Flood Mitigation Assessment of Stream Debris Removal

Neuse River Bridge on New Bern Ave, Raleigh, 9/17/21 News & Observer

Haywood County 8/18/21 ABC 13 News

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NC STATE UNIVERSITY Bio&Ag ENGINEERING

Sea Grant North Carolina

NC STATE UNIVERSITY

Stream Wood Debris Removal

- Congressional appropriations date to late 1700s
- Major early focus of the US Army Corps of Engineers
- Most wood removed from streams and rivers by early 20th century
- Perception that steams should be free of large wood

Wohl et al. (2016)

Stream Wood Debris Removal in North Carolina

- The Streamflow Rehabilitation Assistance Program (StRAP)
  - $38 million in 2021-2022 state budget
  - “Projects that help reduce flooding and restore streams across North Carolina”

- > $100 million for Hurricanes Matthew and Florence

- Limited study of flood mitigation benefits
  - Mostly anecdotal reports of flood reduction

- Many ecological benefits of wood in streams

Objective: Determine the flood mitigation benefit of large wood removal from streams in North Carolina

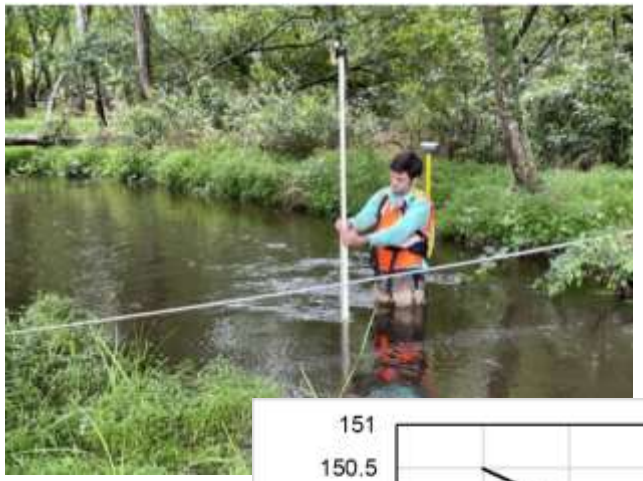
Identify Study Reaches

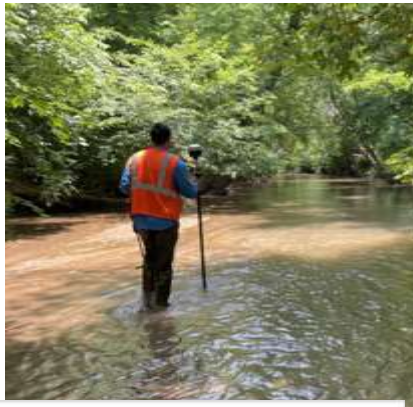
- NCDA Provided Data on Hurricane Florence Requests/Funded Projects

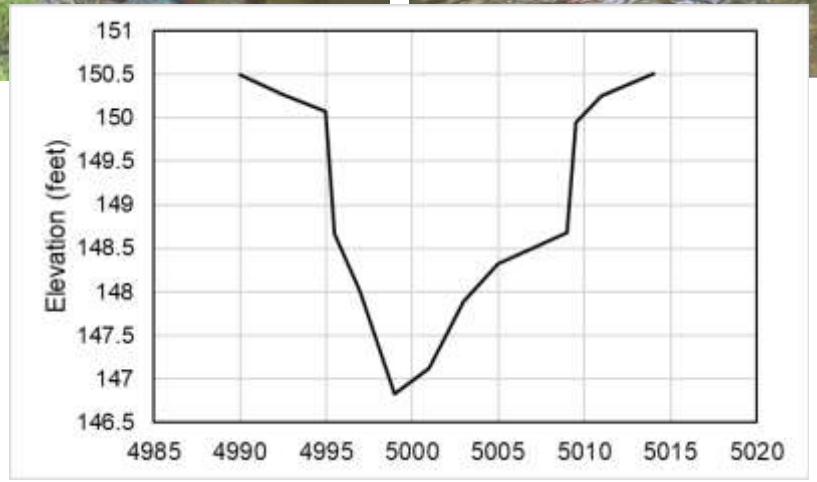
Site Visits

- Wayne County
  - Charles Holland
  - Longhorn Stream
  - Bear Creek (Completed)
  - Cabin Branch
  - Beaver Dam
- Harnett County
  - Lower Little River
  - Neil's Creek
- Cumberland County
  - Lower Little River
  - Little Rockfish Creek
  - Harrison Creek
  - Locks Creek

Study Locations



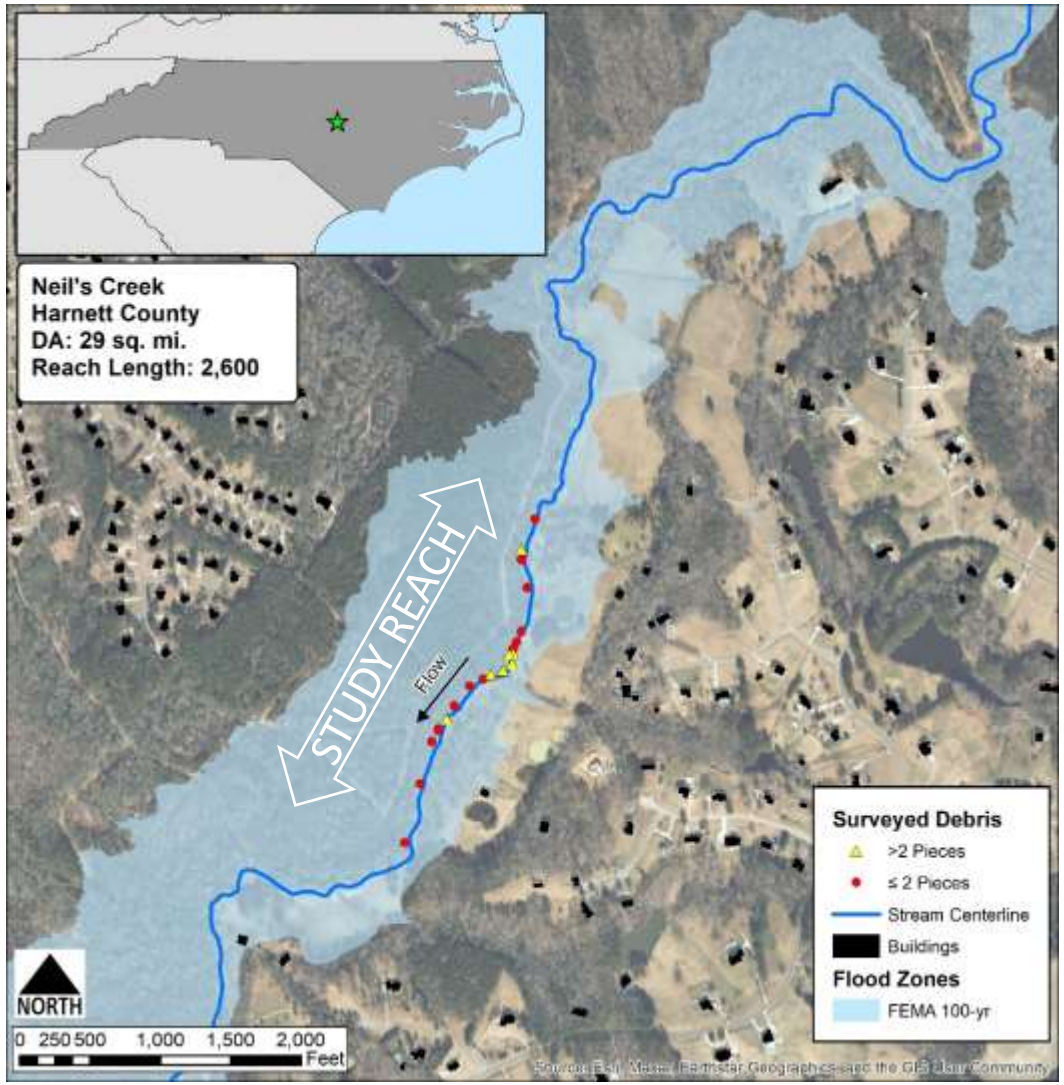




Site Assessment

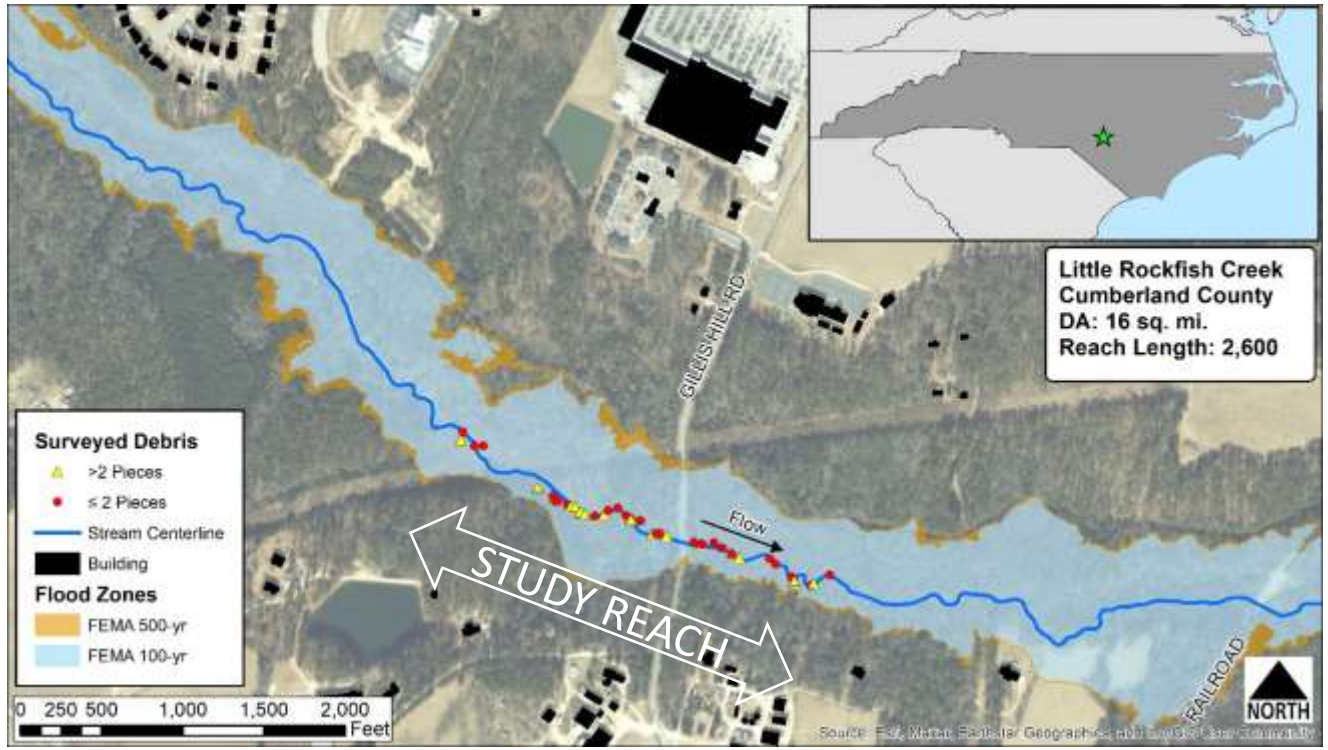
- 2400 – 4000 ft. reaches
- Inventoried all wood debris (LWD Index)
- Cross section surveys

Neil’s Creek



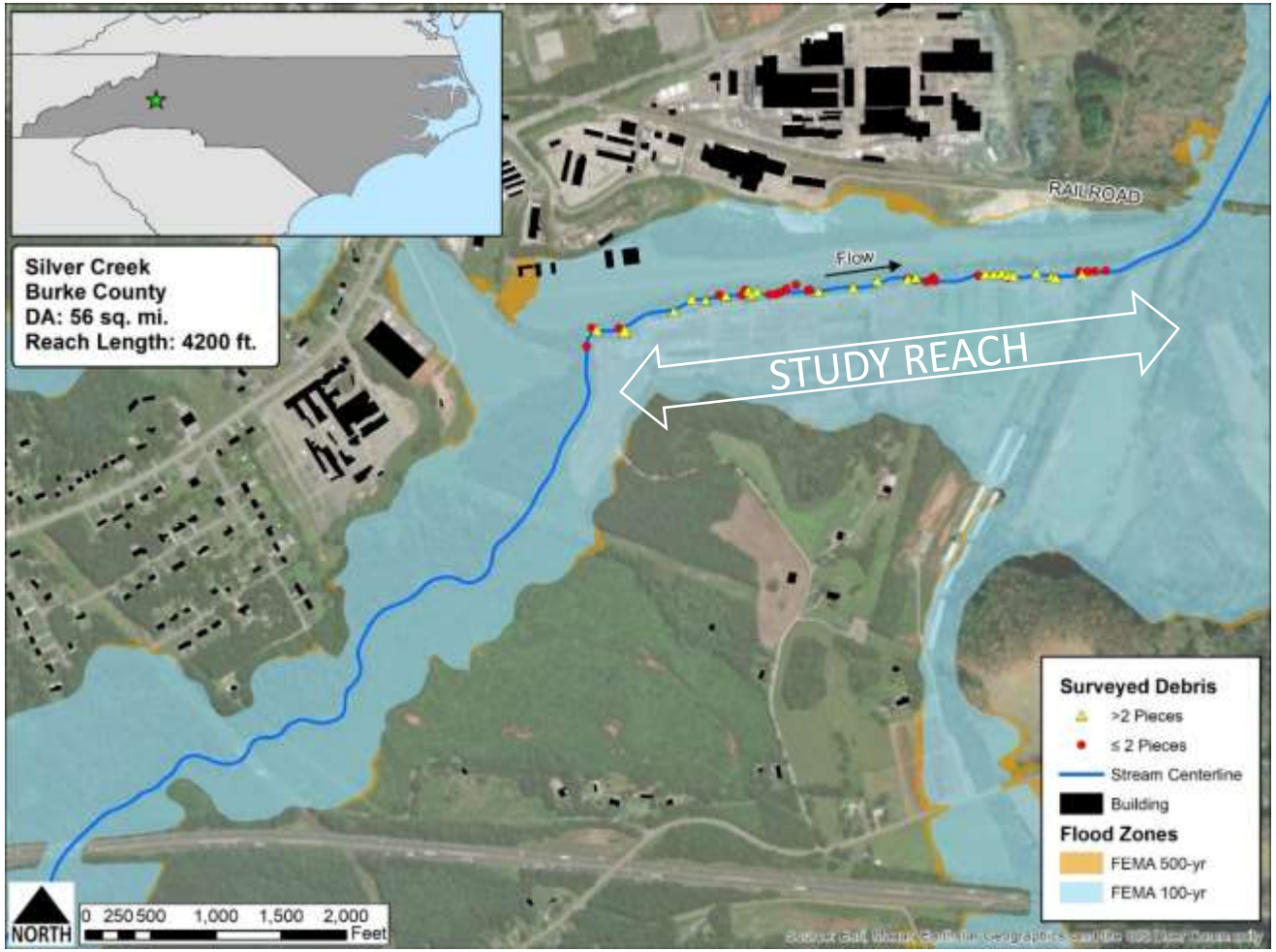
- Resident complaints of flooding
  - Most severe channel blockage = ~30%

Little Rockfish Creek



- Moderate debris accumulation
- Reference quality stream
- Wide, well-connected floodplain
- Most severe channel blockage = ~40%

Silver Creek

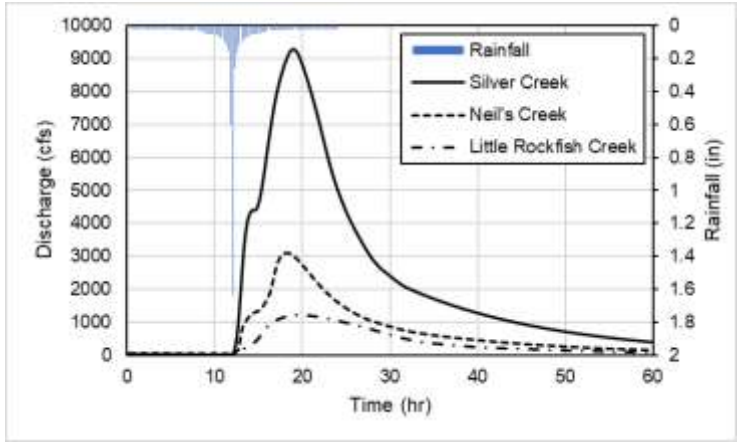


- Most substantial debris accumulation
- Incised, bank erosion at debris dams
- Most severe channel blockage = 50%

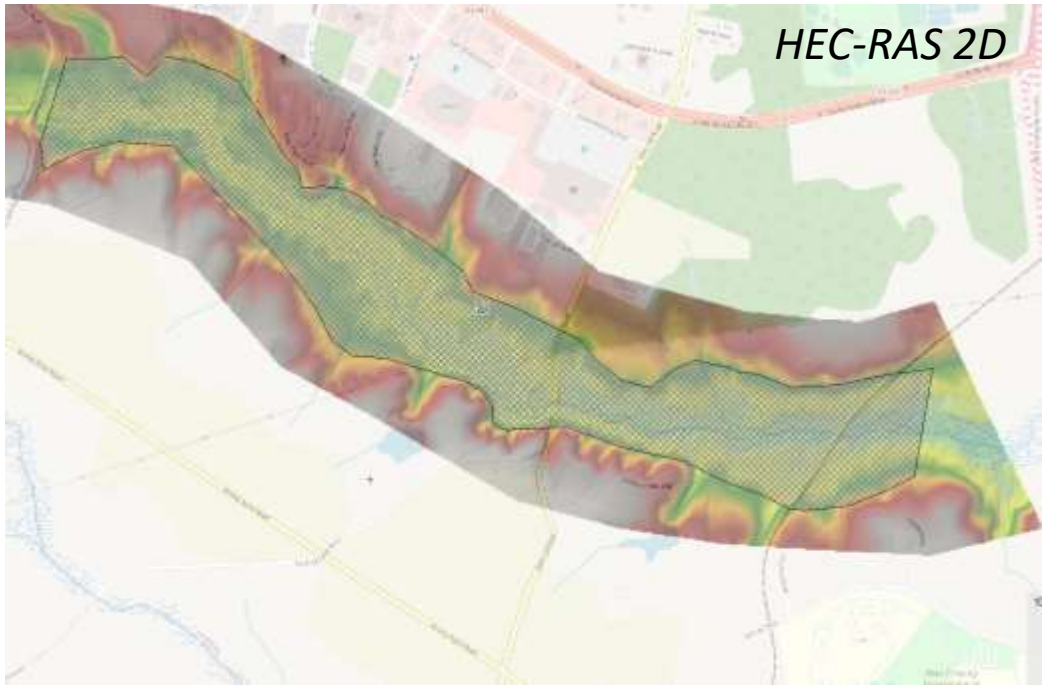
Silver Creek

Modeling Approach

HEC-HMS



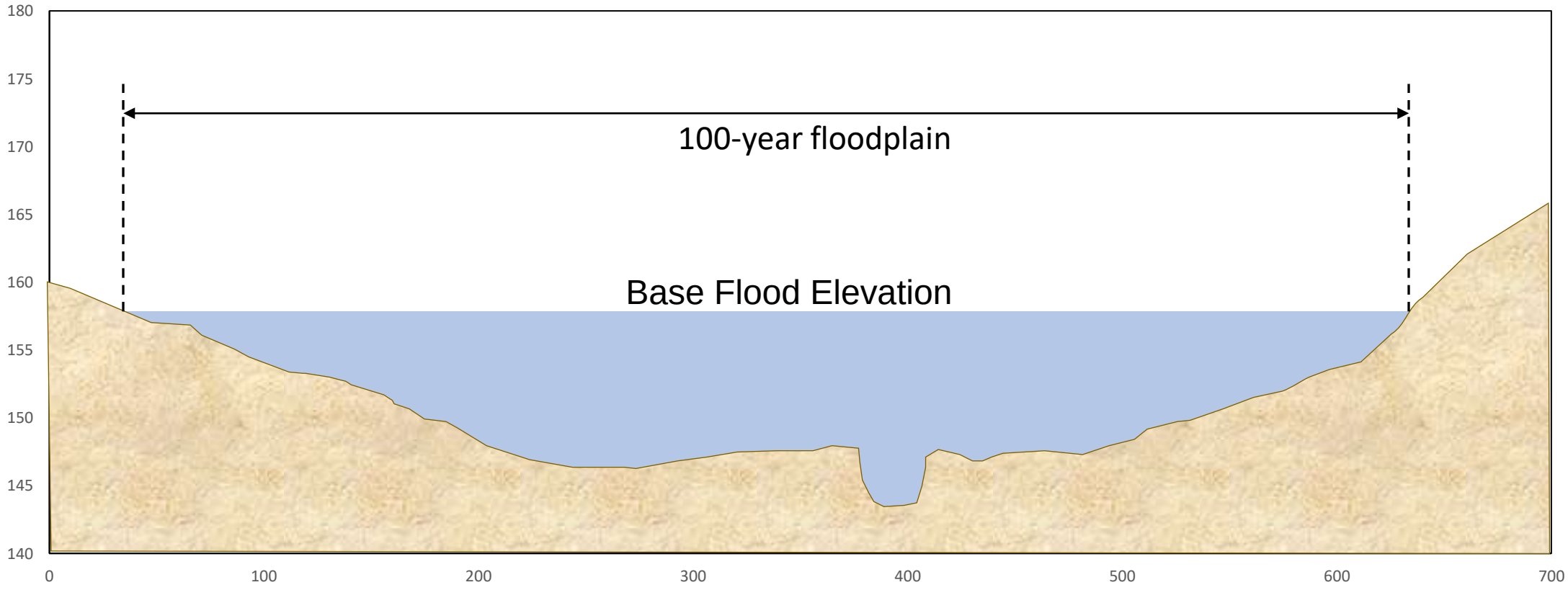
- *Survey XS*
- *Lidar*
- *Land Cover*



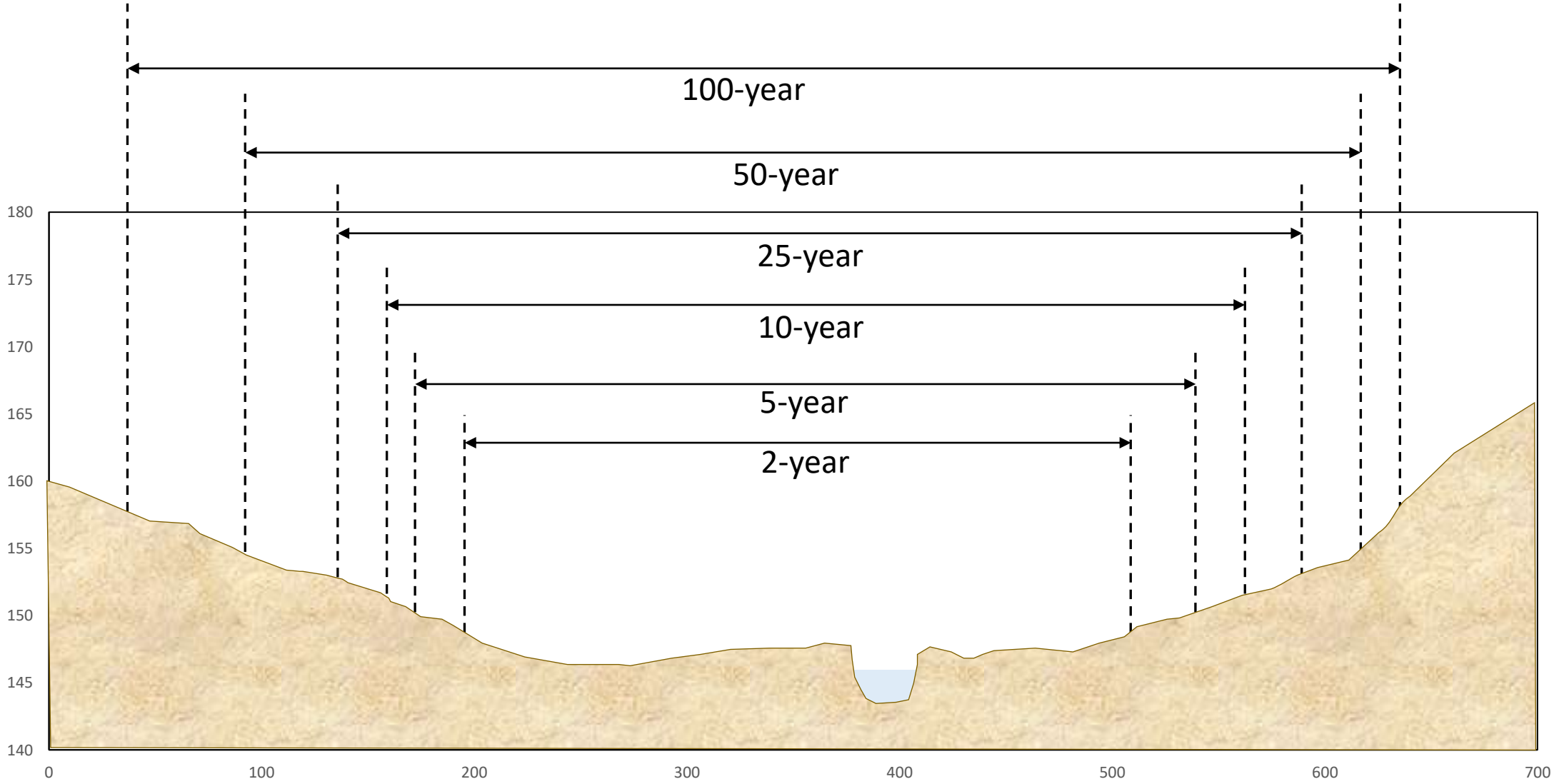
- *WSE*
- *Inundation Maps*

Floodplains Flood!

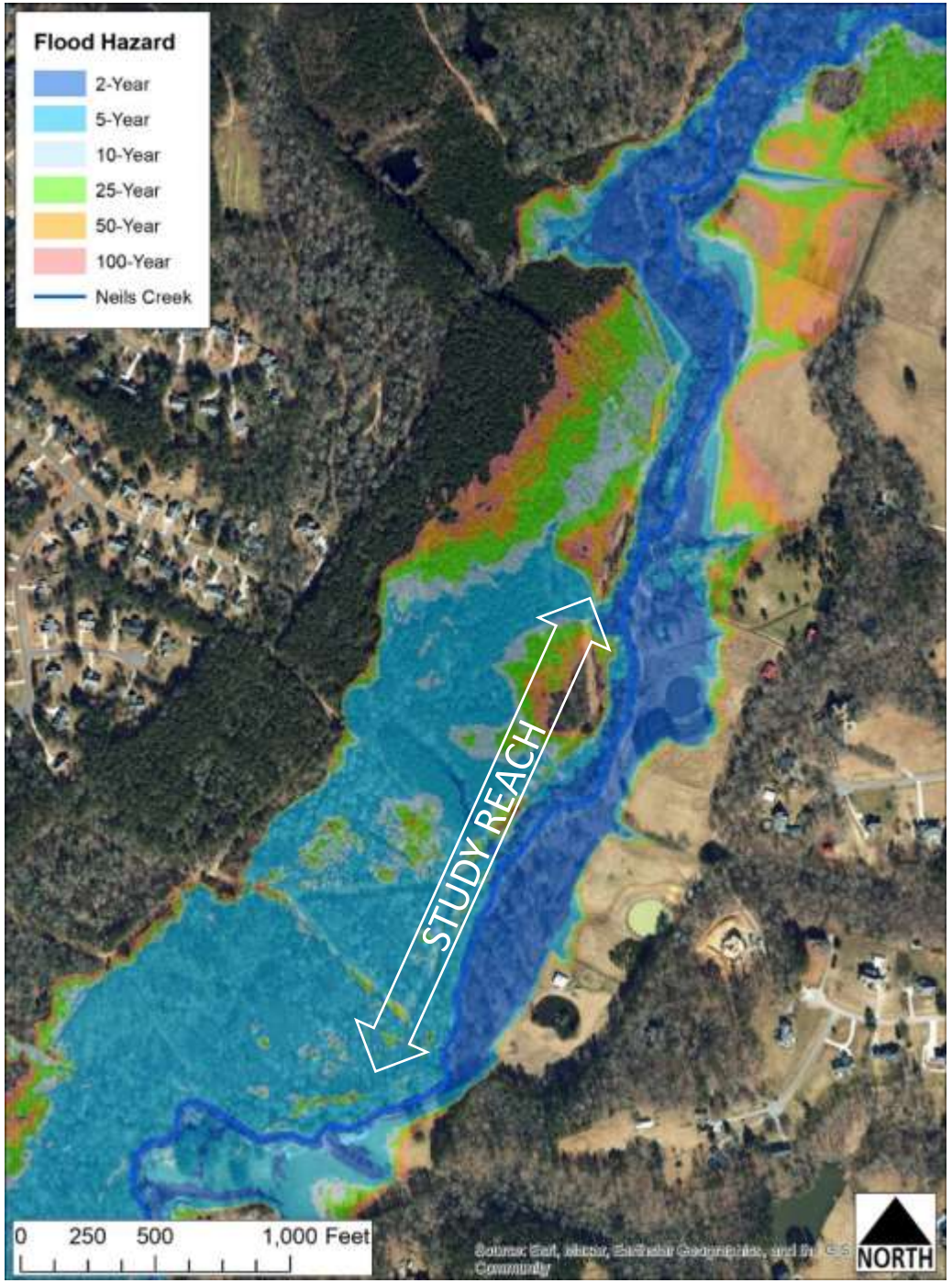
100-year floodplain: 1% annual chance of flooding to a modeled elevation (Base Flood Elevation)



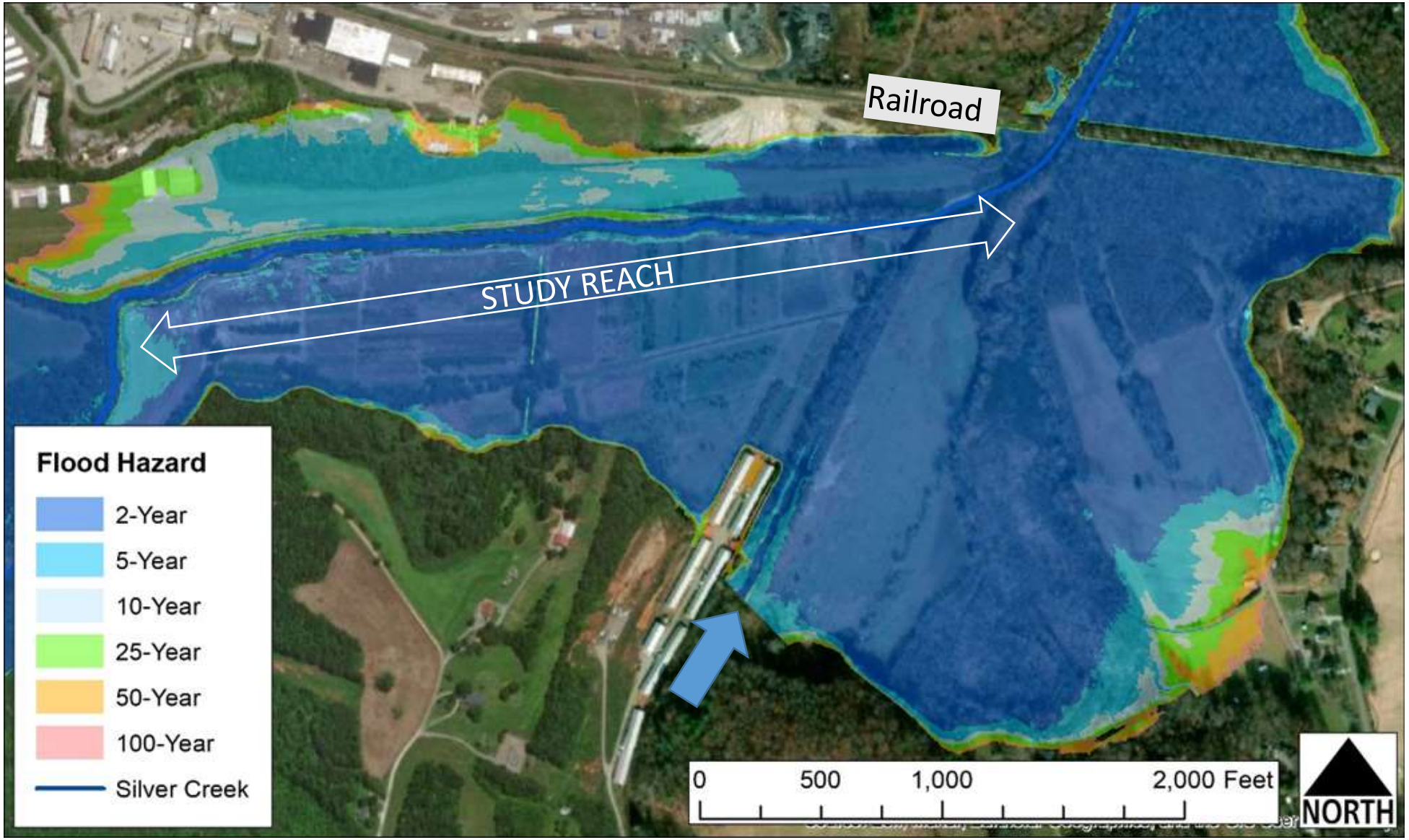
Floodplains Flood!



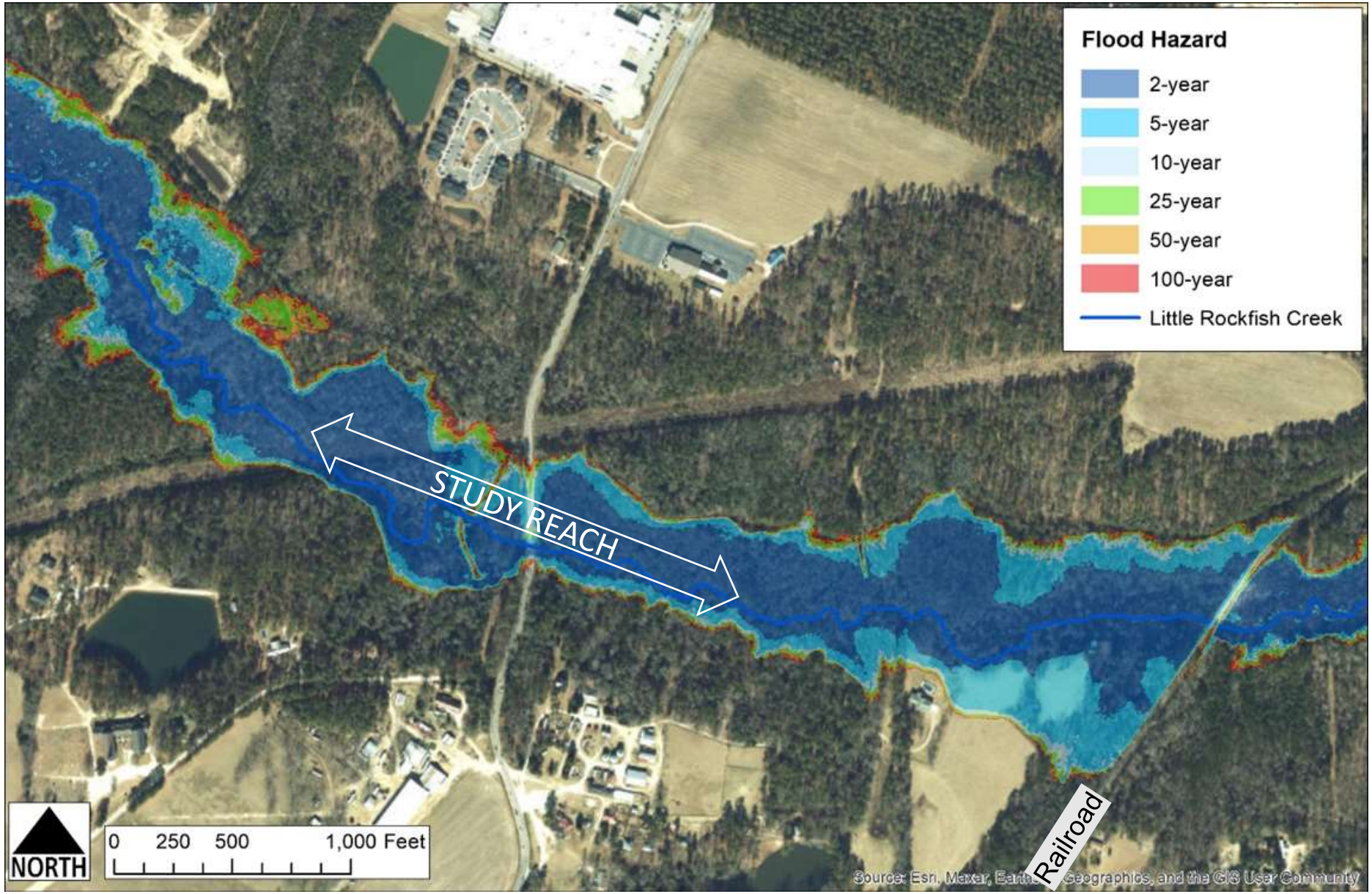
Neil’s Creek


Flood Hazard
2-Year
5-Year
10-Year
25-Year
50-Year
100-Year
Neils Creek
STUDY REACH
0 250 500 1,000 Feet
NORTH

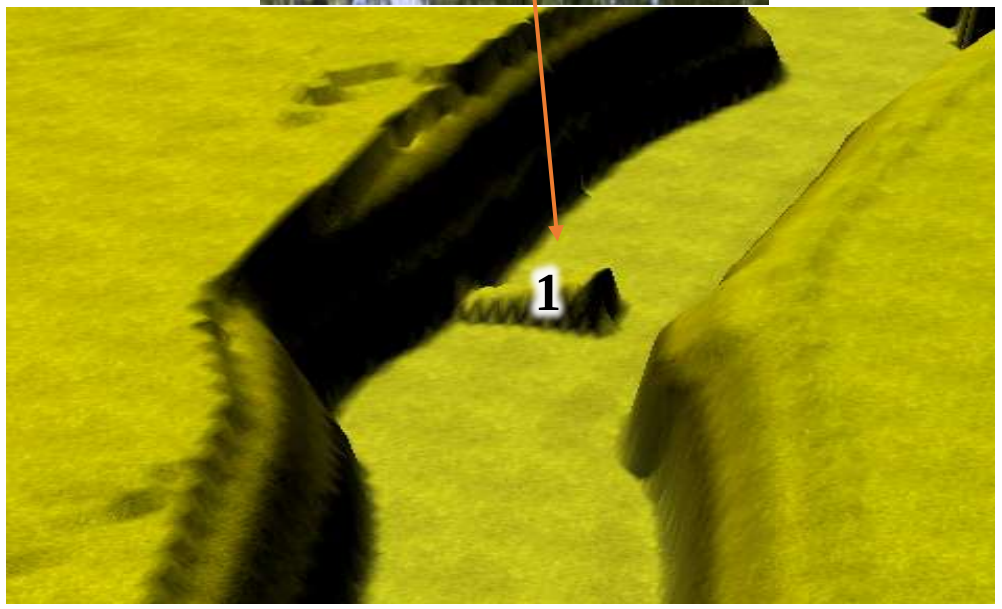
Silver Creek

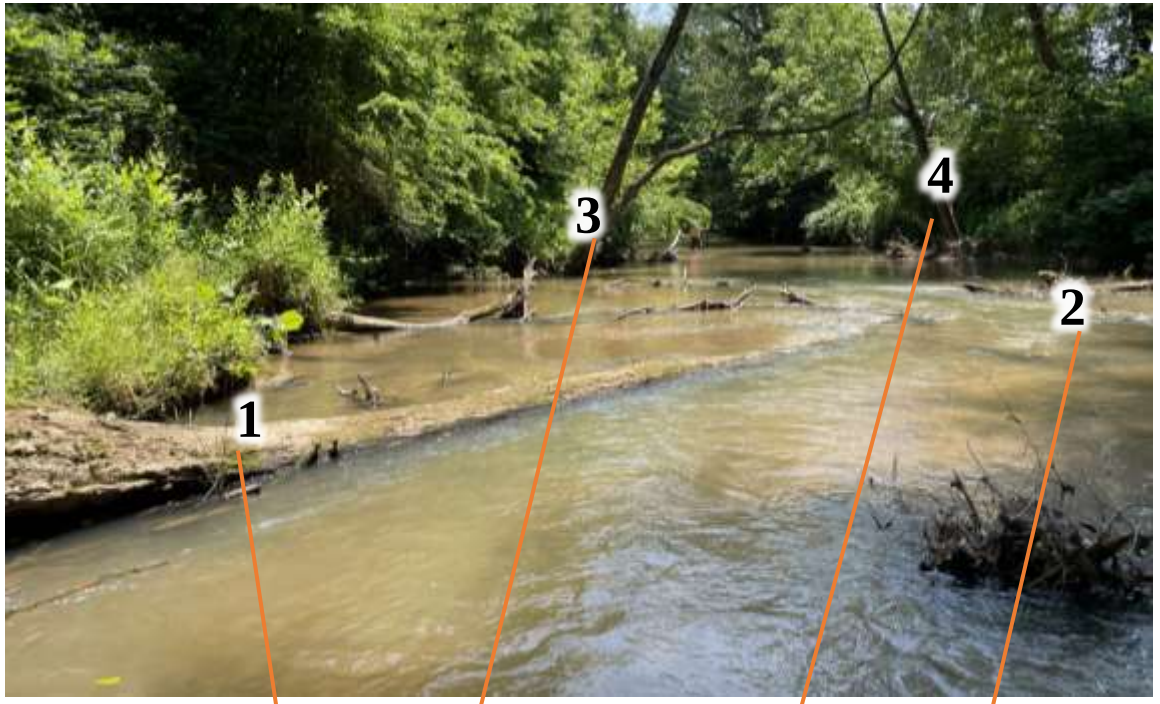


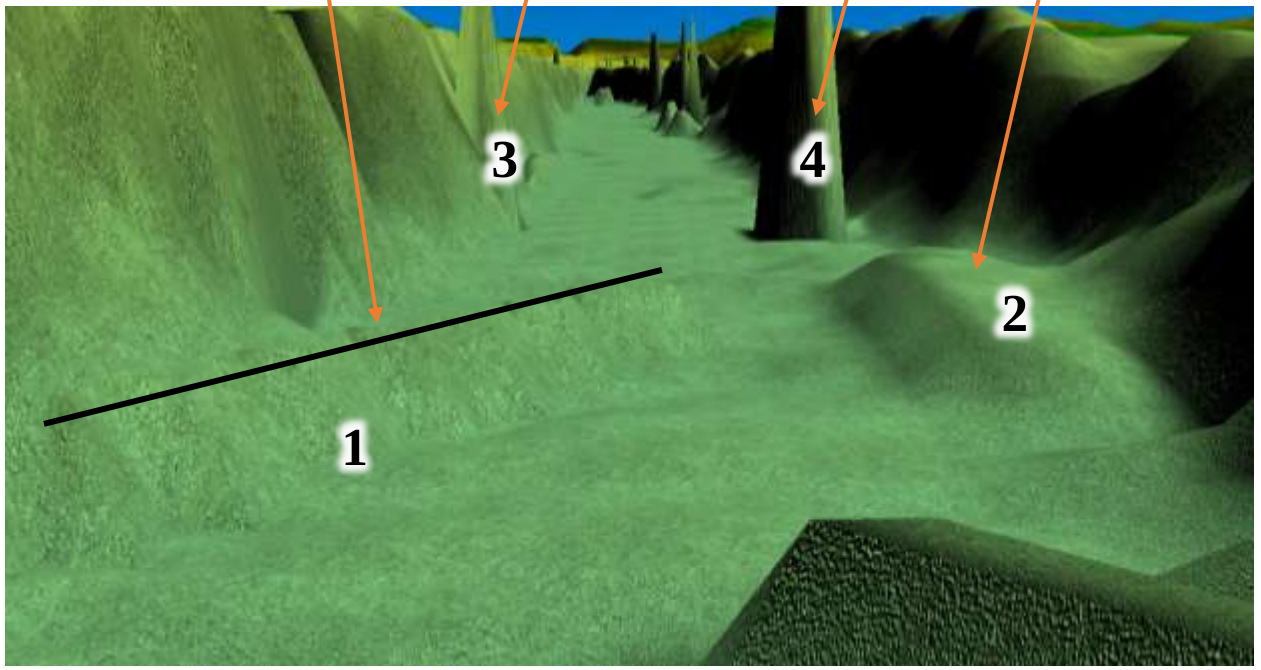
Little Rockfish Creek



Representing Wood Debris in HEC-RAS 2D Mesh



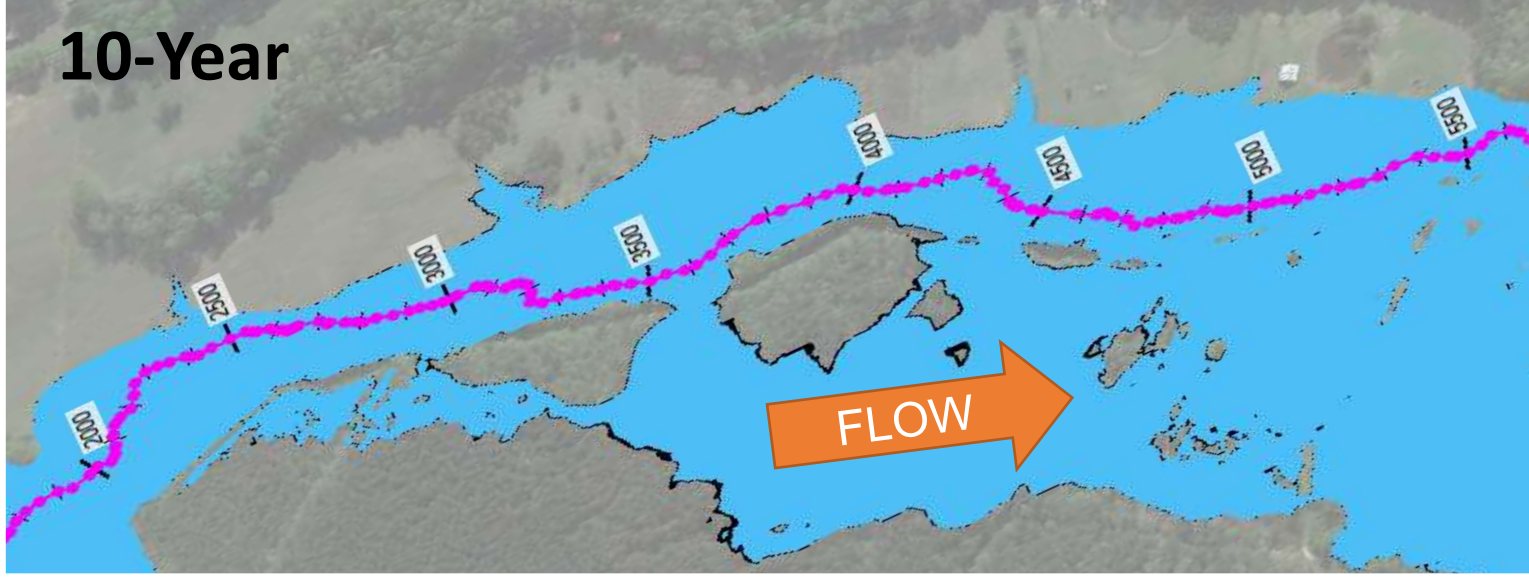


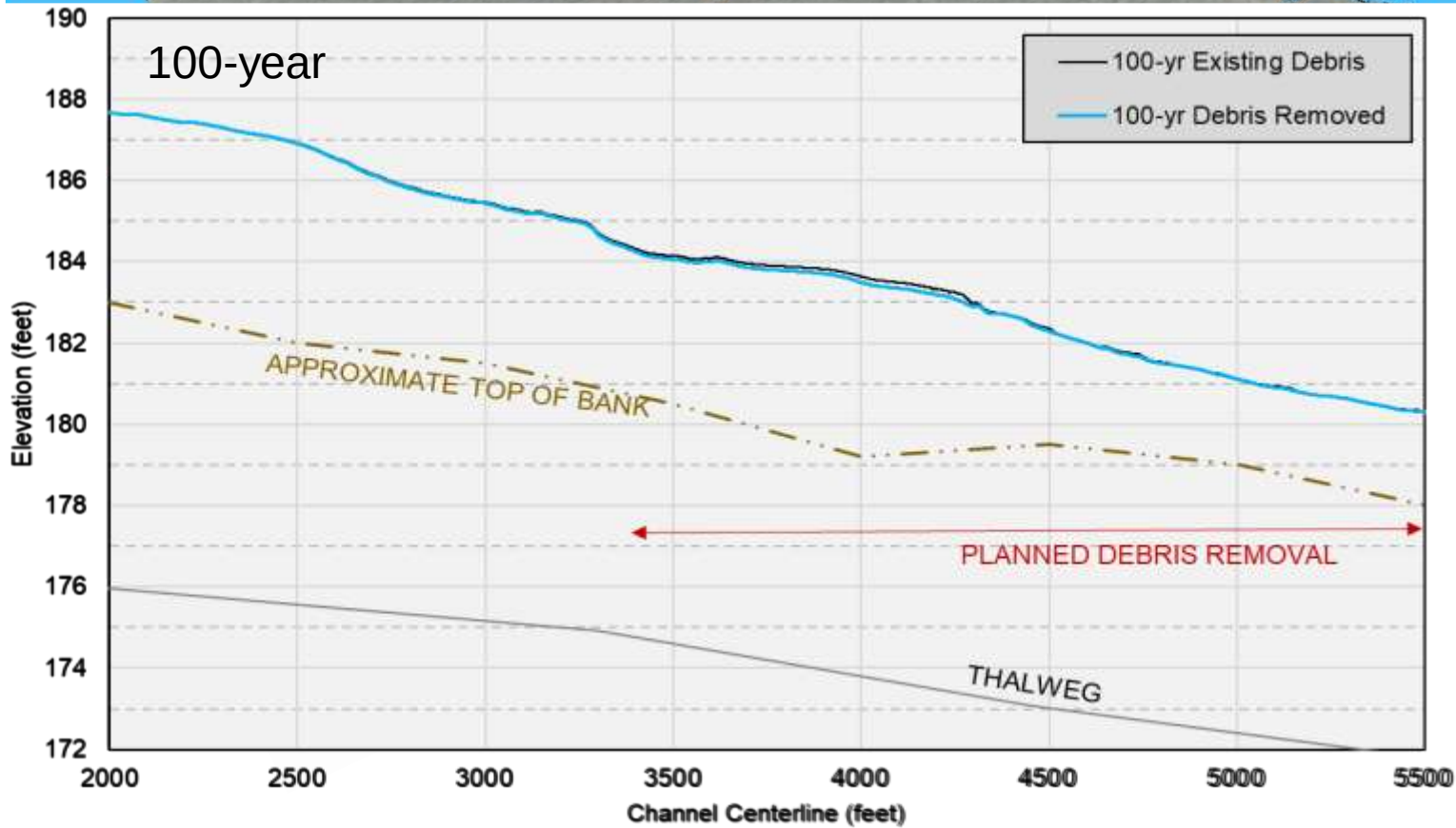


Neil's Creek

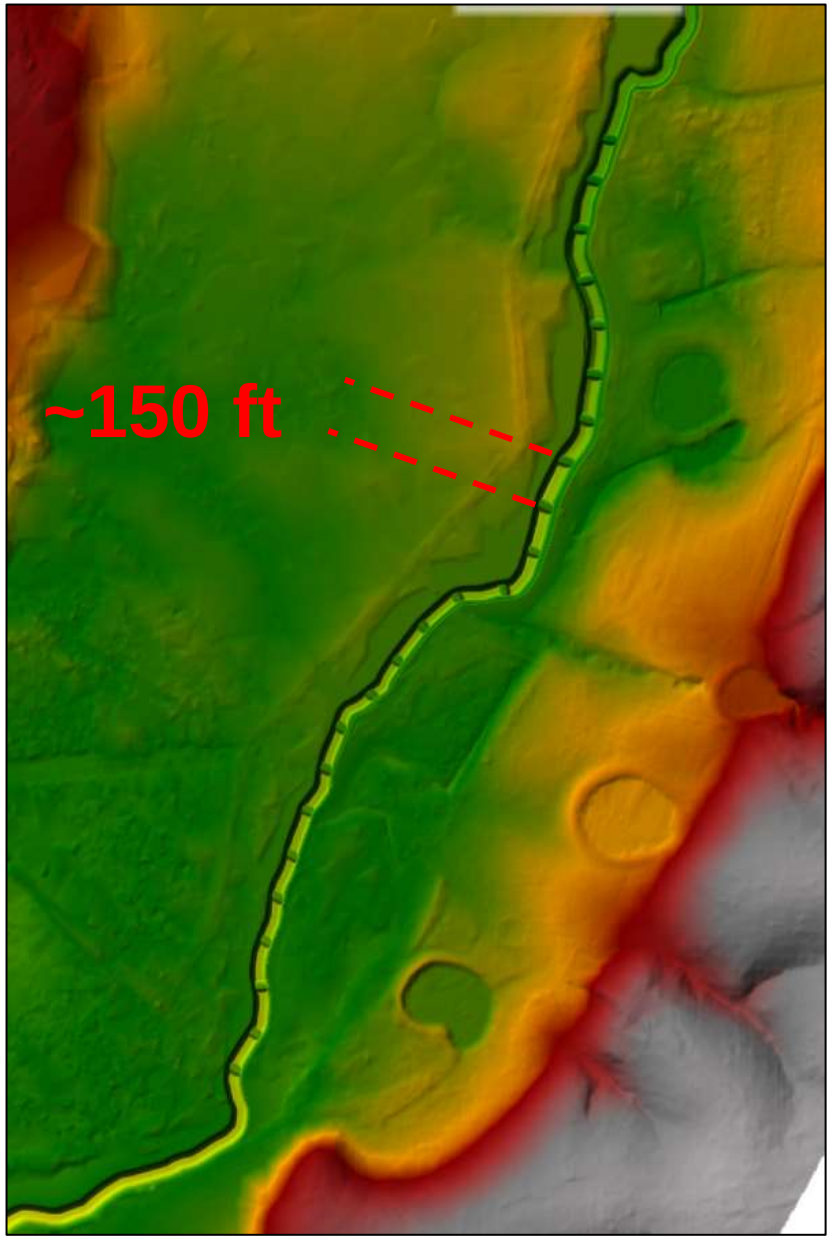
Harnett County

- Minor debris accumulation
- Wide floodplain





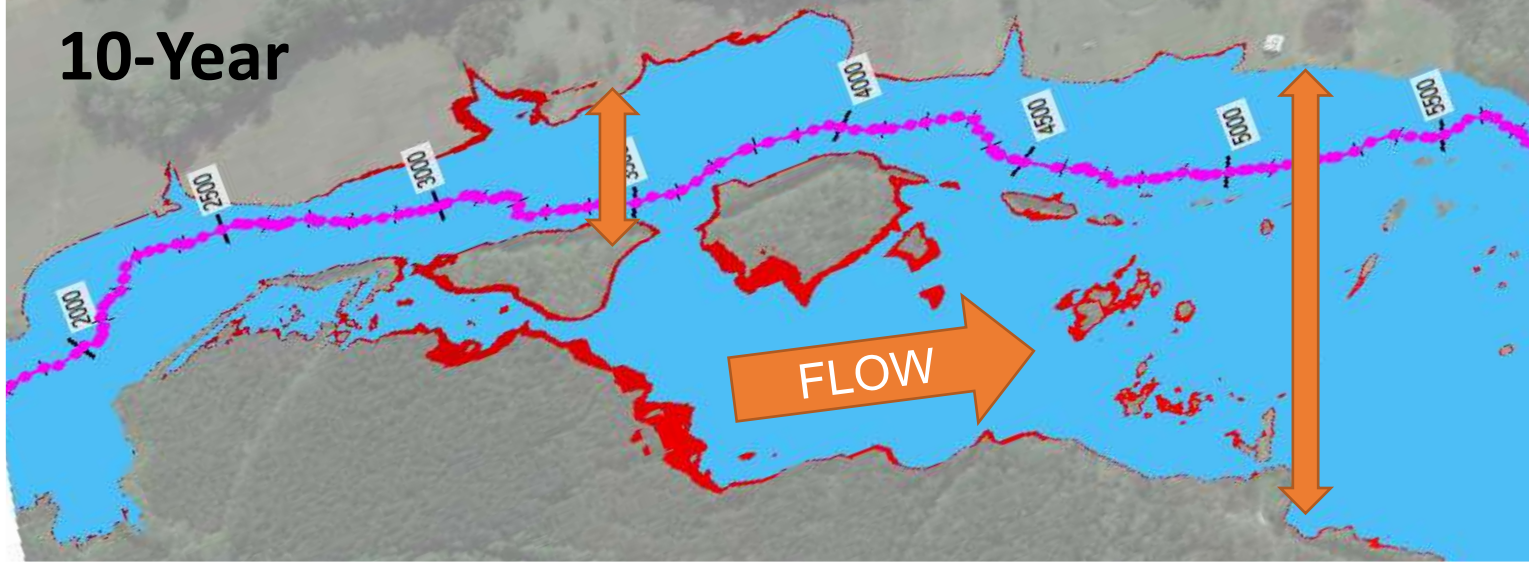
Hypothetical Debris Blockage - 25%, 50%, 75%



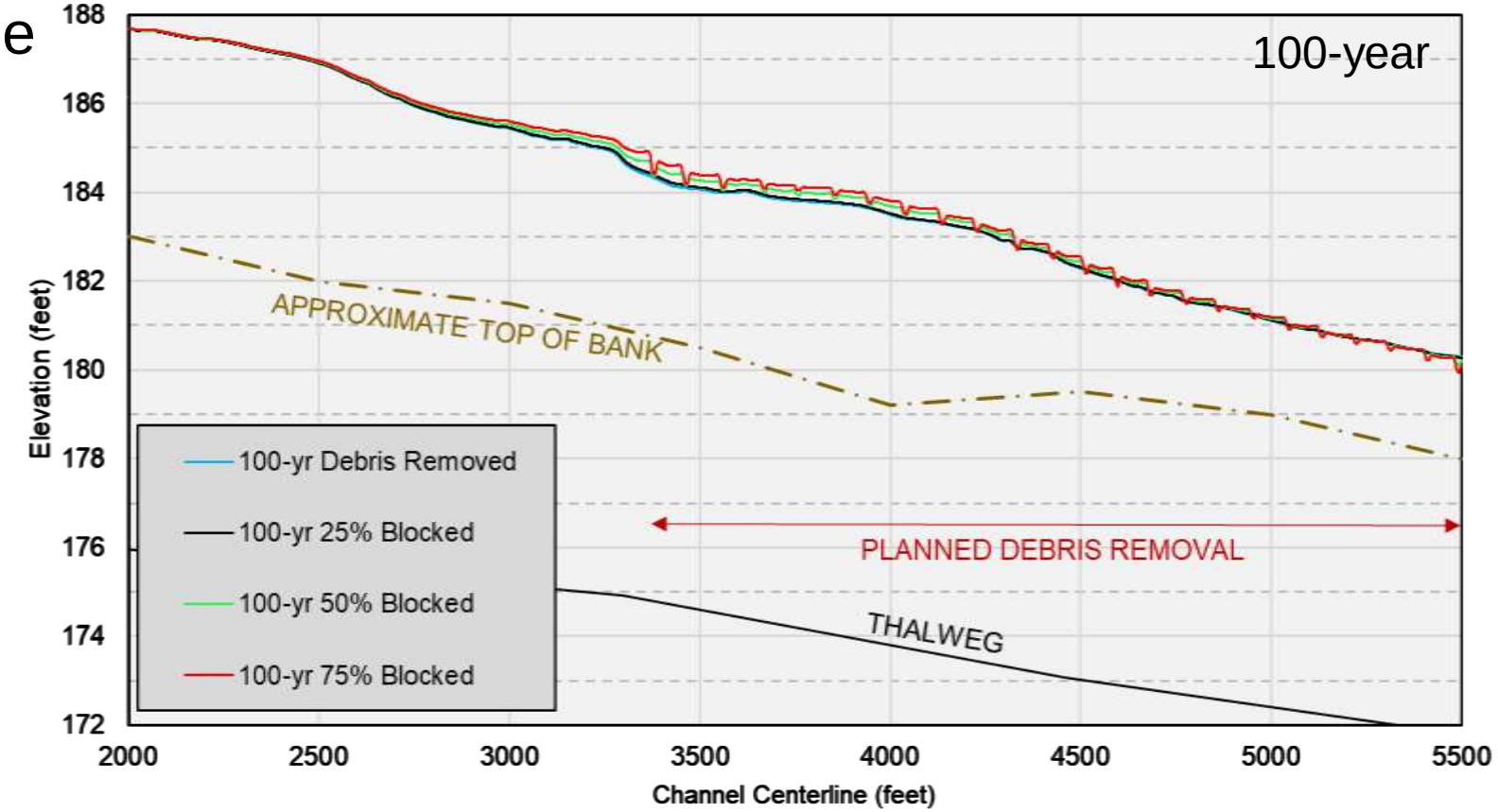
- Large Woody Debris dams typically occur every 7–10 channel widths (Linstead and Gurnell, 1998)
  - For this example
    - 210 - 300 ft

Debris Dam in HEC-RAS

Neil's Creek



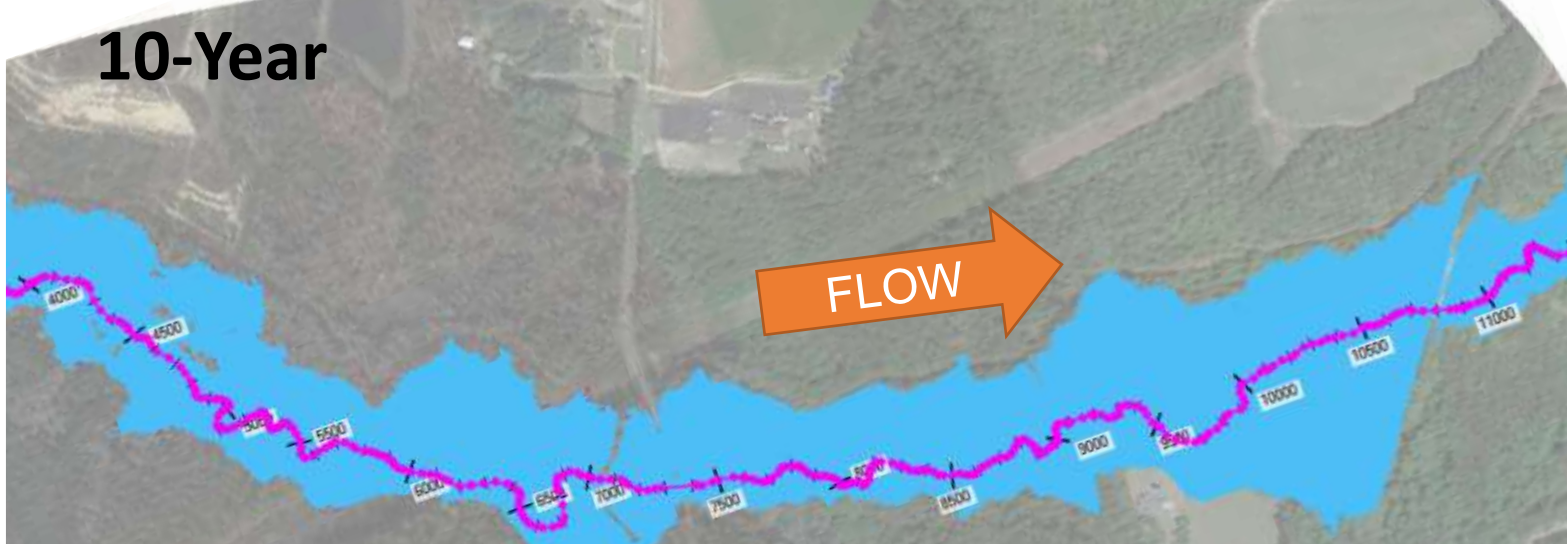
- 10-year: 75% channel blockage
  - ~1 ft WSE rise
- Floodplain width
- 100-year: 75% blockage
  - ~0.5 ft WSE rise

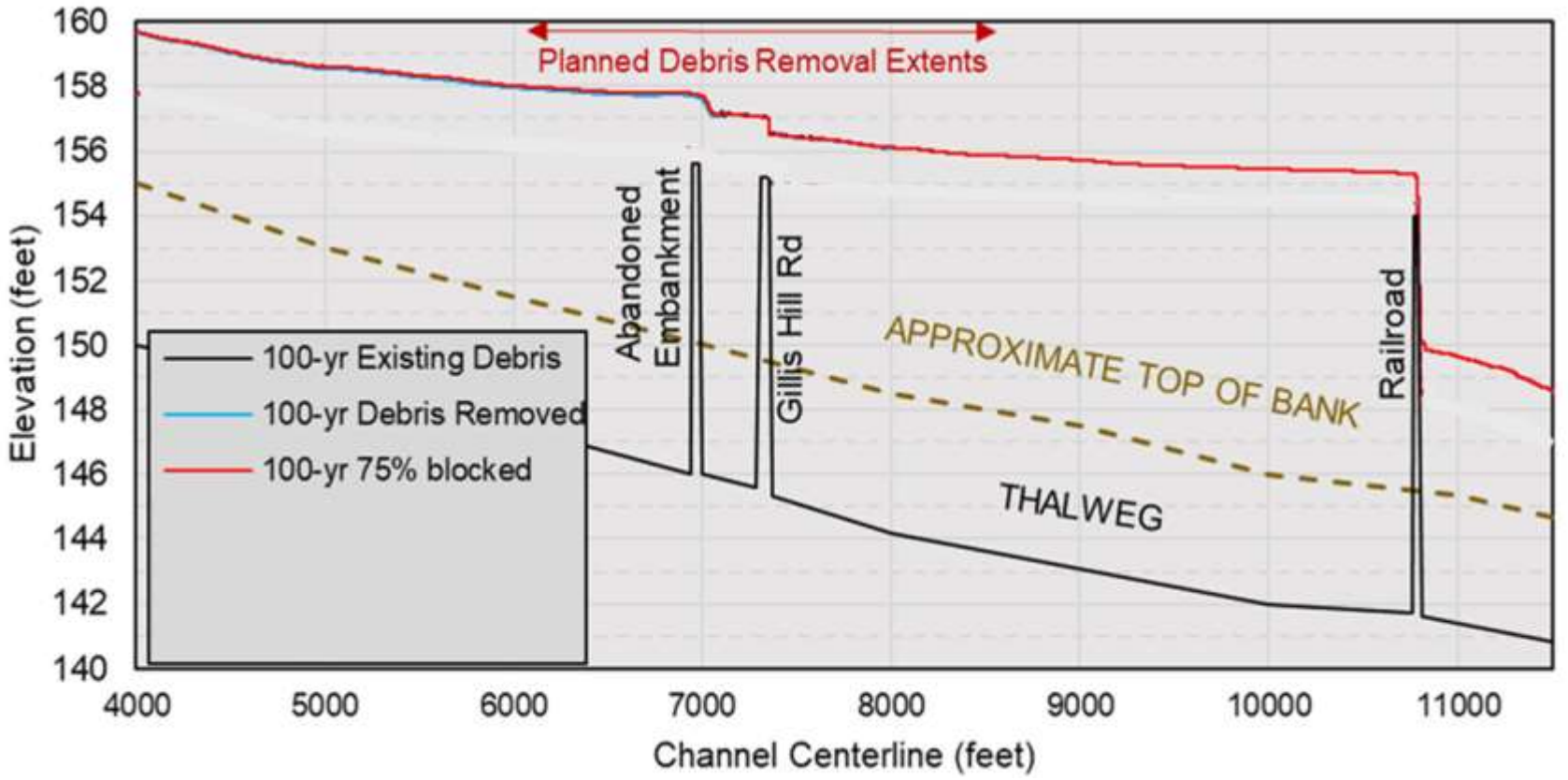


Little Rockfish Creek

Cumberland County

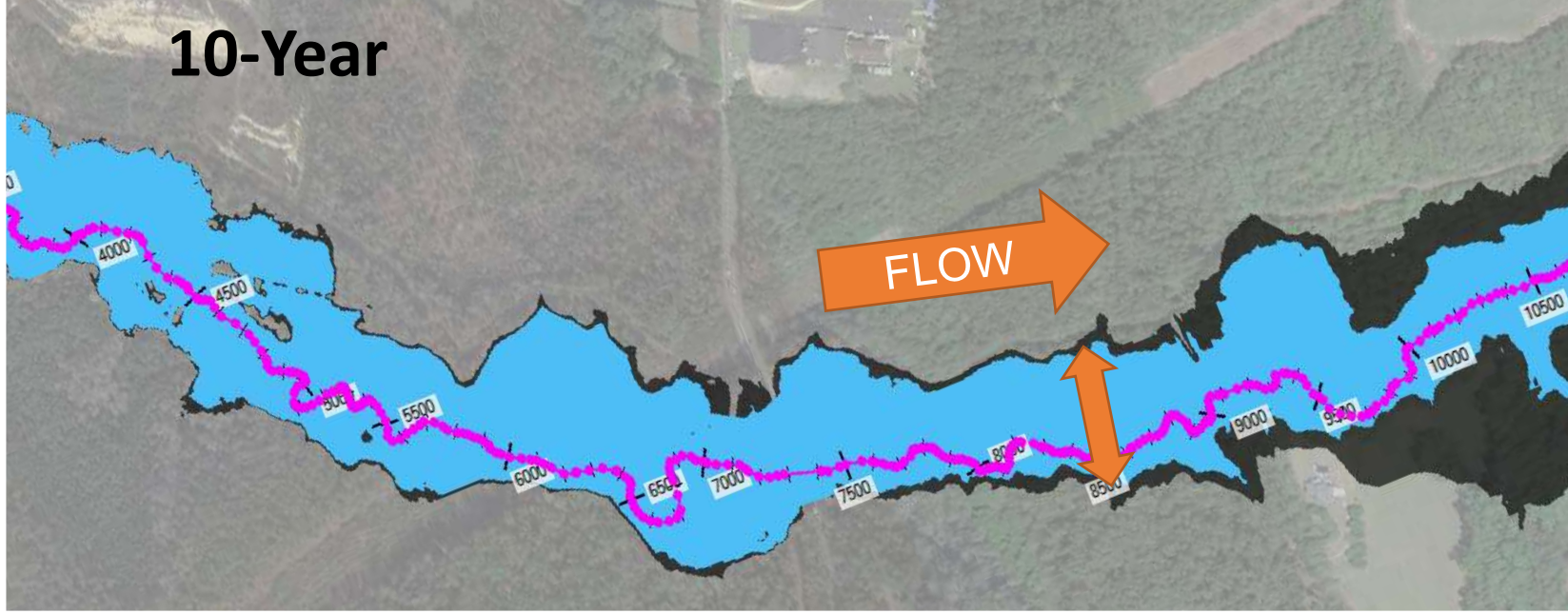
- Moderate debris accumulation
- Reference stream
- Embankments

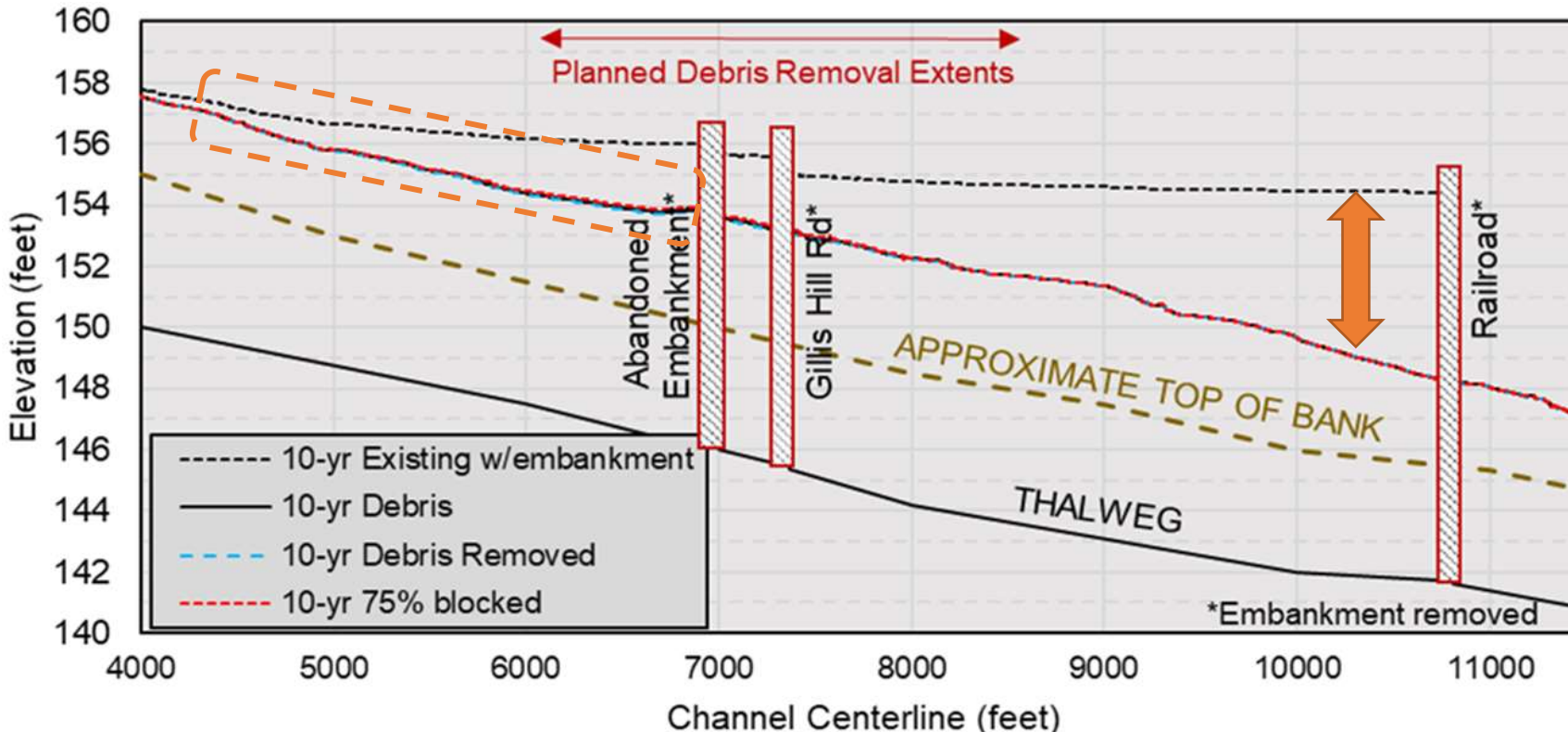




Little Rockfish Creek

- Wide Floodplain
  - ER > 30

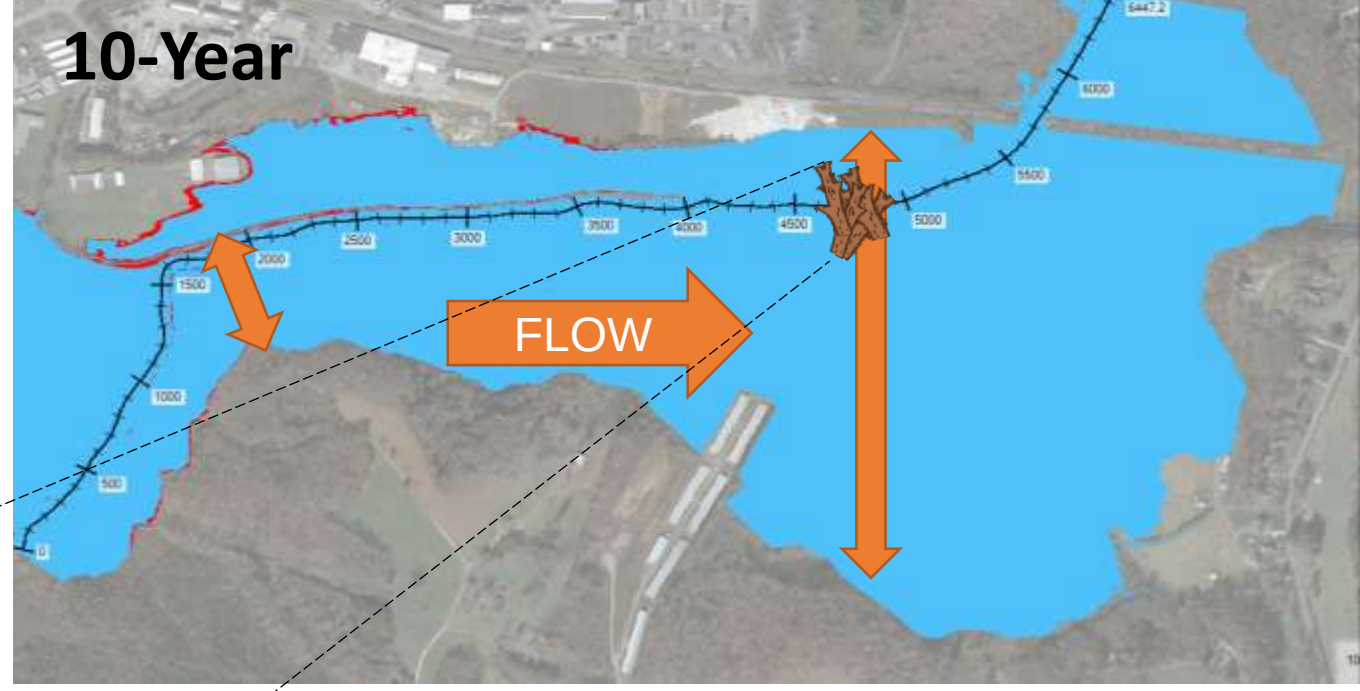


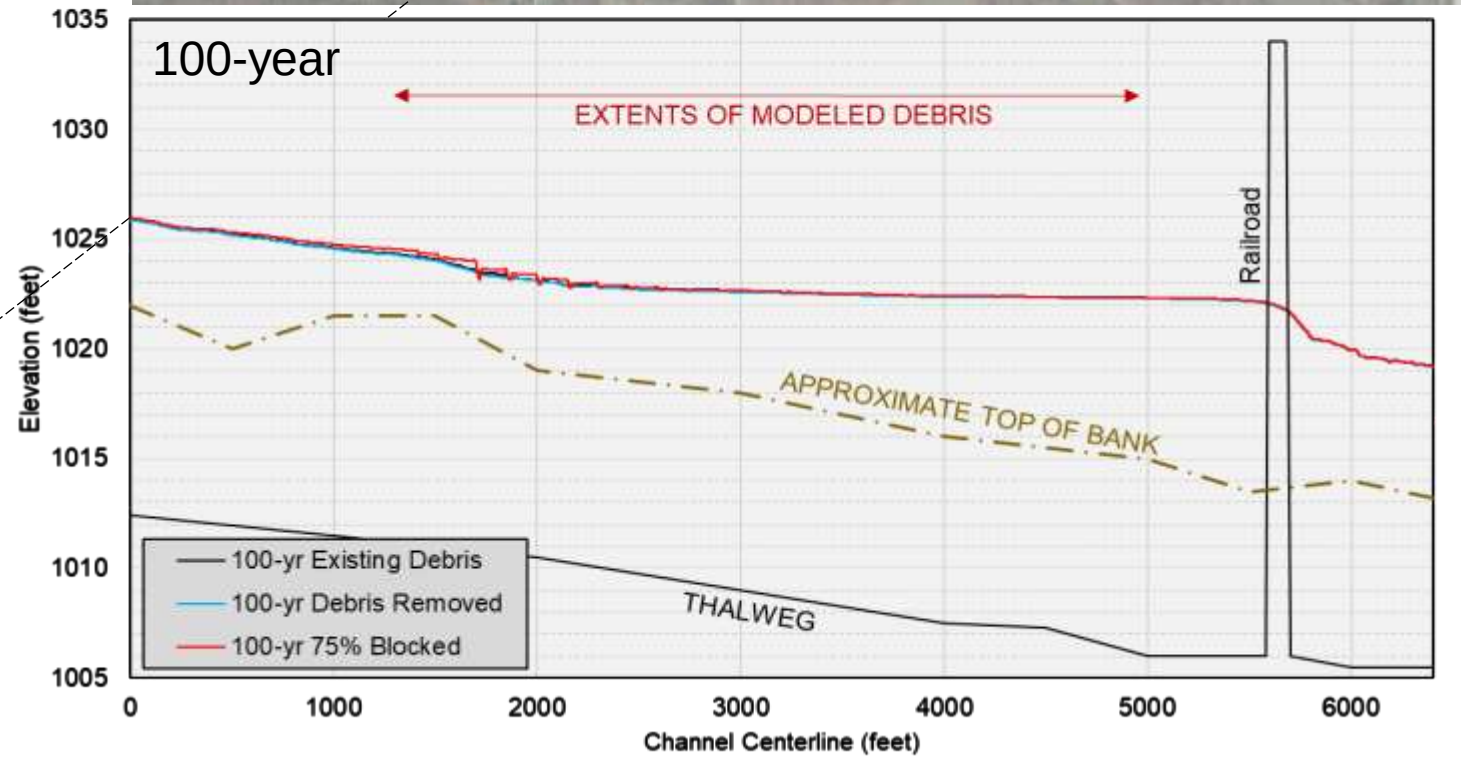


Silver Creek

Burke County

- Railroad backwater
- 10-year
  - Existing debris: <0.2 ft.
  - 75% blockage = 0 - 1 ft
- Floodplain width





Sensitivity Analysis

Entrenchment Ratio (ER)

=

FLOODPLAIN WIDTH
CHANNEL WIDTH

20

5

Channel Blockage

75%

10%

Channel/Floodplain Longitudinal Slope

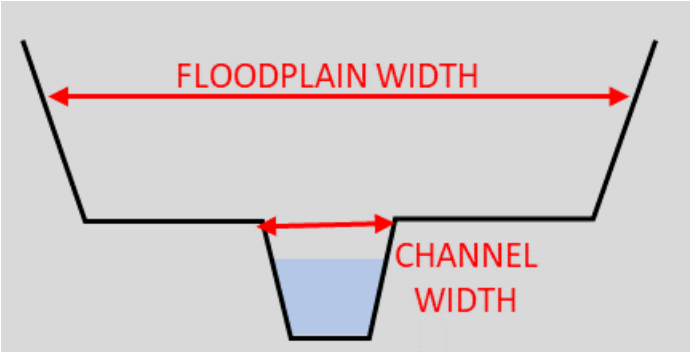
1%

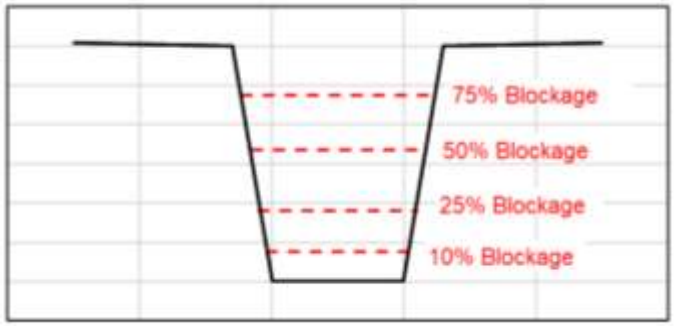
0.1%

Return Period

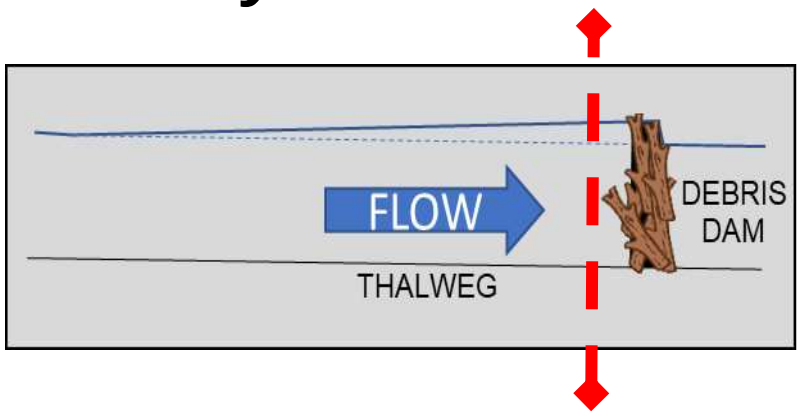
100 year

10 year

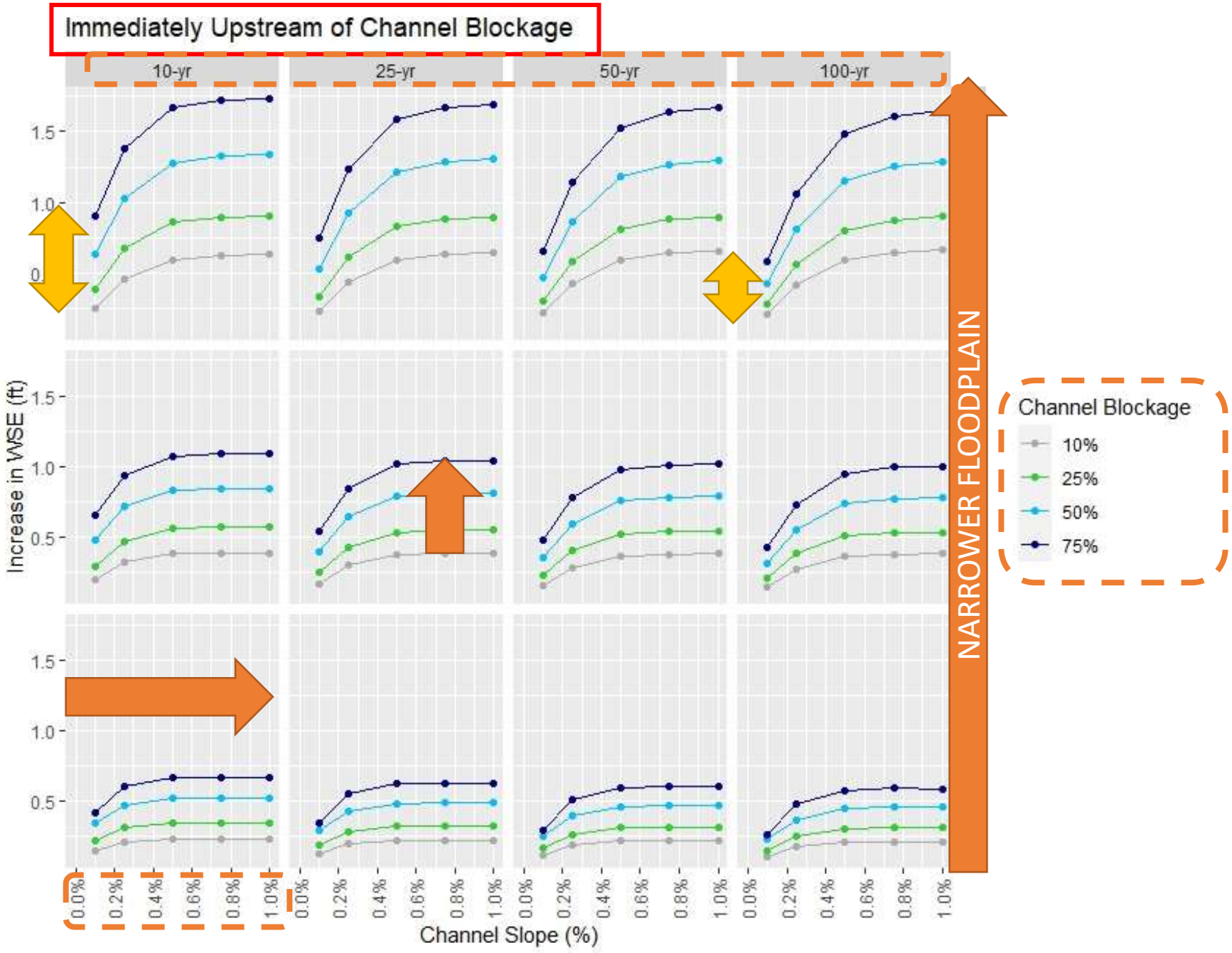




Sensitivity Analysis



- WSE ↑ narrow floodplain
- WSE ↑ steeper slope
- WSE ↑ more channel blockage
- Low slope: WSE rises more for smaller events (10-yr vs 100-yr)
  - Differences negligible for steeper slopes



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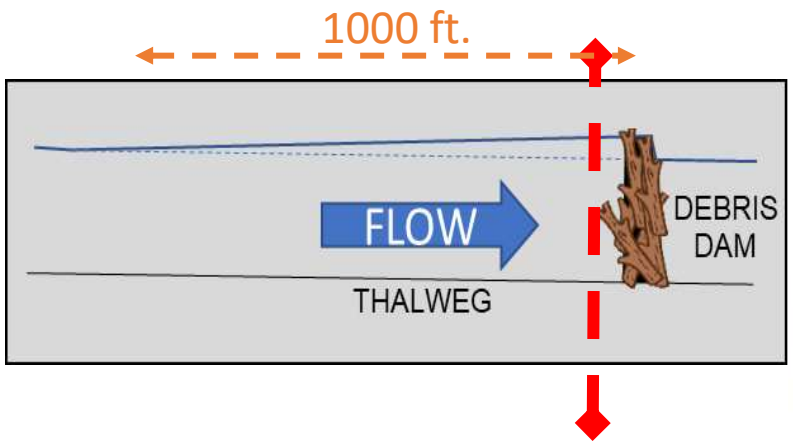
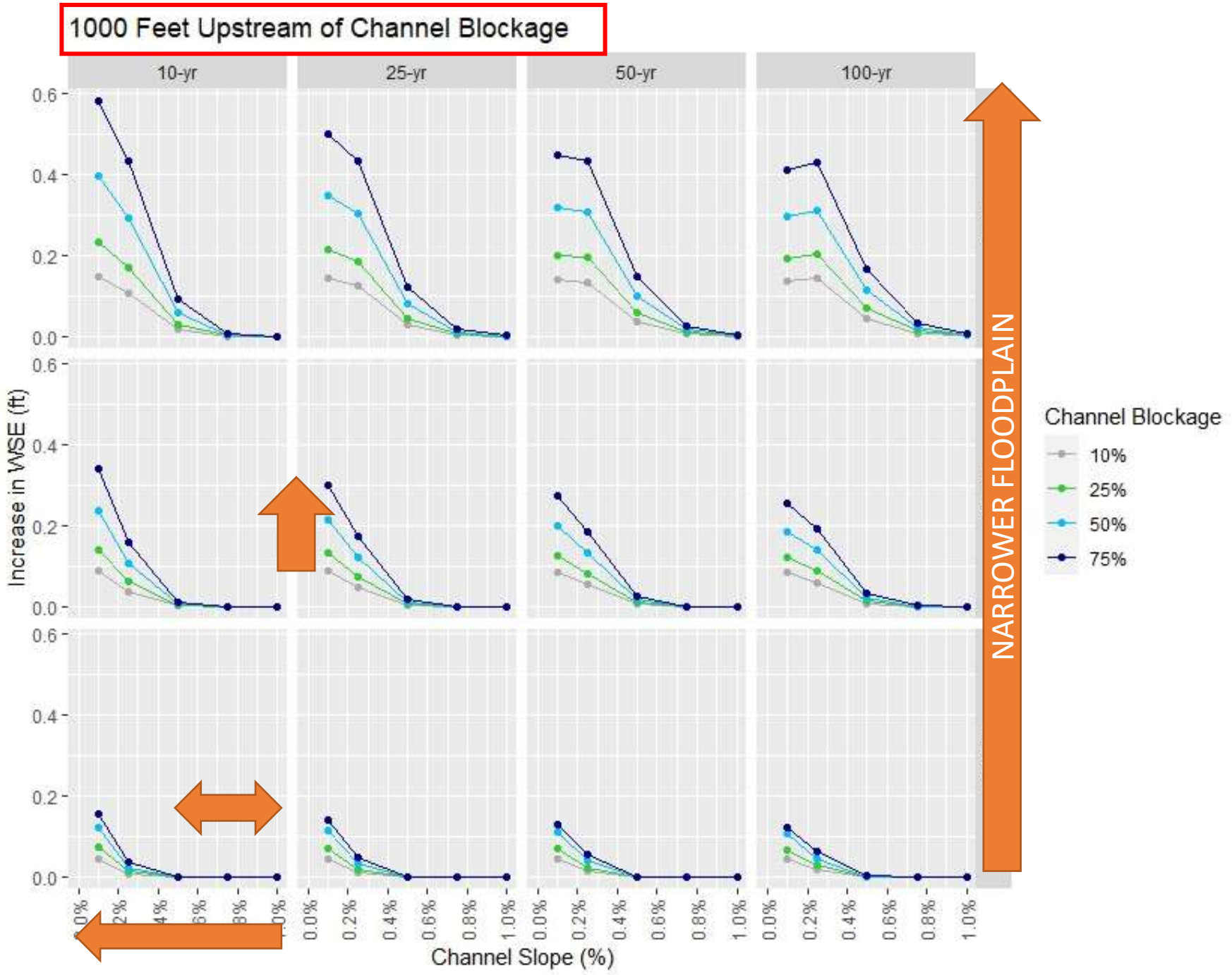


- WSE ↑ narrow floodplain
- WSE ↑ lower slope
- WSE ↑ more channel blockage
- Effects are negligible for channel slope > 0.5%



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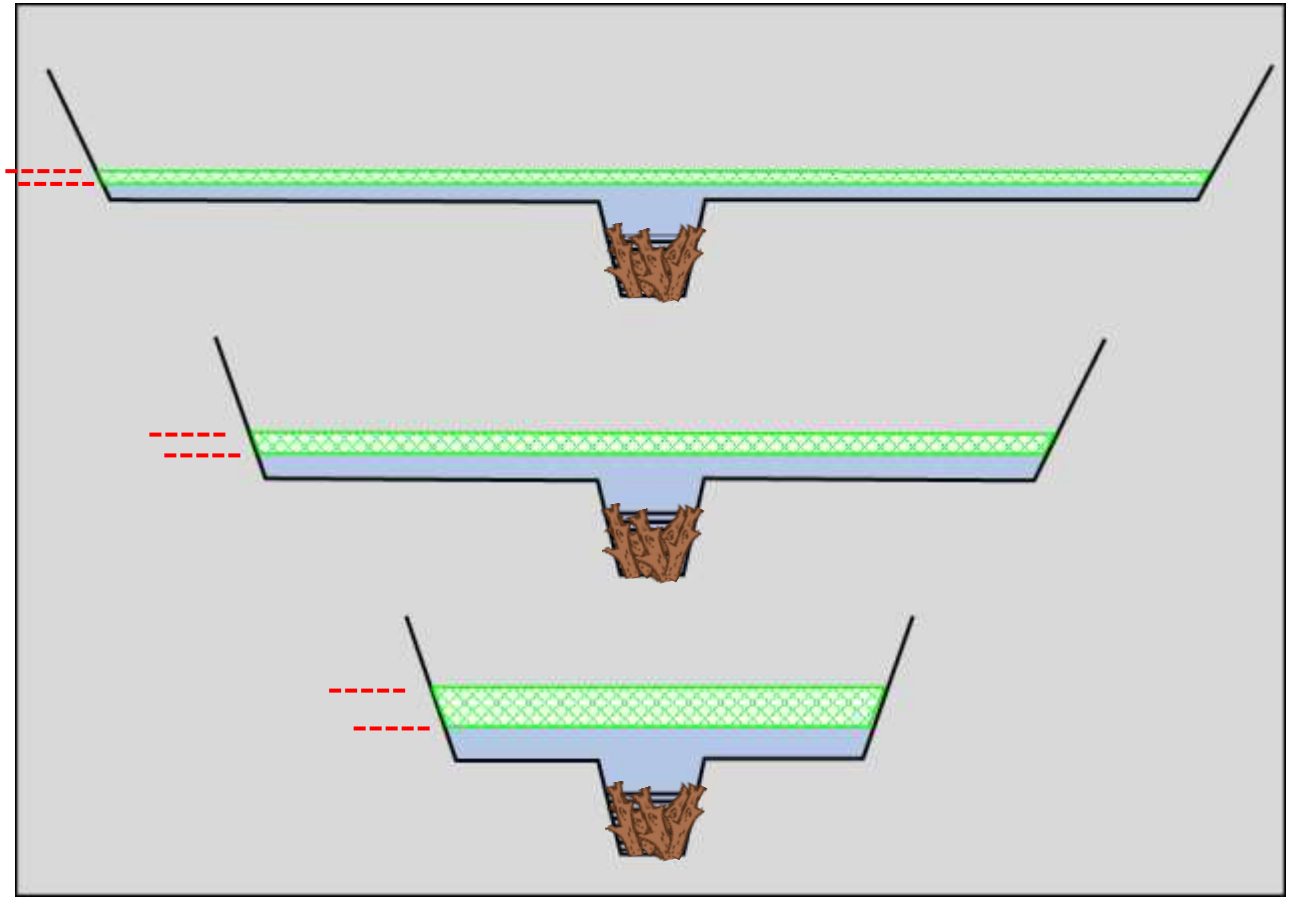
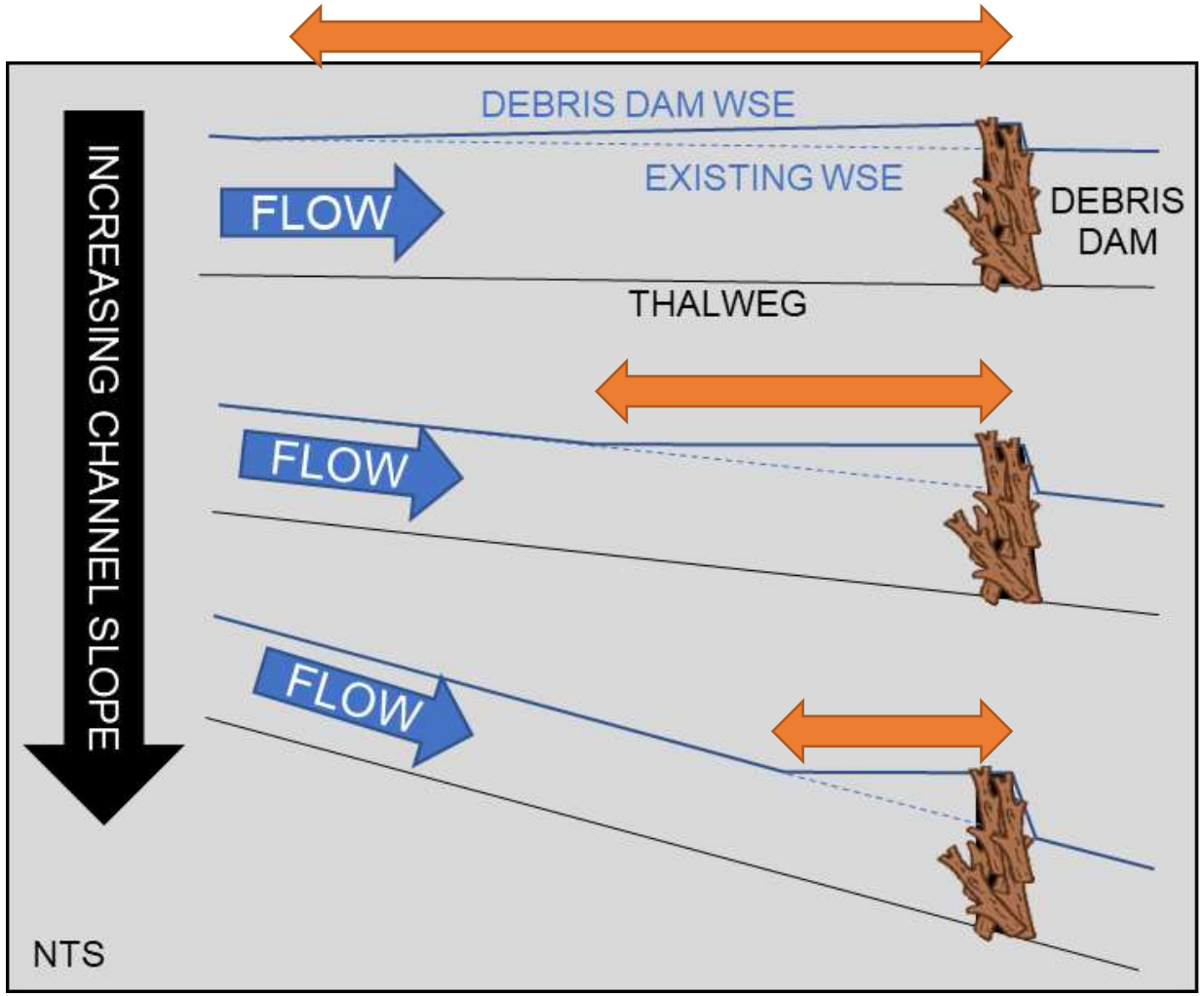
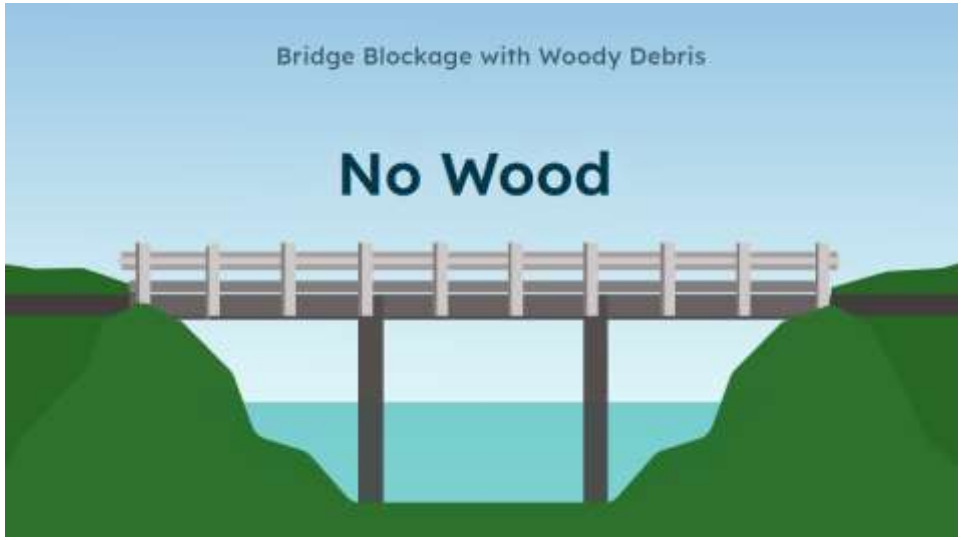
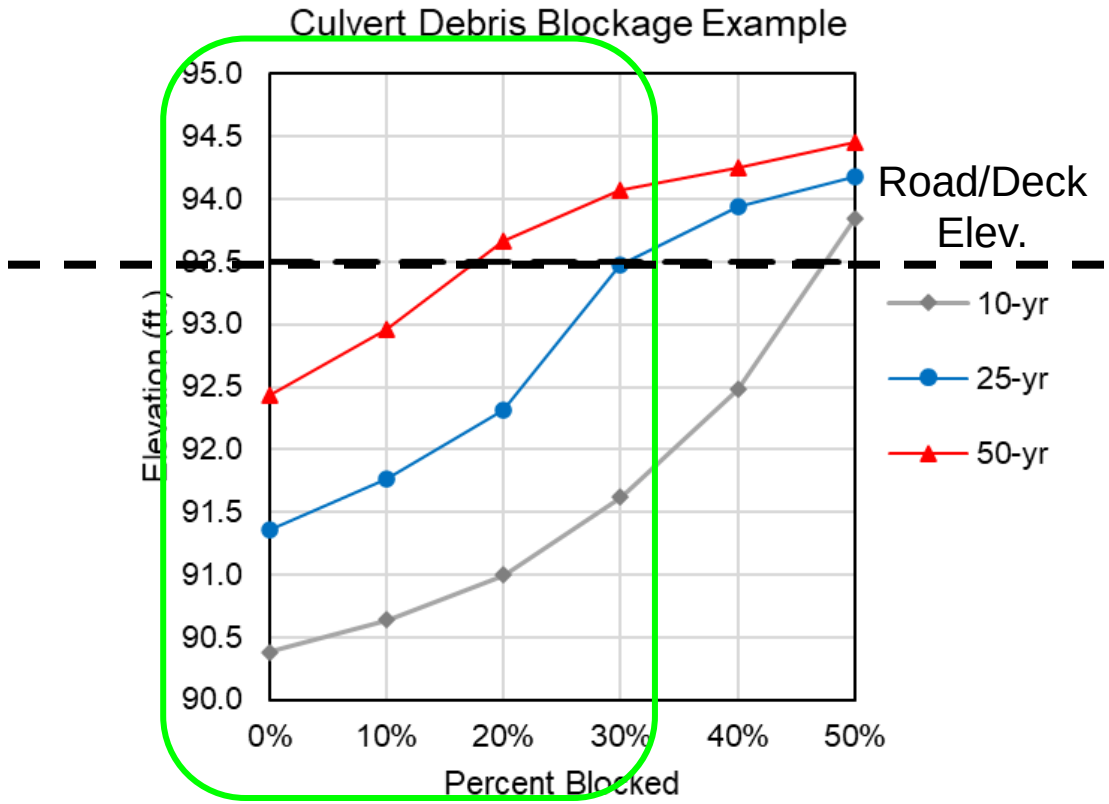




Bridge and Culvert Blockage





Summary

- Removal of existing debris along three study streams will have **minimal impact on reducing flooding** (<0.2 ft)
- Debris accumulation has **negligible impact** on flooding for storms **>10-yr event**
- Backwater from **existing undersized infrastructure** (culverts) can override any potential impacts of woody debris removal
- Large blockages **(75%)** increased water surface by only 0 to 0.5 ft on wide floodplains and <1.5 ft on narrower floodplains
- 20% blockage or more at bridges can increase risk of bridge overtopping and road flooding

When should we remove debris from streams?

- **Always Warranted**
  - At bridges and culverts
  - Navigation (canoe, kayak)
  - Bank erosion risk
  - Removal of non-natural debris

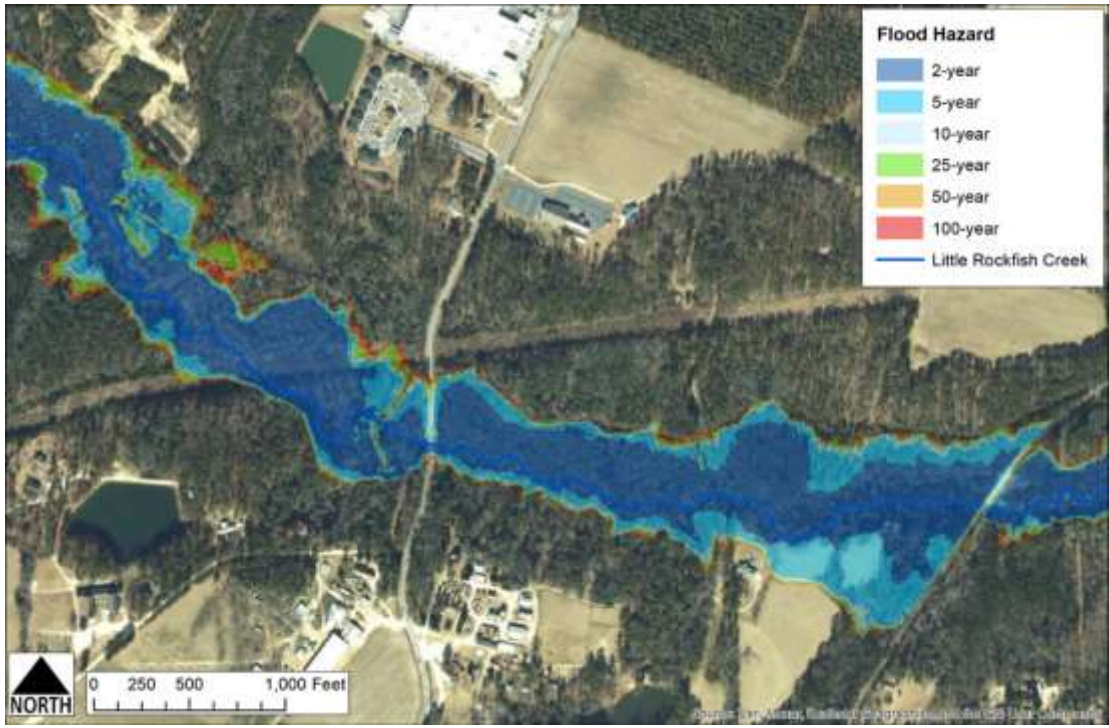
- **Likely to reduce flooding:**
  - Narrow floodplain on steeper slopes

- **Unlikely to reduce flooding:**
  - Wide floodplain on low slopes
  - Substantial downstream obstructions - undersized culverts, embankments

- **No Impact**
  - Debris accumulation is located upstream flooding issues

Recommendations

- Always warranted - At bridges and culverts, Navigation, Bank erosion risk, Removal of non-natural debris
- Education Needed - Flooding on floodplains is a natural occurrence
- Implement infrastructure upgrades and stream restoration efforts that provides permanent solutions
- Move vulnerable structures out of flood prone areas – flood risk is increasing
- Objective process for site selection



Questions?

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Funding:

collaboratory
science. policy. solutions.

Environmental Defense Fund