

Colorado Front Range Flood of 2013: Peak Flows, Flood Frequencies, and Impacts

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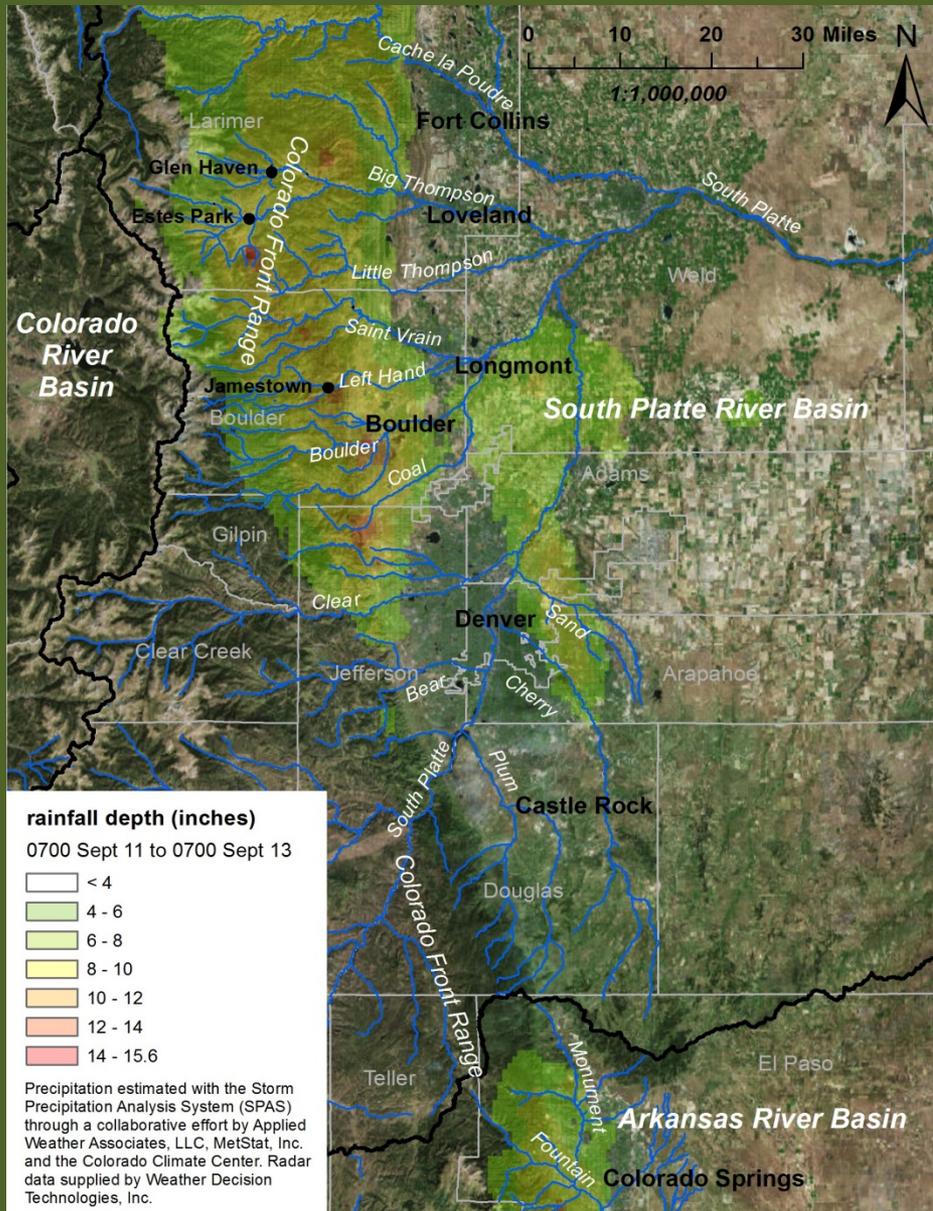


Presentation Overview

- Provide overview of rainfall extent and impacts
 - flooding, debris flows, etc...
- At multiple scales, provide an overview of:
 - Peak flow estimates
(Methods: critical depth, 1-D modeling, 2-D modeling)
 - Data developed by: NRCS, USGS, Bob Jarrett
 - Flood frequencies (peak flow analyses of streamgage data, using Bulletin 17B methodologies)
 - Not regulatory flow frequencies
 - Impacts to streams and communities
- Compare unit stream power for the most-impacted reaches
 - $>300 \text{ W/m}^2$ threshold noted in literature for major geomorphic adjustments (Magilligan 1992 and others since...)

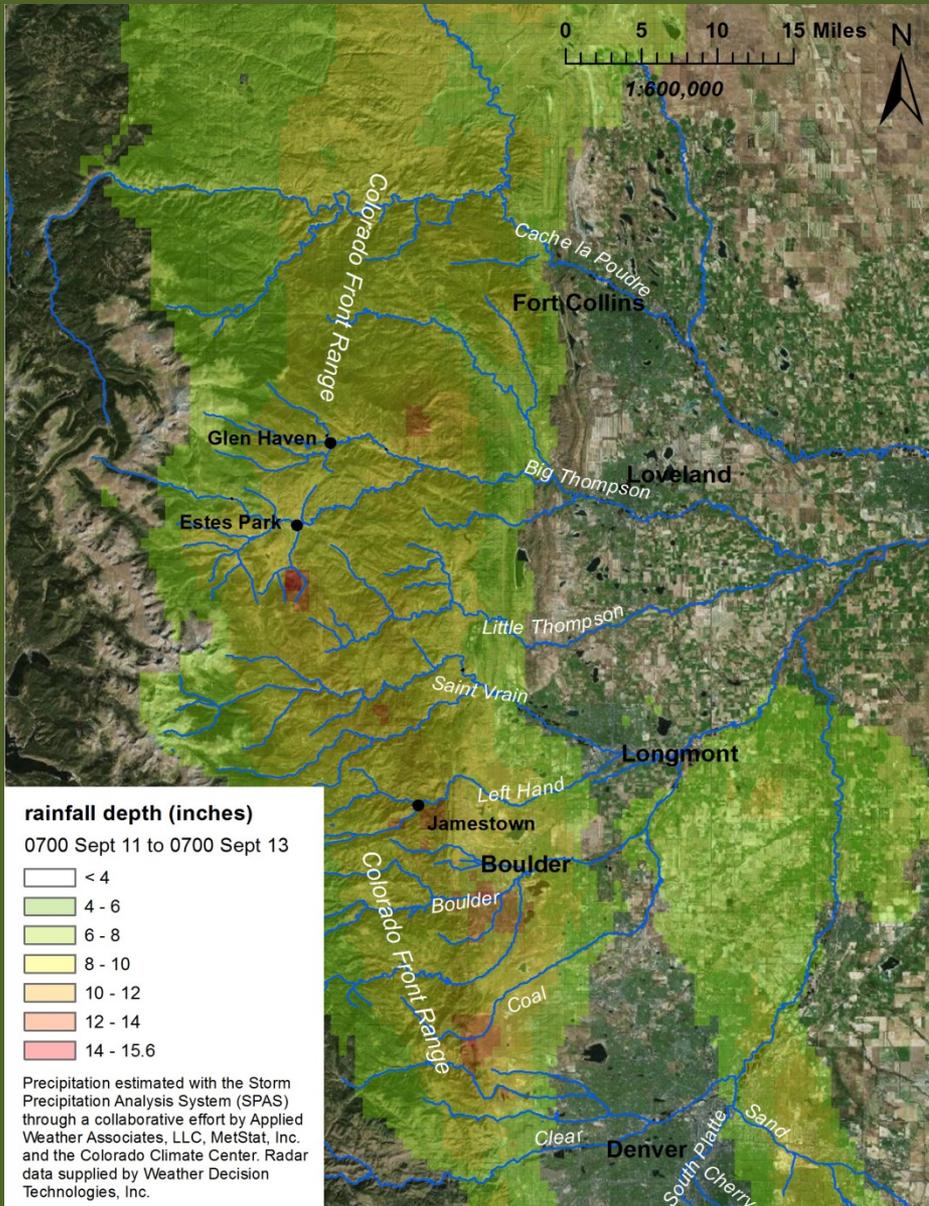
Precipitation

- Overview of Impacted Area



Precipitation

- Rainfall depths similar to average annual precipitation over 10 days
- 15 to 18 inches in high-impact areas
- Majority during a 36 hour period: Sept 11-12, 2013



Flood Response



Borga et al. 2014, Alfieri et al. 2012



Big Thompson River, 9/13 @ 1549

- Flood response due to the most intense rainfall periods varied on both spatial and temporal scales
- Debris flows on minutes to hours scale, on mountain slopes
- Small to medium-size foothills streams flooded on an hours to day scale
- Primary riverine floods peaking on a day to days scale, with the South Platte at Fort Morgan peak on 9/15.

Flood Response Prediction

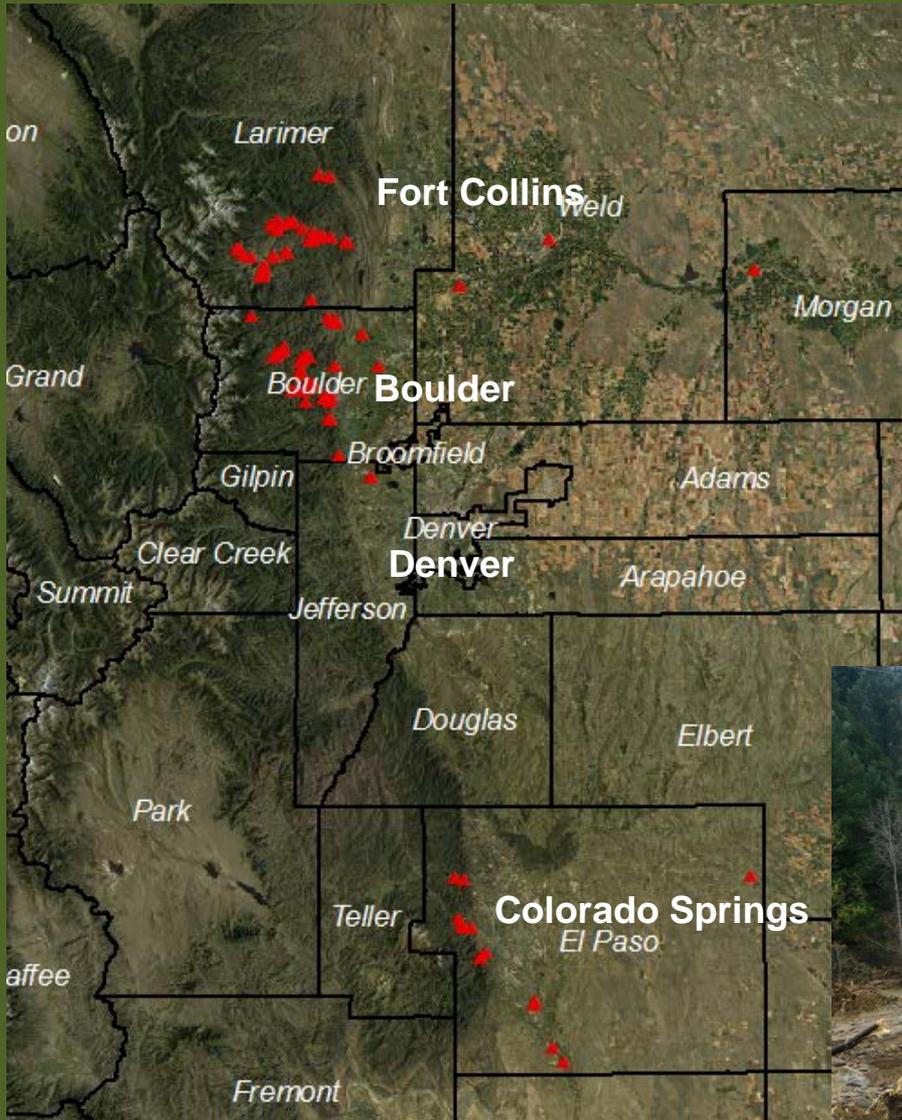


Bridge over the Big Thompson River, 9/13

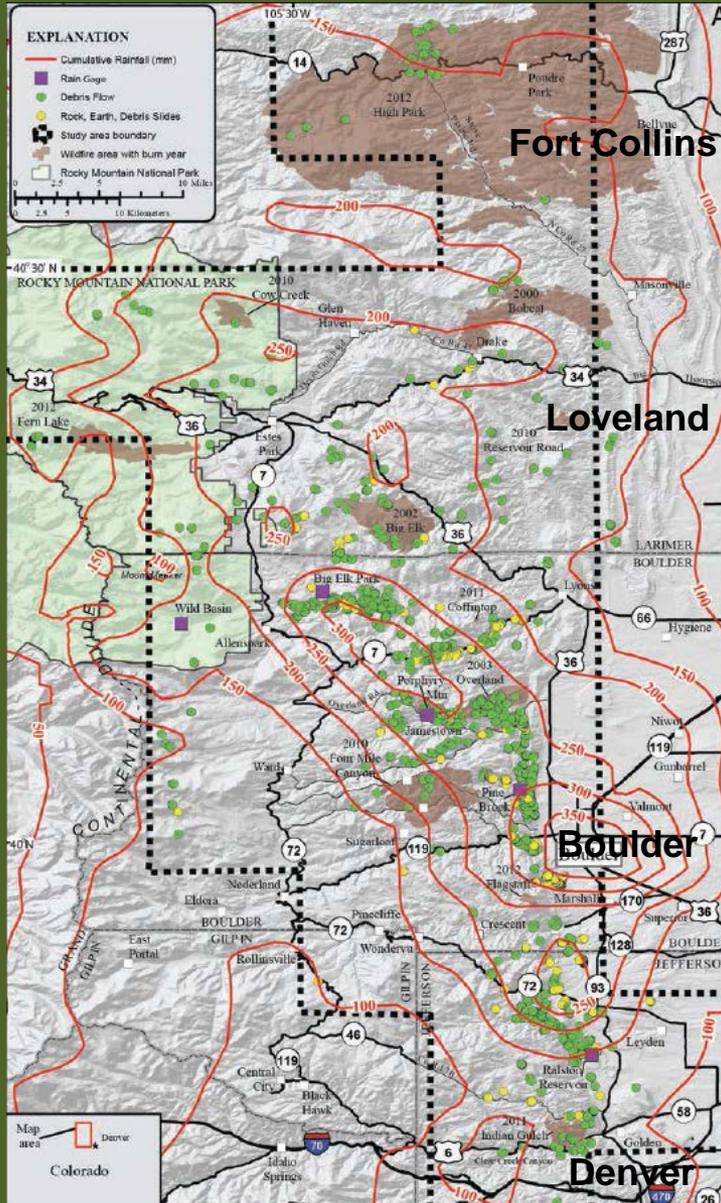
- Large floods such as September 2013 Event are due to threshold-exceeding precipitation inputs
- Such events are rare and poorly observable
- Data collected for below-threshold behavior can have little value for predicting response for more extreme events
 - Very problematic for development of such tools as rainfall-runoff models

Exigent EWP Locations

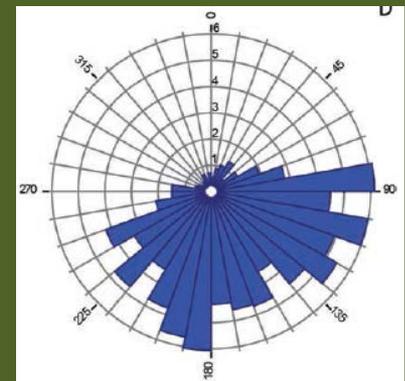
- EWP: Emergency Watershed Protection Program (NRCS)
- Exigent: Substantial near-term threat to life and property
- Locations where most substantial flood damages occurred (on private lands), and most threatened by 2014 spring flows



Debris Flows



- Rapidly-flowing gravity-driven mixtures with roughly equal parts of sediment/debris and water
- Green dots: documented debris flow
- >1100 documented debris flows
- Three deaths due to debris flows
- Highly unusual to have so many debris flows in just two days in Colorado
- Predominantly initiated on south- and east-facing slopes



Coe et al. 2014

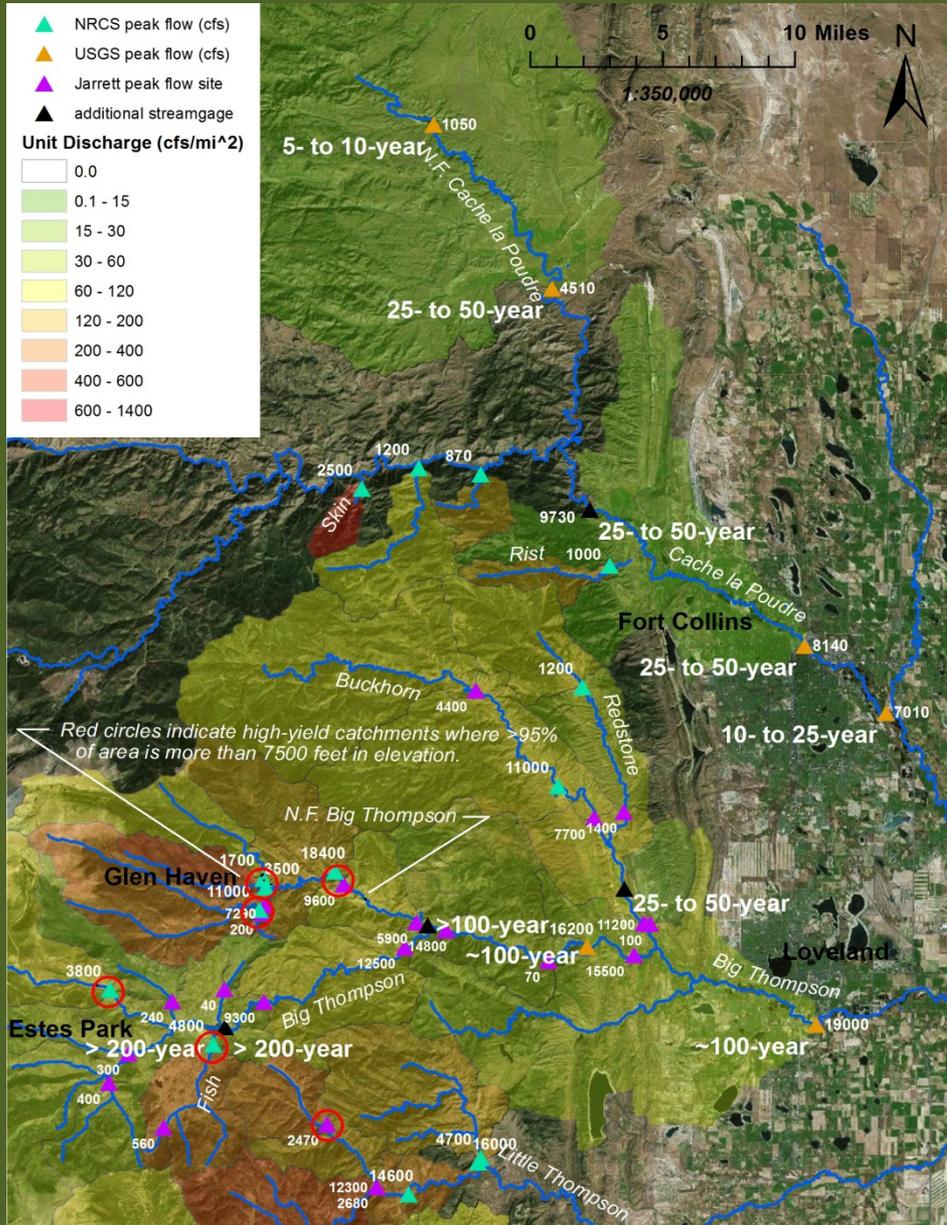
Debris Flows

- The longest debris flow: East side of Twin Sisters
- 2.5 miles long, with 2400 feet of elevation drop



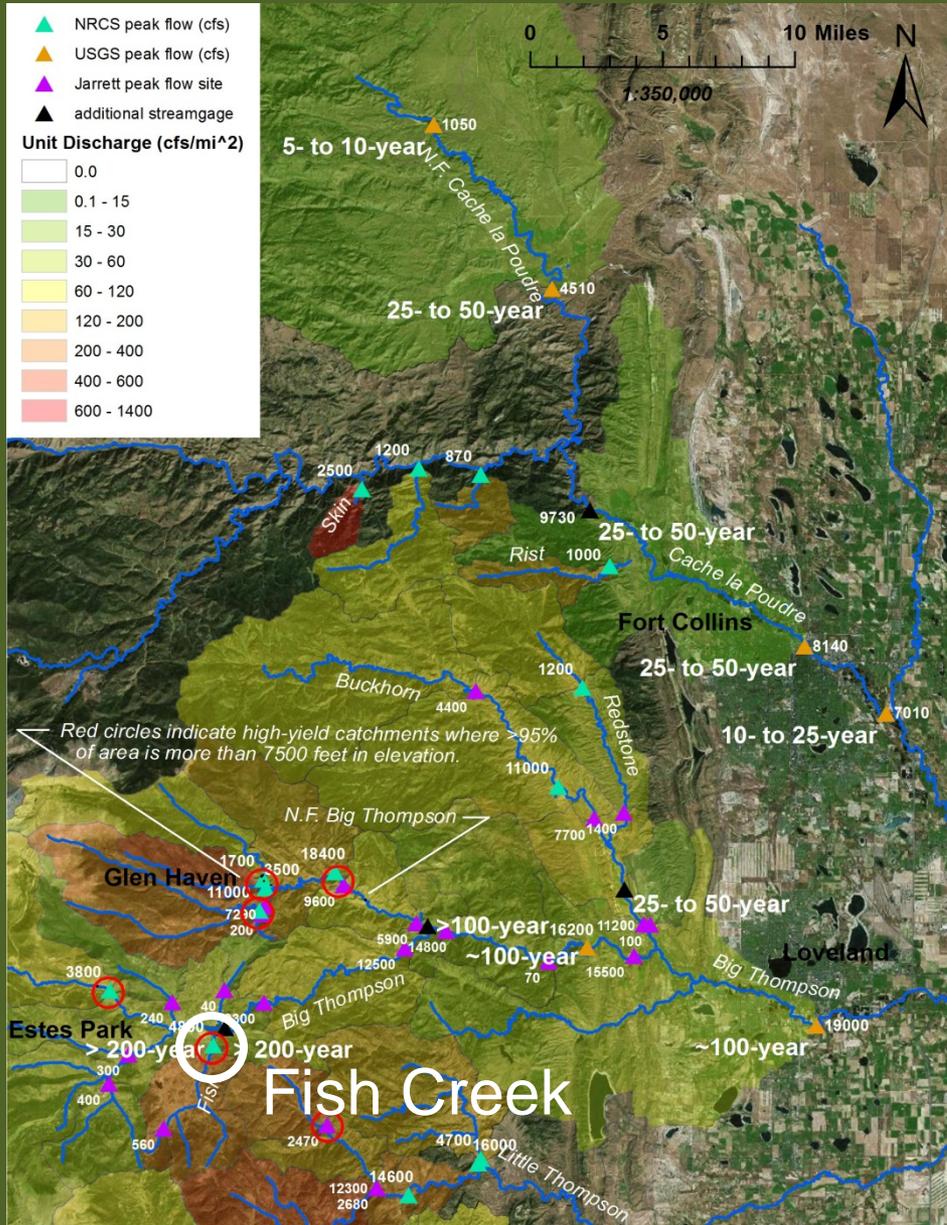
11/8/2013

Google Earth



Northern Flood Extent

- Triangles: peak flow estimate locations
- Unit discharges up to 480 cfs/mi² recorded (red polygons – highest yields)
- Peaks flows:
 - Cache la Poudre: 8100 cfs, 25- to 50-year flood
 - Big Thompson: 19,000 cfs, 100-year flood (1976: 31,000 cfs, 144 deaths)
 - Headwaters of Big Thompson (and likely Little Thompson): >200-year flood



Northern Flood Extent

- White Circles (examples of heavily-impacted communities):
 - Fish Creek (Estes Park)

Northern Flood Extent

- Fish Creek

10/29/2013



10/16/2013



Northern Flood Extent

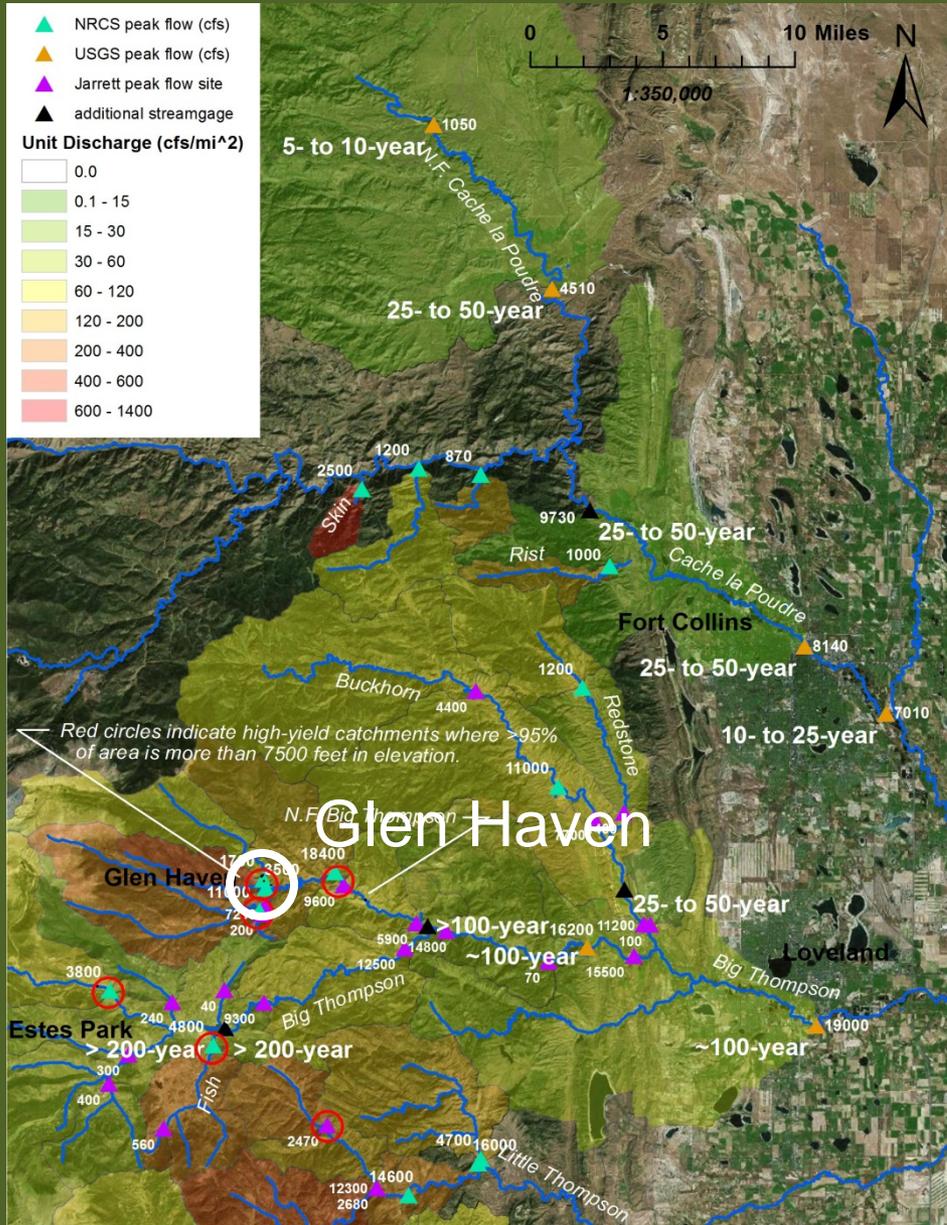
- Fish Creek, Estes Park area (~4800 cfs)
- >200-year flood (<0.5% chance of occurrence)



Northern Flood Extent

- Fish Creek, Estes Park area (~4800 cfs)
- Unit stream power: 280 to 750 $\text{W}/\text{m}^2 > 300 \text{ W}/\text{m}^2$





Northern Flood Extent

- White Circles (examples of heavily-impacted communities):
 - Fish Creek (Estes Park)
 - Glen Haven

Northern Flood Extent

- Glen Haven



10/16/2013

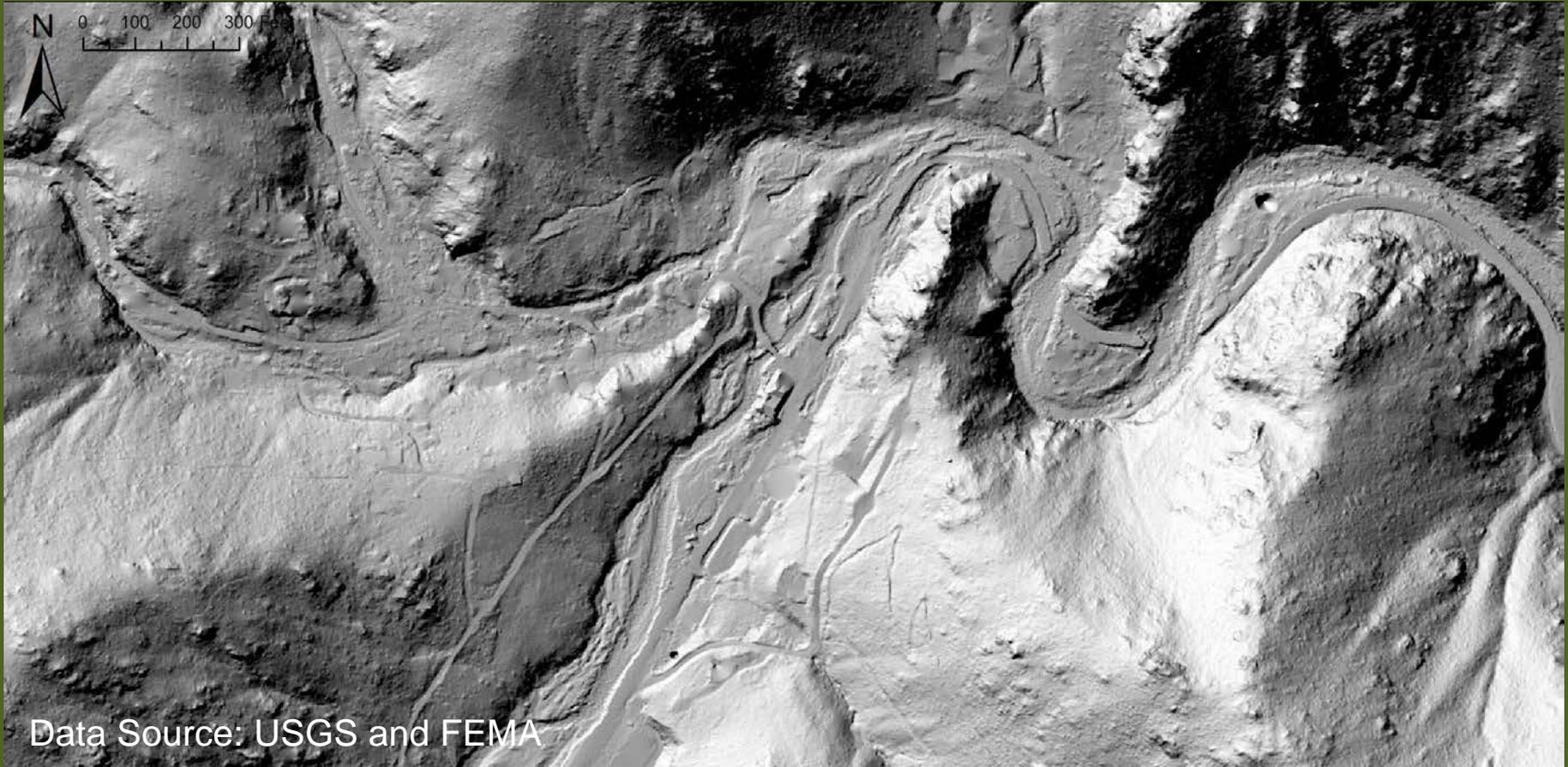
Northern Flood Extent

- Glen Haven



Northern Flood Extent

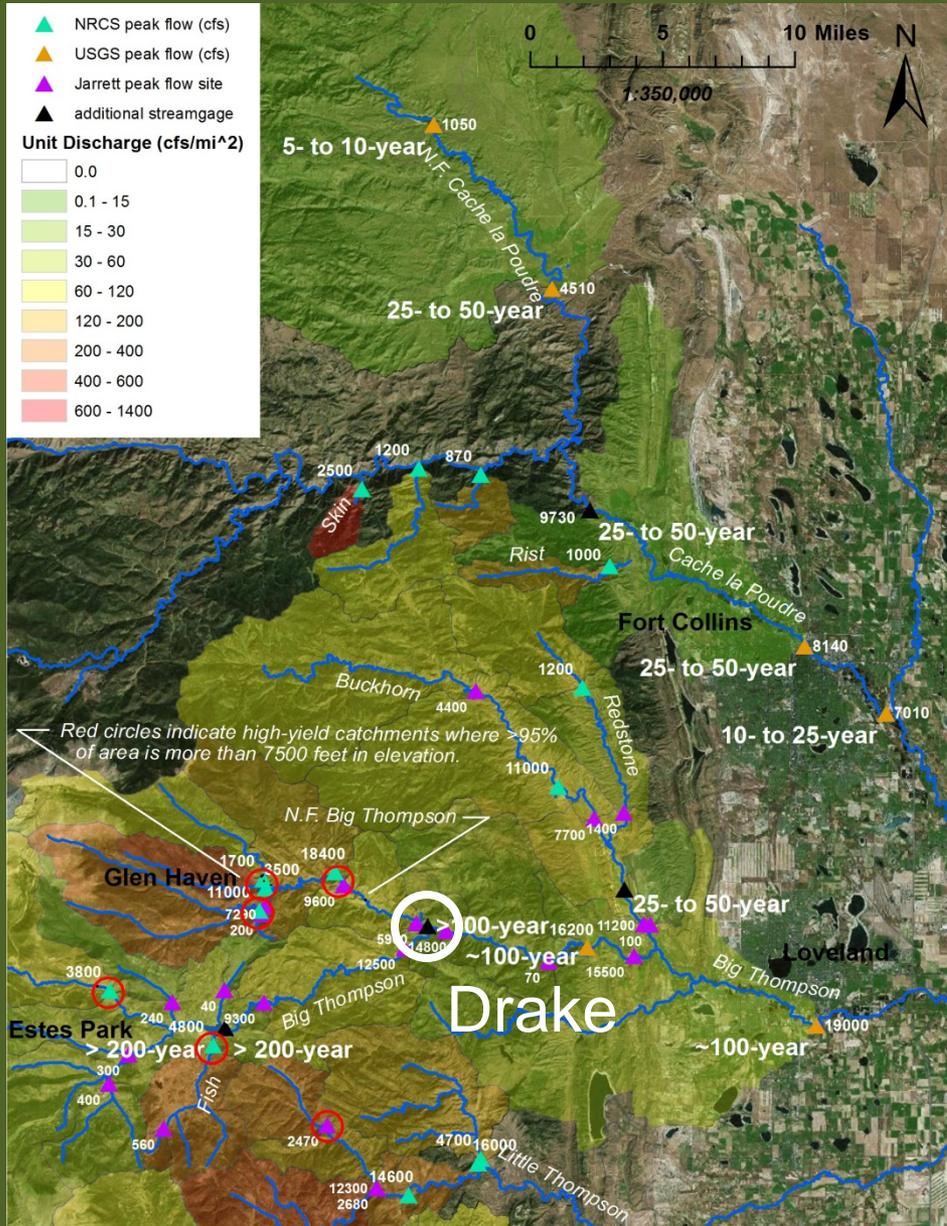
- Glen Haven (West Creek: ~7,000 to ~11,000 cfs, Fox Creek: ~3500 cfs, Upper North Fork Big Thompson: ~1700 cfs)



Northern Flood Extent

- West Creek: 970 to 2700 W/m² >> 300 W/m² threshold





Northern Flood Extent

- White Circles (examples of heavily-impacted communities):
 - Fish Creek (Estes Park)
 - Glen Haven
 - Drake

Northern Flood Extent

- Drake



- Impacted homes were well out of the floodplain
- high flows & long flood durations eroded high banks



Image source: NRCS exigent EWP

Northern Flood Extent

- Drake
 - N. F. Big Thompson: ~5900 to 9600 cfs (>100- to 200-yr, <1% to 0.5% prob. of occurrence)
 - Big Thompson River: ~12,500 cfs (>~100-year, <1% prob. occurrence)

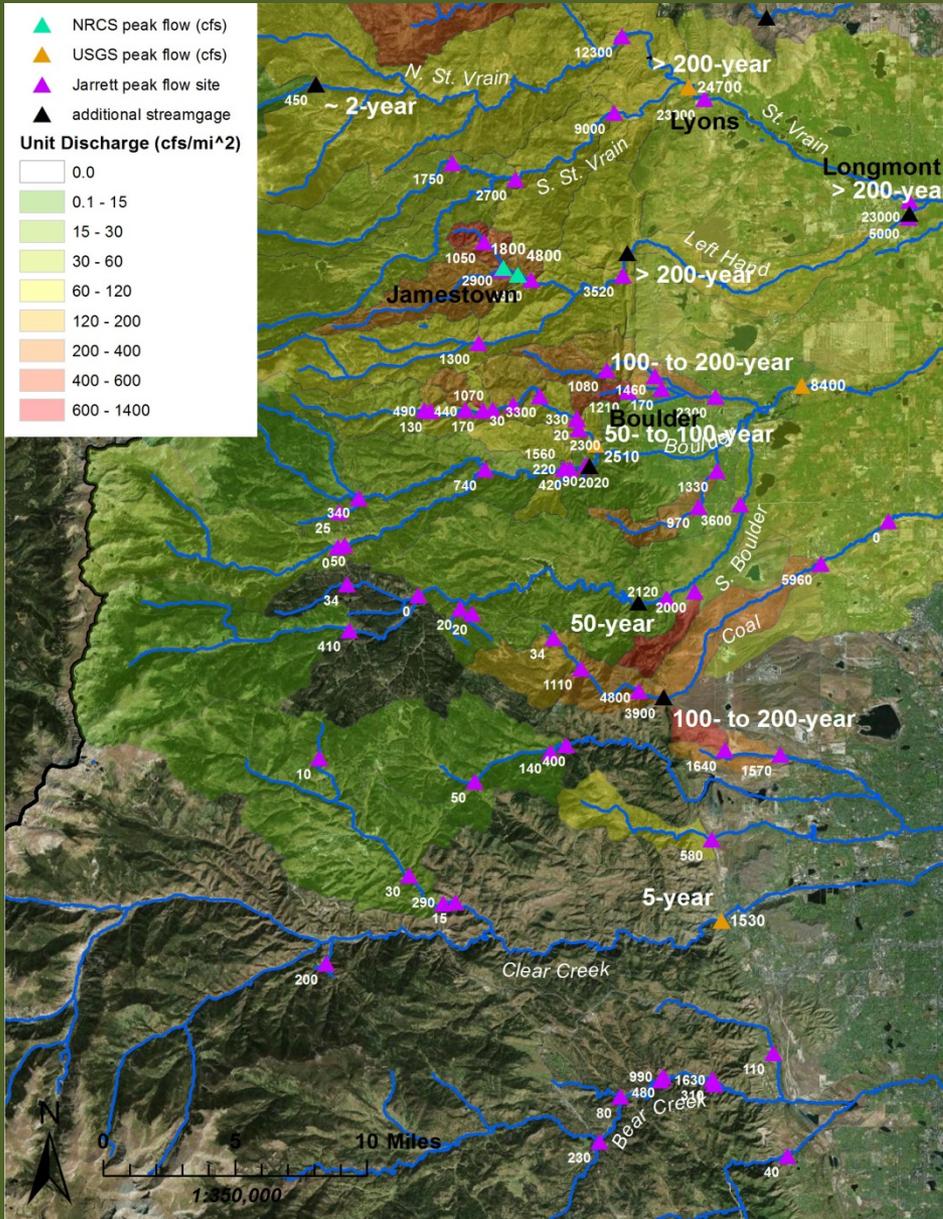


Northern Flood Extent

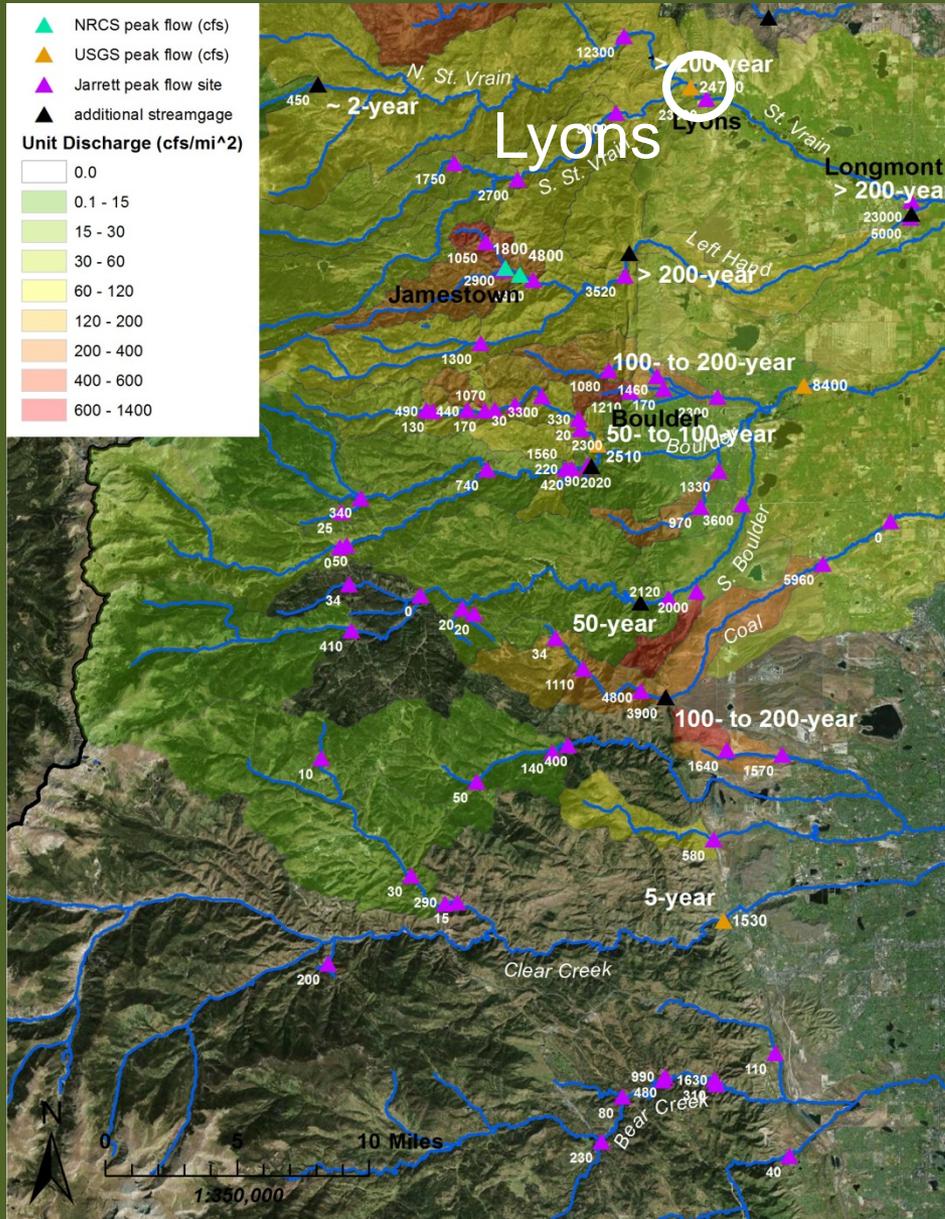
- Drake
 - N. F. Big Thompson: 570 to 620 W/m²
 - Big Thompson River (u.s. of confluence): 1200 to 3500 W/m² >> 300



Central Flood Extent



- Unit discharges up 1340 cfs/mi² (red polygons – highest yields)
- Peaks flows:
 - St. Vrain: 24,700 cfs, >200 year flood
 - Left Hand: 3500 cfs, >200 year flood
 - Boulder Creek: 8400 cfs, 100- to 200-year flood
 - Coal Creek: 3900 cfs, 100- to 200-year flood
 - Clear Creek: 1500 cfs, 5-year flood



Central Flood Extent

- White Circles (examples of heavily-impacted communities):
 - Lyons

Central Flood Extent

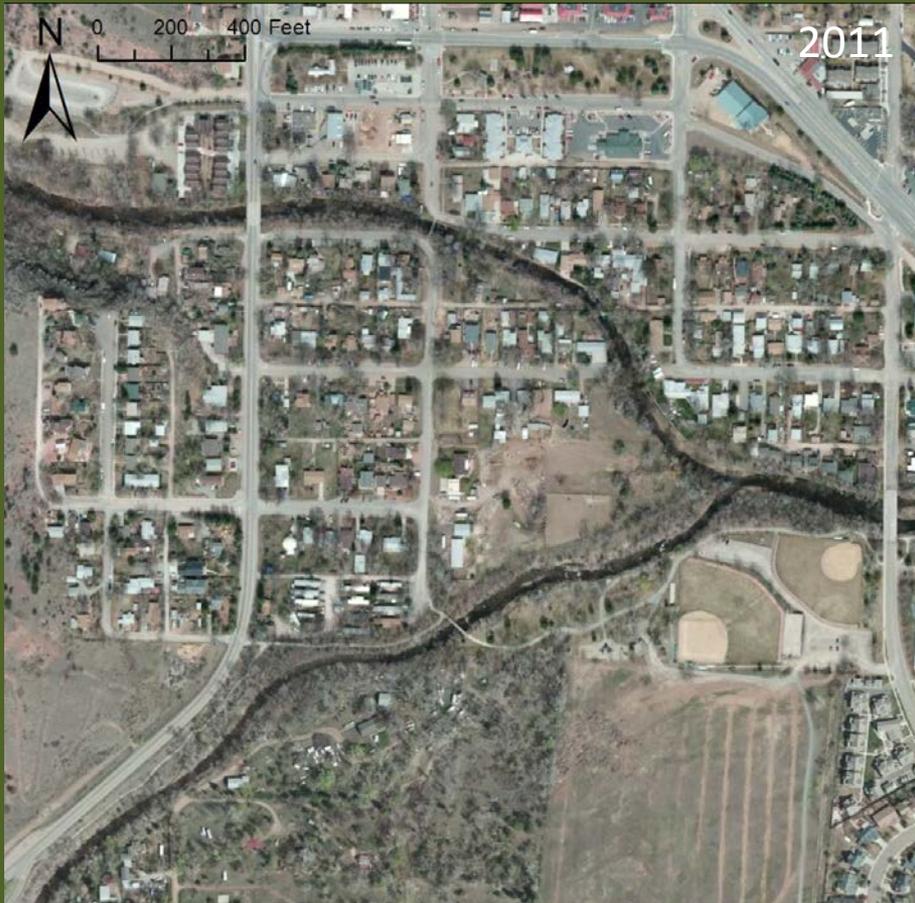
- Lyons



11/13/2013

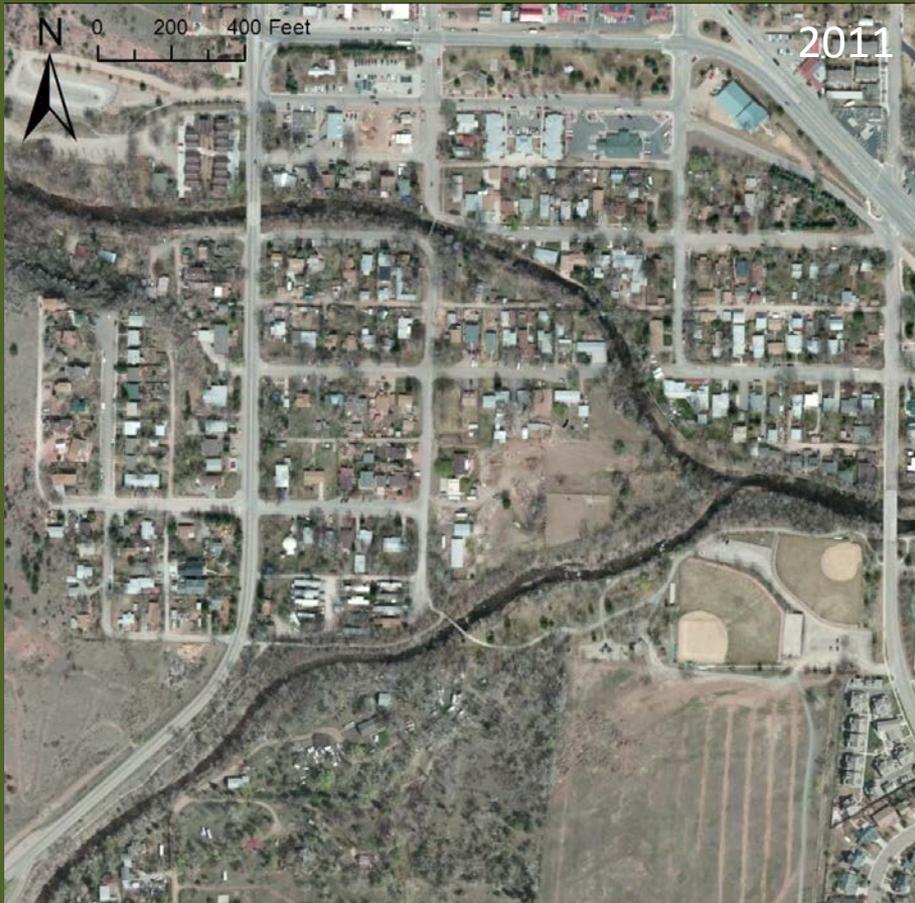
Central Flood Extent

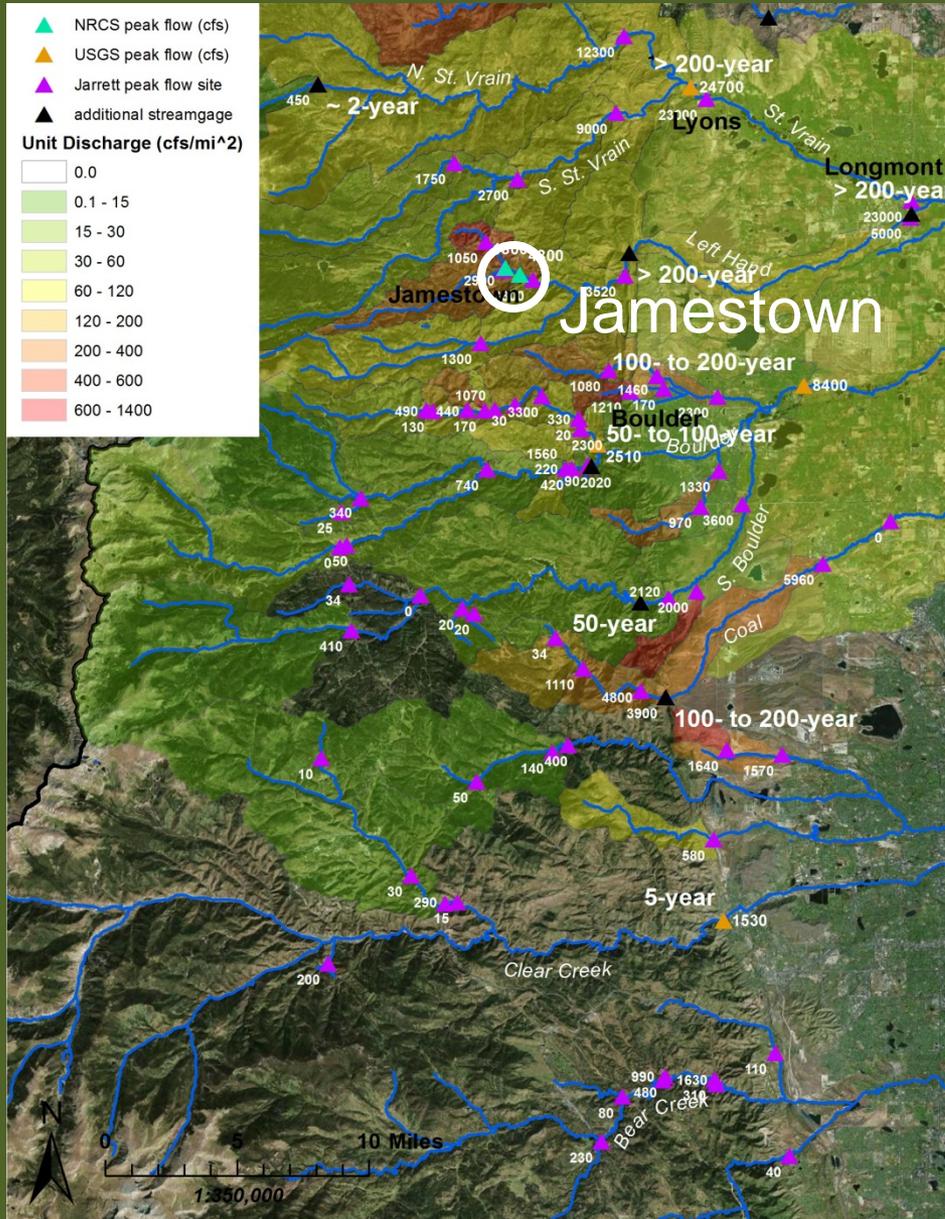
- Lyons: ~24,700 cfs (>200 year event, < 0.5% prob. of occurrence)
 - 122 years of record, previous max. flow of 10,500 cfs (1941)



Central Flood Extent

- Lyons: 170 to 290 W/m² , similar to the 300 W/m² threshold
 - D. S. of this site, damages are substantially reduced





Central Flood Extent

- White Circles (examples of heavily-impacted communities):
 - Lyons
 - Jamestown

Central Flood Extent

- Jamestown



10/29/2013

10/29/2013



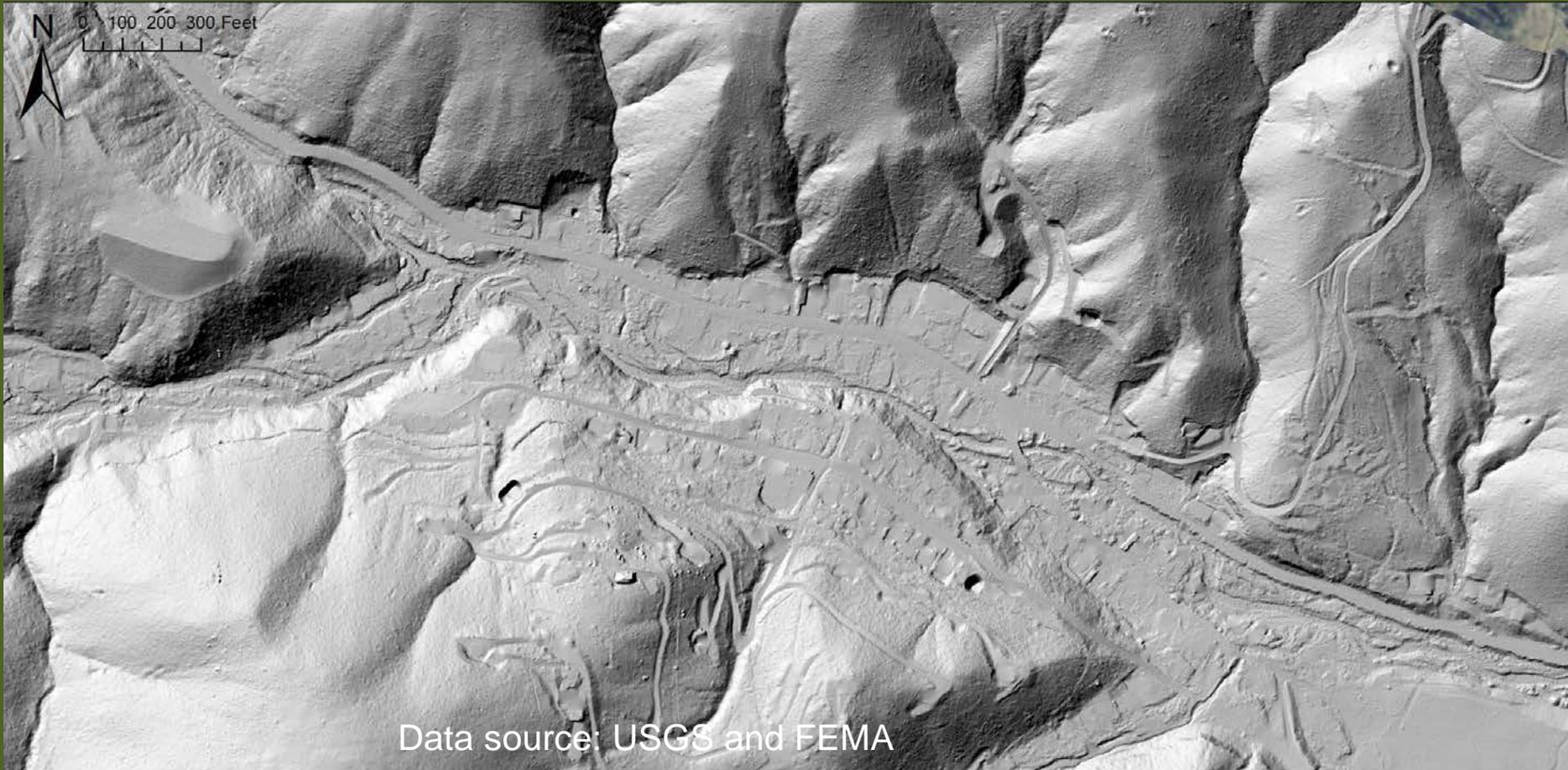
Central Flood Extent

- Jamestown
 - James Creek: ~3300 to ~4800 cfs (d.s.: >~200-year flood, <0.5% prob.)
 - Little James: ~1800 cfs



Central Flood Extent

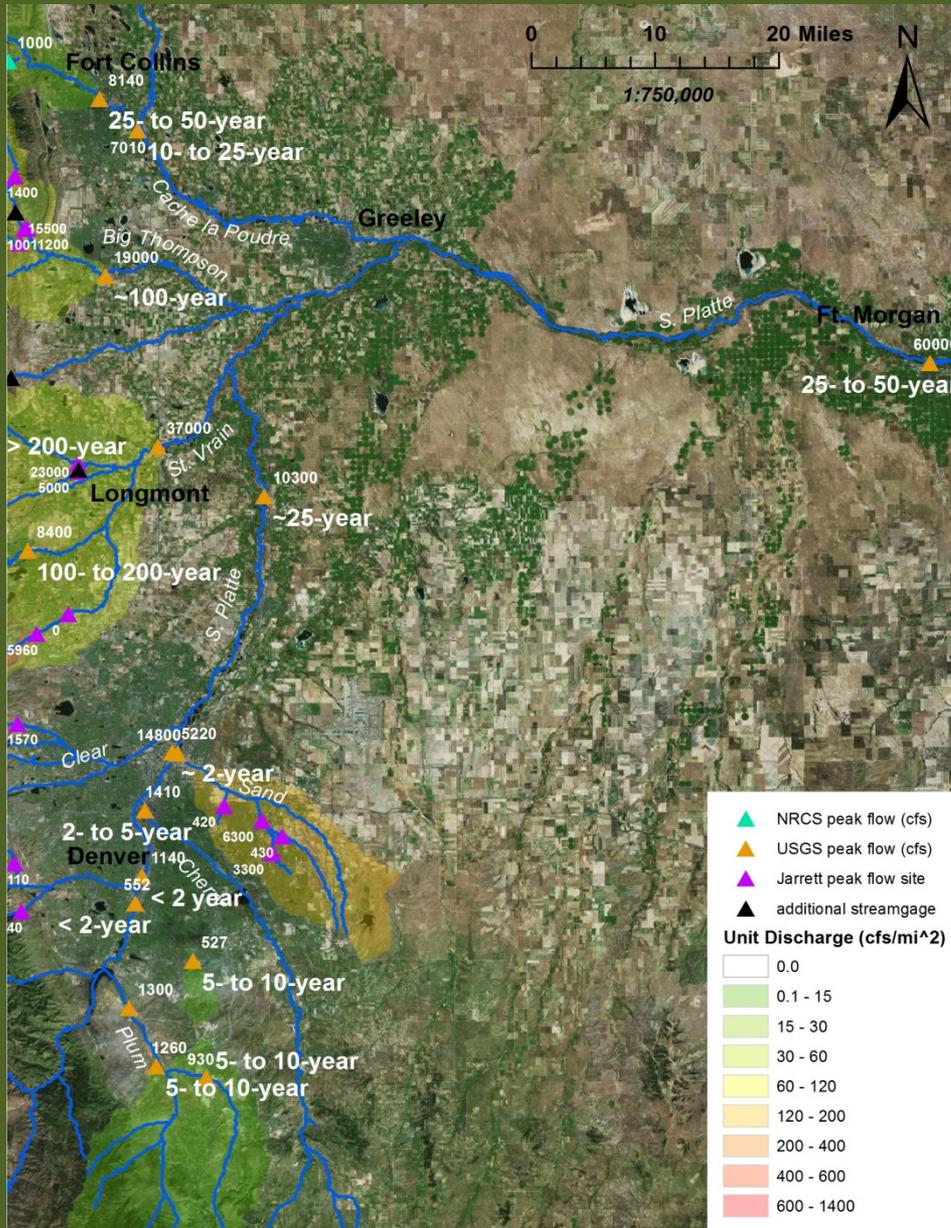
- Jamestown, with LiDAR shaded relief image



Central Flood Extent

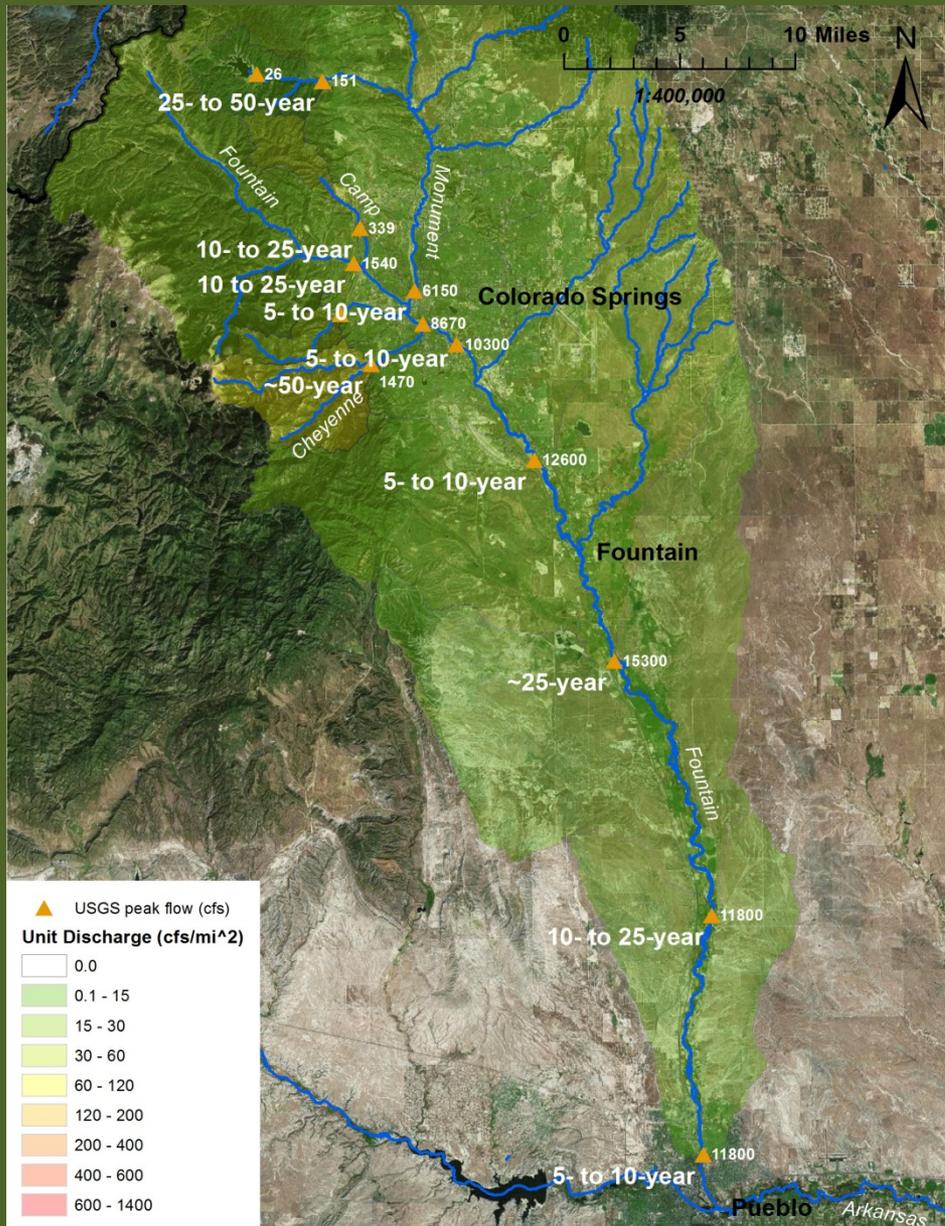
- Jamestown
 - James Creek: 440 to 1200 W/m² >> 300 W/m² threshold





S. Platte Flood Extent

- Unit discharges up 190 cfs/mi² (Sand Creek)
- Peaks flows:
 - South Platte in Denver (Commerce City, above Sand Creek): 5200 cfs, 2-year flood
 - Sand Creek: 15,000 cfs
 - South Platte at Fort Lupton: 10,300 cfs, ~25-year flood
 - South Platte at Fort Morgan: 60,000 cfs, 25- to 50-year flood



Southern Flood Extent

- Unit discharges up 70 cfs/mi²
- Peaks flows:
 - Upper Fountain Creek: 1500 cfs, 10- to 25-year flood
 - Cheyenne Creek: 1500 cfs, ~50-year flood
 - Lower Fountain Creek: 15,300 cfs, ~25-year flood

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Questions?

