COLLECTION OF PALEOFLOOD EVIDENCE

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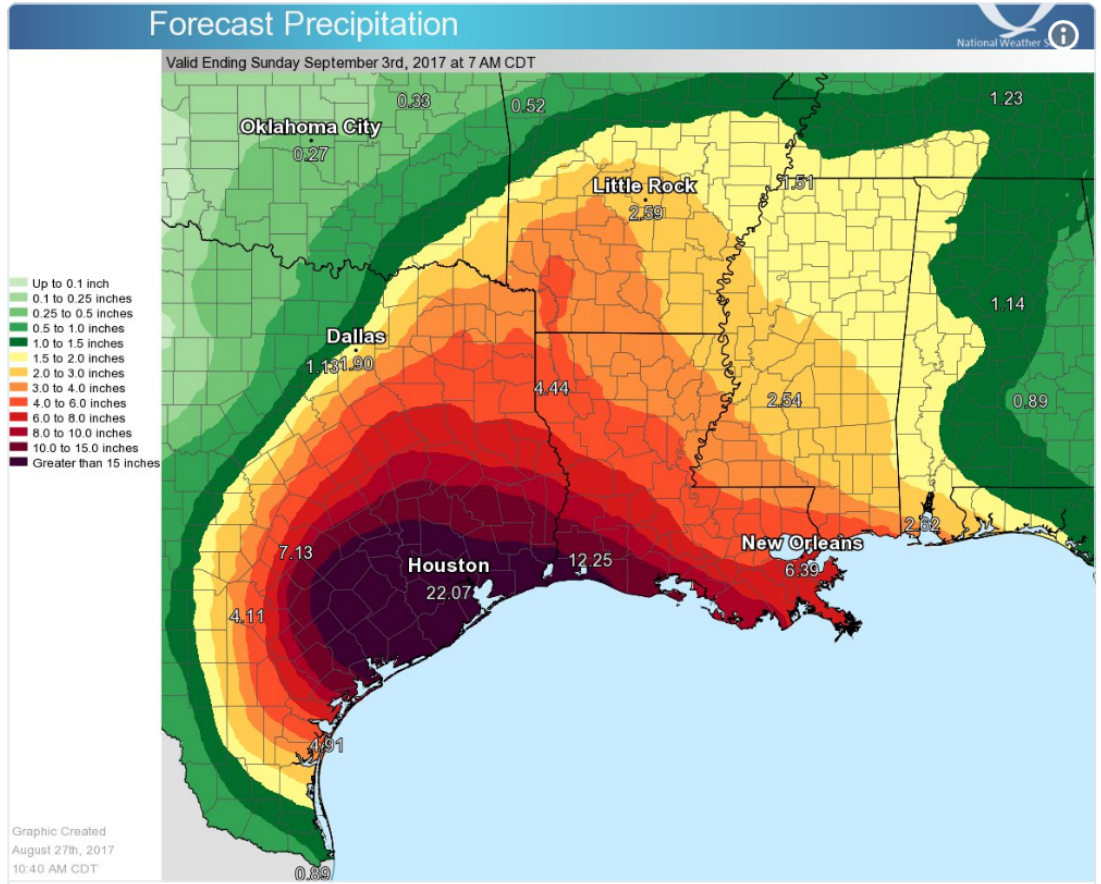
Hurricane Harvey: an unprecedented precipitation event?



NWS
@NWS

Follow

This event is unprecedented & all impacts are unknown & beyond anything experienced. Follow orders from officials to ensure safety. #Harvey

10:44 AM - Aug 27, 2017

851 29,138 23,177

Paleocontext can improve understanding of extreme events

SCIENTIFIC REPORTS

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SUBJECT AREAS:
GEOMORPHOLOGY
PALAEOCLIMATE
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SEDIMENTOLOGY

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How Unique was Hurricane Sandy? Sedimentary Reconstructions of Extreme Flooding from New York Harbor

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The magnitude of flooding in New York City by Hurricane Sandy is commonly believed to be extremely rare, with estimated return periods near or greater than 1000 years. However, the brevity of tide gauge records result in significant uncertainties when estimating the uniqueness of such an event. Here we compare resultant deposition by Hurricane Sandy to earlier storm-induced flood layers in order to extend records of flooding to the city beyond the instrumental dataset. Inversely modeled storm conditions from grain size trends show that a more compact yet more intense hurricane in 1821 CE probably resulted in a similar storm tide and a significantly larger storm surge. Our results indicate the occurrence of additional flood events like Hurricane Sandy in recent centuries, and highlight the inadequacies of the instrumental record in estimating current flood risk by such extreme events.

On October 29, 2012 Hurricane Sandy inundated New York City, NY, raising water levels to 3.4 m above 2012 mean sea level (MSL) at the Battery (located at the south end of lower Manhattan). The return period of this storm tide is estimated to be 1570 years based on generalized extreme value return curves from existing tide gauge data[1], and simulated hurricane climatology ranks this storm as a 1-in-900 year event[2]. However, tide gauge data alone is generally too short to either obtain accurate extreme value statistics or evaluate the skill of extreme flood probabilities derived solely from numerical simulations[3]. Thus there is a real need for longer flood reconstructions, particularly for critically important coastlines like New York City. Historical documentation of storm activity for the city (i.e. newspapers, nautical logs, etc.) can extend storm records back to the mid-1600s for the U.S. east coast[4–7]. While these records provide valuable information on the occurrence of storms, detailed quantitative information on specific storm characteristics prior to 1844[8] is limited, particularly with respect to flood magnitudes.

Research Questions

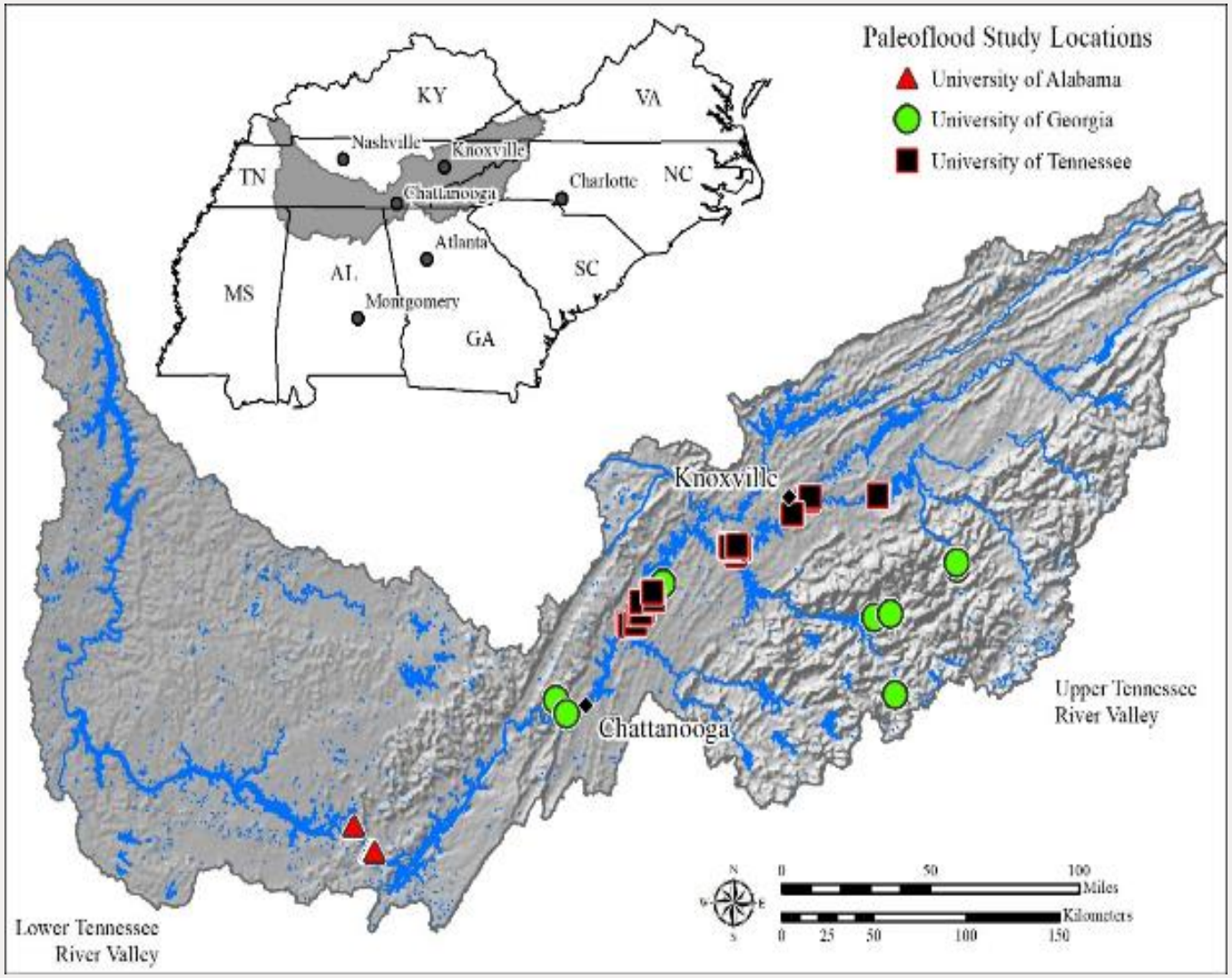
Do paleoflood indicators of extreme floods exist in the Tennessee River basin?

Can these paleoflood indicators be used to estimate peak stage, **discharge**, and **flood age**?

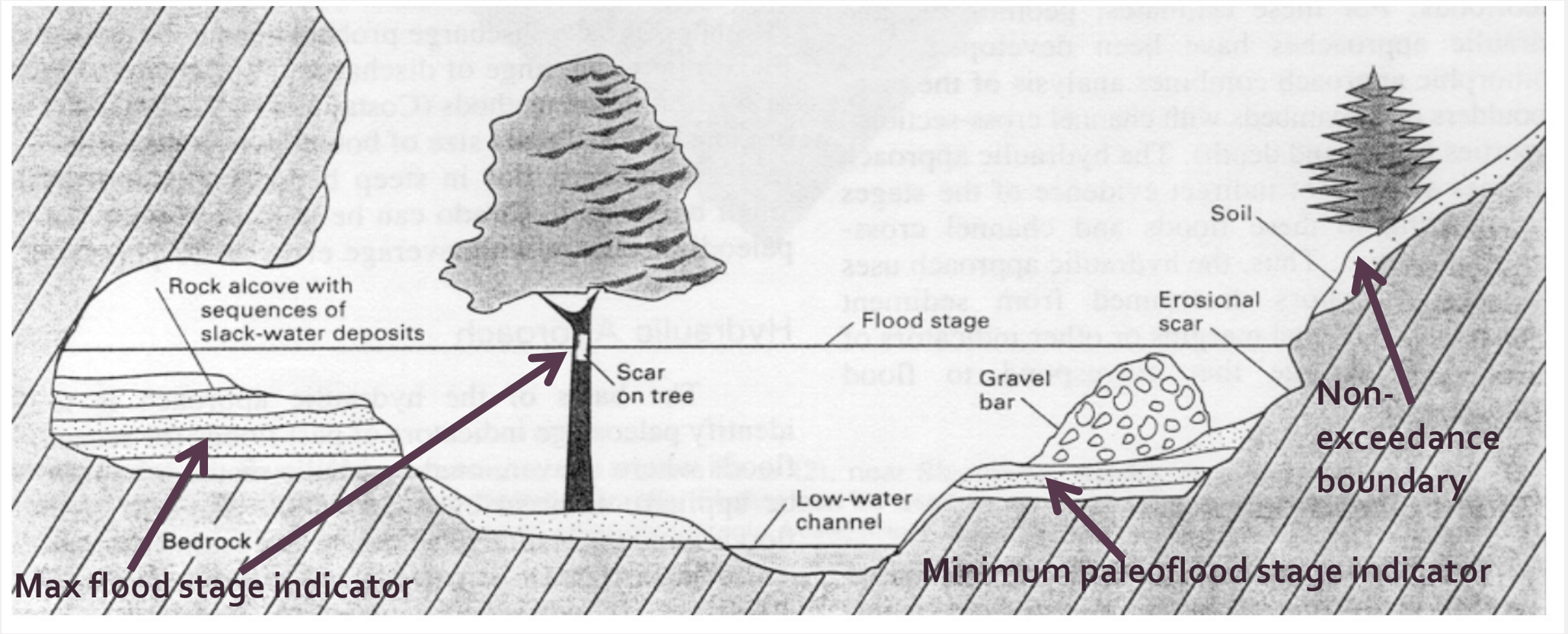
Are the proxies reproducible among different teams?

Flood of record (1867) on the Tennessee River at Knoxville, TN (image from McClung Museum, University of Tennessee)

The Tennessee River



Methods



Schematic from: Jarrett, R.D., 1998. Paleoflood investigations to assess extreme flooding for Elkhead Reservoir, Northern Colorado: Proceedings from the First Interagency Hydrologic Modeling Conference, Las Vegas, NV.

Methods: multi-pronged, multi-site approach

Instrumented Record

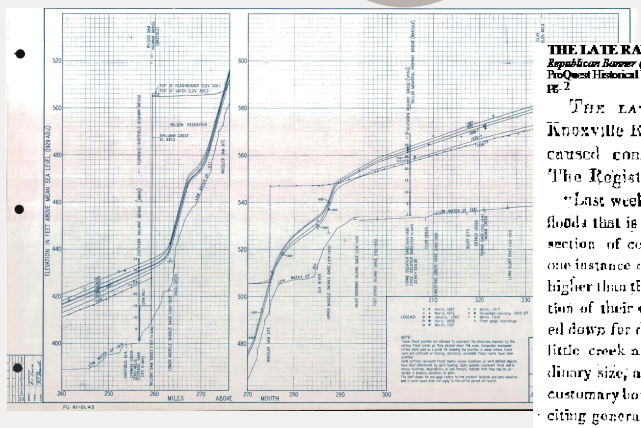
Historic Record

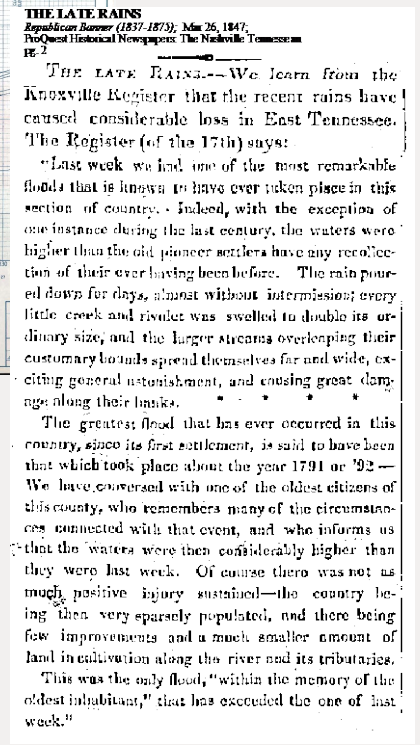
Tree Ring Record

Sedimentary Record

Present

Past





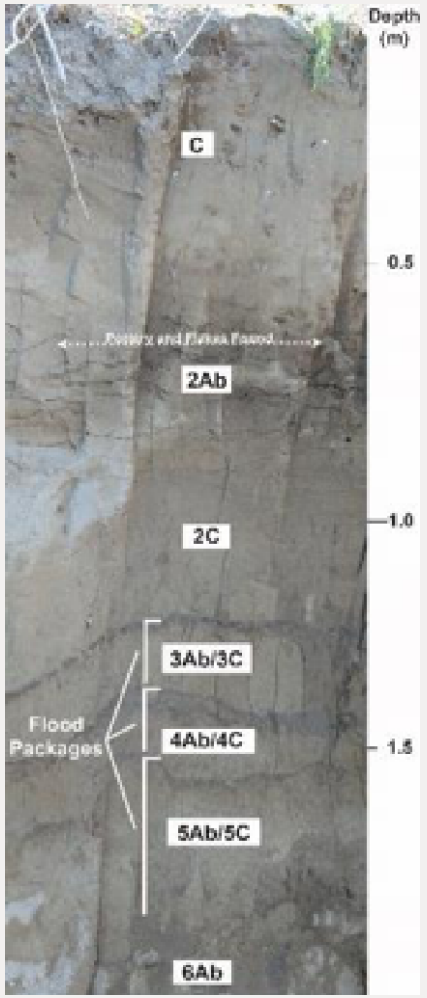
THE LATE RAINS
Republican Banner (1837-1873); Mar 26, 1847;
ProQuest Historical Newspapers: The Nashville Tennessean
Pg. 2

THE LATE RAINS.—We learn from the Knoxville Register that the recent rains have caused considerable loss in East Tennessee. The Register (of the 17th) says:

"Last week we had one of the most remarkable floods that is known to have ever taken place in this section of country. Indeed, with the exception of one instance during the last century, the waters were higher than the old pioneer settlers have any recollection of their ever having been before. The rain poured down for days, almost without intermission; every little creek and rivulet was swelled to double its ordinary size, and the larger streams overleaping their customary bounds spread themselves far and wide, exciting general astonishment, and causing great damage along their banks. * * * * *

The greatest flood that has ever occurred in this country, since its first settlement, is said to have been that which took place about the year 1791 or '92.—We have conversed with one of the oldest citizens of this county, who remembers many of the circumstances connected with that event, and who informs us that the waters were then considerably higher than they were last week. Of course there was not as much positive injury sustained—the country being then very sparsely populated, and there being few improvements and a much smaller amount of land in cultivation along the river and its tributaries.

This was the only flood, "within the memory of the oldest inhabitant," that has exceeded the one of last week."



River Terrace Sites

- All teams sampled terrace deposits with the goal of reconstructing the number and relative size of floods experienced at each location

- Landforms sampled on terrace surfaces included paleomeander bends, relict natural levees, and topographic lows

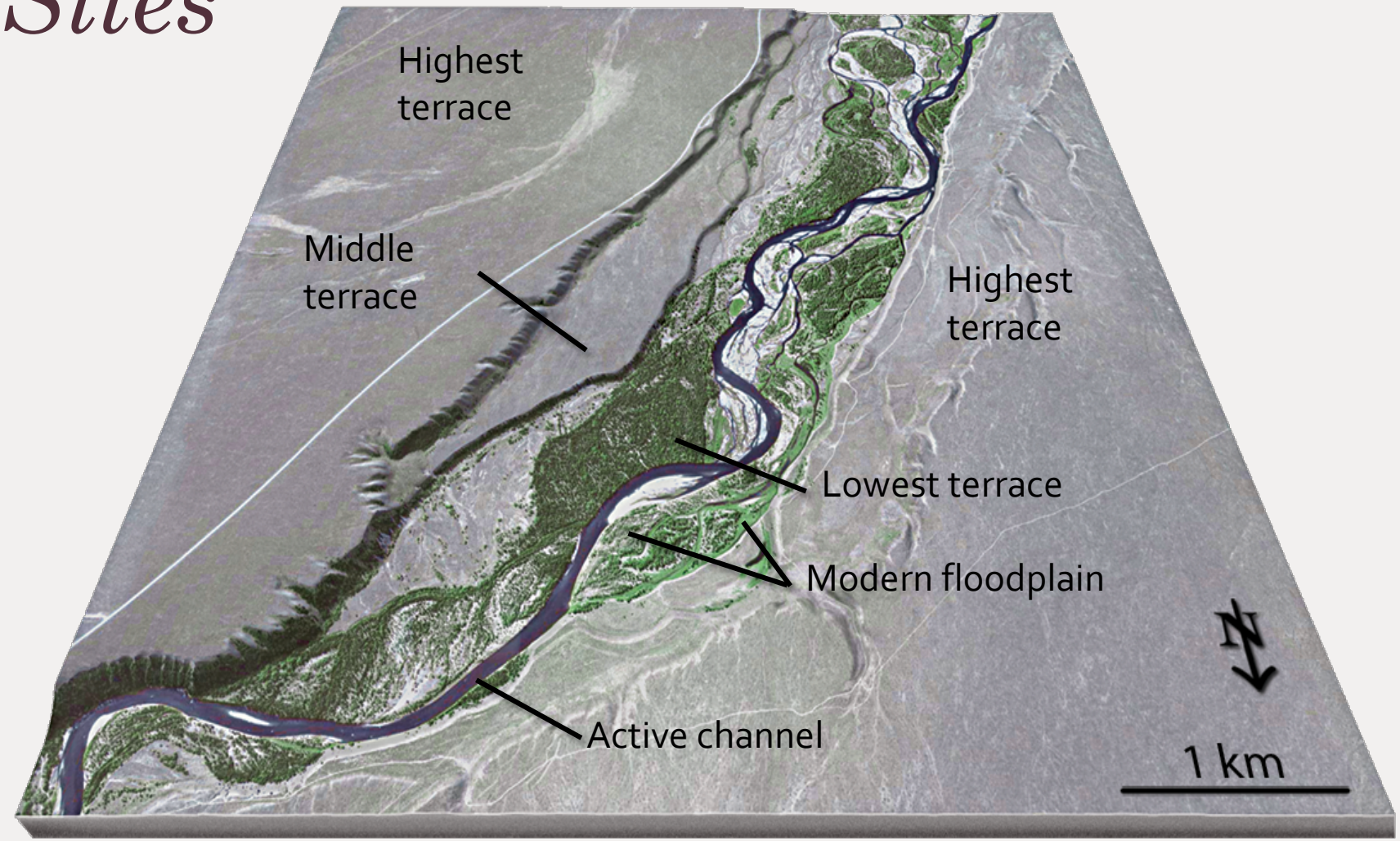
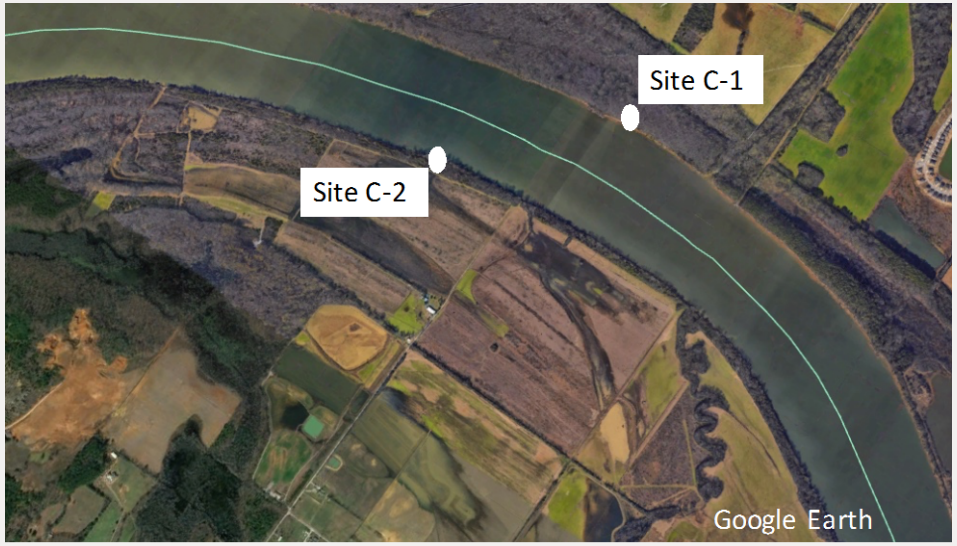
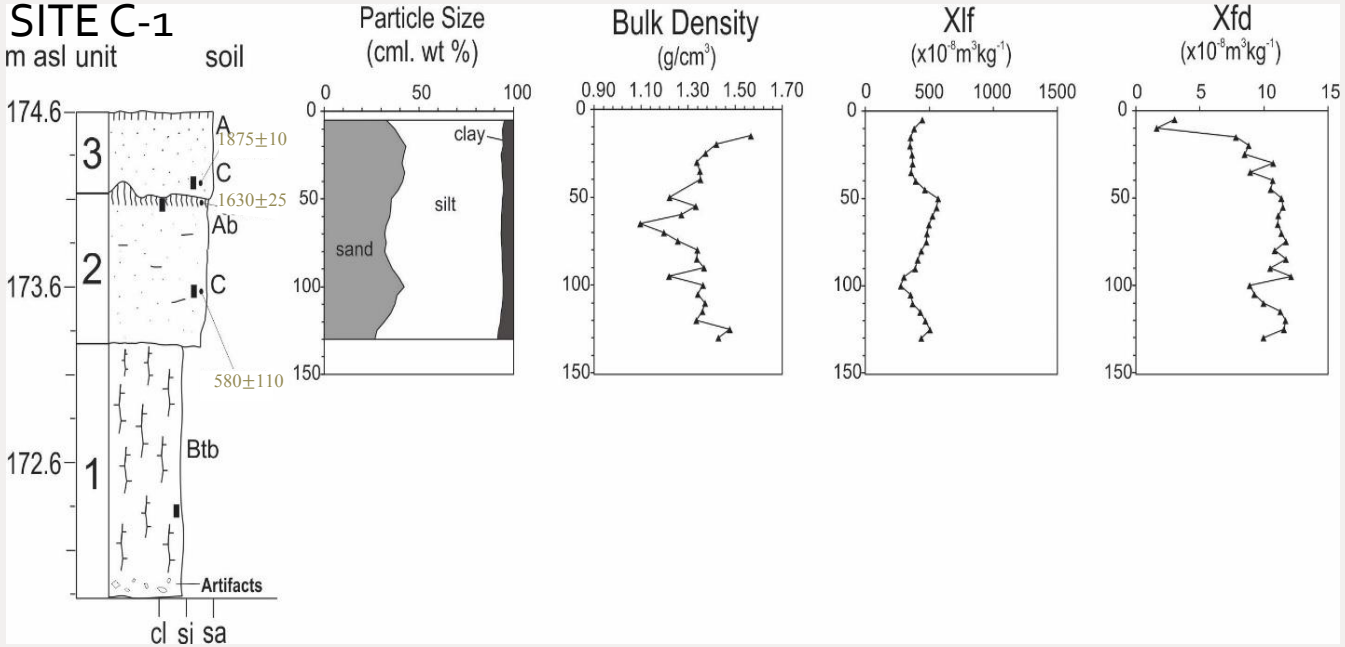


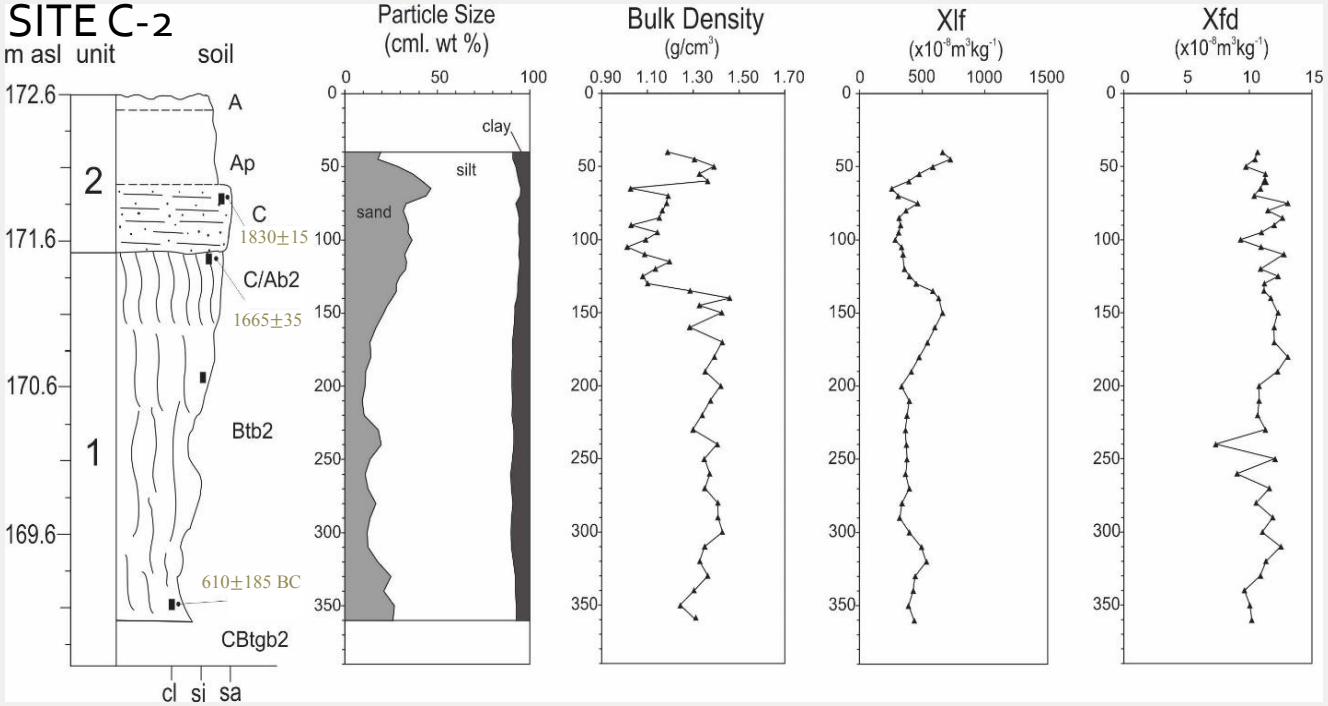
Figure from: Reynolds, S., Rohl, R., Johnson, J., Waylen, P., Francek, M., 2014. Exploring Physical Geography. McGraw-Hill Education.

Terrace Sites C-1 and C-2

4 flood deposits

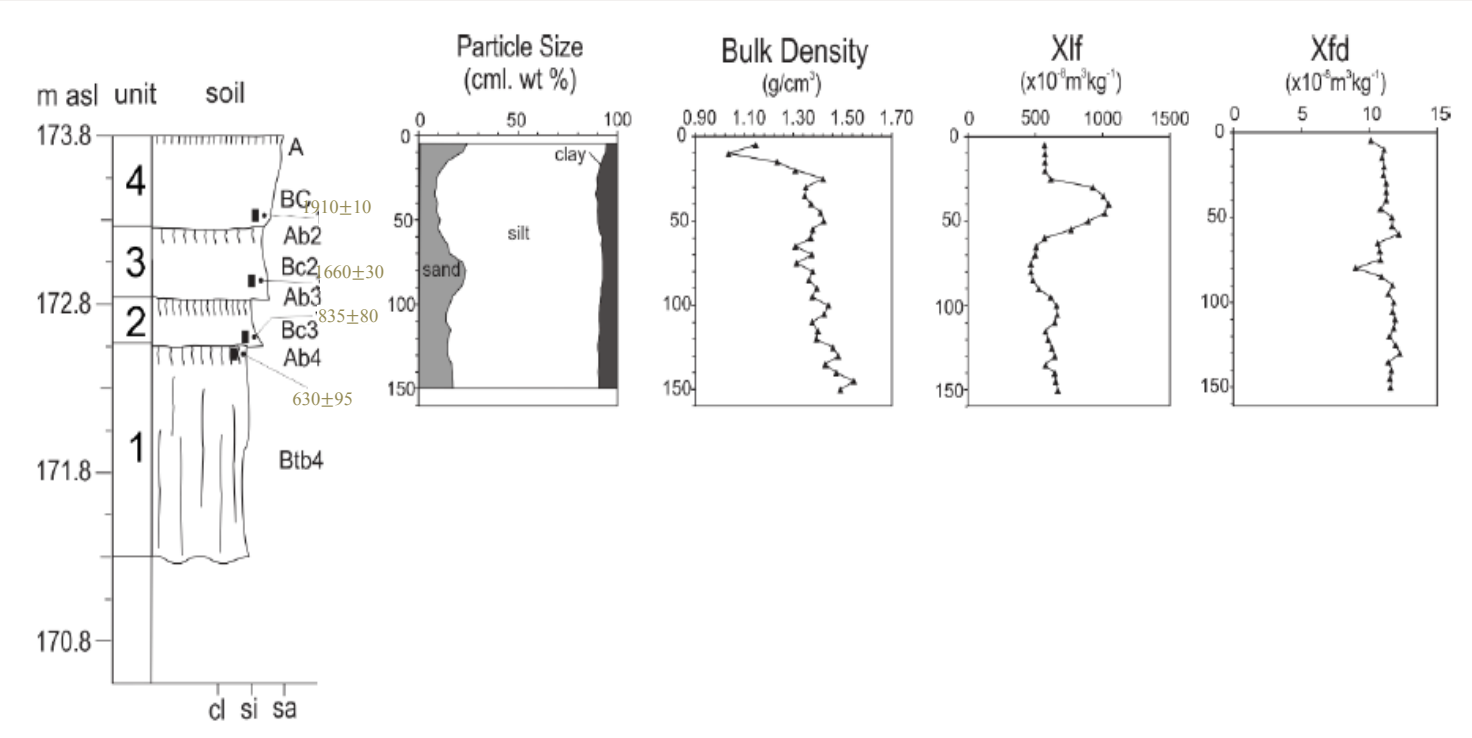






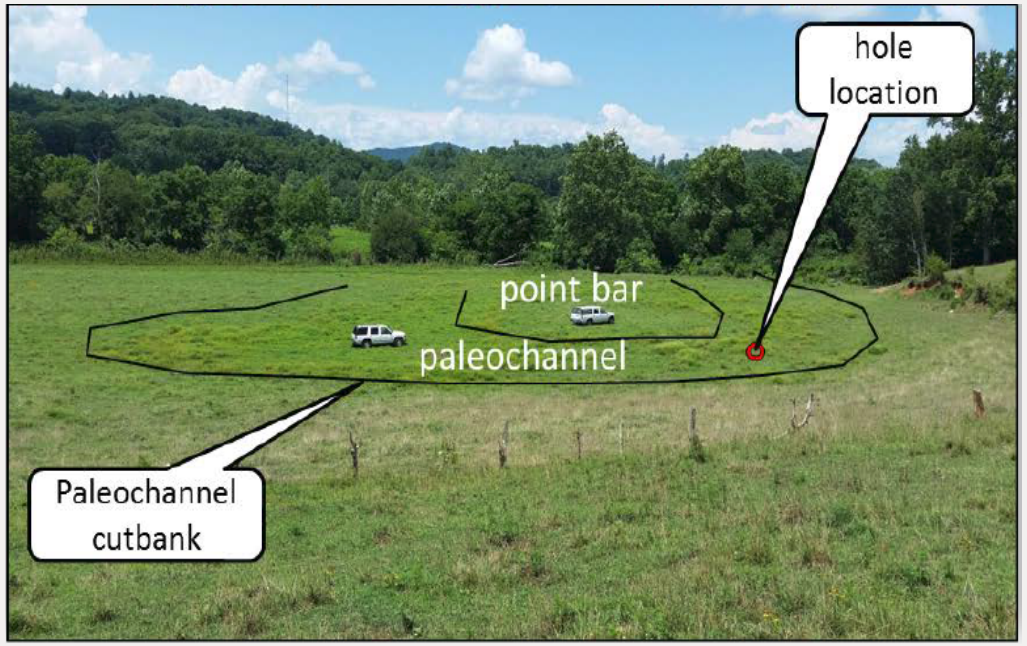
Terrace Sites

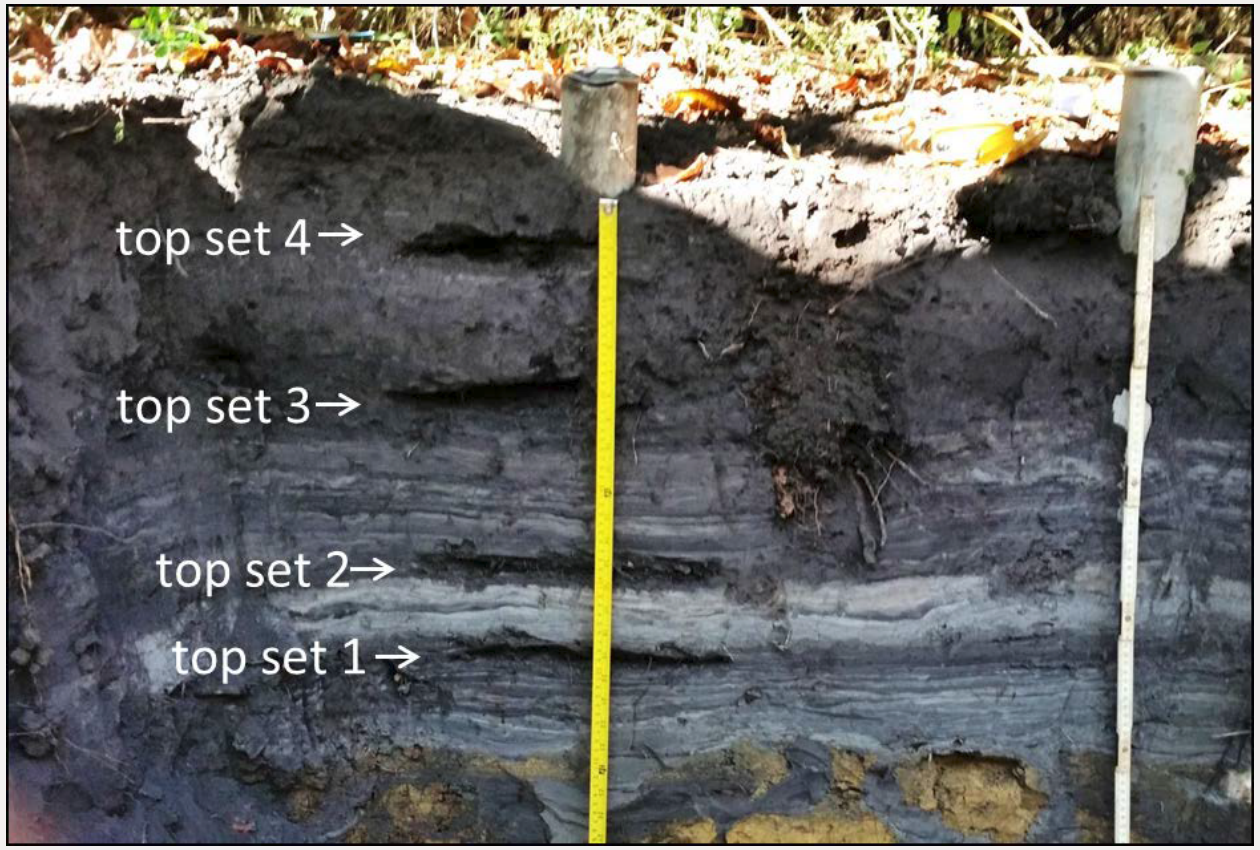
4 flood deposits



Terrace Site A-6

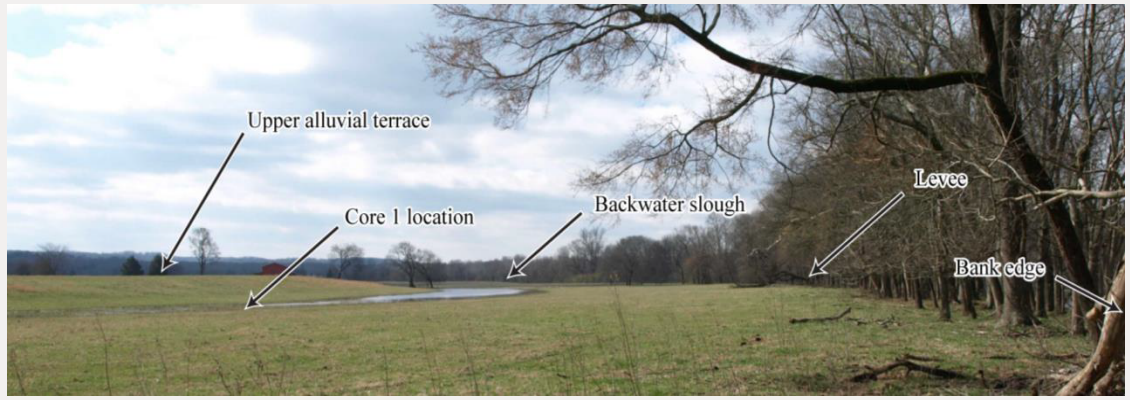
- 5 flood deposits dated to: ~1607, ~1867, ~1875, ~1886, ~1917

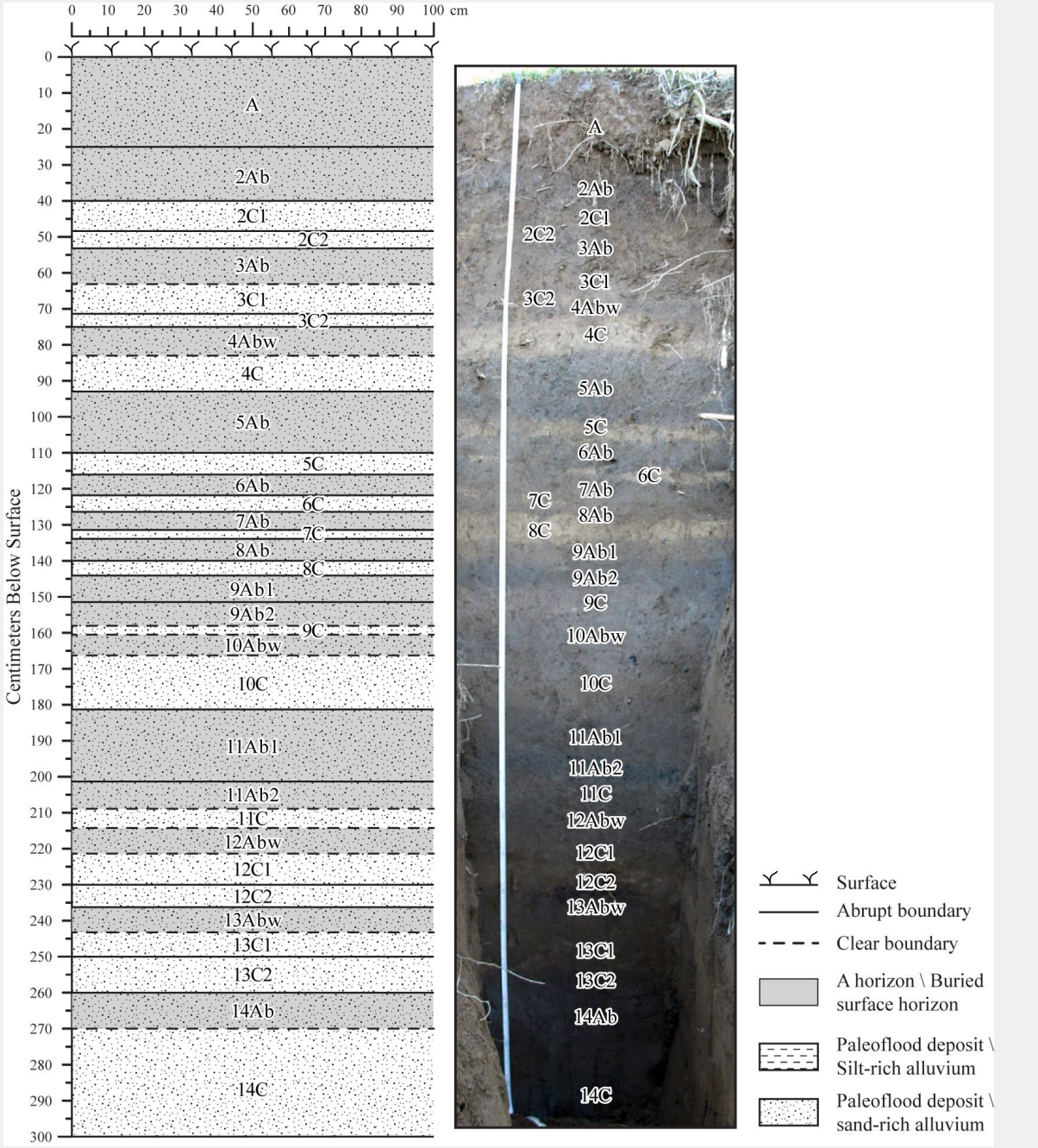




Terrace Site B-21

- 12 flood deposits
- Flood of record (1867) found at multiple sites
- Two sites had flood deposit that radiocarbon-dated to early 1600s





Bluff, Cave and Canyon Sites

- Slackwater deposits
- Potential for *max paleostage reconstruction*

MURRAY STATE UNIVERSITY

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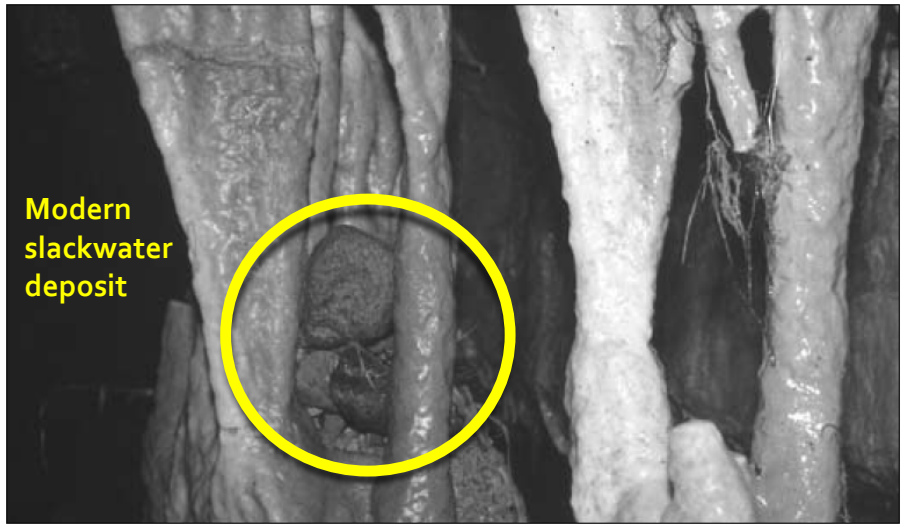


Fig. 10. Stream cobbles wedged into a group of speleothems.

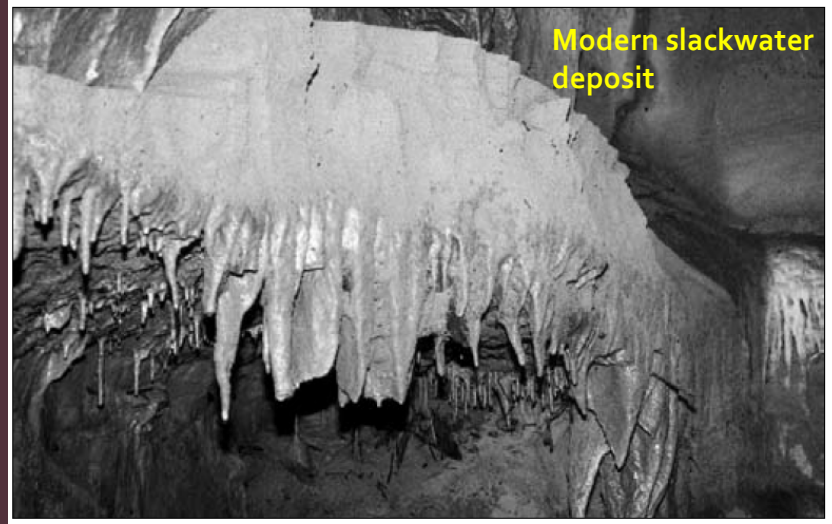


Fig. 9 Sand deposited on a flowstone shelf.

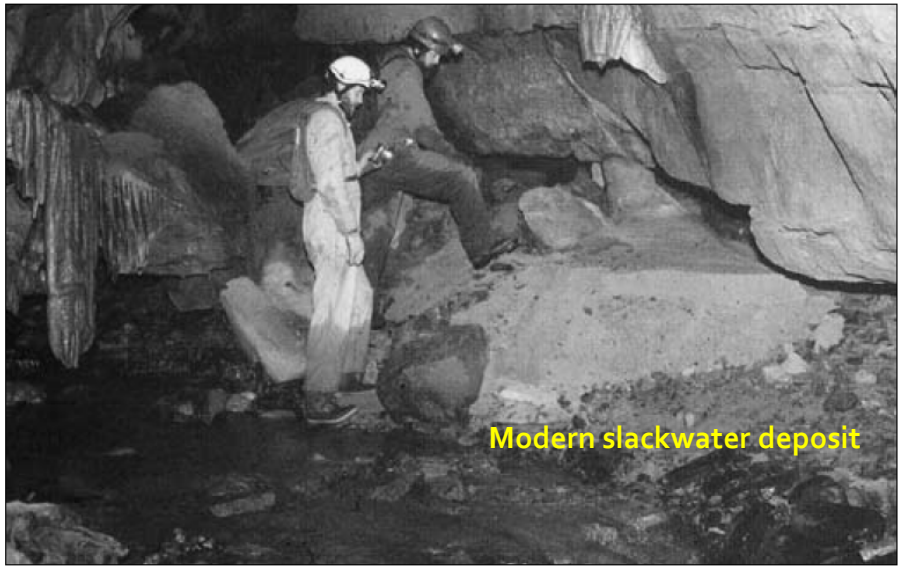
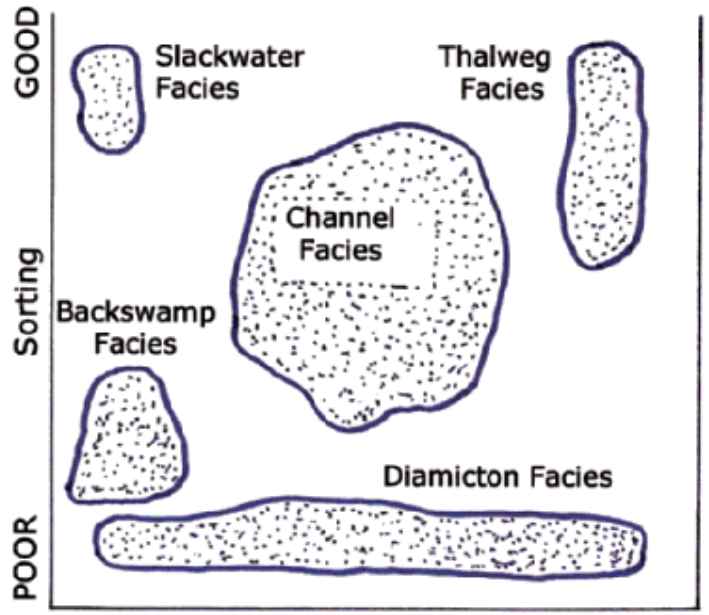
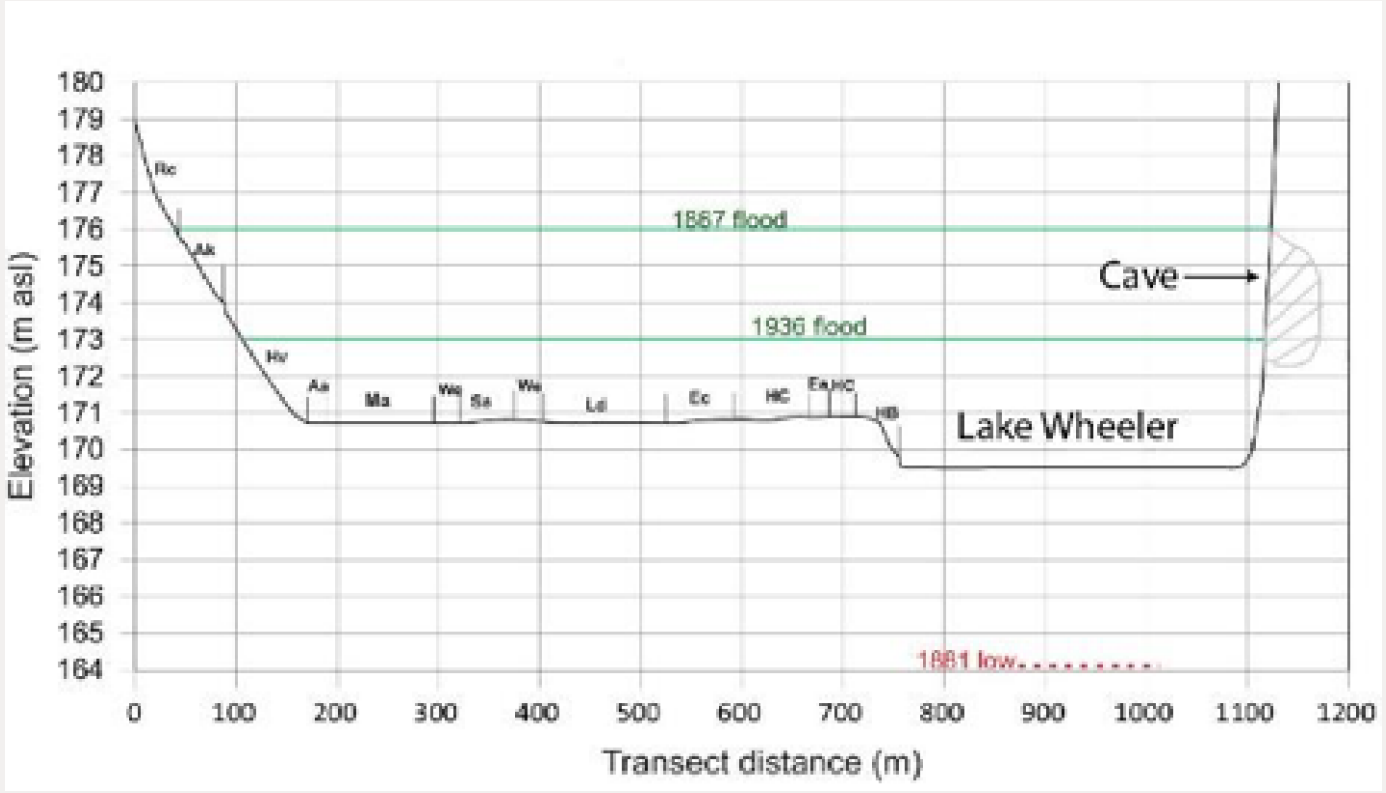


Fig. 8. The post-storm stream channel. The only evidence of massive sediment movement is the sand bar on the bank of the stream.

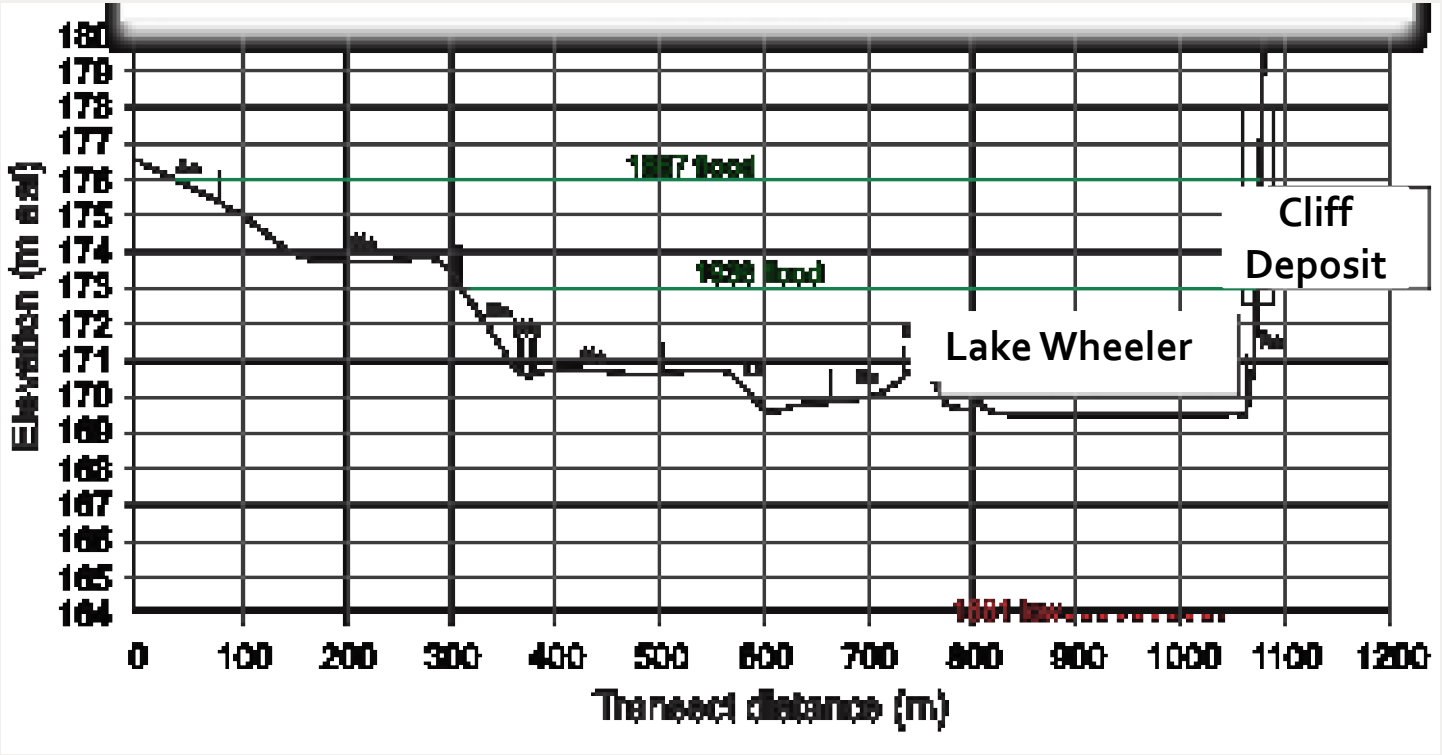


Cave sediment facies figure from: Studies of Cave Sediments: Physical and Chemical Records of Paleoclimate, Edited by Sasowskey and Mylorie.
Figs. 8-10 from: Gundy and White, 2009. Sediment flushing in Mystic Cave, WV, USA, in response to 1985 Potomac Valley flood, International Journal of Speleology 38(2): 103-109.

Cave deposits



Bluff deposit

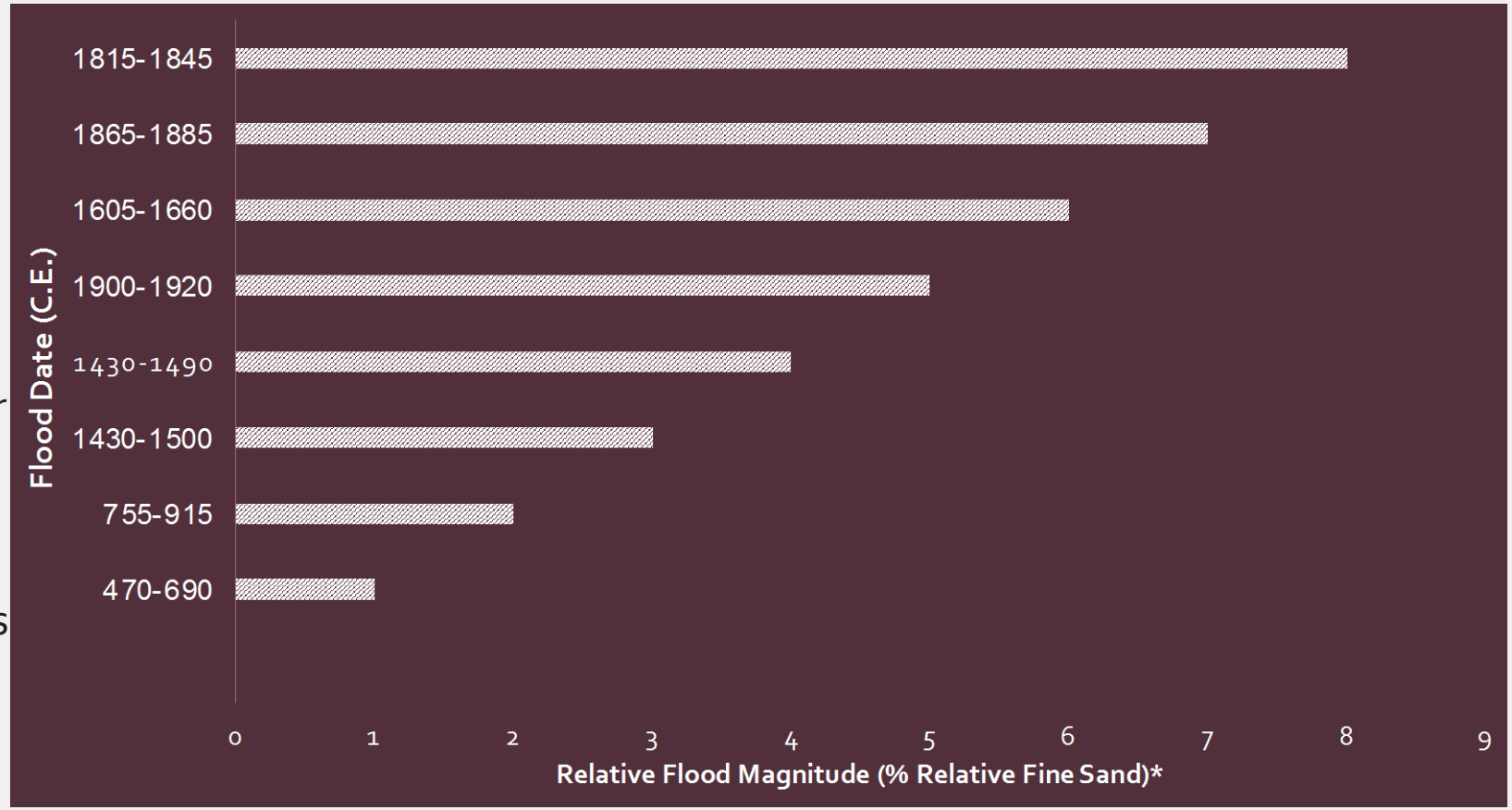


Boulder sheltered deposits

Flood deposit located on downhill/stream side of large in canyon of tributary to TN River

Summary of findings to date

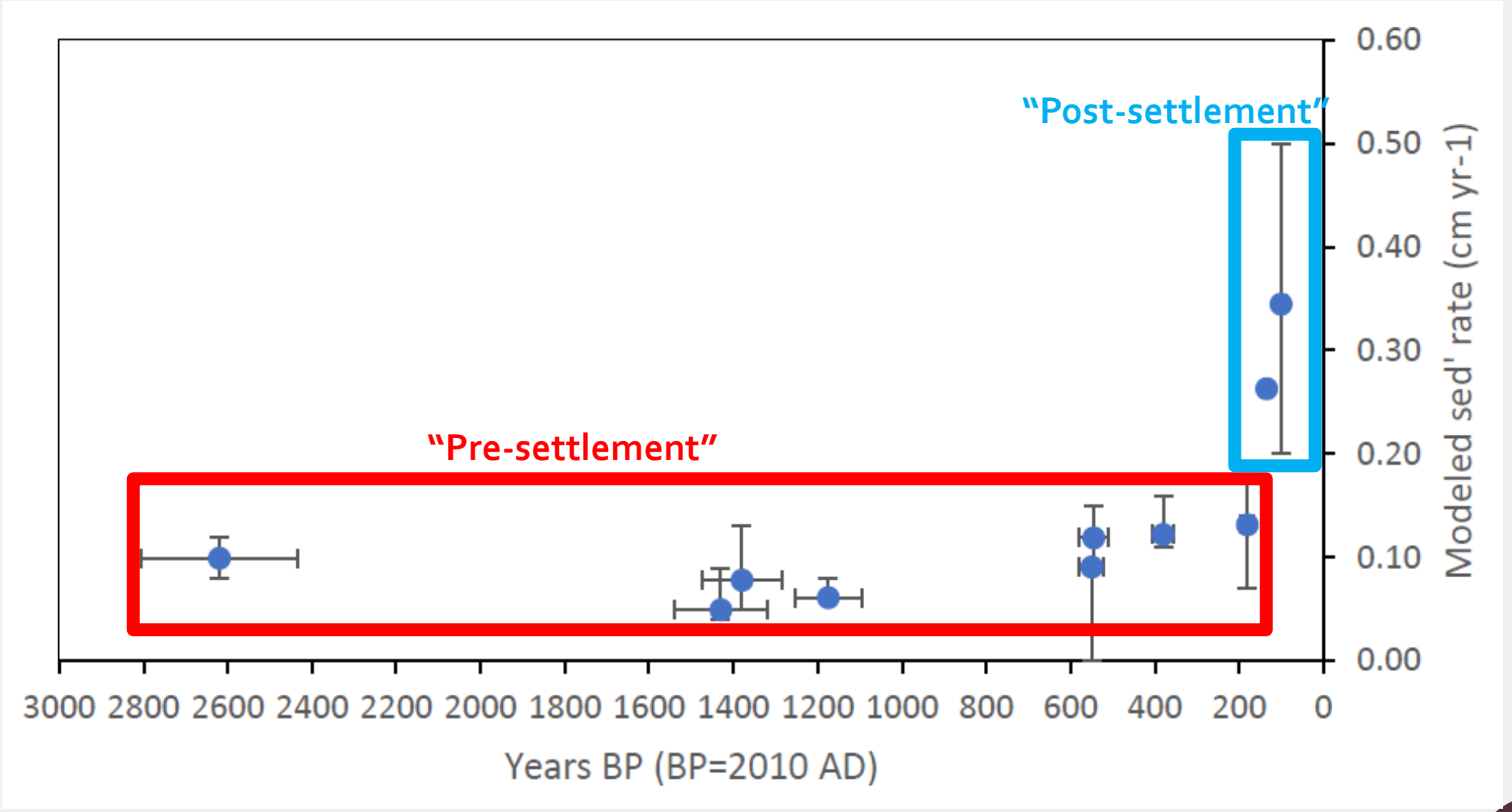
- Extended the flood record of the TN River by ~ 1200 years
- Discovered evidence of several pre-historic, large floods
- Flood of 1847, validated by deposit dated to 1830 +/- 15? This flood potentially larger than the flood of record?
- Some of the (pre) historic floods correlate between all three research groups, such as the 1910, 1867, 1630 floods
- All of the surfaces predicted to be inundated by TVA's extrapolated water surface elevations for the 1867 flood were found to have been inundated



*Method based on Leigh, D.S., 2017. Vertical accretion sand proxies of gaged floods along the Upper Little Tennessee River, Blue Ridge Mountains, USA. Sedimentary Geology, *Article in Press*, https://doi.org/10.1016/j.sedgeo.2017.09.007.

Summary of findings to date

Modeled sediment accumulation rates are faster during past 170 years, compared to older record.



These rates are consistent with pre-settlement and post-settlement sedimentation rates observed along Upper Little Tenn. R. basin (Wang and Leigh, 2015)

Acknowledgements

- EPRI
- TVA for permitting access to sites
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