



COLORADO

Department of
Transportation

Bridging the Gap to Resilience
Western Bridge Preservation Partnership
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Presenter

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Highlights

1. 2013 Flood Event
2. Opportunity to;
 - a. Collect New Data
 - b. Engage Agency Partners
 - c. Advance new concepts
 - d. Refine the state of practice moving forward
3. Case Studies in Recovery and Resiliency





September 2013 Flood Event

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Emergency Response



**100%
Reopen**
November 26,
2013





“Build Back Better than Before”

Reduce
Risk



Protect
Assets



Improve
Safety

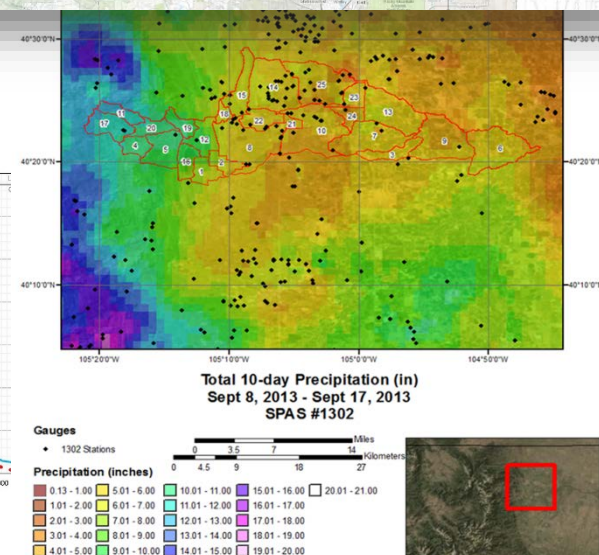
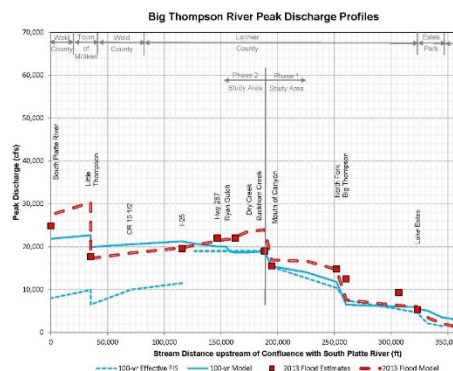
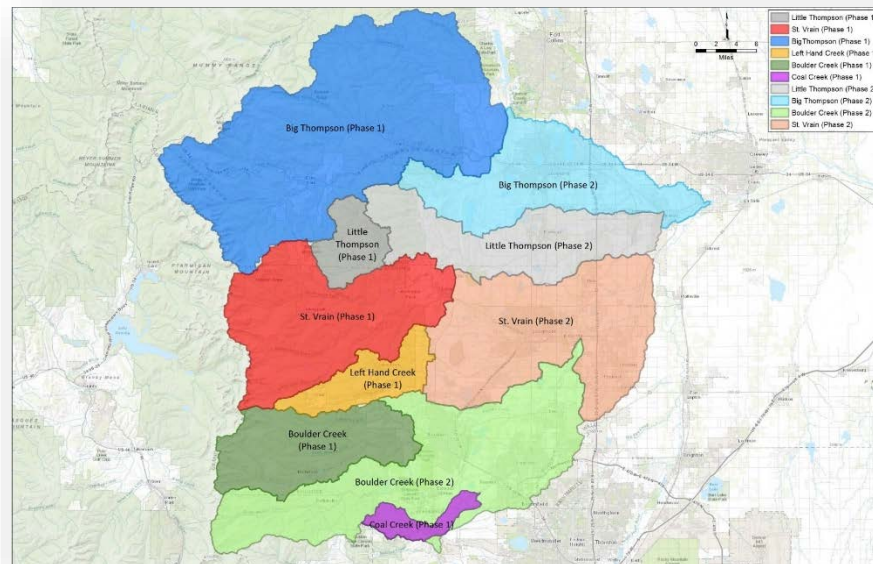




Collecting New Data

CDOT & CWCB Hydrology Studies

- 40 years of additional data
- Connecting studies from the Headwaters to the Stateline
- Multiple methodologies used to collect data / validate results
- Successful partnerships





Stakeholder 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



**US Army Corps
of Engineers.**





New Needs and Concepts Emerge

- Roadway Overtopping
 - “Controlled” overtopping points
 - Anticipate overtopping in Eastern Plains to S. Platte

Sometimes a bridge replacement isn't always feasible. How can we utilize overtopping locations to safely convey flows and recover from large storms?

- Bridge Replacements
 - New risks have been identified post 2013 flood
 - More work will likely take place in the future to replace structures and reduce risk

How can we utilize pre-cast and other construction techniques to reduce downtime and roadway closures?



What is Resilience?



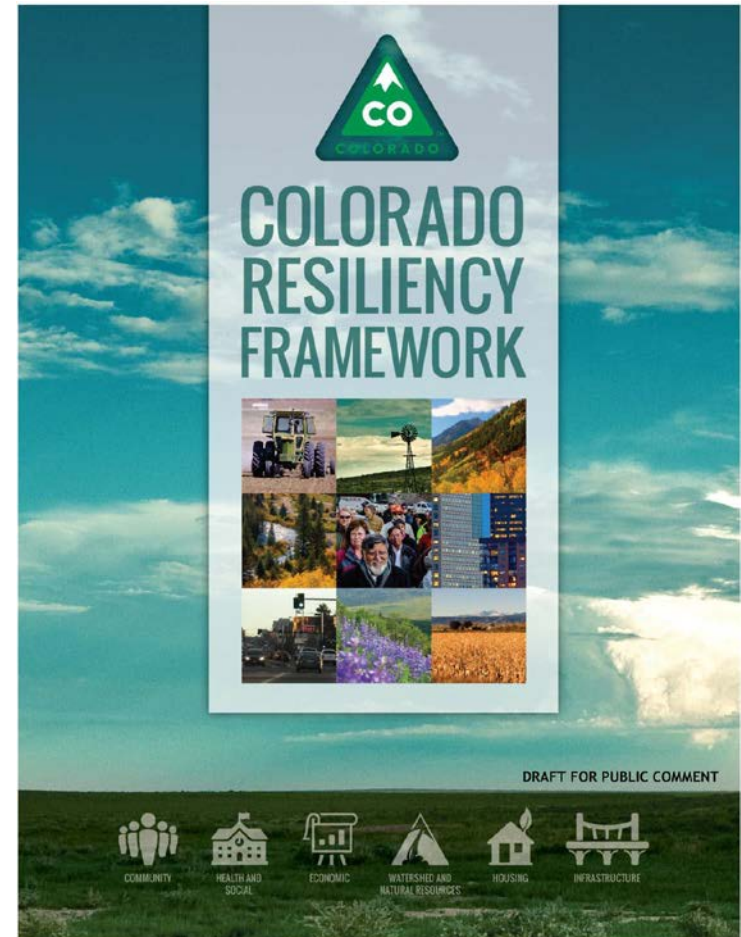
Resilience is the ability of communities to rebound, positively adapt to, or thrive amidst changing conditions or challenges – including disasters and climate change – and maintain quality of life, healthy growth, durable systems, and conservation of resources for present and future generations.

- Colorado Resiliency Working Group



Resilience: the *New Business as Usual*

- Includes extreme weather events, human-caused threats and accidents, and climate change
- Assessing **risks** to assets, determining the **vulnerability** of facilities and **prioritizing** infrastructure improvements is the new way of doing business.
- ***Colorado Resiliency Framework*** signed by Governor Hickenlooper in May 2015





CDOT Risk & Resiliency Pilot

- For management and decision making purposes **risk** is best reflected as a annualized monetary expected loss from threats based on asset design, characteristics, vulnerability and probability
 - Level of operational uncertainty in a threat-filled environment
 - Allows for assets to be analyzed/assessed with similar metric
- **Resilience** is reflected as a measure of loss of service
 - Can be quantified in revenues lost or economic impact from the loss of essential traffic
- Measure asset **criticality** to prioritize investments
 - Triple Bottom Line – Social, Economic, Environmental



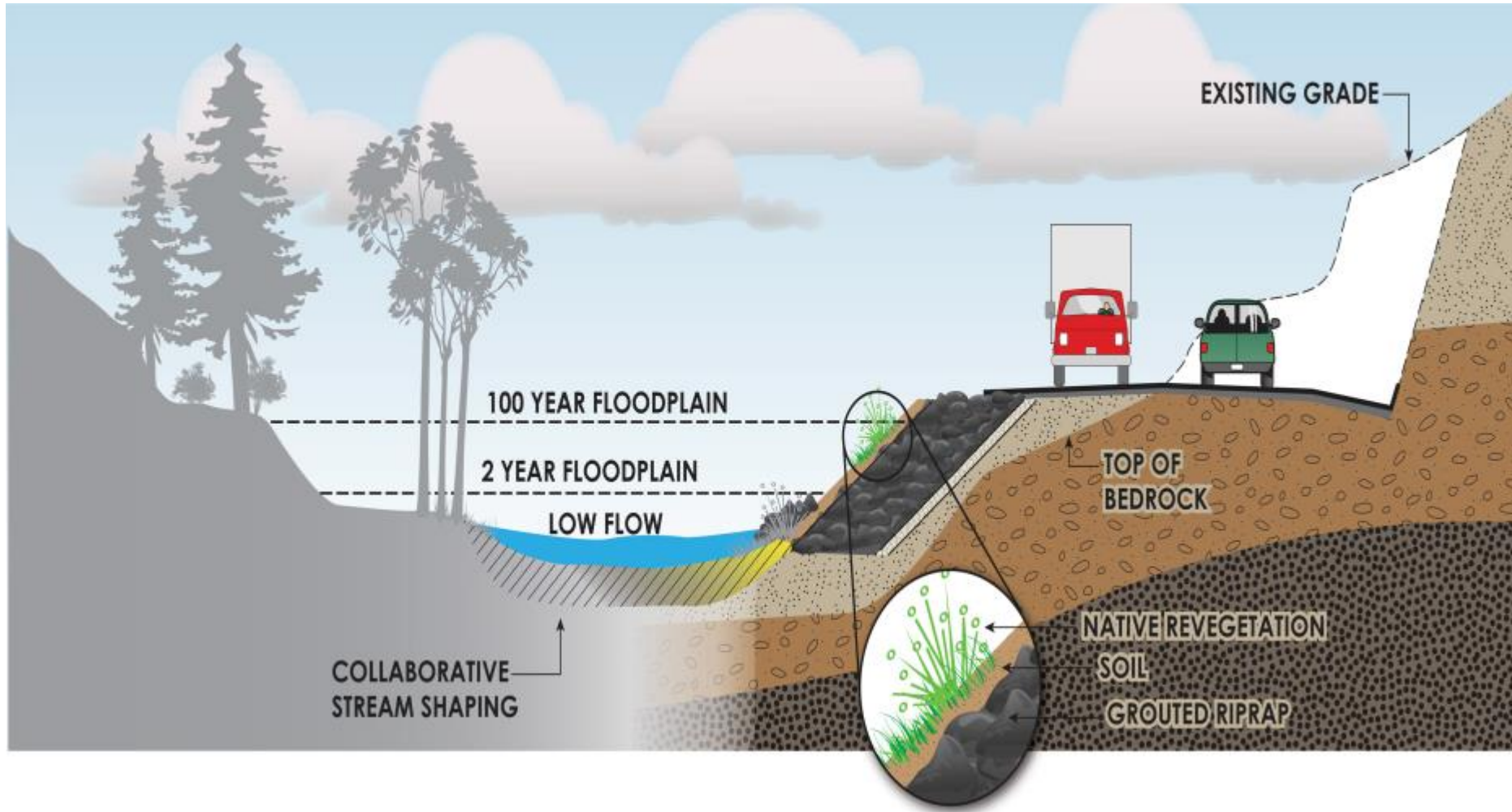
Trends in Resilience

- Interface between infrastructure and the natural environment
 - Systems approach to reconstruction - Looking at the roads, bridges, rivers, and natural environment as a system
 - Making room for the water
 - Requires a more natural and integrated approach to design solutions

How can the bridge industry move the needle forward on tying into natural solutions that accommodate larger events?



Resilient Repair Concept





Resilient Design Solutions

Current Practices

- Increasing **bridge capacities** to more effectively convey flows and debris
- Utilizing **revetment** to armor roadway embankments and structures to minimize future scour potential
- Incorporating hydraulic drops in river before bridge crossings to dissipate energy of flows

New Practices

- **Moving alignment** of roadway horizontally and vertically outside of the floodplain on to more stable ground (**bedrock**)
- **Rock Base** for the roadway prism to allow for increased water filtration and embankment protection
- Consider design alternatives based on the best solution for the river and the roadway as one **system**.

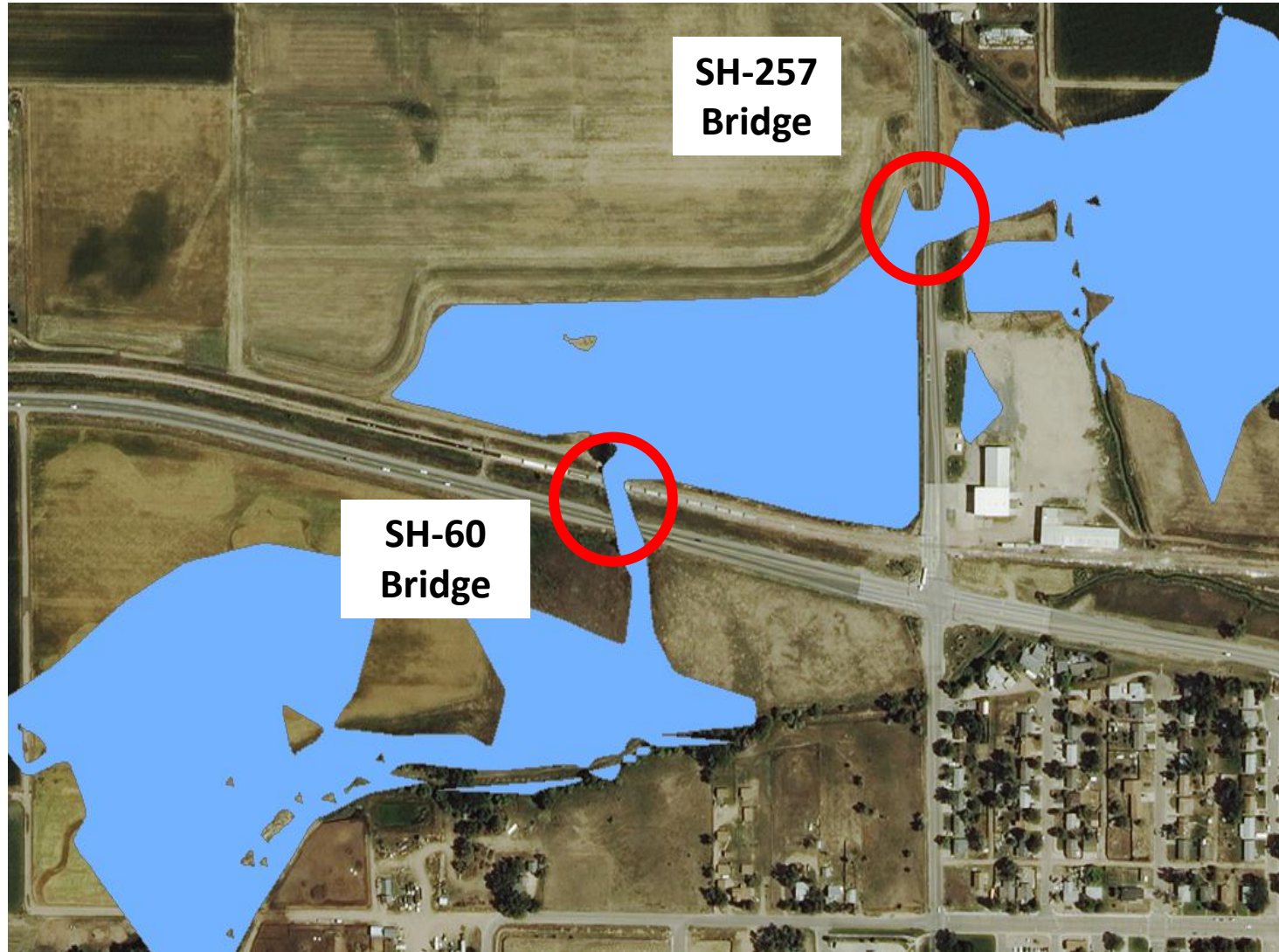


Case Study – SH 60 / SH 257





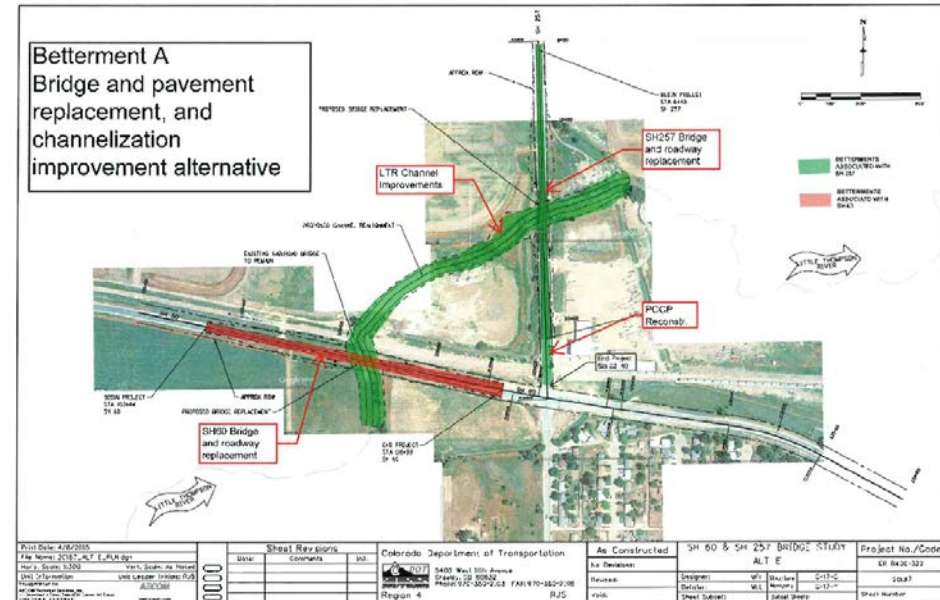
Case Study – SH 60 / SH 257





Case Study – SH 60 / SH 257

- Undersized bridges and flood water bypassed destroying the approaches and overtopping the intersection
- CDOT utilized their pilot R&R program to justify 100-year bridges



- 1D and 2D modeling was used to inform the design and reduce structure length
- CDOT has partnered with the Little Thompson Watershed Coalition to complete river restoration through this reach



Case Study – SH 71





Case Study – SH 71



- SH 71 was flooded again in 2015 during the permanent repairs

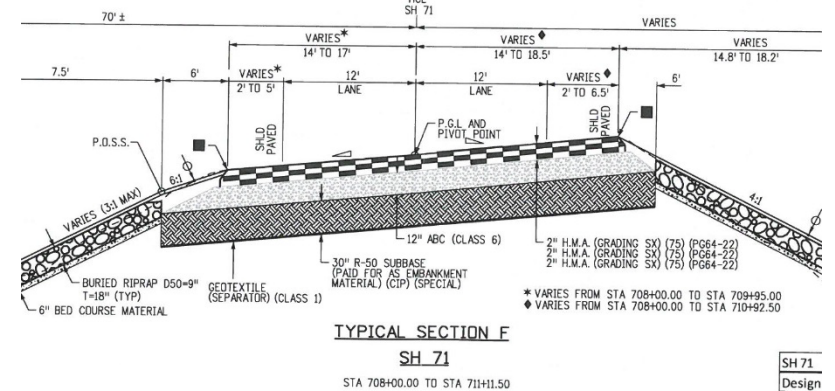
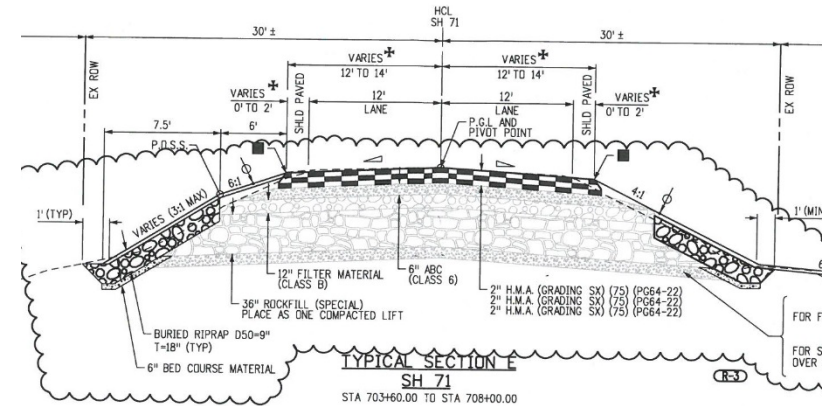
- Utilizing rock base proved beneficial and the project incorporated additional protection





Case Study – SH 71

- Two flood events established a new best practice





Case Study – US 34 East of Greeley





Case Study – US 34 East of Greeley





Case Study – US 34 East of Greeley

- Replaced the blown out roadway with a bridge to pass future flows in that area





Case Study – US 34 East of Greeley

- 2015 flooding put the new bridge to good use





Case Study – US 36 Canyon

- Moved the roadway over
- Established the river channel
- Provided room for the river to spread out
- Reinforced embankments
- Root wads

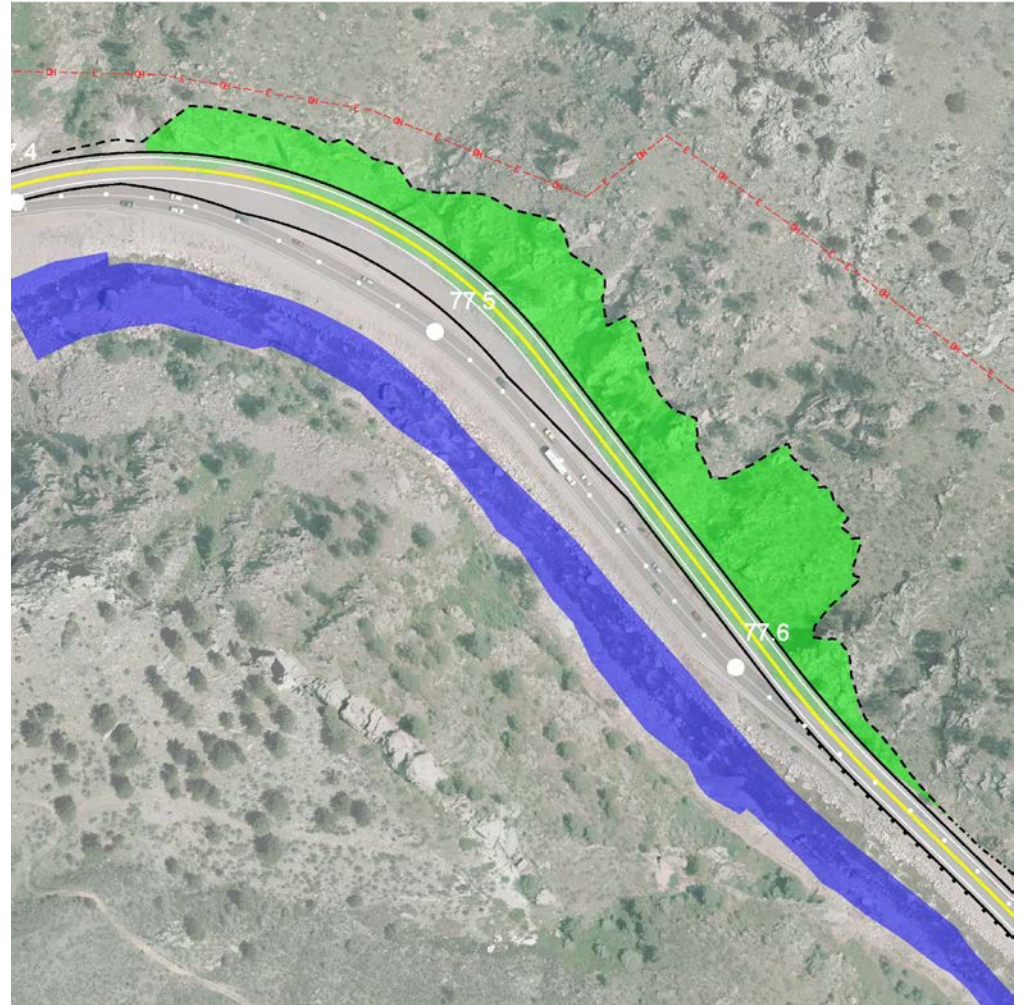




Case Study – US 34 Big Thompson

Idylwilde Area Rock Cut

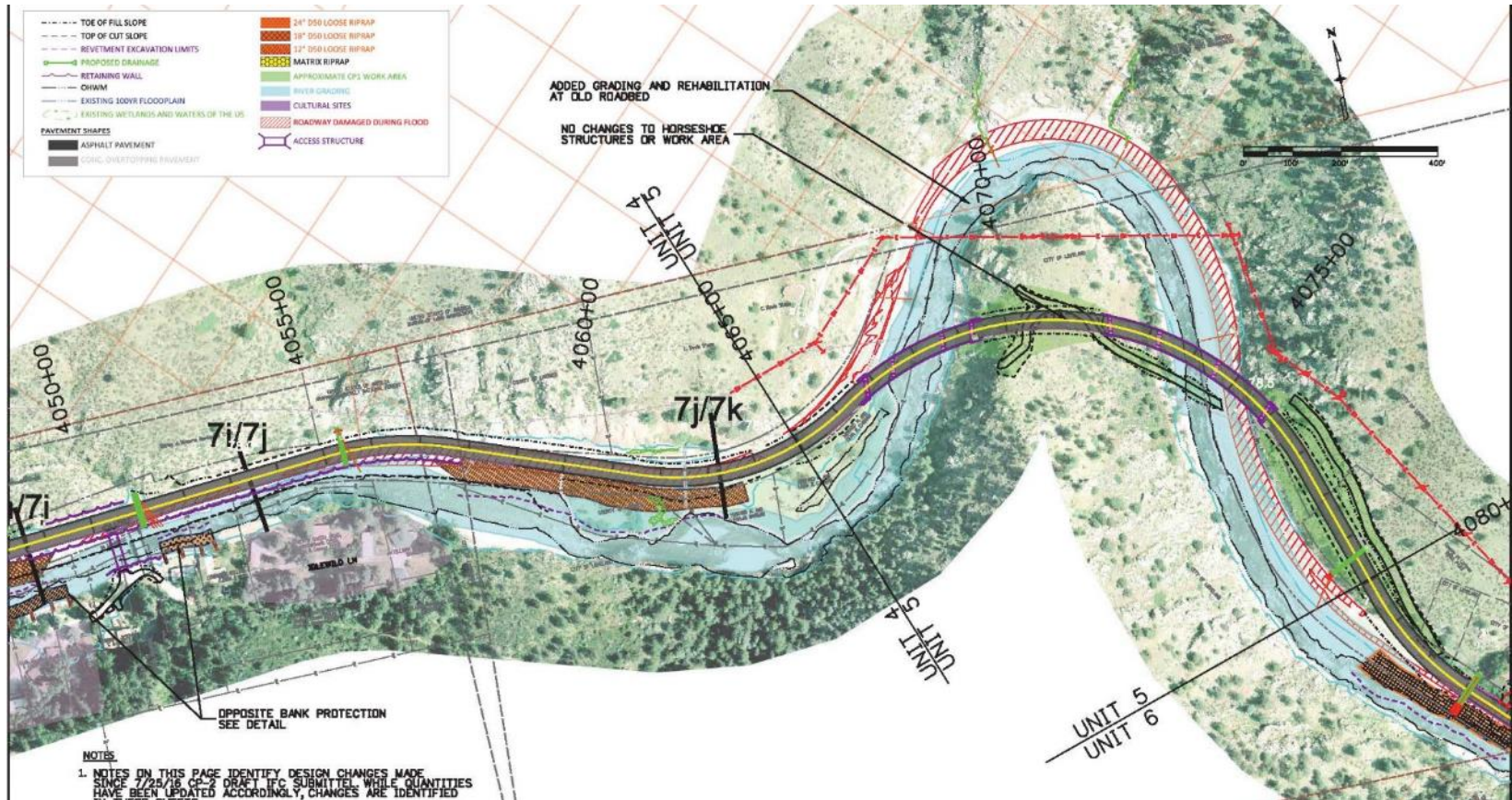
- High risk location
- Cut to allow 15' of roadway on bedrock on outside bend
- Almost 200,000 Cubic Yards of rock cut and removal
- Opens channel & floodplain





Case Study – US 34 Big Thompson

Horseshoe Bend – Switching the River & Road





Case Study – US 34 Big Thompson

Horseshoe Bend – Switching the River & Road





Case Study – Private Access Bridges

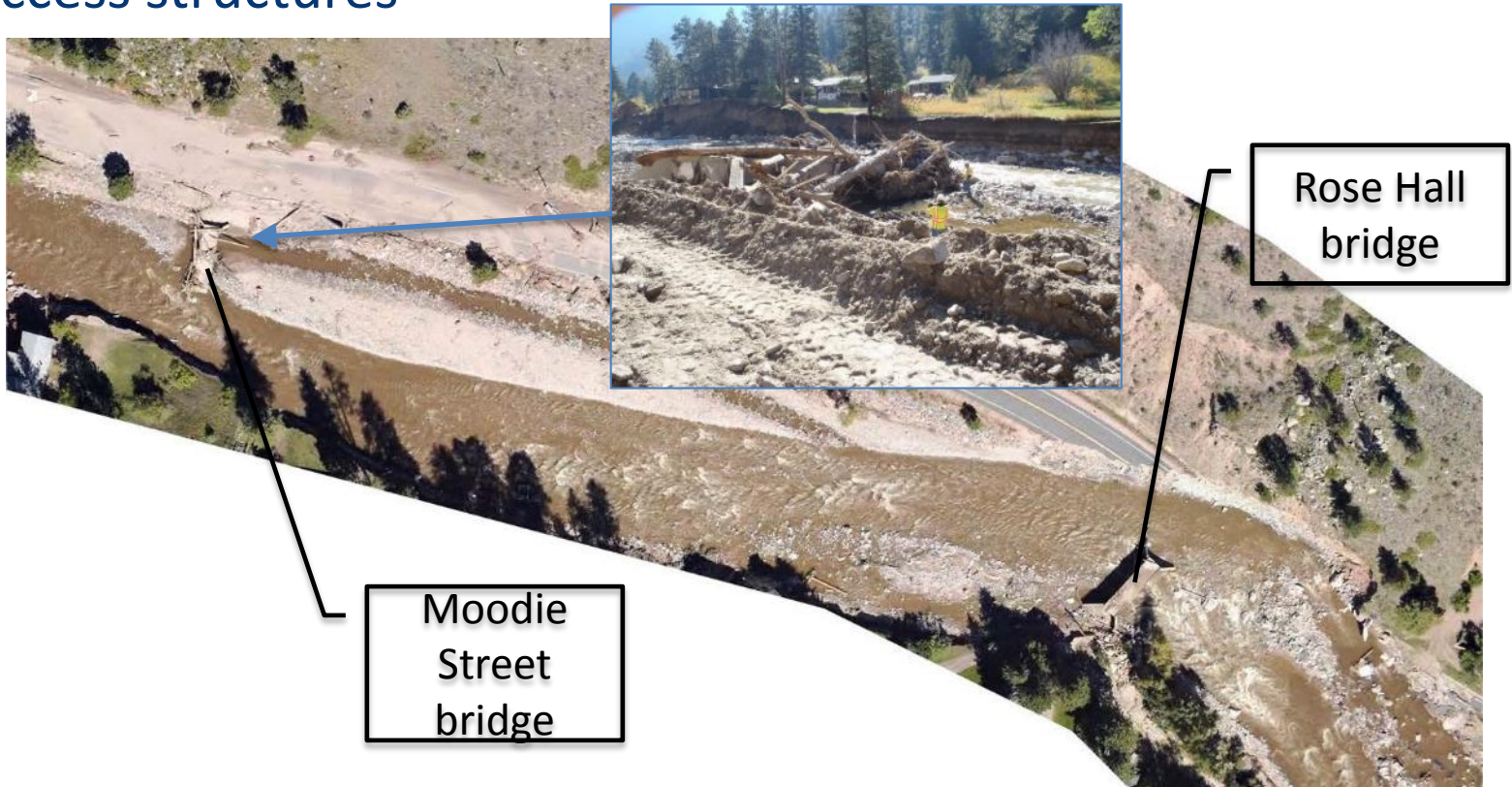


- 15 access bridges were reviewed
- Several to be replaced with 100-yr capacity (CDOT and Larimer County)



Case Study – Private Access Bridges

- Combining private accesses to reduce the threat of future damage from debris and river migration
- Protecting the highway and residents by investing in larger access structures





Closing Remarks

How do you bridge the gap to resilience?

- Recognize that your “bridge” is part of system
- Break out of your silo of excellence and
Communicate and Collaborate with your partners
- Learn the risk and resiliency of the asset
- Appreciate the solution may not be structural in
nature



Thank you / Questions?

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