Flood Impacts and Resilience Field Trip: Supporting Documentation

Lewis Creek at Cota Field, Starksboro, Vermont
CIROH Developers Conference May 27, 2025

Field trip organizers

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Summary

During a field visit to the Cota Field Site, we describe recent flooding impacts within the Lewis Creek Watershed in Central Vermont and more broadly across the state of Vermont. UVM CIROH researchers have established a research station at the property in recent years that helped describe the dynamics of the recent historic flooding. Their findings have highlighted the importance of geologic and landscape setting in routing floodwaters and either exacerbating or mitigating impacts to communities. Watershed partners will join the field visit and share their experience advocating for, and conserving, land along river corridors to build flood resilient communities. The UVM Spatial Analysis Lab will also be on hand to demonstrate the use of drones for rapid flood response and for collection of imagery and lidar-based topography.

On July 10-11, the Lewis Creek Watershed received between 5 and 7 inches of precipitation from the remnants of Hurricane Beryl distributed relatively uniformly across the basin, resulting in widespread flooding. At the outlet of the watershed, a USGS gage recorded a stream flow peak of 5,750 cfs on July 11 associated with a 50 year flood event. Analyses conducted by UVM CIROH researchers, informed by field observations, monitoring data and hydrodynamic modelling, suggest that the upper part of the watershed experienced a 500 year flood, which was attenuated as it traveled downstream. While erosional and depositional impacts were experienced upstream, extensive wetlands and well-functioning floodplains filled with floodwaters and helped to attenuate the flood as it moved through the watershed, reducing downstream impacts. The story of the Lewis Creek, flood impacts in Vermont, and the broader results from UVM research, highlights the mechanisms by which river valley characteristics mediate the movement of floodwaters. Such findings are contributing to targeted watershed management actions to meet flood resilience and water quality objectives and may be used to improve modeling skill.

Acknowledgements

Adam Zylka and the UVM Spatial Analysis Lab have been instrumental in documenting flood impacts in recent years and generously volunteered their time for this field trip. We are grateful to the Town of Starksboro and the Lewis Creek Association for supporting research at the Cota Field and throughout the Lewis Creek Watershed. The UVM Water Resources Institute provided support for these materials.

Elizabeth Doran, Alexander Prescott, Beverley Wemple, David Baude, Ijaz Ul Haq, Julianne Scamardo, Lauren Waters, and Scott Lawson have contributed to the research and findings presented.

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Information on Attached Figures

1- Map of the Lewis Creek Watershed and the Lake Champlain Basin. Lewis Creek is located at the transition of the Green Mountain and Champlain Valley province in central Vermont. Flooding on July 10-11, 2024 had variable impacts throughout the watershed because of this landscape setting. Floodwaters filled floodplains along conserved portions of the watershed, reducing flood peaks from ~a 500 yr event in the upper watershed to a ~50 yr event at the outlet, likely reducing downstream damages. Hydrograph at Cota Field from UVM CIROH temporary gage. Basin scale map from the Lewis Creek Association.

2- Floodwaters at the Cota Field site on the morning of July 11, 2024 on the receding limb of an estimated 500 year flood. Flood extents predicted from a 2D hydrodynamic model match observed flood extents. The 2D model is being used to evaluate flood dynamics. Photo and data credits: Stew Kabis and Ken Johnston.

3- Example of silt line, indicative of maximum flood depths, collected following the July 10-11, 2024 flood at the gazebo at Cota Field. Such high water marks (red dots on map) were used to validate a 2D hydrodynamic (HEC-RAS) model. Modeled flood extents were compared to those predicted by the National Water model. Photo and data credits: Stew Kabis and Ken Johnston.
4- Debris on the baseball dugout collected immediately following the July 10-11, 2024 flooding at the Cota Field on Lewis Creek. Photo credit: Stew Kabis
5- Foot bridge washed out during the July 10-11, 2024 flood. Photo taken on the receding limb, ~8:30 am on July 11, by Stew Kabis.
6- Floodwater filled the floodplain on the receding limb of the July 10-11, 2024 flood. Looking upstream towards UVM monitoring equipment. Photo taken on the receding limb, ~8:30 am on July 11, by Stew Kabis.
7- Field trip map of photo points and informational stations.
8- Research poster by Lauren Waters (UVM CEE 2025) for the Northeastern and North-Central Section GSA meeting in Eerie, PA March 27-30, 2025
9- Research poster by Stew Kabis (UVM MS Geology 2025) for the UVM Student Research Conference

Additional links:

University of Vermont Water Resources Institute: https://www.uvm.edu/water

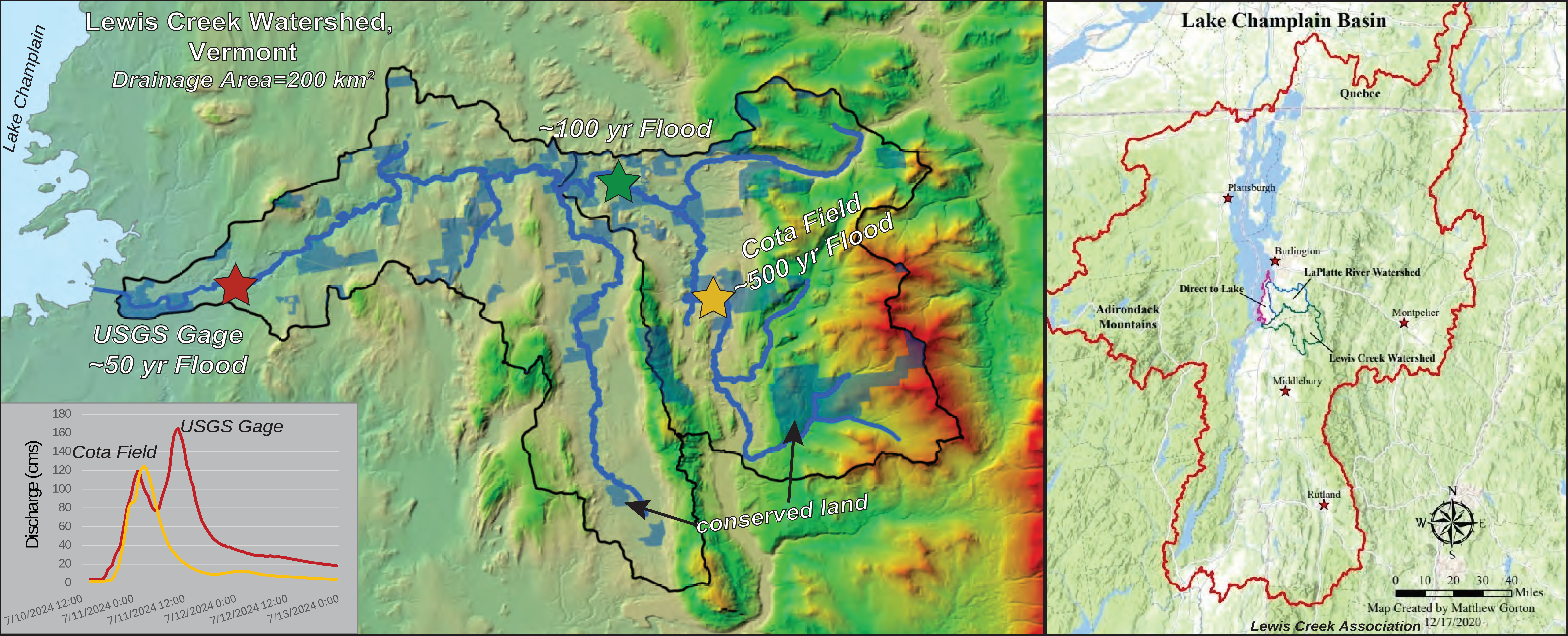
University of Vermont CIROH: https://www.uvm.edu/water/ciroh

The Vermont Functioning Floodplain Initiative: https://ffi.stone-env.net/explore-data

Lewis Creek Association. https://www.lewiscreek.org/

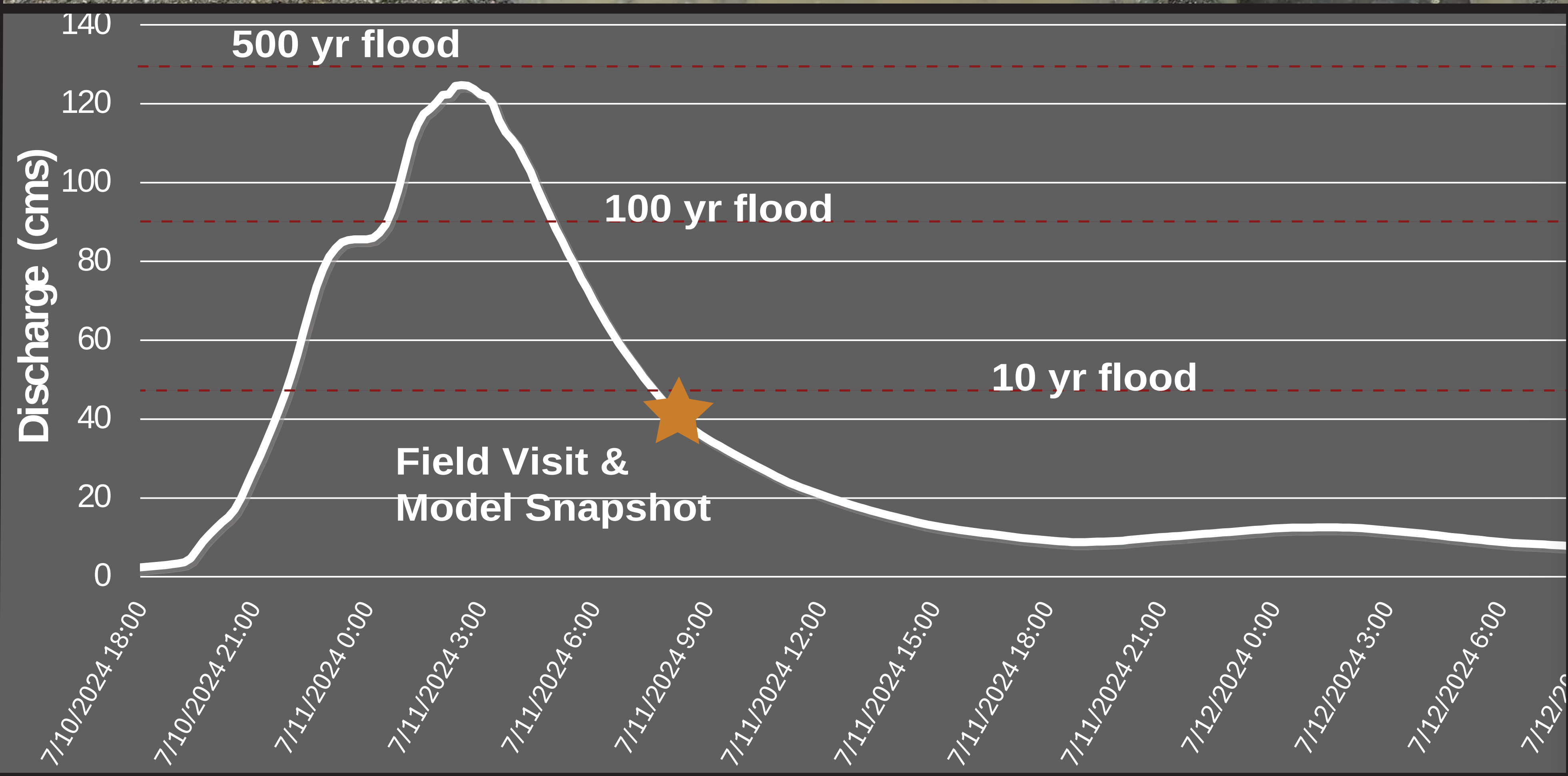
Imagery and elevation datasets collected following 2023 and 2024 flooding by the UVM Spatial Analysis Lab and others: https://experience.arcgis.com/experience/2d835581b93e4f5abdd9f4863135bf32/

A presentation by Kristen Underwood to the Starksboro Conservation Commission on July 2024 flooding: https://www.youtube.com/watch?v=Z7WPNY_c5I0



Lewis Creek Watershed, Vermont
Drainage Area=200 km²
Lake Champlain
~100 yr Flood
Cota Field ~500 yr Flood
USGS Gage ~50 yr Flood
conserved land
USGS Gage
Cota Field
Discharge (cms)
180
160
140
120
100
80
60
40
20
0
7/10/2024 12:00
7/11/2024 0:00
7/11/2024 12:00
7/12/2024 0:00
7/12/2024 12:00
7/13/2024 0:00
Lake Champlain Basin
Quebec
Plattsburgh
Burlington
LaPlatte River Watershed
Direct to Lake
Adirondack Mountains
Montpelier
Lewis Creek Watershed
Middlebury
Rutland
N
W
E
S
0 10 20 30 40 Miles
Map Created by Matthew Gorton 12/17/2020
Lewis Creek Association


photo & map credit: Stew Kabis


Discharge (cms)
140
120
100
80
60
40
20
0
500 yr flood
100 yr flood
10 yr flood
Field Visit &
Model Snapshot
7/10/2024 18:00
7/10/2024 21:00
7/11/2024 0:00
7/11/2024 3:00
7/11/2024 6:00
7/11/2024 9:00
7/11/2024 12:00
7/11/2024 15:00
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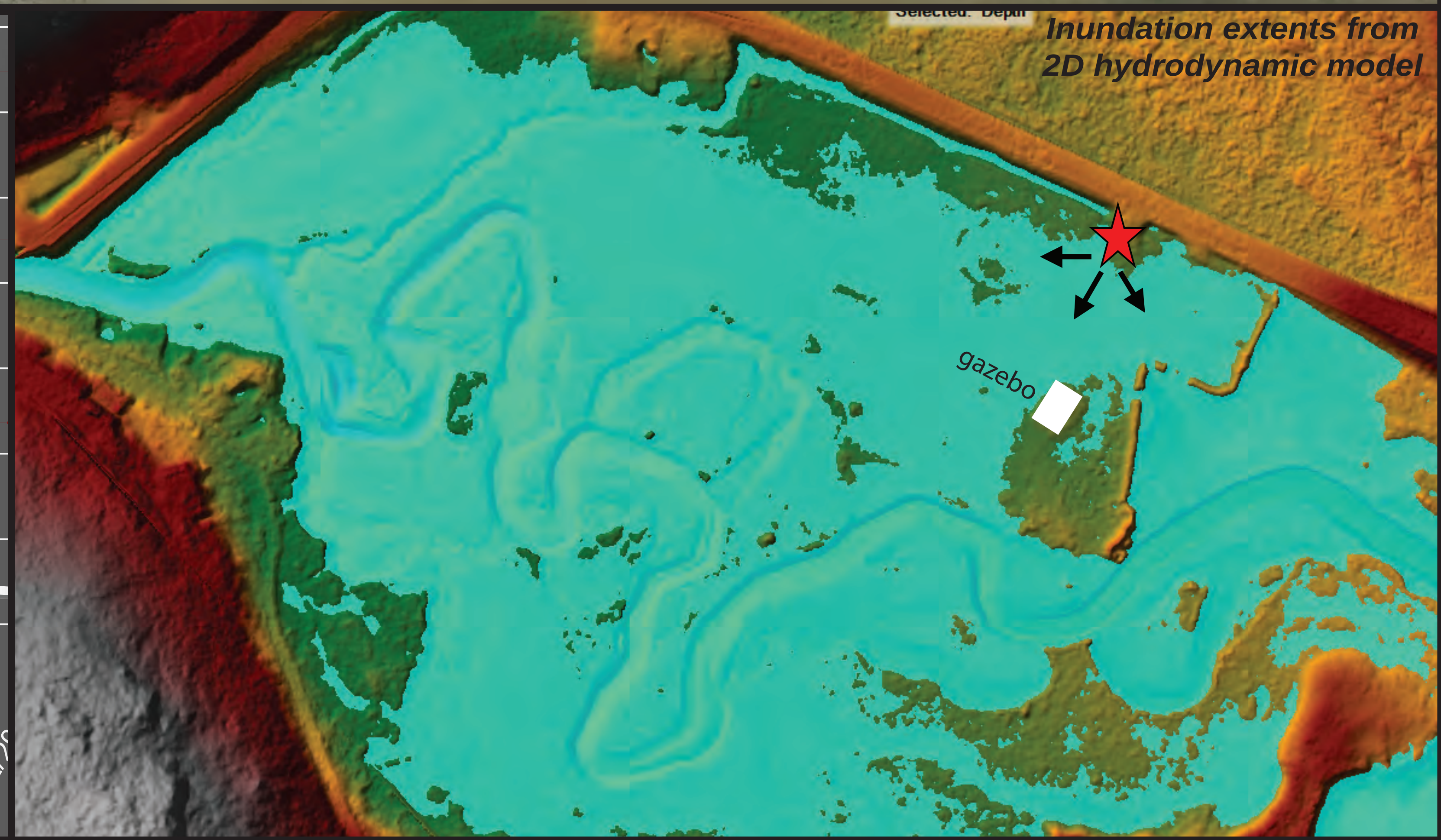
Inundation extents from
2D hydrodynamic model
gazebo

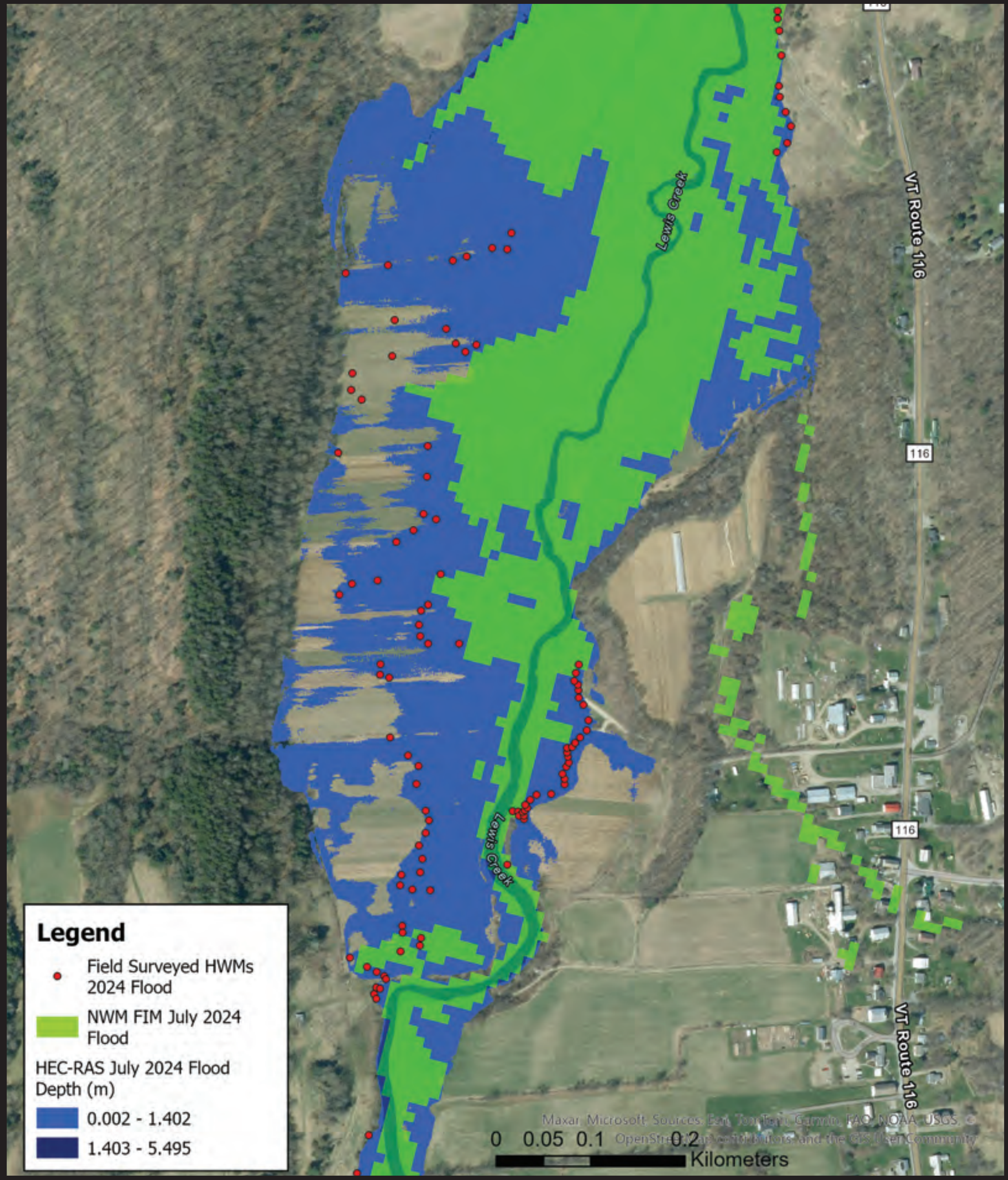

photo & map credit: Stew Kabis

photo credit: Stew Kabis


photo credit: Stew Kabis

photo credit: Stew Kabis

States Prison Hollow Rd
States Prison Hollow Rd
VT Route 116
VT Route 116
UVM Spatial Analysis
Lab UAS Demo
Hike along path
Monitoring
Equipment
Lewis Creek
Lewis Creek
Lewis Creek
Lewis Creek
Lewis Creek
ADCP Discharge
Measurement
Demo
Equipment & Demo Station
Flood Photo Points

Well-Connected Floodplains Enhance Resilience to Extreme Events: A Case Study in Flood Attenuation From The Lewis Creek Watershed, Central Vermont

Lauren Waters[1,2], Natalie Lyon[3], Stewart Kabis[3], Ken Johnston[2,3], Kristen Underwood[1,2], Rebecca Diehl[3,2]

[1]Civil & Environmental Engineering, University of Vermont (UVM); [2]UVM Water Resources Institute; [3]Department of Geography & Geosciences, UVM

BACKGROUND

Extreme precipitation events are happening more frequently in the Northeast, causing significant flooding impacts. In July 2024, Vermont experienced widespread flooding from the remnants of Hurricane Beryl, impacting communities across the state.

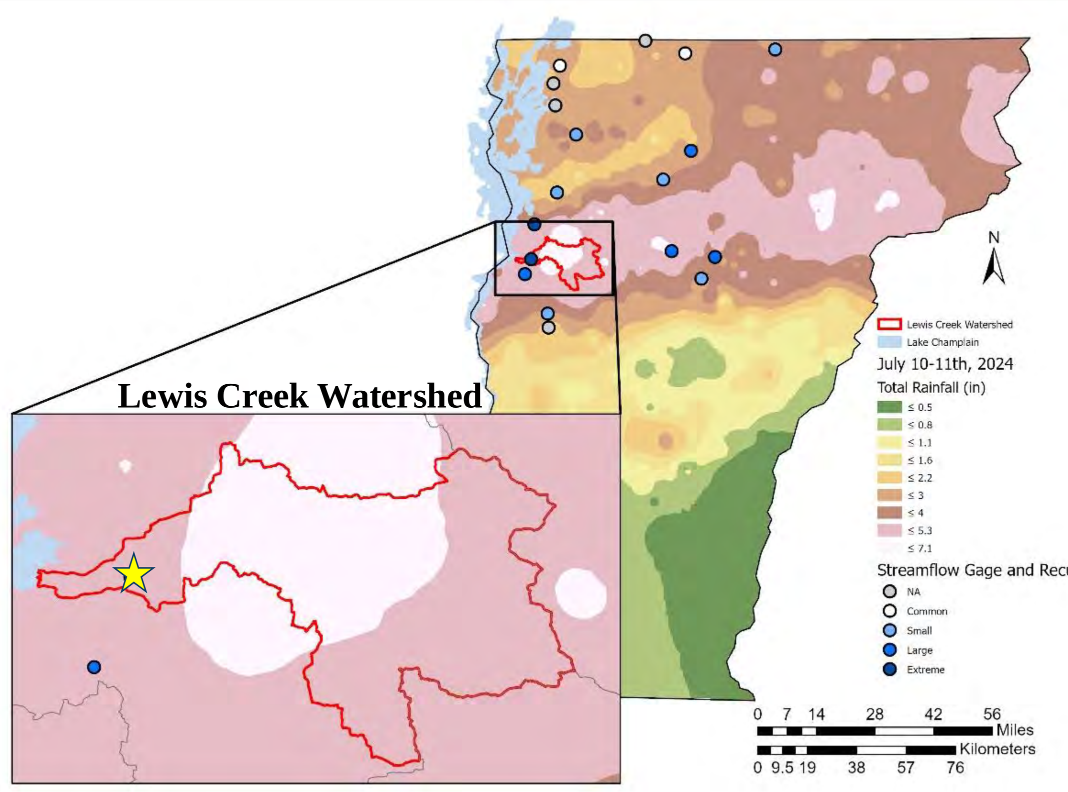

Figure 1. Precipitation map of July 10-11th, 2024, made using Inverse Distance Weighting of observation station data, with focus on the Lewis Creek watershed, receiving 5-7 inches. USGS gage indicated by a yellow star.

50-year flood peak measured at USGS Lewis Creek gage.

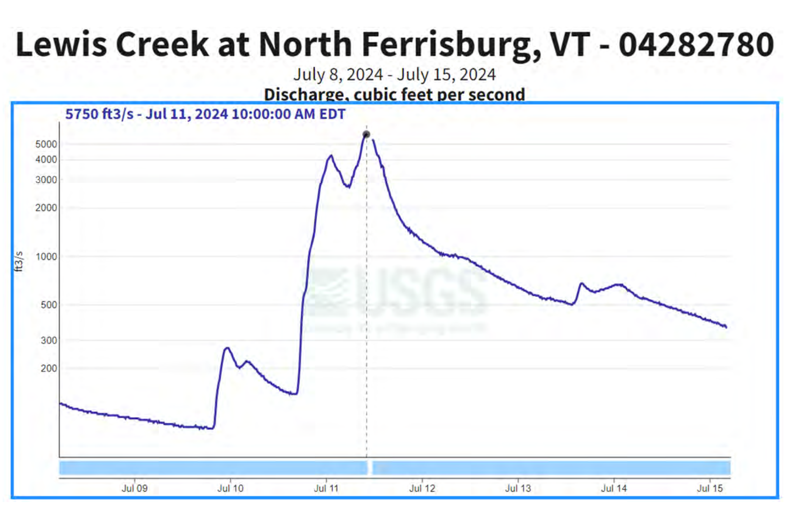

Figure 2. USGS hydrograph the week of the July 2024 floods.

STUDY AREA & IMPORTANCE

The Lewis Creek watershed was greatly impacted by the July 2024 floods. Its floodplains were crucial in attenuating flood waters and protecting communities downstream. By restoring and protecting floodplains, we can help build flood-resilient communities and better prepare for future precipitation events.

Highest peak recorded in this history of 30 years.

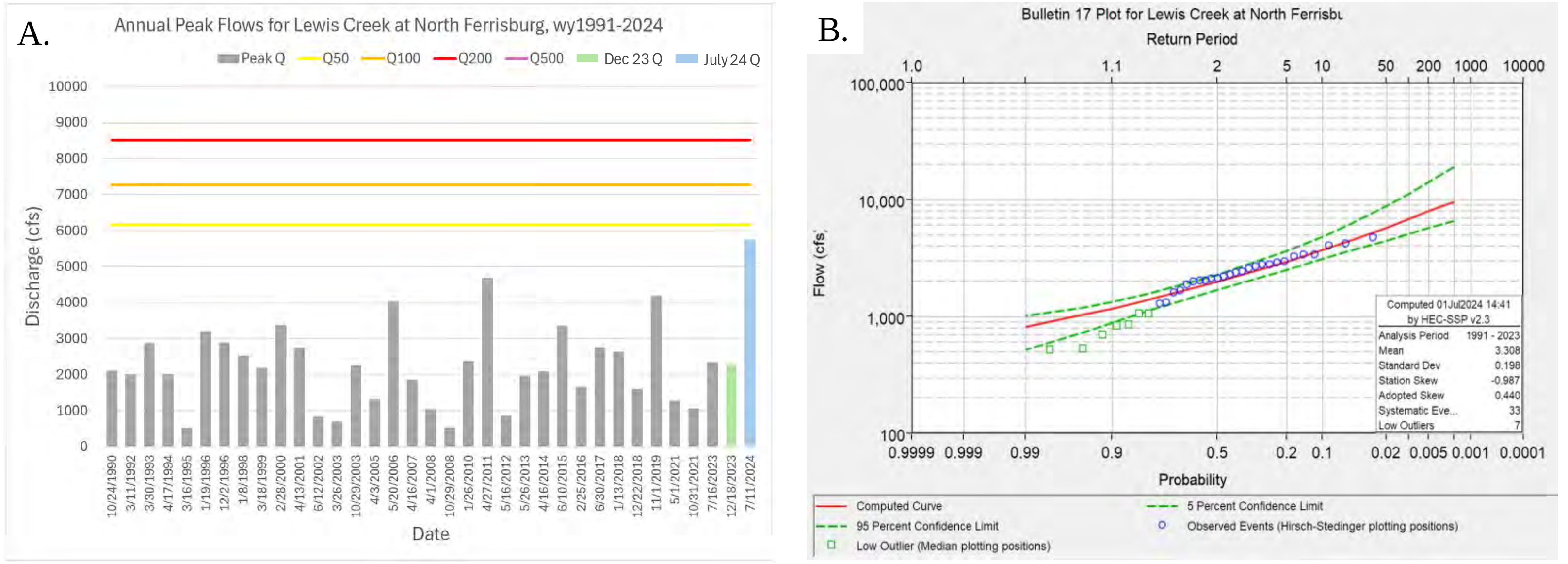

Figure 3. (A) Annual peak flows and (B) Flow Frequency Curve for the USGS Lewis Creek gage.

METHODS

We analyzed the role of floodplain attenuation in the Lewis Creek watershed using the following methods:

- USGS streamflow gage (Figure 2)
- High water marks and imagery (Figure 4)
- Streamflow measurements (Figure 4)
- Flow frequency analysis (Figure 3)
- Indirect discharge estimation using the Slope-Area method

By comparing peak runoff rates and flow reduction between the upstream and downstream areas, we evaluated the effectiveness of floodplain attenuation in reducing downstream impacts.

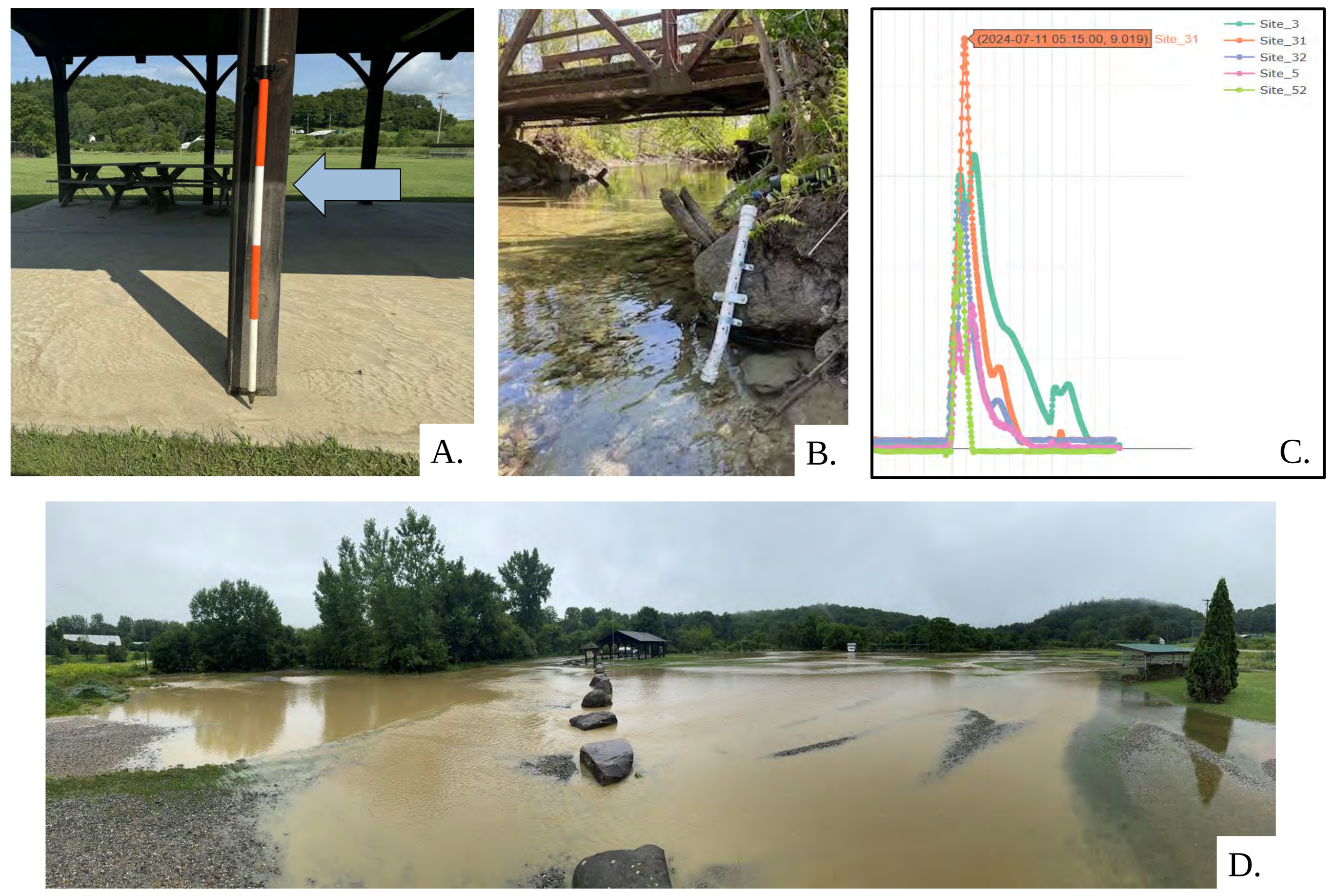

Figure 4. (A) High water mark measurement. (B) UVM deployed stream sensor with PVC housing. (C) Readings from UVM floodplain sensors on 07/11/2024 distributed throughout the watershed. (D) Cota Ball Fields, Starksboro, VT – 11 July 2024, 8:39 am.

Field evidence suggested larger peaks in upper watershed.

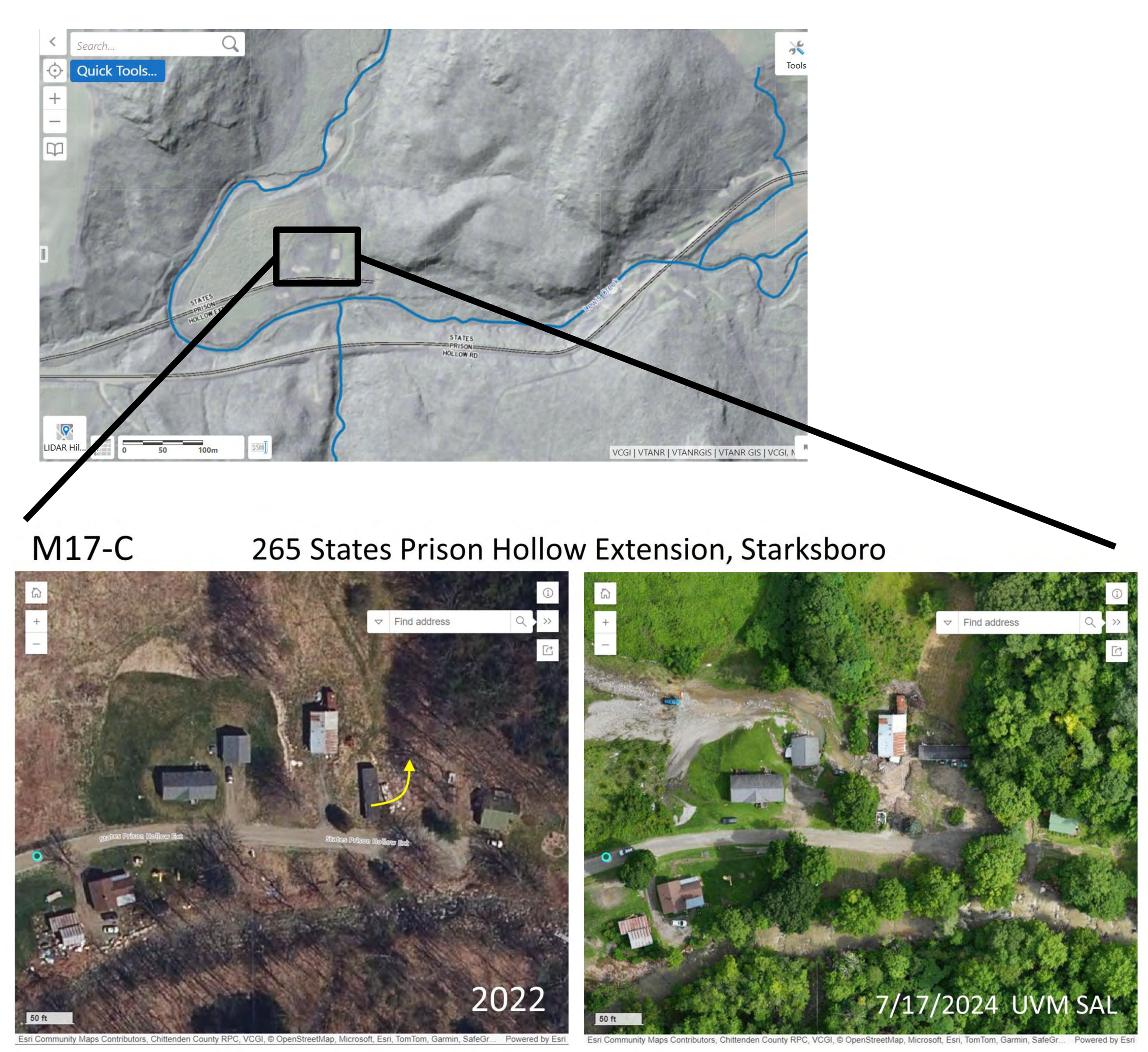

Figure 5. Example of damages caused by deposition and avulsions seen during the July 2024 floods at a site in the upper watershed, where the flood peak was classified as a 500-year event.

RESULTS

In the upstream portion of the Lewis Creek watershed, a peak runoff rate corresponding to an approximate 500-year flood event, with a discharge of 2.8 cms per square kilometer was recorded. Approximately 27 kilometers downstream, at the USGS gage, peak flow was attenuated to 0.81 cms per square kilometer and classified as a 50-year flood event, despite the increased contributing drainage area.

Access to floodplains attenuated flood peaks.

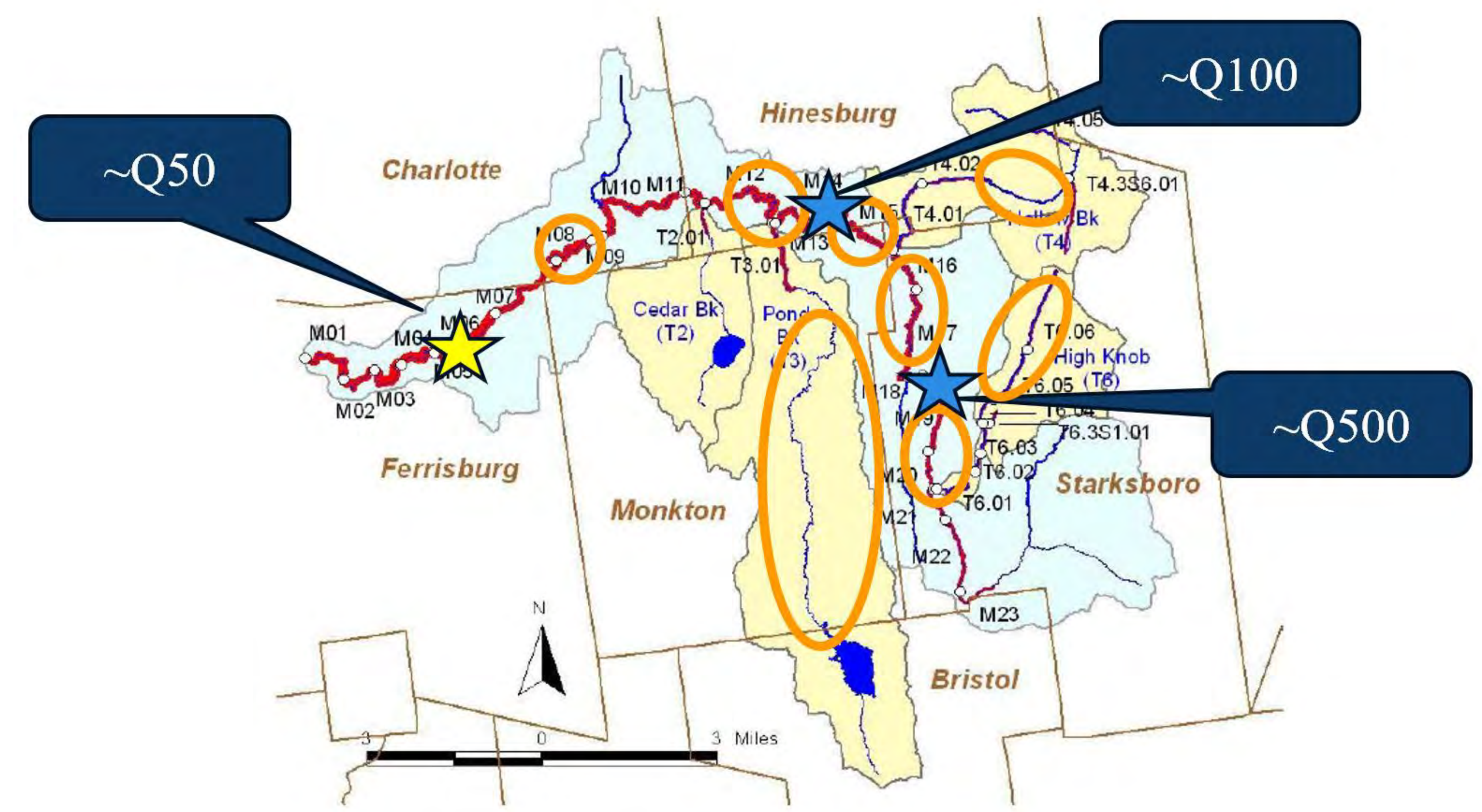

Figure 6. Recorded and estimated peak runoff rates at 3 locations throughout the Lewis Creek Watershed. USGS gage depicted as a yellow star. Blue stars are locations where peak discharges were calculated indirectly using the slope-area method. Orange locations are preserved floodplains and wetlands.

Likely saving downstream infrastructure.

Figure 7. Flood inundation extents estimated from imagery provides an example of flood water storage on floodplains around the Quinlan Covered bridge on the Lewis Creek on 7/11/2024.

Lewis Creek has rehabilitated and preserved floodplains between the upstream and downstream locations that stored flood water, reduced the flow, and protected infrastructure including the Quinlan Covered bridge (Figure 7) and homes in North Ferrisburg village in the downstream watershed.

CONCLUSIONS

Extensive wetland and well-functioning floodplains attenuated the flows and helped to prevent damages to downstream infrastructure.

Acknowledgements

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How Does Floodplain Geomorphic Heterogeneity Influence Flood Routing and Attenuation?

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3: Department of Watershed Sciences, Utah State University, UT

1. Introduction

- Floodplains help attenuate floods by slowing down and providing storage of floodwaters. *(Sholtes and Doyle, 2011; Woltemade and Potter, 1994.)*
  - Little is known about how the meso- and micro-scale topography of a floodplain influences floods.
- How does a floodplain's geomorphic heterogeneity influence flood routing and attenuation?
- **Geomorphic heterogeneity (GH):**
  - Diversity and spatial arrangement of topographic landforms.
  - Channels, levees, depressions, etc. found on a floodplain surface.
  - Different types of landforms have different effects (e.g., slowing, diverting, storing) on overbank flood water.
- **Hypothesis**: The natural floodplain topography of a reach will more effectively attenuate floods than an alternate version of the floodplain that has been digitally flattened to remove all GH.

Study Site Locations

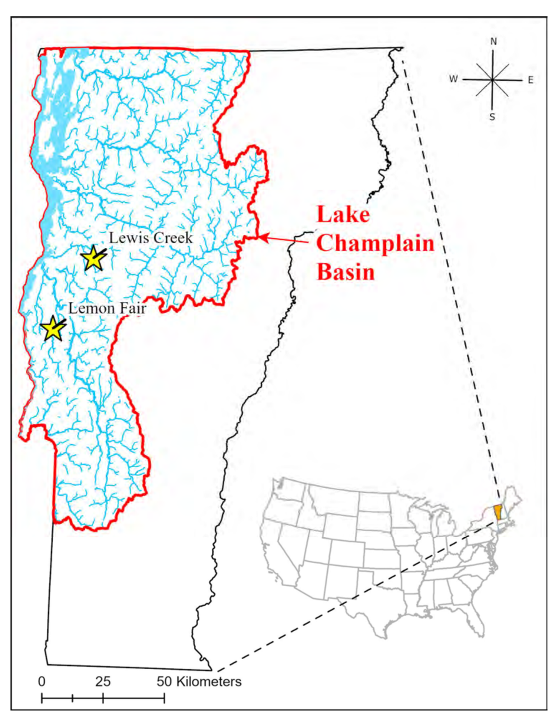


Figure 1: Locations of two study sites.

Two study reaches:

- These reaches have notably different watershed and hydraulic characteristics as shown in Table 1.
- Expected to rout and attenuate floods differently.

2. Simulating Flood Routing and Topographic Variability

HEC-RAS 2D Models

- 2D models are useful for measuring flow (velocity, depth, etc.) across 2D surfaces, like floodplains.
- Two scenarios modeled for each site: the "natural floodplain" and the 'No GH' floodplain (see Figures 4 and 5).
- Models calibrated using field surveyed high-water marks and continuous stage records from field sensors.

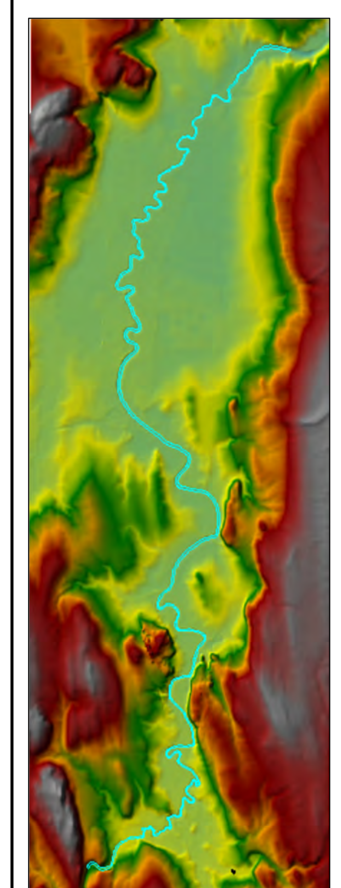


Figure 2: HEC-RAS model for Lemon Fair River

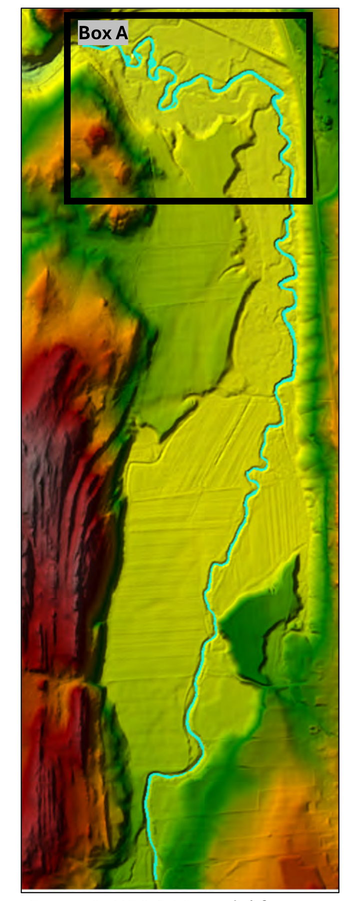


Figure 3: HEC-RAS model for Lewis Creek.

Natural Floodplain

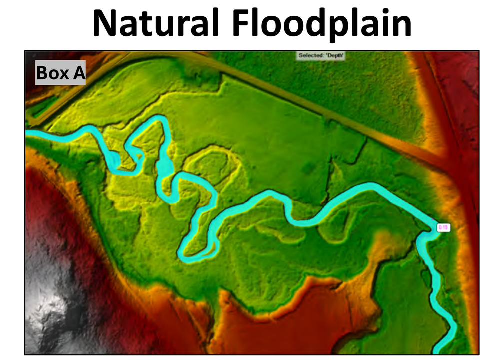


Figure 4: Example of natural floodplain topography. Note old meander channels, berms, etc.

'No GH' Floodplain

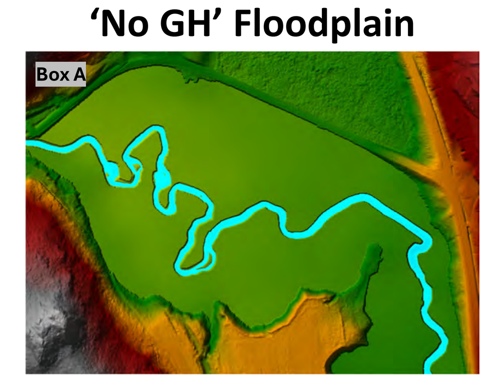


Figure 5: Model terrain with digitally flattened floodplain topography. Down-valley slope, lateral slope, and Manning's n roughness values were preserved in the flattened terrain.

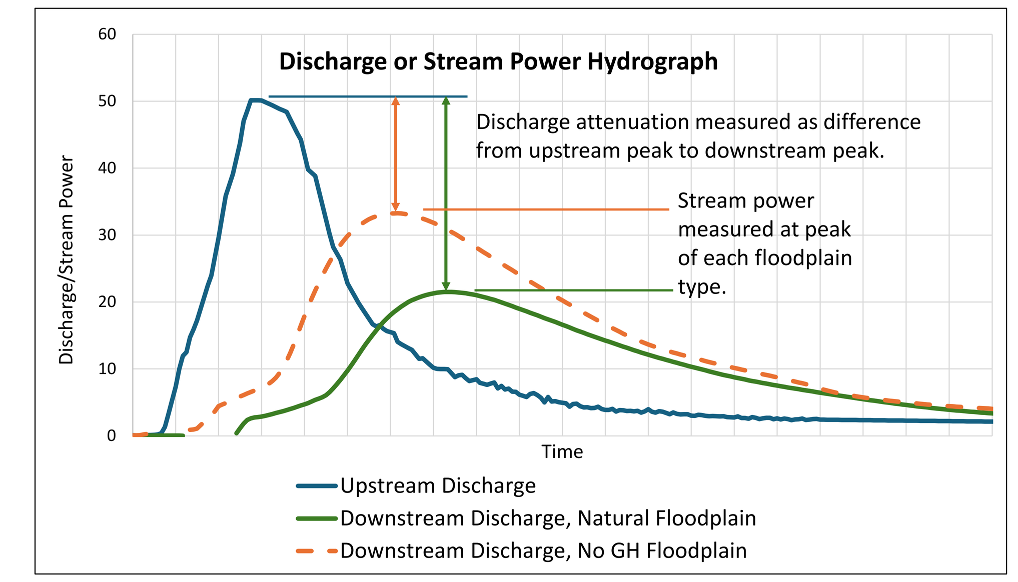
Table 1 – Study Site Characteristics

Reach Characteristic	Lewis Creek	Lemon Fair River
Main Channel Length (km)	3.9	15.4
Channel Slope	3.3E-3	8.1E-5
Gradient Classification	Moderate Gradient	Low Gradient
Average 500-year Floodplain Width (meters)	131	660
5-year, 500-year Flood Peak Discharges (m^3/s)	34_1, 130_1	50_2, 167_2
Floodplain Land Use	Crop fields, grassland	Crop fields, grassland
Drainage Area (km^2)	48	176

[1] Jacobs, 2010; [2] Streamstats, 2024.

Measuring Reach-Scale Attenuation

- Three flood sizes were simulated for each floodplain scenario (6 total sets of conditions) for each site.
- Attenuation calculated as change of peak discharge and difference in peak stream power.
  - Discharge – rate of flow of water
  - Stream power – potential energy of flowing water *(Fonstad, 2003)*



Characterizing Floodplain Geomorphic Heterogeneity

- Natural floodplain topography classified into geomorphons, categories based on general landform shape: concave, convex, and flat.
- Metrics used to characterize the geomorphic heterogeneity of each natural floodplain:
  - % concave features
  - % flat features
  - Rugosity: ratio of surface area of floodplain to surface area of a plane occupying the same x, y extent. *(Scown et al., 2015)*

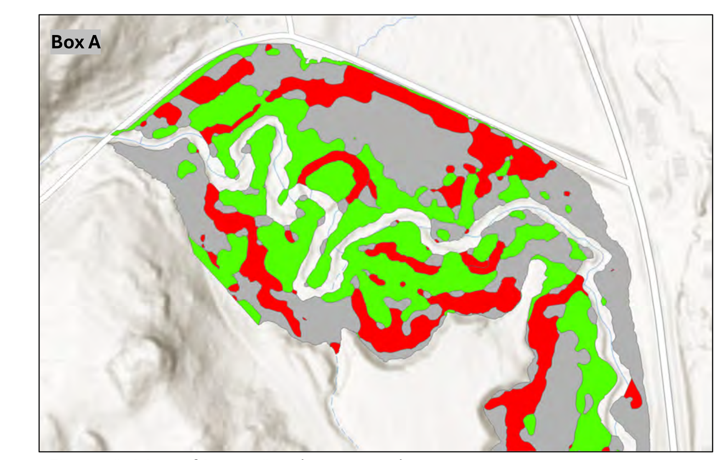


Figure 6: Map of Lewis Creek geomorphons.

Legend

- concave geomorphon
- convex geomorphon
- flat geomorphon

Table 2 – Floodplain Geomorphic Heterogeneity Metrics

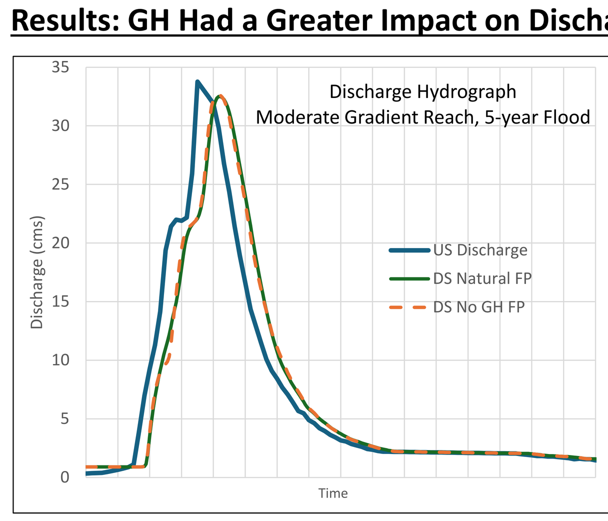
Attribute	Lewis Creek	Lemon Fair River
% Concavities	19%	16%
% Flats	60%	67%
Rugosity	1.28	1.07

Measuring Unit-Scale Flow

1. HEC-RAS simulation using natural floodplain provides output raster of inundation duration.
2. Map of geomorphons overlain on raster.
3. Pool all cell values for each geomorphon type (e.g., all values in concave features pooled together).
4. Using pooled data values, create three density graphs, one for each geomorphon type.
5. Repeat process for No GH floodplain results; add second density curve to corresponding graph.

3. What Changed When Floodplain Geomorphic Heterogeneity Was Removed?

Results: GH Had a Greater Impact on Discharge at the Low Gradient Reach



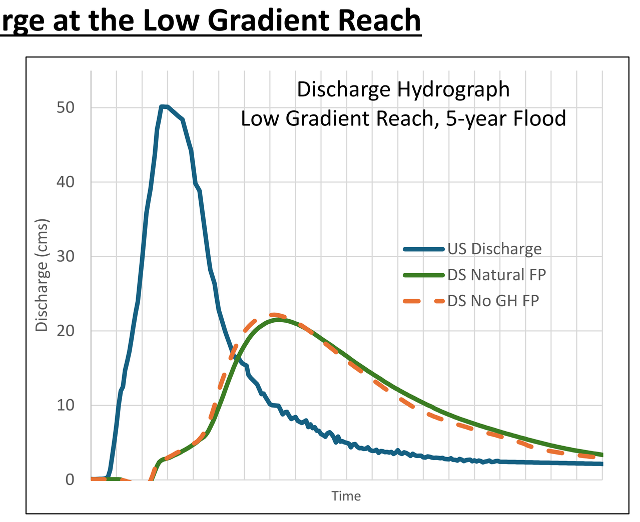


Table 3 – Δ Peak Discharge (US to DS, %)

Moderate Gradient Reach			Low Gradient Reach		
Natural FP	No GH FP	Difference	Natural FP	No GH FP	Difference
-3.8%	-3.3%	-0.5%	-55.4%	-53.9%	-1.5%

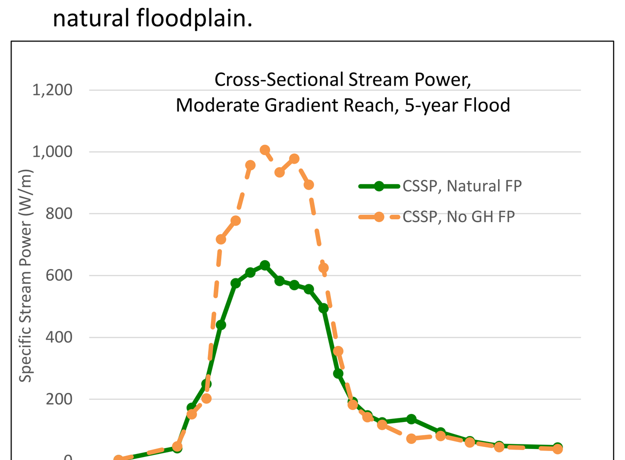
- Low gradient reach exhibited much more attenuation than moderate gradient site for both floodplain types.
- No GH floodplain caused less discharge attenuation than the natural floodplain at both sites.

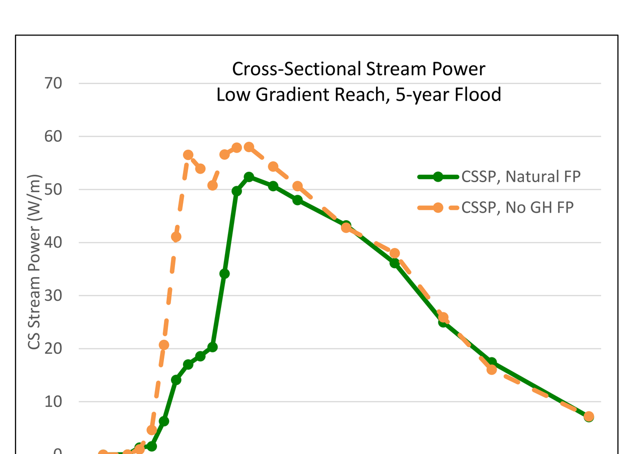
Results: GH Had a Greater Impact on Stream Power at the Moderate Gradient Reach

- Moderate gradient reach exhibited larger difference in stream power (between floodplain types) than the low gradient reach.
- No GH floodplain exhibited higher stream power at both reaches compared to the natural floodplain.

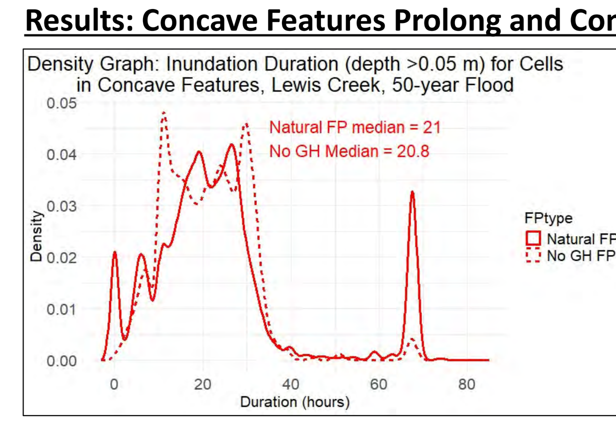
Table 4 – Peak Stream Power (W/m)

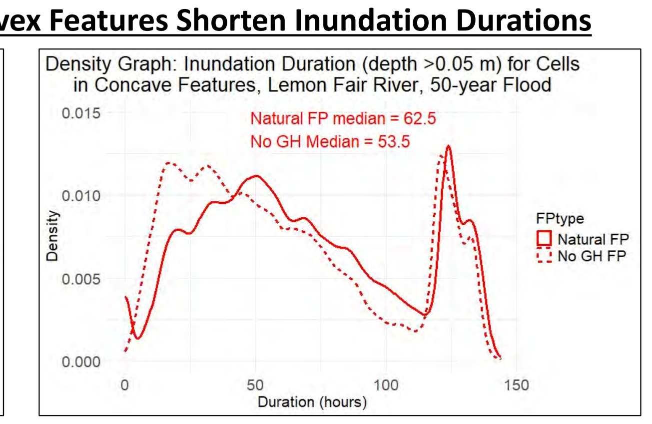
Moderate Gradient Reach			Low Gradient Reach		
Natural FP	No GH FP	Difference	Natural FP	No GH FP	Difference
634	1,007	**+59%**	52.4	58.0	**+11%**



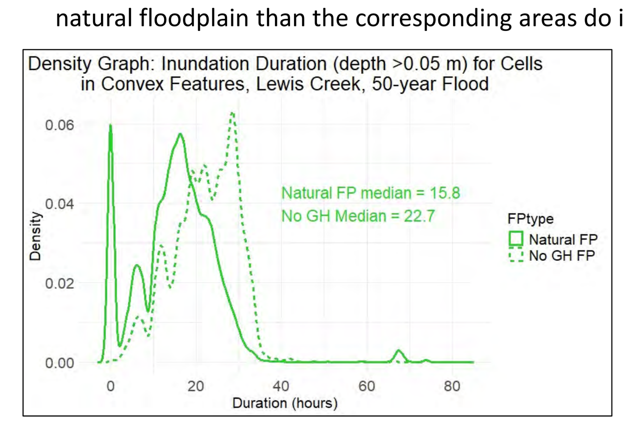


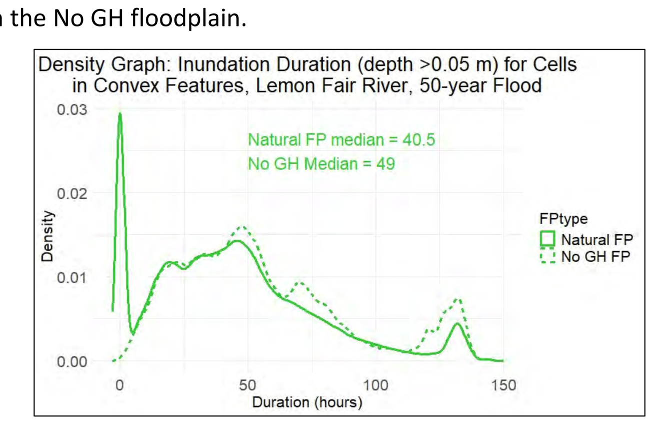
Results: Concave Features Prolong and Convex Features Shorten Inundation Durations



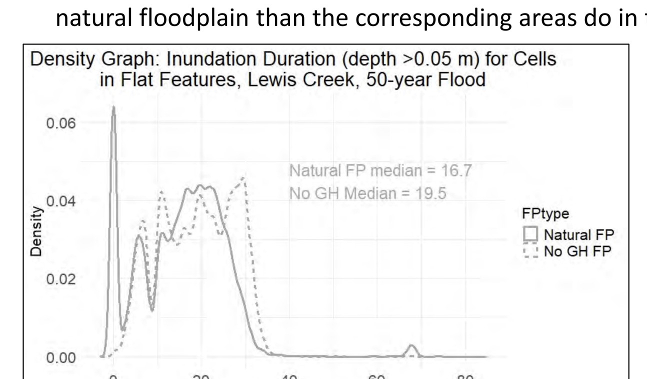


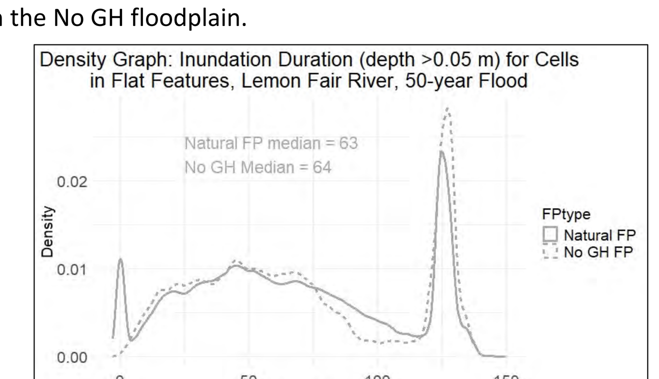
- In the No GH floodplain, concave features have been filled in/raised to the level of the surrounding ground.
- Graphs and median values for both sites show that concave features have longer inundation durations in the natural floodplain than the corresponding areas do in the No GH floodplain.





- In the No GH floodplain, convex features have been flattened or smoothed out.
- Graphs and median values for both sites show that convex features have shorter inundation durations in the natural floodplain than the corresponding areas do in the No GH floodplain.





- In the No GH floodplain, flat features have generally the same flatness as they do in the natural floodplain.
- Graphs and median values for both sites show that flat features have slightly shorter inundation durations in the natural floodplain than the corresponding areas do in the No GH floodplain.

4. Conclusions

- Floodplain GH can provide some downstream discharge attenuation, but it's limited to a small % of upstream discharge.
  - May have more potential to attenuate discharge in low gradient reaches compared to moderate or high gradient reaches.
- Floodplain GH reduces downstream stream power.
  - Larger reduction for moderate gradient reaches than for low gradient reaches.
- Different topographic feature shapes have distinct effects on inundation time.
  - Convex features may not be as important as concave and flat features for slowing down floodwaters.
  - What causes the difference in inundation times of flat features between the two floodplain types if their shape isn't significantly changing?
- **The effects of floodplain GH on overbank floodwaters are measurable and should be considered in river corridor management and flood mitigation projects, especially where stream power is high and fluvial erosion is a concern.**
- **Omitting floodplain topography from large hydrodynamic models (like the National Water Model) could lead to model inaccuracies in select types of reaches.**

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