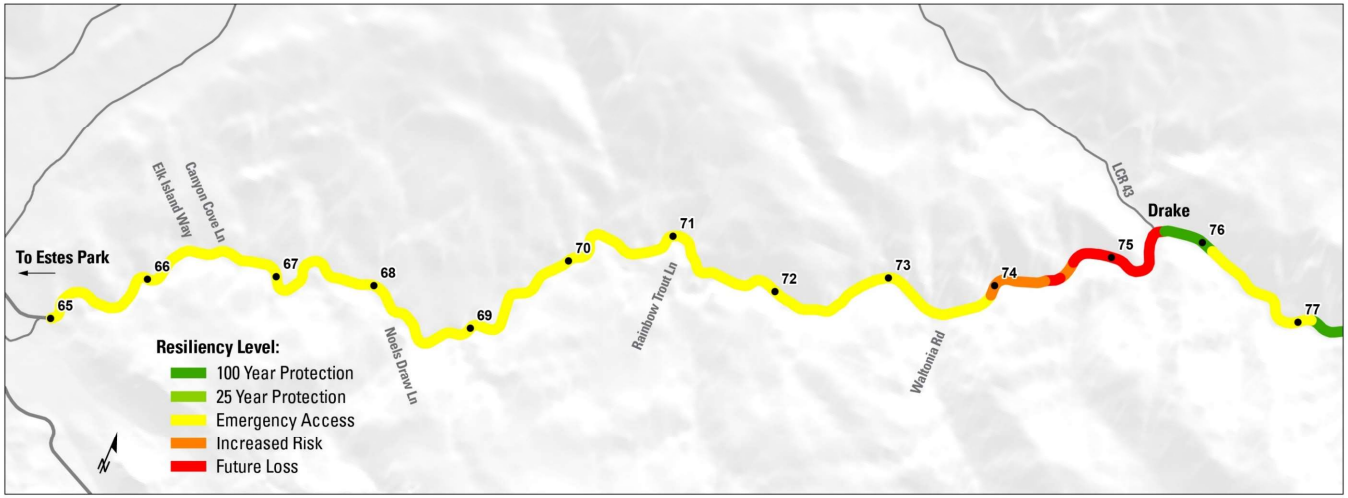


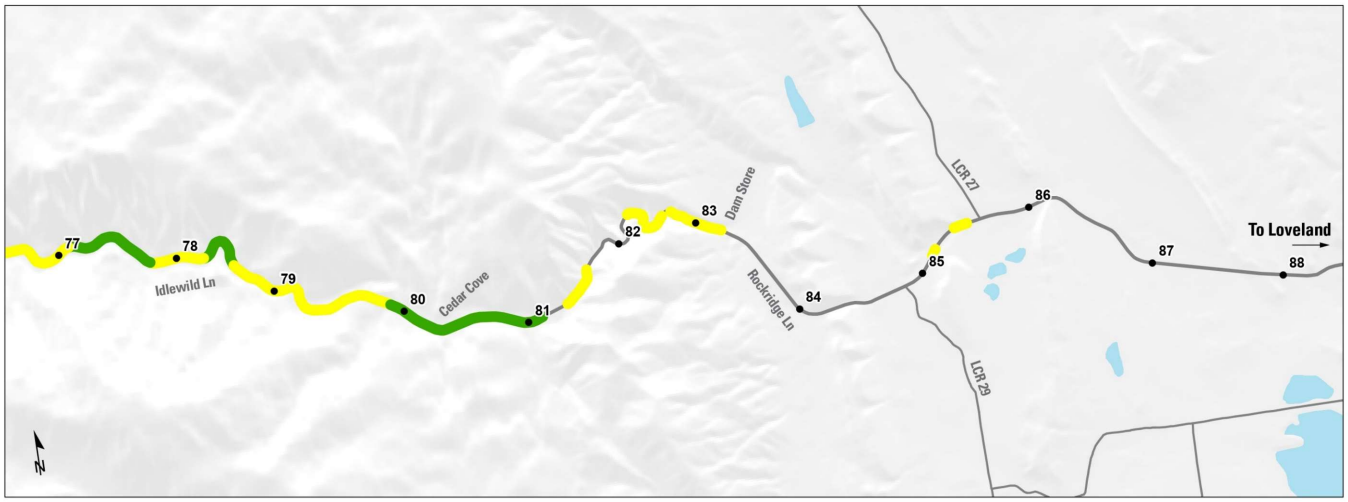
100-year protection of full roadway to budget:

$280 Million




Maximize
100-Year
Protection
for 15-feet:
$280
Million


To Estes Park
Elk Island Way
Canyon Cove Ln
Noels Draw Ln
Rainbow Trout Ln
Waltonia Rd
LCR 43
Drake
65
66
67
68
69
70
71
72
73
74
75
76
77
Resiliency Level:
100 Year Protection
25 Year Protection
Emergency Access
Increased Risk
Future Loss

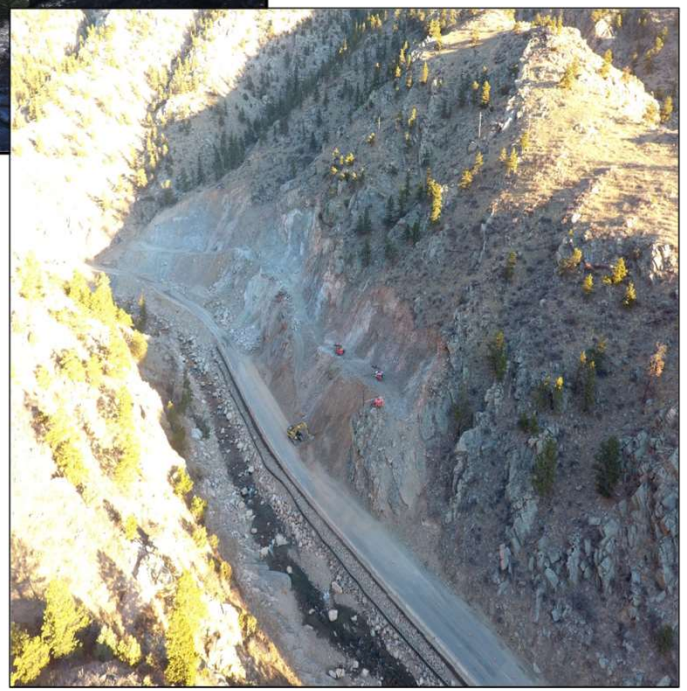

77
78
Idlewild Ln
79
80
Cedar Cove
81
82
83
Dam Store
Rockridge Ln
84
LCR 27
85
86
87
88
To Loveland
LCR 29

US 34 Big Thompson Canyon Project Team

- Kiewit
- Jacobs Engineering
- Muller Engineering
- Ayres Associates
- Yeh and Associates, Inc.
- WSP
- Rocksol
- CIG
- 105 West
- HC Peck
- Centennial Archeology
- FlyWater

Key Innovations

Shift Highway onto Bedrock



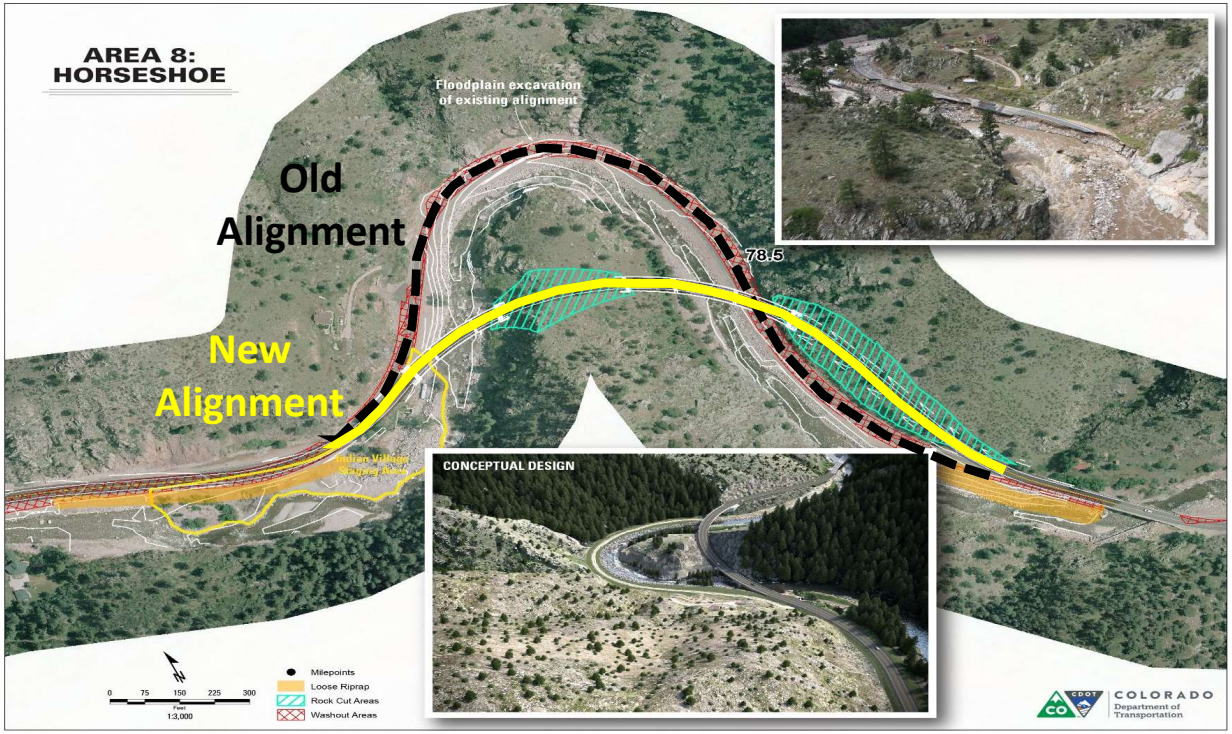
- Shift roadway onto rock cuts
- Opens up channel and floodplain


The Horseshoe Bridges 1976


The Horseshoe Bridges 2013

Best of Both Worlds: The Horseshoe Bridges

- Switches the river and the roadway
- Shifts roadway onto bedrock
- Gives the river room



Key Innovations

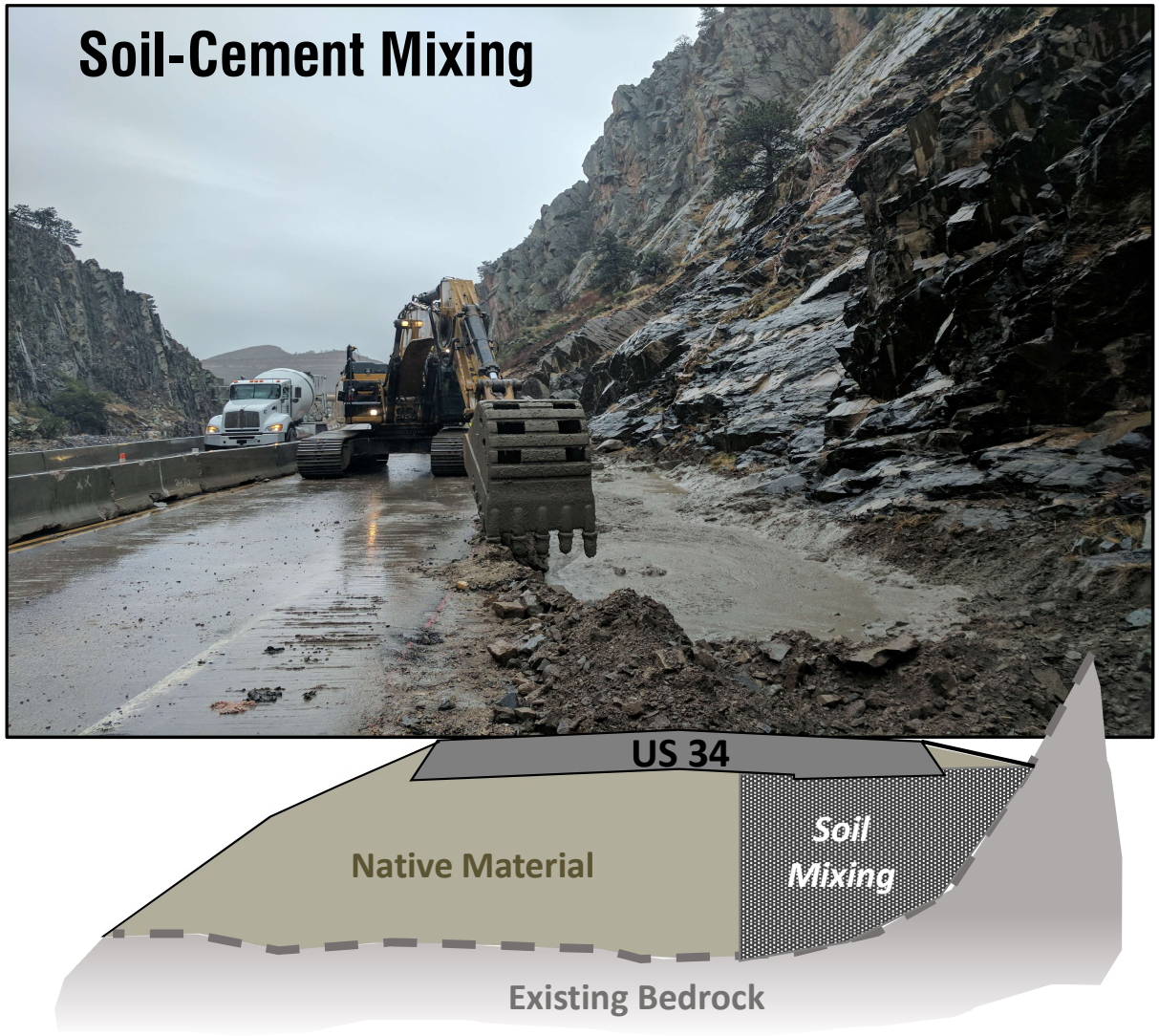
Best of Both Worlds: The Horseshoe Bridges

Constructing the East Bridge

Girder Erection on the West Bridge

Key Innovations

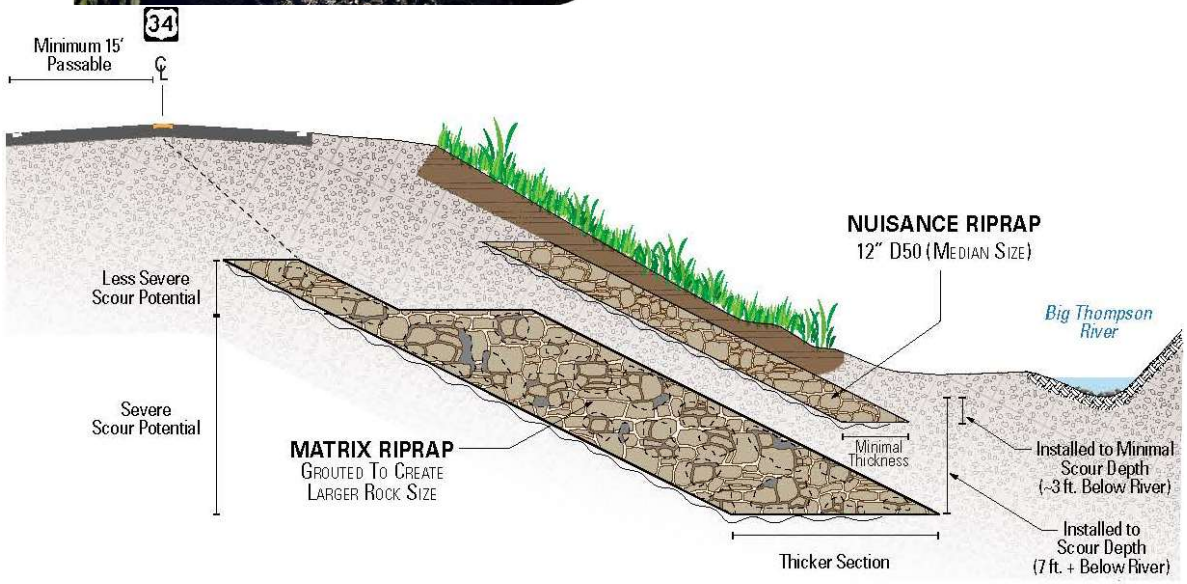
- Narrow, difficult work area
- Typical design cost-prohibitive
- Soil-cement mixing solution allows for cost-effective emergency access post-event.



Key Innovations

- Set-Back Riprap
  - Allows adequate key-in to scour depth
  - Matrix riprap used project-produced rock

Set-Back Matrix Riprap



2D Hydraulics Example Area

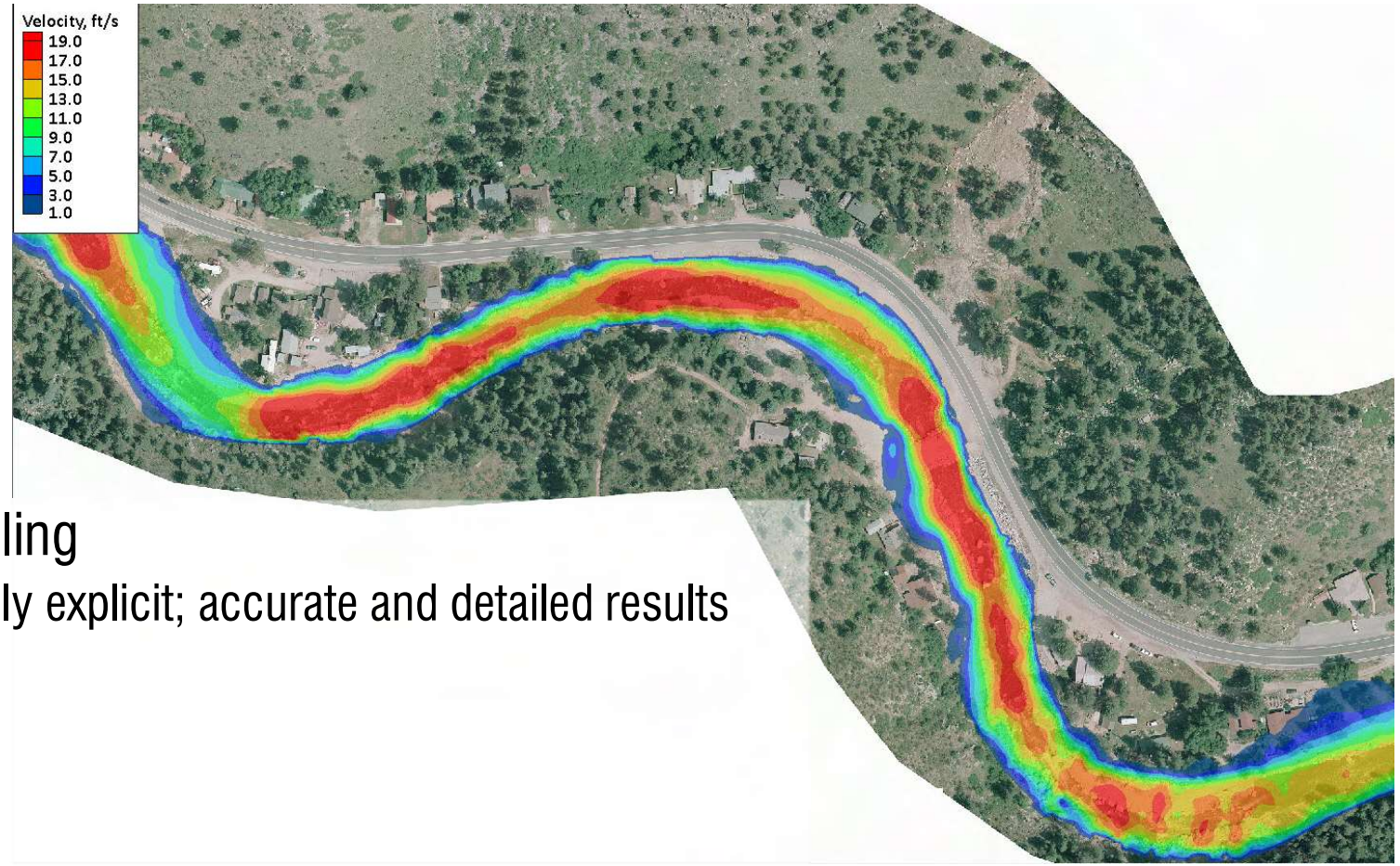
2013 Post-Flood Imagery

2D Hydraulics Example Area

2D Hydraulics Example Area

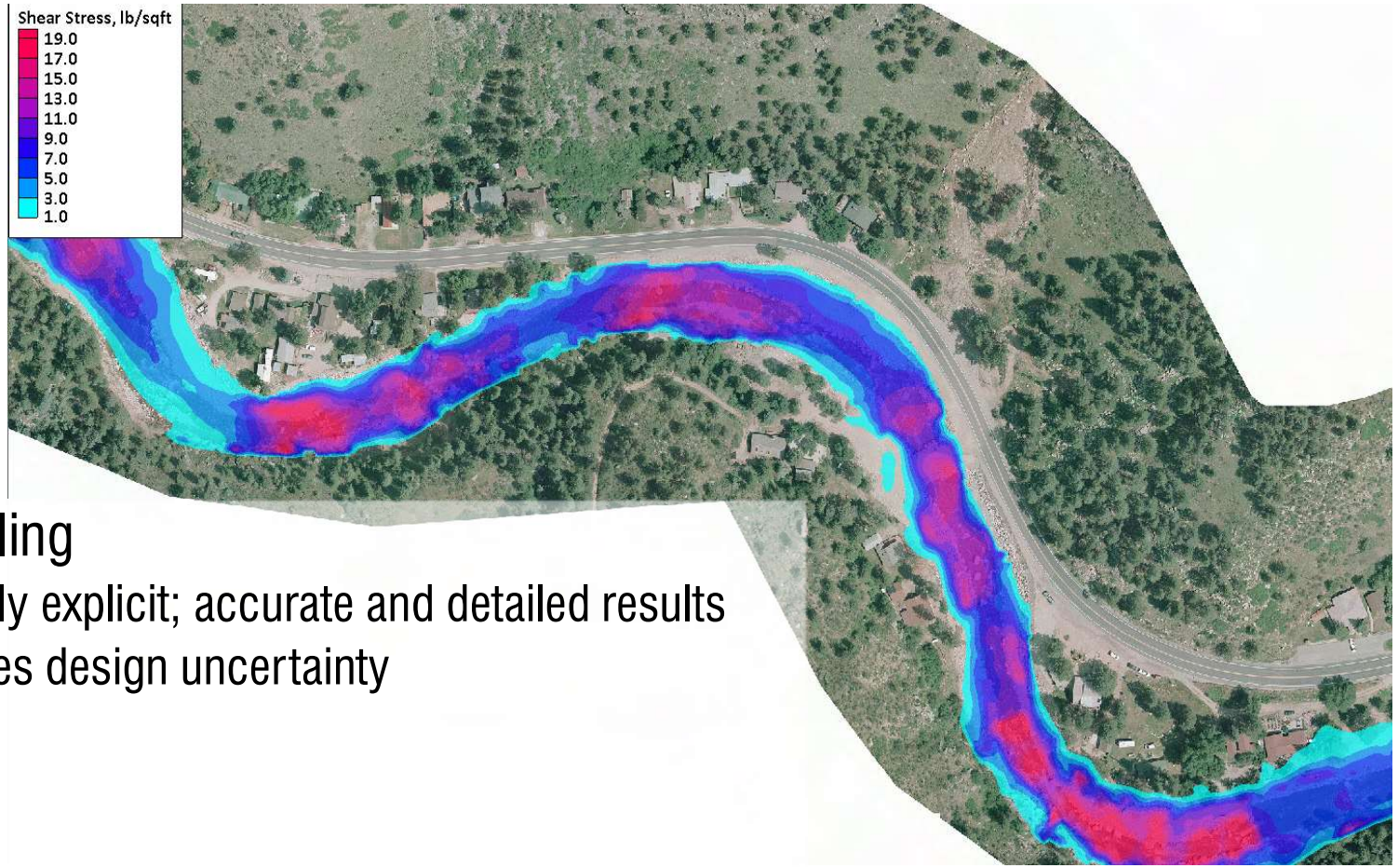
2014 Post-ER Imagery

2D Hydraulics Example Area



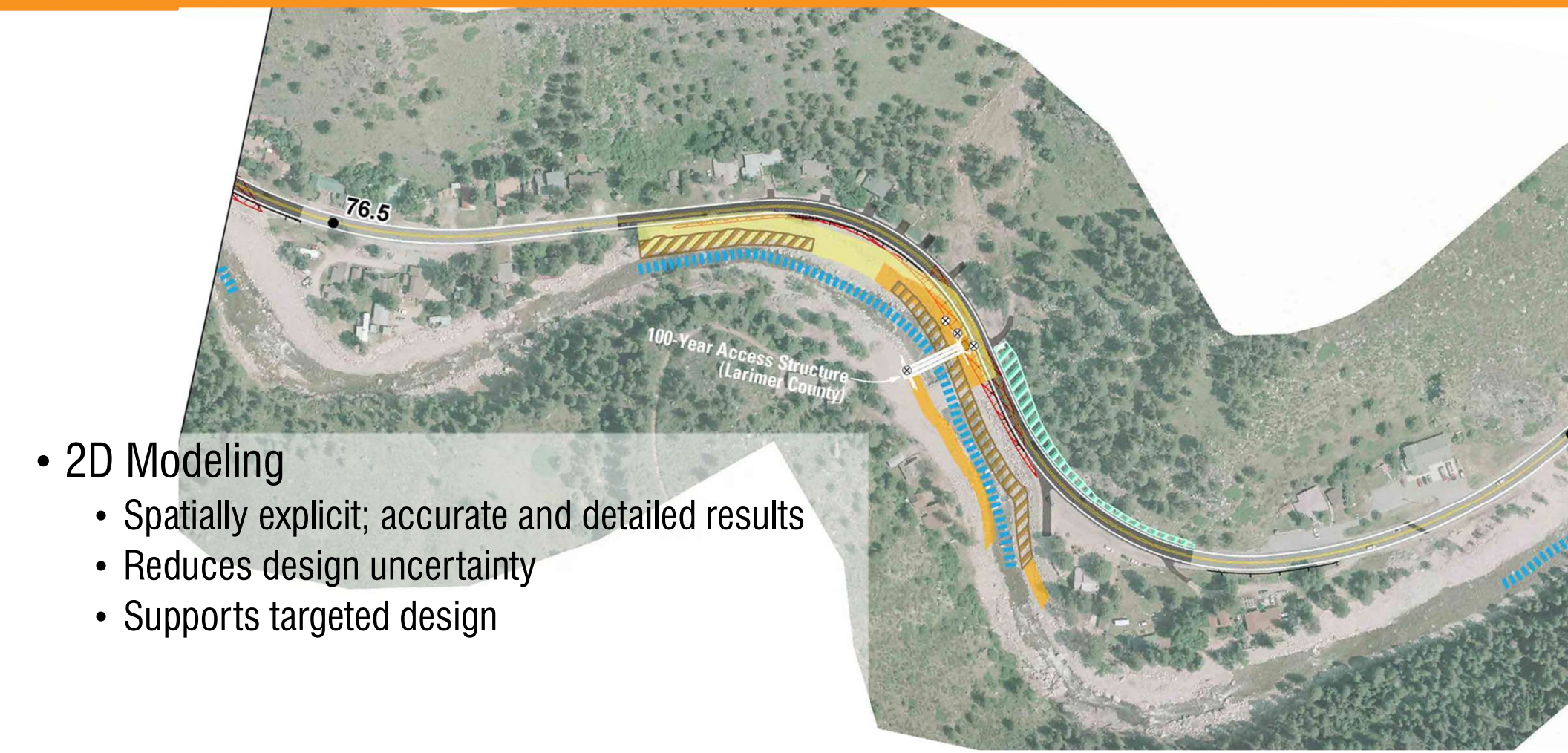
- 2D Modeling
  - Spatially explicit; accurate and detailed results

2D Hydraulics Example Area



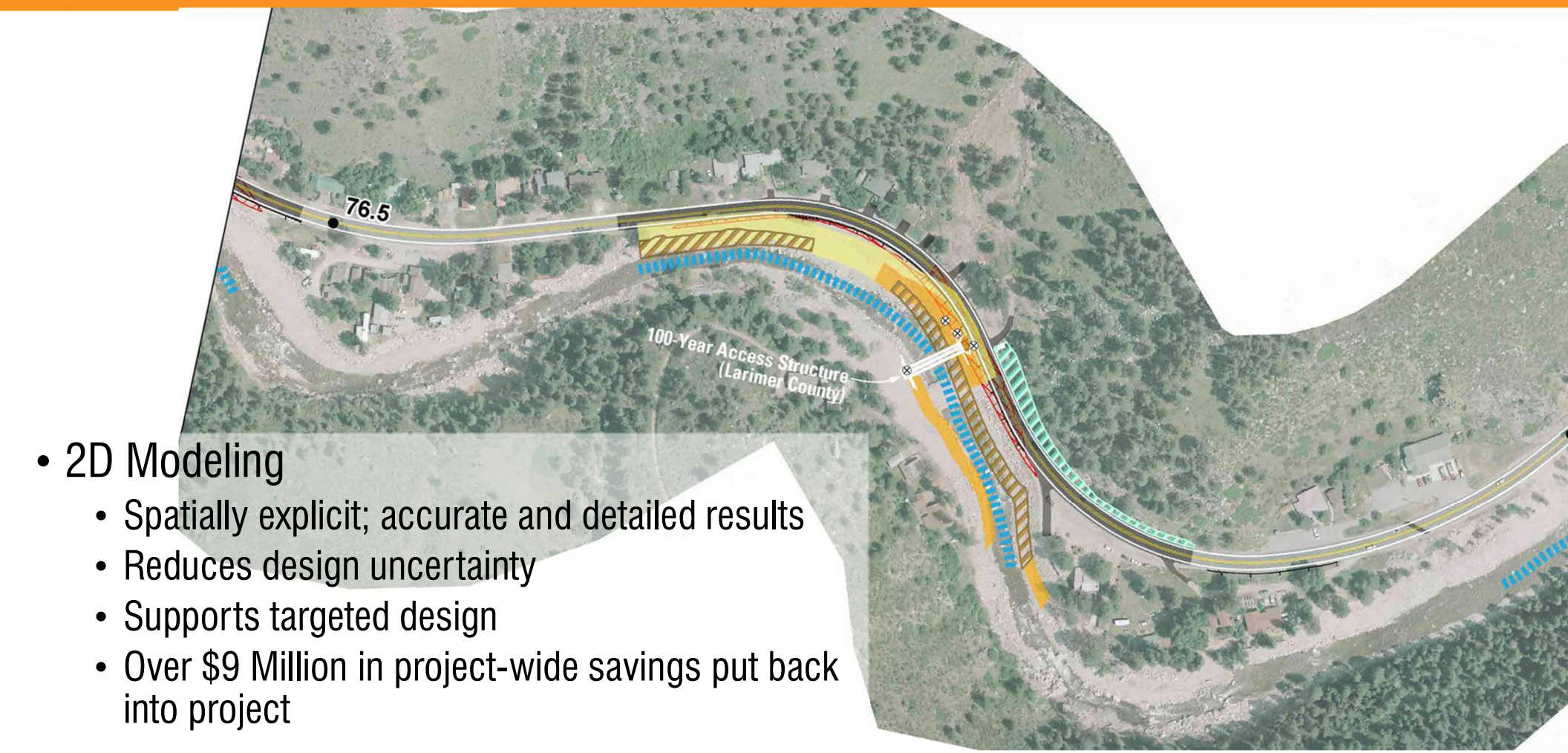
- 2D Modeling
  - Spatially explicit; accurate and detailed results
  - Reduces design uncertainty

2D Hydraulics Example Area



- 2D Modeling
  - Spatially explicit; accurate and detailed results
  - Reduces design uncertainty
  - Supports targeted design

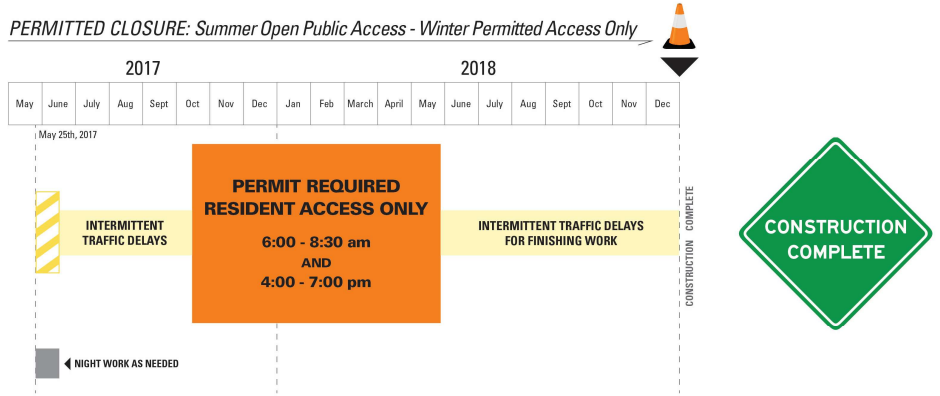
2D Hydraulics Example Area



- 2D Modeling
  - Spatially explicit; accurate and detailed results
  - Reduces design uncertainty
  - Supports targeted design
  - Over $9 Million in project-wide savings put back into project

Permitted Closure

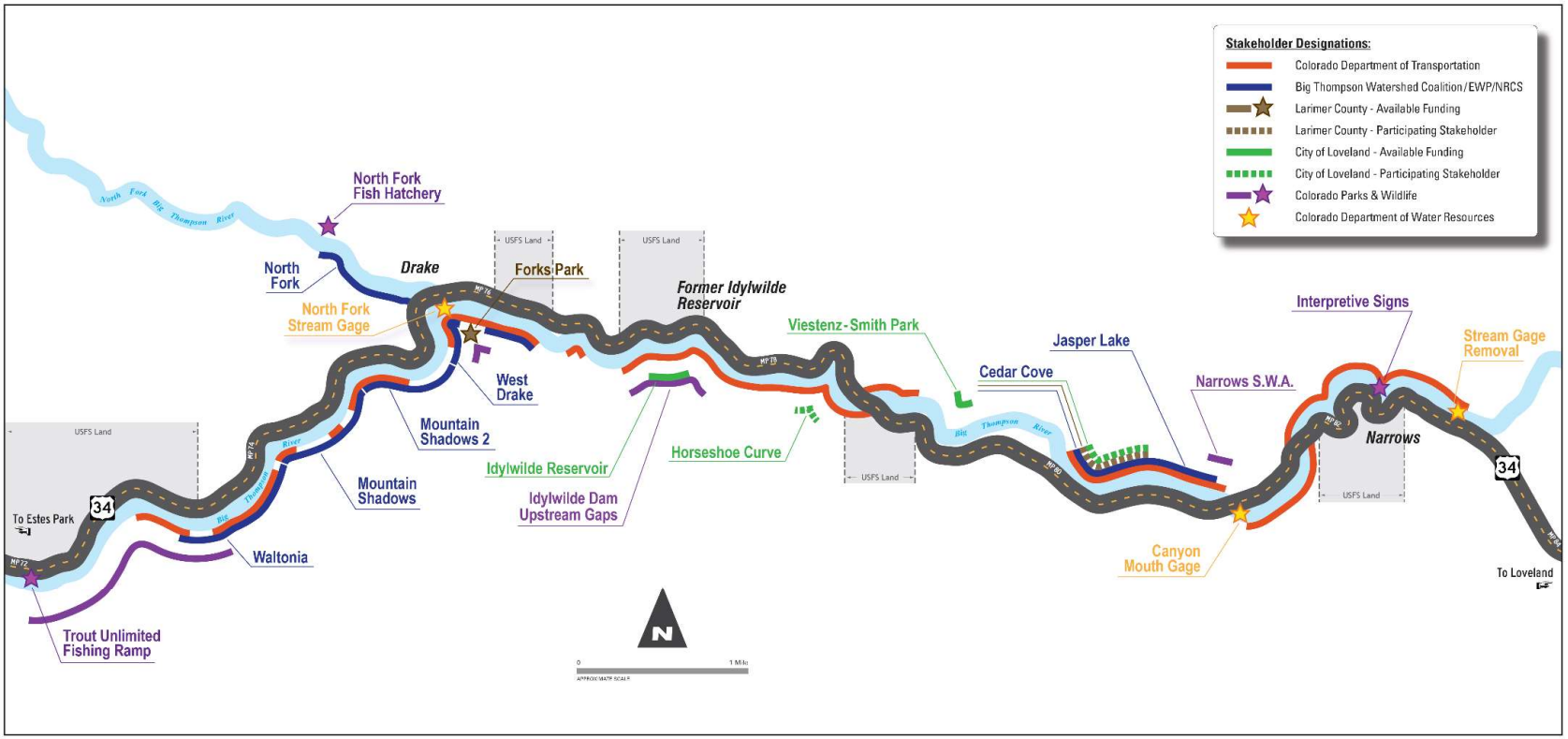
- Two Permitted Closures in Winter Season (2017, 2018)
- 24/7 Access Service to residents, essential services
- Benefits to the project
  - **$53 Million** total savings
  - **Over 1 year** in schedule savings
  - **550,000 man-hours** without incident.
  - **Allowed for improved** resilient options



US 34 Big Thompson Canyon Partnerships

- US Federal Highway Administration
- US Forest Service
- US Fish & Wildlife Service
- US Army Corps of Engineers
- US Bureau of Reclamation
- Larimer County
- City of Loveland
- Town of Estes Park
- Big Thompson Watershed Coalition
- Colorado Parks & Wildlife
- Colorado Department of Natural Resources
- Colorado State Historic Preservation Office

River Project Partnering

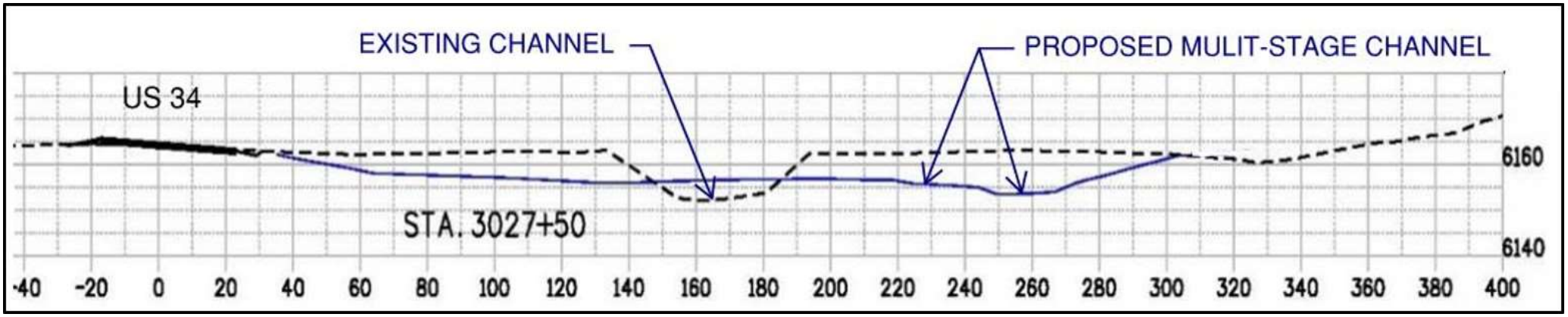


US 34 Big Thompson Canyon
Overview of River Projects

March 7th, 2016

River Rehabilitation

- 10 miles of river rehabilitation
  - Floodplain expansion/reconnection
  - Multi-stage channel development
  - Give the river room to move
- Coordinated with watershed partners and agencies



The Proof is in the Partnership

15-Foot Minimum Access

- Prioritized approach
- FHWA partnership
- Permitted Closure
- Construction safety

Set-back Matrix Riprap:

- Test sections
- Flexible and adaptive design
- Challenge Team
- Resiliency focus
- Floodplain Conveyance
- Using on-site materials

Dewatering:

- Stakeholder Coordination
- WQ monitoring
- River rehabilitation design

River Rehabilitation

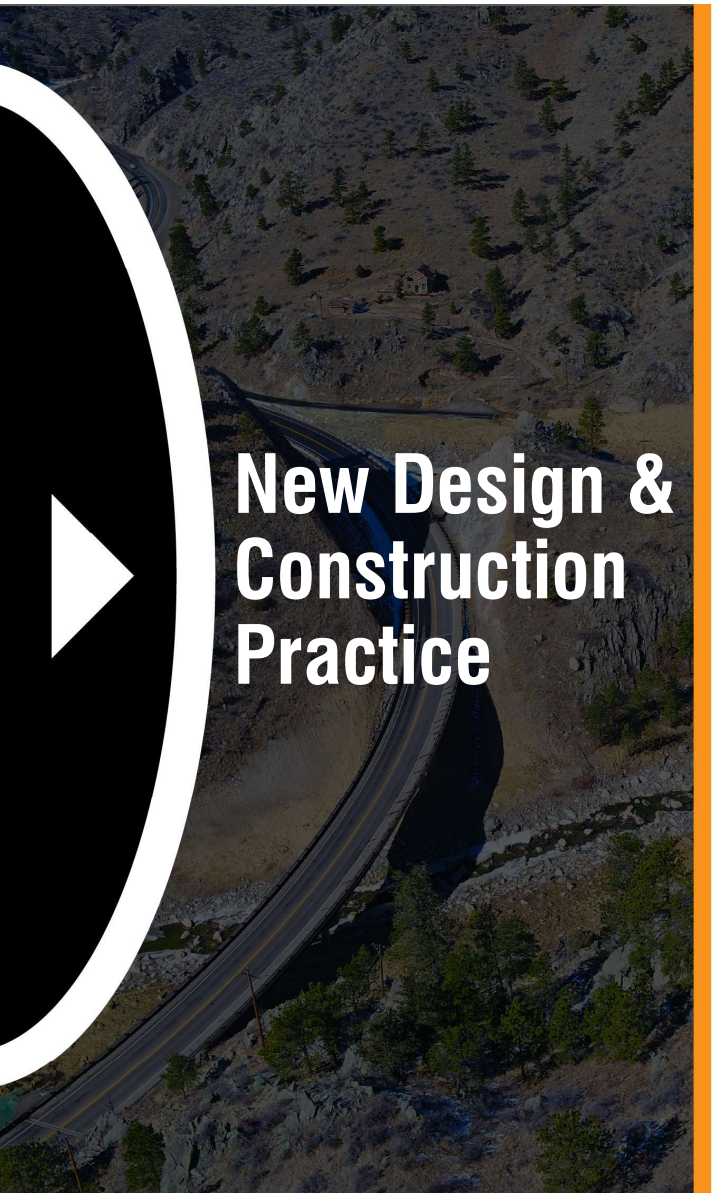
During Construction

After Construction

Carrying Lessons Forward from US 34

1. New design & construction practices adopted
2. Supporting statewide change initiatives
3. Adaptive planning for natural hazards

Resiliency by Design: *create a non-erodible roadway core*



Resiliency by Commitment:

COLORADO DEPARTMENT OF TRANSPORTATION	■ POLICY DIRECTIVE □ PROCEDURAL DIRECTIVE	
Subject **Building Resilience into Transportation Infrastructure and Operations**		Number **1905.0**
Effective **11/15/18**	Supersedes **New**	Originating Office **Division of Transportation Development**

I. PURPOSE

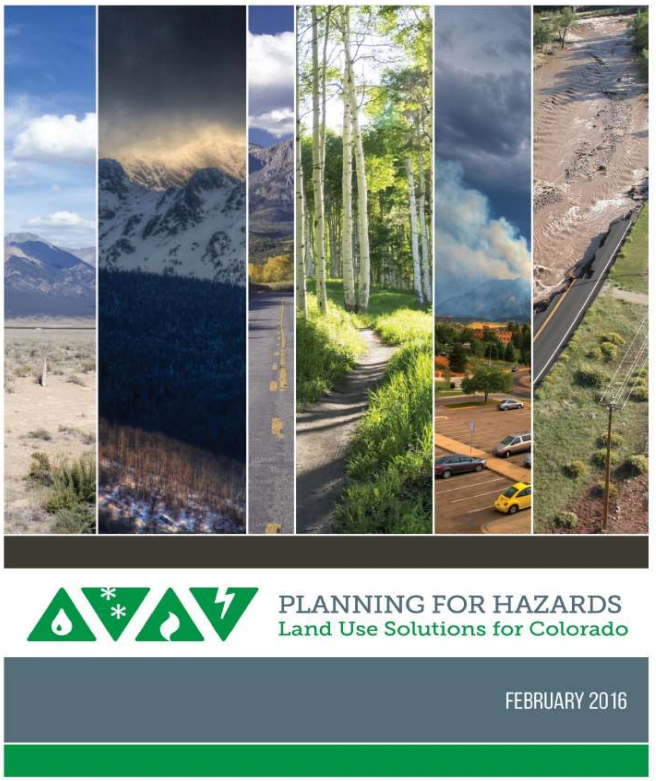
The purpose of this Policy Directive is to implement the principles of resilience into Colorado's transportation system practices. This will enable the Colorado Department of Transportation to proactively manage risks, minimize disruptions and adapt to changing conditions in order to provide continuous transportation service in Colorado. Colorado's transportation infrastructure directly or indirectly affects the lives of all people living in the state, and provides the essential services that underpin the state's economy and the movement of people, goods, and information. Maintaining a secure, functioning, and resilient infrastructure is critical to the state's safety, prosperity, and well-being.

The benefits or resilience are widespread, including fiscal benefits by saving the state money, social and economic benefits, by saving the public time and ensuring timely access to markets for businesses, and safety benefits, by taking action before a disruption becomes disastrous.

CDOT Policy Directive 1905.0 (2018)

- Commit to resilience across Colorado
- Integrate multiple agency functions
- Fund research
- Provides knowledge and resources

Integrating with Community Plans

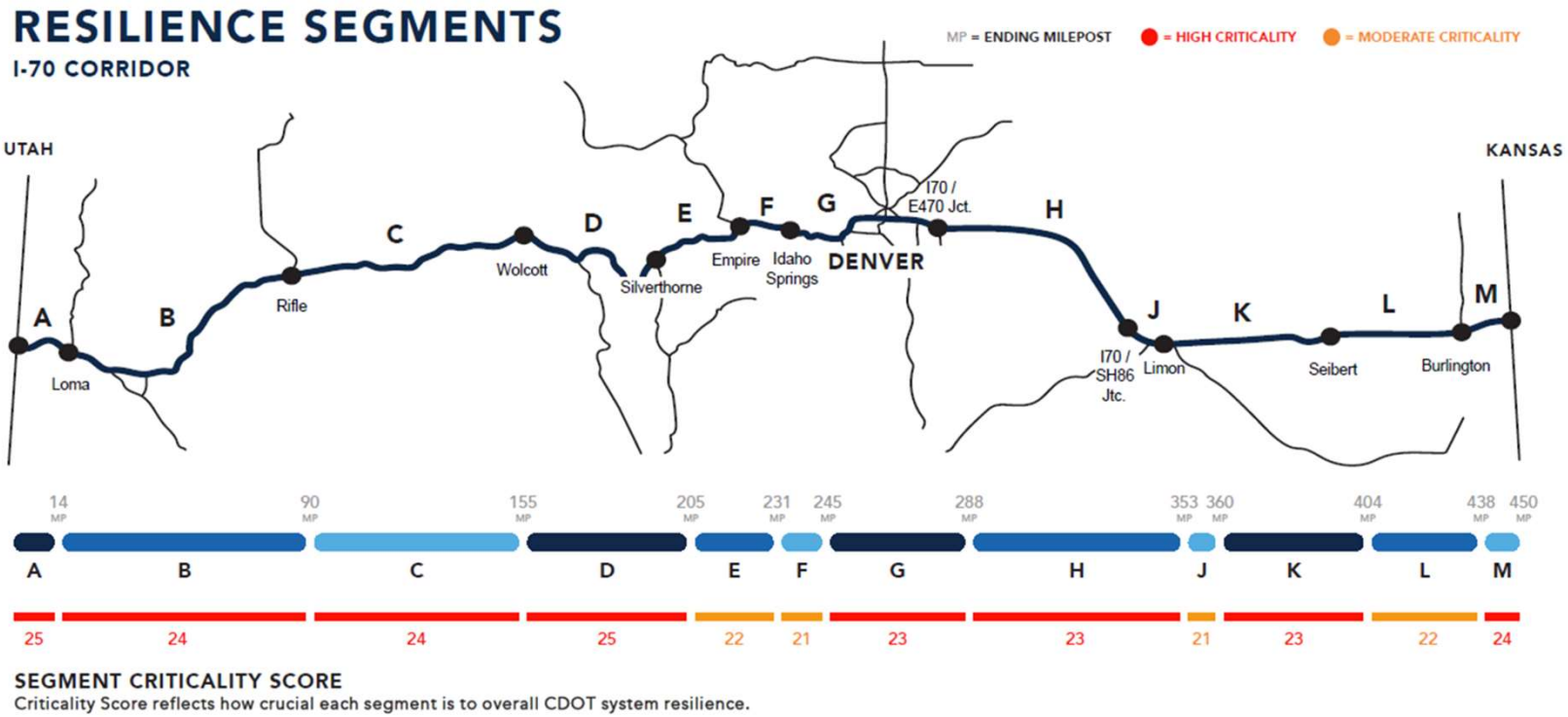


- Identify Potential Hazards
- Assess Risks & Vulnerabilities
- Select Tools & Strategies

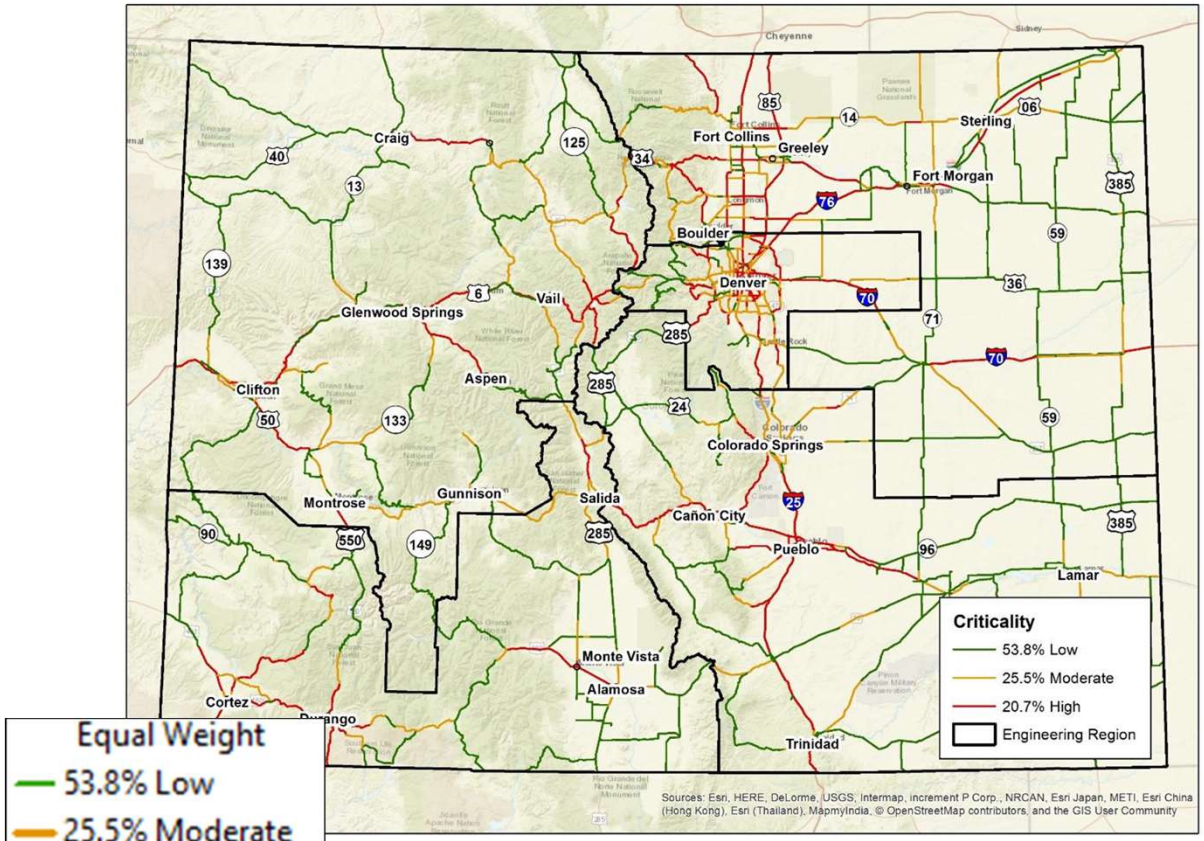
Source: Colorado Dept. of Local Affairs and UC Denver
Available online: ***www.planningforhazards.com***

Adaptive Planning for National Hazards

Identifying Critical Assets: *I-70 Risk & Resiliency Pilot Project (AEM Corp., 2017)*:



Planning for Critical Actions: *I-70 Risk & Resiliency Pilot Project (AEM Corp., 2017)*:



"Process improvement is an evolution."

-- Heather Paddock, PE
Flood Recovery Program Manager
Regional Transportation Director