Welcome! The webinar will begin shortly. As you wait, please open menti.com on your phone or in another browser.

Welcome

→ Carol Ekarius, Coalitions & Collaboratives, Inc.

MITIGATION BEST PRACTICES (MBP) TRAINING

The MBP national level training is designed for current or future mitigation specialists, wildfire program leads & others who work with residents & their communities, to become more efficient & effective at reducing wildfire risk.

AIM GRANT

COCO offers a unique funding opportunity available for a wide variety of capacity building activities, including personnel, planning efforts & wildfire risk reduction work on non-federal land.

AIM

Action, Implementation & Mitigation

COMMUNITY MITIGATION ASSISTANCE TEAM

The CMAT works closely with Incident Management Teams, the U.S. Forest Service or other land management agencies, & community residents & leaders to identify mitigation opportunities before fire impacts the community.

CMAT

PHOTO PROVIDED BY KARA KARBOSKI, WASHINGTON RESOURCE CONSERVATION & DEVELOPMENT COUNCIL

VISIT CO-CO.ORG

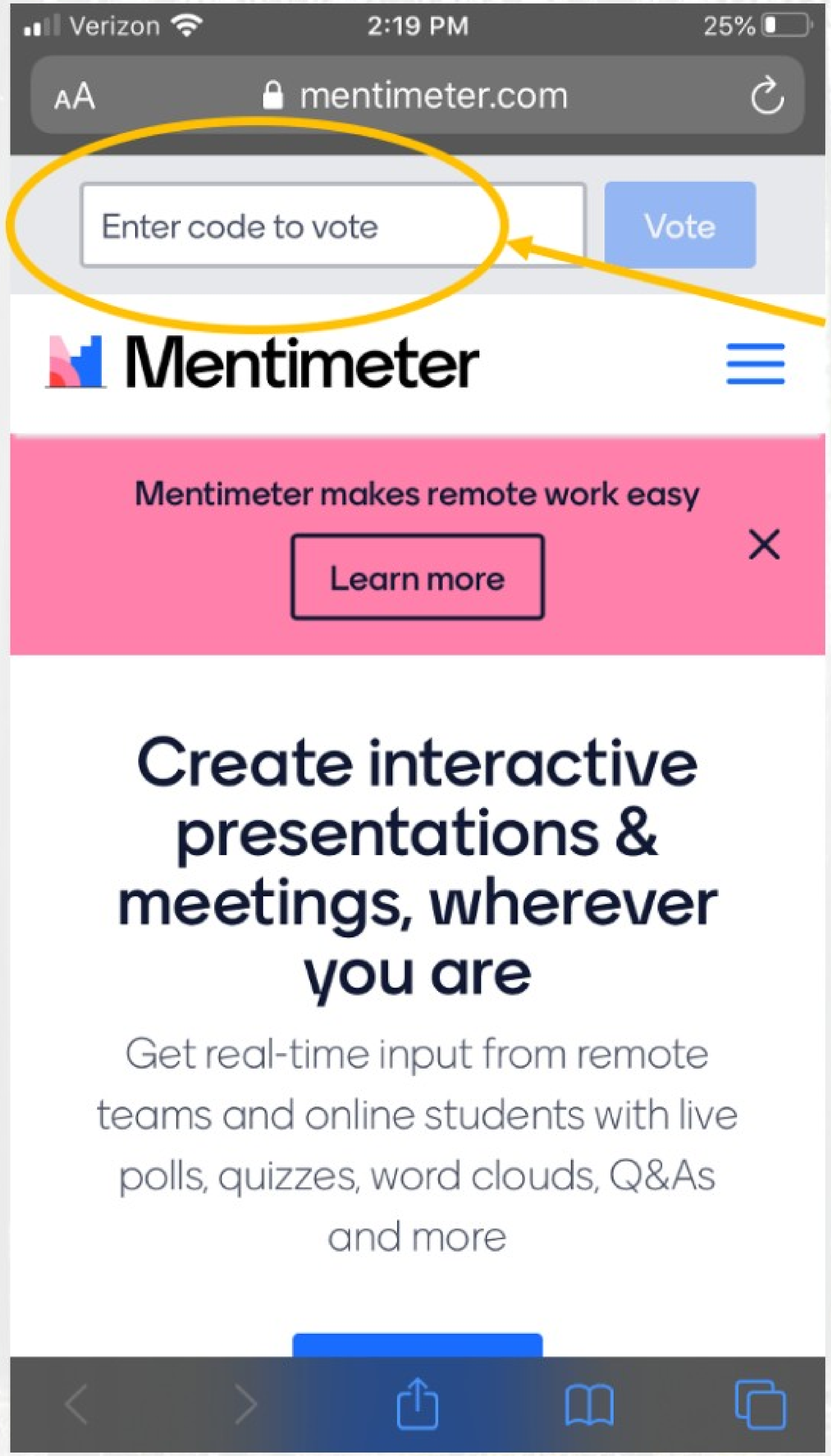
FOR MORE INFO ON OUR PROGRAMS!

COCO COALITIONS & COLLABORATIVES, INC

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

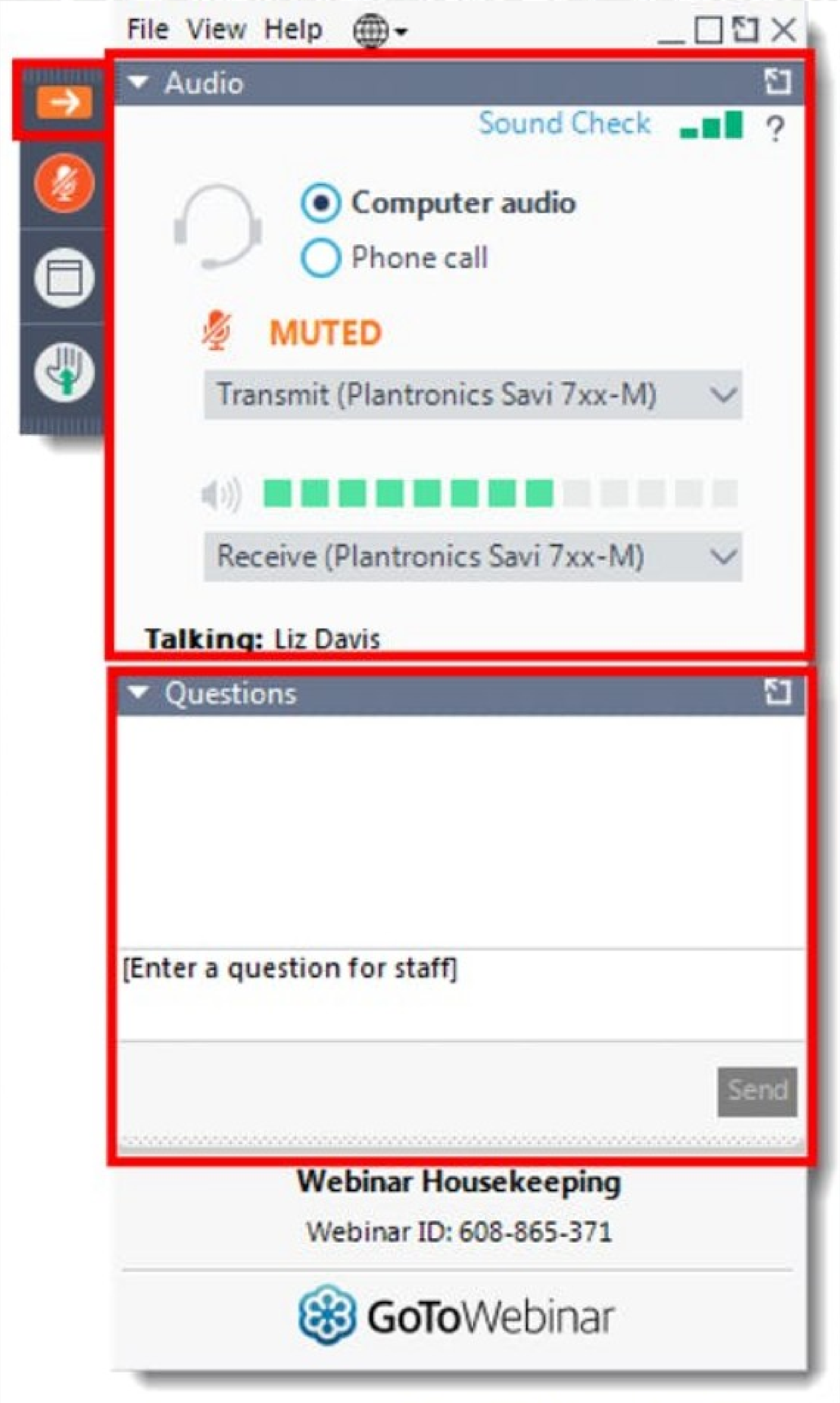
MITIGATION MENTORS

The Mitigation Mentors Program (MMP) provides one-on-one mentorship to increase wildfire mitigation, increase organizational capacity, improve community resilience & support wildland fire adaptation.



Using Mentimeter

- Type Menti.com into your phone or computer's web browser
- Enter the code above into the code bar
- Follow along & participate in the webinar



Panel Discussions, Q&A, Polling

- Polling is anonymous. Please be respectful & professional.
- Please reserve GoToWebinar's 'Question' box for technical issues & the 'Chat' box for resources.
- We have a fixed time for questions. Please note that unanswered questions are documented.

Who do you work for?

Federal	State	Local government	NGO	Consultant	Other
0	0	0	0	0	0

Where do you work?

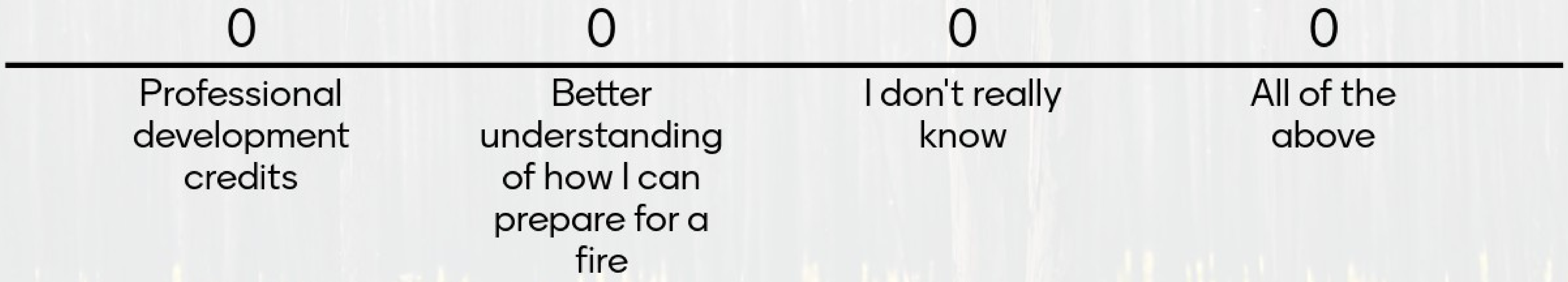
What is your level of experience in hydrology?

I know the word	I have taken classes before	I'm a student	I apply hydrology sometimes	I routinely build & apply various hydraulic methods for science & engineering
0	0	0	0	0

What is your level of involvement for emergencies?

Consultant that provides information to local agencies	Work for local agency & support recovery group	Technical professional in government/local agency	Watershed coordinator for owners & agencies	None or limited
0	0	0	0	0

What do you hope to get from this seminar?



What Can Be Done Before The Fire?

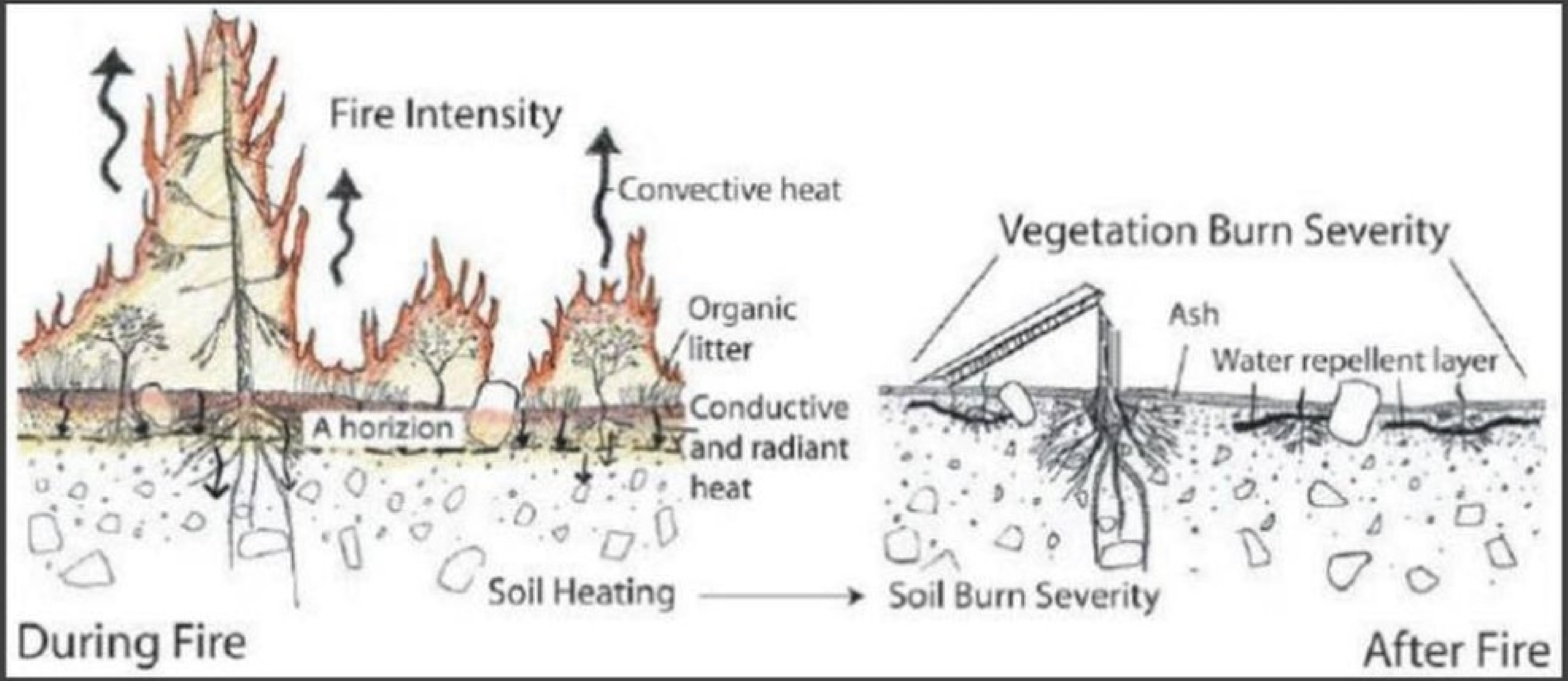
Discussion of rapid hydrologic & hydraulics pre & post-fire assessments & lessons learned

About me:

- PE, PhD, DWRE in Water Resources focusing on Hydrology and Hydraulics.
- Have worked for both public and private agencies.
- Honorably Discharged VFW
- Likes kids, dogs, hiking, generally okay with most adults.
- First fire I ever worked on was Bandelier National Monument while at FHWA.
- Have performed engineering in response to declared disasters in Colorado, New Mexico, Minnesota, California, and Missouri.
- We have supported EWP work for Spring Creek and the 2020 fires in Colorado

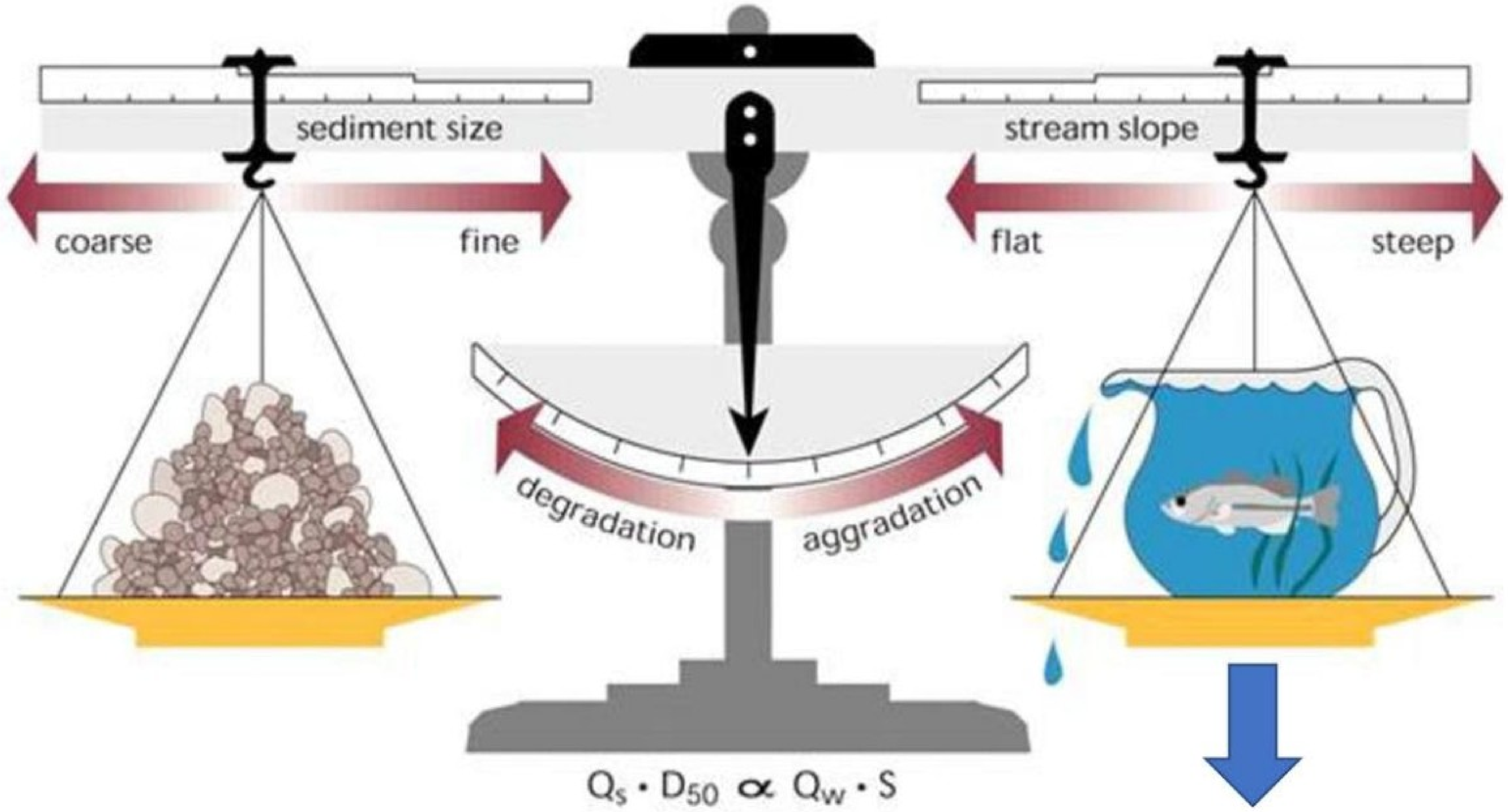
Overview

Effects of Fire on Hydrology

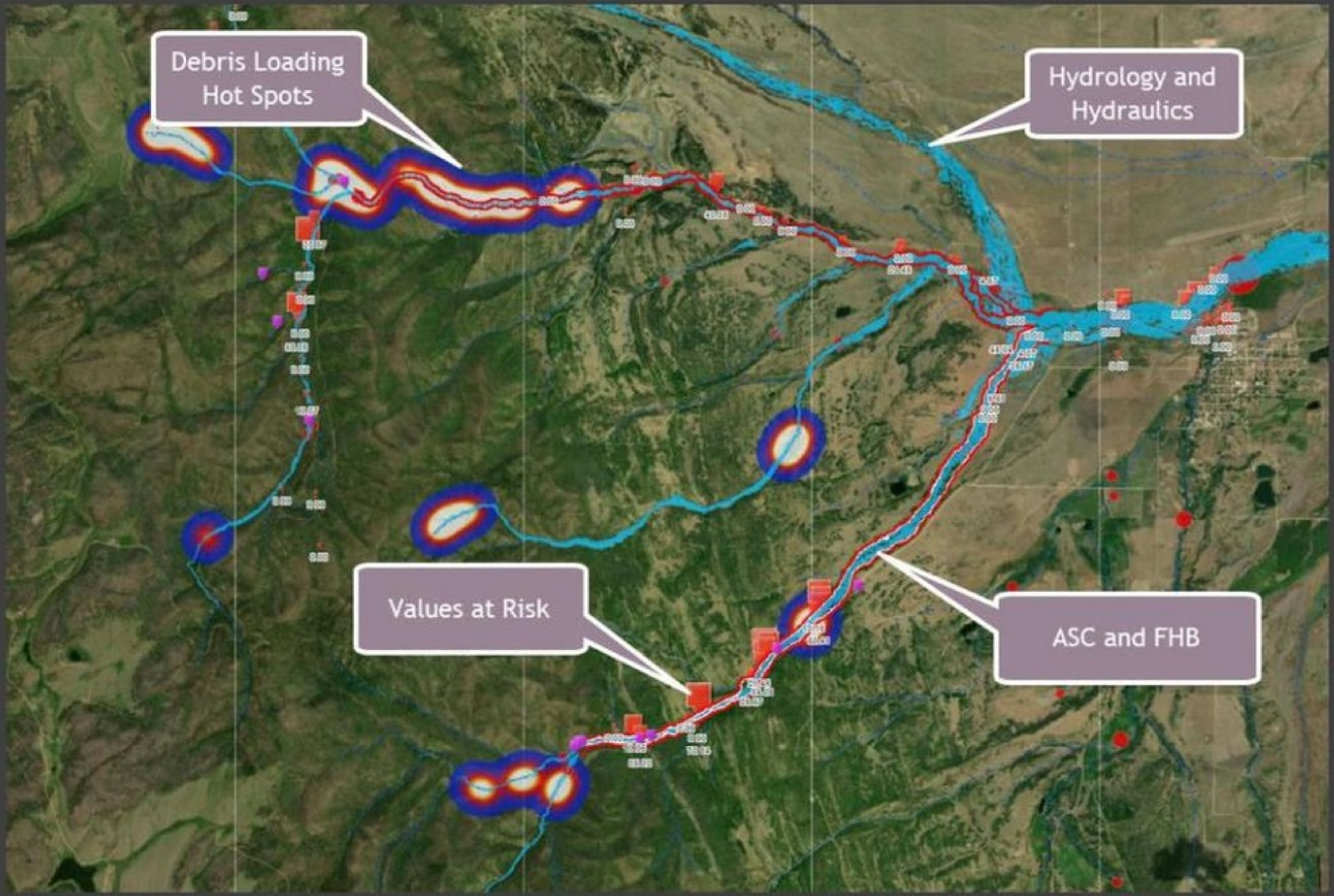


- Increased Flows
- Increased Sediment and Debris
- Faster Peaking Times
- Overall, increased risks for people inside and downstream of a burn scar

Sediment Balance



Story behind Today's Presentation



- Spring Creek Fire
- Rapid Pre and Post Hydrology and Hydraulics
- It was better to have something even if not perfect then to wait for a longer study.
- Longer more accurate studies *didn't necessarily change the outcomes*
  - Post fire flows were higher
  - Values at risk were still at risk
  - Resulting hydraulics had minimal differences
- We could do this before it happens!

Lessons Learned

- Rapid Hydrology and Hydraulics could be Conducted Before, During, or Immediately After
  - Better to have some information than to wait for a more refined study.
  - Take effort to calibrate or match regional estimates, but nothing needs to be perfect.
- Large Scale 2D hydraulics can be developed quickly
  - A comparison of three different hydraulic studies on Spring Creek showed that the first, rapid 2D model developed in a week provided just as much information as ones developed over a year.
  - Weigh the value of detail versus time
- Values at Risk can be Quickly Identified with GIS
  - Compare Relative Risk
  - Don’t get too hung up on the exact number, what's at higher and lower risk

General tasks typically performed after a fire

- Community engagement and understanding of risk
- Flood warning systems
- Hydrology estimates
- Hydraulics
- Identifying "Values at Risk"
- Damage Survey Reports
- Agencies coordination on land agreements, usage, etc
- Mulch, seed, debris clean up, project identification

But some of these can start before fires happen

- Community engagement
- Thinking about where flood warning systems should go
- Thinking about values at risk
- Agencies coordination
- Projects to increase resilience to flooding (e.g. improving riparian vegetation, changing culverts, etc)
- And…

Pre-Fire Work

Land Management Practices

Fire Breaks and Clearing

Technical Work (H and H, VAR, etc)

Today's Presentation will Focus on These Items

Common Tasks Performed After a Fire

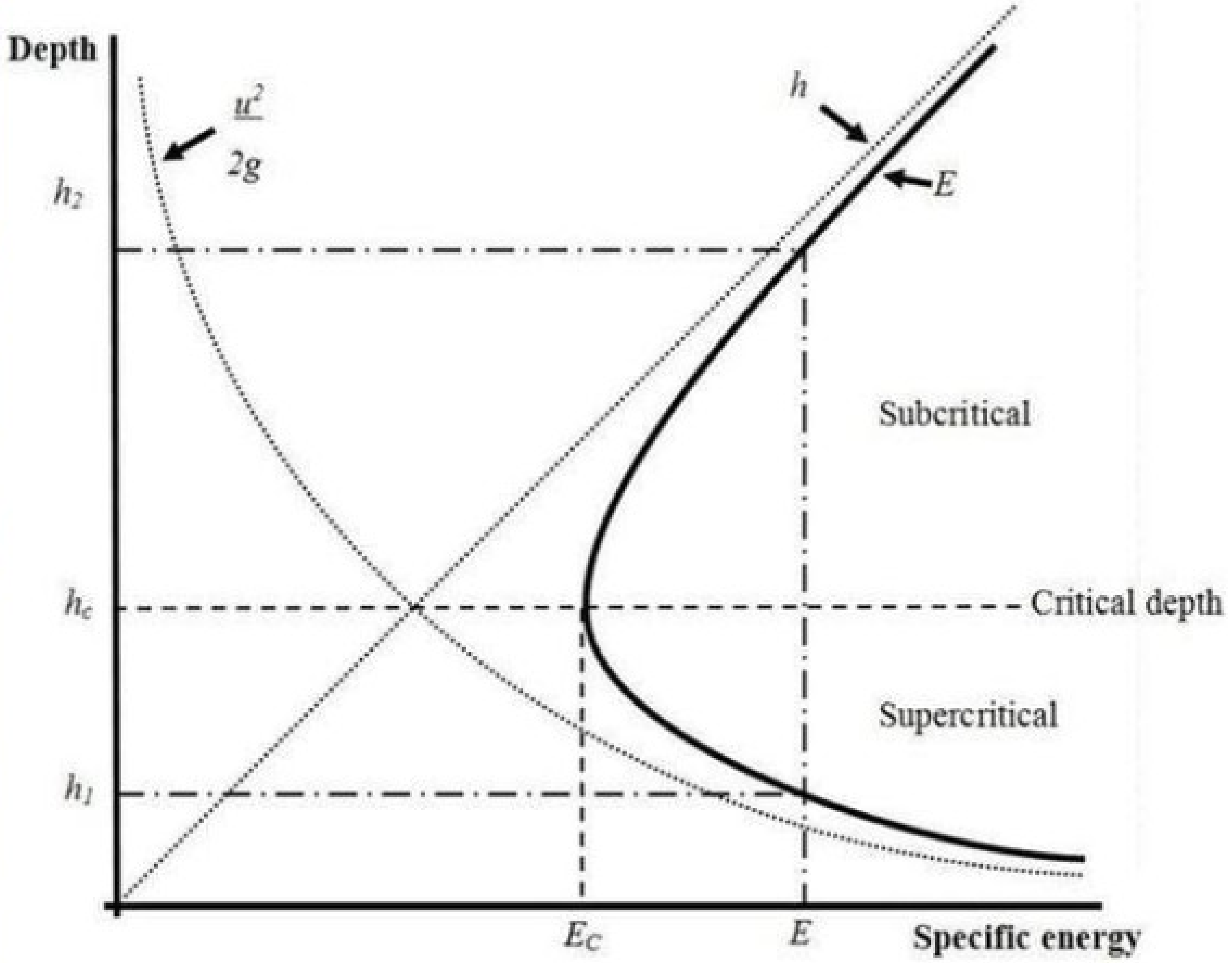
Community Engagement

- Not my expertise, Engineer's can't do everything
- Critical to Recovery and Safety
- Get an Expert
- Likely Difficult to get started without the fire, but can plan ahead

Flood Warning Systems

- Rainfall, Velocity and Depths
- Identify Existing Gages if Unknown
- Understand coverage in area, for example does NWS have good coverage, would extra rain networks help?
- ID Potential Locations with access and Lead Times
- Sign up for Alerts through USGS, NWS, or Local Flood Control.
- Is there QPF Forecasting available? What would it take to activate this if a Fire Happened?
- Have a Draft SOW and Plan for Procuring, Installing, and Monitoring a Warning System

Flood Warning Systems

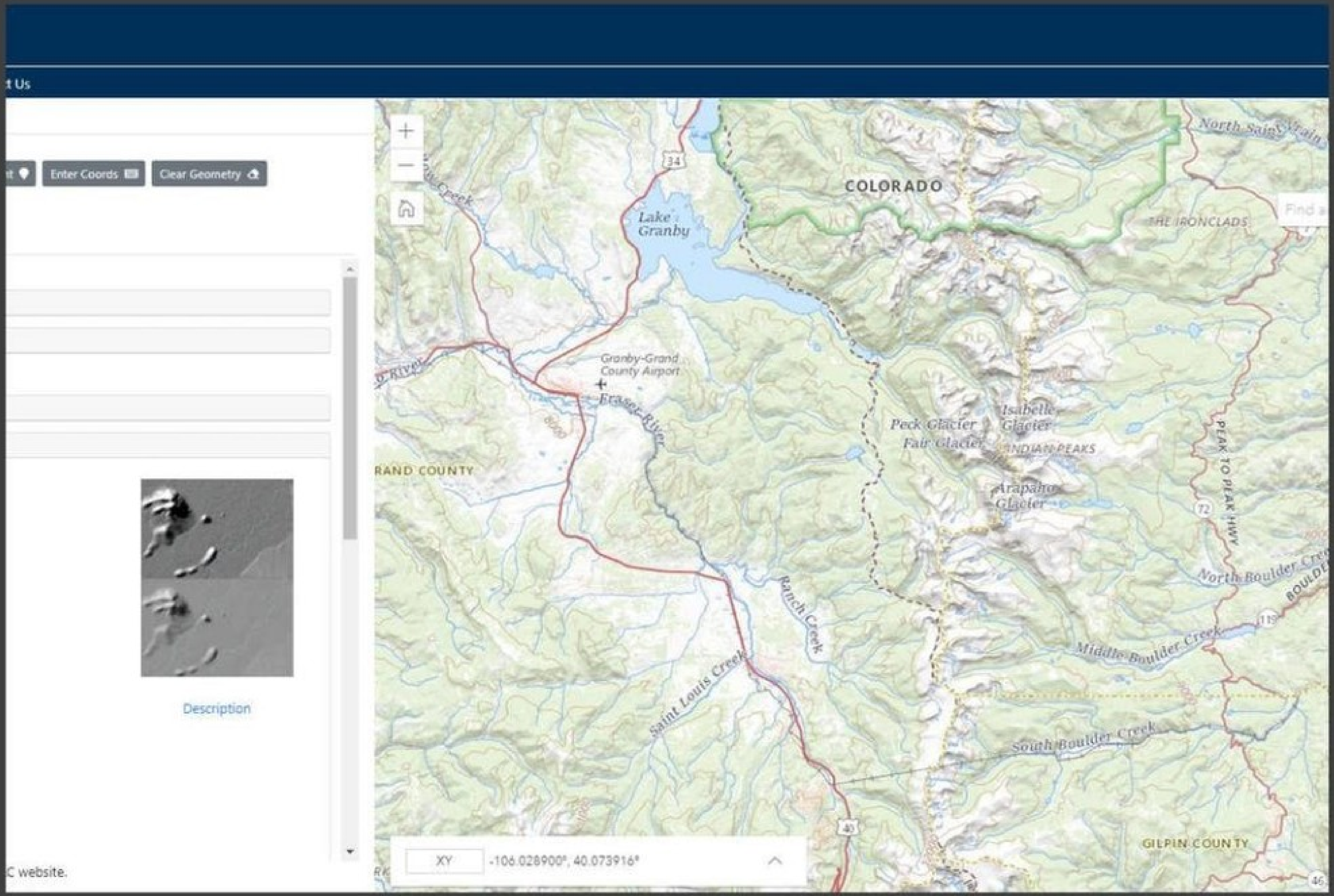


- Selecting a Location
- Lead Times
  - Critical Depth
  - L/v $= L/\sqrt{gy}$
  - Or Normal Depth
  - $v = \frac{1.49}{n} * R^{\frac{2}{3}} * \sqrt{S}$
  - Kinematic
  - $t = \frac{0.93 * L^{0.6} * n^{0.6}}{R^{0.4} * S^{0.3}}$
- Control Section (Minimum Specific Energy)
- Stability

What tasks do you wish you had worked on before the fire?

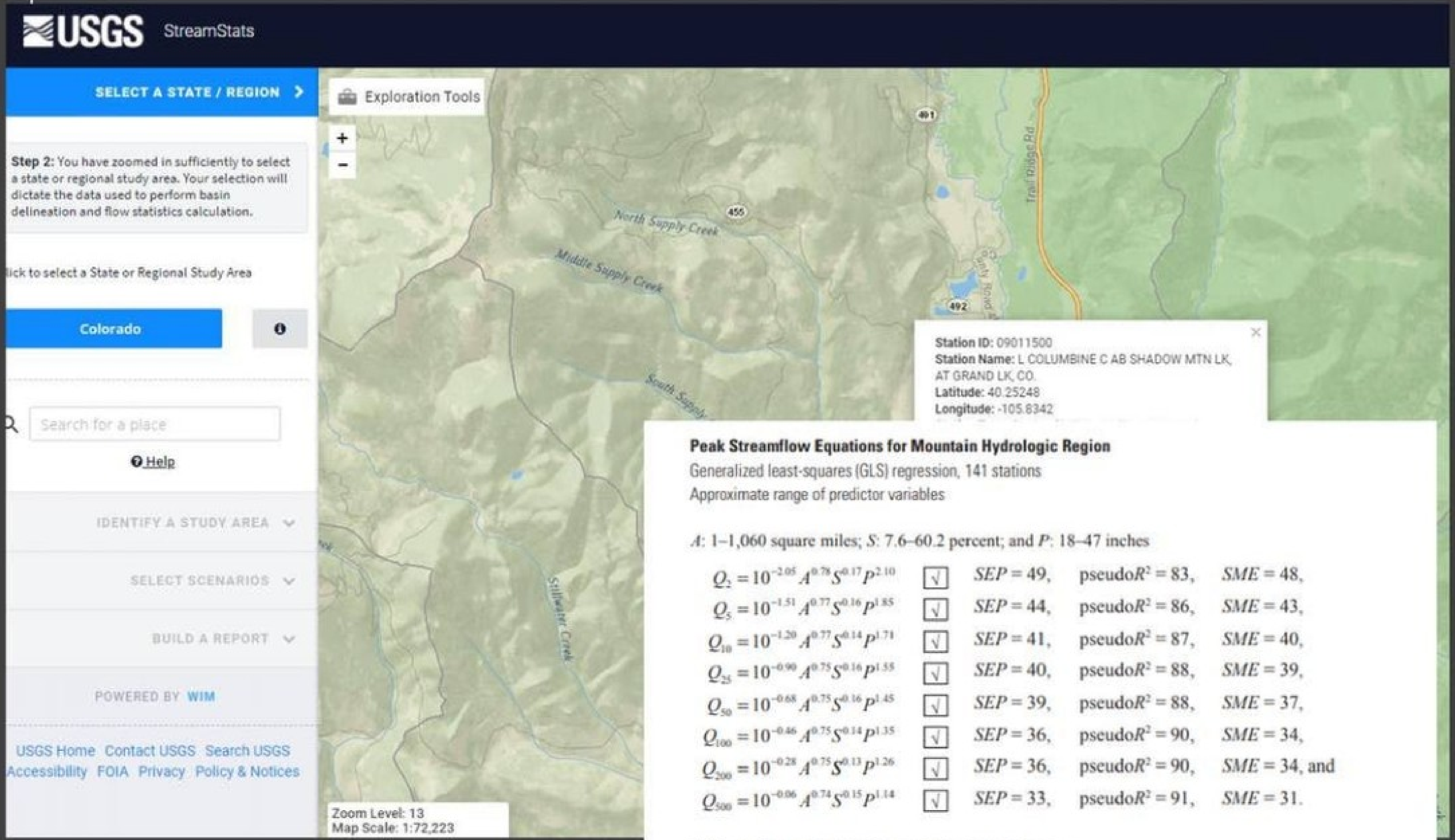
What Data is Available Before or After a Fire

Hydrology Data



- National Elevation Data Set
  - What is the resolution of a 1/3 arc second?
    - 10m
- Soils
  - SSURGO and STATSGO
- Land Use
  - NLCD 2006, 2011, 2016

Hydrology Data



Peak Streamflow Equations for Mountain Hydrologic Region

Generalized least-squares (GLS) regression, 141 stations

Approximate range of predictor variables

A: 1–1,060 square miles; S: 7.6–60.2 percent; and P: 18–47 inches

$Q_2 = 10^{-2.05} A^{0.78} S^{0.17} P^{2.10}$ √ $SEP = 49$, pseudo$R^2 = 83$, $SME = 48$,

$Q_5 = 10^{-1.51} A^{0.77} S^{0.16} P^{1.85}$ √ $SEP = 44$, pseudo$R^2 = 86$, $SME = 43$,

$Q_{10} = 10^{-1.20} A^{0.77} S^{0.14} P^{1.71}$ √ $SEP = 41$, pseudo$R^2 = 87$, $SME = 40$,

$Q_{25} = 10^{-0.90} A^{0.75} S^{0.16} P^{1.55}$ √ $SEP = 40$, pseudo$R^2 = 88$, $SME = 39$,

$Q_{50} = 10^{-0.68} A^{0.75} S^{0.16} P^{1.45}$ √ $SEP = 39$, pseudo$R^2 = 88$, $SME = 37$,

$Q_{100} = 10^{-0.46} A^{0.75} S^{0.14} P^{1.35}$ √ $SEP = 36$, pseudo$R^2 = 90$, $SME = 34$,

$Q_{200} = 10^{-0.28} A^{0.75} S^{0.13} P^{1.26}$ √ $SEP = 36$, pseudo$R^2 = 90$, $SME = 34$, and

$Q_{500} = 10^{-0.06} A^{0.74} S^{0.15} P^{1.14}$ √ $SEP = 33$, pseudo$R^2 = 91$, $SME = 31$.

Minimum Streamflow for Mountain Hydrologic Region

Generalized least-squares (GLS) regression, 124, 118, and 111 stations

Approximate range of predictor variables

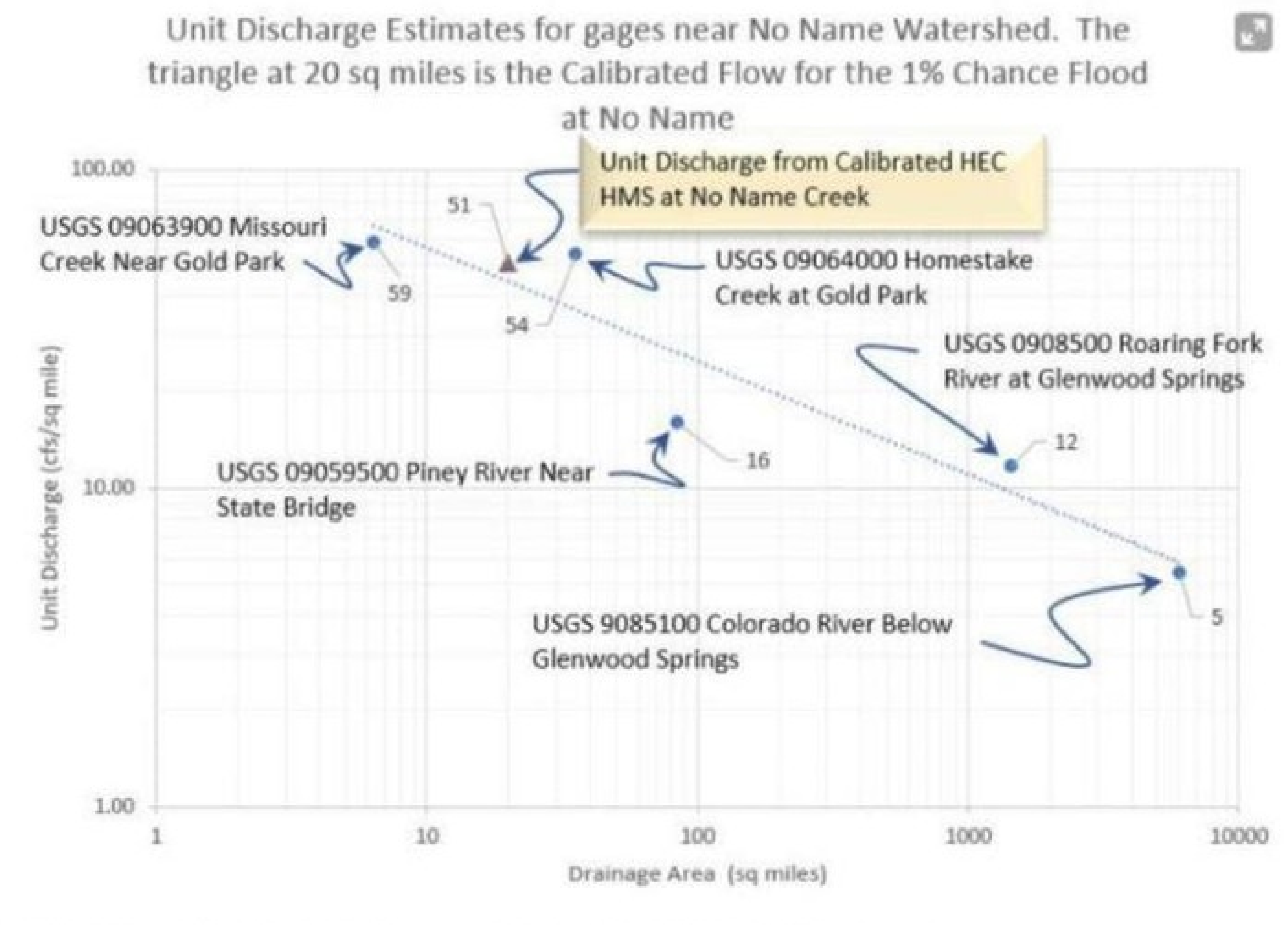
A: 1–1,060 square miles; P: 18–47 inches; and E: 8,600–12,000 feet elevation

${}_7Q_2^{min} = 10^{-26.56} A^{1.13} P^{1.26} E^{5.85}$ √ $SEP = 89$, pseudo$R^2 = 80$, $SME = 87$,

${}_7Q_{10}^{min} = 10^{-33.76} A^{1.20} P^{2.25} E^{7.20}$ √ $SEP = 153$, pseudo$R^2 = 67$, $SME = 148$, and

${}_7Q_{50}^{min} = 10^{-18.56} A^{1.17} P^{1.86} E^{3.56}$ √ $SEP = 126$, pseudo$R^2 = 72$, $SME = 122$.

- Regional Regression
- Gage Data
- Good for Pre-Fire Calibration, Hard for Post Fire
- Pay attention to Standard Model Error (SME) and Standard Error of Prediction (SEP)

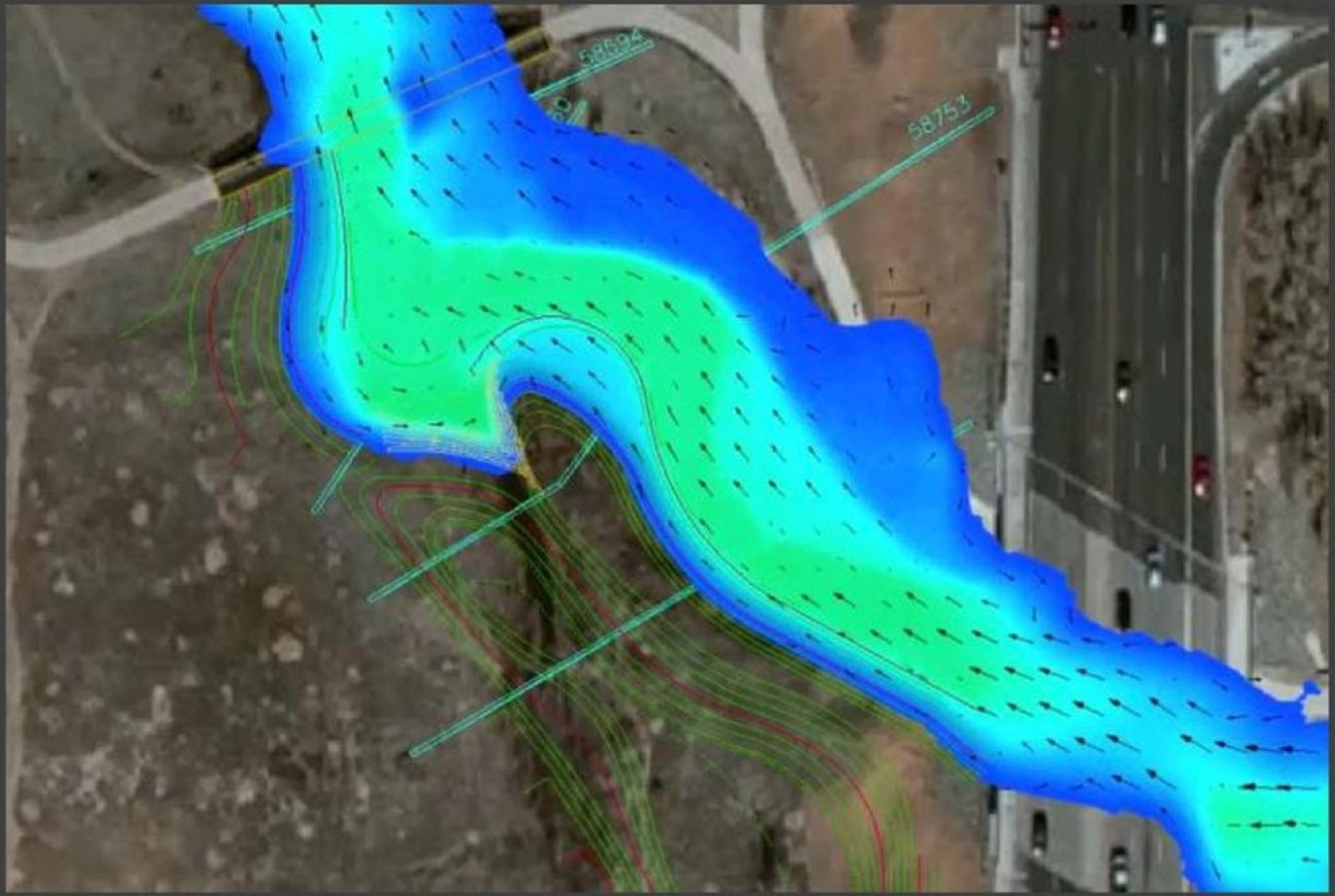


Unity Discharge of Gages with Drainage Areas ranging from 6,000 to six (6) Square Miles

Hydrology Data

- Gage Data
- Good for Pre-Fire Calibration, Hard for Post Fire
- Try to find similar drainage areas for unit discharge comparisons

Hydraulic Data

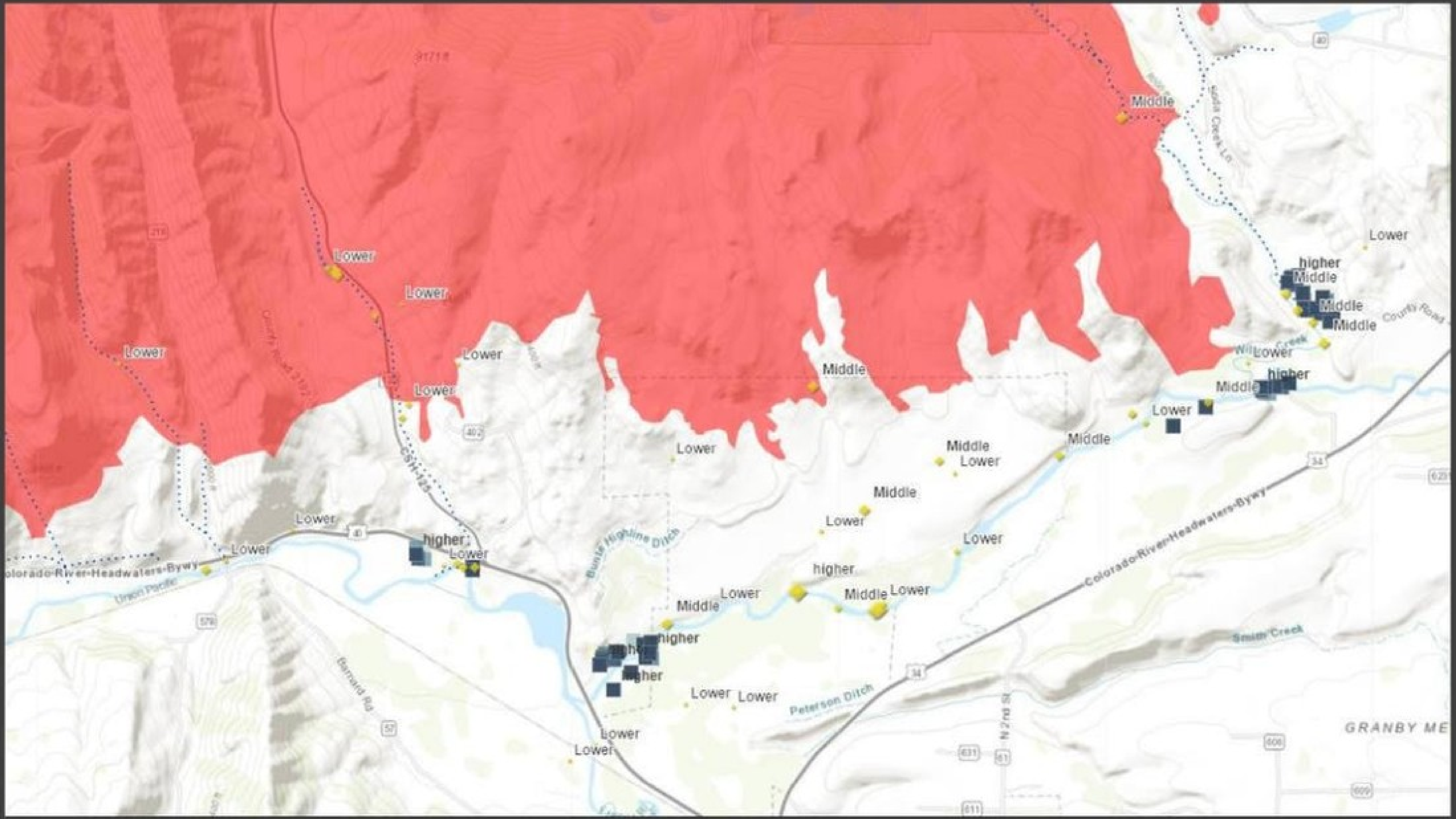


- Information Required:
  - Topography
    - Usually Available
  - Roughness
    - Can use NLCD
  - Flow from Hydrology or Past Studies

Information Gathered:

1. Depths
2. Velocities
3. Stream Power
4. Shear
5. Banks and Channel

GIS Data



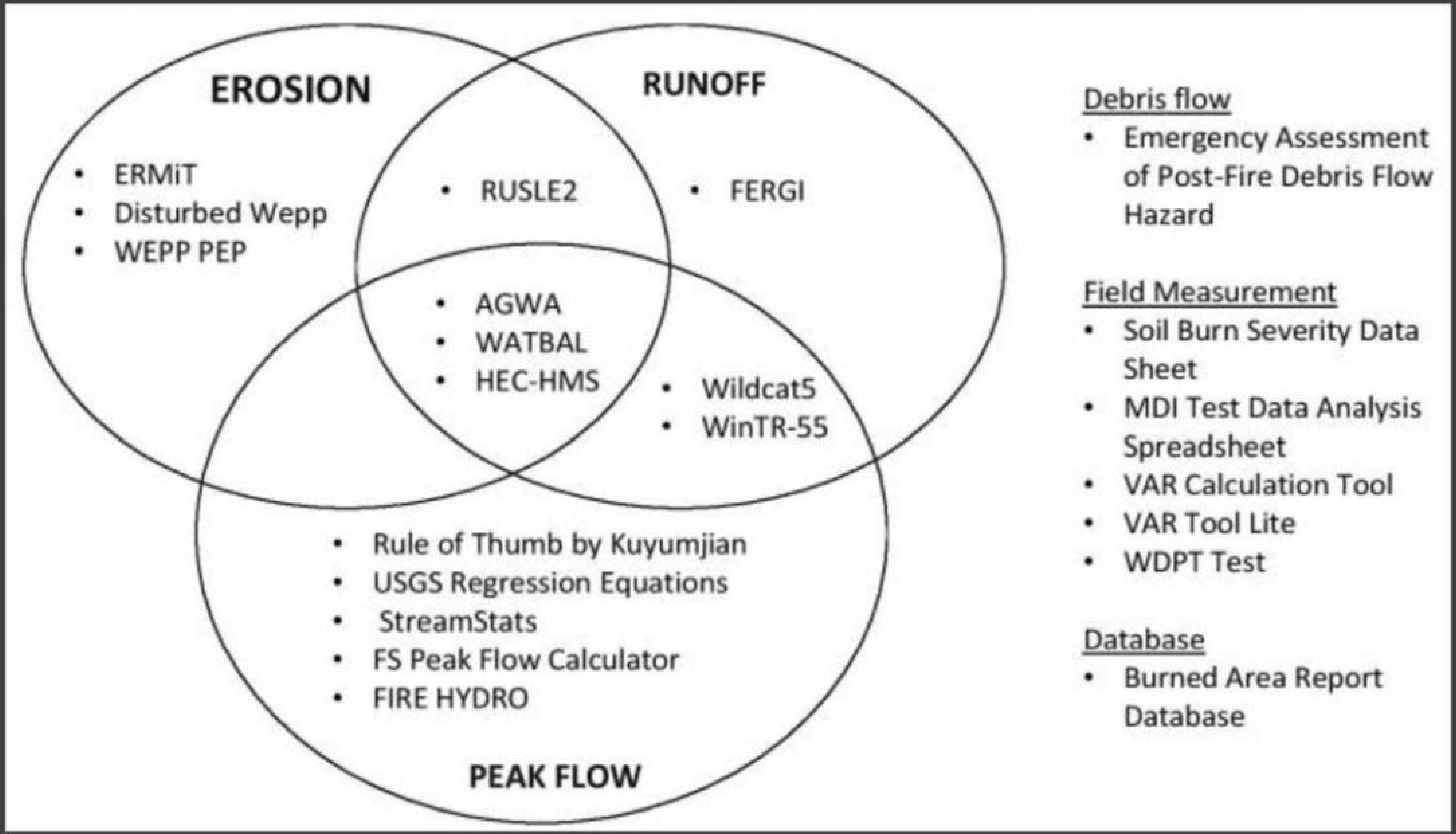
- Much of the GIS Data Pre Fire is usually available, Such as:
  - Structure Footprints
  - Diversions
  - Culverts
  - Bridges
- Missing GIS Data Pre Fire is Typically
  - Burn Severity (BAER) and Perimeter

Questions & Comments

Bio Break! Please enjoy the The Adventures of Junior Raindrop during the short break.

More on Effects of Fire on Hydrology

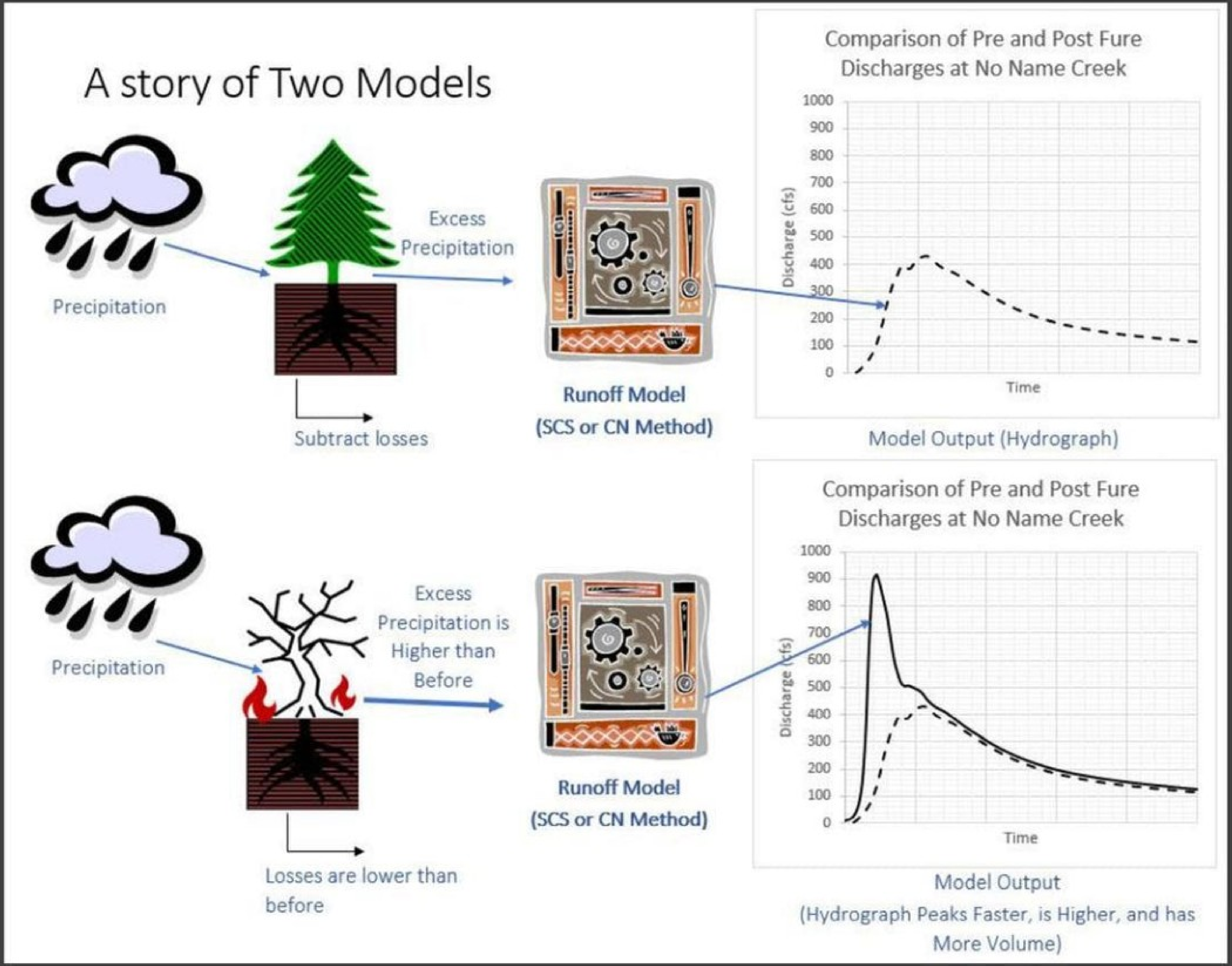
Modeling Effects of Fire on Hydrology



Insert REFERENCE

- When estimating the impacts from a fire, we want to know:
  - Change in Volume
  - Change in Peak Flow
  - Change in Erosion
  - Change in Basins “timing”

Effects of Fire on Hydrology



- HEC HMS can simulate
  - Increased Sediment and Debris
  - Faster Peaking Times
  - Changes in Runoff Volume and Peak
  - Precipitation Frequency
- Simpler Programs such as Stream Stats can simulate
  - Pre fire peak flow
  - Annual Volumes
  - Gage statistics

In a few words, describe an experience you had with post-fire flooding:

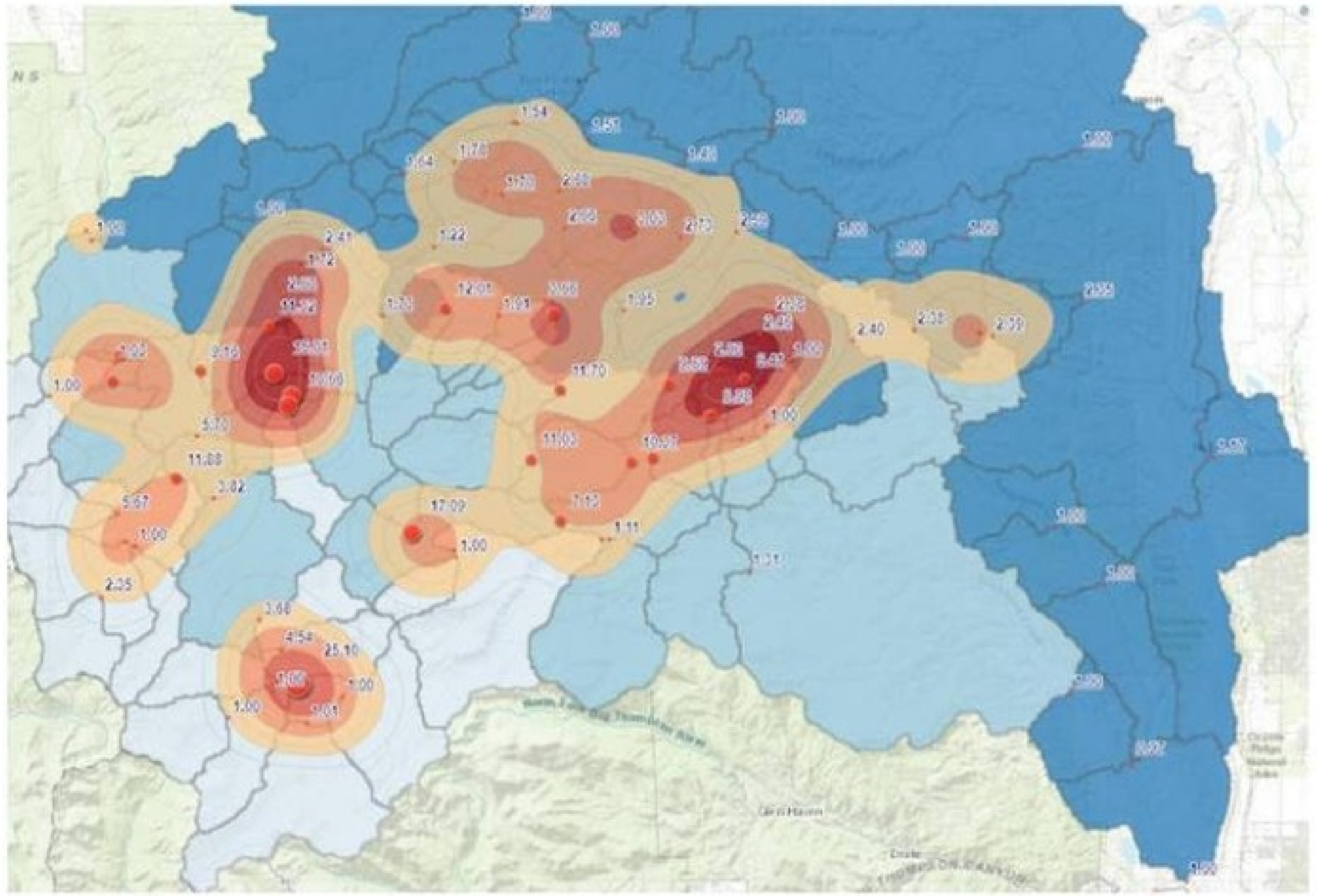
Estimating Future, Unknown Events

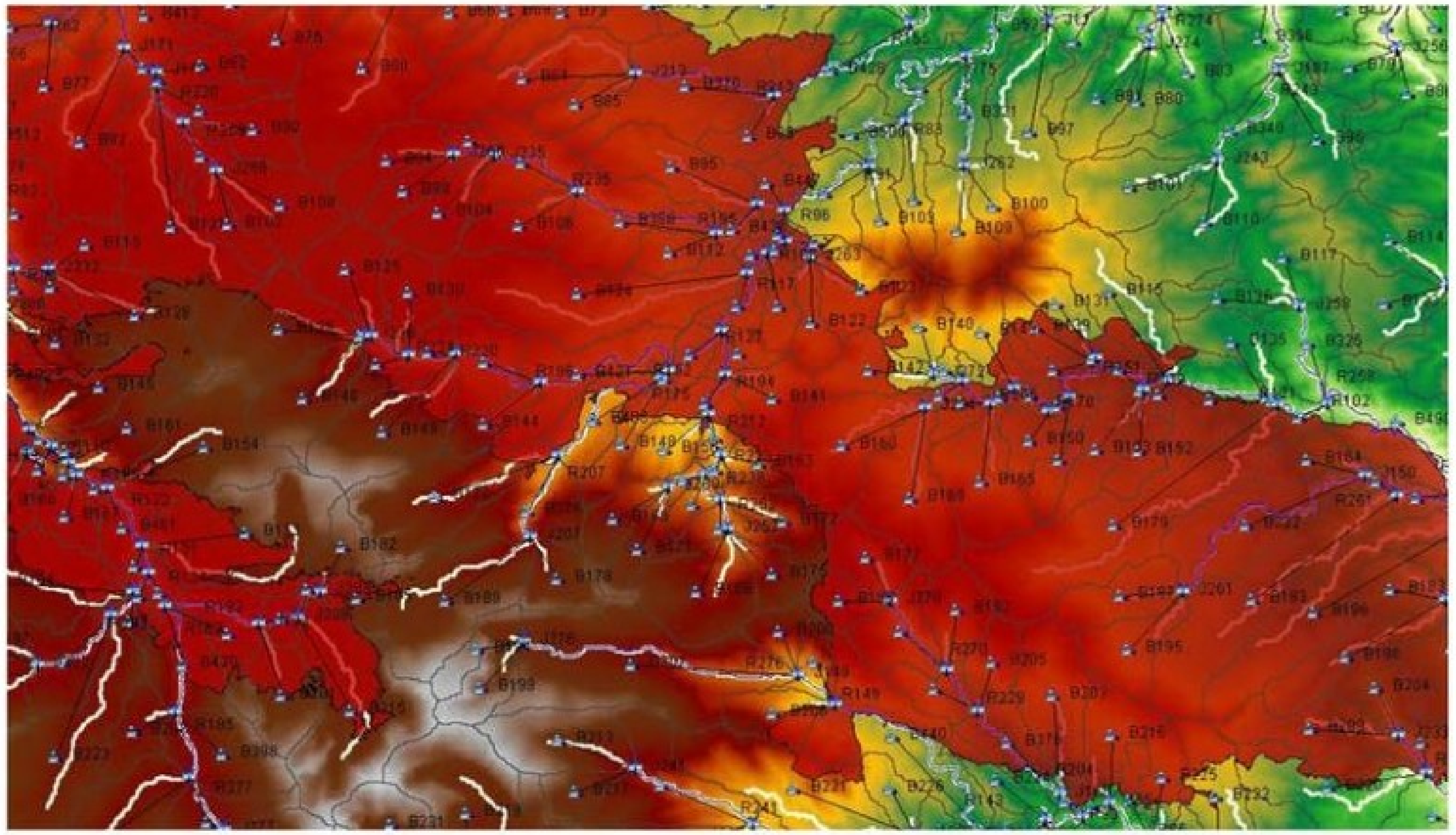
It's easy to explain what has already happened, its much harder to predict and protect from what is yet to occur.

The Buffalo Creek Fire in May 1996 burned 4,690 hectares in the mountains southwest of Denver, Colorado. This wildfire lowered the erosion threshold of the watershed. As a consequence of this wildfire, a 100-year rainstorm in July 1996 caused erosion upstream and deposition of this alluvial fan at the mouth of a tributary to Buffalo Creek. Buffalo Creek is flowing to the right at the bottom of the photograph. (Credit: R. H. Meade, USGS.)

Estimating Unknown Events

- We don’t know the storm.
- We don’t necessarily know the response.
- We can estimate these ranges by following standards for:
  - Changes in time of response from burn. (Timing)
  - Changes in land cover from burn scar.
  - Changes in infiltration and volume.
  - Hypothetical Storms.

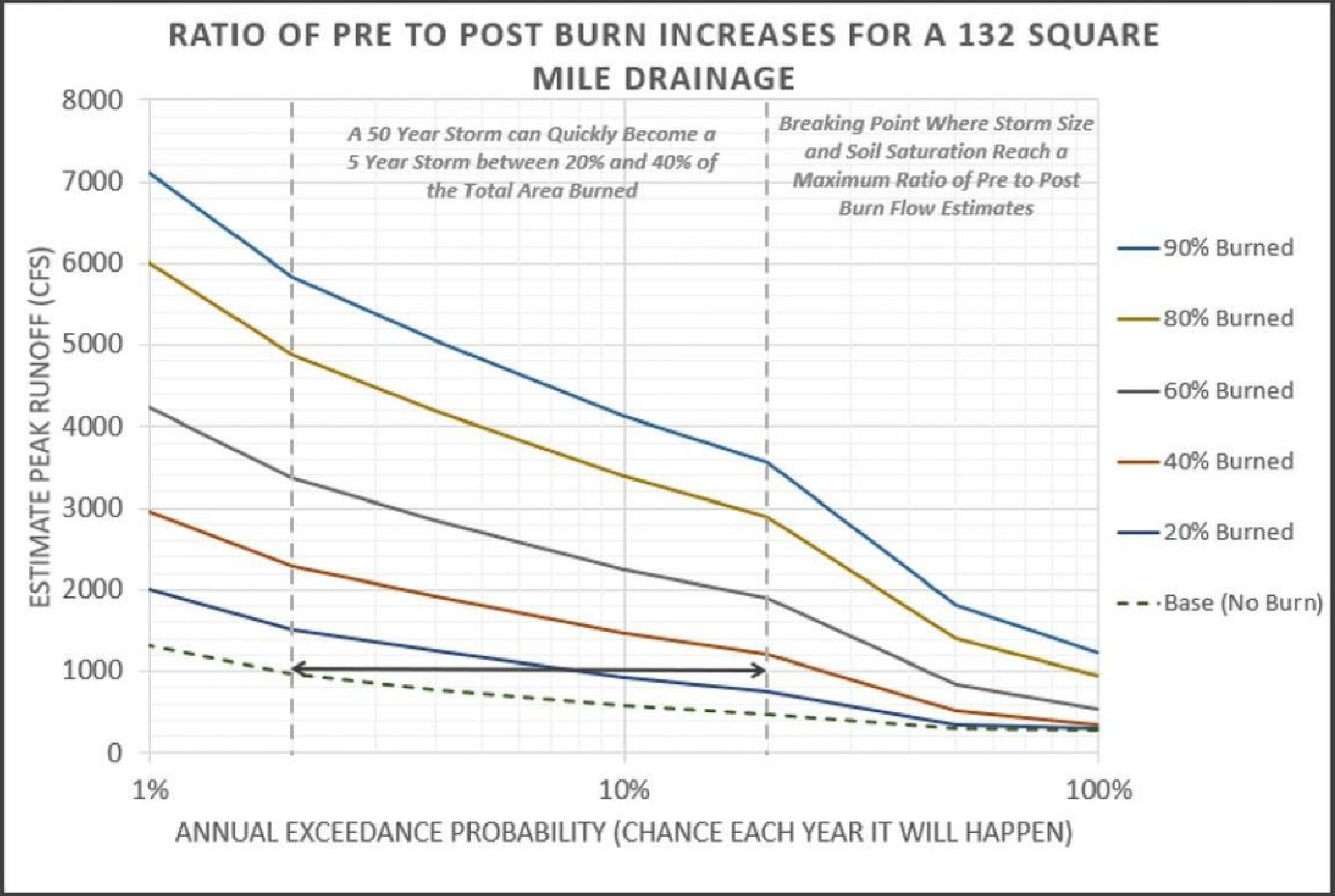




Estimating Risks from Fire Before the Fire

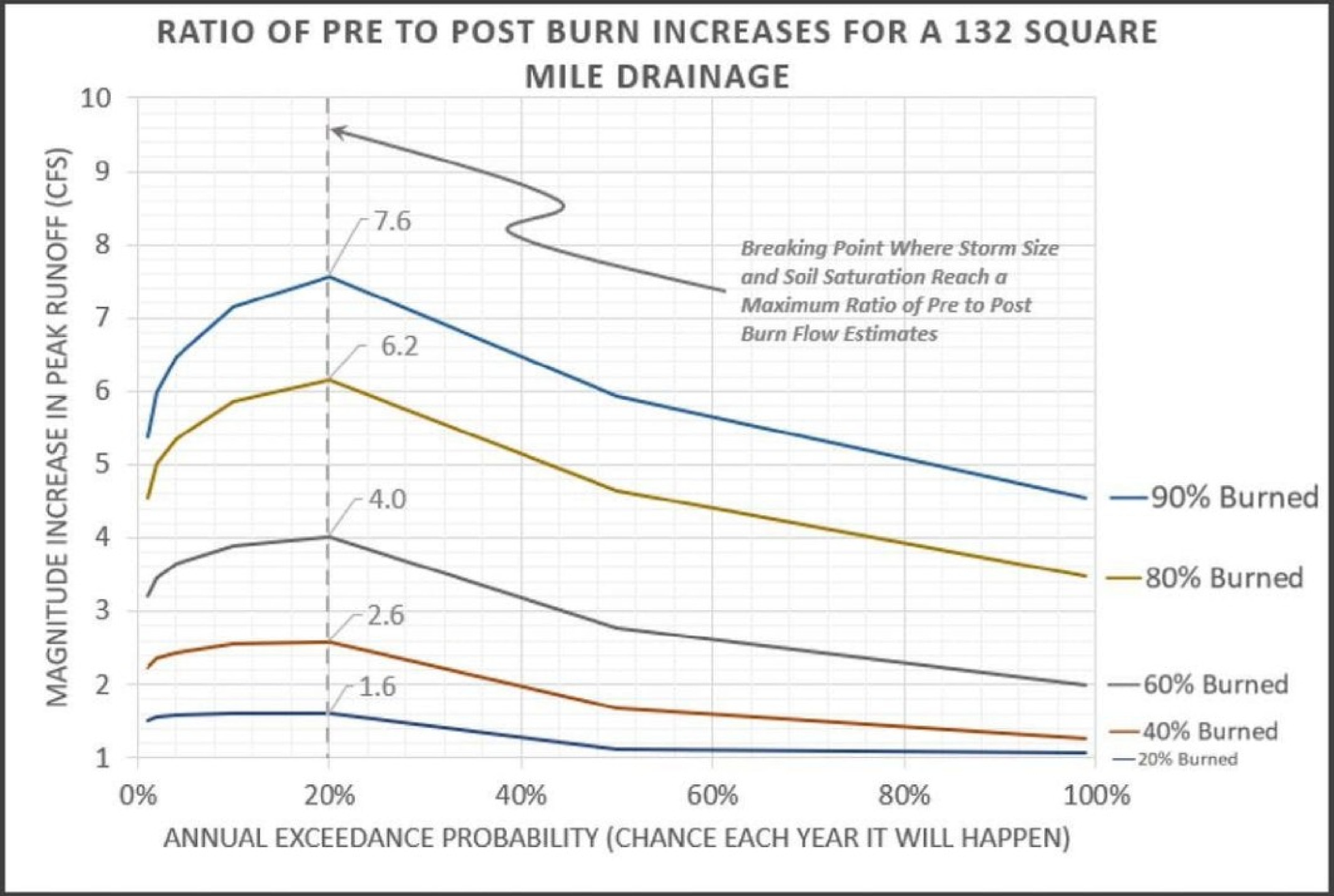
- Don’t know Area Burned
- Don’t Know Intensity
- But we can make a range of estimates of what might happen after a fire

Change in Peak Runoff by Percentage Burned



- Depending on the Burn Severity, the Increases in Runoff can be Dramatic.
- A 100-year Storm can quickly become a 10-year storm
- A 50-year runoff event can quickly become something expected in 5 years

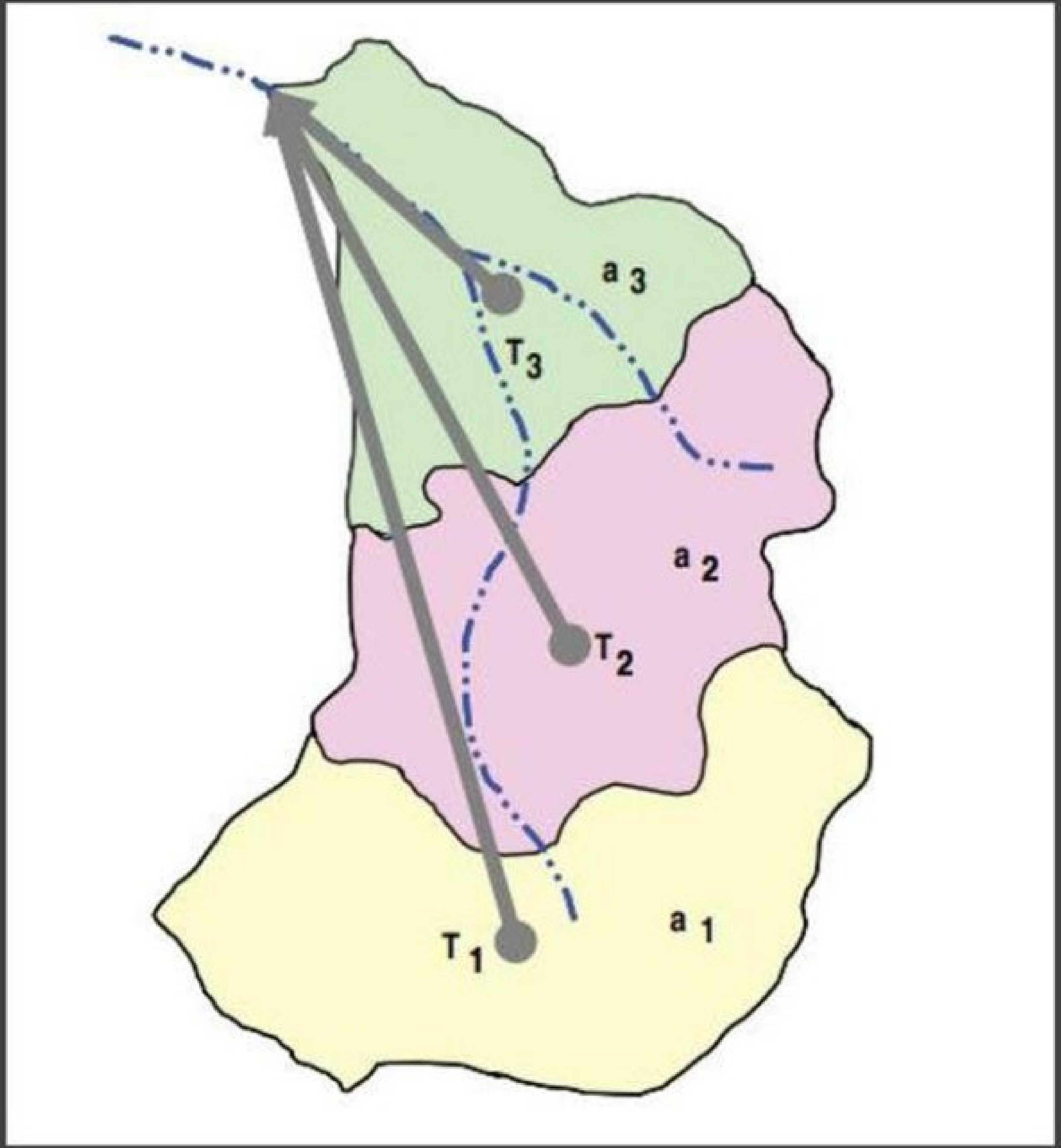
Magnitude Change by Percentage Burned

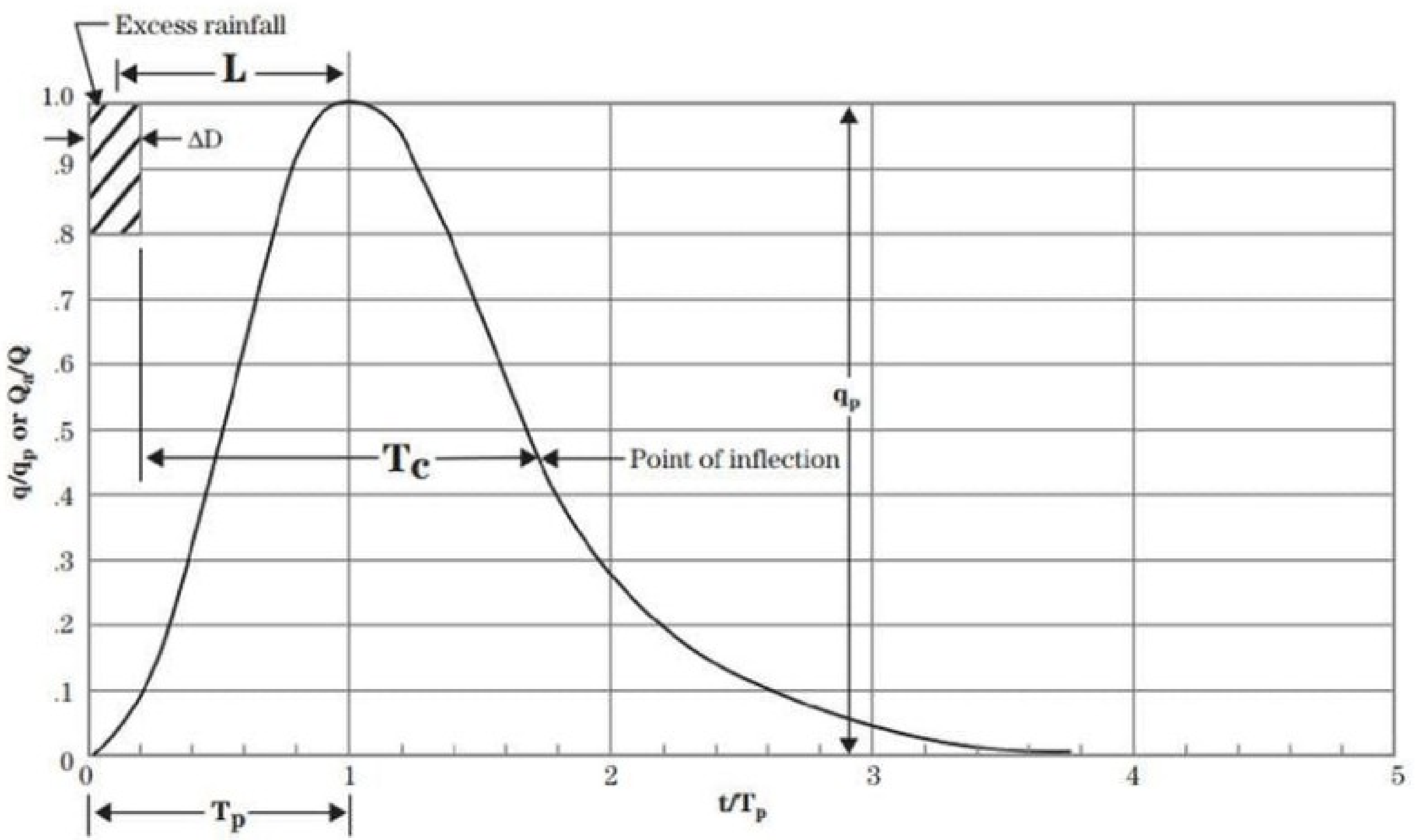


- Graphing by Ratios Helps Understand the Most Common Question, How Much More?
- Graphing Orders of Magnitude can Show Interesting Results when Compared with Annual Exceedance Probabilities (AEP).
- Following the SCS Procedure, there is a breaking point on the AEP that produces a Maximum Increase.
- The location of this Maximum will be unique for each storm, watershed, and locality.

Applying Common Methods for Burn Hydrology - Timing

- When we model unknown/future events, we follow a standard of practice using hypothetical storms and synthetic unit graphs.
- One of the most fundamental concepts is the time of concentration.
  - ***The storm duration must be longer than the time of concentration of a basin***





where:
L = Lag, h
T_c = time of concentration, h
T_p = time to peak, h
ΔD = duration of excess rainfall, h
t/T_p = dimensionless ratio of any time to time to peak

Lag Method

$$T_c = \frac{\ell^{0.8}(S+1)^{0.7}}{1{,}140Y^{0.5}}$$

where:

L = lag, h

T_c = time of concentration, h

ℓ = flow length, ft

Y = average watershed land slope, %

S = maximum potential retention, in

$$= \frac{1{,}000}{cn'} - 10$$

where:

cn′ = the retardance factor

Velocity Method

$$T_c = T_{t1} + T_{t2} + T_{t3} + \ldots T_{tn} \qquad \text{(eq. 15–7)}$$

where:

T_c = time of concentration, h

T_{tn} = travel time of a segment n, h

n = number of segments comprising the total hydraulic length

Travel Time

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5}S^{0.4}} \qquad \text{(eq. 15–8)}$$

where:

T_t = travel time, h

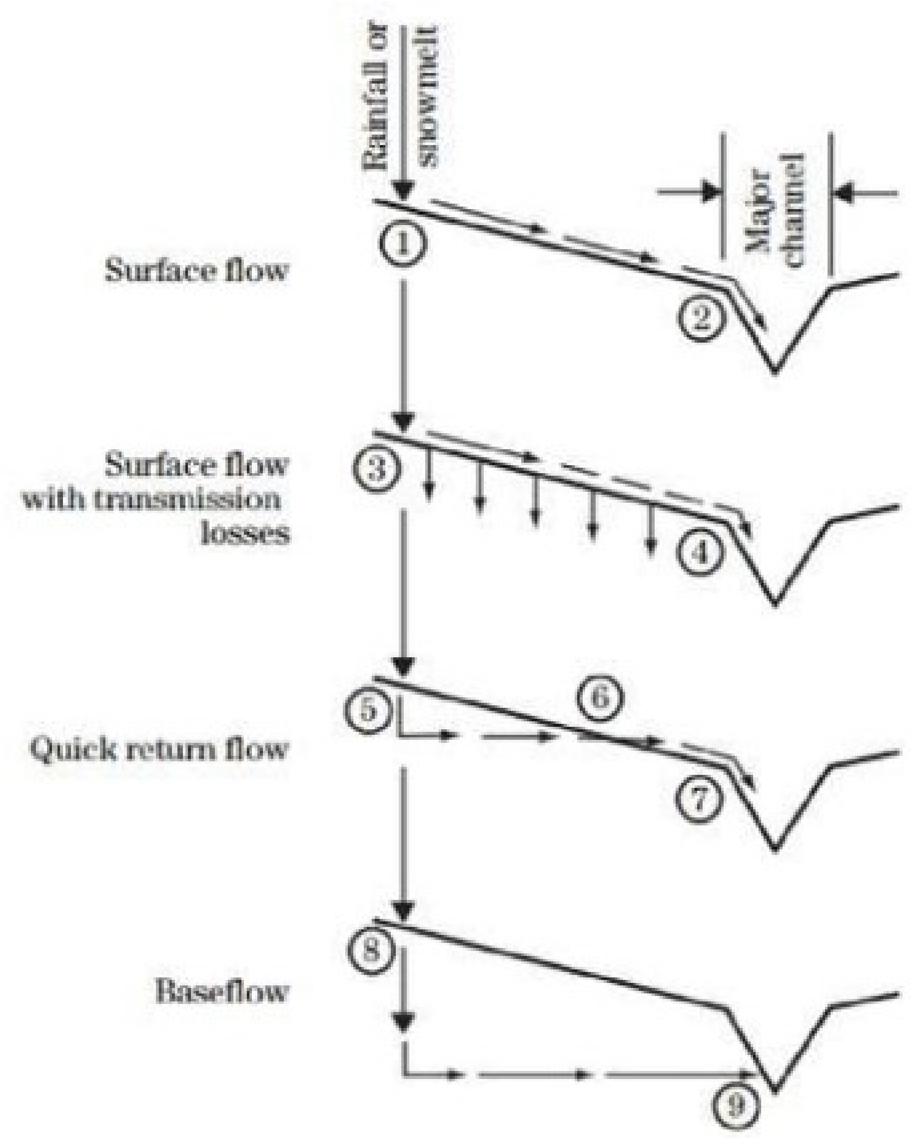
n = Manning's roughness coefficient (table 15–1)

ℓ = sheet flow length, ft

P_2 = 2-year, 24-hour rainfall, in

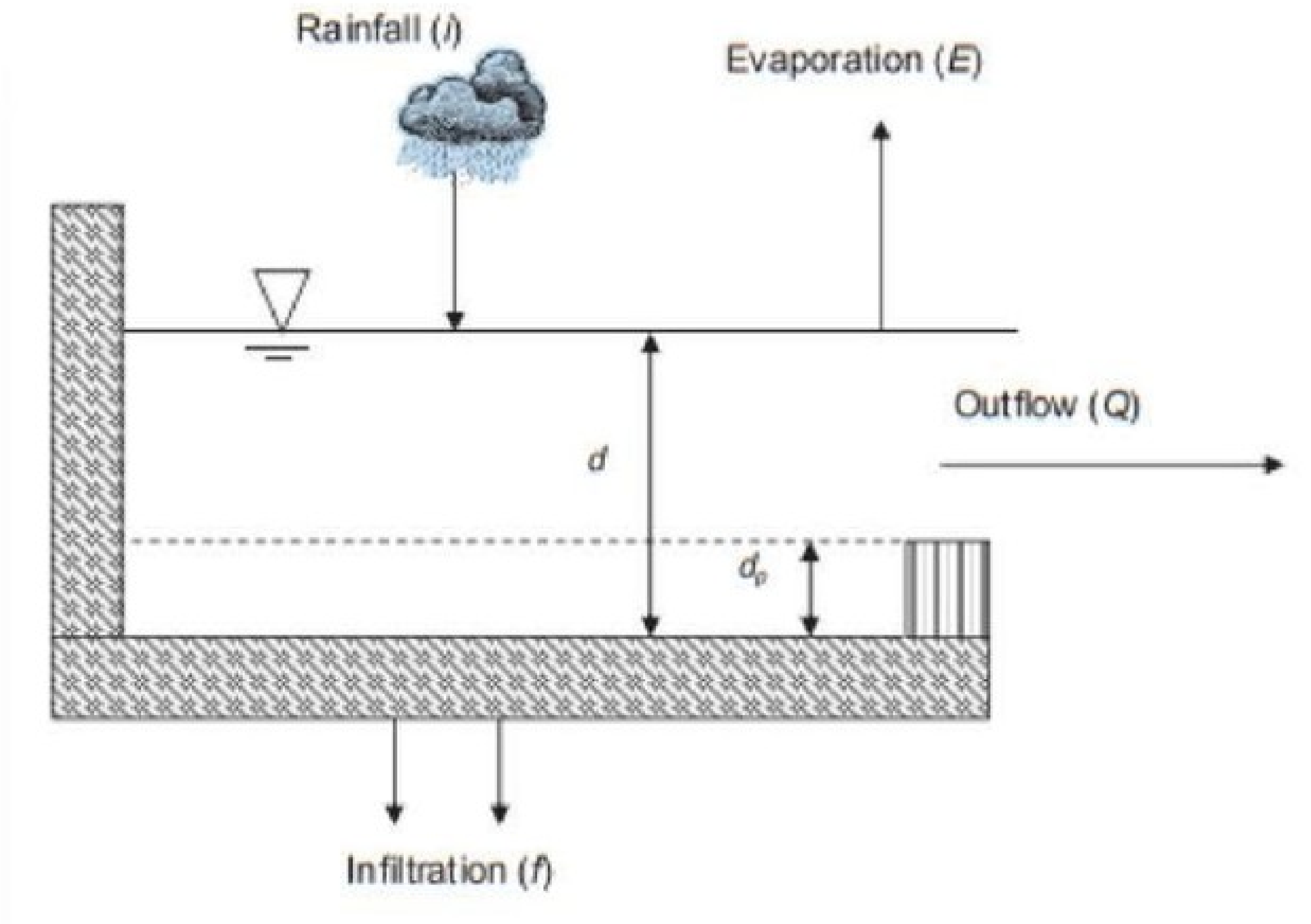
S = slope of land surface, ft/ft

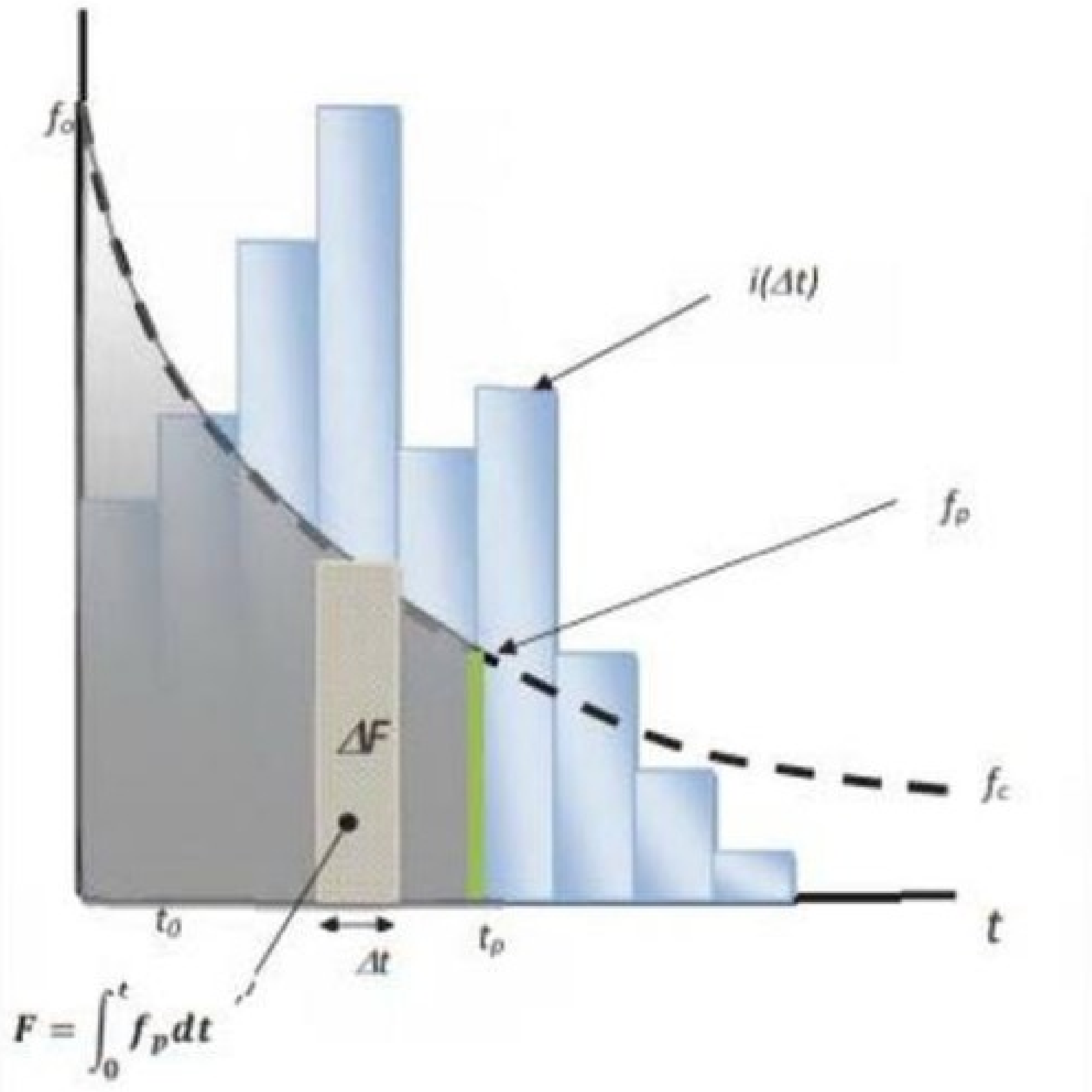
Types of Flow



Estimating Travel Time

- Use a method that changes with the changed land cover that results from a fire
- This can be a watershed method that changes with a retardance factor
- Or a combination of travel segments that are adjusted for lower roughness values





Estimating Losses

- Be cognizant of the methodology:
- Is it time dependent?
- Are there good post fire reference values?

Estimating Hydrologic Losses Post Fire

Storage Method

$$S = \begin{cases} \frac{1000 - 10\,CN}{CN} & \text{(foot – pound system)} \\ \frac{25400 - 254\,CN}{CN} & \text{(SI)} \end{cases}$$

$$CN_{composite} = \frac{\sum A_i CN_i}{\sum A_i}$$

Good Post Fire Research, not Time Dependent

Initial and Constant Method

$$pe_t = \begin{cases} 0 & \text{if } \sum p_i < I_a \\ p_t - f_c & \text{if } \sum p_i > I_a \text{ and } p_t > f_c \\ 0 & \text{if } \sum p_i > I_a \text{ and } p_t < f_c \end{cases}$$

Limited Post Fire Research, Easy to Apply

Green Ampt

$$f_t = K\left[\frac{1 + (\phi - \theta_i)S_f}{F_t}\right]$$

Some Post Fire Research, Complicated Variables

Runoff Coefficient

$$Q = CIA$$

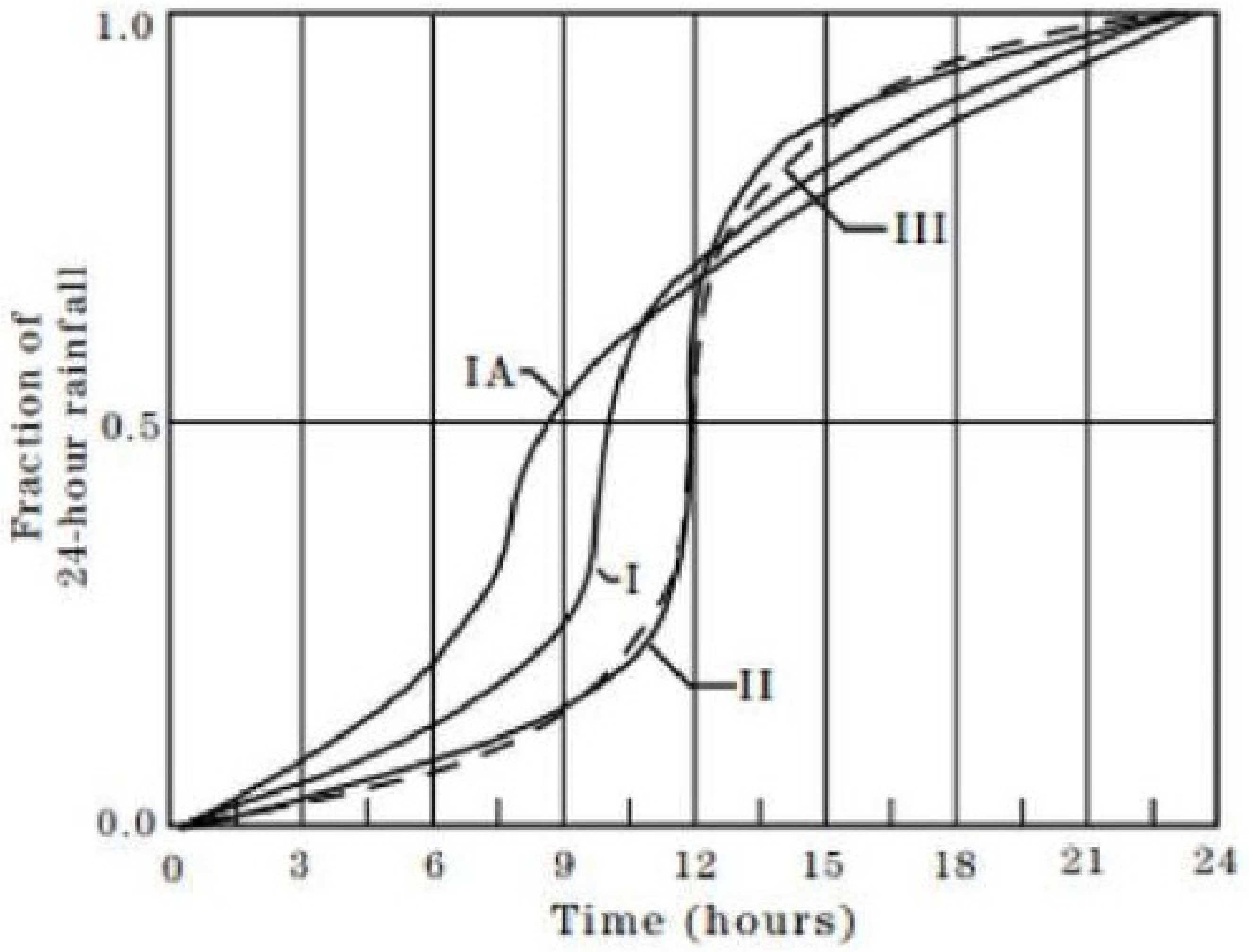
C= Runoff Coefficient

Some Post Fire Research, Limited to Small Basins, Easy to Apply

Picture of Rill Erosion after Buffalo Creek Fire, taken from USGS "Hydrologic and Erosion Responses of Burned Watersheds" (Moody J, USGS)

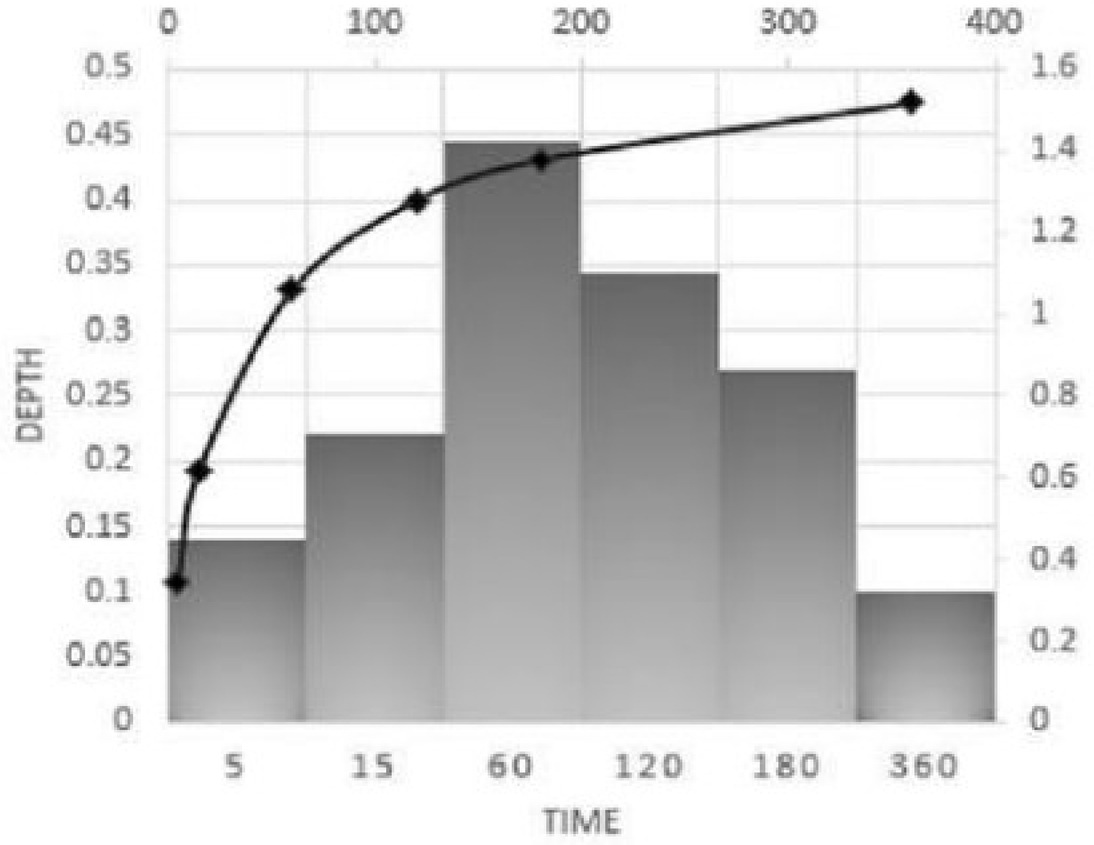
Building a Synthetic Storm

SCS Storms



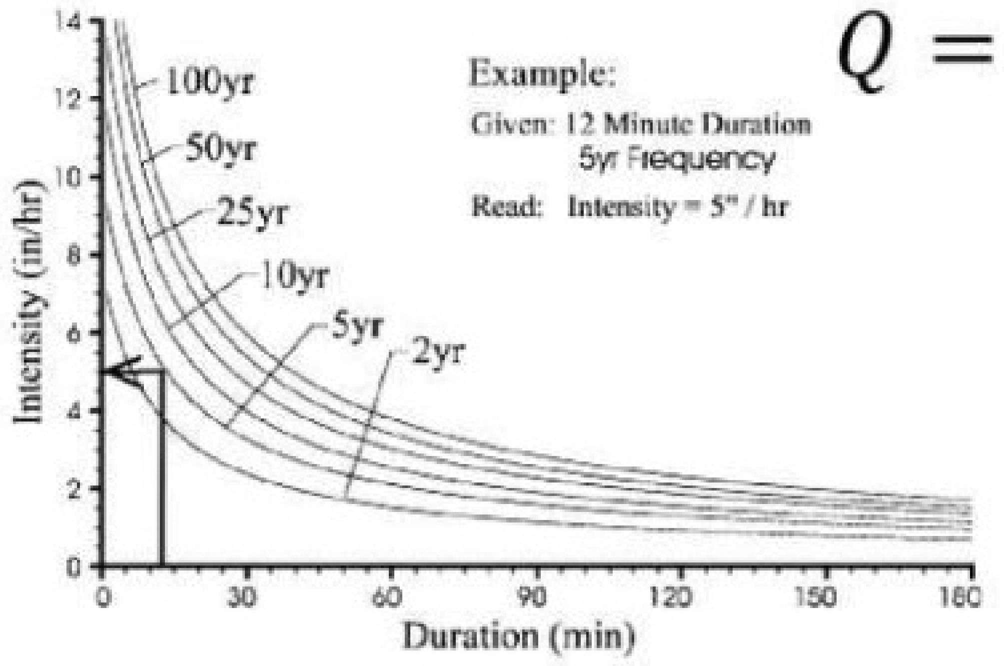
Frequency Storms

Depths from NOAA		Incrimental	Frequency Storm	
Time	Depth		Time (hr)	Depth (in)
5	0.345	0.345	1	0.14
15	0.615	0.27	2	0.22
60	1.06	0.445	3	0.445
120	1.28	0.22	4	0.345
180	1.38	0.1	5	0.27
360	1.52	0.14	6	0.1



Max Intensity Storms

$$Q = CIA$$



Local Storms

- Hydromet (Colorado)
- Local Drainage Criteria Manual

A synthetic storm is:

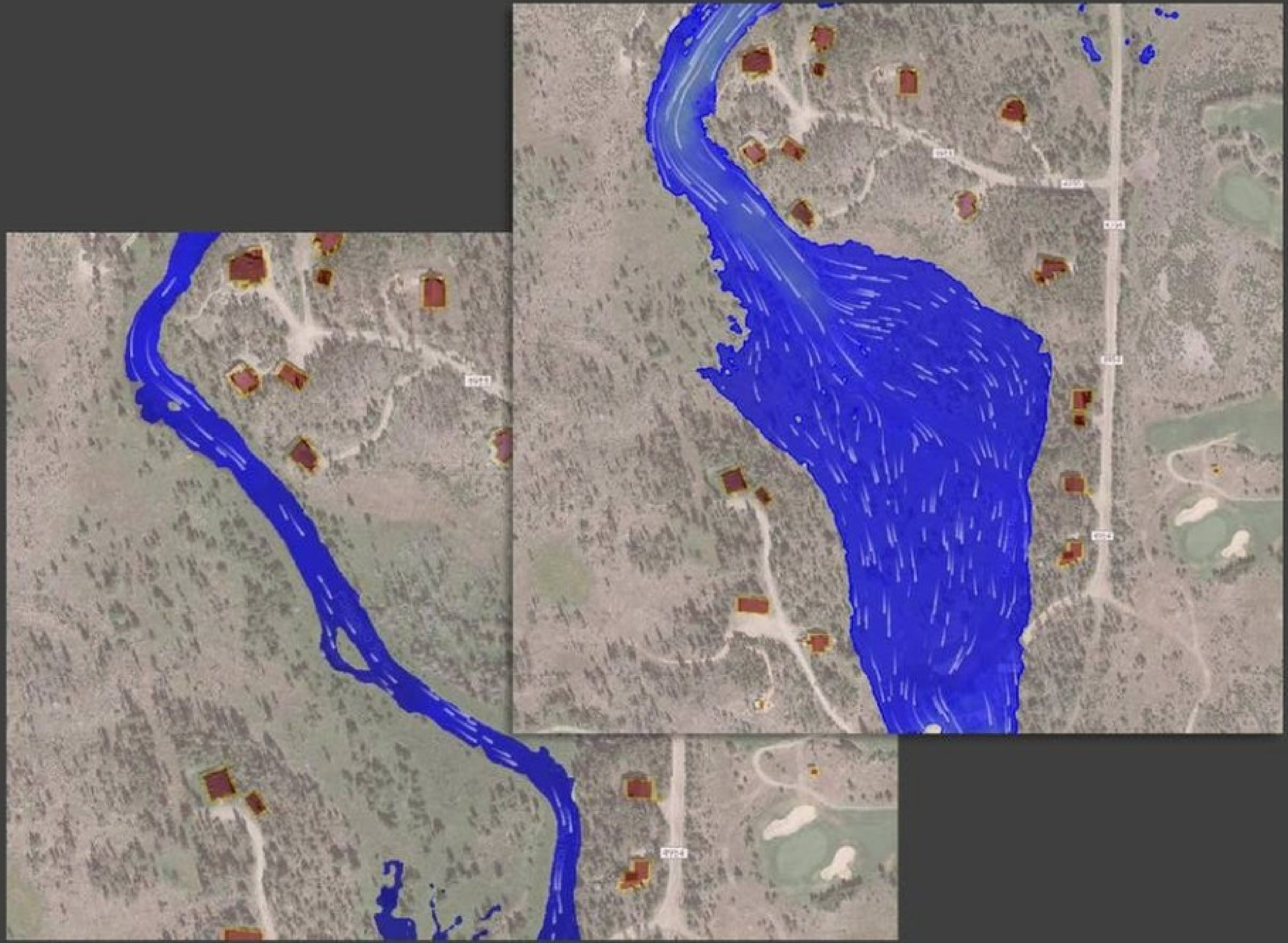
- ✓ A storm that is long enough to be longer than Tc.
- ✓ A storm that has a peak intensity in the middle (sometimes leading or lagging).
- ✓ Selected by Statistics in the Region.
- ✓ If SCS is used, care should be taken if using a different duration than 24 hours since Storage does not change with time.
- ➢ Rainfall data is available at: https://www.nws.noaa.gov/ohd/hdsc/

Questions & Comments

Bio Break

Hydraulics and Sedimentation

Hydraulic Analysis



Pre (left) and post (right) fire flood hazard mapping within the East Troublesome burn perimeter.

- Usefulness – Make Useful Models
  - Usefulness includes time
- Equations –
  - 2D – Momentum versus Diffusive
  - 1D Energy
- Sediment Transport
- Keep end Goal in Mind

"All models are wrong, some models are useful…"

Hydraulic Analysis

2 Dimensional

- Easy to make a quick model for large areas
- Longer computational time
- Big data sets
- Good 2D Summary Reports by FHWA and USACE
  - https://www.fhwa.dot.gov/engineering/hydraulics/pubs/hif19058.pdf

1 Dimensional

- Quick Computations
- Hard to automate X-Sections for Large Areas (some CAD Programs help).
- Large or Small Data Sets

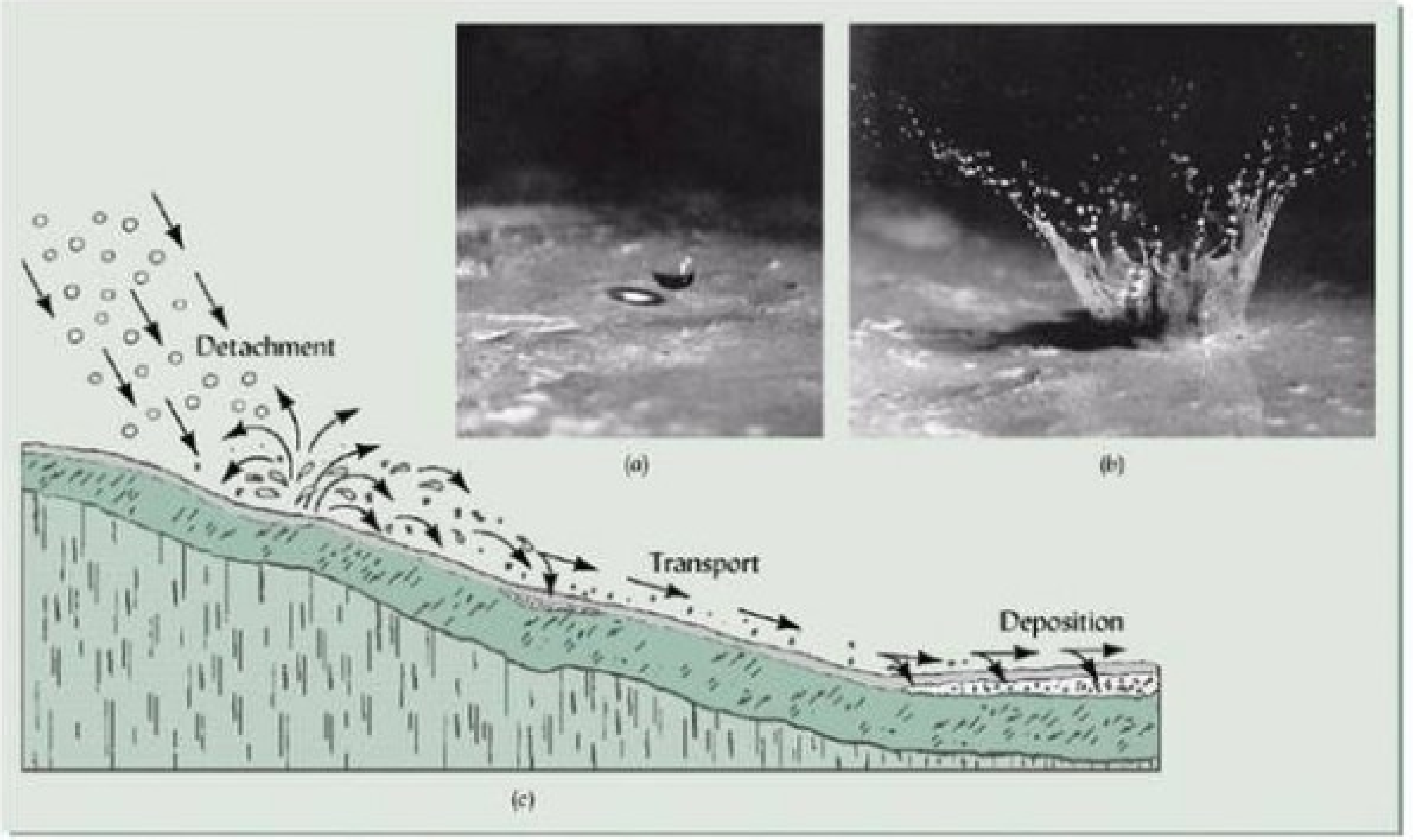
Commonly Applied 2D Models

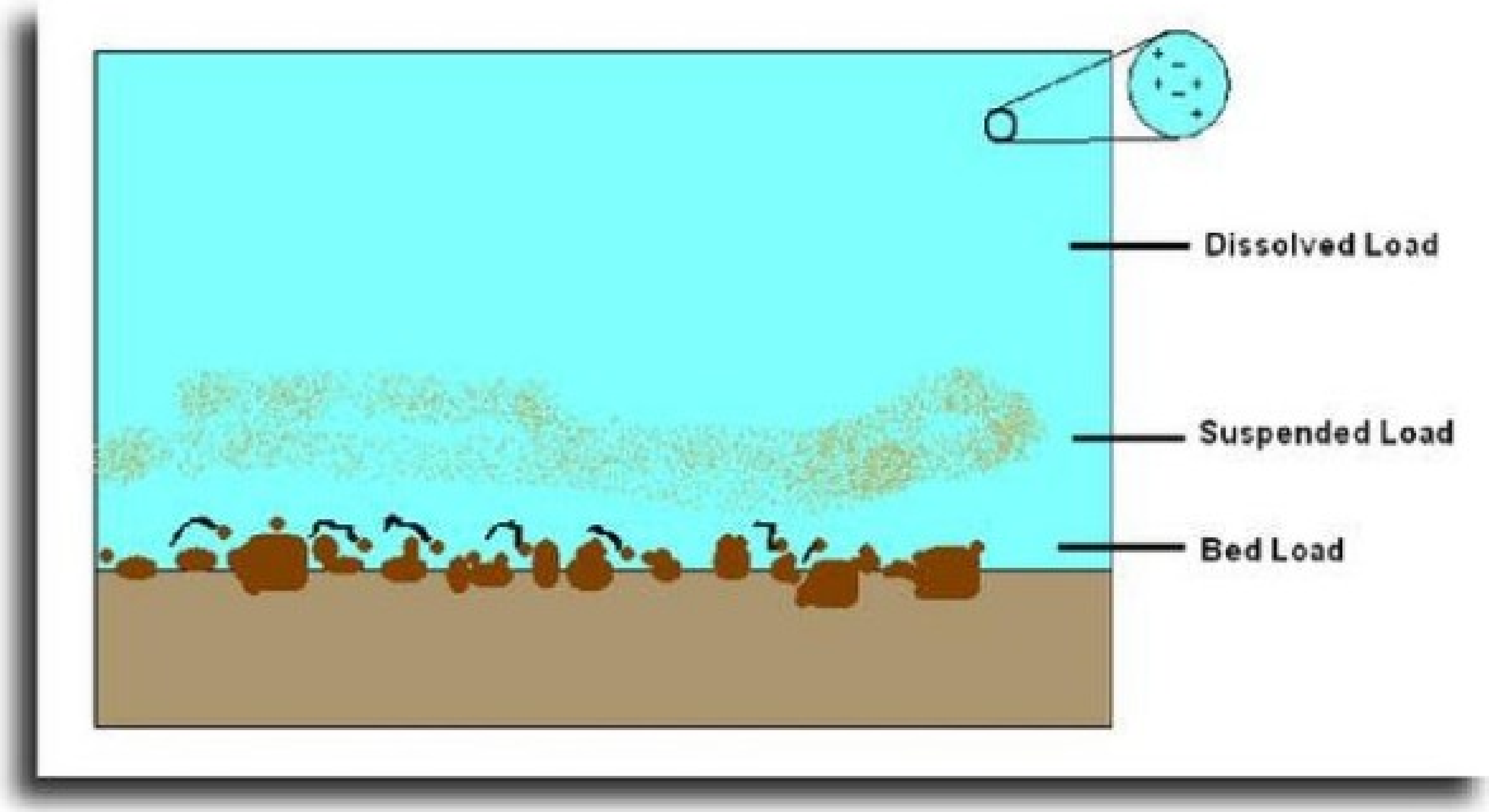
Model	Type	Mesh	Sediment Transport?	Rain on Grid?	Availability	Computing Time	User Friendly?
HEC-RAS 2D	Full Formed 2D with options of Diffusive Wave or Full Momentum	Modified Rectangular	Yes – V6 has Non Newtonian	Yes – V6 has Infiltration	Public	Good (Parallel Processing)	Very User Friendly (Easy)
SRH2D	Full Dynamic Wave Momentum Equation	Flexible Mesh	Yes	No (unless that has changed)	Public Code, need interface (SMS)	Medium (Stable Solution Algorithm but no Parallel Processing)	Very User Friendly (Easy)
FLO2D	Full Dynamic Wave Momentum Equation	Rectangular	Yes – Has non newtonian	Yes	Private	Medium to Slow	Medium to Difficult
River Flow2D	Full Dynamic Wave Momentum Equation	Flexible Mesh	Yes+ Dynamic Surface Changes	Yes	Private	Fastest (GPU over CPU)	Very User Friendly (Easy)
GSSHA	2D Diffusive Wave (No Momentum)	Rectangular	Yes + Dynamic Surface Changes	Yes	Public Code, Need Interface (WMS)	Good (Parallel Processing)	User Friendly but not Easy
xp2d	diffusive wave 2D	Rectangular	No	Yes	Private	Medium	Very User Friendly (Easy)

Note: The comments in the above table are based only on experience of the presenter. Other users, vendors, or developers may have differing opinions.

Three Main Components of Sediment Transport

- **Suspended Load:** Part of the Sediment Transport that remains in Suspension and does not come into contact with the Stream Bed.
- **Bed Load:** The portion of sediment transport in continuous contact with the bed.
- **Wash Load:** Part of the suspended load that is composed of sizes smaller than those in the bed material. (Often Ignored in Sediment Transport Analysis but important for watershed wide Analysis)



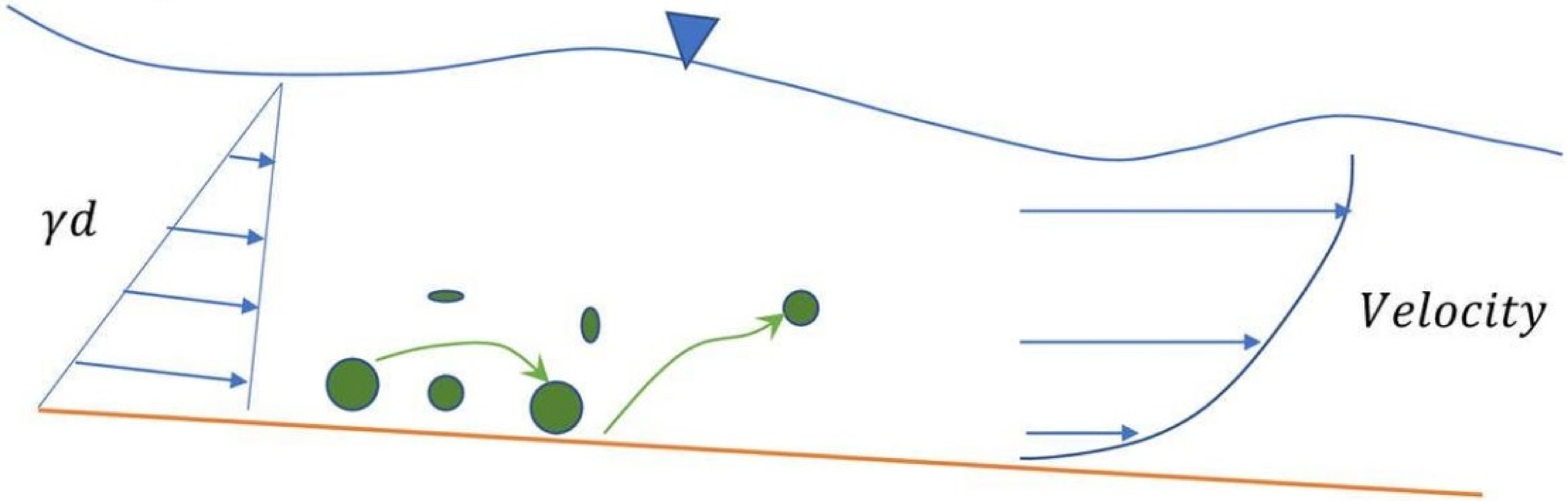


Basic Functions

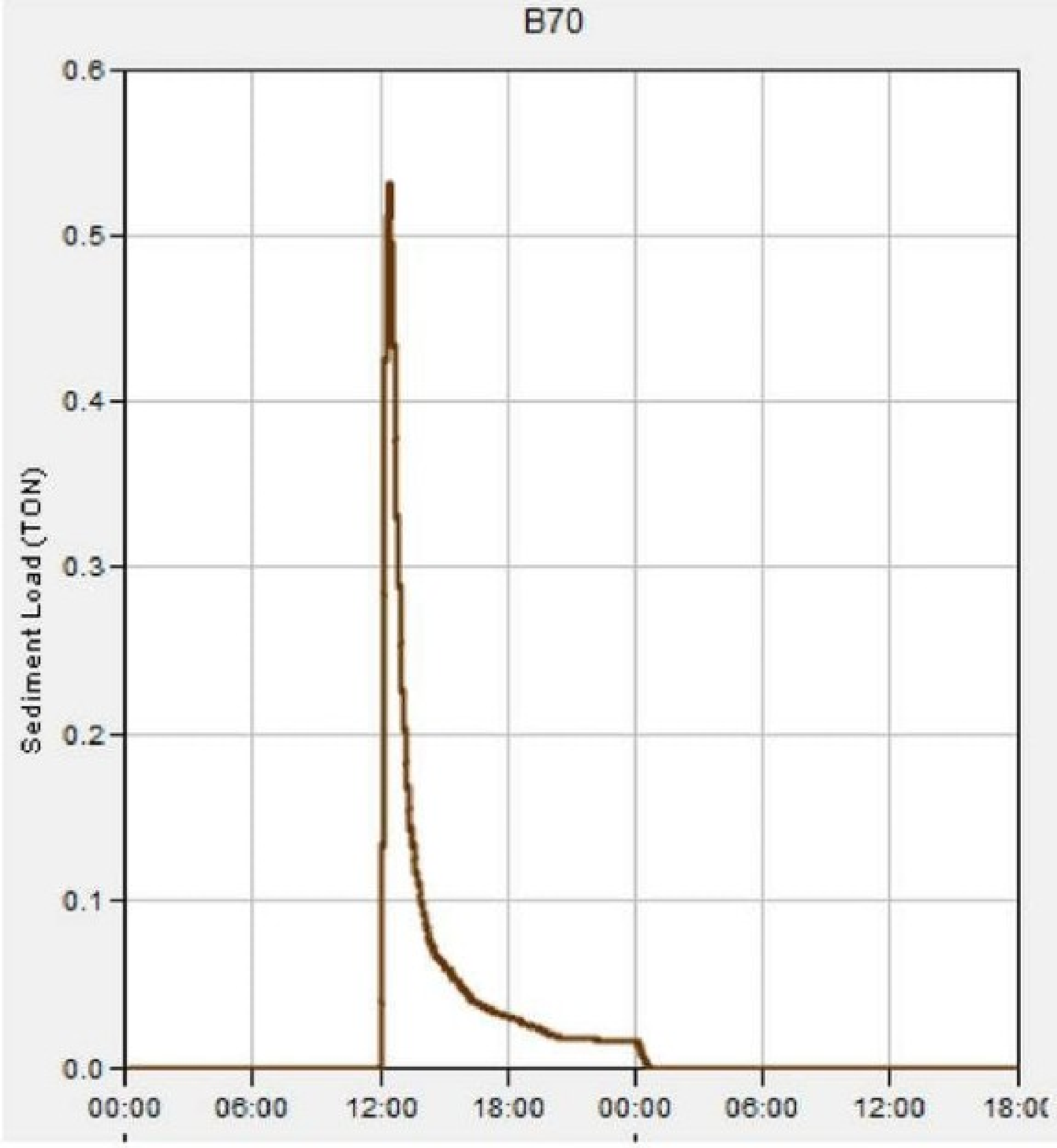
- Shear / Incipient Motion
- Fall Velocity / Deposition Rate
- Transport Capacity

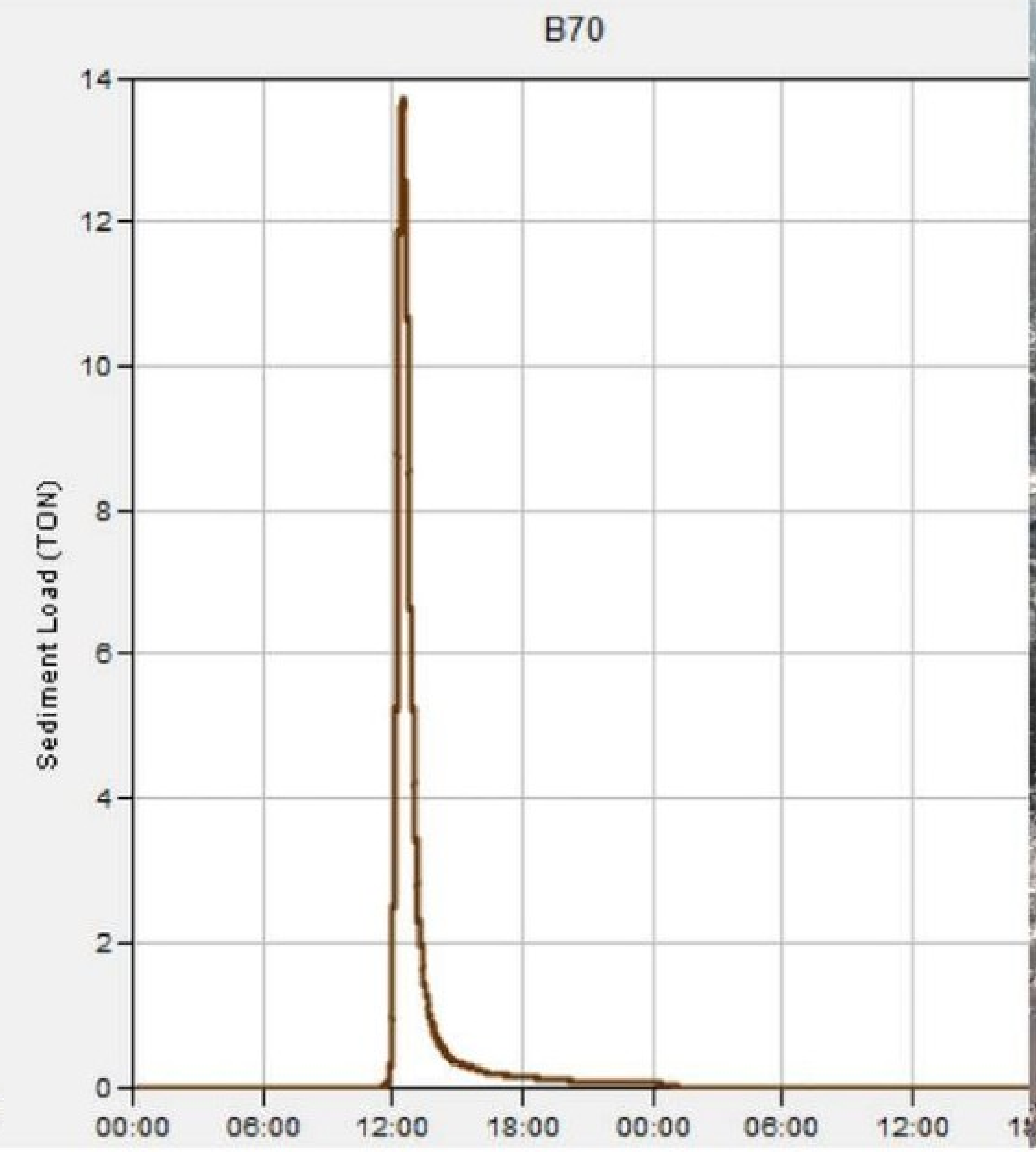
$$\tau_o = \gamma R S$$

$$\omega = \frac{(s-1)gd}{18\nu} \quad 0.001 < d \le 0.1 \text{ mm}$$



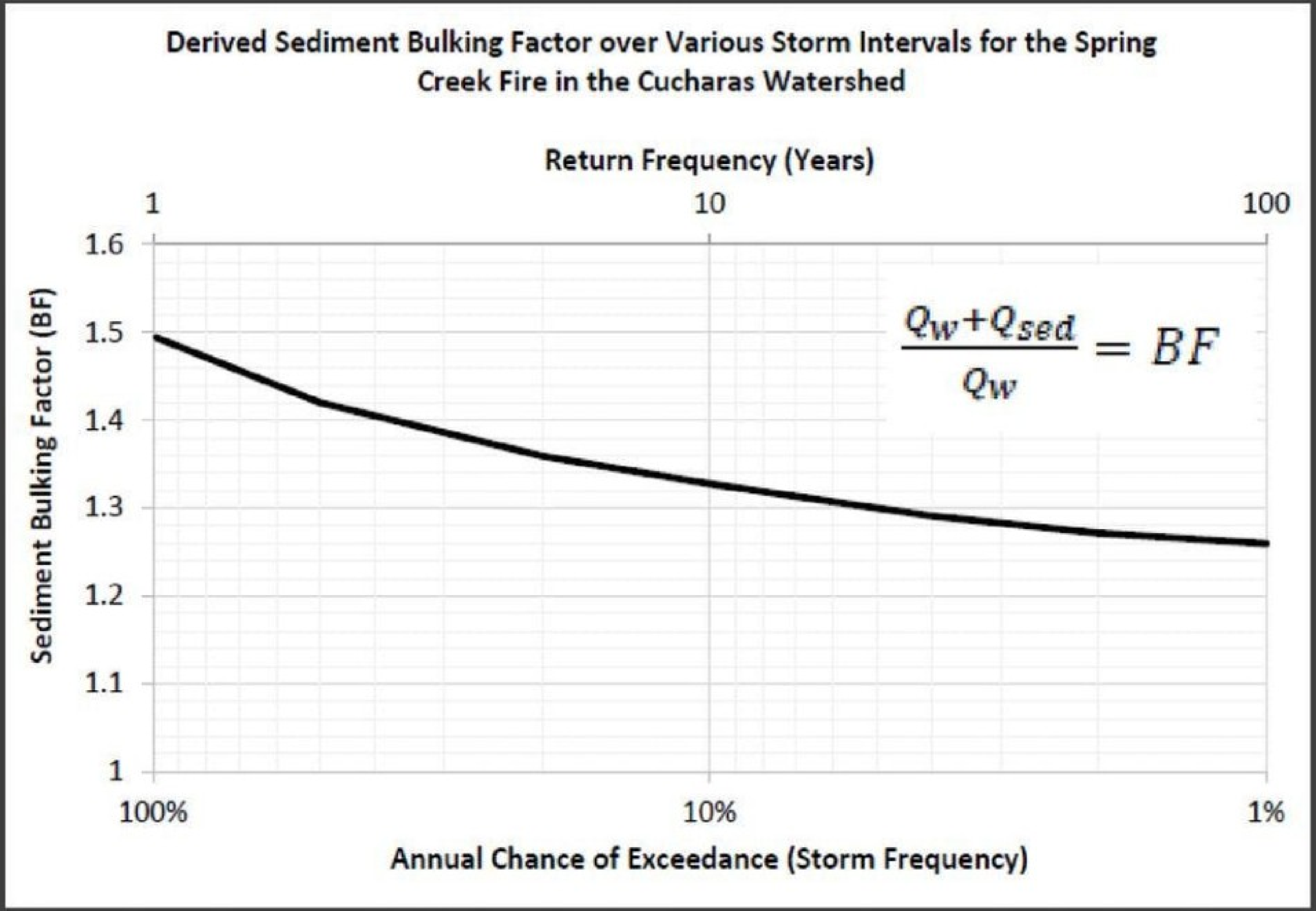
Sediment Loading





Left is the Expected Sediment Loading Before the Fire, Middle, is the Expected Sediment Loading after the Fire (Methods use the Modified Universal Soil Loss Equation (MUSLE) in HEC HMS, Picture on the Right is From S. Abeyta Creek showing the amount of Ash transported downstream

Bulking Factors

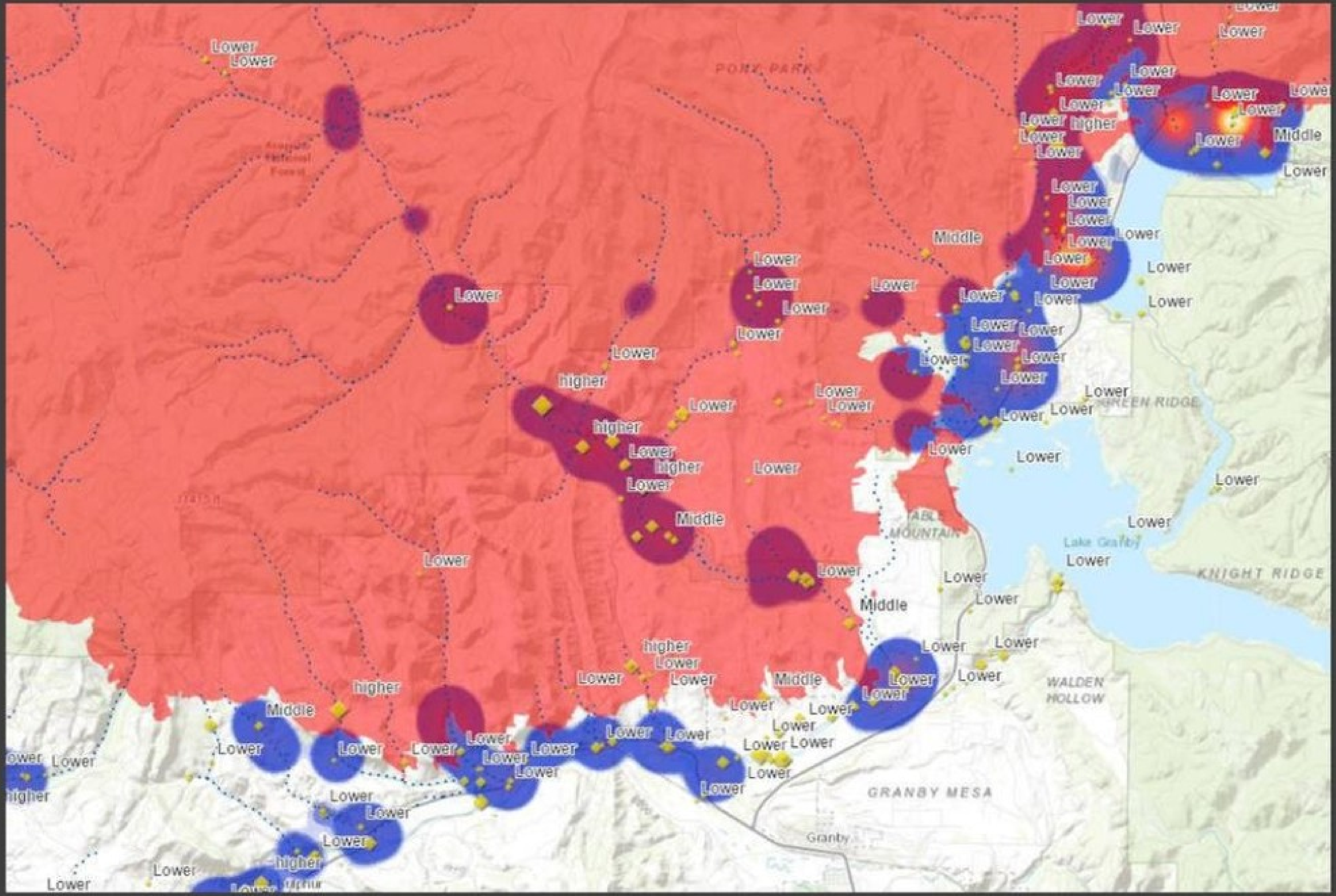


- Bulking Factors are an Easy Way to Approximate a Complicated Process
- Many Various Methods
- Can Vary by Frequency
- Moore Research Needed
- Estimates range from not dramatic (1 to 1.2) some anecdotally say 4 to 5 times.
- Highly bulked flows turn Non-Newtonian (Wet Concrete)

Questions & Comments

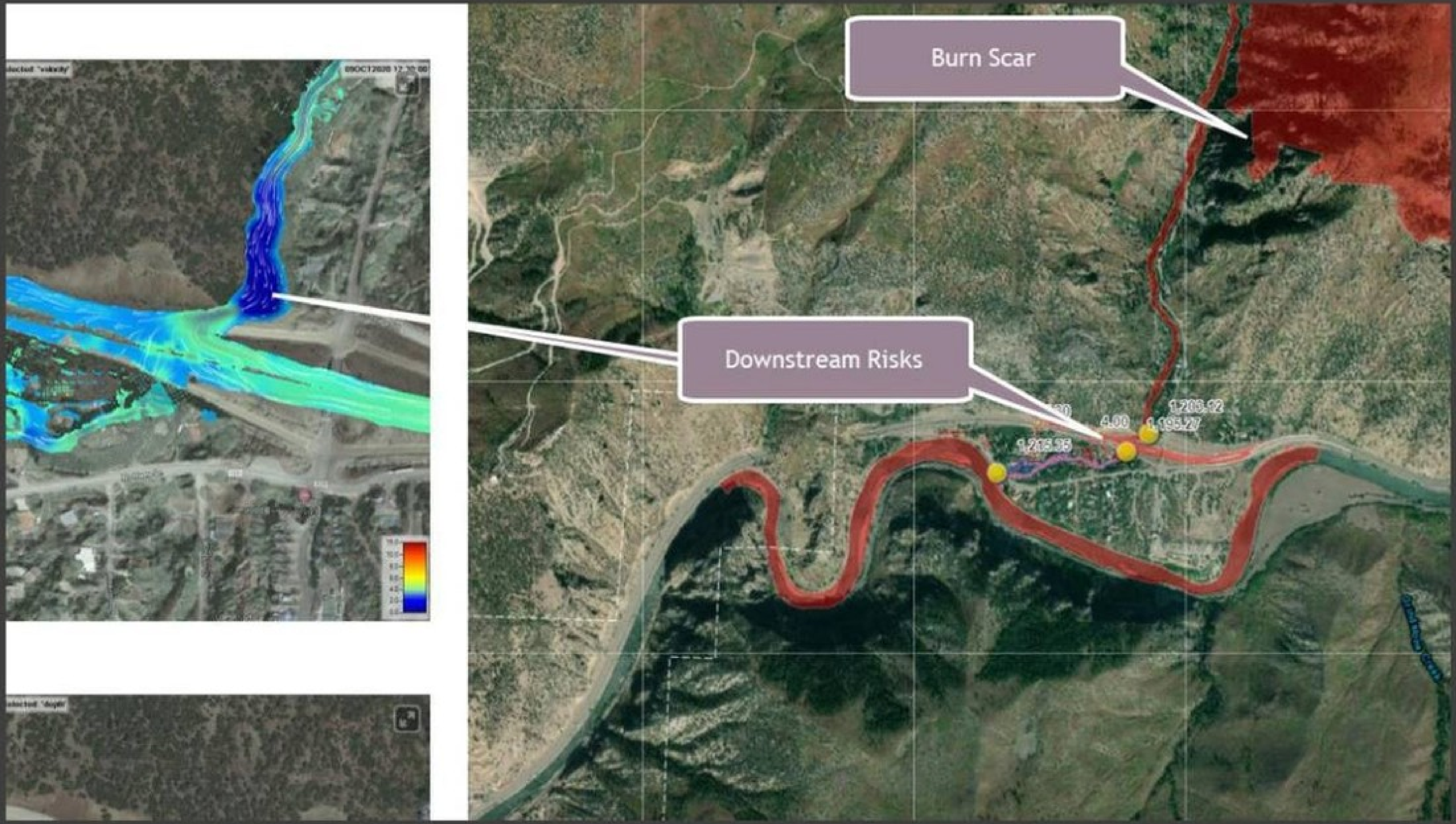
Estimating Values at Risk

Values at Risk



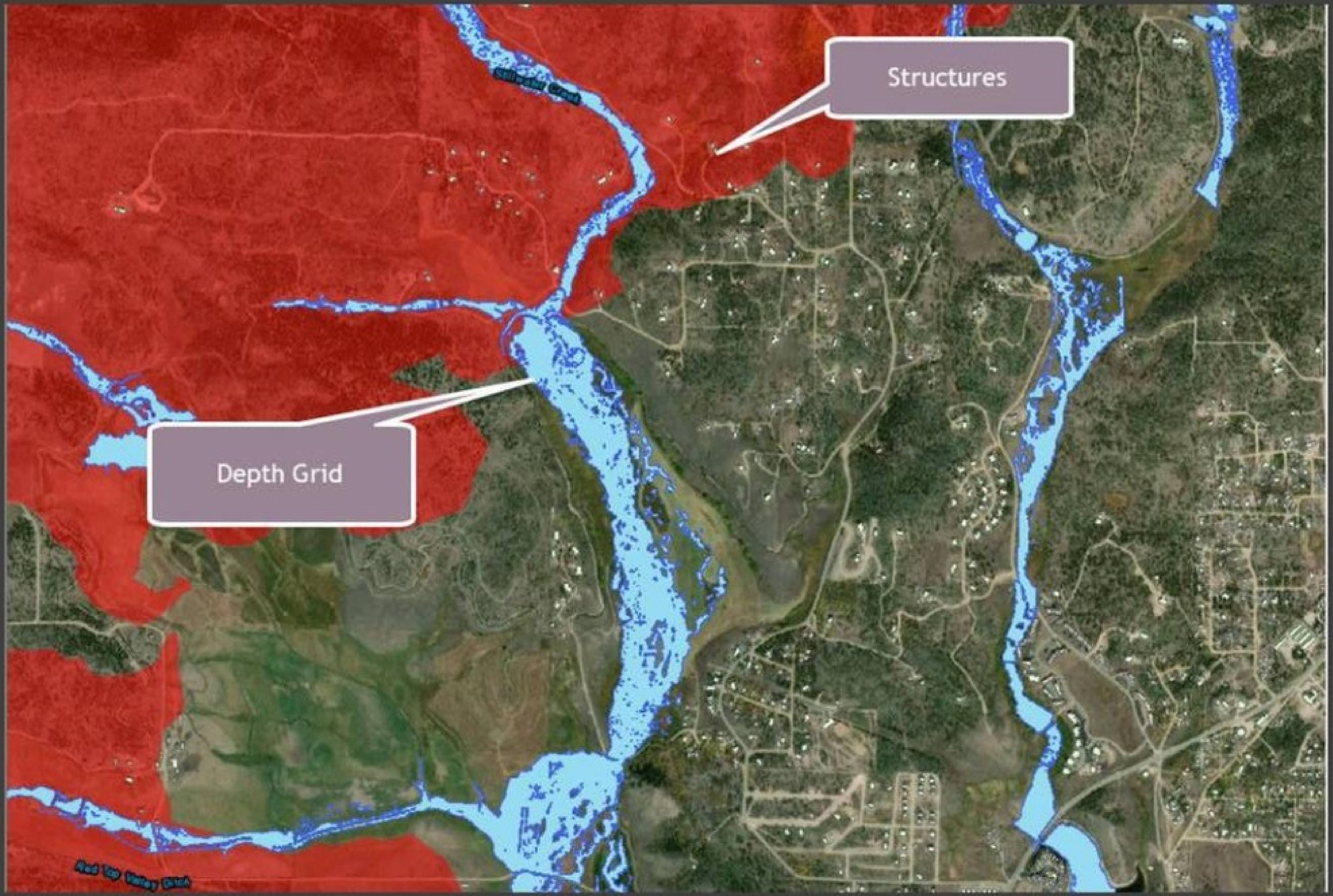
- Ultimately, we want to know what the risks are
- When developing the models, keep the goal in mind.
- Comparing "relative" risk can simplify the process.

Risks within and Downstream



- Risks are not just within the burn scar
- Keep an eye downstream
- Rapid H and H can help Identify Values at Risk

Assessing Risks



- Depth and Velocity Grids x with GIS Data
- Keep Ranking Simple
- Consider Frequent Storms (2-yr, 10-yr)
- Everything as some risk, which is higher and Lower

- Then, Weighted by Frequency
  - 1-Year (Higher)
  - 10-Year (Middle)
  - 100-Year (Lower)
- Results (Cucharas)

Rank	No.	Percentage
Higher	16	23%
Middle	14	20%
Lower	40	57%

- Results (Huerfano)

Rank	No.	Percentage
Higher	9	17%
Middle	4	8%
Lower	40	75%

Questions & Comments

Thank you

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