Museum Fire Response and Risk Assessment

Joe Loverich, PE, CFM - JE Fuller

Ann Youberg, PhD, RG – AZGS

John Carr, PE, CFM – Coconino County

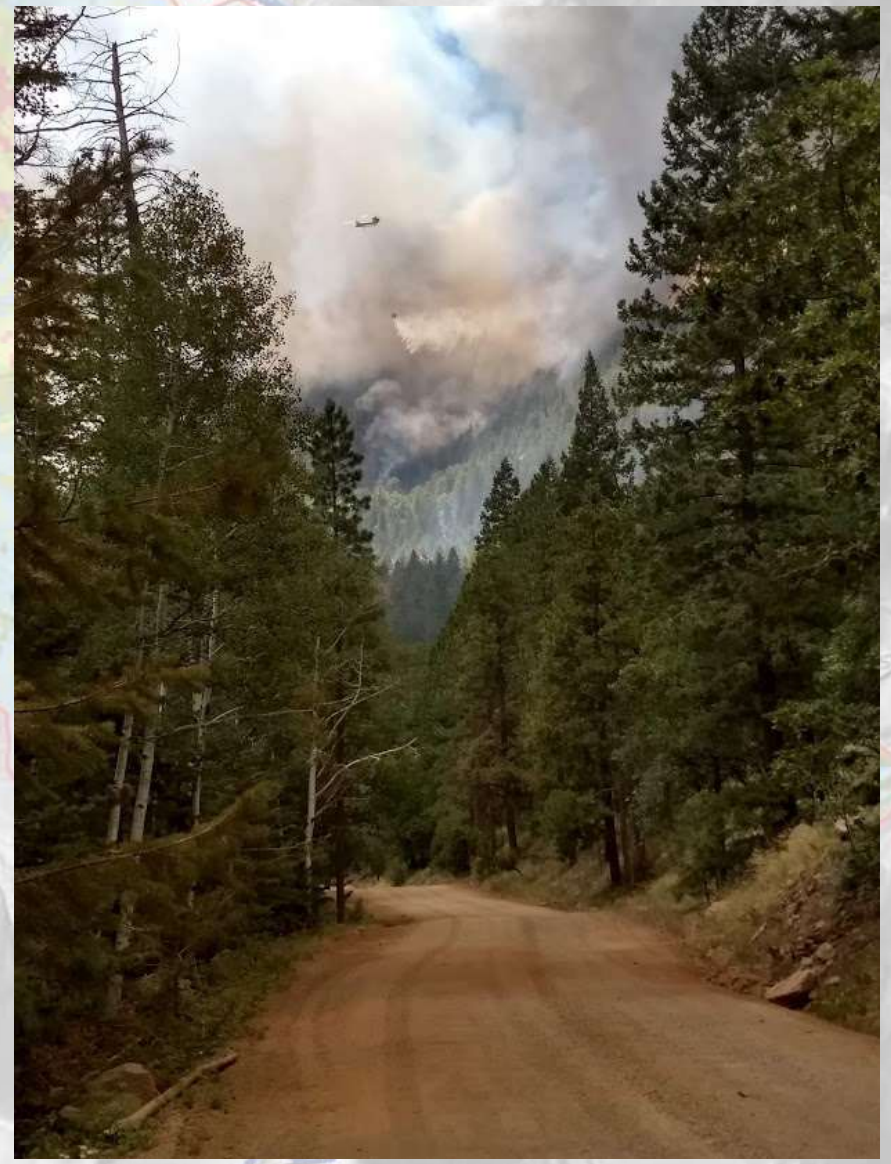
Ed Schenk, MS – City of Flagstaff

Museum Fire

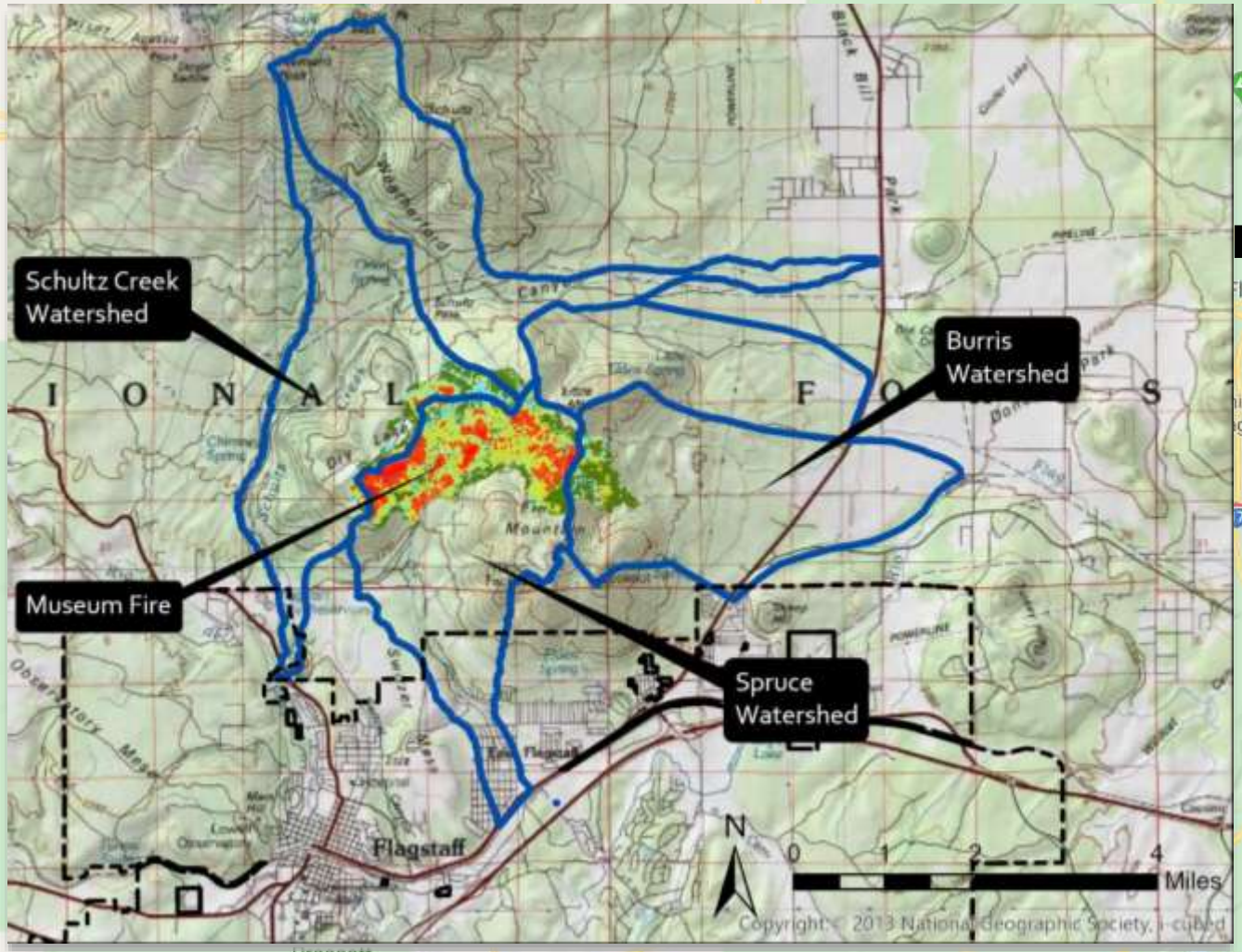
- Burned 1,961 acres
- Impacted the Spruce Avenue Wash
  - Watershed
- 52% of the watershed burned
- Of the total area burned, 53% burned severely and moderately = hydrophobic soils
- Much of the area is steep slopes

- Potential flooding could affect over 400 homes and 50 businesses
- Total property valuation is
- $303,000,000

Museum Fire



Location


Schultz Creek Watershed
Burris Watershed
Museum Fire
Spruce Watershed
Flagstaff
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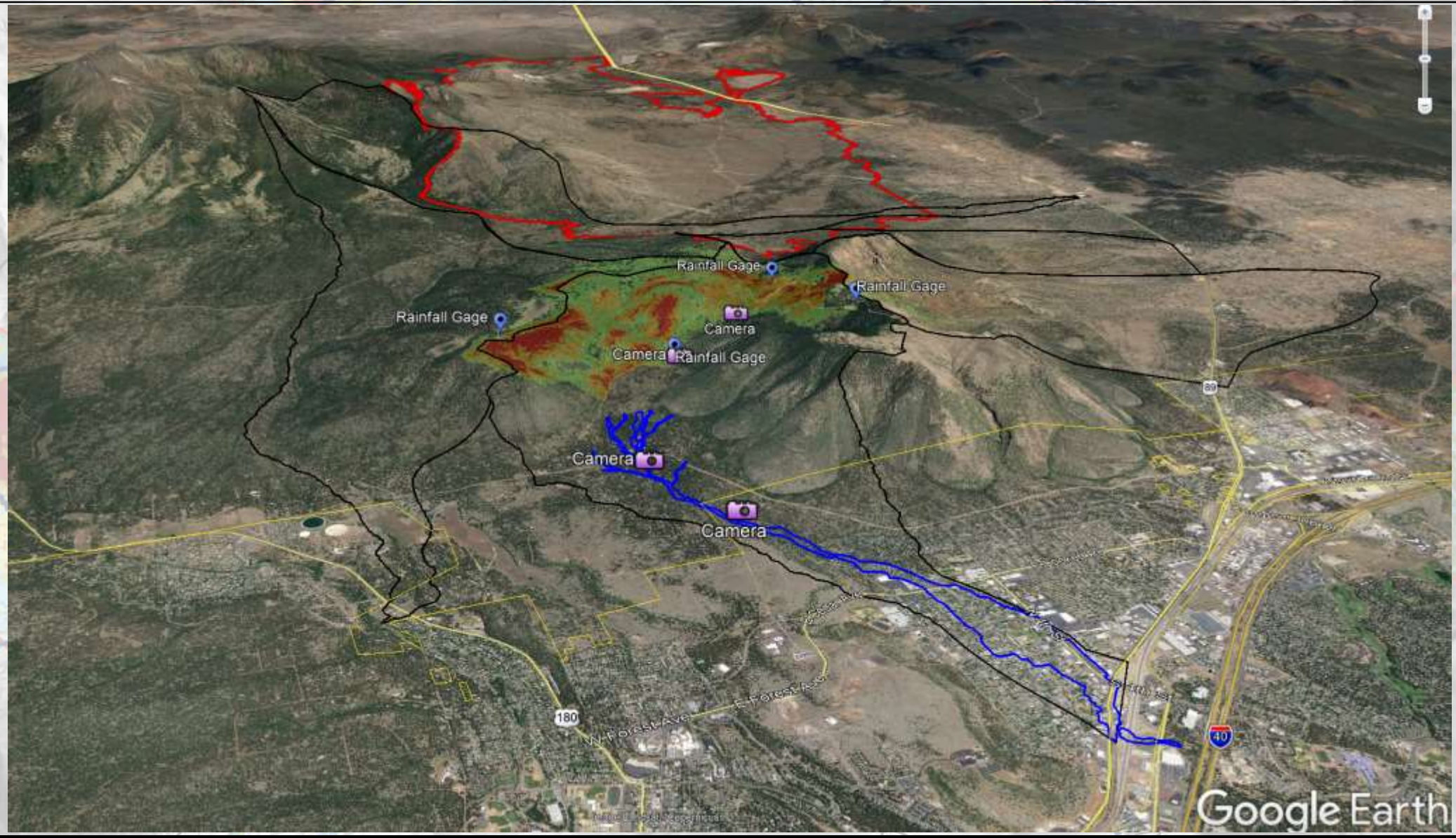
Museum Fire


Rainfall Gage
Rainfall Gage
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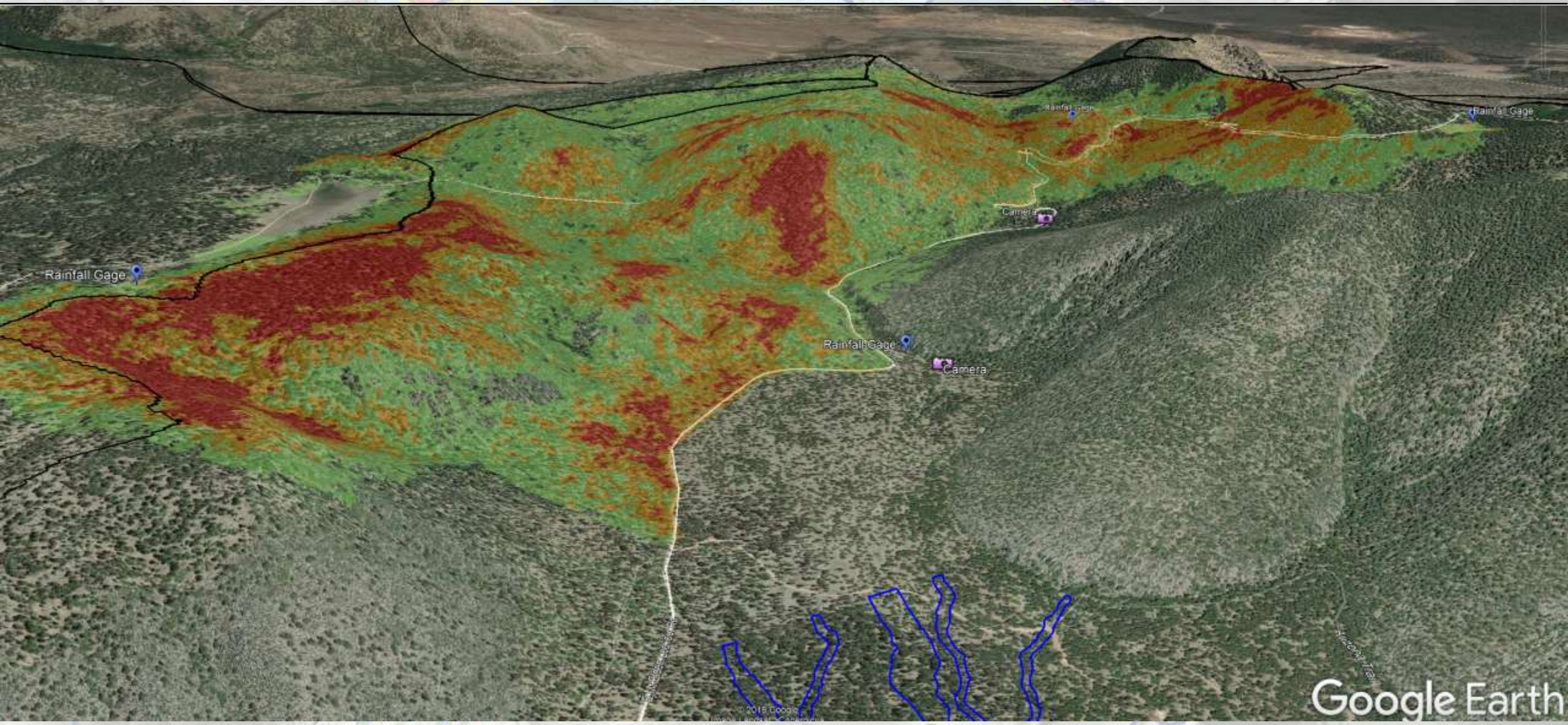
Museum Fire


Rainfall Gage
Camera
Rainfall Gage
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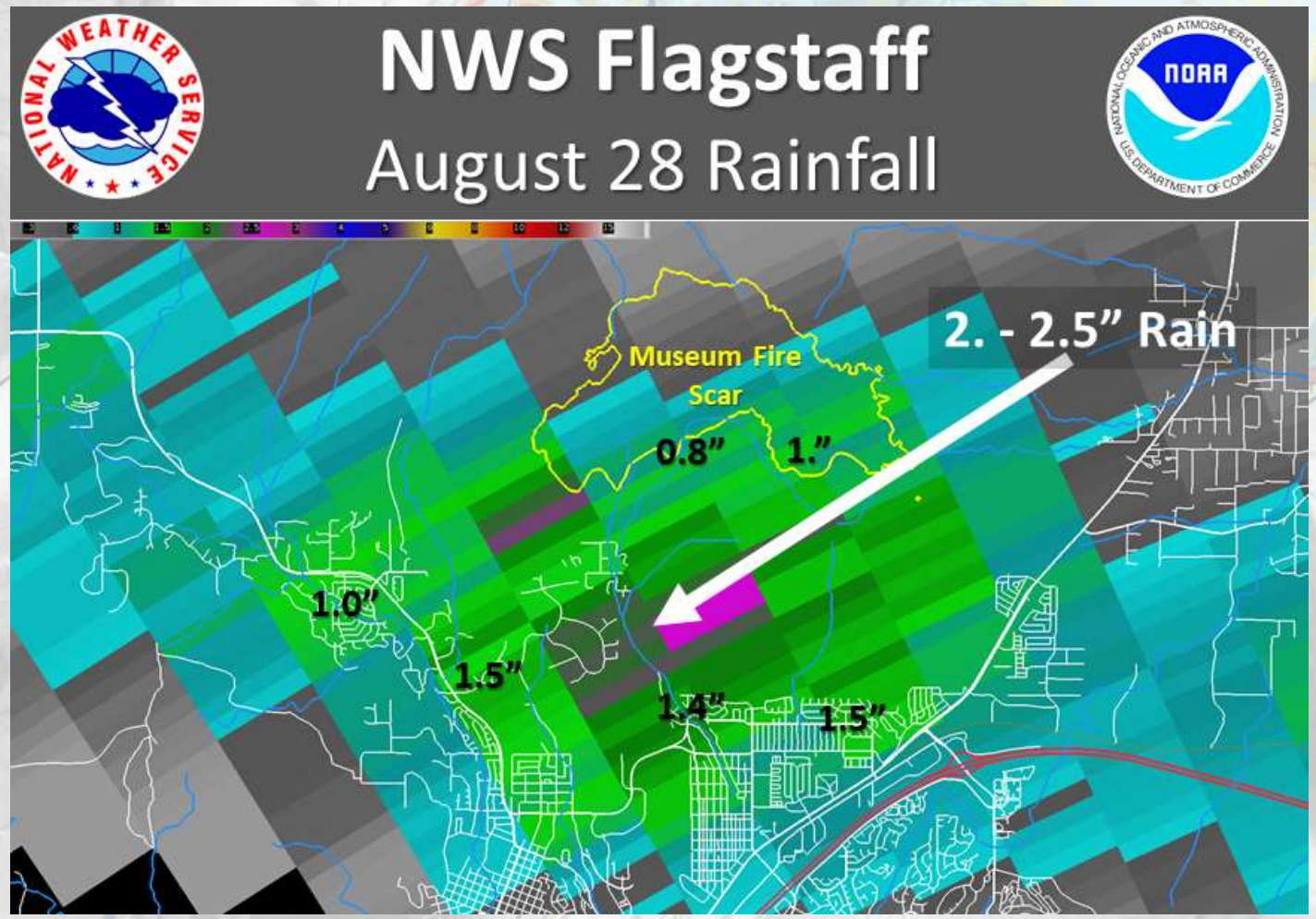
Rainfall Gage
Google Earth

Timeline

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
21 JULY 	22 	23 	24	25 	26	27 **BAER**
28 **BAER**	29 	30 **PRELIM BAER SBS**	31	Aug 1	2  **100+/- Runs**	3 **BAER Report**
4	5 	6 **USGS DF Results**	7	8	9	10
11	12	13  **"Final Model"**	14	15	16 **90% Complete** 	17

August 28th – 2.5" rain just south of fire

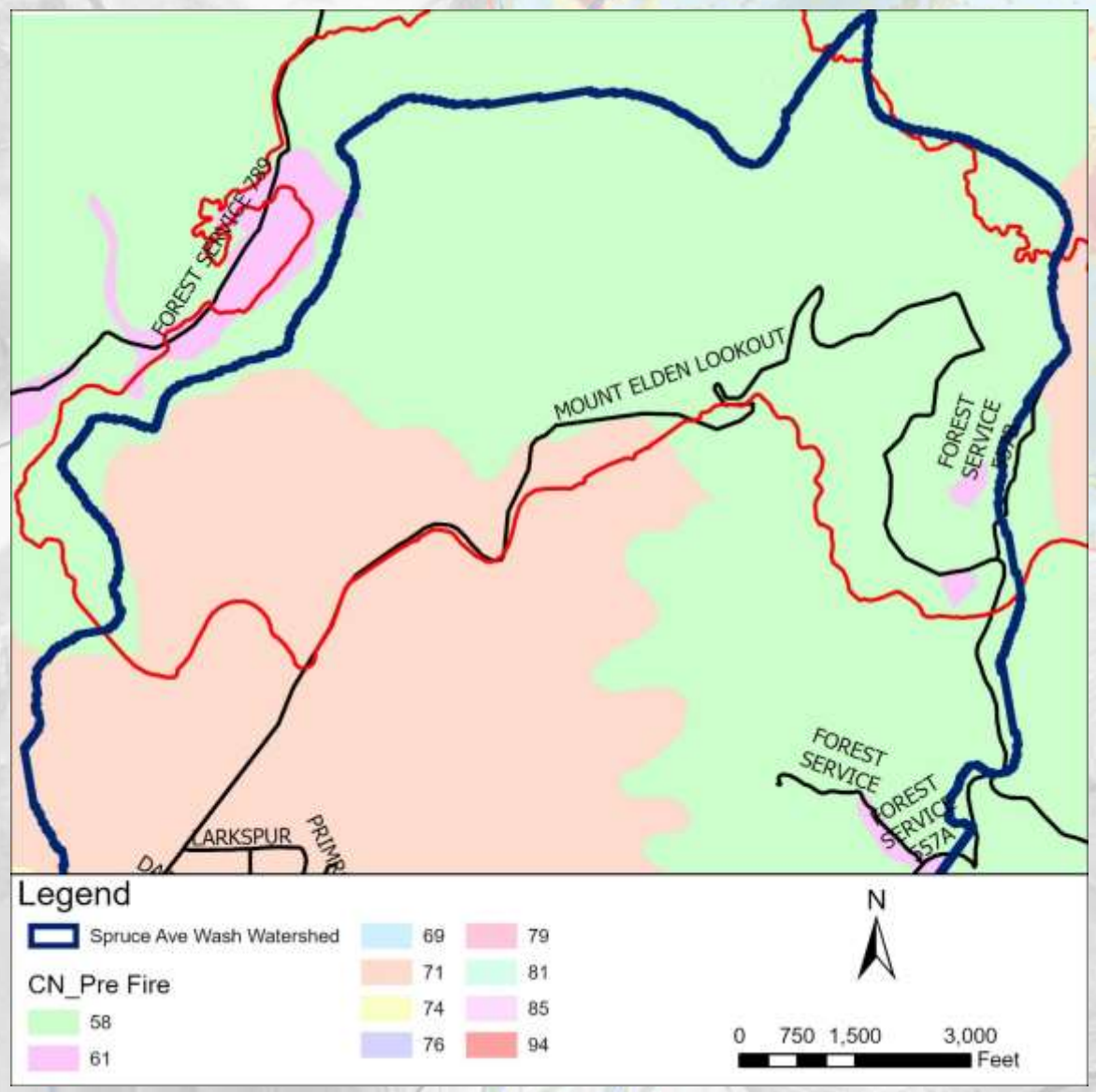
August 28 Rain Event (South of burn scar)

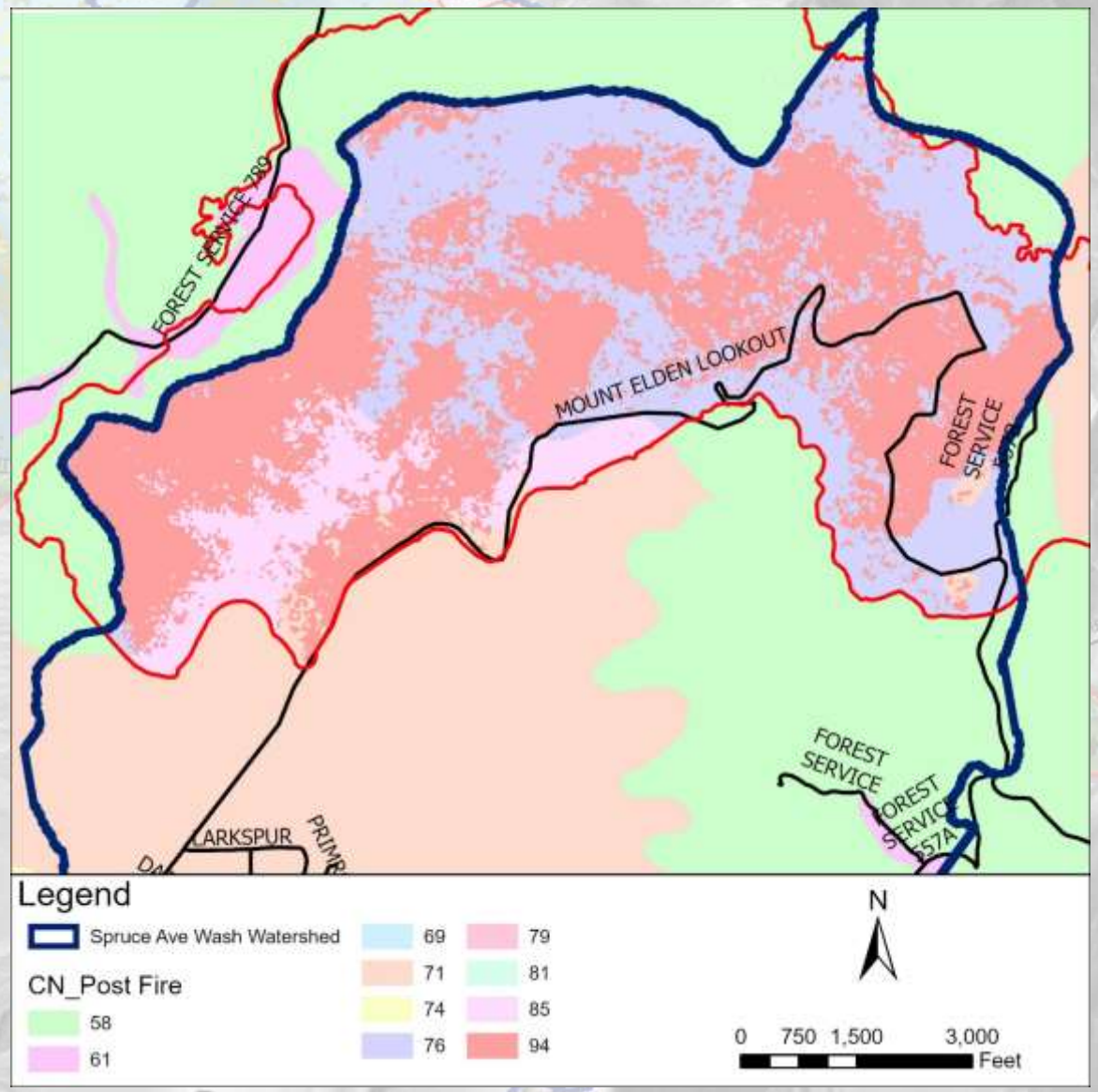


Soil Burn Severity

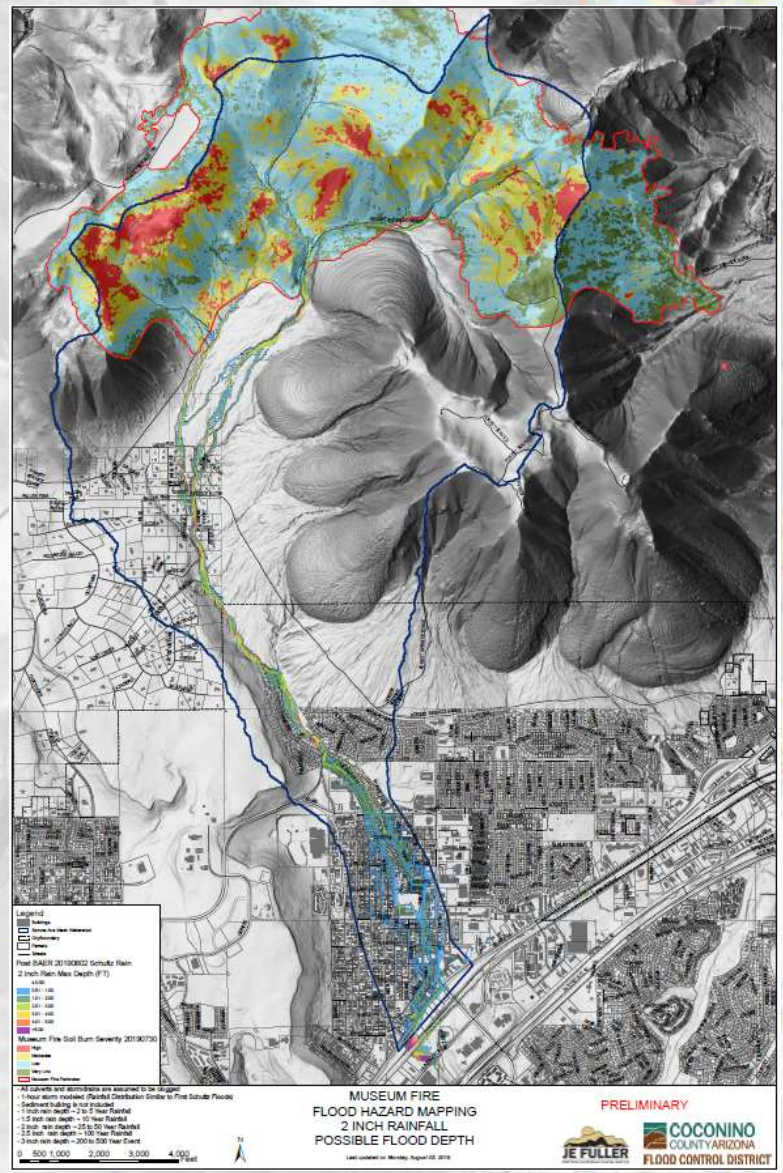
Vegetation Burn Severity ≠ Soil Burn Severity

Hydrology – CN Modifications





FLO-2D Modeling



- SCS Curve Number
- FLO-2D with 20’ grid
- 1 hour Storm
  - 1” – 2 to 5 Year
  - 1.5” – 10 Year
  - 2” – 25 to 50 Year
  - 2.5” – 100 Year
  - 3” – 200 to 500 Year
- Rain over whole watershed
- Clear Water
- Culverts Clogged

Game Cameras

Museum Fire Flow Conditions

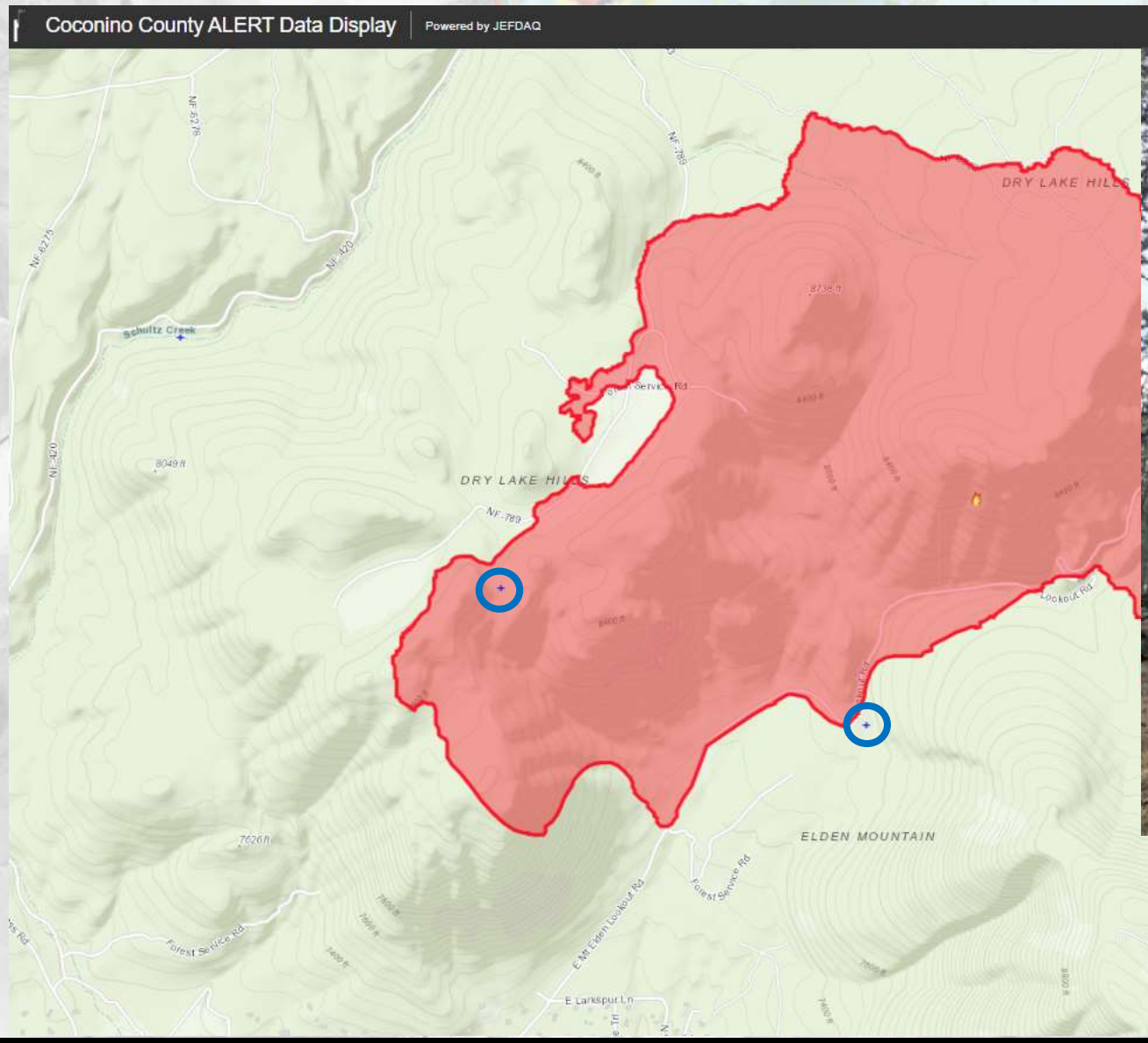
Museum Fire Upper (Oldham) Camera

Museum Fire South Camera

Near Morning Glory (Ogden) Camera

Above Paradise Camera

Rainfall Gages



Ann Youberg – BAER/Debris-Flow

- BAER Response
- Soil Burn Severity
- Debris Flow Hazard Assessment

Burned Area Emergency Response (BAER)

- **What is BAER?**
- A program to identify imminent post-wildfire threats to human life and safety, property and critical natural or cultural resources on NFS lands and take immediate actions to manage unacceptable risk.
- Who: USDA and DOI agencies
- Where: Federal Lands (USFS, NPS, BLM, FWS, BIA)
- Fires greater than 500 acres
- When: Assessment: Immediately
- Treatments: ASAP and no later than one year

Horseshoe 2 Fire BAER

BAER Program Information from R3 BAER Coordinator: Anna Jaramillo-Scarborough

Burned Area Emergency Response (BAER)

BAER Process

Step 1: Identify critical values

- Human Life and Safety
- Property
- Natural/Cultural Resources

Step 2: Assess for threats and evaluate risk

- Obtain BARC Map
- Field assessments -> Soil Burn Severity Map
- Establish Watershed Response

Step 3: Develop response strategy

Step 4: Implement selected treatments

Step 5: Monitor for effectiveness

BAER Program Information from H2F BAER Coordinator: Mark Stamer

BAER Assessment and Reporting

BAER Implementation

Photo: Coronado NF

Photo: A. Stevenson

on soil

Soil Structure

LOW
Structure and fine
roots unchanged
Granular aggregates intact

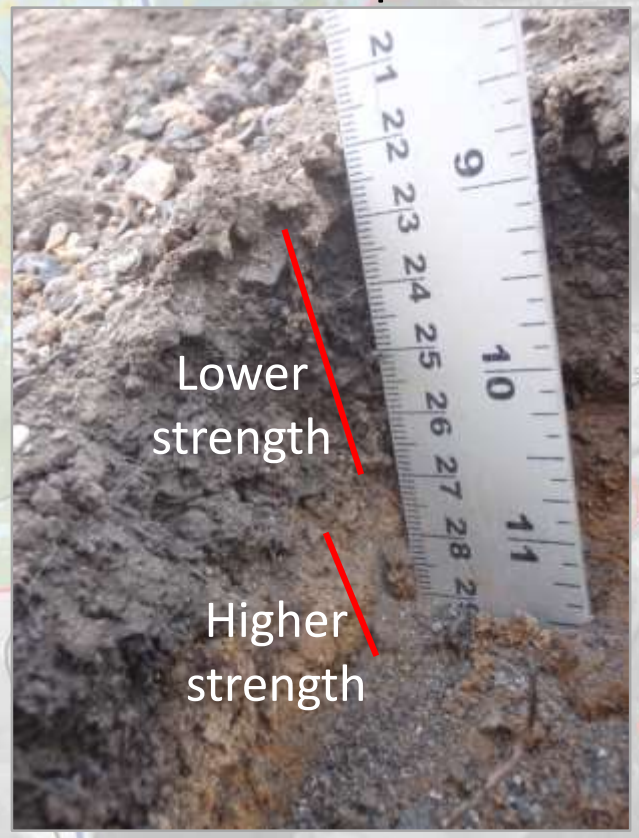
MODERATE
Structure slightly altered
Some consumption of OM
Fine roots charred near surface

HIGH
Structure reduced or destroyed
Single-grained soil dominates
Many/most fine roots
charred/consumed near surface

USDA RMRS-GTR-243. 2010

OM/Roots

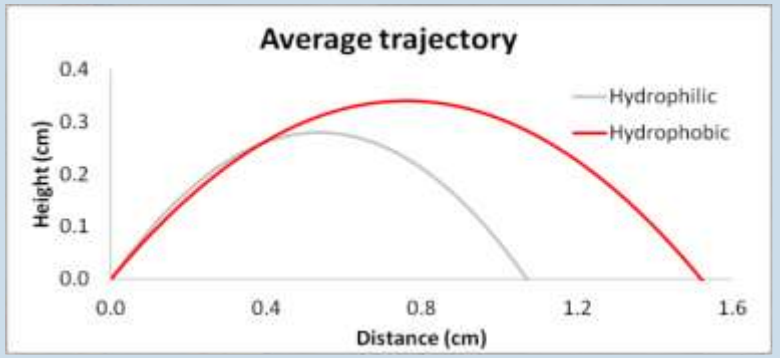
Disaggregation of Soil =>
More Sediment Available
for Transport

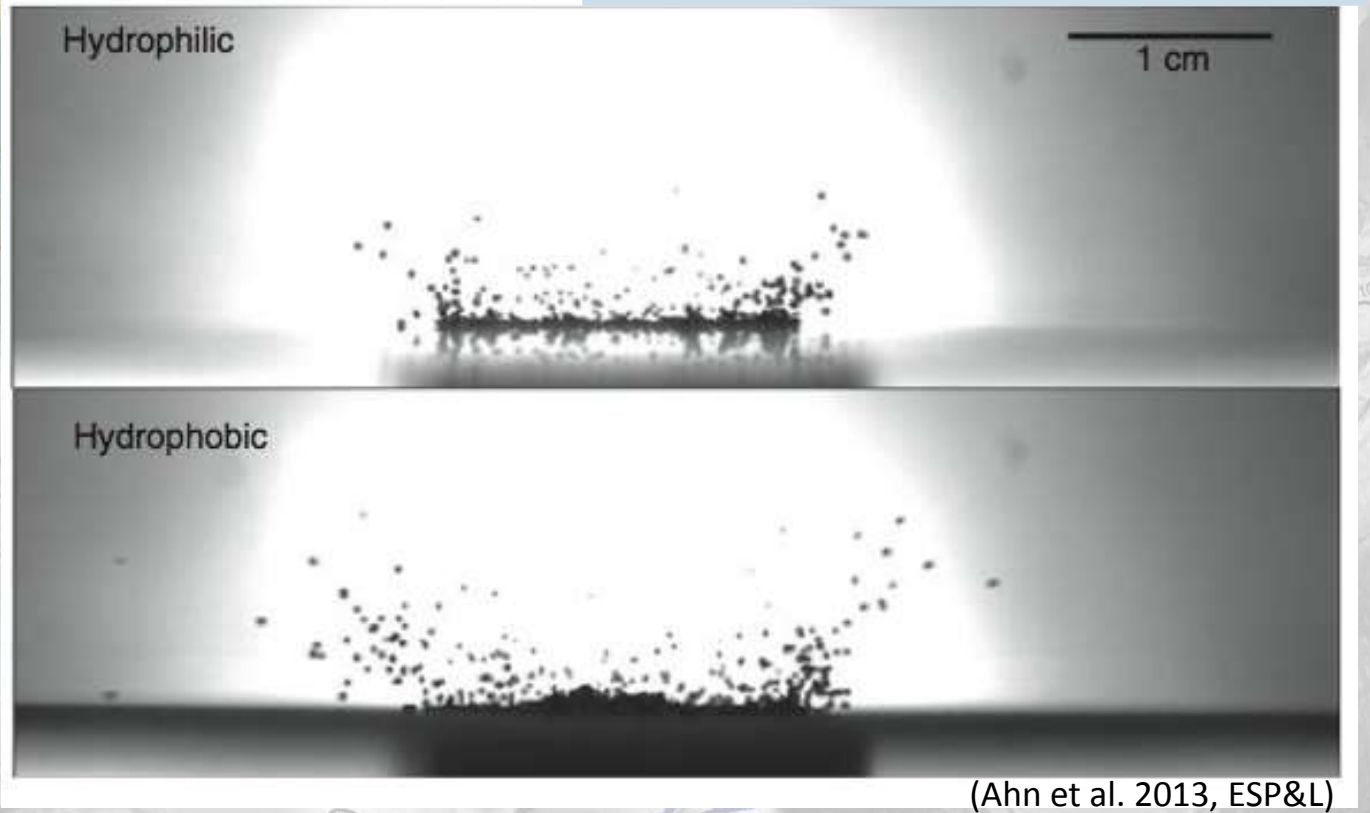


Nyman et al., 2013, JGR

on soil

- Soil-water repellency:
  - soil particles coated with organic substances released during burning
  - hyper-dry soils
- Spatially heterogeneous and temporally variable
- Impedes infiltration





(Ahn et al. 2013, ESP&L)

Hydrologic and Erosional Impacts of Fire Disturbance

Loss of soil organic matter and soil structure

Loss of ground cover

Enhanced soil water repellency and ΔK_{fs}

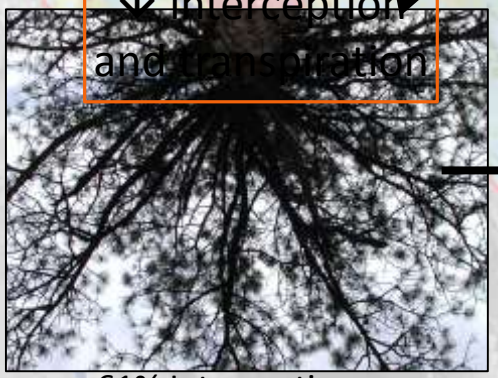
Loss of plant canopy

↓ Infiltration

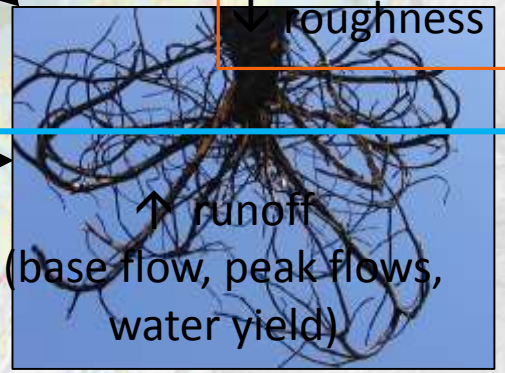
↓ interception and transpiration

↓ roughness

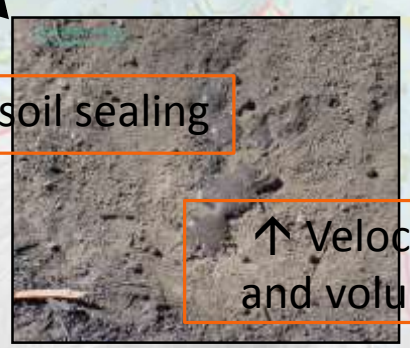
↑ runoff (base flow, peak flows, water yield)



61% Interception

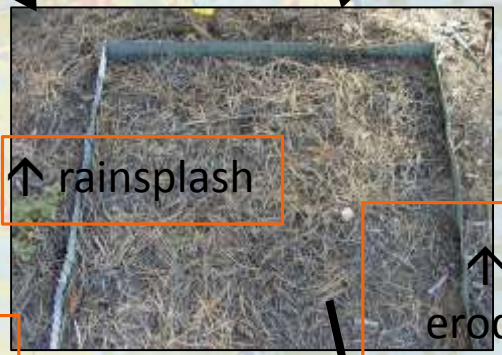


20% Interception



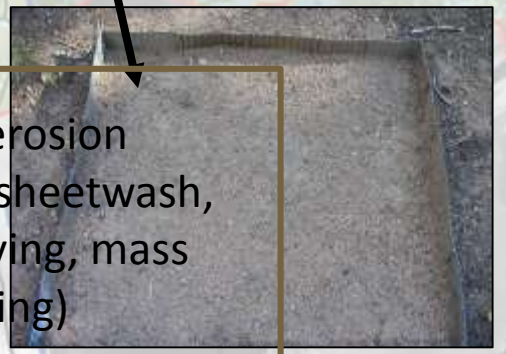
↑ soil sealing

↑ Velocity and volume



↑ rainsplash

↑ soil erodibility



↑ soil erosion (rainsplash, sheetwash, rilling, gullying, mass wasting)

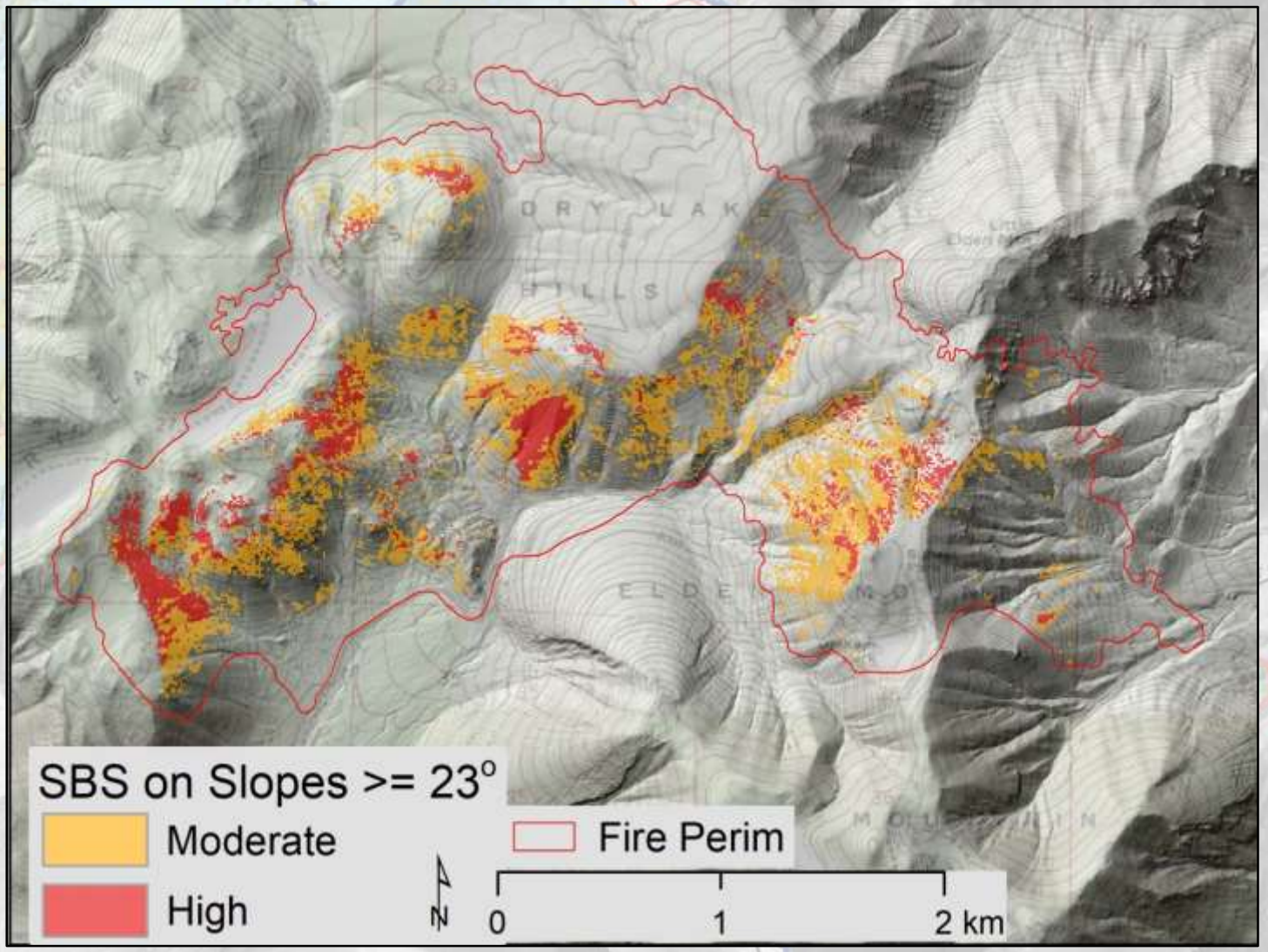
Modified from Wagenbrenner et al. (2015), Forest Ecology and Management

BAER Debris-Flow Hazard Assessment

USGS Debris-Flow Probability Model

Probability of debris-flow determined by:

- %upslope area with Hi/Mod SBS on slopes ≥ 23°
- Average dNBR/1000
- Average KF Factor (soil erosion - STATSGO)
- I_{15} rainfall intensity (mm/h) of the design storm



Staley et al., 2017, Geomorphology

https://landslides.usgs.gov/hazards/postfire_debrisflow/

BAER Debris-Flow Hazard Assessment

USGS Debris-Flow Volume Model

Debris-flow volume determined by:

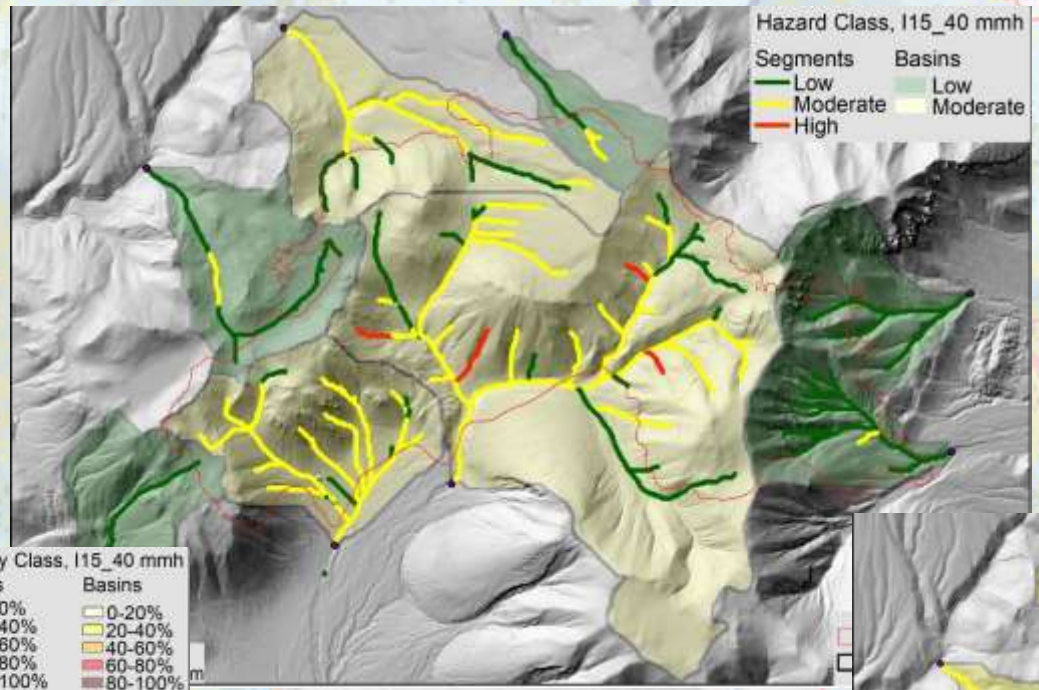
- Elevation range within the watershed (m)
- %upslope area burned at mod/high SBS (km2)
- I_{15} rainfall intensity (mm/h) of the design storm

Gartner et al., 2014, Engineering Geology

https://landslides.usgs.gov/hazards/postfire_debrisflow/

BAER Debris-Flow Hazard Assessment

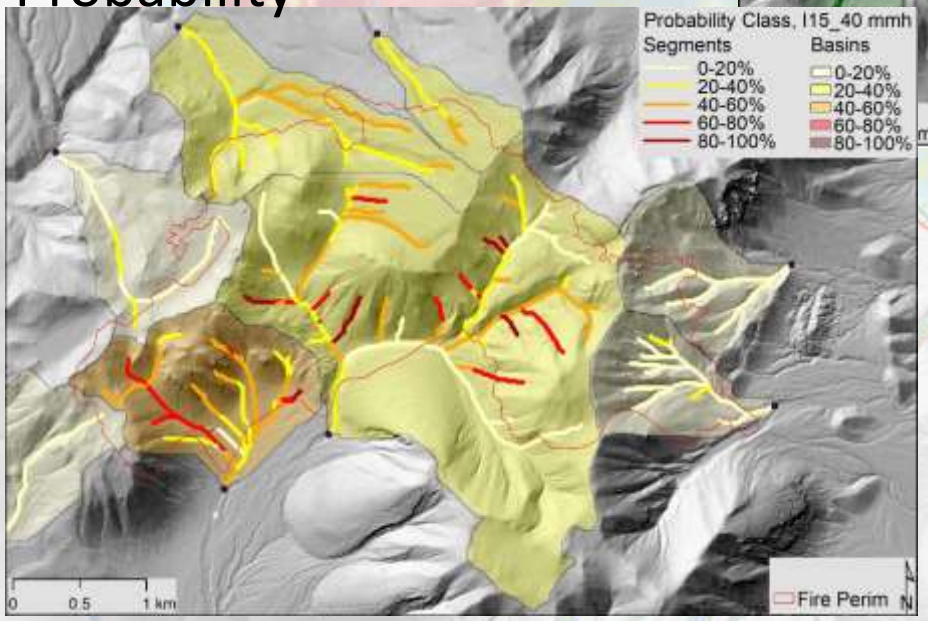
Debris-Flow Probability + Volume = Hazard Class



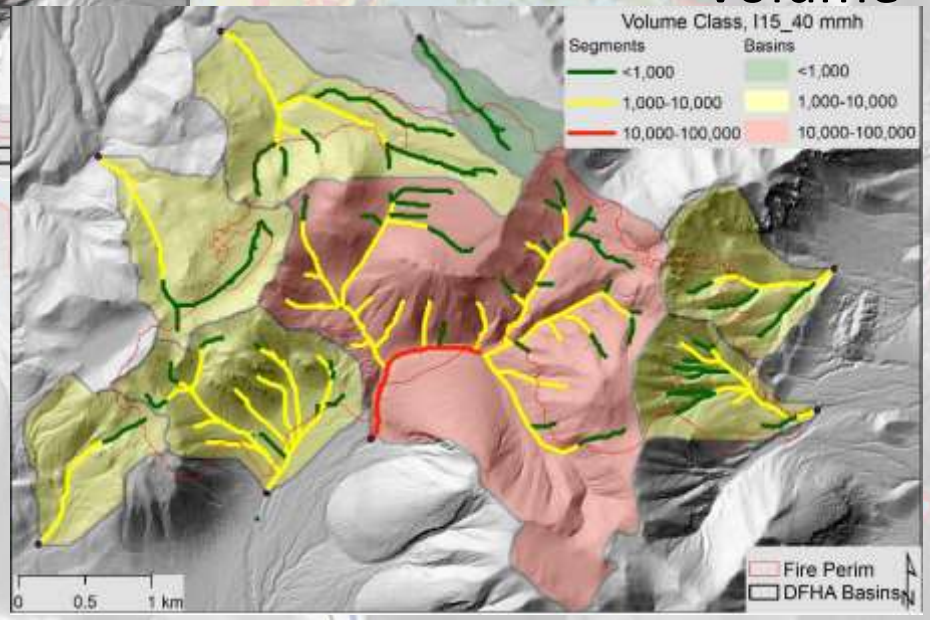
Hazard Class

USGS model results provides BAER teams with helpful information when assessing threats to critical values.

Probability



Volume



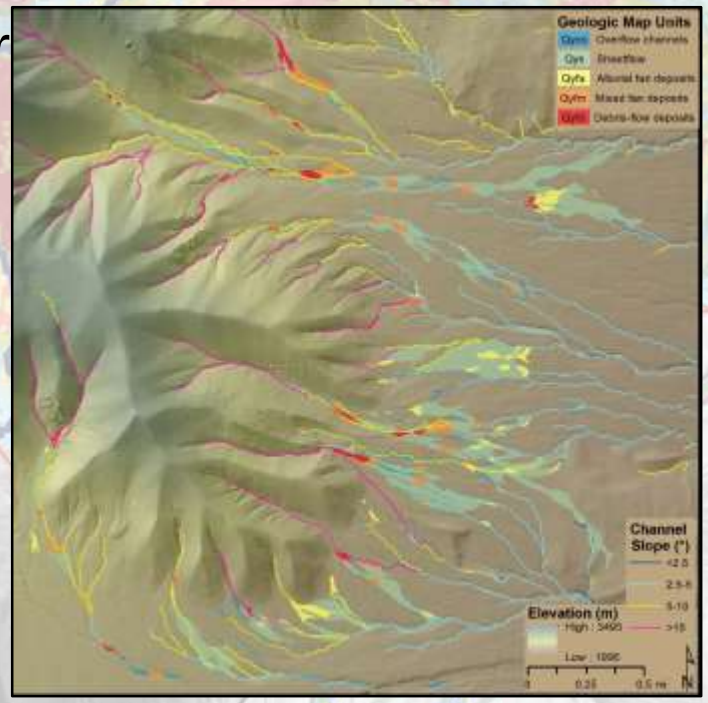
https://landslides.usgs.gov/hazards/postfire_debrisflow/

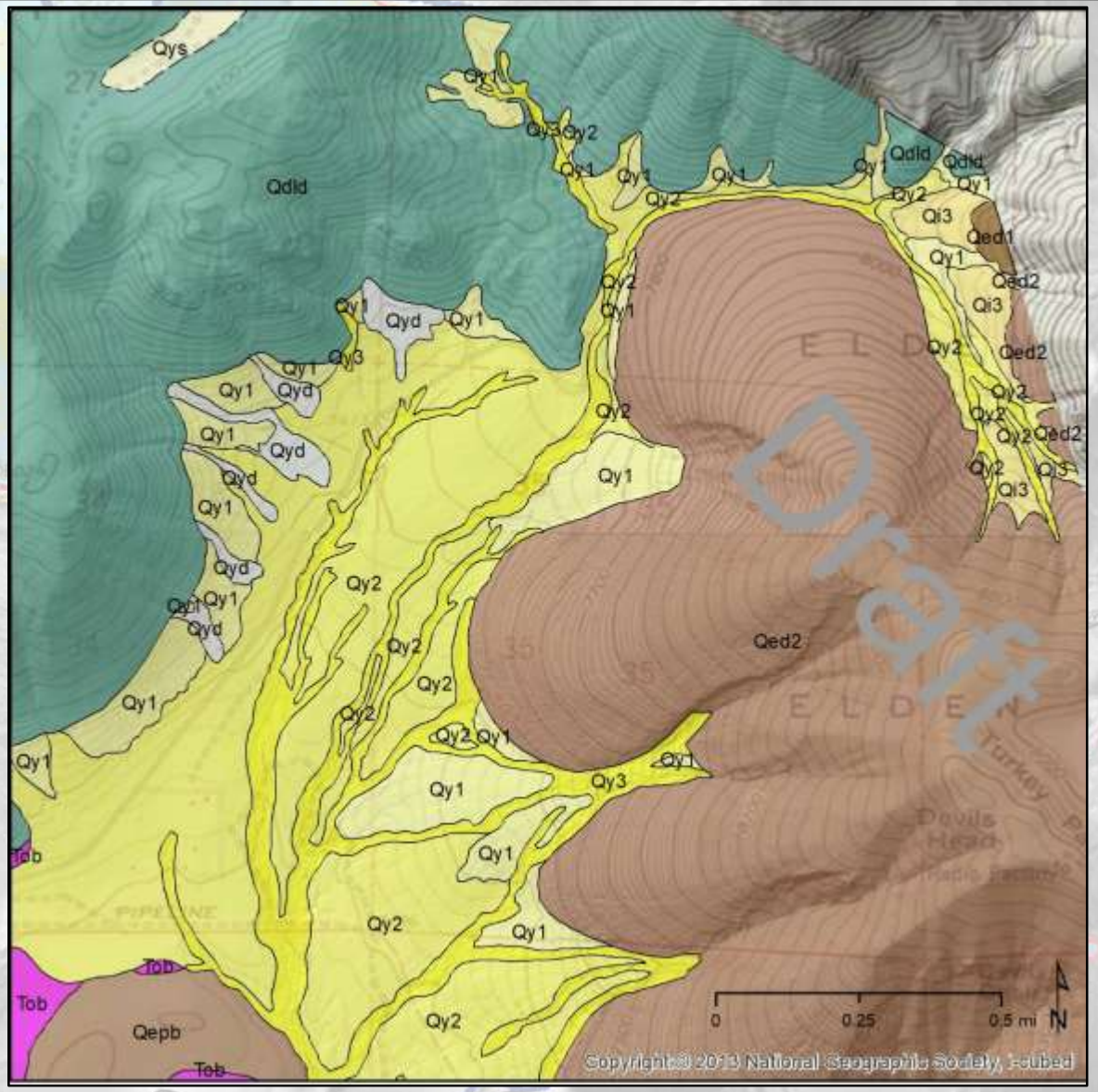
Assessment

- Due to cloud cover, BARC map based on NDVI instead of dNBR so USGS couldn't run their models
- Debris-flow hazard assessment was based on multiple assessments including:

Assessment

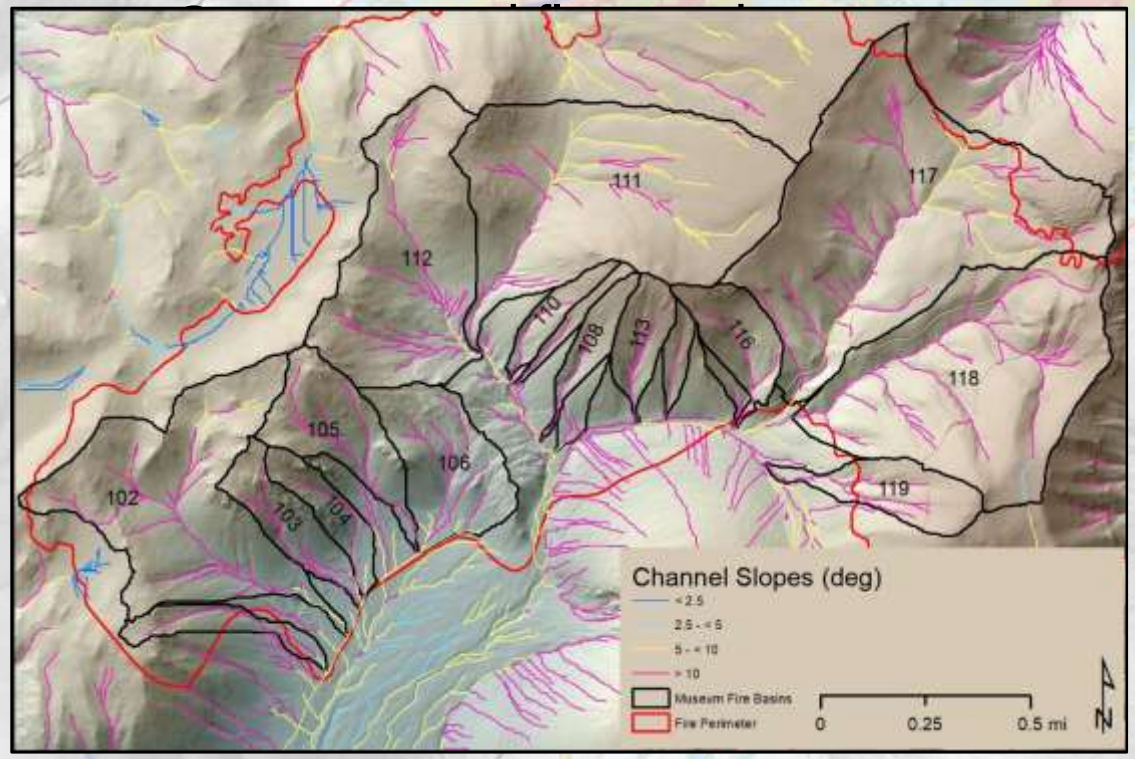
- Preliminary surficial geologic mapping during the summer of 2018 (DGM-128, to be released later this year)
- Post-Schultz Fire mapping and analyses
- Results from the Coconino Pre-fire Assessment of Post-Fire Flooding and Debr

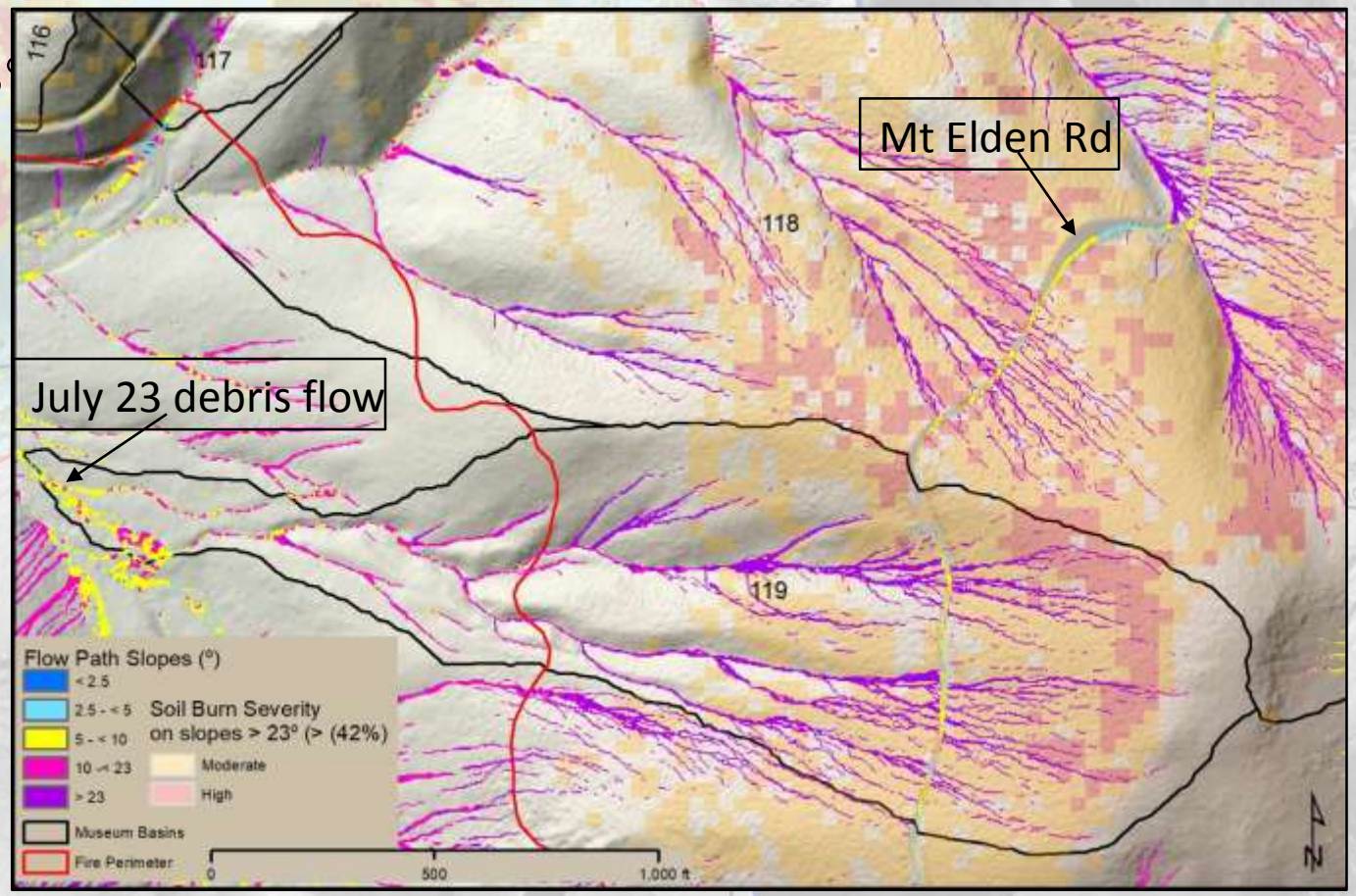




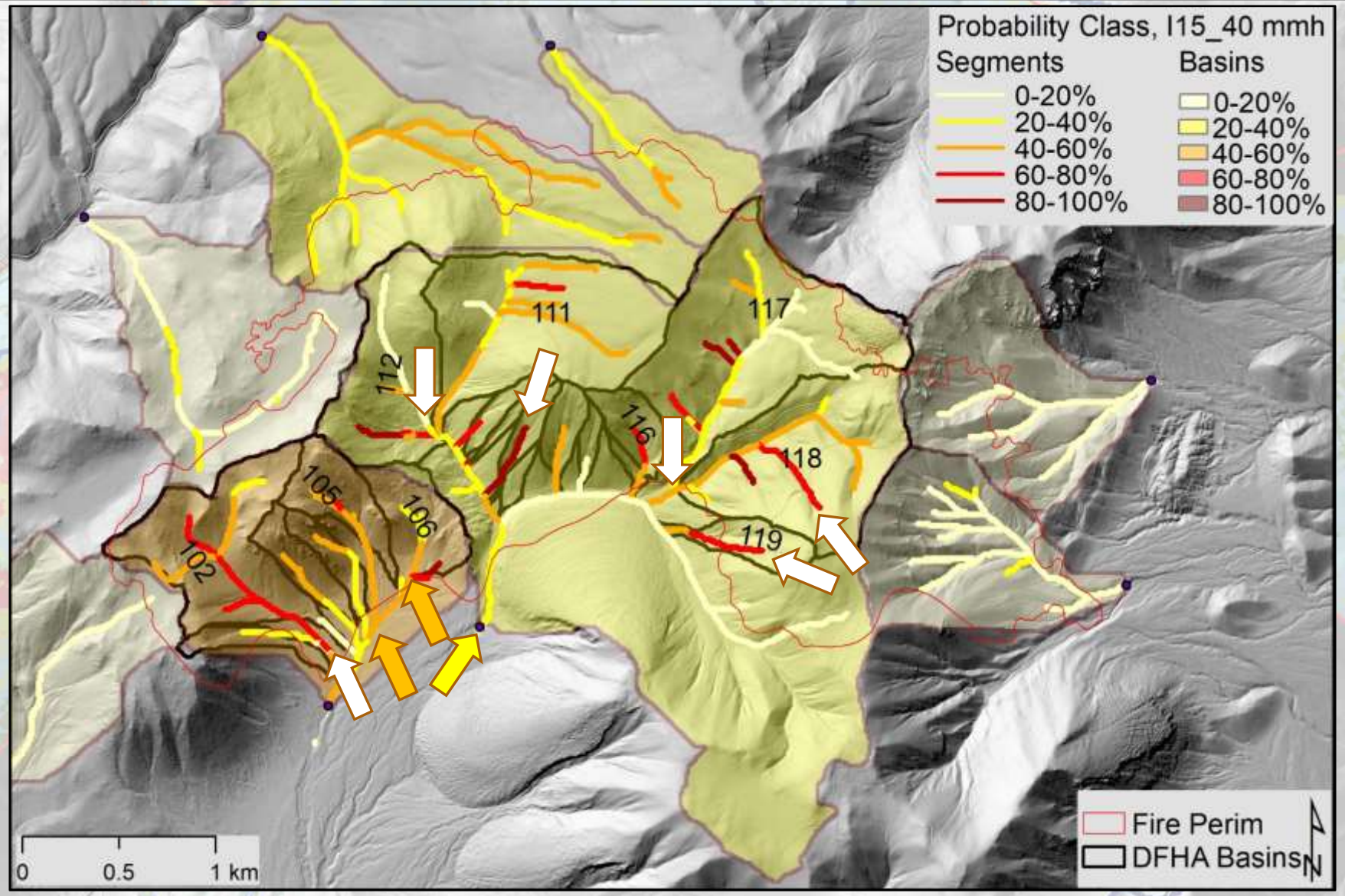
Assessment

- GIS analyses using lidar data (1 m resolution)
  - %Basin @ Mod/Hi SBS on slopes ≥23°
  - Channel gradients



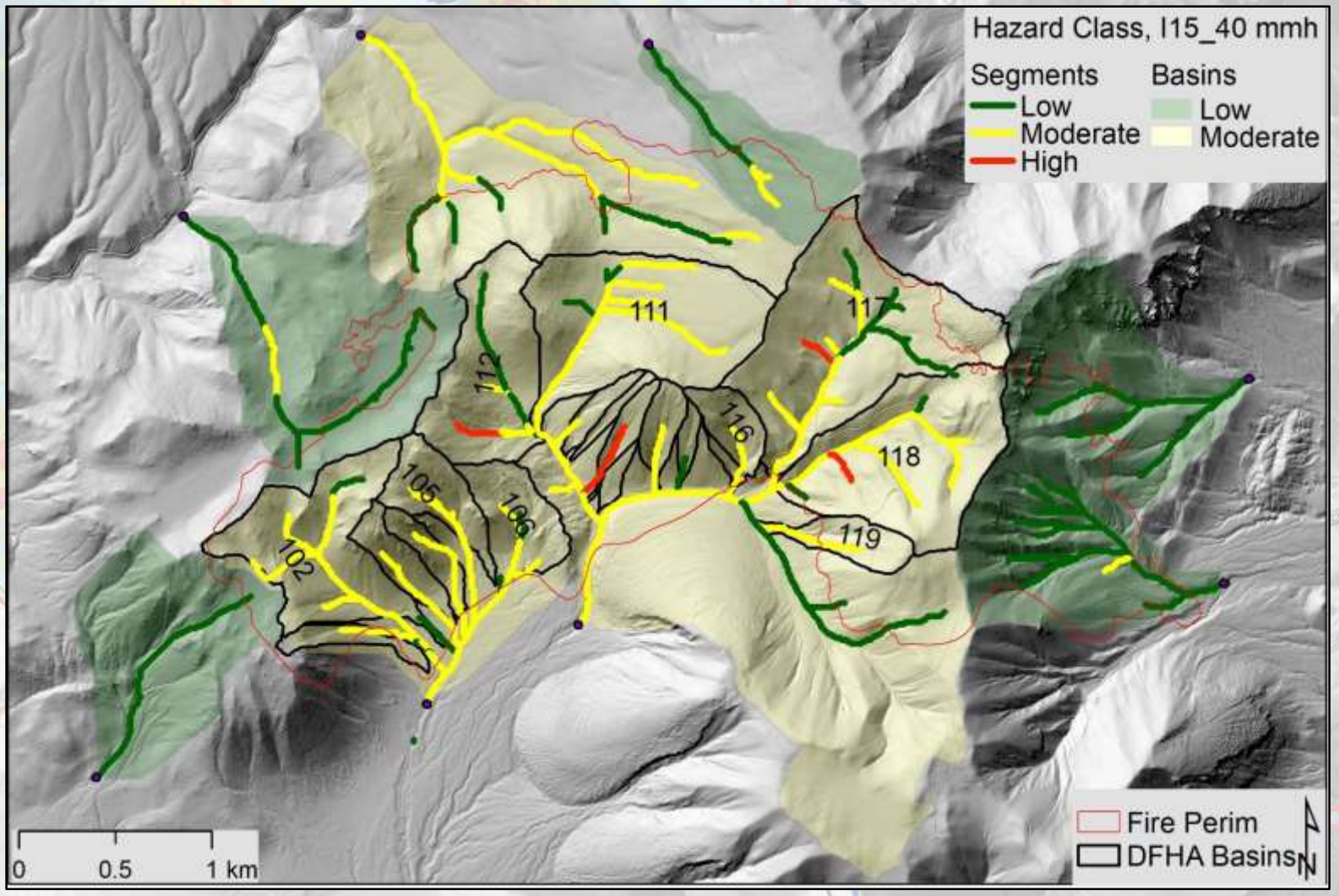


Assessment


Probability Class, I15_40 mmh
Segments
0-20%
20-40%
40-60%
60-80%
80-100%
Basins
0-20%
20-40%
40-60%
60-80%
80-100%
111
117
112
116
118
105
106
102
119
0
0.5
1 km
Fire Perim
DFHA Basins
N

Assessment

- Debris-flows from the Museum Fire are likelyto be confined to forest lands.
- Debris flows could, however,
  - Release significant amounts of sediment,
  - Cause channel avulsions,
  - Enhance magnitude of hyperconcentrated and flood flows,
  - Indirectly impact downstream areas.



John Carr - Museum Fire Response

- Public Outreach
- Neighborhood flood mitigation efforts
- Utility Coordination

Public Outreach – Door-to-Door

Assessments

- Is mitigation required?
- Is owner available and willing to sign Cooperative Agreement?

Cooperative Agreements

- Flood Control District (FCD) to install sandbags or concrete barriers
- Cooperator agrees to indemnify FCD & maintain flood mitigation devices
- Either party can terminate agreement no sooner than December 30, 2019
- The FCD strongly recommends that flood mitigation remain in place until September 30, 2020

Door-to-door Citizen Responses

- "Jeepers. I sure hope you know what you're doing"
- "Why in the world are you doing this?"
- "Tell County Management to go to *&%$ [not a good place]
- "I've lived here __-years and I've never seen water in the street, and never near my home."

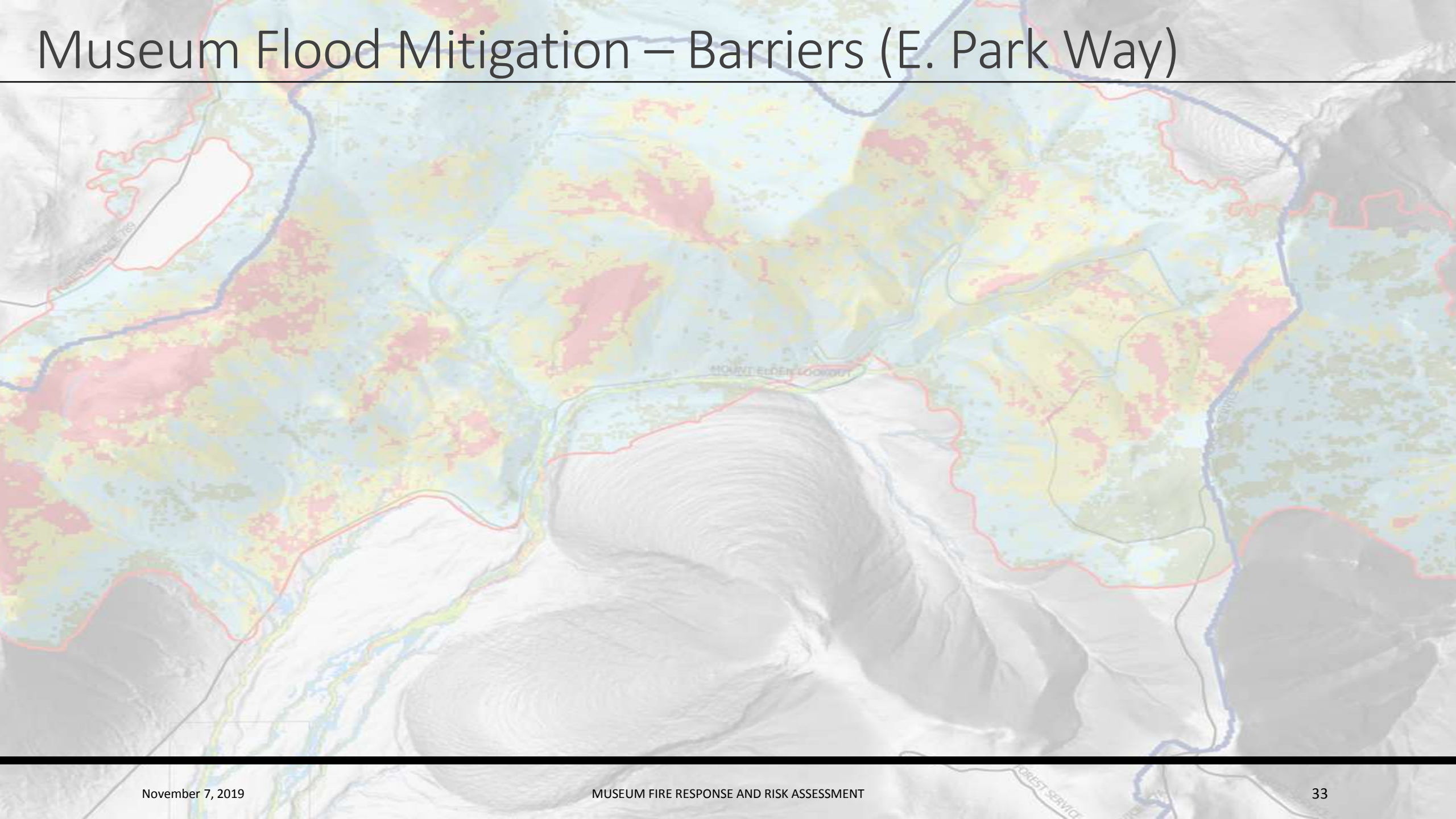
Public Outreach – Public Meetings

Community Meetings (15) were held

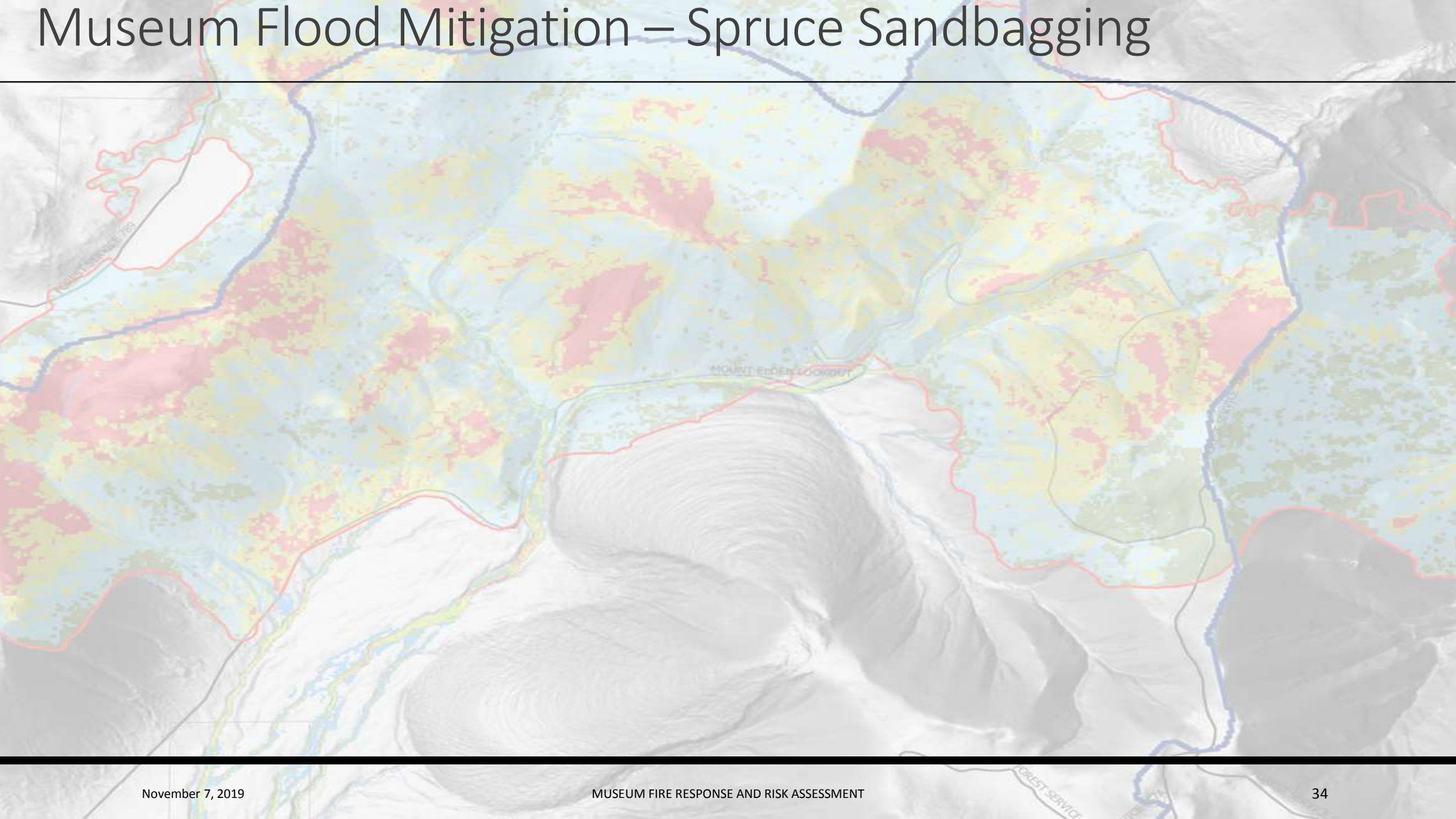
Museum Flood Mitigation - Barriers

- Mitigated ~400 homes & ~35 businesses in ~2 weeks
  - Concrete barrier placement
  - Water barrier placement
    - For high-hazard area
    - Water barriers are used in lieu of concrete barriers where accessibility is an issue

Museum Flood Mitigation – Barriers (E. Park Way)



Museum Flood Mitigation – Spruce Sandbagging



Museum Flood Mitigation – Barriers - Primrose

Museum Flood Mitigation – Automated Sandbagging

- The Ultimate Bagger
  - 1200 Bags per hour w/four-person crew
  - Two Cubic Yard Hopper

Museum Flood Mitigation – Manual Sandbagging

- Over 600,000 Polypropylene sandbags sand bags were deployed
- 2364 volunteer hours required to fill bags
- Sandbags are effective from 3 to 6 months under direct sunlight

Sandbag Filling and Deployment

- Sandbag Deployment often required human chains to access homes

Utility Coordination

- Gas
  - Unisource – local services
  - Kinder Morgan – major transmission lines
- Electric – APS
- Cable
  - CenturyLink
  - Suddenlink
- Most of the Utility Companies required the FCD to sign a non-disclosure agreement

Ed Schenk- Watershed Mitigation and Monitoring

- Vegetation Removal
- Watershed Mitigation
- Watershed Monitoring

Watershed Mitigation & Monitoring Efforts

Vegetation removal

Trees and brush were removed during the first week of the fire between Paradise Road and Arroyo Seco (approximately a mile).

Volunteer groups (Arizona Hydrological Survey and Boy Scouts) removed trees and trash from the channel downstream of the Sunnyside Neighborhood.

July 2019

August 2019

July 2019

August 2019

July 2019

August 2019

Watershed mitigation

BAER – Channel improvements

BAER – mulching

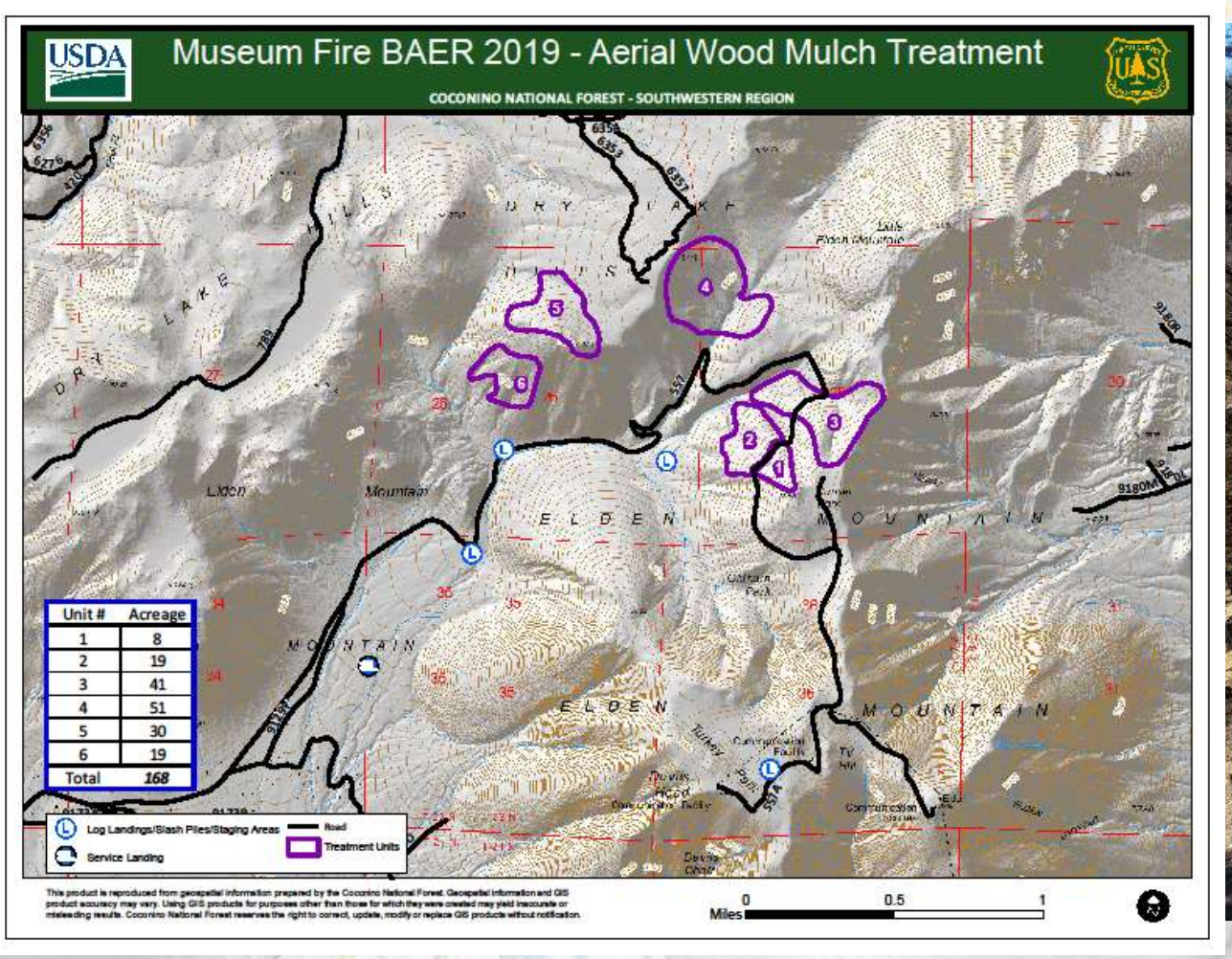
Cross-vein weirs

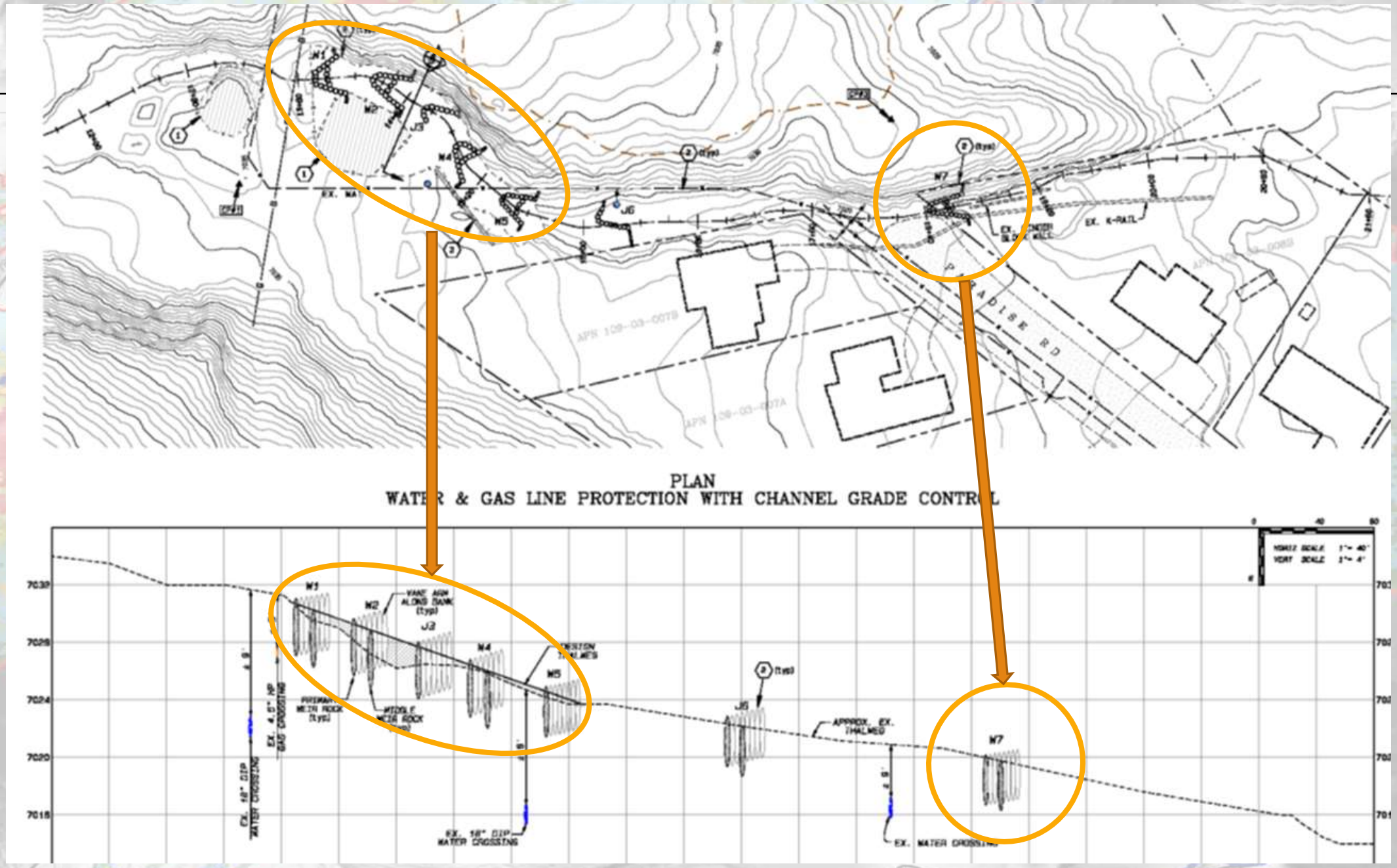
Debris collection bollards at key intersections

BAER response – Channel Improvement

BAER response (Cont'd) - Mulching

160 acres of mulch spread on severe burn steep slopes (September 2019)





PLAN
WATER & GAS LINE PROTECTION WITH CHANNEL GRADE CONTROL

Cross Vein Weirs

Seven cross-vein weirs with 4 foot keystone members to protect existing water main and natural gas pipeline

Debris Bollards

New debris bollards at Linda Vista and Dortha

Monitoring efforts

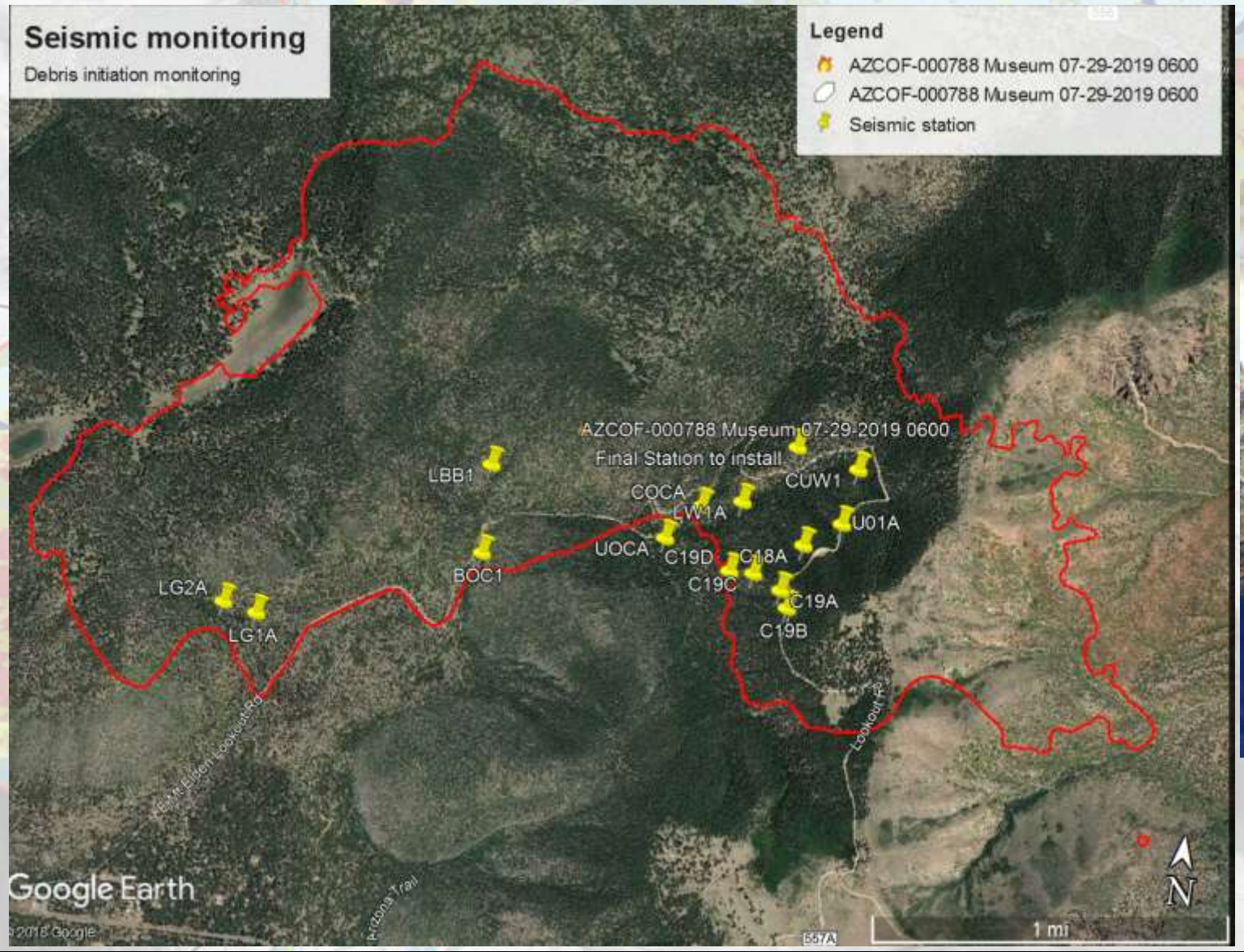
Seismic gauges (debris flow initiation)

Geomorphic monitoring – headcut migration, erosion potential

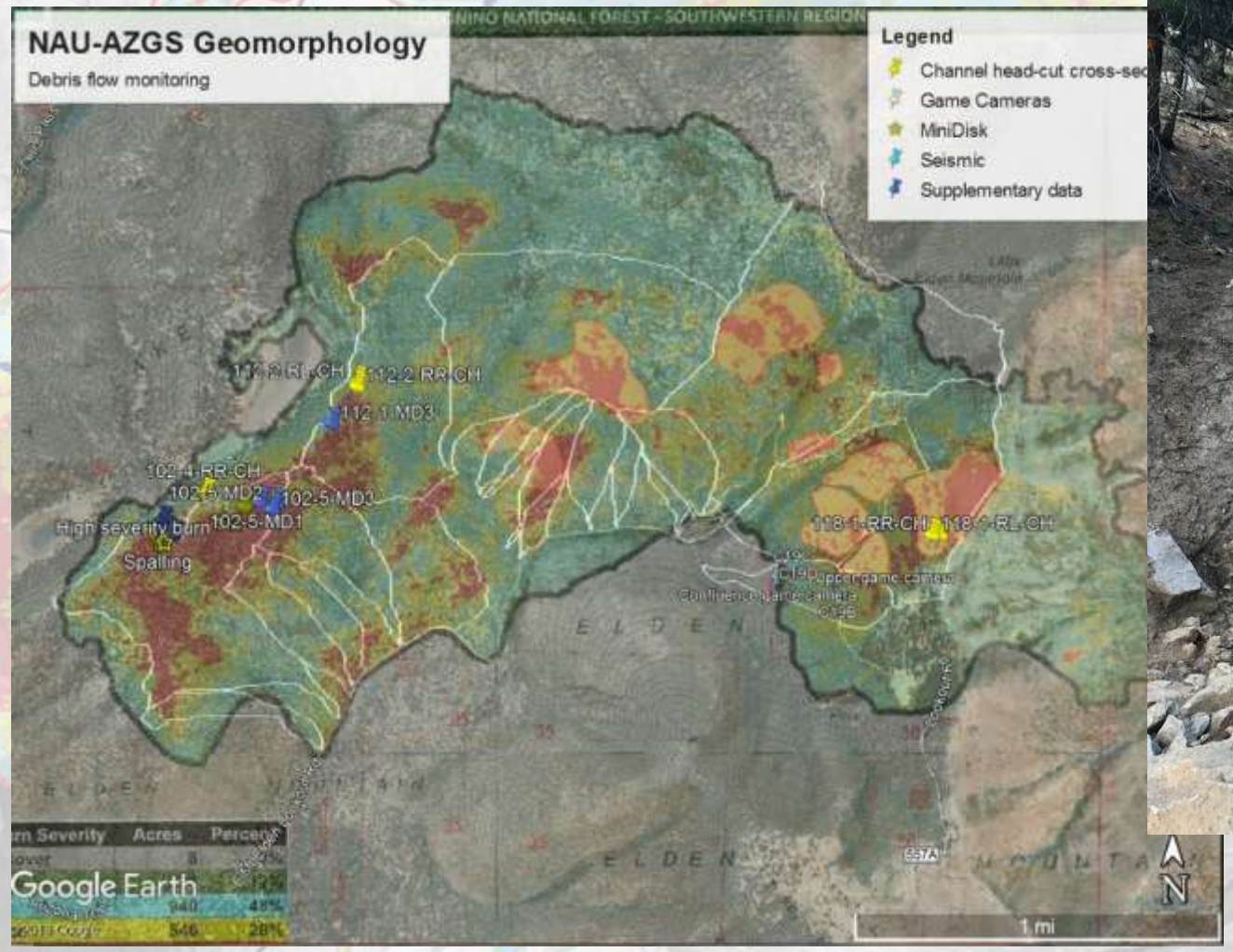
Gauges (mostly covered earlier)

Repeat LiDAR (not covered in this presentation)

Seismic Monitoring



Geomorphic Monitoring



Cameras

Final Thoughts

- It has not really rained on the burn scar…Yet
- A significant potential risk remains for several years to come