RISK, RESILIENCE, INNOVATION, & PLANNING

IN THE AGE OF THE UNEXPECTED

WESTERN ITE ANNUAL MEETING PRESENTATION BY JODIE SNYDER

IN PARTNERSHIP WITH:

COLORADO Department of Transportation

AND

MULLER ENGINEERING COMPANY
September 2013 Colorado Front Range extreme storms and floods
Up to 17 inches of rain in 4 days
EXTENSIVE TEMPORARY AND PERMANENT RECOVERY
RESILIENCY
AT CDOT
BACKGROUND
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
RESILIENCY IN PLANNING

What happened next for CDOT Region 4?
PEL Study

Consultant Team: ch2m
MULLER ENGINEERING COMPANY
Stolfus

Status: 2019 – study complete
Length: 34 miles

Consultant Team: Felsburg Holt & Ullevig

Planned Completion: September 2019

Length: 20 miles

https://www.codot.gov/library/studies/co-66-pel
Speaking of traffic operations, don’t PELs already emphasize that focus?

But not in this resilience sort of way…

Figure 3.9. Home-based tour with a work-based subtour.

... think about unexpected or unplanned travel demand
RESILIENCY AT CDOT PROCESS
Physical Resiliency:
Consider natural or man-made hazards that could shut down highway operations for more than 4 hours
Physical Resiliency Process

Resiliency is the ability of communities to rebound, positively adapt to, or thrive amidst changing conditions or challenges — including disaster 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 -

Once funds have been identified, resiliency opportunities during the PEL process will be used to consider implementing improvements.

Threats
- Avalanches
- Bridge Surch from Floods
- Debris Flow
- Fires
- Landslides
- Rockfalls
- High Winds
- Tornadoes

Assets
- Roads
- Railroads
- Utilities
- Visibility
- Cyber
- Sidewalks
- Trails
- Culverts
- Roadside
- Bridges
- Walls

 Identify Threats and CDOT Assets
- Identify applicable threats and hazards along project corridor.
- Determine location of assets that exist in the corridor.
- Evaluate if the asset is independent or a part of an impacted system to threats.

Deliverable: Map of Threats and Assets

Document Vulnerability and Consequence
- What do we already know about the asset (age, condition, to standard, proximity)?
- Identify high level infrastructure and user costs.
- Determine expected effects from each threat.
- Determine countermeasures in place to reduce vulnerability.

Assess Risk
- Determine likelihood of occurrence.
- Understand risk profile in the corridor.

Resilient Recommendations
- Recommend ROW preservation of system related opportunities for resiliency.
- Integrate with PEL implementation.
- Prioritize resiliency improvements.

Project Delivery
- NEPA, RnR Analysis (b/c ratio), Funding, and Decision Making
  - Revisit identified options to reduce risk and increase resilience
  - Assess risk reduction and mitigation alternatives
- Design and Construction
  - Implement resilient design solutions
Step 1: Mapping Inventory

IDENTIFY THREATS and CDOT ASSETS

- Identify applicable threats and hazards along project corridor.
- Determine location of assets that exist in the corridor.
- Evaluate if the asset is independent or a part of an impacted system to threats.

DELIVERABLE:
Map of Threats and Assets
US 34 Planning and Environmental Linkages Study

Natural and Man-made Threats

Risk Area Locations

- **Risk Area ID: 1**
  - Threat: Flood
  - Priority Level: High

- **Risk Area ID: 2**
  - Threat: Flood
  - Priority Level: Moderate

- **Risk Area ID: 3**
  - Threat: Flood
  - Priority Level: Moderate

- **Risk Area ID: 4**
  - Threat: Flood
  - Priority Level: High

Legend:
- 100 Year Floodplain
- Utility: Pressurized Water Mains ≥ 24"
- Bridge, Canal, or Ditch Crossing
- Railroadproximity
Step 2: Qualitative Assessment

**DOCUMENT VULNERABILITY and CONSEQUENCE**
- What do we already know about the asset (age, condition, to standard, proximity)?
- Identify high level infrastructure and user costs.
- Determine expected effects from each threat.
- Determine countermeasures in place to reduce vulnerability.

**ASSESS RISK**
- Determine likelihood of occurrence.
- Understand risk profile in the corridor.

**RESILIENT RECOMMENDATIONS**
- Recommend ROW preservation of system related opportunities for resiliency.
- Integrate with PEL implementation.
- Prioritize resiliency improvements.

**DELIVERABLE:**
PEL Risk Assessment Matrix
### Step 2: Analyze qualitatively and make recommendations

<table>
<thead>
<tr>
<th>Risk Area ID</th>
<th>Threat</th>
<th>MP</th>
<th>Assets in Threat Area</th>
<th>Description of Asset</th>
<th>Infrastructure Costs (cost to CDOT to replace asset)</th>
<th>User Costs</th>
<th>Consequences (conditional probability that the consequences estimated will be realized)</th>
<th>Vulnerability</th>
<th>Risk (consequence x Vulnerability)</th>
<th>Prioritization</th>
<th>Resilient Recommendations (includes social, economic, and environmental benefits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flood</td>
<td>86.1</td>
<td>Big Thompson River, MP 86.044, Length = 219', Width = 40', deck area = 9,413sf</td>
<td>C-16-DD</td>
<td>High</td>
<td>High</td>
<td>Concrete box grade pre-cast (CBGP), sufficiency rating 98.3, &gt; 1% annual probability of loss</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Ensure structure C-16-DD is built to withstand a 100-year flood event.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Big Thompson Creek (replaced historical structure C-26), MP 66.5, 185 CFG,</td>
<td>C-16-AE (retained structure)</td>
<td>Low</td>
<td>High</td>
<td>Concrete Box Culvert (CBC), Sufficiency rating = 98.6, built in 1990's, &lt;1% annual probability of loss</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Ensure structure is built to withstand a 100-year flood event, perform floodplain conveyance improvements to channelize flow and prevent flooding on the north side of the highway (see Risk Area 0.5 mi).</td>
</tr>
<tr>
<td>2</td>
<td>Flood</td>
<td>86.6</td>
<td>1250' x 30' W</td>
<td>Pavement</td>
<td>Low</td>
<td>High</td>
<td>&gt;1% annual probability of loss</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Reduce vertical profile of road out of the floodplain or replace with overtopping pavement</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>300' Type 3, N side of roadway</td>
<td>Guardrail</td>
<td>Low</td>
<td>High</td>
<td>&gt;1% annual probability of loss</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Reduce vertical profile of road out of the floodplain or replace with overtopping pavement</td>
</tr>
<tr>
<td>3</td>
<td>Flood</td>
<td>86.9</td>
<td>Big Thompson River, MP 86.911, 2-lane, variable shoulders (assume 18'x60')</td>
<td>C-16-AE</td>
<td>High</td>
<td>High</td>
<td>Concrete pre-stressed girder continuous (CPSC), sufficiency rating = 98.8, condition = 5, &lt;1% Annual probability of loss</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Ensure channel and structure C-16-AE is built to convey and withstand a 100-year flood event (see Risk Area 0.45), or raise vertical profile of roadway out of floodplain or reinforce with overtopping pavement</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22' x 90 W</td>
<td>Pavement</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Ensure channel and structure C-16-AE is built to convey and withstand a 100-year flood event (see Risk Area 0.45), or raise vertical profile of roadway out of floodplain or reinforce with overtopping pavement</td>
</tr>
<tr>
<td>4</td>
<td>Flood</td>
<td>87.1 to 87.7</td>
<td>Draw, MP 87.651, 2-lane, variable shoulders (assumed double CBC, 20'x20', 72' long</td>
<td>C-16-AR</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Work with utility owner to replace or reinforce existing waterline</td>
</tr>
<tr>
<td>5</td>
<td>Utility Failure</td>
<td>88.1</td>
<td>36' transmission water main just west of Langston Ln., 20' x 32' W</td>
<td>Pavement</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Modify to increase the elevation of the pipe to meet floodplain standards.</td>
</tr>
</tbody>
</table>
Operational Resiliency:
Consider unplanned land development that has unanticipated highway operation impacts.
Step 1: Determine Sensitivity/Risk

- 2040 Growth Scenario 2
- 2040 Growth Scenario 1
- 2040 Base Volume
- 2040 No Action
- Existing

Legend:
- Green = 0-5% decrease below posted speeds
- Yellow = 5-15% decrease below posted speeds
- Orange = 15-25% decrease below posted speeds
- Red = +25% decrease below posted speeds

Westbound

Eastbound
Step 2: Determine Vulnerability
### Prioritization

**Step 3: Prioritize and Collaborate**

<table>
<thead>
<tr>
<th>Intersection ID</th>
<th>Name</th>
<th>Total Score</th>
<th>Existing ICU</th>
<th>2040 No-Build ICU</th>
<th>2040 Build Effect</th>
<th>2040 Build LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>83rd Ave</td>
<td>14</td>
<td>98.6%</td>
<td>94.3%</td>
<td>Improved</td>
<td>Improved</td>
</tr>
<tr>
<td>28</td>
<td>65th Ave</td>
<td>14</td>
<td>91.2%</td>
<td>143.6%</td>
<td>Improved</td>
<td>Improved</td>
</tr>
<tr>
<td>29</td>
<td>CR-17</td>
<td>11</td>
<td>98.5%</td>
<td>142.5%</td>
<td>Improved</td>
<td>Improved</td>
</tr>
<tr>
<td>30</td>
<td>47th Ave</td>
<td>10</td>
<td>82.7%</td>
<td>114.1%</td>
<td>Improved</td>
<td>Improved</td>
</tr>
<tr>
<td>31</td>
<td>35th Ave</td>
<td>10</td>
<td>97.9%</td>
<td>116.8%</td>
<td>Improved</td>
<td>Improved</td>
</tr>
<tr>
<td>32</td>
<td>CR-9</td>
<td>8</td>
<td>--</td>
<td>152.2%</td>
<td>Improved</td>
<td>Improved</td>
</tr>
<tr>
<td>33</td>
<td>Laramie River</td>
<td>7</td>
<td>83.7%</td>
<td>116.4%</td>
<td>Improved</td>
<td>Improved</td>
</tr>
<tr>
<td>34</td>
<td>Colorado Ave</td>
<td>5</td>
<td>53.6%</td>
<td>64.7%</td>
<td>No Effect</td>
<td>Improved</td>
</tr>
<tr>
<td>19</td>
<td>44th Ave</td>
<td>5</td>
<td>82.5%</td>
<td>128.1%</td>
<td>Improved</td>
<td>No Effect</td>
</tr>
<tr>
<td>10</td>
<td>23rd Ave</td>
<td>4</td>
<td>88.5%</td>
<td>98.5%</td>
<td>No Effect</td>
<td>Improved</td>
</tr>
<tr>
<td>21</td>
<td>CR-3</td>
<td>4</td>
<td>68.1%</td>
<td>101.3%</td>
<td>No Effect</td>
<td>Improved</td>
</tr>
<tr>
<td>22</td>
<td>17th Ave</td>
<td>4</td>
<td>68.3%</td>
<td>103.6%</td>
<td>No Effect</td>
<td>Improved</td>
</tr>
<tr>
<td>31</td>
<td>17th Ave</td>
<td>3</td>
<td>82.9%</td>
<td>103.7%</td>
<td>No Effect</td>
<td>Improved</td>
</tr>
<tr>
<td>17</td>
<td>Sculptor Ave</td>
<td>3</td>
<td>83.3%</td>
<td>128.1%</td>
<td>No Effect</td>
<td>Improved</td>
</tr>
<tr>
<td>26</td>
<td>Promontory Pkwy</td>
<td>3</td>
<td>--</td>
<td>101.3%</td>
<td>No Effect</td>
<td>Improved</td>
</tr>
<tr>
<td>3</td>
<td>Rossum Rd</td>
<td>2</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>Morning Dr</td>
<td>2</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>N Van Buren Ave</td>
<td>2</td>
<td>56.7%</td>
<td>79.0%</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
<tr>
<td>7</td>
<td>N Taft Ave</td>
<td>2</td>
<td>82.5%</td>
<td>107.9%</td>
<td>No Effect</td>
<td>Improved</td>
</tr>
<tr>
<td>12</td>
<td>N Monroe Ave</td>
<td>2</td>
<td>60.9%</td>
<td>84.5%</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
<tr>
<td>13</td>
<td>Redwood Ave</td>
<td>2</td>
<td>68.3%</td>
<td>77.4%</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
<tr>
<td>14</td>
<td>US 54 Business</td>
<td>2</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>15</td>
<td>E St Ave</td>
<td>2</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>16</td>
<td>CR 49</td>
<td>2</td>
<td>68.3%</td>
<td>63.0%</td>
<td>No Effect</td>
<td>Improved</td>
</tr>
<tr>
<td>2</td>
<td>Glade Rd</td>
<td>1</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>10</td>
<td>Cleveland Ave</td>
<td>0</td>
<td>83.0%</td>
<td>118.2%</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
<tr>
<td>15</td>
<td>N Boise Ave</td>
<td>0</td>
<td>84.7%</td>
<td>116.9%</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
<tr>
<td>32</td>
<td>31st Ave</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>14</td>
<td>Madison Ave</td>
<td>-3</td>
<td>68.4%</td>
<td>90.9%</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
<tr>
<td>1</td>
<td>Wilson Ave</td>
<td>-2</td>
<td>76.1%</td>
<td>94.1%</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
<tr>
<td>9</td>
<td>N Garfield Ave</td>
<td>-2</td>
<td>73.0%</td>
<td>88.2%</td>
<td>No Effect</td>
<td>FALSE</td>
</tr>
<tr>
<td>18</td>
<td>N Denver Ave</td>
<td>-2</td>
<td>87.5%</td>
<td>147.6%</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
<tr>
<td>18</td>
<td>N Boyd Lake Ave</td>
<td>-3</td>
<td>92.6%</td>
<td>150.4%</td>
<td>No Effect</td>
<td>No Effect</td>
</tr>
</tbody>
</table>

*ICUs for PM Peak Hour Only*
Subsequent Steps for Incorporating R&R Recommendations into Planning and CDOT Project Delivery

SHORT TERM:
- PEL Prioritization
- PEL Study Documentation
- Ongoing Agency/Stakeholder Collaboration

LONG TERM:
- Future Funding
- NEPA
- Design
- Construction

For more info, visit CDOT’s website:
https://www.codot.gov/library/studies/co-66-pel
THANKS FOR YOUR INTEREST!